Rainbow Lake 2020-2023
BC Lake Stewardship and Monitoring Program
Summary Report

The BC Lake Stewardship Society (BCLSS) and the Ministry of Environment and Parks (ENV) partner with local volunteers and stewardship groups to characterize lake water quality through the *BC Lake Stewardship and Monitoring Program* (BCLSMP). The BCLSMP's focus is on understanding water clarity, temperature, oxygen, and nutrients because these factors contribute to the basic understanding of lake processes which influence biological productivity. Concerns about productivity are common, specifically because high productivity can negatively impact recreation, drinking water and aquatic health due to harmful algal blooms. For more information about the BCLSMP please visit www.gov.bc.ca/lakestewardshipmonitoring.

Photo 1. Photo of Rainbow Lake - Photo by Marge Sidney

Background

Rainbow Lake is located in the North Cariboo region of British Columbia, beside the town of Nazko, BC. The Nazko Band members have historically used the lake for fishing and the surrounding area for hunting and berry picking (Sidney, 2024). With little residential development around the lake (5 homes total) and no public access sites, the lake is quiet the majority of the time and there is very little motor use on the lake (Helfrich, 2024). All 5 residences use water from the lake (Sidney, 2024).

Rainbow Lake has a surface area of 75.5 hectares, a perimeter of 6.9 km and lies at an elevation of approximately 850 m. The average depth of the lake is 7.3 m, while the deepest spot is 17 m. Rainbow is a spring fed lake that drains into the Nazko river (Sidney, 2024).

Severe fires in the summer of 2017 resulted in significant ash and debris deposits on the lake (Helfrich, 2024). Since then, residents report significant increases in aquatic plant beds and algae growth within the lake, as well as reductions in clarity and odd smells coming from the water (Helfrich, 2024). Wildfires can have significant impacts to lake ecosystems. Wildfire smoke can alter light penetration and affect water temperatures, as well as deposit ash, which is high in nutrients, into aquatic systems. Also, the loss of vegetation in the watershed can lead to increased overland flow and the additional deposition of nutrients into lakes and streams.

There is little historical limnological information available for Rainbow Lake. However, the lake was part of the Lake Pulse project in 2019. Lake Pulse was a nationwide project (ended in 2023) funded by NSERC examining a wide range of problems affecting our lakes https://lakepulse.ca/ (Lake Pulse, n.d). Rainbow Lake was sampled once on August 22, 2019 as part of this project where a range of parameters were collected and results applicable to this report were as follows (Lake Pulse, n.d):

Phosphorus status: Oligomesotrophic
Chlorophyll a status: Oligotrophic
Transparency status: Oligotrophic

A BCLSS representative conducted a Quality Control site visit in the spring of 2024. Sidney (2024) noted that there are large areas of white bottom sediments in Rainbow Lake. This indicates a potential marl lake due to calcium carbonate deposition. Marl lakes are less sensitive to phosphorus inputs; however, no testing was conducted to determine if Rainbow Lake is indeed a marl lake. Sidney (2024) also noted that the abundant plant beds mostly consisted of *Chara spp.,* which are commonly called stonewort or muskgrass, an advanced form of algae often mistaken for a plant, and *Potamogeton spp.,* a genus of freshwater aquatic plants commonly called pondweed. Marl lakes are often dominated by *Chara spp.*.

Sidney (2024) also identified species of fish spotted during her visit which included; redsided shiner (*Richardsonius balteatus*), kokanee (*Oncorhynchus nerka*), rainbow trout (*Oncorhynchus mykiss*), burbot (*Lota lota*), and sculpins (not identified to species). Sidney (2024) also identified freshwater bryozoans, simple, non-harmful aquatic invertebrate animals that typically live in sedentary colonies. These bryozoans appeared in the lake as cream colored, jelly-like blobs (see **Photo 2**).

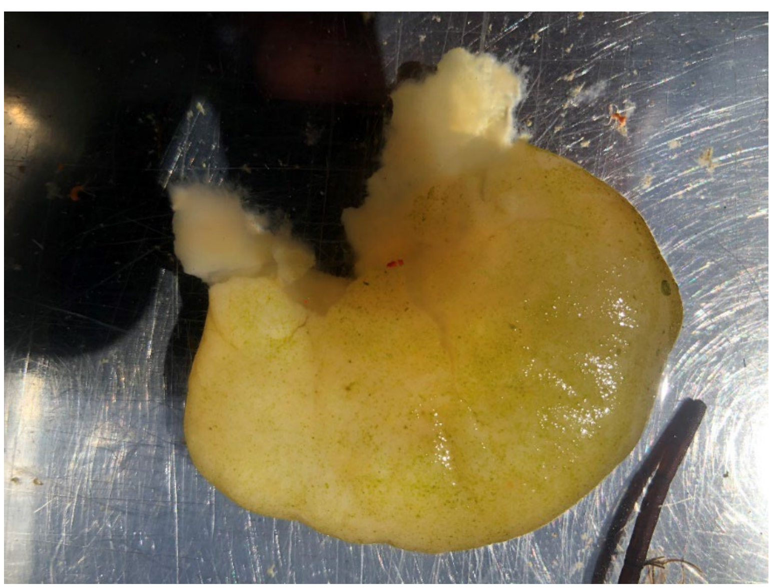


Photo 2. Photo of Rainbow Lake bryozoan - Photo by Marge Sidney

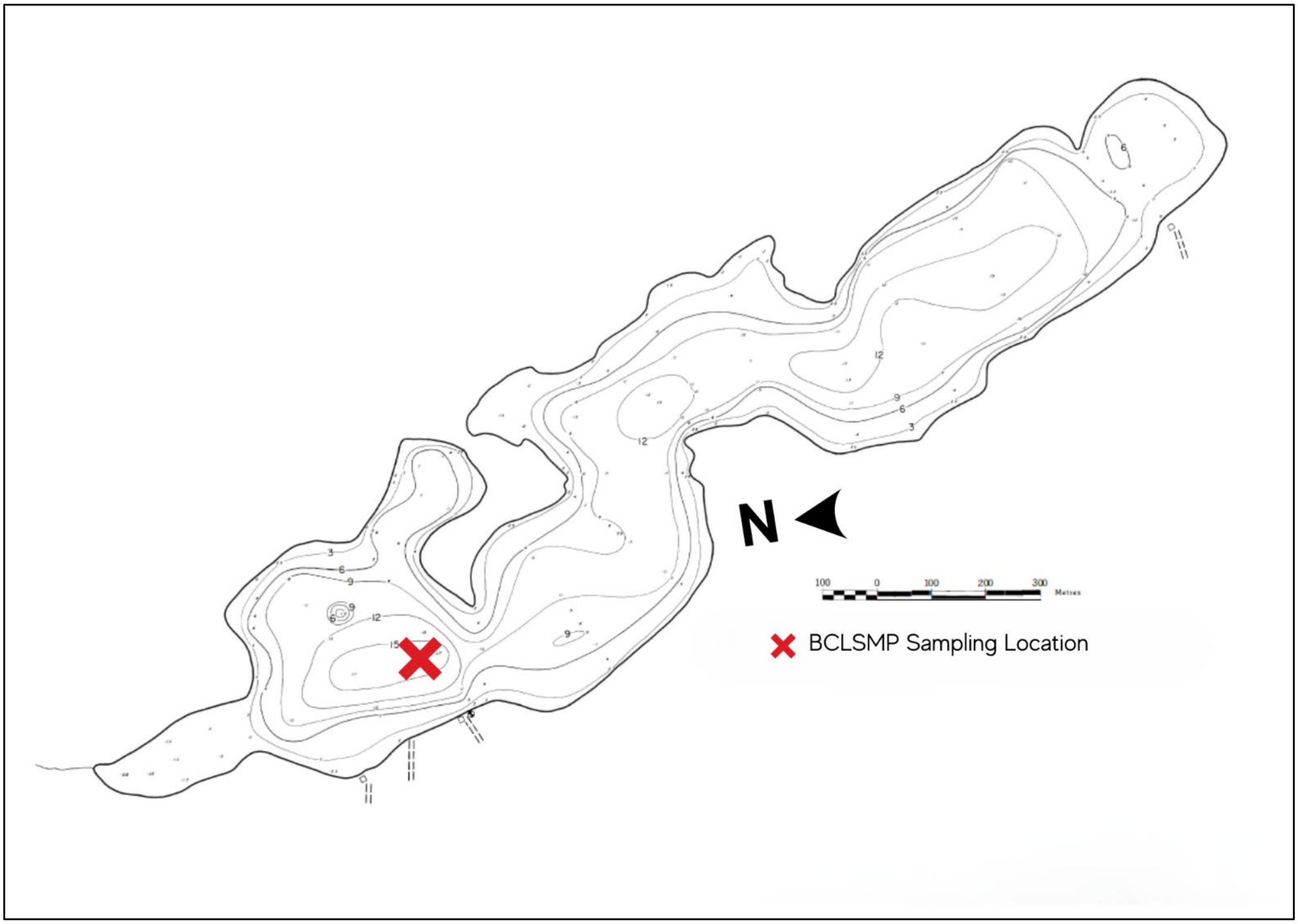
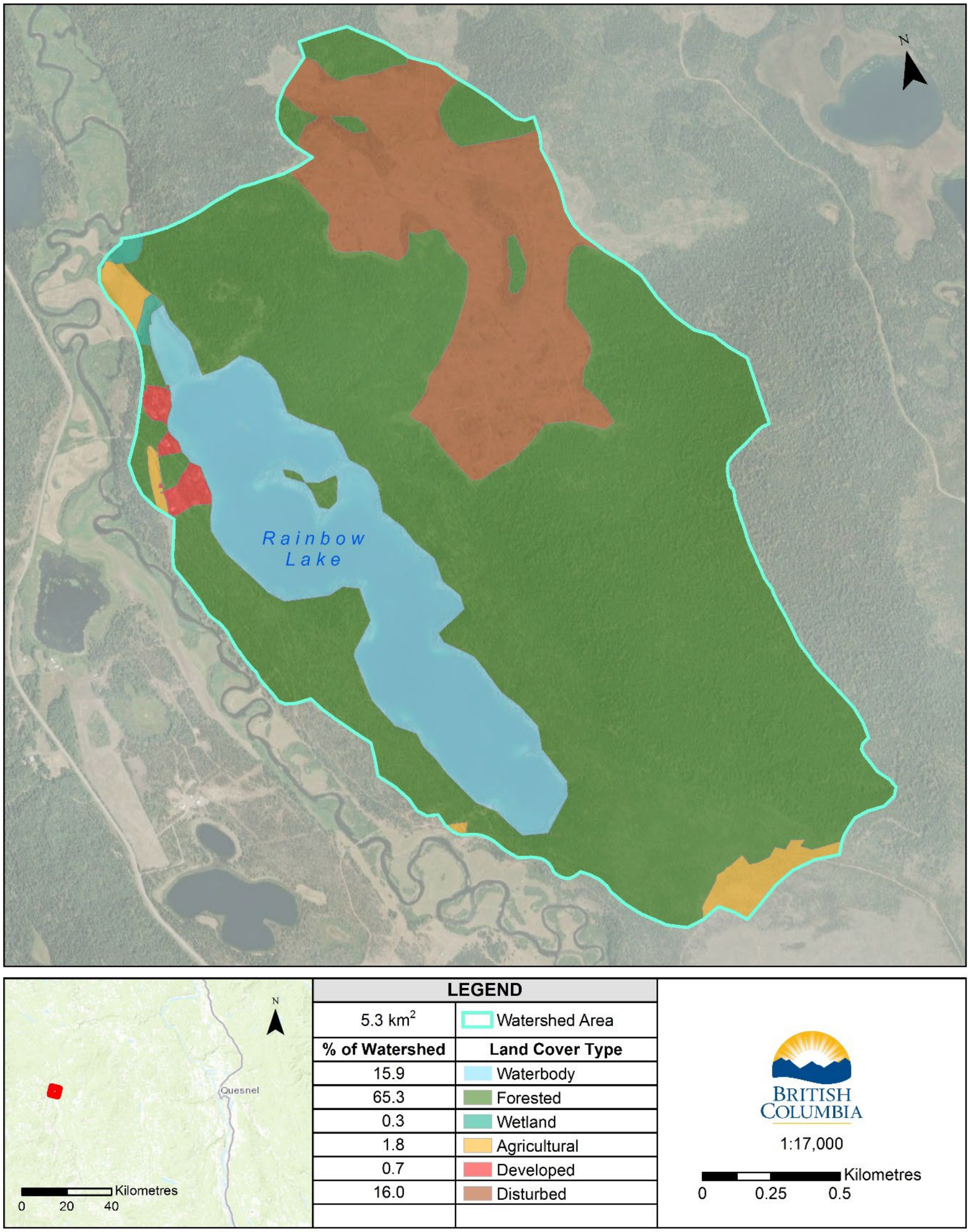


Figure 1. Bathymetric map of Rainbow Lake, including BCLSMP Deep Station sampling site identified by the **red x** (53°00'19.5"N, 123°36'47.5"W)

Monitoring Approach

This report focuses on summarizing Level 1 Study data collected by volunteers from 2020 to 2023. A Level 1 BCLSMP Study collects information from the lake location that best represents the entire lake, such as the centre or deepest point, and includes monitoring of surface temperature and water clarity. Information on these parameters is recommended to be collected at least twelve times during the open water season for three years to characterize the temporal variability typical of lake systems. This data provides valuable baseline and background information, that helps us in understanding what is happening in aquatic environments and observe long term trends.

Level 1 BCLSMP water quality information was collected from Rainbow Lake Deep Station between May and November in 2020, between April and November for sampling events in 2021 and 2022, and data was collected between April and October in 2023. Twenty-seven sampling events occurred in 2020 and 2022, 29 in 2021, and 20 in 2023.



Map By: B.C. Ministry of Environment and Climate Change Strategy. Land Cover Type based on Sentinel-2 10m land cover time series of the world. Produced by Impact Observatory, Microsoft, and Esri. Land Cover Types are checked against orthophotography (Esri basemaps) but have not been field verified. Date Saved: 2024-07-11 10:54:19 AM Coordinate System: NAD 1983 UTM Zone 10N Datum: Transverse Mercator

Figure 2. Rainbow Lake watershed and associated land uses

Surface Temperature

Surface temperature readings serve as an important ecological indicator. By measuring surface temperature, we can record and compare readings from season to season and year to year. Surface temperature helps to determine much of the seasonal oxygen, phosphorus, and algal conditions. Surface temperature readings were collected by volunteers throughout the 2020-2023 monitoring seasons. The minimum data requirements of 12 readings were exceeded for all years, and the spread of measurements were fairly evenly distributed from spring through fall. It should be noted that in August of 2023, 3 weeks of monitoring was missed, so the 2023 surface temperature is lacking data around the hottest time of the summer. The highest reading in 2021 was 22.5°C on July 8th, which was the highest temperature recorded for all years. 2022 saw the second highest surface temperature of 21.5°C on August 25th. **Figure 3** shows the minimum, mean, and maximum surface temperature readings recorded at the monitoring site, as well as the number of readings each year (n).

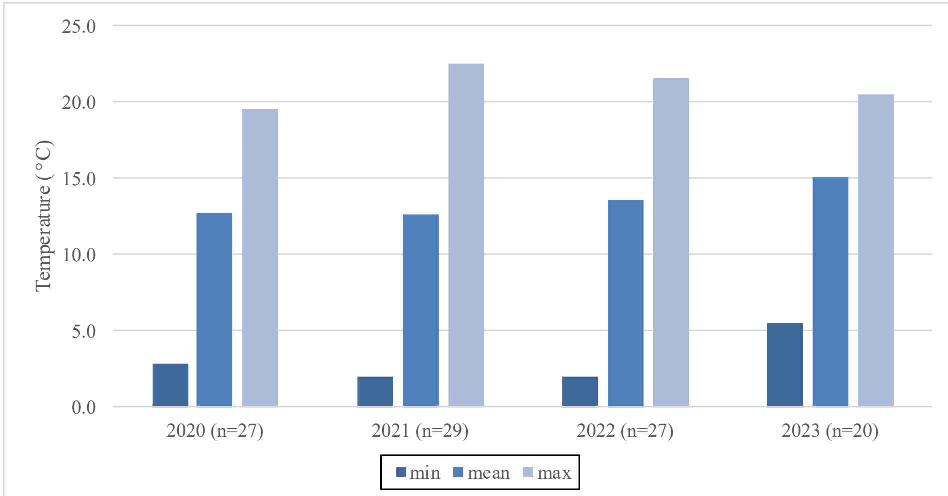


Figure 3 2020-2023 Rainbow Lake Surface Temperature Summary by year including the number of sampling events (n)

The minimum temperature recorded was 2°C in both 2021 and 2022 (Nov 17th and Nov 9th respectively). The monitoring program in 2023 concluded in October, and the lowest temperature recorded in that year was 5.5°C (April 30th). The shorter season in 2023 likely accounts for the warmer minimum temperature recorded than those in other years. There is no evidence to suggest that surface temperature changed significantly over the last four years.

It is worth noting that the maximum surface temperatures for Rainbow Lake through 2020-2023 are above the preferred temperature range for salmonid species. Many fish species, especially salmonids, show signs of stress at temperatures greater than 18ºC (Truelson,1997). However, with a maximum depth of around 17 meters, most of the water column likely remains within the preferred temperature range for salmonid species during these peak summer surface water temperatures.

For subsequent years of data collection, it is recommended that dissolved oxygen and temperature profiles be collected from ice off and continue at least biweekly until complete turnover is caught in the fall. These profiles would provide valuable baseline data for Rainbow Lake for comparison going forward. Additionally, by taking profiles of a lake, it may be possible to detect changes to the depth of the thermocline, or changes in the timing of lake turnover, which can have marked effects on dissolved oxygen and nutrient cycling. One of the impacts of climate change on lakes in BC is that stratification may occur for longer periods of time, which can have extensive implications on dissolved oxygen levels, nutrient cycling, and habitat availability for salmonid species (Ashley, 2024). Due to the sensitivity of lakes and lake ecosystems to climate change, it is important that proactive measures be taken in order to better predict how lakes throughout BC will respond. The more lakes that provide temperature and DO profiles, the more data points there are for different regions and lake characteristics so that steps can be taken to mitigate impacts or provide information in advance of an extreme shift.

Water Clarity

Water clarity is an indicator of algae, suspended sediments, and other particles in the water. The clarity of the water can be evaluated by using a Secchi disc, a 20 cm diameter black and white disc that measures the depth of light penetration. Natural variation and trends in Secchi depth and temperature not only occur between years, but also throughout one season. In general, as temperatures increase during the summer months, Secchi depth typically decreases. This is due to algal growth patterns; as the temperature of the lake increases, so do some species of algae. Due to the increase in algae, the water clarity can decrease. However, there can be other influences on Secchi readings such as suspended solids from turbid inflowing streams or overland flow.

Water clarity was measured in Rainbow Lake from 2020-2023. The graphs in **Figure 4** show the Secchi readings collected by volunteers from 2020-2023, as well as the surface temperature readings collected. The minimum data requirement of 12 Secchi readings over the sampling season was met each year, however, some of the readings were outside of the ideal sampling timeframe of 10:00 am – 2:00 pm. The difference in sun angle outside of this timeframe can significantly impact the readings, so those readings are less reliable than the readings taken within the 10:00-2:00 timeframe. Any readings outside of this timeframe have been marked with a * in **Figure 4**. Most readings outside of the timeframe were close to the preferred time, which would have less of an impact than readings taken in the late evening or very early morning. Because of this, all the readings have been included for the Secchi summary statistics calculations and have been accounted for in **Figure 5**.

The general trend of increasing surface temperature leading to decreasing Secchi readings is not apparent in the graphs of **Figure 4**. However, the graphs show another common pattern of lower Secchi readings in the spring and the fall which appears to overlap with overturn patterns in dimictic lakes. Dimictic lakes turnover, or mix, twice per year during which the water column becomes isothermal (breaking down density differences that result in stratification) for a period each spring and fall. Lake overturn allows nutrients that are trapped in the bottom waters of a lake during the stratified period to become mixed throughout the water column, making them available to plants and algae within the photic zone (BCLSS, 2022). This increase in available nutrients during overturn can lead to algae blooms and lower Secchi readings. However, lower Secchi readings may also be caused by increasing turbidity from rain events/inflowing turbid water which are quite common in the spring and fall. Either, or potentially a combination, of these situations could have resulted in the lower Secchi readings recorded in Rainbow Lake. Collecting chlorophyll-*a* data and dissolved oxygen/temperature profiles in Rainbow Lake would provide more insight into this pattern and verify if the lower Secchi readings in the spring and fall are due to lake overturn spurring algae growth, the inflow of turbid water, or both.

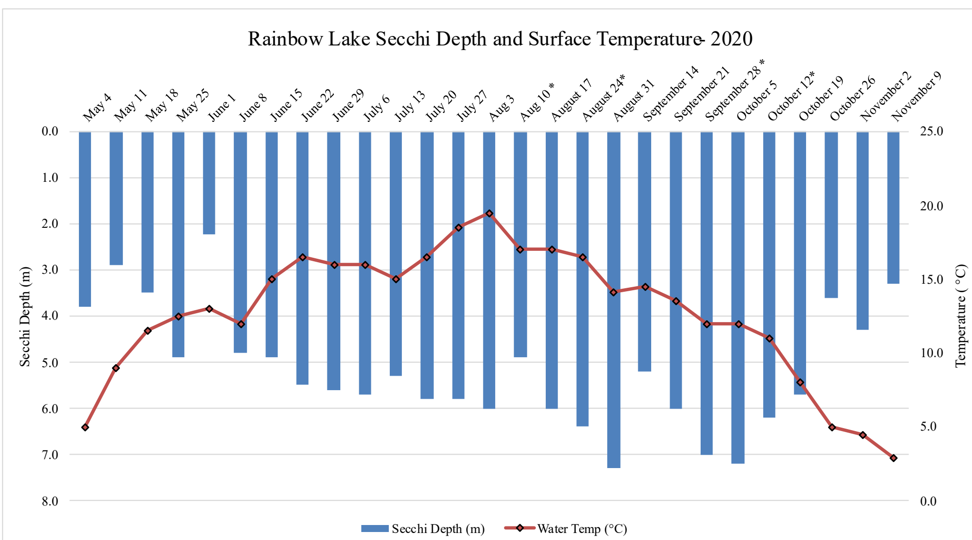


Figure 4 Secchi depth and surface temperature graphs for Rainbow Lake 2020-2023. A date with * indicates the reading was taken outside of the ideal 10:00 am – 2:00 pm timeframe

The graph in **Figure 5** shows the minimum, average, and maximum Secchi depths recorded at the monitoring site, as well as the number of readings each year (n). The maximum reading was 7.6 m (September 21, 2022) and the minimum was 2.2 m (June 1, 2020). The average Secchi depth measurements in Rainbow Lake ranged from 4.8 m (2022) to 5.2 m (2020). The average Secchi values in Rainbow Lake are quite consistent year to year, with a maximum difference of only 0.4 m in the average Secchi depth between years. Based on these average Secchi values, Rainbow Lake was exhibiting mesotrophic (3-6 m average Secchi depth) conditions during all four years of monitoring.

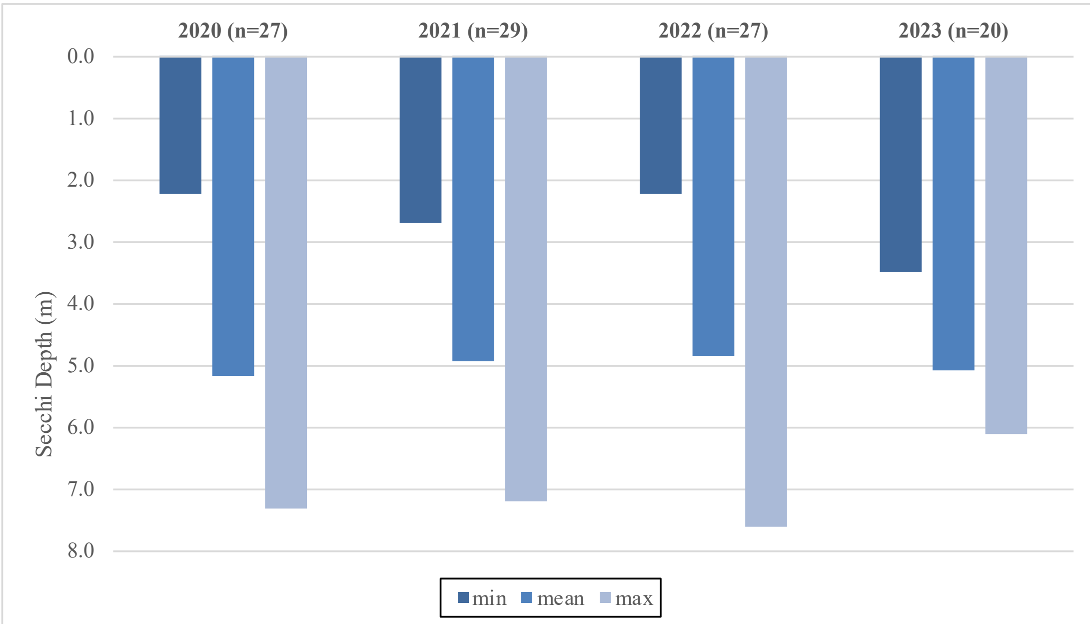


Figure 5 2020-2023 Secchi summary statistics for Rainbow Lake with the number of sampling events (n)

Trophic Status

Trophic status describes the level of biological productivity within a waterbody and is measured by using Secchi depth, chlorophyll-*a*, and total phosphorus concentrations (Nordin, 1985). Low productivity lakes are called *oligotrophic* and tend to have clear water and sufficient oxygen for aquatic life throughout the year. Lakes with moderate productivity are called *mesotrophic*. *Eutrophic* lakes have high productivity and often have high densities of aquatic plants and/or algae. Algal blooms may occur in these lakes frequently, reducing recreational opportunities and potentially impacting aquatic habitat. Based on the average Secchi values obtained between 2020-2023, Rainbow Lake was exhibiting mesotrophic conditions over the four years of monitoring. Due to the potential for suspended sediment and other factors that impact Secchi readings, it is not recommended to draw any firm conclusions of trophic status based only on Secchi data. There is little limnological information available for Rainbow Lake to supplement the level 1 BCLSMP data, so it is recommended that a level 3 be initiated on the lake, if possible, which would expand the parameters currently collected to include bi-weekly monitoring of multi-depth water chemistry and biological sampling. This data would provide insight into total phosphorus levels as well as chlorophyll-*a* production in Rainbow Lake to better advise the current trophic status and for comparison moving forward.

Table 1. Rainbow Lake trophic indicator results (as per Nordin, 1985).

Parameters	Trophic Categories			Rainbow Lake
	Oligotrophic	Mesotrophic	Eutrophic	BCLSMP L1 (2020-2023)
Chlorophyll-a (µg/L)[3]	0 - 2	2 - 7	>7	-
Secchi Depth (m)[1]	>6.0	3.0 - 6.0	<3.0	5
Total Phosphorus (µg/L)[2]	1 - 10	10 - 30	>30	-

[1] Average of all year's annual average, [2] spring overturn conditions, [3]Average.

The Lake Pulse program sampled Rainbow Lake once on August 22, 2019 and found that phosphorus levels indicated Rainbow was Oligomesotrophic and chlorophyll-*a* levels indicated the lake was Oligotrophic (Lake Pulse, n.d). However, more samples over multiple years would have to be conducted to confirm that these levels of phosphorus and chlorophyll-*a* are representative of the average conditions of Rainbow Lake.

Summary

A great dataset of Secchi depth and surface temperature has been established by volunteers from 2020-2023. Secchi data in Rainbow Lake from 2020-2023 indicates the lake is likely mesotrophic. There is little limnological data available for Rainbow Lake, and without results for chlorophyll-*a* or phosphorus levels in the lake, a firm conclusion on trophic status should not be drawn as Secchi readings can be impacted by other factors.

Rainbow Lake appears to exhibit a pattern of lower Secchi readings in the spring and fall, which may be related to lake overturn spurring algae growth. However, more data such as dissolved oxygen and temperature profiles as well as chlorophyll-*a* data is needed to determine if this hypothesis if correct.

The maximum surface water temperatures recorded in Rainbow Lake from 2020-2023 are warm and above the preferred temperature range for salmonid species. Many fish species, especially salmonids, show signs of stress at temperatures greater than 18ºC (Truelson,1997). With a maximum depth of around 17 meters, most of the water column likely remains within the preferred temperature range for salmonid species. However, this warrants further investigation so collecting dissolved oxygen and temperature profiles is recommended.

Going Forward

Local volunteers could continue to record Secchi and surface temperature readings, with an emphasis on collecting a minimum of 12 evenly spaced readings between ice-off and ice-on. Recognizing there are logistical difficulties (distance from a courier for sample shipment) in increasing the monitoring on Rainbow Lake it is still recommended that his lake have additional water chemistry sampling including phosphorus and chlorophyll-*a* to better advise current productivity levels and provide additional baseline data for comparison moving forward.

The volunteers received a YSI 550A and training on how to collect profiles from the BCLSS in the spring of 2024. Obtaining dissolved oxygen and temperature profiles every two weeks from ice-off to ice-on will be very valuable data for this lake and help to determine if the low Secchi readings are occurring around lake overturn. There is strong evidence that climate change is exacerbating existing issues in lakes and creating issues where they previously did not exist, whether expected or unexpected. This will make management of BC's water resources more challenging. One climate change impact already observed in many northern hemisphere lakes is reduced oxygen concentrations and earlier onset and longer periods of stratification, which will make internal nutrient loading more problematic (Woolway et al., 2020). Volunteer collected data is important for long-term records and can help identify early warning signs should there be a deterioration in water quality from its current state. Local volunteer monitors are also encouraged to continue recording ice-on and ice-off dates for long term climate change records. These observations can be submitted online through BC Ice Reporting Tool (https://arcg.is/qy1e5).

Keeping Rainbow Lake Healthy

Though there is very little development in the Rainbow Lake Watershed, 16% of the watershed has been disturbed through logging. Adequate shoreline protections including healthy riparian buffer zones can act to mitigate logging and development impacts on water quality and fish habitat (Dosskey et al., 2010). Additionally, intense logging around a lake (even out of the riparian zone) can lead to changes in water quality. Shah et al. (2022) undertook a review of the effects of a range of forestry activities on water quality and found that "studies report a wide range of water quality impacts after forest operations including sediment delivery, nutrient losses, carbon transport, metal and base cation releases, and changes to acidity and temperature." However, there are best management practices that can mitigate or eliminate negative forestry impacts to water quality such as the use of buffers, low impact techniques and phased felling (Shah et al., 2022). It is beyond the scope of this report to investigate the forestry practices around Rainbow Lake and compare to best management practices, however, it is recommended that any forestry follow best management practices to protect the water quality of Rainbow Lake. Additionally, to retain the resilience of the Rainbow Lake watershed, preserving, enhancing, and restoring riparian areas should be a key action.

Other Tips for Keeping Rainbow Lake Healthy:

See link under Monitoring Resources on: www.gov.bc.ca/lakestewardshipmonitoring
BCLSS's LakeKeepers Manual: https://www.bclss.org/programs#lake-keepers-manual

Who to Contact for More Information

The Ministry of Environment and Parks	**The BC Lake Stewardship Society**
3rd Floor, 1011-4th Ave Prince George, BC V2L 3H9 Email: volunteerlakes@gov.bc.ca Website: www.gov.bc.ca/lakestewardshipmonitoring	Box 110, 5505 Jacobson Road, Big Lake Ranch, BC, V0L 1G0 Email: info@bclss.org Website: www.bclss.org

Acknowledgements

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Report Review: Norm Zirnhelt (BCLSS) and Kirsten McNeill (ENV)
Land Use Map by: Kim Klaczek (ENV)

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