City of Bonney Lake

Volunteer Lake Monitoring Program

Introduction

The City of Bonney Lake's volunteer lake monitoring program began in 2004 with the goal of collecting data to establish long-term trends in lake water quality, encourage lake stewardship through participation in the lake monitoring program, and provide information on Lake Bonney and Lake Debra Jane that will be helpful in making appropriate management decisions. While conditions may vary from year to year, long-term data collection is the key to tracking trends in water quality over time. This report contains a summary of the data collected during the 2019 lake monitoring season (May – October). Lake Bonney and Debra Jane volunteers participated in a lake refresher training in April, and eleven volunteers contributed 72 hours of volunteer time to sample the lakes monthly.

Lake Bonney is a 17-acre lake with a maximum depth of 20 feet, and Lake Debra Jane is a 19-acre lake with a maximum depth of less than 10 feet. Both lakes are in the Puyallup River watershed within the city limits of Bonney Lake.

Monitoring Program

Water chemistry and physical characteristics of lakes vary both seasonally and with depth. Lake volunteers collected physical data (water transparency, water color, weather conditions, lake level), recorded observations of lake conditions, measured temperature and dissolved oxygen, and collected water samples for chemical analysis (total phosphorus, chlorophyll *a*) on a monthly basis beginning in early May and ending in late October.

Measurements of temperature and dissolved oxygen were made throughout the water column at the deepest point in both lakes. The "shallow" samples for total phosphorus and chlorophyll *a* analysis were collected one meter below the surface of the lake in both lakes. Additional "deep" samples for total phosphorus were collected one meter above the bottom in Lake Bonney; deep samples were not collected in Lake Debra Jane, a shallow lake. Field data and lab results for both lakes collected in 2019 can be found in Table 1.

Dissolved Oxygen and Water Temperature Profiles

With the onset of warmer weather in spring and early summer, deep lakes will begin to separate into a warmer, low-density layer at the surface, known as the epilimnion, and a cooler, high-density layer at the bottom, known as the hypolimnion. Between the epilimnion and the hypolimnion is a layer of rapidly changing temperature called the thermocline. This process is called thermal stratification. Once this condition is fully developed, in summer, there is very little vertical mixing of the upper and lower layers because of their density differences.

The vertical profiles of temperature and dissolved oxygen are similar during stratification (see figure 1 & figure 2); warmer water with abundant oxygen near the surface, and cooler water with declining or no oxygen at depth. A well oxygenated epilimnion is usually the result of the diffusion of oxygen from the atmosphere and the presence of algae that generate oxygen as a byproduct of photosynthesis. A hypolimnion with reduced or no oxygen is the result of the decomposition of organic matter that settles into that layer. These conditions occur despite the general rule that, all other factors being equal, cold water can hold more dissolved oxygen than warm water.

With the onset of cooler weather in the fall, the separation of thermal layers begins to break down and the shallow and deep layers of water begin to mix vertically once again. This phenomenon is usually called turnover.

This year the temperature and dissolved oxygen profiles show that stratification of Lake Bonney was well underway in early May (blue line). Turnover was complete by late October (green line) with the temperature profile almost uniform from top to bottom (see Figure 1). The dissolved oxygen profiles are similar to temperature profiles (Figure 2). However, Lake Bonney is a relatively shallow lake and may not remain stratified throughout the summer; it could mix on windy and stormy days. This year's temperature and dissolved oxygen profiles are similar to those of previous years.

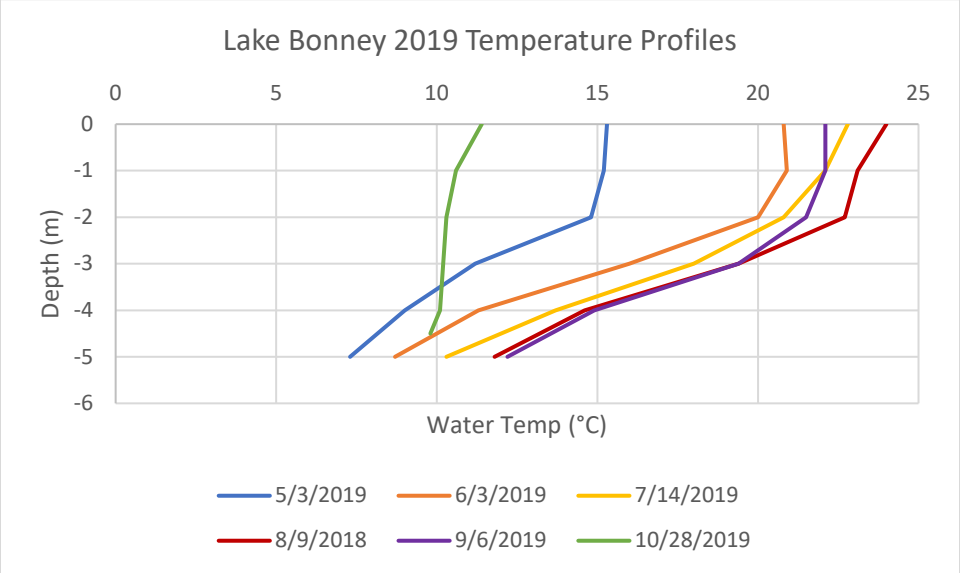


Figure 1.

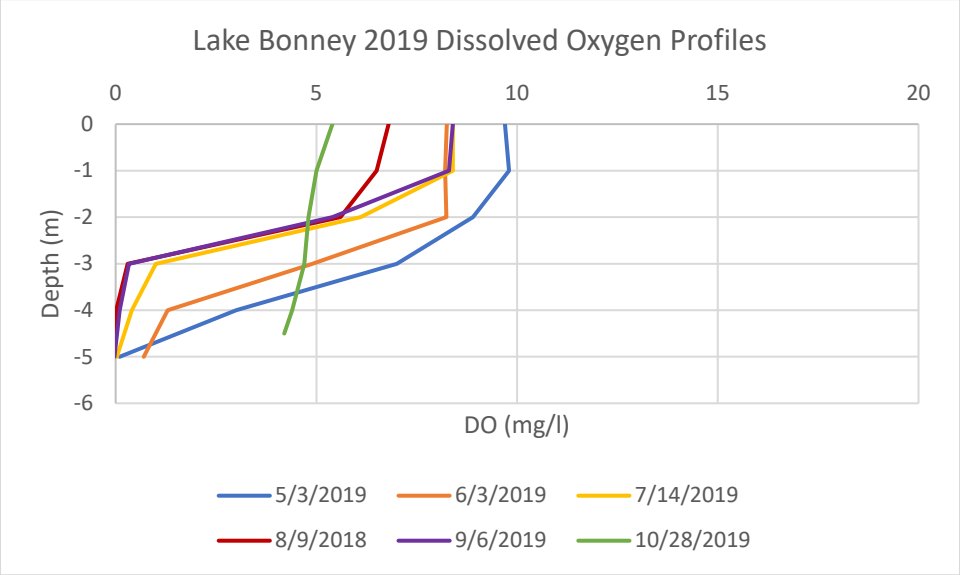


Figure 2.

Lake Debra Jane is a very shallow lake and therefore its temperature and dissolved oxygen profiles show very little if any stratification (see Figure 3 & 4).

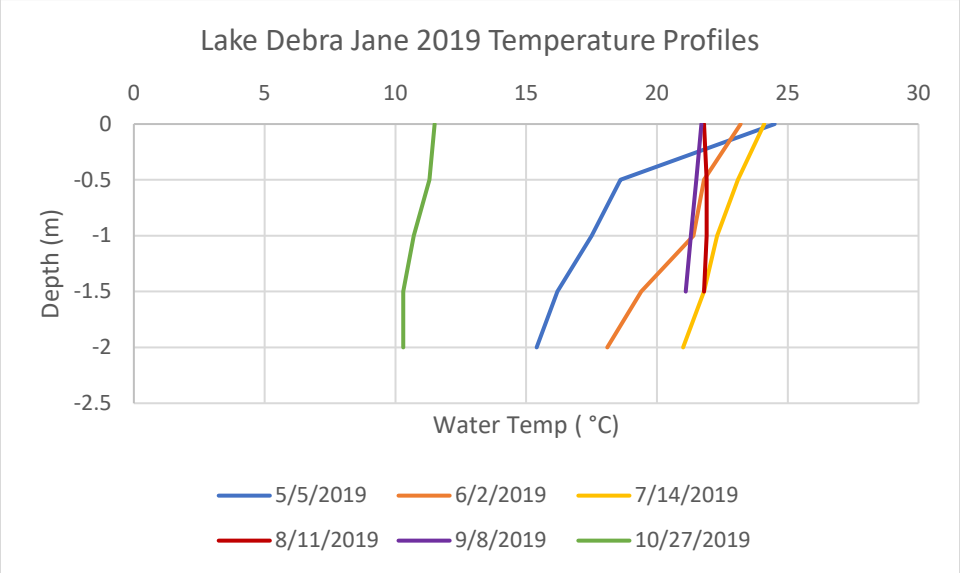


Figure 3.

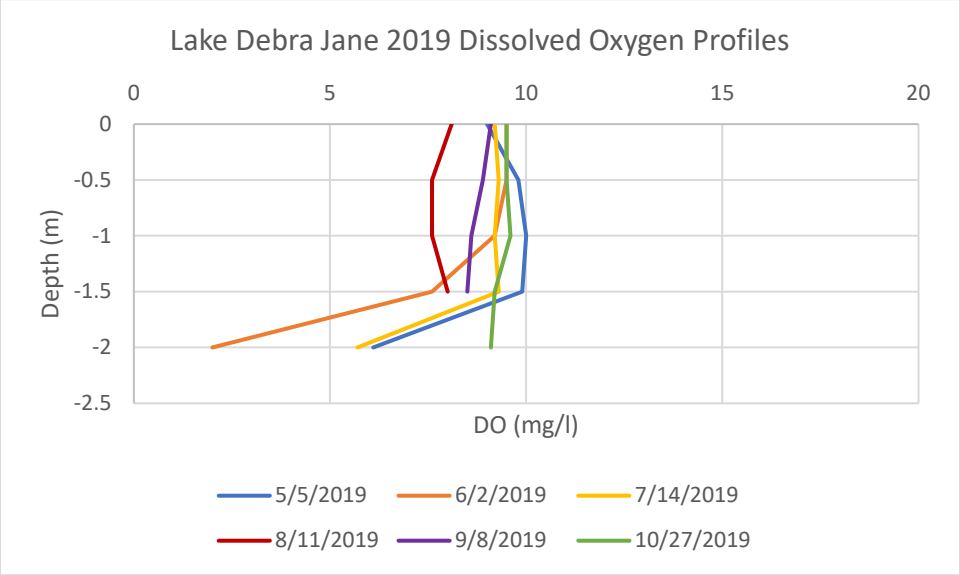


Figure 4.

Lake Levels

Lake levels are dependent on inflows and outflows of water and vary both seasonally and year to year. While precipitation and evaporation are the main cause of fluctuating lake levels, they are also influenced by watershed area, land uses in the watershed, vegetation types and cover, presence of wetlands, geology, surface and subterranean hydrology, and type of outflow structure (if present). The source and composition of the water flowing into lakes impacts the water quality of the lake. Lake monitors record lake levels each sampling session.

Both Lake Bonney and Lake Debra Jane show a typical lake-level fluctuation pattern of highest levels in spring, with a decline throughout the summer, to a seasonal low in fall just before the rains begin. The change observed in lake levels in Lake Bonney during the 2019 monitoring season was 1.78 feet. The change observed in lake levels in Lake Debra Jane in 2018 was 1.2 feet. Both lakes exhibited their lowest lake levels in September. Lake levels for both lakes for all monitored years are presented below in Figure 5. While Lake Bonney levels did not drop as much in 2019 as the last three years, the lake level was lower at the start of the season than the previous three years. Lake Debra Jane residents report that lake levels in Debra Jane are seasonally augmented with well-water. As in Lake Bonney, lake levels in Lake Debra Jane did not decline as much as the previous several years, but the lake level started the season lower than in previous years.

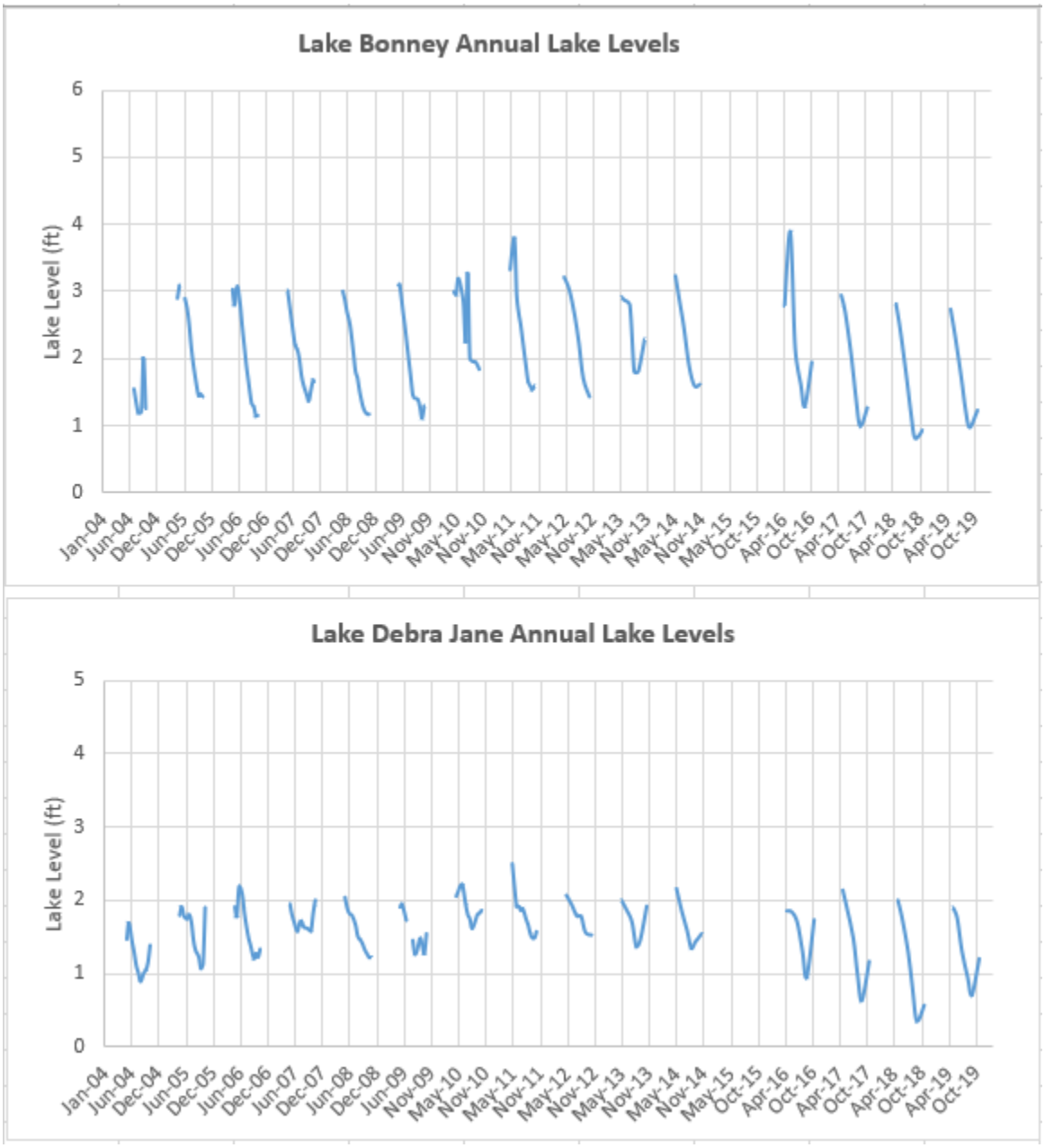


Figure 5.

Water Clarity

Water clarity is measured using a black-and-white secchi disk and is a measure of how deep one can see into the lake. This measurement is reported as secchi depth. Clarity is affected by the amount of algae, sediment particles, and by water color. Lakes with higher secchi depth readings (clearer water) usually have lower amounts of algae while lakes with lower secchi depth readings (cloudier water) usually have more algae present.

Secchi depth measurements observed in the 2019 monitoring season for Lake Bonney ranged from 1.3 to 2.4 meters with greater transparency occurring in spring. Secchi depths were shallower (cloudier

water) in 2019 than in previous years. The summer averages for secchi depths over the years of data collection are shown below in Figure 6.

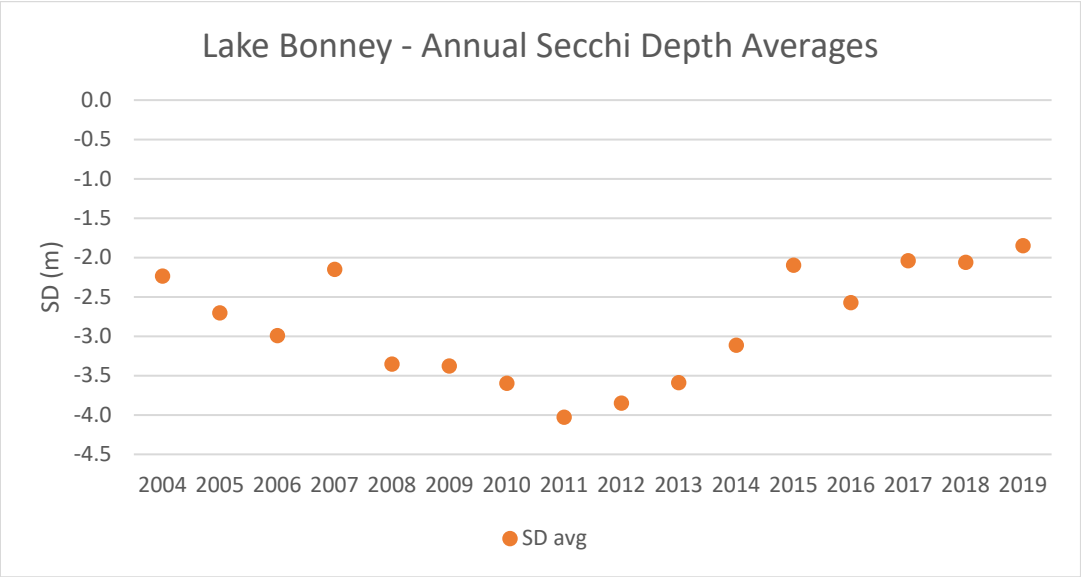


Figure 6.

Secchi depth measurements observed in the 2019 monitoring season for Lake Debra Jane ranged from 1.4 meters to 2.7 meters, with greater transparency occurring in spring. Secchi depths in Debra Jane in 2019 were deeper (clearer water) than the last several years. The summer averages for secchi depths over the years of data collection are shown below in Figure 7.

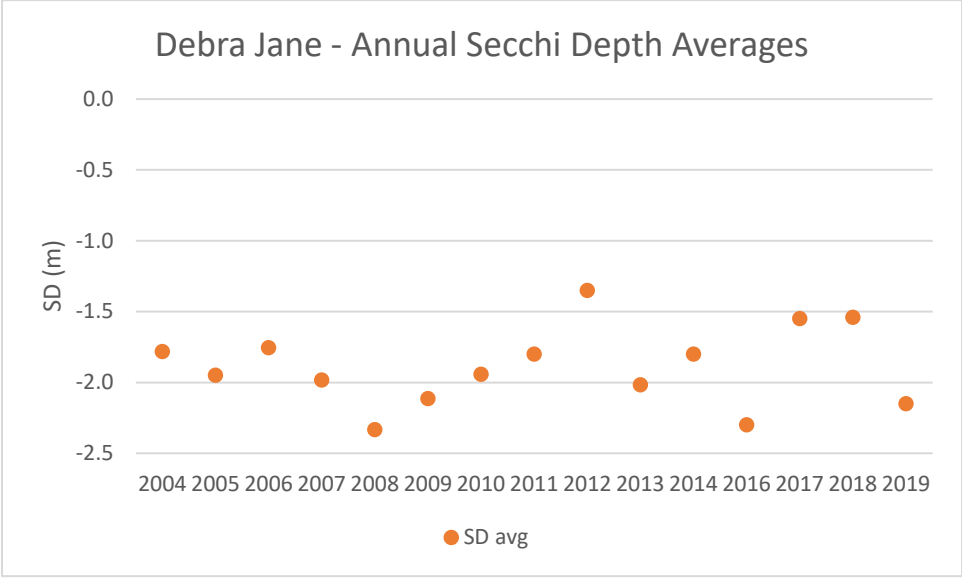


Figure 7.

Nutrients

Nutrients in lakes are essential for the growth of algae and aquatic plants. Phosphorus and nitrogen are the key nutrients in a lake system. In many lakes, phosphorus is the limiting nutrient in the system, which means it is only available to plants and algae in very limited quantities. Once the limited supply of phosphorus is exhausted, the algal population will stop expanding.

In lakes that are deep enough to stratify in summer, total phosphorus concentrations in the hypolimnion increase and remain higher than in the epilimnion until the time of turnover in the fall. This increase in phosphorus in the hypolimnion is caused in large part by the decomposition of phosphorus-rich organic matter at depth, a process that also consumes any oxygen present. Once oxygen is depleted or very low, phosphorus is typically released from the bottom sediments. When vertical mixing eventually occurs in the lake, usually in the fall, the high phosphorus load in the hypolimnion is brought to the epilimnion. With this influx of phosphorus, algal populations in that layer can increase to the point of producing an algal bloom.

The total phosphorus concentrations of the shallow samples for Lake Bonney ranged from 22 µg/l to 384 µg/l, and are higher than those observed in previous years. It was also noted that the shallow and deep total phosphorus samples for August may have accidentally been switched. The shallow total phosphorus summer averages for the years of data collection are shown below in Figure 8.

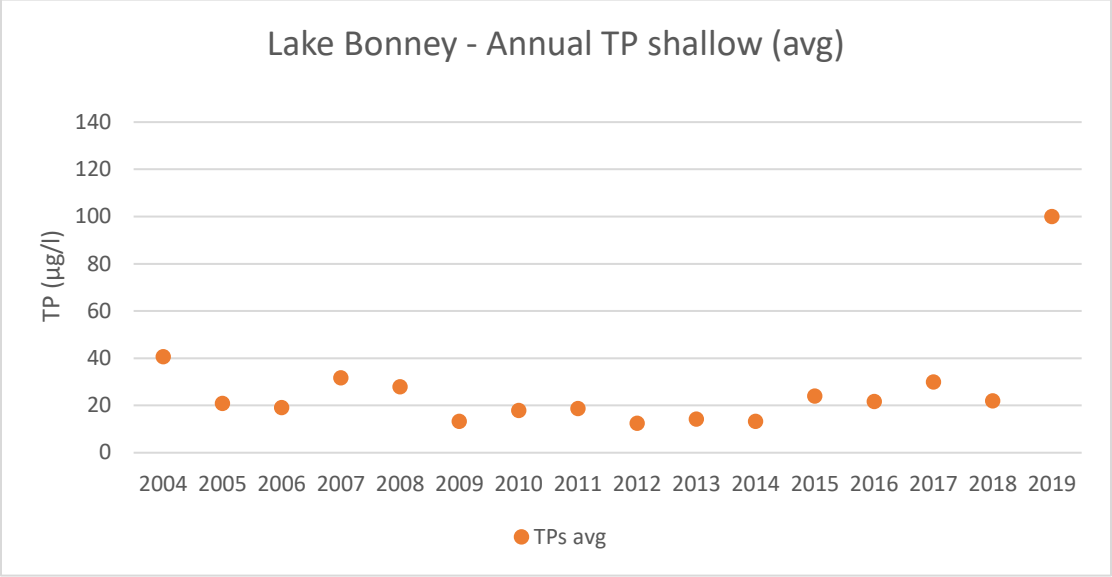


Figure 8.

Deep samples for total phosphorus analysis were collected 2 times (early, mid) during the sampling season in Lake Bonney. Total phosphorus concentrations ranged from 123 µg/l to 147 µg/l; higher than the previous two years. The summer averages for total phosphorus concentrations of deep samples are found in Figure 9 below.

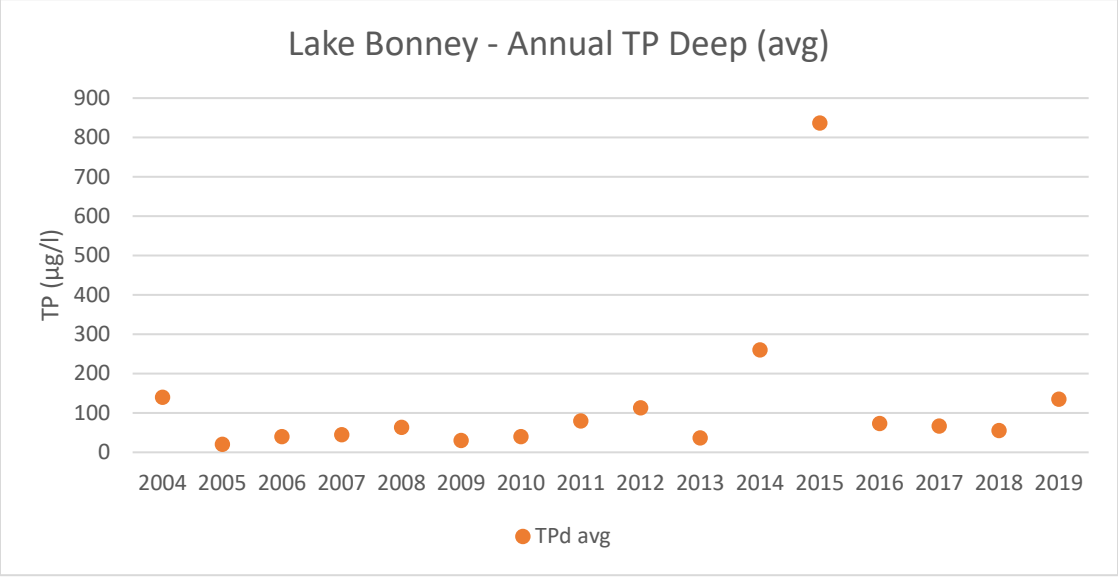


Figure 9.

The total phosphorus concentrations in shallow samples from Lake Debra Jane ranged from below detection levels to 41 µg/l. The total phosphorus concentrations in 2019 are lower than 2018, and similar to 2017 and 2016 results. The summer averages for total phosphorus concentrations in Lake Debra Jane over the years of data collection are shown below in Figure 10. Deep samples are not collected in Lake Debra Jane due to the shallow nature of the lake.

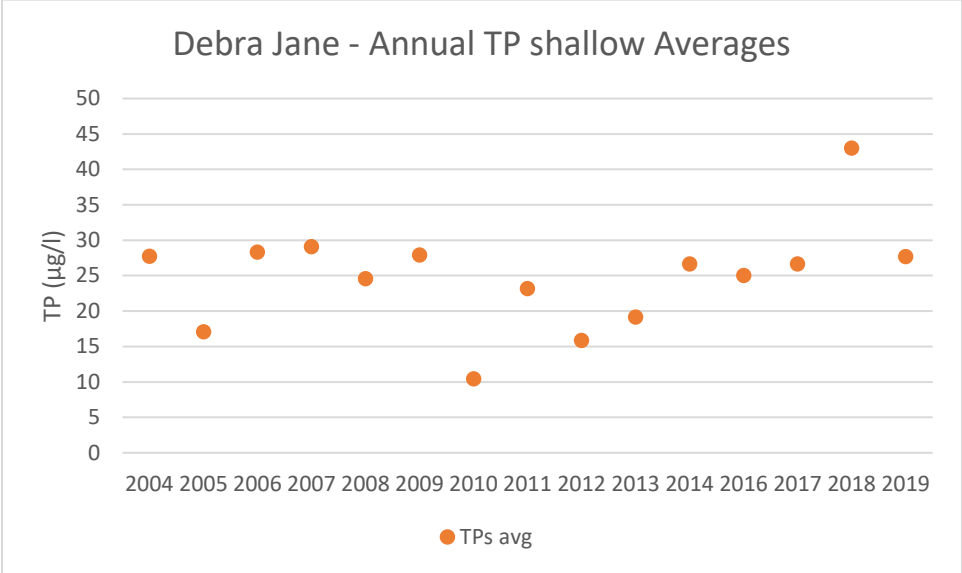


Figure 10.

Chlorophyll *a*

Chlorophyll *a* is one of the green pigments found in nearly all algae. The concentration of chlorophyll *a* is commonly used to estimate algal biomass and to measure the productivity (trophic state – how much life it supports) of the lake. Test results must be interpreted carefully, however, because chlorophyll *a* levels can be variable in time and space. In addition, various species of algae contain differing amounts

of chlorophyll per cell. The amount of chlorophyll can also vary with the health and age of the algal population, as well as with weather conditions. Also, algae typically concentrate at different levels in the water column in response to preferred light and temperature conditions, thereby escaping collection.

Chlorophyll *a* results for shallow samples collected in Lake Bonney varied from 4.8 mg/m^3 to 41.1 mg/m^3. The 2019 chlorophyll *a* results are higher than the previous three years. Summer averages for chlorophyll *a* results are shown below in Figure 11.

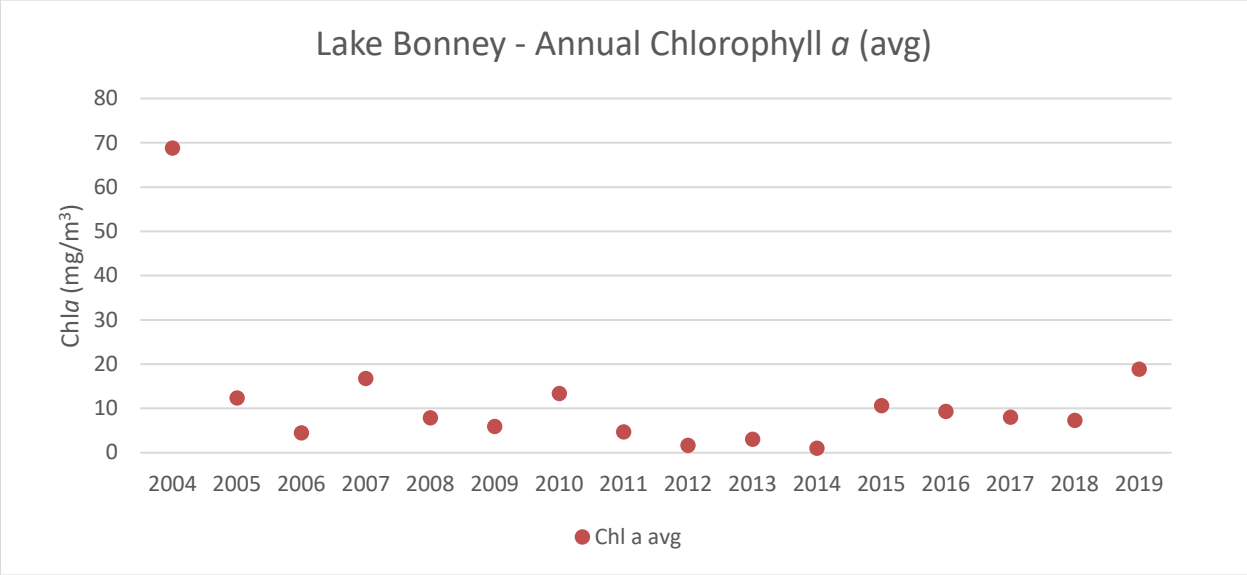


Figure 11.

Chlorophyll *a* results for shallow samples collected from Lake Debra Jane ranged from below detection levels to 8 mg/m^3, and similar to 2018 results. The summer averages are shown below in Figure 12.

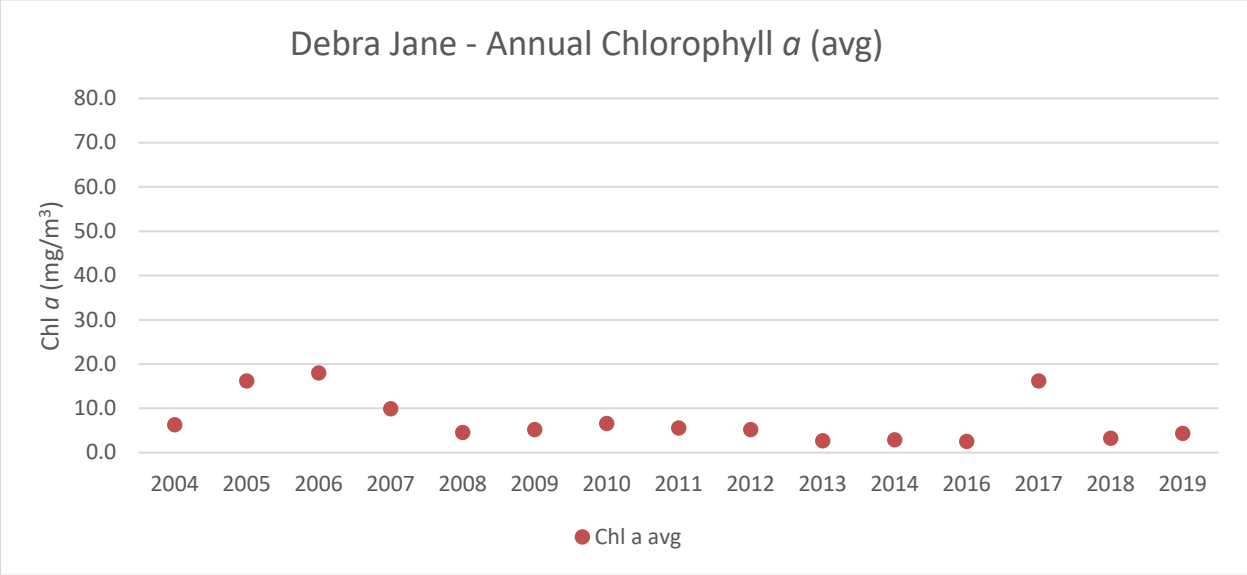


Figure 12.

Trophic State Index

All lakes go through a natural process of aging as a result of enrichment by nutrients and sediment. This process is called eutrophication and as more nutrients and sediment flow into lakes there is increased growth of aquatic plants and algae. Lakes will gradually fill up with organic material over thousands of years.

Lakes can be classified by their degree of eutrophication, also referred to as the trophic state. Lakes are usually classified as being in one of three possible trophic states - oligotrophic, mesotrophic, or eutrophic. Oligotrophic lakes have very clear water, low levels of nutrients, and few aquatic plants and animals. Mesotrophic lakes have more nutrients and tend to support more aquatic plants, and algae, and have lower water clarity. Eutrophic lakes are quite biologically productive and support an abundance of aquatic plants and animals, tend to have frequent algae blooms, lower water clarity, and lower dissolved oxygen in bottom waters.

Trophic state of a lake does not necessarily indicate good or poor water quality because eutrophication is a natural process. However, the natural aging process is accelerated by human activities that add sediment and nutrients to a lake and can result in declining water quality. Stormwater runoff from agricultural areas, fertilized lawns, failing septic systems, logging, urban development, and construction areas all contribute to accelerated enrichment (aging) of our lakes.

The Trophic State Index (TSI), a rating system, is used to determine the trophic state of a lake. The index ranges from 1 to 100 (see Table 2) with low TSI values indicating low biological productivity (oligotrophic) and high TSI (eutrophic) values indicating high biological productivity. TSI values are calculated each year for Lake Bonney and Lake Debra Jane based on averaging three (July, August, September) results for secchi depth, total phosphorus, and chlorophyll *a.* Because there are only 3 results used in calculating the TSI, one very different (high or low) result can skew the averages.

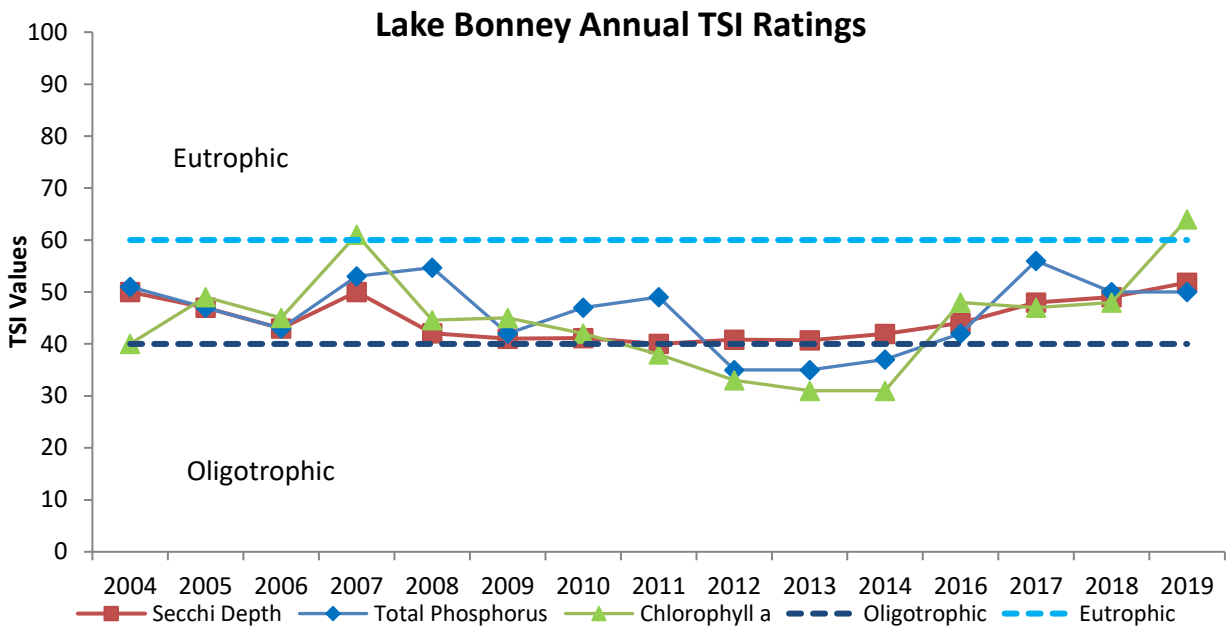
Table 2: Comparison of Trophic State Index to Water Quality Parameters and Lake Productivity

Trophic State	TSI	Secchi Disk (m)	Total Phosphorus (µg/l)	Chlorophyll *a* (µg/l)
Oligotrophic	0	64	0.75	0.04
	10	32	1.5	0.12
	20	16	3	0.34
	30	8	6	0.94
Mesotrophic	40	4	12	2.60
	50	2	24	6.40
Eutrophic	60	1	48	20
	70	0.5	96	56
	80	0.25	192	154
	90	0.12	38	427
	100	0.062	768	1,183

(NOTE: The original source of this table and the equations is Carlson, R.E., 1977. A Trophic State Index for Lakes. Limnology and Oceanography, 22:361-369.)

The August total phosphorus sample for Lake Bonney was not included in the calculation due to uncertainty of the result. Both Lake Bonney and Lake Debra Jane are mesotrophic lakes. A mesotrophic lake produces and supports moderate populations of living organisms (plants & animals). Mesotrophic

lakes generally have moderate nutrient concentrations, moderate algae and aquatic plant growth, and water clear enough for swimming.



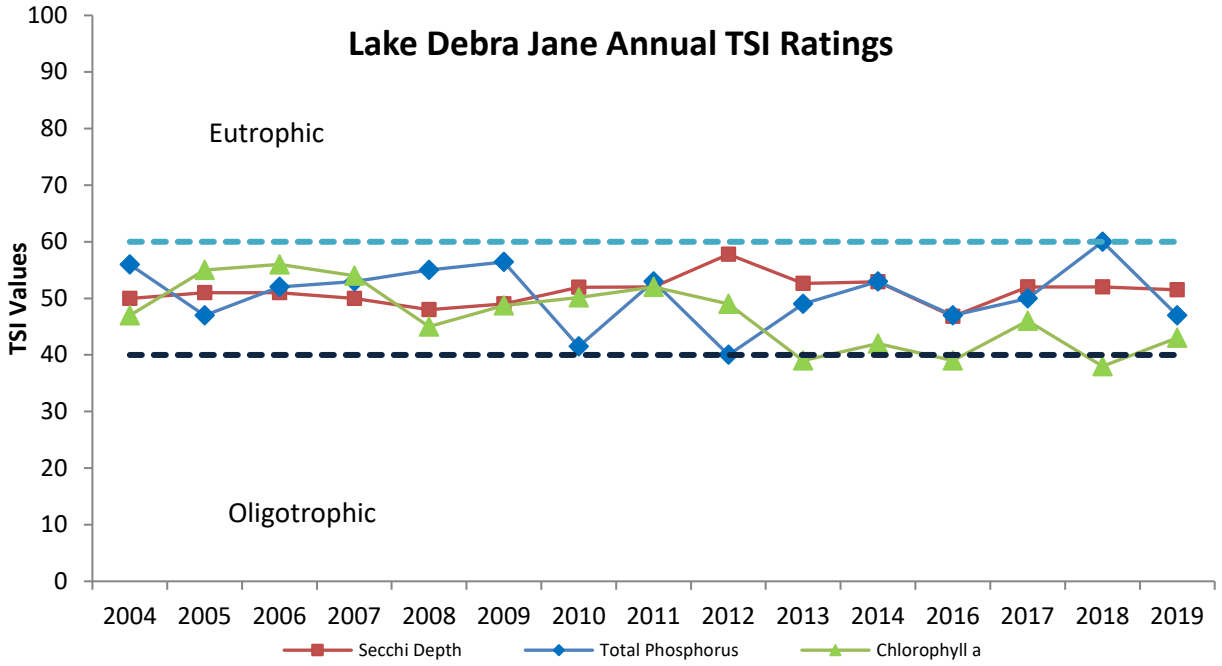


Figure 13.

Summary

Volunteers collected field data in 2019 on Lake Bonney and Lake Debra Jane beginning in early May and ending in late October. The data are summarized as follows:

- Temperature and dissolved oxygen stratification in Lake Bonney was well underway at the first sampling date in early May, and turnover was complete by the last sampling date in late October. Both temperature and dissolved oxygen profiles are similar to previous years. Lake Debra Jane is too shallow to separate into layers based on temperature and dissolved oxygen.
- Both Lake Bonney and Debra Jane display a typical lake level fluctuation with higher lake levels in spring declining to a seasonal low in the fall prior to onset of fall rains. While the lake level in Lake Bonney did not decline in 2019 as much as in previous years, its lake level was lower at the start of the season than in the previous years. Lake Debra Jane similarly had a lower lake level at the start of this season than the last couple of years.
- Secchi depth (water clarity) in Lake Bonney ranged from 1.3 to 2.2 meters, with an average of 1.9 meters. Secchi depths were shallower in 2019 indicating cloudier water than in previous years. Secchi depth in Lake Debra Jane ranged from 1.4 to 2.7 meters, with an average of 2.2 meters. Secchi depths in Debra Jane were greater(indicating clearer water) than in the last several years.
- Shallow total phosphorus concentrations ranged from 22 to 384 µg/l in Lake Bonney and were higher than total phosphorus results from previous years. Shallow total phosphorus concentrations for Debra Jane varied from below detection levels to 41 µg/l. These results are lower than 2018 total phosphorus concentrations and similar to 2017 and 2016 results. Deep total phosphorus concentrations in 2019 in Lake Bonney were 147 µg/l and 123 µg /l in Lake Bonney. These results are higher than in previous years. Deep samples were not collected in Lake Debra Jane.
- Chlorophyll *a* concentrations ranged from 4.8 to 41.1 mg/m^3 in Lake Bonney, and these results are higher than the previous three years. Chlorophyll *a* concentrations in Debra Jane ranged from 1.0 to 6.9 mg/m^3, similar to 2018.
- TSI calculations for this (2019) summer classify both Lake Bonney and Lake Debra Jane as mesotrophic lakes.

Lake conditions vary from year to year with the change in seasons, weather patterns, and climate conditions. Long-term lake monitoring helps us to understand how our lakes are doing and if they are degrading over time. Graphs displaying the data collected for both lakes since the program began can be found in Appendix 1.

Recommendations

Lakes are a reflection of their watershed. They receive water, dissolved substances carried in water, and sediment from its watershed. Lakes also receive particulates and gases from the atmosphere; and energy from the sun and wind. The condition of a lake at any one time is determined by what is already in the lake, and by what is coming into the lake – attesting to the fact that lakes are complex ecosystems.

Many lakes suffer from too many nutrients (phosphorus and nitrogen) entering a lake with stormwater or soil erosion from the surrounding watershed. When it rains, nutrients wash into ditches and down storm drains eventually ending up in the lake. This can lead to problems such as excessive aquatic plant growth, nuisance and/or toxic algae blooms, lower water clarity, stressed fish and wildlife, and lower property values.

Lake management is a complicated job that takes the combined efforts of local government, community groups, individuals, and landowners. To be effective lake management is a long-term commitment and investment.

Here are some voluntary actions that can be taken to protect the health of the lake:

- Avoid fertilizer. If you do fertilize choose phosphorus-free products.
- Scoop pet waste, bag it and toss it in the trash.
- Divert runoff from roofs and driveways into stable vegetated areas.
- If you have a septic system, schedule routine inspections.
- Cover bare soil area with mulch or plants.
- Fix eroding areas in the yard, driveway, and parking areas.
- Don’t dump aquarium contents into the lake.
- Maintain existing natural shorelines – these areas provide additional wildlife benefits for birds, turtles, frogs and other aquatic life.
- Re-establish shoreline vegetation by replacing some lawn with other plants such as shrubs, trees, and perennials. The deeper roots of native trees and shrubs can trap and filter more phosphorus.
- Check boats and trailers for weeds and other invasive species.
- Be active in your lake homeowners’ association.

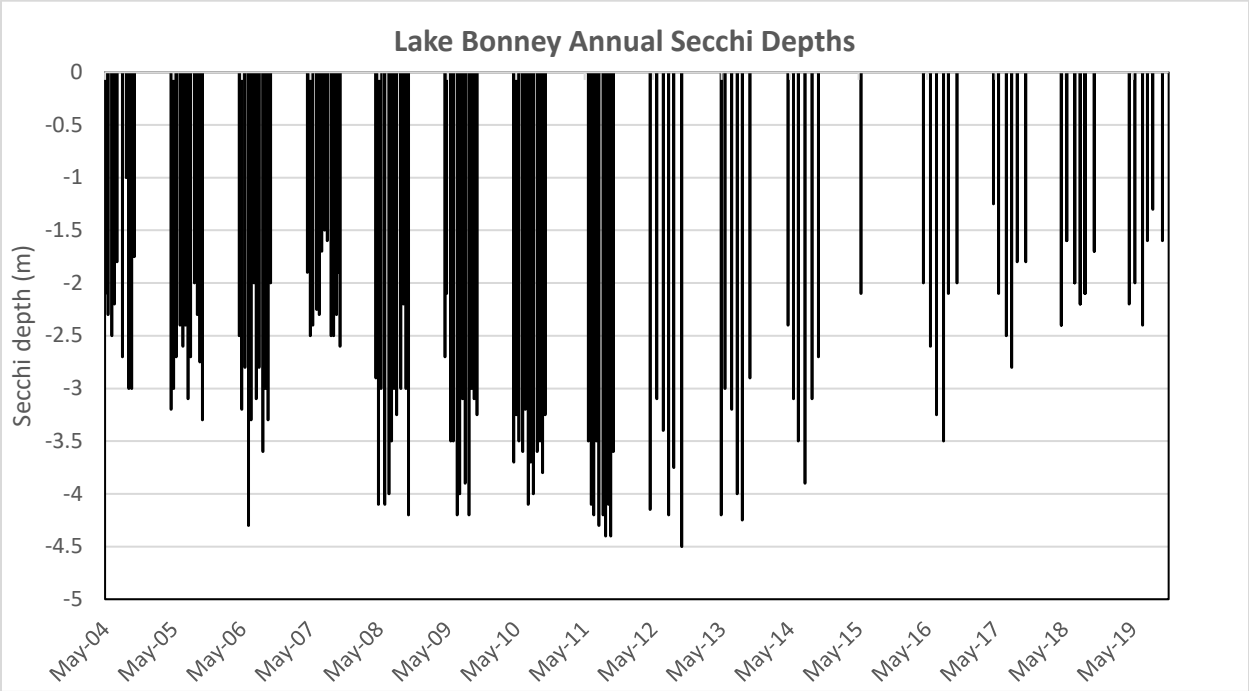
Table 1. Lake Summer Data 2019

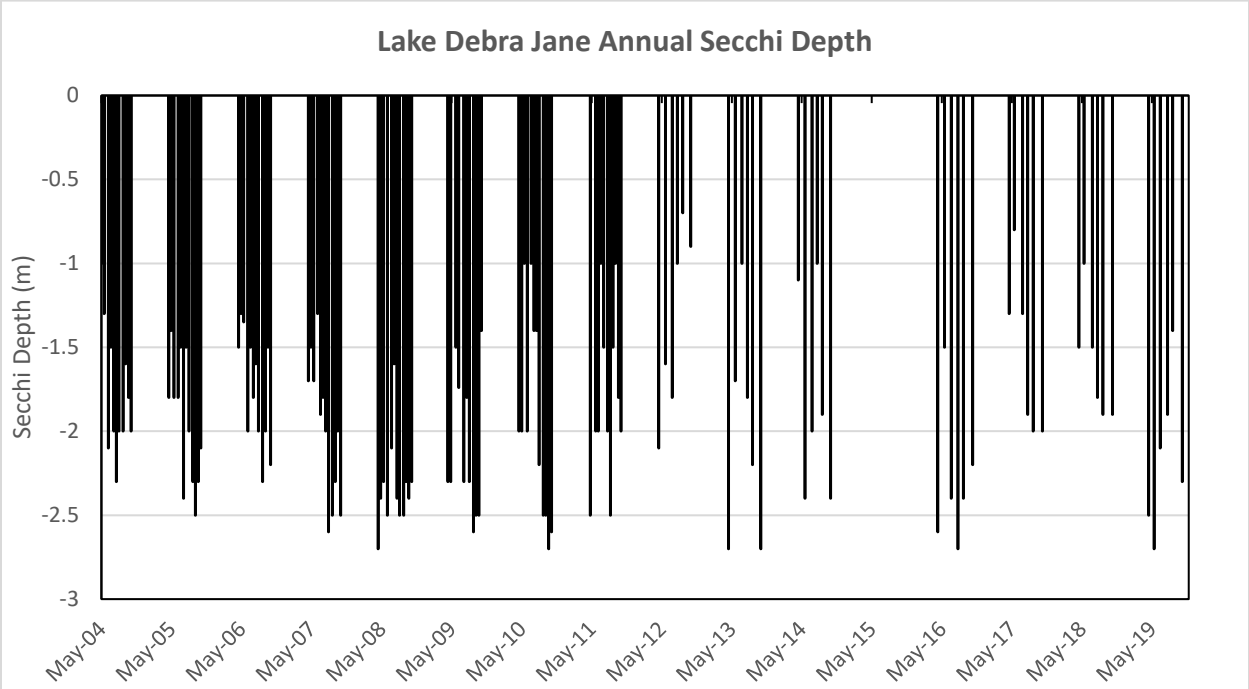
Lake	Date	Time	Site Depth (m)	Secchi Depth (m)	Air Temp (C)	Water Temp (C) Top	Dissolved Oxygen (mg/l) Top	Water Temp (C) Bottom	Dissolved Oxygen (mg/l) Bottom	Lake Level	# of waterfowl	Suspended Algae	Chlorophyll *a* (mg/m^3) shallow	Total Phosphorus (ug/l) shallow	Total Phosphorus (ug/l) deep	Comments
Bonney	5/3/2019	11:20 AM	6	2.2	15	15.3	9.7	7.3	0.1	2.74	12	0	7.5	45	147	Wind cond: light, WSW; partly cloudy; ripples, bright cloud conditions. No odor; 1 boat 1 fishing.
	6/3/2019	11:50 AM	5.6	2	15.4	20.8	8.25	8.4	0.7	2.32	30	none	7.5	22		Light wind, W; ripples; overcast, bright cloud conditions. No odor. 1 boat. Many fishermen, kids swimming over the weekend.
	7/14/2019	11:30 AM	5.1	2.4	19	22.8	8.4	10.3	0.03	1.69	50	none	4.8	23		Wind conditions - calm, W; clear weather; calm water surface, strong sunlight. Waterfowl - heron, geese, ducks. 10 boats, 4 people fishing, 7 waders/swimmers.
	8/9/2019	12:26 PM	5.5	1.6	21.6	24	6.8	11.8	-0.06	1.24	30	none	41.1	168*	51	Wind conditions" light, N; partly cloudy; ripples, strong sunlight. No odor. 4 boats, 4 people fishing, 6-12 swimmers/waders. Waterfowl - geese & mallards. *** Shallow & deep samples may have been switched**.
	9/6/2019	11:11 AM	5.7	1.3	21.2	22.1	8.4	12.2	-0.03	0.96	60	none	41.1	25	123	Wind conditions - light; WSW; overcast; ripples; bright cloud conditions. No odor. Geese & mallards. 5 boats, 10 peop;e fishing, 10 swimmers/waders. B sample results: Chla= 35.8mg/m3; TP = <10 ug/l
	10/28/2019	2:30pm	5.5	1.6	20.2	11.4	5.4	9.8	4.2	1.22	200	none	11.2	384		Wind conditions - calm; clear weather; calm water surface; strong sunlight. No water odor. Widgeons, geese, and mallards. 5 boats, 5 people fishing. Deep TP sample not collected.

Lake	Date	Time	Site Depth (m)	Secchi Depth (m)	Air Temp (C)	Water Temp (C) Top	Dissolved Oxygen (mg/l) Top	Water Temp (C) Bottom	Dissolved Oxygen (mg/l) Bottom	Lake Level	# of waterfowl	Suspended Algae	Chlorophyll *a* (mg/m^3) shallow	Total Phosphorus (ug/l) shallow		Comments
Debra Jane	5/5/2019	2:00 PM	2.5	1.5	30	24.5	9	15.4	6.1	1.9	38	light	<2.0*	35		Light wind,; clear; ripples, strong sunlight. No water odor; geese & mallards; 8 boats. 5 waterboarders, 13 people fishing; 5 children wading.
	6/2/2019	2:00 PM	2.7	1.1	23	23.2	9.5	18.1	2	1.76	49	none	8	33		Light wind, N; ripples; clear, strong sunlight. No water odor; geese, mallards. 12 boats, 6 people fishing, 7 waders/swimmers
	7/4/2019	2:00 PM	2.1	1.9	30	24.1	9.2	21	5.7	1.3	15	none	3.2	21		Wind conditions - calm; clear, strong sunlight, water surface - calm. 10+ boats, 10 people fishing, 5 swimmers/waders
	8/11/2019	2:00pm	2.1	1.9	24	21.8	8.1	21.8	8	0.94	12	none	4.8	31		Wind conditions: light, S; overcast; ripples; bright cloud conditions. No odor. Waterfowl - ducks; 0 boats, 0 fishing, 0 swimmers/waders.
	9/8/2019	2:00pm	2	1.4	23	21.7	9.1	21.1	8.5	0.7	52	light	2.1	<10		Light wind conditions; overcast; calm water surface; bright cloud conditions. No odor, waterfowl - geese & mallards. 3 paddleboards. B sample results: Chla = 2.1 mg/m3; TP = <10ug/l.
	10/27/2019	2:00pm	2.3	2.3	17	11.5	9.5	10.3	9.1	1.2	160	light	6.9	41		Light wind conditions, N; clear weather; water surface - ripples; secchi disk hit bottom. No water odor. 2 paddle boats, 3 people fishing.

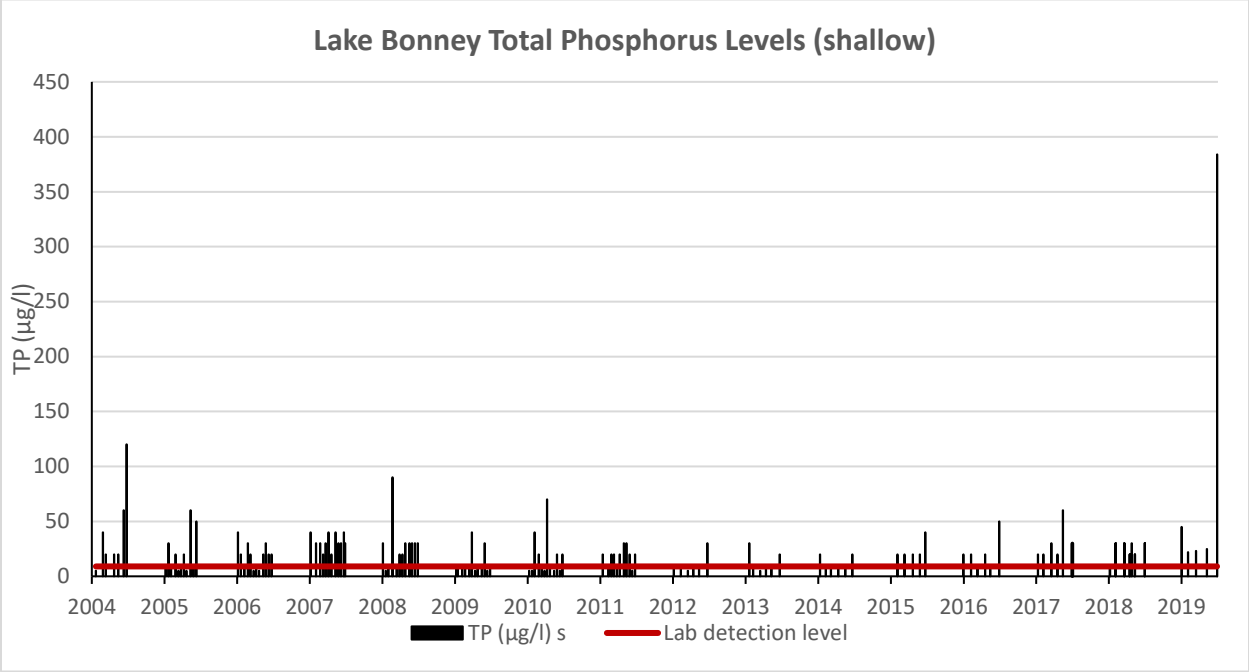
Appendix 1. Lake Bonney and Lake Debra Jane Data

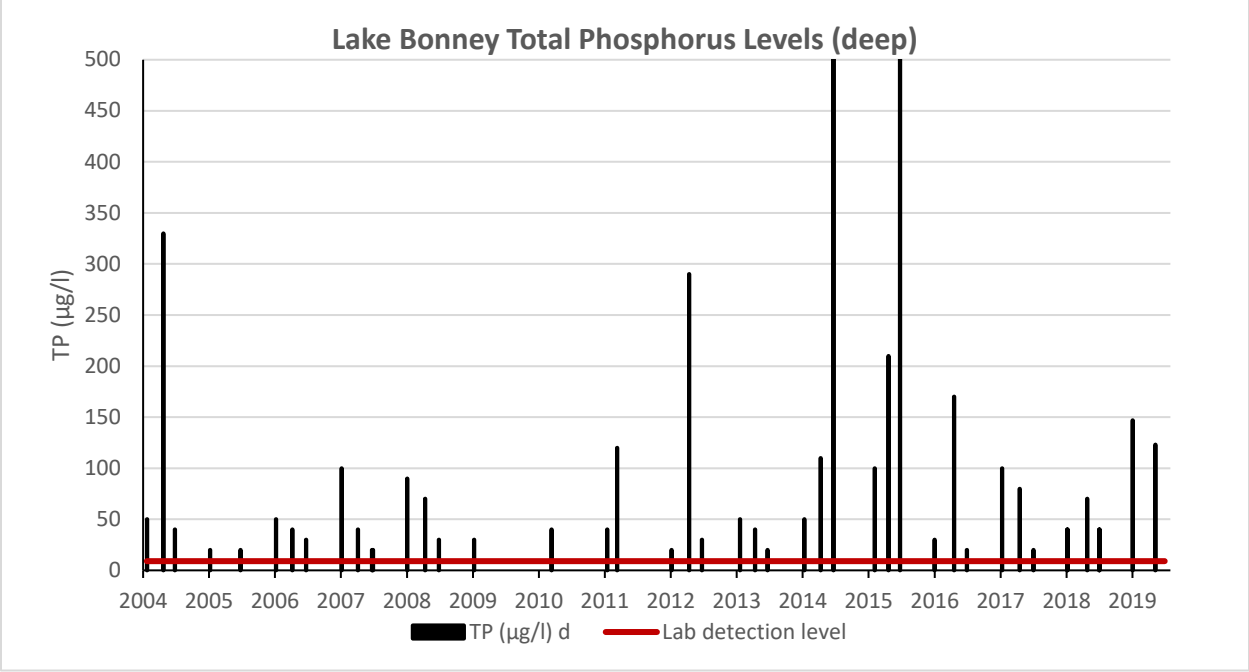
Secchi Depth

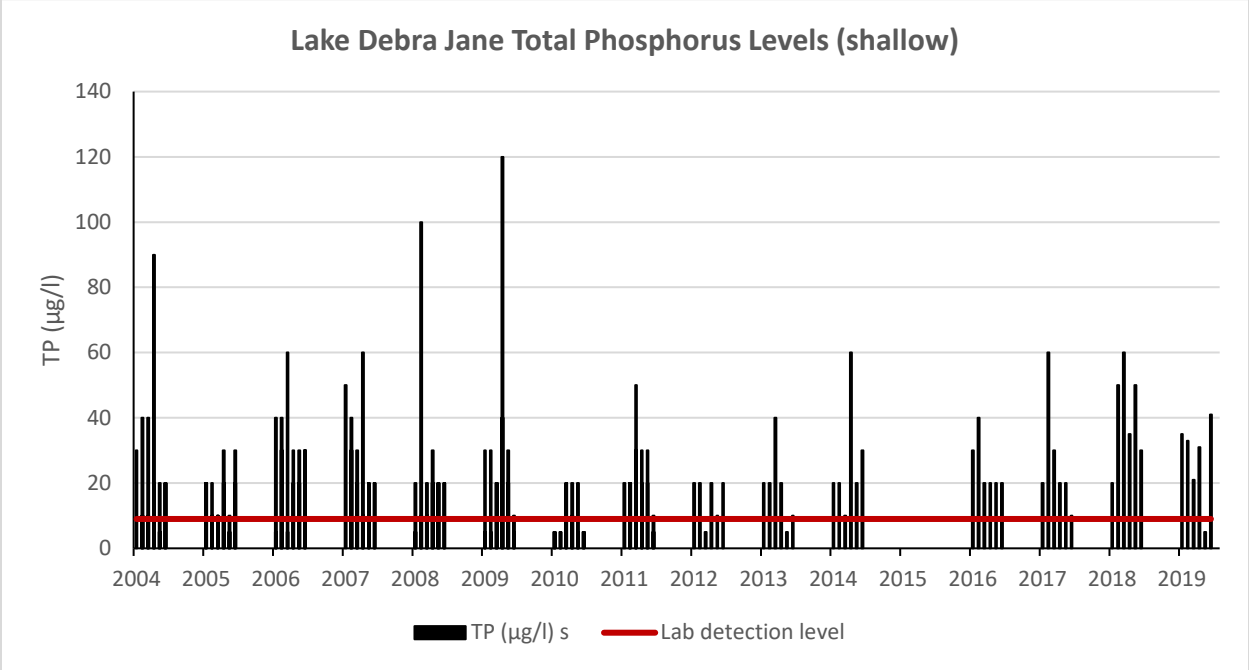




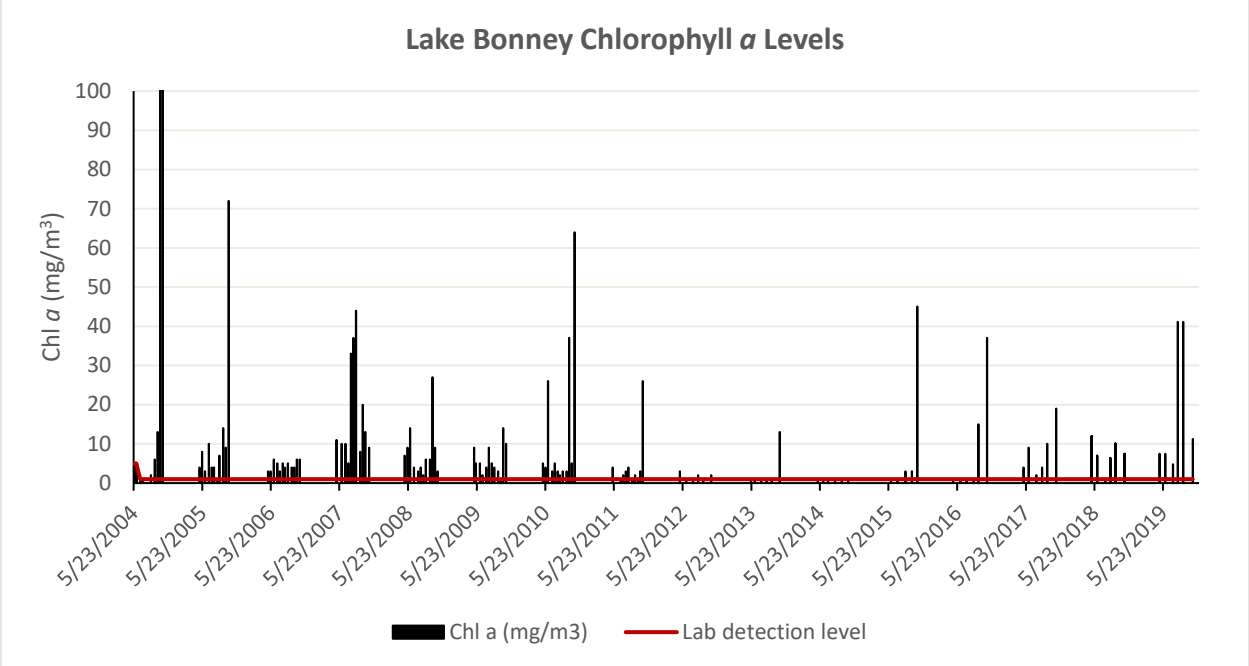
Total Phosphorus

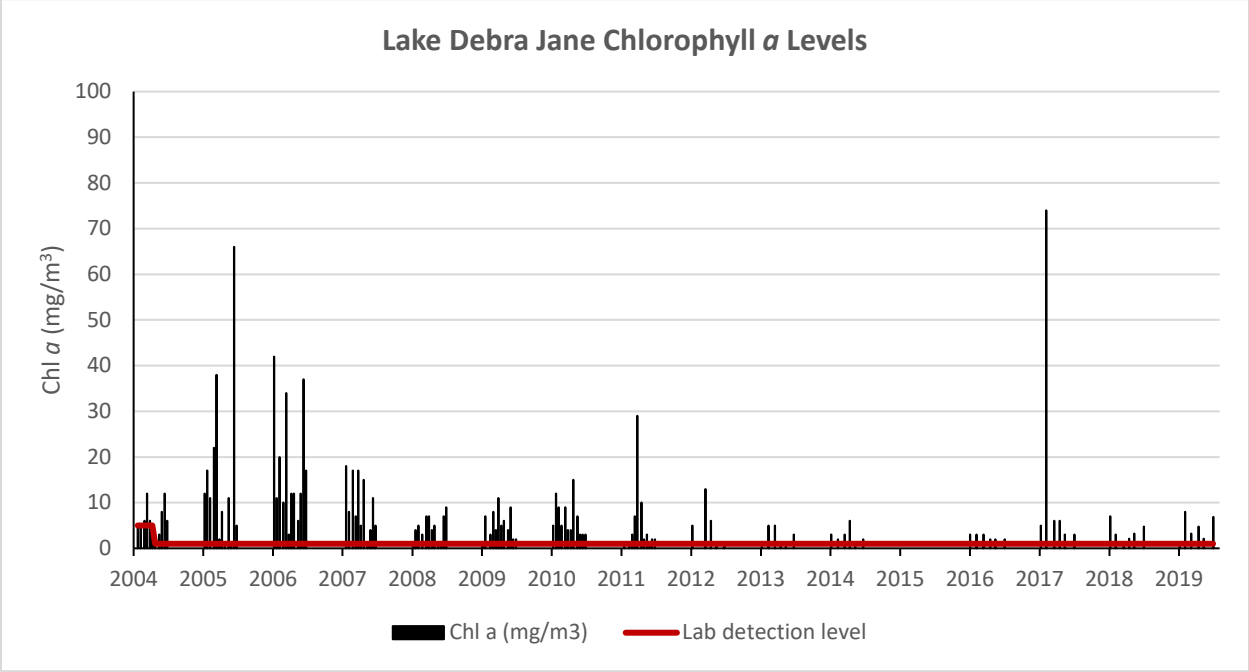






Chlorophyll *a*




Lake Debra Jane Chlorophyll *a* Levels
Chl *a* (mg/m³)
100
90
80
70
60
50
40
30
20
10
0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Chl a (mg/m3)
Lab detection level