Enos Lake Water Quality Monitoring Program

2020 Annual Report

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BRITISH COLUMBIA CONSERVATION FOUNDATION

Executive Summary

From February to November 2020, the British Columbia Conservation Foundation (BCCF) conducted water quality sampling in Enos Lake based on a monitoring schedule and sampling procedures outlined in the *Enos Lake Protection and Monitoring Program* (ELPMP).

Data collection was completed with volunteer assistance from the *Friends of Enos Lake*, a dedicated local stewardship group interested in the conservation and protection of the lake and its ecosystem.

Results were sent to a professional limnologist for analysis and review. Sample results indicated that chlorophyll-*a* was within the target, with no significant increase above baseline levels on dates of sample collection. Half of the total phosphorous samples (6 of 12) surpassed the target value (12 µg/L) at depth in May, August, and November of 2020; however, the annual average met this target. Dissolved oxygen results met the target for the epilimnion (≥5 mg/L) in all months, but did not meet the target for the hypolimnion (2 mg/L) in August 2020 (and likely from late May – August, as suggested by Secchi depth results and lake stratification patterns). This occurred from 2017 – 2019, and is thought to be a natural condition of Enos Lake; however, the severity of oxygen depletion in the hypolimnion has increased since 2017 and should be closely monitored going forward.

In 2021, ongoing monitoring and water quality protection efforts should continue following the suggested schedule and guidelines as laid out in the ELPMP. Increasing confidence in field data collection methods and lab analysis results can be gained from at least one duplicate sample analyzed for each laboratory parameter (chlorophyll-*a*, total phosphorous, orthophosphate) in 2021. Secchi readings should be collected whenever possible during the summer, when the lake is stratified (March – November) with at least one or two additional winter readings (December – March). An online, public repository for water quality data should be developed, where data and reports can be stored and made available to the public.

A more thorough data review should be initiated post-sampling in 2022 to examine 5-year trends, review the monitoring program, and provide feedback for ongoing sustainable watershed management.

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Background

An annual water quality monitoring program for Enos Lake was established in 2017 by the British Columbia Conservation Foundation (BCCF) per the management recommendations of the *Enos Lake Protection and Monitoring Plan* (ELPMP) (PGL 2016). This report summarizes water quality monitoring results for 2020, and compares them to established water quality targets for Enos Lake.

This report presents a summary of the findings from the 2020 water sampling program and includes the suggestions for reporting as outlined in the ELPMP, including:

- A summary of work performed, including dates, individuals, weather conditions, methods, QA/QC protocols, and any challenges encountered during the work.
- A presentation of the water quality results compared against targets in the ELPMP.
- A summary of preventative actions taken with respect to aquatic invasive species in the past year (e.g. signage, educational materials for residents or visitors, etc.).
- Any anecdotal observations related to Enos Lake ecology, including but not limited to aquatic invasive species.
- An interpretation of the results of the program for the past year, conducted by an experienced, qualified limnologist provided in report form, including but not limited to input provided for stormwater management practices or new phases of construction (included as an appendix).
- Recommendations for augmentation to the program, if relevant.
- Laboratory certificates and raw data for the year, as appendices.

1.0 Introduction

Enos Lake is a small, relatively productive lake located on Vancouver Island's Nanoose peninsula (Fig. 1). The lake is approximately 18 ha and surrounded by nearby ponds and wetlands, supporting a wide diversity of birds and aquatic life. The lake is approximately 12 metres at its deepest point, and drains into Enos Creek via a weir established at its north outlet since 1956 (PGL 2016).

Enos Lake undergoes thermal stratification in the summer months, resulting in a warm, well-mixed surface water layer (epilimnion); this layer is separated from the cooler, lower water (hypolimnion) by a narrow zone of rapid temperature change (thermocline). Solar radiation and wind movement at the water's surface work together to warm the uppermost layer, while the water at depth receives very little sunlight and remains cool and dark. Density differences prevent these two layers from mixing during the summer months. From the fall through the early spring, as air temperatures drop and the amount of solar radiation decreases, the warm surface waters gradually cool, becoming denser. This denser water settles down into the hypolimnion and initiates mixing throughout the entire water column, a process known as turnover.

Due to the mild coastal climate of Vancouver Island, Enos Lake rarely freezes long enough to result in winter stratification, tending to remain mixed through the winter (Nordin 2017). Lake mixing is a vital part of seasonal changes to water quality as it ensures adequate nutrient and oxygen exchange from the surface throughout the water column. Enos Lake is frequently subjected to low oxygen (hypoxia) conditions in the hypolimnion during the summer months, which is likely a naturally existing condition of the lake ecosystem (MESL 2014; PGL 2016).

This report summarizes the monitoring of select chemical and physical water quality parameters undertaken by BCCF in 2020 to evaluate the seasonal water quality and productivity status of Enos Lake.

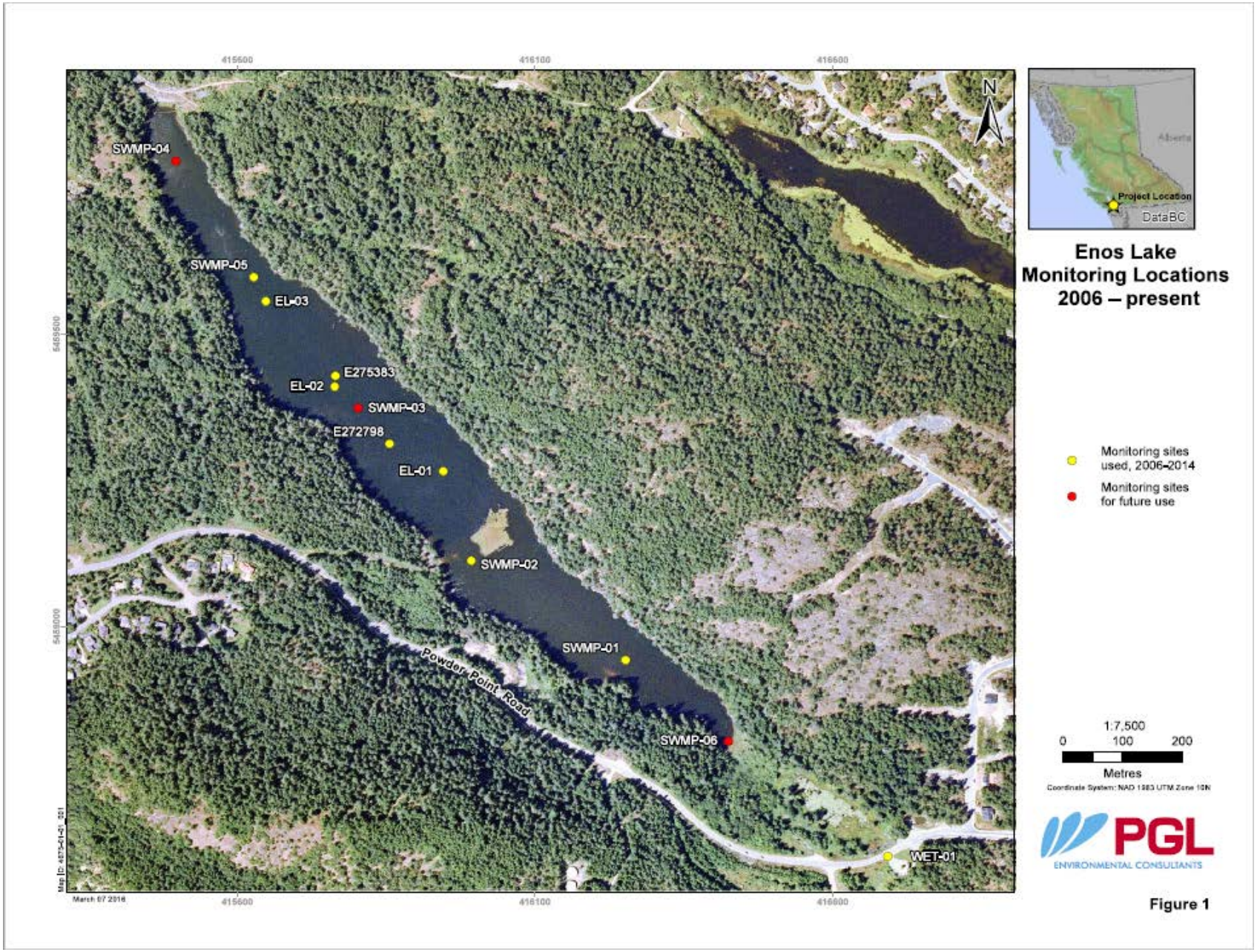

Figure 1: Enos Lake sampling locations (PGL 2016).

2.0 Methods

2.1 Scope of Work

BCCF was contracted to conduct water quality sampling as described in the ELPMP (Table 1) in 2020. Sampling occurred quarterly and field crews consisted of a BCCF biologist with an additional volunteer or staff member as required. Extra safety precautions had to be taken in 2020 due to COVID-19, which prevented the use of volunteers in certain cases. All samples were collected from site SWMP-03 (Fig. 1), located at the deepest part of the lake. The site was accessed by boat with an electric motor.

Table 1: Proposed ELPMP Monitoring Schedule for 2020 (PGL 2016).

2020												
Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Dissolved Oxygen		F			F			F			F	
Temperature		F			F			F			F	
Redox potential		F			F			F			F	
pH		F			F			F			F	
Secchi Depth		F			F			F			F	
Chlorophyl *a*		L			L			L			L	
Phosphorhus		L			L			L			L	
E Coli												
Metals												
Hardness												
PAH												
Legend	*L = Water sample from three depths at SWMP-03* *F = 1m in situ profiles from SWMP-03* *E = Five samples in 30 days, from SWMP-03 and any two shoreline locations.* *M = Five samples in 30 days, from SWMP-03* *P = Surface sediment from SWMP-03, SWMP-06 and SWMP-04*											

2.2 Data Collection

FIELD EQUIPMENT

The following equipment was utilized for field sampling:

- YSI Professional Plus QUATTRO handheld multi-parameter water quality sonde with probes for Galvanic Dissolved Oxygen, Temperature/Conductivity, pH, and ORP
- 1 L Van Dorn water sampler
- Sample bottles, supplied by ALS Laboratories (Burnaby, BC)
- Chain of Custody (COC) forms, supplied by ALS
- Cooler with ice
- Secchi disk
- Field notebook
- Safety kit (waders, gloves, Personal Flotation Devices (PFDs))
- 10-ft Zodiac with an electric outboard motor

IN SITU FIELD PARAMETERS

In situ water quality parameters were collected once per quarter at site SWMP-03 using the YSI handheld sonde. The sonde was calibrated by a BCCF technician immediately prior to each sampling date and calibration records kept for reference. Readings were recorded at 1 m intervals throughout the water column to a depth of between 10 - 12 m, depending on site depth. Parameters included:

- Temperature (°C)
- Dissolved oxygen (mg/L and %)
- pH
- Conductivity (µS/cm)
- Redox potential (mV)

Weather and lake surface observations were noted on each sampling date. A Secchi depth (water clarity) measurement was recorded once per quarter using a Secchi disk, between the hours of 10am – 4pm; care was taken to remove sunglasses and make the observation on the shady side of the boat. Monitoring for incidental observations of invasive species occurred concurrently with water sampling.

The *Friends of Enos Lake* (FoEL) undertook six dates of additional Secchi monitoring between March – July of 2020, as per limnologist recommendations in past reports (Deniseger 2019; Nordin 2017).

WATER SAMPLES

Grab samples were collected at 1, 5, and 9 m depths at site SWMP-03 (9.5 m on August 18) using a 1 L Van Dorn water sampler. Samples were collected for chlorophyll-*a* (unfiltered), orthophosphate (raw water) and total phosphorous (preserved H_2SO_4) analyses.

Sample bottles were pre-labelled, and handled so as to prevent contamination of the interior cap or bottle. The Van Dorn was rinsed with surface water before each sampling event, and allowed to remain at depth for 10 seconds before retrieving samples to ensure adequate flow and rinsing throughout the sampling tube.

Water sampling procedures followed guidelines provided by ALS, in addition to guidelines outlined in the *Ambient Freshwater and Effluent Sampling Manual* (BC Ministry of Water, Land and Air Protection 2003) and those provided in the ELPMP (PGL 2016). Water samples were transferred to the bottles provided from ALS and packed in a cooler with ice and completed COC form. Samples were immediately shipped to the ALS lab in Burnaby for analysis.

2.3 Analysis

An accredited facility for conducting water quality testing, ALS Laboratories (Burnaby, BC) performed all sample analyses. Laboratory procedures, including Quality Assurance/Quality Control (QA/QC), are based upon recognized Provincial and Federal methodologies. Water quality reports were received by BCCF within one to two weeks of sample submission (Appendix 1).

All laboratory and *in situ* results were compiled and sent to professional limnologist John Deniseger for analysis and comparison to water quality guidelines and data previously collected for Enos Lake. Deniseger's analysis is summarized in "*Enos Lake Protection and Monitoring Program: Review of 2020 Water Quality Data*" (Appendix 2).

3.0 Results

Water quality targets as listed in the ELPMP are summarized in Table 2. Each parameter is discussed in detail in Deniseger (2020) (Appendix 2).

Table 2: Summary of Water Quality Monitoring Targets for data collected in 2020 (PGL 2016).

Parameter (units)		Water Quality Target
***In situ* parameters**	Secchi depth (m)	None - supporting context only
	Dissolved Oxygen (mg/L)	• ≥5 mg/L epilimnion • ≥2 mg/L hypolimnion
	Conductivity (µS/cm)	None - supporting context only
	Temperature (°C)	None - supporting context only
	pH	None - supporting context only
	Redox (mV)	None - supporting context only
Lab result	Total phosphorous	≤12 µg/L
	Chlorophyll-a	Avoid any increase [1]

[1] Chlorophyll-*a* baseline data for Enos Lake (2009-2013) ranges from 0.17 to 19.8 µg/L; values are typically in the range of 4-5 µg/L (PGL 2016).

A summary of mean daily air temperature and precipitation for the summer months of 2016-2020 is provided in Table 3. Summer weather patterns followed a similar trend in 2020 as in 2019, with a relatively cooler July and August than in previous years. August 2020 had the highest mean daily precipitation of the previous four years, which was mainly delivered as two large rain events (10.3 and 19.3 mm on August 6 and August 20, respectively). July and August of 2017 and 2018 had drought-like conditions, with high temperatures and very little precipitation.

Table 3: Summer mean daily air temperature and precipitation for the Qualicum Beach Airport, 2016-2020 (Environment Canada 2020).

JUNE					
	2016	**2017**	**2018**	**2019**	**2020**
Air temp (°C)	15.8	15.3	15.2	16.1	14.9
Precipitation (mm)	1.2	0.6	1.2	0.4	1.8
JULY					
	2016	**2017**	**2018**	**2019**	**2020**
Air temp (°C)	17.9	18.0	19.3	17.8	17.6
Precipitation (mm)	0.5	0.0	0.2	0.9	0.5
AUGUST					
	2016	**2017**	**2018**	**2019**	**2020**
Air temp (°C)	18.7	19.2	18.8	18.4	17.1
Precipitation (mm)	0.5	0.1	0.0	0.3	1.2
SEPTEMBER					
	2016	**2017**	**2018**	**2019**	**2020**
Air temp (°C)	13.6	15.5	14.0	14.6	15.9
Precipitation (mm)	1.5	0.7	3.0	2.5	1.0

	Mean daily precip < 0.5 mm		Mean daily precip 0.5 ≤ 1.0 mm		Mean daily precip > 1.0 mm

3.1 Insitu Field Parameters

A summary of *in situ* field parameters is provided in Tables 4 and 5. Parameters of interest are discussed here, while each parameter is discussed in detail in Deniseger (2020) (Appendix 2).

WATER CLARITY

Additional Secchi depth readings (March – July) were captured with the assistance of volunteer effort by the FoEL. Water clarity varied from a minimum of 0.97 m in February to a maximum of 4.3 m in May. A slight decrease occurred in June (2.0 m), before increasing again in late July (4.0 m). After this second peak, clarity gradually decreased into November (Table 4).

TEMPERATURE

In 2020, water temperature varied widely with the season and the lake's thermal stratification. The maximum noted water temperature was 23.8 °C at the lake surface on August 18 (Table 5). The lake was relatively isothermal in February and November, but exhibited strong thermal stratification in May and August.

DISSOLVED OXYGEN

A supersaturation of dissolved oxygen (DO) occurred in February, with a maximum DO value of 14.92 mg/L at 1 m depth. DO results were very close to falling below the water quality target for the hypolimnion (Table 2) in May, with a minimum DO value of 2.80 mg/L at 10 m depth (Table 5).

Hypoxic conditions in the hypolimnion presumably continued from late May well into August, as the lake's thermal stratification intensified throughout the summer. The water quality target for the hypolimnion (Table 2) was not met during August sampling, as severely hypoxic conditions had developed below 6 m with a minimum DO value of 0.05 mg/L at 9 m depth (Table 5). By November, DO values had returned to acceptable levels.

Table 4: Secchi Depth Summary from Enos Lake 2020 Water Quality Monitoring.

Date	Time	Site	Secchi (m)	Collected by
Feb 28	11:00	SWMP-03	0.97	TR
Mar 22	13:00	SWMP-03	1.7	PL
Apr 5	12:00	SWMP-03	1.7	PL
Apr 19	12:00	SWMP-03	2.3	PL
May 11	11:00	SWMP-03	4.3	TR
Jun 21	13:00	SWMP-03	2.4	PL
Jul 5	14:00	SWMP-03	3.6	PL
Jul 23	14:00	SWMP-03	4.0	PL
Aug 18	10:30	SWMP-03	3.7	TR
Nov 23	10:30	SWMP-03	2.1	TR

Table 5: Summary of *in situ* Results from Enos Lake 2020 Water Quality Monitoring.

1st Quarter Sampling	**Crew: TR, PH**	**Site: SWMP-03**	**Weather: Cloudy, light wind, <10 °C**			
	Date: Feb 28, 2020	**Time: 11:00**	**Staff gauge: not noted**			**Secchi: 0.97 m**
	Depth (m)	Temp. (°C)	D.O. (mg/L)	D.O. (%)	pH	Sp.Con. (µS/cm)	Redox (mV)
Isothermal	0.5	5.5	14.83	117.5	6.86	122.0	132.6
	1	5.4	14.92	118.3	7.07	121.7	131.0
	2	5.4	14.90	118.1	7.19	121.9	130.9
	3	5.4	14.73	116.6	7.29	121.8	131.0
	4	5.4	14.70	116.3	7.36	121.7	131.3
	5	5.4	14.78	116.7	7.42	121.7	132.4
	6	5.4	14.67	116.4	7.45	121.7	133.5
	7	5.4	14.65	115.8	7.47	121.8	132.2
	8	5.4	14.68	116.0	7.48	121.8	135.0
	9	5.4	14.52	114.8	7.50	121.7	135.4
	10	5.3	3.19	24.8	6.76	151.7	20.0
2nd Quarter Sampling	**Crew: TR, ER**	**Site: SWMP-03**	**Weather: Overcast, light breeze, ~ 15 °C**			
	Date: May 11, 2020	**Time: 11:00**	**Staff gauge: 0.88m**			**Secchi: 4.3 m**
	Depth (m)	Temp. (°C)	D.O. (mg/L)	D.O. (%)	pH	Sp.Con. (µS/cm)	Redox (mV)
Epi	0.5	18.5	9.42	100.0	7.62	123.0	205.0
	1	17.9	9.87	103.8	7.73	122.9	201.6
Thermocline	2	16.2	10.73	109.3	7.83	121.8	198.0
	3	15.0	11.11	109.9	7.80	121.7	198.0
	4	13.8	11.24	108.2	7.63	121.3	202.4
	5	10.2	12.77	113.6	7.55	119.5	198.3
	6	8.2	11.32	96.4	7.21	120.0	196.6
	7	7.2	8.53	70.5	7.28	120.3	193.1
Hyp	8	6.7	8.59	70.2	7.19	121.6	192.4
	9	6.4	5.35	43.5	6.93	124.6	191.2
	10	6.3	2.80	22.7	6.89	129.3	177.2
3rd Quarter Sampling	**Crew: TR, PL**	**Site: SWMP-03**	**Weather: Sunny, warm, calm, ~ 20 °C**			
	Date: Aug 18, 2020	**Time: 10:20**	**Staff gauge: 0.65m**			**Secchi: 3.7 m**
	Depth (m)	Temp. (°C)	D.O. (mg/L)	D.O. (%)	pH	Sp.Con. (µS/cm)	Redox (mV)
Epi	0.5	23.8	7.46	88.4	7.76	140.4	176.6
	1	23.7	7.45	88.1	7.82	140.7	177.7
	2	22.8	7.90	91.9	7.99	139.3	183.4
	3	21.9	7.80	89.1	7.86	139.0	183.3
Thermocline	4	21.0	6.76	76.0	7.58	138.4	188.4
	5	17.5	6.47	61.8	6.95	130.0	190.0
	6	12.3	5.73	53.5	6.56	128.3	199.0
	7	9.5	0.11	1.0	6.19	132.8	205.5
	8	8.1	0.07	0.6	6.15	137.6	203.7
Hyp	9	7.3	0.05	0.4	6.14	152.0	166.3
	10	7.2	0.06	0.5	6.03	155.7	149.2
4th Quarter Sampling	**Crew: TR, AA**	**Site: SWMP-03**	**Weather: Overcast, calm ~ 9 °C**			
	Date: Nov 23, 2020	**Time: 09:45**	**Staff gauge: 0.92m**			**Secchi: 2.1 m**
	Depth (m)	Temp. (°C)	D.O. (mg/L)	D.O. (%)	pH	Sp.Con. (µS/cm)	Redox (mV)
Isothermal	0.5	7	10.94	90.20	7.25	123.2	174.5
	1	6.8	10.88	89.30	6.99	122.9	182.9
	2	6.8	10.25	84.10	6.84	122.7	186.7
	3	6.8	9.45	77.50	6.81	122.5	187.2
	4	6.8	9.45	77.50	6.8	122.5	187.8
	5	6.8	9.54	78.60	6.81	122.8	188.8
	6	6.8	9.39	77.00	6.85	122.7	189.2
	7	6.8	9.07	74.40	6.86	122.6	189.4
	8	6.8	9.11	74.80	6.93	122.7	189.6
	9	6.7	9.23	75.60	6.94	122.7	190.6
	10	6.8	8.27	67.80	6.59	123.6	181.7

3.2 Water Samples

A summary of laboratory analyzed samples is provided in Table 6. Each parameter is discussed in detail in Deniseger (2020) (Appendix 2).

PHOSPHOROUS

In 2020, the average Total P results across all samples was 12.0 µg/L (*SD* = 2.5), which is at the limit of the suggested water quality target of ≤12 µg/L (Table 2). This limit was exceeded by individual samples on six occasions from May – November of 2020 (Table 6). In 2019, the average across all samples was 7.3 µg/L (*SD* = 5.0), below the suggested water quality target of ≤12 µg/L. In 2018 and 2017, the averages were above target at 16.6 µg/L (*SD* = 10.6) and 20.4 µg/L (*SD* = 11.1), respectively.

Orthophosphate was relatively undetectable in 2020, with values below the Reported Detection Limit of 1 µg/L for almost all samples, except one result of 1.3 µg/L on August 18 at 5m depth.

CHLOROPHYLL-A

A similar trend was observed for chlorophyll-*a.* The concentration of chlorophyll-*a*, a major photosynthetic pigment of algae, is an indicator of the amount of algae in water. Values did not rise above the upper limit of baseline conditions (19.8 µg/L) as specified in the ELPMP (Table 2), on any of the sample collection dates. The maximum chlorophyll-*a* concentration was 16.6 µg/L, collected on August 18 at 5 m depth.

The average chlorophyll-*a* results across all depths and dates for 2020 (*M* = 9.21 µg/L, *SD* = 4.97) was higher than in 2019 (*M* = 4.54 µg/L, *SD* =2.22), but lower than in 2018 (*M* = 10.22 µg/L, *SD* = 3.65) and 2017 (*M* = 10.55 µg/L, *SD* = 6.52). Note that no chlorophyll-*a* samples were collected in February of 2019, which may have skewed the mean as February is typically a month with higher chlorophyll-*a* concentrations in Enos Lake (>8 µg/L). However, the average midsummer (August) result in 2019 (*M* = 4.14 µg/L, *SD* = 1.2) was also much lower than in 2020 (*M* = 10.93 µg/L, *SD* = 6.60), 2018 (*M* = 12.36 µg/L, *SD* = 5.19) and 2017 (*M* =13.78 µg/L, *SD* = 12.68) giving further confidence to this result.

3.3 Invasive Species

No invasive species were noted during field sampling in 2020.

Table 6: Summary of Laboratory Results from Enos Lake 2020 Water Quality Monitoring.

		Date	Feb 28, 2020			May 11, 2020			Aug 18, 2020			Nov 23, 2020		
		Site	SWMP-03			SWMP-03			SWMP-03			SWMP-03		
Water Quality Parameters	**Units**	**RDL[1]**	**1 m**	**5 m**	**9 m**	**1 m**	**5 m**	**9 m**	**1 m**	**5 m**	**9.5 m**	**1 m**	**5 m**	**9 m**
Chlorophyll-*a*	µg/L	0.50	10.1	10.5	10.3	2.88	3.29	1.91	3.69	16.6	12.5	11.9	13.2	13.7
Anions														
Orthophosphate-Dissolved (as P)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0013	<0.001	<0.001	<0.001	<0.001
Nutrients														
Total Phosphorus (P)	mg/L	0.002	0.0101	0.0112	0.0106	**0.0134** [2]	0.0113	**0.0121** [2]	0.0103	**0.0139** [2]	**0.0175** [2]	0.0075	**0.0125** [2]	**0.0132** [2]

[1] RDL = Reportable Detection Limit

[2] Total phosphorous (Total P) values exceeding the water quality target of ≤12 µg/L

4.0 Discussion

The primary intent of the Enos Lake monitoring program is to better understand the lake's productivity trends (PGL 2016; Deniseger 2019) and to build a consistent, long-term database to assess the overall health of Enos Lake with respect to ongoing development, land use, and increasing population within the watershed (Deniseger 2020; Nordin 2017; PGL 2016). The general management objective for Enos Lake is to maintain pre-development water quality and to avoid eutrophication (PGL 2016).

Watershed disturbances such as logging, road building, development, and climate change impacts all have potential to shift the lake's trophic status through increased stormwater runoff, nutrient loading, rising air and water temperatures, and seasonal variability in precipitation. Therefore, it is important to take surrounding land use and seasonal climate patterns into account when interpreting the water quality trends of Enos Lake.

4.1 In situ Field Parameters

WATER CLARITY

Of note for Enos Lake in 2020, an early spring phytoplankton bloom likely occurred which was captured in the February results, and possibly continued throughout March and April as suggested by the additional Secchi depth readings in these months (Deniseger 2020).

A slight decrease in Secchi depth observed in June 2020 could have been caused by another smaller bloom in early summer, however a lack of supporting nutrient and chlorophyll-*a* data makes this interpretation inconclusive. Decreased Secchi depth may also be caused by other factors, such as heightened turbidity or Total Suspended Solids in the water column which can occur as a result of soil erosion or stormwater runoff during rain events. Without laboratory samples for chlorophyll-*a* or metals, or additional Secchi readings from previous years to compare against this result, it is difficult to conclude the cause. This does, however, demonstrate the advantage of continued Secchi depth observations throughout the year, as it allows for a broader understanding of the lake's ecological dynamics.

TEMPERATURE

Enos Lake usually begins to thermally stratisfy as early as March – April, and undergoes fall turnover between October – November (Nordin 2017 and Deniseger 2018). In 2020, isothermal mixing was noted in February while a strong stratification was observed in May, suggesting adherence to this typical spring pattern. Stratification continued through late summer, contributing to the anoxic conditions observed below 6m depth in August. November's depth profile suggests the lake had only recently undergone fall turnover and not yet undergone complete mixing (Deniseger 2020), which may indicate a slightly later fall pattern than usual for this year.

The maximum water temperature noted was 23.8 °C on August 18 at the lake surface. For comparison, the maximum recorded surface water temperatures were 20.8 °C, 21.9 °C and 22.6 °C in September 2019, August 2018, and August 2017, respectively. Average water temperatures in February of 2020 were 1.5 – 2 degrees warmer than in February of 2019, and 1 degree warmer than in February 2018, reflecting the mild and dry late winter season experienced this year (Deniseger 2020).

DISSOLVED OXYGEN

An early spring phytoplankton bloom that likely occurred in February is reflected in the DO results. Significant blooms can result in daytime oxygen supersaturation in lake waters, and is a probable explanation for the high DO concentrations reported in February (Deniseger 2020).

DO concentration targets for the epilimnion (≥5 mg/L) were met in all months, however targets for the hypolimnion (≥2 mg/L) were not met in August. Per Deniseger (2020), "a very steep, compressed thermocline was observed in August between 4-8 m, causing stratification and preventing oxygen replenishment in deeper waters". A strong thermocline, in combination with biological decomposition of organic matter at the lake bottom, can result in severe oxygen depletion within the hypolimnion – a phenomenon that was observed in August 2020. The greater the amount of organic matter and the smaller the volume of water in the hypolimnion, the more rapidly the oxygen gets depleted at depth (MSU 2008). The risk of this is triggering internal P loading from lake sediments (Deniseger 2020).

This appears to be a typical pattern of summer stratification and hypoxia for Enos Lake, with the hypolimnion frequently experiencing conditions ≤1 mg/L (MESL 2014). However, Nordin (2017) suggests that climate change poses a serious threat to Enos Lake, as rising water temperatures will likely result in increased productivity and longer stratification times and, in turn, even larger effects on DO levels in the hypolimnion. This appears to be reflected in the results of recent years: mid-summer hypoxia recorded in 2020 was at its most extreme since 2017, with a minimum DO in the epilimnion of 0.05 mg/L, as compared to 0.09 mg/L, 0.25 mg/L and 1.27 mg/L in 2019, 2018 and 2017, respectively (BCCF 2019; BCCF 2018; BCCF 2017).

As mentioned in the ELPMP, this type of severe hypoxia to anoxia in the hypolimnion is considered a natural existing condition of Enos Lake, and hence the focus is on the epilimnion where hypoxic conditions would have the most negative impact on the ecology of the lake (PGL 2016). However, a trend of worsening hypoxia at depth should be closely monitored in summer to ensure the oxygen depletion does not extend too far up into the thermocline, restricting the habitable range for aquatic life. If the hypolimnion volume increases and dwarfs the epilimnion, it could cause total dieoffs for fish at fall turnover, bringing the entire lake below suitable DO levels for aquatic life (J. Damborg, pers. comm., December 2020).

4.2 Water Samples

PHOSPHOROUS

Total P results suggest the productivity of Enos Lake in 2020 increased relative to 2019, but remained lower than in 2017 and 2018. In 2020, the highest Total P value was 17.5 µg/L at 9 m depth in August, as compared to 13.6 µg/L at 10m depth in August 2019, 35.8 µg/L at 10m depth in August 2018, and 33.0 µg/L at 10 m depth in August 2017.

Deniseger (2020) suggests these variances are likely due to year-to-year variability related to weather patterns: in 2020, summer temperatures were cooler on average than in past years, and tempered by reasonable summer precipitation and the lack of an extended summer drought. In 2019, the summer weather was relatively cool and highlighted by a rain event in early August, which may have resulted in

improved nutrient removal and oxygen replenishment at depth over the short term (Deniseger 2019). 2018 and 2017 both experienced high air temperatures and drought-like conditions during the months of July and August (Environment Canada 2020).

CHLOROPHYLL-A

Chlorophyll-*a* followed a similar pattern to Total P in 2020. The 2020 data had an annual mean of 9.2 µg/L, higher than that of last year's 4.5 µg/L, but similar to the higher 2018 and 2017 averages of 10.2 µg/L and 10.6 µg/L, respectively (BCCF 2019; BCCF 2018; BCCF 2017).

General trophic status classification using Total P and chlorophyll-*a* is summarized in Table 6 below, per comments in Deniseger (2020).

Table 7: Summary of trophic status classification based on chlorophyll-*a* and total phosphorous.

Total phosphorous	<10 µg/L [1]	Oligotrophic
	10 - 30 µg/L [1]	Mesotrophic
	>30 µg/L [1]	Eutrophic
Chlorophyll-*a*	<2 µg/L	Oligotrophic
	2 - 7 µg/L	Mesotrophic
	>7 µg/L	Eutrophic

[1] In lakes with longer residence times (>1 year), the Total P assessment is based on concentrations at spring overturn, prior to the establishment of a thermocline. In lakes with shorter residence times (<1 year), it is based on an annual mean.

Using these assessment methods for Total P, Enos Lake would be considered mesotrophic in 2020 and in both 2018 and 2017, but oligotrophic in 2019 (Deniseger 2020). Using the assessment of mean chlorophyll-*a* concentration, 2020 was indicative of a eutrophic lake, as was the case in both 2018 and 2017. The lower annual average in 2019 was the exception, as it was indicative of a mesotrophic or moderately productive lake (Deniseger 2020).

Therefore, the trophic classification of Enos Lake for 2020 is between a mesotrophic to eutrophic lake. This is very similar to the classification in 2017, when chlorophyll-*a*, Total P and Secchi results showed the characteristics of being mainly a mesotrophic lake with high concentrations of total phosphorus and DO deficiencies in the hypolimnion, indicating the lake may be more productive than is desirable (Nordin 2017). This year-to-year variability highlights the importance of building a longer term dataset which can help tease out trends over time. All results are discussed in further detail in Deniseger (2020) (Appendix 2).

4.3 Invasive Species

A BCCF biologist trained in aquatic invasive plant ID attended all sampling dates and made incidental observations of aquatic and terrestrial plants, per recommendations in the ELPMP (PGL 2016). No aquatic invasive species were noted in 2020. A draft of invasive species awareness signage was developed in late 2020 with input from the Friends of Enos Lake and printing and installation will be pursued 2021.

5.0 Recommendations

- Ongoing monitoring and water quality protection efforts will help prevent Enos Lake from undergoing significant detrimental change to its productivity. Future monitoring should, at minimum, follow the suggested schedule and guidelines as laid out in the ELPMP (PGL 2016).

- Of specific concern in 2020, a trend of intensifying hypoxia at depth prompts paying close attention to this phenomenon in the coming years.

- 2020 results showed the value of additional Secchi measurements, as recommended in 2019. This should continue as volunteer capacity allows. The critical period for monitoring is during the summer, when the lake is stratified (March – November); at least one or two additional winter readings (December – March) are required.

- Deniseger (2020) recommends the establishment of an Enos Lake website where data and reports can be stored and made available to the public. The ELPMP also recommends having data housed on the provincial EMS web portal (PGL 2016). Steps were taken in 2020 towards developing a page for Enos Lake on the Mid-Vancouver Island Habitat Enhancement Society's webpage, on behalf of the Friends of Enos Lake. EMS data submission will be pursued in 2021.

- No duplicate samples were collected in 2020. At least one duplicate sample for each of chlorophyll-*a*, total phosphorous and orthophosphate should be collected in 2021 to increase confidence in the sampling protocol and laboratory analysis results.

- A more thorough data review should be done every 5 years to examine trends, review the monitoring program, and provide a feedback loop to watershed management. This should be completed after sampling in 2022.

References

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Appendix 1

Laboratory results

BRITISH COLUMBIA CONSERVATION FOUNDATION
ATTN: Thea Rodgers
PO Box 7, Unit 1 - 7217
Lantzville BC V0R 2H0

Date Received: 29-FEB-20
Report Date: 11-MAR-20 16:09 (MT)
Version: FINAL

Client Phone: 250-390-2525

Certificate of Analysis

Lab Work Order #: L2422539

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers: 17-760887
Legal Site Desc:

Rojina Ghavami
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2422539-1	L2422539-2	L2422539-3		
	Description	Water	Water	Water		
	Sampled Date	28-FEB-20	28-FEB-20	28-FEB-20		
	Sampled Time	12:00	11:55	11:50		
	Client ID	SWMP03-1M	SWMP03-5M	SWMP03-9M		
Grouping	**Analyte**					
WATER						
Anions and Nutrients	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	<0.0010		
	Phosphorus (P)-Total (mg/L)	0.0101	0.0112	0.0106		
Plant Pigments	Chlorophyll a (ug/L)	10.1	10.5	10.3		

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CHLOROA-F-VA	Water	Chlorophyll a by Fluorometer	EPA 445.0

This analysis is done using procedures modified from EPA Method 445.0. Chlorophyll-a is determined by a routine acetone extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

17-760887

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2422539-COFC

COC Number: 17 - 760887

Page 1 of 1

Report To	Contact and company name below will appear on the final report
Company:	BC Conservation Foundation
Contact:	Jamieson Atkinson
Phone:	1-250-390-2525 x. 222
	Company address below will appear on the final report
Street:	#1 - 7217 Lantzville Road
City/Province:	Lantzville, BC
Postal Code:	V0R 2H0
Invoice To	Same as Report To [X] YES [ ] NO
	Copy of Invoice with Report [ ] YES [X] NO
Company:	
Contact:	

Report Format / Distribution

Select Report Format: [X] PDF [ ] EXCEL | | EDD (DIGITAL)
Quality Control (QC) Report with Report [X] YES [ ] NO
[ ] Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: [X] EMAIL | | MAIL [ ] FAX
Email 1 or Fax: jatkinson@bccf.com
Email 2: trodgers@bccf.com
Email 3:

Invoice Distribution

Select Invoice Distribution: [X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax: jatkinson@bccf.com
Email 2: lfimerick@bccf.com

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] [X] Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4-20%] [ ] | 3 day [P3-25%] [ ] | 2 day [P2-50%] [ ]

EMERGENCY: 1 Business day [E - 100%] [ ] | Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] [ ]

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #: Q78255
Job #:
PO / AFE:
LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: | PO#
Major/Minor Code: | Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only):

ALS Contact: Rojina G. | Sampler: TR / PH

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm) PST	Sample Type	NUMBER OF CONTAINERS	Chlorophyll-a (unfiltered)	Total P (H_2SO_4 preserved)	Orthophosphate	SAMPLES ON HOLD	SUSPECTED HAZARD (see Special Instructions)
	SWMP03 - 1m	28-02-20	12:00	Water	3	X	X	X		
	SWMP03 - 5m	28-02-20	11:55	"	3	X	X	X		
	SWMP03 - 9m	28-02-20	11:50	"	3	X	X	X		

All bottles say CO, but sampled @ 9

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? [ ] YES [ ] NO
Are samples for human consumption/ use? | | YES | | NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

Chl-a - please filter w/i 48 hours if possible. (saturday)
(Bottles only half-filled ~500 mL)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen [ ] | SIF Observations Yes [ ] No [ ]
Ice Packs [X] Ice Cubes [ ] | Custody seal intact Yes [ ] No [ ]
Cooling Initiated [ ]

INITIAL COOLER TEMPERATURES °C				FINAL COOLER TEMPERATURES °C			
				7			

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:
TR / PH	28 / 02 / 2020	14:00				JC	FEB 29 2020	8:25AM

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA20A6209**	Page	: 1 of 2
Client	: **The British Columbia Conservation Foundation**	Laboratory	: Vancouver - Environmental
Contact	: Jamieson Atkinson	Account Manager	: Rojina Ghavami
Address	: 7217 Lantzville Road Suite 1 Lantzville BC Canada V0R 2H0	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 12-May-2020 09:25
PO	: ----	Date Analysis Commenced	: 12-May-2020
C-O-C number	: 17-760888	Issue Date	: 20-May-2020 16:12
Sampler	: T R		
Site	: ----		
Quote number	: Q78255 - Standing offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caitlin Macey	Team Leader - Inorganics	Inorganics - Water Quality, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics - Water Quality, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
µg/L	micrograms per litre
mg/L	milligrams per litre

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in reports identified as "Preliminary Report" are considered authorized for use.

Analytical Results

Sub-Matrix: **Water** (Matrix: **Water**)				*Client sample ID*	**SWMP 03 - 1m**	**SWMP 03 - 5m**	**SWMP 03 - 9m**	**----**	**----**
				Client sampling date / time	11-May-2020 12:10	11-May-2020 12:15	11-May-2020 12:25	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA20A6209-001**	**VA20A6209-002**	**VA20A6209-003**	**--------**	**--------**
					Result	Result	Result	----	----
Anions and Nutrients									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	<0.0010	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0134	0.0113	0.0121	----	----
Plant Pigments									
chlorophyll a	479-61-8	E870	0.010	µg/L	2.88	3.29	1.91	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA20B3007**	Page	: 1 of 2
Client	: **The British Columbia Conservation Foundation**	Laboratory	: Vancouver - Environmental
Contact	: Thea Rodgers	Account Manager	: Rojina Ghavami
Address	: 7217 Lantzville Road Suite 1 Lantzville BC Canada V0R 2H0	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 250-390-2525	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 19-Aug-2020 09:00
PO	: ----	Date Analysis Commenced	: 19-Aug-2020
C-O-C number	: ----	Issue Date	: 25-Aug-2020 14:11
Sampler	: T R		
Site	: ----		
Quote number	: Q78255 - Standing offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caitlin Macey	Team Leader - Inorganics	Inorganics - Water Quality, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics - Water Quality, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
µg/L	micrograms per litre
mg/L	milligrams per litre

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in reports identified as "Preliminary Report" are considered authorized for use.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	*Client sample ID*	**SWMP 03 (1m)**	**SWMP 03 (5m)**	**SWMP 03 (10m)**	**----**	**----**
					Client sampling date / time	18-Aug-2020 10:45	18-Aug-2020 11:00	18-Aug-2020 11:08	----	----
						VA20B3007-001	**VA20B3007-002**	**VA20B3007-003**	**--------**	**--------**
						Result	Result	Result	----	----
Anions and Nutrients										
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L		<0.0010	0.0013	<0.0010	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L		0.0103	0.0139	0.0175	----	----
Plant Pigments										
chlorophyll a	479-61-8	E870	0.010	µg/L		3.69	16.6	12.5	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA20B3007**	Page	: 1 of 6
Client	: **The British Columbia Conservation Foundation**	Laboratory	: Vancouver - Environmental
Contact	: Thea Rodgers	Account Manager	: Rojina Ghavami
Address	: 7217 Lantzville Road Suite 1 Lantzville BC Canada V0R 2H0	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 250-390-2525	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 19-Aug-2020 09:00
PO	: ----	Issue Date	: 25-Aug-2020 14:11
C-O-C number	: ----		
Sampler	: T R		
Site	: ----		
Quote number	: Q78255 - Standing offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- No Analysis Holding Time Outliers exist.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 15:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 15:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE SWMP 03 (10m)	E378-U	18-Aug-2020	----	----	----		19-Aug-2020	3 days	1 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE SWMP 03 (1m)	E378-U	18-Aug-2020	----	----	----		19-Aug-2020	3 days	1 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE SWMP 03 (5m)	E378-U	18-Aug-2020	----	----	----		19-Aug-2020	3 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) SWMP 03 (10m)	E372-U	18-Aug-2020	21-Aug-2020	28 days	3 days	✓	22-Aug-2020	24 days	0 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) SWMP 03 (1m)	E372-U	18-Aug-2020	21-Aug-2020	28 days	3 days	✓	22-Aug-2020	24 days	0 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) SWMP 03 (5m)	E372-U	18-Aug-2020	21-Aug-2020	28 days	3 days	✓	22-Aug-2020	24 days	0 days	✓
Plant Pigments : Chlorophyll-a by Fluorometry										
Opaque HDPE SWMP 03 (10m)	E870	18-Aug-2020	19-Aug-2020	2 days	0 days	✓	24-Aug-2020	28 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Plant Pigments : Chlorophyll-a by Fluorometry										
Opaque HDPE										
SWMP 03 (1m)	E870	18-Aug-2020	19-Aug-2020	2 days	0 days	✓	24-Aug-2020	28 days	4 days	✓
Plant Pigments : Chlorophyll-a by Fluorometry										
Opaque HDPE										
SWMP 03 (5m)	E870	18-Aug-2020	19-Aug-2020	2 days	0 days	✓	24-Aug-2020	28 days	4 days	✓

Legend & Qualifier Definitions

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	73927	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	75085	1	18	5.5	5.0	✓
Laboratory Control Samples (LCS)							
Chlorophyll-a by Fluorometry	E870	73867	1	3	33.3	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	73927	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	75085	1	18	5.5	5.0	✓
Method Blanks (MB)							
Chlorophyll-a by Fluorometry	E870	73867	1	3	33.3	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	73927	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	75085	1	18	5.5	5.0	✓
Matrix Spikes (MS)							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	73927	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	75085	1	18	5.5	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Chlorophyll-a by Fluorometry	E870 Vancouver - Environmental	Water	EPA 445.0 (mod)	Chlorophyll a is determined by a 90 % acetone extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b. Sample volume provided by client.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Chlorophyll-a Extraction	EP870 Vancouver - Environmental	Water	EPA 445.0 (mod)	Chlorophyll a is determined by a 90 % acetone extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b. Sample volume provided by client.

QUALITY CONTROL REPORT

Work Order	: **VA20B3007**	Page	: 1 of 3
Client	: The British Columbia Conservation Foundation	Laboratory	: Vancouver - Environmental
Contact	: Thea Rodgers	Account Manager	: Rojina Ghavami
Address	: 7217 Lantzville Road Suite 1 Lantzville BC Canada V0R 2H0	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 250-390-2525	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 19-Aug-2020 09:00
PO	: ----	Date Analysis Commenced	: 19-Aug-2020
C-O-C number	: ----	Issue Date	: 25-Aug-2020 14:11
Sampler	: T R		
Site	: ----		
Quote number	: Q78255 - Standing offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caitlin Macey	Team Leader - Inorganics	Inorganics - Water Quality, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics - Water Quality, Burnaby, British Columbia

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Anions and Nutrients (QCLot: 73927)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	96.5	80.0	120	----
Anions and Nutrients (QCLot: 75085)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	90.2	80.0	120	----
Plant Pigments (QCLot: 73867)									
chlorophyll a	479-61-8	E870	0.01	µg/L	5 µg/L	103	80.0	120	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 73927)										
VA20B2963-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0278 mg/L	0.03 mg/L	92.6	70.0	130	----
Anions and Nutrients (QCLot: 75085)										
VA20B2880-002	Anonymous	phosphorus, total	7723-14-0	E372-U	ND mg/L	0.05 mg/L	ND	70.0	130	----

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 17 -

Page 1 of 1

Report To	Contact and company name below will appear on the final report
Company:	BC Conservation Foundation
Contact:	Thea Rodgers
Phone:	250-390-2525 ext 227
	Company address below will appear on the final report
Street:	#1-7217 Lantzville Rd
City/Province:	Lantzville, BC
Postal Code:	V0R 2H0
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☑ YES ☐ NO
Company:	
Contact:	

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax: trodgers@bccf.com
Email 2:
Email 3:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax: trodgers@bccf.com
Email 2: llimerick@bccf.com

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days):
- 4 day [P4-20%] ☐
- 3 day [P3-25%] ☐
- 2 day [P2-50%] ☐

EMERGENCY:
- 1 Business day [E1 - 100%] ☐
- Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #: Q78255
Job #:
PO / AFE:
LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#:
Major/Minor Code: Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only):

ALS Contact: Rojina G. Sampler: TR

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Chlorophyll a (UNFILTERED)	Total Phosphorous	Orthophosphate	SAMPLES ON HOLD	Sample is hazardous (please provide further detail)	NUMBER OF CONTAINERS
	SWMP 03 (1m)	18-Aug-20	1045	Water	R	R	R			3
	SWMP 03 (5m)	18-Aug-20	1100	Water	R	R	R			3
	SWMP 03 (10m)	18-Aug-20	1108	Water	R	R	R			3

Environmental Division
Vancouver
Work Order Reference
VA20B3007

Telephone : +1 604 253 4188

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO
Are samples for human consumption/ use? ☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

Please filter chlorophyll-a ASAP.
Thank you. (< 48 hours)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C	FINAL COOLER TEMPERATURES °C
	10°C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: TR	Date: Aug 18	Time: 1300	Received by:	Date:	Time:	Received by: RCS	Date: Aug 19 2020	Time: 9:00 a.m.

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

SEPT 2017 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

10°C

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA20C1537**	Page	: 1 of 2
Client	: **The British Columbia Conservation Foundation**	Laboratory	: Vancouver - Environmental
Contact	: Thea Rodgers	Account Manager	: Sneha Sansare
Address	: 7217 Lantzville Road Suite 1 Lantzville BC Canada V0R 2H0	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 250-390-2525	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 24-Nov-2020 08:40
PO	: ----	Date Analysis Commenced	: 24-Nov-2020
C-O-C number	: ----	Issue Date	: 01-Dec-2020 18:06
Sampler	: T R		
Site	: ----		
Quote number	: Q78255 - Standing offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
µg/L	micrograms per litre
mg/L	milligrams per litre

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in reports identified as "Preliminary Report" are considered authorized for use.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

					Client sample ID	**SWMP 03 (1m)**	**SWMP 03 (5m)**	**SWMP 03 (9m)**	**----**	**----**
					Client sampling date / time	23-Nov-2020	23-Nov-2020	23-Nov-2020	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*		**VA20C1537-001**	**VA20C1537-002**	**VA20C1537-003**	**--------**	**--------**
						Result	Result	Result	----	----
Anions and Nutrients										
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L		<0.0010	<0.0010	<0.0010	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L		0.0075	0.0125	0.0132	----	----
Plant Pigments										
chlorophyll a	479-61-8	E870	0.010	µg/L		11.9	13.2	13.7	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA20C1537**	Page	: 1 of 6
Client	: **The British Columbia Conservation Foundation**	Laboratory	: Vancouver - Environmental
Contact	: Thea Rodgers	Account Manager	: Sneha Sansare
Address	: 7217 Lantzville Road Suite 1 Lantzville BC Canada V0R 2H0	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 250-390-2525	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 24-Nov-2020 08:40
PO	: ----	Issue Date	: 01-Dec-2020 18:06
C-O-C number	: ----		
Sampler	: T R		
Site	: ----		
Quote number	: Q78255 - Standing offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- No Analysis Holding Time Outliers exist.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 15:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 15:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE SWMP 03 (1m)	E378-U	23-Nov-2020	----	----	----		25-Nov-2020	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE SWMP 03 (5m)	E378-U	23-Nov-2020	----	----	----		25-Nov-2020	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE SWMP 03 (9m)	E378-U	23-Nov-2020	----	----	----		25-Nov-2020	3 days	2 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) SWMP 03 (1m)	E372-U	23-Nov-2020	28-Nov-2020	28 days	5 days	✓	29-Nov-2020	22 days	0 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) SWMP 03 (5m)	E372-U	23-Nov-2020	29-Nov-2020	28 days	6 days	✓	30-Nov-2020	21 days	0 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) SWMP 03 (9m)	E372-U	23-Nov-2020	29-Nov-2020	28 days	6 days	✓	30-Nov-2020	21 days	0 days	✓
Plant Pigments : Chlorophyll-a by Fluorometry										
Opaque HDPE SWMP 03 (1m)	E870	23-Nov-2020	24-Nov-2020	2 days	1 days	✓	26-Nov-2020	28 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Plant Pigments : Chlorophyll-a by Fluorometry										
Opaque HDPE SWMP 03 (5m)	E870	23-Nov-2020	24-Nov-2020	2 days	1 days	✓	26-Nov-2020	28 days	1 days	✓
Plant Pigments : Chlorophyll-a by Fluorometry										
Opaque HDPE SWMP 03 (9m)	E870	23-Nov-2020	24-Nov-2020	2 days	1 days	✓	26-Nov-2020	28 days	1 days	✓

Legend & Qualifier Definitions

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	121764	1	18	5.5	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	123662	2	17	11.7	5.0	✓
Laboratory Control Samples (LCS)							
Chlorophyll-a by Fluorometry	E870	121648	1	15	6.6	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	121764	1	18	5.5	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	123662	2	17	11.7	5.0	✓
Method Blanks (MB)							
Chlorophyll-a by Fluorometry	E870	121648	1	15	6.6	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	121764	1	18	5.5	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	123662	2	17	11.7	5.0	✓
Matrix Spikes (MS)							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	121764	1	18	5.5	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	123662	2	17	11.7	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Chlorophyll-a by Fluorometry	E870 Vancouver - Environmental	Water	EPA 445.0 (mod)	Chlorophyll a is determined by a 90 % acetone extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b. Sample volume provided by client.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Chlorophyll-a Extraction	EP870 Vancouver - Environmental	Water	EPA 445.0 (mod)	Chlorophyll a is determined by a 90 % acetone extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b. Sample volume provided by client.

QUALITY CONTROL REPORT

Work Order	: **VA20C1537**	Page	: 1 of 4
Client	: The British Columbia Conservation Foundation	Laboratory	: Vancouver - Environmental
Contact	: Thea Rodgers	Account Manager	: Sneha Sansare
Address	: 7217 Lantzville Road Suite 1 Lantzville BC Canada V0R 2H0	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 250-390-2525	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 24-Nov-2020 08:40
PO	: ----	Date Analysis Commenced	: 24-Nov-2020
C-O-C number	: ----	Issue Date	: 01-Dec-2020 18:06
Sampler	: T R		
Site	: ----		
Quote number	: Q78255 - Standing offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Anions and Nutrients (QC Lot: 121764)											
VA20C1529-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0100	mg/L	0.0640	0.0670	0.0030	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 123662)											
VA20C1526-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	<0.0020	<0.0020	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 123796)											
VA20C1537-002	SWMP 03 (5m)	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0125	0.0106	0.0019	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Anions and Nutrients (QCLot: 121764)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 123662)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 123796)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Plant Pigments (QCLot: 121648)						
chlorophyll a	479-61-8	E870	0.01	µg/L	<0.010	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Anions and Nutrients (QCLot: 121764)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	101	80.0	120	----
Anions and Nutrients (QCLot: 123662)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	89.0	80.0	120	----
Anions and Nutrients (QCLot: 123796)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	98.2	80.0	120	----
Plant Pigments (QCLot: 121648)									
chlorophyll a	479-61-8	E870	0.01	µg/L	5 µg/L	107	80.0	120	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 121764)										
VA20C1529-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0311 mg/L	0.03 mg/L	104	70.0	130	----
Anions and Nutrients (QCLot: 123662)										
VA20C1537-001	SWMP 03 (1m)	phosphorus, total	7723-14-0	E372-U	0.0378 mg/L	0.05 mg/L	75.7	70.0	130	----
Anions and Nutrients (QCLot: 123796)										
VA20C1537-003	SWMP 03 (9m)	phosphorus, total	7723-14-0	E372-U	0.0467 mg/L	0.05 mg/L	93.4	70.0	130	----

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 17 -

Page of

Report To	Contact and company name below will appear on the final report
Company:	BC Conservation Foundation
Contact:	Thea Rodgers
Phone:	250-390-2525 ext 227
	Company address below will appear on the final report
Street:	#1-7217 Lantzville Rd
City/Province:	Lantzville, BC
Postal Code:	V0R 2H0
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☑ YES ☐ NO
Company:	
Contact:	

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax trodgers@bccf.com
Email 2
Email 3

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax trodgers@bccf.com
Email 2 llimerick@bccf.com

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4-20%] ☐ ; 3 day [P3-25%] ☐ ; 2 day [P2-50%] ☐
EMERGENCY: 1 Business day [E1 - 100%] ☐ ; Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] ☐

Date and Time Required for all E&P TATs:

For tests that can not be performed according to the service level selected, you will be contacted.

Project Information

ALS Account # / Quote #:	Q78255
Job #:	
PO / AFE:	
LSD:	

Oil and Gas Required Fields (client use)

AFE/Cost Center:	PO#
Major/Minor Code:	Routing Code:
Requisitioner:	
Location:	

ALS Lab Work Order # (lab use only): c1537
ALS Contact: Rojina G. Sampler: TR

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Chlorophyll a (UNFILTERED)	Total Phosphorous	Orthophosphate	SAMPLES ON HOLD	Sample is hazardous (please provide further detail)	NUMBER OF CONTAINERS
	SWMP 03 (1m)	23-Nov-20		Water	R	R	R			3
	SWMP 03 (5m)	23-Nov-20		Water	R	R	R			3
	SWMP 03 (9m)	23-Nov-20		Water	R	R	R			3

Environmental Division
Vancouver
Work Order Reference
VA20C1537

Telephone : - 1 604 253 4188

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ YES ☐ NO
Are samples for human consumption/ use? ☐ YES ☐ NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C				FINAL COOLER TEMPERATURES °C			
				4.1°C			

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: TR	Date:	Time:	Received by:	Date:	Time:	Received by: RK	Date: 24/11/20	Time: 8:40 am

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

SEPT 2017 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Appendix 2

Limnologist's Report

Enos Lake Protection and Monitoring Program:

Review of 2020 Water Quality Data

From PGL, 2016

For: **BC Conservation Foundation, Lantzville Office**

PO Box 7

Lantzville, B.C.

V0R 2H0

By: John Deniseger

December 2020

Summary

Year 4 of the BCCF's Enos Lake annual water quality monitoring program was completed in 2020. The program includes components that are done annually and others that are done on a 5-year cycle beginning in 2017. This report examines the results from the annual component collected in 2020, and compares them to water quality targets for Enos Lake.

In 2020, Enos Lake appeared to be more productive than 2019 but less productive than in previous years. The lack of a prolonged summer drought in 2020 may have created summer conditions in Enos Lake representing a mid-range scenario between 2017/18 and 2019. The annual mean total phosphorus was borderline as it was right at the target of 12 ug/L. Dissolved oxygen at depth did not meet the target for water quality – the lake was virtually anoxic below the thermocline in August. Chlorophyll a and secchi data were indicative of a eutrophic lake, while total phosphorus indicated a mesotrophic lake.

While conditions will vary from year to year, Enos Lake is a relatively productive lake based on indicators such as phosphorus, chlorophyll a and secchi depth, as well as lack of dissolved oxygen at depth.

1.0 Background

Enos Lake is a small lake with a surface area of 18 ha, and a watershed area of approximately 235 ha. It is in a largely undeveloped area of the Fairwinds Community in Nanoose Bay, B.C. Approximately 12 ha have been developed with predominantly low-density residential housing (PGL, 2016, Nordin 2017).

While some water quality sampling has been carried out since 2006, a standardized sampling program was established in 2017. Sampling history prior to 2017 is further outlined in Nordin (2017). The 2018 and 2019 data are reviewed in Deniseger (2018 and 2019).

The current water sampling program is intended to build a consistent, long-term database used to assess the overall health of Enos Lake with respect to ongoing development, land use, and increasing population within the watershed over the next 10 to 20 years. Fundamental water chemistry and biology are indicators of water quality, potential change and overall lake and watershed health. The data will be used to assess year-to-year lake health and trends over time.

The purpose of this report is to review the data collected in 2020 and provide a summary report documenting any changes or potential trends observed since 2017.

2.0 Water Quality Results

Table 2.0 below (PGL, 2016) outlines the standardized water quality monitoring which began in 2017. It also lays out the targets used to assist the interpretation of the water quality results for the various parameters.

Table 2.0 Summary of Water Quality Monitoring Program for Enos Lake (PGL, 2016)

Parameter (units)		Water Quality Target	Future Monitoring[a]
Field Parameters (profiles at 1m increments)	Secchi Depth (m)	None – supporting context only	Quarterly sampling[b] at site SWMP-03, starting in 2017 and repeated annually
	Dissolved Oxygen (mg/L and % saturation)	• ≥5 mg/L epilimnion • ≥2 mg/L hypolimnion	Quarterly sampling[b] at site SWMP-03, starting in 2017 and repeated annually
	Conductivity (µS/cm)	None – supporting context only	Quarterly sampling[b] at site SWMP-03, starting in 2017 and repeated annually
	Temperature (°C)	None – supporting context only	Quarterly sampling[b] at site SWMP-03, starting in 2017 and repeated annually
	pH	None – supporting context only	Quarterly sampling[b] at site SWMP-03, starting in 2017 and repeated annually
	Redox (mV)	None – supporting context only	Quarterly sampling[b] at site SWMP-03, starting in 2017 and repeated annually
Laboratory Parameters	*E. coli* (# per mL)	BC Water Quality Guidelines (recreation – secondary contact)[c]	August 2017: 5 times in 30 days. Surface sample from SWMP-03 and any two shoreline locations. Repeat on 5 year increment.
	PAHs (µg/mg)	BC Water Quality Guidelines (freshwater sediments)	August 2017: surface sediment from three locations: SWMP-06, SWMP-04 and SWMP-03.
	Metals (various)	BC Water Quality Guidelines (total metals, freshwater aquatic life). Both average and short-term maximum guidelines apply, where applicable.	February 2017 and August 2017: five samples in a 30 day period. Each sample to occur at three depths from SWMP-03. Sampling to be repeated on five year increments.
	Chlorophyll *a* (µg/L)	Avoid any increase	Quarterly sampling at site SWMP-03, starting in 2017, and repeated annually. Samples to be taken from three depths (surface, mid, deep water)
	Hardness (as $CaCO_3$)	None – required to interpret metals data	February 2017 and August 2017: five samples in a 30 day period. Each sample to occur at three depths from SWMP-03. Sampling to be repeated on five year increments. Data required to interpret metals concentrations.
	Phosphorous (mg/L)	12 µg/L	Quarterly sampling at site SWMP-03, starting in 2017. Samples to be taken from three depths (surface, mid, deep water)

[a]Future monitoring is limited to the scope being taken on by the Developer and will continue until at least one year post build-out within the Enos Lake watershed. It is anticipated that some form of longer term monitoring will be undertaken by RDN in support of long term operation of stormwater infrastructure.
[b]Quarterly sampling is defined as February, May, August, and November.
[c]It is assumed that swimming will not be a recreational use of Enos Lake. If that assumption is incorrect, primary contact guidelines should apply.

2.1 Secchi Depth

Secchi depth is a standard measure of water clarity, providing insight into lake health and productivity from both an aesthetic and ecological perspective.

The 11 data points collected in 2017 showed substantial variation from 1.4 to 4.8 m with an average of 3 m. Due to the inherent variability in secchi data, Nordin (2017) recommended that the base sampling program include monthly secchi data collection.

In each of 2018 and 2019, only 5 data points were collected, ranging from 2.0 to 3.5 m, and 1.5 to 2.8 m, respectively.

As recommended in previous reports, more secchi measurements were collected in 2020. The 10 data points varied from 1.0 to 4.3 m, with an annual average of 2.7 m. Interestingly, the lowest secchi depth readings were taken as part of the February 28th sampling trip. This coincided with the highest chlorophyll a value measured in 2020, highly likely associated with an early spring phytoplankton bloom.

While the next chlorophyll a measurement occurred on May 11th, the secchi readings of 1.7 m in March and April likely indicate the continuation of the phytoplankton bloom. The secchi measurement of 4.3 m on May 11th coincided with substantially lower chlorophyll a levels, indicating that the early spring "bloom" had likely ended.

Secchi Disc data for 2020 (station 03)

Date	Secchi (m)
Feb 28	1.0
March 22	1.7
April 5	1.7
April 19	2.3
May 11	4.3
June 21	2.4
July 5	3.6
July 23	4.0
August 18	3.7
November 23	2.1

Annual average 2.7 meters

Average summer secchi depth of less than 3 meters are normally indicative of a eutrophic lake. Based on that criterion, Enos Lake would be considered a eutrophic lake.

2.2 Temperature

Field data collection in 2020 included temperature, dissolved oxygen, conductivity and redox potential profiles taken quarterly at station 03, the mid lake sampling station.

Lake temperature has fundamental effects on a lake's seasonal susceptibility to watershed activities and disturbance. Thermal stratification is an important factor in understanding fundamental lake ecology and natural processes. Table 2.1 summarizes the lake temperature profiles for 2020. The late February profile shows the lake to be effectively isothermal, unstratified and mixing. The water temperature was 1.5 to 2 degrees C warmer than in February 2019 and nearly 1 degree C warmer than in 2018, reflecting the relatively milder and drier February 2020 weather patterns. By May, the profile indicates strong stratification with a shallow upper warm layer (epilimnion) overlying a deeper cool layer(hypolimnion). The transition zone between the two layers is known as the thermocline – it is defined by having a change of greater than 1 C per meter of depth change. The overall difference from top to bottom was 12.2 C. In August, the upper 4 meters of Enos Lake were greater than 20 C, with a very steep, compressed thermocline between 4 and 8 meters in depth. The strong thermocline is continuous at least from mid-spring through early fall, effectively isolating the deeper waters of the lake. The surface water was 16.6 C warmer than the deepest waters of the lake. In late November, the lake was once again isothermal, unstratified and mixing. Enos Lake's thermal stratification patterns appear to be fairly typical of small, east coast Vancouver Island lakes.

Table 2.1 Enos Lake temperature profiles for 2020

Profile - Site SWMP-03				
	2/28/2020	5/11/2020	8/18/2020	11/23/2020
Depth (m)	Temp. (°C)	Temp. (°C)	Temp. (°C)	Temp. (°C)
0.5	5.5	18.5	23.8	7
1	5.4	17.9	23.7	6.8
2	5.4	16.2	22.8	6.8
3	5.4	15.0	21.9	6.8
4	5.4	13.8	21.0	6.8
5	5.4	10.2	17.5	6.8
6	5.4	8.2	12.3	6.8
7	5.4	7.2	9.5	6.8
8	5.4	6.7	8.1	6.8
9	5.4	6.4	7.3	6.7
10	5.3	6.3	7.2	6.8
11		6.3	7.2	6.9
12				6.9

2.3 Dissolved Oxygen

See tables 2.2 and 2.3 for dissolved oxygen concentrations and percent saturation.

The late February sampling was done when the lake was virtually isothermal with temperatures from 5.3 to 5.5 C (see table 2.2). Dissolved oxygen levels were high, consistently greater than 14.0 mg/L, with saturation greater than 100%. The exception is the reading of 3.19 mg/L at 10 meters depth. It is likely that this measurement was taken near the sediment water interface. Overall, this reflects isothermal conditions and subsequent mixing throughout the water column. The relatively high saturation levels may be related to a phytoplankton bloom occurring in the early spring, as indicated by both the chlorophyll a and secchi data. Significant “blooms” can result in daytime oxygen supersaturation in lake waters.

The May sampling indicates a stratified lake with a thermocline between 2 and 7 meters deep, with significant oxygen depletion below 9 meters and greater than 90% saturation above 6 meters.

The August 2020 profile indicates a warm layer of surface water down to 5 meters, with a deeper, very steep thermocline down to 8 meters. This steep thermocline effectively isolates the deeper, denser colder waters of the lake, so that very little mixing and replenishment occurs. Decomposition of organic matter in the deeper waters gradually consumes the oxygen present below the thermocline. As a result, there is severe oxygen depletion below 6 meters in depth.

The November profile reflects isothermal conditions due to the breakdown of the thermocline with dissolved oxygen levels greater than 9 mg/L at depths to 9 meters, and dissolved saturation ranging from 74.4 to 90.2%. However, with increasing depth, oxygen levels continued to decrease, down to 7.2

at 12 meters. This may indicate that the thermocline has only recently broken down, so that mixing and oxygen replenishment at depth has not quite been completed.

Table 2.2 Enos Lake Dissolved Oxygen concentration profiles for 2020

Profile - Site SWMP-03				
	2/28/2020	**5/11/2020**	**8/18/2020**	**11/23/2020**
Depth (m)	D.O. (mg/L)	D.O. (mg/L)	D.O. (mg/L)	D.O. (mg/L)
0.5	14.83	9.42	7.46	10.94
1	14.92	9.87	7.45	10.88
2	14.90	10.73	7.90	10.25
3	14.73	11.11	7.80	9.45
4	14.70	11.24	6.76	9.45
5	14.78	12.77	6.47	9.54
6	14.67	11.32	5.73	9.39
7	14.65	8.53	0.11	9.07
8	14.68	8.59	0.07	9.11
9	14.52	5.35	0.05	9.23
10	3.19	2.80	0.06	8.27
11		2.62	0.05	7.62
12				7.20

Table 2.3 Enos Lake Dissolved Oxygen saturation profiles for 2020 (from Standard Methods for the examination of water and wastewater)

Profile - Site SWMP-03 dissolved oxygen (% saturation)				
	2/28/2020	**5/11/2020**	**8/18/2020**	**11/23/2020**
Depth (m)	D.O. (%saturation)	D.O. (%saturation)	D.O. (%saturation)	D.O. (%saturation)
0.5	117.5	100.0	88.4	90.20
1	118.3	103.8	88.1	89.30
2	118.1	109.3	91.9	84.10
3	116.6	109.9	89.1	77.50
4	116.3	108.2	76.0	77.50
5	116.7	113.6	61.8	78.60
6	116.4	96.4	53.5	77.00
7	115.8	70.5	1.0	74.40
8	116.0	70.2	0.6	74.80
9	114.8	43.5	0.4	75.60
10	24.8	22.7	0.5	67.80
11		21.2	0.4	62.20
12				59.30

In the epilimnion layer (above the thermocline), the water quality target for dissolved oxygen is greater than 5 mg/L. This target was met in each sample set. Below the thermocline in the hypolimnion, the target is 2 mg/L. This target was not met during the late spring and not met through the summer (May through August at least). The August 18th data was particularly concerning as the lake was virtually anoxic below the thermocline. This is indicative of a eutrophic lake with internal loading and subsequent release of phosphorus from the sediments.

2.4 Conductivity

As a simple measure of dissolved ions in the water, conductivity is a general indicator of lake health and watershed disturbance, in support of other data.

The profile for late February when the lake was not stratified showed minimal variability ranging from 121.7 to 122.0 µS/cm, with the exception of the reading 151.7 µS/cm just above the lake bottom. In May, conductance ranged from 119.5 µS/cm to 123.0 µS/cm, rising to 163 µS/cm at depth. In August, conductance increased slightly ranging from 128.3 µS/cm to 140.7 µS/cm from the surface through the thermocline. Below the thermocline, conductance increased steadily to a peak of 172.3 µS/cm at 11 meters. In November, the lake was once again effectively isothermal, and conductance showed minimal variability ranging from 122.5 µS/cm to 123.6 µS/cm.

Overall, conductivity appears to be within the range to be expected for this area, given the precipitation, watershed runoff and previous data (Nordin, 2017).

Table 2.4 Enos Lake conductivity profiles for 2020

Profile - Site SWMP-03				
	2/28/2020	**5/11/2020**	**8/18/2020**	**11/23/2020**
Depth (m)	Conductivity (µS/cm)	Conductivity (µS/cm)	Conductivity (µS/cm)	Conductivity (µS/cm)
0.5	122.0	123.0	140.4	123.2
1	121.7	122.9	140.7	122.9
2	121.9	121.8	139.3	122.7
3	121.8	121.7	139.0	122.5
4	121.7	121.3	138.4	122.5
5	121.7	119.5	130.0	122.8
6	121.7	120.0	128.3	122.7
7	121.8	120.3	132.8	122.6
8	121.8	121.6	137.6	122.7
9	121.7	124.6	152.0	122.7
10	151.7	129.3	155.7	123.6
11		163	172.3	123.6
12				123.5

2.5 pH

Enos Lake pH data is summarized in table 2.5 below

In both 2018 and 2019, pH data was limited due to equipment issues. In 2020, the pH data collection and quality improved considerably. Through the year, pH ranged from 6.03 to 7.99, showing considerable variability. While the range of nearly 2 pH units through the year may remain slightly questionable, the trends with depth for each sampling date are thought to be reasonable. In February, with the exception of the upper 2 to 3 meters which appeared to be a little low, pH generally reflected the isothermal conditions present. In May, pH was somewhat higher in the upper waters of Enos Lake and through much of the thermocline. However, beginning at 5 meters, pH decreased from 7.55 to 6.89, a decrease of 0.66 units. A similar but more pronounced decrease was observed in August with pH values ranging from 7.76 to 7.99 above the thermocline, before steadily declining with depth to less than 6.2 below 7 meters, with a low of 6.03 at 10 meters. In November, the lake had returned to isothermal conditions, with minimal pH fluctuation down to 9 meters in depth. However, there was a pH decrease of 0.35 pH units in the deeper waters of the lake.

The pH trends with depth, which were most pronounced in May and August, may be related to phytoplankton blooms and gradual oxygen depletion at depth. In eutrophic lakes, photosynthesizing phytoplankton blooms can raise pH levels in the surface waters. At depth, the bacterial decomposition of organic matter consumes oxygen and releases acidic byproducts, which can cause pH to decrease. The slight pH decrease at depth in November may indicate that the thermocline has only recently broken down. It is likely that the decrease in pH would gradually disappear through the winter months as deep water mixing and replenishment occurs.

Table 2.5 Enos Lake pH profiles for 2020

Profile - Site SWMP-03				
	2/28/2020	**5/11/2020**	**8/18/2020**	**11/23/2020**
Depth (m)	pH (pH units)	pH (pH units)	pH (pH units)	pH (pH units)
0.5	6.86	7.62	7.76	7.25
1	7.07	7.73	7.82	6.99
2	7.19	7.83	7.99	6.84
3	7.29	7.80	7.86	6.81
4	7.36	7.63	7.58	6.8
5	7.42	7.55	6.95	6.81
6	7.45	7.21	6.56	6.85
7	7.47	7.28	6.19	6.86
8	7.48	7.19	6.15	6.93
9	7.50	6.93	6.14	6.94
10	6.76	6.89	6.03	6.59
11		6.89	6.11	6.59
12				6.59

2.6 Redox

Redox potential (sometimes referred to as ORP) measures the lake's ability to be in balance while breaking down organic waste products such as dead and decaying plant matter and plankton. When redox values remain higher, there is lots of oxygen in the water reflecting a balance between lake productivity, watershed health and available oxygen. In general, the higher the redox values, the healthier the lake is, so that bacteria can break down organic matter more efficiently. However, even in healthy lakes, there is generally less oxygen as you approach the bottom sediments, a reflection of the bacteria activity in the sediments.

There can be an accumulation of slowly decomposing organic matter on the lake bottom, which will further drive the redox and oxygen levels down. This is not a healthy environment for fish or other aquatic organisms. In healthy lakes, redox potential values often range from 300 to 500 mV. In poorly oxygenated water, such as the deeper water of stratified lakes or the sediment of eutrophic lakes, the redox potential will be low (less than 100 mV or even negative values). When redox is low, dissolved oxygen is low, and phosphorus is released from the sediments. This is often referred to as "internal loading" of phosphorus, a process which further exacerbates the eutrophication of lakes, making recovery more difficult.

While redox potential can only be measured in the field, it can frequently be a challenge. Redox reactions are slow to equilibrate in the natural environment, so that the readings are often considered "semi-quantitative". Probes need frequent maintenance, can have a relatively short shelf life and can become very slow to respond in the field as they age. In 2020, redox data was collected as part of each sampling event.

Table 2.6 Enos Lake redox potential profiles for 2020

Profile - Site SWMP-03				
	2/28/2020	**5/11/2020**	**8/18/2020**	**11/23/2020**
Depth (m)	Redox (mV)	Redox (mV)	Redox (mV)	Redox (mV)
0.5	132.6	205.0	176.6	174.5
1	131.0	201.6	177.7	182.9
2	130.9	198.0	183.4	186.7
3	131.0	198.0	183.3	187.2
4	131.3	202.4	188.4	187.8
5	132.4	198.3	190.0	188.8
6	133.5	196.6	199.0	189.2
7	132.2	193.1	205.5	189.4
8	135.0	192.4	203.7	189.6
9	135.4	191.2	166.3	190.6
10	20.0	177.2	149.2	181.7
11		154.0	137.9	173.5
12				167.1

The redox potential data collected in 2020 is shown above in Table 2.6. The February data shows a significant decrease at 10 meters, just above the sediment water interface, where oxygen levels were also low. In May, redox was very consistent from the surface to 9 meters, below which it began to decline, again coinciding with the dissolved oxygen levels of less than 3 mg/L. The August redox data was remarkably consistent through the lower end of the thermocline to a depth of 8 meters before gradually decreasing. Given the anoxic conditions apparent below 6 meters, redox measurements should have been substantially lower than what was measured. While it is possible that the dissolved oxygen readings for August are a little low (possible calibration error or probe fouling), they are also very similar to the readings for 2018, providing a higher degree of confidence in the data for 2020. While dissolved oxygen concentrations below 6 meters indicate anoxic conditions and subsequent "internal loading" of phosphorus from the sediments, the redox data cannot be used as a confirmation tool.

2.7 Chlorophyll a

Chlorophyll a is a measure of the algal pigments in lake water and is used to assess overall lake biological productivity.

Interestingly, 8 of the 12 samples taken in 2020 were higher than 10 ug/L. The exceptions were each of the three samples taken in May and the surface sample taken in August. By May, the spring phytoplankton bloom had ended and it would appear that a deeper phytoplankton layer was present in August. This is also reflected by the "deeper" secchi readings taken in May and August.

The 2020 data had an annual mean of 9.2 ug/L, approximately twice that of last year's 4.54 ug/L and similar to the 2017 and 2018 averages of 10.55 and 10.2 ug/L, respectively.

General trophic status classification using chlorophyll a is based on: <2 ug/L indicates an oligotrophic lake; 2 to 7 ug/L indicates a mesotrophic lake; >7ug/L indicates a eutrophic lake. Enos Lake's 2020 mean concentration of 9.2 ug/L was indicative of a eutrophic lake, as was the case in both 2017 and 2018. The lower annual average in 2019 was the exception as it was indicative of a mesotrophic or moderately productive lake.

Table 2.7 Enos Lake chlorophyll a data for 2020

SWMP-03 - chlorophyll a ug/L				
	2/28/2020	**5/11/2020**	**8/18/2020**	**11/23/2020**
Depth (m)				
1	10.1	2.88	3.69	11.9
5	10.5	3.29	16.6	13.2
9	10.3	1.91	12.5*	13.7
Daily mean	**10.3**	**2.69**	**10.9**	**12.9**
Annual mean	**9.2**			

(*sample taken at 9.5m)

2.8 Phosphorus

In lakes, phosphorus is an important nutrient and a key indicator of lake productivity. Excessive phosphorus can result in significant algal blooms and subsequent low dissolved oxygen levels, impacts on drinking water, fish health and recreational use. The water quality target for Enos Lake appears to be an annual average total phosphorus of 12 ug/L. In 2020, the annual average of 12.0 ug/L did just meet the target. While the 2020 annual average was 63% higher than that of 2019, it remained substantially lower than the 2017 and 2018 averages of 19 and 16.6 ug/L, respectively.

In 2017 and 2018, very high phosphorus values were found through the summer and fall, particularly at depth, likely an indication of a prolonged oxygen deficit in the hypolimnion and subsequent internal loading of phosphorus from the lake sediments. Concentrations between 20 and 40 ug/L were not uncommon. In 2019, the highest level was only 13.6 ug/L, substantially lower than in previous years. In 2020, the highest value was 17.5 ug/L, higher than the previous year but still lower than that found in 2017 and 2018. This is likely due to year-to-year variability related to varying weather patterns. In 2019, the summer weather was relatively cooler and highlighted by an unusual but substantial rain event in early August. The rain event may have resulted in improved summer flows entering the lake and improved nutrient removal and oxygen replenishment at depth, at least over the short term. In 2020, summer temperatures were not as cool, with periods above 30 degree C, but this was tempered by reasonable summer precipitation and the lack of an extended summer drought.

Another method of evaluating lake trophic status is based on the assessment of total phosphorus. In lakes with longer residence times (>1 year), the assessment is based on concentrations at spring overturn, prior to the establishment of a thermocline. In lakes with shorter residence times (<1 year), it is based on an annual mean. Lakes are considered to be oligotrophic if total phosphorus is less than 10 ug/L; mesotrophic when ranging from 10 to 30 ug/L; and eutrophic when greater than 30 ug/L. Using this assessment method, Enos Lake would be considered mesotrophic in 2020, and in both 2017 and 2018, but oligotrophic in 2019.

Table 2.8 Enos Lake total phosphorus data for 2020

Site SWMP-03 - total Phosphorus ug/L				
	2/28/2020	**5/11/2020**	**8/18/2020**	**11/23/2020**
Depth (m)				
1	10.1	13.4	10.3	7.5
5	11.2	11.3	13.9	12.5
9	10.6	12.1	17.5*	13.2
Annual mean	12.0			

(*sample taken at 9.5m)

Table 2.9 Enos Lake orthophosphate data for 2020

Site SWMP-03 - Orthophosphate ug/L				
	2/28/2020	5/11/2020	8/18/2020	11/23/2020
Depth (m)				
1	<1	<1	<1	<1
5	<1	<1	1.3	<1
9	<1	<1	<1*	<1

(*sample taken at 9.5m)

3.0 Discussion

The primary intent of the annual portion of the Enos Lake monitoring program is to gain insight into trends in lake productivity. This is important in that watershed disturbance and land use, together with potential climate change impacts, have the potential to shift the lake's trophic status. As lakes become more eutrophic (more biologically productive), algal blooms (including blue green algal blooms) can become more prevalent leading to lower dissolved oxygen levels, impaired water quality, and impacts on recreational use and drinking water. There are examples of lakes on the east coast of Vancouver Island and the Gulf Islands where this has occurred.

Chlorophyll a, total phosphorus and secchi depth are fundamental indicators used to assess lake trophic status. The secchi depth data has consistently suggested that Enos Lake is eutrophic. The increased collection of secchi depth data in 2020 confirmed that Enos Lake appears to be eutrophic.

Mean annual average chlorophyll a data for 2020 once again classified Enos Lake as eutrophic, as was the case in 2017 and 2018. In 2019, Enos Lake appeared to be less productive and classified as mesotrophic. Phosphorus levels in 2020, were right at the phosphorus target of 12 ug/L, while indicating that Enos Lake was mesotrophic.

Table 3.1 Year to year status of key indicators and targets

	2017	2018	2019	2020
Secchi	eutrophic	eutrophic	eutrophic	**eutrophic**
Dissolved oxygen at epilimnion – target of >5 mg/L	Target met	Target met	Target met	**Target met**
Dissolved oxygen at hypolimnion – target of >2 mg/L	Target not met	Target not met	Target not met	**Target not met**
Chlorophyll a	eutrophic	eutrophic	mesotrophic	**eutrophic**
Total phosphorus target of 12 ug/L	Target not met – indicates mesotrophic	Target not met – indicates mesotrophic	Target met – indicates oligotrophic	**Target just met- Indicates mesotrophic**

During the summer months, dissolved oxygen levels below the thermocline did not meet the target of 2 ug/L. Spring through summer, the dissolved oxygen levels at depth were very low, virtually anoxic, indicative of reducing conditions. Reducing conditions are typically indicative of internal loading – the release of phosphorus from the sediments into the water column. In 2020, this would explain the relatively higher concentrations of total phosphorus at depth, particularly in late summer. The peak levels were higher than that found in 2019 but lower than that of 2017 and 2018

Weather patterns for the summer of 2020 were relatively "benign", and somewhat atypical of the area, with reasonable precipitation occurring periodically throughout the summer as well as periods of warmer weather (>30 degrees C). As a result, 2020 water quality appears to represent a scenario somewhere between the dry summers of 2017/18 and the mild, wet summer of 2019. Despite this, the deeper waters of the lake were virtually anoxic during the late summer. This further highlights year-to-year variability and the importance of building longer term datasets which can tease out trends over time. This leads to better management decisions, particularly when factoring in ongoing land use, disturbance and the impacts of climate change.

Enos Lake's high productivity, strong summer stratification, low dissolved oxygen at depth, apparent internal loading and subsequent sediment release of phosphorus make it susceptible to ongoing watershed disturbance impacts, regardless of year-to-year variability.

4.0 Recommendations

The increased Secchi depth data collection in 2020 should be continued. In 2019, lab pH data was added to the sampling program for that year. It should be re-established as standard practice as a check on field pH data. Redox field data continues to be a challenge and may require probe maintenance or replacement.

Data is normally collected as the probes are lowered through the water column. As a further check on field data, and to further enhance confidence in the data, it may be useful to repeat the field data collection of pH and dissolved oxygen as the probes are brought back up to the surface.

As noted by Nordin (2017), a water budget for Enos Lake is needed. It would be useful over the longer term in the support of watershed management planning. PGL (2016) reported that 12 ha of the watershed area of 235 ha had been developed. Further updates on the area's development within the watershed are needed, including data on impervious surfaces.

A more thorough data review should be done every 5 years, to examine trends, review the monitoring program, and provide a feedback loop to watershed management. This should be done in 2022, following completion of the more detailed portion of the water quality sampling program.

5.0 Acknowledgements

This document has been prepared as a contract for the BC Conservation Foundation. The conclusions, opinions and any other information in this report represent the author's best professional judgement based on the information available at the time of its completion.

6.0 References

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