Swan Lake Phytoplankton Summary Report 2021-2022

Overview

Samples were collected from one site on Swan Lake during 2021 and 2022 (Figure 1; Table 1). Algae were identified to the taxonomic level genus and grouped into broad alga types for analysis.

Table 1: Sample sites and dates sampled in 2021 and 2022

Sample Site (EMS#)	Dates
SWAN L CENTER DEEP STN. (0400935)	2021-06-01
	2021-08-25
	2022-05-25
	2022-08-09
	Total= 4 samples

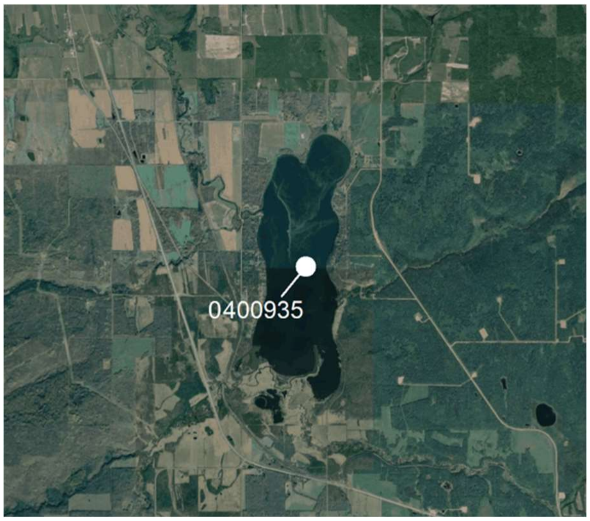

Figure 1: Aerial view of Swan Lake

Samples contained low concentrations of diatoms, green algae, and dinoflagellates. Dominant diatom genera included *Aulacoseira* and *Stephanodiscus*. Summer samples contained very high concentrations of cyanobacteria. Blooming cyanobacteria in Swan Lake can produce toxins.

Spring samples contained higher concentrations of detritus and lower concentrations of cyanobacteria relative to summer samples (Figure 2). Elevated quantities of suspended debris can affect the health and aesthetics of a water system. Particulates in the water column can cause cloudy hues and provide attachment zones for pollutants; notably metals and bacteria (Water Science School et al., 2018). Turbidity spikes during the spring are common due to elevated wind, rain, erosion, and runoff events (Card et al., 2014). Suspended materials can include clay, silt, organic and inorganic matter, algae, dissolved color compounds, and bacteria (Card et al., 2014).

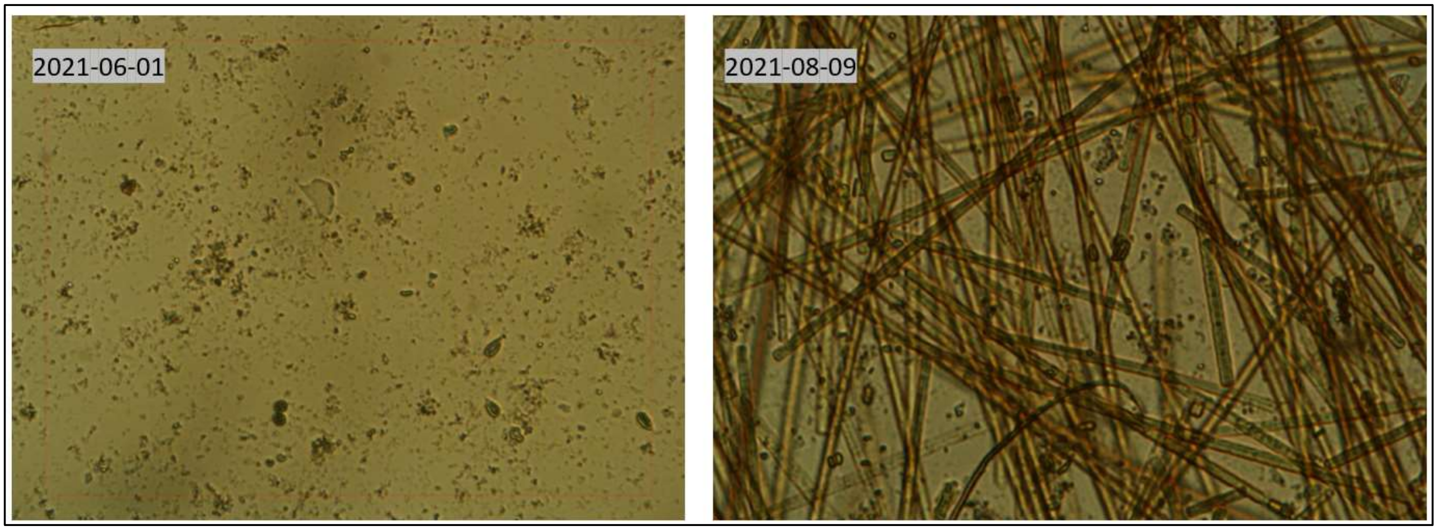

Figure 2: Contrasting algal community composition in the spring (high concentrations of detritus) vs. summer (dense cyanobacteria bloom)

Overview (continued)

Cyanobacteria often dominate algae counts, but because of their small cell size cyanobacteria biovolume is typically low relative to other agal types. The large total biovolume of *Aphanizomenon flos-aquae* (96%; cyanobacteria) reflects its dominance in Swan Lake (Figure 3).

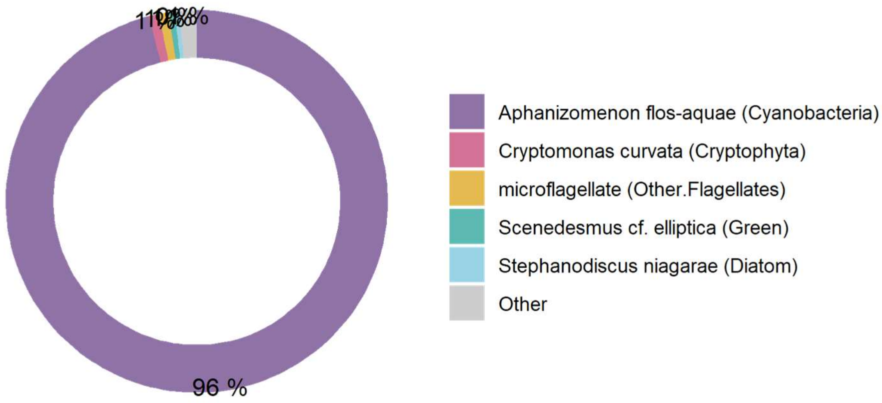

Figure 3: Dominant organisms from Swan L Center Deep Stn. (0400935) as percent of total biovolume

Spring samples contained low algae concentrations. Summer samples contained large blooms of *Aphanizomenon flos-aquae* (Figure 3). The scale of cyanobacterial blooms recorded in Swan Lake could be reflective of nutrient imbalances.

Methods of algae identification involves settling 50 mL of a shaken sample in a Utermohl chamber. 50 mL of samples containing *Aphanizomenon flos-aquae* were too dense to read and methods had to be adjusted to 10 mL for identification (Figure 4). Adjustment of methods also reflects the density of cyanobacteria present.

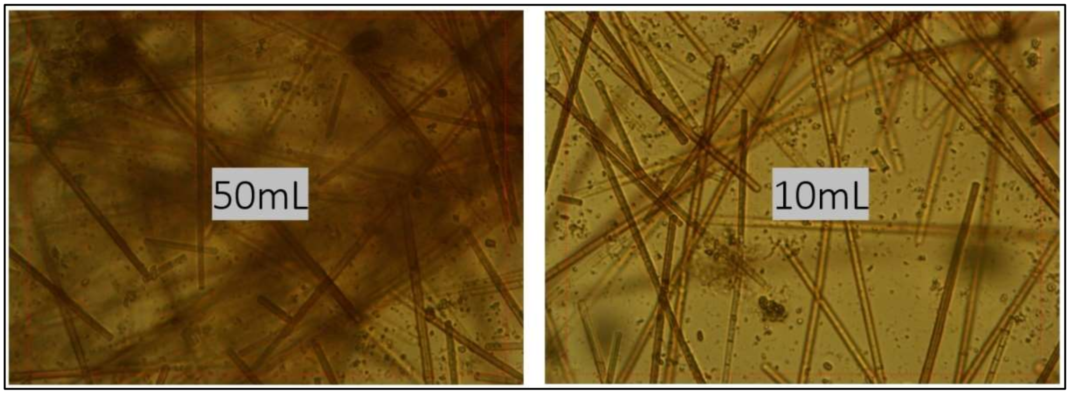

Figure 4: Comparison of EMS site#400935 collected on 2022-08-09; 50mL vs 10mL settled

Algae – why should we care?

Algae blooms are becoming more frequent and severe worldwide due to excessive nutrient loading and warming summer lake temperatures. Diatom blooms can cause filter clogging, and odor issues.

Intense cyanobacteria blooms can threaten human safety and aquatic health through their toxicity. Illness related to cyanotoxins can include liver, kidney, and nerve cell damage, cancer, skin and gut irritation, and neurological issues. Cyanotoxins, including microcystins, are now known to accumulate in the food chain (Lance et al. 2014). Fish from lakes with heavy cyanobacteria blooms can have higher toxin concentrations than the lake water (Greer et al. 2021) and consuming them can increase the risk of liver disease (Zhao et al., 2020).

Cyanobacterial Presence

Spring contained low concentrations of cyanobacteria relative to summer (Figure 5). *Aphanizomenon flos-aquae* dominated all summer counts but, *Pseudoanabaena* and *Anabaena* species were also observed (Figure 5). Cyanobacterial concentrations in Swan Lake represented very high risk to public health on 2022-08-09 (Figure 5; Table 2; Figure 6).

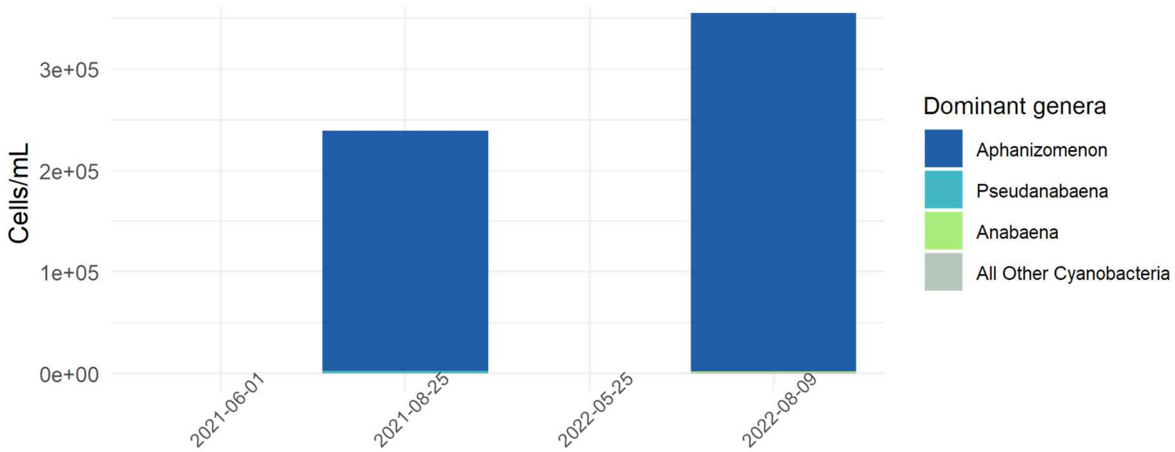

Figure 5: cell abundance for dominant cyanobacteria genera on Swan Lake

During blooms, species of *Aphanizomenon* produce both negative odor/taste compounds and toxic secondary metabolites (EPA, 2022). *Aphanizomenon* is a filamentous, nitrogen-fixing cyanobacteria capable of forming dense, odorous, and toxic blooms. *Aphanizomenon* cells can produce liver toxins, nerve toxins, and skin irritants upon cell lysis (Cirés & Ballot, 2016). Other dominant cyanobacteria identified in the summer samples are also associated with several cyanotoxins that represent risks to public health (Table 2). Illness related to cyanotoxins can include: liver, kidney, and nerve cell damage, cancer, skin and gut irritation, and neurological issues (Lance et al., 2014).

Table 2: Dominant genera of cyanobacteria on Swan Lake and their associated toxins

Genus	Maximum Abundance* (Cells/mL)	Toxins Produced
Aphanizomenon	353072	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Cylindospermopsin CYN, Microcystin MC, Anatoxins (-a) ATX, Saxitoxins SAX neosaxitoxin NEO, BMAA, Anabaenopeptins APT, Taste and Odor
Pseudanabaena	2504	Lyngbyatoxin LYN, Lipopolysaccharide LPS, Microcystin MC, Anatoxins (-a) ATX, BMAA, Taste and Odor
Anabaena	1138	Lyngbyatoxin LYN, Apoptogen Toxin (ApopTX), Lipopolysaccharide LPS, Cylindospermopsin CYN, Microcystin MC, Anatoxins (-a) ATX, Saxitoxins SAX neosaxitoxin NEO, BMAA, Cyanopeptolins CPL, Anabaenopeptins APT, Taste and Odor

Note: * = counted in samples

Cyanobacterial Presence (Continued)

Dominant species of cyanobacteria identified in Swan Lake can produce cyanotoxins (Table 2).

Swan Lake displayed a range of cyanobacteria levels from negligible to high risk depending on the season, with a mean cyanobacteria abundance of 148,606 cells/mL (Figure 6). Figure 6 exhibits the range of cyanobacterial abundance observed in Swan Lake as compared to alert levels defined by authorities including the WHO and EPA.

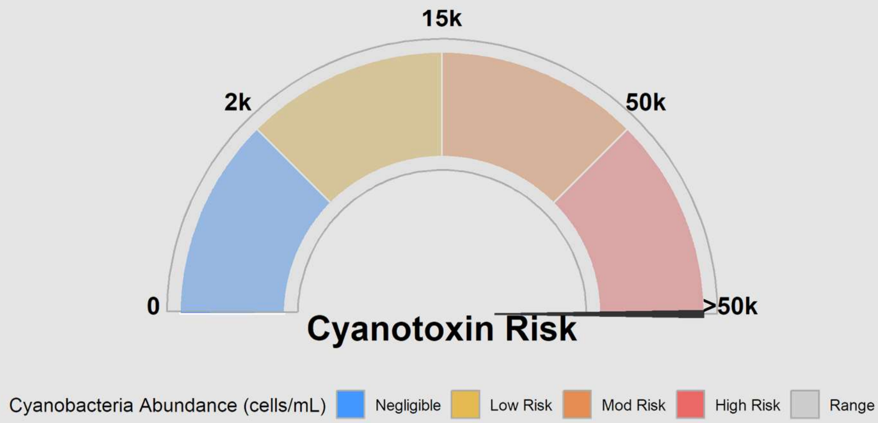

Figure 6: Cyanotoxin risk posed by cyanobacteria blooms in Swan Lake

Cyanobacteria frequently dominate algal communities in total cell count, but because of their small cell size their biovolume is usually low relative to the other types of algae present (Figure 7). The cyanobacterial blooms in Swan Lake were so dense that they dominated biovolume. Due the monocultural nature of Swan Lake's algae community, the cell abundance and biovolume figures both highlight cyanobacteria as the dominant algae (Figure 8; Figure 9).

Figure 7: Size comparison of Crytomonas flagellate (green box) to Aphanizomenon cell (blue box)

Species Composition

Algae samples were identified to the genus level and grouped into broad alga types for analysis. The figures below display the total cell counts for each broad algae group alongside their biovolume. Note the dominance of cyanobacteria in both Figure 8 (cell abundance) and Figure 9 (biovolume).

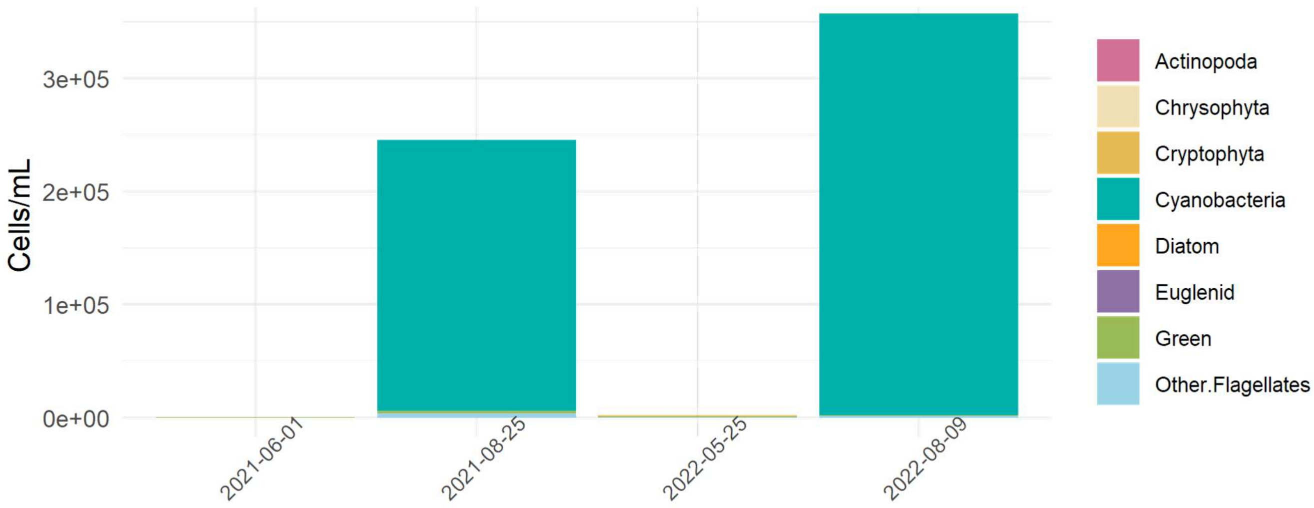

Figure 8: Cell abundance of high-level taxa groups on Swan Lake

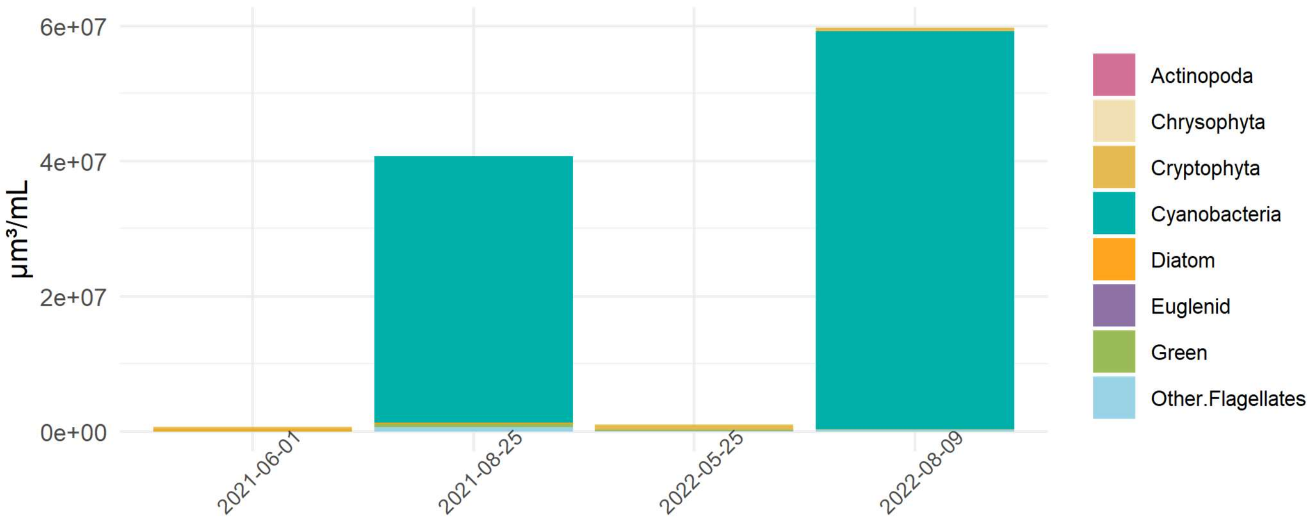

Figure 9: Biovolume of high-level taxa groups on Swan Lake

References

Card, A., Fitch, K., Kelly, D., Kemker, C., & Rose, K. (2014, June 13). *Turbidity, Total Suspended Solids & Water Clarity*. FONDRIEST.

Cirés, S., & Ballot, A. (2016). A review of the phylogeny, ecology and toxin production of bloom-forming Aphanizomenon spp. and related species within the Nostocales (cyanobacteria). *Harmful Algae*, *54*, 21–43. https://doi.org/10.1016/j.hal.2015.09.007

EPA. (2022, September). *Learn about Cyanobacteria and Cyanotoxins*. United States Environmental Protection Agency.

Lance, E., Petit, A., Sanchez, W., Paty, C., Gérard, C., & Bormans, M. (2014). Evidence of trophic transfer of microcystins from the gastropod Lymnaea stagnalis to the fish Gasterosteus aculeatus. *Harmful Algae*, *31*, 9–17. https://doi.org/10.1016/J.HAL.2013.09.006

Water Science School, Swanson, H. A., & Baldwin, H. L. (2018, June 18). *Turbidity and Water* . USGS.

Zhao, Y., Yan, Y., Xie, L., Wang, L., He, Y., Wan, X., & Xue, Q. (2020). Long-term environmental exposure to microcystins increases the risk of nonalcoholic fatty liver disease in humans: A combined fisher-based investigation and murine model study. *Environment International*, *138*, 105648. https://doi.org/10.1016/J.ENVINT.2020.105648

Report prepared by: Larratt Aquatic Consulting Ltd.

Stephanie Butt: Taxonomist, H. B.Sc., BIT.

Jamie Self: Senior Aquatic Biologist, R.P. Bio

Reviewed by:

Sara Knezevic: Field Biologist, B.Sc., BIT.

Appendix

Additional figures and raw data are listed below:

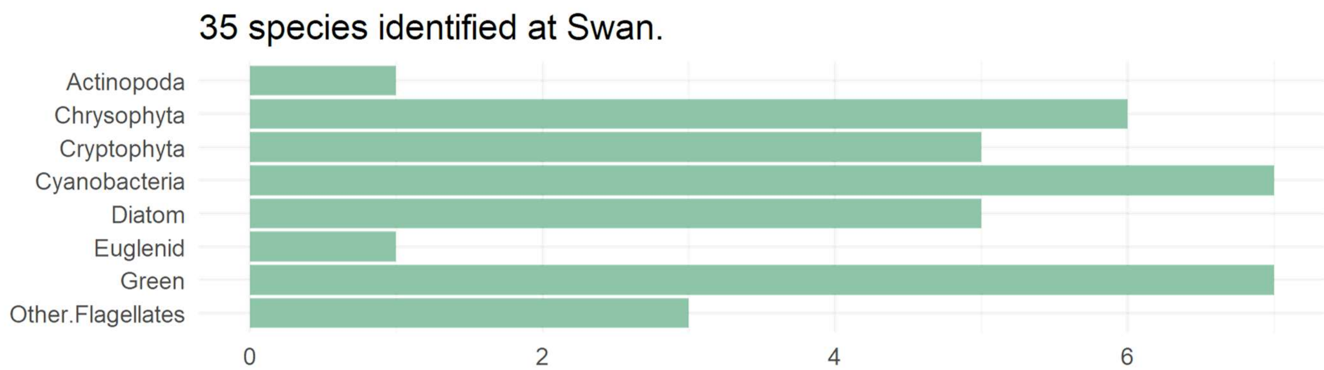

Figure 10: Identified species sorted into categories of higher-level taxa

EMS ID: 0400935	**Total Abundance (cells/mL):**	**483**		
Collection Date: 2021-06-01	**Total Biovolume (µm³/mL):**	**675212**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Mallomonas sp.	11	33267	Chrysophyta	1598
Chrysococcus sp.	4	1328	Chrysophyta	1751
Cryptomonas curvata	27	170098	Cryptophyta	10635
Cryptomonas ovata	38	82684	Cryptophyta	10635
Cryptomonas marssonii	34	69424	Cryptophyta	10635
Rhodomonas lacustris	19	2063	Cryptophyta	10663
Aphanizomenon flos-aquae	30	4995	Cyanobacteria	1191
Aulacoseira granulata	190	62496	Diatom	590863
Asterionella formosa	30	20890	Diatom	3116
Stephanodiscus niagarae	19	199524	Diatom	2415
Paranema sp.	27	16103	Euglenid	
Ankistrodesmus falcatus	19	2686	Green	5877
Schroederia setigera	27	6871	Green	
UID flagellate	8	2783	Other.Flagellates	

Figure 11: Raw data from 2021-06-01 EMS site 0400935

EMS ID: 0400935	**Total Abundance (cells/mL):**	**245438**		
Collection Date: 2021-08-25	**Total Biovolume (µm³/mL):**	**40829518**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Chrysococcus sp.	38	12617	Chrysophyta	1751
Dinobryopsis sp.	38	10207	Chrysophyta	1557
Rhodomonas lacustris	95	10315	Cryptophyta	10663
Aphanizomenon flos-aquae	236216	39331006	Cyanobacteria	1191
Pseudanabaena minima	2504	78024	Cyanobacteria	1175
Planktolyngbya sp.	342	4251	Cyanobacteria	
Stephanodiscus niagarae	19	199524	Diatom	2415
Ankistrodesmus falcatus	19	2686	Green	5877
Tetraedron minimum	76	9348	Green	5661
Scenedesmus cf. elliptica	2201	513643	Green	6104
microflagellate	3871	651288	Other.Flagellates	
UID flagellate	19	6609	Other.Flagellates	

Figure 12: Raw data from 2021-08-25 EMS site 0400935

EMS ID: 0400935	**Total Abundance (cells/mL):**	**2088**		
Collection Date: 2022-05-25	**Total Biovolume (µm³/mL):**	**1057552**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Actinophryida	19	3197	Actinopoda	
Chrysochromulina sp.	19	731	Chrysophyta	2160
Cryptomonas sp.	38	70378	Cryptophyta	10635
Cryptomonas curvata	57	359097	Cryptophyta	10635
Cryptomonas ovata	95	206709	Cryptophyta	10635
Cryptomonas marssonii	19	38796	Cryptophyta	10635
Rhodomonas lacustris	854	92725	Cryptophyta	10663
Synechocystis sp.	38	1273	Cyanobacteria	799
Nitzschia acicularis	57	45003	Diatom	5070
Nitzschia palea	38	7987	Diatom	5070
Ankistrodesmus falcatus	19	2686	Green	5877
Monoraphidium fontinale	95	62938	Green	5990
Schroederia setigera	19	4835	Green	
Didymocystis fina	152	40948	Green	55858
Chlamydomonas sp.	57	34106	Green	5448
microflagellate	512	86143	Other.Flagellates	

Figure 13: Raw data from 2022-05-25 EMS site 0400935

EMS ID: 0400935	**Total Abundance (cells/mL):**	**358044**		
Collection Date: 2022-08-09	**Total Biovolume (µm³/mL):**	**59836952**		
Report.Name	**Abundance (cells/mL)**	**Biovolume (µm³/mL)**	**High.Level.Taxa**	**ITIS Genus Number**
Chrysochromulina sp.	95	3654	Chrysophyta	2160
Chromulina sp.	38	67152	Chrysophyta	1717
Dinobryon spp.	19	30143	Chrysophyta	1515
Ochromonas sp.	247	52875	Chrysophyta	1455
Cryptomonas sp.	38	70378	Cryptophyta	10635
Cryptomonas curvata	57	359097	Cryptophyta	10635
Rhodomonas lacustris	190	20630	Cryptophyta	10663
Anabaena sp.	1138	85326	Cyanobacteria	1100
Anacystis sp.	930	1770	Cyanobacteria	609
Aphanizomenon flos-aquae	353072	58788045	Cyanobacteria	1191
Microcystis sp.	285	2332	Cyanobacteria	747
Synechocystis sp.	38	1273	Cyanobacteria	799
Pseudanabaena limnetica	114	10476	Cyanobacteria	1175
Schroederia setigera	19	4835	Green	
Didymocystis fina	417	112336	Green	55858
microflagellate	1347	226630	Other.Flagellates	

Figure 14: Raw data from 2022-08-09 EMS site 0400935