

# Total Maximum Daily Load (TMDL) for Phosphorus in Onondaga Lake

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## **1.0 Introduction**

### **1.1 Background**

In April of 1991, the United States Environmental Protection Agency (EPA) Office of Water's Assessment and Protection Division published "Guidance for Water Quality-based Decisions: The Total Maximum Daily Load (TMDL) Process". In July 1992, EPA published the final "Water Quality Planning and Management Regulation" (USEPA, April 1991). Together, these documents describe the roles and responsibilities of EPA and the states in meeting the requirements of Section 303(d) of the Federal Clean Water Act (CWA) as amended by the Water Quality Act of 1987, Public Law 100-4. Section 303(d) of the CWA requires each state to identify those waters within its boundaries not meeting water quality standards for any given pollutant applicable to the water's designated uses.

Further, Section 303(d) requires EPA and states to develop TMDLs for all pollutants violating or causing violation of applicable water quality standards for each impaired water body. A TMDL determines the maximum amount of pollutant that a water body is capable of assimilating while continuing to meet the existing water quality standards. Such loads are established for all the point and nonpoint sources of pollution that cause the impairment at levels necessary to meet the applicable standards with consideration given to seasonal variations and margin of safety. TMDLs provide the framework that allows states to establish and implement pollution control and management plans with the ultimate 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, March 1991).

In January 1998, the State of New York, Atlantic States Legal Foundation (ASLF) and Onondaga County (County) reached an agreement, known as the Onondaga Lake Amended Consent Judgment (ACJ), settling litigation in connection with alleged violations of federal and state water pollution control laws. The ACJ and subsequent amendments established compliance schedules for the County to meet stringent effluent limitations for phosphorus at the Metropolitan Syracuse Wastewater Treatment Plant (Metro), and to achieve compliance with Combined Sewer Overflow (CSO) volume reductions. In March of 1998, New York State Department of Environmental Conservation (NYSDEC) promulgated a Phase I Phosphorus TMDL for Onondaga Lake focusing primarily on load reductions from Metro. The ACJ allows NYSDEC to develop a revised TMDL to promulgate a modification to the effluent limitations set forth in the Phase I TMDLs and ACJ.

### **1.2 Problem Description**

Onondaga Lake is located on the northern edge of the City of Syracuse, in Onondaga County, New York. Historically the Lake has a number of domestic and industrial pollution problems resulting from population growth and industrialization in the Syracuse area over the last century. Onondaga Lake was identified as a high priority water body in the 1996 303(d) list of impaired waters as being impaired by phosphorus (NYSDEC, 1996). Additionally, Onondaga Lake experiences anoxia in the hypolimnion during summer stratification. Subsequent to the approved Phase I Phosphorus TMDL, Onondaga Lake was delisted for phosphorus.

Additional water quality impairments in Onondaga Lake and its watershed are listed in Table 1. Note that not all waters listed in Table 1 are addressed in this TMDL. Onondaga Lake was also listed as a Federal Superfund Site in 1994. The Superfund Site currently includes the Lake bottom as well as 10 subsites around the Lake and its tributaries.

| <b>Waterbody Name</b>                       | <b>Water Index Number</b>        | <b>Cause/Pollutant</b>                                                   | <b>Year Listed</b>           |
|---------------------------------------------|----------------------------------|--------------------------------------------------------------------------|------------------------------|
| Bloody Brook and Tribs.                     | Ont 66-12-12-P154-2              | Aquatic Toxicity<br>Pathogens                                            | 2010<br>2008                 |
| Geddes Brook and Tribs.                     | Ont 66-12-12-P154-6-2            | Ammonia                                                                  | 1998                         |
| Harbor Brook lower and Tribs.               | Ont 66-12-12-P154-5              | Pathogens<br>Phosphorus<br>Ammonia                                       | 2008<br>1998<br>1998         |
| Ley Creek and Tribs.                        | Ont 66-12-12-P154-3              | Pathogens<br>Phosphorus<br>Ammonia<br>Cyanide                            | 2008<br>1998<br>1998<br>2008 |
| Minor Tribs to Onondaga Lake                | Ont 66-12-12-P154-               | Pathogens<br>Phosphorus<br>Nitrogen (NH <sub>3</sub> , NO <sub>2</sub> ) | 2008<br>2008<br>2008         |
| Ninemile Creek lower and Tribs.             | Ont 66-12-12-P154-6              | Pathogens<br>Phosphorus                                                  | 2008<br>1998                 |
| Onondaga Creek Upper and Tribs.             | Ont 66-12-12-P154-4              | Turbidity                                                                | 2008                         |
| Onondaga Creek Middle and Tribs             | Ont 66-12-12-P154-4              | Turbidity<br>Pathogens<br>Phosphorus<br>Ammonia                          | 2008<br>2008<br>1998<br>1998 |
| Onondaga Creek Lower and Tribs.             | Ont 66-12-12-P154-4              | Turbidity<br>Pathogens<br>Phosphorus<br>Ammonia                          | 2010<br>2008<br>1998<br>1998 |
| Onondaga Lake Outlet                        | Ont 66-12-12                     | DO/Oxygen Demand                                                         | 2008                         |
| Onondaga Lake northern end<br>(North basin) | Ont 66-12-12-P154<br>(portion 1) | Dioxin<br>Mercury<br>PCBs                                                | 1998<br>1998<br>1998         |
| Onondaga Lake southern end<br>(South basin) | Ont 66-12-12-P154<br>(portion 2) | Dioxin<br>Mercury<br>PCBs<br>Pathogens                                   | 1998<br>1998<br>1998<br>2008 |
| Seneca River main stem portion 1            | Ont 66-12 (portion 1)            | DO/Oxygen Demand                                                         | 1998                         |
| Seneca River main stem portion 2            | Ont 66-12 (portion 2)            | DO/Oxygen Demand<br>Pathogens                                            | 1998<br>1998                 |

**Table 1: Water Quality Impairments in the Onondaga Lake Watershed (NYSDEC, 2010)**

### **1.3 TMDL Scope**

In 1998, NYSDEC established a phosphorus TMDL for Onondaga Lake. Subsequently, NYSDEC moved Onondaga Lake to sub-part 4a of the Section 303(d) list. This list pertains to waters where TMDLs have been developed and approved the US EPA. The TMDL in this document serves to revise the 1998 TMDL and addresses the following waters: Onondaga Lake northern end (Water Index Number [WIN]: Ont 66-12-12-P154 [portion 1]) and Onondaga Lake southern end (WIN: Ont 66-12-12-P154 [portion 2]). Since Onondaga Lake is currently not listed on the 303(d) list for phosphorus, there is no priority ranking associated with this water body and pollutant.

The purpose of this TMDL is to address excess phosphorus loading to Onondaga Lake with the goal of improving water quality such that the Lake meets its current designated best use as identified in 6 NYCRR §895 (see also Table 4) by utilizing the extensive effluent and ambient monitoring data available along with enhanced water quality models. It is noted that this TMDL does not specifically address all of the water quality impairments identified in Table 1, however, the phosphorus load reductions and best management strategies specified in this TMDL, intended to meet recreational and aquatic life uses in Onondaga Lake, will provide additional water quality benefits throughout the watershed. Ongoing remediation of Superfund sites as well as CSO abatement will provide further benefits to water quality.

## **2.0 System Characterization**

### **2.1 Watershed Characterization**

The Onondaga Lake watershed is located in the Seneca-Oneida-Oswego Rivers drainage basin and has a direct drainage area of 285 square miles situated mainly in Onondaga County with a small portion of the headwaters extending into Cortland County. Eighteen Towns, six Villages, the City of Syracuse and the Onondaga Nation Territory have jurisdiction in the watershed (Figure 1). The Lakes two largest tributaries are Ninemile Creek and Onondaga Creek with drainage areas of 115 and 110 square miles respectively (Figure 2). The discharges from these two tributaries, which account for approximately 66% of the total surface water inflow to Onondaga Lake (Coon and Reddy, 2008), are more dense than the Lake waters and often plunge to depths within the metalimnion as a result of lower temperatures and higher salinity (Owens, et al., 2010).

Existing land use and land cover in the watershed was determined from digital aerial photography and geographic information system (GIS) datasets. Digital land use/land cover data were obtained from the 1992 National Land Cover Dataset (NLCD) (USGS, 1999). 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. Much of the land within the Onondaga Lake watershed is designated as Municipal Separate Storm Sewer System (MS4) areas (Figure 3). All developed land within the MS4 areas, 29,774 acres, is included in the MS4 category for this TMDL. There is also over 8,000 acres of land centered on the city of

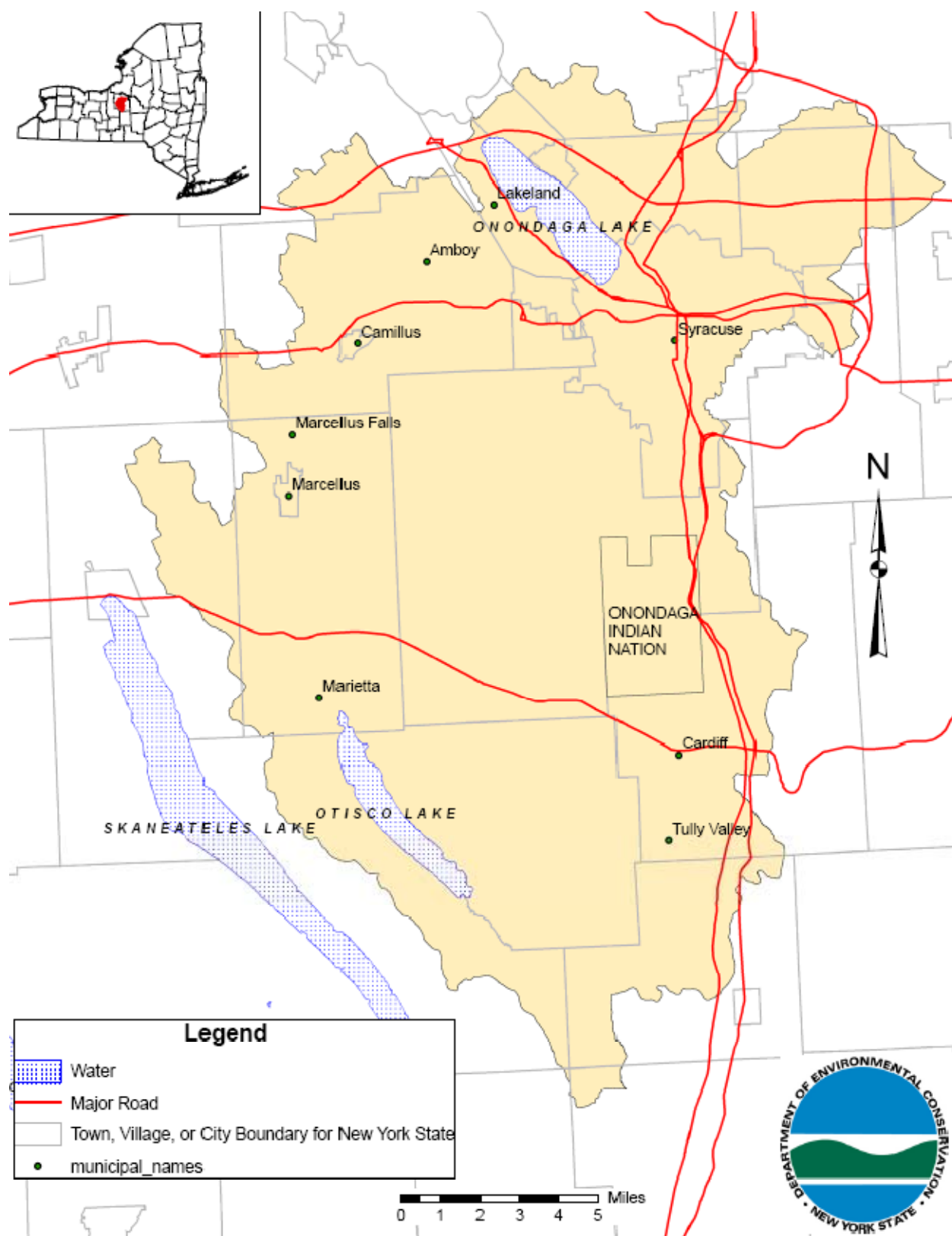


Figure 1: Onondaga Lake watershed

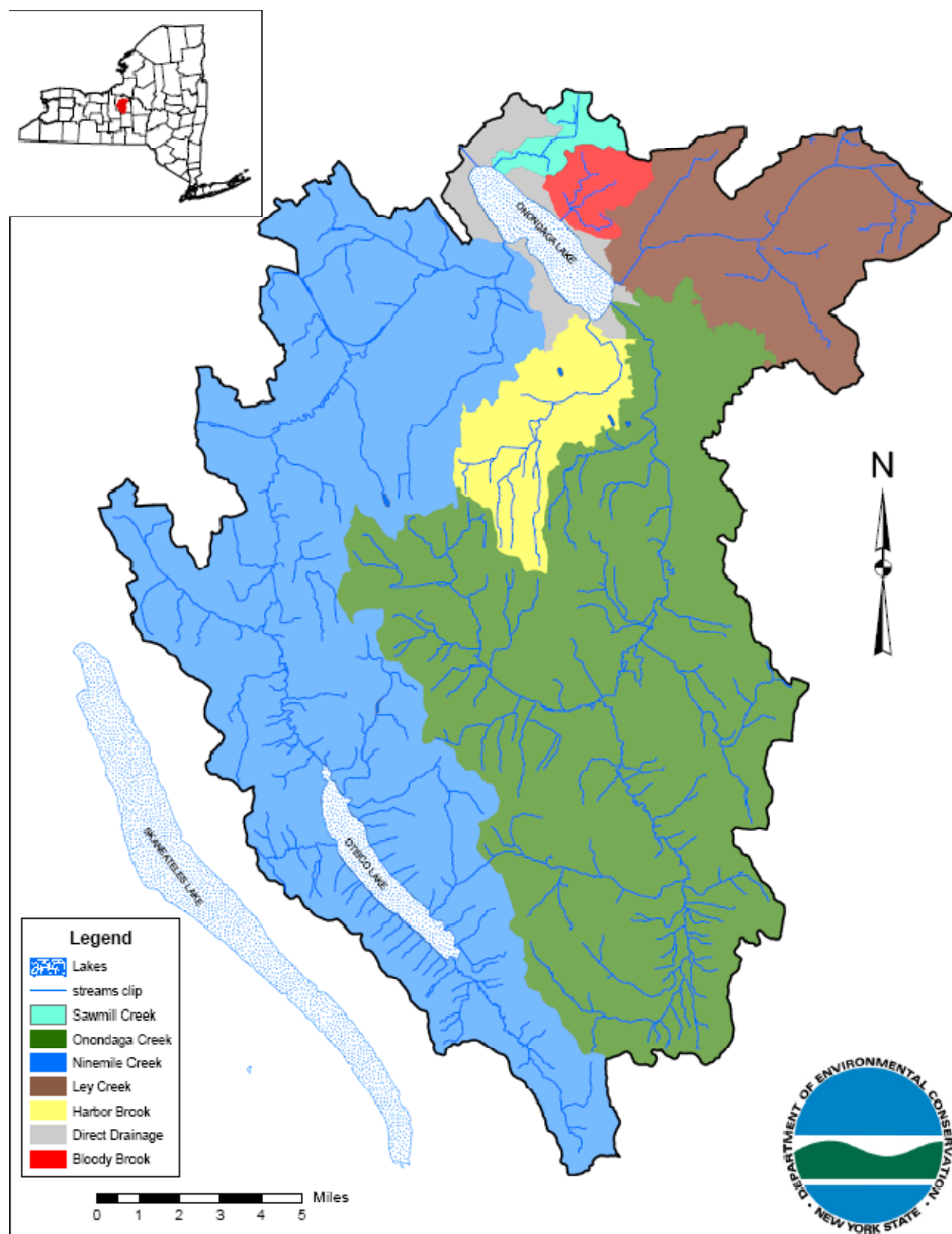


Figure 2: Major Sub Watersheds

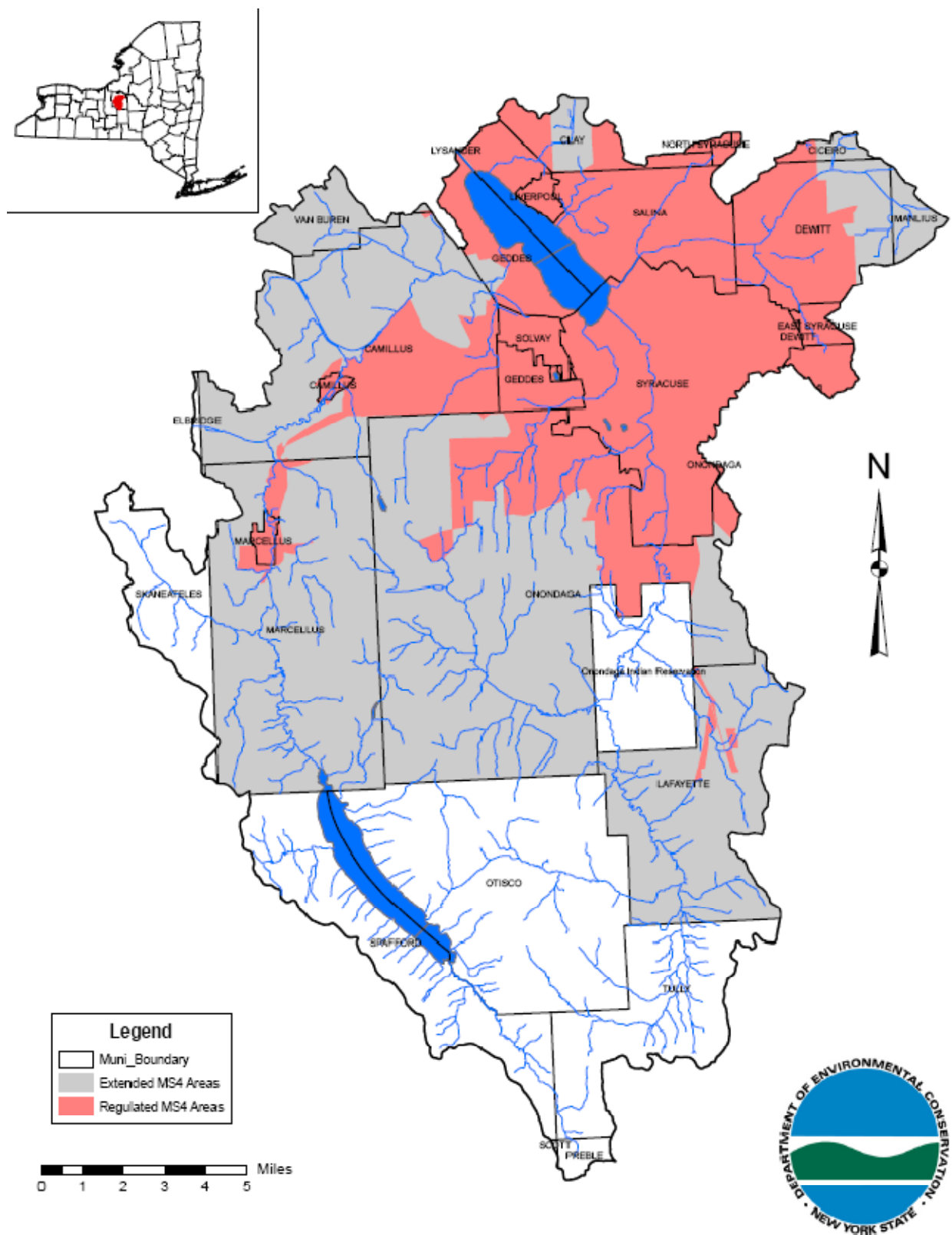


Figure 3: MS4 Boundaries

Syracuse served by a combined sewer system. For the purpose of this TMDL, developed land (not including agricultural land) appearing in the NLCD datasets as low and high intensity residential, commercial, industrial & transportation and urban & recreational grass are further separated into MS4 and combined sewer categories. These were differentiated because, from a management and implementation standpoint, the MS4 and combined sewer systems are regulated under separate permits. Land use categories (including individual category acres and percent of total) in the Onondaga Lake watershed are listed in Table 2 and presented in Figures 4 and 5.

### ***2.1.1 Updated Land Use Data***

The land use/land cover data used in the models for the Onondaga watershed for the development of this TMDL was based upon the best available data at the time of development, the 1992 NLCD dataset (USGS, 1999). Subsequent to the model development two new land use/land cover dataset have been made available, the first released in 2005 based upon circa 2001 imagery and the second in 2011, based upon circa 2006 satellite data (Fry et al. 2011).

There are several notable differences between the 1992 and 2006 land use/land cover data sets within the Onondaga Lake watershed. Wetland/water area increased by 3,031 acres and now makes up 9.3% of the watershed. This increase is due to better identification of wetlands, some of which had previously been identified as forests. This deficiency of the 1992 dataset was known to Coon and Reddy (2008) when the watershed model was developed and steps were taken to correctly represent the true extent of wetlands. Overall, total agricultural acreage stayed roughly constant relative to what is listed in 1992 dataset (Table 2), but pasture and hay lands were estimated at 35,614 acres in 2006, a decrease of 8,754 acres from 44,368 acres estimated from the adjusted 1992 data. Row crops in 2006 were estimated at 18,797 acres, an increase of 7,908 acres over the 10,889 acres estimated in 1992 dataset. In the 2006 dataset, the two land use categories represent 19.3% and 10.2%, respectively, of the total acreage within the watershed. A similar shift from pasture and hay over to row crops was noted by Coon and Reddy (2008) when comparing the 1992 and 2001 datasets.

A trend towards urbanization was also observed when comparing the 1992 and 2006 data sets, with low and high intensity residential areas increasing by 2,693 and 1,765 acres, respectively. Low and high intensity residential now accounts for, respectively, 10.1% and 5.8% of the total watershed area. Much of the urban growth appears to have occurred at the expense of forested lands. Coon and Reddy (2008) had similarly noted an increase in nearly 400 acres of urbanized land when comparing the 1992 and 2001 data sets.

Changes also occurred within the Urban & Recreational Grass and Commercial, Industrial & Transportation land use categories. However, these changes are less clear due to the better inclusion of road surfaces in the 2006 dataset and the apparent miscategorization of some tracts of land. Such discrepancies are common with these datasets as they are generated without oversight and often require substantial verification before they can be implemented.

The recent release of the 2006 dataset relative to the development of this TMDL precludes its inclusion as part of the analysis. Although roughly 5% of the watershed changed from undeveloped to developed land, it is not expected that the land use change greatly affected the

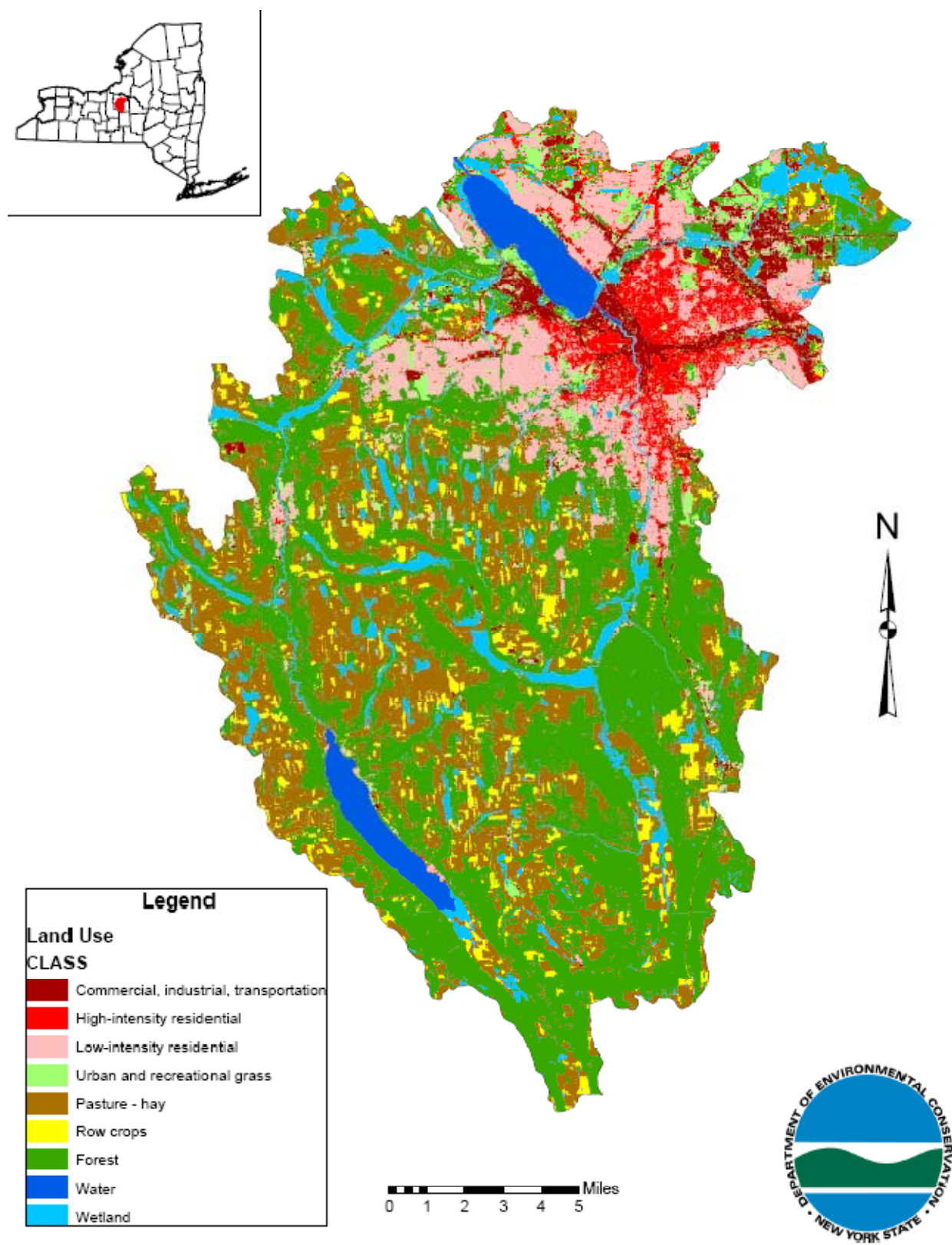
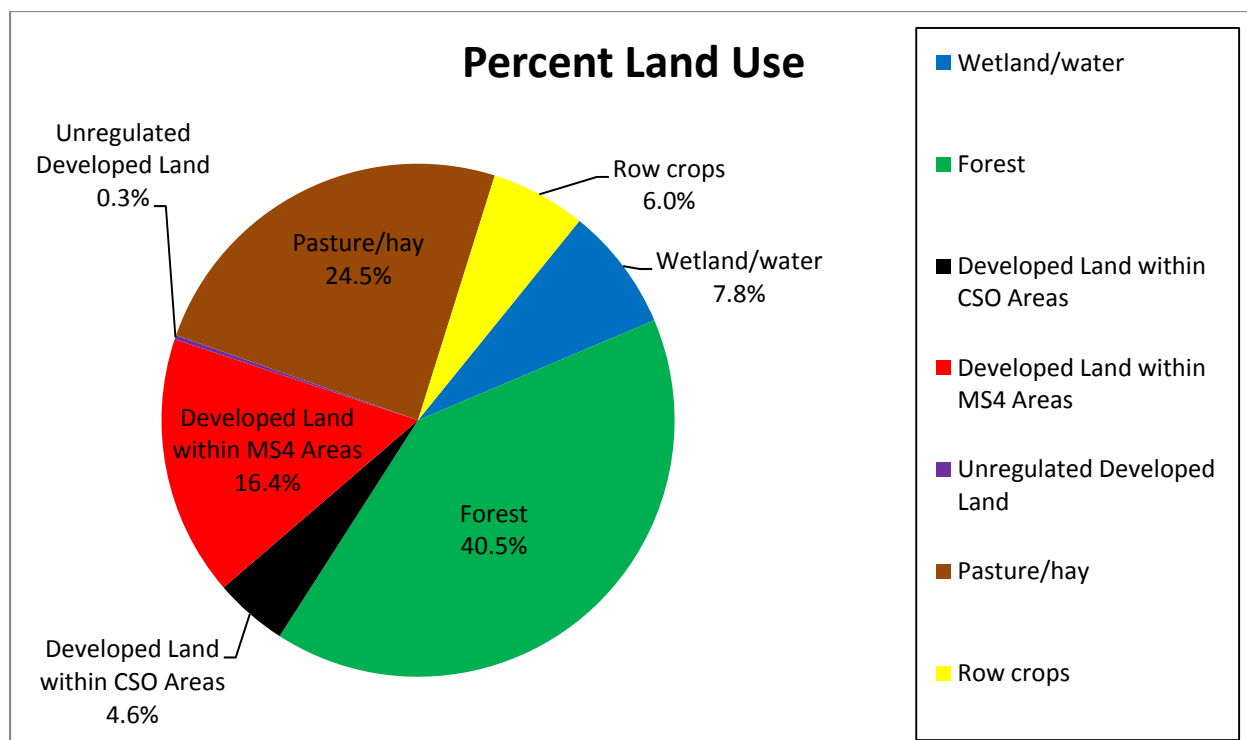


Figure 4: Land Use Map



**Figure 5: Land Use Composition**

| Land Use                         | Acres   | Percent of Watershed |
|----------------------------------|---------|----------------------|
| Wetland/water                    | 14,144  | 7.8%                 |
| Forest                           | 73,403  | 40.5%                |
| Developed Land within CSO Areas  | 8,383   | 4.6%                 |
| <i>Urban, Recreational Grass</i> | 309     | 0.2%                 |
| <i>Low residential</i>           | 2,637   | 1.5%                 |
| <i>High residential</i>          | 4,233   | 2.3%                 |
| <i>Comm., Ind., Trans.</i>       | 1,204   | 0.7%                 |
| Developed Land within MS4 Areas  | 29,774  | 16.4%                |
| <i>Urban, Recreational Grass</i> | 4,966   | 2.7%                 |
| <i>Low residential</i>           | 13,326  | 7.3%                 |
| <i>High residential</i>          | 4,628   | 2.6%                 |
| <i>Comm., Ind., Trans.</i>       | 6,854   | 3.8%                 |
| Unregulated Developed Land       | 495     | 0.3%                 |
| <i>Urban, Recreational Grass</i> | 283     | 0.2%                 |
| <i>Low residential</i>           | 48      | 0.0%                 |
| <i>High residential</i>          | 0       | 0.0%                 |
| <i>Comm., Ind., Trans.</i>       | 164     | 0.1%                 |
| Agriculture                      | 55,257  | 30.5%                |
| <i>Pasture/hay</i>               | 44,368  | 24.5%                |
| <i>Row crops</i>                 | 10,889  | 6.0%                 |
| <b>Total</b>                     | 181,456 | 100.0%               |

**Table 2: Land Use Characteristics as determined from the 1992 National Land Cover Dataset**

model predictions. The watershed model was calibrated to data collected from October 1997 to September 2003. Some of the effects of the land use changes will have been incorporated into the model during the calibration process. However, the watershed model will not incorporate observed urbanization or any of the best management practices put in place within the watershed following the calibration period.

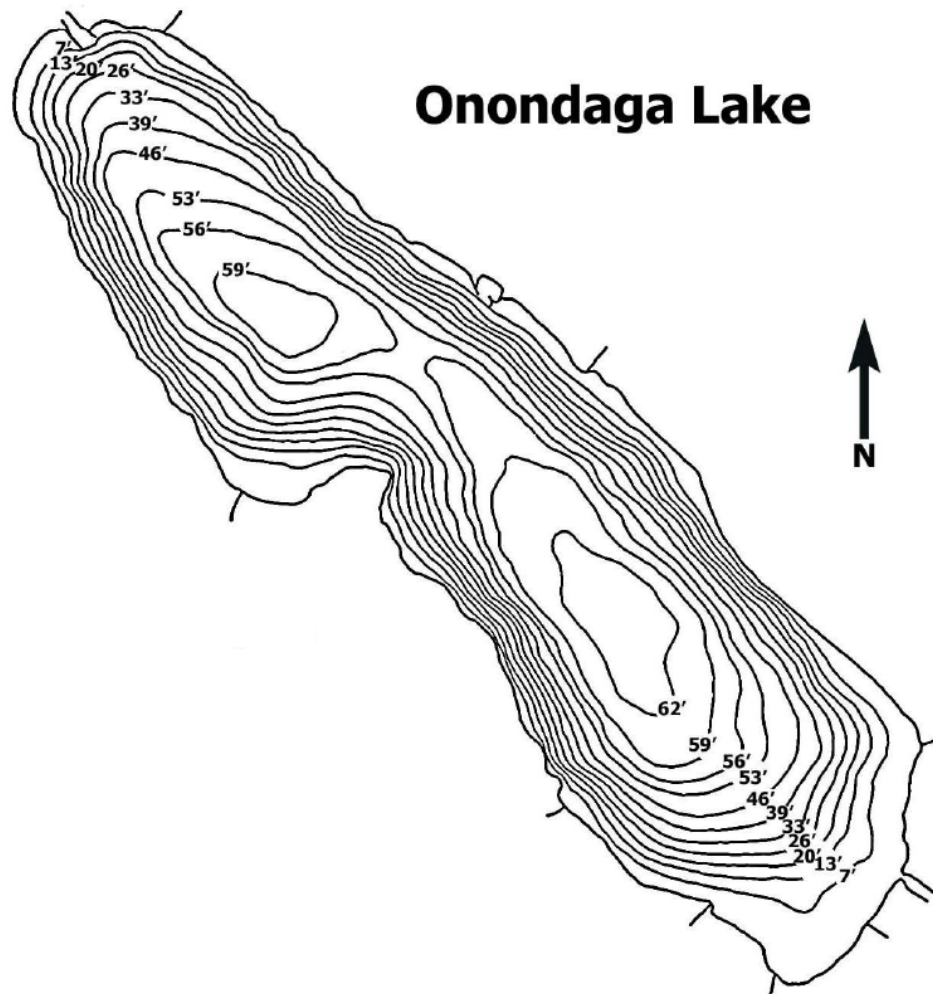


Figure 6: Bathymetric Map

|                       |                     |
|-----------------------|---------------------|
| Surface area          | 4.6 mi <sup>2</sup> |
| Volume                | 35 billion gallons  |
| Maximum length        | 4.7 mi.             |
| Maximum width         | 1.2 mi.             |
| Maximum depth         | 63 ft.              |
| Average depth         | 35 ft.              |
| Average elevation     | 364 ft.             |
| Average flushing rate | ~4 times/yr.        |

Table 3: Morphometric Characteristics

## **2.2 Lake Characterization**

Onondaga Lake is a dimictic lake (a lake that mixes from top to bottom two times per year: spring and fall) which stratifies and consists of two deep basins, identified as the North basin and South basin, respectively, with a total surface area of 2,988 acres. The Lake is 4.7 miles in length along a northwest-southeast axis and approximately 1.2 miles wide at its widest point and is oriented longitudinally to the prevailing wind. The Lake has an average depth of 35 feet and a maximum depth of 63 feet. The Lake flushes approximately 4 times per year and as a result responds rapidly to changes in external loading (Doerr, et al., 1994). Figure 6 shows a bathymetric map for Onondaga Lake (NYSDEC, 2011). Table 3 summarizes key morphometric characteristics for Onondaga Lake.

Water density decreases as temperature increases. In the spring, when the water temperature is about the same from top to bottom, wind-induced turbulence mixes the entire water column. As solar radiation is absorbed by the water, the surface waters warm. Eventually, the upper waters become too warm and buoyant to mix with the colder and denser deeper waters of the Lake. Layers of water with different temperatures begin to form within the water column. As summer progresses, the temperature (and density) differences between layers become more distinct and eventually form discrete layers: a warm and buoyant epilimnion at the surface and a colder and denser hypolimnion at the Lake bottom, with a metalimnion as the transition between the two layers. The thermocline lies within the metalimnion and forms an effective barrier to the movement of oxygen between layers, thus isolating the hypolimnion from the well-oxygenated epilimnion. This thermally stratified condition persists until autumn, when falling air temperatures cool the water in the epilimnion of the Lake, increasing its density and reducing its buoyancy. At fall turnover, stratification between water layers breaks down and the upper and lower layers of the lake mix.

The official water body classifications are contained in Title 6 of the New York Codes, Rules and Regulations. The Onondaga Lake watershed is covered in Part 895; Onondaga Lake's Waters Index Number is P 154 and is identified as having both a "B" and "C" classification (NYSDEC, 1996). Table 4 and Figure 7 identify the water quality standards and classifications for Onondaga Lake.

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 (NYSDEC, 1998).

The best usage of Class C waters is fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes (NYSDEC, 1998).

## **2.3 Water Quality**

The 1998 ACJ obligates the County to monitor water quality and report annually on the progress towards achieving compliance with State and Federal standards in Onondaga Lake. As a result, the County established the Ambient Monitoring Program (AMP) to monitor the water quality

| Item No. | Waters Index Number           | Name          | Description                                                                                                                                                                                                                                                          | Map Ref. No. | Class | Standards |
|----------|-------------------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------|-----------|
| 1        | P 154<br>portion as described | Onondaga Lake | Northwest of a line extending from a point located on the west shore 0.25 mile northwest of the mouth of trib. 5A to a point on the east shore located 0.6 mile southeast of the mouth of Bloody Brook, except portions of the lake designated as item nos. 2 and 3. | 4            | B     | B         |
| 2        | P 154<br>portion as described | Onondaga Lake | Southeast of a line extending from a point located on the west shore 0.25 mile northwest of the mouth of trib. 5A to a point located on the east shore 0.6 mile southeast of the mouth of Bloody Brook, except portions designated as item nos. 1 and 3.             | 4            | C     | C         |
| 3        | P 154<br>portion as described | Onondaga Lake | Area within 0.25 mile radius of the mouth of Ninemile Creek, except portions designated as item nos. 1 and 2.                                                                                                                                                        | 4            | C     | C         |

Table 4: Onondaga Lake Water Quality Classifications and Standards

response associated with improvements to wastewater infrastructure and treatment. Water quality is monitored at various stations in Onondaga Lake and its tributaries as well as in the Seneca River. The locations of the North Deep Station (43° 05.930' N Latitude, 76° 13.730' W Longitude) and the South Deep Station (43° 04.670' N Latitude, 76° 11.880' W Longitude) are shown in Figure 7. Figure 8 shows epilimnetic summer mean total phosphorus (TP) concentrations taken at the South Deep Station. TP concentrations have been significantly reduced as a result of the enhanced phosphorus removal at Metro starting in 2005. The Lake met, on average, the State's guidance value of 20  $\mu\text{g}\cdot\text{l}^{-1}$  total phosphorus during the summers of 2008 and 2009. The mean TP concentration during the summer of 2010 increased from the previous year and exceeded the State's guidance value. This variability in TP may be the result of top-down (food web) effects as opposed to bottom-up (external loading) changes (Effler, et al., 2010). External phosphorus loads remained relatively constant from 2009 to 2010; however, there was a larger alewife population in 2010 that led to a decrease in the Daphnia population due to alewife predation, resulting in a shift in internal phosphorus cycling (Effler, et al., 2010). Daphnia and other plankton take up phosphorus in the water column, helping to reduce concentrations. Suppression of Daphnia populations by alewives would reduce the uptake of phosphorus, resulting in higher water column concentrations. Final data from Onondaga County AMP for 2011 indicate an epilimnetic summer mean TP concentration of 22  $\mu\text{g}\cdot\text{l}^{-1}$  (Onondaga County Pers. Comm. 2012).

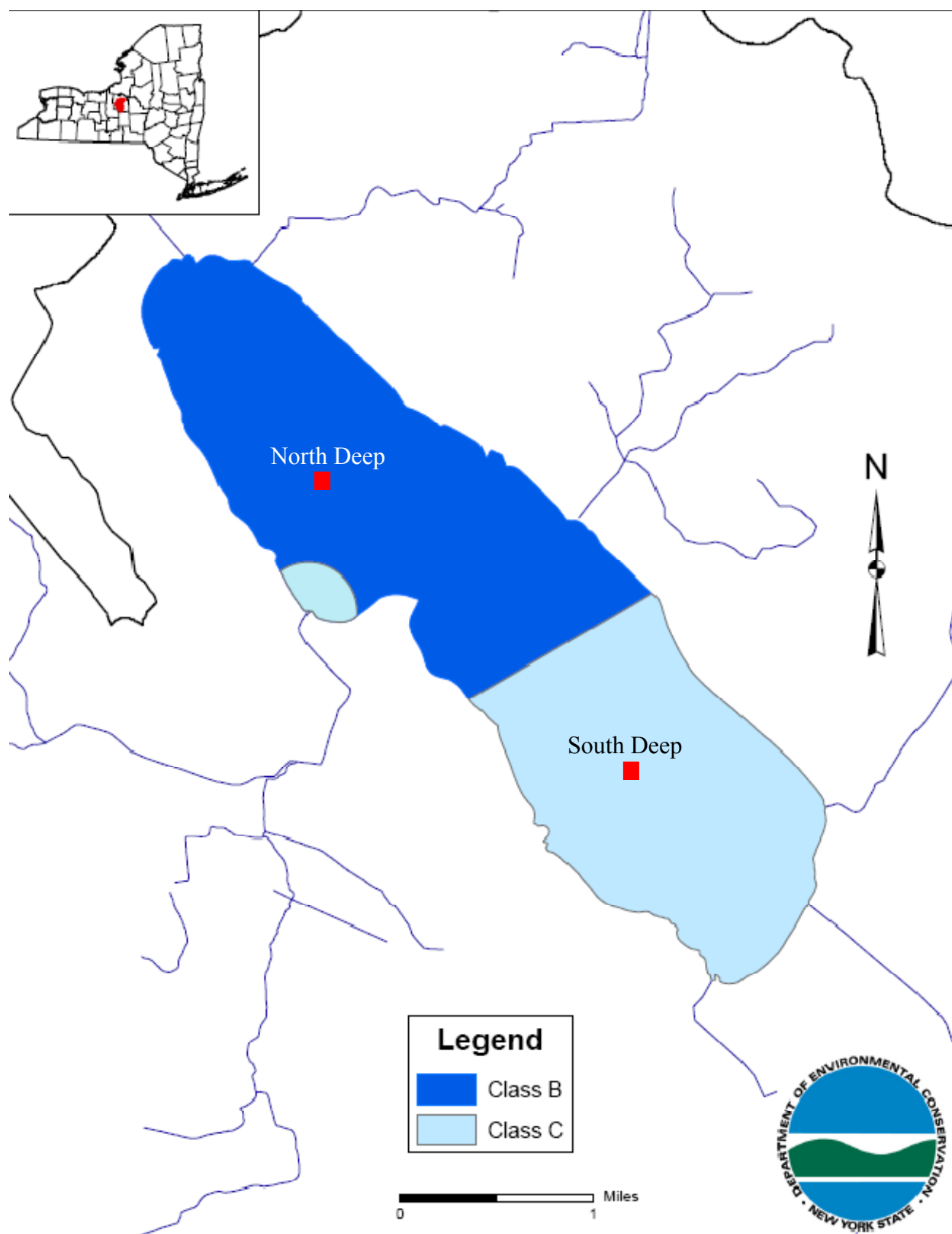


Figure 7: Onondaga Lake Water Quality Standards and Classifications

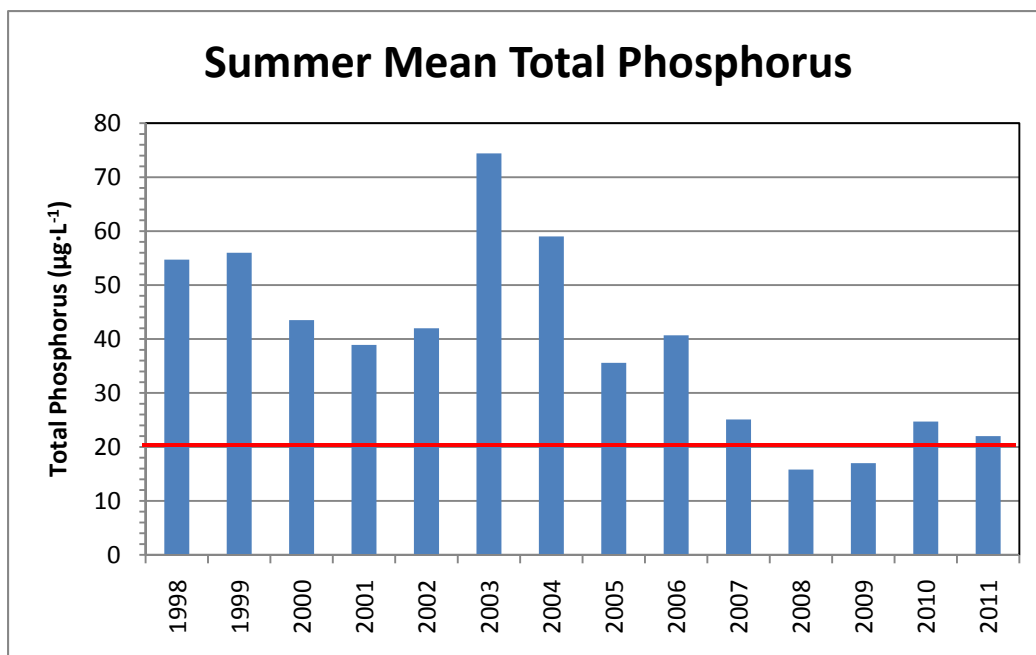


Figure 8: South Deep Summer Mean Total Phosphorus Concentrations (Onondaga County, 2012).

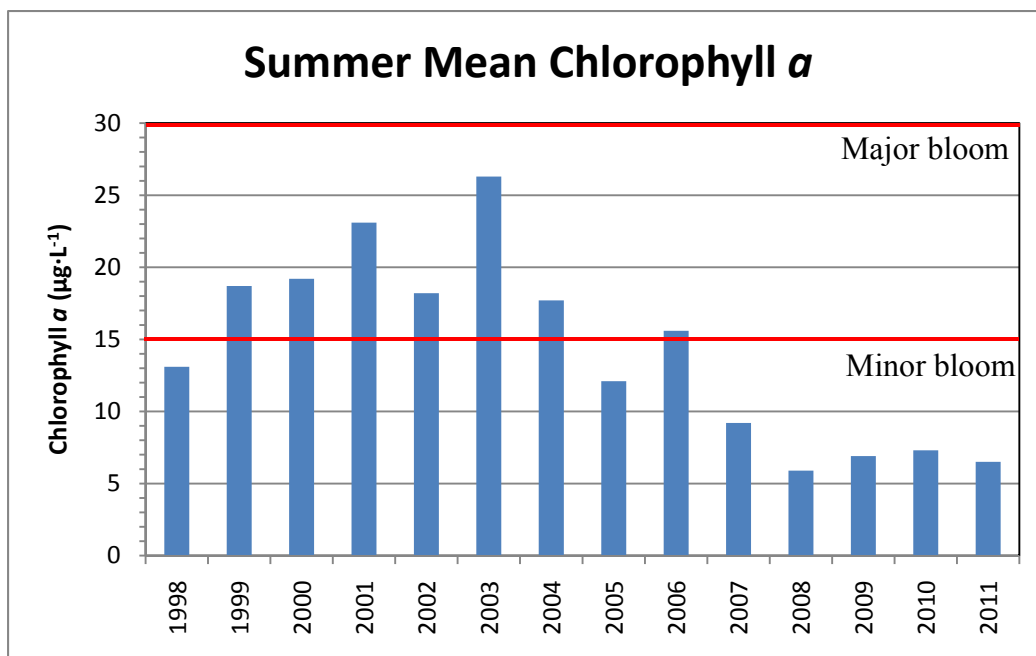


Figure 9: South Deep Summer Mean Chlorophyll *a* Concentrations (Onondaga County, 2011).  
Data from 2011 are provisional as the 2011 final report has not yet been released by the County

Figure 9 shows summer mean epilimnetic chlorophyll *a* concentrations at the South Deep Station. Chlorophyll *a* is an indicator of algal productivity. Chlorophyll *a* concentrations have been substantially reduced with summer mean concentrations less than 10 µg·L<sup>-1</sup> since 2007. Since NYSDEC does not have a standard or guidance value for chlorophyll *a*, Onondaga County

AMP uses thresholds of  $15 \text{ ug}\cdot\text{l}^{-1}$  and  $30 \text{ ug}\cdot\text{l}^{-1}$  to screen for minor and major algal blooms, respectively (Onondaga County WEP, 2011a).

Figure 10 shows summer mean secchi disk measurements taken at the South Deep Station. Secchi disk transparency is a measure of water clarity with greater depth indicating clearer water. Spada, et al. (2010) has shown that food web dynamics have a major impact on secchi disk measurements in Onondaga Lake. Mean secchi disk transparencies of greater than 3 meters and lower chlorophyll *a* concentrations during the summers of 2008 and 2009 were a result of clear water phases which are associated with increased grazing pressure on the algal community by *Daphnia* (Spada, et al., 2010).

Upon stratification each summer, the hypolimnion is isolated from the atmosphere, effectively cutting off any resupply of oxygen to these waters as long as the stratification persists. Sediments in the bottom of the Lake continue to exert an oxygen demand upon the hypolimnetic waters, resulting in a decrease of DO as the summer progresses and the eventual onset of anoxia in the hypolimnion of the Lake. Figure 11 shows the 2011 time series of daily average DO concentrations in the epilimnion and hypolimnion as well as the 10-year daily averages at the South Deep station.

Figure 12 shows the volume-days of anoxia ( $\text{DO}$  less than  $0.5 \text{ mg}\cdot\text{l}^{-1}$ ) and hypoxia ( $\text{DO}$  less than  $2 \text{ mg}\cdot\text{l}^{-1}$ ) in Onondaga Lake at the South Deep station. Volume-days is a measure of a lakes DO status in which both the affected volume of water and duration of anoxia and hypoxia are calculated in a single measurement that can be tracked from year to year. The volume-days of anoxia and hypoxia have decreased since the early 1990s (Figure 12). Decreases, particularly in volume-days of anoxia, have continued in recent years, due in part to the tertiary treatment for phosphorus put into operation at Metro in 2005. The daily average DO data from 2011 compared to the 10 year average (Figure 11), however, indicates the anoxia and hypoxia continue to occur in the hypolimnion for 2 to 3 months each year beginning around mid-July.

## **2.4 Biological Conditions**

The biology in Onondaga Lake has responded favorably as a result of improved water quality conditions. The Lake has experienced increases in macrophyte densities in the littoral zone which provide greater habitat and shelter for fish and other aquatic organisms. Figure 13 shows the substantial increase in macrophyte coverage from 85 acres in 2000 to 409 acres in 2010 (Onondaga County Department of Water Environment Protection and State University of New York College of Environmental Science and Forestry, 2011). Macrophyte species richness also increased from 10 species observed in 2000 to 23 species in 2010 with all the gains associated with native species with the exception of two (EcoLogic, 2011). Considerable improvements in littoral macroinvertebrate species richness, diversity and abundance of more sensitive species have also been observed since 2000 (EcoLogic, 2011).

Onondaga Lake currently supports a diverse fish community including several species highly valued by anglers such as largemouth and smallmouth bass, and walleye (Onondaga County Department of Water Environment Protection and State University of New York College of Environmental Science and Forestry, 2011). Species richness has increased from 24 species

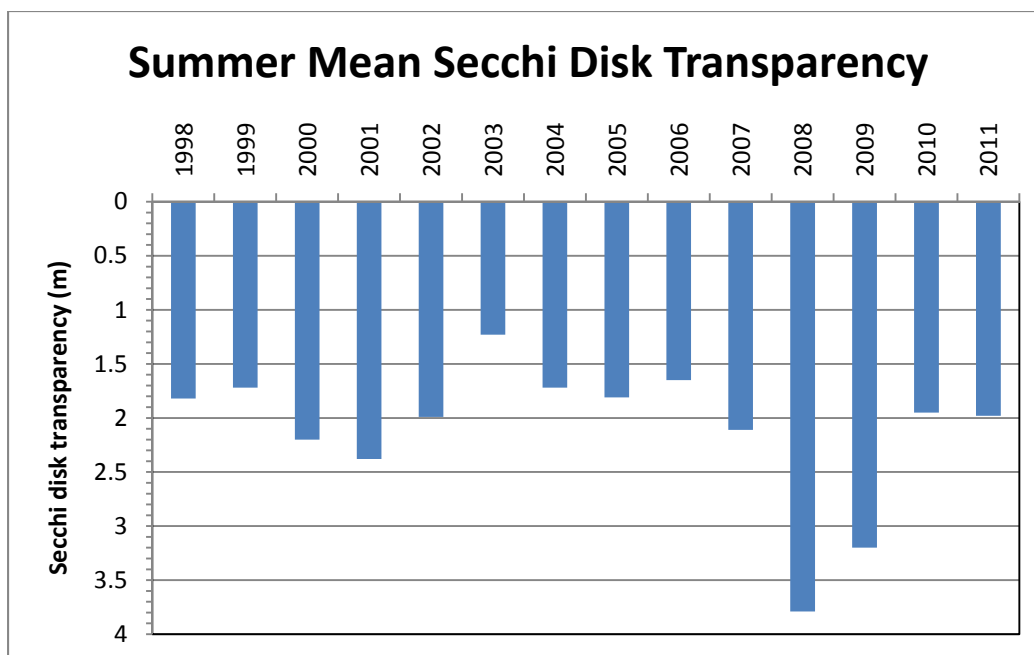


Figure 10: South Deep Summer Mean Secchi Disk Transparencies (Onondaga County, 2011). Data from 2011 are provisional as the 2011 final report has not yet been released by the County.

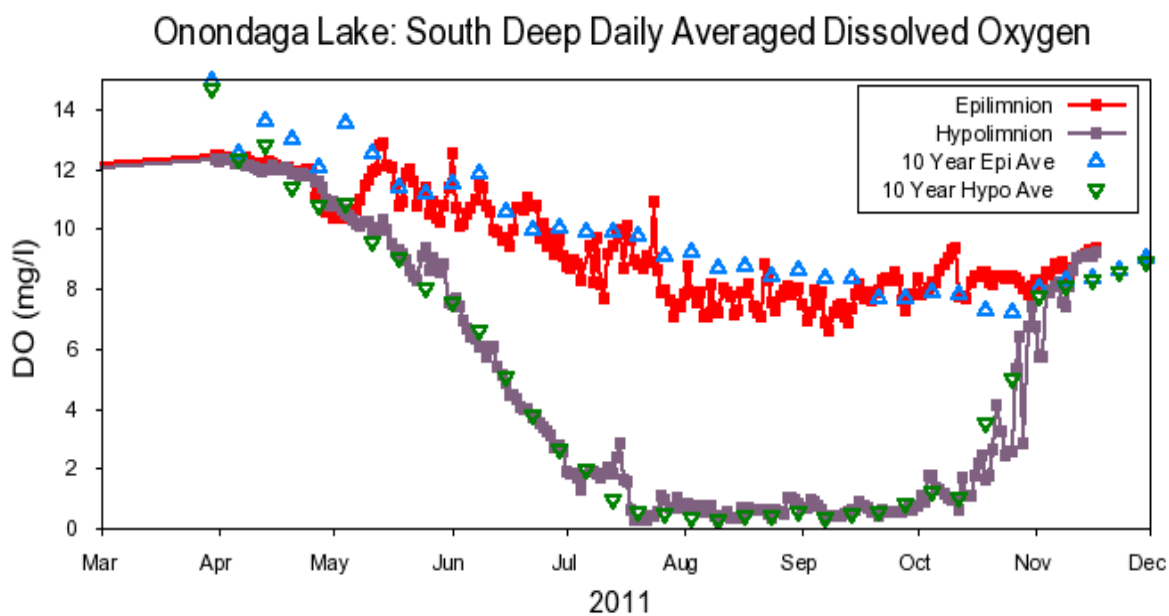


Figure 11: 2011 Daily Average Dissolved Oxygen Concentrations ([www.ourlake.org](http://www.ourlake.org))

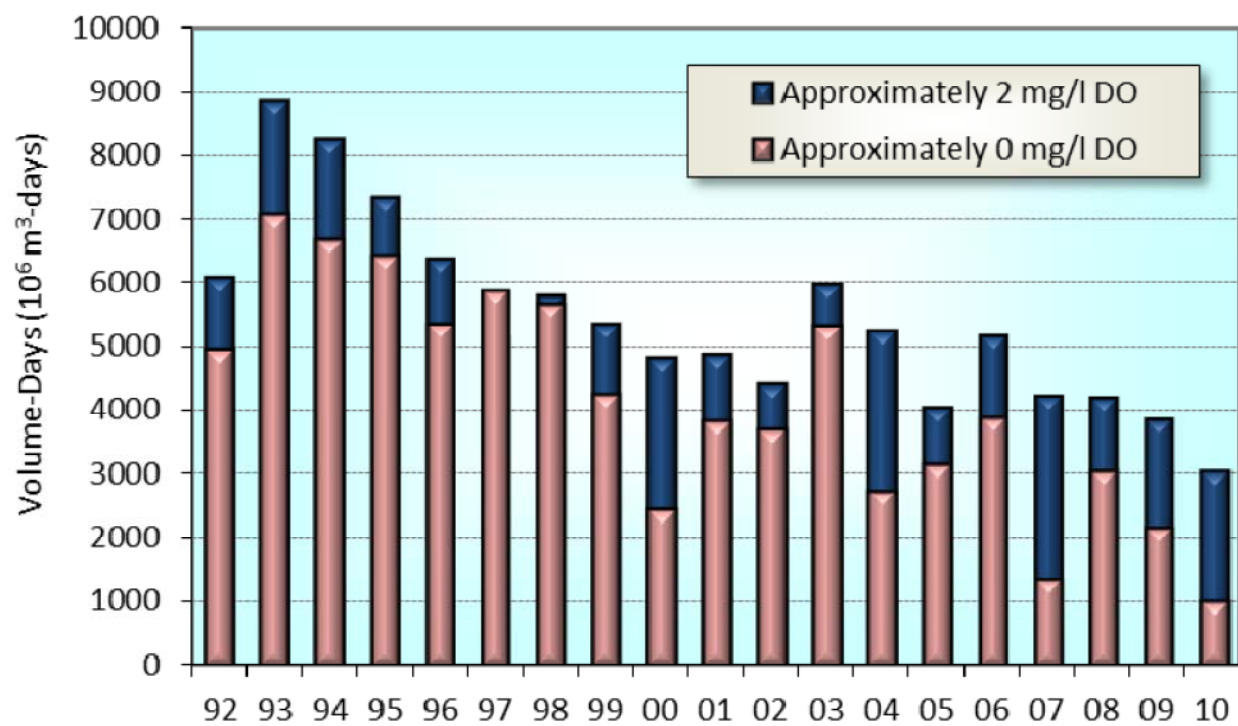


Figure 12: Volume Days of Anoxia ( $\text{DO} \leq 0.5 \text{ mg}\cdot\text{l}^{-1}$ ) and Hypoxia ( $\text{DO} \leq 2 \text{ mg}\cdot\text{l}^{-1}$ ).  
(Anchor QEA, EcoLogic, and Conestoga Rovers and Associates, 2011)

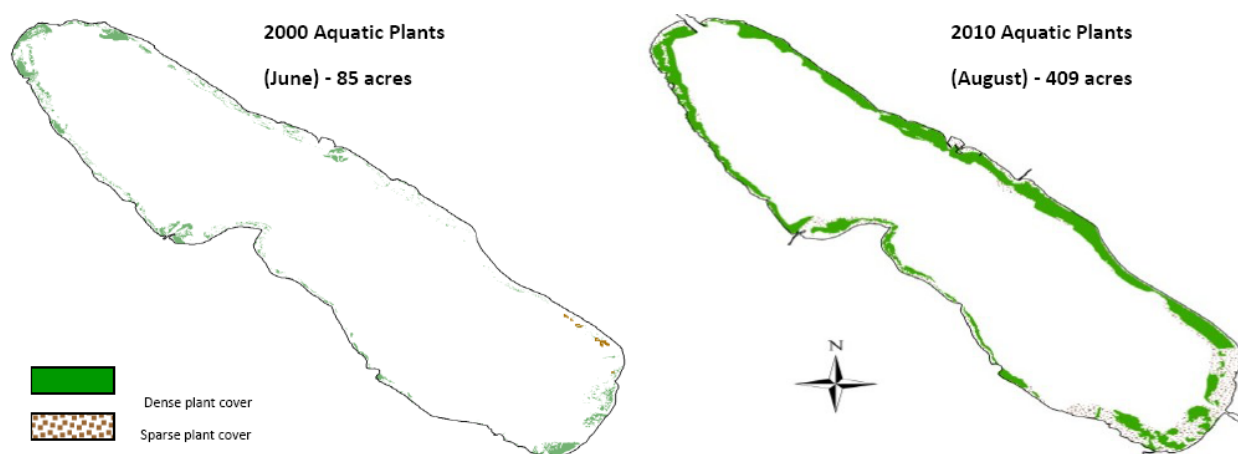


Figure 13: Aquatic Macrophyte Coverage (Onondaga County Department of Water Environment Protection, 2011c)

documented in 2000 to 28 in 2009. Fish migration through the Seneca River system has resulted in 45 fish species being documented in the Lake. AMP nesting surveys and sampling of larval and year-of-young fish confirms that diversity and richness have increased over the past decade. The studies indicate that more species are successfully reproducing, resulting in a more balanced community (Onondaga County Department of Water Environment Protection [OCDWEP], 2010).

### 3.0 Water Quality Standards and Supporting Modeling for Numeric Water Quality Targets

#### 3.1 *Applicable Water Quality Standards and Guidance Values*

The official water body classifications are contained in Title 6 of the New York Codes, Rules and Regulations. The Onondaga Lake watershed is covered in Part 895; Onondaga Lake's Waters Index Number is Ont.-66-12-12-P 154 and is identified as having both a "B" and "C" classification (NYSDEC, 1996). This has been covered in detail previously in Section 2.2.

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 (NYSDEC, 2008).

The best usage of Class C waters is fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes (NYSDEC, 2008)

NYS Regulations (6 NYCRR §180.5) define the terms "trout waters, trout streams, trout ponds and trout lakes" as those waters, streams, ponds and lakes inhabited (as defined by § 11-0103 of the Environmental Conservation Law) by trout. The NYS Environmental Conservation Law §11-0103 defines the term "inhabited" as permanent occupancy by a species as contrasted with a temporary presence of an occasional individual. NYS Regulations (6 NYCRR § 700.1) define the term trout as "any fish in the following genera: *Coregonus*, *Oncorhynchus*, *Prosopium*, *Salmo*, *Salvelinus*, and *Thymallus*". Waters, streams, ponds and lakes for which a standard (T) or (TS) is designated are trout waters or trout spawning waters, respectively. NYS Regulations (6 NYCRR § 700.1) defines trout waters as "waters that provide habitat in which trout can survive and grow within a normal range on a year-round basis, or on a year-round basis excepting periods of time during which almost all of the trout inhabiting such waters could and would temporarily retreat into and survive in adjoining or tributary waters due to natural circumstances." NYS Regulations (6 NYCRR § 700.1) defines trout spawning waters as "trout waters in which trout eggs can be deposited and be fertilized by trout inhabiting such waters (or connecting waters) and in which those eggs can develop and hatch, and the trout hatched therefrom could survive and grow to a sufficient size and stage of development to enable them to either remain and grow to adult trout therein, or migrate into and survive in other trout waters."

For entries appearing in 6 NYCCR § 800 through 941, the symbol (T) in the "standards" column in the classification tables "means that the classified waters in that specific item are trout waters. Any water quality standard, guidance value, or thermal criterion that specifically refers to trout or trout waters applies". The symbol (TS), appearing in an entry in the "standards" column in the classification tables of 6 NYCCR § 800 through 941, "means that the classified waters in that specific item are trout spawning waters. Any water quality standard, guidance value, or thermal criterion that specifically refers to trout, trout spawning, trout waters, or trout spawning waters applies". The classifications for Onondaga Lake of Class B and C are not at this time followed by the symbol (T) or (TS).

The TMDL target is a numeric endpoint that ensures protection of the designated best uses of a water body. The applicable water quality standard to protect the best uses in this case, is for the nutrient, phosphorus. New York State has a narrative standard for phosphorus which states: “none in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages” (NYSDEC, 2008).

As part of its Technical and Operational Guidance Series (TOGS) 1.1.1, NYS DEC has interpreted this narrative language for Class B (and above) ponded waters (i.e., lakes, reservoirs and ponds, excluding Lakes Erie, Ontario, and Champlain), that the epilimnetic growing season mean total phosphorus level shall not exceed  $20 \mu\text{g}\cdot\text{l}^{-1}$  ( $0.02 \text{ mg}\cdot\text{l}^{-1}$ ). This mean value is based on a minimum of biweekly sampling, conducted from June 1 to September 30 (New York State, 1993). This number was developed from statistical analysis of surveys of lake users conducted throughout New York State as to their perception of the suitability of specific waterbodies for swimming and other forms of contact recreation (Kishbaugh, 1994). This phosphorus value was used as the endpoint in the Phase I Onondaga Lake Phosphorus TMDL.

New York State is in the process of developing an equivalent statewide guidance value for phosphorus designed to protect the fishing best use. Since this value has not yet been determined, the narrative phosphorus standard needs to be interpreted specifically for this TMDL to protect the best use of fishing.

In addition to the narrative phosphorus standard for the protection of the fishing best use, New York State has a numeric standard for dissolved oxygen (DO) as follows: “for nontrout waters, the minimum daily average shall not be less than  $5.0 \text{ mg}\cdot\text{l}^{-1}$ , and at no time shall the DO concentration be less than  $4.0 \text{ mg}\cdot\text{l}^{-1}$ ” (NYSDEC, 2008). As a plant nutrient, phosphorus can cause nuisance algal blooms, and the settling of this algal material can create an oxygen demand in the lower waters of deeper lakes. Deeper lakes in the temperate region, such as Onondaga Lake, are often thermally stratified into a well mixed surface layer (epilimnion) and a cold deep layer (hypolimnion). Since this deeper layer is not in contact with the atmosphere and does not mix with the surface layer, the oxygen demand caused by algal production can lead to DO depletion. This process will be discussed further in Section 3.3.

### **3.2 Modeling Ensemble Approach**

A modeling ensemble approach was chosen to quantify the relationship between phosphorus loads and ambient Lake water quality. A paleolimnologic study of the Onondaga Lake sediment bed stratigraphy in combination with model hindcasting using existing Onondaga Lake water quality models was used to develop a reliable, quantitative assessment of phosphorus and DO throughout the Lake’s history. A number of water quality models were used to forecast future conditions within the Lake as it responds to load reduction scenarios and natural environmental variability.

#### **3.2.1 Onondaga Lake Watershed Model (OLWM)**

The Onondaga Lake Watershed Model (OLWM) is a precipitation-runoff model developed by United States Geological Survey (USGS) using Hydrological Simulation Program FORTRAN

(HSPF). OLWM has the ability to simulate streamflow, water temperature, dissolved oxygen concentrations, and concentrations and loads of sediment, organic phosphorus, orthophosphate, total phosphorus, nitrate, ammonia and organic nitrogen in the tributaries of Onondaga Lake. OLWM can simulate pollutant loads generated in the watershed and can account for instream processes to simulate loads delivered to Onondaga Lake. The primary use of the model is to simulate the time series of pollutant loads generated in the watershed for Base Case conditions as well as various management scenarios. OLWM output was used as input data sets for the Onondaga Lake Water Quality Model (OLWQM). USGS Scientific Investigations Report 2008-5013 discusses the development and calibration of OLWM (Coon and Reddy, 2008). OLWM was calibrated to data collected from 1997-2003. The model simulation period was later extended to cover 1994-2009 to yield the 16 year watershed loading cycle used to force the OLWQM.

### **3.2.2 Onondaga Lake Water Quality Model (OLWQM)**

The Onondaga Lake Water Quality Model (OLWQM), a hydrodynamic model of Onondaga Lake, was developed by Anchor QEA. OLWQM is a two-dimensional laterally averaged model encompassing two hydrodynamic codes: the Dynamic Reservoir Simulation Model (DYRESM) and the Environmental Fluid Dynamics Code (EFDC). DYRESM is a one-dimensional model of vertical stratification, temperature and mixing. EFDC is a two-dimensional model of water depth, advection and horizontal mixing. OLWQM uses 40 vertical layers and six longitudinal grid cells to model the Lake. Inputs for the model include inflows to the Lake, air temperature, solar radiation, wind speed and direction, cloud cover and other meteorological conditions. State variables modeled for the Lake include DO, carbon, ammonia, nitrate, nitrite and phosphorus. Phytoplankton, zooplankton, zebra mussels and macrophytes are included through a biological submodel. A sediment flux submodel is used for oxygen and nutrient exchange between the sediment bed and water column. Kinetic reactions within the submodel include the conversion of particle organic material to dissolved nutrient and the concurrent consumption of oxidized compounds from the overlying water column.

Model output is generated at daily time steps. The model was calibrated using data from 1994 to 2003. Validation was carried out using data from 2004 to 2009. Development, calibration, peer review and validation of the OLWQM are documented in a series of reports issued by Anchor QEA (2007, 2008 and 2011a). Data from the 16 year period, 1994-2009, were used to drive the model simulations. Meteorological and hydrological data from this period was repeated three times as the forcing for a 48 year model period. Loadings from this period were modified as needed to develop the model scenarios, i.e. decreasing Metro outfall concentrations to reflect current conditions. Data sets from that 16 year period include precipitation, air temperature, tributary flow volumes and concentrations, and time series of flows from Metro outfalls 001 and 002. Complete discussions of the input data sets are included in the aforementioned reports.

### **3.2.3 Sediment Redox Model (SED2K<sub>s</sub>)**

SED2K is a sediment flux model developed by Steve Chapra of Tufts University and Martin Auer of Michigan Technological University. Sed2K is a physical and biogeochemical representation of the sediments and diagenesis state variables that includes multiple redox

processes, electron acceptors and reduced by-products. Fate and transport of particulate organic material (POM) within the sediment bed encompasses burial and diagenesis, with the flux of POM to the bed from the water column serving as the upper boundary condition and primary driver of the SED2K model.

A simplified version, SED2K<sub>s</sub>, was applied to Onondaga Lake. The primary simplification of the model assumed quasi-steady state for the pore water pool of soluble oxygen-demanding decomposition products, dissolved inorganic carbon and CH<sub>4</sub>, which diffuse into the water column. SED2K<sub>s</sub> was linked with a one-dimensional vertical hydrodynamic model, UFILS4, as an overall water quality model to capture the effects of the sediment oxygen demand (SOD) on the DO resources of the hypolimnion. Profiles of porosity with depth were determined from sediment cores and the rate of decay of POM was modeled as a first-order process dependent upon material age.

The sediments exert a significant SOD upon the water column, driven by past and current fluxes of POM to the sediment bed. The flux of POM is driven in part by the phosphorus concentrations in the upper waters of the Lake. A number of phosphorus reduction scenarios are modeled with Sed2K<sub>s</sub> to determine how the SOD may decrease under the nutrient reductions outlined in this TMDL. Decreased SOD resulted in increased DO and improved water quality throughout the water column. However none of the management alternatives modeled resulted in DO concentrations which meet the DO standard (Gelda et al., 2012).

The SED2K<sub>s</sub> model is a second tool for assessing likely water quality improvements as a result of actions implemented as a part of this TMDL. Inclusion of the sediment bed provides an additional piece of information about the impact sediment deposition and decomposition will have upon the long term recovery of water quality parameters within the Lake.

### ***3.2.4 Pre-Colonization Hindcasting***

The OLWM was used to simulate the Pre-Colonization loadings of phosphorus from the Onondaga Lake watershed based on estimated historical land use. This hindcasting scenario model run incorporated the following land use changes in order to best represent the watershed in its natural state:

1. All agricultural, developed, and impervious land types were converted to forested land types, except in those areas adjacent to Onondaga Lake, which were changed to wetlands as indicated on historical maps.
2. The Onondaga Reservoir and its associated mitigative effects on sediment and particulate loads were removed.
3. The dam at the north end of Otisco Lake, as well as the withdrawals by Onondaga County Water Authority were removed from the model and a new stage discharge relation to reflect these changes was created.

4. All commands pertaining to the simulation of the tunnel through which Harbor Brook flows for about half of its length in subbasin 206 were removed.
5. The anthropogenic inputs from Metro and the Marcellus WWTP were removed.

Model output from this scenario indicates that a given tributary to Onondaga Lake would generate and transport 38 to 79 percent less orthophosphate and 47 to 81 percent less total phosphorus on an annual average basis under Pre-Colonization land use conditions compared with contemporary land use conditions.

The OLWQM was then run with the simulated Pre-Colonization loading to predict phosphorus and DO levels in Onondaga Lake prior to anthropogenic impacts.

### **3.2.5 *Paleolimnology***

A paleolimnologic study of the constituents of Onondaga Lake sediments was performed to provide a modeled assessment of water quality for the last 300-plus years, with particular respect to phosphorus and dissolved oxygen levels in the Lake. Results from the paleolimnology will serve, in part, as “ground truth” for hindcast predictions of water quality derived from existing water quality models (Figure 14). This work involved sediment core recovery, close visual description, dating and sectioning of the sediment material for biological and chemical analysis, followed by data analysis and interpretation. In addition, biota-based, water quality inference modeling for lake productivity was performed.

The conclusions of the paleolimnology inference modeling for TP and DO are briefly presented here, more extensively in Appendix A, and in detail in subsequent reports. The inference models were developed by comparing water quality conditions in a large selection of lakes to the remains of biota in the surface sediments of those lakes. From this dataset the preferred water quality tolerances of individual species were derived using weighted averaging regression techniques.

Diatom inferred TP for pre-1800 Onondaga Lake ranged from 7 to 11  $\mu\text{g}\cdot\text{l}^{-1}$  with a mean of 9  $\mu\text{g}\cdot\text{l}^{-1}$ . OLWQM results ranged between 2 to 8  $\mu\text{g}\cdot\text{l}^{-1}$  TP with a mean of 4  $\mu\text{g}\cdot\text{l}^{-1}$ . Recent TP values in Onondaga Lake from 2008 to 2010 vary between 16 to 24  $\mu\text{g}\cdot\text{l}^{-1}$ , suggesting a wide enough range in natural TP variability to account for much of the observed difference in the inference and hindcasting TP results. Results and interpretation of the diatom inference model are discussed further in Appendix A.

Chironomid inferred DO results for pre-1800 Onondaga Lake imply a hypolimnion with 50% of its volume below 4  $\text{mg}\cdot\text{l}^{-1}$  DO and 25% below 1  $\text{mg}\cdot\text{l}^{-1}$  DO. Comparison with the OLWQM implies 25% volume of the Lake below 1.4  $\text{mg}\cdot\text{l}^{-1}$ . This discrepancy falls within the uncertainty of both the modeling methods and natural variability (Appendix A). Therefore, it can be concluded that the inference models validate the DO model hindcasting results.

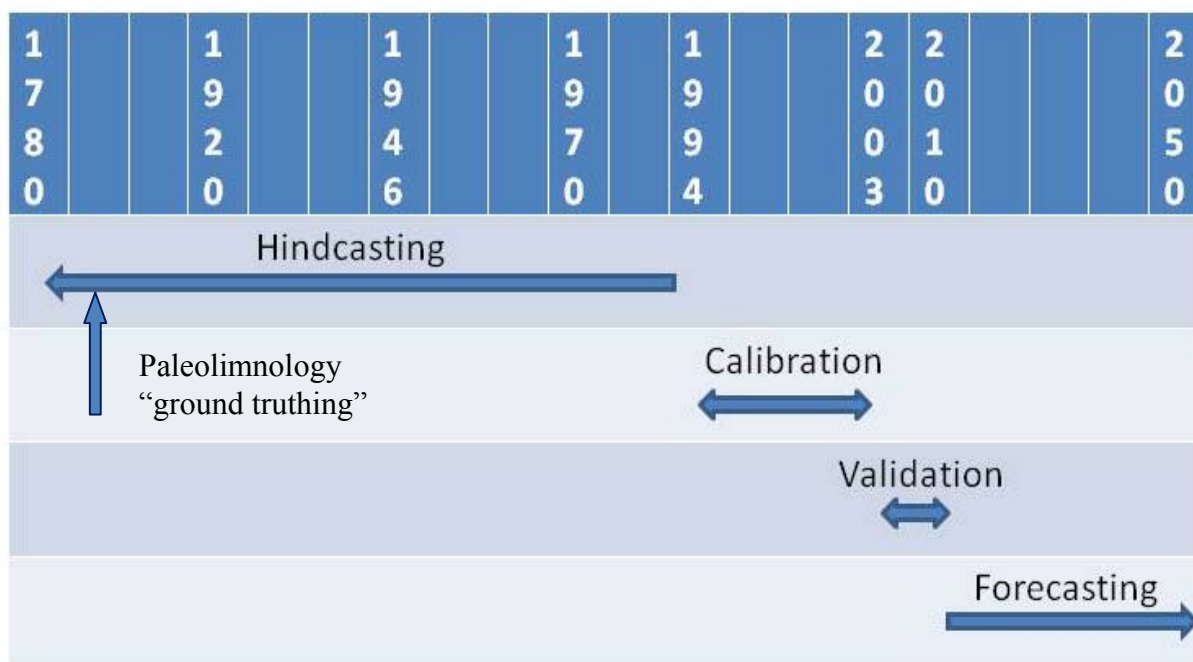


Figure 14: Lake Simulation Model Testing

Taking the hindcasting and inference model results together, epilimnetic TP levels in Onondaga Lake before 1800 are seen to vary across the mid to upper oligotrophic range (4 to 9  $\mu\text{g}\cdot\text{l}^{-1}$  as a mean), inducing hypolimnetic DO depletion that varied in annual intensity but always resulted in some summer period of hypoxia (<4-5  $\text{mg}\cdot\text{l}^{-1}$ ) and at least a short summer period of anoxia (<1  $\text{mg}\cdot\text{l}^{-1}$ ) at the bottom of the lake.

### 3.3 Numeric Water Quality Targets

The State's phosphorus guidance value of 20  $\mu\text{g}\cdot\text{l}^{-1}$  will be used as the endpoint for protection of primary and secondary contact recreational best use of Onondaga Lake. This endpoint will address impairment based solely upon aesthetics caused by phosphorus enrichment. Other sources of impairment, e.g. pathogens, are not addressed by this TMDL and may continue to cause the primary and secondary contact recreation uses of the Lake to be impaired. New York State is in the process of developing an equivalent statewide guidance value for phosphorus for protection of the best use of fishing. Since this value has not yet been determined, the narrative phosphorus standard needs to be interpreted to establish a guidance value protective of the best use of fishing specifically for this TMDL. As discussed further below, an analysis of the current Onondaga Lake fish community indicated that the 20  $\mu\text{g}\cdot\text{l}^{-1}$  primary and secondary contact recreational guidance value would also be protective of the fishing best use. The 20  $\mu\text{g}\cdot\text{l}^{-1}$  summer mean epilimnetic concentration will, therefore, be used as the numeric water quality target for this TMDL.

An analysis of the relationship between phosphorus and fish production in lakes and reservoirs throughout the country, as well as a careful review of the number and types of fish species present in Onondaga Lake was conducted. Data from the extensive Onondaga County Ambient Monitoring Program (AMP; <http://www.ongov.net/wep/we15.html>) indicate that the Lake

currently supports an abundant and diverse fish community, maintained by natural reproduction and immigration from the Seneca River and tributaries to the Lake (Appendix B). Although trout are occasionally captured in the Lake, they reside primarily in several tributaries.

Typically, an increase in phosphorus results in an increase in overall fish production, although too much phosphorus can result in a reduction of diversity and excessive production of planktivorous species such as alewife and shad. The review suggests that the guidance value of  $20 \mu\text{g}\cdot\text{l}^{-1}$  derived for the protection of recreation (Class B uses) would also adequately sustain the existing fishery in Onondaga Lake (Class C uses). The rationale used to determine the guidance value and to determine that the Lake is currently supportive of a diverse fish community is included in Appendix B. While the Lake is suitable for fish propagation and survival of a wide variety of other species, other sources of impairment, e.g. mercury concentrations in fish, are not addressed by the TMDL and may continue to cause the best use of fishing to be impaired.

This Phase II TMDL is being developed based on substantially improved knowledge of the Lake and how phosphorus affects both use attainment and water quality. The Lake has been sampled intensively over the past decade by Onondaga County, NYSDEC, the Upstate Freshwater Institute and academic researchers from a variety of universities, including Syracuse University, the SUNY College of Environmental Science and Forestry, and Cornell University. This extensive effort has provided a robust data set for the development and calibration of the sophisticated models used for the Phase II TMDL development. The model developed for this TMDL reflects a much better understanding of the Lake and allows for a much better assessment of how further reductions in phosphorus loading will impact Lake water quality and use attainment. Details of the Lake models are discussed in Section 3.2.2.

Results and conclusions from both the water quality modeling and paleolimnology have been used to explore any relationships between phosphorus loads and the potential of the Lake to meet its current best designated uses of: 1) primary and secondary contact recreation and 2) fishing. These models were also used to better define the relationship between phosphorus and DO. Based upon these modeling results, the NYSDEC has determined that the DO standard is not applicable as a numeric water quality target to this TMDL. This determination is based upon the following:

As discussed in Section 2.2, Onondaga Lake stratifies each summer, effectively preventing the transfer of any additional oxygen to the waters of the hypolimnion for as long as the stratification persists. The Lake currently experiences depletion of DO in the hypolimnion during the summer stratification period. Results from both the paleolimnologic studies of the Lake's sediments (Section 3.2.5) and the lake model hindcasting (Section 3.2.4) indicate that Onondaga Lake has historically exhibited periods of deep water oxygen depletion since well before 1800. The results of these studies also indicate that phosphorus loading and hypolimnetic DO concentrations in the Lake are not as closely linked as previously thought. Furthermore, the modeling results indicate that even with substantial reductions in phosphorus loading, hypolimnetic DO depletion will not be prevented and the New York State DO standard will continue to not be met. In summary, Onondaga Lake is unable to meet the existing statewide DO water quality standard at all times during the year in the lower depths of the Lake because natural conditions contribute to the depletion of oxygen in the hypolimnion.

When the 1998 TMDL was issued, it was thought that the phosphorus loading to the Lake and the DO concentrations were closely related and that by addressing the former, protection of the fish community would be assured. Reduction in loads to the Lake over the last decade has decreased the duration and severity of oxygen depletion (Figure 12) but has not prevented DO depletion during the summer stratification period each year. AMP biological data indicates that the Lake is in full attainment of its best use designation for fishing under current water quality conditions.

Adequate habitat is available for fish survival and propagation as evidenced by the existing aquatic life community. A careful review of the habitat preferences of fish species present suggests that most of the fish species would not be adversely impacted by the lack of hypolimnetic oxygen because hypolimnetic waters are not a habitat that they would utilize. Survival of fish, their ability to reproduce, and the food web supporting the aquatic community does not appear to be adversely affected by the existing condition of anoxia in the hypolimnion during the Lake's summer stratification. Tolerance of low DO concentrations varies by species and most fish species can avoid areas of the Lake where anoxia persists during stratification. During non-stratified periods (typically November to April) the water column is well oxygenated and fish are not exposed to low oxygen concentrations. Reproduction of the current fish community does not occur in the hypolimnion. Thus, maintenance of existing conditions will provide for the continued survival and propagation of the existing fish community. Attainment of the best use of fishing does not appear to be adversely impacted by the observed seasonal deep water DO depletion in the Lake. Additionally, the level of hypolimnetic DO has no bearing on the best use of primary and secondary contact recreation.

The NYSDEC is committed to identifying an appropriate mechanism to address waters with low DO due to natural conditions through the development of a statewide criteria for all naturally stratified waters by modification of the State's water quality standards regulations (6 NYCRR 700-706) in the State's next triennial review rule making (2013).

Acknowledging that further phosphorus reductions will not address the DO depletion in the Lake this TMDL is being pursued to ensure that the best uses of the Lake are met (Table 4). The State's phosphorus guidance value of  $20 \mu\text{g}\cdot\text{l}^{-1}$  is the endpoint identified as protective of all of the best uses (as identified in Section 3.1) of the Lake, and therefore will serve as the numeric water quality target for this TMDL.

## **4.0 Source Assessment**

### **4.1 Analysis of Phosphorus Contributions**

Using OLWM, pollutant loads were modeled at a daily time-step during the simulation period of October 1997 through September 2008. Post processing of HSPF model output was performed by NYSDEC in order to attribute the pollutant loads to each of the land use categories identified in Table 2. The post processing procedure is described in Appendix D.

The post processing procedure was used to express OLWM output as both annual average delivered TP load and seasonal average delivered orthophosphorus (OP) load in order to account for seasonality and bioavailability of the watershed loads entering the Lake. Graphical representations and a comparison of the loads are provided in Appendix E. For purposes of this TMDL, annual TP loads will be presented; however, the comparison of annual TP vs. seasonal OP loads informed the allocation process and implementation recommendations. Sources which delivered large amounts of bioavailable orthophosphate during the growing season were targeted first for load reductions as reducing those loads should provide the greatest benefit to the Lake.

## ***4.2 Sources of Total Phosphorus Loading Delivered to Onondaga Lake***

OLWM input data sets for Metro and Marcellus Water Pollution Control Plant (WPCP) were obtained from discharge monitoring reports. The model was originally developed and calibrated using 1997-2003 data. Tertiary treatment for phosphorus removal was brought online at Metro in 2005. The Base Case for the OLWQM utilized updated data for the Syracuse Metro plant, reflecting average TP values from 2005-2009. The annual average total phosphorus loads delivered to Onondaga Lake from each land use type, Metro outfalls 001 and 002 and the Marcellus WPCP are listed in Table 5 and shown in Figure 15.

### ***4.2.1 Wetlands/Water***

Wetlands/water includes 14,144 acres (7.8%) of the watershed. Loading from wetlands/water is estimated to contribute 2,658 lbs/yr of total phosphorus (3% of the total load) to Onondaga Lake. Phosphorus contribution from wetlands is considered a component of background loading.

### ***4.2.2 Forest Land Runoff***

Forested land includes 73,403 acres (40.5%) of the watershed. Loading from forested land is estimated to contribute 6,442 lbs/yr of total phosphorus (8% of the total load) to Onondaga Lake. Phosphorus contribution from forested land is considered a component of background loading.

### ***4.2.3 Developed Land within Combined Sewer Overflow (CSO) Areas***

Areas served by CSO's include 8,383 acres (4.6%) of the watershed. Loading from this source contributes 6,482 lbs/yr of total phosphorus (8% of the total load) to Onondaga Lake. Effler et al. (2009) estimated that CSO's were responsible for 2,299 lbs/yr on average from 2005-2009. Figure 16 identifies CSO outfalls in the watershed which are also listed in Appendix F.

The remaining load of 4,183 lbs/yr is attributed to human activities, such as fertilizer applications and development/redevelopment. Additionally, ambient sampling of Onondaga Creek indicates high concentrations of dissolved forms of phosphorus within the urban portion of the stream during periods of low flow (Effler, et al., 2009). It is suspected that dry weather discharges such as leaky sewers may be responsible for a portion of this load. A Phase II Microbial Trackdown Study workplan is currently being developed to identify sources of fecal coliform bacteria during dry weather conditions. Total phosphorus monitoring will also be conducted as part of this study.

| Annual Average Delivered TP Load  | Model Base Case (2005-2009) |             |
|-----------------------------------|-----------------------------|-------------|
| Land Use                          | Load (lbs/yr)               | Percent     |
| Wetland/water                     | 2,658                       | 3%          |
| Forest                            | 6,442                       | 8%          |
| CSO Areas                         | 6,482                       | 8%          |
| <i>CSO's</i>                      | 2299                        | 3%          |
| <i>Developed Land</i>             | 4183                        | 5%          |
| Developed Land within MS4 Areas   | 16,536                      | 19%         |
| Rural, Unregulated Developed Land | 181                         | 0.2%        |
| Pasture/hay                       | 6,426                       | 8%          |
| Row crops                         | 13,761                      | 16%         |
| Marcellus WPCP                    | 1,737                       | 2%          |
| Metro Outfall 001                 | 24,030                      | 28%         |
| Metro Outfall 002                 | 6,173                       | 7%          |
| Small SPDES Discharges            | 1,018                       | 1%          |
| <b>Total</b>                      | <b>85,444</b>               | <b>100%</b> |

Table 5: Total Phosphorus Loads

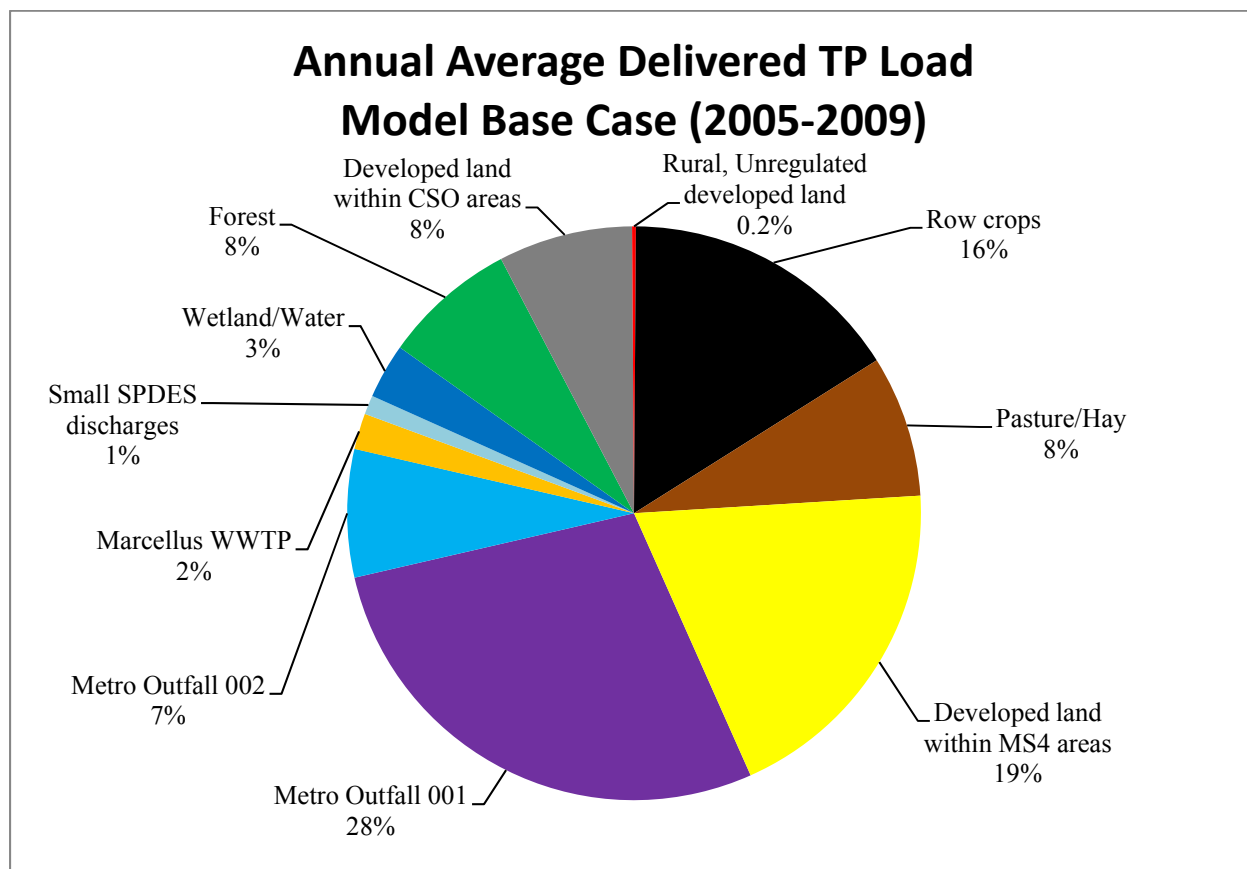


Figure 15: Annual Average Total Phosphorus Loads from 2005-2009.

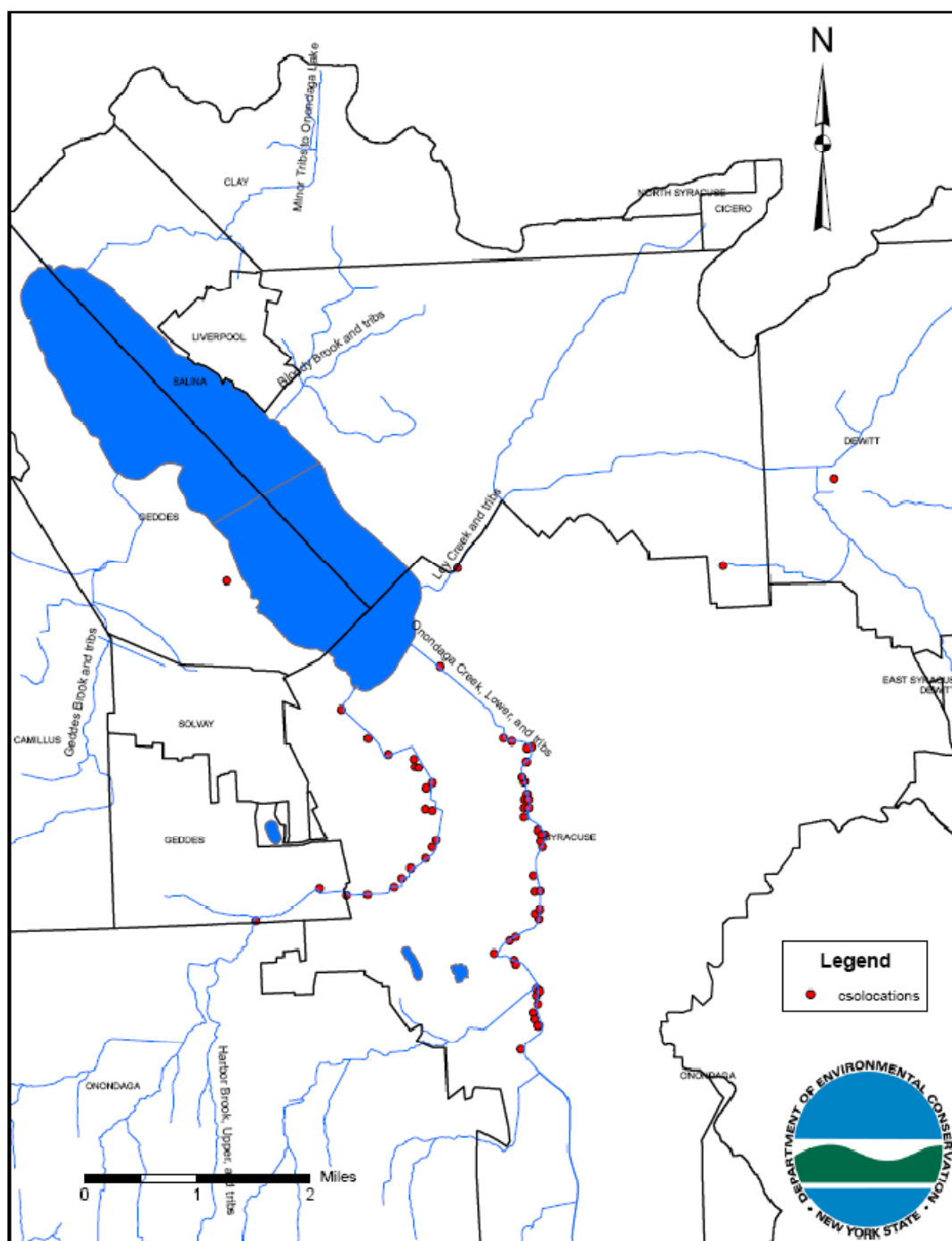


Figure 16: CSO Outfall Locations. Some outfalls shown have already been removed from service by sewer improvement projects

#### ***4.2.4 Developed Land within Municipal Separate Storm Sewer Systems (MS4s) Areas***

Regulated developed land within MS4 areas includes 29,774 acres (16.4%) of the watershed. All developed land within the MS4 areas are assigned to this category. Some of these lands may not drain through the MS4 systems or may be covered by industrial multi-sector permits. Lands within CSO areas are not included. Loading from this source contributes 16,536 lbs/yr of total phosphorus (19% of the total load) to Onondaga Lake. Phosphorus loading from developed areas originates primarily from human activities, such as fertilizer applications to lawns and development. Shoreline and streamside 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. Regulated MS4 areas and extended MS4 areas in the watershed are shown in Figure 3.

#### ***4.2.5 Rural/Unregulated Developed Land***

Developed land located in municipalities not regulated under the MS4 permit includes 495 acres (0.3%) of the watershed. Unregulated stormwater runoff is estimated to contribute 181 lbs/yr of total phosphorus (0.2% of the total load) to Onondaga Lake.

Phosphorus loading from developed areas originates primarily from human activities, such as fertilizer applications to lawns. Streamside 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.

#### ***4.2.6 Agricultural Land***

The OLWM quantified agricultural lands as including 44,368 acres (24.5% of the watershed) of pasture/hay lands and 10,889 acres (6.0% of the watershed) of row cropland. These estimates are based on revisions to the 1992 NLCD (Coon and Reddy, 2008). Pasture/hay lands are estimated to contribute 6,426 lbs/yr of total phosphorus (8% of the total load) and row cropland is estimated to contribute 13,761 lbs/yr of total phosphorus (16% of the total load) to Onondaga Lake. Phosphorus loading from agricultural land originates primarily from soil erosion and the application of manure and fertilizers.

Current statistics provided by Onondaga County Soil and Water Conservation District (OCSWCD) show that approximately 29,100 acres are actively farmed in the Onondaga Lake watershed, with 10,532 acres operated by CAFOs (OCSWCD, 2011). Table 6 provides recent OCSWCD animal counts in the watershed.

| Animal Type              | Animal Counts |          |         | Animal Equivalent Units |              |               |
|--------------------------|---------------|----------|---------|-------------------------|--------------|---------------|
|                          | CAFO          | Non-CAFO | Total   | CAFO                    | Non-CAFO     | Total         |
| Mature Cattle            | 5,123         | 2,637    | 7,760   | 7,172                   | 3,692        | 10,864        |
| Heifers                  | 4,339         | 2,583    | 6,922   | 4,339                   | 2,583        | 6,922         |
| Veal Calves              | 0             | 0        | 0       | 0                       | 0            | 0             |
| Other Cattle             | 0             | 443      | 443     | 0                       | 443          | 443           |
| Swine 55 lbs. or greater | 0             | 49       | 49      | 0                       | 19.6         | 19.6          |
| Swine < 55 lbs.          | 0             | 34       | 34      | 0                       | 1.7          | 1.7           |
| Horses                   | 0             | 187      | 187     | 0                       | 374          | 374           |
| Sheep/Lambs              | 0             | 485      | 485     | 0                       | 48.5         | 48.5          |
| Turkey                   | 0             | 15       | 15      | 0                       | 2.7          | 2.7           |
| Broilers (Chicken)       | 0             | 45       | 45      | 0                       | 0.5          | 0.5           |
| Layers (Chicken)         | 133,000       | 33       | 133,033 | 1330                    | 0.33         | 1330          |
| Ducks                    | 0             | 0        | 0       | 0                       | 0            | 0             |
| Other                    | 1             | 0        | 1       | 1                       | 0            | 1             |
| <b>Total</b>             | -             | -        | -       | <b>12,842</b>           | <b>7,165</b> | <b>20,007</b> |

Table 6: Animals Contained Within the Watershed for Concentrated Animal Feeding Operations (CAFO) and Non-CAFO Operations

#### 4.2.7 State Pollution Discharge Elimination System (SPDES) Discharges

##### 4.2.7.1 Municipal and Industrial Point Source Discharges

Municipal and industrial SPDES discharges located in the watershed that contribute phosphorus to Onondaga Lake are identified in Table 7. The yearly average TP load for each facility except Metro was calculated using discharge monitoring report (DMR) data from 1998-2007.

Additional information provided by Honeywell during the public comment period indicated that the loading included in the draft TMDL document,  $62 \text{ lb} \cdot \text{yr}^{-1}$ , is due to stormwater runoff. Those loads therefore fall under the MS4 category (Section 4.2.4). The load associated with their SPDES permit is therefore determined to be *de minimus*. The loading for Metro is discussed in Section 4.2.7.1.1. Table 7 represents the loads used for the model calibration and the model Base Case periods, and reflects the most recent data at the time of model development. More recent DMR data, through December, 2011, for Marcellus WPCP and Metro Outfalls 001 and 002 was considered when setting the final load allocations for this TMDL. Loads from Marcellus WPCP and Metro Outfalls 001 and 002 represent TP load delivered to Onondaga Lake. Loads for the remaining facilities represent TP load at the discharge location and do not take into account in-stream processing and removal.

##### 4.2.7.1.1 Metropolitan Syracuse WWTP (Metro)

Discharge from the Metro is routed through two outfalls, 001 and 002 (Bypass). Flows up to 126.3 MGD receive tertiary treatment and are discharged from outfall 001. Flows in excess of that limit bypass the plant and are discharged via outfall 002 after primary treatment and chlorination/dechlorination. Occasional flow bypass at the headworks of the plant, prior to primary treatment, has been reported. The annual number of events and total annual discharge volumes for 2004-2011 are listed in Table 8. Data for 2004 and 2005 are from OCDWEP (2005,

| Facility Name                           | SPDES ID  | Facility Type              | Receiving Waters          | Avg. TP Load (lbs·yr <sup>-1</sup> ) |
|-----------------------------------------|-----------|----------------------------|---------------------------|--------------------------------------|
| Bristol-Myers Squibb                    | NY0233251 | Industrial                 | Ley Cr.                   | 0.06                                 |
| Crucible Industries, LLC                | NY0000825 | Industrial                 | Trib. 5A                  | 179                                  |
| Frazer and Jones                        | NY0232491 | Industrial                 | Geddes Br.                | 2.5                                  |
| Honeywell International, Inc.           | NY0002275 | Industrial/<br>Remediation | Ninemile Cr. & Geddes Br. | <i>de minimus</i>                    |
| Lockheed Martin Corp.                   | NY0002101 | Industrial                 | Bloody Br.                | 362                                  |
| New Process Gear, Inc                   | NY0001384 | Industrial                 | Ley Cr.                   | 221                                  |
| Marcellus (V) WPCP                      | NY0020532 | Municipal                  | Ninemile Cr.              | 1,737                                |
| Wabash Aluminum <sup>†</sup>            | NY0110311 | Industrial/<br>Stormwater  | Ley Cr.                   | 40                                   |
| Metropolitan Syracuse WWTP, Outfall 001 | NY0027081 | Municipal                  | Onondaga L.               | 24,030                               |
| Metropolitan Syracuse WWTP, Outfall 002 | NY0027081 | Municipal                  | Onondaga L.               | 6,173                                |
| Oberdorfer, LLC                         | NY0003026 | Industrial                 | Ley Cr.                   | 0.4                                  |
| Onondaga Renewables, LLC*               | NY0262030 | Industrial                 | Trib. 5A                  | 14                                   |
| Otisco Lake WTP                         | NY0155888 | Municipal                  | Ninemile Cr.              | 1.6                                  |
| Syracuse Energy Corp                    | NY0213586 | Industrial/<br>Stormwater  | Onondaga L.               | 165                                  |
| WPS Syracuse Generation                 | NY0231681 | Industrial                 | Geddes Br.                | 32                                   |

\* NYS DES has received a request to terminate this permit.

<sup>†</sup> This permit has been split between Thompson Corners LLC. (NY0110311) and Metalico Aluminum Recovery, LLC. (NY0261947). Industrial water from these sites is currently sent to the Metropolitan Syracuse WWTP and is no longer a source of TP.

**Table 7: SPDES Permits.**

| Year | Number of events | Annual volume (MG) |
|------|------------------|--------------------|
| 2004 | 0                | 0                  |
| 2005 | 3                | 43*                |
| 2006 | 2                | 115 <sup>†</sup>   |
| 2007 | 6                | 137 <sup>†</sup>   |
| 2008 | 3                | 6.5                |
| 2009 | 5                | 27.6               |
| 2010 | 3                | 36.9               |
| 2011 | 2                | 11.4               |

\*No discharge volume was available for one event.

<sup>†</sup>Includes a single event of more than 100 MG.

**Table 8: Headworks bypass events at Metro. Flow from these events was discharged through Outfall 001.**

2006). Data for 2006 through 2011 are from “Metropolitan Syracuse Bypass Event Reports” sent to NYSDEC by OCDWEP. Headworks bypass events are discharged through outfall 001.

Significant treatment upgrades have been made to Metro as a result of the ACJ and Phase I TMDL. The installation of a biological aerated filter (BAF) system which came online in January of 2004 enables the facility to provide year-round nitrification. As a result, the Lake now meets the States water quality standard for ammonia and was delisted from the 303(d) list in 2008.

A high rate flocculated settling (HRFS) system (Actiflo) brought online in 2005 uses coagulation, flocculation and sedimentation processes to convert soluble phosphorus to a particulate form which is readily removed. Figure 17 shows Metro total phosphorus loading from 1997-2011. In the Base Case simulations, average loading from Metro was estimated to be  $24,030 \text{ lb}\cdot\text{yr}^{-1}$ , calculated from 2005-2009 flow data at an assumed effluent concentration of  $0.12 \text{ mg}\cdot\text{l}^{-1}$ , the permit limit for that period. An effluent limit of  $0.10 \text{ mg}\cdot\text{l}^{-1}$  became effective on November 16, 2010 per the Fourth Stipulation and Order Amending the Amended Consent Judgment. Reliable phosphorus removal by the Actiflo system has achieved an average load of  $15,986 \text{ lb}\cdot\text{yr}^{-1}$  during the 2008-2011 period.

Upstate Freshwater Institute and Department of Civil and Environmental Engineering at Michigan Technological University (UFI and MTU, 2010) determined through bioavailability assays that only 1% of the particulate phosphorus in Metro effluent is bioavailable and that the total concentration of bioavailable forms of phosphorus only account for approximately  $30 \text{ }\mu\text{g}\cdot\text{l}^{-1}$ , or approximately  $6,000 \text{ lb}\cdot\text{yr}^{-1}$  at current average flows. The iron rich solids from the Actiflo process are larger than tributary particles and therefore tended to settle faster with high localized deposition near the Metro outfall. In addition, it was found that Metro effluent has a tendency to plunge during the summer months to depths within the metalimnion (UFI, 2010).

The treatment plant upgrades at Metro have had a profound positive effect on water quality and have substantially reduced the load of effective phosphorus to the Lake. The load to the Lake is largely mitigated by reductions in bioavailable phosphorus, plunging tributary loads and the settling of particulate phosphorus (UFI and MTU, 2010). Phosphorus concentrations in the epilimnion have decreased substantially with summer mean concentrations below the State’s  $20 \text{ }\mu\text{g}\cdot\text{l}^{-1}$  guidance value during 2008 and 2009.

As noted above, during periods of high flows effluent may be discharged through outfall 002 (Bypass) following primary treatment and chlorination/dechlorination. Flow and total phosphorus concentration data for the Bypass are available from 1997 through 2011. Loads from the Bypass are shown in Figure 18, as annual totals. On a 12 month rolling average basis, the average load from the Bypass is  $4,491 \text{ lb}\cdot\text{yr}^{-1}$ . The minimum observed load from the Bypass was  $1,924 \text{ lb}\cdot\text{yr}^{-1}$  and the maximum load was  $8,528 \text{ lb}\cdot\text{yr}^{-1}$ . The average modeled Bypass load from 1994-2009 was  $6,173 \text{ lb}\cdot\text{yr}^{-1}$ , with minimum and maximum modeled loads during that period of  $1,913 \text{ lb}\cdot\text{yr}^{-1}$  and  $13,636 \text{ lb}\cdot\text{yr}^{-1}$ , respectively. Recent revisions to the Metro Bypass flows have impacted slightly the loads used for the model (Anchor QEA, 2011f). The average, minimum and maximum modeled loads to the Lake from the Bypass for 1994-2009 were revised to: 5,804, 1,695 and  $13,977 \text{ lb}\cdot\text{yr}^{-1}$ , respectively. Differences between the modeled and measured Bypass

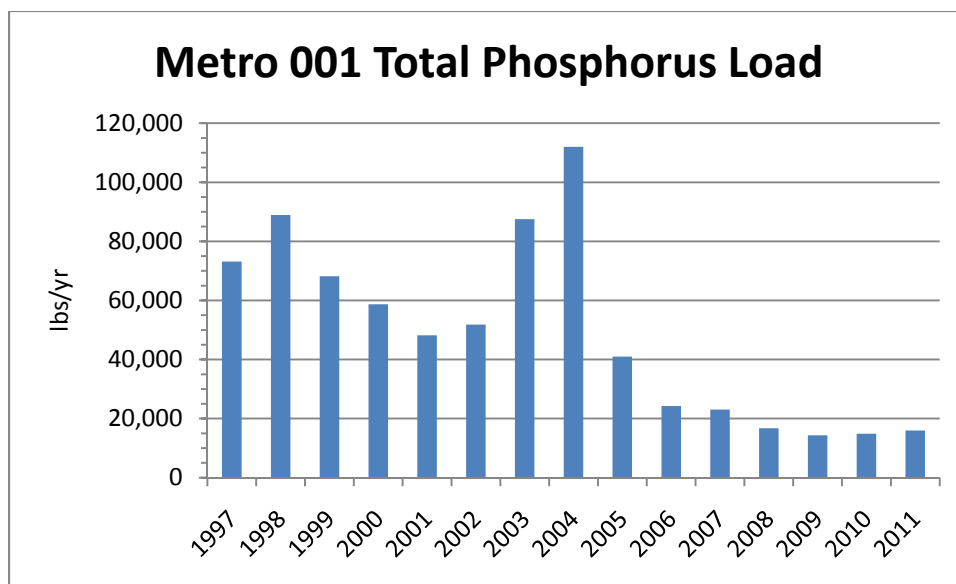


Figure 17: Metro TP Load for Outfall 001 (1997-2011)

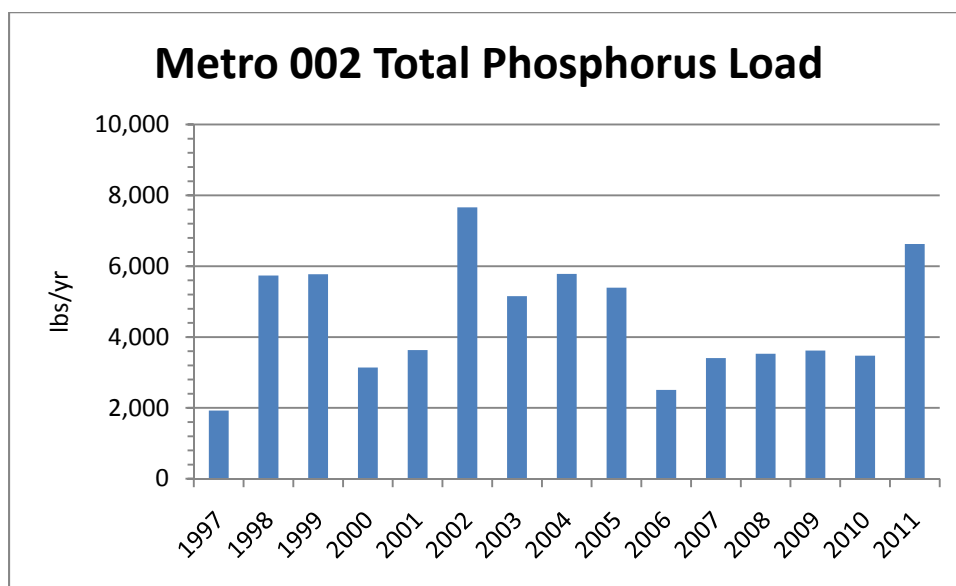


Figure 18: Metro TP Load for Outfall 002 (Bypass) (1997-2011)

loads may be due to regional differences in rainfall intensity and duration between the Metro service area and the meteorological stations where rainfall data was available, as well as the modeling of the 1994-1996 period for which monitoring data is not available.

#### 4.2.7.2 Concentrated Animal Feeding Operations (CAFOs)

Farmsteads located in the watershed that are covered under CAFO permits are identified in Table 9. Under the CAFO program no direct discharge of process water is permitted, except during extreme precipitation events (i.e. the 25-year, 24-hour storm event) and nutrients applied to the landscape are done so at agronomic rates. As such, the load attributed to CAFO barnyards is assumed to be *de minimus* and runoff from CAFO farm fields is accounted for in the nonpoint source agricultural load.

| <b>Facility Name</b>       | <b>SPDES ID</b> |
|----------------------------|-----------------|
| Covale Holsteins           | NYA000240       |
| Cowles Farm                | NYA001536       |
| D. Michael Hourigan        | NYA000290       |
| Elmer Richards and Sons    | NYA000033       |
| Hudson Egg Farms, LLC.     | NYA000066       |
| Lawrence Doody & Sons      | NYA000500       |
| Leu Maple Lane Dairy Farms | NYA000473       |
| Ralph Volles Farms         | NYA000548       |
| William Richards and Sons  | NYA001429       |

Table 9: CAFOs

| <b>Facility Name</b>                             | <b>SPDES ID</b> |
|--------------------------------------------------|-----------------|
| Carousel Center                                  | NY0232386       |
| GMC Fisher Guide Div-Syracuse                    | NY0000566       |
| Syracuse Hancock International Airport           | NY0244074       |
| 174 <sup>th</sup> FW Syracuse Air National Guard | NY0244066       |

Table 10: Individual Industrial SPDES Permits

#### 4.2.7.3 **Construction**

Construction activities that involve one or more acres of soil disturbance in the Onondaga Lake watershed are subject to the conditions of the SPDES General Permit for Stormwater Discharges from Construction Activity (GP-0-10-001) and must also comply with the New York State Stormwater Management Design Manual to control post-construction stormwater discharges and the Enhanced Phosphorus Removal Standards.

Implementation of the practices required by GP-0-10-001 should prevent loading of sediment and nutrients due to construction activity and would therefore preclude it as a significant source of phosphorus to the Lake. For this reason phosphorus loading as a result of construction activity was not included in the model.

#### 4.2.7.4 **Industrial Stormwater**

Stormwater discharges from industrial sites within the watershed are covered under individual industrial SPDES permits, the SPDES Multi-Sector General Permit (MSGP) for Stormwater Discharges Associated with Industrial Activity (GP-0-06-002), or are not potential pollutant dischargers under the Non Exposure Exclusion. Those facilities with individual industrial SPDES permits are listed in Table 10. Under the conditions set forth in the MSGP or in the individual permits, there is no source of phosphorus greater than that which would be expected from stormwater runoff from developed land. Contributions from industrial facilities are incorporated by applying the Commercial-Industrial-Transportation and CSO (Commercial-Industrial-Transportation) phosphorus loading rates included in the model to the industrial areas identified within the watershed. Loading rates on a per acre basis are included in Appendix E.

#### 4.2.8 Other Sources

Mudboils have been observed in the Tully Valley region of the Onondaga Lake watershed since the late 1890s. These mudboils discharge sediment laden water into Onondaga Creek and therefore may be a source of phosphorus to Onondaga Lake. In the early 1990s mudboils delivered 30 tons of sediment per day to Onondaga Creek. Remediation efforts had reduce the current loading to less than one ton per day but the development of new mudboils has increased the sediment loading by an estimated five to eight tons per day (CRA et al., 2011). The delivery of phosphorus with the sediments has not been assessed but it could be a potential source. Continuation of efforts to reduce sediment loading originating from the mudboils will help to improve water quality above and beyond what is specified in this TMDL.

The importance of atmospheric deposition to the phosphorus mass balance on Onondaga Lake was assessed as part of the 2004 Onondaga Lake Ambient Monitoring Program Annual Report (EcoLogic, 2005). Based upon precipitation amounts for 2000-2004 and a regional average  $30 \mu\text{g}\cdot\text{l}^{-1}$  phosphorus concentration, precipitation delivered an estimated  $750 \text{ lb}\cdot\text{yr}^{-1}$ , or less than 1% of the total phosphorus load to the Lake. This number is nearly 4 times greater than the load based on an annual wet and dry depositional flux of  $42.8 \text{ lb}\cdot\text{mi}^{-2}$  (Smil, 2000). Reductions in phosphorus loading to the Lake under this TMDL will increase the relative importance of atmospheric deposition, however it will never account for more than a few percent of the total annual load.

As the OLWQM includes a sediment submodel, internal loading of phosphorus is handled within the model structure and does not need to be accounted for explicitly within this TMDL. Internal loading was assessed within the model for the calibration period, the Base Case and model scenarios 1-6 (Anchor QEA, 2011a), and was found to introduce a significant amount of phosphorus into the water column but was found to be highly responsive to changes in the external phosphorus loading. The majority of the internal loading derived from highly labile, recently deposited material. Only a small fraction originated from slowly degraded, historically deposited material. Average internal loading during the calibration/validation period of 1994-2009 was  $60,075 \text{ lb}\cdot\text{yr}^{-1}$ . Base Case projections, representing a significant external load reduction from the calibration/validation period, produced an estimated average internal loading of  $30,313 \text{ lb}\cdot\text{yr}^{-1}$ . Further reductions in external loading under this TMDL will reduce the internal loading further.

Remediation efforts undertaken in 2011 for the suppression of methyl mercury release from the sediments of the Lake will impact the internal phosphorus loading as well. Under these efforts nitrate concentrations of at least  $1 \text{ mg}\cdot\text{l}^{-1}$  are being maintained in the waters directly above the sediments in the Lake bottom. This suppresses the redox conditions necessary for the release of methyl mercury from the sediments but also suppresses the redox conditions necessary for sediment bound phosphorus to be released into the water column. The result will be a substantial reduction in the internal phosphorus loading. This apparent removal of a significant loading source to the Lake was not incorporated into the modeling undertaken for this TMDL, but is expected to have significant positive effects for the Lake phosphorus budget and water quality.

Dredging followed by capping is being planned with the Lake to address contaminated sediments. For the five years during which dredging will occur, water from the dredged sediments will be treated and returned to the Lake. This water will undergo a series of treatment steps before being sent to Metro for final treatment. An estimated 875 million gallons of water will be sent to Metro containing an estimated 5,253 pounds of phosphorus each year when operations are at full capacity. Most of the TP will be removed by the Actiflo system, however the acceptance of the additional water by Metro will result in an estimated TP discharge increase from the Metro facility of  $730 \text{ lb}\cdot\text{yr}^{-1}$ . Treatment capacity at the Metro plant exists to handle this additional load. Storage capacity has been included in the dredging operations to prevent delivery of this additional water to Metro during periods of wet weather so as not to contribute to any bypass events.

## **5.0 Determination of Load Capacity**

### **5.1 Onondaga Lake Water Quality Model (OLWQM)**

The Onondaga Lake Water Quality Model (OLWQM) is a two dimensional hydrodynamic model of Onondaga Lake developed by Anchor QEA. Model development and calibration are detailed in Development of a Mechanistic Water Quality Model of Onondaga Lake, Phase 2 Report: Model Development and Calibration (Anchor QEA, 2007). Several refinements were made to OLWQM to better represent the effective phosphorus load by incorporating the plunging nature and phosphorus bioavailability of inflows from tributaries and Metro (Anchor QEA, 2011a).

#### **5.1.1 Scenarios**

The OLWQM was used to simulate Base Case load conditions and 15 separate load reduction scenarios representing varying degrees of management. Descriptions and loading for the scenarios are included in Appendix G. Model hindcasting was performed to estimate pre-colonial conditions (Scenario 7) which represent a lower bounding condition in terms of load reduction. Sensitivity analyses (Scenario 11) were also simulated to determine which loads have the greatest influence on the Lake. OLWQM validation, Base Case and scenarios 1-6 are documented in the Model Validation and Application Report (Anchor QEA, 2011a). Scenarios 7-11 are documented in Setup of Additional Model Scenarios (Anchor QEA, 2011b). Full implementation of the 4th Stipulation of the ACJ which required a reduction of 95% by volume, on a system-wide annual average basis of the combined sewage generated during precipitation events, is modeled in Scenario 8. Scenarios 12-15 are documented as part of the Metropolitan Syracuse WWTP Analysis of Phosphorus Treatment Technologies and Metro Diversion to the Seneca River Report prepared by CRA (2011). Point and non-point source reductions along Ninemile Creek are modeled in Scenarios 13 and 14. Scenario 15 models the combined effects of completion of the 4th Stipulation of the ACJ green and grey infrastructure projects (Scenario 8), improvements to Ninemile Creek point and non-point sources (Scenario 14) and anticipated reductions from the fertilizer phosphorus restrictions.

### 5.1.2 Results

Model results for the epilimnetic mean summer TP concentration for the Base Case and Scenarios 1-15 are presented as a temporal plot for the years 2010-2057 in Figure 19. Summary metrics for all of the modeling scenarios are included in Appendix G. The model predictions indicate that some of the model scenarios result in epilimnetic mean summer TP concentrations below the  $20 \mu\text{g}\cdot\text{l}^{-1}$  guidance value, but that none of the model scenarios are capable of returning the Lake to conditions predicted by the pre-colonial scenario (Scenario 7).

The model results also indicate that none of the model scenarios are able to prevent the onset of anoxia in the hypolimnion during the period of summer stratification (Figure 20). The management scenarios considered are, at best, able to delay the onset of anoxia by a few weeks and even in the pre-colonial model scenario, anoxia is not prevented every year.

The OLWQM projects that under Scenario 15, which represents completion of Fourth Stipulation Projects, point and non-point source reductions along Ninemile Creek and the effects of the fertilizer restriction law, the TP target of  $20 \mu\text{g}\cdot\text{l}^{-1}$  is met in 46 out of 48 years (Figure 21). The mean annual TP load delivered to the Lake over the 16 year simulation period under that scenario was  $77,668 \text{ lb}\cdot\text{yr}^{-1}$  (Appendix G, Table 26). The 16 year average summer mean epilimnetic TP concentration in Scenario 15 was  $14 \mu\text{g}\cdot\text{l}^{-1}$ . Total phosphorus loads and summer mean epilimnetic TP concentrations in the Lake for each of the 48 years of the Scenario 15 simulation are included in Appendix G.

TP loads from Metro 001 in Scenario 15 showed only small variations,  $18,274 \text{ lb}\cdot\text{yr}^{-1}$  to  $21,511 \text{ lb}\cdot\text{yr}^{-1}$ , reflective of consistent flow volumes and effluent concentrations over the last several years. The total load on a water year basis to the Lake was considerably more variable, from  $50,008 \text{ lb}\cdot\text{yr}^{-1}$  to  $114,975 \text{ lb}\cdot\text{yr}^{-1}$ . The maximum load was caused primarily by high watershed loads, and in particular from Onondaga Creek which contributed more than half of the total load delivered. The model scenario for the maximum loading year was based upon water year 1996 observed hydrologic data for the watershed. While not a particularly wet year, water year 1996 was marked by several high intensity runoff events which delivered the high concentrations of phosphorus to the Lake that year. This load was likely delivered primarily as particulate phosphorus (PP) as Effler et al. (1999) noted a shift away from dissolved forms of phosphorus towards PP during high flows. The measured hydrologic data for the watershed used to force the models spanned 1994-2009. Measured data for 1994 forced model years 2010, the first year of the simulations, and was repeated again to force 2026 and 2042. Similarly, data from 1996 forced model years 2012, 2028 and 2044.

Even under those high loading conditions the model predicts a summer mean epilimnetic TP concentration of  $20 \mu\text{g}\cdot\text{l}^{-1}$ . It was not until the following year that the summer mean epilimnetic TP concentration exceeded the guidance value at a modeled concentration of  $21 \mu\text{g}\cdot\text{l}^{-1}$  in 2013. The delay in response is attributed to a carryover of phosphorus to the following year. The model estimates that about 30% of the phosphorus load delivered to the Lake is from internal loading, most of which originates from material deposited within the last year (Anchor QEA, 2011a). The summer mean epilimnetic TP concentration in exceedance of the  $20 \mu\text{g}\cdot\text{l}^{-1}$  TMDL endpoint was

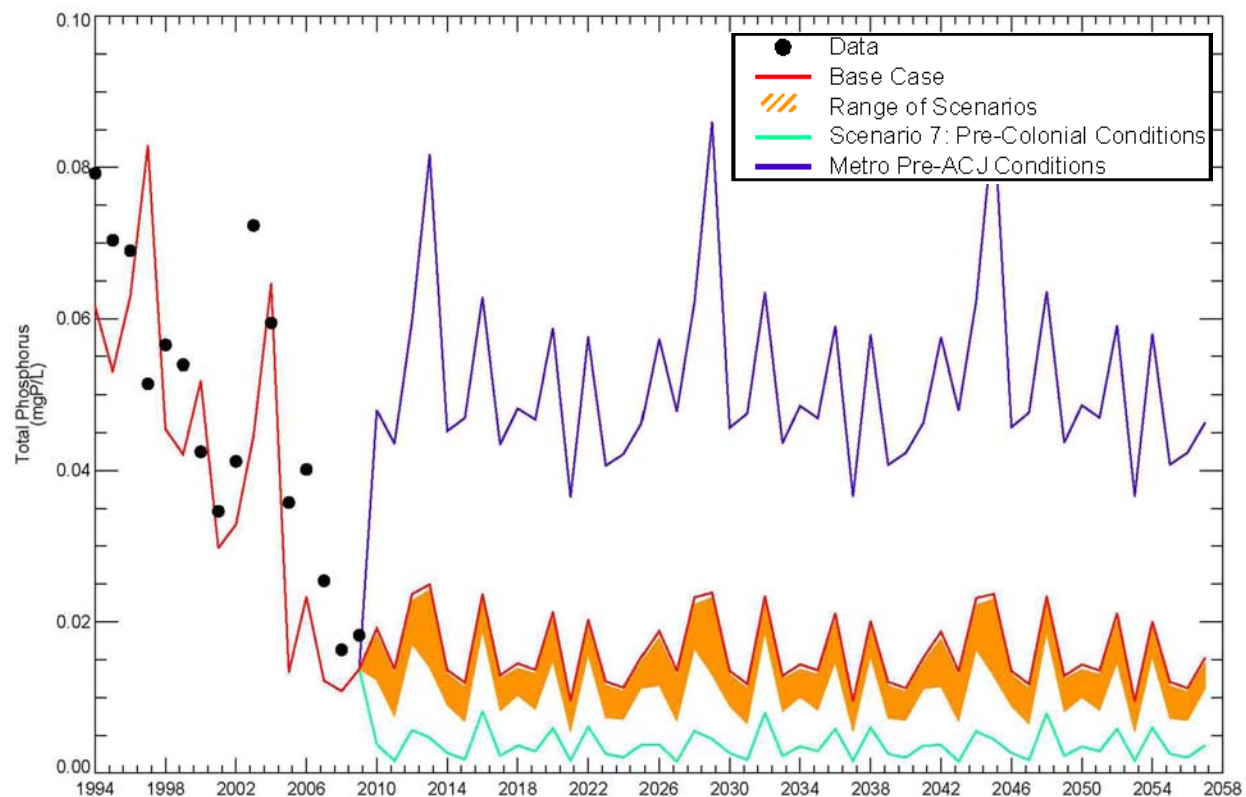


Figure 19: Epilimnetic Mean Summer TP Concentrations (CRA, 2011)

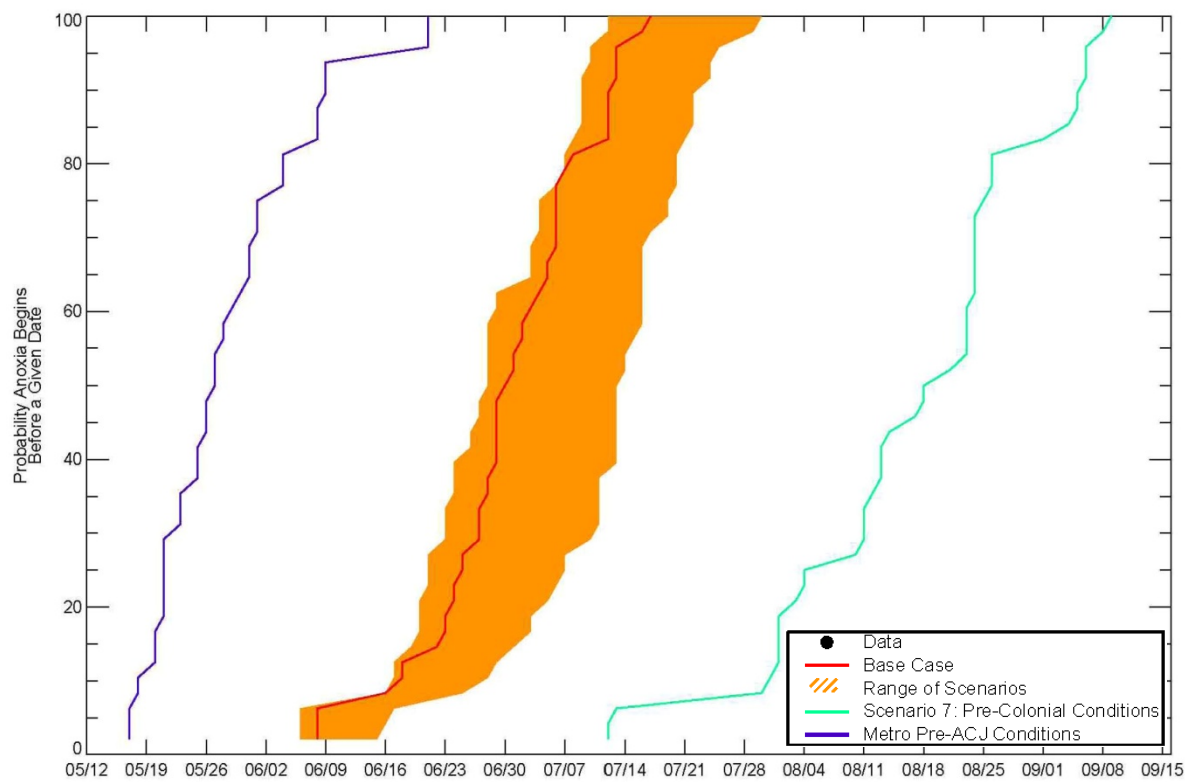
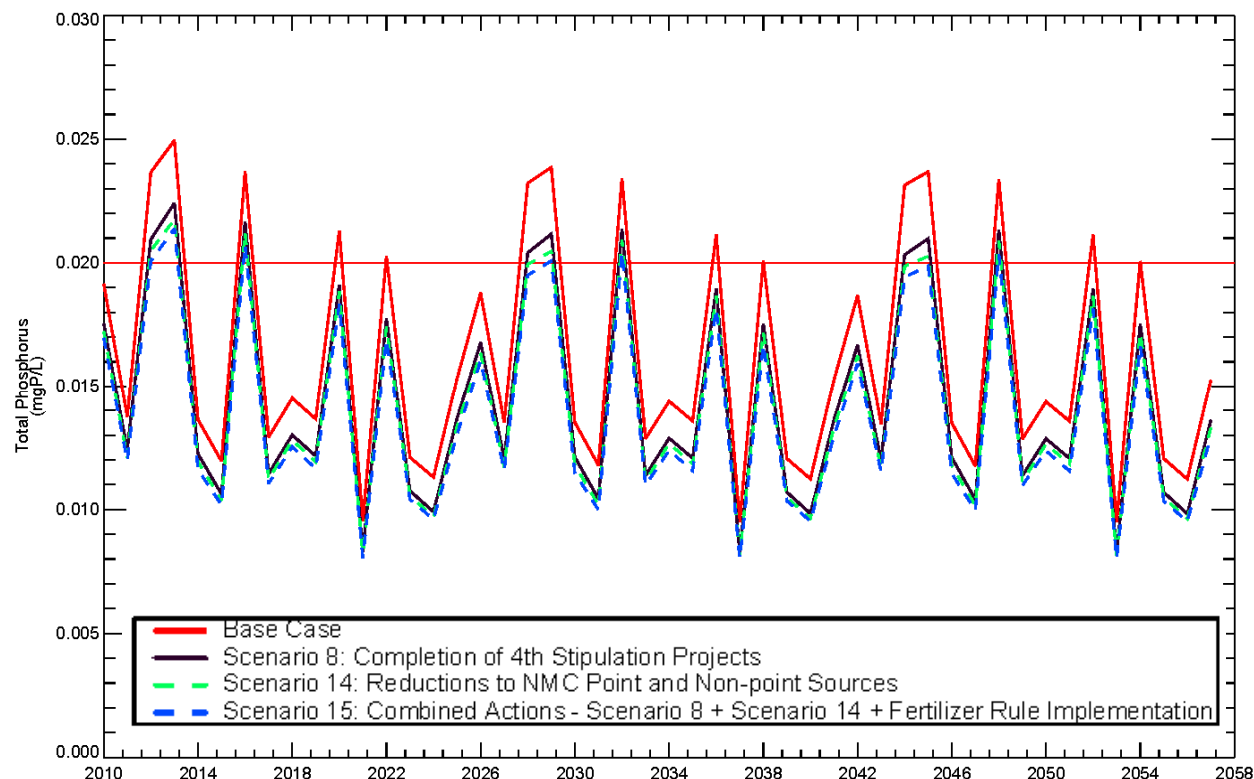


Figure 20: Probability of Observing Anoxia at the Sediment Water Interface Before a Given Date During Summer Stratification (CRA, 2011)



**Figure 21: Summer Average Total Phosphorus in the Upper Mixed Layer for Model Scenarios 8, 14 and 15 (Anchor QEA, 2011e)**

only observed during the first 16 year model cycle, in model years 2013 and 2016 (Appendix G, Table G-4). The same watershed hydrologic loading conditions which produced the 2013 and 2016 model year results were repeated within the 48 year model period. Those loading conditions reoccurred as 2029 and 2032, respectively, and again as 2045 and 2048, respectively. For those years, 2029, 2032, 2045 and 2048, the summer mean epilimnetic TP concentrations is modeled to be  $20 \mu\text{g l}^{-1}$ , which meets the water quality guidance value. The model results indicate that, in the long term, the water quality guidance value will be met even under occasional high years of watershed derived phosphorus loads.

## 6.0 Pollutant Load Allocations

The objective of a TMDL is to provide a basis for allocating acceptable loads among all of the known pollutant sources so that appropriate control measures can be implemented and water quality standards achieved. Individual waste load allocations (WLAs) are assigned to discharges regulated by State Pollutant Discharge Elimination System (SPDES) permits (commonly called point sources) and unregulated loads (commonly called non-point sources) are contained in load allocations (LAs). A TMDL is expressed as the sum of all individual WLAs for point source loads, LAs for nonpoint source loads, and an appropriate margin of safety (MOS), which takes into account uncertainty (Figure 22).

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

**Figure 22: TMDL Equation**

As noted in Section 4.2.7.1.1, the Metro 002 (Bypass) loads used in the model have been revised. The 16 year average Bypass load decreased by  $369 \text{ lb}\cdot\text{yr}^{-1}$ , a 6% reduction. The impact of these revisions on the model calibration and on model Scenario 15 was assessed by Anchor QEA (2011f). As the changes to the total loading were minor, impacts on water quality were not substantial. In some years the summer mean epilimnetic TP model projections changed by  $0.001 \text{ mg}\cdot\text{l}^{-1}$  relative to the original projections. Both the original and revised summer mean epilimnetic TP model projections are included in Table 27 of Appendix G. Since the impact of these revisions upon the loading to the Lake and upon the water quality projections for the Lake are relatively minor and well within the MOS, the original model projections were used for setting the pollutant load allocations for this TMDL.

Based upon the results of the numerical modeling discussed in Section 5.1.2, two pollutant load allocation scenarios have been developed for this TMDL: an average pollutant load allocation and a maximum pollutant load allocation. The former is based upon the average results from Scenario 15 and was developed to protect the Lake in the long run, with a total allocation of  $77,668 \text{ lb}\cdot\text{yr}^{-1}$ . This load is the 16 year average load from model Scenario 15. The maximum load allocation acknowledges that loading to the Lake through the tributaries can be variable, but that, despite the occasional high load, the Lake can still meet its designated best uses. The total allocation is set at  $114,975 \text{ lb}\cdot\text{yr}^{-1}$ , the maximum load delivered under Scenario 15, which as discussed above, resulted in TP concentrations which exceeded the guidance value only twice in the 48 year model period. For the purpose of developing permit limits, the maximum pollutant load allocation will be utilized.

The pollutant load allocations for both the average and maximum conditions are listed in Table 11 on a pound per year basis. Figure 23 provides a graphical representation of this information. Pollutant load allocations on a pound per day basis are included in Appendix H. Implementation of the pollutant load allocations is covered in Section 7, including how the reductions are expected to be achieved and how permit limits will be derived from the allocations.

The load allocations for this TMDL take into account several factors: load reductions which have already occurred within the watershed, load reductions for which the mechanisms are already in place, and load reductions which can be achieved in the future with reasonable assurance. The Syracuse Metro plant has already undergone substantial upgrade as a result of the Phase I TMDL. Additional load reductions from Metro 001 will have very high associated costs on a per pound removal basis. More cost effective load reduction options should be exhausted prior to requiring additional reductions from Metro. Additionally, some additional load capacity above current levels might be required at Metro to allow for growth within the design capacity of the treatment plant, to account for load uncertainty and to allow Metro to accept the water from the dredging operations (Section 4.2.8). Reductions from Metro 002 were targeted in order to address a highly bioavailable source of phosphorus that is discharged to shallow waters and is a significant portion of the growing season load. Expected reductions for which mechanisms are already in place include CSO load reductions under the 4<sup>th</sup> Stipulation of the ACJ, CAFO permits, and fertilizer use restrictions. Reductions from these mechanisms are used to determine anticipated load reductions and therefore the load allocations for those categories. The

Table 11: Annual Total Phosphorus Allocations in Pounds per Year<sup>†</sup>

| Source                                              | Base Case     |                | Average Load Allocation |               |             | Maximum Load Allocation |               |             |
|-----------------------------------------------------|---------------|----------------|-------------------------|---------------|-------------|-------------------------|---------------|-------------|
|                                                     | Average       | Maximum        | Allocated               | Reduction     | % Reduction | Allocated               | Reduction     | % Reduction |
| Wetland/Water                                       | 2,658         | 4,440          | 2,658                   | 0             | 0%          | 4,440                   | 0             | 0%          |
| Forest                                              | 6,442         | 10,760         | 6,442                   | 0             | 0%          | 10,760                  | 0             | 0%          |
| Unregulated Developed Land                          | 181           | 302            | 136                     | 45            | 25%         | 227                     | 75            | 25%         |
| Agriculture                                         | 20,187        | 33,719         | 16,653                  | 3,534         | 18%         | 27,656                  | 6,063         | 18%         |
| <b>LA</b>                                           | <b>29,468</b> | <b>49,221</b>  | <b>25,889</b>           | <b>3,579</b>  | <b>12%</b>  | <b>43,083</b>           | <b>6,138</b>  | <b>12%</b>  |
| Developed Land (Regulated MS4 Stormwater)           | 16,536        | 27,621         | 13,573                  | 2,963         | 18%         | 22,649                  | 4,972         | 18%         |
| Developed Land within CSO Areas                     | 6,482         | 10,827         | 3,977                   | 2,505         | 39%         | 6,605                   | 4,222         | 39%         |
| Metropolitan Syracuse WWTP, Outfall 001 (NY0027081) | 24,030        | 25,243         | 21,511                  | 2,519         | 10%         | 21,511                  | 3,732         | 15%         |
| Metropolitan Syracuse WWTP, Outfall 002 (NY0027081) | 6,173         | 13,636         | 6,173                   | 0             | 0%          | 7,602                   | 6,034         | 44%         |
| Marcellus (V) WPCP (NY0020532)                      | 1,737         | 1,737          | 1,158                   | 579           | 33%         | 1,158                   | 579           | 33%         |
| Lockheed Martin Corp. (NY0002101)                   | 362           | 362            | 205                     | 157           | 43%         | 205                     | 157           | 43%         |
| Crucible Industries, LLC (NY0000825)                | 179           | 179            | 179                     | 0             | 0%          | 179                     | 0             | 0%          |
| Onondaga Renewables, LLC (NY0262030)*               | 14            | 14             | 0                       | 14            | 100%        | 0                       | 14            | 100%        |
| New Process Gear Inc. (NY0001384)                   | 221           | 221            | 221                     | 0             | 0%          | 221                     | 0             | 0%          |
| WPS Syracuse Generation (NY0231681)                 | 32            | 32             | 32                      | 0             | 0%          | 32                      | 0             | 0%          |
| Syracuse Energy Corp (NY0213586)                    | 165           | 165            | 165                     | 0             | 0%          | 165                     | 0             | 0%          |
| Wabash Aluminum (NY0110311)**                       | 40            | 40             | 0                       | 40            | 100%        | 0                       | 40            | 100%        |
| Aggregated Minor SPDES Discharges <sup>#</sup>      | 5             | 5              | 5                       | 0             | 0%          | 5                       | 0             | 0%          |
| <b>Reserve</b>                                      | <b>---</b>    | <b>---</b>     | <b>62</b>               | <b>---</b>    | <b>---</b>  | <b>62</b>               | <b>---</b>    | <b>---</b>  |
| <b>WLA</b>                                          | <b>55,976</b> | <b>80,082</b>  | <b>47,261</b>           | <b>8,715</b>  | <b>16%</b>  | <b>60,394</b>           | <b>19,750</b> | <b>25%</b>  |
| <b>LA + WLA</b>                                     | <b>---</b>    | <b>---</b>     | <b>73,150</b>           | <b>12,294</b> | <b>14%</b>  | <b>103,477</b>          | <b>25,888</b> | <b>20%</b>  |
| <b>MARGIN OF SAFETY</b>                             | <b>---</b>    | <b>---</b>     | <b>4,518</b>            | <b>---</b>    | <b>---</b>  | <b>11,498</b>           | <b>---</b>    | <b>---</b>  |
| <b>TOTAL</b>                                        | <b>85,444</b> | <b>129,303</b> | <b>77,668</b>           | <b>7,776</b>  | <b>9%</b>   | <b>114,975</b>          | <b>14,328</b> | <b>11%</b>  |

\* NYS DEC has received a request to terminate this permit.

\*\* This permit has been split between Thompson Corners LLC. (NY0110311) and Metalico Aluminum Recovery, LLC. (NY0261947). Industrial water from these sites is currently sent to the Metropolitan Syracuse WWTP and is no longer a source of TP.

<sup>#</sup> Includes four facilities: Bristol-Myers Squibb, Frazer and Jones, Oberdorfer, LLC. and Otisco Lake WTP. These dischargers are considered *de minimus* and account for only 0.006% (under base case) and 0.004% (maximum load allocation) of the total load. Refer to Table 7 for individual SPDES numbers and loads.

<sup>†</sup>Permits will be based upon the maximum load allocations as a running 12-month average. Pound per day allocations are included in Appendix H.

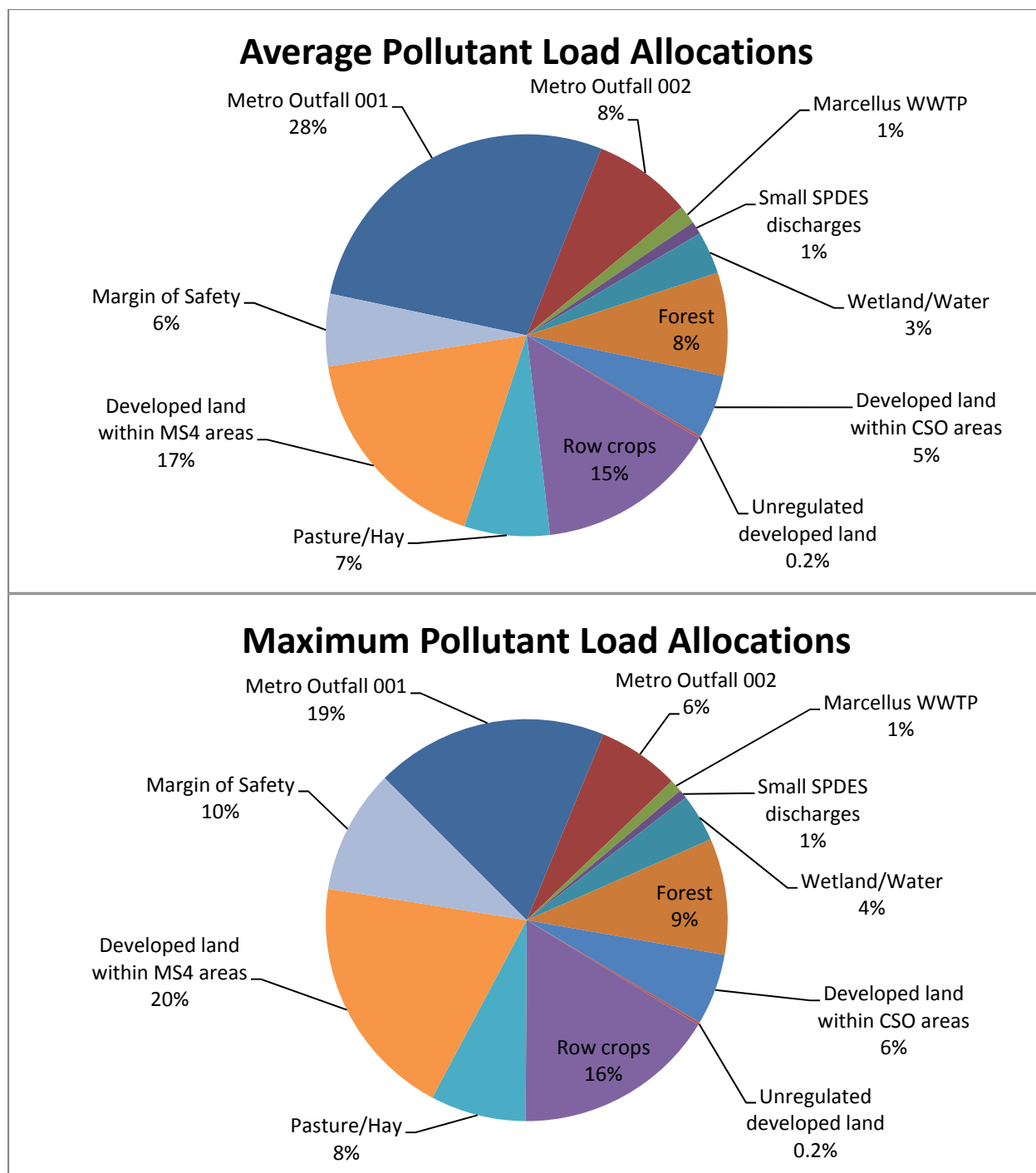


Figure 23: Pollutant Load Allocations. Allocations may not sum to 100% due to rounding.

imposition of a limit on the Marcellus WWTP through their SPDES permit and reductions from the agricultural sector can be achieved with reasonable assurances detailed in Section 7.

### 6.1 Waste Load Allocation (WLA)

The WLA for Onondaga Lake is set at  $47,261 \text{ lb}\cdot\text{yr}^{-1}$ , on average, with a maximum allocation of  $60,394 \text{ lb}\cdot\text{yr}^{-1}$ . There are 16 permitted discharges from industrial and WWTP operations, 9

permitted CAFOs and 20 permitted MS4s within the Onondaga Lake basin. The WLA for each source is included in Table 11. Discharges contributing less than 10 lb·yr<sup>-1</sup> of phosphorus were lumped together as “Aggregated Minor SPDES Discharges.” Table 7 lists all of the SPDES permitted discharges and associated annual loads.

The WLA for the Marcellus WPCP, 1,158 lb·yr<sup>-1</sup>, is reflective of a plant design flow of 0.38 MGD and an effluent phosphorus concentration of 1.0 mg·l<sup>-1</sup>. This WLA is applied to both the average and maximum load allocation tables. This allocation represents an end-of-pipe value. Reduced bio-availability following the increased level of treatment and reduced phosphorus precipitation due to seepage from waste beds will change the delivery factor for phosphorus originating from Marcellus WPCP. As a conservative measure, the end-of-pipe value is included in Table 11.

For the Metro 001, the WLA is 21,511 lb·yr<sup>-1</sup>. This load was the maximum modeled load under Scenario 15, and is applied to the average and maximum load allocations. This is equivalent to the plant permitted flow of 84.2 MGD at an average effluent concentration 0.084 mg·l<sup>-1</sup>. The measured average effluent concentration for 2008-2011 was 0.083 mg·l<sup>-1</sup>. This WLA is reflective of maintaining the current level of treatment at the current plant permitted flow. For Metro 002 the average WLA is set at 6,173 lb·yr<sup>-1</sup> while the maximum WLA is set at 7,602 lb·yr<sup>-1</sup>. The former limit is reflective of the 16 year average Bypass load from the model while the latter limit is reflective of the reduction needed to meet the TMDL limits. The maximum WLA, upon which the permit will be based, is less than the maximum measured load discharged through the Bypass.

WLAs for the private, commercial and institutional (PCI) SPDES dischargers listed in Tables 7 and 10 reflect current discharge values, with the exception of Onondaga Renewables, which is currently being terminated, Lockheed Martin, which has been given a more stringent limit, and Wabash Aluminum, which no longer a source of phosphorus to the Lake, as noted in Table 11. As noted in Section 4.2.7.1 and indicated in Table 7, the load from Honeywell was determined to be *de minimus*. The 62 lb·yr<sup>-1</sup> allocation for Honeywell indicated in the draft TMDL is being held in reserve, but may be reallocated in the future at the discretion of DEC.

The WLA for the regulated MS4 stormwater area is 13,573 lb·yr<sup>-1</sup> on average and 22,649 lb·yr<sup>-1</sup> as a maximum load allocation. The 2,963 lb·yr<sup>-1</sup> reduction for the average case will come about from the fertilizer restrictions recently put in place (see section 7.2.3). Estimates of load reductions were determined by applying a 40% reduction to the total phosphorus loading rates used in the model. These reduced loading rates were applied to the pervious lands within the MS4, CSO and unregulated, developed land categories, i.e. those lands likely to receive fertilizer. The 40% reduction is based off of observed reductions of soluble phosphorus in runoff from turf grass (Struss, 2011). For the maximum load allocation, the WLA was set at the same 18% percentage reduction as indicated for the average WLA.

The CSO Area WLA for the average load allocation is based upon reductions from two sources, a reduction of 301 lb·yr<sup>-1</sup> as a result of the fertilizer restrictions and a 2,204 lb·yr<sup>-1</sup> reduction from the requirements of the 4<sup>th</sup> Stipulation Agreement to the ACJ. The fertilizer reduction was determined as discussed above for the MS4 areas. The 4<sup>th</sup> Stipulation reduction was determined from the Scenario 8 modeling results and is reflective of 95% by volume capture or elimination

of CSO, on a system-wide annual average basis. The maximum load allocation was similarly determined from the Scenario 8 results.

## **6.2 Load Allocation (LA)**

The average LA for Onondaga Lake is set at  $25,889 \text{ lb}\cdot\text{yr}^{-1}$  and the maximum LA is set at  $43,083 \text{ lb}\cdot\text{yr}^{-1}$  (Table 11). Nonpoint sources that contribute total phosphorus to Onondaga Lake include loads from agricultural land and developed land outside of MS4 areas. Phosphorus originating from natural sources (including forested land and wetlands/water) is assumed to be a minor source of loading that is unlikely to be reduced further and therefore the load allocation is set at current loading.

For the unregulated, developed land a small reduction in loading of  $45 \text{ lb}\cdot\text{yr}^{-1}$  is expected from the fertilizer restrictions (see section 7.2.3). The extent of the reduction was estimated as detailed for the MS4 areas in section 6.1. A similar percent reduction is required under the maximum loading allocation.

The LA for agricultural lands was set at  $16,653 \text{ lb}\cdot\text{yr}^{-1}$  for the average load allocation and  $27,656 \text{ lb}\cdot\text{yr}^{-1}$  for the maximum load allocation. Implementation of BMPs in the Ninemile Creek watershed were modeled by changing the farmstead land use category over to row crops, resulting in a seven fold reduction in phosphorus loading rates. For these purposes, farmsteads, as defined by Coon and Reddy (2008) are lands used for confined livestock feeding operations and the associated fields used for manure spreading. For the average load allocation the reduction is based upon the reductions of phosphorus loading from the farmstead lands within the model plus a small additional reduction from other BMPs implemented throughout the watershed. A discussion of other BMPs implemented or for which interest has been expressed is included in section 7.3. A similar percent reduction is required under the maximum load allocation and is similarly met through the Ninemile Creek reductions estimated in the model plus some additional BMPs to be implemented in the rest of the watershed.

## **6.3 Margin of Safety (MOS)**

The margin of safety (MOS) can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loadings) or a combination of both. However, making conservative assumptions in the modeling analysis can lead to errors in projecting the benefits of BMPs and in projecting lake responses. Therefore, the recommended method is to formulate the mass balance using the best scientific estimates of the model input values and keep the margin of safety in the “MOS” term.

The models used to develop this TMDL have undergone rigorous calibration and validation procedures against a combined 16 years of monitoring data (Anchor QEA 2007, 2011a). Additionally, the model has undergone peer review (Anchor QEA 2008). There is therefore a considerable amount of confidence in the models being used. Some uncertainty exists in even the best model projections, however, so an explicit MOS is still considered prudent for this analysis.

The NYS DEC has elected to include an explicit 10%, or 11,498 lb·yr<sup>-1</sup>, MOS in the maximum load allocation and a 5.8%, or 4,518 lb·yr<sup>-1</sup> MOS for the average load allocation. The NYS DEC recognizes that uncertainties exist and therefore has opted to include explicit MOS in the load allocation tables to account for uncertainties between the model projections and the actual resulting quality of the receiving water. A MOS of 10% has often been used in TMDLs to account for uncertainty, including the Phase I TMDL. A 10% MOS for the maximum load allocation appears reasonable and is therefore proposed for this analysis. A smaller explicit MOS is proposed for the average load allocation because at the average phosphorus loading, the average TP concentration in the epilimnion was 14 µg·l<sup>-1</sup>, well below the guidance value of 20 µg·l<sup>-1</sup>. The average TP loading is therefore quite conservative.

As was discussed in section 4.2.8, the addition of nitrate to the hypolimnetic waters inhibits the release of phosphorus from the sediments during the period of anoxia. The first year of a three-year pilot test of nitrate additions was completed in 2011. Official results have yet to be released but preliminary results indicate sufficient nitrate levels were maintained to achieve the goal of methyl mercury release suppression. A successful pilot test will result in continued nitrate treatments into the foreseeable future. The effects of this pilot test on phosphorus releases have not been quantified nor were the nitrate additions included in the models used for this TMDL; however suppression of internal phosphorus cycling is possible. The reduction in internal cycling will not be accounted for explicitly within this TMDL, but will be left as an additional, implicit MOS.

#### **6.4 Critical Conditions**

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Onondaga Lake is most vulnerable to degradation of water quality during the period of summer stratification. It is during this period that increases in chlorophyll-*a* are observed along with decreases in secchi disk depth (OCDWEP 2005, 2010). Degradation of these parameters during the summer increases the risk of impairment with respect to primary and secondary contact recreation. In terms of loading, summer wet weather events may have increased significance because of the short residence time in Onondaga Lake and the spring runoff period is considered to be important as wet weather events transport significant quantities of nonpoint source loads to the Lake (Effler et al. 2009). These critical conditions were accounted for in the model through the use of a 16 year simulation period. The meteorological and loading data over the 16 year simulation period is based off of observed data and includes both wet and dry years and variable point and nonpoint source loading. Water quality is simulated year round using the model including the critical spring loading and summer stratification periods.

As the Lake is most vulnerable during the summer stratification period, the epilimnetic average total phosphorus concentration during the period of stratification is used as the metric to determine attainment of the water quality criteria for Lake. To ensure protection of the water quality of the Lake, under the wet weather permitted loads, total loading to the Lake will not exceed the modeled maximum total load received by the Lake which still allowed the lake to meet the water quality objective of 20 µg·l<sup>-1</sup> for total phosphorus set forth in this TMDL.

## **6.5 Seasonal Variations**

Seasonal variation in nutrient loading and the Lake response is captured within the models used for this TMDL. Inputs to the water quality model are specified on a daily basis and the output for most of the state variables are generated as daily averages. Seasonal variation of the loading to the Lake from the watershed is within the 16 year meteorological and loading data. Assessment of seasonal variation is therefore possible by looking at the daily time series of model results. Comparisons can be made between the seasons within a single year and also among the same season across several years. In both cases variations in loading are captured due to the inherent variability of forcing the model with 16 years of measured data.

Several years were identified in the 16-year data cycle to characterize seasonal variations captured by the model. Comparisons were made between a flow year with average flows in all seasons except high flows in the fall (average year; model projection year 2044 using the 1996 hydrograph), a year with low flows in all seasons (low flow; model projection year 2047 using the 1999 hydrograph) and a year with high flows in all seasons except the spring, which experienced low flows (high flows; model projection year 2054 using the 2006 hydrograph). Average, low and high flows were identified based on percentiles of seasonal average flows (Anchor QEA, 2011a).

Seasonal variation of the water quality parameters for the Lake is observed in the annual time series model projections. TP concentrations are generally higher from October through April than the rest of the year. There is also some inter-annual variation in the TP concentrations within each season due to seasonal flow variations. The effects, however appear to be short lived with little carry over from one season to the next. Low flows in the spring for the model projection year 2054 do not appear to change water quality parameters for the rest of the year, which behaves as expected for the high flow conditions modeled for the rest of the year. Inter-annual difference in water quality due to seasonal loading is likely diminished due to the short residence time of the lake. As discussed previously (Section 5.1.2) seasonal loading may be carried over as internal loads. The model results indicate the impact on Lake TP is small and these impacts will be reduced further as the overall internal loading is reduced due to the reduced external loading specified in this TMDL.

## **7.0 Implementation Plan**

One of the critical factors in the successful development and implementation of TMDLs is the identification of potential management alternatives, such as best management practices (BMPs) and screening and selection of final alternatives in collaboration with the involved stakeholders. Coordination with state and federal agencies, local governments, Sovereign Nations and stakeholders such as the general public, environmental interest groups, and representatives from the nonpoint pollution sources will ensure that on-going adaptive management alternatives are technically and financially feasible. NYS DEC, in coordination with these local interests, will address any additionally identified sources of impairment, using regulatory and non-regulatory tools, matching management strategies with sources, and aligning available resources to effect implementation.

It has been NYSDEC practice to implement TMDLs adaptively by making minor adjustments among the waste load allocations (WLAs) in a TMDL when new information becomes available or circumstances arise during the implementation of the TMDL that suggests such modifications are appropriate. NYSDEC will notify EPA and the public regarding any shifts in loading it makes within the sum of the WLAs of this TMDL. Subsequent to approval of this TMDL, re-characterization of a source within a LA to a regulated point source given a WLA of the same magnitude, character, and location as the original LA, will not require the submission of a revised TMDL. Advance notification will be provided to EPA 30 days prior to such a re-characterization. Use of the reserve capacity to permit new or increased discharges within the WLA similarly will not require submission of a revised TMDL, however EPA will be provided with 30 days advanced notification.

New information generated during TMDL implementation may include: monitoring data, BMP effectiveness information and land use information. NYSDEC will make such shifts only in the event that the shifts will not result in a change to the sum of the WLAs, the sum of the LAs, or the total loading capacity of the Lake. NYSDEC may also consider the nature of the loads, e.g. bioavailable phosphorus content, when loads are reallocated between sources to ensure the reallocation will not negatively impact the Lake. In addition, any adjusted WLAs will be set at a level necessary to implement the applicable water quality standards. Reasonable assurance will be provided where appropriate.

NYSDEC is willing to consider water quality trading as a means of providing flexibility for the implementation of this TMDL. Water quality trading is a voluntary, market based option that regulated point sources can use to meet the water quality-based effluent limits in their SPDES permits. Trades among individual WLAs may be implemented in the individual SPDES permits of those agreeing to the trade through corresponding adjustments among the SPDES permit limits. NYSDEC may consider the nature of the loads, e.g. bioavailable phosphorus content, when trading between sources is being considered to ensure the trade will not cause additional impact to the Lake.

Some bubble permits are included within this TMDL. Additional bubble permits may be considered by NYSDEC in the future.

Consistent with the overall approach for minor adjustments above, NYSDEC will notify EPA of any proposed water quality trading or additional bubble permits 30 days prior to their implementation. Public notice would be provided through the SPDES permitting process.

Re-allocation between the WLA and LA, except for the minor re-characterization of LA to a regulated point source, or changes in the TMDL's loading capacity will be submitted to EPA for review and approval as a revised TMDL according to the same procedures as for a new TMDL, and as such NYSDEC will also provide an opportunity for public comment on any shifts in loadings between WLAs and LAs.

NYSDEC recognizes that TMDL designated load reductions alone may not be sufficient to restore eutrophic lakes. The TMDL establishes the required nutrient reduction target; however, the nutrient load only affects the eutrophication potential of a lake. The implementation plan

therefore calls for the collection of additional monitoring data, as discussed in Section 7.8, to determine the effectiveness of nutrient reduction management practices, and adapt implementation according to the future response in Lake water quality.

### **7.1 Reasonable Assurance**

Reasonable assurance that the TMDL will be met is provided through implementation of existing regulatory programs supplemented by load reduction commitments required by the ACJ. WLAs for Metro outfalls 00, informed by the METRO WWTP Optimization Report (CRA, 2011), will be promulgated upon TMDL approval. The Optimization Report will ensure that the WLA for METRO will be reliably and consistently achieved. The WLA for the Village of Marcellus WPCP will be implemented through an implementation schedule incorporated into their SPDES permit. A WLA will be assigned to the CSOs based on the load reductions anticipated from the CSO capture requirements set forth in the ACJ. SPDES General Permits regulate stormwater discharges from construction activities (GP-0-10-001) and MS4s (GP-0-10-002) requiring control of post-construction stormwater discharges and implementation of the Enhanced Phosphorus Removal Standards in accordance with New York State Stormwater Management Design Manual. Phosphorus reductions anticipated from Environmental Conservation Law §17-2103, which limits the use of lawn fertilizer containing phosphorus, will also be credited to developed lands.

Green infrastructure has been incorporated into the ACJ as a strategy to aid in abatement of CSO discharges by reducing stormwater inputs to the combined sewer system (CSS). (Fourth Stipulation and Order at Paragraphs 17, 20, 26 and 27). EPA has also recognized the benefits of green infrastructure in addressing sediment and nutrient impairments and has expressly encouraged its incorporation as a pollutant control strategy in TMDLs as an implementation strategy and/or to address the impacts of future growth (“Incorporating Green Infrastructure Concepts into Total Maximum Daily Loads (TMDLs),” October, 2008). Green infrastructure (GI) and Low Impact Development (LID) are terms used to describe stormwater management approaches and practices that can be used to eliminate or reduce urban runoff and pollutant loadings by managing the runoff as close to its sources as possible. A collection of small-scale practices, linked together on a site, is used to reduce the impacts of development and redevelopment activities on water resources by maintaining or replicating the predevelopment hydrology of the site.

Green infrastructure, alone, or in combination with other strategies outlined in this section are available to achieve the waste load allocation and/or load reduction targets of the TMDL and/or to assure that future growth does not result in increases in phosphorus loads to Onondaga Lake that degrade current water quality. As use of green infrastructure gains wider acceptance and adoption, green infrastructure development practices can be expected to play an important role in protecting Onondaga Lake and its watershed while allowing for future growth in the Onondaga Lake watershed.

## **7.2 Recommended Phosphorus Management Strategies for SPDES Discharges**

### **7.2.1 Municipal and Industrial Point Source Discharges**

Load reductions from Metropolitan Syracuse WWTP and the Marcellus (V) WPCP will be required in order to provide reasonable assurance that the TMDL will be met. The waste load allocations set forth in this TMDL will be translated into permit limits for these facilities. The phosphorus waste load allocation for Metro 001 is set at 21,511 lb·yr<sup>-1</sup>, a reduction of 15% from the model Base Case. Improved operational efficiency at the Metro WWTP has continued to decrease the TP load from outfall 001. The annual average TP load for 2008-2011 was 15,986 lb yr<sup>-1</sup>. Additional reductions should be realized through the implementation of strategies outlined in the Phosphorus Optimization Report (CRA, 2011). The WLA for outfall 002 (Bypass) is set at 7,602 lb·yr<sup>-1</sup>. This limit was required to meet the TMDL allocation endpoint. This WLA is a reduction of 926 lb·yr<sup>-1</sup> from the maximum recorded Bypass load since 1997.

To allow for the natural variability inherent of combined sewer systems, a bubble permit for outfalls 001 and 002 of 27,212 lb·yr<sup>-1</sup> is proposed. To determine the total load for the bubble permit the fractions of bioavailable phosphorus in outfalls 001, 33% bioavailable (CRA 2011), and 002, 50% bioavailable (CRA 2011) were considered. The original WLA for 002, 7,602 lb·yr<sup>-1</sup>, was separated into non-bioavailable fraction, 3,801 lb·yr<sup>-1</sup>, and the bioavailable fraction, 3,801 lb·yr<sup>-1</sup>. The full allocation for the non-bioavailable fraction was given. The allocation for the bioavailable phosphorus was reduced to 1,901 lb·yr<sup>-1</sup> such that bioavailable phosphorus made up only 33% of the total outfall 002 load of 5,701 lb·yr<sup>-1</sup> (3,801 lb·yr<sup>-1</sup> non-bioavailable plus 1,901 lb·yr<sup>-1</sup> bioavailable phosphorus for a 5,701 lb·yr<sup>-1</sup> total allocation for the Bypass under the bubble permit). As noted above, a similar fraction of bioavailable phosphorus has been measured in the outfall 001 effluent. The bubble permit limit is then the sum of the outfall 001 WLA (21,511 lb·yr<sup>-1</sup>) plus the reduced 002 allocation (5,701 lb·yr<sup>-1</sup>) for a total limit of 27,212 lb·yr<sup>-1</sup>. The limit of the bubble permit represents a reduction of 1,901 lb·yr<sup>-1</sup> from the combined individual permits.

Permits for outfalls 001 and 002 will not be considered in violation under the bubble permit so long as the combined load from outfalls 001 and 002 are below the bubble permit limit on a 12 month rolling average basis. Monitoring data indicates the proposed bubble limit would have been met continuously since 2008 on a 12 month rolling average basis. The Phosphorus Optimization Report outlines steps that might provide better assurance against poor phosphorus removal by the Actiflo system and therefore would further reduce the probability of a high year which would exceed the permit limit.

The permit for Metro 001 will be modified to reflect the phosphorus WLA on a 12 month rolling average basis which will become effective upon TMDL approval. In addition to the waste load allocation, a TP concentration limit of 0.10 mg·l<sup>-1</sup> will be maintained in the permit. The Metro 002 (Bypass) WLA will be applied on a 12 month rolling average basis. As the WLA for the Bypass is less than the maximum measured Bypass load, implementation will be required by December 31, 2018. Should a bubble permit for 001 and 002 be the selected option, the limit will be applied on a 12 month rolling average basis calculated from the monthly total loads from the

two outfalls with implementation also required by December 31, 2018. The total phosphorus limit of  $0.10 \text{ mg}\cdot\text{l}^{-1}$  would apply to outfall 001 under the bubble permit as well.

The WLA for the Marcellus (V) WPCP is  $1,158 \text{ lb}\cdot\text{yr}^{-1}$ , a reduction of 33%. As noted in section 6.1., the WLA is an end-of-pipe value, with a smaller load delivered to the Lake due to in-stream losses. The end-of-pipe reduction achieved will be 42%. With a design flow of 0.38 MGD, the WLA is equivalent to a phosphorus effluent limit of  $1 \text{ mg}\cdot\text{l}^{-1}$ . Comments submitted by the Village of Marcellus during the public comment period indicated that the  $1 \text{ mg}\cdot\text{l}^{-1}$  limit could not be achieved by chemical addition alone as had been anticipated due to the clarifier design at the facility. As significant retrofits may be required, an implementation schedule will be included in their SPDES permit. Permit limits as a result of this TMDL will take effect on January 1, 2016, calculated as a 12 month rolling average. The first calculation for compliance with the limit will therefore occur after the December 2016 monitoring data have been collected.

In addition to the SPDES dischargers above, there are 12 private, commercial and institutional (PCI) dischargers to Onondaga Lake and its tributaries. Where treatment is provided by the PCI dischargers, due to the nature of treatment provided by these small systems it would not be financially feasible to require phosphorus removal at these facilities. Addition of treatment capabilities to those PCI dischargers currently without it may similarly not be a cost effective method for reducing phosphorus loading to the Lake. For the purpose of permitting, the SPDES permitted entities with WLAs in Table 11 less than  $1,000 \text{ lb}\cdot\text{yr}^{-1}$  will be combined under a bubble permit with a combined limit of  $807 \text{ lb}\cdot\text{yr}^{-1}$  on a 12 month rolling average basis. As long as the combined load from these discharges is less than the permit limit these entities will not be in violation. Should the combined limit be exceeded, the individual WLAs listed in Table 11 will be used to determine those facilities in violation. Use of the reserve capacity, for either a new permitted discharge or to provide additional load to any of the permittees covered under this bubble permit, would increase the bubble permit limit by the amount reserve capacity allocated. Discharge limits as a result of this TMDL will take effect on January 1, 2016, calculated on a 12 month rolling average basis. This will allow these dischargers time to assess their phosphorus discharges relative to the limits established by this TMDL and to take any action which may be required to meet their limits. The first calculation for compliance with the limit will therefore occur after the December 2016 monitoring data have been collected.

### **7.2.2 Combined Sewer Overflows (CSOs)**

The 4<sup>th</sup> Stipulation of the ACJ (4<sup>th</sup> Stipulation) requires phased reductions of the CSO volume over the next several years, requiring the volume capture percentages listed below, on a system-wide annual average basis, of the combined sewage generated during precipitation events, by the following dates:

- 89.5% capture by December 31, 2013
- 91.4% capture by December 31, 2015
- 93.0% capture by December 31, 2016
- 95.0% capture by December 31, 2018

Onondaga County has elected to meet these requirements through the implementation of a number of green and grey infrastructure projects. A list of grey infrastructure projects to be constructed and a non-exhaustive list of green infrastructure projects are included in the 4<sup>th</sup> Stipulation.

An annual report is to be submitted by Onondaga County to the parties of the 4<sup>th</sup> Stipulation setting forth in detail the status and progress during the prior calendar year of the required green and grey infrastructure projects. The annual report is also to include those programs and projects Onondaga County intends to implement/construct to satisfy the ACJ and 4<sup>th</sup> Stipulation requirements, including those additional projects required to address compliance shortfalls.

Failure to meet deadlines outline in the 4<sup>th</sup> Stipulation will result in the required construction of additional green and/or grey infrastructure to address the shortfalls as well as the incursion of monetary fines. The WLA for the CSO areas will be staged to be met by the final date of December 31, 2018.

The majority of the reductions required from the CSO areas will come from the above outlined CSO volume reductions. The 95% reduction was incorporated into model Scenario 8, the results of which were used to determine the load reduction anticipated from the CSO areas once these projects have been fully implemented. A small reduction will also be realized from the fertilizer restrictions (see section 7.2.3 for further discussion of the fertilizer restrictions [ECL §17-2103]).

Identification and abatement of dry weather pathogen sources as part of the Phase II Microbial Trackdown Study will likely provide additional phosphorus reductions.

### ***7.2.3 Municipal Separate Storm Sewer Systems (MS4s)***

Discharges from Municipal Separate Storm Sewer Systems (MS4s) in Urbanized and Additionally Designated Areas must be authorized in accordance with SPDES General Permit, GP-0-10-002, [http://www.dec.ny.gov/docs/water\\_pdf/ms4gp2011.pdf](http://www.dec.ny.gov/docs/water_pdf/ms4gp2011.pdf). This permit was issued April 1, 2010, and became effective on May 1, 2010.

MS4 municipalities are required to develop, implement and enforce a stormwater management program (SWMP). A SWMP is designed to reduce the discharge of pollutants to the maximum extent practicable (MEP) to protect water quality and to satisfy the appropriate water quality requirements of the Environmental Conservation Law and the CWA. MEP is a technology-based standard established by Congress in the CWA. No precise definition of MEP exists, therefore it allows for maximum flexibility on the part of MS4 operators as they develop their programs. The SWMP must describe the Best Management Practices for each of the following six Minimum Control Measures (MCMs):

1. Public education and outreach program to inform the public about the impacts of stormwater on receiving water quality.
2. Public involvement and participation.
3. Illicit discharge detection and elimination.

4. Construction site stormwater runoff control program for sites disturbing one or more acres.
5. Post-construction runoff control program for new development and redevelopment sites disturbing one or more acres.
6. Pollution prevention and good housekeeping operation and maintenance program.

Part II.F. of the MS4 permit requires traditional land use control MS4s to extend the implementation of MCMs 4 and 5 to municipal boundaries in accordance with criterion 3 of the Designation Criteria. Figure 3 shows the Regulated and Extended MS4 areas in the watershed.

The permittees listed in Table 12 are subject to the Additional BMPs for Watershed Improvement Strategies for Other Phosphorus Watershed MS4s outlined in Section IX.B of the MS4 permit.

Section IX.B includes enhanced phosphorus requirements to the six MCMs outlined above for MS4s in the Onondaga Lake watershed. The types of enhanced requirements include but are not limited to: use of the “Enhanced Phosphorus Removal Design Standards” for post construction stormwater management, retrofits, sewer system mapping and enhanced public education programs. The permittees identified in Table 12 must develop or modify their SWMP to address the watershed specific additional requirements to achieve a pollutant load reduction of 18% by the deadlines as defined in Table IX.B of the MS4 permit and Table 13. The extent of the MS4 reduction was based upon reduced loading rates as a result of the removal of phosphorus from most fertilizers, which is discussed further below. The methods for determining this reduction were discussed in section 6.1. The mechanism for this reduction had already been put in place; however, it may take some time for these reductions to be realized within the streams. The implementation of green infrastructure projects within the MS4 areas may be part of the strategy for meeting the required load reductions. MS4s would need to demonstrate a pollutant load reduction of 18% by the TMDL approval date plus 13 years.

The pollutant load reduction is the reduction necessary from the discharge loads associated with MS4s that, when combined with the other WLAs and LAs set forth in this TMDL, will meet water quality standards in Onondaga Lake.

A major portion of the load reduction required from MS4s will be realized due to legislation signed into New York State law on July 15, 2010<sup>1</sup>, to limit the use of residential fertilizer containing phosphorus. Environmental Conservation Law §17-2103 will prohibit the application of phosphorus fertilizer on lawn or non-agricultural turf, except when: (1) a soil test demonstrates that additional phosphorus is needed for lawn or non-agricultural turf growth, or (2) new lawn or non-agricultural turf is being established. ECL § 17-2103 requires retail stores to comply with the requirements of Agriculture and Markets Law § 146-g related to the display of phosphorus fertilizer and the posting of educational signs. It would also prohibit the application of fertilizer on lawn or non-agricultural turf: between December first and April first; on impervious surfaces; and within twenty feet of surface water except where there is a continuous vegetative buffer of at least ten feet from the water body, and except that, where a

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<sup>1</sup> <http://www.dec.ny.gov/chemical/74956.html>

| <b>Permittee</b>            | <b>SPDES No.</b> |
|-----------------------------|------------------|
| City of Syracuse            | NYR20A186        |
| County of Onondaga          | NYR20A074        |
| NYS Dept. of Transportation | NYR20A288        |
| NYS Thruway Authority       | NYR20A024        |
| Town of Camillus            | NYR20A295        |
| Town of Cicero              | NYR20A155        |
| Town of Clay                | NYR20A395        |
| Town of DeWitt              | NYR20A156        |
| Town of Geddes              | NYR20A041        |
| Town of Lafayette           | NYR20A039        |
| Town of Marcellus           | NYR20A261        |
| Town of Onondaga            | NYR20A286        |
| Town of Salina              | NYR20A374        |
| Town of Van Buren           | NYR20A217        |
| Village of Camillus         | NYR20A248        |
| Village of East Syracuse    | NYR20A348        |
| Village of Liverpool        | NYR20A206        |
| Village of Marcellus        | NYR20A276        |
| Village of North Syracuse   | NYR20A205        |
| Village of Solway           | NYR20A057        |

**Table 12: Permittees Subject to Additional BMPs for Watershed Improvement Strategies**

| <b>Watershed Improvement Strategy Deadline</b> | <b>Retrofit Plan Submission Deadline</b> | <b>Pollutant Load Allocation</b> | <b>Pollutant Load Reduction Deadline</b> |
|------------------------------------------------|------------------------------------------|----------------------------------|------------------------------------------|
| TMDL Approval Date + 3 years                   | TMDL Approval Date + 3 years             | 13,560 lb·yr <sup>-1</sup>       | TMDL Approval Date + 13 years            |

**Table 13: Deadlines for Watershed Improvements as Defined in Table IX.B of the MS4 Permit**

spreader guard, deflector shield or drop spreader is used, the application would be prohibited within three feet of a New York surface water. This new Title 21 will not impair or supersede the authority of the Commissioner of Agriculture and Markets under Articles 10 and 25-AA of the AML. ECL §17-2105 will allow local governments to adopt more stringent standards for non-agricultural fertilizer applications after demonstrating to the Department that such action is necessary to address local water quality conditions.

Section 4 of this bill will add a new ECL § 17-1945 to provide for the enforcement of Title 21 of Article 17. This new section will provide that a New York owner, owner's agent or occupant of a household who violates a New York provision of Title 21 would receive a written warning and educational materials for a first violation, be liable for a civil penalty not to exceed \$100 for a second violation, and be liable for a civil penalty not to exceed \$250 for third and subsequent violations. A New York other person who violates a New York provision of Title 21 would be liable for a civil penalty not to exceed \$500 for a first violation, and not to exceed \$1,000 for each subsequent violation.

Section 6 of this bill will add a new section AML § 146-g to require retail stores that sell or offer to sell to consumers specialty fertilizer in which the available phosphate content is greater than 0.67 percent to display such fertilizer separately from non-phosphorus specialty fertilizer, and to post a sign in the location where phosphorus-containing specialty fertilizer is displayed stating that phosphorus runoff poses a threat to water quality, and therefore phosphorus-containing fertilizer may only be applied to lawn or non-agricultural turf when a soil test indicates a phosphorus deficiency or new lawn or non-agricultural turf is being established.

#### **7.2.4 Construction Stormwater**

Before commencing construction activities, the owner or operator of a construction project that will involve soil disturbance of one or more acres must obtain coverage under the State Pollutant Discharge Elimination System (SPDES) General Permit for Stormwater Discharges from Construction Activity (GP-0-10-001). This permit is available at: <http://www.dec.ny.gov/chemical/43133.html>. This permit was issued in January 2010, and became effective on January 29, 2010.

Owner/operators with projects covered under the SPDES General Permit for Stormwater Discharges from Construction Activities are required to develop and implement a Stormwater Pollution Prevention Plan (SWPPP) that meets criteria set forth by NYSDEC. All SWPPPs must include practices consistent with the New York Standards and Specifications for Erosion and Sediment Control. Construction activities that involve one or more acres of soil disturbance in the Onondaga Lake watershed must also comply with the New York State Stormwater Management Design Manual to control post-construction stormwater discharges and the Enhanced Phosphorus Removal Standards.

#### **7.2.5 Industrial Stormwater**

Under the Clean Water Act stormwater discharges associated with industrial activity must be authorized by a permit. In New York, industrial facilities must obtain permit coverage through either an individual industrial SPDES permit, the SPDES Multi-Sector General Permit (MSGP) for Stormwater Discharges Associated with Industrial Activity (GP-0-06-002), or provide certification using the Non Exposure Exclusion, with industrial facilities defined as those engaged in activities defined in 40 CFR 122.26(b)(14)(i-ix) and (xi).

The MSGP (GP-0-06-002) became active on December 27, 2006 and will remain in effect until March 27, 2012. An interim permit (GP-0-11-009) will become effective on March 28, 2012 and will expire on September 30, 2012. The interim permit will reflect minor changes to GP-0-06-002. The interim permit has been enacted to allow for sufficient time to produce a further revision of the MSGP. The revised version will replace GP-0-11-009 when it expires on September 30, 2012 and will be made available for public comment prior to March 27, 2012.

Permittees covered under the MSGP must develop and implement a Stormwater Pollution Prevention Plan (SWPPP). A complete list of the required contents of the SWPPP is included in Part III.C of the MSGP (GP-0-06-002). The basic elements of a SWPPP include:

- The identification and location of potential sources of contamination
- Location(s) of place(s) where stormwater is discharged off-site (outfalls)
- Structural and non-structural Best Management Practices (BMPs) used to treat, divert or contain contaminated stormwater to prevent discharge of pollutants to surface water
- Monitoring and reporting requirements that apply to the facility.

Annual reports documenting the results of monitoring and inspections conducted at a facility must be submitted to the NYS DEC as part of the permit.

Additionally, most of the industrialized areas within the Onondaga Lake watershed occur within MS4 areas. Industrial stormwater sites covered under the MSGP or individual industrial SPDES permits within these areas will benefit from the MS4 program requirements outlined in Section 7.2.3.

### ***7.2.6 Concentrated Animal Feeding Operations (CAFOs)***

Following the first CAFO general permit issuance in New York in 1999, CAFO operators were required to obtain and comply with state wastewater discharge permits. New York has one of the most robust CAFO permitting programs in the nation, covering 150 large and over 450 medium-sized CAFO farms. New York State's CAFO program is actively implemented and enforced, practical, scientifically supported and applicable statewide. New York State recognizes the need for farm-specific, technical evaluations by qualified professionals to ensure that the farm understands and implements the latest developments in land grant university guidelines, United States Department of Agriculture Natural Resources Conservation Services (USDA-NRCS) technical standards and State regulatory requirements. New York requires New York Certified Planners to develop Comprehensive Nutrient Management Plans (CNMPs) for CAFO farms and Professional Engineers to design and certify NRCS engineering practices on farms.

New York's CAFO farms must comply with stringent technical standards designed to afford superior protection of the environment. These technical standards take the form of USDA-NRCS conservation practice standards and state regulatory requirements, both of which exceed the minimum requirements set by EPA and USDA-NRCS and are tailored to be most effective for New York's conditions based on applied research from Cornell University – New York's land grant university.

As such, CAFO farms must utilize professional engineers in the design and implementation of their waste management and storage structures, must adhere to stringent setbacks for nutrient applications in farmlands adjacent to New York's waters, must control erosion on crop fields and must make nutrient applications in accordance with science-based nutrient management plans. The CAFO program ensures that manure nutrients from medium and large livestock farms are recycled to grow crops rather than allowing those nutrients to reach the waters of New York

State. It is these stringent technical standards and the CAFO program's proven rate of implementation and enforcement that protects water quality.

Existing medium sized CAFOs have until March 31, 2012 to have all NRCS practices fully operational. Existing large CAFOs were required to be in compliance with the conditions of the permit upon the current permit effective date of July 1, 2009. Currently five CAFOs have achieved full compliance. Full compliance by all CAFOs is required by March 31, 2012, covering 64% of all of the animal units within the watershed.

### **7.3 *Recommended Phosphorus Management Strategies for Agricultural Runoff***

The New York State Agricultural Environmental Management (AEM) Program was codified into law in 2000. Its goal is to support farmers in their efforts to protect water quality and conserve natural resources, while enhancing farm viability. AEM provides a forum to showcase the soil and water conservation stewardship farmers provide. Details of the AEM program can be found at the New York State Soil and Water Conservation Committee (SWCC) website, <http://www.nys-soilandwater.org/aem/index.html>.

Using a voluntary approach to meet local, state, and national water quality objectives, AEM has become the primary program for agricultural conservation in New York. It also has become the umbrella program for integrating and coordinating all local, state, and federal agricultural programs. For instance, farm eligibility for cost sharing under the SWCC Agricultural Non-point Source Abatement and Control Grants Program is contingent upon AEM participation.

AEM core concepts include a voluntary and incentive-based approach, attending to specific farm needs and reducing farmer liability by providing approved protocols to follow. AEM provides a locally led, coordinated and confidential planning and assessment method that addresses watershed needs. The assessment process increases farmer awareness of the impact farm activities have on the environment and by design, it encourages farmer participation, which is an important overall goal of this implementation plan.

AEM utilizes the National Resource Conservation Service (NRCS) Planning Process that is enhanced through a five-tiered framework:

- **Tier 1** – A resource professional collects farm contact information; inventories farm infrastructure, land use, and livestock; determines the farm's future plans; informs the farmer of their watershed(s) and watershed concerns, and identifies potential environmental concerns and opportunities. Tier 1 activities are supported by technical assistance funding supplied to Conservation Districts through the AEM Base Program which is supported by an annual allocation from New York State's Environmental Protection Fund (EPF). [www.nys-soilandwater.org/aem/techtools.html](http://www.nys-soilandwater.org/aem/techtools.html)
- **Tier 2** – A resource professional utilizes pertinent worksheets to conduct an on farm environmental assessment based on watershed concerns and the potential concerns and

opportunities identified in Tier 1. Tier 2 documents existing environmental stewardship, provides an educational opportunity with the farmer, and verifies environmental concerns or flags issues for further evaluation during the planning process. Information gathered at this stage allows for the prioritization of farms and resource concerns on the farm to receive further technical assistance and potentially financial assistance with relatively little time invested on the part of the resource professional. Tier 2 activities are supported through the AEM Base Program. [www.nys-soilandwater.org/aem/techtools.html](http://www.nys-soilandwater.org/aem/techtools.html)

- **Tier 3** – Priority farms develop a conservation plan with assistance from a team of resource professionals addressing priority resource concerns derived from the integration of the farm’s business objectives, watershed concerns (as derived through the local AEM Strategic Plan), condition of the involved resources (water, soil, air, plants, and animals), and environmental risk. The level and extent of planning considers farm resources and is often progressive (on-going and seeking continual improvement through behavioral change). All Best Management Practices (BMPs) must be planned according to NRCS Conservation Practice Standards and Cornell University Guidelines. Plan components addressing nutrient management must be completed by an AEM or NRCS Certified Planner. Conservation planning activities are supported through the AEM Base Program or competitive State and Federal programs such as NYS Agricultural Nonpoint Source Abatement and Control Program (ANSACP) or USDA’s Environmental Quality Incentives Program (EQIP).
- **Tier 4** – Implementation of priority BMPs in priority conservation plans. All BMPs must meet NRCS Conservation Practice Standards and Cornell University Guidelines. BMPs designated as engineering must be designed by Professional Engineers licensed in NYS. Technical assistance for BMP design and installation oversight is supported by the AEM Base Program, or by successful application to NYS ANSACP or USDA Farm Bill Programs. Financial assistance for BMP implementation (generally cost sharing) is provided to the farmer through successful application to the appropriate program such as ANSACP or USDA Farm Bill programs. If approved for funding within a State or federal cost share program, farms must implement practices according to strict technical requirements and within the timelines set forth by contract.
- **Tier 5** – Conduct evaluations of conservation plans, and implemented BMPs to ensure effectiveness in protecting the environment, proper operation and maintenance, and needed support to the farmer to safeguard public investment. Conservation plan updates according to current standards and guidelines assure continuous improvement and address concerns resulting from expanding operations and management changes. Tier 5 activities are supported through the AEM Base Program. Through various AEM tools evaluation can take place at the BMP, farm, watershed and/or county levels.

Tier 1 could be used to identify farmers that for economic or personal reasons may be changing or scaling back operations, or contemplating selling land. These farms would be candidates for conservation easements, or conversion of cropland to hay, as would farms identified in Tier 2 with highly-erodible soils and/or needing stream management. Tier 3 should include a Comprehensive Nutrient Management Plan (CNMP) with phosphorus indexing. Additional

| <b>Cumulative Number of Farms</b> | <b>AEM Tier</b> | <b>Cumulative Animal Units Equivalents (AEU)</b> | <b>Cumulative Percentage of AEUs</b> |
|-----------------------------------|-----------------|--------------------------------------------------|--------------------------------------|
| 30                                | Tier V          | <b>3,641</b>                                     | <b>51%</b>                           |
| 50                                | Tier IV         | <b>4,600</b>                                     | <b>64%</b>                           |
| 61                                | Tier III        | <b>5,623</b>                                     | <b>78%</b>                           |
| 72                                | Tier II         | <b>6,658</b>                                     | <b>93%</b>                           |
| 84                                | Tier I          | <b>6,893</b>                                     | <b>96%</b>                           |
| 91                                | No Tier         | <b>7,165</b>                                     | <b>100%</b>                          |

**Table 14: Level of AEM Implementation on Non-CAFO Farms as of October 2011**

practices could be fully implemented in Tier 4 to reduce phosphorus loads, such as conservation tillage, stream fencing, rotational grazing and cover crops. Also, riparian buffers reduce losses from upland fields and stabilize stream banks in addition to the reductions from taking the land in buffers out of production.

Onondaga County Soil and Water Conservation District has made great advances in implementing the AEM program and should continue their good efforts, focusing on identification of management practices that reduce phosphorus loads. These practices would be eligible for state or federal funding and because they address a water quality impairment associated with this TMDL, should score well. Currently, out of 91 non-CAFO farms in the watershed, 84 participate in AEM (Table 14). Thirty farms have completed up to tier V, 20 have completed up to tier IV, 11 have completed up to tier III, 11 have completed up to tier II and 12 have completed up to tier I of the program.

BMPs completed to date include 46 barnyards, 18 silage leachate systems, 19 manure storage systems, 37 process water systems, 158 erosion/runoff control practices, 55 pasture practices, 55 nutrient management plans/record keeping and 15 other BMPs such as composting facilities, streambank stabilization projects, wetlands and calf facilities. Including those on CAFOs, by March 2012, 92% of the animal units within the watershed will be on farms with at least Tier 3 implementation, which includes at least some form of nutrient management. Many of these BMPs were put in place following the calibration period for the watershed and Lake models. The reductions in phosphorus loading as a result are not fully accounted for within the Base Case model predictions. It is anticipated that much of the load reductions required by this TMDL from the agricultural sector will be realized through the BMPs already implemented. Interest from farmers has been expressed for securing assistance to implement the use of cover crops within the watershed. Efforts to continue BMP implementation and AEM participation will be continued throughout the watershed with an implementation date of December 31, 2022 for the needed 18% reduction.

Additionally, of the 55,257 acres of agricultural land included in the watershed model, recent data from the Onondaga County Soil and Water Conservation District indicate that approximately 29,100 acres are currently being farmed within the watershed, a reduction of 47%. Fallow lands contribute considerably less phosphorus than actively farmed lands so it is expected that the reduction in active farmland will also contribute to the phosphorus load reductions needed from the agricultural sector.

#### **7.4 Recommended Phosphorus Management Strategies for Rural/Unregulated Development Runoff**

Stormwater management in rural areas can be addressed through the Nonpoint Source Management Program. There are several measures, which, if implemented in the watershed, could directly or indirectly reduce phosphorus loads in stormwater discharges to the Lake or watershed.

- Public education regarding:
  - Lawn care, specifically reducing fertilizer use or using phosphorus-free products, now commercially available. The NYS Household Detergent and Nutrient Runoff Law restricts the sale and application of fertilizers containing phosphorus (see section 7.2.3);
  - Cleaning up pet waste; and
  - Discouraging waterfowl congregation by restoring natural shoreline vegetation.
- Management practices to address any significant existing erosion sites.
- Construction site and post construction stormwater runoff control ordinance and inspection and enforcement programs.
- Pollution prevention practices for road and ditch maintenance.
- Management practices for the handling, storage and use of roadway deicing products.

#### **7.5 CERCLA Remedial Work**

The following remedial work is scheduled to be performed as part of the Onondaga Lake Superfund Site:

1. The calcium nitrate Lower Water Layer pilot project will be conducted for three years, beginning in 2011 and ending in 2013.
2. Infrastructure construction (wastewater treatment plant, sediment consolidation area, etc.), that is needed for dredging operations, began in 2010 and will be completed in early 2012.
3. Dredging (0-9 m water depth) will begin in 2012 and completed by 2016.
4. Thin Layer Capping (TLC) will not begin until dredging and capping in the littoral zone is complete, so TLC should start in 2016-2017. The TLC area will be evaluated and revised as necessary in 2015. TLC and habitat construction will be completed by 2017-2018.
5. Habitat construction will begin in 2012 and conclude in 2016-2017.
6. Monitored Natural Recovery (MNR) activities will continue until 2027.

## 7.6 *Additional Protection Measures*

Measures to further protect water quality and limit the increase of phosphorus load that would otherwise offset load reduction efforts should be considered. The basic protections afforded by local zoning ordinances could be enhanced to limit non-compatible development, preserve natural vegetation along shorelines and tributaries and promote smart growth and low impact development. Identification of wildlife habitats, sensitive environmental areas, and key open spaces within the watershed could lead to their preservation or protection by way of conservation easements or other voluntary controls.

In addition to preservation and protection, restoration of wetland, stream, and riparian resources within the watershed would contribute to phosphorus load reductions. Easements and incentives for private landowners, combined with active restoration of riparian wetlands, riparian forest, stream meanders, instream structure, and other lost or degraded aspects of stream systems, would contribute significantly to sediment and phosphorus retention within the watershed, as well as improve aesthetics, recreational use, aquatic habitat, and potentially land values.

## 7.7 *Implementation Schedule*

Table 15 summarized the final implementation schedules for the entities affected by the Waste Load Allocations and Load Allocations developed in this TMDL. Details and staged interim dates are discussed under the relevant section headings above.

## 7.8 *Follow-Up Monitoring*

The ultimate measure of the success of the Onondaga Lake Phosphorus TMDL is the extent to which the in-lake total phosphorus criteria and beneficial uses are achieved. Lake phosphorus concentrations can be monitored relatively easily and unambiguously. However, in-lake phosphorus concentrations may or may not respond as expected to phosphorus management programs in the watershed. A follow up monitoring effort is therefore necessary in order to understand the reasons for any changes, or lack of changes, observed in lake phosphorus levels so that management efforts can be redirected if necessary.

| <b>Entity</b>                                | <b>Implementation Date</b>              |
|----------------------------------------------|-----------------------------------------|
| CSO                                          | 12/31/2018                              |
| MS4                                          | 12/31/2025                              |
| Agriculture                                  | 12/31/2022                              |
| SPDES Permits in Table 7,<br>excluding Metro | Permit limits apply beginning<br>1/1/16 |
| Metro Outfall 001                            | TMDL Approval                           |
| Metro Outfall 002 (Bypass)                   | 12/31/2018                              |

**Table 15: Implementation Schedule**

| <b>Parameters</b> | <b>Results</b>                          |
|-------------------|-----------------------------------------|
| Total Phosphorus  | Average Epilimnion Concentration (mg/L) |
| Chlorophyll a     | Average Epilimnion Concentration (mg/L) |
| Secchi Depth      | (m)                                     |

**Table 16: Follow-up Monitoring Program Parameters and Reporting**

USEPA guidance (1999a, 1999b) recommends that TMDL submittals include a monitoring plan to determine whether implementation of the TMDL has resulted in attainment of water quality standards and to support any revisions to the TMDL that might be required.

### **7.8.1 Location of Sampling**

A targeted post-assessment monitoring effort is necessary to determine the effectiveness of the implementation plan associated with the TMDL. Onondaga Lake will be sampled at its deepest location, the South Deep Sampling Station (Figure 7) during the summer growing season (June 1 through September 30). Additional quarterly sampling will be conducted at the North Deep Station (Figure 7).

### **7.8.2 Field Sampling Design**

Sampling frequency will be bi-weekly in the South Basin and quarterly in the North Basin. Discrete samples will be collected in the epilimnion. The samples will be analyzed for the Total Phosphorus (TP). Additional sampling will include temperature, chlorophyll a and clarity (Secchi disk depth). Dissolved oxygen and temperature profiles will be done at 1-meter intervals from the Lake surface to the bottom of the hypolimnion or until anoxic conditions (Dissolved Oxygen concentration: 0.5 mg/L) is encountered. The results will be reported as listed in Table 16.

### **7.8.3 Sample Analysis**

Water samples for analysis will be collected and analyzed according to EPA requirements for Water Planning and Management (40 CFR 136, 1991 or latest version) and EPA 600/4-82-029.

Standard Methods for the Examination of Water and Wastewater, 19th Edition 1995, Prepared and published jointly by American Public Health Association, American Water Works Association, Water Environment Federation will be used for all analytical methods. Sampling and analysis will also be consistent with New York State's Environmental Laboratory Approval Program (ELAP).

## **8.0 Public Participation**

NYSDEC met with technical representatives of the MS4s and Central New York Regional Planning and Development Board (CNYRPDB) on September 22, 2010 and December 6, 2011, respectively, to discuss potential TMDL implications and to collect available data to aid in TMDL development. The Department has had ongoing discussions with County representatives

regarding the development of the Phosphorus Removal Work Plan and Metro Optimization Analysis, both of which informed the TMDL process. On October 20, 2011 the Department gave a presentation to members of the Onondaga Lake Partnership (OLP) Project Committee to discuss TMDL development as well as model results and scientific findings. A meeting was held to explain the scope and impact of this TMDL with Onondaga County and the Metro WWTP on February 9, 2012. A similar meeting was held with members of the agricultural community on March 19, 2012.

The Onondaga Nation has cultural and historic ties to Onondaga Lake and the surrounding lands. Representative of the Nation have been present at some of the public meetings listed above and formal interaction regarding the development of this TMDL continues through the U.S. Environmental Protection Agency as Sovereign Nations. The NYS DEC will meet with the Onondaga Nation regarding this TMDL at their request.

Public meetings to explain the TMDL proposal to the general public and elected officials in the watershed will be held during the public comment period, and with affected parties as requested.

### **8.1 Response to Public Comments**

Public notice of the availability of the Draft TMDL document for public comments appeared in the March 28<sup>th</sup>, 2012 Environmental Notice Bulletin. Additionally, notices of the document availability were sent to the following entities: all municipalities with lands in the Onondaga Lake watershed including towns, villages, counties and cities; SPDES permit holders listed in the TMDL document, CAFO permit holders within the watershed and all other parties who had expressed interest in the TMDL. Additional notice of the draft TMDL Document was provided by email via the Onondaga Lake News Listserve and the DEC Division of Water MakingWaves email list. Comments were accepted until close of business on April 27<sup>th</sup>, 2012.

Public comments were received from the following:

- Atlantic States Legal Foundation, Inc.
- New York State Department of Transportation Region 3
- The Town of Fitch
- Honeywell
- Lockheed Martin
- The Village of Marcellus
- Onondaga County
- General Counsel for the Onondaga Nation
- Onondaga Shoreline Heritage Restoration
- Philippe Vidon, SUNY-ESF

Comments received were consolidated and summarized as appropriate. Comments and DEC responses are included below.

### 8.1.1 General Comments

1. A TMDL document should look at annual loads, but also look at (literally) maximum daily loads so no acute impact on the Lake occurs.

**Response:** Seasonal and smaller time scales assessments of the Lake were handled through the model. The use impairments in Onondaga Lake, though, are not caused by acute impacts, thus daily limits were not considered appropriate. Rather, the use impairments caused by excess algal growth and subsequent DO depletion respond to long term phosphorus loading, hence the use of annual limits in the TMDL. The U.S. EPA has, however, indicated that all TMDL documents must include total maximum daily loads in order to receive their approval. Those quantities are included in Appendix H of the TMDL document.

2. The TMDL first and foremost should recognize that this recovery process is a process, and one that has not been fully completed. This TMDL should be considered only the next step in a phased TMDL, as recovery aspects of the lake are examined and better understood. Whether an additional TMDL in future will be necessary is unclear. Into the future, the NYS DEC and EPA should continue to monitor the lake's recovery to ensure that it does recover consistent with the Clean Water Act goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters, where integrity is defined as "the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region." DEC should commit to revisiting this TMDL as required by development of new standards and/or continuing improvements in the health of the Lake-based ecosystem.

**Response:** Upon approval, TMDLs become part of the continuous planning process the State uses for managing its waters. Follow up monitoring is an important part of the TMDL process. The monitoring plan established under this TMDL is indicated in Section 7.8. Attainment of the water quality criteria established in this document, or other criteria established through the development of new water quality standards, will continue to be assessed by the DEC. See also the response to Comment 46.

### 8.1.2 TMDL Endpoint

3. The  $0.02 \text{ mg} \cdot \text{l}^{-1}$  concentration is a good goal.

**Response:** The comment is noted.

4. Onondaga County remains concerned that placing too great a focus on meeting the guidance value of  $0.02 \text{ mg/l}$ . The Lake data incorporated into the draft TMDL confirms what the County has observed analyzing the extensive database created by the Onondaga Lake Ambient Monitoring Program (AMP): That the TMDL target phosphorous level for Onondaga Lake may not accurately reflect the stated relationship between phosphorus and public perceptions of impairment upon which the guidance value was premised. That is, at

least with respect to Onondaga Lake, a target value of 0.02 mg/l total phosphorus concentration might be unnecessarily stringent.

**Response:** DEC is not aware of any data collected by the AMP which may be used to assess whether the relationship between phosphorus and public perception of impairment. The County could, of its own volition, undertake such a study to develop a site specific relationship. DEC would recommend using a survey similar to that employed by the NY Citizens Statewide Lake Assessment Program (CSLAP) volunteers to assess the public perception of impairment. DEC notes that incorporating such a change would require revision of the TMDL and would therefore be subject to U.S. EPA approval.

DEC is also in the process of revising its numeric nutrient criteria (NNC). This process includes revisions of NNC for recreation in lentic systems (lakes), the development of NNC for the protection of aquatic life in lentic systems and the development of NNC for the protection of aquatic life in lotic systems (flowing waters including streams and rivers). See <http://www.dec.ny.gov/chemical/77704.html> for more information. It may, in the future, be necessary to reconsider this TMDL with regard to these NNC.

5. This TMDL is "intended to meet recreational and aquatic life uses in Onondaga Lake" yet the criterion, the 20 µg/l phosphorus guidance value, only considers recreational use. We do not accept that this 20 µg/l guidance value fully protects aquatic life as its adequacy has not been demonstrated. We believe the regulatory burden to protect aquatic life remains on the NYS DEC and should be demonstrated as statewide nutrient standards are developed. Although NY nutrient standards for protection of aquatic life are apparently under development for flowing waters, we are unclear from page 23 paragraph 3 of the TMDL, whether a similar evaluation is underway for static waters. Historic trophic status of both water quality (nutrient loads) and aquatic communities should be considered in the guidance value for protection of aquatic life. Evidence presented in this TMDL suggests that historic P loads to Onondaga Lake were on average approximately 6.5 µg/l (mean of the means of model and paleolimnology estimates), less than a third the current load, and that the lake was oligo-mesotrophic. That the lake is currently ~meeting the 20 µg/l guidance value limit but is barely within the mesotrophic range suggests that the guidance value may be inadequate to fully protect aquatic communities and the water quality of Onondaga Lake.

**Response:** The comment expresses several points: that the phosphorus guidance value only considers recreational use, that it is not protective of aquatic life and that a TP guidance value of 6.5 µg/l would be more appropriate.

The guidance value of the 20 µg/l TP was derived for the protection of the best use of primary and secondary contact recreation. However, the potential impact of that guidance value to aquatic life was thoroughly evaluated in Appendix B, which document DEC's assessment that this guidance value is protective of aquatic life. Consider just one component of the overall aquatic community, the fish. It is well documented in the scientific literature that fish production is proportionally related to nutrient (e.g. phosphorus and nitrogen) availability. The TP concentration proposed in the TMDL is supportive of the abundance and diverse fishery that is currently present in Onondaga Lake. The species (alewife and gizzard

shad) which make up a significant fraction of the forage base for top level predators in Onondaga Lake are dependent upon substantial level of primary production. Further reducing the TP concentration to 6.5 µg/l could significantly diminish primary production to the point where maintenance of the existing forage base could be threatened, resulting in a lake with a fishery that was significantly reduced in overall fish production and diversity. Yurk and Ney (1989) state: “The evidence accumulated in this and other studies of the nutrient/primary production fishery productivity relationship demonstrates that clean, oligotrophic waters will generally support less fish biomass than more fertile systems.” See also the response to Comment 4 regarding the development of numeric nutrient criteria.

Other components of the aquatic community are just as dependent upon primary production as the fish component. Less algal production could result in a smaller zooplankton community. As discussed in Appendix B, in the past Onondaga Lake suffered from excessive nutrient availability that resulted in a suite of adverse impacts including the loss of habitat for aquatic life. Reductions in the nutrient loading have resulted in a better balance between nutrient availability and biomass production, as demonstrated by the diverse aquatic community now present in the Lake. Furthermore, it is not clear that additional reductions in phosphorus will necessarily result in an improved aquatic community.

It is appropriate to consider historic trophic status and phosphorus concentration in establishing the guidance value. However, they are only two of a number of factors which must be considered. DEC must make the most informed management decisions possible, monitor results and make adjustments as changes occur.

The aquatic community of Onondaga Lake has been altered significantly since historic times (defined as the period of time that coincides with TP concentrations on the order of 6.5 µg/l). For example, since that time non-native species such as alewife, gizzard shad, carp, and zebra and quagga mussels have become established in the Lake. The established presence of these non-native species could by itself serve as a barrier that would preclude restoration of the fish community that existed in those historic times. Thus, maintaining the diverse and abundant aquatic community that is present in the Lake today was deemed a more achievable goal than trying to create conditions that would be supportive of a historical fish community that would be less diverse and abundant.

### ***8.1.3 System Characteristics and Source Assessment***

6. We do not understand the difference between a species richness of 28, and 45 (Section 2.4, page 21) species being documented in the lake. Additional detail would help.

**Response:** Refer to Section 6.4.1 of the source document cited (Onondaga Lake Ambient Monitoring Program 2010 Annual Report). The 24 – 28 species are the species collected with spring and fall electrofishing surveys. The 45 species is the total number of species documented in the Lake over the last 10 years from all methods of capture.

7. We suggest adding a Section 4.3 that specifically examines significant sources of SRP during the growing season.

Presenting values for load/acre in Table 5 as well as total load/yr would help to highlight land uses contributing significant phosphorus loads.

**Response:** Seasonal orthophosphate (OP) watershed loads are presented in Appendix E. For reference, the estimated OP loads from Metro Outfalls 001 and 002 were 8,010 lb/yr and 3,087 lb/yr, respectively, on average for the 2005-2009 period.

Addition of the suggested column to Table 5 would be misleading. As noted in Appendix D, phosphorus loading rates for each land use category differ between the 5 precipitation areas defined for the Onondaga Lake watershed (Figure 36). Loads per acre are therefore dependent upon both the land use category and location within the watershed.

8. A table separating load reductions already accomplished or mandated from new load allocations, by source, would be very helpful.

**Response:** At this time, load reductions have occurred: at the Metro WWTP, through CSO reductions mandated by the ACJ, through the implementation of agricultural BMPs, and through the implementation of the fertilizer phosphorus restrictions. The first two are well documented. CSO reductions are subject to an implementation schedule established by the ACJ. Onondaga County is implementing a mix of green and gray infrastructure to attain the required reductions. See Section 8.1.11 for additional information on the green infrastructure implementation which has been incorporated into the final document. Estimates of current load reductions achieved through green infrastructure is beyond the scope of this TMDL, however Onondaga County may be able to provide additional information as a result of their annual reporting requirements. Extensive agricultural BMP implementation has already occurred within the Onondaga Lake watershed and the fertilizer restrictions law has already taken effect. Determination of the current reductions from these nonpoint sources is beyond the scope of this TMDL. Implementation of additional BMPs will result in further agricultural reductions outlined in the TMDL. DEC also notes that some time will be required before the full effect of these reductions is completely understood. The other reductions required are the result of new load allocations developed within this TMDL.

9. The pasture/hay category shown in Figure 15 increase in % load allocation, from 7% in the base case (Figure 15) to 15% in the Load Allocations (Figure 23). We assume this will be due to land conversion from other uses that produce more phosphorus, but it is not clear.

On page 31, there is a discrepancy between the information presented in Table 5 and on Figure 15. In Table 5 and on Figure 15, the annual average delivered total phosphorus load for Small SPDES Discharges is shown at 1% and 2%, respectively. Would NYSDEC please explain the difference in the percentages?

**Response:** Pasture/hay and row crop categories were transposed in the preparation of Figure 23. The correct Average Pollutant Load Allocation for row crops is 15% and for pasture/hay is 7% for the average load allocations, and for the maximum load allocations row crops are 16% and hay/pasture 8% of the load, respectively. Figure 23 in the final document has been

updated to include corrected numbers and to add a Maximum Pollutant Load Allocation chart.

An error was made in the preparation of Figure 15. The Small SPDES Discharges make up 1% of the Annual Average Delivered TP Load – Model Base Case (2005-2009). An updated figure has been incorporated into the final document.

#### **8.1.4 Load Allocations**

10. The TMDL mentions that a 10% Safety Factor was used to create the Maximum Allocations. Based on the small size of this watershed and the amount of data analyzed to create the nutrient load modeling, this value is excessively conservative. Therefore, a smaller Safety Factor is more appropriate with the allocations determined within the Safety Factor category being redistributed to the other allocated sources. This would still result in the same reduction to Onondaga Lake.

**Response:** A 10% MOS is typically used for many TMDLs. In this case, as the maximum loading allocations are being used for permit development, this level of MOS is warranted especially since some of the load allocations in the TMDL are impacted by unpredictable events such as weather patterns. There are also additional uncertainties associated with climate change and the variation seen in the relationship between loads and lake response.

DEC also notes that reallocation of loads contained within the MOS to other allocated sources would result in an increase of loading to the Lake as the MOS loads are withheld from the lake to ensure the criteria set forth in the TMDL are met.

11. It is unclear how the average pollutant load allocations will be used, particularly for WLAs, if the maximum load allocations are to be incorporated into permit limits. It would help to provide a bit more explanation of how these two allocations limits will be used.

**Response:** The average load allocations represent a reasonable expectation of the phosphorus loading to the Lake over many years, derived from the 16 years of data used to force the model. The average load allocations are included as frames of reference for comparison with most other lake TMDLs. Results from the model indicate that the long term average TP in the epilimnion during the summer would be well below the water quality target established for this TMDL. As this 16 year period included both wet and dry years, permit development based upon the 16 year average would result in numerous permit violations for years wetter than average, or force improvements not required to meet the water quality target in order to avoid permit violations. Use of the maximum load allocations for permit development allows for the flexibility to accommodate wet years. Modeling indicated that even in wet years the water quality target would be met.

##### **8.1.4.1 Metropolitan Syracuse WWTP**

12. Onondaga County strongly supports the prompt adoption of the State's proposed effluent limit at Metro's outfall 001 of 0.10 mg/l.

**Response:** The comment is noted, although this TMDL does not establish that concentration limit, but took that level of treatment capability into consideration in proposing the WLA for Metro's outfall 001.

13. The State has proposed a "bubble permit" of 27,212 lb/yr for the Metropolitan Syracuse Wastewater Treatment Plant outfall 001 and 002. Onondaga County is concerned that the premature imposition of the proposed combined Waste Load Allocation (WLA) is unnecessarily stringent and could require the commitment of scarce financial resources for costly improvements at outfall 002 when water quality conditions in the lake might not warrant it.

Beyond the current investments in the CSOs, through green and gray capture and the Metro Phosphorus Optimization Project, no action should be required at outfall 002 if the phosphorus concentration in the lake remains at or near the final phosphorus target value for the lake.

**Response:** A compliance schedule has been included for the County to meet the WLA for outfall 002. As noted in the response to Comment 27, the County may use their discretion in determining the best method(s) for meeting the WLA. DEC notes, however, that action may be required of outfall 002 to address water quality violations and strongly encourages the County to address the phosphorus load at the same time it addresses those violations.

The TMDL will allow for additional exchanges of load (trading) between permitted sources, which would be reflected in revised limits, if the overall WLA is still met and the exchange can be shown to have the same impact on water quality.

Should the Lake meet the numeric water quality target for a number of years, requirements under this TMDL may be reconsidered as part of a future TMDL revision or reallocation of WLA.

#### **8.1.4.2 Marcellus WPCP**

14. On page 45, the Average Load Allocation for the Marcellus (V) WPCP equals the Maximum Load Allocation. Why is this the case? Please clarify.

**Response:** The WLA given to Marcellus WPCP was developed using the permitted flow of the plant, 0.38 MGD. Different maximum and average WLA were not developed because Discharge Monitoring Reporting data indicated the plant was operating at or near capacity. Any average WLA developed would have been less than what appears in the TMDL currently. The use of the plant permitted capacity in the WLA determination should allow the Village of Marcellus added flexibility as they address infiltration and inflow problems.

15. Based on the operational records of the treatment plant from 2009 through 2011, it appears that the average concentration of phosphorus leaving the Marcellus WPCP is 2.62 mg/l.

Additionally, the calculated loading leaving the WPCP was found to be 7.83 lb/day (2,847lb/year) at average daily flows. This is significantly higher than the Base Case values listed on page 45 of the Draft TMDL (1, 737 lb/year). It is unknown what values were used to create the Base Case for this facility, but it appears they were underestimated. The resulting % Reduction for this facility using the newly calculated average loading was then calculated to be 59%, which would be the highest reduction value of all of the major sources listed. These results also confirm that the assumed impacts to the solids processing capabilities of this facility are underestimated to meet the requirements of this TMDL.

**Response:** The 1,737 lb/yr Base Case load represents the average load from the Marcellus WPCP which reached Onondaga Lake. The end-of-pipe value was calculated to be 1,999 lb/yr. This value was determined using monthly discharge monitoring report values of flow and total phosphorus from 1998-2007. The discrepancy between end-of-pipe values may be due to larger flows from 2009-2011 or higher phosphorus concentrations. The final load contributed by the Marcellus WPCP is the relevant aspect of the TMDL rather than the exact reduction required.

16. The existing final clarifiers at the Marcellus WPCP were constructed to past design standards and are shallower and more prone to short circuiting during peak flows than their modern contemporaries. Therefore, the addition of the chemicals will most likely flocculate the phosphorus particles properly, but the settling zones within these shallow clarifiers may not adequately capture these solids prior to discharge, Significant capital upgrades will become necessary to modify these structures properly.

**Response:** The DEC was unaware of the design limitations of the clarifiers at the Marcellus WPCP. In light of this new information a compliance schedule has been incorporated into the final TMDL. DEC will work with the Village of Marcellus to develop an implementation schedule which will be incorporated into their SPDES permit. The permit limits required by this TMDL will go into effect on January 1, 2016. The limit will be expressed as a 12 month rolling average basis such that the first calculation for compliance with the permit limit will occur after collection of the December 2016 monitoring data.

17. The Village of Marcellus expressed concern regarding their ability to fund upgrades which may be required to meet their Waste Load Allocation. Reasons cited included a diminished tax base and the undertaking of multiple public works improvement projects. They question why the TMDL does not include discussion of funding sources and why the Village, as an identified source requiring load reduction, has not received funding as other sources have.

**Response:** The availability of funding is not a required component to a TMDL, but is sometimes discussed in the implementation section. Funding opportunities for which the Village of Marcellus may be eligible include:

CWSRF Engineering Planning Grant Program. These funds are available to support traditional CWSRF applicants in completion of engineering studies and reports, environmental reviews and associated project planning expenses. Specific details such as

application format, deadlines, or matching fund requirements are available at <http://www.dec.ny.gov/pubs/81196.html>.

NYS Clean Water State Revolving Fund (CWSRF). This program provides financing for projects that improve, maintain or protect water quality. The program is administered by the NYS Environmental Facilities Corporation (EFC). EFC's Community Assistance unit provides direct consultation on needs assessment, procurement of professional services, funding strategies, public outreach, interagency coordination and other aspects of project development. The EFC contact serving the central New York area is Terrance A. Deuel, Environmental Project Manager, at (607) 753-3095 ext. 252 or [Terrance.deuel@efc.ny.gov](mailto:Terrance.deuel@efc.ny.gov). More descriptive information about the CWSRF program and other EFC activities, application materials and forms, policy and the current fiscal year intended use plan is available at <http://www.efc.ny.gov>.

USDA Rural Development Rural Utilities Service. More information can be found at <http://www.rurdev.usda.gov/NYHome.html>. For Onondaga County contact Ms. Christina Cerio, Rural Development Specialist at (607) 753-0851 ext. 118 or [Christina.Cerio@ny.usda.gov](mailto:Christina.Cerio@ny.usda.gov).

DEC also suggests consulting the NYS Water and Sewer Co-Funding Initiative at <http://www.nycofunding.org>, which a community can use to find out what grants and loans for which they are eligible.

#### **8.1.4.3 Minor SPDES Permits**

18. In Section 4.2.7.1, the text indicates that the industrial SPDES discharges located in the watershed that contribute phosphorus to Onondaga Lake are identified in Table 7 which presents the yearly average Total Phosphorus (TP) load for each facility, except Metro. The text explains that the yearly average TP load for each facility was calculated using Discharge Monitoring Report (DMR) data from 1998 to 2007. Lockheed Martin submitted DMRs from 1998 to 2007, but no phosphorus data was submitted with those DMRs. Would NYSDEC please explain the method used to calculate the yearly average TP load for the individual SPDES discharges; and in particular the source of data for the Lockheed Martin calculation?

**Response:** In the absence of actual measurements of total phosphorus data, DEC uses the best available information to estimate loads. The 205 lb/yr load was estimated based upon information provided by the permittee on a Water Treatment Chemical Usage Notification Form which indicated an average phosphorus concentration of 0.24 mg/l for outfalls 001, 003 & 007. DMR data indicated an average flow of 0.28 MGD. This estimate did not include the estimated phosphorus load resulting from the addition of zinc orthophosphate to the public water supply (see Comments 24 and 25). DEC recognizes that the current load from Lockheed Martin is greater than the 205 lb/yr included in the Draft TMDL document. See also the response to Comment 19.

19. Lockheed Martin's analytical data from February and March 2012 along with the flow data collected during the sampling events were used to estimate the yearly average TP load

discharge. The estimated load calculated by Lockheed Martin is significantly different than the WLA stated in the draft document. Due to the uncertainty regarding the yearly average TP load, Lockheed Martin is requesting that the NYSDEC allow one year for samples to be collected and analyzed for phosphorus concentrations to determine the current TP load being discharged. Analytical results collected over a year would allow for Lockheed Martin and NYSDEC to better estimate the average annual TP discharge and seasonal fluctuations of TP.

**Response:** The estimated load, based upon WTC usage (Comment 18) and OCWA zinc orthophosphate (Comment 25) provides a value of 362 lb/yr. This estimate has been incorporated into the final document as the load currently attributed to Lockheed Martin. This is congruous with estimates made from limited TP sampling data from February, March and April, 2012 provided by Lockheed Martin, which ranged from 196 – 399 lb TP/yr.

The implementation timeframe of this TMDL has been extended for all of the permittees listed in Table 7, except Metropolitan Syracuse WWTP, to allow monitoring to more accurately determine loads and investigate load reduction options if needed. Some additional load is being held in reserve (see Comment 20) pending monitoring results. See also the response to Comment 22 regarding the development of nutrient standards for flowing waters which may impact future load allocations and future decisions by DEC to allocate the reserve capacity.

For all of the permittees listed in Table 7, excepting the Metropolitan Syracuse WWTP, the permit limits required by this TMDL will go into effect on January 1, 2016. The limit will be expressed as a 12 month rolling average basis such that the first calculation for compliance with the permit limit will occur after collection of the December 2016 monitoring data.

20. Measured TP discharges from Honeywell's outfalls for the period of January 2008 through March 2012 shows the TP average mass loading to Onondaga Lake and its tributaries at 498 lb/yr. A 12-month rolling average was calculated to be as high as 778 lb/yr. Of the 498 lb TP/yr average, 371 lb/yr are estimated to discharge through Outfall 015 for which the vast majority of water is from others' discharges.
  - a. Periodic discharge from the Willis Avenue groundwater treatment plant (GWTP) is the largest Honeywell flow contributor. The GWTP only discharges to Outfall 015 during rain events when discharge to Metro is suspended, and contributes an estimate average of 1.2 lb/yr TP to Outfall 015.
  - b. The most significant upstream flow contributor to Outfall 015 comes from others such as Suez Syracuse Energy Corporation's SPDES (NY0213586) discharge, the Village of Solvay storm sewer system and other manufacturers' storm water discharges.

While the TMDL attributes 165 lb/yr to Syracuse Energy Corporation's SPDES discharge it is unclear how additional nonpoint source contributions associated with Outfall 015 are accounted for in the TMDL.

- c. Outfalls 011, 018 and 019 discharge to Ninemile Creek and Geddes Brook. The SPDES TP average mass loading to these waterbodies is calculated as 127 lb/yr based on discharge monitoring reports. In the case of Outfall 011, which discharges surface water runoff from the north side of Wastebeds 9, 10 and 11, runoff from an adjacent golf course is collected and discharged. For Outfall 018, the discharge is only surface water runoff, an intermittent flow. These flows are affected by weather conditions and precipitation levels. Outfall 019 is a continuous discharge, but it too collects surface water runoff from precipitation events. TP loadings from these outfalls will vary and can increase significantly with large precipitation events.

Based on this information, Honeywell requests NYSDEC provide an accounting for the 62 lb/yr and adjust the actual loading in the “bubble” to reflect actual discharges that warrant control or are capable of being controlled.

**Response:** With the exception of the load from Syracuse Energy Corporation (NY0213586), the loads from the Honeywell site consist of stormwater runoff and are therefore already covered by the MS4 allocation, which includes stormwater loads associated with multi-sector general permits. Loads mentioned in the comment are subject to the conditions of the MS4 and multi-sector general permits. As a minor contributor resulting from groundwater withdrawal, the load from the GWTP is considered to be *de minimus*.

The individual SPDES allocation for Honeywell has been eliminated. The 62 lb/yr allocation will be held in reserve pending monitoring data from other minor discharges, e.g. Lockheed Martin (see Comment 19), or to accommodate new, small discharges to the Lake.

21. The text (page 52 in the last paragraph of section 7.2.1 of the draft) states that based on the nature of treatment provided by these systems, it would not be financially feasible to require phosphorous removal at these facilities. Please explain what is meant by, "the nature of treatment provided by these systems".

**Response:** In the case of many small dischargers of phosphorus, including those from industrial sources, treatment technologies that are cost effective for larger municipal treatment plants are often not financially feasible. This may be due to the small volumes of water requiring treatment or larger volumes of water with low concentrations of phosphorus. While treatment options do exist they would be very costly. In the development of TMDLs, it is preferable to achieve load reductions in the most cost effective manner possible. It is also noted that, in the case of some discharges listed in this TMDL, no treatment is currently provided prior to discharge. The notion of financial feasibility still applies. The paragraph has been edited for clarity.

22. With regard to Comment 21, how can the department impose a limit, that if exceeded would be a violation, when it readily admits that "...it would not be financially feasible to require phosphorous removal at these facilities?" Lockheed Martin suggests that a discharge limit is inappropriate and that non-enforceable guidance values be established for the bubble permit and individual WLA.

**Response:** Cost, or more appropriately cost per pound phosphorus removal, is one aspect considered when determining where reductions will be made to meet the assimilative capacity of a waterbody. In general, the goal is to avoid requiring reductions which will require expensive investments with little phosphorus removal. Paramount to this, however, is the need to reduce phosphorus loading to Onondaga Lake and the DEC has the authority, through SPDES and other permit systems, to impose limits determined necessary to ensure water quality standards are met. In recognition that inequities in removal costs may result, DEC is willing to consider water quality trading as a means of providing flexibility for the implementation of this TMDL. Water quality trading is a voluntary, market based option that regulated point sources can use to meet the water quality-based effluent limits in their SPDES permits.

DEC also notes that, following the development of phosphorus standards for flowing waters, reductions in loads from dischargers identified in this TMDL may be required to meet those standards as well. See the response to Comment 4. This may result in limits more stringent than those developed here, particularly when the receiving water offers little dilution.

Non-enforceable guidance values do not provide the level of reasonable assurance that the limits will be met, as required in a TMDL. Thus, all permittees listed in Table 7 will receive a phosphorus limit. However, as noted in the response to Comment 19, additional time for monitoring and implementation for small dischargers has been incorporated into the final TMDL.

23. On page 52 in the last paragraph of section 7.2.1, the text indicates that the combined WLA will be included in a bubble permit. Please explain how a bubble permit works.

**Response:** Bubble permits aggregate the WLAs of the permits being considered for compliance in aggregate. So long as the total load from the bubbled permits does not exceed the total permit load limit equal to the aggregated WLA, none of the permits will be considered in violation. Should the total load limit be exceeded, the individual permit limits will be used to determine the permittee(s) in violation.

For the bubble permit to operate effectively, each discharge must meet their individual WLA on average. Occasional deviations from individual WLAs, caused for example by operational upsets, are likely to be accommodated within the bubble permit so long as all the permittees are not discharging at full capacity at all times. The bubble permit allows some operational flexibility, therefore reducing the financial burden upon these small dischargers, while still meeting the needs of the TMDL to reduce overall phosphorus loading to Onondaga Lake.

24. Onondaga County Water Authority (OCWA) adds zinc orthophosphate to create a protective film to prevent leaching and corrosion of these fittings. While it is understood that adding it is a necessity to protect the public health of the community and surrounding communities, the Village of Marcellus feels it is unwarranted for us to shoulder the heavy financial burden to remove the phosphorus from the waste stream solely by ourselves. Studies have shown that the phosphorus contribution from water mains within sewer systems can be as high as 5%.

**Response:** DEC is aware that OCWA addition of zinc orthophosphate to the public water supply is the source of substantial fractions of the phosphorus load for several of the SPDES permitted entities. DEC recognizes the public health reasons for adding the corrosion control chemical. The decision to use a non-phosphorus based chemical must be approved by the Department of Health according to their regulations. SPDES permit holders are responsible for ensuring their effluent meets their permit limits.

25. Based on the limited sampling to date, Lockheed Martin has calculated that the average phosphorous loading from incoming water to be approximately 157 pounds per year. Much of the phosphorous that is added to the public water supply passes through the facility. Some of it is discharged to sanitary, where it is removed by the Metro treatment plant. Some of it is discharged as non-polluted water through SPDES discharges. Will SPDES dischargers be credited for the amount of phosphorous that is not added by the facility, but is added by the public utility and passes through the facility into its SPDES discharge?

**Response:** Efforts were made to account for the phosphorus supplied through the public water supply when developing the load estimates for the SPDES permitted entities. The addition of zinc orthophosphate was overlooked when the load for Lockheed Martin was developed. This has been corrected within the final document, using the estimated load provided by commenter (see Comment 19).

As Lockheed Martin adds additional phosphorus to the waters they discharge, some reduction in load will be required, although the final WLA currently is set greater than the estimated amount attributed to OCWA supply water. See also the response to Comment 22 which discusses likely reductions resulting from the development of numeric water quality standards for phosphorus in flowing waters.

#### **8.1.4.4 Onondaga County**

26. While the County remains confident that the water quality improvement trends we have witnessed in recent years will continue in the years ahead, in the event additional actions may be required to address phosphorous levels in Onondaga Lake we urge the state to provide Onondaga County with sufficient flexibility in the context of "adaptive management," to facilitate the development of watershed wide load and waste load reductions, the deployment of aggressive green infrastructure and trading/reallocation mechanisms so long as projected overall phosphorus loading reductions are met.

**Response:** While the WLAs outlined in this document must be met, it is up to the discretion of Onondaga County to determine the best method for meeting those limits. These strategies may include the methods outlined by the commenter, which would tend to decrease loads at outfall 002, and likely for outfall 001 and CSOs as well. DEC also notes that, in addition to the WLAs, the County is also subject to other requirements as outlined in the ACJ and subsequent stipulations.

Provision will be included in the TMDL to redistribute loads between WLAs provided it can be demonstrated that the redistributed permit limits/condition would have a comparable effect on water quality. This may provide additional flexibility to the County and perhaps facilitate trading with or among other permit holders.

27. We request that the final TMDL should explicitly recognize the acceptability of using green infrastructure that, in addition to reducing flow to Metro and phosphorus to Onondaga Lake, also represents reinvestment in neighborhoods by the use of rain gardens, green roofing, trees, porous pavement, cisterns, etc. and represents a viable alternative to traditional gray solutions that tend to raze neighborhoods for treatment facilities.

**Response:** The comment is noted, and the flexibility for adjusting waste load allocation will be provided (see Comment 26). The suggested text additions provided by the County (see Section 8.1.11) regarding green infrastructure and low impact development have been incorporated into the final document in Section 7.1.

28. In the event Honeywell dredging operations extend beyond the anticipated five year period noted in the Draft TMDL, and the temporary additional flows and loads are sent to Metro for treatment, such flows and loads should not be counted against the County's waste load allocation.

**Response:** The comment is noted and will be evaluated at that time. Barring substantial development within the Metro service area over the next 5 years, sufficient capacity should exist at Metro to incorporate the additional load. DEC notes that no additional WLA is provided to Metro for the Honeywell dredging operations, but rather the cessation of those loads will provide Metro with additional capacity to accommodate growth.

29. As noted in the County's Phosphorus Work Plan (submitted to DEC in August 2010), "...performance of decision modeling and Compliance Plan development are not considered part of the studies mandated in the ACJ. However, these two efforts cannot start until a final TMDL is established, which is targeted from December 31, 2011." The State has advised the County that they now expect the TMDL to be finalized at the end of June, 2012, six months beyond the anticipated date. It is the County's expectation that the State will allow the County a six month extension, as well, to submit its Phosphorus TMDL Compliance Plan.

**Response:** A six month extension for submission of the Compliance Plan is acceptable to the DEC, but will be addressed separately from the TMDL as required through the ACJ process.

#### **8.1.4.5 MS4 Permits**

30. The County supports the State's proposed target value for municipal separate storm sewer systems (MS4s) within the watershed. The proposed implementation schedule is reasonable, and allows for continued sampling and analysis to ensure costly investments will not be required unnecessarily. Again, the County recommends that the TMDL remain flexible enough to allow for the use of green infrastructure in new development to offset increases in loading.

**Response:** Green Infrastructure and Low Impact development are already recognized in the MS4 General Permit. See also the responses to Comments 26 and 27.

31. Because the expected decrease in phosphorus from pervious surfaces is an estimate, monitoring will be important to assess whether the total load to the Lake from this source is reduced as expected. Does the 40% value factor in both the amount of P that will no longer be lost to runoff and the % of total pervious surface where fertilizer was actually applied (not all potential acres will actually be fertilized)?

**Response:** Demonstration of the required load reductions by the MS4 permittees (the primary parties impacted by the fertilizer phosphorus restrictions, although CSO areas and unregulated, developed land are also impacted to a much lesser extent) is a requirement of the MS4 permits. MS4 entities must develop a plan to demonstrate they are meeting their WLA; these efforts may include monitoring and/or modeling.

The 40% phosphorus reduction accounts for a reduction in phosphorus contained within runoff as a result of the removal of phosphorus from fertilizer. As noted in the TMDL, this reduction was applied to the pervious lands within the MS4, CSO and unregulated, developed land categories, i.e. those lands likely to receive fertilizer. The commenter is correct that some potential acres may not receive fertilizer. As stated, the anticipated load reduction is an estimate based upon the best available information and research conducted elsewhere. Demonstration of load reductions will therefore remain important.

32. Notice was provided to the Town of Scott that the Onondaga Lake TMDL may impact the Town. The Town of Scott is located within the Skaneateles Lake watershed. Please elaborate upon the impact the TMDL will have upon the water quality of Skaneateles Lake or the Town of Scott.

**Response:** The Skaneateles Lake watershed is not affected by this TMDL. Maps of town boundaries indicate that for the Town of Scott, and several other Towns, some portion of the Town lands fall within the Onondaga Lake watershed. Those lands are therefore subject to this TMDL. Towns not covered under MS4 permits or other specific regulatory authority noted in this TMDL are still subject to statewide laws, including, but not limited to, the fertilizer restrictions and general permits covering construction and stormwater.

33. Region 3 NYSDOT requests the following information regarding their obligations under the TMDL:
- d. Information as to sampling process and procedures is needed, i.e. when, how and where samples should be taken.
  - e. What is the start date for baseline concentrations?
  - f. Document requirements for the 3 year retrofit submission would be helpful.
  - g. How will combined efforts between agencies and communities be quantified toward the reduction requirements? Especially in light that NYSDOT falls under several source categories.

**Response:** These details will be the subject of the watershed improvement strategy required by the MS4 permit. The document is prepared by the permittee and submitted to the DEC. DEC will work with all MS4s to develop guidance on the watershed improvement strategy including assessing the need for retrofits.

34. The deadlines to meet allocation reductions are somewhat long (6-13 years). When does the fertilizer law go into effect? Why do MS4s get 13 years to demonstrate required load reductions? Are there intermediate deadlines? A better explanation of deadlines would be appreciated.

**Response:** The fertilizer restriction was signed into law on July 15, 2010 and went into effect January 1, 2012.

The 13 year deadline is already specified in the MS4 General Permit, and was chosen to allow time for the MS4 entities to develop their watershed improvement strategy and retrofit plan documents (3 years) and to allow time for these plans to be implemented and/or for measurable decreases in phosphorus loads to be documented (10 years). Unlike point sources which can reduce loads immediately upon completion of necessary retrofits or upgrades, distributed, watershed sources of phosphorus require additional time to achieve load reductions as excess phosphorus works its way through and ultimately out of the watershed. The MS4s will have to demonstrate individually or collectively that they are reducing loads by 18 percent. If the MS4s document in their watershed improvement strategy/retrofit plan(s) that all of the required load reduction can be attributed to the fertilizer law, they would be expected to maintain this level of load reduction by offsets to additional loads created by new construction. If the MS4s demonstrate somewhat less reduction by the fertilizer law, they will have the 10 year period to install retrofits to achieve the 18 % overall reduction. DEC will develop guidance for the MS4 on the format and content of the watershed improvement strategy and retrofit plan.

### ***8.1.5 Reasonable Assurance and Monitoring***

35. The lead sentence in Section 7.1, Reasonable Assurance, states that the reasonable assurance requirement will be met through existing regulatory and legal structures. But, reasonable assurance must be demonstrated, not presumed. SPDES and other permit holders must demonstrate that permit limits are met; monitoring will be important to demonstrate that load reductions from LA sources such as fertilizer use reductions and nonpoint source pollution occur as well.

**Response:** Compliance with SPDES permit limits is the responsibility of the DEC Bureau of Water Compliance. Monitoring results for SPDES permits are provided through Discharge Monitoring Reports submitted to the DEC.

Monitoring or other demonstration of load reductions is a requirement of the other permits as discussed in the response to Comments 31, 33 and 34. See also the response to Comment 36. Section 7.1, Reasonable Assurance has also been expanded to include a discussion of green infrastructure as an allowable means for meeting permit requirements.

36. Sampling only within the lake will not enable demonstration of load reduction success from sources such as fertilizer reduction or nonpoint pollution. We believe tributary monitoring will also be required.

**Response:** Tributary monitoring conducted by the AMP is envisioned to continue. DEC also conducts periodic monitoring of tributaries. Implementation of numeric nutrient criteria, including phosphorus standards for flowing waters, will likely require additional tributary monitoring, however that is beyond the scope of this TMDL. For those entities which hold a permit, monitoring or other demonstration of load reductions is a requirement. See the responses to Comments 31, 33, 34 and 35. Demonstration of load reductions from other nonpoint sources, including agricultural lands and unregulated developed land is not required, however the TMDL document must include reasonable assurance that the reductions will occur. Monitoring of the Lake will provide sufficient information to determine if the numeric water quality target for the Lake is being met, which is the goal of this TMDL.

37. With regards to the nitrate additions (see Sections 4.2.8 and 6.3), it will be important to monitor to ensure that nitrate additions are effective at retaining phosphorus with lake sediments.

**Response:** The nitrate additions are still in the trial phase. Monitoring is therefore a substantial portion of assessing the efficacy of these efforts. The follow-up monitoring included in the TMDL (Section 7.8) will provide additional data.

DEC notes that potential reductions in phosphorus loading to the Lake as a result of the nitrate additions were not incorporated into the development of this TMDL. Cessation of these activities would therefore not impact the ability of the Lake to meet the numeric water quality criteria under this TMDL.

#### **8.1.6 Onondaga Lake Watershed**

38. Based on the results of a recent study published in the Journal of the American Water Resources Association, led by Steven W. Effler, the Marcellus WPCP does supply a measurable amount of Phosphorus in the form, Soluble Reactive Phosphorus (SRP), to Nine Mile Creek. However, this study showed that this Phosphorus is precipitated by the mineral clays and soils in the stream prior to discharge into Onondaga Lake, "These deposits cause a disconnect between upstream inputs of highly bioavailable SRP and the SRP<sub>L</sub> that is actually delivered to the lake. Accordingly, upstream changes in SRP<sub>L</sub> would probably not be fully transferred to the lake because of the sorptive capacity of the deposits..." (Effler, 2011). Therefore, based on this information, imposing a Phosphorus limit on the Village of Marcellus will not result in a noticeable change in the Phosphorus levels in Onondaga Lake and will not help to achieve the goal of the TMDL.

**Response:** The referenced paper (presumed to be: Effler, Steven W., Anthony R. Prestigiacomo, David A. Matthews, and Feng Peng, 2012. Sources and Sinks of Phosphorus

for a Perturbed Stream and the Effects of Mineral Deposits. *Journal of the American Water Resources Association* (JAWRA) 48(2): 321-335. DOI: 10.1111/j.1752-1688.2011.00617.x) indicates that much of the SRP released to Ninemile Creek reacts with  $\text{CaCO}_3$  deposits found in the creek bed.

The existence of these deposits may result in decreased phosphorus loading to the Lake. DEC notes several potential difficulties associated with Marcellus (V) relying upon these deposits to remove their contribution of phosphorus to the Lake: 1. The Village would need to demonstrate continued load reductions due to the deposits comparable to those required by the TMDL. 2. These deposits may be subject to removal in the future as a result of continued remedial efforts along Ninemile Creek. 3. Development of numeric nutrient standards for phosphorus in flowing waters may impose additional restrictions on effluent concentrations to protect water quality upstream of the deposits. For these reasons, DEC does not consider reliance upon these deposits for load reductions to be a prudent means for load reductions within the scope of this TMDL or future effluent requirements. DEC acknowledges that these deposits may provide beneficial phosphorus load reductions while Marcellus (V) WPCP comes into compliance with the requirements of this TMDL.

39. It is our understanding that several of the private, industrial facilities within the Onondaga Lake watershed may be abandoning their SPDES permits by redirecting their waste streams to other systems that will not discharge to the nearby creeks. If this is the case, the Village of Marcellus would like to petition to have the allocated amounts of these industrial dischargers, or at least a portion of these allocated amounts, shifted to allocated amounts for the Village of Marcellus WPCP. Since the ultimate loads to Onondaga Lake will not increase, we hope this request is viewed favorably and acceptable so as to help alleviate some of the potential financial impacts to the Village of Marcellus.

**Response:** DEC is unaware of any planned termination of SPDES permits other than those already noted in the TMDL. See also the responses to Comments 26 and 27 concerning flexibility in allowing the reallocation of WLA within this TMDL.

40. It is our understanding that there is a proposal to construct a filtering structure or process at the outlet of Nine Mile Creek prior to discharge into Onondaga Lake. The Village of Marcellus is in full support of this proposal as it provides a more controllable means to limit Phosphorus from entering Onondaga Lake. Since the Village of Marcellus is also subject to allocations as a listed MS4 permittee, this mitigation option also provides a means to limit the risk of future violations of Phosphorus by the various MS4 communities located along Nine Mile Creek.

**Response:** DEC is unaware of such a proposal. Such a proposal would be subject to the approval of the DEC. Additionally, DEC notes that prevention of phosphorus entering Onondaga Lake may not be sufficient to protect water quality in the Creek, which is listed on the 303(d) list as impaired for phosphorus. See also the response to Comments 4 and 22 regarding the potential impact of the development of numeric nutrient standards for flowing waters.

41. In addition to preservation and protection, restoration of wetland, stream, and riparian resources within the watershed would contribute to phosphorus load reductions. Other than the lake, the aquatic resources of the watershed are in relatively poor shape, particularly in urbanized areas. Easements and incentives for private landowners, combined with active restoration of riparian wetlands, riparian forest, stream meanders, instream structure, and other lost or degraded aspects of stream systems, would contribute significantly to sediment and phosphorus retention within the watershed, as well as improve aesthetics, recreational use, aquatic habitat, and potentially land values.

Most major tributaries to Onondaga Lake are 303(d) listed for phosphorus. DEC has missed an opportunity to address the phosphorus issue in a more holistic way by incorporating analysis of or controls for tributaries, which contribute significantly to the phosphorus loadings in the Lake. OLWQM modeling results (tributary P loads were 38 to 79% lower under historic conditions) also establish the tributaries as a significant source of phosphorus, and in particular SRP. DEC identifies some of the largest potential contributors of phosphorus to the tributaries, including the Tully Mud Boils, but does not take the next logical step of imposing load limits for the tributaries or identifying the changes or controls that might be required to manage the most significant sources of phosphorus. While this may be outside the typical scope of the TMDL, stretching to incorporate such concerns could be of tremendous value.

**Response:** The actions noted by the commenter would provide benefits to Onondaga Lake, its tributaries and surrounding areas and will be added to Section 7.6. The implementation plan requires a series of watershed restoration actions, such as phosphorus reductions from point sources, CSO controls and agricultural BMPs. These restoration activities will also improve the condition of the Lake's tributaries and will push them closer to attaining the NYS narrative standard for phosphorus. As noted in Comments 4 and 22, the department is in process of developing numeric nutrient criteria, but these criteria are not in place for consideration in this TMDL. See <http://www.dec.ny.gov/chemical/77704.html>. The implementation of stream standards for phosphorus is another reason why DEC has added flexibility to the TMDL to adjust WLA among permits to allow for adaptive implementation to focus load reductions where they best affect local water quality while meeting the overall water quality targets for Onondaga Lake.

It should be noted that the various tributaries of the Lake are listed in the NY 2010 303(d) List Part 3c. This part of the list is for "Waterbodies for which TMDL Development May be Deferred (Pending Implementation/Evaluation of Other Restoration Measures)." These restoration measures are spelled out in the ACJ.

#### ***8.1.7 Onondaga Lake Classification and Water Quality Standards***

42. ASLF would like to go on record expressing concern regarding the adequacy of the ambient water quality standards generally and as applied to this TMDL. Specifically, the NY standards do not appear to fully implement the Clean Water Act because they:

- a. Do not include a concept of ecological integrity, which acknowledges the importance of native species, the ecoregional context of New York's water bodies, and the importance of intact aquatic communities,
- b. Do not adequately characterize many NY lake fish communities as coolwater.  
Classifying lakes as only trout or warmwater inadequately protects these waterbodies by allowing degradation of the many lakes already or predicted to be affected by climate change, to a warmwater fish community that lacks many non-native fishes, and
- c. Are heavily biased toward recreational use at the expense of aquatic life protection.  
The phosphorus guidance value is based on protection of aesthetics for recreation, the narrative criteria protect only aesthetics, and the protection of aquatic life term in the ambient water quality standards is termed "fishing." The Clean Water Act protects more than just recreational use for humans – it was intended to protect ecological sustainability of our native/indigenous aquatic communities.

**Response:** The comment is noted. However, evaluation of the adequacy of the ambient water quality standards is outside the scope of this TMDL. As part of the Continuous Planning Process after this TMDL, DEC will be open to discussions about the classification of Onondaga Lake. However, as noted by DEC in the public involvement process during development of this TMDL, reintroduction of native species would involve substantive issues such as invasive species, aquatic habitat, hydromodification and other physical changes to the Lake and connecting waters that may be more important than water quality considerations.

43. Onondaga Lake's water quality as Class B and Class C water should be listed correctly as Class B(T) and Class C(T), indicating it as a trout water in accordance with New York State Regulations 6 NYCRR §180.5, 6 NYCRR § 700.1, and New York State Environmental Conservation Law §11-0103. The report clarifies the regulations and law (see Section 3.1).

Omitted from this explanation is the understanding that due to a lack of resources, the NYSDEC has not performed water quality re-classifications for the vast majority of New York's waters for the last 25 years. This is particularly important with Onondaga Lake as it has long been considered among the most polluted lakes in the country, if not the world, and is now being celebrated for a relatively recent and extremely dramatic water quality improvement that is known to support a diverse fish habitat. Instead of describing the presence and health of its trout species, it employs circular logic to describe the adverse conditions, like reduced dissolved oxygen levels and associated warm water temperature, that limit trout's success – conditions present in Onondaga Lake that are directly related to its level of phosphorous

**Response:** As indicated in Section 2.2, the current official water body classifications for Onondaga Lake are both class B and class C. It is beyond the scope of this document to change the classification. Such changes require a different and separate process. The DEC acknowledges that reassessment of the water body classification may be warranted in the future (see the response to Comment 42).

44. Why do TMDL requirements for thermal discharges require protection and propagation of a balanced indigenous population of fish but other TMDLs do not?

**Response:** This TMDL does not deal with thermal discharges. However, with regards to thermal discharges, NYS regulations do distinguish between trout and non-trout waters.

### 8.1.8 Aquatic Community

45. DEC should recognize the importance of preserving the integrity of the aquatic habitat within Onondaga Lake. Rather than assuming the Lake has met its “best use” if it can sustain any healthy and recreation-friendly fishery, DEC should consider whether the Lake supports a balanced and intact aquatic ecosystem, which sustains key indigenous or native fish populations. Best use assessments should not rely solely on meeting aesthetic standards based on clarity and algae levels or recreational standards defined by the preferences of sport fishers. In addition to failing to consider the ecological integrity of the Lake, such a limited perspective ignores the existence value and cultural importance of an intact ecosystem, including historically-present fish populations, to the Onondaga Nation and other groups. It also fails to consider the recreational and cultural needs of subsistence fishers, who rely on the Lake and its fish populations in different ways than sports fishers.

**Response:** This TMDL addresses the existing use and classification of the Lake. See comments 42 and 43.

46. We do not believe the Clean Water Act equates intact native fish communities in their ecoregional context with "fish" as used in Section 3.3 and "aquatic life" in Appendix B. Protecting just "fish," or the "current" or "existing" fish community, does not fully demonstrate recovery of Onondaga Lake within the context of the Clean Water Act. The broad goal of the Clean Water Act is: restoring and maintaining the chemical, physical, and biological integrity of the nation's waters, where integrity is defined as "the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region."

**Response:** Section 101 of the CWA recognizes that water resource quality is defined by all of its components – the chemical, physical, and biological, and that water resource integrity depends on complex interactions among all three components. Since a TMDL is a restoration plan which targets the chemical integrity (and possibly some improvement in the biological condition of the waterbody), it has a limited ability to attain the entire suite of comprehensive goals of the CWA. This topic is covered more fully by U.S. EPA at <http://water.epa.gov/type/watersheds/archives/chap2.cfm>.

The definition of integrity as “*the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region*” (Karr & Dudley, 1981), was adapted from a personal observation made by Frey (1977) contained on page 128 of an U.S. EPA-sponsored symposium proceedings.

The existing aquatic life community of Onondaga Lake is consistent with the definition of integrity provided by the commenter. Section 6.4.1 of the Onondaga Lake Ambient Monitoring Program 2010 Annual Report states that: “Over the last decade, 45 fish species have been documented in the lake, *comparable to regional waters* (emphasis added).”

47. We do not believe the statement in the second paragraph of Appendix B has been fully demonstrated and believe this statement should be qualified by adding an acknowledgement that the existing phosphorus guidance value was developed for recreation and its adequacy for protection of aquatic life has not been fully evaluated.

**Response:** The first sentence of the paragraph acknowledges that the existing phosphorus water quality value was established to protect primary and secondary contact recreation. The second part of that paragraph established the task of Appendix B, namely whether “a value *more stringent than 20 µg/l* is necessary to protect aquatic life” in the Lake. See the response to Comment 5 for further discussion of the adequacy of the 20 µg/l limit for the protection of aquatic life.

### **8.1.9 Onondaga Lake Fish Community**

48. We suggest deleting all the trout material and including additional detail regarding the biological condition of the lake. We consider the TMDL to be a status summary and informational document as well as a guidance document for further water quality improvements. As such it should provide at least a basic description of the biology of Onondaga Lake within its ecoregional context.

**Response:** The TMDL is a regulatory document that explains and justifies regulatory proposals and/or decisions. Adequate background material on the biology of Onondaga Lake has been included to support the recommendations proposed (see Sections 2.2, 2.3 and Appendix B). The TMDL cites references that can provide additional background information.

49. Since 1998, Onondaga County, through its Water Environmental Protection Department (OCDEWP), together with the State University of New York College of Environmental Science and Forestry (SUNY ESF) has closely monitored the lake's water quality. In October, 2011, they released a report "Onondaga Lake Fishery, 2011 Fact Sheet", which states:

"The remarkable recovery of the system is exemplified by the increased numbers and wider distribution of large brown trout, which are stocked in Ninemile Creek, and now persist throughout most of the year in the lake."

[http://static.ongov.net/WEP/wepdf/OnondagaLakeFishery-2011\\_FactSheet%20\(Oct2011\).pdf](http://static.ongov.net/WEP/wepdf/OnondagaLakeFishery-2011_FactSheet%20(Oct2011).pdf)

The Fact Sheet shows 52 fish species found in Onondaga Lake during the years of 2001-2010 and groups them by their relative abundance within three categories; Very Common,

Common, and Uncommon. Brown Trout are included in the list of 17 Common species. A TMDL Phosphorous determination must take into account that trout now inhabit Onondaga Lake, are reproducing in its system, and that the lake is supporting their growth and survival.

**Response:** See the response to Comment 43.

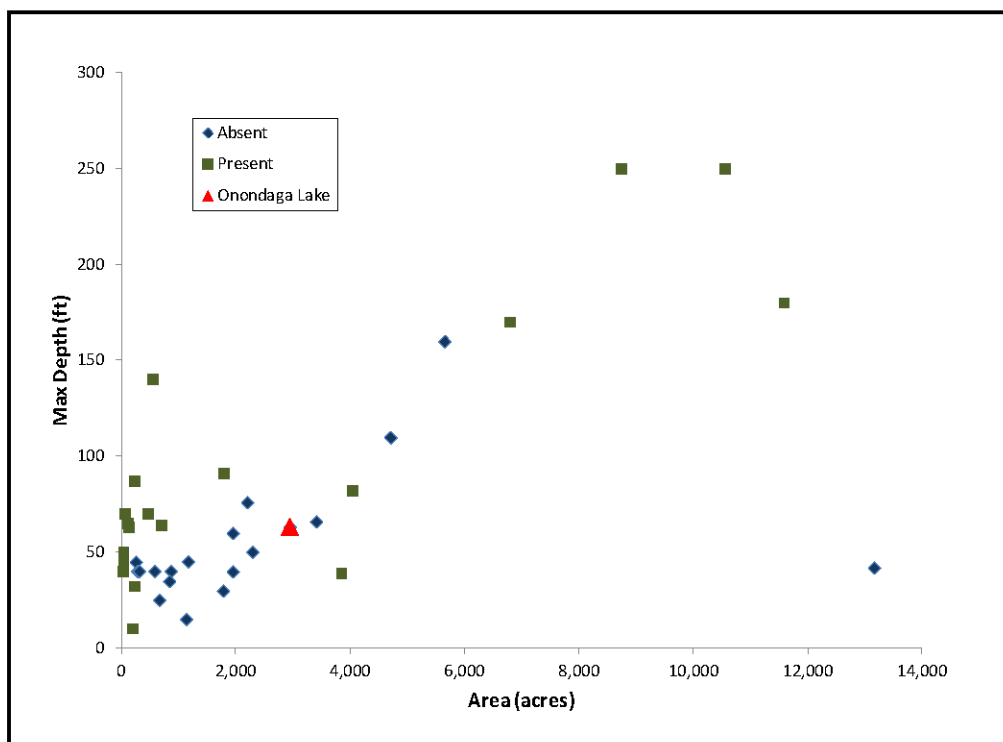
50. ASLF believes that focus on the hypolimnion is misplaced with respect to survival of cold and coolwater species in Onondaga Lake. A preliminary examination of AMP data from 2007, 2008, and 2009, that indicates that a narrow stratum of suitable to marginally unsuitable habitat ( $\text{DO} \geq 4.0 \text{ mg/l}$  and temperature  $\leq 23.4^\circ\text{C}$ ) exists through the critical late summer period, widening as water temperature decreases. This stratum occurs at a depth of 5.0 to 7.5 m, not at the bottom of the hypolimnion. Over the three years, there was a period of 1-3 weeks/year in which the stratum was less than 0.5 m (or absent) to 1.5 m thick. A more thorough analysis of this "refuge stratum" including years prior to WEP phosphorus treatment upgrades, and employing the analytical capabilities of Onondaga County's consultants, would greatly enlighten relative to effect of further phosphorus reduction on dissolved oxygen and the capacity for Onondaga Lake to support coldwater fishes under current climate conditions, and cold and coolwater fishes under climate change forecast scenarios. The interplay between these two variables will be key to the survival of cold and coolwater fish species as climate change continues to affect this habitat.

**Response:** The TMDL does not assert that because anoxia has historically occurred in the hypolimnion that Onondaga Lake could not have been inhabited by resident cold water fish species. The presence of Lake Whitefish (*Coregonus artedii*) in Onondaga Lake is a documented historic fact. The commenter is correct in noting that the availability of cool, oxygenated water during the summer is a necessity for sustaining a coldwater fish population. Given the biodegradation of dead algae is a primary cause of hypolimnetic anoxia, a further reduction of TP concentration in the Lake below the proposed TP guidance value of  $20 \mu\text{g/l}$  could reduce anoxia in the upper levels of the hypolimnion to the extent that larger refugia for cold water fish would be available.

As stated in the response to Comment 5, the goal of the present action is the protection of the present ecological community with existing levels of diversity and abundance. While restoration of a historical, cold water community is a worthwhile goal, it has not been established whether or not the proposed level of TP concentration would be an impediment to achieving that goal, or what impact any further reductions would have on the existing community.

51. The link between phosphorus and dissolved oxygen, and therefore the relevance of the dissolved oxygen standard to this TMDL, is a complex issue. We accept that the current standard of 4.0/5.0 mg/l may not realistically apply to Onondaga Lake because the lake may not have maintained these concentrations at all depths under natural conditions. However, we do not accept the simple conclusion that lakes the size and depth of Onondaga Lake do not support coldwater fishes because the hypolimnion goes anoxic in late summer, and believe this question deserves careful consideration outside of this TMDL. We examined the academic literature and DEC information regarding presence/absence of coldwater fishes

relative to lake size and depth and did not find the question to be simple (Figure 24). Regarding lake size/depth, there is considerable overlap between lakes having and not having coldwater species in New York, and Onondaga Lake centrally located within the cluster of data points. We do not see evidence for a simple conclusion that Onondaga Lake "should not" support coldwater fishes simply because of its depth or size.



**Figure 24: Influence of lake size and depth on presence of coldwater fish species in New York lakes.**

Lake dataset is available from Atlantic States Legal Foundation (ASLF) on request. Figure is reproduced from the comments submitted by ASLF in response to the draft version of this document.

**Response:** The TMDL does not make general assertions about lakes the size and depth of Onondaga Lake and the presence or absence of coldwater species. The figure that the commenter provided (included as Figure 24) suggests that, considering mean depth and surface area alone, there is about an equal probability of coldwater fish species being present or absent in a lake the size and depth of Onondaga Lake.

#### 8.1.10 Paleolimnology

52. It was our impression that absence of varves indicated life within the sediments and therefore presence of dissolved oxygen. Some clarification would be appreciated.

**Response:** Anoxia can, and does, exist in the hypolimnia of lakes where the duration of oxygen depletion is short enough to allow re-colonization of the profundal sediments by benthos during most of the year. Under such conditions, laminations do not form due to the churning activity of the benthos.

53. It was unclear in this section, what the inferences were from the chironomid head capsule VWHO (third bullet and third plot in Fig 28).

**Response:** The number of chironomid head capsules found in the sediment (third plot in Figure 28) indicates the relative abundance of benthic life. A drop in numbers indicates an increase in profundal anoxia, and the total lack of head capsules (except for a few washed in littoral forms) indicates anoxia of sufficient duration to prevent any benthos re-colonization once oxygen returns (for a limited time) to the Lake's bottom waters. The last bulleted paragraph has been reworded to incorporate these clarifications.

54. The discussion of VWHOs is quite difficult to understand for the layperson. A citation or two providing additional background information would be greatly appreciated.

**Response:** The VWHOs discussion is presented in more detail in the paleolimnology reports. See Comment 55.

55. We would appreciate receipt of both Rowell publications when they become available.

**Response:** The reports will be made available for general distribution upon completion of the peer review process and subsequent revisions.

### **8.1.11 Suggested alternate phrasing**

Multiple editorial comments were received on the TMDL document. Suggested edits were incorporated when they clarified the text. Comments that would have changed the meaning from what was intended were not included. Suggested additions are in italics and suggested deletions are indicated by strikethrough.

#### **1.2 Problem Description**

Onondaga Lake is located on the northern edge of the City of Syracuse, in Onondaga County, New York. *Historically* the Lake has had a number of domestic and industrial pollution problems resulting from population growth and industrialization in the Syracuse area over the last century.

**Response:** This change has been incorporated.

#### **1.3 TMDL Scope**

The purpose of this TMDL is to address excess phosphorus loading to Onondaga Lake with the goal of protecting water quality such that the Lake *continues to meet* ~~meets~~ its current designated best use as identified in 6 NYCRR §895 (see also Table 4) by utilizing the extensive effluent and ambient monitoring data available along with enhanced water quality models.

**Response:** This suggestion is rejected as the Lake does not currently meet the standard every year.

### 3.3 Numeric Water Quality Targets

(Last paragraph)

Acknowledging that further phosphorus reductions will not address the DO depletion in the Lake this TMDL is being pursued *to ensure that the Lake continues to meet its current designated best use of the Lakes are met* (Table 4)."

**Response:** This suggestion is rejected as it would change the intent of that section.

#### 5.1.2 Results

For those years, 2029, 2032; 2045 and 2048, the summer mean epilimnetic TP concentrations is modeled to be  $0.20 \mu\text{g}\cdot\text{l}^{-1}$ , which meets the water quality *guidance value* ~~criteria~~. The model results indicate that, in the long term, *and subject to biological food web conditions described in Section 2.3 or yet to be experienced impacts of climate change that exceed current projections* the water quality *guidance value* ~~criteria~~ will be met even under occasional high years of watershed derived phosphorus loads.

**Response:** The substitution of guidance value for criteria is acceptable. The remaining suggestions are rejected as the modeling did not address these conditions.

### 6.0 Pollutant Load Allocations

The objective of a TMDL is to provide a basis for allocating acceptable loads among all of the known pollutant sources so that appropriate control measures can be implemented and water quality standards *maintained* ~~achieved~~.

**Response:** This suggestion is rejected as it would change the intent of that sentence.

### 6.0 Pollutant Load Allocations

Additionally, some additional load capacity above current levels ~~is~~ *might be* required at Metro to allow for growth within the design capacity of the treatment plant, to account for load uncertainty and to allow Metro to accept the water from the dredging operations.

**Response:** This change has been incorporated.

### 6.4 Critical Conditions

Degradation of these parameters during the summer ~~corresponds to impaired best uses for~~ *increases the risk of impairment with respect to* primary and secondary contact recreation.

**Response:** This change has been incorporated.

#### Add to end of Section 6.4:

*Green infrastructure has been incorporated into the ACJ as a strategy to aid in abatement of CSO discharges by reducing stormwater inputs to the combined sewer system (CSS). (Fourth Stipulation and Order at Paragraphs 17, 20, 26 and 27). EPA has also recognized the benefits of green infrastructure in addressing sediment and nutrient impairments and has expressly encouraged its incorporation as a pollutant control strategy in TMDLs as an implementation strategy and/or to address the impacts of future growth ("Incorporating*

*Green Infrastructure Concepts into Total Maximum Daily Loads (TMDLs),” October, 2008). Green infrastructure (GI) and Low Impact Development (LID) are terms used to describe stormwater management approaches and practices that can be used to eliminate or reduce urban runoff and pollutant loadings by managing the runoff as close to its sources as possible. A collection of small-scale practices, linked together on a site, is used to reduce the impacts of development and redevelopment activities on water resources by maintaining or replicating the predevelopment hydrology of the site.*

*Green infrastructure, alone, or in combination with other strategies outlined in this section are available to achieve the waste load allocation and/or load reduction targets of the TMDL and/or to assure that future growth does not result in increases in phosphorus loads to Onondaga Lake that degrade current water quality. As use of green infrastructure gains wider acceptance and adoption, green infrastructure development practices can be expected to play an important role in protecting Onondaga Lake and its watershed while allowing for future growth in the Onondaga Lake watershed.*

**Response:** This change has been incorporated in Section 7.1.

## 9.0 References

- 40 CFR Part 130** Water Quality Planning and Management. - 1992.
- Anchor QEA** Development of a Mechanistic Water Quality Model of Onondaga Lake, Phase 2 Report: Model Development and Calibration [Report]. - 2007.
- Anchor QEA** Response to Phase 2 Peer Review, Summary Report. - 2008.
- Anchor QEA** Phase 3 Model Validation and Application Report, Onondaga Lake Water Quality Monitoring Project [Report]. - 2011a.
- Anchor QEA** Setup of Additional Model Scenarios. - Syracuse : [s.n.], 2011b. - Prepared for Onondaga Lake Partnership Scenario Development Small Technical Group.
- Anchor QEA** Results of Additional Management Scenario Simulations with Onondaga Lake Water Quality Model [Report]. - 2011c.
- Anchor QEA** Results of Additional Management Scenario Simulations with Onondaga Lake Water Quality Model: Scenarios 8 and 10 [Report]. - 2011d.
- Anchor QEA** Onondaga Lake -- Comprehensive Model Scenario Simulation Results [Pers. Comm.]. - 2011e.
- Anchor QEA** Evaluation of the Changes to Onondaga Lake Water Quality Model Validation and Model Scenario Simulations due to Revisions to Metro Bypass Flows [Memorandum]. - 2011f.
- CRA Infrastructure & Engineering, Inc.** Metro WWTP optimization analysis of total phosphorus treatment [Report]. - Prepared for Onondaga County Department of Water Environment Protection. - 2001. - p. 210.
- CRA Infrastructure & Engineering, Inc.** Metropolitan Syracuse WWTP Analysis of Phosphorus Treatment Technologies and Metro Diversion to the Seneca River [Report]. - Prepared for Onondaga County Department of Water Environment Protection. - 2011. -p. 1231.
- CRA Infrastructure & Engineering, Anchor QEA and Ecologic (CRA et. al.)** Onondaga Lake Phosphorus White Paper [Report]. - Prepared for Onondaga County Department of Water Environment Protection. - 2011. - p. 72.
- Coon W.F., and Reddy, J.E.** Hydrologic and Water Quality Characterization and Modeling of the Onondaga Lake Basin, Onondaga County, New York: U.S. Geological Survey Scientific Investigations Report 2008-5013 [Report]. - 2008. - p. 85.
- EcoLogic** Onondaga Lake Ambient Monitoring Program 2004 Annual Report and Appendices 1-12 [Report]. Prepared for Onondaga County, New York - 2005.
- EcoLogic** 2010 Onondaga Lake Aquatic Macrophyte and Littoral Macroinvertebrate Surveys [Conference]. - 2011.
- Effler Steven [et al.]** Metro Retrospective Analysis and Context for the Future. - 2010.
- Effler Steven [et al.]** Partitioning Phosphorus Concentrations and Loads in Tributaries of a Recovering Urban Lake [Journal] // Lake and Reservoir Management. - 2009. - pp. 225-239.
- Frey, D.** 1977. "Biological integrity of water: an historical approach." Pages 127-140 in Ballentine, R.K. and L.J. Guarraia (Eds.) The Integrity of Water. Proceedings of a Symposium, March 10-12, 1975, USEPA, Washington, D.C. EPA Publication No. 832-R-75-103.

- Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J.**, 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, *PE&RS*, Vol. 77(9):858-864.
- Gelda, R.K., Owens, E.M., Matthews, D.A., Effler, A.W., Chapra, S.C., Auer, M.T. and Gawde, R.K.** Modeling Effects of Sediment Diagenesis on Recovery of Hypolimnetic Oxygen. 2012. *In prep.*
- Karr, James R. and Daniel R. Dudley.** 1981, Ecological perspective on water quality goals. Environmental Management Volume 5, Number 1 (1981), 55-68
- New York State** New York State Fact Sheet, Ambient Water Quality Value for Protection of Recreational Uses, Substance: Phosphorus [Report] / NYS Department of Environmental Conservation, Bureau of Technical Services and Research. - 1993.
- NYSDEC** 6 NYS Codes Rules and Regulations, Chapter I, § 180.5, Definition of trout waters. - 2010.
- NYSDEC** 6 NYS Codes Rules and Regulations, Chapter X, § 700.1, Definitions. - 2008.
- NYSDEC** 6 NYS Codes Rules and Regulations, Chapter X, § 701, Classifications-Surface Waters and Groundwaters. - 2008.
- NYSDEC** 6 NYS Codes Rules and Regulations, Chapter X, § 703.2, Narrative Water Quality Standards. - 2008.
- NYSDEC** 6 NYS Codes Rules and Regulations, Chapter X, § 703.3. Water quality standards for pH, dissolved oxygen, dissolved solids, odor, color and turbidity. - 2008.
- NYSDEC** 6 NYS Codes Rules and Regulations, Chapter X, § 895, Onondaga Lake Drainage Basin. - 1996.
- NYSDEC** Contour Maps for Selected Lakes in Onondaga County [Online] // New York State Department of Environmental Conservation. - May 18, 2011. - [http://www.dec.ny.gov/docs/fish\\_marine\\_pdf/ononlkmap.pdf](http://www.dec.ny.gov/docs/fish_marine_pdf/ononlkmap.pdf).
- NYSDEC** New York State 1996 Section 303(d) List of Impaired Waters Requiring a TMDL/Other Strategy [Report] / NYS Department of Environmental Conservation, Division of Water, Bureau of Watershed Assessment and Management. - 1996.
- NYSDEC** New York State 2010 Section 303(d) List of Impaired Waters Requiring a TMDL/Other Strategy [Report] / NYS Department of Environmental Conservation, Division of Water, Bureau of Watershed Assessment and Management. - 2010.
- NYS Environmental Conservation Law** §11-0103. Definitions.
- Onondaga County Department of Water Environment Protection and State University of New York College of Environmental Science and Forestry** Onondaga Lake Fishery: 2011 Factsheet [Report]. - 2011.
- Onondaga County Department of Water Environment Protection (OCDWEP)** Onondaga Lake Ambient Monitoring Program 2004 Annual Report [Report]. - 2005.
- Onondaga County Department of Water Environment Protection** Onondaga Lake Ambient Monitoring Program 2005 Annual Report [Report]. - 2006.
- Onondaga County Department of Water Environment Protection** Onondaga Lake Ambient Monitoring Program 2007 Annual Report [Report]. - 2009.
- Onondaga County Department of Water Environment Protection** Onondaga Lake Ambient Monitoring Program 2009 Annual Report [Report]. - 2010.
- Onondaga County Department of Water Environment Protection** [Excel Spreadsheet]. - October 19, 2011a. - Email coorespondance with Jankaki Suryadava of OCDWEP.

- Onondaga County Department of Water Environment Protection** [Excel file] / prod. Suryadevara Janaki. - 2 25, 2011b.
- Onondaga County Department of Water Environment Protection** Onondaga Lake: Progress Report 2010 [Report]. - July 2011c.
- Onondaga County Personal Communication.** Janaki Suryadevara, Onondaga County Department of Water Environment Protection [Email]. May 5, 2012.
- Schoen Mary E., Mitchell Small, Michael L. DeKay, Elizabeth Casman and Chuck Kroll** Effect of Climate Change on Design-Period Low Flows in the Mid Atlantic US [Conference] // ASCE Conf. Proc. 243 67. - 2007. - doi: 10.1061/40927(243)67.
- Spada Michael [et al.]** The Daphnia Record for Onondaga Lake: Physical and Chemical Signatures of the Clear Water Phase. - 2010.
- Smil, Vaclav** Phosphorus in the environment: Natural flows and human interferences [Journal] Annu. Rev. Energy Environ. - 2000. - 25. - pp. 53-83.
- Struss, Ron.** Nitrogen and phosphorus pollution series: State and local policies to restrict the use of lawn fertilizers. [Seminar] USEPA Watershed Academy Webcast. September 21 2011.
- Taner M. U., J. N. Carleton and M. Wellman** Integrated model projections of climate change impacts on a North American lake [Journal] // Ecological Modeling. - 2011. - 18 : Vol. 222. - pp. 3380-3393.
- Thomas R. Karl Jerry M. Melillo, and Thomas C. Peterson, (eds.)** Global Climate Change Impacts in the United States [Online] // U.S. Global Change Research Program. - 2009. - September 26, 2011. - <http://www.globalchange.gov/what-we-do/assessment/previous-assessments/global-climate-change-impacts-in-the-us-2009>.
- USEPA** Final Chesapeake Bay TMDL [Online] // U.S. Environmental Protection Agency. - 2010. - September 26, 2011. - <http://epa.gov/reg3wapd/tmdl/ChesapeakeBay/tmdlexec.html>.
- USEPA** Guidance for Water Quality-based Decisions: The Total Maximum Daily Load (TMDL) Process [Report]. - April, 1991. - EPA 440/4-91-001.
- USEPA** Technical support document for water quality-based toxics control [Report] / Office of Water. - Washington, D.C. : [s.n.], March 1991. - EPA/505/2-90-001.
- USGS** National Land Cover Data. - 1999.

## Appendix A. Onondaga Lake TMDL Core Analysis Project – Summary of Paleolimnology Results for Pastoral Lake TP and DO Conditions

Selecting TMDL endpoints for water quality parameters in a culturally eutrophied lake requires some degree of certainty that those concentration levels are possible to attain in the system. In the case of phosphorus, and particularly its tie to dissolved oxygen levels, such certainty can be demonstrated by showing that the desired TMDL levels actually existed in the lake at some time in the past. The Onondaga Lake TMDL uses the Onondaga Lake Water Quality Model (OLWQM) (and, for comparison, SED2K) to hindcast pre-pollution, or “pastoral,” lake conditions for TP and DO by removing pollutant loadings in one of its management scenarios (Figure 25). Verification of the hindcast results is provided by independently derived, biologically-based paleolimnologic inference models, the topic of this section.

Separate reports (Rowell et al., 2012a; 2012b) detail the paleolimnology results summarized here. Funded by Honeywell International as an environmental benefit project, the Onondaga Lake TMDL Core Analysis Project involved direction by the New York State Department of Environmental Conservation, with laboratory analyses conducted by investigators from the

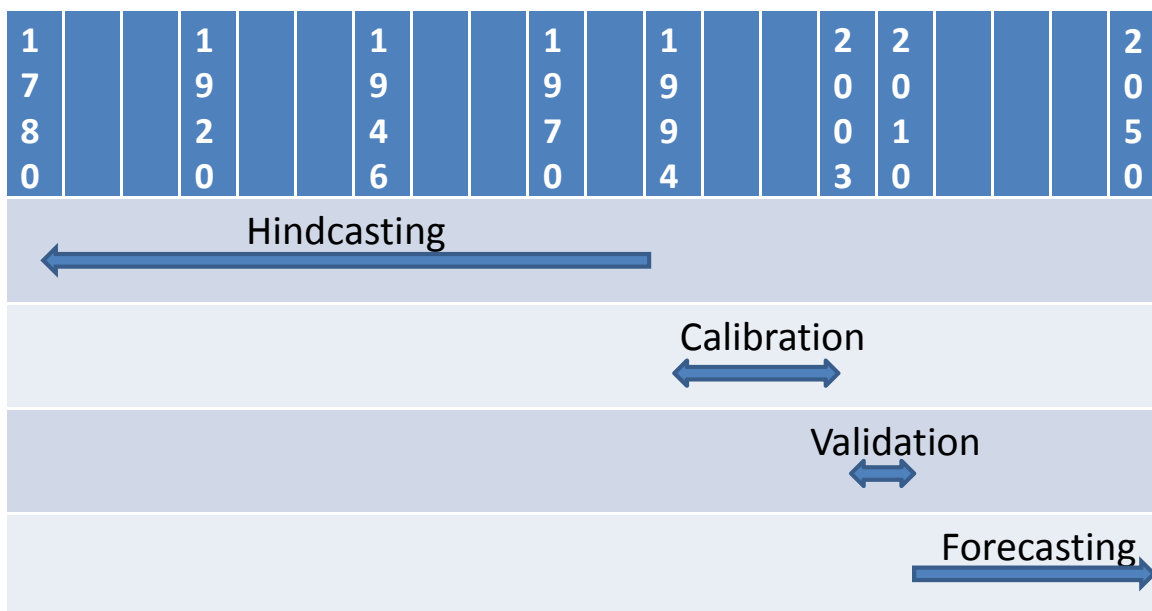
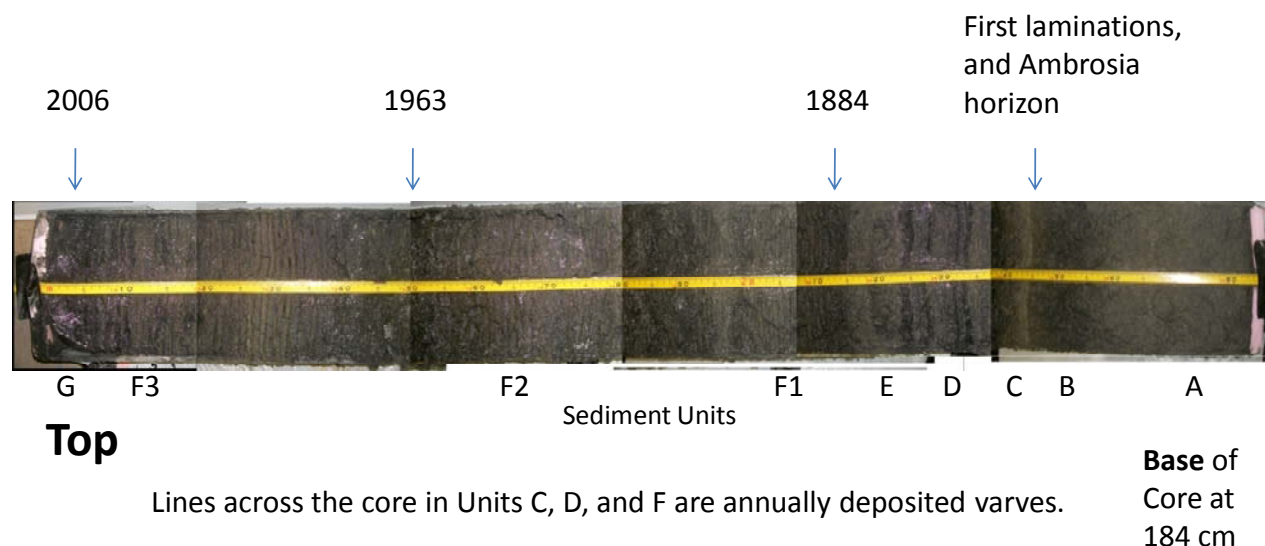


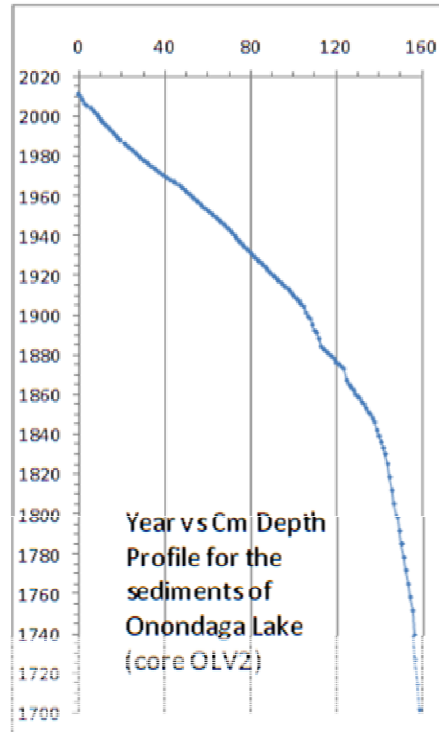
Figure 25: Lake Simulation Model Testing



**Figure 26: 2011 Sediment Core from Center South Basin of Onondaga Lake**

Philadelphia Academy of Natural Sciences, Rensselaer Polytechnic Institute, and the Upstate Freshwater Institute. Large data sets associating diatom ( $n = 1071$  lakes) and chironomid ( $n = 81$  lakes) sediment assemblages with measured TP and DO values, respectively, formed the basis for inferring past concentrations of these parameters in Onondaga Lake. Our study focused on the evidence of water quality found in a sediment core taken from the center of the south basin (South Deep) of Onondaga Lake, and the stratigraphic age determinations necessary to place that water quality in historical context.

The center of Onondaga Lake's southern basin provides the best sediment record of the Lake's history, being the deepest point, the most removed from shoreline influences, most directly the recipient of wastewater, industry, and tributary loadings, and having a broad areal extent relative to the Lake as a whole. The sediment core analyzed for this study is shown in Figure 26. It contains annual pairs of laminations (varves) which can be counted back as far as 1822, providing a firm chronology against which to compare water quality inferences. The profile of sediment accumulation rate (Figure 27) is typical for an increasingly productive lake receiving increasingly heavier sediment loads over time. It rises slowly throughout the 1700s but does not increase dramatically until after permanent settlement of the area which started around 1800.

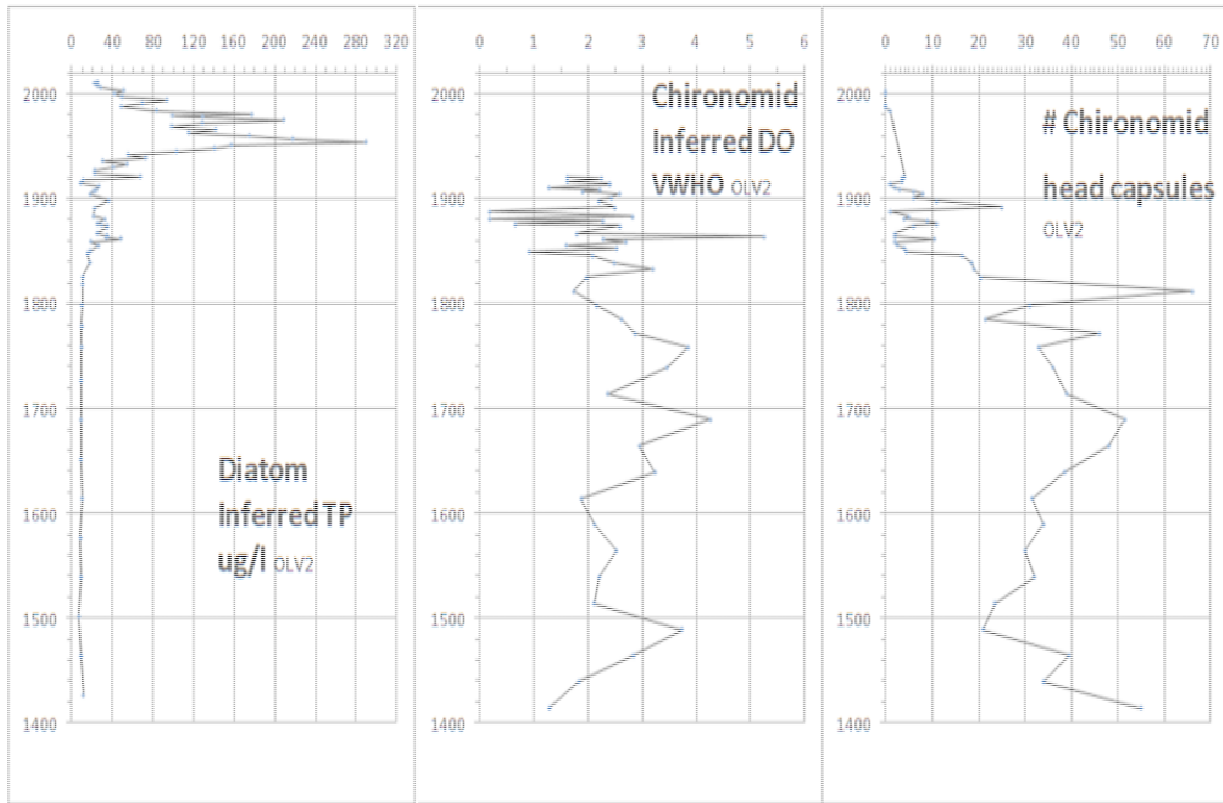


**Figure 27: Profile of Sediment Accumulation Rate in Core from Onondaga Lake**

Three components make up the inference model results (Figure 28).

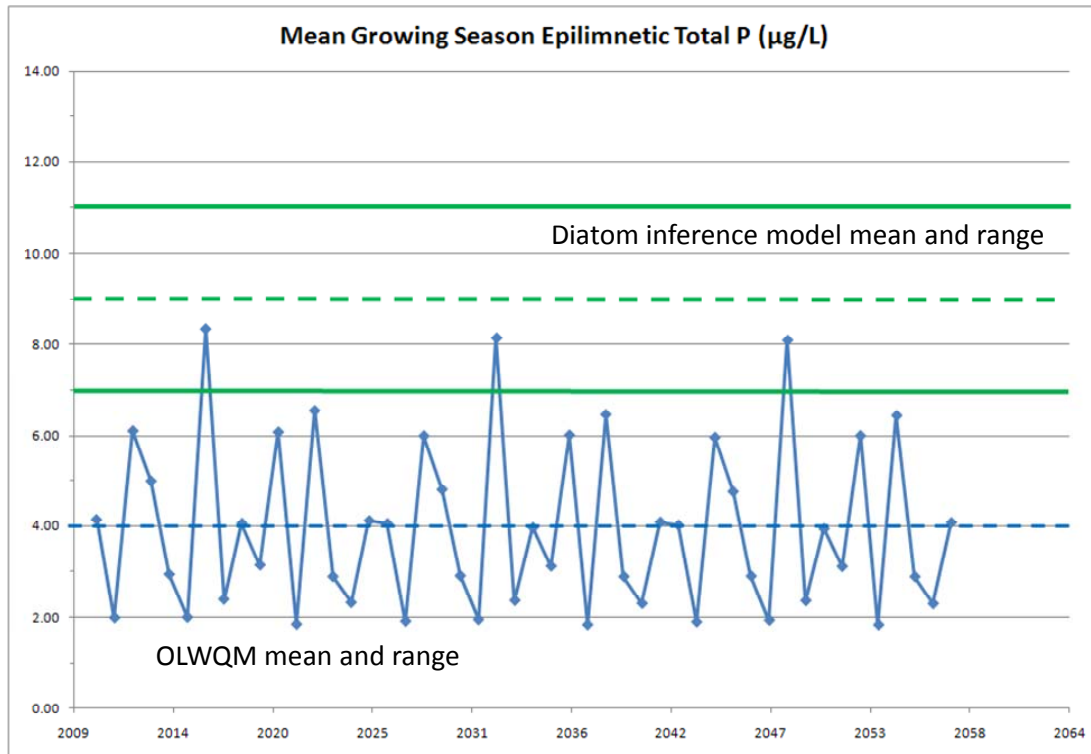
- Diatom inferred TP – prior to 1800 the profile is essentially flat, with values ranging from 7 to 11  $\mu\text{g}\cdot\text{l}^{-1}$  with a mean of 9  $\mu\text{g}\cdot\text{l}^{-1}$ .
- Chironomid inferred DO - quantified as a volume weighted hypolimnetic oxygen level (VWHO), relatable through a lake's hypsographic curve to actual DO measurements. For Onondaga Lake the pre-1820 inferred VWHO averages around 3  $\text{mg}\cdot\text{l}^{-1}$ .
- Number of chironomid head capsules – used to determine the applicability of the DO inference model. In this case head capsules are too few after 1850 for application of the model. Apparently DO was too low, for too long a period of time, to support life in the Lake's profundal sediments. Prior to 1820, although variable, the number of head capsules is adequate for VWHO inferences.

These component profiles, and the steady, lower portion of the sediment accumulation rate profile (Figure 27), constrain our pastoral reference period in Onondaga Lake to around and before the year 1800.



**Figure 28: Components of Inference Models - Diatoms and Chironomids**

Figure 29 compares the results of the diatom TP inference model to the OLWQM hindcasting. Using recent hydrologic variation over a 16 year cycle, modeled repeatedly for 48 years, the OLWQM results range between 2 to 8  $\mu\text{g}\cdot\text{l}^{-1}$  TP with a mean of 4  $\mu\text{g}\cdot\text{l}^{-1}$ , as opposed to the inference model mean of 9  $\mu\text{g}\cdot\text{l}^{-1}$ . A 27% discrepancy can be expected between the inference and hindcasting results, based on comparison of the core's diatom TP inference results from 1978 to 2010 with annual means calculated from actual measurements in the lake ( $n=13$ ) over the same period. Other factors that could contribute to the disagreement between the TP means include different hydrologic conditions during the "Little Ice Age" climate shift that continued until 1850, biasing of diatom assemblages relative to the inference model calibration due to the Lake's historically reported marl and hard water condition, benthic species exposure to higher levels of phosphorus at the sediment surface, and winter growth of some species under higher phosphorus level conditions than during summer. Additionally, recent summer mean TP values in Onondaga Lake from 2008 to 2010 bounce between 14 to 25  $\mu\text{g}\cdot\text{l}^{-1}$ , suggesting a wide enough range in natural TP variability to account for much of the observed difference in the inference and hindcasting TP results.



**Figure 29: Comparison between Diatom Inference Model TP and OLWQM Hindcast TP**

The OLWQM, SED2K, and chironomid-based inference models express hypolimnetic DO in different metrics (units of measurement), but their hindcasts all describe the same pastoral conditions for Onondaga Lake (see Rowell et al. 2012b for a detailed discussion). At the lake bottom, the OLWQM scenario for pastoral conditions reached  $\text{DO} < 1 \text{ mg}\cdot\text{l}^{-1}$  (anoxic) every year, and  $\text{DO} = 0$  in ten of the 16 years in the hindcast cycle (Figure 30). The length of time that anoxia was maintained at the bottom of the lake was considerably shorter (Figure 31a) than for post-pastoral conditions (Figure 31b). According to independent results of the SED2K model (see Rowell et al. 2012b), under best case pastoral conditions the period of anoxia could be as short as two to three weeks, with a layer of  $\text{DO} > 5 \text{ mg}\cdot\text{l}^{-1}$  at the top of the hypolimnion. The DO inference model indicates that up to 70% of the volume of the Lake's hypolimnion had  $\text{DO} < 4.0 \text{ mg}\cdot\text{l}^{-1}$  (hypoxic) during late summer, and up to 15% volume had  $\text{DO} < 1 \text{ mg}\cdot\text{l}^{-1}$ . That all three model metrics indicate summer bottom anoxia in pastoral Onondaga Lake is compatible with the variability shown in the pre-1800 chironomid VWHO inference profile (Figure 28b), the pattern of previously reported faint and discontinuous lamina in pre-1800s Onondaga Lake

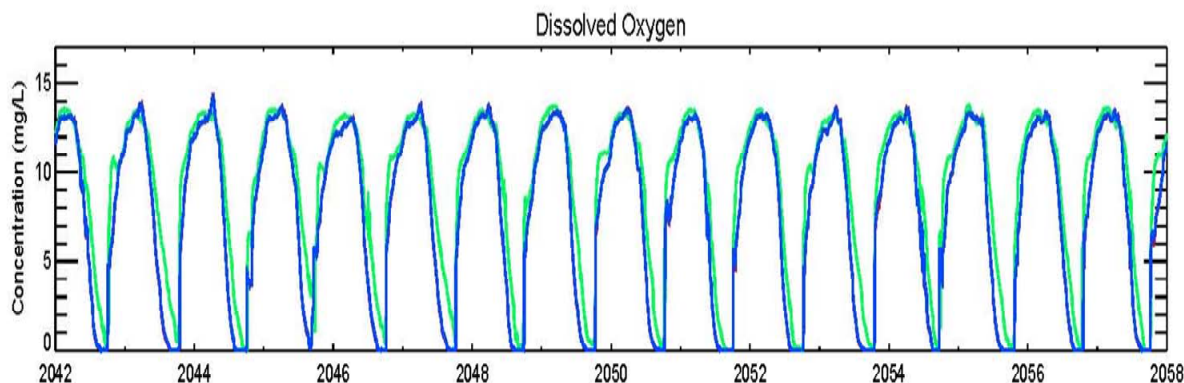


Figure 30: OLWQM Presentation of Pastoral DO Hindcasting Results (light line) Compared to Model Scenario 9 (Current Metro Loading, dark line) (Anchor QEA 2001)

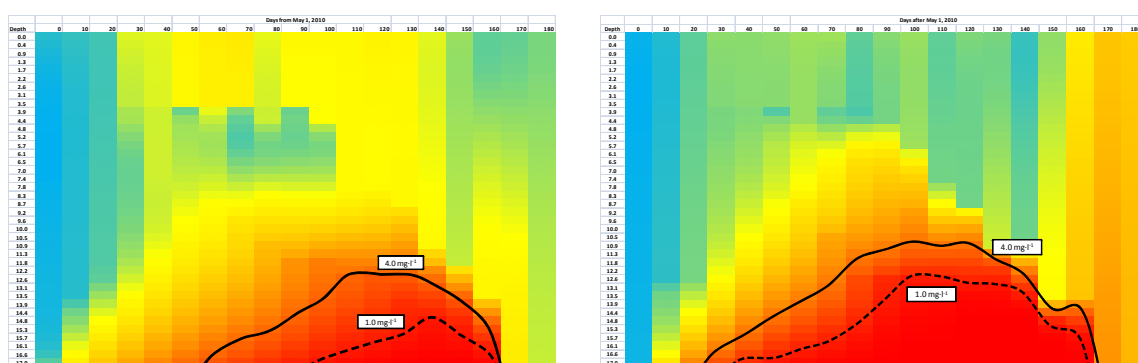


Figure 31: Duration of hypolimnetic anoxia (red) in Onondaga Lake for (a) 2010 as pastoral conditions: anoxia from day 90 to day 160 and (b) 2010 for current conditions: anoxia from day 30 to day 160.

sediments (Rowell 1996) and the observation that anoxia is not uncommon in temperate North American oligotrophic lakes (see Rowell et al. 2012b).

The relationship between TP and DO in pastoral Onondaga Lake is schematically illustrated in Figure 32, representing the results of all the modeling methods employed by the TMDL modeling study. Inference model TP, OLWQM hindcast TP, and SED2K AHOD variability are shown along tracks of the relationships between TP and DO determined from both a literature source (Nurnberg 1995) and from the recent lake itself (UFI unpubl. data). Defined by the overlapping results (and keeping in mind the 2008-2010 fluctuations in lake TP concentrations mentioned above), pre-1800 Onondaga Lake was an oligotrophic lake with epilimnetic TP concentrations varying from 4 to 9  $\mu\text{g}\cdot\text{l}^{-1}$  as a mean. Hypolimnetic DO depletion fluctuated in annual intensity but always resulted in some summer period of DO concentrations at  $< 4$  to 5  $\text{mg}\cdot\text{l}^{-1}$  within the hypolimnion and at least a short summer period of anoxia at the very bottom of

the lake. This study concludes that, within the uncertainty of the modeling methods and natural variability, the paleolimnologic inference models validate the use of the OLWQM and SED2K to hindcast TP and DO conditions for pastoral Onondaga Lake.

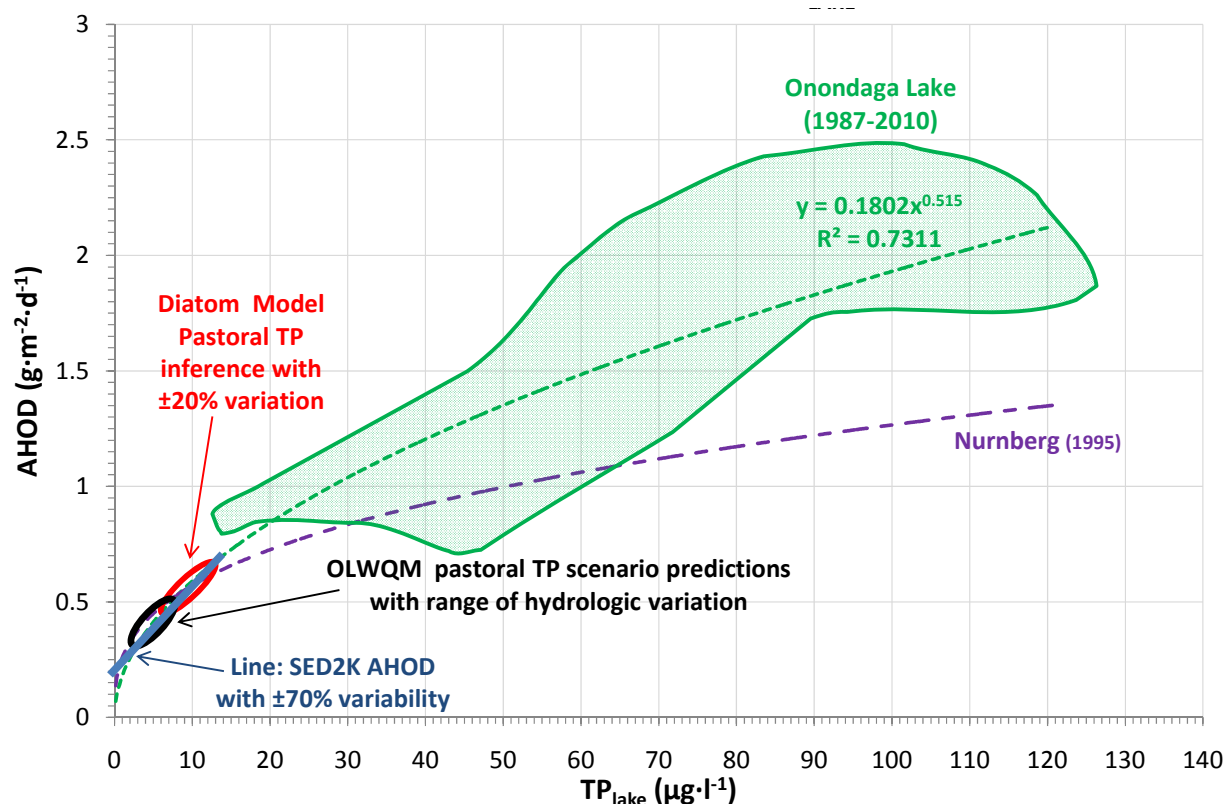


Figure 32: Schematic Representation of the TMDL Modeling Results for Pastoral Conditions in Onondaga Lake

## References

- Anchor QEA, 2011, Results of Additional Management Scenario Simulations with Onondaga Lake Water Quality Model.
- Nurnberg, G. K., 1995, Quantifying Anoxia in Lakes; *Limol. Oceanogr.*, 40(6), 1100-1111.
- Rowell, H. C., 1996, Paleolimnology of Onondaga Lake: the History of Anthropogenic Impacts on Water Quality. *Lake and Reserv. Manage.* 12(1):35-45.
- Rowell et al., 2012a. Varved Sediments in Onondaga Lake, NY: a year by year record through the 19<sup>th</sup> and 20<sup>th</sup> centuries. *In prep.*
- Rowell et al., 2012b. Water Quality Model Hindcasting, and Paleo-Inference Model Verification for a Classic North American Lake: Onondaga Lake, NY, USA. *In prep.*

## Appendix B. Phosphorus Limit for the Protection of Aquatic Life

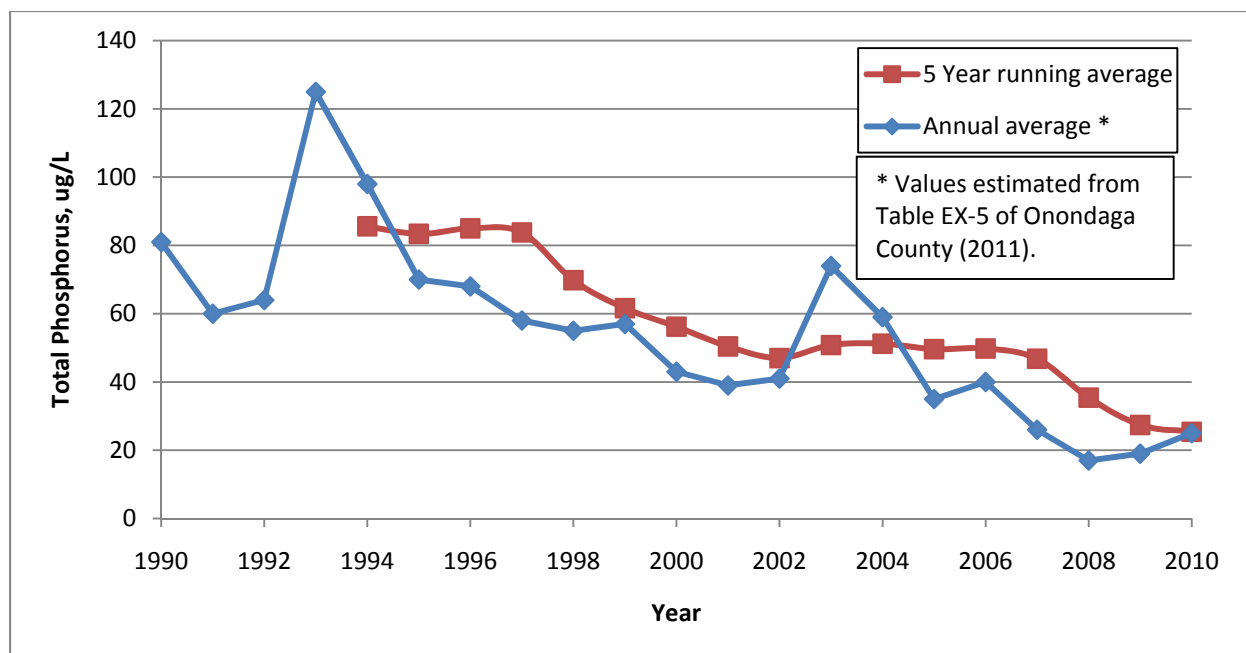
The objective of the Phase II Onondaga Lake Phosphorus TMDL is to establish a numerical limit for total phosphorus that is protective of the best uses. Because Onondaga Lake contains segments that are classified both Class B and C, two best uses must be protected: primary and secondary contact recreation (Class B) and fishing - the waters shall be suitable for fish, shellfish, and wildlife propagation and survival (Class C) (see Section 3.1)

A water quality value of  $20 \mu\text{g}\cdot\text{l}^{-1}$  total phosphorus has already been established to protect primary and secondary contact recreation (see Section 3.1). When multiple types of standards are applicable to the same water body, the most stringent standard applies (6NYCRR Part 703.5(b)). Thus, unless a value *more stringent than*  $20 \mu\text{g}\cdot\text{l}^{-1}$  is necessary to protect aquatic life, the value of  $20 \mu\text{g}\cdot\text{l}^{-1}$  would be applied as the total phosphorus (TP) limit throughout the lake by the Onondaga Lake Phosphorus TMDL.

Productivity of a lake is one of several factors that influence the fish community composition. Lakes with a TP  $< 10 \mu\text{g}\cdot\text{l}^{-1}$  are classified as oligotrophic, lakes with TP  $> 20 \mu\text{g}\cdot\text{l}^{-1}$  are considered to be eutrophic, and lakes between  $10\text{--}20 \mu\text{g}\cdot\text{l}^{-1}$  TP are considered to be mesotrophic (NYSDEC, 2009). Onondaga Lake was historically meso-oligotrophic, with TP concentration estimates ranging from 2 to  $11 \mu\text{g}\cdot\text{l}^{-1}$  based on sediment diatom analyses and OLWQM outputs (see Section 3.2.5). TP concentration in Onondaga Lake have declined dramatically since the 1990s (Figure 33) with the Lake now considered to be meso-eutrophic.

Unlike conventional toxic pollutants, phosphorus (and nitrogen) are not directly harmful to aquatic life, but are in fact, essential nutrients for sustaining primary production. Potential productivity at all trophic levels is set by the nutrient supply (Carpenter, et al., 1985). The biomass and species composition of phytoplankton (i.e., primary production) are regulated by the availability of nutrients, principally phosphorus (McQueen, et al., 1986). Fish production has been shown to be highly correlated to both annual phytoplankton production and total phosphorus (Downing, et al., 1990, Bachmann, 1985; Oglesby, 1977). Higher nutrient levels support greater fish productivity but excess nutrients and algal production can limit habitat for some fish species, create conditions of hypoxia and anoxia (reduced or no dissolved oxygen), affect the nature and spatial distribution of plant life (and therefore fish habitat) and shift the fish community composition to favor populations of fish species that are less desirable for fishing uses (Egertson and Downing, 2004). Finding the appropriate nutrient level for a given lake is a management challenge of balancing demands for fishing, aesthetics and support of aquatic life.

A best use of “fishing” suggests two components. The first component is ecological; the waters must be suitable for fish, shellfish, and wildlife propagation and survival. Onondaga Lake has attained the ecological component of the best use. As of 2010, Onondaga Lake has been inhabited by a diverse variety of fish species (Onondaga County, 2011). In 2000, 24 different fish species were captured in Onondaga Lake by the County’s Ambient Monitoring Program (AMP), and that number increased to 28 species in 2010. Since 1987 more than 50 different fish species have been identified in Onondaga Lake, with 14 species characterized as abundant, 17 species characterized as common, and 20 species described as rare (Onondaga County 2011a).



**Figure 33: Average Summer Total Phosphorus Concentrations in Onondaga Lake Upper Waters**

The second component of the best use is that fishing describes a human use of capturing and harvesting fish for either food, recreation, or both. This second component of the best use implies that a fishery comprised of fish that are desirable for human uses is present, assuming that the presence of such species is consistent with the habitat of the water body. Populations of several important native sport or game fish species including large and smallmouth bass, bluegill and pumpkinseed have rebounded in Onondaga Lake. Other desirable game species such as walleye and Northern pike have been caught in the Lake, but sustaining populations have not yet become reestablished for a variety of reasons. The Lake also abounds with numerous species of “forage” fish, or fish that serve as food for larger piscivorous fish (fish that feed on other fish), such as alewife, gizzard shad, minnows, shiners, and darters. Still other fish that are not highly sought or desired by anglers are presents, such as carp, gar and numerous sucker species.

Thus, the present fish community of Onondaga Lake satisfies both aspects of the best use of fishing; there is an abundant, diverse and largely self-sustaining fish community present which is well represented by species that are desirable to anglers.

Figure EX-5 of Onondaga County (2011) illustrates the changes in the average summer total phosphorus (TP) concentration in the epilimnion of Onondaga Lake since 1990 (reproduced as Figure 33). It shows a descending trend, broken by two upward spikes in 1993 and 2003. The effect of the spikes can be dampened by looking at the 5 year running average over the same period. This analysis shows that the running TP concentration average was steady at slightly more than  $80 \mu\text{g}\cdot\text{l}^{-1}$  from 1994 to 1997, then steadily declined from 1997 to 2000, when it stabilized again at around  $50 \mu\text{g}\cdot\text{l}^{-1}$  until 2007, where it again entered a period of steady decline until attaining the present value of about  $25 \mu\text{g}\cdot\text{l}^{-1}$ .

The steady, nearly threefold decline of TP from a running average of around  $80 \mu\text{g}\cdot\text{l}^{-1}$  in the early 1990s to the present level of around  $25 \mu\text{g}\cdot\text{l}^{-1}$ , and the concomitant reduction in primary (algal)

production, would be expected to have both positive and negative impacts on the rest of the aquatic life community of Onondaga Lake. Algae are a major food source for zooplankton, which in turn are the food source for many invertebrates and forage fish, which in turn are the food source for game fish. The fish community composition of any lake is determined by multiple factors including: temperature, productivity, size, depth and connectivity to adjacent waterbodies. Declining TP concentrations will affect total fish productivity (biomass) in Onondaga Lake but will affect some species more than others. For example, Yurk and Ney (1989) reported that when phosphorus levels were similarly reduced in Smith Mountain Lake, Virginia, the standing stock of planktivorous fish (i.e. fish that feed on plankton) such as gizzard shad and alewives, declined dramatically, whereas the standing stock of species such as striped bass, walleye, and largemouth and smallmouth bass were not significantly affected. They hypothesized that the reason for the dramatic impact to planktivores without similar impacts to game species was because the dominant forage fish in the lake was the planktivorous gizzard shad. Gizzard shad rapidly outgrow the size range of forage fish readily consumed by the piscivores in the lake (Noble 1981), effectively trapping energy in a pool of large, invulnerable planktivores. Once the gizzard shad reached a size that could not be ingested by the available predators, they were no longer available as forage. In Onondaga Lake, both gizzard shad and alewife are the primary planktivores present, and both are described as abundant. Kohler (1982) suggests that alewives, like gizzard shad, have the capacity to outgrow the size range available to the piscivores present in Onondaga Lake. A significant reduction in phosphorus would be expected to result in significant reductions to gizzard shad and alewife standing stock, but such a reduction may not translate to an impact on the biomass of game fish present.

The alewife biomass in Onondaga Lake has not, in fact, experienced a reduction in biomass proportional to the reduction of phosphorus. One possible reason for the lack of impact is an expansion of available habitat. The reduction of phosphorus has reduced algal production. Excessive algae production in Onondaga Lake has resulted in the deposition of dead algae to the lower levels of the lake, where it was aerobically degraded initially, resulting in the depletion of hypolimnetic oxygen and anoxia. With reduced algae production, the rate and extent of hypolimnetic anoxia has diminished, leading to an increase in the lake volume where dissolved oxygen is sufficient for fish activity. Alewives are pelagic fish, and would take advantage of the increase in available deeper, open water habitat. Exploiting this increase in pelagic habitat would help them elude the primary predators in the lake, large- and smallmouth bass, which prefer littoral habitat (Kohler 1982). However, recent changes in the size distribution of smallmouth bass suggest that perhaps they too are adapting to the increased habitat availability and are shifting to deeper, offshore foraging (Onondaga County 2011). The benefit of increased habitat availability from reduced TP might mask adverse impacts to the alewife population from decreased algae production.

The proposed value of  $20 \mu\text{g}\cdot\text{l}^{-1}$  TP to protect recreational uses is not inconsistent with the concentration of TP found in the majority of lakes in New York State. In a detailed study NYSDEC (2009) evaluated the water quality of 1,328 lakes and reported that 911 (67%) had TP of  $20 \mu\text{g}\cdot\text{l}^{-1}$  or less. Since the targeted concentration of  $20 \mu\text{g}\cdot\text{l}^{-1}$  TP is consistent with the concentration of TP in most lakes in New York State, it would sustain the aquatic life in Onondaga Lake.

The increased water clarity resulting from reduced algae production has allowed for a vast expansion of rooted aquatic macrophytes within the littoral zone, providing significantly improved fish habitat. The percent of the littoral zone with macrophytes has increased fivefold since 2000, and the number of macrophyte species has increased from less than ten in 2000 to more than 20 in 2010 (Onondaga County 2011). Macrophytes are a very important component of a healthy lake ecosystem. They provide cover and shelter for fish and invertebrates. Engel (1985) reported that bottom macroinvertebrates were more diverse and numerous under submerged macrophytes than on bare bottom, and that in June-August nearly three-fourths of all bottom fauna occurred beneath macrophytes. Juvenile fish are better able to survive and grow when they can hide and forage in macrophytes. Clearly, the fish community has benefited from the expansion of macrophyte beds.

Finally, despite a continuous decrease in TP in Onondaga Lake since 1993, fisheries metrics have only improved. For example, the electrofishing catch rate for large- and smallmouth bass combined has increased from less than 20 per hour in 2001 to more than 40 per hour in 2009. Furthermore, the proportion of fish in larger size classes has increased for bass, sunfish, perch, and bullheads (Onondaga County 2011).

In general, fish production is proportionally related to TP, with more TP resulting in more fish. In Onondaga Lake, however, it appears that excessive nutrient loading and algae production in the past has suppressed fish production, probably by limiting habitat. By reducing the TP, increased habitat resulted, both in terms of a greater volume of oxygenated water and an expansion of littoral area covered by macrophytes. The present state of the Onondaga Lake fish community suggests that it has benefited from the phosphorus abatement program, and that attainment of the recreationally-based TP limit of  $20 \mu\text{g}\cdot\text{l}^{-1}$  will protect and sustain the aquatic life.

## References

- Bachmann, R.W., B.L. Jones, D.D. Fox, M. Hoyer, L.A. Bull, and D.E. Canfield, Jr., 1985. Relations between trophic state indicators and fish in Florida (U.S.A.) lakes. *Can. J. Fish. Aquat. Sci.* 53(4): 842-855 (1996).
- Carpenter, S.R., J.F. Kitchell, and J.R. Hodgson, 1985. Cascading trophic interactions and lake productivity. *Bioscience* 35(10):634-639.
- Downing, J.A., C. Plante, and S. Lalonde. 1990. Fish production correlated with primary productivity, not the morphoedaphic index. *Can. J. Fish. Aquat. Sci.* 47(10): 1929-1936.
- Egertson, C.J. and J.A. Downing. 2004. Relationship of fish catch and composition to water quality in a suite of agriculturally eutrophic lakes. *Can. J. Fish. Aquat. Sci.* 61(9): 1784-1796.
- Engel, S., 1985. Aquatic community interactions of submerged macrophytes. Technical Bulletin No. 156, Department of Natural Resources, Madison Wisconsin

- Kohler, C.C., 1982. The impact of transplanted forage fish, the alewife (*Alosa pseudoharengus*) on a reservoir fishery in southeastern United States. In Documents presented at the symposium on stock enhancement in the management of freshwater fisheries. EIFAC Technical Paper No. 42, supplement volume 2.
- McQueen, D.J., J.R. Post, and E.L. Mills, 1986. Trophic relationships in freshwater pelagic ecosystems. Can. J. Fish Aquat. Sci. 43(8):1571-1581.
- Noble, R.L., 1981. Management of forage fishes in impoundments of the southern United States. Trans. Am. Fish Soc. 110(6):738-750.
- Oglesby, R.T., 1977. Relationships of fish yield to lake phytoplankton standing crop, production, and morphoedaphic factors. J. Fish. Res. Board Canada 34(12):2271-2279.
- NYSDEC, 2009. Clean Lakes Assessment Report. New York State Department of Environmental Conservation, Division of Water.  
([http://www.dec.ny.gov/docs/water\\_pdf/305blakes10.pdf](http://www.dec.ny.gov/docs/water_pdf/305blakes10.pdf))
- Onondaga County, 2011. Onondaga Lake Ambient Monitoring Program, 2010 Annual Report Final, November 2011. Onondaga County Department of Water Environment Protection, Syracuse, NY
- Onondaga County 2011a. Onondaga Lake Fishery: 2011 Fact Sheet. Onondaga County Department of Water Environment Protection, Syracuse, NY, October 2011.  
[http://static.ongov.net/WEP/wepdf/OnondagaLakeFishery-2011\\_FactSheet%20\(Oct2011\).pdf](http://static.ongov.net/WEP/wepdf/OnondagaLakeFishery-2011_FactSheet%20(Oct2011).pdf)
- Smith, C.L., 1985. The Inland Fishes of New York State. New York State Department of Environmental Conservation.
- Yurk, J.J., and J.J. Ney, 1989. Phosphorus-fish community biomass relationships in southern Appalachian reservoirs: can lakes be too clean for fish? Lake and Reservoir Management 5(2):83-90.

## Appendix C. Climate Change and Onondaga Lake

Scientists at the United States Environmental Protection Agency used a collection of general atmospheric circulation models (GCMs), watershed and lake simulation models to predict the impacts of future climate change on the physical chemical and biological nature of Onondaga Lake (Taner et al., 2011). The modeling approach used by Taner et al. (2011) is shown in Figure 34.

The modeling approach consisted of projecting future climatic conditions and using that information to produce hydrologic inputs to Onondaga Lake using the watershed model HSPF (Bicknell et al., 2005) and the Lake thermal structure, using the model UFILS4 (Effler, 1996). These two mechanistic models were then coupled with the lake ecosystem model AQUATOX (Park et al., 2008) to forecast the future chemical and biological conditions in the Lake.

Several GCMs exist, which predict a range of possible future climates based upon possible future emission scenarios. There is no one model or outcome which best predicts the future climate for a given region. There is, however, a general agreement amongst the GCMs in terms of how the climate may change. In New York, the predicted changes include (US Global Change Research Program, 2009):

- More frequent days with temperatures above 90°F (32.2°C)
- A longer growing season
- Increased heavy precipitation
- Less winter precipitation falling as snow and more as rain
- Reduced snowpack
- Earlier breakup of winter ice on lakes and rivers
- Earlier spring snowmelt resulting in earlier peak river flows
- Rising sea surface temperatures and sea level
- Short term droughts of 1 to 3 months as frequently as each summer
- Continued increase in air temperature particularly in winter

Downscaling of the GCM results for the Onondaga Lake region by Taner et al. (2011) predicted increases in air temperatures of up to 5°F (3°C) by 2039 and up to 10°F (6°C) by 2069. Precipitation in the model was varied between 80% and 120% of the 1996 – 2008 measured amounts. Taner et al. (2011) took into account the downscaled climate predictions to predict the changes to the physical and chemical properties of Onondaga Lake as well as the response of 16 Lake biota including phytoplankton, macroinvertebrates and several species of fish. Both a near future (2010 – 2039) and a mid-century (2040 – 2069) period was modeled.

Predicted average increases in the water temperature were up as much as 4.1°F (2.3°C) and 9.4°F (5.2°C) in the epilimnion by 2039 and 2069, respectively, and as much as 2.7°F (1.5°C) and 6.7°F (3.7°C) in the hypolimnion by 2039 and 2069, respectively. Lake warming was predicted to be greater during the fall than during the winter. Depth to the summer thermocline was predicted to increase with earlier onset, particularly during the latter modeling period. Thermal stratification was predicted to last from 150 – 155 days during the 2010 to 2039 period and 172

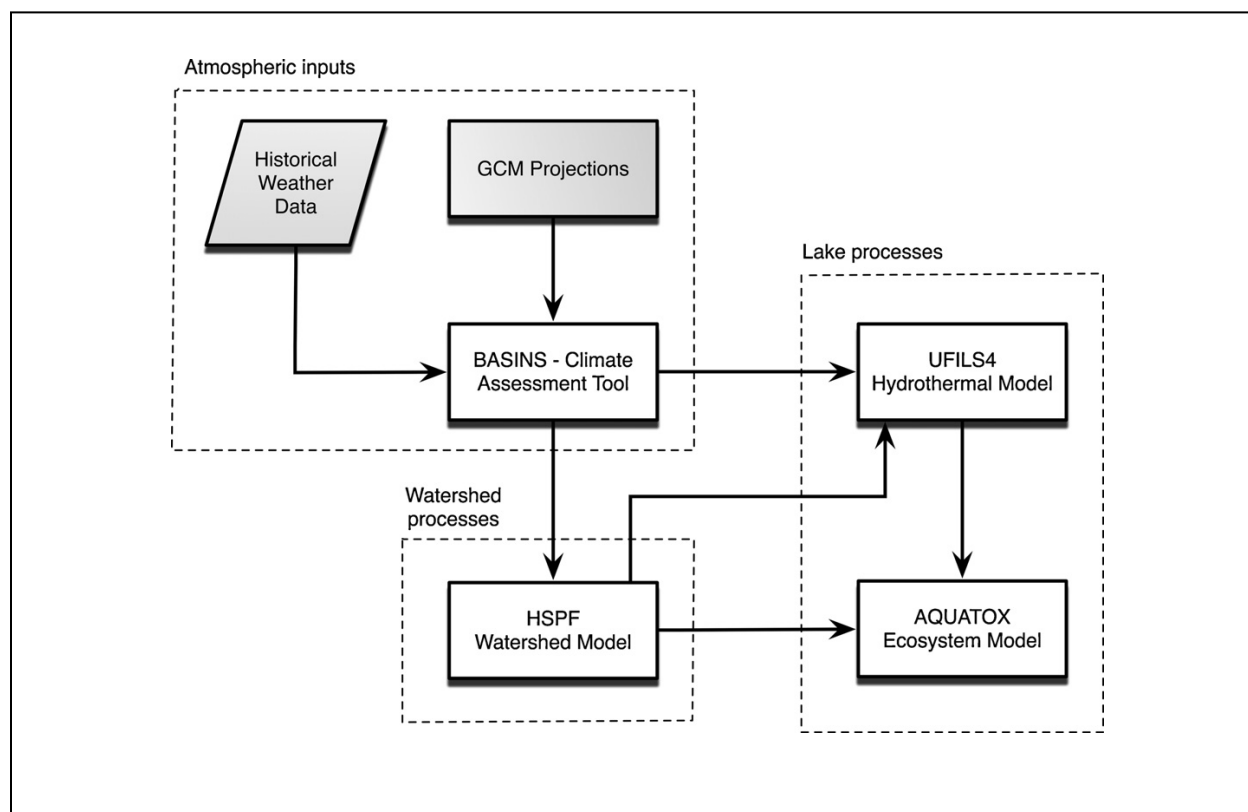


Figure 34: Onondaga Lake Climate Change Modeling Framework (Taner et al., 2011)

days during the 2040 – 2069 modeling period. Currently the period of thermal stratification varies between 133 to 203 days.

Predicted changes in the chemical composition of the Lake include earlier onset of the springtime depletion of  $\text{NH}_3$  and total soluble phosphorus (TSP) in the epilimnion. Hypolimnetic dissolved oxygen (DO) is significantly affected during both modeling periods (Figure 35), with the periods of DO less than  $6 \text{ mg}\cdot\text{l}^{-1}$  increasing by up to 15 and 30 days in the 2010 to 2039 and 2040 to 2069 periods, respectively. Periods of anoxia were predicted to occur in the hypolimnion annually in August and September during both modeling periods.

The biologic response to the changing environmental conditions was less certain but plankton taxa were projected to thrive while the responses of higher trophic levels was mixed. In the model, macroinvertebrates and fish responses were species dependent based upon food availability and tolerance of increased water temperatures.

A report currently being developed by the U.S. Fish and Wildlife Service (U.S. FWS, 2012) and other agencies expands upon observed and anticipated impacts on plants and animals as a result of climate change. The increased air temperatures are anticipated to impact cold water fisheries. Some fish species of the northeast coast have already been observed to be shifting northward or to deeper waters in response to increasing water temperatures. In deep freshwater lakes longer periods of thermal stratification and depleted oxygen are impacting cold water fish such as lake trout and cisco. Harmful algal blooms are anticipated to occur more often as well as starting

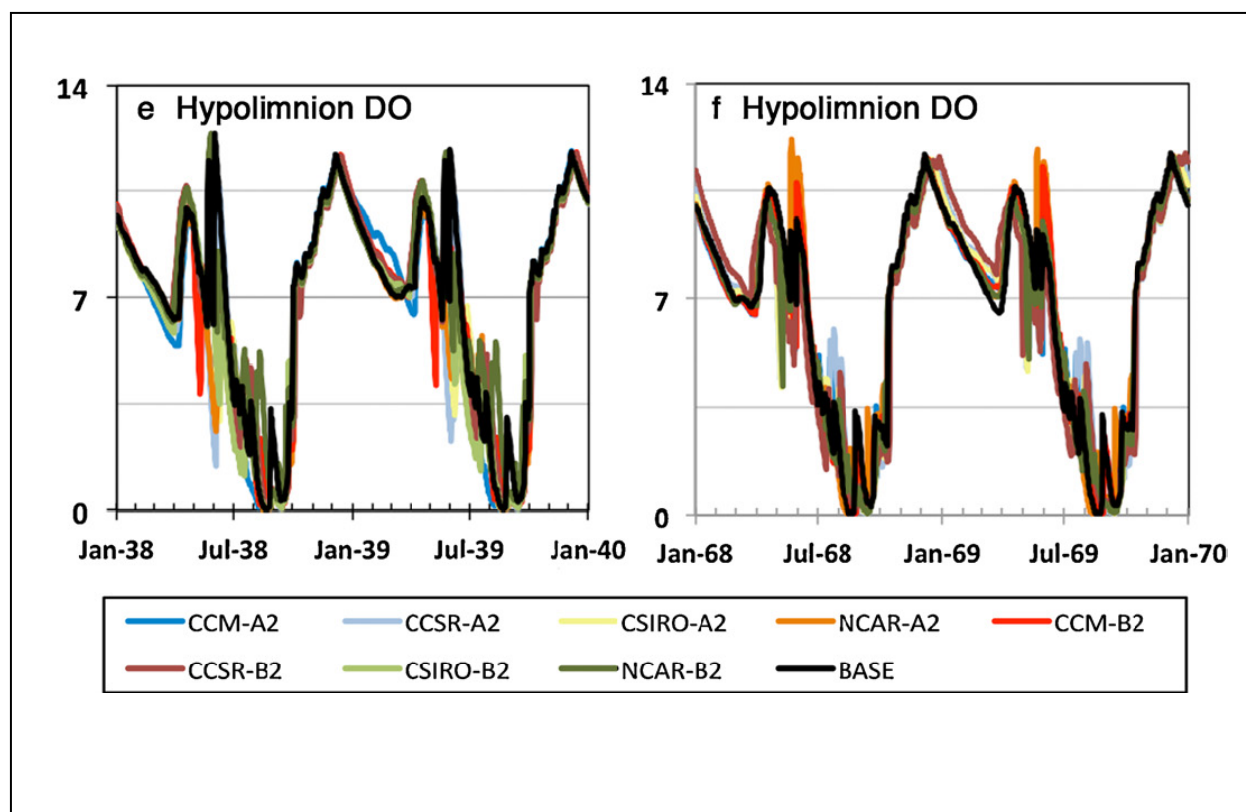


Figure 35: Predicted Climate Change Impacts (2038-2040 and 2068-2070) on Hypolimnetic Dissolved Oxygen in Onondaga Lake (Taner et al., 2011)

earlier and continuing later in the year. Such trends have already been observed in Puget Sound. Lakes may also experience shorter periods of ice cover, increased evapotranspiration (ET) and increased winter productivity. Changes in precipitation patterns may lead to decreased lake levels and changes in salinity and flows.

Several other studies of the potential effects of climate change in North America confirm many of the findings of Taner et al. (2011) and the U.S. FWS (2012) and also indicate other areas of potential change which should be taken into consideration. As a part of the Chesapeake Bay TMDL study (U.S. EPA, 2010) 42 climate change scenarios were modeled. On an annual basis, sediment loads increased while nitrogen and phosphorous loads decreased. For phosphorus, however, increased loading was predicted during the months of June through August while decreased loading was predicted for the winter months. Total suspended solids were also predicted to increase during June through August and were attributed to increased rainfall intensity.

Schoen et al. (2007) predicted that the largest changes in stream flow will be to snow-dominated basins. In New York, with less winter precipitation as snow fall and more as rain fall, winter stream flows will be greater while the spring snow melt runoff will be diminished. Even considering the anticipated increases in precipitation, Schoen et al. (2007) predicted decreased low flow values for streams (calculated as the 7Q10) due to increased ET. Taner et al. (2011) and the Chesapeake Bay TMDL study (U.S. EPA, 2010) reached similar conclusions. Coupled with the predicted increases in short term summer droughts, TMDL limits may need to be decreased

as river flows decrease. Such limits will be particularly important for streams, but may also become important for other water bodies such as Onondaga Lake depending upon management practices, e.g. if lake levels can be maintained due to the changing hydrologic cycle and increased ET. Furthermore the timing of nutrient delivery to the lake may be important, as demonstrated by the predicted increase in phosphorous delivery during the growing season.

Results from studies on the potential effects of climate change in Canada draw similar conclusions and point out possible effects on lakes as well (Canada, 2010). These results correlated well with those of Taner et al. (2011) and the U.S. FWS (2012) and included increased lake temperatures causing changes in water chemistry and thermal stratification, both of which may change nutrient cycling in those water bodies. Increased temperatures may also increase the use of dissolved oxygen by plants and animals, increasing the potential for dissolved oxygen depletion. Warmer lake temperatures would also likely cause a shift away from cold water fish towards species more tolerant of warmer waters.

Climate change will also cause changes in land use and land cover. Warming and a longer growing season may change the types and amounts of viable crops in the region as the current crops are pushed further north to a more tolerable climate. Different crops may have different nutrient requirement which could increase or decrease the amount of fertilizer applied. Warming temperatures may also increase the trend of the conversion of seasonal homes into year round occupancies. This may increase nutrient loads from septic systems but could also provide the justification for the expansion of municipal sewer systems. Increased populations would also place increased demand on water resources.

The level of uncertainty surrounding climate change at the local level, and the human response to it, makes it difficult to predict how the delivery of phosphorous to Onondaga Lake will change in the future. Recognizing that the climate will continue to change in the coming years, we must adopt an adaptive management strategy for dealing with the effects. This may include a reevaluation of the phosphorous TMDL in the future as the impacts of global climate change on the local environment become clearer.

## References

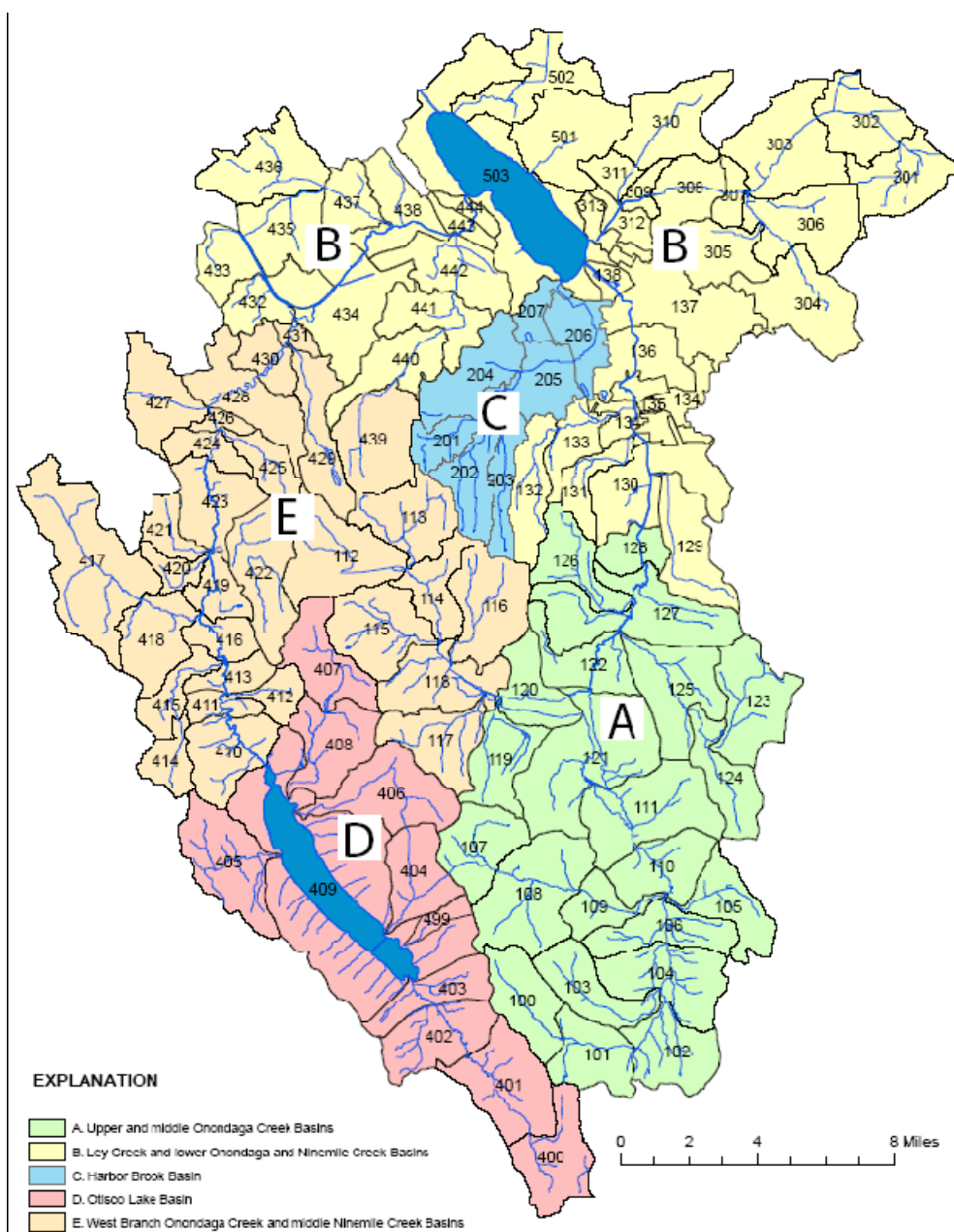
- Bicknell, B., Imhoff, J., Kittle, J., Jobes, T.H., Donigian, A.S., (2005). Hydrological Simulation Program – FORTRAN (HSPF). User's Manual for Release 12.2. Athens,GA.
- Effler, S.W., (1996). Limnological and Engineering Analysis of a Polluted Urban Lake: Prelude to Environmental Management of Onondaga Lake, New York. Springer-Verlag, New York, 832 pp.
- National Round Table on the Environment and the Economy. (2010). Degrees of Change: Climate Warming and the Stake for Canada. Ottawa, Canada.
- Schoen, M. E., M. Small, M. L. DeKay, E.H Casman and C. Kroll (2007). Effect of Climate Change on Design-Period Low Flows in the Mid Atlantic US. *ASCE Conf. Proc.* 243 67.

- Taner, M. U., J. N. Carleton and M. Wellman (2011). Integrated model projections of climate change impacts on a North American lake. *Ecological Modeling* 22:3380-3393.
- U.S. Environmental Protection Agency (2010). "Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment." <http://www.epa.gov/reg3wapd/tmdl/ChesapeakeBay/tmdlexec.html> Accessed September 26, 2011.
- U.S. Fish and Wildlife Service (2011). "National Fish, Wildlife and Plants Climate Adaptation Strategy - Public Review Draft." January, 2012.
- U.S. Global Change Research Program. (2009). "Global Climate Change Impacts in the United States." T. R. Karl, J. M. Melillo, and T. C. Peterson, (eds.). Cambridge University Press. <http://www.globalchange.gov/what-we-do/assessment/previous-assessments/global-climate-change-impacts-in-the-us-2009> Accessed September 26, 2011.

## Appendix D. HSPF Output Post Processing Procedure

The following procedure was followed to attribute simulated total phosphorus (TP) loads to the land use categories listed in Table 5.

1. HSPF does not simulate TP directly from the hydrologic response units therefore, loading rates cannot be computed. The model does however simulate orthophosphate (OP) and organic phosphorus (Org P) from the hydrologic response units. The loading rates are specific to each of the five precipitation areas in the watershed as depicted in Figure 36. The sum of the OP and Org P loading rates was used as an estimate of the TP loading rate. Loading rates for OP, Org P and TP are listed in Tables 17 to 19.
2. Multiply applicable TP loading rates for each land type by the acreages contained in `lulc5_by_subbasin.xlsx` (provided by Bill Coon, USGS) for each sub basin. This yields TP loads generated by each land type in a particular sub basin.
3. TP loads calculated in step 2 were compared to the TP load fluxes per sub basin simulated by the HSPF contained in `WatershedOutput_by_RCH.xlsx` (provided by Bill Coon, USGS). In general the TP loads calculated using the estimated loading rates were comparable to the load flux model output. Discrepancies between the computed and modeled loads can be attributed to inter basin processes accounted for in the model as well as model calibration to field data.
4. The sum and percentage of TP load attributed to each land type were computed for the following three sub basin characteristics:
  - Sub basins containing both CSO and Non CSO areas
  - Sub basins containing CSO areas only
  - Sub basins containing Non CSO areas only
5. Delivered TP loads were calculated for each sub basin using HSPF output contained in `HotSpotAnalysis2.xlsx` (provided by Bill Coon, USGS). The Base TP delivered load was subtracted from the delivered load associated with the removal of a particular sub basin from the simulation. This difference in load represents the delivered load attributed to that particular sub basin. This exercise was performed for all sub basins with the exception of sub basin 503. Sub basin 503 was not simulated using HSPF; rather, USGS estimated yearly loads using export coefficients.
6. The percentage of TP load generated by each land type calculated in Step 4 was then multiplied by the delivered load calculated in Step 5 for all the sub basins except basin 503. This yields delivered TP loads per land type for the entire watershed.



**Figure 36: Map of the 5 Precipitation Areas Defined in the HSPF Model**

Table 17: Orthophosphate Loading Rates

| Orthophosphate loading rates (lbs/ac/yr)   |                    |       |       |       |       |         |
|--------------------------------------------|--------------------|-------|-------|-------|-------|---------|
|                                            | Precipitation Area |       |       |       |       |         |
| Land Use Category                          | A                  | B     | C     | D     | E     | Average |
| Forest (low)                               | 0.017              | 0.016 | 0.01  | 0.021 | 0.017 | 0.02    |
| Forest (high)                              | 0.018              | 0.018 | 0.012 | 0.021 | 0.018 | 0.02    |
| Pasture-hay (low)                          | 0.02               | 0.018 | 0.01  | 0.024 | 0.02  | 0.02    |
| Pasture-hay (high)                         | 0.021              | 0.02  | 0.015 | 0.025 | 0.022 | 0.02    |
| Row                                        | 0.145              | 0.076 | 0.061 | 0.775 | 0.26  | 0.26    |
| Farmstead                                  | 0.254              | 0.218 | 0.172 | 1.61  | 0.91  | 0.63    |
| Wetland                                    | 0.139              | 0.142 | 0.088 | 0.254 | 0.234 | 0.17    |
| Low-intensity res                          | 0.085              | 0.065 | 0.052 | 0.097 | 0.089 | 0.08    |
| High-intensity res                         | 0.101              | 0.065 | 0.054 | 0.121 | 0.111 | 0.09    |
| Commercial-industrial-transportation       | 0.113              | 0.073 | 0.06  | 0.142 | 0.127 | 0.1     |
| CSO (low intensity)                        | --                 | 0.11  | 0.12  | --    | --    | 0.12    |
| CSO (high intensity)                       | --                 | 0.14  | 0.32  | --    | --    | 0.23    |
| CSO (commercial-industrial-transportation) | --                 | 0.07  | 0.29  | --    | --    | 0.18    |
| Urban/Rec grass                            | 0.056              | 0.035 | 0.024 | 0.064 | 0.063 | 0.048   |

Table 18: Organic Phosphorus Loading Rates

| Organic Phosphorus loading rates (lbs/ac/yr) |                    |       |       |       |       |         |
|----------------------------------------------|--------------------|-------|-------|-------|-------|---------|
|                                              | Precipitation Area |       |       |       |       |         |
| Land Use Category                            | A                  | B     | C     | D     | E     | Average |
| Forest (low)                                 | 0.06               | 0.009 | 0.006 | 0.09  | 0.08  | 0.05    |
| Forest (high)                                | 0.14               | 0.08  | 0.08  | 0.18  | 0.16  | 0.13    |
| Pasture-hay (low)                            | 0.1                | 0.014 | 0.009 | 0.14  | 0.13  | 0.08    |
| Pasture-hay (high)                           | 0.3                | 0.18  | 0.16  | 0.38  | 0.33  | 0.27    |
| Row                                          | 1.18               | 0.31  | 0.3   | 1.56  | 1.45  | 0.96    |
| Farmstead                                    | 8.91               | 3.3   | 3.3   | 11.3  | 10.9  | 7.54    |
| Wetland                                      | 0.08               | 0.06  | 0.02  | 0.11  | 0.11  | 0.08    |
| Low-intensity res                            | 0.49               | 0.43  | 0.42  | 0.53  | 0.52  | 0.48    |
| High-intensity res                           | 0.770              | 0.700 | 0.630 | 0.860 | 0.330 | 0.660   |
| Commercial-industrial-transportation         | 0.960              | 0.850 | 0.780 | 1.110 | 1.070 | 0.950   |
| CSO (low intensity)                          | --                 | 0.450 | 0.420 | --    | --    | 0.440   |
| CSO (high intensity)                         | --                 | 0.540 | 0.710 | --    | --    | 0.630   |
| CSO (commercial-industrial-transportation)   | --                 | 0.670 | 0.860 | --    | --    | 0.770   |
| Urban/Rec grass                              | 0.350              | 0.103 | 0.083 | 0.368 | 0.352 | 0.242   |

Table 19: Total Phosphorus Loading Rates

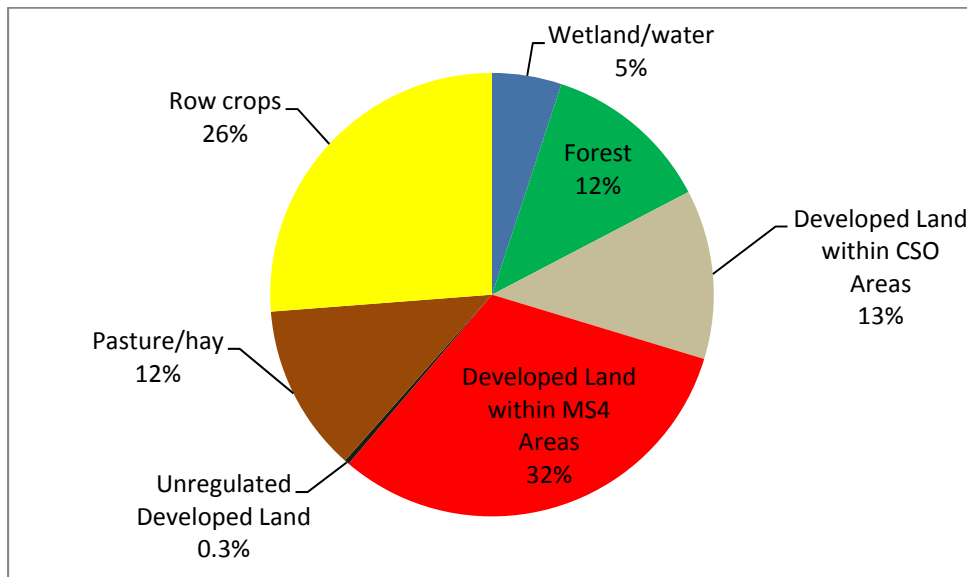
| Estimated Total Phosphorus loading rates (lbs/ac/yr) |                    |       |       |       |       |         |
|------------------------------------------------------|--------------------|-------|-------|-------|-------|---------|
| Land Use Category                                    | Precipitation Area |       |       |       |       | Average |
|                                                      | A                  | B     | C     | D     | E     |         |
| Forest (low)                                         | 0.077              | 0.025 | 0.016 | 0.111 | 0.097 | 0.0652  |
| Forest (high)                                        | 0.158              | 0.098 | 0.092 | 0.201 | 0.178 | 0.1454  |
| Pasture-hay (low)                                    | 0.12               | 0.032 | 0.019 | 0.164 | 0.15  | 0.097   |
| Pasture-hay (high)                                   | 0.321              | 0.2   | 0.175 | 0.405 | 0.352 | 0.2906  |
| Row                                                  | 1.325              | 0.386 | 0.361 | 2.335 | 1.71  | 1.2234  |
| Farmstead                                            | 9.164              | 3.518 | 3.472 | 12.91 | 11.81 | 8.1748  |
| Wetland                                              | 0.219              | 0.202 | 0.108 | 0.364 | 0.344 | 0.2474  |
| Low-intensity res                                    | 0.575              | 0.495 | 0.472 | 0.627 | 0.609 | 0.5556  |
| High-intensity res                                   | 0.871              | 0.765 | 0.684 | 0.981 | 0.441 | 0.7484  |
| Commercial-industrial-transportation                 | 1.073              | 0.923 | 0.84  | 1.252 | 1.197 | 1.057   |
| CSO (low intensity)                                  | 0                  | 0.56  | 0.54  | 0     | 0     | 0.22    |
| CSO (high intensity)                                 | 0                  | 0.68  | 1.03  | 0     | 0     | 0.342   |
| CSO (commercial-industrial-transportation)           | 0                  | 0.74  | 1.15  | 0     | 0     | 0.378   |
| Urban/Rec grass                                      | 0.406              | 0.138 | 0.107 | 0.432 | 0.415 | 0.2996  |

## Appendix E. Watershed Loads

Table 20: Annual Average Delivered TP Loads

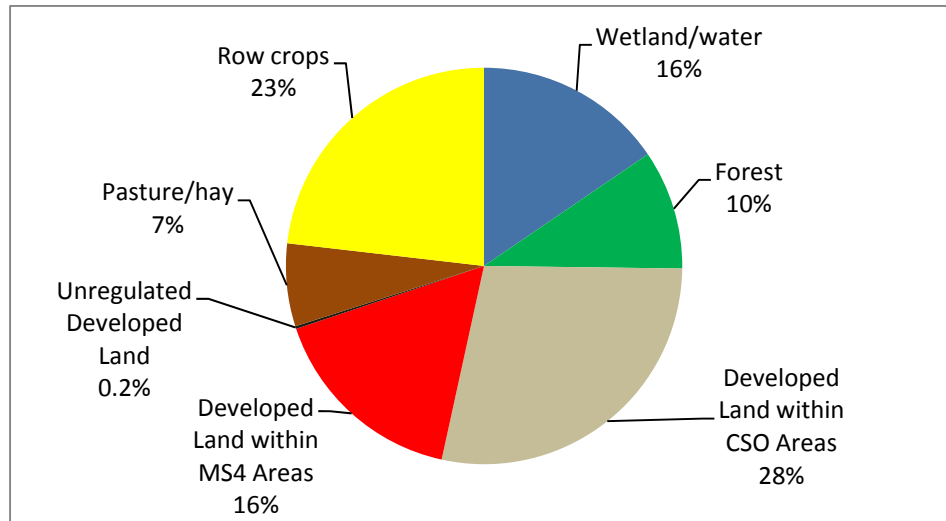
| Annual Average Delivered TP Load (1998-2007) |               |         |
|----------------------------------------------|---------------|---------|
| Land Use                                     | Load (lbs/yr) | Percent |
| Wetland/water                                | 2,658         | 5%      |
| Forest                                       | 6,442         | 12%     |
| Developed Land within CSO Areas              | 6,482         | 12%     |
| Developed Land within MS4 Areas              | 16,536        | 32%     |
| Unregulated Developed Land                   | 181           | 0.3%    |
| Pasture/hay                                  | 6,426         | 12%     |
| Row crops                                    | 13,761        | 26%     |
| Total                                        | 52,486        | 100%    |

Figure 37: Annual Average Delivered TP Load (1998-2007)



**Table 21: Seasonal (May - Sept.) Average Delivered OP Loads**

| <b>Seasonal Average Delivered OP Load (1998-2007)</b> |                      |                |
|-------------------------------------------------------|----------------------|----------------|
| <b>Land Use</b>                                       | <b>Load (lbs/yr)</b> | <b>Percent</b> |
| Wetland/water                                         | 269                  | 15%            |
| Forest                                                | 169                  | 10%            |
| Developed Land within CSO Areas                       | 490                  | 28%            |
| Developed Land within MS4 Areas                       | 285                  | 16%            |
| Unregulated Developed Land                            | 4                    | 0.2%           |
| Pasture/hay                                           | 117                  | 7%             |
| Row crops                                             | 402                  | 23%            |
| Total                                                 | 1,736                | 100%           |

**Figure 38: Seasonal Average Delivered OP Load (1998-2007)**

### **Comparison**

Loads are expressed as annual average TP and seasonal average OP. Effler et al. (2009) concluded that loads delivered outside of the May-September interval have drastically diminished influence on the Lake due to its rapid flushing rate. Seasonality and bioavailability are important factors that act to mitigate annual TP loads into the fraction that is available to support algal growth (2009). When loads are expressed in terms of effective phosphorus it becomes evident that the importance of some sources will change. For example, the importance of loads attributed to pasture/hay lands and developed land within MS4 areas are diminished when the concept of effective phosphorus is quantified. Alternatively, developed land within CSO areas becomes the predominant contributor of effective phosphorus load in the watershed. Effler et al. (2009) estimated that CSOs contribute 514 lbs of total dissolved phosphorus (TDP) on a seasonal average basis and that the average seasonal loading rate is approximately 60% greater than the average annual loading rate. It should be noted that the discrepancy between Effler's CSO estimate and the load attributed to developed land within CSO areas in Table 21 is due to the fact that TDP includes OP as well as the dissolved organic phosphorus (DOP) fraction.

## Appendix F. SPDES Discharger Information

Table 22: CSOs Covered Under the Metropolitan Syracuse WWTP Permit (NY0027081)

| Outfall No. | Description                                                 | Latitude/Longitude          | Receiving Water |
|-------------|-------------------------------------------------------------|-----------------------------|-----------------|
| 003         | Hiawatha Boulevard (North of State Fair Blvd.)              | 43° 03' 20" N/76° 11' 07" W | Harbor Brook    |
| 004         | State Fair Blvd.                                            | 43° 03' 13" N/76° 10' 54" W | Harbor Brook    |
| 005         | West Genesee and Sackett Street                             | 43° 03' 11" N/76° 10' 38" W | Harbor Brook    |
| 006         | Park Avenue and Sackett St. Overflow (West of Harbor Brook) | 43° 03' 07" N/76° 10' 35" W | Harbor Brook    |
| 006A        | Park Avenue and Sackett St. Overflow (East of Harbor Brook) | 43° 03' 07" N/76° 10' 35" W | Harbor Brook    |
| 007         | Richmond Avenue and Liberty Street                          | 43° 03' 00" N/76° 10' 26" W | Harbor Brook    |
| 008         | Lakeview Avenue and Liberty Street                          | 43° 02' 57" N/76° 10' 29" W | Harbor Brook    |
| 009         | West Fayette Street (West of Harbor Brook)                  | 43° 02' 47" N/76° 10' 33" W | Harbor Brook    |
| 010         | West Fayette Street (East of Harbor Brook)                  | 43° 02' 45" N/76° 10' 21" W | Harbor Brook    |
| 011         | Gifford Street (East of Harbor Brook)                       | 43° 02' 34" N/76° 10' 23" W | Harbor Brook    |
| 013         | Seymour Street                                              | 43° 02' 30" N/76° 10' 28" W | Harbor Brook    |
| 014         | Delaware Street                                             | 43° 02' 24" N/76° 10' 29" W | Harbor Brook    |
| 015         | Herriman Street and Grand Avenue                            | 43° 02' 20" N/76° 10' 38" W | Harbor Brook    |

|     |                                                            |                             |                   |
|-----|------------------------------------------------------------|-----------------------------|-------------------|
| 016 | Lydell Street                                              | 43° 02' 16" N/76° 10' 43" W | Harbor Brook      |
| 017 | Hoeffler Street                                            | 43° 02' 12" N/76° 10' 47" W | Harbor Brook      |
| 018 | Rowland Street                                             | 43° 02' 07" N/76° 11' 05" W | Harbor Brook      |
| 020 | Butternut Floatables Control Facility<br>Route 690         | 43° 03' 17" N/76° 09' 26" W | Onondaga<br>Creek |
| 021 | Burnet Floatables Control Facility<br>Route 690 and Burnet | 43° 03' 16" N/76° 09' 25" W | Onondaga<br>Creek |
| 027 | W. Fayette Street (Eastside of<br>Onondaga Creek)          | 43° 02' 55" N/76° 09' 28" W | Onondaga<br>Creek |
| 028 | Walton Street (Westside of Onondaga<br>Creek)              | 43° 02' 53" N/76° 09' 27" W | Onondaga<br>Creek |
| 029 | Walton Street (Eastside of Onondaga<br>Creek)              | 43° 02' 53" N/76° 09' 27" W | Onondaga<br>Creek |
| 030 | W. Jefferson Street (Eastside of<br>Onondaga Creek)        | 43° 02' 50" N/76° 09' 27" W | Onondaga<br>Creek |
| 031 | W. Jefferson Street (Westside of<br>Onondaga Creek)        | 43° 02' 49" N/76° 09' 28" W | Onondaga<br>Creek |
| 032 | Tully Street                                               | 43° 02' 45" N/76° 09' 28" W | Onondaga<br>Creek |
| 033 | Dickerson Street                                           | 43° 02' 40" N/76° 09' 19" W | Onondaga<br>Creek |
| 034 | Clinton & West Onondaga Street                             | 43° 02' 37" N/76° 09' 17" W | Onondaga<br>Creek |
| 035 | Gifford Street                                             | 43° 02' 37" N/76° 09' 17" W | Onondaga<br>Creek |
| 036 | West Onondaga Street                                       | 43° 02' 33" N/76° 09' 18" W | Onondaga<br>Creek |
| 039 | Tallman Street (East of Onondaga<br>Creek)                 | 43° 02' 12" N/76° 09' 19" W | Onondaga<br>Creek |

|             |                                                                        |                             |                |
|-------------|------------------------------------------------------------------------|-----------------------------|----------------|
| 037         | Adams & Oneida Street                                                  | 43° 02' 32" N/76° 09' 18" W | Onondaga Creek |
| 042         | Midland Street (Westside of Onondaga Creek)                            | 43° 01' 59" N/76° 09' 29" W | Onondaga Creek |
| 044         | West Castle Street and South Avenue                                    | 43° 01' 50" N/76° 09' 34" W | Onondaga Creek |
| 052         | Hunt Street & Elmhurst Avenue                                          | 43° 01' 15" N/76° 09' 21" W | Onondaga Creek |
| 060/<br>077 | West Colvin Street                                                     | 43° 01' 25" N/76° 09' 17" W | Onondaga Creek |
| 063         | Emerson & Milton Avenue                                                | 43° 03' 33" N/76° 09' 23" W | Harbor Brook   |
| 065         | Plum and Evans Streets                                                 | 43° 03' 20" N/76° 09' 37" W | Onondaga Creek |
| 066         | Maltbie and Evans Street<br>Maltbie Floatables Control Facility        | 43° 03' 20" N/76° 09' 41" W | Onondaga Creek |
| 067         | Newell Street                                                          | 43° 00' 58" N/76° 09' 28" W | Onondaga Creek |
| 071         | Spencer Street Bypass                                                  | 43° 03' 26" N/76° 09' 41" W | Onondaga Creek |
| 073         | Teall and Mildred Avenues<br>Teall Floatables Control Facility         | 43° 04' 42" N/76° 07' 25" W | Teall Brook    |
| 074         | Spring Street & Hiawatha Blvd.<br>Hiawatha Regional Treatment Facility | 43° 04' 36" N/76° 10' 19" W | Ley Creek      |
| 075         | Route 81 & Hiawatha Blvd. (Associated with Kirk Patrick PS)            | 43° 03' 54" N/76° 10' 25" W | Onondaga Creek |
| 076         | Midland Avenue and Brighton Avenue                                     | 43° 01' 09" N/76° 09' 18" W | Onondaga Creek |
| 078         | Bellevue Avenue & Velasko Road                                         | 43° 02' 08" N/76° 11' 19" W | Harbor Brook   |
| 079         | Park Avenue & Lakeview Avenue                                          | 43° 03' 08" N/76° 10' 36" W | Onondaga Creek |

|      |                                                                                                                                                                                                                                                                                           |                             |                                                                                              |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|----------------------------------------------------------------------------------------------|
| 080  | Erie Blvd Storage System & Onondaga Creek                                                                                                                                                                                                                                                 | 43° 03' 03" N/76° 09' 30" W | Onondaga Creek                                                                               |
|      | A - James Street Relief Sewer<br>B - Fayette Street & Irving Avenue<br>C - S. Crouse Avenue & Washington<br>D - Burnet Ave & Elm Street<br>E - E. Washington & Pine Street<br>F - S. Beech & Canal Street<br>G - Burnet & Sherwood<br>H - Burnet & Teall<br>I - Genesee & Westcott Street |                             | EB<br>SS<br>EB<br>SS<br>EB<br>SS<br>EB<br>SS<br>EB<br>SS<br>EB<br>SS<br>EB<br>SS<br>EB<br>SS |
| M01  | Main CSO Outfall at Midland RTF                                                                                                                                                                                                                                                           | 43 ° 02' 00"N/76 ° 09' 30"W | Onondaga Creek                                                                               |
| M02  | Emergency CSO Outfall at Midland RTF                                                                                                                                                                                                                                                      | 43 ° 02' 01"N/76 ° 09' 30"W | Onondaga Creek                                                                               |
| 022* | Wallace & West Genesee Street                                                                                                                                                                                                                                                             | 43° 03' 11" N/76° 09' 29" W | Onondaga Creek                                                                               |
| 045* | West Castle Street and Hudson Street                                                                                                                                                                                                                                                      | 43° 01' 49" N/76° 09' 38" W | Onondaga Creek                                                                               |
| 061* | Crehange Street & Onondaga Creek Overflow                                                                                                                                                                                                                                                 | 43° 01' 19" N/76° 09' 18" W | Onondaga Creek                                                                               |

\* Denotes CSO outfalls scheduled for elimination as part of sewer separation projects.

Table 23: SSOs Covered Under the Metropolitan Syracuse WWTP Permit (NY0027081)

| Outfall No. | Description                                          | Latitude/Longitude          | Receiving Water             |
|-------------|------------------------------------------------------|-----------------------------|-----------------------------|
| 068         | Westside Pump Station                                | 43° 04' 10" N/76° 04' 10" W | Onondaga Lake               |
| 069         | Hillcrest Pump Station                               | 43° 02' 11" N/76° 11' 38" W | Harbor Brook                |
| 070         | Brookside Pump Station                               | 43° 02' 10" N/76° 11' 38" W | Harbor Brook                |
| 084         | Ley Creek Pump Station                               | 43° 05' 21" N/76° 09' 37" W | Ley Creek                   |
| 085         | Liverpool Pump Station                               | 43° 05' 52" N/76° 12' 04" W | Blood Brook                 |
| 086         | Town of Salina – Manhole @ Toas Ave. and Young Ave.  | 43° 05.56' N/76° 08.59' W   | Ley Creek                   |
| 087         | Town of Salina – Manhole @ Garden City Drive         | 43° 05.27' N/76° 09.74' W   | Ley Creek                   |
| 088         | OCDWEP – Westside Trunk Sewer Manhole @ Bronson Road | 43° 02.80 N/76° 13.11' W    | Geddes Brook                |
| 089         | OCDWEP – Westside Trunk Sewer/Crucible               | 43° 04.30' N/76° 12.28' W   | Tributary 5A                |
| 090         | OCDWEP – Floradale Road Manhole                      | 43° 06.15' N/76° 11.88' W   | West Branch of Blood Brook  |
| 091         | OCDWEP – Ley Creek Pump Station                      | 43° 05.27' N/76° 09.74' W   | Ley Creek                   |
| 092         | OCDWEP – Viking Place Manhole                        | 43° 05.99' N/76° 11.61' W   | East Branch of Blood Brook  |
| 093         | OCDWEP – Electronics Park Trunk Sewer Manhole        | 43° 05.91' N/76° 11.49' W   | East Branch of Bloody Brook |

## Appendix G. Model Scenarios

Table 24: OLWQM Scenario Descriptions (Anchor QEA, 2011c)

| Scenario  | Description                                                                            | Metro Effluent TP                                                      | Metro Outfall Location                | Watershed Action                                                                                                                                         |
|-----------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Base Case |                                                                                        | 2005-2009 Average                                                      | Lake                                  | 1994-2009 Levels                                                                                                                                         |
| 1         | ~50% Metro Reduction                                                                   | Stage 3 at 0.05 mg/L                                                   | Lake                                  | 1994-2009 Levels                                                                                                                                         |
| 2         | ~80% Metro Reduction                                                                   | Stage 3 at 0.02 mg/L                                                   | Lake                                  | 1994-2009 Levels                                                                                                                                         |
| 3         | Metro Diversion                                                                        | 2005-2009 Average                                                      | Divert to River                       | 1994-2009 Levels                                                                                                                                         |
| 4         | Watershed Load Reduction <sup>1</sup>                                                  | 2005-2009 Average                                                      | Lake                                  | 11% Reduction in TP Load from Watershed During Each 16-year Cycle                                                                                        |
| 5         | Urban Source Reduction <sup>2</sup>                                                    | 2005-2009 Average                                                      | Lake                                  | Urban Source Reduction                                                                                                                                   |
| 6         | Urban Source Reduction Coupled with ~50% Metro Reduction                               | Stage 3 at 0.05 mg/L                                                   | Lake                                  | Urban Source Reduction                                                                                                                                   |
| 7         | Pre-colonial Conditions                                                                | None                                                                   | None                                  | Modify Land Use in all Sub-basins to Forested in HSPF Model                                                                                              |
| 8         | Completion of 4th Stipulation Projects <sup>3</sup>                                    | Stage 2 at 0.1 mg/L                                                    | Lake                                  | Simulation of Phosphorus Reduction Associated with Volume Reductions from Completion of CSO Abatement                                                    |
| 9         | Current Metro Loading                                                                  | Stage 2 at 0.1 mg/L                                                    | Lake                                  | 1994-2009 Levels                                                                                                                                         |
| 10        | Metalimnetic Discharge                                                                 | 2005-2009 Average                                                      | Lake (Change to Deep Water Discharge) | 1994-2009 Levels                                                                                                                                         |
| 11        | Incremental P Source Reduction Assessment                                              | A series of simulations setup with TP set to zero one inflow at a time |                                       |                                                                                                                                                          |
| 12        | Removal of Metro Particulate Phosphorus                                                | Stage 3 at 0.05 mg/L                                                   | Lake                                  | 1994-2009 Levels                                                                                                                                         |
| 13        | Marcellus WWTP 1 mg/L TP limit                                                         | State 2 at 0.1 mg/L                                                    | Lake                                  | Point source control on Ninemile Creek and 4 <sup>th</sup> Stipulation Projects                                                                          |
| 14        | Marcellus WWTP 1 mg/L TP and agricultural input reductions in Ninemile Creek Watershed | Stage 2 at 0.1 mg/L                                                    | Lake                                  | Point and non-point source controls on Ninemile Creek                                                                                                    |
| 15        | Scenario 8 + Scenario 14 + P reduction from fertilizer restriction law                 | Stage 2 at 0.1 mg/L                                                    | Lake                                  | Completion of CSO abatement infrastructure, point and non-point source controls on Ninemile Creek and reductions from fertilizer phosphorus restrictions |

### Footnotes

1. A 20% reduction in loads was targeted based on estimated regression relationships developed from monthly flows based on HSPF model simulations from 1997-2008. However, when applied to daily flows from 1994-2009, actual percent reduction calculated for OLWQM TP inputs was 11% for each 16-year cycle.
2. This is an upper bound estimate of urban source reduction simulated using AMP water quality data at monitoring stations upstream of the City of Syracuse as inputs to OLWQM for Onondaga Creek and Harbor Brook. This translates to TP reductions of 35% and 50% for Onondaga Creek and Harbor Brook respectively. Includes application of SWMM and HSPF models.

Table 25: Average Annual TP Loads Used in Model Simulations (Anchor QEA, 2011c)

| Scenario                             | Metro Main Outfall (001)       |                              | Metro Bypass (002)             |                              | Watershed                      |                              | Total                          |                              |
|--------------------------------------|--------------------------------|------------------------------|--------------------------------|------------------------------|--------------------------------|------------------------------|--------------------------------|------------------------------|
|                                      | TP Load (lb·yr <sup>-1</sup> ) | Reduction from Base Case (%) | TP Load (lb·yr <sup>-1</sup> ) | Reduction from Base Case (%) | TP Load (lb·yr <sup>-1</sup> ) | Reduction from Base Case (%) | TP Load (lb·yr <sup>-1</sup> ) | Reduction from Base Case (%) |
| Base Case                            | 24,133                         | -                            | 6,230                          | -                            | 56,977                         | -                            | 87,340                         | -                            |
| Scenario 1                           | 9,921                          | 59%                          | 6,230                          | 0%                           | 56,977                         | 0%                           | 73,128                         | 16%                          |
| Scenario 2                           | 3,968                          | 84%                          | 6,230                          | 0%                           | 56,977                         | 0%                           | 67,175                         | 23%                          |
| Scenario 3                           | 0                              | 100%                         | 0                              | 100%                         | 56,977                         | 0%                           | 56,977                         | 35%                          |
| Scenario 4                           | 24,133                         | 0%                           | 6,230                          | 0%                           | 50,706                         | 11%                          | 81,069                         | 7%                           |
| Scenario 5                           | 24,133                         | 0%                           | 6,230                          | 0%                           | 46,738                         | 18%                          | 77,101                         | 12%                          |
| Scenario 6                           | 9,921                          | 59%                          | 6,230                          | 0%                           | 46,738                         | 18%                          | 62,889                         | 28%                          |
| Scenario 7                           | 0                              | 100%                         | 0                              | 100%                         | 27,778                         | 51%                          | 27,778                         | 68%                          |
| Scenario 8                           | 19,905                         | 18%                          | 6,230                          | 0%                           | 54,674                         | 4%                           | 80,809                         | 7%                           |
| Scenario 9                           | 19,905                         | 18%                          | 6,230                          | 0%                           | 56,977                         | 0%                           | 83,112                         | 5%                           |
| Scenario 10-AQ                       | 24,133                         | 0%                           | 6,230                          | 0%                           | 56,977                         | 0%                           | 87,340                         | 0%                           |
| Scenario 10-UF11                     | 21,164                         | 12%                          | 6,230                          | 0%                           | 56,977                         | 0%                           | 84,371                         | 3%                           |
| Scenario 10-UF12                     | 21,164                         | 12%                          | 5,732                          | 7%                           | 56,977                         | 0%                           | 83,873                         | 4%                           |
| Scenario 11a: Metro 001 TP=0         | 0                              | 100%                         | 6,230                          | 0%                           | 56,977                         | 0%                           | 63,207                         | 28%                          |
| Scenario 11b: Metro 002 TP=0         | 24,133                         | 0%                           | 0                              | 100%                         | 56,977                         | 0%                           | 81,110                         | 7%                           |
| Scenario 11c:<br>Ninemile Creek TP=0 | 24,133                         | 0%                           | 6,230                          | 0%                           | 39,242                         | 31%                          | 69,605                         | 20%                          |
| Scenario 11d:<br>Onondaga Creek TP=0 | 24,133                         | 0%                           | 6,230                          | 0%                           | 28,660                         | 50%                          | 59,203                         | 32%                          |
| Scenario 11e:<br>Harbor Brook TP=0   | 24,133                         | 0%                           | 6,230                          | 0%                           | 55,115                         | 3%                           | 85,478                         | 2%                           |
| Scenario 11f:<br>Ley Creek TP=0      | 24,133                         | 0%                           | 6,230                          | 0%                           | 48,501                         | 15%                          | 78,864                         | 10%                          |
| Scenario 11g:<br>East Flume TP=0     | 24,133                         | 0%                           | 6,230                          | 0%                           | 56,977                         | 0%                           | 87,340                         | 0%                           |
| Scenario 11h:<br>Tributary 5A TP=0   | 24,133                         | 0%                           | 6,230                          | 0%                           | 56,438                         | 1%                           | 86,801                         | 1%                           |
| Scenario 11i:<br>TP=0 at all inflows | 0                              | 100%                         | 0                              | 100%                         | 0                              | 100%                         | 0                              | 100%                         |
| Scenario 12                          | 9,921                          | 59%                          | 6,230                          | 0%                           | 56,977                         | 0%                           | 73,128                         | 16%                          |
| Scenario 13                          | 19,905                         | 18%                          | 6,230                          | 0%                           | 53,572                         | 6%                           | 79,707                         | 9%                           |
| Scenario 14                          | 19,905                         | 18%                          | 6,230                          | 0%                           | 53,437                         | 6%                           | 79,572                         | 9%                           |
| Scenario 15                          | 19,905                         | 18%                          | 6,230                          | 0%                           | 51,533                         | 9%                           | 77,668                         | 11%                          |

**Table 26: Annual Modeled Loads and Summer Mean Epilimnetic Phosphorus Concentrations**

| Scenario         | Total phosphorus load delivered to Lake (lb·yr <sup>-1</sup> ) |                | Total phosphorus concentration (µg·l <sup>-1</sup> ) |       |
|------------------|----------------------------------------------------------------|----------------|------------------------------------------------------|-------|
|                  | Mean                                                           | Range          | Mean                                                 | Range |
| Base Case        | 87,339                                                         | 57,393-128,197 | 16                                                   | 10-25 |
| Scenario 2       | 67,186                                                         | 38,854-106,967 | 12                                                   | 5-19  |
| Scenario 3       | 56,977                                                         | 27,623-90,149  | 11                                                   | 5-21  |
| Scenario 5       | 77,100                                                         | 51,506-119,909 | 14                                                   | 9-22  |
| Scenario 7       | 27,715                                                         | 8,702-42,129   | 4                                                    | 2-8   |
| Scenario 8       | 80,873                                                         | 52,061-119,632 | 14                                                   | 8-22  |
| Scenario 9       | 83,111                                                         | 53,224-123,462 | 15                                                   | 9-24  |
| Scenario 10-AQ   | 87,341                                                         | 57,115-127,917 | 15                                                   | 7-24  |
| Scenario 10-UF11 | 84,390                                                         | 54,121-124,938 | 14                                                   | 8-23  |
| Scenario 10-UF12 | 83,932                                                         | 52,651-124-629 | 14                                                   | 8-23  |
| Scenario 11b     | 81,109                                                         | 49,823-115,572 | 15                                                   | 9-23  |
| Scenario 12      | 73,157                                                         | 44,067-112,975 | 15                                                   | 9-24  |
| Scenario 13      | 79,774                                                         | 50,970-118,139 | 14                                                   | 8-22  |
| Scenario 14      | 79,572                                                         | 50,788-117,870 | 14                                                   | 8-22  |
| Scenario 15      | 77,668                                                         | 50,008-114,975 | 14                                                   | 8-21  |

Table 27: Yearly Model Results for Scenario 15

| Model Simulation Water Year | Summer Mean TP in upper mixed layer (mg·l <sup>-1</sup> ) | Revised Summer Mean TP in upper mixed layer (mg·l <sup>-1</sup> )** | Metro 001 Load (lb·yr <sup>-1</sup> ) | Metro 002 (Bypass) Load (lb·yr <sup>-1</sup> ) | Watershed Load (lb·yr <sup>-1</sup> ) | Total Load to Lake (lb·yr <sup>-1</sup> ) |
|-----------------------------|-----------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------|------------------------------------------------|---------------------------------------|-------------------------------------------|
| 2010                        | 0.017                                                     | 0.017                                                               | NA*                                   | NA*                                            | NA*                                   | NA*                                       |
| 2011                        | 0.012                                                     | 0.012                                                               | 18,311                                | 7,571                                          | 24,126                                | 50,008                                    |
| 2012                        | 0.020                                                     | 0.020                                                               | 20,970                                | 12,626                                         | 81,380                                | 114,975                                   |
| 2013                        | 0.021                                                     | 0.021                                                               | 20,176                                | 5,444                                          | 71,293                                | 96,912                                    |
| 2014                        | 0.012                                                     | 0.012                                                               | 21,511                                | 5,970                                          | 52,708                                | 80,189                                    |
| 2015                        | 0.010                                                     | 0.010                                                               | 18,274                                | 5,930                                          | 36,886                                | 61,090                                    |
| 2016                        | 0.021                                                     | 0.021                                                               | 20,293                                | 3,803                                          | 49,533                                | 73,629                                    |
| 2017                        | 0.011                                                     | 0.011                                                               | 19,162                                | 3,266                                          | 45,297                                | 67,725                                    |
| 2018                        | 0.013                                                     | 0.012                                                               | 19,064                                | 6,389                                          | 37,663                                | 63,116                                    |
| 2019                        | 0.012                                                     | 0.011                                                               | 20,833                                | 5,922                                          | 42,567                                | 69,322                                    |
| 2020                        | 0.018                                                     | 0.018                                                               | 21,466                                | 6,893                                          | 63,301                                | 91,659                                    |
| 2021                        | 0.008                                                     | 0.008                                                               | 20,582                                | 3,953                                          | 45,905                                | 70,439                                    |
| 2022                        | 0.017                                                     | 0.017                                                               | 20,437                                | 3,875                                          | 59,597                                | 83,909                                    |
| 2023                        | 0.010                                                     | 0.010                                                               | 19,699                                | 3,119                                          | 53,789                                | 76,607                                    |
| 2024                        | 0.010                                                     | 0.009                                                               | 18,771                                | 4,529                                          | 57,793                                | 81,093                                    |
| 2025                        | 0.013                                                     | 0.012                                                               | 18,451                                | 6,749                                          | 64,506                                | 89,706                                    |
| 2026                        | 0.016                                                     | 0.016                                                               | 20,483                                | 13,636                                         | 38,190                                | 72,310                                    |
| 2027                        | 0.012                                                     | 0.011                                                               | 18,311                                | 7,571                                          | 24,126                                | 50,008                                    |
| 2028                        | 0.019                                                     | 0.019                                                               | 20,970                                | 12,626                                         | 81,380                                | 114,975                                   |
| 2029                        | 0.020                                                     | 0.019                                                               | 20,176                                | 5,444                                          | 71,293                                | 96,912                                    |
| 2030                        | 0.011                                                     | 0.012                                                               | 21,511                                | 5,970                                          | 52,708                                | 80,189                                    |
| 2031                        | 0.010                                                     | 0.010                                                               | 18,274                                | 5,930                                          | 36,886                                | 61,090                                    |
| 2032                        | 0.020                                                     | 0.020                                                               | 20,293                                | 3,803                                          | 49,533                                | 73,629                                    |
| 2033                        | 0.011                                                     | 0.011                                                               | 19,162                                | 3,266                                          | 45,297                                | 67,725                                    |
| 2034                        | 0.012                                                     | 0.012                                                               | 19,064                                | 6,389                                          | 37,663                                | 63,116                                    |
| 2035                        | 0.012                                                     | 0.011                                                               | 20,833                                | 5,922                                          | 42,567                                | 69,322                                    |
| 2036                        | 0.018                                                     | 0.018                                                               | 21,466                                | 6,893                                          | 63,301                                | 91,659                                    |
| 2037                        | 0.008                                                     | 0.008                                                               | 20,582                                | 3,953                                          | 45,905                                | 70,439                                    |
| 2038                        | 0.017                                                     | 0.016                                                               | 20,437                                | 3,875                                          | 59,597                                | 83,909                                    |
| 2039                        | 0.010                                                     | 0.010                                                               | 19,699                                | 3,119                                          | 53,789                                | 76,607                                    |
| 2040                        | 0.010                                                     | 0.009                                                               | 18,771                                | 4,529                                          | 57,793                                | 81,093                                    |
| 2041                        | 0.013                                                     | 0.012                                                               | 18,451                                | 6,749                                          | 64,506                                | 89,706                                    |
| 2042                        | 0.016                                                     | 0.016                                                               | 20,483                                | 13,636                                         | 38,190                                | 72,310                                    |
| 2043                        | 0.012                                                     | 0.011                                                               | 18,311                                | 7,571                                          | 24,126                                | 50,008                                    |
| 2044                        | 0.019                                                     | 0.019                                                               | 20,970                                | 12,626                                         | 81,380                                | 114,975                                   |
| 2045                        | 0.020                                                     | 0.019                                                               | 20,176                                | 6,444                                          | 71,293                                | 96,912                                    |
| 2046                        | 0.011                                                     | 0.012                                                               | 21,511                                | 5,970                                          | 52,708                                | 80,189                                    |
| 2047                        | 0.010                                                     | 0.010                                                               | 18,274                                | 5,930                                          | 36,886                                | 61,090                                    |
| 2048                        | 0.020                                                     | 0.020                                                               | 20,293                                | 3,803                                          | 49,533                                | 73,629                                    |
| 2049                        | 0.011                                                     | 0.011                                                               | 19,161                                | 3,266                                          | 45,297                                | 67,725                                    |
| 2050                        | 0.012                                                     | 0.012                                                               | 19,064                                | 6,389                                          | 37,663                                | 63,116                                    |
| 2051                        | 0.012                                                     | 0.011                                                               | 20,833                                | 5,922                                          | 42,567                                | 69,322                                    |
| 2052                        | 0.018                                                     | 0.017                                                               | 21,466                                | 6,893                                          | 63,301                                | 91,659                                    |
| 2053                        | 0.008                                                     | 0.008                                                               | 20,582                                | 3,953                                          | 45,905                                | 70,439                                    |
| 2054                        | 0.017                                                     | 0.016                                                               | 20,437                                | 3,875                                          | 59,597                                | 83,909                                    |
| 2055                        | 0.010                                                     | 0.010                                                               | 19,399                                | 3,119                                          | 53,789                                | 76,607                                    |
| 2056                        | 0.010                                                     | 0.009                                                               | 18,771                                | 4,529                                          | 57,793                                | 81,093                                    |
| 2057                        | 0.013                                                     | 0.012                                                               | 18,451                                | 6,749                                          | 64,506                                | 89,706                                    |

\*Model simulations were run on a calendar year basis starting January 2010. Model loading is therefore not available for Water Year 2010.

\*\*These simulations reflect the revised Metro 002 (Bypass) loads.

**Appendix H. Table 28: Pound per Day Load Allocations†^**

| Source                                              | Base Case  |            | Average Load Allocation |            |             | Maximum Load Allocation |            |             |
|-----------------------------------------------------|------------|------------|-------------------------|------------|-------------|-------------------------|------------|-------------|
|                                                     | Average    | Maximum    | Allocated               | Reduction  | % Reduction | Allocated               | Reduction  | % Reduction |
| Wetland/Water                                       | 7          | 12         | 7                       | 0          | 0%          | 12                      | 0          | 0%          |
| Forest                                              | 18         | 29         | 18                      | 0          | 0%          | 29                      | 0          | 0%          |
| Unregulated Developed Land                          | 0.5        | 0.8        | 0.4                     | 0.1        | 25%         | 0.6                     | 0.2        | 25%         |
| Agriculture                                         | 55         | 92         | 46                      | 10         | 18%         | 76                      | 17         | 18%         |
| <b>LA</b>                                           | <b>81</b>  | <b>135</b> | <b>71</b>               | <b>10</b>  | <b>12%</b>  | <b>118</b>              | <b>17</b>  | <b>12%</b>  |
| Developed Land (Regulated MS4 Stormwater)           | 45         | 76         | 37                      | 8          | 18%         | 62                      | 14         | 18%         |
| Developed Land within CSO Areas                     | 18         | 30         | 11                      | 7          | 39%         | 18                      | 12         | 39%         |
| Metropolitan Syracuse WWTP, Outfall 001 (NY0027081) | 66         | 69         | 59                      | 7          | 10%         | 59                      | 10         | 15%         |
| Metropolitan Syracuse WWTP, Outfall 002 (NY0027081) | 17         | 37         | 17                      | 0          | 0%          | 21                      | 17         | 44%         |
| Marcellus (V) WPCP (NY0020532)                      | 4.8        | 4.8        | 3.2                     | 1.6        | 33%         | 3.2                     | 1.6        | 33%         |
| Lockheed Martin Corp. (NY0002101)                   | 1.0        | 1.0        | 0.6                     | 0.4        | 43%         | 0.6                     | 0.4        | 43%         |
| Crucible Industries, LLC (NY0000825)                | 0.5        | 0.5        | 0.5                     | 0          | 0%          | 0.5                     | 0          | 0%          |
| Onondaga Renewables, LLC (NY0262030)*               | 0.04       | 0.04       | 0                       | 0.04       | 100%        | 0                       | 0.04       | 100%        |
| New Process Gear Inc. (NY0001384)                   | 0.6        | 0.6        | 0.6                     | 0          | 0%          | 0.6                     | 0          | 0%          |
| WPS Syracuse Generation (NY0231681)                 | 0.1        | 0.1        | 0.1                     | 0          | 0%          | 0.1                     | 0          | 0%          |
| Syracuse Energy Corp (NY0213586)                    | 0.5        | 0.5        | 0.5                     | 0          | 0%          | 0.5                     | 0          | 0%          |
| Wabash Aluminum (NY0110311)**                       | 0.1        | 0.1        | 0                       | 0.1        | 100%        | 0.1                     | 0.1        | 100%        |
| Aggregated Minor SPDES Discharges <sup>#</sup>      | 0.01       | 0.01       | 0.01                    | 0          | 0%          | 0.01                    | 0          | 0%          |
| Reserve                                             | ---        | ---        | 0.2                     | ---        | ---         | 0.2                     | ---        | ---         |
| <b>WLA</b>                                          | <b>153</b> | <b>219</b> | <b>129</b>              | <b>24</b>  | <b>16%</b>  | <b>165</b>              | <b>54</b>  | <b>25%</b>  |
| <b>LA + WLA</b>                                     | <b>---</b> | <b>---</b> | <b>200</b>              | <b>34</b>  | <b>14%</b>  | <b>283</b>              | <b>71</b>  | <b>20%</b>  |
| <b>MARGIN OF SAFETY</b>                             | <b>---</b> | <b>---</b> | <b>13</b>               | <b>---</b> | <b>---</b>  | <b>32</b>               | <b>---</b> | <b>---</b>  |
| <b>TOTAL</b>                                        | <b>234</b> | <b>354</b> | <b>213</b>              | <b>21</b>  | <b>9%</b>   | <b>315</b>              | <b>39</b>  | <b>11%</b>  |

^ Rounding may cause small discrepancies within the summations of this table. \* NYS DEC has received a request to terminate this permit.

\*\* This permit has been split between Thompson Corners LLC. (NY0110311) and Metalico Aluminum Recovery, LLC. (NY0261947). Industrial water from these sites is currently sent to the Metropolitan Syracuse WWTP and is no longer a source of TP.

<sup>#</sup> Includes four facilities: Bristol-Myers Squibb, Frazer and Jones, Oberdorfer, LLC. and Otisco Lake WTP. These dischargers are considered *de minimus* and account for only 0.006% (under base case) and 0.004% (maximum load allocation) of the total load. Refer to Table 7 for individual SPDES numbers and loads.

† Permits will be based upon the maximum load allocations as a running 12-month average.