FINAL REPORT

Lake Carey 2025 Water Quality Monitoring Program

Lake Carey Welfare Association
PO Box 637
Tunkhannock, PA 18657

Prepared by:

Aqua Link, Inc.
Pond, Lake & Stream Management & Supplies
P.O. Box 605
Doylestown, PA 18901
Ph: 215.230.9325
www.aqualinkinc.com

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The photograph was taken by Tyler Bender of Aqua Link while monitoring in July 2025.

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1. Introduction

Aqua Link, Inc. was hired by Lake Carey Welfare Association (hereafter referred to as the Association) to monitor the water quality of Lake Carey during the Summer 2025. This is the time of year when lakes experience their highest recreational use, and water quality can decline rapidly. Lake Carey is located in Tunkhannock, Wyoming County, Pennsylvania. The consists of two lake basins – the larger and deeper North basin and the smaller and shallower South basin (Figure 1.1). Water discharged from Lake Carey flows into an unnamed tributary for a short distance into Billings Mill Brook. From Billings Mill Brook, water flows into Tunkhannock Creek and further into the Susquehanna River. This is the first year that Aqua Link monitored the water quality of Lake Carey.

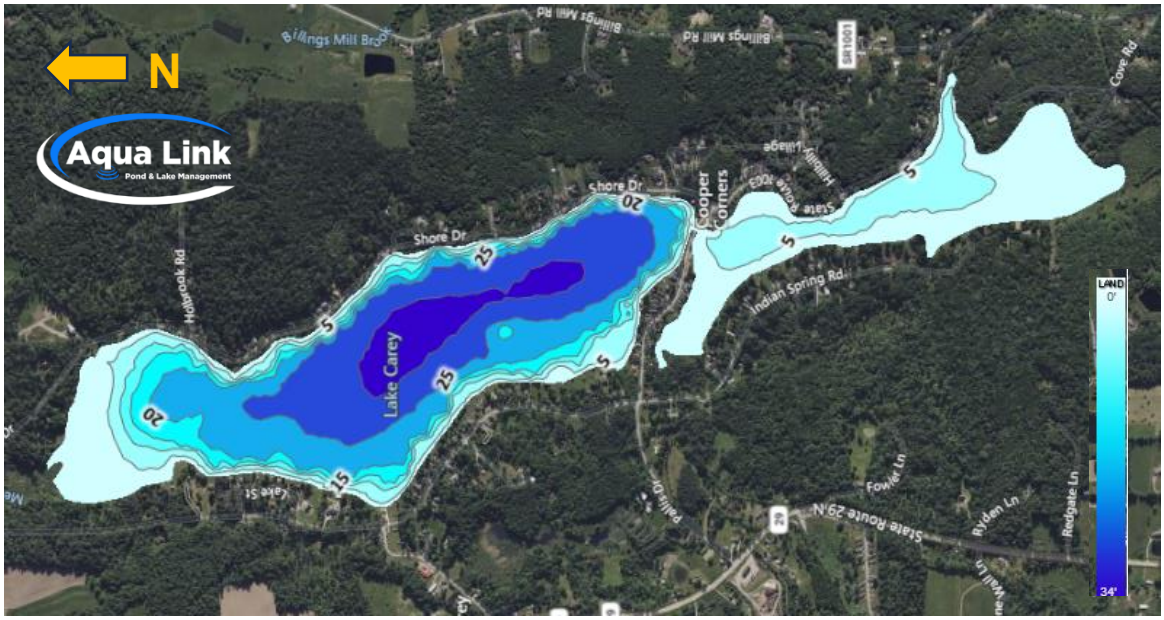

Figure 1.1 Bathymetric Map of Lake Carey

Lake Carey, the combination both the North and South lake basins, has a surface area of 249 acres. The surface areas for the North and South basins are 185 and 64 acres, respectively. The maximum water depths of the North and South basins are 33.5 and 6.6 feet, respectively (Figure 1.1). The above lake information is based upon a recently performed lake mapping project by Aqua Link for the Association in 2025. Figure 1.1 is one of several maps that Aqua Link prepared for the Lake Carey lake mapping project. In addition to bathymetry, Aqua Link prepared sediment density and biovolume of aquatic vegetation maps for the entire Lake Carey lake basin.

The primary goal of the water quality monitoring program was to collect high quality water quality data for key lake parameters which relate to the overall ecological health (trophic state) of the lake and the natural process of lake aging (known as eutrophication). A secondary goal of the 2025 lake monitoring program was to eventually track lake water quality over time, which is referred to as water quality trend analysis. In subsequent years, the 2025 lake water quality data will be compared to newly acquired data in order to assess whether lake water quality has improved or degraded over time and to determine the overall success and effectiveness of any implemented lake or watershed best management practices. It should be noted that the water quality database for Lake Carey will become increasingly more powerful as more and more lake data are acquired and analyzed over time.

Trophic status or trophic state of a lake is a general term used to quantify the overall biological productivity in lakes. Biological productivity includes the amount or biomass of algae, aquatic plants, and other forms of aquatic life including fish. Trophic state is directly influenced by the amount of nutrients (namely phosphorus and to a lesser extent nitrogen). Trophic state ranges from oligotrophic (nutrient poor and biologically unproductive) to eutrophic (nutrient enriched and highly, biologically productive) lakes. Increases in trophic state are often associated with decreases in both water quality and clarity.

The water quality monitoring program for this lake assessment is discussed in Section 2, Section 3 provides a primer on lake ecology and watershed dynamics, and the results of your lake assessment are presented in Section 4. Lastly, our conclusions and recommendations to improve and protect the water quality and aesthetics of the lake are discussed in Section 5.

In addition to monitoring water quality, Aqua Link was also retained and performed both a macrophyte survey and a bathymetric survey of the entire lake basin in 2025. Details for each of these additional surveys can be found separate reports.

2. Lake Water Quality Monitoring & Field Observations

2.1. Lake Water Quality Monitoring Program

Aqua Link monitored water quality at Lake Carey on June 24th, July 23rd, and August 26th in 2025. On these study dates, Aqua Link visually inspected the overall appearance and ecological condition of the lake. The lake was monitored at the primary station, Station LC1, which is located in the larger and deeper Large Lake (Northern) Basin, and at the secondary station, Station LC2, which is located in the smaller and shallower Small Lake (Southern) Basin. The maximum water depth during the 2025 study period at LC1 and LC2 were 9.4 meters (30.8 feet 1.4 meters (4.7 feet), respectively.

Figure 2.1 Lake Carey with LC1 & LC2 Monitoring Stations

On each study date, *in-situ* water quality data were measured and recorded by Aqua Link. *In-situ* water quality data (pH, dissolved oxygen, temperature, conductivity, specific conductance, total dissolved solids, salinity, and oxidation-reduction potential (ORP), chlorophyll-a and phycocyanins) were measured and recorded simultaneously using a YSI ProDSS Sonde and data logger (Yellow Spring Instruments). *In-situ* data were collected at 0.5 to 1.0 meter intervals throughout the water column at Station LC1 and LC2. Secchi disk transparency was measured and recorded at both stations using a standard 8-inch (20 cm) freshwater Secchi disk.

Water samples were collected at Station LC1 at two different depths on each study date. Surface samples were collected 1.0 meter (3.3 feet) below the lake surface and bottom samples were collected 1.0 meter (3.3 feet) above the lake sediments. All water samples were collected using a Kemmerer water sampler unit. Once collected, all water samples were placed in bottles, preserved accordingly in the field, and then shipped to the certified contract laboratory for further analysis.

The collected surface water samples were analyzed for alkalinity, hardness, total phosphorus, dissolved reactive phosphorus (namely orthophosphorus), nitrate, nitrite, ammonia, total Kjeldahl nitrogen, total suspended solids, chlorophyll-a, and phaeophytin. The bottom water samples were analyzed for all of the above parameters except chlorophyll-a and phaeophytin. Lastly, an additional lake water sample was collected at station LC1 at a depth of 1.0 meter for phytoplankton identification and enumeration. All phytoplankton samples were preserved in the field and subsequently analyzed by an expert in plankton taxonomy.

2.2. Field Observations

The water clarity of the lake was considered very good in June 2025. Lake water clarity declined sharply in July and then further declined in August, primarily as a result of increased amounts of phytoplankton (planktonic algae). In July, the lake took on a greenish tint, which intensified in August.

Submerged aquatic plants or macrophytes, consisting of primarily Eurasian water milfoil, were abundant and sometimes dense in the shallower portions of the large lake and throughout much of the small lake in 2025. Eurasian water milfoil is an invasive plant species that, if left unchecked, can become dominant in shallow lake areas and severely impact many recreational lakes uses like boating, fishing, swimming and aesthetics. Additionally, floating leaved aquatic vegetation such as waterlilies and watershield occupied similar areas. Although these species are not invasive, these floating leaved plants can still limit recreational activities and access to lakefront properties and docks.

Overall, it should be noted that maintaining a balance of between algae and aquatic vegetation can be quite challenging in shallow to moderate depth lakes. The smaller, south basin of Lake Carey can be particularly sensitive, but the larger, north basin can become out of balance if treated too heavily as well. This is especially true when a lake is nutrient enriched or eutrophic. To complicate matters even more, achieving balance often becomes increasingly difficult when invasive, non-native aquatic vegetation are present that can potentially outcompete more beneficial and easier to control native plants. Since Eurasian water milfoil is an invasive species that is present in Lake Carey, extra care must be taken if treatments are to be performed for control of this species.

3. Primer on Lake Ecology and Watershed Dynamics

A glossary of lake and watershed terms is provided in Appendix A (U.S. EPA 1980). This glossary is intended to serve as an aid to understanding this section and contains many of the technical terms used throughout the remainder of this report.

The water quality of a lake is often described as a reflection of its surrounding watershed. The term "lake" collectively refers to both reservoirs (man-made impoundments) and natural lake systems. Water from the surrounding watershed enters a lake as streamflow, surface runoff and groundwater. The water quality of these water sources is greatly influenced by the characteristics of the watershed such as, geology, soils, topography and land use. Of these characteristics, changes in land use (e.g., forested, agriculture, silviculture, residential, commercial, industrial) can greatly alter the water quality of lakes.

Nutrients (e.g., phosphorus, nitrogen, carbon, silicon, calcium, potassium, magnesium, sulfur, sodium, chloride, iron) are primarily transported to lakes via streamflow, surface runoff and groundwater while sediments are mainly conveyed as streamflow and surface runoff. As streamflow and surface runoff enter a lake, their overall velocity decreases, which allows transported sediments to settle to the lake bottom. Many of these incoming nutrients may be bound to sediment particles and subsequently will also settle to the lake bottom. Very small sediment particles, such as clays, may resist sedimentation and subsequently pass through the lake without settling.

Once within the lake, water quality is further modified through a complex set of physical, chemical and biological processes. These processes are significantly affected by the lake's morphological characteristics (morphology). Some of the more important morphological characteristics of lakes are size, shape, depth, volume, and bottom composition. In addition, the hydraulic residence time (i.e., the lake's flushing rate) also greatly affects these processes and is directly related to the lake's volume and the annual volume of water flowing into the lake.

With respect to nutrients, phosphorus and nitrogen are generally considered the most important nutrients in freshwater lakes. Phosphorus and, to a lesser degree, nitrogen typically determines the overall amount of aquatic plants present. Aquatic plants adsorb and convert available nutrients into energy, which is then used for additional growth and reproduction. In lakes, aquatic plants are mainly comprised of phytoplankton (free-floating microscopic plants or algae) and macrophytes (higher vascular plants). The most readily available form of phosphorus is dissolved orthophosphate (analytical determined as dissolved reactive phosphorus), while ammonia (NH_3-N) and nitrate (NO_3-N) are the most readily available forms of nitrogen.

The transfer and flow of energy in lakes is ultimately controlled by complex interactions between various groups of aquatic organisms (both plants and animals). The feeding interactions that exist between all aquatic organisms is called the food web. A simplistic diagram of a food chain for a lake is presented as Figure 3.1. As shown in this figure, algae (phytoplankton) and aquatic macrophytes capture energy from the sun and convert this energy into chemical energy through the process known as photosynthesis. During photosynthesis, carbon dioxide, nutrients, water and captured sunlight energy are used to produce organic compounds (chemical energy), which are then used to support further growth and reproduction.

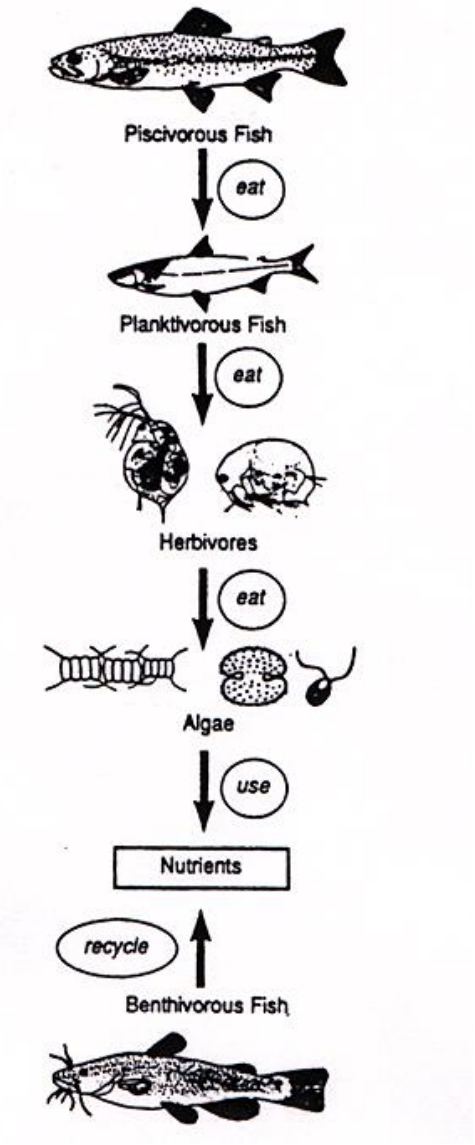

Figure 3.1 Aquatic Food Chain

Energy continues to flow upward through the food chain. Algae are primarily grazed upon by zooplankton. Zooplankton are tiny aquatic animals that are barely visible to the naked eye. Next, zooplankton serve as prey for planktivorous (plankton-eating) fish and larger invertebrates (macroinvertebrates), which then are consumed by larger piscivorous (fish-eating) fish. Overall, these aquatic organisms (zooplankton, macroinvertebrates and fish) derive energy by breaking down organic matter through the process known as respiration. During respiration, organic matter, water and dissolved oxygen are converted into carbon dioxide and nutrients.

At the bottom of the food chain (Figure 3.1), particulate organic waste products (excrement) from aquatic organisms along with dead aquatic organisms settle to the lake bottom and are subsequently feed upon by other organisms. Organisms that live or reside along the lake bottom are referred to as benthivores. After settling to the lake bottom, dead organic materials and organic waste products are now called detritus. Some benthivorous fish (catfish and carp) and microorganisms (bacteria, fungi and protozoans) feed upon detritus. Aquatic organisms that feed upon detritus in lakes are referred to as decomposers. Decomposers obtain energy by breaking down detritus (dead organic matter) via the process of respiration. During decomposition, some of the nutrients are recycled back into lake water and can now once again be used by algae and aquatic plants for growth and reproduction. Any unused detritus will accumulate and eventually become part of the lake sediments, thereby increasing the organic content of these sediments.

Ultimately, the amount of nutrients in lakes controls the overall degree of aquatic productivity (Figure 3.1). Lakes with low levels of nutrients and low levels of aquatic productivity are referred to as oligotrophic. Oligotrophic lakes are typically clear and deep with low quantities of phytoplankton and rooted aquatic plants. In these lakes, the deeper, colder waters are generally well-oxygenated and capable of supporting coldwater fish, such as trout. Conversely, lakes with high nutrient levels and high levels of aquatic productivity are referred to as eutrophic. Eutrophic lakes are generally more turbid and shallower due to the deposition of sediments and the accumulation of detritus. If deep enough, the bottom waters of eutrophic lakes are generally less oxygenated. Eutrophic lakes are often capable of supporting warmwater fish, such as bluegill and bass. Mesotrophic lakes lie somewhere in between oligotrophic and eutrophic lakes. These lakes contain moderate levels of nutrients and moderate levels of aquatic productivity. In some instances, the flow of energy through the food web may be disrupted. In hyper-eutrophic (highly eutrophic) lakes, aquatic productivity is extremely high and is dominated by very large numbers of a few, undesirable species. The phytoplankton community is typically comprised largely by blue-green algae during the summer months. Many species of blue-green algae are not readily grazed upon by the zooplankton community. Under these conditions, the blue-green algae community is allowed to flourish due to the lack of predation, while the zooplankton community collapses. Decreases in zooplankton biomass in a lake may in turn adversely affect the lake's fishery. In addition, shallow lake areas may be completely infested with dense stands of aquatic macrophytes and the fishery may be dominated by rough fish such as the common carp and catfish.

4. Water Quality Data Results

Section 4 provides an in-depth discussion of all data gathered and analyzed as part of the 2025 Lake Carey water quality monitoring program. The 2025 lake data are presented and discussed extensively in Section 4.1. As mentioned previously, the approximate maximum water depth for Station LC1 was approximately 9.4 meters (30.8 feet). The approximate maximum water depth for Station LC2 was approximately 1.4 meters (4.7 feet). Chemical water quality data for the surface and bottom waters were monitored at Station LC1. Surface water data represent lake water samples collected at approximately 1.0 meter below the lake's surface (LC1-S) and bottom samples were collected 1.0 meter above the lake sediments (LC1-B).

In subsequent years, Aqua Link will enter newly acquired data into the Lake Carey database and these data will be compared to past water quality data. This process is commonly referred to as *water quality trend analysis*, which provides a powerful tool in assessing lake water quality improvements or degradation. For water quality trend analysis, lake water quality data will be presented as graphs and many of these graphs will contain linear trend lines indicating whether water quality is improving or degrading over time.

All lake water quality data for both of the lake monitoring stations (LC1 and LC2) are presented in Appendix B. The calculated Carlson Trophic State Index (TSI) values for Secchi depth, chlorophyll-a, and total phosphorus for 2025 are also presented for Station LC1 in Appendix B. Refer to Section 2 for more information about the study design and data acquisition for this project. ***For the remainder of Section 4, lake water quality data will primarily focus on Station LC1, which is located in the larger, deeper North basin of Lake Carey.***

4.1. Lake Water Quality Data

4.1.1. Temperature and Dissolved Oxygen

In late spring or the beginning of summer, many moderately deep to deep temperate lakes develop stratified layers of water. Under stratified conditions, warmer and colder waters are near the lake's surface (epilimnion) and the lake's bottom (hypolimnion), respectively. As the temperature differences become greater between these two water layers, the resistance to mixing increases. During lake stratification, the epilimnion is usually oxygen-rich due to photosynthesis and direct inputs from the atmosphere, while the hypolimnion may become depleted of oxygen due to the respiration of aquatic organisms. As previously discussed, aquatic organisms (e.g., bacteria, fungi, protozoan, zooplankton, macroinvertebrates, & fish) consume dissolved oxygen in order to metabolize prey or detritus (U.S. EPA 1980, U.S. EPA 1990 and U.S. EPA 1993).

Conversely, shallow temperate lakes may only become weakly stratified during the summer months or some lakes may never stratify at all. The overall degree and duration of stratification

in weakly stratified lakes are largely dependent upon local wind conditions and the morphological characteristics of the lake itself. During windy days, surface wave action may be sufficient to partially or completely destratify (mix) a lake. Conversely, a shallow lake may become partially stratified on windless days.

Overall, water temperatures and dissolved oxygen concentrations are very important with regards to a lake's fishery. In general, the optimal water temperature for salmonid fish (i.e., trout) is 55 to 60 ^{o}F (12.8 to 15.6 ^{o}C). Trout may withstand water temperatures above 80 ^{o}F (26.7 ^{o}C) for several hours, but if water temperatures exceed 75 ^{o}F (23.9 ^{o}C) for extended periods, high trout mortality is expected (Pennsylvania State University). Conversely, non-salmonid fish such as golden shiners, bass, bluegills, can grow well even when water temperatures exceed 80 ^{o}F (26.7 ^{o}C). In general, safe minimum dissolved oxygen concentrations for adult salmonid and non-salmonid fish are 5.0 and 3.0 mg/L, respectively. When dissolved oxygen concentrations fall below these concentrations, production impairment of the lake's fishery can be expected.

In addition to impacting the lake's fishery, low dissolved oxygen levels in the bottom waters of a lake will often accelerate the release of nutrients such as soluble orthophosphorus (analytically measured as dissolved reactive phosphorus) and ammonia nitrogen, from anoxic (oxygen depleted) in-lake sediments. In particular, the accelerated release rates of nutrients (referred to as internal loading) can represent a substantial portion of all incoming nutrients to a lake. Increased nutrient loadings via in-lake sediments may further degrade lake water quality by increasing the production of both phytoplankton and aquatic macrophytes (vascular plants).

Lake Carey

The 2025 water temperature and dissolved oxygen profile data for Lake Carey at LC1 are graphically presented in Figures 4.1 and 4.2, respectively. The approximate maximum water depth for Station LC1 was approximately 9.4 meters (30.8 feet). At Station LC1, Lake Carey was strongly, thermally stratified during all three study dates from June through August. As a result of this thermal stratification, dissolved oxygen levels decreased in deeper lake waters (hypolimnion). This decrease in dissolved oxygen concentrations was most pronounced during the month of August, when the lake was strongly, thermally stratified. The thermocline, which is the point where the temperature change is the greatest, divides the epilimnion (surface waters) and the hypolimnion (bottom waters), was located at a depth of approximately 2.0 to 4.0 meters (6.6 to 13.1 feet) during the month of June, 3.0 to 5.0 meters (9.8 to 16.4 feet) in the month of July, and 4.0 to 6.0 meters (13.1 to 19.7 feet) in the month of August at Station LC1 in Lake Carey. It should also be noted that Lake Carey had a sufficient amount of dissolved oxygen to support aquatic life in approximately half of the water column on all monitoring dates.

The low dissolved oxygen concentrations measured near the lake bottom in June, July, and August at Station LC1 may have allowed for accelerated phosphorus release rates from anoxic in-lake sediments. Anoxic sediments are those sediments containing very low or no dissolved

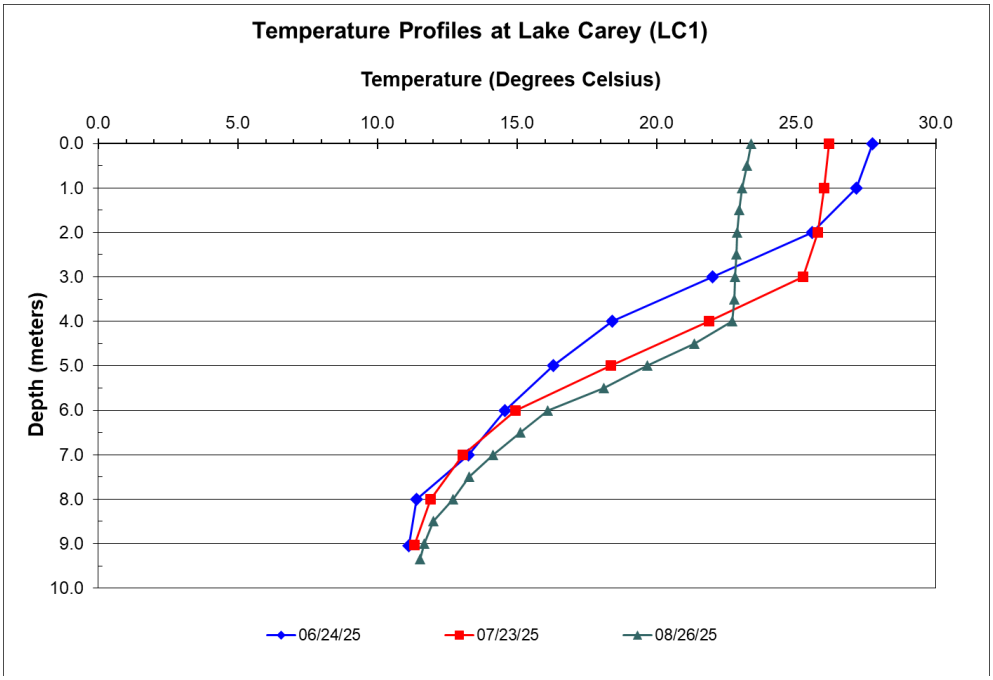

Figure 4.1 2025 Temperature Profiles of Lake Carey at Station LC1

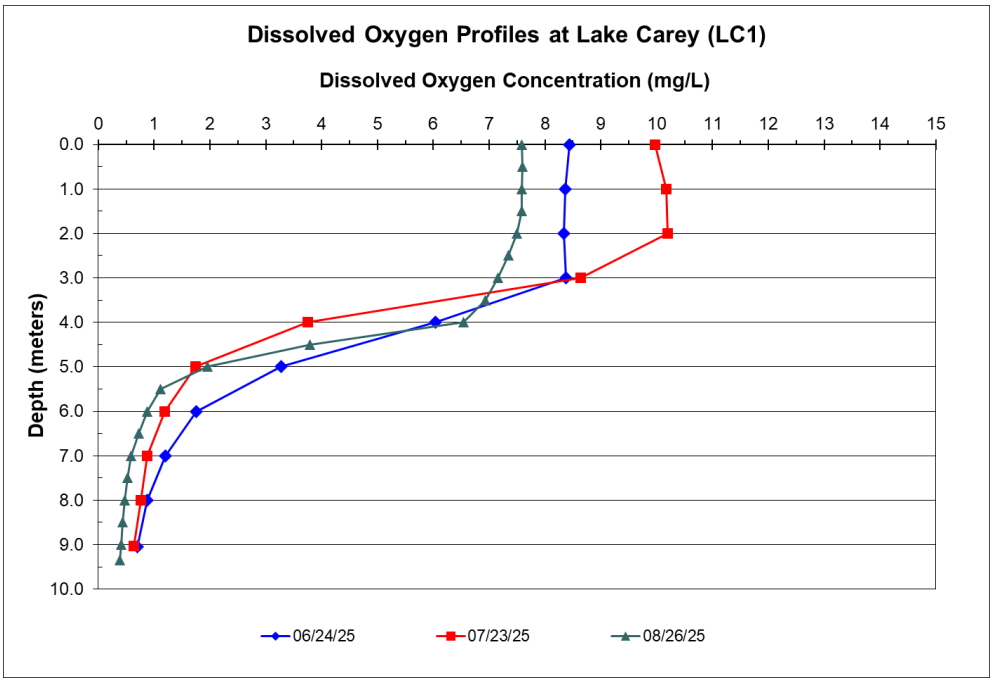

Figure 4.2 2025 Dissolved Oxygen of Lake Carey at Station LC1

oxygen. Under anoxic conditions, phosphorus is often released from lake sediments into the overlying lake waters. This newly released phosphorus is now available for the additional growth of algae. The release of nutrients like phosphorus from lake sediments is referred to as internal loading.

Based on the above data, Lake Carey at Station LC1 was classified as a moderately deep, dimitic lake that is best suited as a warmwater fishery. Dimictic lakes are those lakes that thermally stratify during the growing season (May through September). Low dissolved oxygen levels in the colder, deeper lake waters limit the lake's ability to support a coldwater fishery year-round. In addition, warm water temperatures would likely limit the lake's ability to support a coldwater fishery year-round.

4.1.2. pH, Alkalinity, & Hardness

The pH and alkalinity of water are directly related to one another. In general, as alkalinity increases, the pH of the water also increases. The acidity or basicity of a solution is most often expressed as pH. The term pH is defined as the logarithm of the reciprocal (or its negative logarithm) of the hydrogen ion concentration. Therefore, a one unit change in pH represents a ten-fold increase or decrease in the hydrogen ion concentration (as pH decreases, the hydrogen ion concentration increases). The pH scale ranges 0 to 14 standard units where a value of 7 indicates neutral conditions. Water becomes more acidic when pH values fall below 7 and more basic when pH values rise above 7. In general, most natural waters usually have a pH value between 6.5 and 8.5.

Aquatic life in lakes can be adversely impacted when pH levels drop too low in lakes. When pH concentrations fall below 6.0 standard units, there is a greater risk to increase the concentration of heavy metals, in particular aluminum. High concentrations of hydrogen and aluminum ions are known to adversely affect the ion regulation of aquatic organisms, a condition referred to as "osmoregulatory failure". When osmoregulatory failure occurs, high hydrogen and aluminum concentrations induce the leaching of sodium and chloride ions from the body fluids of fish and other aquatic organisms (U.S. EPA, 1990). As summarized by J. Baker, pH values ranging from 5.5 to 6.0 standard units can result in the loss of sensitive minnows and dace, which may be important as forage fish for game fish. In addition, the pH levels below 6.0 are also known to adversely affect the reproductive success rates of game fish, such as walleye (U.S. EPA, 1990).

Alkalinity refers to the capacity of water to neutralize (or buffer against) acid inputs. Alkalinity of natural waters is due primarily to the presence of hydroxides (OH^-), bicarbonates (HCO_3^-), carbonates (CO_3^{2-}) and occasionally borates, silicates and phosphates. Therefore, the carbonate–bicarbonate equilibrium system (CO_2 - HCO_3^- - CO_3^{2-}) is the major buffering mechanism in freshwater lakes (Wetzel 1983).

Alkalinity is typically expressed in units of milligrams per liter (mg/L) of $CaCO_3$ (calcium carbonate). Waters having a pH below 4.5 contain no alkalinity. Low alkalinity is the m ain indicator of susceptibility of aquatic organisms to acidic inputs (e.g., acid rain and acidic dry fallout). Waters with pH values ranging from 6 to 9 are largely comprised of bicarbonate (HCO_3^-). At higher pH values, carbonate ($CO_3^=$) plays a more important role in the buffering capacity of the water. Lakes with watersheds that contain sedimentary carbonate rocks are high in dissolved carbonates (hard-water lakes). Conversely, lakes in granite or igneous rocks are low in dissolved carbonates (soft water lakes). In the Northeastern U.S., the alkalinity of natural surface waters typically ranges from 5 to over 200 mg/L as $CaCO_3$.

Hardness is the amount of dissolved calcium and magnesium and to a lesser extent, other divalent and trivalent metallic elements such as iron, manganese and aluminum. The term hardness was originally derived to describe waters that were hard to wash clothing, thereby referring to the soap washing properties of water. Hardness prevents soap from lathering by causing the development of an insoluble precipitates in the water. Hardness typically causes the buildup or "scaling" of precipitates in pipes and water heaters and can cause numerous problems in laundry, kitchen, and bath facilities. Overall, dissolved calcium and magnesium salts are primarily responsible for most scaling problems. Hardness is often described as soft, slightly hard, moderately hard, hard and very hard. Soft water is less than 17 mg/L as calcium carbonate ($CaCO_3$). Slightly hard water is greater than 17 to 60 mg/L as $CaCO_3$. Moderately hard water is greater than 60 to 120 mg/L as $CaCO_3$. Hard water is greater than 120 to 180 mg/L as $CaCO_3$, while very hard water is above 180 mg/L as $CaCO_3$.

Lake Carey

The 2025 annual mean pH values for surface and bottom waters of Lake Carey at Station LC1 are presented in Table 4.1. The mean pH values for surface and bottom waters were 8.28 and 6.71, respectively. Overall, the surface and bottom waters are considered moderately basic near the lake surface to slightly acidic near the lake bottom. Although the pH values have a wide range, the mean pH values for both surface and bottom waters are considered acceptable and should not pose a risk for metabolic or reproductive stress for the aquatic organisms that inhabit the lake. However, episodic reductions in pH in Lake Carey may cause the pH to drop below 6.0 which could cause short term stress to aquatic organisms until the pH is buffered back to levels above 6.0.

The 2025 annual mean alkalinity concentrations for surface and bottom waters were somewhat similar in Lake Carey. The mean alkalinity concentrations were 34.7 mg/L for surface waters and 53.0 mg/L for bottom waters (Table 4.1). The differences between surface and bottom waters may be attributed to high consumption rates of dissolved carbon dioxide (CO_2) by phytoplankton during photosynthesis. Alkalinity concentrations in the surface waters can vary depending on phytoplankton biomass in the lake. For example, the larger the phytoplankton biomass, the more dissolved carbon dioxide will be consumed which will increase the pH. Also,

Table 4.1 Annual Mean Surface & Bottom pH, Alkalinity, and Hardness Values in 2025

Stations	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Hardness (mg/L as $CaCO_3$)
LC1 Surface	8.28	34.7	37.0
LC1 Bottom	6.71	53.0	53.3

deeper lake waters likely receive shallow groundwater inputs containing higher alkalinities. In general, the alkalinity concentrations in Lake Carey are considered low to moderate, but should be sufficient to buffer the pH of the lake, protecting aquatic organisms from sudden or drastic drops in pH that may occur due to deposition of acidic material. Fortunately, the lake is not at risk for high deposition rates of acid rain, snowmelt, or dry deposition of acidic material.

Mean hardness values for the surface and bottom of Lake Carey are also represented in Table 4.1. The mean hardness concentration for surface waters was 37.0 mg/L and 53.3 mg/L for bottom waters. Lake Carey surface and bottom waters were considered slightly to moderately hard in 2025, but typical and similar to other lakes in the region.

4.1.3. Transparency

The transparency, or clarity, of a lake is most often reported as the Secchi disk depth. This measurement is taken by lowering a circular black-and-white disk, which is 20 cm (8 inches) in diameter, into the water until it is no longer visible. Observed Secchi disk depths range from a few centimeters in very turbid lakes to over 40 meters in the clearest known lakes (Wetzel, 1983). Although somewhat simplistic and subjective, this field monitoring method probably best represents those lake conditions that are most often perceived by lake users and the general public.

Secchi disk transparency is related to the transmission of light in water, and depends on both the absorption and scattering of light. The absorption of light in dark-colored waters reduces light transmission. Light scattering is usually a more important factor than absorption in determining Secchi depths. Scattering can be caused by water discoloration or by the presence of both particulate organic matter (e.g., algal cells) and inorganic materials (e.g., suspended clay particles).

In general, a lake is classified as oligotrophic at values greater than 4.0 meters, mesotrophic between 2.0 and 4.0 meters, eutrophic between 1.0 and 1.9 meters, and hypereutrophic less than 1.0 meter (Nurnberg 2001).

Lake Carey

The 2025 Secchi disk transparency values varied significantly from a low of 1.43 meters in August to a high of 4.30 meters in June at Station LC1. The annual mean Secchi disk transparency value for Lake Carey at Station LC1 was 2.51 meters (8.24 feet) in 2025. Overall, the lake is best described as oligotrophic in June and then becoming eutrophic in July and August. The mean Secchi disk value for the 2025 study period suggests mesotrophic lake conditions.

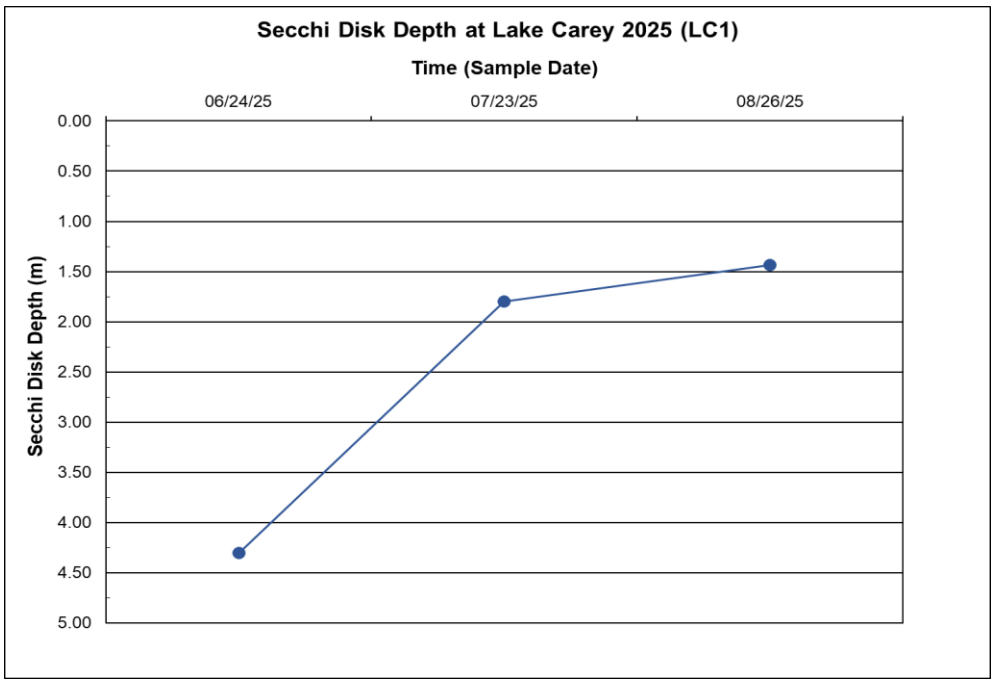

Figure 4.3 2025 Secchi Disk Depths of Lake Carey at Station LC1

4.1.4. Nutrient Concentrations

Phosphorus and nitrogen are major nutrients required for the growth of phytoplankton (free floating, microscopic photosynthetic organisms) and macrophytes (aquatic vascular plants) in lakes. The lake monitoring program for this study included the analysis of lake samples for both total and dissolved inorganic forms of both nutrients. The dissolved inorganic nutrients, namely dissolved reactive phosphorus, nitrate, and ammonia nitrogen, are regarded as the forms most readily available to support aquatic plant growth, while the total nutrient amounts provide an indication of the maximum growth potential that could be achieved in lakes.

4.1.4.1. Phosphorus

Total phosphorus represents the sum of all forms of phosphorus. Total phosphorus includes dissolved and particulate organic phosphates (e.g., algae and other aquatic organisms), inorganic particulate phosphorus as soil particles and other solids, polyphosphates from detergents and dissolved orthophosphates. Soluble (or dissolved) orthophosphate (determined analytically as dissolved reactive phosphorus) is the phosphorus form that is most readily available for algal uptake. Soluble orthophosphate is usually reported as dissolved reactive phosphorus because laboratory analysis takes place under acid conditions and may result in the hydrolysis of some other phosphorus forms. Total phosphorus levels are strongly affected by the daily phosphorus loadings to a lake, while soluble orthophosphate levels are largely affected by algal consumption during the growing season.

Based on criteria established by Nurnberg (2001), a lake is classified as oligotrophic, mesotrophic, eutrophic, and hypereutrophic when surface total phosphorus concentrations are less than 0.010 mg/L as P, 0.010 to 0.030 mg/L as P, 0.031 to 0.100 mg/L as P and greater than 0.100 mg/L as P, respectively.

Lake Carey

The 2025 total phosphorus concentrations for each study date in surface and bottom waters are illustrated in Figures 4.4 & 4.5, respectively. Surface water concentrations remained consistent at 0.020 mg/L for all three study dates. In bottom waters, the total phosphorus concentration in June had a value of 0.380 mg/L, increased substantially to 0.710 mg/L in July, only to remain fairly consistent with a value 0.700 mg/L in August. The higher phosphorus values in July and August were likely due to the release of phosphorus from sediment during anoxic conditions (little to no dissolved oxygen) while the lake was stratified – refer to Figures 4.1 and 4.2.

The 2025 mean total phosphorus concentrations at Station LC1 for surface waters were 0.020 mg/L and 0.597 mg/L for the bottom waters as P. The higher concentrations in the bottom waters are likely due to the settling of dead algae and the release of phosphorus from anoxic sediments. Based upon the above criteria, the mean total phosphorus concentration for surface waters suggest that Lake Carey was classified as moderately mesotrophic in 2025.

The 2025 dissolved reactive phosphorus concentrations for each study date in surface and bottom waters are illustrated in Figures 4.6 & 4.7, respectively. Surface water concentrations in June had a value of 0.013 mg/L, decreased moderately to 0.001 mg/L in July, only to decrease very slightly to below the detection limit of 0.001 mg/L in August. In bottom waters, the dissolved reactive phosphorus concentration in June had a value of 0.087 mg/L, increased

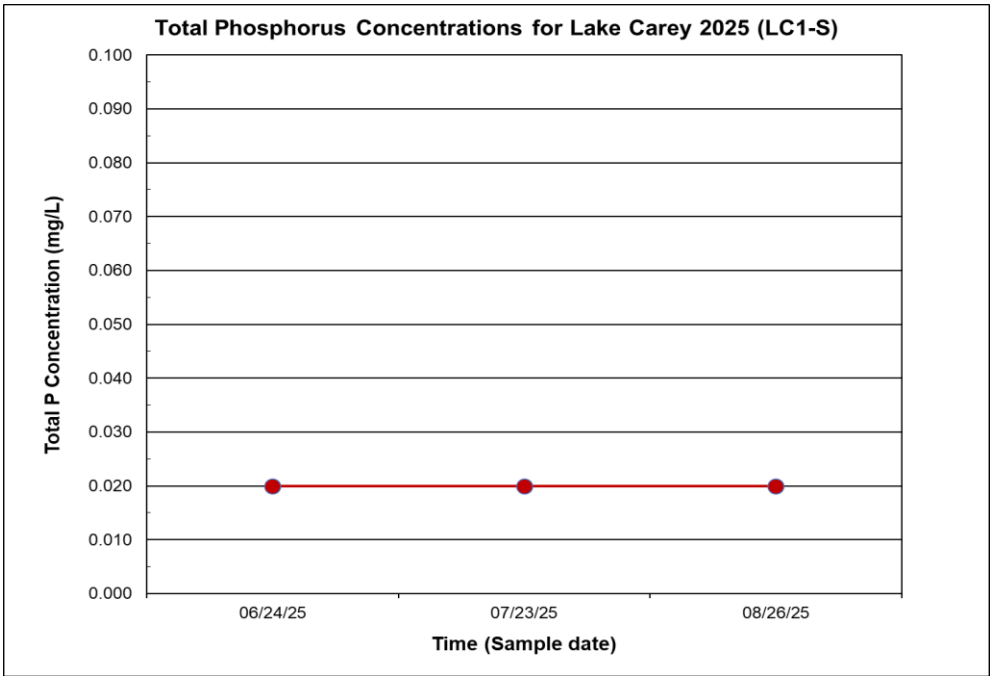

Figure 4.4 Total Phosphorus Concentrations at Surface in Lake Carey (Station LC1)

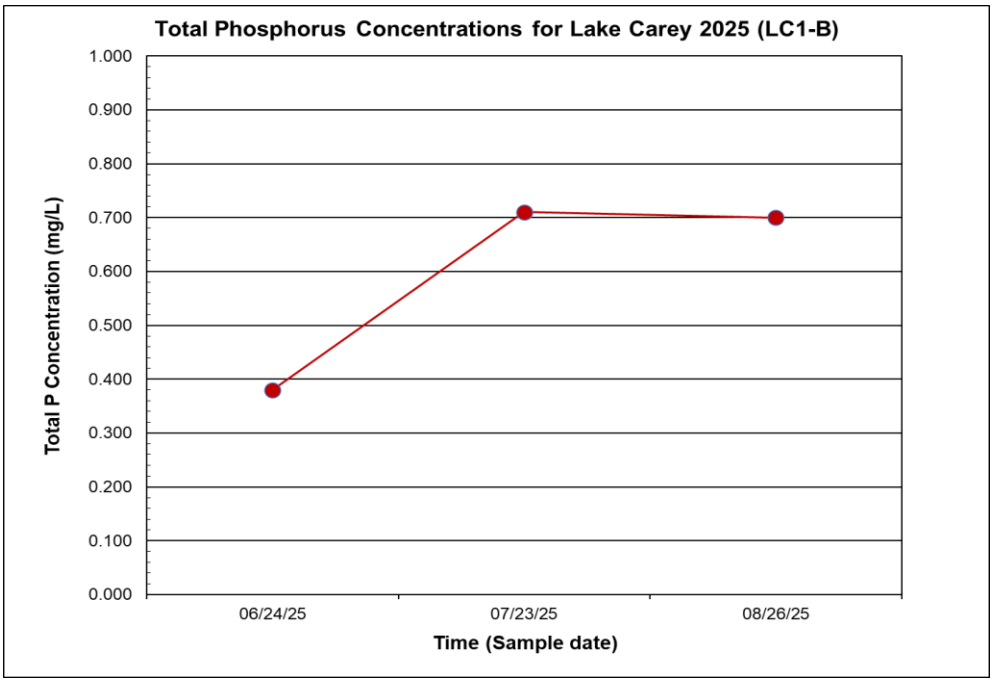

Figure 4.5 Total Phosphorus Concentrations at Bottom in Lake Carey (Station LC1)

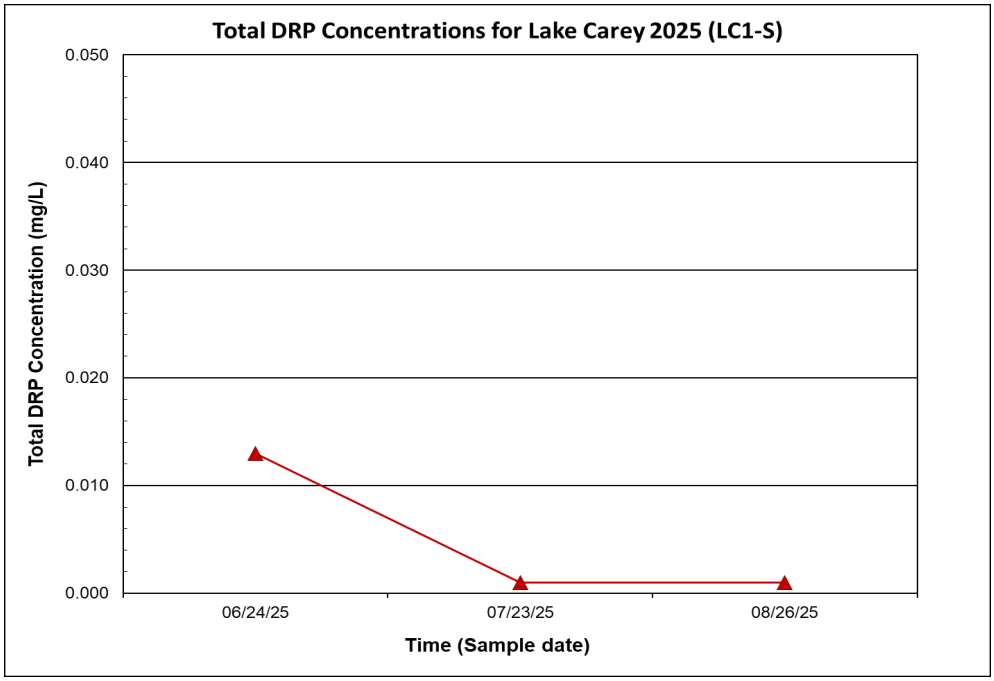

Figure 4.6 DRP Concentrations at Surface in Lake Carey (Station LC1)

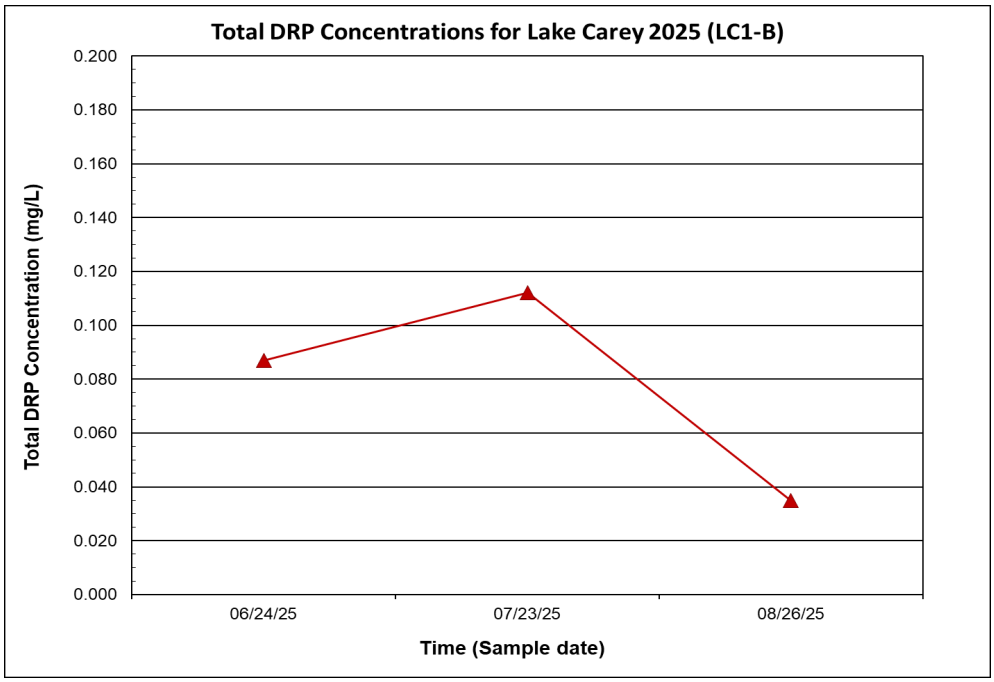

Figure 4.7 DRP Concentrations at Bottom in Lake Carey (Station LC1)

moderately to 0.112 mg/L in July, and decrease substantially to a value 0.035 mg/L in August.

The 2025 mean dissolved reactive phosphorus concentrations at Station LC1 for surface waters were 0.005 mg/L and 0.078 mg/L for the bottom waters as P. Lower dissolved reactive phosphorus concentrations in the surface waters, most evident in July and August of 2025, indicate that this form of phosphorus is rapidly used by phytoplankton as soon as it becomes available.

4.1.4.2. Nitrogen

Nitrogen compounds are also important for the growth and reproduction of phytoplankton and aquatic macrophytes. The common inorganic forms of nitrogen in water are nitrate (NO_3^-), nitrite (NO_2^-) and ammonia (NH_3). In water, ammonia is present primarily as ammonium (NH_4^+) and undissociated ammonium hydroxide (NH_4OH). Of these two forms, undissociated ammonium hydroxide is toxic and its toxicity increases as pH and water temperature increase. Overall, the most dominant form of inorganic nitrogen present in lakes depends largely on the dissolved oxygen concentrations. Nitrate is the form usually found in surface waters, while ammonia is only stable under anaerobic (low oxygen) conditions. Nitrite is an intermediate form of nitrogen, which is generally considered unstable. Nitrate and nitrite (referred to as total oxidized nitrogen) are often analyzed together and reported as $NO_3 + NO_2$-N, although nitrite concentrations are usually insignificant as noted previously. Total Kjeldahl nitrogen (TKN) concentrations include ammonia and organic nitrogen (both soluble and particulate forms). Organic nitrogen can be easily estimated by subtracting ammonia nitrogen from total Kjeldahl nitrogen concentrations. Total nitrogen is calculated by summing the nitrate-nitrite, ammonia, and organic nitrogen fractions together.

According to Nurnberg (2001), lakes with surface total nitrogen concentrations less than 0.350 mg/L as N are classified as oligotrophic, from 0.350 to 0.650 mg/L as N are classified as mesotrophic, from 0.651 to 1.200 mg/L are classified as eutrophic, and greater than 1.200 mg/L as N are classified as hypereutrophic.

Lake Carey

The 2025 mean total nitrogen, total Kjeldahl nitrogen (TKN), nitrate plus nitrite nitrogen, and ammonia nitrogen concentrations for surface and bottom waters are presented in Table 4.2. Overall, the mean total nitrogen concentration for the bottom waters was higher than the mean concentration for the surface waters. This higher value in the bottom waters is attributed to higher levels of ammonia nitrogen and nitrate plus nitrite nitrogen. Higher ammonia concentrations in the bottom waters are due to lower dissolved oxygen concentrations plus the accelerated release rates by anoxic sediments (sediments containing no dissolved oxygen).

Based upon the Nurnberg criteria (2001), the mean total nitrogen concentration of 1.030 mg/L for surface waters is moderately high and thereby suggests that Lake Carey was classified as moderately eutrophic in 2025.

Table 4.2 Mean Nitrogen Concentrations in Lake Carey at Station LC1 in 2025

Station	Total Nitrogen (mg/L as N)		Total Kjeldahl Nitrogen (mg/L as N)		Nitrate + Nitrite (mg/L as N)		Ammonia (mg/L as N)	
	Surface	*Bottom*	*Surface*	*Bottom*	*Surface*	*Bottom*	*Surface*	*Bottom*
LC1	1.030	2.851	0.900	2.567	0.130	0.285	0.027	1.200

4.1.4.3. Limiting Nutrient

Phytoplankton growth depends on a variety of nutrients. This includes macronutrients (phosphorus, nitrogen and carbon) as well as trace nutrients (iron, manganese and many others). According to Liebig's law of the minimum, biological growth is limited by the substance that is present in the minimum quantity with respect to the needs of the organism. Nitrogen and phosphorus are usually the nutrients limiting algal growth in most natural waters.

Depending on the species, algae require approximately 15 to 26 atoms of nitrogen for every atom of phosphorus. This ratio converts to 7 to 12 mg of nitrogen per 1 mg of phosphorus on a mass basis. A ratio of total nitrogen to total phosphorus of 15:1 is generally regarded as the dividing point between nitrogen and phosphorus limitation (U.S. EPA, 1980). Identification of the limiting nutrient becomes more certain as the total nitrogen to total phosphorus ratio moves farther away from the dividing point, with ratios of 10:1 or less providing a strong indication of nitrogen limitation and ratios of 20:1 or more strongly indicating phosphorus limitation.

In many instances, inorganic nutrient concentrations provide a better indication of the limiting nutrient because the inorganic nutrients are the forms directly available for algal growth. Ratios of total inorganic nitrogen (TIN = ammonia, nitrate, and nitrite) to dissolved reactive phosphorus (DRP) greater than 12 are indicative of phosphorus limitation, ratios of TIN:DRP less than 8 are indicative of nitrogen limitation, and TIN:DRP ratios between 8 and 12 indicate either nutrient can be limiting.

Lake Carey

The mean surface total phosphorus to total nitrogen (TN:TP) and the mean surface total inorganic nitrogen to dissolved reactive phosphorus (TIN:DRP) ratios for the lake are presented in Table 4.3. The mean TN:TP ratio was 51 and values ranged from 44 to 56. In addition, the mean TIN:DRP ratio was 97 and values ranged from 15 to 143. Both the mean TN:TP and the TIN:DRP ratios strongly suggest that the lake was phosphorus limiting in 2025.

Table 4.3 Mean Nitrogen to Phosphorus Ratios at Surface in Lake Carey in 2025

Station	*Nitrogen to Phosphorus Ratios*	
	TN:TP	*TIN:DRP*
LC1S	51	97

4.1.5. Plankton and Chlorophyll-a

The quantity of phytoplankton (free floating, microscopic photosynthetic organisms, commonly referred to as algae) and macrophytes (vascular aquatic plants) are primary biological indicators of lake trophic conditions. Small aquatic animals, namely zooplankton and macroinvertebrates, graze upon algae and fragments of aquatic plants. Larger invertebrates and fish then consume the above grazers and to a lesser extent, some aquatic plants.

Information about the plankton community composition and succession is extremely useful when attempting to gain a better understanding about various lake problems. For example, eutrophic lakes often support unbalanced phytoplankton communities characterized by very large numbers of relatively few species. The number of larger zooplankton will tend to decrease during periods when blue-green algae are dominant. Conversely, oligotrophic lakes and acidic lakes often have smaller populations of both phytoplankton and zooplankton, which typically consist of fewer species.

4.1.5.1. Phytoplankton

Phytoplankton are free floating, microscopic photosynthetic organisms that have little or no resistance to currents and live suspended in open water. Their forms may be unicellular, colonial

or filamentous. As photosynthetic organisms (primary producers), phytoplankton form the base of aquatic food chain and are grazed upon by zooplankton and herbivorous fish.

A healthy lake should support a diverse assemblage of phytoplankton, in which many algal species are represented. Excessive growth of a few species is usually undesirable. Such growth can result in dissolved oxygen depletion during the night, when the algae are respiring rather than photosynthesizing. Dissolved oxygen depletion also can occur shortly after a massive "algal bloom" due to increased levels of respiration by bacteria and other microorganisms that are metabolizing dead algal cells. Excessive growth of some species of algae, particularly members of the blue-green group, may cause taste and odor problems, release toxic substances to the water, or give the water an unattractive green soupy or scummy appearance.

Planktonic productivity is commonly expressed in terms of density and biomass. Phytoplankton densities are most frequently expressed as cells per milliliter (cells/mL). Biomass is commonly expressed on a mass per volume basis as micrograms per liter (µg/L). Of the two, biomass provides a better estimate of the actual standing crop of phytoplankton in lake systems.

Lake Carey

The phytoplankton community in 2025 was represented by genera from seven different taxa: Bacillariophyta (diatoms), Chlorophyta (green algae), Chrysophyta (golden-brown algae), Cryptophyta (cryptomonads), Cyanophyta (blue-green algae), Euglenophyta (euglenoids), and Pyrrhophyta (fire algae). The phytoplankton biomasses in Lake Carey ranged from a low of 1,918 ug/L (micrograms per liter) in June to a high of 3,704 ug/L in July of 2025, as shown in Figure 4.8. In general, phytoplankton biomasses below 2,500 ug/L are considered low, ranging from 2,500 to 7,500 ug/L are moderately low to moderately high, ranging from 7,500 to 10,000 ug/L are high, and above 10,000 are considered very high. Biomasses often exceeding 5,000 ug/L are considered often perceived by many as "algal bloom" conditions.

In June, phytoplankton biomass was at a low level and was largely dominated by *Dinobryon* (Chrysophyta) followed by *Aphanizomenon* (Cyanophyta) and *Cryptomonas* (Cryptophyta), further followed by *Schroederia* (Chlorophyta) as shown in Figure 4.8. An increase in biomass to a moderate level and shift in dominant taxa occurred in July when *Calothrix/Rivularia* (Cyanophyta) became largely dominant, followed distantly by *Dolichospermum* (Cyanophyta). In August, a decrease in total biomass to a moderately low level was observed, when *Raphidiopsis* (Cyanophyta) became dominant, followed closely by *Dolichospermum* and further followed by *Cryptomonas* and *Calothrix/Rivularia*. The distribution of biomass was moderately well distributed among taxa in June, but Cyanophyta was largely dominant in July and August.

Phytoplankton densities ranged from a low of 3,216 cells/mL (cells per milliliter) in June to a high of 109,652 cells/mL in August as shown in Figure 4.9. The lowest overall phytoplankton density occurred in June, and was primarily dominated by *Aphanizomenon* distantly followed by

Dinobryon and further by *Schroederia*. In July, a significant increase in density occurred and became dominated by *Calothrix/Rivularia*, followed very distantly by *Dolichospermum* and *Woronichina* (Cyanophyta). Another significant increase in phytoplankton density occurred in August and the taxa was very strongly dominated by *Raphidiopsis* followed very distantly by *Woronichina*, *Calothrix/Rivularia,* and further by *Dolichospermum*. The phylum Cyanophyta was consistently the most dominant in terms of density during June, July, and August. The difference in dominance between biomass and density is largely due to the smaller cell size of certain phytoplankton in relation to other phytoplankton.

In terms of biomass in Lake Carey, in June, the moderate diversity of taxa indicates a fairly healthy phytoplanktonic community. However, the low diversity of taxa in August and even more so in July of 2025 indicates an unhealthy phytoplanktonic community. The genera within the phylum Cyanophyta happened to be smaller and more numerous than other phytoplankton making the two graphs comparing biomass and density appear somewhat different (Figures 4.8 & 4.9). When blue-green algae are the dominant taxa of algae, the algal bloom is often referred to as a harmful algal bloom (HAB). This is because many blue-green algae (cyanobacteria) can potentially produce toxins that can impact both aquatic and terrestrial life. If produced at high enough levels, blue-green algal toxins can affect the liver, the skin and the nervous system of livestock, pets, and humans. It should be noted that not all blue-green algal blooms produce toxins but may have the potential to produce toxins. More research is presently occurring to determine when and why blue-green algal blooms produce and release toxins to lake waters.

For this study, *Calothrix/Rivularia* was the most dominant form of blue-green algae in terms of biomass found in Lake Carey in July, and *Raphidiopsis* was the most dominant form of blue-green algae found in August. July had a moderately higher blue-green algal biomass assemblage than the biomass observed in August. *Calothrix/Rivularia* and *Raphidiopsis* are commonly found in many other nutrient-rich freshwater lakes and these genera often form gas vesicles, which allows them to become buoyant (planktonic). *Calothrix/Rivularia* and *Raphidiopsis* are capable of converting dissolved nitrogen gas ammonium, and these genera can dominate blooms when inorganic nitrogen (ammonium, nitrate, and nitrite) is limiting to other types of algae. Overall, nitrogen fixation requires a large amount of energy, so the relationship between nitrogen concentrations and other Cyanophyta blooms are complicated; blooms can develop under both low and high inorganic nitrogen concentrations.

The annual mean biomass of cyanobacteria (Cyanophyta) compared to the annual mean total biomass of all phytoplankton is illustrated in Figure 4.10. This figure shows that the biomass of cyanobacteria in relation to other phytoplankton was well over half of the total biomass, and was the most dominant phylum for the 2025 season. Since Cyanophyta are less palatable for zooplankton and other phyla are more palatable, a relatively low concentration of the total phytoplankton biomass was available for zooplankton consumption. More consumption of phytoplankton by zooplankton improves the food web for larger aquatic species.

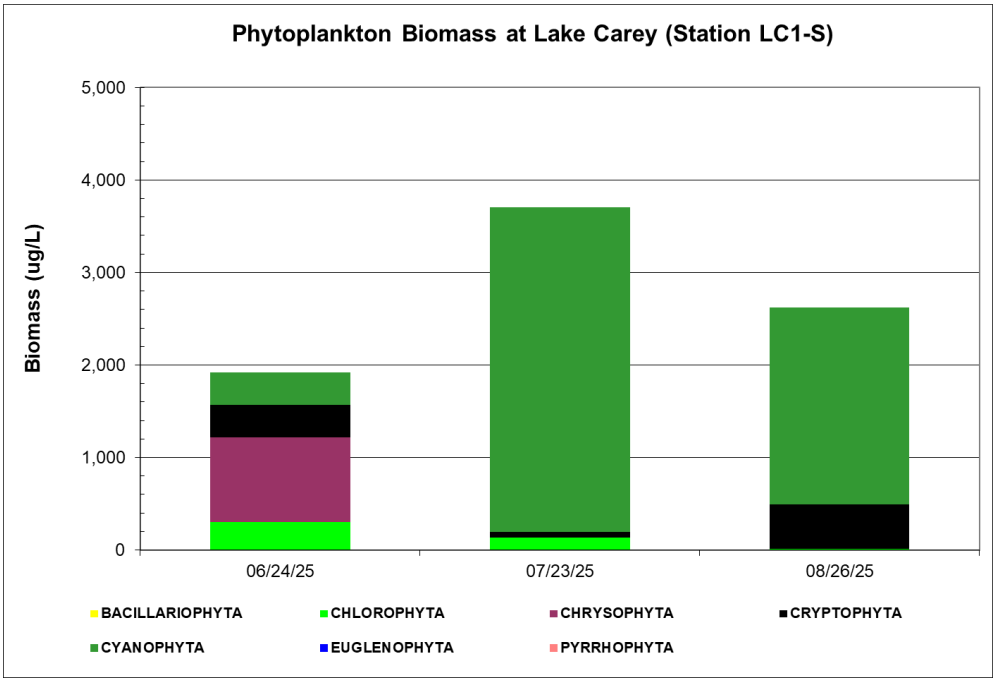

Figure 4.8 Phytoplankton Biomass in Lake Carey (Station LC1)

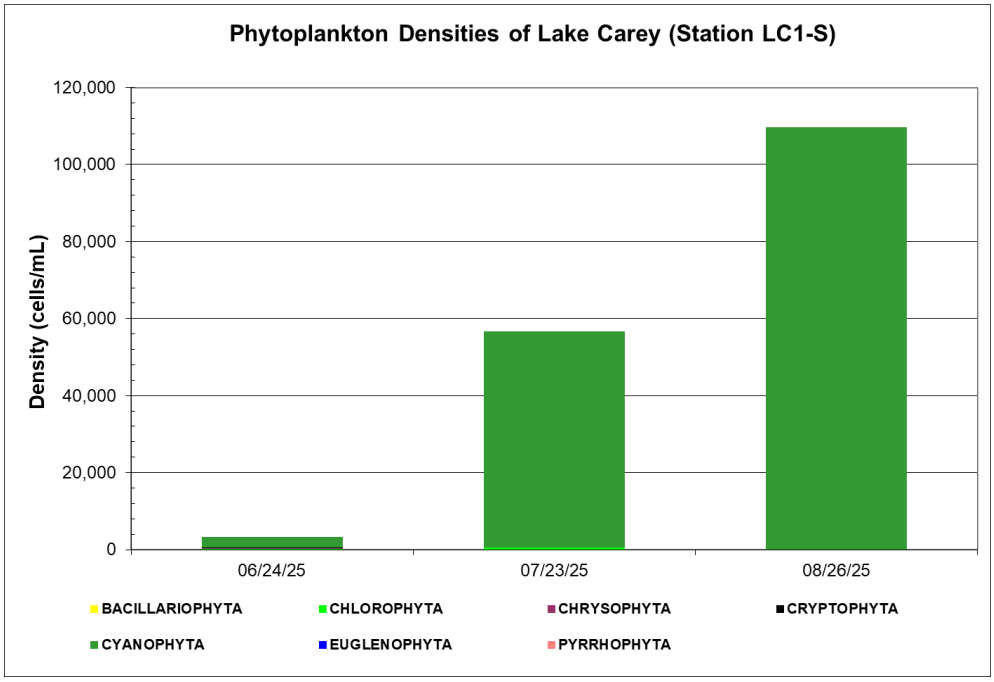

Figure 4.9 Phytoplankton Densities in Lake Carey (Station LC1)

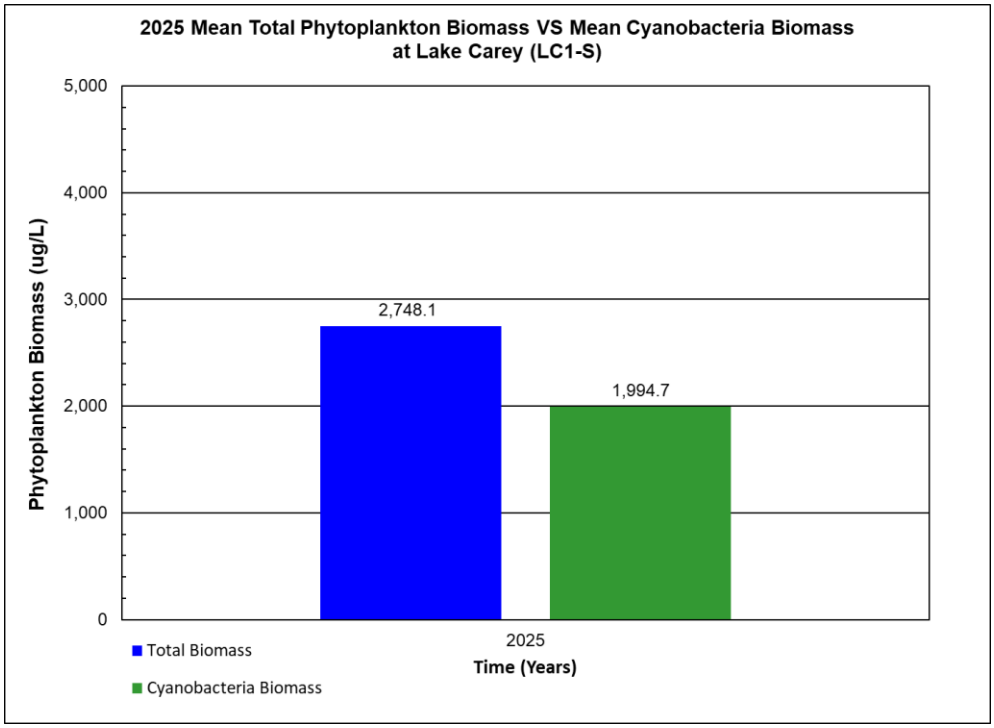

Figure 4.10 Phytoplankton vs. Cyanobacteria Biomass in Lake Carey (Station LC1)

4.1.5.2. Chlorophyll-a

Chlorophyll-a is a pigment that gives all plants their green color. The function of chlorophyll-a is to convert sunlight to chemical energy in the process known as photosynthesis. Because chlorophyll-a constitutes about 1 to 2 percent of the dry weight of planktonic algae, the amount of chlorophyll-a in a water sample is an indicator of phytoplankton biomass. According to Nurnberg (2001), a lake is generally classified oligotrophic, mesotrophic, eutrophic and hypereutrophic when chlorophyll-a concentrations are less than 3.5 ug/L, 3.5 to 9.0 ug/L, 9.1 to 25.0 ug/L, and greater than 25.0 ug/L (micrograms per liter), respectively.

Lake Carey

The 2025 mean chlorophyll-a concentration in Lake Carey was 11.9 ug/L. Chlorophyll-a concentrations ranged from a low of 0.71 ug/L in June to a high of 21.0 ug/L in July during the study period as shown in Figure 4.11. According to the Nurnberg criteria, the mean chlorophyll-a concentration indicates slightly eutrophic conditions. The range of chlorophyll-a values for all study dates suggests oligotrophic to highly eutrophic conditions. Also, the range for chlorophyll-

a concentration covers a broad spectrum, indicating plankton concentrations can increase somewhat rapidly in Lake Carey.

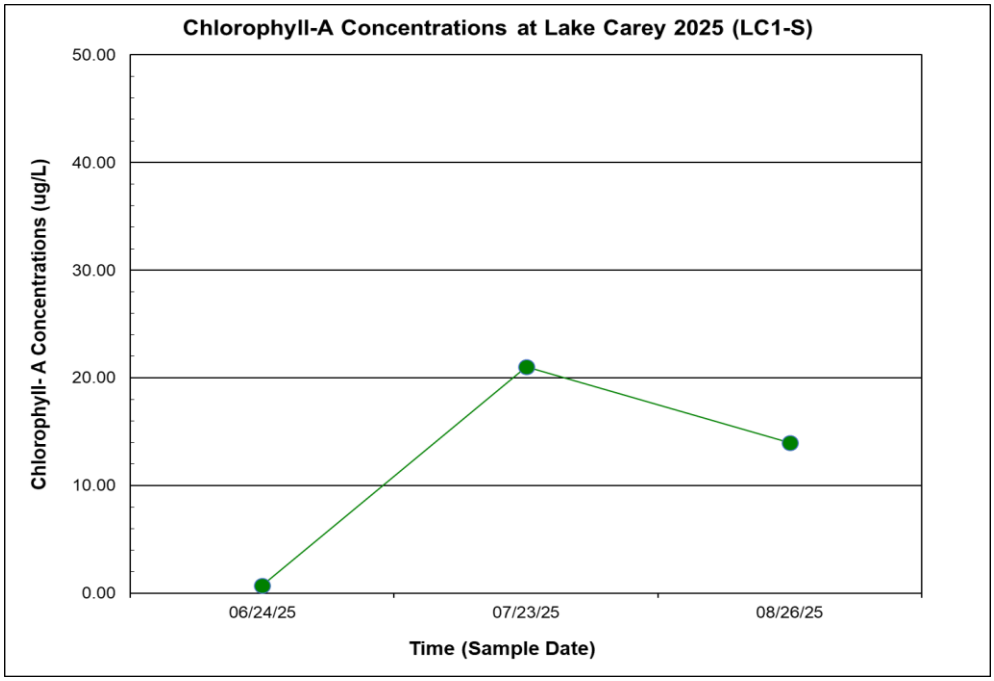

Figure 4.11 Chlorophyll-a Concentrations in Lake Carey (Station LC1)

4.1.6. Trophic State Index

The Trophic State Index (TSI) developed by Carlson (1977) is among the most commonly used indicators of lake trophic state. This index is actually composed of three separate indices based on measurements of Secchi disk depths, chlorophyll-a concentrations, and total phosphorus concentrations for many lakes. Total phosphorus was chosen for the index because phosphorus is often the nutrient limiting for phytoplanktonic growth in lakes. Chlorophyll-a is a plant pigment present in all algae and is used to provide an indication of the biomass of phytoplankton and Secchi disk depth is a common measure of lake transparency.

As part of this study, TSI values were determined for Secchi depth, chlorophyll-a, and total phosphorus data for each of the study dates. Secchi disk depths, chlorophyll-a concentrations, and total phosphorus concentrations were logarithmically converted to a trophic state scale ranging from 1 to 100. Increasing values for the Trophic State Index are indicative of increasing lake trophic states.

In general, index values 35 to 40 are indicative of oligotrophic conditions, while index values greater than 50 to 65 are indicative of eutrophic lake conditions. The Pennsylvania Department of Environmental Protection (PA DEP) classifies lakes according to the following: oligotrophic (less than 40), mesotrophic (40 to 50), eutrophic (50 to 65), and hyper-eutrophic (greater than 65) as noted in its 2002 PA Water Quality Assessment 305(b) Report.

Lake Carey

The calculated 2025 annual mean TSI values for Secchi depth, chlorophyll-a, and total phosphorus are presented in Table 4.4. In addition, annual mean TSI values and the individual TSI values for all study dates in the 2025 study period are graphical presented in Figure 4.12 and 4.13, respectively.

Table 4.4 Mean Carlson's TSI Values in Lake Carey at Station LC1 in 2025

Station	Trophic State Index (TSI) Values		
	Secchi Depth	Chl-a	Total P
LC1	46.7 [39.0 – 54.8]	54.9 [27.2 – 60.4]	47.4 [47.4 – 47.4]

Note: *Mean TSI values determined by averaging the individual TSI values for each parameter during the 2025 study period. [ ] represents range of TSI values for each parameter.*

The average mean TSI values for Secchi disk transparency and total phosphorous suggest moderately mesotrophic conditions while the mean TSI value for chlorophyll-a concentrations suggest slightly to moderately eutrophic conditions (Table 4.4 and Figure 4.12). Based on the above, Lake Carey was best described as boarder-line highly mesotrophic to slightly eutrophic in 2025.

The TSI values for Secchi disk transparency, chlorophyll-a concentrations, and total phosphorous for each sampling event in 2025 is illustrated in Figure 4.13. The TSI values for total phosphorous remained the same and represents highly mesotrophic lake conditions. The TSI values for Secchi disk transparency increased throughout the study period indicating that water clarity declined as the season progressed. The Secchi disk TSI value in June indicates highly mesotrophic conditions, and the values in July and August represent eutrophic conditions. The TSI values for chlorophyll-a increased from June to July to a moderately high level, and decreased slightly from July to August. The TSI chlorophyll-a value for June represent highly oligotrophic conditions while the values for July and August represent eutrophic conditions.

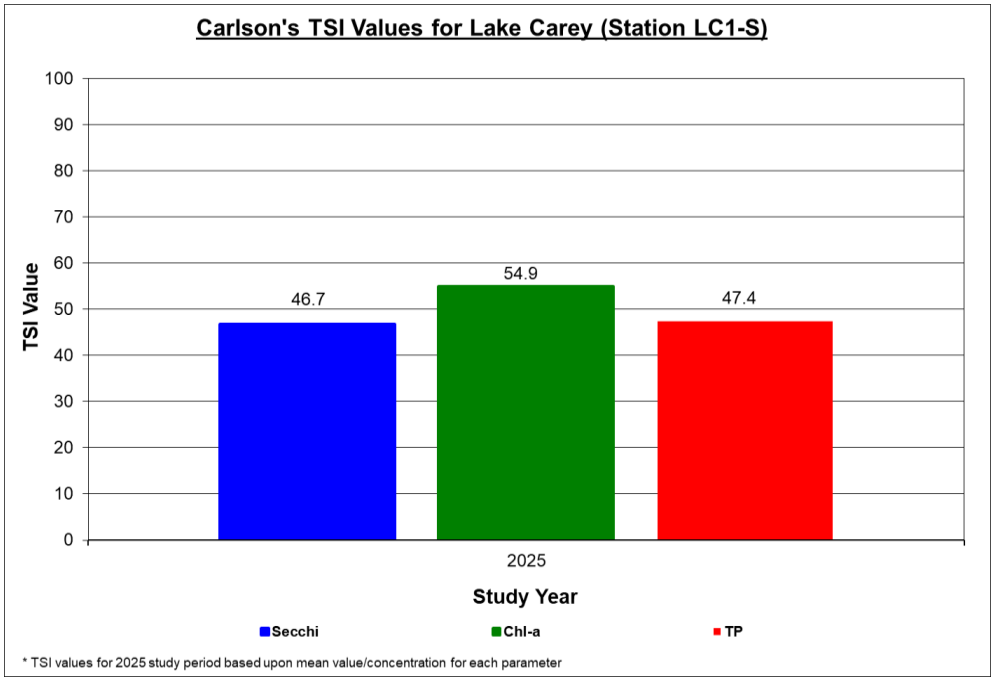

Figure 4.12 Mean Carlson's TSI Values in Lake Carey at Station LC1

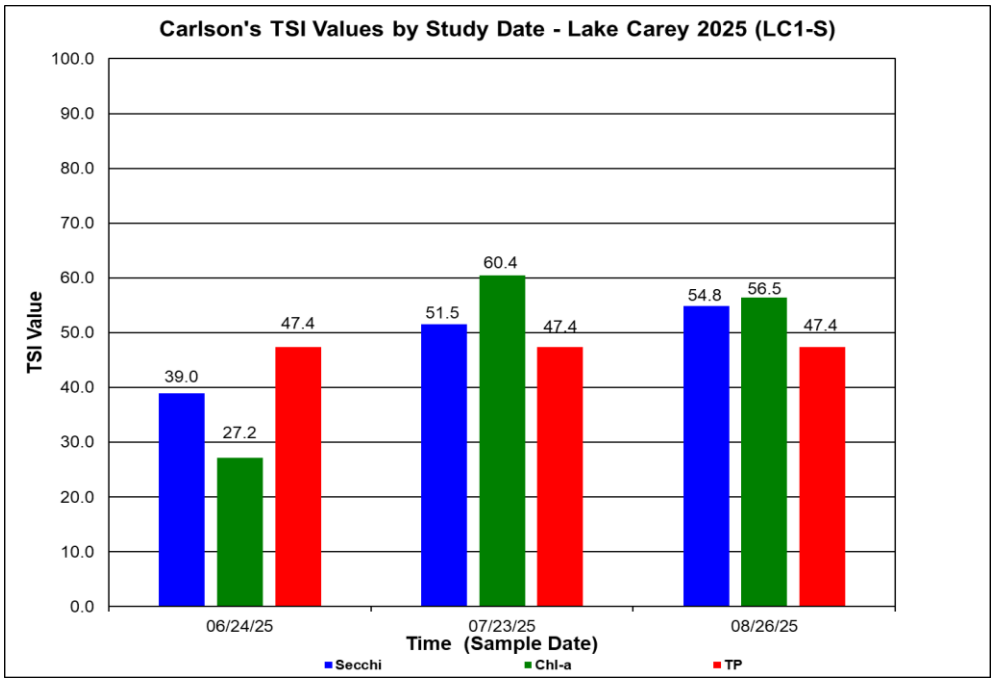

Figure 4.13 Carlson's TSI Values for Each Study Date at Lake Carey (Station LC1)

5. Conclusions and Recommendations

Lake Carey, approximately 249 acres in surface area consists of two lake basins – the larger, deep North basin and the smaller, much shallower South basin. The surface areas of the North and South basins are 185 and 64 acres, respectively. The maximum water depths of the North and South basins are 33.5 and 6.6 feet, respectively. Most of the water quality data collected during this study primarily focused on the North basin, as detailed below.

Lake Carey was classified as boarder-line highly mesotrophic to slightly eutrophic during the 2025 study period (June through August). The mean Carlson TSI values for Secchi disk transparency, chlorophyll-a, and total phosphorus were 46.7, 54.9, and 47.4, respectively. Lakes classified as boarder-line highly mesotrophic to slightly eutrophic typically have fair to good water clarity, moderate to moderately high concentrations of nutrients, and moderate to moderately high biological production of rooted aquatic plants (macrophytes) and phytoplankton. Overall, the water quality and clarity at Lake Carey was considered fair to good in 2025. The best water clarity was reported in June. Lake water clarity then declined in July and continued to decline through August, mostly as a result of increased biomass of planktonic algae (phytoplankton). Water quality data collected during this study suggests that

Lake Carey was strongly, thermally stratified during all three study dates from June through August in the larger lake basin (North basin). As a result of this thermal stratification, dissolved oxygen levels generally fell below 1 mg/L (milligram per liter) in deeper lake waters (hypolimnion). This decrease in dissolved oxygen concentrations was most pronounced during the months of July and August, when the lake was strongly, thermally stratified. The thermocline, which is the point where the temperature change is the greatest, divides the epilimnion (surface waters) and the hypolimnion (bottom waters), was located at a depth of approximately 2.0 to 4.0 meters (6.6 to 13.1 feet) during the month of June, 3.0 to 5.0 meters (9.8 to 16.4 feet) in the month of July, and 4.0 to 6.0 meters (13.1 to 19.7 feet) in the month of August at Station LC1 in Lake Carey.

Lake Carey is also classified as a moderately deep, dimitic lake that is best suited as a warmwater fishery. Dimictic lakes are those lakes that thermally stratify during the growing season (May through September) and eventually destratify and mix during the fall or early winter months. Very low dissolved oxygen levels in the colder, deeper lake waters during thermal stratification will limit the lake's ability to some degree to support a thriving, coldwater fishery year-round.

The internal loading of phosphorus from lake sediments appears to be significant when the lake was thermally stratified. The main lake basin (North basin) was thermally stratified during the entire 2025 study period – June through August. During thermal stratification, dissolved

oxygen levels were very low and either approached or fell below 1 mg/L (milligrams per liter). In turn, the total phosphorus concentrations in deeper lake waters were 35 times greater than surface water concentrations. In general, the internal release of phosphorus via in-lake sediments is accelerated when dissolved oxygen concentrations in deeper lake waters (hypolimnion) fall below 1 mg/L and in-lakes sediments become highly anoxic (devoid of dissolved oxygen). Under anoxic conditions, phosphorus is often easily released from lake sediments into overlying lake waters. Once released, this newly released phosphorus was now available for the additional growth of algae.

The phytoplankton biomasses in Lake Carey ranged from a low of 1,918 ug/L (micrograms per liter) in June to a high of 3,704 ug/L in July 2025. In terms of diversity, phytoplankton biomass was moderately well distributed among taxa in June, but Cyanophyta (blue-green algae) became dominant in July and August. This suggests that the phytoplankton community was considered fairly healthy in June. However, low species diversity was observed in July and August of 2025, causing a less healthy and unbalanced phytoplanktonic community.

When blue-green algae are the dominant taxa of algae, algal blooms are often referred to as harmful algal blooms (HABs). This is because many blue-green algae (cyanobacteria) potentially have the capability of producing toxins that can impact both aquatic and terrestrial life. If produced at high enough levels, blue-green algal toxins can affect the liver, the skin and the nervous system of livestock, pets and humans. It should be noted that not all blue-green algal blooms produce toxins but may have the potential to produce toxins. Based upon 2025 phytoplankton biomass data, blue-green algae were the dominant phylum of algae in Lake Carey in July and August.

Lastly, submerged aquatic plants or macrophytes, consisting of primarily Eurasian water milfoil, were abundant and sometimes dense in the shallower portions of the large lake and throughout much of the small lake in 2025. Eurasian water milfoil is an invasive plant species that, if left unchecked, can become dominant in shallow lake areas and severely impact many recreational lakes uses like boating, fishing, swimming and aesthetics. Additionally, floating leaved aquatic vegetation such as waterlilies and watershield occupied similar areas. Although these species are not invasive, these floating leaved plants can still limit recreational activities and access to lakefront properties and docks.

Based upon the above conclusions, Aqua Link offers the following recommendations:

1. Lake Carey should continue collecting baseline water quality data in 2026. Newly acquired water quality data should be analyzed and compared to those data in the existing 2025 database. The overall importance of collecting baseline lake water quality data on an annual basis cannot be over emphasized. Without these data, lake organizations become severely limited in their capacity of determining whether lake water quality is actually

improving, degrading or remaining unchanged. In addition, annual baseline data allows lake managers the ability to critically evaluate whether implemented in-lake or watershed restoration techniques are actually improving lake water quality.

2. Concentrated bacteria additives, namely MicroLife Clear Max (Hydro Logic Products), should be applied to the entire lake in 2026. The purpose of these treatments is to improve lake water quality and clarity. It should be noted that many bacteria additives including MicroLife Clear Max work even better when lakes are properly aerated. MicroLife Clear Max should be applied to the lake in late May and continue through September. Ideally, these treatments should be applied every three to four weeks during this period. An earlier initial application is recommended in order to establish populations of beneficial bacteria before noxious blue-green bacteria (Cyanophyta) populations have an opportunity to become established. MicroLife Clear bacteria additives have shown to dramatically decrease blue-green algae dominance when applied regularly during the growing season (May through September).

3. Low dose algaecide treatments are recommended in conjunction with the MicroLife Clear Max treatments discussed above in Item 2. This combination or hybrid approach has been used quite successful in many lakes that we manage. Using both products at the same time has allowed for better control over noxious, blue-green algae while promoting the growth of more beneficial algae like diatoms and green algae. Another advantage is using low dosing rates of algaecides, thereby reducing the risk of pesticide resistance.

   Peroxide based algaecides (Green Clean Pro) are an alternative to using copper-based algaecides in lakes. Although very effective, the cost of these types of algaecides will be significantly more that copper sulfate, but may be similar in price when compared to some chelated copper-based products.

4. In-lake best management practices to reduce the internal loading of phosphorus from anoxic in-lake sediments should be evaluated for future implementation. Aquatic products to be evaluated should include the use of alum, PAC (polyaluminum chloride), Phoslock, and Eutrosorb. The above products can be used with or without lake aeration and the use of algaecides like copper sulfate, flumioxazin, or a peroxide-based algaecide.

5. The Association should evaluate the possibility of installing a lake aeration system in the larger, North lake basin. The lake aeration feasibility study should use all lake water quality and mapping data that were recently

acquired by Aqua Link in 2025. This lake aeration feasibility study should consider both destratification and hypolimnetic type systems. Destratification aerations system are designed to mix and aerate the entire lake water column. Conversely, hypolimnetic aeration systems allow the lake to remain thermally stratified during the summer months and therefore only aerates deeper, lake waters. In general, hypolimnetic aeration systems cost significantly more than destratification systems and this is why destratification systems tend to be more popular amongst private lake associations.

6. The smaller, shallower South basin of Lake Carey should be treated with concentrated bacteria additives, such as MicroLife Muck Out, to begin breaking down and digesting organic sediments. MicroLife Muck Out (aka Get the Muck Out by Hydro Logic Products) is applied as time released, bio pucks that sink directly into the sediments. Concentrated strains of Bacillus bacteria rapidly growth within the sediments and release enzymes that accelerate the digestion of accumulated organic matter. This recommendation should be performed annually to increase the water depths in this section of he lake.

7. Phosphorus transported to the lake via inflowing streams and stormwater conveyance structures (swales, ditches, culverts) should be treated using Eutrosorb F phosphorus filtration socks or a similar product. This product is a mesh sock that contains a bentonite clay enriched with the mineral lanthanum. These socks are anchored within inflowing streams plus stormwater swales, ditches and culverts. When phosphorus enriched water passes through these socks, sodium and/or calcium ions are exchanged for lanthanum, thereby releasing lanthanum from the clay into the surrounding waters. In turn, lanthanum, which has a high affinity to bind with free reactive phosphorus (FRP), will bind with soluble phosphorus to form an inert complex known as rhabdophane (LaPO4). This inert complex is extremely stable and insoluble. As a result, phosphorus will not release and become bio-available for the growth of algae in the lake.

8. Any non-native, invasive aquatic plants should be controlled immediately when identified in the lake. During the 2025 season, numerous stands of Eurasian water milfoil were observed. Eurasian water milfoil is a non-native, invasive aquatic plant that is quite aggressive.

   Eurasian water milfoil has the ability to form a monoculture threatening species diversity and dramatically reducing the value of a waterbody by making boating, fishing, and swimming difficult; lowering property values;

and affecting the general ecology of the lake. Also, if dense stands form, there is a potential for a fish kill when the plants die back for the season which results in reduced dissolved oxygen concentrations when these plants decompose.

9. Any problematic floating leaved vegetation as identified by the Association should be treated twice in 2026. These floating leaved treatments would likely target both water lilies and watershield. It is typically recommended to treat these plants during mid to late June with a follow-up treatment in mid to late August, but timing of treatment can be flexible.

10. A follow-up aquatic macrophyte (aquatic vascular plant) survey should be performed in 2026. The results of this survey should be compared to the macrophyte survey performed in 2025. As in the past, the primary objective of the 2026 survey would be to identify the aquatic plants (both native and non-native, invasive) and their overall densities at pre-determined locations throughout the lake. It should be noted that many non-native, invasive aquatic plants can be very aggressive and spread quickly by out-competing other native plant species. Controlling the spread of these aquatic plants can be very costly if not detected early.

11. A fishery survey should be performed to assess the overall health of the ecosystem, as well as improve the fishery. Fishery surveys provide important data on the current condition of the fishery. These surveys have become increasingly popular among lake associations and other lake owners. Increasing the number of fish in a lake, as well as the quality of game fish for anglers to catch, greatly improves the public's perception of the lake. By continuing to perform fishery surveys, a more accurate management plan can then be implemented to enhance the fishing in Lake Carey.

    Fish and aquatic habitat data will be used to develop a fisheries management plan for Lake Carey. This plan will focus on how to improve your fishery based upon your objectives and needs. At a minimum, your management plan will provide recommendations for future fish stockings (including forage fish), fish removals (if applicable), improving aquatic habitats, and institutional practices (e.g. no harvest, harvest slot sizes, creel limits).

    Aside from the game fish, the health of the entire aquatic ecosystem can be monitored through a fishery survey. Invasive species that have the ability to destroy an entire fish population can be discovered in a lake and, in turn, removed from the water body. Also, diseases in the fish population can be exposed, often avoiding mass mortality of thousands of fish. Fishery

assessments can be performed during the spring or fall seasons and fishery management strategies can be determined from the findings of the survey.

All of our recommendations, as discussed above, will require a high level of expertise in the field of lake management. Some of our recommendations will also require obtaining state permits prior to implementation. Aqua Link is a nationally recognized consulting firm specializing in pond and lake management and we are fully capable of implementing all of the recommendations offered in this report.

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APPENDIX A

Glossary of Lake & Watershed Management Terms

Glossary

Algae - Mostly aquatic, non-vascular plants that float in the water or attach to larger plants, rocks, and other substrates. Also called phytoplankton, these individuals are usually visible only with a microscope. They are a normal and necessary component of aquatic life, but excessive numbers can make the water appear cloudy and colored.

Alkalinity - The acid-neutralizing capacity of water. It is primarily a function of the carbonate, bicarbonate, and hydroxide content in water. The lower the alkalinity, the less capacity the water has to absorb acids without becoming more acidic.

Ammonia (NH3) - A nitrogen-containing substance which may indicate recently decomposed plant or animal material.

Benthos - The communities of aquatic life which dwell in or on the bottom sediments of a water body.

Chlorophyll - Pigments (mostly green) in plants, including algae, that play an important part in the chemical reactions of photosynthesis. A measurement of chlorophyll-a (one type of chlorophyll) is commonly used as a measure of the algae content of water.

Conductivity (Cond) - A measure of water's capacity to convey an electric current. It is related to the total amount of dissolved charged substances in the water. Therefore, it can be used as a general indicator of the quality of the water and can also suggest presence of unidentified material in the water. It is often used as a surrogate for salinity measurements.

Combined Sewer Overflow (CSO) -Discharges of combined sewage and stormwater into water bodies during very wet or storm weather. These discharges occur to relieve the sewer system as it becomes overloaded with normal sewer flow and increased storm run-off. The term is also used to denote a pipe that discharges those overflows.

Dissolved oxygen (DO) - Oxygen that is dissolved in the water. Certain amounts are necessary for life processes of aquatic animals. The oxygen is supplied by the photosynthesis of plants, including algae, and by aeration. Oxygen is consumed by animals and plants at night, and bacterial decomposition of dead organic matter (plant matter and animal waste).

Effluent - Liquids discharged from sewage treatment plants, septic systems, or industrial sources to surface waters.

Epilimnion - The warmer, well-lit surface waters of a lake that are thermally separated from the colder (hence denser), water at the bottom of the lake when a lake is stratified.

Eutrophication - The acceleration of the loading of nutrients to a lake by natural or human-induced causes. The increased rate of delivery of nutrients results in increased production of algae and consequently, poor water transparency. Human-induced (cultural) eutrophication may be caused by input of treated sewage to a lake, deforestation of a watershed, or the urbanization of a watershed.

Fecal Coliform Bacteria - Bacteria from the intestines of warm-blooded animals. Most of the bacteria are not in themselves harmful, so they are measured or counted as an indicator of the possible presence of harmful bacteria.

Groundwater - Water stored beneath the surface of the earth. The water in the ground is supplied by the seepage of rainwater, snowmelt, and other surface water into the soil. Some groundwater may be found far beneath the earth surface, while other groundwater may be only a few inches from the surface. Groundwater discharges into lowland streams to maintain their baseflow.

Hydrology -The science dealing with the properties, distribution and circulation of water. The term usually refers to the flow of water on or below the land surface before reaching a stream or man-made structure.

Hypolimnion - The dark, cold, bottom waters of a lake that are thermally separated from the warmer (hence less dense) surface waters when a lake is stratified.

Invertebrates - Animals without internal skeletons. Some require magnification to be seen well, while others such as worms, insects, and crayfish are relatively large. Invertebrates living in stream and lake sediments are collected as samples to be identified and counted. In general, more varied invertebrate communities indicate healthier water bodies.

Limiting nutrient - The nutrient that is in lowest supply relative to the demand. The limiting nutrient will be exhausted first by algae which require many nutrients and light to grow. Inputs of the limiting nutrient will result in increased algal production, but as soon as the limiting nutrient is exhausted, growth stops. Phytoplankton growth in lake waters of temperate lowland areas is generally phosphorus limited.

Limnology - Scientific study of inland waters.

Littoral zone - portion of a water body extending from the shoreline lakeward to the greatest depth occupied by rooted plants.

Loading rate - Addition of a substance to a water body; or the rate at which the addition occurs. For example, streams load nutrients to lakes at various rates as in "500 kilograms per year (500 kg/yr)" or "227 pounds per year (227 lb/yr)."

Macrophytes - rooted and floating aquatic plants, larger (macro-) than the phytoplankton.

Mesotrophic - A condition of lakes that is characterized by moderate concentrations of nutrients, algae, and water transparency. A mesotrophic lake is not as rich in nutrients as a eutrophic lake, but richer in nutrients than an oligotrophic lake.

Monomictic - A lake which has one mixing and one stratification event per year. If a lake does not freeze over in the winter, the winter winds will mix the waters of the lake. In summer, the lake resists mixing and becomes stratified because the surface waters are warm (light) and the bottom waters are cold (dense). Deep lakes in the Puget lowlands are monomictic lakes.

Nitrate, nitrite (NO3, NO2) - Two types of nitrogen compounds. These nutrients are forms of nitrogen that algae may use for growth.

Nitrogen - One of the elements essential as a nutrient for growth of organisms.

Non-point source pollution - Pollution that originates from diffuse areas and unidentifiable sources, such as agriculture, the atmosphere, or ground water.

Nutrients - Elements or compounds essential for growth of organisms.

Oligotrophic - A condition of lakes characterized by low concentrations of nutrients and algae and resulting good water transparency. An oligotrophic lake has less nutrients than a mesotrophic or eutrophic lake.

Pathogens -Microorganisms that can cause disease in other organisms or humans, animals, and plants. Pathogens include bacteria, viruses, fungi, or parasites found in sewage, in runoff from farms or city streets, and in water used for swimming. Pathogens can be present in municipal, industrial, and nonpoint source discharges.

Pelagic Zone - Deep, open water area of a lake away from the edge of the littoral zone towards the center of the lake.

pH - Measure of the acidity of water on a scale of 0 to 14, with 7 representing neutral water. A pH less than 7 is considered acidic and above 7 is basic.

Phosphorus - One of the elements essential as a nutrient for the growth of organisms. In western Washington lakes, it is usually the algae nutrient in shortest supply relative to the needs of the algae. Phosphorus occurs naturally in soils, as well as in organic material. Various measures of phosphorus in water samples are made, including total-phosphorus (TP) and the dissolved portion of the phosphorus (orthophosphorus).

Photic zone - The lighted region of a lake where photosynthesis occurs.

Phytoplankton - Floating, mostly microscopic algae (plants) that live in water.

Point-source Polution - An input of pollutants into a water body from discrete sources, such as municipal or industrial outfalls.

Primary Treatment - The first stage of wastewater treatment involving removal of debris and solids by screening and settling.

Pump Station -A structure used to move wastewater uphill, against gravity.

Regulator -A structure that controls the flow of wastewater from two or more input pipes to a single output. Regulators can be used to restrict or halt flow, thus causing wastewater to be stored in the conveyance system until it can be handled by the treatemnt plant.

Salmonids - Salmon, trout, char and whitefish species of fish.

Secchi depth - Measure of transparency of water obtained by lowering a 10 cm black and white disk into water until it is no longer visible.

Secondary Treatment - Following primary treatment, bacteria are used to consume organic wastes. Wastewater is then disinfected and discharged through an outfall.

Separation -A method for controlling combined sewer overflow whereby the combined sewer is separated into both a sanitary sewer and a storm drain, as is the practice in new development.

Sewage -That portion of wastewater that is composed of human and industrial wastes from homes, businesses, and industries.

Standard - A legally established allowable limit for a substance or characteristic in the water, based on criteria. Enforcement actions by the appropriate agencies can be taken against parties who cause violations.

Stratification of lakes - A layering effect produced by the warming of the surface waters in many lakes during summer. Upper waters are progressively warmed by the sun and the deeper waters remain cold. Because of the difference in density (warmer water is lighter), the two layers remain separate from each other: upper waters "float" on deeper waters and wind induced mixing occurs only in the upper waters. Oxygen in the bottom waters may become depleted. In autumn as the upper waters cool, the whole lake mixes again and remains mixed throughout the winter, or until it freezes over.

Stormwater -Water that is generated by rainfall and is often routed into drain systems.

Thermocline - Depth in a stratified lake where the greatest change in temperature occurs. Separates the epilimnion from the hypolimnion

Total suspended solids (TSS) - Particles, both mineral (clay and sand) and organic (algae and small pieces of decomposed plant and animal material), that are suspended in water.

Toxic -Causing death, disease, cancer, genetic mutations, or physical deformations in any organism or its offspring upon exposure, ingestion, inhalation, or assimilation.

Transparency - A measure of the clarity of water in a lake, which is measured by lowering a standard black and white Secchi disk into the water and recording the depth at which it is no longer visible. Transparency of lakes is determined by the color of the water and the amount of material suspended in it. Generally in colorless waters of the Puget lowland, the transparency of the water in summer is determined by the amount of algae present in the water. Suspended silt particles may also have an effect, particularly in wet weather.

Trophic status - Rating of the condition of a lake on the scale of oligotrophic-mesotrophic-eutrophic (see definition of these terms).

Turbidity - Cloudiness of water caused by the suspension of minute particles, usually algae, silt, or clay.

Wastewater -Total flow within the sewage system. In combined systems, it includes sewage and stormwater.

Water Column - Water in a lake between the surface and sediments. Used in vertical measurements used to characterize lake water.

Watershed - The areas that drain to surface water bodies, including lakes, rivers, estuaries, wetlands, streams, and the surrounding landscape.

Water of Statewide Significance - Legal term from the state Shoreline Management act, which recognizes particular bodies of water and sets criteria and standards for their protection.

Zooplankton - Small, free swimming or floating animals in water, many are microscopic.

Source: King County, Washington (http://dnr.metrokc.gov/wlr/waterres/lakes/glossary)

APPENDIX B

Lake Water Quality Data

Lake Carey **Prepared by Aqua-Link, Inc.**
ALI Project No. 1876-01

Lake Water Quality Data

Parameter:	Units of Measure:
pH (pH)	Expressed in Standard Units (s.u.)
Alkalinity (Alk)	Expressed in milligrams per liter as calcium carbonate(mg/l as CaCO3)
Hardness	Expressed in milligrams per liter as calcium carbonate(mg/l as CaCO3)
Conductivity (Cond)	Expressed in micromhos per cm (umhos/cm)
Conductivity (Cond)	Expressed in microsiemens per cm (uS/cm)
Specific Conductance (Sp Cond)	Expressed in micromhos per cm (umhos/cm) @ 25.0 degrees Celsius
Total Phosphorus (TP)	Expressed as milligrams per liter as phosphorus (mg/l as P)
Dissolved Reactive Phosphorus (DRP)	Expressed in milligrams per liter as phosphorus (mg/l as P)
Nitrate (NO3)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Nitrite (NO2)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Ammonia nitrogen (NH3)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Total Kjeldahl Nitrogen (TKN)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Total Suspended Solids (TSS)	Expressed in milligrams per liter (mg/l)
Turbidity	Epressed in ntu's (nephelometric turbidity units)
Color	Expressed in Pt/Co Units
Oil & Grease	Expressed in milligrams per liter (mg/l)
Iron (Fe) total/dissolved	Expressed in milligrams per liter (mg/l)
Manganese (Mn) total/dissolved	Expressed in milligrams per liter (mg/l)
Dissolved Oxygen (Dissol Oxy)	Expressed in milligrams per liter (mg/l)
Temperature (Temp)	Expressed in degress Celsius (degrees C)
Secchi Disk Depth	Expressed in meters (m)
Chlorophyll-a	Expressed in micrograms per liter (ug/l)
Fecal coliform bacteria (FC)	Expressed as number of organisms per one hundred milliliters (No./100 ml)
Fecal streptococcus bacteria (FS)	Expressed as number of organisms per one hundred milliliters (No./100 ml)
Phytoplankton	Expressed as number of organisms per liter (No.per ml)
Phytoplankton	Expressed as biomass in micrograms per liter (ug/l)
Zooplankton	Expressed as number of organisms per liter (No.per liter)
Zooplankton	Expressed as biomass in micrograms per liter (ug/l)

Note(s):
TIN denotes total inorganic nitrogen and is the sum of nitrite, nitrate, and ammonia nitrogen
TN denotes total nitrogen and is the sum of total Kjeldahl nitrogen and nitrite and nitrate nitrogen
TN:TP denotes the ratio ot total nitrogen and total phosphorus
TIN:DRP denotes the ratio of total inorganic nitrogen and dissolved reactive phosphorus
(b) denotes below detection limit, therefore data reported as the detection limit
(*) indicates calculated value
(**) indicates *in-situ* field data collected on the study date (also refer to *in-situ* data)
(^^) indicates inconsistent values outside of typical ranges

Lake Carey **Prepared by Aqua-Link, Inc.**
ALI Project No. 1876-01

Insitu Water Quality Data

Station No. LC1 (large-lake)
Station No. LC2 (small-lake)

Date	Time		Depth	Temp	DO	DO	Cond	Sp Cond	pH	TDS	Salinity	ORP	Chl-a	PC	Conversions		Chg Temp
mm/dd/yy	hh:mm:ss	Site	m	°C	% sat	mg/L	us/cm	us/cm	s.u.	mg/L	ppt	mV	RFU	RFU	Depth ft	Temp °F	° C
06/24/25	11:27:29 AM	LC1	0.0	27.7	107.3	8.44	120.5	114.5	8.15	74.0	0.05	103.2	0.2	0.0	0.0	81.9	0.6
06/24/25	11:28:03 AM	LC1	1.0	27.1	105.1	8.36	119.3	114.6	8.09	74.0	0.05	103.2	0.2	0.0	3.3	80.9	1.6
06/24/25	11:28:20 AM	LC1	2.0	25.6	102.1	8.34	115.8	114.5	8.05	74.0	0.05	104.3	2.1	0.0	6.6	78.0	3.6
06/24/25	11:28:37 AM	LC1	3.0	22.0	95.8	8.37	108.6	115.2	8.01	75.0	0.05	106.3	1.6	0.0	9.8	71.6	3.6
06/24/25	11:28:55 AM	LC1	4.0	18.4	64.3	6.04	102.6	117.4	7.76	76.0	0.05	115.0	1.1	0.0	13.1	65.1	2.1
06/24/25	11:29:14 AM	LC1	5.0	16.3	33.4	3.27	99.7	119.6	7.47	78.0	0.06	125.2	0.6	0.0	16.4	61.3	1.7
06/24/25	11:29:34 AM	LC1	6.0	14.6	17.2	1.75	98.6	123.2	7.30	80.0	0.06	127.4	0.5	0.6	19.7	58.2	1.3
06/24/25	11:29:50 AM	LC1	7.0	13.3	11.4	1.20	102.2	131.8	7.15	86.0	0.06	77.7	0.3	0.1	23.0	55.9	1.8
06/24/25	11:30:09 AM	LC1	8.0	11.4	8.0	0.87	110.0	148.5	6.94	97.0	0.07	-60.6	0.5	0.2	26.2	52.5	0.3
06/24/25	11:30:26 AM	LC1	9.0	11.1	6.4	0.70	111.1	151.2	6.88	98.0	0.07	-128.0	0.4	0.3	29.7	52.0	
<<insert>>																	
	Min		0.0	11.1	6.4	0.7	98.6	114.5	6.9	74.0	0.1	-128.0	0.2	0.0	0.0	52.0	
	Max		9.0	27.7	107.3	8.4	120.5	151.2	8.2	98.0	0.1	127.4	2.1	0.6	29.7	81.9	
	Max - Min		9.0	16.6	100.9	7.7	21.9	36.7	1.3	24.0	0.0	255.4	1.9	0.6	29.7	29.9	
	Count		10	10	10	10	10	10	10	10	10	10	10	10	10	10	

Date	Time		Depth	Temp	DO	DO	Cond	Sp Cond	pH	TDS	Salinity	ORP	Chl-a	PC	Conversions		Chg Temp
mm/dd/yy	hh:mm:ss	Site	m	°C	% sat	mg/L	us/cm	us/cm	s.u.	mg/L	ppt	mV	RFU	RFU	Depth ft	Temp °F	° C
06/24/25	11:43:56 AM	LC2	0.0	29.0	119.4	9.18	125.1	116.3	8.17	76.0	0.05	50.9	1.8	0.0	0.0	84.2	1.4
06/24/25	11:44:28 AM	LC2	0.5	27.6	117.2	9.23	122.0	116.2	8.07	76.0	0.05	55.7	3.0	0.3	1.6	81.7	1.7
06/24/25	11:44:43 AM	LC2	1.0	25.9	108.5	8.82	117.5	115.5	7.83	75.0	0.05	64.0	6.9	0.9	3.3	78.6	1.2
06/24/25	11:45:20 AM	LC2	1.4	24.7	63.0	5.24	117.8	118.5	7.28	77.0	0.05	-43.4	16.4	5.7	4.6	76.4	
<<insert>>																	
	Min		0.0	24.7	63.0	5.24	117.5	115.5	7.28	75.0	0.05	-43.4	1.76	0.00	0.0	76.4	
	Max		1.4	29.0	119.4	9.23	125.1	118.5	8.17	77.0	0.05	64.0	16.37	5.72	4.6	84.2	
	Max - Min		1.4	4.3	56.4	3.99	7.6	3.0	0.89	2.0	0.00	107.4	14.61	5.72	4.6	7.8	
	Count		4	4	4	4	4	4	4	4	4	4	4	4	4	4	

Lake Carey **Prepared by Aqua-Link, Inc.**
ALI Project No. 1876-01

Insitu Water Quality Data

Station No. LC1 (large-lake)
Station No. LC2 (small-lake)

Date	Time		Depth	Temp	DO	DO	Cond	Sp Cond	pH	TDS	Salinity	ORP	Chl-a	PC	Conversions		Chg Temp
mm/dd/yy	hh:mm:ss	Site	m	°C	% sat	mg/L	us/cm	us/cm	s.u.	mg/L	ppt	mV	RFU	RFU	Depth ft	Temp °F	° C
07/23/25	10:23:25 AM	LC1	0.0	26.2	123.3	9.97	119.7	117.0	9.02	76.0	0.05	97.4	0.4	1.2	0.0	79.1	0.2
07/23/25	10:23:42 AM	LC1	1.0	26.0	125.4	10.17	119.5	117.3	9.04	76.0	0.05	97.0	0.7	1.6	3.3	78.8	0.2
07/23/25	10:24:00 AM	LC1	2.0	25.8	125.2	10.20	118.8	117.1	9.00	76.0	0.05	98.3	0.6	1.9	6.6	78.4	0.5
07/23/25	10:24:27 AM	LC1	3.0	25.2	105.1	8.64	117.3	116.8	8.24	76.0	0.05	119.4	0.7	3.0	9.8	77.4	3.4
07/23/25	10:24:47 AM	LC1	4.0	21.9	42.9	3.75	111.2	118.2	7.65	77.0	0.05	143.5	0.5	0.3	13.1	71.4	3.5
07/23/25	10:25:06 AM	LC1	5.0	18.4	18.5	1.74	105.0	120.2	7.38	78.0	0.06	155.5	1.5	3.1	16.4	65.0	3.4
07/23/25	10:25:24 AM	LC1	6.0	14.9	11.7	1.19	106.6	132.0	7.10	86.0	0.06	135.2	0.7	0.9	19.7	58.9	1.9
07/23/25	10:25:43 AM	LC1	7.0	13.1	8.4	0.88	111.6	144.6	6.75	94.0	0.07	-0.6	0.6	0.8	23.0	55.5	1.1
07/23/25	10:25:58 AM	LC1	8.0	11.9	7.0	0.76	119.5	159.3	6.57	104.0	0.08	-76.0	0.4	0.7	26.2	53.4	0.6
07/23/25	10:26:15 AM	LC1	9.0	11.3	5.9	0.64	126.3	170.9	6.52	111.0	0.08	-99.4	0.6	1.4	29.6	52.4	
<<insert>>																	
	Min		0.0	11.3	5.9	0.64	105.0	116.8	6.52	76.0	0.05	-99.4	0.40	0.29	0.0	52.4	
	Max		9.0	26.2	125.4	10.20	126.3	170.9	9.04	111.0	0.08	155.5	1.48	3.06	29.6	79.1	
	Max - Min		9.0	14.9	119.5	9.56	21.3	54.1	2.52	35.0	0.03	254.9	1.08	2.77	29.6	26.8	
	Count		10	10	10	10	10	10	10	10	10	10	10	10	10	10	

Date	Time		Depth	Temp	DO	DO	Cond	Sp Cond	pH	TDS	Salinity	ORP	Chl-a	PC	Conversions		Chg Temp
mm/dd/yy	hh:mm:ss	Site	m	°C	% sat	mg/L	us/cm	us/cm	s.u.	mg/L	ppt	mV	RFU	RFU	Depth ft	Temp °F	° C
07/23/25	10:38:56 AM	LC2	0.0	25.4	117.0	9.60	81.7	81.0	7.96	53.0	0.04	67.3	3.5	1.8	0.0	77.7	0.2
07/23/25	10:39:17 AM	LC2	0.5	25.2	117.3	9.66	116.8	116.4	8.01	76.0	0.05	67.3	4.1	2.1	1.6	77.3	0.5
07/23/25	10:39:35 AM	LC2	1.0	24.7	111.4	9.26	116.3	116.9	7.88	76.0	0.05	72.0	6.3	2.5	3.3	76.5	0.0
07/23/25	10:39:54 AM	LC2	1.3	24.7	93.0	7.73	117.6	118.4	7.40	77.0	0.05	-39.2	11.2	5.8	4.3	76.4	
<<insert>>																	
	Min		0.0	24.7	93.0	7.73	81.7	81.0	7.40	53.0	0.04	-39.2	3.51	1.79	0.0	76.4	
	Max		1.3	25.4	117.3	9.66	117.6	118.4	8.01	77.0	0.05	72.0	11.21	5.78	4.3	77.7	
	Max - Min		1.3	0.7	24.3	1.93	35.9	37.4	0.61	24.0	0.01	111.2	7.70	3.99	4.3	1.3	
	Count		4	4	4	4	4	4	4	4	4	4	4	4	4	4	

Lake Carey **Prepared by Aqua-Link, Inc.**
ALI Project No. 1876-01

Insitu Water Quality Data

Station No. LC1 (large-lake)
Station No. LC2 (small-lake)

Date mm/dd/yy	Time hh:mm:ss	Site	Depth m	Temp °C	DO % sat	DO mg/L	Cond us/cm	Sp Cond us/cm	pH s.u.	TDS mg/L	Salinity ppt	ORP mV	Chl-a RFU	PC RFU	Conversions Depth ft	Conversions Temp °F	Chg Temp ° C
08/26/25	11:26:14 AM	LC1	0.0	23.4	89.1	7.59	113.7	117.3	7.63	76.0	0.05	128.7	0.5	0.8	0.0	74.1	0.1
08/26/25	11:26:38 AM	LC1	0.5	23.2	89.0	7.60	113.4	117.3	7.67	76.0	0.05	126.7	0.6	0.9	1.6	73.8	0.2
08/26/25	11:27:06 AM	LC1	1.0	23.0	88.6	7.59	113.0	117.4	7.70	76.0	0.05	125.3	1.0	1.3	3.3	73.5	0.1
08/26/25	11:27:29 AM	LC1	1.5	22.9	88.4	7.59	112.7	117.3	7.71	76.0	0.05	125.0	1.3	1.6	4.9	73.3	0.1
08/26/25	11:27:50 AM	LC1	2.0	22.9	87.2	7.50	112.5	117.2	7.70	76.0	0.05	125.3	1.5	1.6	6.6	73.2	0.0
08/26/25	11:28:10 AM	LC1	2.5	22.8	85.4	7.34	112.4	117.3	7.67	76.0	0.05	126.5	1.3	1.6	8.2	73.1	0.0
08/26/25	11:28:33 AM	LC1	3.0	22.8	83.2	7.16	112.4	117.3	7.64	76.0	0.05	128.0	1.3	1.6	9.8	73.1	0.0
08/26/25	11:28:53 AM	LC1	3.5	22.8	80.5	6.93	112.0	117.0	7.59	76.0	0.05	129.6	1.3	1.7	11.5	73.0	0.1
08/26/25	11:29:14 AM	LC1	4.0	22.7	75.8	6.54	111.9	117.1	7.52	76.0	0.05	131.9	1.0	1.4	13.1	72.9	1.4
08/26/25	11:29:35 AM	LC1	4.5	21.3	42.8	3.79	102.7	110.4	7.34	72.0	0.05	138.1	2.1	4.4	14.8	70.4	1.7
08/26/25	11:29:53 AM	LC1	5.0	19.7	21.3	1.95	110.7	123.2	7.12	80.0	0.06	146.9	0.9	2.0	16.4	67.4	1.6
08/26/25	11:30:17 AM	LC1	5.5	18.1	11.8	1.11	115.6	133.1	7.02	87.0	0.06	148.1	0.6	0.7	18.0	64.6	2.0
08/26/25	11:30:34 AM	LC1	6.0	16.1	9.0	0.88	118.3	142.6	6.93	93.0	0.07	129.5	0.6	1.0	19.7	61.0	1.0
08/26/25	11:30:54 AM	LC1	6.5	15.1	7.1	0.72	117.5	144.8	6.76	94.0	0.07	-46.2	0.4	0.4	21.3	59.2	1.0
08/26/25	11:31:22 AM	LC1	7.0	14.2	5.7	0.59	118.3	149.3	6.68	97.0	0.07	-108.3	0.5	0.5	23.0	57.5	0.9
08/26/25	11:31:42 AM	LC1	7.5	13.3	5.0	0.52	121.5	156.6	6.67	102.0	0.07	-123.9	0.5	0.6	24.6	55.9	0.6
08/26/25	11:32:04 AM	LC1	8.0	12.7	4.5	0.47	125.6	164.2	6.65	107.0	0.08	-130.3	0.4	0.6	26.2	54.9	0.7
08/26/25	11:32:27 AM	LC1	8.5	12.0	4.1	0.44	130.9	174.1	6.63	113.0	0.08	-133.0	0.5	0.6	27.9	53.6	0.3
08/26/25	11:32:52 AM	LC1	9.0	11.7	3.7	0.41	133.4	178.9	6.62	116.0	0.08	-134.8	0.5	0.9	29.5	53.0	0.1
08/26/25	11:33:11 AM	LC1	9.4	11.5	3.5	0.38	141.3	190.3	6.59	124.0	0.09	-134.7	0.5	4.6	30.7	52.8	
<<insert>>																	
	Min		0.0	11.5	3.5	0.4	102.7	110.4	6.6	72.0	0.1	-134.8	0.4	0.4	0.0	52.8	
	Max		9.4	23.4	89.1	7.6	141.3	190.3	7.7	124.0	0.1	148.1	2.1	4.6	30.7	74.1	
	Max - Min		9.4	11.8	85.6	7.2	38.6	79.9	1.1	52.0	0.0	282.9	1.7	4.3	30.7	21.3	
	Count		20	20	20	20	20	20	20	20	20	20	20	20	20	20	

Date mm/dd/yy	Time hh:mm:ss	Site	Depth m	Temp °C	DO % sat	DO mg/L	Cond us/cm	Sp Cond us/cm	pH s.u.	TDS mg/L	Salinity ppt	ORP mV	Chl-a RFU	PC RFU	Conversions Depth ft	Conversions Temp °F	Chg Temp ° C
08/26/25	12:11:03 PM	LC2	0.0	22.5	116.0	10.04	110.2	115.7	8.30	75.0	0.05	61.3	4.6	7.9	0.0	72.5	0.7
08/26/25	12:11:28 PM	LC2	0.5	21.8	114.4	10.03	108.6	115.7	8.27	75.0	0.05	64.0	14.4	10.4	1.6	71.2	0.6
08/26/25	12:11:50 PM	LC2	1.0	21.2	101.2	8.99	107.7	116.2	8.05	76.0	0.05	70.0	17.2	10.4	3.3	70.1	0.0
08/26/25	12:12:11 PM	LC2	1.4	21.1	86.2	7.66	108.6	117.3	7.76	76.0	0.05	57.2	24.0	12.9	4.7	70.0	
<<insert>>																	
	Min		0.0	21.1	86.2	7.66	107.7	115.7	7.76	75.0	0.05	57.2	4.57	7.87	0.0	70.0	
	Max		1.4	22.5	116.0	10.04	110.2	117.3	8.30	76.0	0.05	70.0	23.98	12.86	4.7	72.5	
	Max - Min		1.4	1.4	29.8	2.38	2.5	1.6	0.54	1.0	0.00	12.8	19.41	4.99	4.7	2.5	
	Count		4	4	4	4	4	4	4	4	4	4	4	4	4	4	

Lake Carey **Prepared by Aqua-Link, Inc.**

ALI Project No. 1876-01

Analytical Lake Water Quality Data

Station No. LC1 (large-lake)

Station No. LC2 (small-lake)

Station	Depth	Date	Sp Cond** (uS/cm)	pH** (std units)	Alkalinity (mg/L as CaCO3)	Hardness (mg/L as CaCO3)		DRP (mg/L as P)	TP (mg/L as P)	Ammonia (mg/L as N)
LC1S	Surface	06/24/25	114.6	8.09	34.0	35.0		0.013	0.020	0.020
		07/23/25	117.3	9.04	34.0	42.0		0.001	0.020	0.020
		08/26/25	117.4	7.70	36.0	34.0	b	0.001	0.020	0.040
<<insert>>										
		Min	114.6	7.70	34.0	34.0	b	0.001	0.020	0.020
		Max	117.4	9.04	36.0	42.0		0.013	0.020	0.040
		Mean	116.4	8.28	34.7	37.0		0.005	0.020	0.027
		Median	117.3	8.09	34.0	35.0		0.001	0.020	0.020
		Stds	1.6	0.69	1.2	4.4		0.007	0.000	0.012
		Std	1.3	0.56	0.9	3.6		0.006	0.000	0.009
		Count	3	3	3	3		3	3	3

Lake Carey **Prepared by Aqua-Link, Inc.**

ALI Project No. 1876-01

Analytical Lake Water Quality Data

Station No. LC1 (large-lake)

Station No. LC2 (small-lake)

Station	Depth	Date	Nitrate (mg/L as N)		Nitrite (mg/L as N)	TKN (mg/L as N)	TIN* (mg/L as N)	TN* (mg/L as N)	TN:TP*	TIN:DRP*		TSS (mg/L)	Chlorophyll-a (ug/L)		Pheophytin-a (ug/L)
LC1S	Surface	06/24/25	0.170		0.003	0.700	0.193	0.873	43.7	14.8		6.0	0.71		1.10
		07/23/25	0.110	b	0.003	1.000	0.133	1.113	55.7	133.0	b	2.0	21.00		1.70
		08/26/25	0.100	b	0.003	1.000	0.143	1.103	55.2	143.0		6.0	14.00	b	0.75
<<insert>>															
		Min	0.100	b	0.003	0.700	0.133	0.873	43.7	14.8	b	2.0	0.7	b	0.75
		Max	0.170		0.003	1.000	0.193	1.113	55.7	143.0		6.0	21.0		1.70
		Mean	0.127		0.003	0.900	0.156	1.030	51.5	96.9		4.7	11.9		1.18
		Median	0.110		0.003	1.000	0.143	1.103	55.2	133.0		6.0	14.0		1.10
		Stds	0.038		0.000	0.173	0.032	0.136	6.8	71.3		2.3	10.3		0.48
		Std	0.031		0.000	0.141	0.026	0.111	5.5	58.2		1.9	8.4		0.39
		Count	3		3	3	3	3	3	3		3	3		3

Lake Carey **Prepared by Aqua-Link, Inc.**

ALI Project No. 1876-01

Analytical Lake Water Quality Data

Station No. LC1 (large-lake)

Station No. LC2 (small-lake)

Station	Depth	Date	Sp Cond** (uS/cm)	pH** (std units)	Alkalinity (mg/L as CaCO3)	Hardness (mg/L as CaCO3)	DRP (mg/L as P)	TP (mg/L as P)	Ammonia (mg/L as N)
LC1B	Bottom	06/24/25	148.5	6.94	46.0	47.0	0.087	0.380	1.200
		07/23/25	159.3	6.57	58.0	77.0	0.112	0.710	1.200
		08/26/25	174.1	6.63	55.0	36.0	0.035	0.700	1.200
<<insert>>									
		Min	148.5	6.57	46.0	36.0	0.035	0.380	1.200
		Max	174.1	6.94	58.0	77.0	0.112	0.710	1.200
		Mean	160.6	6.71	53.0	53.3	0.078	0.597	1.200
		Median	159.3	6.63	55.0	47.0	0.087	0.700	1.200
		Stds	12.9	0.20	6.2	21.2	0.039	0.188	0.000
		Std	10.5	0.16	5.1	17.3	0.032	0.153	0.000
		Count	3	3	3	3	3	3	3

Lake Carey **Prepared by Aqua-Link, Inc.**

ALI Project No. 1876-01

Analytical Lake Water Quality Data

Station No. LC1 (large-lake)

Station No. LC2 (small-lake)

Station	Depth	Date	Nitrate (mg/L as N)		Nitrite (mg/L as N)	TKN (mg/L as N)	TIN* (mg/L as N)	TN* (mg/L as N)	TN:TP*	TIN:DRP*	TSS (mg/L)	Chlorophyll-a (ug/L)	Pheophytin-a (ug/L)
LC1B	Bottom	06/24/25	0.180	b	0.003	1.900	1.383	2.083	5.5	15.9	14.0		
		07/23/25	0.370		0.004	2.700	1.574	3.074	4.3	14.1	4.0		
		08/26/25	0.290		0.007	3.100	1.497	3.397	4.9	42.8	14.0		
<<insert>>													
		Min	0.180	b	0.003	1.900	1.383	2.083	4.3	14.1	4.0	na	na
		Max	0.370		0.007	3.100	1.574	3.397	5.5	42.8	14.0	na	na
		Mean	0.280		0.005	2.567	1.485	2.851	4.9	24.2	10.7	na	na
		Median	0.290		0.004	2.700	1.497	3.074	4.9	15.9	14.0	na	na
		Stds	0.095		0.002	0.611	0.096	0.685	0.6	16.1	5.8	na	na
		Std	0.078		0.002	0.499	0.078	0.559	0.5	13.1	4.7	na	na
		Count	3		3	3	3	3	3	3	3	na	na

Note(s):

TIN denotes total inorganic nitrogen and is the sum of nitrite, nitrate, and ammonia nitrogen
TN denotes total nitrogen and is the sum of total Kjeldahl nitrogen and nitrite and nitrate nitrogen
TN:TP denotes the ratio ot total nitrogen and total phosphorus
TIN:DRP denotes the ratio of total inorganic nitrogen and dissolved reactive phosphorus
(b) denotes below detection limit, therefore data reported as the detection limit
(*) indicates calculated value
(**) indicates *in-situ* field data collected on the study date (also refer to *in-situ* data)
(^^) indicates inconsistent values outside of typical ranges

Lake Carey **Prepared by Aqua-Link, Inc.**

ALI Project No. 1876-01

Secchi Disk Depth & General Observations

Station No. LC1 (large-lake)

Station No. LC2 (small-lake)

Station	Date	Secchi Depth (meters)	Secchi Depth (feet)	
LC1	06/24/25	4.30	14.11	Slightly turbid with green tint, trace planktonic algae, clarity very good
	07/23/25	1.80	5.91	Water moderately turbid with green tint, planktonic bloom present
	08/26/25	1.43	4.70	Water moderately cloudy, planktonic apperance - olive green color
<<insert>>				
	Min	1.43	4.70	
	Max	4.30	14.11	
	Mean	2.51	8.24	
	Median	1.80	5.91	
	Stds	1.56	5.12	
	Std	1.27	4.18	
	Count	3	3	

Station	Date	Secchi Depth (meters)	Secchi Depth (feet)	
LC2	06/24/25	1.10	3.61	Very turbid and brown colored
	07/23/25	1.00	3.28	Highly turbid with brown tint
	08/26/25	0.43	1.40	Water cloudy and planktonic; brighter olive green than LC1
<<insert>>				
	Min	0.43	1.40	
	Max	1.10	3.61	
	Mean	0.84	2.76	
	Median	1.00	3.28	
	Stds	0.36	1.19	
	Std	0.30	0.97	
	Count	3	3	

Lake Carey **Prepared by Aqua Link, Inc.**

ALI Project No. 1876-01

Carlson's Trophic State Index

Station No. LC1 (large-lake)

Station No. LC2 (small-lake)

Station	Date	Secchi (meters)	Chl-a* (ug/l)	TP* (mg/l as P)	TSI Values Secchi	TSI Values Chl-a	TSI Values TP	Mean TSI Values Secchi	Mean TSI Values Chl-a	Mean TSI Values TP
LC1	06/24/25	4.30	0.71	0.020	39.0	27.2	47.4	46.7	54.9	47.4
	07/23/25	1.80	21.00	0.020	51.5	60.4	47.4			
	08/26/25	1.43	14.00	0.020	54.8	56.5	47.4			
<<insert>>										
	Min	1.43	0.71	0.020	39.0	27.2	47.4			
	Max	4.30	21.00	0.020	54.8	60.4	47.4			
	Mean	2.51	11.90	0.020	------	------	------			
	Median	1.80	14.00	0.020	------	------	------			
	Stds	1.56	10.31	0.000	------	------	------			
	Std	1.27	8.41	0.000	------	------	------			
	Count	3	3	3	3	3	3			

Note(s): * values reported at 0.5 meter

Station	Year	Mean TSI Values Secchi	Mean TSI Values Chl-a	Mean TSI Values TP
LC1	2025	46.7	54.9	47.4

Plankton Identification & Enumeration

Kenneth Wagener, Ph.D.

Algae – Phytoplankton

Sample Collection

Samples are normally received by mail or courier. If collected by K. Wagner, samples are either grab samples collected about 1 ft below the surface or are composite samples from a flexible tube lowered to a depth equal to twice the Secchi transparency or the depth of the thermocline, whichever is least. Samples are collected in straight sided plastic containers with a volume of 125 to 1000 ml. Sample bottles are filled to the shoulder of the bottle (straight sided part is filled, air space left by not filling the neck). Samples are preserved in either gluteraldehyde (0.3 to 0.5% by volume) or Lugol's solution (1 to 2% by volume), depending upon client preference. With the use of gluteraldehyde, samples should froth slightly when shaken. For Lugol's solution, the sample should have a weak tea color. If algae appear dense, a little more preservative (up to about double) may be warranted. Samples are labeled with waterbody name, station, date and type of preservative.

Sample Processing

Preserved samples are allowed to stand undisturbed for at least 3 days and normally for 1 week. Each sample is viewed for visual signs of algal density (amount of material accumulated on the container bottom or floating at the surface). Unless the sample obviously contains visually large amounts of algae, the supernatant is decanted or siphoned from the middle to concentrate the sample by a factor of 2 to 6, depending upon how easy it is to remove supernatant without disturbing settled particles (this is a function of container geometry). The remaining sample is then vigorously shaken for 1 minute and 50 mL of sample is poured into a 50 mL graduated test tube.

Test tubes are clear cylinders with a height to diameter ratio of 5:1, with a conical bottom containing approximately 5 mL. Tubes are labeled to match the original sample bottles. Samples in the tubes are allowed to stand undisturbed for at least 3 days and normally for 1 week, after which the concentration process described for the original sample is repeated. Final concentrate volume is typically about 10 mL, concentrating the sample in the tube by a factor of approximately 5. Final concentration factors are therefore typically on the order of 10 to 30, although samples with high algal density may not be concentrated at all and samples with very low density may be concentrated by factors up to 100.

Sample Examination

The concentrated sample is shaken vigorously for about 1 minute to homogenize the contents, then 0.1 mL is pipetted into a Palmer-Maloney style counting chamber. This circular chamber has a depth of 0.04 cm and a diameter of 1.75 cm. The slide is allowed to stand for 5-15 minutes. The slide is then scanned at 200X power (20X objective and 10X oculars) under phase contrast optics and a list of all encountered algal taxa is constructed. Viewing at 400X is conducted if necessary to identify taxa. Using a standard microscope slide and a separate sample aliquot, it is also possible to view specimens at 1000X under oil immersion if necessary. Identifications are made from a variety of reference books as needed, relying mainly on Wehr and Sheath 2003. Actual counting (see below) is performed at 400X.

Sample Enumeration

Counts of algal cells are made along complete transects across the slide; these transects are called strips. A strip count involves recording the cells of each taxon (usually genus) encountered along the transect. To avoid overcounting, cells partially visible on the left side are counted, while those partially visible along the right side are ignored. If appropriate to the project, natural units, colonies, filaments, or other cell groupings may be counted, but in all cases an average number of cells per algal grouping is obtained to allow calculation of density as cells/mL. Based on cell measurements, cells of each taxon are recorded as small, medium or large specimens of the corresponding taxon. The size categories are genus-specific; a large specimen of one taxon with typically smaller cells may be smaller than a small specimen of another taxon with typically larger cells. At least two strips are counted, after which results from each strip are compared. If the increase in taxa is more than 10% of the

total or the abundance of any two possible dominants (genera comprising more than 20% of the total count) differs by more than 10%, additional strips are counted until the "10% rule" is satisfied.

Calculations

All counts are recorded in a spreadsheet file. A multiplication factor is established as the inverse of the product of the fraction of 1 mL viewed and the sample concentration factor. For example, if one tenth of the slide was viewed, with that slide representing one tenth of a mL, and the sample had been concentrated by a factor of 10, the multiplication factor would be 1/(0.1X0.1X10), or 10. Multiplication factors are typically between 6 and 30. The cell count for each taxon is multiplied by this factor and recorded in a separate portion of the spreadsheet for easy printing, as cells/mL. Cell counts are tallied by genus, ecologically significant groupings within algal divisions (e.g., flagellated greens, filamentous blue-greens), algal division (e.g., blue-greens, greens, diatoms) and as a grand total.

Based on the number of cells of each taxon in each corresponding size category, a biomass estimate is calculated. Each size category for each taxon is assigned a biomass per cell, based on the average cell dimensions for that category and a specific gravity of 1.0. Multiplication of the genus and size specific factor by the number of cells in that taxon and size category yields both a biovolume and biomass estimate. The sum for each genus (three possible size categories) is reported as ug/L. The sum for each ecologically significant grouping, algal division and the grand total are reported as well.

If requested, a conversion to algal standard units (ASU) is also made. The average area (two dimensional) of each cell for each genus and size category is multiplied by the corresponding number of cells and divided by 400 square microns to derive an ASU value for each taxon. The ASUs are summed for each ecologically significant grouping, algal division and as a grand total as well.

The total number of taxa per ecologically significant grouping, algal division and per sample is also reported, simply as a summation of the taxa observed. Shannon-Weiner Diversity (S) is calculated by the appropriate formula based on the number of cells recorded for each taxon and for the biomass of each taxon. Pielou's Evenness (J) is also calculated, based on S divided by the maximum possible S value for the number of taxa observed, yielding a value between 0 and 1. Additional indices can be calculated as warranted.

Quality Control

Approximately one sample in every ten is subjected to re-analysis. Samples for QC checks are chosen randomly from samples available at the time of analysis. Differences of 10-20% are typical for phytoplankton samples counted by the same analyst and considered acceptable for use in evaluating aquatic conditions.

Algae – Periphyton

Sample Collection

Samples are normally received by mail or courier. If collected by K. Wagner, samples are collected by scraping a defined area of natural or artificial substrate. Enough distilled water is added to create a mixture of appropriate density for microscopic analysis of an aliquot of well-mixed sample. Samples are preserved in either gluteraldehyde or Lugol's solution, depending upon client preference, but as algal density is likely to be high, double the amount of preservative used for phytoplankton samples (1% gluteraldehyde, 2-4% Lugols). Container shape is not critical, but small size (125-250 ml) plastic bottles are preferred, as periphyton samples tend to be very concentrated to begin with. Samples are labeled with waterbody name, station, date and type of preservative, plus the area that was sampled in square centimeters.

Sample Processing, Examination and Enumeration

Samples should not require any concentration, but may be diluted by addition of distilled water. If necessary, concentration by settling is performed as described for phytoplankton analysis above. Examination and enumeration follow the phytoplankton analysis protocols above.

Calculations

All counts are recorded in a spreadsheet file. A multiplication factor is established in the same manner as for phytoplankton, except that the factor for converting cell count to cells/mL is then multiplied by the number of mL of sample and divided by the square centimeters of substrate sampled to yield a measure of cells/cm^2. All other calculations follow the phytoplankton analysis procedures.

Zooplankton

Sample Collection

Samples are normally received by mail or courier. If collected by K. Wagner, samples are concentrates obtained by towing a plankton net with a 53 um mesh size through at least 30 m of water (multiple shorter tows as needed). The net is typically retrieved at an oblique angle after allowing it to settle to within 1 m of the bottom of the lake. Care is taken to avoid tows long enough to cause net clogging. Samples are preserved in either formalin (2%) or gluteraldehyde (2%) or Lugol's solution (strong tea color, usually about 4%), depending upon client preference. Container shape is not critical, but small size (125-250 ml) plastic bottles are preferred, as zooplankton tow samples tend to be very concentrated to begin with. Samples are labeled with waterbody name, station, date and type of preservative, plus the length of the tow and the diameter of the net used.

Sample Processing

Samples are allowed to stand undisturbed for at least 10 minutes and normally for several hours. Each sample is viewed for visual signs of zooplankton density (amount of apparent zooplankton and other particles accumulated on the container bottom). The supernatant is decanted or siphoned until the concentrated sample will fit into a 50 mL graduated test tube. This may require multiple episodes of settling and transfer, depending upon container geometry and the quantity of algae present, to get a zooplankton sample that can be properly viewed at an appropriate concentration. Where considerable algae are present, siphoning is timed to remove as much algae as possible without losing zooplankton; zooplankton settle faster than most algae. Multiple refills with distilled water, with repeat of the settling/siphoning process, are used to clear the sample of algae to the extent necessary to facilitate unobstructed viewing of zooplankton.

Test tubes are clear cylinders with a height to diameter ratio of 5:1, with a conical bottom containing approximately 5 mL. Tubes are labeled to match the original sample bottles. Final concentrate volume is typically 20 to 50 mL, representing 500 to 1000 L of filtered lake water, depending upon net diameter. Final concentration factors are therefore typically on the order of 20,000 to 30,000.

Sample Examination

The concentrated sample is shaken vigorously for about 30 seconds to homogenize the contents, then 1 mL is pipetted into a Sedgewick-Rafter style counting chamber. This rectangular chamber has a depth of 0.1 cm, a length of 5 cm and a width of 2 cm. The slide is then scanned at 40X power (4X objective and 10X oculars) under brightfield optics and a list of all encountered zooplankton taxa is constructed. Viewing at 100X or higher power is conducted as necessary to identify taxa. Identifications are made from a variety of reference books as needed.

Sample Enumeration

Counts of zooplankton individuals are made along complete transects across the slide; these transects are called strips. A strip count involves recording the individuals of each taxon (usually genus) encountered along the transect. To avoid overcounting, individuals partially visible on the top side are counted, while those partially visible along the bottom side are ignored. Based on body length measurements, individuals of each taxon are recorded as small, medium or large specimens of the corresponding taxon. The size categories are genus-specific; a large specimen of a small-bodied taxon may be smaller than a small specimen of a large-bodied taxon. At least two strips are counted, after which results from each strip are compared. If the increase in taxa is more than 10% of the total or the ratio of any two possible dominants (genera comprising more than 20% of the total count) is greater than 10%, additional strips are counted until the "10% rule" is satisfied. The slide is refilled with fresh sample if more than 3 strips are needed.

Calculations

All counts are recorded in a spreadsheet file as individuals/L. A multiplication factor is established by dividing the sample volume in mL by the product of the fraction of 1 mL viewed and the number of liters of water filtered. For example, if half of the slide was viewed, with that slide representing 40 mL of concentrated sample, and the concentrated sample represented 800 liters, the multiplication factor would be 40/(0.5X800), or 0.1. The specimen count for each taxon is multiplied by this factor and recorded in a separate portion of the spreadsheet for easy printing, as individuals/L. Counts are tallied by genus and zooplankton group (e.g., rotifers, copepods, cladocerans, etc.), and as a grand total.

Based on the number of individuals of each taxon in each corresponding size category, a biomass estimate is calculated. Each size category for each taxon is assigned a biomass per individual, based on the average body length for that category and standard regressions for body weight as a function of length. Multiplication of the genus and size specific factor by the number of individuals in that taxon and size category yields a biomass estimate. The sum for each genus (three possible size categories) is reported as ug/L. The sum for each zooplankton group and the grand total are reported as well.

The total number of taxa per zooplankton group and per sample is also reported, simply as a summation of the taxa observed. Shannon-Weiner Diversity (S) is calculated by the appropriate formula based on the number of individuals recorded for each taxon. Pielou's Evenness (J) is also calculated, based on S divided by the maximum possible S value for the number of taxa observed, yielding a value between 0 and 1.

A size distribution is also generated, based on the observed body lengths. Average body length for all zooplankton is reported in mm, as well as the average body length for crustacean zooplankton (primarily copepods and cladocerans).

Quality Control

Approximately one sample in every ten is subjected to re-analysis. Samples for QC checks are chosen randomly from samples available at the time of analysis. Differences of 10-20% are typical for zooplankton samples counted by the same analyst and considered acceptable for use in evaluating aquatic conditions.

PHYTOPLANKTON DENSITY (CELLS/ML)

*** = potentially toxic**
**** = likely toxic**
 # = taste and odor producer

TAXON	LC1 06/24/25	LC1 07/23/25	LC1 08/26/25
BACILLARIOPHYTA			
Centric Diatoms			
Aulacoseira #	0.0	0.0	0.0
Cyclotella/related taxa #	0.0	0.0	0.0
Araphid Pennate Diatoms			
Asterionella #	13.4	0.0	0.0
Colonial Fragilaria/related taxa #	0.0	0.0	0.0
Single Fragilaria/Synedra	0.0	0.0	0.0
Tabellaria #	0.0	0.0	0.0
Monoraphid Pennate Diatoms			
Biraphid Pennate Diatoms			
Navicula/related taxa	0.0	0.0	0.0
Nitzschia #	0.0	0.0	0.0
CHLOROPHYTA			
Flagellated Chlorophytes			
Eudorina	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes			
Actinastrum	0.0	0.0	0.0
Ankistrodesmus	0.0	0.0	0.0
Coelastrum	0.0	0.0	0.0
Crucigenia	0.0	0.0	0.0
Dictyosphaerium #	0.0	0.0	0.0
Elakatothrix	0.0	0.0	0.0
Kirchneriella	0.0	0.0	0.0
Monoraphidium	0.0	0.0	0.0
Oocystis	0.0	109.6	0.0
Paulschulzia	0.0	0.0	0.0
Pediastrum #	0.0	0.0	0.0
Quadrigula	0.0	0.0	0.0
Scenedesmus #	0.0	0.0	0.0
Schroederia/Ankyra	120.6	0.0	0.0
Sphaerocystis	0.0	438.4	0.0
Tetraedron	0.0	0.0	0.0
Filamentous Chlorophytes			
Ulothrix	0.0	0.0	0.0
Desmids			
Closterium #	0.0	0.0	0.0
Cosmarium #	0.0	0.0	0.0
Euastrum	0.0	0.0	0.0
Mougeotia/Debarya	0.0	0.0	0.0
Octacanthium	0.0	0.0	0.0
Spirogyra #	0.0	0.0	0.0
Staurastrum #	0.0	0.0	13.2
Staurodesmus	0.0	0.0	0.0

PHYTOPLANKTON DENSITY (CELLS/ML)

*** = potentially toxic**
**** = likely toxic**
 # = taste and odor producer

TAXON	LC1 06/24/25	LC1 07/23/25	LC1 08/26/25
CHRYSOPHYTA			
Flagellated Classic Chrysophytes			
Dinobryon #	294.8	0.0	0.0
Mallomonas #	0.0	0.0	0.0
Synura #	40.2	0.0	0.0
Other Flagellated Goldens	0.0	0.0	0.0
Non-Motile Classic Chrysophytes			
Haptophytes			
Tribophytes/Eustigmatophytes			
Centritractus	0.0	0.0	0.0
Pseudostaurastrum	0.0	0.0	0.0
Raphidophytes			
CRYPTOPHYTA			
Cryptomonas #	67.0	41.1	79.2
CYANOPHYTA			
Unicellular and Colonial Forms			
Aphanocapsa * #	0.0	0.0	0.0
Chroococcus	0.0	0.0	0.0
Dactylococcopsis	0.0	0.0	0.0
Microcystis ** #	0.0	0.0	0.0
Woronichinia * #	0.0	5480.0	10560.0
Filamentous Nitrogen Fixers			
Aphanizomenon ** #	2680.0	0.0	0.0
Calothrix/Rivularia	0.0	44388.0	8580.0
Cylindrospermum *	0.0	0.0	0.0
Dolichospermum ** #	0.0	6165.0	3630.0
Raphidiopsis *	0.0	0.0	86790.0
Filamentous Non-Nitrogen Fixers			
Limnothrix *	0.0	0.0	0.0
Planktolyngbya	0.0	0.0	0.0
Pseudanabaena/Komvophoron * #	0.0	0.0	0.0
EUGLENOPHYTA			
Euglena	0.0	0.0	0.0
Phacus	0.0	0.0	0.0
Trachelomonas	0.0	0.0	0.0
PYRRHOPHYTA			
Ceratium #	0.0	0.0	0.0
Gymnodinium	0.0	0.0	0.0
Peridinium #	0.0	0.0	0.0

PHYTOPLANKTON DENSITY (CELLS/ML)

*** = potentially toxic**
**** = likely toxic**
 # = taste and odor producer

TAXON	LC1 06/24/25	LC1 07/23/25	LC1 08/26/25
DENSITY (CELLS/ML) SUMMARY			
BACILLARIOPHYTA	**13.4**	**0.0**	**0.0**
Centric Diatoms	0.0	0.0	0.0
Araphid Pennate Diatoms	13.4	0.0	0.0
Monoraphid Pennate Diatoms	0.0	0.0	0.0
Biraphid Pennate Diatoms	0.0	0.0	0.0
CHLOROPHYTA	**120.6**	**548.0**	**13.2**
Flagellated Chlorophytes	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes	120.6	548.0	0.0
Filamentous Chlorophytes	0.0	0.0	0.0
Desmids	0.0	0.0	13.2
CHRYSOPHYTA	**335.0**	**0.0**	**0.0**
Flagellated Classic Chrysophytes	335.0	0.0	0.0
Non-Motile Classic Chrysophytes	0.0	0.0	0.0
Haptophytes	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	0.0	0.0	0.0
Raphidophytes	0.0	0.0	0.0
CRYPTOPHYTA	**67.0**	**41.1**	**79.2**
CYANOPHYTA	**2680.0**	**56033.0**	**109560.0**
Unicellular and Colonial Forms	0.0	5480.0	10560.0
Filamentous Nitrogen Fixers	2680.0	50553.0	99000.0
Filamentous Non-Nitrogen Fixers	0.0	0.0	0.0
EUGLENOPHYTA	**0.0**	**0.0**	**0.0**
PYRRHOPHYTA	**0.0**	**0.0**	**0.0**
TOTAL	**3216.0**	**56622.1**	**109652.4**
CELL DIVERSITY	**0.28**	**0.31**	**0.32**
CELL EVENNESS	**0.36**	**0.40**	**0.41**
NUMBER OF TAXA			
BACILLARIOPHYTA	**1**	**0**	**0**
Centric Diatoms	0	0	0
Araphid Pennate Diatoms	1	0	0
Monoraphid Pennate Diatoms	0	0	0
Biraphid Pennate Diatoms	0	0	0
CHLOROPHYTA	**1**	**2**	**1**
Flagellated Chlorophytes	0	0	0
Coccoid/Colonial Chlorophytes	1	2	0
Filamentous Chlorophytes	0	0	0
Desmids	0	0	1
CHRYSOPHYTA	**2**	**0**	**0**
Flagellated Classic Chrysophytes	2	0	0
Non-Motile Classic Chrysophytes	0	0	0
Haptophytes	0	0	0
Tribophytes/Eustigmatophytes	0	0	0
Raphidophytes	0	0	0
CRYPTOPHYTA	**1**	**1**	**1**
CYANOPHYTA	**1**	**3**	**4**
Unicellular and Colonial Forms	0	1	1
Filamentous Nitrogen Fixers	1	2	3
Filamentous Non-Nitrogen Fixers	0	0	0
EUGLENOPHYTA	**0**	**0**	**0**
PYRRHOPHYTA	**0**	**0**	**0**
TOTAL	**6**	**6**	**6**

PHYTOPLANKTON BIOMASS (UG/L)

*** = potentially toxic**
**** = likely toxic**
 # = taste and odor producer

TAXON	LC1 06/24/25	LC1 07/23/25	LC1 08/26/25
BACILLARIOPHYTA			
Centric Diatoms			
Aulacoseira #	0.0	0.0	0.0
Cyclotella/related taxa #	0.0	0.0	0.0
Araphid Pennate Diatoms			
Asterionella #	2.7	0.0	0.0
Colonial Fragilaria/related taxa #	0.0	0.0	0.0
Single Fragilaria/Synedra	0.0	0.0	0.0
Tabellaria #	0.0	0.0	0.0
Monoraphid Pennate Diatoms			
Biraphid Pennate Diatoms			
Navicula/related taxa	0.0	0.0	0.0
Nitzschia #	0.0	0.0	0.0
CHLOROPHYTA			
Flagellated Chlorophytes			
Eudorina	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes			
Actinastrum	0.0	0.0	0.0
Ankistrodesmus	0.0	0.0	0.0
Coelastrum	0.0	0.0	0.0
Crucigenia	0.0	0.0	0.0
Dictyosphaerium #	0.0	0.0	0.0
Elakatothrix	0.0	0.0	0.0
Kirchneriella	0.0	0.0	0.0
Monoraphidium	0.0	0.0	0.0
Oocystis	0.0	43.8	0.0
Paulschulzia	0.0	0.0	0.0
Pediastrum #	0.0	0.0	0.0
Quadrigula	0.0	0.0	0.0
Scenedesmus #	0.0	0.0	0.0
Schroederia/Ankyra	301.5	0.0	0.0
Sphaerocystis	0.0	87.7	0.0
Tetraedron	0.0	0.0	0.0
Filamentous Chlorophytes			
Ulothrix	0.0	0.0	0.0
Desmids			
Closterium #	0.0	0.0	0.0
Cosmarium #	0.0	0.0	0.0
Euastrum	0.0	0.0	0.0
Mougeotia/Debarya	0.0	0.0	0.0
Octacanthium	0.0	0.0	0.0
Spirogyra #	0.0	0.0	0.0
Staurastrum #	0.0	0.0	10.6
Staurodesmus	0.0	0.0	0.0

PHYTOPLANKTON BIOMASS (UG/L)

*** = potentially toxic**
**** = likely toxic**
 # = taste and odor producer

TAXON	LC1 06/24/25	LC1 07/23/25	LC1 08/26/25
CHRYSOPHYTA			
Flagellated Classic Chrysophytes			
Dinobryon #	884.4	0.0	0.0
Mallomonas #	0.0	0.0	0.0
Synura #	32.2	0.0	0.0
Other Flagellated Goldens	0.0	0.0	0.0
Non-Motile Classic Chrysophytes			
Haptophytes			
Tribophytes/Eustigmatophytes			
Centritractus	0.0	0.0	0.0
Pseudostaurastrum	0.0	0.0	0.0
Raphidophytes			
CRYPTOPHYTA			
Cryptomonas #	348.4	65.8	483.1
CYANOPHYTA			
Unicellular and Colonial Forms			
*Aphanocapsa * #*	0.0	0.0	0.0
Chroococcus	0.0	0.0	0.0
Dactylococcopsis	0.0	0.0	0.0
*Microcystis ** #*	0.0	0.0	0.0
*Woronichinia * #*	0.0	54.8	105.6
Filamentous Nitrogen Fixers			
*Aphanizomenon ** #*	348.4	0.0	0.0
Calothrix/Rivularia	0.0	2219.4	429.0
*Cylindrospermum **	0.0	0.0	0.0
*Dolichospermum ** #*	0.0	1233.0	726.0
*Raphidiopsis **	0.0	0.0	867.9
Filamentous Non-Nitrogen Fixers			
*Limnothrix **	0.0	0.0	0.0
Planktolyngbya	0.0	0.0	0.0
*Pseudanabaena/Komvophoron * #*	0.0	0.0	0.0
EUGLENOPHYTA			
Euglena	0.0	0.0	0.0
Phacus	0.0	0.0	0.0
Trachelomonas	0.0	0.0	0.0
PYRRHOPHYTA			
Ceratium #	0.0	0.0	0.0
Gymnodinium	0.0	0.0	0.0
Peridinium #	0.0	0.0	0.0

PHYTOPLANKTON BIOMASS (UG/L)

*** = potentially toxic**
**** = likely toxic**
 # = taste and odor producer

TAXON	LC1 06/24/25	LC1 07/23/25	LC1 08/26/25
BIOMASS (UG/L) SUMMARY			
BACILLARIOPHYTA	**2.7**	**0.0**	**0.0**
Centric Diatoms	0.0	0.0	0.0
Araphid Pennate Diatoms	2.7	0.0	0.0
Monoraphid Pennate Diatoms	0.0	0.0	0.0
Biraphid Pennate Diatoms	0.0	0.0	0.0
CHLOROPHYTA	**301.5**	**131.5**	**10.6**
Flagellated Chlorophytes	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes	301.5	131.5	0.0
Filamentous Chlorophytes	0.0	0.0	0.0
Desmids	0.0	0.0	10.6
CHRYSOPHYTA	**916.6**	**0.0**	**0.0**
Flagellated Classic Chrysophytes	916.6	0.0	0.0
Non-Motile Classic Chrysophytes	0.0	0.0	0.0
Haptophytes	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	0.0	0.0	0.0
Raphidophytes	0.0	0.0	0.0
CRYPTOPHYTA	**348.4**	**65.8**	**483.1**
CYANOPHYTA	**348.4**	**3507.2**	**2128.5**
Unicellular and Colonial Forms	0.0	54.8	105.6
Filamentous Nitrogen Fixers	348.4	3452.4	2022.9
Filamentous Non-Nitrogen Fixers	0.0	0.0	0.0
EUGLENOPHYTA	**0.0**	**0.0**	**0.0**
PYRRHOPHYTA	**0.0**	**0.0**	**0.0**
TOTAL	**1917.5**	**3704.5**	**2622.2**
BIOMASS DIVERSITY	**0.58**	**0.41**	**0.64**
BIOMASS EVENNESS	**0.75**	**0.53**	**0.83**

	06/24/25	07/23/25	08/26/25
BIOMASS (UG/L) SUMMARY			
BACILLARIOPHYTA	2.7	0.0	0.0
CHLOROPHYTA	301.5	131.5	10.6
CHRYSOPHYTA	916.6	0.0	0.0
CRYPTOPHYTA	348.4	65.8	483.1
CYANOPHYTA	348.4	3507.2	2128.5
EUGLENOPHYTA	0.0	0.0	0.0
PYRRHOPHYTA	0.0	0.0	0.0

Lake Carey **Prepared by Aqua Link, Inc.**

Project No. 1876-01

Phytoplankton Data

Station No. LC1 (large-lake)

Station No. LC2 (small-lake)

Station	Date	Total Density (cells/mL)	Total Biomass (ug/L)	Cyanobacteria Density (cells/mL)	Cyanobacteria Biomass (ug/L)
LC1	06/24/25	3216.0	1917.5	2680.0	348.4
LC1	07/23/25	56622.1	3704.5	56033.0	3507.2
LC1	08/26/25	109652.4	2622.2	109560.0	2128.5
<<insert>>					
2025	**Min**	3,216.0	1,917.5	2,680.0	348.4
	Max	109,652.4	3,704.5	109,560.0	3,507.2
	Mean	56,496.8	2,748.1	56,091.0	1,994.7
	Median	56,622.1	2,622.2	56,033.0	2,128.5
	Count	3.0	3.0	3.0	3.0
Annual Mean	**2025**	56,496.8	2,748.1	56,091.0	1,994.7