CHAPTER 4.0

DISCUSSION

This chapter discusses water quality results and related analyses in the context of overall lake conditions, and introduces issues that should be addressed in the future management efforts for the Asylum and Little Asylum Lake watershed.

4.1 Lake Water Quality Conditions

Several water quality parameters can be used as indicators of lake trophic conditions, pressing water quality issues and for sourcing pollutant contributions to both lakes. Additional descriptions of various water quality indicator parameters relevant to Asylum and Little Asylum Lake applications are inset for reference in this section.

Water Quality Indicators

Biotic productivity within aquatic ecosystems is one of the most common ways to assess the condition of lake systems. Varying levels of primary productivity are used to categorize aquatic ecosystems into separate trophic states. The leading driver behind primary productivity is the availability of key nutrients for biological uptake, mainly phosphorus and nitrogen, although other water quality parameters can be used as indicators of trophic status.

Water quality data collected in this study can assist in better understanding the productivity, and ultimately the trophic status, of Asylum and Little Asylum Lake. The average range of TP values measured in Asylum and Little Asylum Lake were above the 20-37 µg/L range that scientific literature suggests is characteristic of eutrophic systems, (i.e., those systems exhibiting very high levels or primary productivity—refer to tables in Appendix G). Total nitrogen concentrations measured in bottom water samples reported very high values, sometimes between 1,000-2,000 µg/L. These values indicate that primary productivity, or biomass growth, is not likely to be nutrient limited. This can result in nuisance growth of algae and aquatic plants, particularly following spring turnover when bottom waters mix with surface waters.

Other water quality variables have been used in the scientific literature to characterize the trophic state of aquatic ecosystems (Chapra, 1997). Chlorophyll *a* concentrations of less than 10 µg/L characterize ecosystems with low productivity and levels greater than 10 µg/L can indicate high levels of productivity. Similarly, secchi disk

PHOSPHORUS

Both algae and aquatic plants require a wide range of nutrients for growth. The nutrient that is typically in shortest supply with respect to aquatic plant and algal growth is termed the "limiting nutrient". This term implies that the relative availability of this nutrient, in regards to availability of other nutrients, will limit plant growth. In most freshwater ecosystems, phosphorus is the limiting nutrient. Therefore, increases in phosphorus will inevitably lead to increases in nuisance plant and algae growth.

The form of phosphorus most often used for general assessments of lake water quality is total phosphorus (TP). Concentrations of TP in lake water can be used to estimate the trophic status of the lake based on scientific data compiled for other similar inland lakes. The term "trophic state" refers to the level of "primary productivity" (algal growth) in an aquatic system. The three trophic states include "oligotrophic", "mesotrophic", and "eutrophic", which respectively correspond to low, medium, and high levels of productivity. The ranges of TP concentrations in each trophic state, based on various scientific literature, are presented in Appendix G. These can serve as a comparison to concentrations of TP in the lake samples documented in this report.

depths greater than four meters indicate oligotrophic systems (low productivity) and depths less than 2 meters indicate eutrophic systems (high productivity). In Michigan lakes, productivity is often greatest during spring and summer months, when both sunlight and nutrients are available. Chlorophyll *a* samples collected at the Asylum Lake outfall in April 2007 were above 10 µg/L, indicating eutrophic conditions. Little Asylum Lake had much lower concentrations of chlorophyll *a*, indicating a more moderate level of algal productivity. Similarly, secchi depths observed in Asylum and Little Asylum Lakes averaged 1.7-3.5 m, which characterizes the lakes between mesotrophic and eutrophic.

Eutrophic conditions, like those found in Asylum and Little Asylum Lake, often produce increased algal growth within the water column. High levels of algae can lead to decreases in available DO through the consumption of oxygen as dead algae (and other aquatic plants) decay. Severely reduced DO levels in aquatic ecosystems can cause problems for other aquatic organisms. DO measured in Asylum Lake shows decreasing levels near the lake bottom throughout the year. This is typical of highly eutrophic lakes. The levels of DO in Little Asylum Lake were greater than Asylum Lake, most likely due to shallow depths and limited temperature stratification in Little Asylum. This temperature stratification precludes mixing of surface and bottom waters in Asylum Lake where well-oxygenated surface waters reaerated by wind, do not mix with oxygen depleted bottom water.

The TP and SRP concentrations observed in bottom waters of both lakes suggest that sediments are releasing large quantities of nutrients back into the water column. This is especially evident in Asylum Lake during periods of stratification when DO levels fall below 2 mg/L. Sediment nutrient release can be several times greater under anoxic conditions. Based on ratios of nitrogen to phosphorus concentrations noted in this study, both Asylum and Little Asylum Lakes may be considered phosphorus-limited. This means that phosphorus will be exhausted first by algae and therefore, reductions in phosphorus should result in decreased biomass and improved trophic conditions. Though sampling conducted during 2006 and 2007 did not reveal nuisance algal conditions (recognized by floating mats and shoreline accumulations), stormwater loads and the obvious internal recycling of phosphorus via sediment release, suggest that opportunities exist for such growing conditions.

CHLOROPHYLL *a*

Algae concentrations are often measured in terms of chlorophyll a, a pigment used by algae for photosynthesis. The more algae present within a lake system, the higher the measurable chlorophyll a content. Lakes with summer chlorophyll a concentrations less that 7µg/l (or parts per billion) are defined as oligotrophic. Lakes with chlorophyll a between 7 and 12 µg/l are mesotrophic, while lakes with concentrations greater than 12 µg/l are considered eutrophic (Thomann and Mueller, 1987).

TEMPERATURE & DO

It is important to understand dissolved oxygen (DO) conditions in lakes as they provide a reliable indication of its health. A sufficient supply of DO in lake water is necessary for most forms of aquatic life. Increased algal growth (i.e., suspended microscopic plants in the water column) associated with nutrients added to the lake can lead to severe decreases in DO, especially in the cooler bottom waters of a lake during periods of temperature stratification. This drop in oxygen is due, in part, to dead algae and other organic matter (such as plant material from shoreline areas and leaves, grass, and other plant debris washed in from storm drains) settling to the bottom of the lake and decaying. This process of decay consumes oxygen. As materials accumulate at the bottom of a lake, these new sediments place a continuous demand on oxygen supplies in the overlying waters (referred to as "sediment oxygen demand"). Impacts of DO are most often observed during periods of temperature stratification in warmer summer months, and to a lesser degree, under winter ice cover. Measuring DO concentrations, temperature, and depth through various seasons of the year provides for: 1) an assessment of the general physical conditions in the lake, and 2) a characterization of habitat conditions.

Other pollutants detected in these lakes merit attention in terms of management strategies that can be tied to addressing issues such as stormwater loads. Bacteria levels, for example, though very low in the lake (and not exceeding standards for recreational uses), were very high in stormwater runoff. Sources such as waterfowl and pet waste are most often the original source of the bacteria. Educational programs and stormwater controls will be the most effective means to address this issue.

Heavy metals such as mercury may be much more challenging to address. Typically, the single largest source of mercury into lakes is via atmospheric deposition either directly onto the lake surface and via wash-off of accumulated mercury deposits on impervious surfaces. Mercury is a naturally occurring metal in geologic formations. Globally, mercury is released into the environment by both natural and anthropogenic means. Anthropogenic sources of mercury range from various industrial and commercial uses to the bi-product of energy production. One of the most common sources of mercury in the environment is atmospheric deposition, which cycles this pollutant between land and water (McCarty et al., 2004). Atmospheric mercury deposition to waterbodies in the U.S. is a common occurrence in all lakes, but has been showing a decreasing trend in accumulated sediments in recent years (Parsons et al., 2007).

There are few practical management solutions to address atmospheric deposition of mercury at the local level. Regional Clean Air Act programs are unfolding to address this issue as mercury is a ubiquitous problem in the Midwest. Where mercury or other heavy metals enter these lakes via stormwater, control solutions targeting loading of other critical pollutants (i.e., nutrients) will likely address these to some extent.

Hydraulic Conditions and Pollutant Loads

The hydrology of Asylum and Little Asylum Lakes appears to have been modified over time to include inlets from stormsewered areas and constructed outlets. Storm sewers deliver a large volume of runoff with high pollutant concentrations to Asylum Lake during wet weather events. Results from this study suggest that the largest and most manageable source of TP to this lake is stormwater inlet #1. Conversely, a significant source of TN appears to come from runoff entering the lake via stormwater inlet #2. The pollutant load to Little Asylum Lake via stormsewers is minimal, however, there is a significant pollutant load contribution to Little Asylum Lake via the outfall structure from Asylum Lake. This downstream transfer is only manageable over time as nutrient inputs into Asylum Lake, and potentially sediment release are managed.

An important factor to consider when assessing in-lake processes such as sediment release (that can dramatically affect lake water quality) is the amount of time it takes for water to move through the system. This is examined in terms of the hydraulic residence time. The significance of this measurement is that a lake with a very short HRT (10 days or less) is relatively immune to pollutant inputs compared to a lake with a long HRT. Pollutants tend to flush through systems with short HRTs before the nutrients can be assimilated into plant or algae biomass. In contrast, some aquatic herbicides used for managing invasive aquatic species may require a long HRT in order for the treatment to be effective. The HRT for Asylum Lake was determined to have a residence time of approximately 260 days. Hydraulic residence times over 100 days allow time for both an abundant supply of nutrients to accrue and adequate time for algae to assimilate those nutrients (EPA, 1990). Evidence of this is now readily available through bottom water data and mass balance calculations. In contrast, Little Asylum Lake was determined to have a very short HRT of approximately 11 days. However, as hydraulic mass balance computations suggest, the vast majority of water loss in this lake is to groundwater and not through the outlet to Cherry Creek. This dramatically increases the effective HRT whereby pollutant retention (and sediment accumulation) becomes significant. Loading estimates from stormwater inlets and lake outlets suggest that pollutant mass entering these lakes is largely retained.

4.2 Lake Bottom Sediments

The presence of very high levels of phosphorus and nitrogen in Asylum and Little Asylum Lake sediments indicates excessive TP and TN concentrations within the lake system. From the phosphorus mass balance, over 70% of the TP entering the lake is retained. Nearly 100% is retained in Little Asylum Lake, particularly during years of average and below average rainfall. These TP loads are likely assimilated into biomass (primarily as aquatic vegetation and algae) and largely accumulate in bottom sediments. This is evidenced by TP and TN concentrations in bottom sediments that are much higher than those noted in other southern Michigan lakes examined by K&A. Notably, both phosphorus and nitrogen levels are greater in Little Asylum Lake sediments than in Asylum Lake, supporting respective estimates of mass retention.

Data clearly indicate that in-lake processes such as sediment oxygen demand and nutrient release are substantial in these lakes. During spring and fall turnover period, phosphorus released from sediments is remixed with surface waters and becomes available for biological uptake. More biological uptake creates more biomass that settles to the bottom worsening sediment oxygen demand. This is turn, pumps out more nutrients from the sediments. This cycling highlights the importance of first managing and restricting external inputs of phosphorus to the lakes. In-lake treatment efforts will otherwise have limited benefit.

4.3 Aquatic Plant Communities

Aquatic plant communities in both lakes are generally diverse, although Little Asylum Lake does have extensive areas with high cattail density. None of the invasive species found in these lakes were present in dense quantities during this survey, although it should be noted that these species can quickly increase to nuisance levels if not aggressively controlled. Species already present in Asylum Lake (e.g., Eurasian water milfoil) could spread to Little Asylum Lake.

Eurasian water milfoil has the potential to spread through a lake system rapidly and dominate the submergent plant populations. This species can out-compete native plants with its ability to grow when spring water temperatures are still cool. This head start over the native vegetation can allow the Eurasian water milfoil to develop a canopy, shading out other submergent plants. In addition, Eurasian water milfoil can reproduce easily from plant fragments that float to new locations and take root. Curly-leaf pondweed is not as invasive as Eurasian water milfoil, though it does grow in cool water while native vegetation remains dormant. Winter foliage can be produced under a cover of ice. Plant respiration can then deplete oxygen supplies as was noted during February in Little Asylum Lake. Plant die-off in mid-summer will also release nutrients into the water column and organically enrich already heavily laden carbon-rich sediments. The latter condition leads to more severe sediment oxygen demand. Whether chemical treatment or physical plant removal is desired and/or practical here, will likely be a cost-based decision.

Purple loosestrife is a highly invasive species, which can quickly dominate wetland and lakeshore areas. One mature plant (4-5 years old) can produce 2,700,000 seeds annually (USGS, 1999). These seeds can remain viable in the soil for many years and can be transported via wind, water, animals, or humans. For this reason, purple loosestrife presents a potential risk to Asylum and Little Asylum Lake plant diversity.

Generalized plant management guidelines suggest that 20-40% native plant cover should be maintained in a lake for healthy fish and wildlife habitat (Madsen et al., 2002). For this reason, a diverse native plant community should be maintained in Asylum and Little Asylum Lakes. In addition to providing habitat for both lakes, a diverse plant community may also serve to stabilize bottom sediments, buffer shoreline areas from erosion, and absorb in-lake nutrients such as phosphorus and nitrogen that would be utilized for algae growth if not taken up by macrophytes. The Asylum Lake Policy and Management Council should recognize these benefits as they consider efforts for future vegetation management.