Swartswood Lake – Water Quality and Macrophyte Survey

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1.0 Introduction

Swartswood Lake is an approximately 519 acre waterbody located in Swartswood State Park, Sussex County, New Jersey. As a focal point of the park, Swartswood Lake serves the dual purpose as an ecological and recreational resource. As such, this lake has been the focus of intensive water quality monitoring which has served to document critical chemical, physical, and biological components of the lake's ecosystem. This data has subsequently served as the empirical basis for extensive watershed and in-lake management measures which have aimed towards improving the lake's trophic state and decreasing the pervasiveness of non-native, invasive macrophyte (aquatic plant) species.

Historically, Swartswood Lake has been intensively managed to control populations of non-native, invasive macrophytes, most notably Eurasian watermilfoil (*Myriophyllum spicatum*). Management of this species has consisted of herbicide applications, winter drawdowns, mechanical harvesting, and the introduction of milfoil weevils. Throughout these processes the New Jersey Department of Environmental Protection (NJDEP) has monitored macrophyte community composition and abundance in order to assess the effectiveness of these management measures and to track what deleterious effects, if any, these management efforts may be having on the lake's native plant community. This assessment is particularly critical within Swartswood Lake given the presence of several state-listed threatened and endangered plant species including Illinois pondweed (*Potamogeton illinoensis*), Flat-stem pondweed (*Potamogeton zosteriformis*), White-stem pondweed (*Potamogeton praelongus*), Fern pondweed (*Potamogeton robbinsii*) and American lotus[1] (*Nelumbo lutea*).

In addition, Swartswood Lake has taken extensive steps towards reducing phosphorus loading to the lake both in terms of reducing the watershed based load and reducing the internal load through the implementation of a hypolimnetic aeration system. Such steps have been taken to control excessive primary productivity while maintaining appropriate fishery habitat within the lake.

The following report details results from water quality monitoring and an aquatic vegetation survey of Swartswood Lake conducted during 18 August 2010. This report serves to not only continue the historical database of macrophyte community composition and abundance throughout the established monitoring sites but will also be evaluated on an intra-annual basis to assess changes in macrophyte community structure as a result of fluridone applications. Furthermore, the water quality data is presented to assess the trophic state of Swartswood Lake at the time of sampling.

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[1] While the American lotus is listed as a native, this plant may have been introduced in New Jersey by Native Americans who carried the plant as a food source (Wiersema, 1997).

2.0 Methodology

2.1 Water Quality Monitoring

This study consisted of a single monitoring event which was conducted on 18 August 2010. Sampling was conducted at five (5) in-lake locations:

- The inlet from Little Swartswood Lake,
- At the central deepest point in the lake,
- Adjacent to the bathing area,
- In the north cove by Greenwood Point, and
- At the southern end of the lake near its point of discharge.

Both *in-situ* and discrete water samples were collected for the purposes of establishing key environmental factors reflective of the lake's present condition. *In-situ* data were collected at all five stations while discrete grab samples were collected at the central, deepest portion of the lake. The *in-situ* data were collected in profile from top to bottom through the water column by means of a calibrated Eureka Manta multi-probe water quality meter and Eureka Amphibian Data Logger. Princeton Hydro is an NJDEP Certified Laboratory (Laboratory Certification # 10006) certified to measure *in-situ* parameters. The measured *in-situ* parameters included dissolved oxygen, dissolved oxygen percent saturation, pH, specific conductance, and temperature. Water clarity or transparency was monitored with a Secchi disk. Discrete water quality samples were also collected during the monitoring event. Discrete samples were collected at approximately 0.5 m below the waters surface and at approximately 1 m above the lakes sediments at the central, deepest station. The discrete samples were forwarded under chain-of-custody procedures to an independent contractor, Environmental Compliance Monitoring, Inc. of Neshanic Station, New Jersey (Laboratory Certification # 18630) for the analysis of Total Phosphorous (TP), Soluble Reactive Phosphorus (SRP), Nitrate-Nitrogen (NO_3-N), Ammonia-Nitrogen (NH_3-N), Total Suspended Solids (TSS), and Chlorophyll *a* (Chl a). Chlorophyll *a* was collected at the lake's surface only.

Each of the above *in-situ* and discrete test parameters are used by NJDEP and USEPA as indicators of lake water quality. In order to effectively assess the lake's water quality, Princeton Hydro utilized a sampling regime that accounted for spatial variation of the lake system by sampling at five stations throughout the lake. All sampling procedures were consistent with the guidelines outlined in the NJDEP Field Sampling Procedures Manual (2005) while the sampling stations were consistent with those established during the 2009 monitoring year.

2.2 Macrophyte Survey

During the 18 August 2010 event Princeton Hydro conducted a macrophyte survey of Swartswood Lake. This survey aimed to identify macrophyte community composition and abundance throughout key locations within Swartswood Lake. Six (6) sample transect locations throughout Swartswood Lake were selected by Princeton Hydro based on our knowledge of weed growth within this lake. The stations monitored during the August event were the same which were monitored during the May 2010 event. Transect locations were mapped using a Magellan© handheld Global Positioning System (GPS) unit. The sampled locations are as follows:

- The inlet from Little Swartswood Lake,
- The north cove adjacent to West Shore Drive,
- Adjacent to the bathing area,
- In the north cove by Greenwood Point,
- At the southern end of the lake near its point of discharge,
- The southwest shore of the Lake (As requested by NJDEP).

Monitoring of the survey transects was conducted by Princeton Hydro staff trained in aquatic plant identification and survey methods. A line intercept sampling methodology (Madsen 1999) was used to sample all transects. At each site, Princeton Hydro established a 100-foot transect which extended from the shoreline out into the center of the lake. Along each transect, transect plots were sampled at approximately 10, 50, and 100 feet from the shoreline. Each plot was delineated by using a floating $1m^2$ quadrat. The area inside the quadrat, defined on the bed of the lake by drop chains, was observed and sampled using an Aquascope® or mask and snorkel. Water clarity was measured at the 100-foot mark using a Secchi disk. The plant community was identified to the lowest practical taxon (generally species) and ranked according to abundance using the following formula: (A) **Abundant**, greater than or equal to 50% of total plant community, (C) **Common,** 10% to 50% of total plant community, (P) **Present,** less than or equal to 10% of total plant community. Species identifications were made utilizing previous identification knowledge and various aquatic plant field guides including (Borman, 1997 & Hellquist, 1980).

3.0 Results

3.1 Water Quality Monitoring

In-situ Parameters

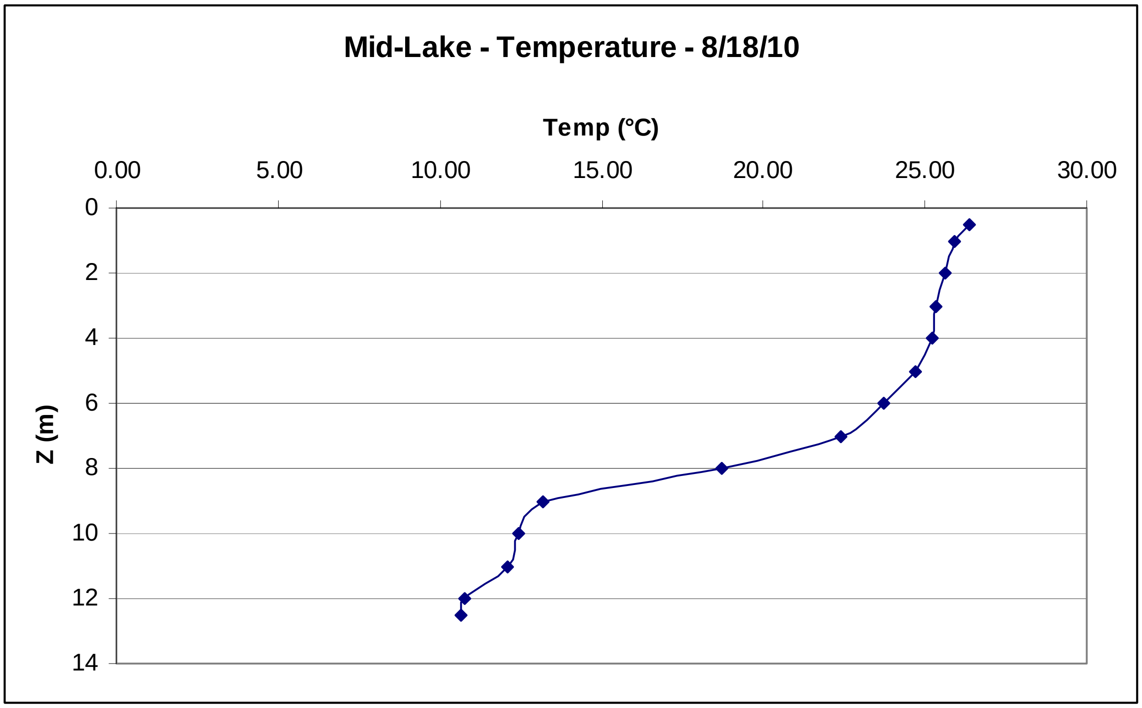
Temperature

A lake's water temperature is often a primary factor controlling many biological and chemical reactions. Primarily dependent upon ambient air temperatures, thermal diffusion is generally aided through wind driven or artificial mixing. Changes in water temperature with depth are primarily dependent upon the degree of light attenuation, water clarity and lake depth.

The morphometry of the lake basin is the primary factor determining temperature distributions throughout the water column. Essentially, shallow basins experience much less spatial variation in temperature distribution throughout the water column than are experienced in deeper basins. An important characteristic of changes in water temperature are the resultant changes in water density. Simply, cooler water is denser than warmer water. Deep lakes, those with maximum depths greater than 8', may exhibit thermal stratification. This is a natural phenomenon that occurs during the summer months whereby increasing air temperatures, in conjunction with a few days of little wind activity, combine to thermally stratify the water column. Thermal stratification consists of a relatively warm upper water layer, termed the epilimnion, a transition zone, termed the metalimnion or thermocline, and a cold, deep water layer, termed the hypolimnion. These density differences throughout the water column serve to prevent wind driven mixing of the water column thereby effectively sealing off the hypolimnetic layer from contact with the atmosphere. This phenomenon has important implications in that bottom waters of thermally stratified systems may become devoid of oxygen due to excessive bacterial decomposition of organic matter and a lack of atmospheric replenishment of dissolved oxygen through diffusion. Resultant conditions of hypolimnetic anoxia include internal sediment release of metals and nutrients, and reduced fish habitat. These conditions may serve to rapidly accelerate eutrophication as phosphorus derived from the lake's surrounding watershed is no longer bound in the sediments but instead serves as a secondary nutrient source to fuel excessive algal growth.

Temperatures measured approximately 0.5 m below the waters surface ranged from a minimum of 25.92°C (78.66°F) at the outlet to a maximum of 27.25°C (81.05°F) at the Bathing Beach. Temperatures measured at the mid-lake station ranged from 26.36°C (79.45°F) 0.5 m below the surface to 10.64°C (51.15°F) at 12.5 m (Z_{max} = 12.6 m). The temperature profile measured throughout the water column at the mid-lake station is presented in figure 3.1.

Figure 3.1: Swartswood Lake – Mid-Lake Temperature Distribution



Swartswood Lake was strongly thermally stratified during the 18 August 2010 event as indicated in figure 3.1. The epilimnion extended from the surface to 4 m with the thermocline extending to 9 m.

Dissolved Oxygen

Dissolved oxygen is crucial to almost all biochemical reactions occurring in freshwater ecosystems. Primary sources of dissolved oxygen are diffusion from the atmosphere and photosynthesis, while sinks are biological respiration and bacterial decomposition of organic matter. The abundance and distribution of dissolved oxygen in a lake system is based on relative rates of producers (photosynthetic organisms) versus consumers (metabolic respiration). Again, as noted above, it is also frequently influenced by the thermal properties of the water column. This affects dissolved oxygen levels not only as a result of stratification, but also in terms of the extent of dissolved oxygen saturation. Simply put, warmer water has less dissolved oxygen retention capacity than does cooler water. As such, the concentration of dissolved oxygen in cooler water is typically greater than warmer water.

As plants (including aquatic macrophytes and single-celled phytoplankton or algae) photosynthesize they take up water and carbon dioxide and through the use of light energy convert those reactants into oxygen and glucose. This serves to increase the net concentration of dissolved oxygen in lakes during the day in the uppermost water layers where there is ample sunlight to support photosynthesis; this layer is termed the photic zone. As such, dissolved oxygen concentrations are generally higher in the upper water layers and lower in the lower water layers due to a lack of photosynthetic activity in conjunction with aquatic animal and bacterial respiration which consume oxygen.

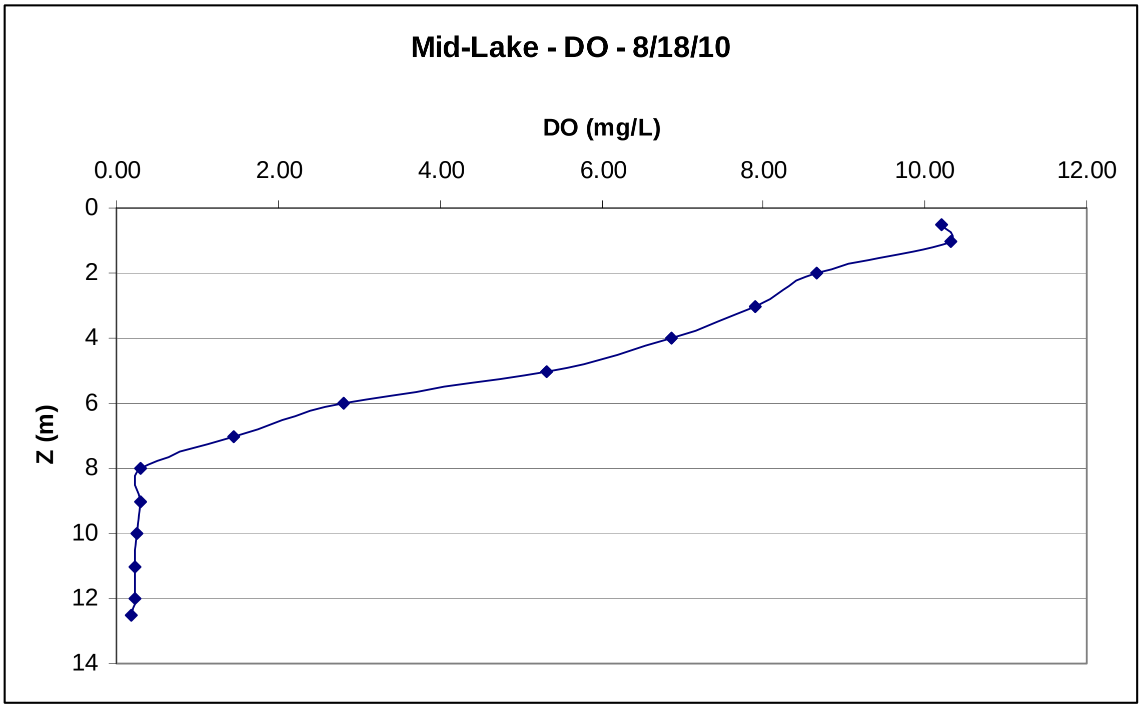
As emphasized above, relative concentrations of dissolved oxygen are also due to temperature and density differences throughout the water column. When lakes thermally stratify there is generally a correlated stratification of dissolved oxygen levels. Lower water layers usually contain less dissolved oxygen as they cannot mix with upper water layers whereby dissolved oxygen concentrations would be replenished with atmospheric sources. In highly productive lakes the hypolimnion may become devoid of oxygen due to bacterial decomposition of excessive inputs of organic material. The source of this material may either be from excessive phytoplankton production in the upper water layers that then sink to the bottom when they die (autochthonous) or from excessive watershed derived sediment loading (allochthonous) or more likely a mixture of the two as they are inherently intertwined. Also, as dissolved oxygen concentrations are generally measured during the daytime, when concentrations are highest, there will be far lower concentrations at night when photosynthesis ceases, respiration continues, and diffusion is the sole input of oxygen to the lake.

An important consequence of anoxic conditions in the hypolimnion includes both reduced fish habitat and release of metals and phosphorus, a process termed *internal loading*. Internal loading occurs when tightly bound iron and phosphate sediment complex are chemically reduced thereby dissociating phosphorus from iron and making it available for diffusion into the water column. This process has been documented to contribute to the overall eutrophication of many lakes as this internal source of phosphorus is pulsed into the photic zone during strong storm events when the lake may mix and whereby these nutrients may serve as fuel for excessive algal growth. A general guideline for dissolved oxygen concentrations in lakes is that a concentration of greater than 1.0 mg/L is needed to preclude internal nutrient and metal release while concentrations of 4.0 mg/L and greater should be kept in order to sustain warm-water fishery habitat. Concentrations of 6.0 mg/L and greater are preferred for coldwater species.

Swartswood Lake has taken a pro-active approach towards mitigating hypolimnetic dissolved oxygen depletion through the installation and operation of a hypolimnetic aeration system. Such a system serves to maintain thermal stratification while allowing for re-oxygenation of the cold, hypolimnetic waters. This system has the benefits of not only mitigating internal phosphorus release from the sediments but also serves to maintain appropriately oxygenated, deep coldwater fishery habitat.

Dissolved oxygen concentrations measured approximately 0.5 m below the waters surface ranged from a minimum of 9.88 mg/L at the Bathing Beach to a maximum of 11.29 mg/L at the North Greenwood Point station. Dissolved oxygen concentrations measured throughout the water column at the Mid-Lake station ranged from 10.20 mg/L at 0.5 m to 0.18 mg/L at 12.5 m (figure 3.2).

Figure 3.2: Swartswood Lake – Mid-Lake Dissolved Oxygen Distribution



Dissolved oxygen concentrations varied significantly throughout the water column due to thermal stratification and varying rates of production versus respiration. DO concentrations were supersaturated in the epilimnion and declined to anoxic conditions at depths of 8 m and greater. DO concentrations were greater than Princeton Hydro's recommended threshold of 4.0 mg/L throughout the upper 5 m of the water column.

pH

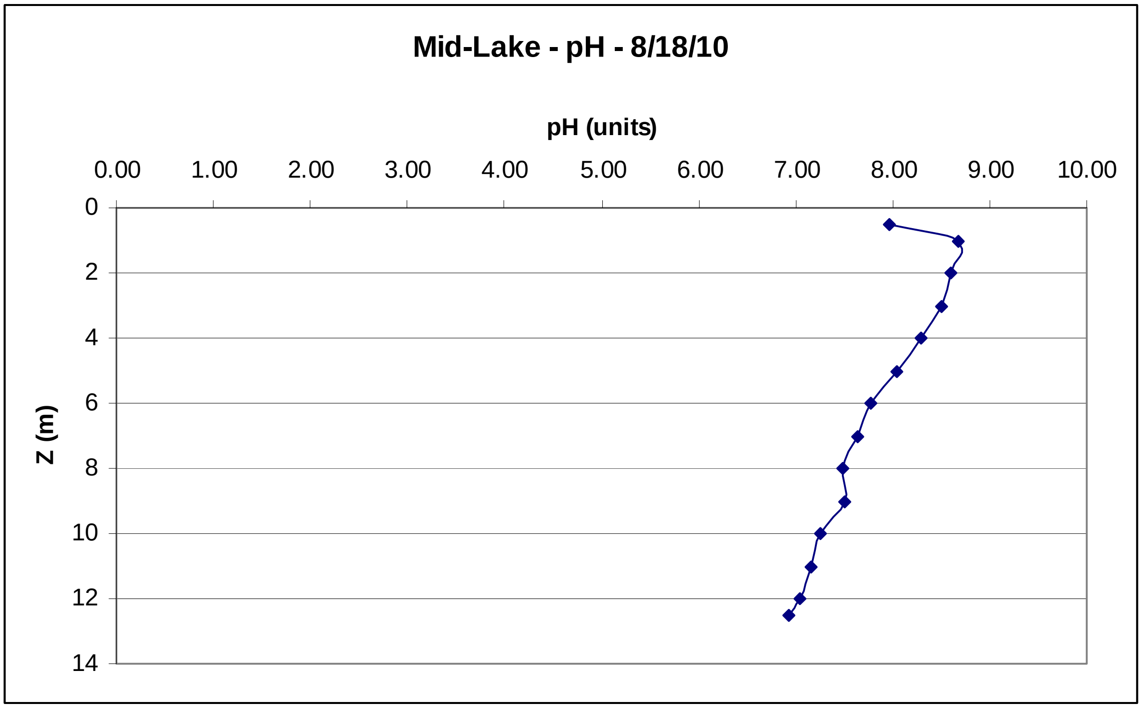
pH is a unit-less measurement of the hydrogen ion concentration in water. Expressed on a negative logarithmic scale from 0 to 14, every change of 1 pH unit represents a 10-fold increase or decrease in hydrogen ion concentration. The pH of pure water is 7 and is termed neutral. Any value less than 7 is termed acidic, while any value greater than 7 is termed basic.

Baseline pH values are primarily determined by the ionic constituency of surrounding geology. Watersheds underlain by soils composed of easily weatherable anionic constituents are generally well buffered and as such have overlying waters with basic pH values (pH above 7) while those waters overlying geologic formations which are resistant to weathering are generally weakly buffered and are therefore characterized by acidic surface waters (pH less then 7).

Spatial variations in pH throughout the water column are largely due to relative rates of production versus respiration. As plants and algae photosynthesize they release anions while collectively taking up acidic compounds related to carbon dioxide species. This serves to produce a net increase in pH. Conversely, respiration releases carbon dioxide which serves to drive down pH values. Given these relationships, pH values may differ substantially between the top and bottom water layers in lakes with a large amount of productivity or respiration throughout the water column.

pH values measured 0.5 m below the waters surface ranged from a minimum of 7.97 at the Mid-lake station to a maximum of 8.59 at the Outlet station. pH values measured throughout the water column at the Mid-lake station ranged from 7.97 at 0.5 m to 6.92 at 12.5 m (figure 3.3.).

Figure 3.3: Swartswood Lake – Mid-Lake pH Distribution



pH values throughout the water column showed normal spatial variation as reflected by varying rates of photosynthesis versus respiration. Overall, pH values were within an appropriate range for the support of aquatic life and were of no cause for concern.

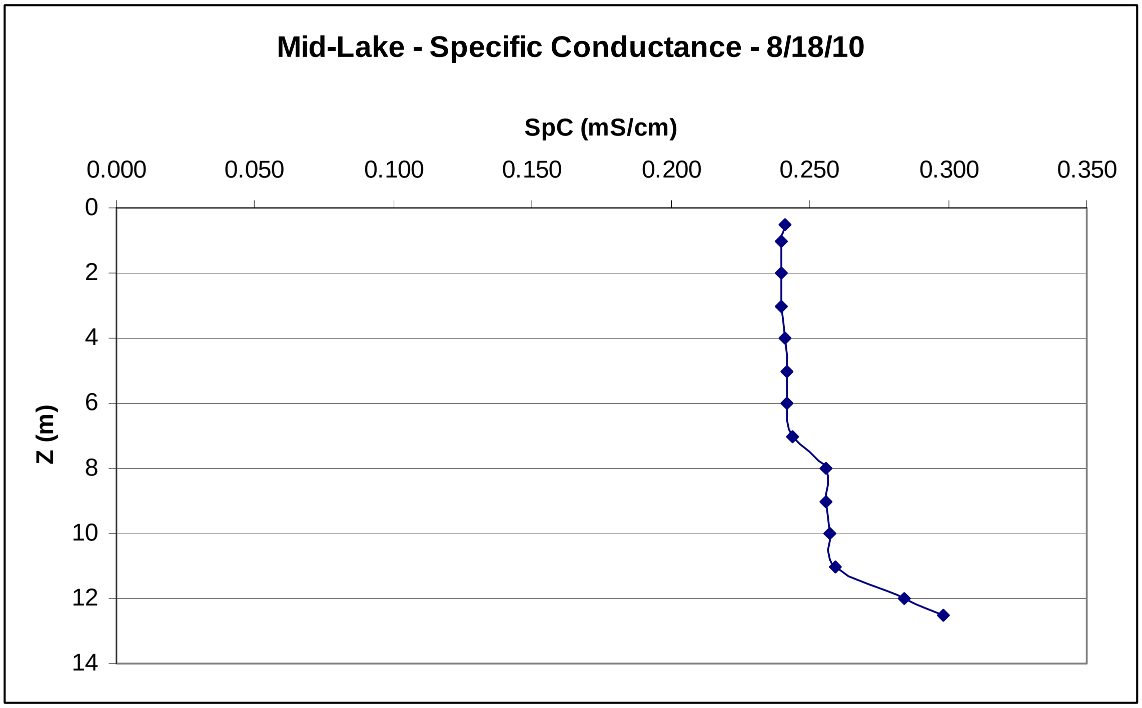
Specific Conductance

Specific conductance is defined as the ability of water to conduct an electrical current. Increases in specific conductance are due to an increase in ionic constituents from watershed soils and biological reactions and are temperature dependent. Specific conductance is normalized for the effects of temperature on conductivity values.

Watershed geology, pH, and the dissolved solids loads in runoff play an important part in determining conductance values for a particular lake. Some rocks and soils release ions very easily when water flows over them; for example, if water of low pH flows over calcareous rocks then ions of calcium (Ca^{2+}) and carbonate (CO_3^{2-}) ions will dissolve in water and raise the conductance values. Some rocks such as quartz and granite are very resistant to weathering and watersheds predominated by this type of geology generally lead to receiving waters of low specific conductance.

Specific conductance values measured 0.5 m below the waters surface ranged from a minimum of 0.233 mS/cm at the Beach station to a maximum of 0.242 mS/cm at the Inlet. Specific conductance values measured at the Mid-Lake station ranged from 0.241 mS/cm at 0.5 m to 0.298 mS/cm at 12.5 m (figure 3.4).

Figure 3.3: Swartswood Lake – Mid-Lake Specific Conductance Distribution



Specific conductance values were homogenous throughout the upper 7 m and then increased throughout the hypolimnion as a result of anoxia and associated reducing conditions at the sediments which served to release ionic constituents into the overlying water.

Transparency

Transparency in lakes is generally determined through the use of a Secchi disk. The Secchi disk is a contrasting white and black disk that is lowered into the lake until no longer visible then retrieved until visible again. The average of those two lengths is termed the Secchi depth. This depth may be influenced by algal density, suspended inorganic particles, organic acid staining of the water or more commonly a combination of all three. This parameter is often times used to calculate the trophic status (productivity) of a lake and as such is a critical tool in lake evaluation. Secchi depths less than 1.0 m are generally associated with reduced water quality due to high concentrations of algae or suspended inorganic sediments and, as such, is generally associated with impaired quality.

Secchi disk measurements ranged from a minimum of 1.0 m at the inlet to a maximum of 1.35 m at the Mid-lake station. Secchi depths at the Mid-lake station were lower than those measured during the May event as a result of an algal bloom which occurred at the time of sampling.

Discrete Parameters

Total and Soluble Reactive Phosphorus (TP & SRP)

In lake ecosystems phosphorus is often the limiting nutrient, one whose abundance is lowest relative to demand. As a result, phosphorus is often the primary nutrient driving excessive plant and algal growth. Given this nutrient limitation only relatively small increases in phosphorus concentrations can fuel algal blooms and excessive macrophyte production. By monitoring total phosphorus concentrations the current trophic status of the lake can be determined and future trends in productivity may be predicted. The current concentration threshold set for total phosphorus concentrations in lakes and ponds by the NJDEP is 0.05 mg/L. This concentration is a blanket value for all of New Jersey's lakes and ponds and is used as a benchmark to limit excessive production. Through careful analysis of many regional waterbodies Princeton Hydro recommends total phosphorus concentrations not exceed 0.02-0.03 mg/L in order to preclude extended nuisance algal blooms.

It is important to note that total phosphorus concentrations account for all species of phosphorus: organic and inorganic, soluble and insoluble. Therefore, this measure accounts not only for those dissolved, inorganic species of phosphorus that are readily available for algal assimilation, but also for those species of phosphorus either tightly bound to soil particles or contained as cellular constituents of aquatic organisms which are generally unavailable for algal assimilation.

Soluble reactive phosphorus represents the dissolved inorganic portion of total phosphorus metrics. This species of phosphorus is readily available for assimilation by all algal forms for growth and is therefore normally present in limited concentrations except in hypereutrophic lakes. Princeton Hydro recommends concentrations of SRP to not exceed 0.005 mg/L to preclude nuisance algal blooms.

TP concentrations, measured at the mid-lake station, were 0.03 mg/L at 0.5 m below the surface and 0.12 mg/L at 11.5 m. SRP concentrations were non-detectable (ND < 0.002 mg/L) approximately 0.5 m below the surface and 0.006 mg/L at 11.5 m. Phosphorus concentrations within the surface waters equaled Princeton Hydro's recommended phosphorus threshold concentration while those in the deep waters were four times higher than those in the surface. Elevated hypolimnetic phosphorus concentrations are indicative of internal loading of phosphorus due to anoxic conditions at the sediment / water interface. Such conditions likely led to the prevalence of nuisance cyanobacterial scums which were observed at the time of sampling.

Chlorophyll *a*

Chlorophyll *a* is the primary photosynthetic component of all algae and as such is often used as a proxy indicator of total algal biomass. Increases in chlorophyll *a* concentrations are generally attributable to increases in total algal biomass and are highly correlated with increasing nutrient concentrations. As such, elevated chlorophyll *a* concentrations are a visible indicator of increased nutrient loading within a waterbody.

Chlorophyll *a* concentrations greater than 6 µg/L are generally associated with eutrophic conditions. Through analysis of many regional waterbodies Princeton Hydro has determined that concentrations greater than 20 µg/L are generally perceived as water quality issues in terms of reduced clarity, noxious odors, and unsightly surface scums. Concentrations greater than 20 µg/L are generally attributed to excessive phosphorus loading and are therefore a visible sign of nutrient impairment.

A chlorophyll *a* concentration of 22.9 µg/L was measured approximately 0.5 m below the waters surface at the mid-lake station. This concentration is greater than the classic eutrophication threshold of 6.0 µg/L and Princeton Hydro's recommended threshold concentration of 20 µg/L. Furthermore, the chlorophyll *a* concentration measured during the August event was more than four times greater than that measured during the May event. Elevated algal growth was likely due to internal loading of phosphorus and as such led to impaired clarity.

Total Suspended Solids (TSS)

The concentration of suspended particles in a waterbody that will cause turbid or "muddy" conditions, total suspended solids is often a useful indicator of sediment erosion and stormwater inputs into a waterbody. Because suspended solids within the water column reduce light penetration through reflectance and absorbance of light waves and particles, suspended solids tend to reduce the active photic zone of a lake while contributing a "muddy" appearance at values over 25 mg/L. Total suspended solids measures include suspended inorganic sediment, algal particles, and zooplankton particles.

In addition, as phosphorus molecules are often tightly bound to soil particles, elevated total suspend solids measures may serve as indicators of not only excessive sediment inputs but also excessive phosphorus inputs to a waterbody.

TSS concentrations were 4 mg/L at 0.5 m below the surface and 7 mg/L at 11.5 m at the mid-lake station during the May event. TSS concentrations were relatively low at the surface while twice as high in the deep waters; likely as the result of the settling of algal particulates.

Nitrate (NO_3-N)

Nitrate is the most abundant form of inorganic nitrogen in freshwater ecosystems. Common sources of nitrate in freshwater ecosystems are derived from bacterial facilitated oxidation of ammonia and through groundwater inputs. The molecular structure of nitrate lends to its poor ability to bind to soil particles but excellent mobility in groundwater.

Nitrate is often utilized by algae, although to a lesser extent than ammonia, for growth. Nitrate distribution is highly dependent on algal abundance and the spatial distribution of dissolved oxygen concentrations. In many eutrophic lake systems nitrate concentrations show temporal and spatial variability due to algal productivity and relative concentrations of dissolved oxygen.

Relatively "healthy" lakes have nitrate concentrations less than 0.05 mg/L. Excessively high concentrations of nitrate are primarily attributable to either wastewater inputs or excessive organic matter decomposition in oxygenated hypolimnion.

Nitrate concentrations were non-detectable (ND < 0.02 mg/L) at both the surface and deep stations. Low nitrate concentrations at the deep station were due to the absence of dissolved oxygen which would have been utilized to oxidize ammonia to nitrate under oxic conditions.

Ammonia (NH_3-N)

In lakes ammonia is naturally produced and broken down by bacterial processes while also serving as an important nutrient in plant growth. In a process termed ammonification, bacteria break down organically bound nitrogen to form NH_4^+. In aerobic systems bacteria then break down excess ammonia in a process termed nitrification to nitrate (NO_3^-). These processes provide fuel for bacteria and are generally kept in balance as to prevent accumulation of any one nitrogen compound.

Ammonia is generally present in low concentrations in oxygenated epilimnetic layers of lakes due to the rapid conversion of the ammonium ion to nitrate. In addition, most plants and algae prefer the reduced ammonium ion to the oxidized nitrate ion for growth and therefore further contribute to reduced concentrations of ammonia in the upper water layer. In the anoxic hypolimnion of lakes ammonia tends to accumulate due to increased bacterial decomposition of organic material and lack of oxygen which would otherwise serve to oxidize this molecule to nitrate.

Increased surface water concentrations of ammonia may be indicative of excessive non-point source pollution from the watershed. The ammonium ion, unlike that of nitrate, may easily bind to soil particles where it may be transported to the lake during storm events. Increases in ammonia concentrations in the hypolimnion of lakes are generally associated with thermal stratification and subsequent dissolved oxygen depletion. Once stratification breaks down a pulse of ammonia rich water may be mixed throughout the entire water column where it will cause undue stress to aquatic organisms.

Toxicity of ammonia to aquatic species generally increases with increasing pH (>8.5) and decreasing temperature (<5°C). The general guideline issued by the EPA is that ammonia should not exceed a range of 0.02 mg/L to 2.0 mg/L, dependent upon water temperature and pH, to preclude toxicity to aquatic organisms.

Ammonia concentrations were 0.02 mg/L 0.5 m below the surface and 0.61 mg/L at 11.5 m. The disparity in ammonia concentrations between the surface and deep waters is due to the absence of oxygen within the hypolimnion which would have served as an electron acceptor in the process of nitrification ($NH_3 \leftrightarrow NO_2 \leftrightarrow NO_3$).

3.2 Macrophyte Survey

The following table (3.1) lists all species identified during the aquatic vegetation survey of Swartswood Lake during the 18 August 2010 event. This list includes those species identified along the survey transects and any species that were observed within the vicinity of the transect location. This list does not represent all the species present within Swartswood Lake given the limited nature of this survey.

Table 3.1: Swartswood Lake – Macrophyte Species List

Name	
Common	**Scientific**
Eurasian watermilfoil	*Myriophyllum spicatum*
Northern milfoil*	*Myriophyllum sibiricum*
Flat-stem pondweed*	*Potamogeton zosteriformis*
Illinois pondweed*	*Potamogeton illinoensis*
Clasping-leaf pondweed	*Potamogeton perfoliatus*
Ribbon-leaf pondweed	*Potamogeton epihydrus*
White-stem pondweed*	*Potamogeton praelongus*
Variable pondweed	*Potamogeton gramineus*
Large-leaf pondweed	*Potamogeton amplifolius*
Small pondweed	*Potamogeton pusillus*
Water stargrass	*Zosterella dubia*
Slender naiad	*Najas flexilis*
Elodea	*Elodea canadensis*
Coontail	*Ceratophyllum demersum*
Watershield	*Brasenia schreberi*
Spatterdock	*Nuphar variegata*
White water lily	*Nymphaea odorata*
American Lotus*	*Nelumbo lutea*
Duckweed	*Lemna minor*
Nitella	*Nitella* spp.

* - Indicates New Jersey listed threatened and endangered species per plants.usda.gov

Nineteen (19) macrophytes and one (1) macro-alga were identified at the sample transects in Swartswood Lake during the 18 August 2010 event. Overall, species richness, diversity and density was high during this event. The following sections detail macrophyte community structure at each of the six (6) transects throughout the lake. Transect coordinates, in decimal degrees, are provided in appendix II.

South Transect

The following table (3.2) lists the species identified and relative abundance along the South (outlet) transect.

Table 3.2: Swartswood Lake – South Transect

Swartswood Lake - South - 8/18/10

Name			Transect	
Common	Scientific	10'	50'	100'
White water lily	*Nymphaea odorata*	A	A	A
Eurasian watermilfoil	*Myriophyllum spicatum*			A
Illinois pondweed	*Potamogeton illinoensis*			P
Coontail	*Ceratophyllum desmersum*		P	P
Northern milfoil	*Myriophyllum sibiricum*			P
Slender naiad	*Najas flexilis*			P
Variable pondweed	*Potamogeton gramineus*		P	
Flat-stem pondweed	*Potamogeton zosteriformis*			P

Species richness was relatively high while diversity was moderate at the south station. The dominant macrophyte throughout this station was White water lily which grew in abundance from the shoreline extending out past the 100’ quadrat. Eurasian watermilfoil was the predominant species past the border of White water lily growth.

Sediments within the south station were comprised primarily by fine to medium sized organic material.

North Greenwood Point

The following table (3.3) lists the species identified and relative abundance along the North Greenwood Point transect.

Table 3.3: Swartswood Lake – North Greenwood Point Transect

Swartswood Lake - North Greenwood Point - 8/18/10

Name		Transect		
Common	Scientific	10'	50'	100'
Water stargrass	*Zosterella dubia*	P		
Eurasian watermilfoil	*Myriophyllum spicatum*	P		
Clasping-leaf pondweed	*Potamogeton perfoliatus*		P	
Large-leaf pondweed	*Potamogeton amplifolius*		P	C
Flat-stem pondweed	*Potamogeton zosteriformis*		A	A
Elodea	*Elodea canadensis*			P
Small pondweed	*Potamogeton pusillus*			C

Species richness gradually increased with distance from the shoreline with little growth at the shoreline quadrat to the identification of four species at the 100 foot quadrat. Additional plants which were identified in the general vicinity of the transect line included Ribbon-leaf pondweed and Eurasian watermilfoil. Plant densities were generally low near shore and increased in density, past the 100 foot quadrat, to the center of the cove.

Sediments at this station were comprised primarily by soft, medium sized organic particulates.

Bathing Beach

The following table (3.4) lists the species identified and relative abundance along the Bathing Beach transect.

Table 3.4: Swartswood Lake – Bathing Beach Transect

Swartswood Lake - Bathing Beach - 8/18/10

Name		Transect		
Common	Scientific	10'	50'	100'
Flat-stem pondweed	*Potamogeton zosteriformis*	P	P	P
Large-leaf pondweed	*Potamogeton amplifolius*	P		A
Nitella	*Nitella* spp.		P	
Slender naiad	*Najas flexilis*		P	
Water stargrass	*Zosterella dubia*		C	
Clasping-leaf pondweed	*Potamogeton perfoliatus*			P

Only sparse macrophyte growth was observed at the shoreline station of the Bathing Beach due to the prevalence of unsuitable substrate characterized by large rocks and a lack of organic material. Species richness and diversity increased further from shore with four and three species identified at the 50 and 100 foot quadrats, respectively. Densities were highest at the 100 foot quadrat with Illinois pondweed comprising the majority of macrophyte abundance.

Inlet

The following table (3.5) lists the species identified and relative abundance along the Inlet transect.

Table 3.5: Swartswood Lake – Inlet Transect

Swartswood Lake - Inlet - 8/18/10

Name		Transect		
Common	Scientific	10'	50'	100'
Spatterdock	*Nuphar variegata*	A	A	A
Coontail	*Ceratophyllum desmersum*	P	C	
Duckweed	*Lemna minor*		P	
White water lily	*Nymphaea odorata*	A		

Spatterdock was the dominant macrophyte at all three quadrats; comprising greater than 50% of the total macrophyte community. Species richness was greatest at the 10’ and 50’ quadrat and decreased at the 100’ quadrat.

Substrate at the inlet station consisted of large particulate organics near shore extending to finer organics at the 100' quadrat.

West Shore Drive

The following table (3.6) lists the species identified and relative abundance along the West Shore Drive transect.

Table 3.6: Swartswood Lake – West Shore Drive Transect

Swartswood Lake - West Shore Drive - 8/18/10

Name		Transect		
Common	Scientific	Shoreline	50'	100'
American Lotus	*Nelumbo lutea*	A	A	A
White water lily	*Nymphaea odorata*	A	A	A

Species richness was low but density was high at the West Shore Drive transect. American lotus and White water lily were the dominant species. Both were present in equal densities, comprising approximately 50% of the macrophyte community.

Sediments within this area were comprised of large particulate organics.

Heritage Site

The following table (3.7) lists the species identified and relative abundance along the Heritage Site transect. This transect was added to the standard set of sampling stations per NJDEP and was located along the southwest shore of the lake (Appendix II).

Table 3.7: Swartswood Lake – Heritage Site

Swartswood Lake - Heritage Site - 8/18/10

Name		Transect		
Common	Scientific	10'	50'	100'
Northern milfoil	*Myriophyllum sibiricum*	P		
White water lily	*Nymphaea odorata*	A	A	
Watershield	*Brasenia schreberi*	P	P	

White water lily was the dominant macrophyte at the 10’ and 50’ quadrat; comprising greater than 50% of the total macrophyte community. Water depths were too great at the 100’ quadrat to support submerged aquatic vegetation.

4.0 Summary

On August 18, 2010 Princeton Hydro collected detailed macrophyte community composition data in concert with water quality data in Swartswood Lake. This sampling event served to continue monitoring which was initiated during the 2009 season. This data hereby may be utilized to assess both inter- and intra-annual variations in water quality and macrophyte community structure and abundance.

Water quality data collected during the August event characterized Swartswood Lake as an eutrophic waterbody. Chlorophyll *a* concentrations measured during the August event (22.9 µg/L) were greater than Princeton Hydro's threshold of 20 µg/L and were more than four times the concentration measured during the May event (5.2 µg/L). Elevated algal growth was dominated by the cyanobacteria as evidence from field observations. The predominance of cyanobacteria in Swartswood Lake at the time of sampling coincided with elevated hypolimnetic phosphorus concentrations (0.12 mg/L) which were four times those measured in the surface waters (0.03 mg/L). Such conditions strongly suggest there is an internal loading source of phosphorus which is fueling algal growth within this waterbody. Subsequently, transparency declined in Swartswood Lake from 1.8 m during the May event to 1.35 m during the August event.

Macrophyte community data collected during the August event was characterized by high species richness, diversity and density. Princeton Hydro identified nineteen macrophyte species during the August event compared to eleven during the May event. The temporal variation in species richness and density is directly related to the length of the growing season and is not abnormal.

Appendix I

Water Quality Data

In-situ Data

Swartswood - Mid - 8/18/10								
Date	Depth (m)			Temp	SpC	DO	DO%	pH
	Max	Secchi	Sample	(°C)	(mS/cm)	(mg/L)	(%)	(units)
8/18/2010	12.6	1.35	0.5	26.36	0.241	10.20	128.4	7.97
			1	25.92	0.240	10.31	128.7	8.68
			2	25.60	0.240	8.65	107.4	8.60
			3	25.36	0.240	7.89	97.3	8.50
			4	25.21	0.241	6.86	84.4	8.30
			5	24.72	0.242	5.33	65.1	8.05
			6	23.71	0.242	2.80	33.5	7.77
			7	22.42	0.244	1.44	17.0	7.63
			8	18.72	0.256	0.30	3.3	7.49
			9	13.20	0.256	0.29	2.8	7.51
			10	12.42	0.257	0.25	2.3	7.26
			11	12.10	0.259	0.23	2.2	7.16
			12	10.74	0.284	0.24	2.1	7.04
			12.5	10.64	0.298	0.18	1.7	6.92

Swartswood - Outlet - 8/18/10								
Date	Depth (m)			Temp	SpC	DO	DO%	pH
	Max	Secchi	Sample	(°C)	(mS/cm)	(mg/L)	(%)	(units)
8/18/2010	4.6	1.1	0.5	25.92	0.240	10.15	126.6	8.59
			1	25.78	0.240	9.97	124.1	8.70
			2	25.60	0.239	9.79	121.5	8.73
			3	25.47	0.240	9.77	120.9	8.74
			4	25.21	0.240	9.12	112.4	8.70
			4.5	24.79	0.244	4.25	51.8	8.16

Swartswood - Inlet - 8/18/10								
Date	Depth (m)			Temp	SpC	DO	DO%	pH
	Max	Secchi	Sample	(°C)	(mS/cm)	(mg/L)	(%)	(units)
8/18/2010	1.9	1	0.5	26.81	0.242	10.29	130.6	8.19
			1	25.90	0.247	8.16	101.8	8.35
			1.8	25.45	0.279	1.32	16.3	7.67

Swartswood - Bathing Beach - 8/18/10								
Date	Depth (m)			Temp	SpC	DO	DO%	pH
	Max	Secchi	Sample	(°C)	(mS/cm)	(mg/L)	(%)	(units)
8/18/10	1.10	1.1+	0.5	27.25	0.233	9.88	126.3	8.32
			1	26.70	0.234	9.98	126.3	8.58

Swartswood - North Greenwood Point - 8/18/10								
Date	Depth (m)			Temp	SpC	DO	DO%	pH
	Max	Secchi	Sample	(°C)	(mS/cm)	(mg/L)	(%)	(units)
8/18/2010	2.5	1.1	0.5	27.05	0.239	11.25	143.3	8.23
			1	26.63	0.239	10.94	138.8	8.69
			2	25.3	0.235	10.91	134.7	8.85
			2.4	24.42	0.248	4.29	52.6	8.11

Discrete Data

Swartswood - Mid - 8/18/10						
Depth	Chl a	NH3	NO3	SRP	TP	TSS
(m)	(µg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
0.5	22.9	0.02	ND<0.02	ND<0.002	0.03	4
11.5	N/A	0.61	ND<0.02	0.006	0.12	7

Appendix II

Macrophyte Survey Transect Locations

Swartswood Lake - SAV Transect Locations 8/18/10		
Station	Latitude	Longitude
South (Outlet)	41.06489	74.85191
Greenwood Point North	41.06816	74.83745
Inlet	41.08015	74.82171
West Shore Drive	41.08084	74.83147
Bathing Beach	41.07374	74.82551
Heritage Site	41.07113	74.846331