FINAL REPORT

Walker Lake 2021 Baseline Water Quality Monitoring Program

Prepared for:

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Shohola Township
Pike County PA

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The photograph was taken during a monitoring event in July of 2021.

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1. Introduction

Walker Lake, which is 110 acres in surface area, is located off Twin Lakes Road in Shohola Township, Pennsylvania as shown in Figure 1.1. The lake runs from southwest to northeast and has the most notable physical characteristics near the northern end. At this location, there are two individual coves. The northwestern cove is the location of the spillway and the community boat launch. The northeastern cove has an island centrally located. Walker Lake is considered slightly shallow with an average depth of approximately 3.5 to 4.5 meters (11.5 to 14.8 feet) and a maximum depth of approximately 6.5 meters (21.3 feet). The deepest section of the lake is located in the southeastern basin at Station WL2. Walker Lake is owned and maintained by the Walker Lake Landowners Association (hereinafter referred to as the Association).

Historically, low to moderate levels of planktonic algae (algal blooms) and mats of filamentous algae have been treated with copper sulfate (aquatic pesticide or algaecide) during the growing season, as needed. Submerged aquatic vegetation and floating leaved aquatic vegetation treatments have been applied to the lake on an as needed basis as determined by the Association. Nuisance aquatic plants have been controlled both mechanically (hand pulling or cutting by hand) by lakeside property owners and the use of aquatic pesticides (herbicides).

Figure 1.1 Walker Lake & Locations of Lake Monitoring Stations

In the past, the Association retained Ecological Solutions to monitor the water quality of the lake, assess the lake's fishery, and control nuisance levels of algae and aquatic plants using aquatic pesticides. In 2016, the Association retained Aqua Link to handle its lake management needs. Our first priority was to overhaul the lake water quality monitoring program. The primary goal of the overhauled lake water quality monitoring program was to now begin collecting high quality water quality data for key lake parameters which relate to the overall ecological health of the lake and the natural process of lake aging (known as eutrophication). In 2016, the Association also hired Aqua Link to control some nuisance stands of floating leaved aquatic plants (namely water lily and water shield) and to reassess the lake's fishery.

In 2021, the Association retained Aqua Link to continue monitoring the water quality of Walker Lake. Lake water quality data reported for 2021 were analyzed and compared to Aqua Link's 2016 - 2020 historical lake database (Aqua Link 2017 - 2021). The comparison of water quality data over time is referred to water quality trend analysis and allows lake managers the ability 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.

Similarly, to 2016 - 2020, Aqua Link continued aquatic pesticide treatments in 2021 to control some nuisance submerged plant species, primarily bladderwort, on two different occasions throughout the lake. The 2021 treatment program was similar to 2020 and considered aggressive with respect to targeting bladderwort and also variable leaf milfoil. In addition, emergent vegetation in areas within close proximity to the dam was treated in 2021.

Additional work performed by Aqua Link included a follow-up aquatic plant survey of the lake in 2021, which is discussed in detail in a separate report. Aqua Link also conducted a follow-up electrofishing fisheries survey in 2021 to further assess the lake's fish population and structure. The analysis of this fishery study is also discussed in a separate report. In addition, a bathymetric survey was performed by Aqua Link in 2021. This bathymetric study is discussed in a separate report as well.

2. Lake Management & Review of Past Data

2.1. Lake Water Quality Monitoring Program

In 2021, Aqua Link continued to monitor the water quality in Walker Lake as part of the baseline monitoring program. Two lake monitoring stations (WL1 and WL2) were monitored three times during the months of June through August. Stations WL1 and WL2 are located near the dam (northern basin) and uplake (southern basin), respectively (Figure 1.1). Station WL2 is the primary monitoring station that will be used in greater detail for trend analysis as well as more thorough comparisons from this point forward. All 2021 water quality data collected for both WL1 and WL2 can be reviewed in Appendix B.

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 conductivity, and oxidation reduction potential) were measured and recorded simultaneously using an YSI Model 600XL Sonde and a YSI 600D data logger. *In-situ* data were collected at 0.5-to-1.0-meter intervals throughout the water column at both Stations WL1 and WL2. Secchi disk transparency was measured and recorded at both stations using a standard freshwater Secchi disk.

In addition to *in-situ* data, Aqua Link collected lake water samples on each study date at Station WL2 (Figure 1.1). Collected water samples were subsequently shipped to the contract laboratory for further analysis. At Station WL2, surface water samples were collected and analyzed for alkalinity, hardness, total suspended solids, phosphorus (total and dissolved reactive), chlorophyll-a, nitrate nitrogen, nitrite nitrogen, total Kjeldahl nitrogen, and ammonia nitrogen. Total nitrogen was calculated from this data as well as the TN to TP ratios to determine the limiting nutrient in your lake. Additional surface samples were collected on each study date at this station for the identification and enumeration of phytoplankton from June through August. Zooplankton samples were also collected from June through August at Station WL2. Zooplankton samples were obtained for later laboratory analysis (identification and enumeration) by using an 80 um (micron) mesh plankton net (6 inch diameter), which was towed vertically, at minimum, a total distance of 30 meters throughout the entire lake water column (bottom to surface).

2.2. Field Observations & Lake Treatments

The water clarity of the lake was considered fair and relatively consistent from June through August. Therefore, the Association did not request any algae treatments during the entire year. In June 2021, several low to moderate density stands of bladderwort (*Utricularia spp.)* were observed still rooted, below the surface, throughout much of the eastern shoreline areas, mostly favoring the northern end of the lake. As a result of a moderately aggressive treatment performed on June 2nd, 2021, a significant reduction in bladderwort was observed in July during the water quality monitoring. However, some of the previously treated areas still had some problematic levels of bladderwort. As a result, a follow-up treatment was performed on August 3rd, 2021, primarily to focus on those areas. Bladderwort was no longer problematic for the remainder of 2021, as observed by Aqua Link. The population of bladderwort has remained a maintenance issue since 2017 in Walker Lake. Therefore, it is expected that the population will need further treatments in future years. Bladderwort is native to the region, but often becomes problematic locally.

Another submerged plant of much concern was the noxious and invasive plant, variable leaf milfoil (*Myriophyllum heterophyllum)* which was observed for the first time exclusively in a small isolated patch located along the southern shoreline in early June of 2020. This small patch was observed and successfully treated the day of observation by using a combination of herbicides. Milfoil was again observed in May of 2021 and successfully treated for on the June 2nd treatment date. During the fall when the electrofishing survey was performed by Aqua Link, a late bloom of milfoil was also observed in multiple locations throughout the lake perimeter. It is likely that this invasive plant will return in subsequent years. Therefore, it is important to remain vigilant to monitor and chemically treat this species if found to keep the plant manageable or possibly eradicate entirely in Walker Lake. It is unknown how the plant entered the lake, but it likely entered by waterfowl or possibly a boat or trailer with the plant attached. This plant is found in lakes nearby and is becoming an increasing threat locally. Variable leaf milfoil can become problematic and grow densely all the way to the surface in shallow to moderately shallow areas if left unchecked, potentially reducing value of the lake for boating, fishing, swimming, and general aesthetics. Furthermore, this plant has the ability to grow in a dense monoculture thereby reducing biodiversity and overall health of the lake ecosystem.

A formerly observed plant species called baby tears is not native this far north in the United States. This plant has the potential to become problematic, but it is not observed frequently in this part of the country. This non-native plant may have been introduced to the lake by a local resident with an aquarium or transported to Walker Lake from another lake via boat trailers or waterfowl. Baby tears is a plant used in the aquarium industry and should be monitored closely to track any potential spreading in the future. This plant was only observed once during a lake monitoring event in 2016, but monitoring should continue to prevent potential spread of this species. If density or abundance of baby tears increases in 2022, then chemical treatment for this plant is recommended to prevent any further spreading.

Another submerged plant observed during Aqua Link's macrophyte surveys from 2017 – 2021 at relatively low abundance was a low growing plant called springtape (*Sagittaria kurziana*). This is another plant that is non-native and was likely introduced from the aquarium industry. For the past three years, springtape was not considered problematic, but should continue to be monitored and treated if the plant becomes problematic.

A more recently observed submerged plant discovered in 2019 was giant hairgrass (*Eleocharis montevidensis)*, which was found at just one sampling location in low density during Aqua Link's 2019 macrophyte survey. In 2021 this plant was again observed at low density during the macrophyte survey. This plant is native to North America and currently does not restrict any recreation uses in Walker Lake. In fact, this plant can potentially serve as habitat for fish and other aquatic organisms, making it beneficial.

As mentioned previously, Walker Lake was treated two times on June 2nd and August 3rd in 2021, for submerged vegetation, focusing on bladderwort and variable leaf milfoil. The general goal of these treatments was to improve the aesthetics and accessibility to the lake from areas with densely populated stands of submerged, floating leaved, and emergent aquatic vegetation. A further goal regarding variable leaf milfoil is eradication for this species is desirable. The scale of floating leaved and emergent aquatic plant treatments should remain the same in 2022 to achieve the desired level of control. A more aggressive approach is recommended primarily for variable leaf milfoil, with continued similar bladderwort control. As mentioned previously, variable leaf milfoil is a plant species that can populate and become problematic very quickly. Therefore, it is important to remain vigilant when treating this plant.

2.3. Review of Past Lake Monitoring Reports

At the request of the Association, Aqua Link reviewed all past lake water quality monitoring reports as received via email as electronic pdfs by the Association. Below is a brief summary of each report that was reviewed by Aqua Link. Overall, each study contains key lake water quality parameters that are important in assessing lake water quality in terms of ecological health and eutrophication (aging process of lakes). Unfortunately, most of the reports did not indicate what laboratory methods were used to analyze wet chemistry parameters such as nutrient (nitrogen and phosphorus) and chlorophyll-a, and where the lake monitoring stations were located.

F.X. Browne, Inc. 2002. Twin and Walker Creeks Watershed 2002 Water Quality Monitoring Program Preliminary Report. Prepared for Twin and Walker Creeks Watershed Conservancy. F.X. Browne, Lansdale, PA.

This report discusses monitoring of Big Twin Lake, Little Twin Lake, and Walker Lake. The lakes were monitored on four occasions between June and September of 2002. The report states that the insitu parameters collected for the surface to bottom waters include temperature and dissolved oxygen profiles and Secchi disk transparency. Chemical parameters collected for the surface waters include dissolved reactive phosphorus, total phosphorus, nitrate & nitrite nitrogen, ammonia nitrogen, total Kjeldahl nitrogen, total suspended solids, total dissolved solids, conductivity, alkalinity, pH, and chlorophyll-a. Chemical parameters collected for the bottom waters include total phosphorus, ammonia nitrogen, total Kjeldahl nitrogen, pH, total dissolved solids, and conductivity. In addition, sediment chemical analyzation was done for total phosphorus, total iron, and total manganese. Biological parameters collected in the surface waters included phytoplankton.

Unfortunately, none of the results are included with this report other than some graphs. These graphs include TSI values, trends in Secchi disk TSI values, and nitrogen to phosphorus ratios. It should be mentioned that the graphs are not particularly clear making it difficult to read definitive values. There are also no locations or number of stations for sampling depicted for any of the three lakes.

F.X. Browne, Inc. 2003. Twin and Walker Creeks 2003 Water Quality Report. Prepared for Twin and Walker Creeks Watershed Conservancy. F.X. Browne, Lansdale, PA.

This report discusses monitoring of Big Twin Lake, Little Twin Lake, and Walker Lake. The lakes were monitored on four occasions between June and September of 2003. The report states that the insitu parameters collected for the surface to bottom waters include temperature and dissolved oxygen profiles and Secchi disk transparency. Chemical parameters collected for the surface waters include total phosphorus and chlorophyll-a. Chemical parameters collected for the bottom waters include total phosphorus.

Average chlorophyll-a concentrations are displayed in a table. Temperature and dissolved oxygen graphs are illustrated. Average total phosphorus for the surface and bottom are shown in a table. Average Secchi disk readings are shown in a table. Comparisons for all three lakes for from 2002 to 2003 for Secchi, chlorophyll-a, and total phosphorous trophic states are displayed graphically. A Secchi trophic state trend for Little Twin Lake only from 1983 to 2003 is shown graphically.

Appendix A includes all 2003 total phosphorus and chlorophyll results for each sampling event in all three lakes. All 2003 dissolved oxygen and temperature data collected is included. Also, all 2003 Secchi disk data is included. In addition, Unfortunately, there are also no locations for sampling depicted for any of the three lakes.

F.X. Browne, Inc. 11/5/2004. Letter Report. Twin and Walker Creek Watershed Monitoring Program. 2004 Water Quality Monitoring Final Report. FXB File No. PA1551-03-001. Prepared for Joyce Laudise. Shandor J. Szalay, Senior Project Scientist of F.X. Browne, Lansdale, PA.

This letter report discusses monitoring of Big Twin Lake, Little Twin Lake, and Walker Lake. The lakes were monitored on four occasions between July and September of 2004. The report states that the insitu parameters include Secchi disk transparency. Chemical parameters collected for the surface waters include total phosphorus and chlorophyll-a.

All collected data for total phosphorus, chlorophyll-a, and Secchi are displayed in a table. Comparisons for all three lakes for from 2002 to 2004 for chlorophyll-a and total phosphorous trophic states are displayed graphically. A Secchi trophic state trend for all three lakes from 1983 to 2004 is shown graphically. However, this Secchi trend graph is missing large amounts of data from the entire timespan, but it is complete for all three lakes from 2002 through 2004. In addition, unfortunately, there are no locations or number of stations for sampling depicted for any of the three lakes. It is assumed that only one station per lake was sampled.

F.X. Browne, Inc. 11/4/2006. Letter Report. Twin and Walker Creek Watershed Monitoring Program. 2006 Water Quality Monitoring Final Report. FXB File No. PA1551-03-001. Prepared for Joyce Laudise. Shandor J. Szalay, Project Manager of F.X. Browne, Lansdale, PA.

This letter report discusses monitoring of Big Twin Lake, Little Twin Lake, and Walker Lake. The lakes were monitored on four occasions between June and September of 2006. The report states that the insitu parameters include Secchi disk transparency. Chemical parameters collected for the surface waters include total phosphorus and chlorophyll-a.

All collected data for total phosphorus, chlorophyll-a, and Secchi are displayed in a table. Comparisons for all three lakes for from 2002 to 2006 for chlorophyll-a and total phosphorous trophic states are displayed graphically. A Secchi trophic state trend for all three lakes from 1983 to 2006 is shown graphically. However, this Secchi trend graph is missing large amounts of data from the entire timespan, but it is complete for all three lakes from 2002 through 2006. In addition, unfortunately, there are no locations or number of stations for sampling depicted for any of the three lakes. It is assumed that only one station per lake was sampled.

F.X. Browne, Inc. 10/15/2007. Letter Report. Twin and Walker Creek Watershed Monitoring Program. 2007 Water Quality Monitoring Final Report. FXB File No. PA1551-06. Prepared for Joyce Laudise – Twin and Walker Creek Watershed Association. Rebecca L. Buerkett, Project Scientist of F.X. Browne, Lansdale, PA.

This letter report discusses monitoring of Big Twin Lake, Little Twin Lake, and Walker Lake. The lakes were monitored on four occasions between June and October of 2007. The report states that the insitu parameters include Secchi disk transparency. Chemical parameters collected for the surface waters include total phosphorus and chlorophyll-a.

All collected data for total phosphorus, chlorophyll-a, and Secchi are displayed in a table. Comparisons for all three lakes for from 2002 to 2007 for chlorophyll-a and total phosphorous trophic states are displayed graphically. A Secchi trophic state trend for all three lakes from 1983 to 2007 is shown graphically. However, this Secchi trend graph is missing large amounts of data from the entire timespan, but it is complete for all three lakes from 2002 through 2007.

Unfortunately, there are no locations or number of stations for sampling depicted for any of the three lakes. It is assumed that only one station per lake was sampled.

F.X. Browne, Inc. 11/30/2010. Letter Report. Twin and Walker Creek Watershed Monitoring Program. 2010 Water Quality Monitoring Final Report. FXB File No. PA1551-08. Prepared for Kirk Mackey – Twin and Walker Creek Watershed Association. Michael R. Martin CLM, Senior Project Scientist of F.X. Browne, Lansdale, PA.

This letter report discusses monitoring of Big Twin Lake, Little Twin Lake, and Walker Lake. The lakes were monitored on four occasions between June and September of 2010. The report states that the insitu parameters include Secchi disk transparency. Chemical parameters collected for the surface waters include total phosphorus and chlorophyll-a.

All collected data for total phosphorus, chlorophyll-a, and Secchi are displayed in a table. Comparisons for all three lakes for from 2002 to 2010 for chlorophyll-a and total phosphorous trophic states are displayed graphically. A Secchi trophic state trend for all three lakes from 1983 to 2010 is shown graphically. However, this Secchi trend graph is missing large amounts of data from the entire timespan, but it is complete for all three lakes from 2002 through 2010.

Unfortunately, there are no locations or number of stations for sampling depicted for any of the three lakes. It is assumed that only one station per lake was sampled.

F.X. Browne, Inc. 12/15/2011. Letter Report. Twin and Walker Creek Watershed Monitoring Program. 2011 Water Quality Monitoring Final Report. FXB File No. PA1551-10. Prepared for Kirk Mackey – Twin and Walker Creek Watershed Association. Michael R. Martin CLM, Senior Project Scientist of F.X. Browne, Lansdale, PA.

This letter report discusses monitoring of Big Twin Lake, Little Twin Lake, and Walker Lake. The lakes were monitored on four occasions between June and October of 2011. The report states that the insitu parameters include Secchi disk transparency as well as dissolved oxygen, temperature, conductivity, and pH throughout the water column. Total dissolved solid data were also collected in September and October only. Chemical parameters collected for the surface waters include total phosphorus and chlorophyll-a.

All collected data for total phosphorus, chlorophyll-a, and Secchi are displayed in a table. Comparisons for all three lakes for from 2002 to 2011 for chlorophyll-a and total phosphorous trophic states are displayed graphically. A Secchi trophic state trend for all three lakes from 1983 to 2011 is shown graphically. However, this Secchi trend graph is missing large amounts of data from the entire timespan, but it is complete for all three lakes from 2002 through 2011. All data for dissolved oxygen, temperature, conductivity, pH, and total dissolved solids (September and October only) are provided in a table. Temperature and dissolved oxygen profiles are displayed in graphs for all three lakes from all four sampling dates.

Unfortunately, there are no locations or number of stations for sampling depicted for any of the three lakes. It is assumed that only one station per lake was sampled.

F.X. Browne, Inc. 2/13/2013. Letter Report. Twin and Walker Creek Watershed Monitoring Program. 2012 Water Quality Monitoring Final Report. FXB File No. PA1551-11. Prepared for Kirk Mackey – Twin and Walker Creek Watershed Association. Marlene R. Martin P.E., Vice President, Watershed Management of F.X. Browne, Lansdale, PA.

This letter report discusses monitoring of Big Twin Lake, Little Twin Lake, and Walker Lake. The lakes were monitored on four occasions between June and September of 2012. The report states that the insitu parameters include Secchi disk transparency as well as dissolved oxygen, temperature, conductivity, pH, and total dissolved solids throughout the water column. Chemical parameters collected for the surface waters include total phosphorus and chlorophyll-a.

All collected data for total phosphorus, chlorophyll-a, and Secchi are displayed in a table. Comparisons for all three lakes for from 2002 to 2012 for chlorophyll-a and total phosphorous trophic states are displayed graphically. A Secchi trophic state trend for all three lakes from 1983 to 2012 is shown graphically. However, this Secchi trend graph is missing large amounts of data from the entire timespan, but it is complete for all three lakes from 2002 through 2012. All data for dissolved oxygen, temperature, conductivity, pH, and total dissolved solids are provided in a table. Temperature and dissolved oxygen profiles are displayed in graphs for all three lakes from all four sampling dates.

Unfortunately, there are no locations or number of stations for sampling depicted for any of the three lakes. It is assumed that only one station per lake was sampled.

F.X. Browne, Inc. 3/18/2014. Letter Report. Twin and Walker Creek Watershed Monitoring Program. 2013 Water Quality Monitoring Final Report. FXB File No. PA1551-12. Prepared for Kirk Mackey – Twin and Walker Creek Watershed Association. Marlene R. Martin P.E., Vice President, Watershed Management of F.X. Browne, Lansdale, PA.

This letter report discusses monitoring of Big Twin Lake, Little Twin Lake, and Walker Lake. The lakes were monitored on four occasions between June and September of 2013. The report states that the insitu parameters include Secchi disk transparency as well as dissolved oxygen, temperature, conductivity, pH, and total dissolved solids throughout the water column. Chemical parameters collected for the surface waters include total phosphorus and chlorophyll-a.

All collected data for total phosphorus, chlorophyll-a, and Secchi are displayed in a table. Comparisons for all three lakes for from 2002 to 2013 for chlorophyll-a and total phosphorous trophic states are displayed graphically. A Secchi trophic state trend for all three lakes from 1983 to 2013 is shown graphically. However, this Secchi trend graph is missing large amounts of data from the entire timespan, but it is complete for all three lakes from 2002 through 2013. All data for dissolved oxygen, temperature, conductivity, pH, and total dissolved solids are provided in a table. Temperature and dissolved oxygen profiles are displayed in graphs for all three lakes from all four sampling dates.

Unfortunately, there are no locations or number of stations for sampling depicted for any of the three lakes. It is assumed that only one station per lake was sampled. Also, it was determined that a sampling error likely occurred for the phosphorus data in 2013. These results were extremely low for all samples and are likely erroneous. These low values are illustrated in the trophic state index for phosphorus.

F.X. Browne, Inc. 1/9/2015. Letter Report. Twin and Walker Creek Watershed Monitoring Program. 2014 Water Quality Monitoring Final Report. FXB File No. PA1551-14. Prepared for Kirk Mackey – Twin and Walker Creek Watershed Association. Marlene R. Martin P.E., Vice President, Watershed Management of F.X. Browne, Lansdale, PA.

This letter report discusses monitoring of Big Twin Lake, Little Twin Lake, and Walker Lake. The lakes were monitored on four occasions between June and September of 2014. The report states that the insitu parameters include Secchi disk transparency as well as dissolved oxygen, temperature, conductivity, pH, and total dissolved solids throughout the water column. Chemical parameters collected for the surface waters include total phosphorus and chlorophyll-a.

All collected data for total phosphorus, chlorophyll-a, and Secchi are displayed in a table. Comparisons for all three lakes for from 2002 to 2014 for chlorophyll-a and total phosphorous trophic states are displayed graphically. A Secchi trophic state trend for all three lakes from 1983 to 2014 is shown graphically. However, this Secchi trend graph is missing large amounts of data from the entire timespan, but it is complete for all three lakes from 2002 through 2014. All data for dissolved oxygen, temperature, conductivity, pH, and total dissolved solids are provided in a table. Temperature and dissolved oxygen profiles are displayed in graphs for all three lakes from all four sampling dates.

Unfortunately, there are no locations or number of stations for sampling depicted for any of the three lakes. It is assumed that only one station per lake was sampled.

F.X. Browne, Inc. 5/2/2016. Letter Report. Twin and Walker Creek Watershed Monitoring Program. 2015 Water Quality Monitoring Final Report. FXB File No. PA1551-15. Prepared for Kirk Mackey – Twin and Walker Creek Watershed Association. Marlene R. Martin P.E., Vice President, Watershed Management of F.X. Browne, Lansdale, PA.

This letter report discusses monitoring of Big Twin Lake, Little Twin Lake, and Walker Lake. The lakes were monitored on four occasions between June and September of 2015. The report states that the insitu parameters include Secchi disk transparency as well as dissolved oxygen, temperature, conductivity, pH, and total dissolved solids throughout the water column. Chemical parameters collected for the surface waters include total phosphorus and chlorophyll-a.

All collected data for total phosphorus, chlorophyll-a, and Secchi are displayed in a table. Comparisons for all three lakes for from 2002 to 2015 for chlorophyll-a and total phosphorous trophic states are displayed graphically. A Secchi trophic state trend for all three lakes from 1983 to 2015 is shown graphically. However, this Secchi trend graph is missing large amounts of data from the entire timespan, but it is complete for all three lakes from 2002 through 2015. All data for dissolved oxygen, temperature, conductivity, pH, and total dissolved solids are provided in a table. Temperature and dissolved oxygen profiles are displayed in graphs for all three lakes from three of the four sampling dates.

Unfortunately, there are no locations or number of stations for sampling depicted for any of the three lakes. It is assumed that only one station per lake was sampled. Missing insitu data for 2015 included conductivity and total dissolved solids for July, temperature, conductivity, dissolved oxygen, pH, and total dissolved solids for the month of August, and total dissolved solids for the month of September.

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 number 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.

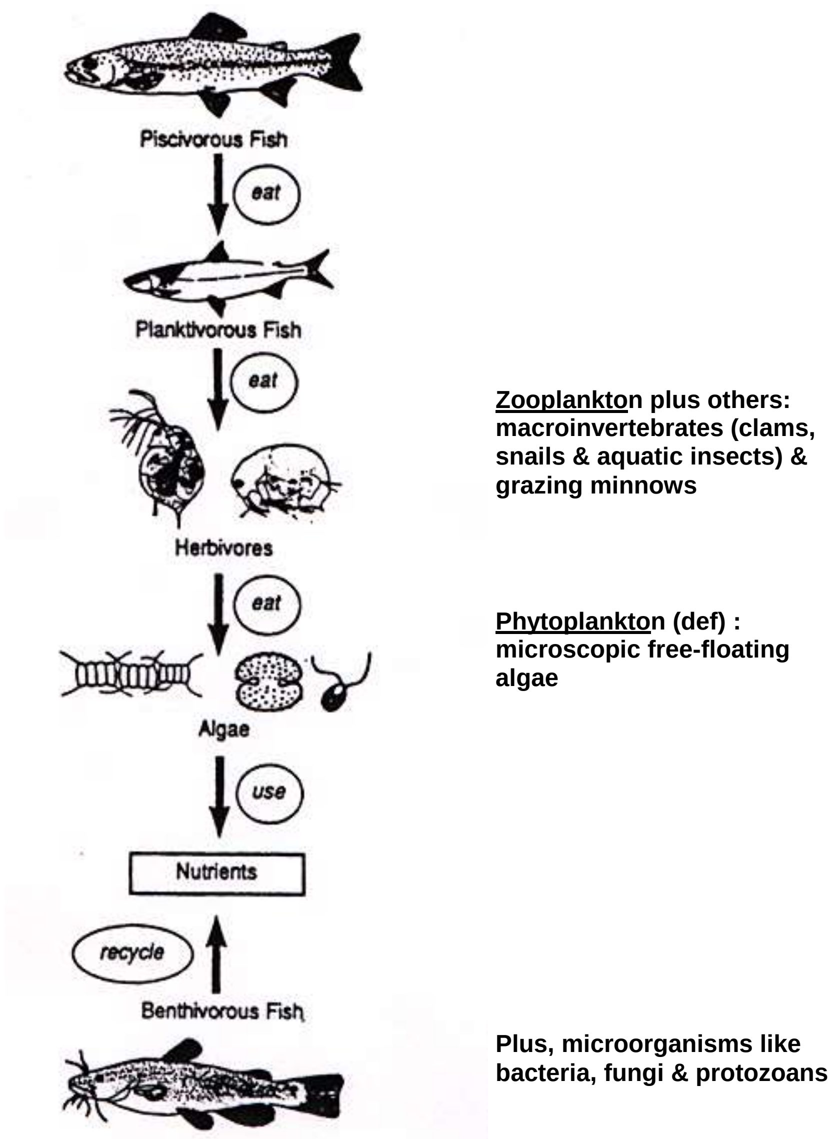

Figure 3.1 Aquatic Food Chain

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 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

Aqua Link analyzed and evaluated the lake water quality data collected in 2021 and compared these data to the data collected during the *Walker Lake 2016 - 2020 Baseline Water Quality Monitoring Program* (Aqua Link 2017 - 2021). The comparison of recently acquired data to past data is commonly referred to as "water quality trend analysis". These data are essential for assessing current lake water quality, and determining whether it has improved or degraded over time. In the following paragraphs, both *in-situ* and chemical water quality data are briefly discussed in terms of trends. Lake water quality data are presented as graphs; many of these graphs contain linear trend lines indicating whether water quality is improving or degrading.

It should be noted that as a historical database (i.e. past data) grows, the accuracy of trend analysis increases. While it is valuable to evaluate trends from one year to the next, these trends cannot be entirely validated with a small database like the current database for Walker Lake which extends only from 2016 - 2021. Overall, water quality trend analysis for Walker Lake will continue to improve and become even more powerful as more lake data are added to the database in subsequent years.

The lake water quality monitoring program was discussed in detail in section 2.1. In this study, two lake monitoring stations (WL1 and WL2) were monitored three times for *in-situ* water quality parameters including Secchi disk depth during the months of June through August of 2021. Stations WL1 (secondary station) and WL2 (primary station) are located near the dam (northern region of the lake) and uplake (southern region of the lake), respectively (Figure 1.1). The maximum water depths at Stations WL1 and WL2 are typically 3 and 6.5 meters (9.8 and 21.3 feet), respectively. Chemical water quality data for the surface waters were monitored at Station WL2. Surface water data represent lake water samples collected at approximately 1.0 meter below the lake's surface. Zooplankton samples were obtained throughout the water column (surface to bottom) at WL2 while towing a six inch, 80 micron mesh plankton net a minimum distance of 30 meters (6 – 5 meter tows per sample).

The following subsections of this report will discuss in detail all of the lake data collected at the primary lake station - Station WL2. All 2021 *in-situ*, chemical, phytoplankton, and zooplankton data for both lake stations are included in Appendix B. This includes the calculated Carlson Trophic State Index (TSI) values for Secchi depth, chlorophyll-a, and total phosphorus for Station WL2. The 2016 - 2020 lake data can be found in the *Walker Lake 2016 – 2020 Baseline Water Quality Monitoring Program Final Report* (Aqua Link 2017 - 2021).

4.1. Water Temperature and Dissolved Oxygen

Water temperature and dissolved oxygen profile data at Station WL2 (deepest, uplake, centrally located area in the southern region) in 2021 are presented in Figures 4.1 through 4.2. The maximum water depth at Station WL2 was 6.4 meters (21.1 feet) in 2021. The lake was strongly, thermally stratified during the months of June through August (Figure 4.1). 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 4.5 meters (6.6 to 14.8 feet) during the study period. Figure 4.2 shows that dissolved oxygen levels rapidly decreased within deeper lake waters (hypolimnion).

4.2. 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.

The 2021 annual mean, (June through August), for total phosphorus was 0.033 mg/L and was 0.002 mg/L for dissolved reactive phosphorous concentrations in the surface water at WL2. It should be noted that the dissolved reactive phosphorous value reported for the August sampling date was not included when calculating the mean for 2021 since the reported value of dissolved reactive phosphorus was higher than the reported total phosphorus value, which cannot happen. In contrast, the 2020 values for total phosphorus and dissolved reactive phosphorous concentrations in the surface water at WL2 were 0.027 mg/L and below the detection limit of 0.002 mg/L, respectively. A slight increase was observed for both total phosphorous and dissolved reactive phosphorus concentrations when compared to data from 2020. These levels of fluctuation for total phosphorous and dissolved reactive phosphorous concentrations are considered to be at a level of normal seasonal fluctuation. Based upon the 2021 mean total phosphorus concentrations for surface waters Walker Lake was classified as slightly eutrophic in 2021.

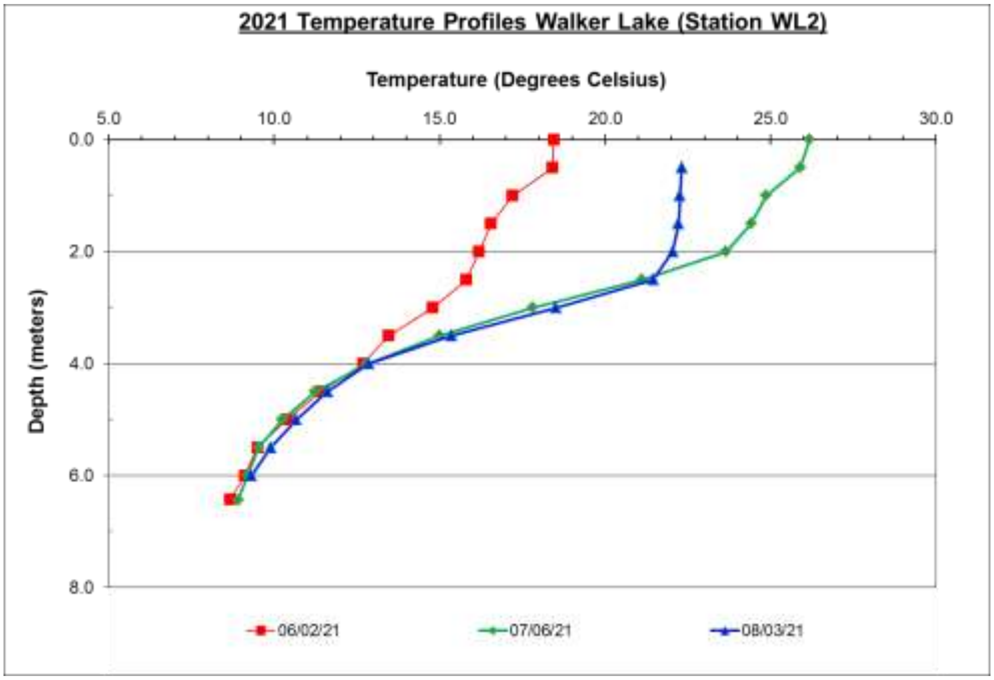

Figure 4.1 2021 Temperature Profiles in Walker Lake at Station WL2

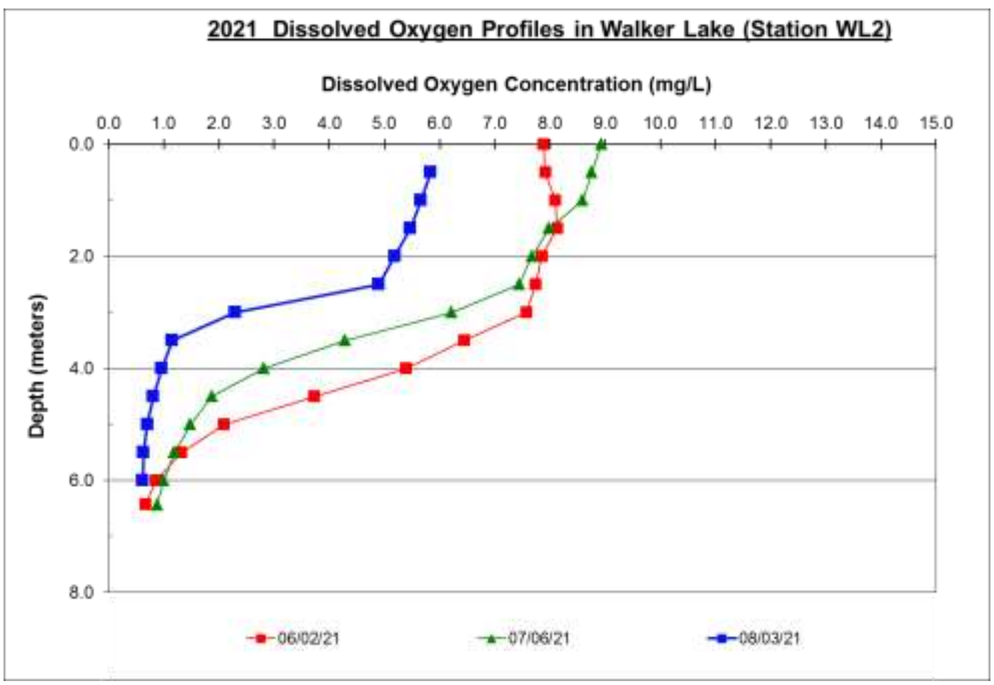

Figure 4.2 2021 Dissolved Oxygen Profiles in Walker Lake at Station WL2

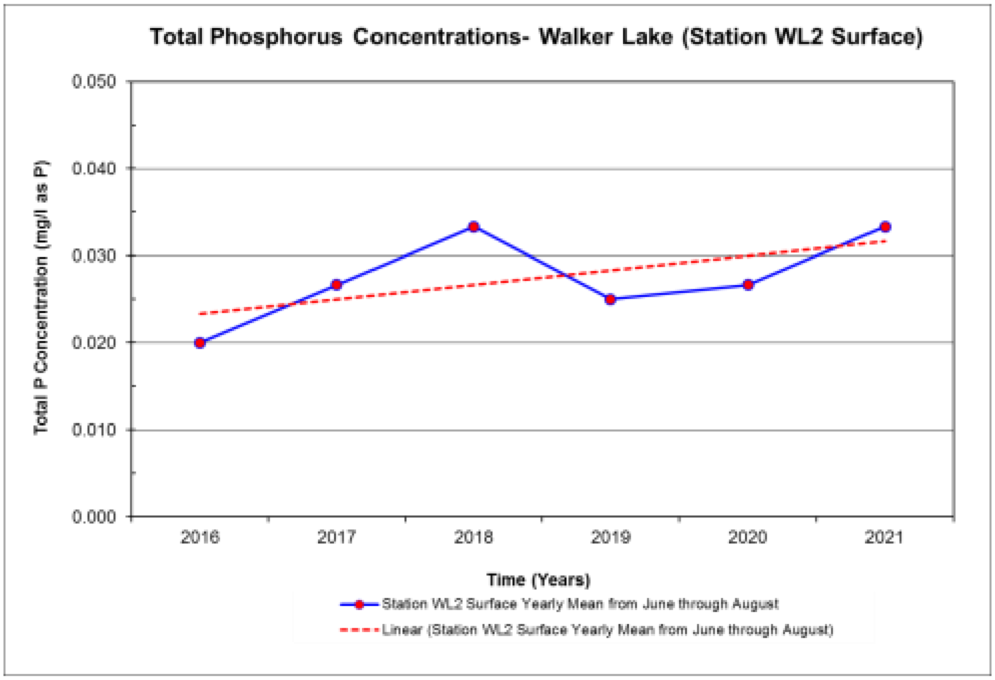

Figure 4.3 Total Phosphorus Concentrations in Walker Lake (2016-2021)

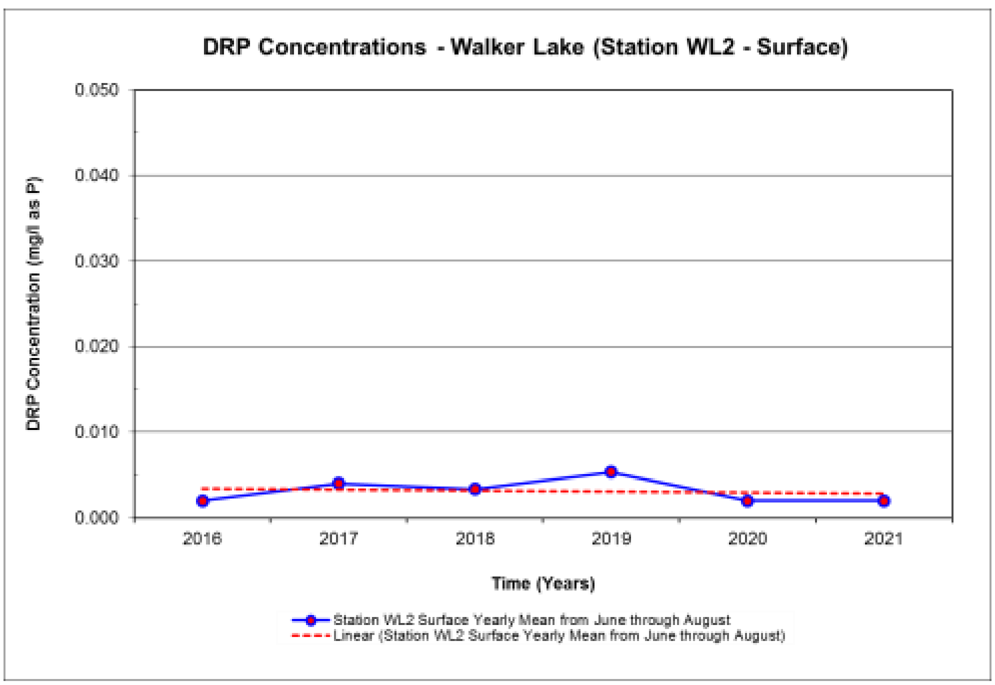

Figure 4.4 Dissolved Reactive Phosphorus Concentrations in Walker Lake (2016-2021)

4.3. 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.

The 2021 mean total nitrogen, total Kjeldahl nitrogen (TKN), nitrate plus nitrite nitrogen, and ammonia nitrogen concentrations for surface waters are presented in Table 4.1. Total nitrogen concentrations increased from 0.170 mg/L in 2020, to 0.247 mg/L in 2021 (Figure 4.5). This observed increase in total nitrogen was considered a normal level of seasonal fluctuation, which are common for lakes.

Table 4.1 Mean Nitrogen Concentrations at WL2 in 2021

Year	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
2021	0.247	n/a	0.200	n/a	0.047	n/a	0.017	n/a

Overall, the 2021 mean total nitrogen concentration for Walker Lake was found to be at a low level. Based upon the Nurnberg criteria (2001), the mean total nitrogen concentrations for surface waters thereby suggest that Walker Lake was classified as oligotrophic in 2021.

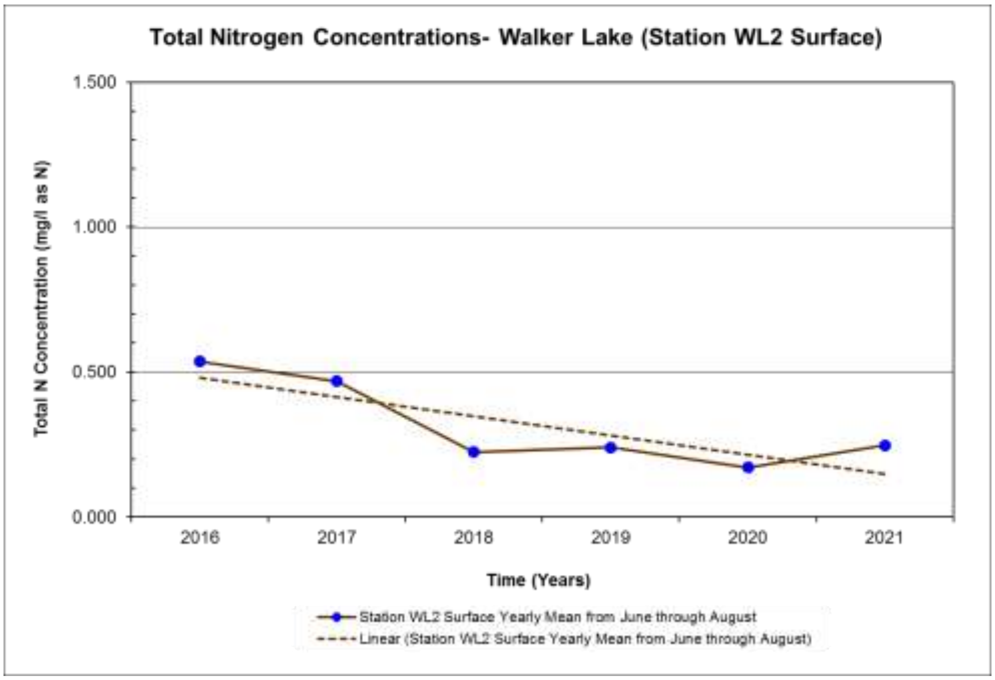

Figure 4.5 Total Nitrogen Concentrations in Walker Lake (2016-2021)

4.4. Secchi 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, mesotrophic, eutrophic and hypereutrophic when Secchi disk transparency values are greater than 4.0 meters, 4.0 to 2.0 meters, 1.9 to 1.0 meters, and less than 1.0 meter, respectively (Nurnberg 2001).

The annual mean Secchi disk transparency values in Walker Lake at Station WL2 from 2016 - 2021 are presented in Figure 4.6. Overall, the mean Secchi disk transparency decreased slightly in 2021 when compared to 2020, but has been relatively consistent since 2016. The 2021 mean Secchi disk transparency value for Walker Lake at WL2 was 1.26 meters and values ranged from 1.16 to 1.37 meters for all study dates. Based upon Nurnberg (2001), the lake was classified as moderately to highly eutrophic in 2021.

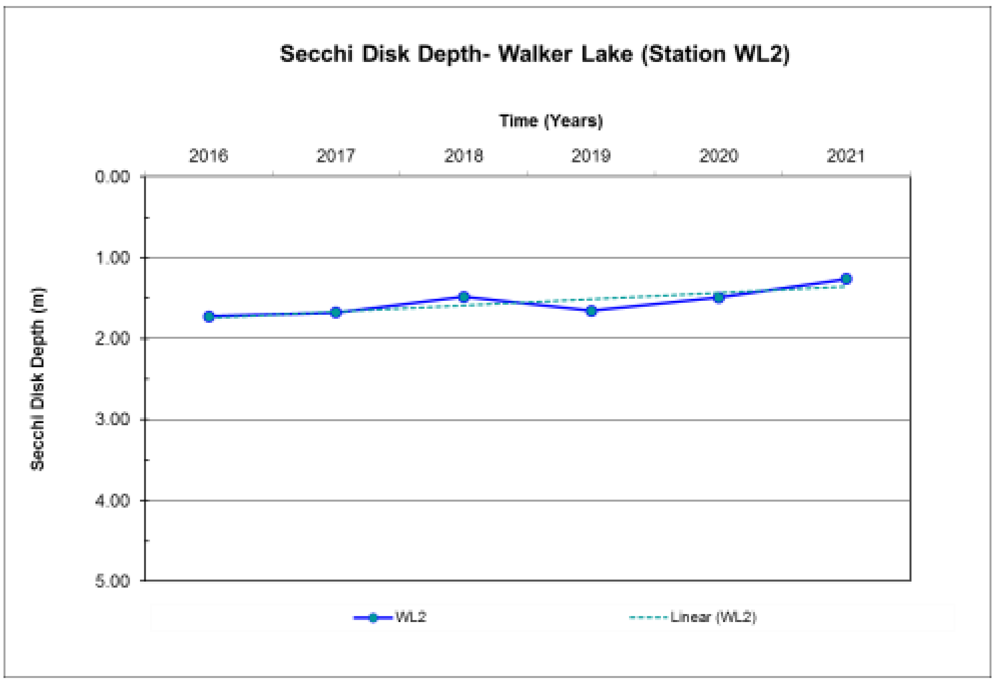

Figure 4.6 Secchi Disk Transparency in Walker Lake (2016-2021)

4.5. 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.

The annual mean chlorophyll-a concentrations in Walker Lake at Station WL2 from 2016 – 2021 are shown in Figure 4.7. The 2021 mean chlorophyll-a concentration in the surface water at WL2 was 9.6 ug/L. The mean chlorophyll-a concentration decreased very slightly when compared to the 2020 value of 10.2 ug/L, and was similar to the mean values reported for 2016 through 2020. Chlorophyll-a concentration ranged from 4.5 ug/L to 15.0 ug/L during the 2021 study period. According to the Nurnberg criteria, the mean chlorophyll-a concentration indicates slightly eutrophic conditions in 2021.

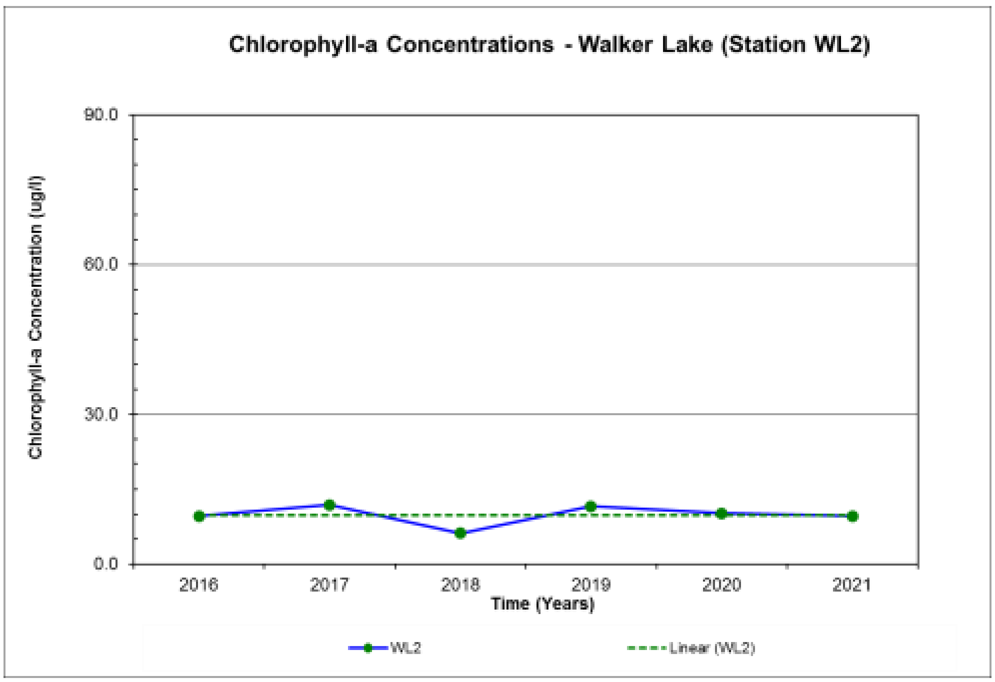

Figure 4.7 Chlorophyll-a Concentrations in Walker Lake (2016-2021)

4.6. Phytoplankton & Zooplankton Biomass

The quantity of phytoplankton (free floating, microscopic aquatic plants 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. Acidic lakes typically will also have lower species diversity.

4.6.1. 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.

It should be noted that the nomenclature of phytoplankton taxonomy (i.e. scientific classification) has experienced some minor revisions. This is a regular occurrence in the scientific community; consequently, our scientists strive to stay up to date with this ever-changing system. The most notable change regards the genus *Anabaena* in the phylum Cyanophyta. *Anabaena* has been the accepted name of this taxon for countless years. However, a change has occurred and now the genus *Anabaena* (Cyanophyta) is known as *Dolichospermum* (Cyanophyta).

The phytoplankton community in 2021 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 total phytoplankton biomasses in Walker Lake ranged from 3,567 ug/L (micrograms per liter) to 4,300 ug/L for 2021, as shown in Figure 4.8. The highest phytoplankton biomass value was reported in August of 2021. In general, phytoplankton biomass 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 perceived by many as “algal bloom” conditions.

Phytoplankton in Walker Lake during 2021 were fairly well balanced (Figure 4.8) in terms of diversity, but not well distributed in terms of biomass. During June, total biomass of the phytoplankton community was strongly dominated by *Synedra* (Bacillariophyta) followed distantly by *Closterium* (Chlorophyta) and *Dinobryon* (Chrysophyta). In July, *Tabellaria* (Bacillariophyta) was solely dominant. Similarly in August, *Tabellaria* continued to be dominant, but *Synedra*, still following distantly, increased in biomass. As previously mentioned, biomass values for 2021, ranged from a minimum of 3.567 ug/L to a maximum of 4,300 ug/L (Figure 4.8). Overall, the phytoplankton assemblages were not well distributed among taxa during the 2021 study period in terms of biomass. However, diatoms were dominant from June to August and are beneficial to the lake. Lower observed biomass values for potentially harmful cyanobacteria and increased beneficial diatom populations in 2021 may be a result of residual effects from bioaugmentation (addition of concentrated bacteria additives) in previous seasons.

An annual mean comparison of phytoplankton biomass and the corresponding biomass of cyanobacteria (Cyanophyta) is illustrated in Figure 4.9 for the study years. The biomass of cyanobacteria is considered to be relatively low in 2016 - 2017 and 2019 - 2021, when compared to overall phytoplankton biomass. This generally means the phytoplankton biomass is distributed among other, more palatable phytoplankton that beneficial zooplankton can utilize. During the 2018 study year, an increase in cyanobacteria biomass in relation to overall phytoplankton biomass was observed. This was likely a result of unusually high temperatures and excessive rainfall in the area, which, in turn set up for a prolific growing season for phytoplankton. The biomass ratio of cyanobacteria to total phytoplankton became, once again, favorable in 2021. The annual mean biomass values remain consistent to levels observed in similar lakes in northeastern Pennsylvania. These observed biomass levels in 2021 are desirable and not considered to be concerning at this time, due in part to the low ratio of cyanobacteria to total biomass. Furthermore, these 2021 values do continue to indicate a healthy balance of palatable plankton.

4.6.2. Zooplankton

Zooplankton are suspended microscopic animals whose movements in a lake are primarily dependent upon water currents. The zooplankton of freshwater ecosystems are dominated primarily by four major groups: the protozoa, the rotifers and two subclasses of crustacea, the cladocerans (i.e., water fleas) and the copepods. Zooplankton are generally smaller than 2 millimeters (one-tenth of an inch) in size and primarily feed on algae, other zooplankton, and plant and animal particles. Zooplankton grazing can have a significant impact on phytoplankton species composition and productivity (i.e. biomass) through selective grazing (e.g., size of zooplankton influences what size phytoplankton are consumed) and nutrient recycling. Zooplankton are then consumed by fish, waterfowl, aquatic insects, and others, thereby playing a vital role in the transfer of energy from phytoplankton to higher trophic levels.

Zooplankton communities in 2021 were represented by genera from all four common taxa: Protozoa (protozoans), Rotifera (rotifers), Copepoda (crustacean), and Cladoceran (crustacean). From 2016 through 2020, Protozoa were not observed. Composite zooplankton samples were collected during June through August of 2021. Zooplankton biomass values from June through August of 2021 are shown in Figure 4.10.

In June, Nauplii of the subclass Copepoda were most dominant followed distantly by *Polyarthra* (Rotifera). Also, in June Ciliophora (Protozoa) were found. Ciliophora is the first Protozoan sampled by Aqua Link in Walker Lake. In July, Nauplii biomass increased, nearly doubling in biomass from June. Nauplii remained dominant in July followed by Chaoboridae also known as phantom midges. In August, the Nauplii decreased to about 1/3 of the biomass observed in July, but remained the most dominant followed by *Cyclops* (Copepoda) and *Asplanchna* (Rotifera). Overall, zooplankton populations were considered fairly well distributed among taxa during 2021, but were dominated by the taxa Copepoda as illustrated in Figure 4.10. The overall total annual mean biomass values for 2021 were similar those of 2018 and 2019, but lower than 2020 as shown in Figure 4.11. This may have been due to environmental factors, high numbers of juvenile fish, or a reduction in more favorable palatable phytoplankton in 2021. At this point, not enough data has been collected to clearly determine if zooplankton biomass levels are responding to phytoplankton palatability or some other environmental factor. As subsequent years of data are collected, these graphs will become more representative of the zooplankton populations in Walker Lake.

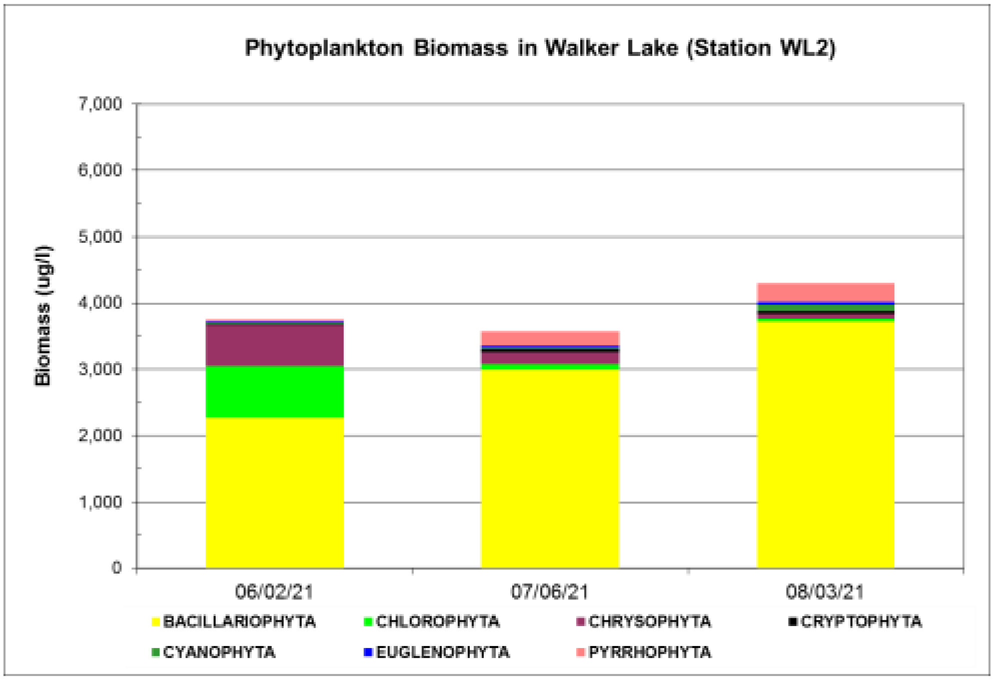

Figure 4.8 Phytoplankton Biomass in Walker Lake in 2021

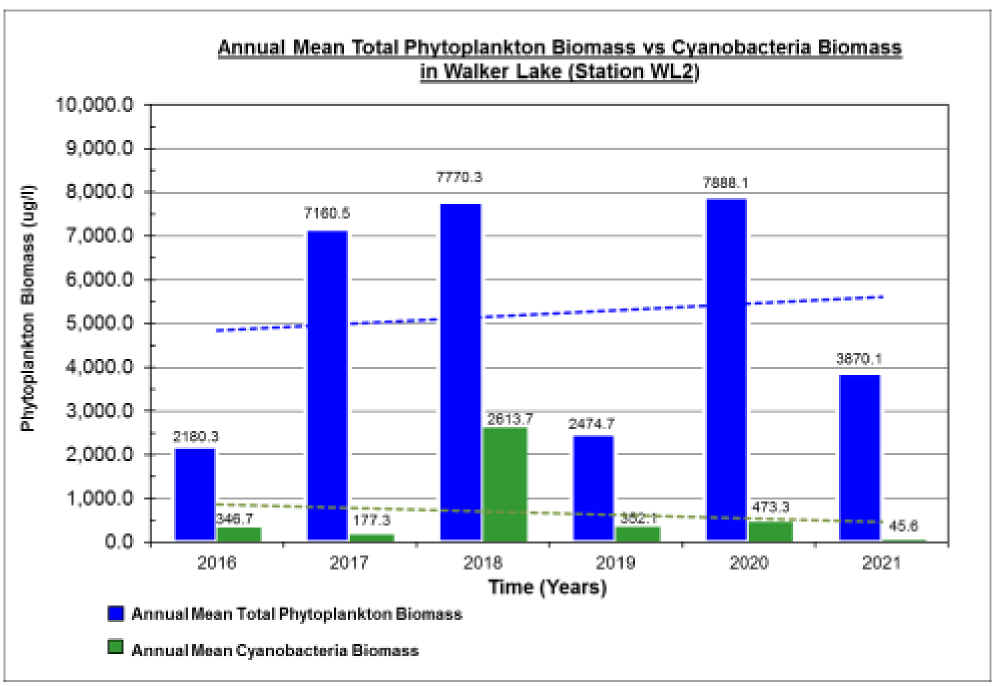

Figure 4.9 Mean Phytoplankton vs. Cyanobacteria Biomass in Walker Lake (2016-2021)

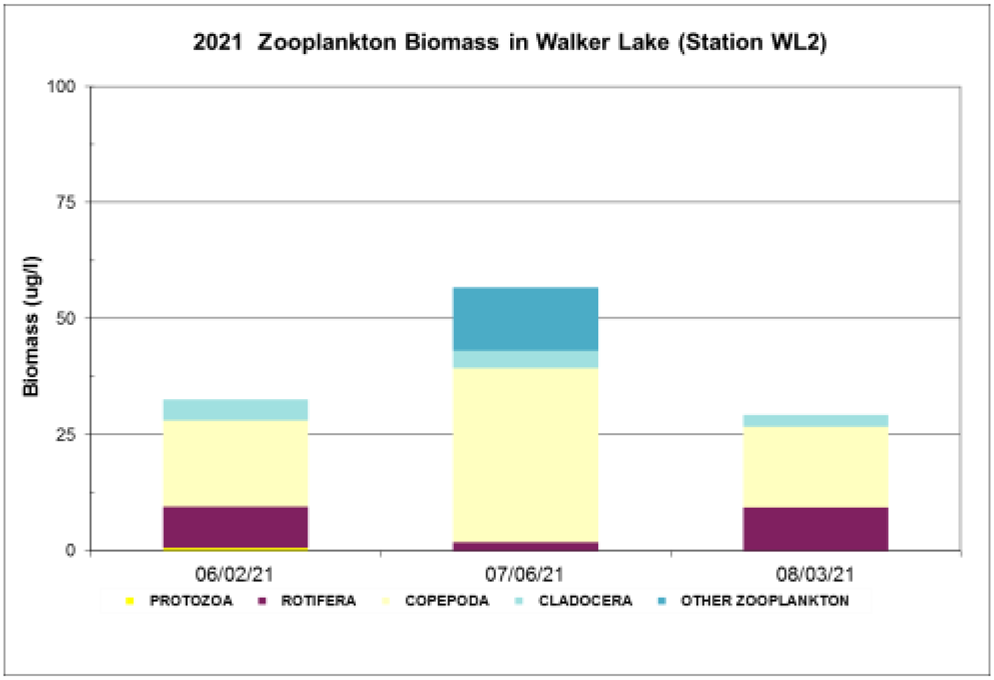

Figure 4.10 Zooplankton Biomass in Walker Lake in 2021

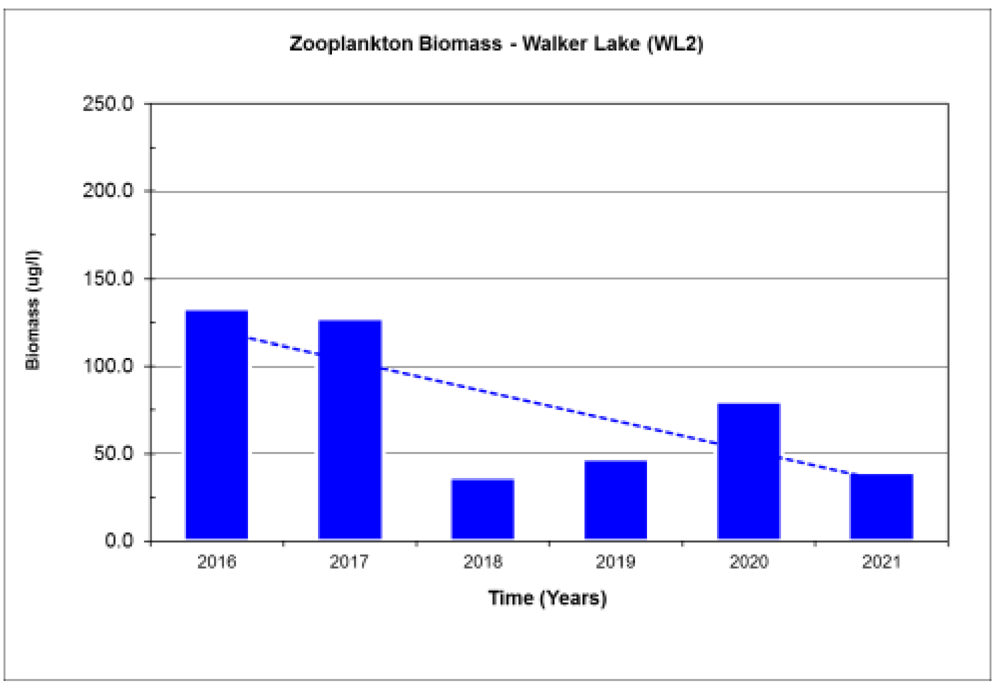

Figure 4.11 Mean Zooplankton Biomass in Walker Lake (2016-2021)

4.7. Carlson's Trophic State Index Values

Carlson's Trophic State Index (TSI) annual mean values were determined at WL2 for Secchi depth, chlorophyll-a, and total phosphorus (surface waters) on all study dates in 2021 (Table 4.2). It should be noted that the mean TSI values were determined by averaging the individual TSI values for Secchi disk values, chlorophyll-a, and total phosphorus.

Table 4.2 Mean Carlson's TSI Values at Station WL2 in 2021

Year	*Trophic State Index (TSI) Values*		
	Secchi Depth	*Chl-a*	*Total P*
2021	57	53	55

Note: Mean TSI values determined by averaging the individual TSI values for each parameter during the 2021 study period.

In 2021, the TSI values for two of the three parameters; Secchi disk transparency and total phosphorus concentrations increased slightly to moderately from the values in 2020, but still remained relatively consistent to the 2016-2020 values (Figure 4.12). The increase in TSI values for Secchi disk transparency and total phosphorus concentrations observed in 2021 is most likely indicative of normal seasonal fluctuation, but could possibly suggest a very slight deterioration in water quality. The other TSI parameter measured was chlorophyll-a. This value remained consistent to that of 2020, with only a marginal decrease observed in 2021. The insignificant fractional decrease in chlorophyll-a value is indicative of normal seasonal fluctuation and does not suggest water quality has necessarily improved at this time. More data will need to be collected in subsequent years to determine, more accurately, whether Walker Lake's water quality is improving, degrading, or remaining consistent.

In general, lakes are classified as hyper-eutrophic when TSI values are greater than 65. Lakes are classified as eutrophic when TSI values are greater than 50 and less than 65. Mesotrophic and oligotrophic lake conditions generally exist when TSI values range between 35 and 50 or are less than 35, respectively. Based upon each of the mean TSI values for Secchi depth, chlorophyll-a, and total phosphorus, Walker Lake was classified as slightly to moderately eutrophic in 2021. Lakes classified as eutrophic typically contain higher amounts of nutrients, moderate water clarity for most of the year, and elevated amounts of algae (phytoplankton) and aquatic plants.

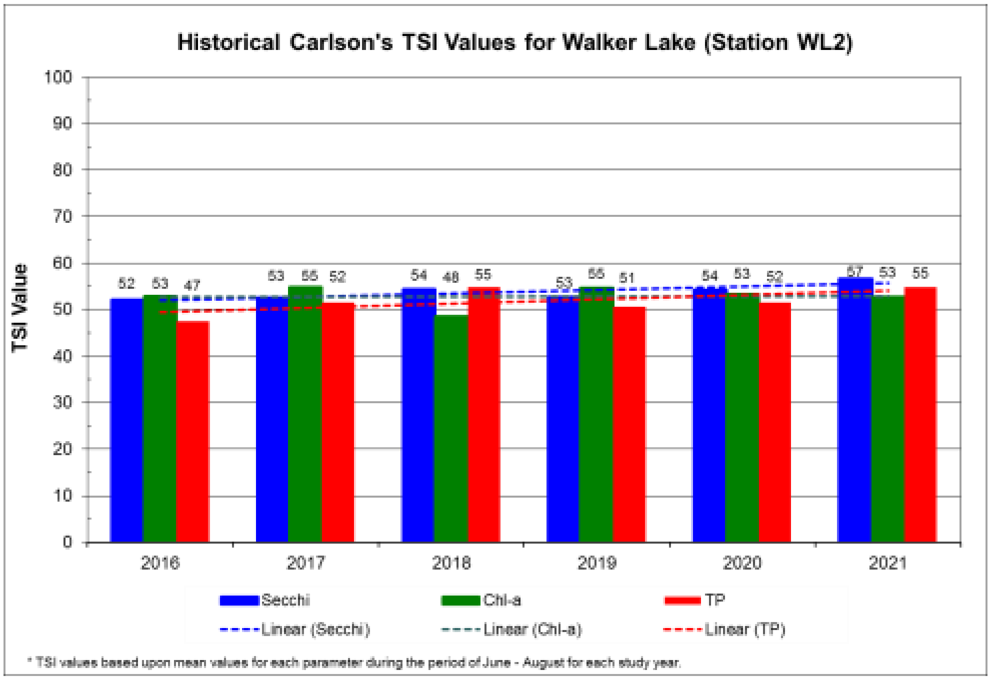

Figure 4.12 Carlson's TSI Values for Station WL2 (2016-2021)

5. Conclusions and Recommendations

Walker Lake was classified as slightly to moderately eutrophic in 2021. The mean (average) Carlson TSI values for Secchi depth, chlorophyll-a, and total phosphorus were 57, 53, and 55. Overall, lakes classified as eutrophic typically contain higher amounts of nutrients, moderate water clarity for most of the year, and elevated amounts of algae (phytoplankton) and aquatic plants. In terms of Carlson TSI values, lake water quality in 2021 was relatively consistent to the 2016 - 2020 study years.

Walker Lake was strongly, thermally stratified during the months of June through August in 2021. The dissolved oxygen levels rapidly decreased within deeper lake waters (hypolimnion). 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 2.0 to 4.5 meters (6.6 to 14.8 feet) during the study period.

Phytoplankton biomass values in Walker Lake during 2021 were shown to be relatively consistent with previous study years and are still consistent to levels observed in similar lakes in northeastern Pennsylvania. Phytoplankton in Walker Lake during 2021 were fairly well balanced in terms of diversity, but not well distributed in terms of biomass. Bacillariophyta were dominant in June, July and August. Biomass values for 2021, ranged from a minimum of 3.567 ug/L to a maximum of 4,300 ug/L.

Overall, the phytoplankton assemblages were not well distributed among taxa during the 2021 study period in terms of biomass. However, diatoms were dominant from June to August and are beneficial to the lake. Lower observed biomass for potentially harmful cyanobacteria and increased beneficial diatom populations in 2021 may be a result of residual effects from bioaugmentation (addition of concentrated bacteria additives) in previous seasons. These observed biomass levels in 2021 are desirable and not considered to be concerning at this time, due in part to the low ratio of cyanobacteria to total biomass. Furthermore, these values do continue to indicate a healthy balance of palatable plankton beneficial zooplankton can utilize.

Overall, zooplankton populations were considered fairly well distributed among taxa during 2021, but were dominated by the taxa Copepoda. The overall total annual mean biomass values for 2021 were similar those of 2018 and 2019, but lower than 2020. This may have been due to environmental factors, high numbers of juvenile fish, or a reduction in more favorable palatable phytoplankton in 2021.

Based upon the above conclusions, Aqua Link offers the following recommendations to the Association for improving Walker Lake:

1. The Association should continue collecting baseline water quality data in 2022. Newly acquired water quality data should be analyzed and compared to those data in the existing 2016 - 2021 database. The overall importance of collecting baseline lake water quality data on an annual basis cannot be over emphasized. Without these data, lake associations 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. Lake water quality samples should be collected from the deep section of the lake and analyzed for at least total phosphorus and ortho-phosphorus (dissolved or soluble reactive phosphorus). The additional nutrient data will help determine the amount of internal nutrient release via deep water lake sediments when dissolved oxygen sharply decline during summer thermal stratification. These anoxic, deep water sediments may serve as an important source of phosphorus during the summer growing season for algal blooms.

3. A more detailed lake water quality database should be developed using all lake water quality data reported by Aqua Link from 2016-21 and previous lake reports from 2002-16. (refer to Section 2.3). Merging all lake water quality data for key parameters such as total phosphorus, chlorophyll-a and Secchi depth transparency will provide significantly more detail about historical water quality changes in the lake.

4. Whole lake aeration should be considered to further improve both the water quality and water clarity in Walker Lake. At a minimum, aeration should be considered in the deepest section of the lake, which is shown in detail in the bathymetric lake water depth map as prepared by Aqua Link in 2021.

   For either whole lake or partial lake aeration, the aeration system should use tubular EPDM rubber membrane air diffusers and compressed air to completely mix, destratify and aerate the entire lake. Aqua Link recommends installing either several Hydro Logic AirLift HighFlow lake aeration systems or a custom Hydro Logic AirLift lake aeration system designed specifically for Walker Lake.

Overall, lake aeration is expected to reduce the internal release of phosphorus from anoxic in-lake sediments (sediments containing no dissolved oxygen) by increasing dissolved oxygen levels in deeper lake waters – especially in the southern section of the lake where water depths exceed 20 ft. Reducing the internal release of nutrients plus mixing lake waters are expected to further improve water clarity by reducing the phytoplankton (planktonic or free-floating microscopic algae) biomass. Increased dissolved oxygen levels in deeper lake waters will also increase the total amount of available habitat for a variety of fish species during the summer months. Lastly, aeration will increase the breakdown of organic based sediments in the lake and reduce any lake odor problems during the summer months.

5. Some of the isolated stands of native macrophytes (rooted aquatic plants) found in Walker Lake should be allowed to propagate and spread. Overall, balanced lake ecosystems generally contain 20 to 30 percent macrophyte coverages. Macrophytes provide habitat for aquatic organisms including fish and compete with phytoplankton (microscopic free-floating algae) for nutrients. Therefore, it is expected that increased quantities of macrophytes will further improve the water clarity of Walker Lake.

6. Nuisance stands of bladderwort should continue to be controlled with aquatic pesticides in 2022. Bladderwort is a native plant to the region but it has the ability to spread quickly and impact aesthetics and desirable lake uses.

   The treatment area of bladderwort in 2022 should remain the same as 2021 for continued thorough control and prevention of problematic spreading into more areas that can be both detrimental to recreational activities as well as being aesthetically unpleasant. Two larger scale bladderwort treatments, starting near mid- to late May, with a follow-up treatment to occur approximately mid-to late July to treat any regrowth or additional locations not targeted in the initial treatment are strongly recommended for the 2022 growing season as performed in recent years.

7. Any non-native, invasive aquatic plants should continue to be controlled immediately when identified in the lake. During the 2021 fisheries survey, performed by Aqua Link in the fall, some stands of variable leaf milfoil were observed along numerous areas on Walker Lake’s perimeter. Variable leaf milfoil is a non-native, invasive aquatic plant that is quite aggressive.

   Variable leaf 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 the affected 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 as a result of reduced dissolved oxygen concentrations when these plants decompose. It may be necessary to use a different herbicide, additional herbicide, or an increased dosage rate for better control.

8. As in previous years, any problematic floating leaved and emergent vegetation as identified by the Association should be treated twice in 2022. These floating leaved treatments targeted both water lilies and water shield. Emergent species included cattails, rush, and several other plants located in the vicinity of the dam. It is typically recommended to treat these plants during mid to late June with a follow-up treatment in mid to late August.

   It is extremely important to have a treatment contract in place prior to the spring of 2022. This enables Aqua Link enough time to have the aquatic pesticide permit modified, if necessary, approved, and also schedule these treatments on the appropriate time line in a proactive, rather than reactive manner.

9. Concentrated bacteria additives (MicroLife Clear Max by Hydro Logic Products) should be applied to the lake in 2022. The purpose of these treatments is to further improve lake water quality and clarity. A slight decline in overall water quality was observed in 2021. This may, in part, be due to not treating the lake with concentrated bacteria additives in 2021. If possible, the Association should consider treating the lake again and increasing the dosing rates of these bacteria additives in 2022. 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 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).

10. Copper sulfate treatments should continue to be an option to control nuisance mats of filamentous algae if needed. These treatments were performed in the past but they have not been required since Aqua Link began managing the lake in 2016.

A follow-up aquatic macrophyte (aquatic vascular plant) survey should be performed in 2022. The results of this survey should be compared to the macrophyte surveys performed in 2017 – 2021. As in the past, the primary objective of the 2022 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-natives, 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 follow-up fishery survey should be performed to reassess the overall health of the ecosystem, as well as improve the fishing. Fishery surveys provide important data on the current condition of the fishery. Fishery surveys were performed on Walker Lake during the fall of 2016-2017 & 2019-2021. Follow-up fishery surveys allow fisheries biologists to determine if the fisheries are improving, declining, or remaining unchanged. These surveys have become increasingly popular among lake associations. 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 Walker Lake.

    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. Over the past few years, some changes have been made in the lake. These changes include aquatic plant herbicide treatments and bacteria additive treatments. It is valuable to determine if these occurrences have had a negative effect on the ecosystem, and if so, what the best management plan would be to counteract any potentially negative effects. 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

Walker Lake **Prepared by Aqua Link, Inc.**
Project No. 1577-24

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	Epresssed 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)

Walker Lake
Project No. 1577-24

Station No. WL1 - Near dam center
Station No. WL2 - Uplake center

Prepared by Aqua Link, Inc.

Insitu Water Quality Data - Station WL1 and WL2

Date M/D/Y	Time hh:mm:ss	Site	Depth m	Temp C	DO% %	DO Conc mg/L	Cond uS/cm	SpCond uS/cm	pH s.u.	TDS mg/L	Salinity ppt	ORP mV	Conversions Depth (feet)	Conversions Temp (Degrees F)
06/02/21	10:35:56	WL1	0.0	19.62	92.0	8.43	62	69	5.63	45	0.03	25	0.00	67.3
06/02/21	10:36:41	WL1	0.5	19.27	89.6	8.26	59	66	5.76	43	0.03	19	1.64	66.7
06/02/21	10:37:12	WL1	1.0	17.33	88.2	8.46	60	70	5.83	46	0.03	17	3.28	63.2
06/02/21	10:37:41	WL1	1.5	16.44	86.6	8.47	55	65	5.84	42	0.03	16	4.92	61.6
06/02/21	10:38:06	WL1	2.0	16.08	81.2	8.00	58	69	5.75	45	0.03	16	6.56	60.9
06/02/21	10:38:35	WL1	2.5	15.85	70.4	6.97	58	70	5.67	45	0.03	9	8.20	60.5
06/02/21	10:38:48	WL1	2.7	15.84	66.8	6.62	60	72	5.65	47	0.03	10	8.96	60.5
<<insert>>														
	Min		0.0	15.84	66.8	6.62	55	65	5.63	42	0.03	9	0.00	60.51
	Max		2.7	19.62	92.0	8.47	62	72	5.84	47	0.03	25	8.96	67.32
	Max - Min		2.7	3.78	25.2	1.85	7	7	0.21	5	0.00	16	8.96	6.80
	Count		7	7	7	7	7	7	7	7	7	7	7	7

Date M/D/Y	Time hh:mm:ss	Site	Depth m	Temp C	DO% %	DO Conc mg/L	Cond uS/cm	SpCond uS/cm	pH s.u.	TDS mg/L	Salinity ppt	ORP mV	Conversions Depth (feet)	Conversions Temp (Degrees F)
06/02/21	10:46:23	WL2	0.0	18.44	84.0	7.88	57	66	6.28	43	0.03	53	0.00	65.2
06/02/21	10:47:21	WL2	0.5	18.41	84.2	7.91	60	69	6.32	45	0.03	28	1.64	65.1
06/02/21	10:47:48	WL2	1.0	17.20	84.1	8.10	58	68	6.36	44	0.03	21	3.28	63.0
06/02/21	10:48:33	WL2	1.5	16.55	83.3	8.13	55	65	6.34	42	0.03	18	4.92	61.8
06/02/21	10:49:02	WL2	2.0	16.19	79.9	7.85	51	61	6.24	40	0.03	19	6.56	61.1
06/02/21	10:49:23	WL2	2.5	15.81	78.1	7.74	55	67	6.15	44	0.03	19	8.20	60.5
06/02/21	10:49:45	WL2	3.0	14.79	74.8	7.57	49	61	6.05	40	0.03	18	9.84	58.6
06/02/21	10:50:20	WL2	3.5	13.46	61.8	6.44	47	60	5.81	39	0.03	12	11.48	56.2
06/02/21	10:50:50	WL2	4.0	12.69	50.8	5.39	47	62	5.53	40	0.03	9	13.12	54.8
06/02/21	10:51:24	WL2	4.5	11.42	34.1	3.73	45	61	5.43	39	0.03	-19	14.76	52.6
06/02/21	10:51:51	WL2	5.0	10.38	18.7	2.09	46	63	5.36	41	0.03	-43	16.40	50.7
06/02/21	10:52:17	WL2	5.5	9.49	11.6	1.32	66	93	5.46	61	0.04	-88	18.04	49.1
06/02/21	10:52:43	WL2	6.0	9.11	7.4	0.86	73	105	5.53	68	0.05	-204	19.68	48.4
06/02/21	10:53:03	WL2	6.4	8.68	5.7	0.67	94	137	5.70	89	0.06	-266	21.06	47.6
<<insert>>														
	Min		0.0	8.68	5.7	0.67	45	60	5.36	39	0.03	-266	0.00	47.62
	Max		6.4	18.44	84.2	8.13	94	137	6.36	89	0.06	53	21.06	65.19
	Max - Min		6.4	9.76	78.5	7.46	49	77	1.00	50	0.03	319	21.06	17.57
	Count		14	14	14	14	14	14	14	14	14	14	14	14

Walker Lake
Project No. 1577-24

Station No. WL1 - Near dam center
Station No. WL2 - Uplake center

Prepared by Aqua Link, Inc.

Insitu Water Quality Data - Station WL1 and WL2

Date M/D/Y	Time hh:mm:ss	Site	Depth m	Temp C	DO% %	DO Conc mg/L	Cond uS/cm	SpCond uS/cm	pH s.u.	TDS mg/L	Salinity ppt	ORP mV	Conversions Depth (feet)	Conversions Temp (Degrees F)
07/06/21	12:45:43	WL1	0.0	27.70	106.5	8.38	70	67	6.25	43	0.03	-14	0.00	81.9
07/06/21	12:46:26	WL1	0.5	27.37	106.1	8.40	69	66	6.12	43	0.03	-36	1.64	81.3
07/06/21	12:47:02	WL1	1.0	27.15	104.6	8.31	70	67	6.16	44	0.03	-34	3.28	80.9
07/06/21	12:47:33	WL1	1.5	26.69	103.9	8.32	66	64	6.14	42	0.03	-28	4.92	80.0
07/06/21	12:48:04	WL1	2.0	26.52	102.6	8.24	72	70	6.02	45	0.03	-17	6.56	79.7
07/06/21	12:48:34	WL1	2.5	24.99	98.9	8.18	63	63	5.65	41	0.03	-4	8.20	77.0
07/06/21	12:48:56	WL1	2.9	23.12	80.0	6.85	76	79	5.77	52	0.04	-40	9.46	73.6
<<insert>>														
	Min		0.0	23.12	80.0	6.85	63	63	5.65	41	0.03	-40	0.00	73.62
	Max		2.9	27.70	106.5	8.40	76	79	6.25	52	0.04	-4	9.46	81.86
	Max - Min		2.9	4.58	26.5	1.55	13	16	0.60	11	0.01	35	9.46	8.24
	Count		7	7	7	7	7	7	7	7	7	7	7	7

Date M/D/Y	Time hh:mm:ss	Site	Depth m	Temp C	DO% %	DO Conc mg/L	Cond uS/cm	SpCond uS/cm	pH s.u.	TDS mg/L	Salinity ppt	ORP mV	Conversions Depth (feet)	Conversions Temp (Degrees F)
07/06/21	13:01:28	WL2	0.0	26.18	110.4	8.93	67	65	6.48	42	0.03	-52	0.00	79.1
07/06/21	13:01:50	WL2	0.5	25.89	107.7	8.76	68	67	6.48	44	0.03	-57	1.64	78.6
07/06/21	13:02:20	WL2	1.0	24.86	103.8	8.59	67	68	6.37	44	0.03	-51	3.28	76.7
07/06/21	13:02:50	WL2	1.5	24.41	95.6	7.98	67	68	6.27	44	0.03	-44	4.92	75.9
07/06/21	13:03:16	WL2	2.0	23.66	90.5	7.67	54	55	6.14	36	0.02	-40	6.56	74.6
07/06/21	13:03:38	WL2	2.5	21.12	83.7	7.44	63	68	5.99	44	0.03	-41	8.20	70.0
07/06/21	13:04:00	WL2	3.0	17.82	65.5	6.22	61	71	5.87	46	0.03	-46	9.84	64.1
07/06/21	13:04:24	WL2	3.5	14.99	42.5	4.29	53	65	5.87	42	0.03	-56	11.48	59.0
07/06/21	13:04:47	WL2	4.0	12.82	26.6	2.81	50	65	5.89	42	0.03	-63	13.12	55.1
07/06/21	13:05:19	WL2	4.5	11.24	17.0	1.87	52	70	5.95	46	0.03	-69	14.76	52.2
07/06/21	13:05:46	WL2	5.0	10.24	13.2	1.48	61	85	5.99	55	0.04	-74	16.40	50.4
07/06/21	13:06:12	WL2	5.5	9.53	10.5	1.19	83	118	6.55	76	0.06	-257	18.04	49.2
07/06/21	13:06:37	WL2	6.0	9.19	8.7	1.00	105	150	7.06	98	0.07	-344	19.68	48.5
07/06/21	13:06:55	WL2	6.4	8.92	7.6	0.88	133	192	7.37	125	0.09	-360	21.11	48.1
<<insert>>														
	Min		0.0	8.92	7.6	0.88	50	55	5.87	36	0.02	-360	0.00	48.06
	Max		6.4	26.2	110.4	8.9	133.0	192.0	7.4	125	0.1	-39.9	21.11	79.12
	Max - Min		6.4	17.3	102.8	8.0	83.0	137.0	1.5	89	0.1	320.0	21.11	31.07
	Count		14	14	14	14	14	14	14	14	14	14	14	14

Walker Lake
Project No. 1577-24

Station No. WL1 - Near dam center
Station No. WL2 - Uplake center

Prepared by Aqua Link, Inc.

Insitu Water Quality Data - Station WL1 and WL2

Date M/D/Y	Time hh:mm:ss	Site	Depth m	Temp C	DO% %	DO Conc mg/L	Cond uS/cm	SpCond uS/cm	pH s.u.	TDS mg/L	Salinity ppt	ORP mV	Conversions: Depth (feet)	Conversions: Temp (Degrees F)
08/03/21	8:20:13	WL1	0.5	21.93	76.4	6.69	62	65	5.75	42	0.03	40	1.64	71.5
08/03/21	8:21:22	WL1	1.0	21.86	71.6	6.28	64	69	5.88	45	0.03	32	3.28	71.3
08/03/21	8:22:01	WL1	1.5	21.71	70.3	6.18	60	64	5.93	42	0.03	29	4.92	71.1
08/03/21	8:22:35	WL1	1.9	21.56	60.9	5.37	65	69	5.96	45	0.03	24	6.30	70.8
<<insert>>														
	Min		0.5	21.56	60.9	5.37	60	64	5.75	42	0.03	24	1.64	70.81
	Max		1.9	21.93	76.4	6.69	65	69	5.96	45	0.03	40	6.30	71.47
	Max - Min		1.4	0.37	15.5	1.32	5	5	0.21	3	0.00	16	4.66	0.67
	Count		4	4	4	4	4	4	4	4	4	4	4	4

Date M/D/Y	Time hh:mm:ss	Site	Depth m	Temp C	DO% %	DO Conc mg/L	Cond uS/cm	SpCond uS/cm	pH s.u.	TDS mg/L	Salinity ppt	ORP mV	Conversions: Depth (feet)	Conversions: Temp (Degrees F)
08/03/21	8:29:55	WL2	0.5	22.31	67.2	5.84	64	68	6.35	44	0.03	8	1.64	72.2
08/03/21	8:30:42	WL2	1.0	22.26	65.0	5.66	65	69	6.39	45	0.03	6	3.28	72.1
08/03/21	8:31:39	WL2	1.5	22.22	62.8	5.47	68	71	6.44	46	0.03	2	4.92	72.0
08/03/21	8:32:17	WL2	2.0	22.04	59.3	5.18	60	63	6.39	41	0.03	2	6.56	71.7
08/03/21	8:33:27	WL2	2.5	21.45	55.4	4.90	63	67	6.31	44	0.03	-2	8.20	70.6
08/03/21	8:34:18	WL2	3.0	18.52	24.4	2.29	59	68	6.08	44	0.03	-7	9.84	65.3
08/03/21	8:35:06	WL2	3.5	15.35	11.5	1.15	56	68	6.02	44	0.03	-11	11.48	59.6
08/03/21	8:35:44	WL2	4.0	12.86	9.1	0.96	60	78	5.98	51	0.04	-13	13.12	55.1
08/03/21	8:36:27	WL2	4.5	11.61	7.4	0.81	66	89	5.61	58	0.04	3	14.76	52.9
08/03/21	8:37:16	WL2	5.0	10.67	6.3	0.70	84	116	6.81	75	0.05	-98	16.40	51.2
08/03/21	8:38:08	WL2	5.5	9.89	5.6	0.63	121	170	^^	111	0.08	-251	18.04	49.8
08/03/21	8:38:41	WL2	6.0	9.31	5.4	0.62	159	227	^^	148	0.11	-262	19.69	48.8
<<insert>>														
	Min		0.5	9.31	5.4	0.62	56	63	5.61	41	0.03	-262	1.64	48.76
	Max		6.0	22.31	67.2	5.84	159	227	6.81	148	0.11	8	19.69	72.16
	Max - Min		5.5	13.00	61.8	5.22	103	164	1.20	107	0.08	270	18.05	23.40
	Count		12	12	12	12	12	12	12	12	12	12	12	12

Walker Lake **Prepared by Aqua Link, Inc.**
Project No. 1577-24
Station No. WL1 - Near dam center
Station No. WL2 - Uplake center

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)		Nitrate (mg/l as N)		Nitrite (mg/l as N)
WL2	surface	06/02/21	68	6.36	14.0	13.0	b	0.002	0.060	0.020		0.040		0.004
WL2	surface	07/06/21	68	6.37	14.0	16.0		0.002	0.020	0.020		0.080		0.003
WL2	surface	08/03/21	69	6.39	14.0	16.0		^	0.020	0.010	b	0.010	b	0.003
<<insert>>														
		Min	68	6.36	14.0	13.0	b	0.002	0.020	0.010	b	0.010	b	0.003
		Max	69	6.39	14.0	16.0		0.002	0.060	0.020		0.080		0.004
		Mean	68	6.37	14.0	15.0		0.002	0.033	0.017		0.043		0.003
		Median	68	6.37	14.0	16.0		0.002	0.020	0.020		0.040		0.003
		Stds	1	0.02	0.0	1.7		0.000	0.023	0.006		0.035		0.001
		Std	0	0.01	0.0	1.4		0.000	0.019	0.005		0.029		0.000
		Count	3	3	3	3		3	3	3		3		3

Walker Lake
Project No. 1577-24
Station No. WL1 - Near dam center
Station No. WL2 - Uplake center

Station	Depth	Date	Nitrate + 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)
WL2	surface	06/02/21	0.044	b	0.100	0.064	0.144	2.4	32.0	b	2.0	4.5		1.1
WL2	surface	07/06/21	0.083	b	0.100	0.103	0.183	9.2	51.5		3.0	15.0	b	0.6
WL2	surface	08/03/21	0.013		0.400	0.023	0.413	20.7	^		8.0	9.3		1.7
<<insert>>														
		Min	0.013	b	0.100	0.023	0.144	2.4	32.0	b	2.0	4.5	b	0.6
		Max	0.083		0.400	0.103	0.413	20.7	51.5		8.0	15.0		1.7
		Mean	0.047		0.200	0.063	0.247	10.7	41.8		4.3	9.6		1.1
		Median	0.044		0.100	0.064	0.183	9.2	41.8		3.0	9.3		1.1
		Stds	0.035		0.173	0.040	0.145	9.2	13.8		3.2	5.3		0.6
		Std	0.029		0.141	0.033	0.119	7.5	9.8		2.6	4.3		0.4
		Count	3		3	3	3	3	3		3	3		3

Analytical Lake Water Quality Data

Note(s):

TIN denotes total inorganic nitrogen and is the sum of nitrite, nitrate, and ammonia nitrogen
Nitrate + Nitrite is the sum of nitrate and nitrite
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 an outlier value, due to sampling and/or laboratory error; not used for calculations.
(^^) indicates inconsistent values outside of typical ranges

Walker Lake | **Lake Water Quality Trend Analysis** | **Prepared by Aqua Link, Inc.**

Project No. 1577-24
Station No. WL1 - Near dam center
Station No. WL2 - Uplake center

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)**		**Nitrate (mg/l as N)**		**Nitrite (mg/l as N)**
WL2	surface	06/07/16	73	6.10	5.5	14.0		0.002		0.020		0.040		0.110		0.002
WL2	surface	07/05/16	76	6.14	9.0	16.0	b	0.002		0.020	b	0.010		0.030		0.003
WL2	surface	08/08/16	77	5.80	10.0	16.0		0.002		0.020	b	0.010		0.050		0.003
WL2	surface	06/06/17	73	5.72	6.7	14.0		0.004		0.030	b	0.010	b	0.020		0.002
WL2	surface	07/17/17	79	6.27	14.0	16.0		0.006		0.020		0.010		0.040		0.002
WL2	surface	08/15/17	76	6.87	14.0	12.0	b	0.002		0.030		0.090		0.180	b	0.002
WL2	surface	06/05/18	77	7.49	20.0	11.9	b	0.002	b	0.010	b	0.010		0.080		0.007
WL2	surface	07/11/18	84	5.53	20.0	15.8		0.006		0.010	b	0.010		0.040	b	0.002
WL2	surface	08/07/18	76	6.31	4.0	18.0		0.002		0.080		0.030		0.060	b	0.002
WL2	surface	06/10/19	66	6.14	11.0	30.0		0.002		^		0.010		0.080		0.002
WL2	surface	07/24/19	77	5.55	24.0	20.0		0.003		0.030		0.030		0.150		0.003
WL2	surface	08/27/19	75	6.23	11.0	15.0		0.011		0.020		0.020		0.040	b	0.003
WL2	surface	06/15/20	68	5.95	7.0	12.0	b	0.002		0.020		0.020		0.020		0.003
WL2	surface	07/15/20	75	6.64	18.0	15.0	b	0.002		0.030		0.010		0.020		0.004
WL2	surface	08/18/20	65	^^	18.0	14.0	b	0.002		0.030		0.010		0.040		0.004
WL2	surface	06/02/21	68	6.36	14.0	13.0	b	0.002		0.060		0.020		0.040		0.004
WL2	surface	07/06/21	68	6.37	14.0	16.0		0.002		0.020		0.020		0.080		0.003
WL2	surface	08/03/21	69	6.39	14.0	16.0		^		0.020		0.010	b	0.010	b	0.003

Station WL2 Surface Yearly Mean from June through August

	Mean	**2016**	**75**	**6.01**	**8.2**	**15.3**		**0.002**		**0.020**		**0.020**		**0.063**		**0.003**
	Mean	**2017**	**76**	**6.29**	**11.6**	**14.0**		**0.004**		**0.027**		**0.037**		**0.080**		**0.002**
	Mean	**2018**	**79**	**6.44**	**14.7**	**15.2**		**0.003**		**0.033**		**0.017**		**0.060**		**0.004**
	Mean	**2019**	**73**	**5.97**	**15.3**	**21.7**		**0.005**		**0.025**		**0.020**		**0.090**		**0.003**
	Mean	**2020**	**69**	**6.30**	**14.3**	**13.7**	**b**	**0.002**		**0.027**		**0.013**		**0.027**		**0.004**
	Mean	**2021**	**68**	**6.37**	**14.0**	**15.0**		**0.002**		**0.033**		**0.017**		**0.043**		**0.003**

Walker Lake
Project No. 1577-24
Station No. WL1 - Near dam center
Station No. WL2 - Uplake center

Station	Depth	Date	Nitrate + 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)
WL2	surface	06/07/16	0.112		0.620	0.152	0.732	36.6	76.0		5.0		5.6		10.3
WL2	surface	07/05/16	0.033		0.440	0.043	0.473	23.7	21.5		4.0		12.0		11.0
WL2	surface	08/08/16	0.053		0.350	0.063	0.403	20.2	31.5	b	3.0		11.3		9.2
WL2	surface	06/06/17	0.022		0.480	0.032	0.502	16.7	8.0		5.0		12.3		3.6
WL2	surface	07/17/17	0.042		0.180	0.052	0.222	11.1	8.7		3.0		7.3		0.6
WL2	surface	08/15/17	0.182		0.500	0.272	0.682	22.7	136.0		3.0		16.0		3.4
WL2	surface	06/05/18	0.087	b	0.160	0.097	0.247	24.7	48.5	b	3.0		12.6	b	0.6
WL2	surface	07/11/18	0.042	b	0.160	0.052	0.202	20.2	8.7	b	3.0	b	0.8	b	0.8
WL2	surface	08/07/18	0.062	b	0.160	0.092	0.222	2.8	46.0		3.0		5.2	b	0.6
WL2	surface	06/10/19	0.082		0.180	0.092	0.262	^	46.0		2.0		5.8	b	0.3
WL2	surface	07/24/19	0.153		0.110	0.183	0.263	8.8	61.0		3.0		16.0		6.0
WL2	surface	08/27/19	0.043		0.150	0.063	0.193	9.7	5.7	b	2.0		13.0		1.4
WL2	surface	06/15/20	0.023		0.220	0.043	0.243	12.2	21.5		4.0		2.4	b	0.6
WL2	surface	07/15/20	0.024	b	0.100	0.034	0.124	4.1	17.0	b	2.0		9.2		0.7
WL2	surface	08/18/20	0.044	b	0.100	0.054	0.144	4.8	27.0	b	2.0		19.0	b	0.5
WL2	surface	06/02/21	0.044	b	0.100	0.064	0.144	2.4	32.0	b	2.0		4.5		1.1
WL2	surface	07/06/21	0.083	b	0.100	0.103	0.183	9.2	51.5		3.0		15.0	b	0.6
WL2	surface	08/03/21	0.013		0.400	0.023	0.413	20.7	^		8.0		9.3		1.7

Station WL2 Surface Yearly Mean from June through August

Mean	**2016**	**0.066**		**0.470**	**0.086**	**0.536**	**26.8**	**43.0**		**4.0**		**9.6**		**10.2**
Mean	**2017**	**0.082**		**0.387**	**0.119**	**0.469**	**16.9**	**50.9**		**3.7**		**11.9**		**2.5**
Mean	**2018**	**0.064**	b	**0.160**	**0.080**	**0.224**	**15.9**	**34.4**	**b**	**3.0**		**6.2**		**0.7**
Mean	**2019**	**0.093**		**0.147**	**0.113**	**0.239**	**9.2**	**37.6**		**2.3**		**11.6**		**2.6**
Mean	**2020**	**0.030**		**0.140**	**0.044**	**0.170**	**7.0**	**21.8**		**2.7**		**10.2**		**0.6**
Mean	**2021**	**0.047**		**0.200**	**0.063**	**0.247**	**10.7**	**41.8**		**4.3**		**9.6**		**1.1**

Analytical Lake Water Quality Data

Note(s):

TIN denotes total inorganic nitrogen and is the sum of nitrite, nitrate, and ammonia nitrogen
Nitrate + Nitrite is the sum of nitrate and nitrite
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 an outlier value, due to sampling and/or laboratory error; not used for calculations.
(^^) indicates inconsistent values outside of typical ranges

Walker Lake
Project No. 1577-24
Station No. WL1 - Near dam center
Station No. WL2 - Uplake center
Secchi Disk Depth & General Observations

Prepared by Aqua Link, Inc.

Station	**Date**	**Secchi Depth (meters)**	**Observations**
WL1	06/02/21	1.16	Water clear, brownish tinit
WL1	07/06/21	1.34	Water cloudy, brownish tint
WL1	08/03/21	1.25	Tea stained water, slight planktonic bloom
<<insert>>			
	Min	1.16	
	Max	1.34	
	Mean	1.25	
	Median	1.25	
	Stds	0.09	
	Std	0.07	
	Count	3	

Station	**Date**	**Secchi Depth (meters)**	**Observations**
WL2	06/02/21	1.16	Water clear, brownish tinit
WL2	07/06/21	1.37	Water cloudy, brownish tint
WL2	08/03/21	1.25	Tea stained water, slight planktonic bloom
<<insert>>			
	Min	1.16	
	Max	1.37	
	Mean	1.26	
	Median	1.25	
	Stds	0.11	
	Std	0.09	
	Count	3	

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

Project No. 1577-24

Station No. WL1 - Near dam center

Station No. WL2 - Uplake center

Secchi Disk Transparency Data:

Station	Date	Secchi Depth (meters)	Secchi Depth (feet)
WL1	06/07/16	1.92	6.30
WL1	07/05/16	1.34	4.40
WL1	08/08/16	1.49	4.90
WL1	06/06/17	1.58	5.20
WL1	07/17/17	1.80	5.90
WL1	08/15/17	1.43	4.70
WL1	06/05/18	1.19	3.90
WL1	07/11/18	1.31	4.30
WL1	08/07/18	1.52	5.00
WL1	06/10/19	1.86	6.10
WL1	07/24/19	1.46	4.80
WL1	08/27/19	1.71	5.60
WL1	06/15/20	1.25	4.10
WL1	07/15/20	1.28	4.20
WL1	08/18/20	1.31	4.30
WL1	06/02/21	1.16	3.80
WL1	07/06/21	1.34	4.40
WL1	08/03/21	1.25	4.10
Mean	**2016**	**1.58**	**5.20**
WL1	**2017**	**1.61**	**5.27**
WL1	**2018**	**1.34**	**4.40**
WL1	**2019**	**1.68**	**5.50**
WL1	**2020**	**1.28**	**4.20**
WL1	**2021**	**1.25**	**4.10**

Walker Lake **Prepared by Aqua Link, Inc.**
Project No. 1577-24
Station No. WL1 - Near dam center
Station No. WL2 - Uplake center
Secchi Disk Transparency Data:

Station	Date	Secchi Depth (meters)	Secchi Depth (feet)
WL2	06/07/16	1.95	6.40
WL2	07/05/16	1.55	5.10
WL2	08/08/16	1.68	5.50
WL2	06/06/17	1.74	5.70
WL2	07/17/17	1.89	6.20
WL2	08/15/17	1.40	4.60
WL2	06/05/18	1.34	4.40
WL2	07/11/18	1.52	5.00
WL2	08/07/18	1.58	5.20
WL2	06/10/19	1.80	5.90
WL2	07/24/19	1.40	4.60
WL2	08/27/19	1.77	5.80
WL2	06/15/20	1.62	5.30
WL2	07/15/20	1.43	4.70
WL2	08/18/20	1.43	4.70
WL2	06/02/21	1.16	3.80
WL2	07/06/21	1.37	4.50
WL2	08/03/21	1.25	4.10
Mean	**2016**	**1.73**	**5.67**
WL2	**2017**	**1.68**	**5.50**
WL2	**2018**	**1.48**	**4.87**
WL2	**2019**	**1.66**	**5.43**
WL2	**2020**	**1.49**	**4.90**
WL2	**2021**	**1.26**	**4.13**

Walker Lake | **Station No. WL1 - Near dam center** | **Prepared by Aqua Link, Inc.**
Project No. 1577-24 | **Station No. WL2 - Uplake center**

Carlson's Trophic State Index

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
WL2	06/02/21	1.16	4.5	0.060	57.9	45.3	63.2	56.7	52.8	54.7
	07/06/21	1.37	15.0	0.020	55.4	57.1	47.4			
	08/03/21	1.25	9.3	0.020	56.8	52.4	47.4			
<<insert>>										
	Min	1.16	4.5	0.0	55.4	45.3	47.4			
	Max	1.37	15.0	0.060	57.9	57.1	63.2			
	Mean	1.26	9.6	0.033	------	------	------			
	Median	1.25	9.3	0.020	------	------	------			
	Stds	0.11	5.3	0.023	------	------	------			
	Std	0.09	4.3	0.019	------	------	------			
	Count	3	3	3	3	3	3			

Note(s): (*) indicates data reported for surface (1.0 m)
(^) indicates an outlier value, due to sampling and/or laboratory error; not used for calculations.

TSI Annual Summary:

Station	Year	Mean TSI Values Secchi	Mean TSI Values Chl-a	Mean TSI Values TP
WL2	2016	52.1	52.8	47.4
WL2	2017	52.5	54.8	51.5
WL2	2018	54.3	48.5	54.7
WL2	2019	52.7	54.6	50.6
WL2	2020	54.2	53.4	51.5
WL2	2021	56.7	52.8	54.7

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.

Walker Lake **Prepared by Aqua Link, Inc.**
Project No. 1577-24

PHYTOPLANKTON DENSITY (CELLS/ML)

TAXON	WL2 06/02/21	WL2 07/06/21	WL2 08/03/21
BACILLARIOPHYTA			
Centric Diatoms			
Aulacoseira	273.6	0.0	0.0
Araphid Pennate Diatoms			
Asterionella	91.2	102.6	0.0
Synedra	1345.2	193.8	478.8
Tabellaria	250.8	3306.0	3545.4
Monoraphid Pennate Diatoms			
Biraphid Pennate Diatoms			
Eunotia	0.0	11.4	0.0
Nitzschia	91.2	0.0	0.0
CHLOROPHYTA			
Flagellated Chlorophytes			
Coccoid/Colonial Chlorophytes			
Crucigenia	0.0	524.4	0.0
Paulschulzia	0.0	0.0	45.6
Pediastrum	364.8	91.2	0.0
Scenedesmus	182.4	0.0	0.0
Filamentous Chlorophytes			
Desmids			
Closterium	171.0	0.0	0.0
Staurastrum	0.0	22.8	34.2
CHRYSOPHYTA			
Flagellated Classic Chrysophytes			
Dinobryon	205.2	45.6	22.8
Uroglenopsis	0.0	319.2	0.0
Non-Motile Classic Chrysophytes			
Haptophytes			
Tribophytes/Eustigmatophytes			
Centritractus	0.0	22.8	57.0
Raphidophytes			
CRYPTOPHYTA			
Cryptomonas	34.2	57.0	45.6
CYANOPHYTA			
Unicellular and Colonial Forms			
Filamentous Nitrogen Fixers			
Dolichospermum	0.0	0.0	228.0
Filamentous Non-Nitrogen Fixers			
Planktolyngbya	0.0	0.0	3420.0
Planktothrix	2280.0	2280.0	1140.0
EUGLENOPHYTA			
Euglena	11.4	11.4	0.0
Trachelomonas	22.8	22.8	45.6
PYRRHOPHYTA			
Peridinium	11.4	102.6	136.8

PHYTOPLANKTON DENSITY (CELLS/ML)

TAXON	WL2 06/02/21	WL2 07/06/21	WL2 08/03/21
BACILLARIOPHYTA			
DENSITY (CELLS/ML) SUMMARY			
BACILLARIOPHYTA	**2052.0**	**3613.8**	**4024.2**
Centric Diatoms	273.6	0.0	0.0
Araphid Pennate Diatoms	1687.2	3602.4	4024.2
Monoraphid Pennate Diatoms	0.0	0.0	0.0
Biraphid Pennate Diatoms	91.2	11.4	0.0
CHLOROPHYTA	**718.2**	**638.4**	**79.8**
Flagellated Chlorophytes	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes	547.2	615.6	45.6
Filamentous Chlorophytes	0.0	0.0	0.0
Desmids	171.0	22.8	34.2
CHRYSOPHYTA	**205.2**	**387.6**	**79.8**
Flagellated Classic Chrysophytes	205.2	364.8	22.8
Non-Motile Classic Chrysophytes	0.0	0.0	0.0
Haptophytes	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	0.0	22.8	57.0
Raphidophytes	0.0	0.0	0.0
CRYPTOPHYTA	**34.2**	**57.0**	**45.6**
CYANOPHYTA	**2280.0**	**2280.0**	**4788.0**
Unicellular and Colonial Forms	0.0	0.0	0.0
Filamentous Nitrogen Fixers	0.0	0.0	228.0
Filamentous Non-Nitrogen Fixers	2280.0	2280.0	4560.0
EUGLENOPHYTA	**34.2**	**34.2**	**45.6**
PYRRHOPHYTA	**11.4**	**102.6**	**136.8**
TOTAL	**5335.2**	**7113.6**	**9199.8**
CELL DIVERSITY	**0.77**	**0.64**	**0.63**
CELL EVENNESS	**0.67**	**0.54**	**0.58**
NUMBER OF TAXA			
BACILLARIOPHYTA	**5**	**4**	**2**
Centric Diatoms	1	0	0
Araphid Pennate Diatoms	3	3	2
Monoraphid Pennate Diatoms	0	0	0
Biraphid Pennate Diatoms	1	1	0
CHLOROPHYTA	**3**	**3**	**2**
Flagellated Chlorophytes	0	0	0
Coccoid/Colonial Chlorophytes	2	2	1
Filamentous Chlorophytes	0	0	0
Desmids	1	1	1
CHRYSOPHYTA	**1**	**3**	**2**
Flagellated Classic Chrysophytes	1	2	1
Non-Motile Classic Chrysophytes	0	0	0
Haptophytes	0	0	0
Tribophytes/Eustigmatophytes	0	1	1
Raphidophytes	0	0	0
CRYPTOPHYTA	**1**	**1**	**1**
CYANOPHYTA	**1**	**1**	**3**
Unicellular and Colonial Forms	0	0	0
Filamentous Nitrogen Fixers	0	0	1
Filamentous Non-Nitrogen Fixers	1	1	2
EUGLENOPHYTA	**2**	**2**	**1**
PYRRHOPHYTA	**1**	**1**	**1**
TOTAL	**14**	**15**	**12**

PHYTOPLANKTON BIOMASS (UG/L)

TAXON	WL2 06/02/21	WL2 07/06/21	WL2 08/03/21
BACILLARIOPHYTA			
Centric Diatoms			
Aulacoseira	82.1	0.0	0.0
Araphid Pennate Diatoms			
Asterionella	18.2	20.5	0.0
Synedra	1897.0	319.2	875.5
Tabellaria	200.6	2644.8	2836.3
Monoraphid Pennate Diatoms			
Biraphid Pennate Diatoms			
Eunotia	0.0	11.4	0.0
Nitzschia	73.0	0.0	0.0
CHLOROPHYTA			
Flagellated Chlorophytes			
Coccoid/Colonial Chlorophytes			
Crucigenia	0.0	52.4	0.0
Paulschulzia	0.0	0.0	18.2
Pediastrum	73.0	18.2	0.0
Scenedesmus	18.2	0.0	0.0
Filamentous Chlorophytes			
Desmids			
Closterium	684.0	0.0	0.0
Staurastrum	0.0	18.2	27.4
CHRYSOPHYTA			
Flagellated Classic Chrysophytes			
Dinobryon	615.6	136.8	68.4
Uroglenopsis	0.0	31.9	0.0
Non-Motile Classic Chrysophytes			
Haptophytes			
Tribophytes/Eustigmatophytes			
Centritractus	0.0	3.4	8.6
Raphidophytes			
CRYPTOPHYTA			
Cryptomonas	6.8	43.3	41.0
CYANOPHYTA			
Unicellular and Colonial Forms			
Filamentous Nitrogen Fixers			
Dolichospermum	0.0	0.0	45.6
Filamentous Non-Nitrogen Fixers			
Planktolyngbya	0.0	0.0	34.2
Planktothrix	22.8	22.8	11.4
EUGLENOPHYTA			
Euglena	5.7	5.7	0.0
Trachelomonas	22.8	22.8	45.6
PYRRHOPHYTA			
Peridinium	23.9	215.5	287.3

Walker Lake
Project No. 1557-24

Prepared by Aqua Link, Inc.

PHYTOPLANKTON BIOMASS (UG/L)

TAXON	WL2 06/02/21	WL2 07/06/21	WL2 08/03/21
BACILLARIOPHYTA			
BIOMASS (UG/ML) SUMMARY			
BACILLARIOPHYTA	**2270.9**	**2995.9**	**3711.8**
Centric Diatoms	82.1	0.0	0.0
Araphid Pennate Diatoms	2115.8	2984.5	3711.8
Monoraphid Pennate Diatoms	0.0	0.0	0.0
Biraphid Pennate Diatoms	73.0	11.4	0.0
CHLOROPHYTA	**775.2**	**88.9**	**45.6**
Flagellated Chlorophytes	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes	91.2	70.7	18.2
Filamentous Chlorophytes	0.0	0.0	0.0
Desmids	684.0	18.2	27.4
CHRYSOPHYTA	**615.6**	**172.1**	**77.0**
Flagellated Classic Chrysophytes	615.6	168.7	68.4
Non-Motile Classic Chrysophytes	0.0	0.0	0.0
Haptophytes	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	0.0	3.4	8.6
Raphidophytes	0.0	0.0	0.0
CRYPTOPHYTA	**6.8**	**43.3**	**41.0**
CYANOPHYTA	**22.8**	**22.8**	**91.2**
Unicellular and Colonial Forms	0.0	0.0	0.0
Filamentous Nitrogen Fixers	0.0	0.0	45.6
Filamentous Non-Nitrogen Fixers	22.8	22.8	45.6
EUGLENOPHYTA	**28.5**	**28.5**	**45.6**
PYRRHOPHYTA	**23.9**	**215.5**	**287.3**
TOTAL	**3743.8**	**3567.1**	**4299.5**
BIOMASS DIVERSITY	**0.66**	**0.47**	**0.48**
BIOMASS EVENNESS	**0.57**	**0.40**	**0.45**

	06/02/21	07/06/21	08/03/21
BIOMASS (UG/ML) SUMMARY			
BACILLARIOPHYTA	2271	2996	3712
CHLOROPHYTA	775	89	46
CHRYSOPHYTA	616	172	77
CRYPTOPHYTA	7	43	41
CYANOPHYTA	23	23	91
EUGLENOPHYTA	29	29	46
PYRRHOPHYTA	24	215	287

Walker Lake **Prepared by Aqua Link, Inc.**
Project No. 1577-24

Phytoplankton Data

Station	Date	Total Density (cells/ml)	Total Biomass (ug/L)	Cyanobacteria Density (cells/ml)	Cyanobacteria Biomass (ug/L)
WL2	06/07/16	2526.5	1038.5	1240.0	12.4
WL2	07/05/16	22351.0	3569.7	19530.0	725.4
WL2	08/08/16	22940.0	1932.9	21390.0	302.3
WL2	06/06/17	6251.0	12602.7	760.0	79.8
WL2	07/17/17	6555.0	3589.1	1900.0	110.2
WL2	08/15/17	7999.0	5289.6	2850.0	342.0
WL2	06/05/18	18,169.2	7180.1	4,635.0	479.0
WL2	07/11/18	29,854.9	8387.3	26,200.0	1048.0
WL2	08/07/18	176,666.6	7743.4	175,540.0	6314.2
WL2	06/10/19	1305.4	616.1	549.0	109.8
WL2	07/24/19	8721.0	4974.8	2430.0	126.9
WL2	08/27/19	52312.5	1833.3	51165.0	819.5
WL2	06/15/20	3450.6	4736.3	810.0	8.1
WL2	07/15/20	15588.0	5104.2	13200.0	132.0
WL2	08/18/20	19522.8	13823.7	14718.0	1279.7
WL2	06/02/21	5335.2	3743.8	2280.0	22.8
WL2	07/06/21	7113.6	3567.1	2280.0	22.8
WL2	08/03/21	9199.8	4299.5	4788.0	91.2

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Walker Lake
Project No. 1577-24

Prepared by Aqua Link, Inc.

Phytoplankton Data

Station	Date	Total Density (cells/ml)	Total Biomass (ug/L)	Cyanobacteria Density (cells/ml)	Cyanobacteria Biomass (ug/L)
2016	**Min**	2526.5	1038.5	1240.0	12.4
	Max	22940.0	3569.7	21390.0	725.4
	Mean	15939.2	2180.3	14053.3	346.7
	Median	22351.0	1932.9	19530.0	302.3
	Count	3.0	3.0	3.0	3.0
2017	**Min**	6251.0	3589.1	760.0	79.8
	Max	7999.0	12602.7	2850.0	342.0
	Mean	6935.0	7160.5	1836.7	177.3
	Median	6555.0	5289.6	1900.0	110.2
	Count	3.0	3.0	3.0	3.0
2018	**Min**	18169.2	7180.1	4635.0	479.0
	Max	176666.6	8387.3	175540.0	6314.2
	Mean	74896.9	7770.3	68791.7	2613.7
	Median	29854.9	7743.4	26200.0	1048.0
	Count	3.0	3.0	3.0	3.0
2019	**Min**	1305.4	616.1	549.0	109.8
	Max	52312.5	4974.8	51165.0	819.5
	Mean	20779.6	2474.7	18048.0	352.1
	Median	8721.0	1833.3	2430.0	126.9
	Count	3.0	3.0	3.0	3.0
2020	**Min**	3450.6	4736.3	810.0	8.1
	Max	19522.8	13823.7	14718.0	1279.7
	Mean	12853.8	7888.1	9576.0	473.3
	Median	15588.0	5104.2	13200.0	132.0
	Count	3.0	3.0	3.0	3.0
2021	**Min**	5335.2	3567.1	2280.0	22.8
	Max	9199.8	4299.5	4788.0	91.2
	Mean	7216.2	3870.1	3116.0	45.6
	Median	12733.3	3743.8	2280.0	22.8
	Count	3.0	3.0	3.0	3.0
Annual					
Mean	**2016**	15939.2	2180.3	14053.3	346.7
	2017	6935.0	7160.5	1836.7	177.3
	2018	74896.9	7770.3	68791.7	2613.7
	2019	20779.6	2474.7	18048.0	352.1
	2020	12853.8	7888.1	9576.0	473.3
	2021	7216.2	3870.1	3116.0	45.6

ZOOPLANKTON DENSITY (#/L)

TAXON	WL2 06/02/21	WL2 07/06/21	WL2 08/03/21
PROTOZOA			
Ciliophora	5.4	0.0	0.0
Mastigophora	0.0	0.0	0.0
Sarcodina	0.0	0.0	0.0
ROTIFERA			
Asplanchna	0.0	0.0	3.2
Conochilus	0.0	0.0	1.4
Keratella	21.6	5.4	25.4
Polyarthra	68.6	13.5	14.0
Trichocerca	5.4	0.5	4.9
COPEPODA			
Copepoda-Cyclopoida			
Cyclops	0.5	1.6	2.2
Mesocyclops	1.1	1.1	1.1
Copepoda-Calanoida			
Other Copepoda-Nauplii	5.9	12.2	4.1
CLADOCERA			
Bosmina	3.2	0.8	1.9
Ceriodaphnia	0.5	1.1	0.3
Diaphanosoma	0.0	0.3	0.0
OTHER ZOOPLANKTON			
Chaoboridae	0.0	0.0	0.0

ZOOPLANKTON DENSITY (#/L)

TAXON	WL2 06/02/21	WL2 07/06/21	WL2 08/03/21
SUMMARY STATISTICS			
ZOOPLANKTON DENSITY (#/L)			
PROTOZOA	5.4	0.0	0.0
ROTIFERA	95.6	19.4	48.9
COPEPODA	7.6	14.9	7.3
CLADOCERA	3.8	2.2	2.2
OTHER ZOOPLANKTON	0.0	0.0	0.0
TOTAL ZOOPLANKTON	112.3	36.5	58.3
TAXONOMIC RICHNESS			
PROTOZOA	1	0	0
ROTIFERA	3	3	5
COPEPODA	3	3	3
CLADOCERA	2	3	2
OTHER ZOOPLANKTON	0	1	0
TOTAL ZOOPLANKTON	9	10	10
S-W DIVERSITY INDEX	0.55	0.67	0.73
EVENNESS INDEX	0.58	0.67	0.73
MEAN LENGTH (mm): ALL FORMS	0.13	0.23	0.18
MEAN LENGTH: CRUSTACEANS	0.35	0.37	0.42

ZOOPLANKTON BIOMASS (UG/L)

TAXON	WL2 06/02/21	WL2 07/06/21	WL2 08/03/21
PROTOZOA			
Ciliophora	0.5	0.0	0.0
Mastigophora	0.0	0.0	0.0
Sarcodina	0.0	0.0	0.0
ROTIFERA			
Asplanchna	0.0	0.0	4.9
Conochilus	0.0	0.0	0.1
Keratella	1.9	0.5	2.3
Polyarthra	6.2	1.2	1.3
Trichocerca	0.9	0.1	0.8
COPEPODA			
Copepoda-Cyclopoida			
Cyclops	1.3	4.0	5.3
Mesocyclops	1.4	1.4	1.4
Copepoda-Calanoida			
Other Copepoda-Nauplii	15.7	32.2	10.7
CLADOCERA			
Bosmina	3.2	0.8	1.9
Ceriodaphnia	1.4	2.8	0.7
Diaphanosoma	0.0	0.3	0.0
OTHER ZOOPLANKTON			
Chaoboridae	0.0	13.5	0.0

ZOOPLANKTON BIOMASS (UG/L)

TAXON	WL2 06/02/21	WL2 07/06/21	WL2 08/03/21
SUMMARY STATISTICS			
ZOOPLANKTON BIOMASS (UG/L)			
PROTOZOA	0.5	0.0	0.0
ROTIFERA	9.0	1.8	9.3
COPEPODA	18.4	37.5	17.4
CLADOCERA	4.6	3.9	2.6
OTHER ZOOPLANKTON	0.0	13.5	0.0
TOTAL ZOOPLANKTON	32.6	56.7	29.2

Date	Station	Total Density (cells/L)	Protozoa	Rotifera	Copepoda	Cladoceran	Other
07/05/16	WL2	80.8	0.0	44.9	32.3	3.4	0.1
08/08/16	WL2	182.7	0.0	144.9	20.2	17.6	0.0
06/06/17	WL2	132.0	0.0	88.3	7.7	36.0	0.0
07/17/17	WL2	118.9	0.0	63.7	37.2	17.7	0.3
08/15/17	WL2	51.3	0.0	28.5	17.9	4.9	0.0
06/05/18	WL2	48.9	0.0	41.6	6.5	0.8	0.0
07/11/18	WL2	60.9	0.0	58.0	2.1	0.8	0.1
08/07/18	WL2	53.1	0.0	44.7	7.3	1.0	0.0
06/10/19	WL2	179.7	0.0	171.7	6.1	1.9	0.0
07/24/19	WL2	53.5	0.0	36.0	15.4	2.2	0.0
08/27/19	WL2	71.1	0.0	42.7	25.3	3.1	0.0
06/15/20	WL2	78.6	0.0	60.3	16.6	1.6	0.1
07/15/20	WL2	85.8	0.0	57.6	25.5	2.6	0.0
08/18/20	WL2	55.4	0.0	36.8	16.0	2.6	0.0
06/02/21	WL2	112.3	5.4	95.6	7.6	3.8	0.0
07/06/21	WL2	36.5	0.0	19.4	14.9	2.2	0.0
08/03/21	WL2	58.3	0.0	48.9	7.3	2.2	0.0
2016	**Min.**	80.8	0.0	44.9	20.2	3.4	0.0
	Max	182.7	0.0	144.9	32.3	17.6	0.1
	Mean	131.8	0.0	94.9	26.3	10.5	0.1
	Count	2	2	2	2	2	2
2017	**Min.**	51.3	0.0	28.5	7.7	4.9	0.0
	Max	132.0	0.0	88.3	37.2	36.0	0.3
	Mean	100.7	0.0	60.2	20.9	19.5	0.1
	Count	3	3	3	3	3	3
2018	**Min.**	48.9	0.0	41.6	2.1	0.8	0.0
	Max	60.9	0.0	58.0	7.3	1.0	0.1
	Mean	54.3	0.0	48.1	5.3	0.9	0.0
	Count	3	3	3	3	3	3
2019	**Min.**	53.5	0.0	36.0	6.1	1.9	0.0
	Max	179.7	0.0	171.7	25.3	3.1	0.0
	Mean	101.4	0.0	83.5	15.6	2.4	0.0
	Count	3	3	3	3	3	3
2020	**Min.**	55.4	0.0	36.8	16.0	1.6	0.0
	Max	85.8	0.0	60.3	25.5	2.6	0.1
	Mean	73.3	0.0	51.6	19.4	2.3	0.0
	Count	3	3	3	3	3	3
2021	**Min.**	36.5	0.0	19.4	7.3	2.2	0.0
	Max	112.3	5.4	95.6	14.9	3.8	0.0
	Mean	69.0	1.8	54.6	9.9	2.7	0.0
	Count	3	3	3	3	3	3

		Total Density (cells/L)	Protozoa	Rotifera	Copepoda	Cladoceran	Other
Annual	**2016**	131.8	0.0	94.9	26.3	10.5	0.1
Mean WL2	**2017**	100.7	0.0	60.2	20.9	19.5	0.1
	2018	54.3	0.0	48.1	5.3	0.9	0.0
	2019	101.4	0.0	83.5	15.6	2.4	0.0
	2020	73.3	0.0	51.6	19.4	2.3	0.0
	2021	69.0	1.8	54.6	9.9	2.7	0.0

Date	Station	Total Biomass (ug/L)	Protozoa	Rotifera	Copepoda	Cladoceran	Other
07/05/16	WL2	145.7	0.0	7.1	67.6	8.1	63.0
08/08/16	WL2	120.3	0.0	22.9	56.4	20.0	21.0
06/06/17	WL2	67.4	0.0	8.2	21.1	38.1	0.0
07/17/17	WL2	257.8	0.0	8.3	74.1	27.9	147.5
08/15/17	WL2	56.9	0.0	2.9	45.9	8.1	0.0
06/05/18	WL2	27.2	0.0	3.9	16.8	0.9	5.6
07/11/18	WL2	41.6	0.0	7.4	5.0	0.8	28.3
08/07/18	WL2	41.1	0.0	5.3	18.3	1.0	16.5
06/10/19	WL2	29.9	0.0	8.8	13.6	3.1	4.4
07/24/19	WL2	42.6	0.0	4.1	29.9	3.0	5.5
08/27/19	WL2	68.3	0.0	2.3	59.3	5.2	1.7
06/15/20	WL2	80.2	0.0	5.1	47.2	2.0	26.0
07/15/20	WL2	96.7	0.0	5.8	65.8	3.1	22.0
08/18/20	WL2	63.3	0.0	2.3	38.1	2.9	20.0
06/02/21	WL2	32.6	0.5	9.0	18.4	4.6	0.0
07/06/21	WL2	56.7	0.0	1.8	37.5	3.9	13.5
08/03/21	WL2	29.2	0.0	9.3	17.4	2.6	0.0
2016	**Min.**	120.3	0.0	7.1	56.4	8.1	21.0
	Max	145.7	0.0	22.9	67.6	20.0	63.0
	Mean	133.0	0.0	15.0	62.0	14.0	42.0
	Count	2	2	2	2	2	2
2017	**Min.**	56.9	0.0	2.9	21.1	8.1	0.0
	Max	257.8	0.0	8.3	74.1	38.1	147.5
	Mean	127.4	0.0	6.5	47.0	24.7	49.2
	Count	3	3	3	3	3	3
2018	**Min.**	27.2	0.0	3.9	5.0	0.8	5.6
	Max	41.6	0.0	7.4	18.3	1.0	28.3
	Mean	36.6	0.0	5.5	13.4	0.9	16.8
	Count	3	3	3	3	3	3
2019	**Min.**	29.9	0.0	2.3	13.6	3.0	1.7
	Max	68.3	0.0	8.8	59.3	5.2	5.5
	Mean	46.9	0.0	5.1	34.3	3.8	3.9
	Count	3	3	3	3	3	3
2020	**Min.**	63.3	0.0	2.3	38.1	2.0	20.0
	Max	96.7	0.0	5.8	65.8	3.1	26.0
	Mean	80.1	0.0	4.4	50.4	2.6	22.7
	Count	3	3	3	3	3	3
2021	**Min.**	29.2	0.0	1.8	17.4	2.6	0.0
	Max	56.7	0.5	9.3	37.5	4.6	13.5
	Mean	39.5	0.2	6.7	24.4	3.7	4.5
	Count	3	3	3	3	3	3

		Total Biomass (ug/L)	Protozoa	Rotifera	Copepoda	Cladoceran	Other
Annual	**2016**	133.0	0.0	15.0	62.0	14.0	42.0
Mean WL2	**2017**	127.4	0.0	6.5	47.0	24.7	49.2
	2018	36.6	0.0	5.5	13.4	0.9	16.8
	2019	46.9	0.0	5.1	34.3	3.8	3.9
	2020	80.1	0.0	4.4	50.4	2.6	22.7
	2021	39.5	0.2	6.7	24.4	3.7	4.5