Enos Lake Water Quality Monitoring Program

2019 Annual Report

Prepared for:

FW Developments Ltd.

305-1788 West 5th Avenue

Vancouver, BC V6J 1P2

Prepared by:

BC Conservation Foundation

#1-7217 Lantzville Road

Lantzville, BC V0R 2H0

BRITISH COLUMBIA CONSERVATION FOUNDATION

Background

An annual water quality monitoring program for Enos Lake was established in 2017 by the British Columbia Conservation Foundation (BCCF) as per the management recommendations of the Enos Lake Protection and Monitoring Plan (EPLMP) published in 2016. This report summarizes the results from water quality monitoring in 2019, and compares them to established water quality targets for Enos Lake.

This report presents a summary of the findings from the 2019 water sampling program. The report 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 presented in graphical form compared against the targets listed in the ELPMP.
- A summary of preventative actions taken with respect to aquatic invasive species undertaken 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 the Nanoose peninsula on Vancouver Island (Fig. 1-1). The lake is approximately 18 ha and surrounded by nearby ponds and wetlands, supporting a wide diversity of birds and aquatic life. It is approximately 12 metres at its deepest point, and drains into Enos Creek via a weir established at the lake's 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, settling down into the hypolimnion and initiating mixing throughout the entire water column.

Lake mixing is a very important 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 conditions of low oxygen (hypoxia) in the hypolimnion during the summer months, which is a naturally existing condition of the lake ecosystem (MESL, 2014; PGL, 2016). Monitoring of dissolved oxygen and other parameters, such as temperature, conductivity, redox potential, total and reactive phosphorous, pH, and chlorophyll-*a*, was undertaken in 2019 to evaluate the seasonal water quality and productivity status of Enos Lake.

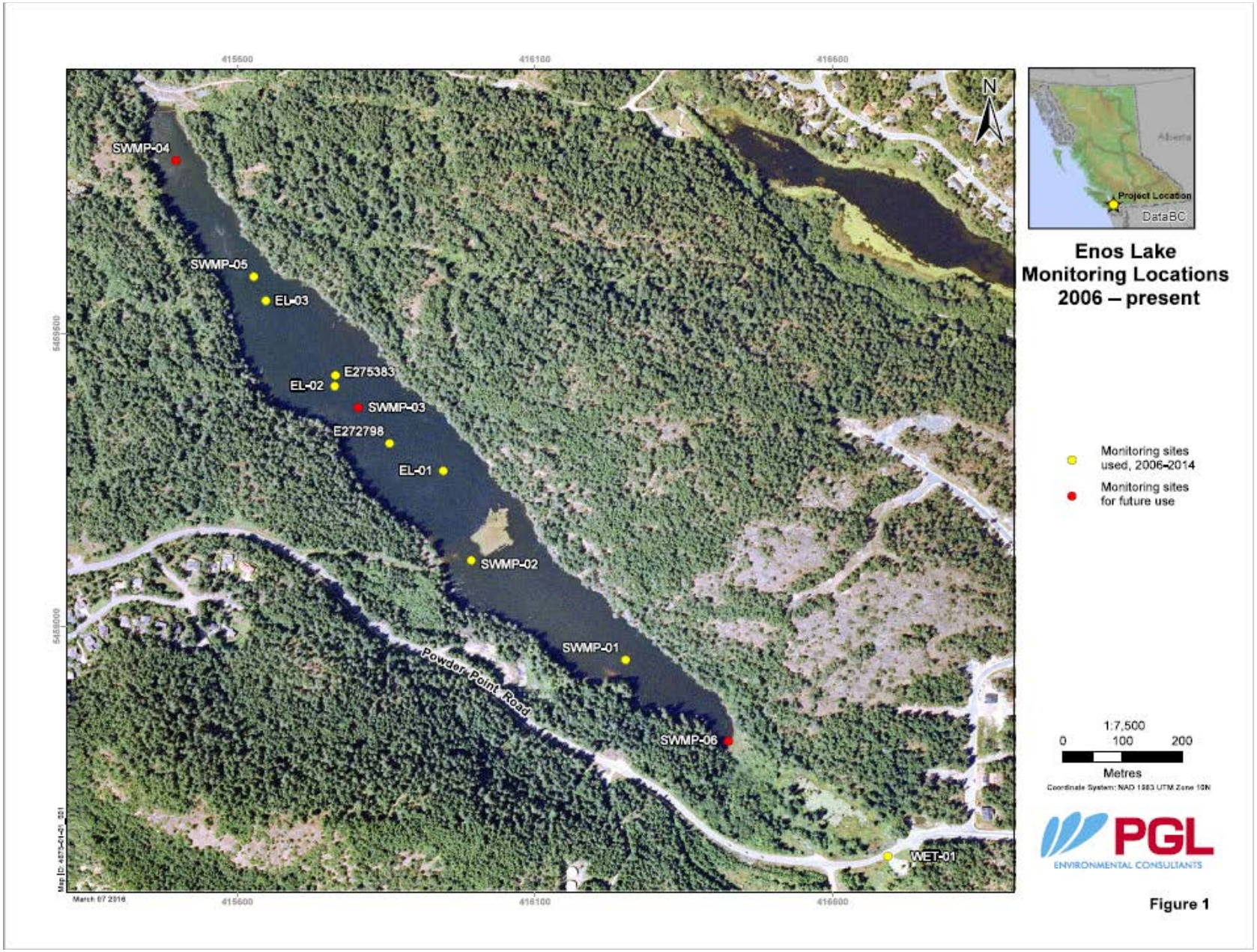

Figure 1-1: Enos Lake Sampling Locations (PGL, 2016).

2.0 Methods

2.1 - Scope of Work

BCCF was contracted to conduct water quality sampling in Enos Lake for 2019, as described in the ELPMP (Table 2-1). Sampling occurred on five days, in February, May, August, September, and November (an additional sampling date was added in September to compensate for equipment error in August). Field crews consisted of a BCCF Biologist with an additional staff member when possible. All samples were collected from site SWMP-03 (Fig. 1-1), located at the deepest part of the lake. The site was accessed by boat.

Table 2-1: Proposed ELPMP Monitoring Schedule for 2019 (PGL, 2016).

2019												
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

2.2.1 - Field Equipment

The following equipment was utilized for sampling:

- YSI Professional Plus QUATRO handheld multi-parameter water quality sonde with probes for Galvanic DO, Temp/Conductivity, pH, and ORP
- 1 L Van Dorn water sampler
- Sample bottles, supplied by Maxxam Analytics/Bureau Veritas
- Chain of Custody (COC) forms, supplied by Maxxam Analytics/Bureau Veritas
- Cooler with ice
- Secchi disk
- Field notebook
- Personal Flotation Devices (PFDs)
- 10-ft aluminum boat with electric outboard motor

2.2.2 - In-situ Field Parameters

In situ water quality parameters were collected once per sampling quarter at site SWMP-03 using the YSI sonde. The sonde was calibrated by a BCCF technician prior to each sampling date. Readings were recorded at 1 m intervals throughout the water column to a depth of approximately 10 m. In-situ parameters included:

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

A Secchi depth (water clarity) measurement was also recorded once per quarter using a Secchi disk. Monitoring for incidental observations of invasive aquatic species also occurred concurrently with water quality monitoring.

2.2.3 - Water Samples

Water samples were collected at 1, 5, and 10 m depths at site SWMP-03. All water samples were collected using a 1 L Van Dorn water sampler. Sample bottles were pre-labelled and handled so as to prevent contact of the interior of the cap or bottle with anything other than the water sample. The Van Dorn was rinsed with surface water (1 m) before each sampling event, and allowed to remain at depth (5 and 10 m) for 10 seconds before retrieving samples to ensure adequate flow throughout the sampling tube. Water sampling procedures followed guidelines provided by Maxxam Analytics/Bureau Veritas, in addition to the 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 sample bottles provided and packed in a cooler with ice and completed COC form. Samples were immediately shipped to the Maxxam Analytics/Bureau Veritas lab in Burnaby for analysis.

2.3 - Analysis

Maxxam Analytics/Bureau Veritas, an accredited facility for conducting water quality testing, analyzed all water samples. The 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 week of sample collection (Appendix 1). Once the 2019 sampling was completed, results were compiled and sent to professional limnologist John Deniseger for analysis and comparison to water quality guidelines and data previously collected on Enos Lake. Deniseger's analysis is summarized in "Enos Lake Protection and Monitoring Program: Review of 2019 Water Quality Data" (Appendix 2).

3.0 Results

3.1 - In-situ Field Parameters

In situ water quality results are provided in Table 3-1. Each parameter is discussed in detail in Deniseger (2019). Of note are results for temperature, dissolved oxygen (DO), pH and ORP (oxidation reduction potential).

Water temperatures and DO concentrations both indicated that field sampling captured two mixed (February/November) and two stratified (May/September) lake samples. As discussed by Deniseger (2019), the November results suggest that the lake may have been recently mixed. Enos Lake likely begins to stratisfy as early as March-April, then undergoes fall turnover between October-November. This has implications for future Secchi monitoring, as discussed in the final section of this report.

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 during sampling in May and September. It should be noted that in Deniseger's report, DO (% saturation) was based on a calculation from Standard Methods for the Examination of Water and Wastewater (Baird and Bridgewater, 2017) to ensure continuity between sample dates.

Deniseger suggests the pH results collected *in situ* were likely skewed due to equipment error during the September sampling, whereas the ORP results were likely skewed during the November sampling.

A BCCF field technician trained in aquatic invasive plant ID attended three of the five field dates and made incidental observations of aquatic and terrestrial plants. No aquatic invasive species were noted in 2019.

3.2 - Water Samples

Laboratory results are provided in Table 3-2. The results are discussed in Deniseger (2019). Of note are results for Chlorophyll-*a* and Total Phosphorous. Both parameters suggest the productivity of Enos Lake in 2019 decreased relative to prior sampling years. The chlorophyll-*a* sample from the February 28 sampling date was misplaced in the lab and was not analyzed within the proper timeline (24-hr). Charges for this analysis were not accrued due to this.

In 2017 and 2018, the average chlorophyll-*a* results across all samples were 10.55 and 10.2 ug/L (respectively), whereas in 2019 the average across samples was 4.54 ug/L. A similar trend was observed for Total Phosphorous. In 2017 and 2018 the average phosphorous results across all samples were 19.0 and 16.6 ug/L (respectively), whereas in 2019 the average across all samples was 7.3 ug/L, below the suggested water quality target of <12 ug/L.

Table 3-1: Summary of In-Situ Water Quality Results from Enos Lake 2019 Water Quality Monitoring Program

1st Quarter Sampling						
Date: Feb 28, 2019		**Crew: JA, PH**			**Site: SWMP-03**	
Time: 11:00		**Weather: Sunny, calm ~ 5 °C**			**Secchi: 1.5 m**	
Depth (m)	Temp. (°C)	D.O. (mg/L)	D.O. (%)	pH	Conductivity (µS/cm)	Redox (mV)
0	3.9	12.69			140.3	
1	3.8	12.71			143.1	
2	3.8	12.70			146.5	
3	3.8	12.70			148.6	
4	3.8	12.62			152.5	
5	3.8	12.54			154.5	
6	3.7	12.51			157.1	
7	3.6	12.49			159.0	
8	3.5	12.33			161.5	
9	3.6	12.04			163.2	
2nd Quarter Sampling						
Date: May 9, 2019		**Crew: PH, TR**			**Site: SWMP-03**	
Time: 11:00		**Weather: Sunny, ~ 23 °C**			**Secchi: 2.3 m**	
Depth (m)	Temp. (°C)	D.O. (mg/L)	D.O. (%)	pH	Conductivity (µS/cm)	Redox (mV)
0	17.4	9.97				
1	17.0	10.01				
2	16.3	10.05				
3	12.7	10.03				
4	12.9	10.30				
5	8.0	11.84				
6	6.1	11.11				
7	5.4	9.81				
8	5.2	9.84				
9	5.0	8.12				
10	5.0	3.01				
11	5.1	0.42				
3rd Quarter Sampling						
Date: Sept 10, 2019		**Crew: PH**			**Site: SWMP-03**	
Time: 12:15		**Weather: Sun/Cloud mix, ~ 20 °C**			**Secchi: 2.5 m**	
Depth (m)	Temp. (°C)	D.O. (mg/L)	D.O. (%)	pH	Conductivity (µS/cm)	Redox (mV)
0	20.9	6.73		6.48	147.4	100.4
1	20.8	6.74		7.00	147.4	111
2	20.7	6.45		7.10	147.3	114.2
3	20.7	6.48		7.13	147.3	112.8
4	20.4	6.06		7.10	146.6	120.2
5	17.0	4.02		6.09	131.5	136.2
6	11.5	2.72		5.95	128.0	131.4
7	8.7	0.63		6.02	131.0	124.3
8	7.1	0.11		6.09	146.9	-184.2
9	6.5	0.09		6.18	153.5	-247.3
10	6.3	0.09		6.21	156.8	-268.3
4th Quarter Sampling						
Date: Nov 19, 2019		**Crew: PH, TR**			**Site: SWMP-03**	
Time: 12:40		**Weather: Sunny, breezy ~ 12 °C**			**Secchi: 2.75 m**	
Depth (m)	Temp. (°C)	D.O. (mg/L)	D.O. (%)	pH	Conductivity (µS/cm)	Redox (mV)
0	9.2	9.89	86	7.28	117.9	-25.3
1	9.2	9.73	84.6	7.48	118.0	-22
2	9.1	9.80	85.2	7.60	118.0	-19
3	9.1	9.73	84.3	7.72	118.0	-13.5
4	9.1	9.79	84.8	7.81	118.0	-9.8
5	9.1	9.70	84.1	7.87	118.0	-6
6	9.1	9.42	81.5	7.92	118.0	-1.3
7	9.1	9.60	83	7.93	118.0	1.2
8	9.0	9.25	80.2	7.93	118.1	5.8
9	9.0	8.73	75.8	7.90	118.4	9
10	8.9	7.18	62	7.78	119.3	9.8
11	8.6	5.46	47.1	7.54	135.7	-12

Table 3-2: Summary of Laboratory Analyzed Water Quality Results from Enos Lake 2019 Water Quality Monitoring Program

2019 WATER QUALITY MONITORING PROGRAM LAB RESULTS			1st Quarter Sampling			2nd Quarter Sampling			3rd Quarter Sampling			4th Quarter Sampling		
Sampling Date			Feb 28, 2019			May 05, 2019			Aug 18, 2019			Nov 19, 2019		
Site			SWMP-03			SWMP-03			SWMP-03			SWMP-03		
Depth			1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m	1 m	5 m	10 m
Water Quality Parameters	**Units**	**RDL**												
Chlorophyll *a*	ug/L	0.50	-	-	-	3.96	8.10	7.78	3.01	4.00	5.40	4.29	2.92	1.41
Anions														
Orthophosphate	mg/L	0.001	0.0021	0.0022	0.0024	<0.0010	<0.0010	<0.0010	0.0021	0.0028	0.0022	0.0028	0.0018	0.0028
Nutrients														
Total Phosphorus (P)	mg/L	0.002	0.0184	0.0111	0.0099	0.0061	0.0090	0.0110	0.0041	0.0090	0.0136	0.0049	0.0058	0.0049
pH														
pH			7.68	7.79	7.69	7.83	7.86	7.85	7.29	7.23	7.22	7.81	7.78	7.77

Notes:
RDL = Reportable Detection Limit
N/A = Not Applicable
- = Parameter not analyzed

4.0 Discussion

The primary intent of the Enos Lake monitoring program is to better our collective understanding of the lake's productivity trends (PGL, 2016; Deniseger, 2019). Watershed disturbances, such as forestry, road building, development, and climate change impacts, all have the potential to shift the lake's trophic status through increased storm water 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 - Productivity

In 2019, Enos Lake exhibited relatively few water quality issues. Based on Secchi depth, Chlorophyll-*a* and Total Phosphorus concentrations, Enos Lake showed characteristics of being mainly mesotrophic (moderately biologically productive), in contrast to prior years where results indicated the lake was leaning towards eutrophic. As lakes become more productive, algal blooms may become more prevalent which can lead to impaired water quality, harm aquatic life, and impact recreational use and drinking water quality (Deniseger, 2019). The results from 2019 show that the productivity of Enos Lake remained relatively balanced through the summer. This could have been due to several factors, one of which may have been the cooler and wetter summer weather as compared to previous years (Deniseger, 2019).

4.2 - Oxygen availability

The main issue in 2019 was a low level of dissolved oxygen (DO) at depth during the summer and early fall. The values recorded below approximately 10 m depth in May and from 7-10 m depth in September did not meet the water quality target of >2 mg/L (PGL, 2016).

Without an accurate depth sounder mounted on the boat, it is difficult to determine the exact depth and therefore to know at which point the YSI sensor has reached the lake-bottom sediment; once immersed in the sediment, DO values will appear very low and conductivity will spike. It is possible that some of the lower YSI readings taken in May and September may have been immersed in sediment, in which case the very low DO should be interpreted with caution. Additionally, Deniseger (2019) points out that the DO data measured in September of 2019 may reflect equipment or calibration issue, as in his opinion the results are lower than would be reasonably expected. Regardless, the data may still be of use, because – similar to the May data – it illustrated a trend of decreasing DO with depth. This is a common trend in thermally stratified lakes, as the thermocline prevents DO transferred to the water from the atmosphere or produced by photosynthesis in the warm, well-lit epilimnion water layer from reaching the cool dark hypolimnion. Therefore, the oxygen supply at depth gradually decreases from the moment the lake first stratifies in the spring until it turns over in the fall.

Microorganisms work to decompose organic matter that settles to the bottom of a lake, consuming oxygen in the process. 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). Hypoxic (critically low oxygen) conditions at depth can impact aquatic organisms which may be confined to the lower layers of a lake due to food, light and temperature requirements. However, almost all living organisms require some amount of oxygen to survive, and with little oxygen available in the hypolimnion, the zone of habitable water available to these organisms decreases throughout the summer and can cause stress.

Additionally, the chemistry of lake-bottom sediments can change under hypoxic conditions, causing phosphorous to be released into the water column. As a result, phosphorous concentrations in the hypolimnion can reach high levels (MSU, 2008). If the conditions are suitable, during fall turnover this phosphorous can get mixed in to surface waters and potentially produce algae blooms.

Although it is likely that the low DO concentrations at depth are a naturally-occurring phenomenon for this small, productive lake with minimal surface drainage (MESL, 2014; PGL, 2016), it is still desirable for Enos Lake to meet the water quality target of >2 mg/L in the hypolimnion (PGL, 2016) so as not to inhibit microbial decomposition processes or harm aquatic life.

4.3 - Invasive Species

No preventative actions were taken concerning aquatic invasive species this year.

Recommendations for Future Monitoring:

- 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).

- Issues with field data collected were again present in the 2019 data. Equipment malfunction resulted in a re-scheduling of the 3rd quarter sampling from August to September. These issues have stemmed from the equipment owned by BCCF, as it now requires professional servicing and probe replacement. If future monitoring is to be undertaken by BCCF, adequate budget must be allocated to replace the instrument probes. Additionally, a written log of YSI calibrations must be kept and included with the annual water quality report.

- Phosphorous and Chlorophyll-*a* are useful parameters for interpreting lake productivity, however Secchi depth can also be used and is the most quick and simple of the three parameters to collect. Secchi depth does not require laboratory analysis and can be performed easily in the field, as the equipment and expertise required is minimal (boat, PFD, sunglasses, hat, Secchi disk with weight and marked line to 15m, note paper, pencil). Deniseger (2019) and Nordin (2017) have both recommended an increased frequency of Secchi depth data collection, on a year-round monthly basis. The critical period for monitoring would be during the summer, when the lake is stratified (March – November); at least one or two additional winter readings (December – March) would be required. Volunteer stewardship groups such as the *Friends of Enos Lake* could undertake this monitoring very easily using a volunteer's personal kayak or canoe. If future monitoring is to be undertaken by BCCF, adequate budget must be allocated to account for travel, equipment, and wages needed to undertake this increased frequency of monitoring.

- Both Deniseger (2019) and Nordin (2017) have recommended that the lake's water budget be calculated to support sustainable watershed planning. Deniseger (2018) also recommended the establishment of an Enos Lake website where data and reports can be stored and made available to the public.

5.0 References

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Michigan State University (MSU), 2008. *Cooperative Lakes Monitoring Program.* Annual Summary Report. 22p + appendices. Available at: <https://www.canr.msu.edu/michiganlakes/uploads/files/2008CLMPFinalReport.pdf>

Nordin, R., 2017. *Enos Lake Protection and Monitoring Program: Review of 2017 Water Quality Data*. 23 p.

PGL Environmental Consultants (PGL), 2016. *Enos Lake Protection and Monitoring Program*. Prepared for FW Enterprises Ltd. c/o Seacliff Properties. PGL file 4675-01.01. 30 p + figures and appendix.

Appendix 1

Laboratory results

Maxxam
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Success Through Science®

Your Project #: 130864
Site Location: ENOS LAKE WQ
Your C.O.C. #: 08466379

Attention: Jamieson Atkinson

BC Conservation Foundation
Nanaimo
#1-7217 Lantzville Road
Lantzville , BC
Canada V0R 2H0

Report Date: 2019/03/12
Report #: R2696414
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B914895
Received: 2019/03/01, 08:40

Sample Matrix: Water
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
pH Water (1)	2	N/A	2019/03/04	BBY6SOP-00026	SM 22 4500-H+ B m
pH Water (1)	1	N/A	2019/03/05	BBY6SOP-00026	SM 22 4500-H+ B m
Orthophosphate by Konelab (low level)	3	N/A	2019/03/02	BBY6SOP-00013	SM 23 4500-P E m
Total Phosphorus - Low Level Unpreserved	3	2019/03/02	2019/03/02	BBY6SOP-00013	SM 23 4500-P E m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam
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Success Through Science®

Your Project #: 130864
Site Location: ENOS LAKE WQ
Your C.O.C. #: 08466379

Attention: Jamieson Atkinson

BC Conservation Foundation
Nanaimo
#1-7217 Lantzville Road
Lantzville , BC
Canada V0R 2H0

Report Date: 2019/03/12
Report #: R2696414
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B914895
Received: 2019/03/01, 08:40

Encryption Key

Maxxam
12 Mar 2019 10:34:56

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Morgan Melnychuk, Burnaby Project Manager
Email: MMelnychuk@maxxam.ca
Phone# (604)638-8034 Ext:8034

==========

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Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B914895
Report Date: 2019/03/12

BC Conservation Foundation
Client Project #: 130864
Site Location: ENOS LAKE WQ
Sampler Initials: SF

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		VH4269	VH4270		VH4271		
Sampling Date		2019/02/27	2019/02/27		2019/02/27		
COC Number		08466379	08466379		08466379		
	UNITS	SWMP 03 (1M) (PHOS+PH)	SWMP 03 (5M) (PHOS+PH)	QC Batch	SWMP 03 (10M) (PHOS+PH)	RDL	QC Batch
Anions							
Orthophosphate (P)	mg/L	0.0021	0.0022	9337681	0.0024	0.0010	9337681
Nutrients							
Total Phosphorus (P)	mg/L	0.0184	0.0111	9337581	0.0099	0.0020	9337581
Physical Properties							
pH	pH	7.68	7.79	9339110	7.69		9339127
RDL = Reportable Detection Limit							

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B914895
Report Date: 2019/03/12

BC Conservation Foundation
Client Project #: 130864
Site Location: ENOS LAKE WQ
Sampler Initials: SF

GENERAL COMMENTS

Results relate only to the items tested.

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B914895
Report Date: 2019/03/12

QUALITY ASSURANCE REPORT

BC Conservation Foundation
Client Project #: 130864
Site Location: ENOS LAKE WQ
Sampler Initials: SF

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9337581	Total Phosphorus (P)	2019/03/02	91	80 - 120	100	80 - 120	<0.0020	mg/L	1.7	20
9337681	Orthophosphate (P)	2019/03/02	NC	80 - 120	98	80 - 120	<0.0010	mg/L	3.1	20
9339110	pH	2019/03/04			101	97 - 103			0.25	20
9339127	pH	2019/03/05					4.63	pH	0.78	20

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

Maxxam Analytics International Corporation o/a Maxxam Analytics Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Maxxam Job #: B914895
Report Date: 2019/03/12

BC Conservation Foundation
Client Project #: 130864
Site Location: ENOS LAKE WQ
Sampler Initials: SF

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Andy Lu, Ph.D., P.Chem., Scientific Specialist

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Burnaby: 4606 Canada Way, Burnaby, BC V5G 1K5, Toll Free (800) 665-8566

CHAIN OF CUSTODY RECO

08466379

BBY FCD-00077/05

COC #:

Page 1 of 1

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required
Company Name:	#1307 BC Conservation Foundation	Company Name:		Quotation #:	B50705	✓ Regular TAT 5 days (Most analyses)
Contact Name:	James or Atkinson	Contact Name:		P.O. #/ AFE#:		PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS
Address:	#1 - 7217 Lantzville Road	Address:		Project #:	130864	Rush TAT (Surcharges will be applied)
	Lantzville, BC PO V0R 2H0		PO:	Site Location:	Enos Lake WQ	Same Day 2 Days
Phone:	(250) 327-1155	Phone:		Site #:		1 Day 3 Days
Email:	jatkinson@bccf.com	Email:		Sampled By:	Sandy Fissel and Pete Law	Date Required:

Regulatory Criteria	Special Instructions
☐ BC CSR Soil ☐ BC CSR Water	☐ Return Cooler
☐ CCME (Specify) ☐ Other (Specify)	☐ Ship Sample Bottles (Please Specify)
☐ Drinking Water ☐ BC Water Quality	

SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

Rush Confirmation #:

LABORATORY USE ONLY

CUSTODY SEAL Y / N		COOLER TEMPERATURES
Present	Intact	
N	N	0.0.0

COOLING MEDIA PRESENT (Y) / N

	Sample Identification	Lab Identification	Date Sampled (YYYY/MM/DD)	Time Sampled (HH:MM)	Matrix	Chlorophyll A	TSS	Dissolved Sulfide (Incl. Hardness)	Dissolved Hardness (CaCO3)	Total Phosphorus	Orthophosphate-Dissolved (DIP)	pH	# OF CONTAINERS SUBMITTED	HOLD - DO NOT ANALYZE	COMMENTS
1	SWMP 03 (1m) CHLORO A					x							1		1 x 1L opaque
2	SWMP 03 (5m) CHLORO A					x							1		1 x 1L opaque
3	SWMP 03 (10m) CHLORO A					x							1		1 x 1L opaque
4	SWMP 03 (1m) (PHOS +pH)									x	x	x	2		2x120ml
5	SWMP 03 (5m) (PHOS + pH)									x	x	x	2		2x120ml
6	SWMP 03 (10m) (PHOS + pH)									x	x	x	2		2x120ml
7															
8															
9															
10															

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)
			BRITTANY BOURDON	2019/08/01	08:40

6914895_COC

578

Maxxam
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Your Project #: 1300017
Site Location: ENOS LAKE WQ
Your C.O.C. #: 08470264

Attention: Jamieson Atkinson
BC Conservation Foundation
Nanaimo
#1-7217 Lantzville Road
Lantzville , BC
Canada V0R 2H0

Report Date: 2019/05/28
Report #: R2728469
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B935204
Received: 2019/05/10, 08:30

Sample Matrix: Water
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
pH Water (3)	3	N/A	2019/05/14	BBY6SOP-00026	SM 22 4500-H+ B m
Orthophosphate by Konelab (low level) (1)	3	N/A	2019/05/14	AB SOP-00025	SM 23 4500-P A, F m
Total Phosphorus - Low Level (1)	3	2019/05/17	2019/05/17	AB SOP-00024	SM 23 4500-P A,B,F m
Chlorophyll A in Water Subcontract (2)	3	N/A	2019/05/28		

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by Maxxam Calgary Environmental
(2) This test was performed by Sub Burnaby to ALS Winnipeg
(3) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

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Maxxam
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Your Project #: 1300017
Site Location: ENOS LAKE WQ
Your C.O.C. #: 08470264

Attention: Jamieson Atkinson
BC Conservation Foundation
Nanaimo
#1-7217 Lantzville Road
Lantzville , BC
Canada V0R 2H0

Report Date: 2019/05/28
Report #: R2728469
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B935204
Received: 2019/05/10, 08:30

Encryption Key

Maxxam
28 May 2019 15:14:09

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Customer Solutions, Western Canada Customer Experience Team
Email: CustomerService@maxxam.ca
Phone# (604) 734 7276

==========

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Maxxam Job #: B935204
Report Date: 2019/05/28

BC Conservation Foundation
Client Project #: 1300017
Site Location: ENOS LAKE WQ

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		VQ8134	VQ8135	VQ8136	
Sampling Date		2019/05/09 13:05	2019/05/09 13:05	2019/05/09 13:05	
COC Number		08470264	08470264	08470264	
	UNITS	SWMP 03 (1M) CHLORO A	SWMP 03 (5M) CHLORO A	SWMP 03 (10M) CHLORO A	QC Batch
Internal Sublet Analysis					
Subcontract Parameter	N/A	ATTACHED	ATTACHED	ATTACHED	9437027

Maxxam ID		VQ8137	VQ8138	VQ8139		
Sampling Date		2019/05/09 13:05	2019/05/09 13:05	2019/05/09 13:05		
COC Number		08470264	08470264	08470264		
	UNITS	SWMP 03 (1M) (PHOS+PH)	SWMP 03 (5M) (PHOS+PH)	SWMP 03 (10M) (PHOS+PH)	RDL	QC Batch
Anions						
Orthophosphate (P)	mg/L	<0.0010	<0.0010	<0.0010	0.0010	9416440
Nutrients						
Total Phosphorus (P)	mg/L	0.0061	0.0090	0.0110	0.0020	9421728
Physical Properties						
pH	pH	7.83	7.86	7.85		9415875
RDL = Reportable Detection Limit						

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Maxxam Job #: B935204
Report Date: 2019/05/28

BC Conservation Foundation
Client Project #: 1300017
Site Location: ENOS LAKE WQ

GENERAL COMMENTS

Sample VQ8137 [SWMP 03 (1M) (PHOS+PH)] : Sample was analyzed past method specified hold time for Orthophosphate by Konelab (low level). Exceedance of hold time increases the uncertainty of test results but does not necessarily imply that results are compromised.

Sample VQ8138 [SWMP 03 (5M) (PHOS+PH)] : Sample was analyzed past method specified hold time for Orthophosphate by Konelab (low level). Exceedance of hold time increases the uncertainty of test results but does not necessarily imply that results are compromised.

Sample VQ8139 [SWMP 03 (10M) (PHOS+PH)] : Sample was analyzed past method specified hold time for Orthophosphate by Konelab (low level). Exceedance of hold time increases the uncertainty of test results but does not necessarily imply that results are compromised.

Results relate only to the items tested.

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Maxxam Job #: B935204
Report Date: 2019/05/28

QUALITY ASSURANCE REPORT

BC Conservation Foundation
Client Project #: 1300017
Site Location: ENOS LAKE WQ

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
9415875	pH	2019/05/14			101	97 - 103						
9416440	Orthophosphate (P)	2019/05/14	108	80 - 120	102	80 - 120	<0.0010	mg/L	NC	20		
9421728	Total Phosphorus (P)	2019/05/17	112	80 - 120	95	N/A	<0.0020	mg/L			92	80 - 120

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

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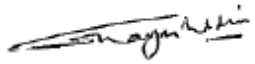
Maxxam Job #: B935204
Report Date: 2019/05/28

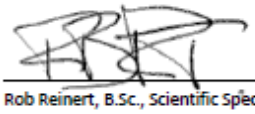
BC Conservation Foundation
Client Project #: 1300017
Site Location: ENOS LAKE WQ

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Ghayasuddin Khan, M.Sc., P.Chem., QP, Scientific Specialist, Inorganics



Rob Reinert, B.Sc., Scientific Specialist

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Burnaby: 4606 Canada Way, Burnaby, BC V5G 1K5, Toll Free (800) 665-8566

CHAIN OF CUSTODY REC

COC #: 08470264

BBY FCD-00077/05

Page 1 of 1

Invoice Information		Report Information (if differs from invoice)		Project Information (where applicable)		Turnaround Time (TAT) Required
Company Name:	41307 BC Conservation Foundation	Company Name:		Quotation #:	B50746	☑ Regular TAT 5 days (Most analyses)
Contact Name:	Jamieson Atkinson	Contact Name:		P.O. #/ AFE#:		PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS
Address:	#1- 7217 Lantzville Road	Address:		Project #:	19000117	Rush TAT (Surcharges will be applied)
	Lantzville, BC PC: V0R 2H0		PC:	Site Location:	Enos Lake WQ	☐ Same Day ☐ 2 Days ☐ 1 Day ☐ 3 Days
Phone:	(250) 327-1155	Phone:		Site #:		Date Required:
Email:	jatkinson@bccf.com; phalinowski@bccf	Email:		Sampled By:	Patricia Halinowski	Rush Confirmation #:

Regulatory Criteria		Special Instructions	Analysis Requested
☐ BC CSR Soil	☐ BC CSR Water	☐ Return Cooler	
☐ CCME (Specify)	☐ Other (Specify)	☐ Ship Sample Bottles (Please Specify)	
☐ Drinking Water	☐ BC Water Quality		

SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

	Sample Identification	Lab Identification	Date Sampled (YYYY/MM/DD)	Time Sampled (HH:MM)	Matrix	Chlorophyll A	DOC	Dissolved Metals (incl. Hardness)	Dissolved Hardness Only	Total Phosphorus	Ortho Phosphorus (SRP)	pH	# OF CONTAINERS SUBMITTED	HOLD - DO NOT ANALYZE
1	SWMP 03 (1m) CHLORO A		2018/05/09	10:05		x							1	
2	SWMP 03 (5m) CHLORO A		2018/05/09	11		x							1	
3	SWMP 03 (10m) CHLORO A		11	11		x							1	
4	SWMP 03 (1m) (PHOS +pH)		11	11						x	x	x	2	
5	SWMP 03 (5m) (PHOS + pH)		11	11						x	x	x	2	
6	SWMP 03 (10m) (PHOS + pH)		11	11						x	x	x	2	
7														
8														
9														
10														

LABORATORY USE ONLY

CUSTODY SEAL Y / N		COOLER TEMPERATURES
Present	Intact	
N	N	8.8.8

COOLING MEDIA PRESENT: (Y) / N

COMMENTS

1	1 x 1L opaque
2	1 x 1L opaque
3	1 x 1L opaque
4	2x120ml
5	2x120ml
6	2x120ml

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)
Patricia Halinowski	2018/05/09	14:25	BRITTANY BURLONE	2018/05/10	08:30

B935204_COC

414

Your Project #: 1300017
Site Location: ENOS LAKE WQ
Your C.O.C. #: 08472525

Attention: Jamieson Atkinson
BC Conservation Foundation
Nanaimo
#1-7217 Lantzville Road
Lantzville , BC
Canada V0R 2H0

Report Date: 2019/09/24
Report #: R2785798
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B968256
Received: 2019/08/17, 09:57

Sample Matrix: Water
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
pH @25°C (3)	3	N/A	2019/08/20	BBY6SOP-00026	SM 22 4500-H+ B m
Orthophosphate by Konelab (low level)	3	N/A	2019/08/17	BBY6SOP-00013	SM 23 4500-P E m
Total Phosphorus - Low Level (1)	3	2019/08/29	2019/08/29	AB SOP-00024	SM 23 4500-P A,B,F m
Chlorophyll A in Water Subcontract (2)	3	N/A	2019/09/24		

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by BV Labs Calgary Environmental
(2) This test was performed by Sub Burnaby to ALS Winnipeg
(3) The CCME method requires pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the CCME holding time. Bureau Veritas Laboratories endeavours to analyze samples as soon as possible after receipt.

Bureau Veritas Laboratories Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Your Project #: 1300017
Site Location: ENOS LAKE WQ
Your C.O.C. #: 08472525

Attention: Jamieson Atkinson
BC Conservation Foundation
Nanaimo
#1-7217 Lantzville Road
Lantzville , BC
Canada V0R 2H0

Report Date: 2019/09/24
Report #: R2785798
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B968256
Received: 2019/08/17, 09:57

Encryption Key

AUTHORIZED REPORT
RAPPORT AUTORISÉ

Bureau Veritas Laboratories
24 Sep 2019 13:15:20

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Customer Solutions, Western Canada Customer Experience Team
Email: customersolutionswest@bvlabs.com
Phone# (604) 734 7276

==========

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BV Labs Job #: B968256
Report Date: 2019/09/24

BC Conservation Foundation
Client Project #: 1300017
Site Location: ENOS LAKE WQ
Sampler Initials: PH

RESULTS OF CHEMICAL ANALYSES OF WATER

BV Labs ID		WH8545	WH8546	WH8547	
Sampling Date		2019/08/16 14:30	2019/08/16 14:20	2019/08/16 14:10	
COC Number		08472525	08472525	08472525	
	UNITS	SWMP 03 (1M) CHLORO A	SWMP 03 (5M) CHLORO A	SWMP 03 (10M) CHLORO A	QC Batch
Internal Sublet Analysis					
Subcontract Parameter	N/A	ATTACHED	ATTACHED	ATTACHED	9601372

BV Labs ID		WH8548	WH8549	WH8550		
Sampling Date		2019/08/16 14:30	2019/08/16 14:20	2019/08/16 14:10		
COC Number		08472525	08472525	08472525		
	UNITS	SWMP 03 (1M) (PHOS+PH)	SWMP 03 (5M) (PHOS+PH)	SWMP 03 (10M) (PHOS+PH)	RDL	QC Batch
Misc. Inorganics						
pH	pH	7.29	7.23	7.22	N/A	9555747
Anions						
Orthophosphate (P)	mg/L	0.0021	0.0028	0.0022	0.0010	9553022
Nutrients						
Total Phosphorus (P)	mg/L	0.0041	0.0090	0.0136	0.0020	9567508

RDL = Reportable Detection Limit
N/A = Not Applicable

Bureau Veritas Laboratories Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

BV Labs Job #: B968256
Report Date: 2019/09/24

BC Conservation Foundation
Client Project #: 1300017
Site Location: ENOS LAKE WQ
Sampler Initials: PH

GENERAL COMMENTS

Results relate only to the items tested.

Bureau Veritas Laboratories Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

BV Labs Job #: B968256
Report Date: 2019/09/24

QUALITY ASSURANCE REPORT

BC Conservation Foundation
Client Project #: 1300017
Site Location: ENOS LAKE WQ
Sampler Initials: PH

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
9553022	Orthophosphate (P)	2019/08/17			94	80 - 120	<0.0010	mg/L				
9555747	pH	2019/08/20			101	97 - 103			0.76	N/A		
9567508	Total Phosphorus (P)	2019/08/29	100	80 - 120	97	80 - 120	<0.0020	mg/L	11	20	94	80 - 120

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Bureau Veritas Laboratories Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

BV Labs Job #: B968256
Report Date: 2019/09/24

BC Conservation Foundation
Client Project #: 1300017
Site Location: ENOS LAKE WQ
Sampler Initials: PH

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Kenneth Goldie, Sample Reception

Harry (Peng) Liang, Senior Analyst

Rob Reinert, B.Sc., Scientific Specialist

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports.
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CHAIN OF CUSTODY RE

COC #: 08472525

BBY FCD-00077/05

Invoice Information	Report Information (if differs from invoice)	Project Information (where applicable)	Turnaround Time (TAT) Required
Company Name: #1302 BC Conservation Fundation	Company Name:	Quotation #: B50746	✓ Regular TAT 5 days (Most analyses)
Contact Name: Jamieson Atkinson	Contact Name:	P.O. #/ AFE#:	PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS
Address: #1- 7217 Lantzville Road	Address:	Project #: 19000117	Rush TAT (Surcharges will be applied)
Lantzville, BC PC: V0R 2H0	PC:	Site Location: Enid Lake WQ	☐ Same Day ☐ 2 Days ☐ 1 Day ☐ 3 Days
Phone: (250) 327 -1155	Phone:	Site #:	Date Required:
Email: jatkinson@bcef.com; ghalinowski@bcef	Email:	Sampled By: Patricia Halinowski	Rush Confirmation #:

Regulatory Criteria	Special Instructions
☐ BC CSR Soil ☐ BC CSR Water	☐ Return Cooler
☐ CCME (Specify) ☐ Other (Specify)	☐ Ship Sample Bottles (Please Specify)
☐ Drinking Water ☐ BC Water Quality	

SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

	Sample Identification	Lab Identification	Date Sampled (YYYY/MM/DD)	Time Sampled (HH:MM)	Matrix	Chlorophyll A	Hold	Dissolved Metals (Field Filtered)	Dissolved Hardness Only	Total Phosphorus	Orthophosphorus (SRP)	pH	# OF CONTAINERS SUBMITTED	HOLD - DO NOT ANALYZE	COMMENTS
1	SWMP 03 (1m) CHLORO A		2019/08/16	13:30		x							1		1 x 1L opaque
2	SWMP 03 (5m) CHLORO A		"	13:20		x							1		1 x 1L opaque
3	SWMP 03 (10m) CHLORO A		"	13:10		x							1		1 x 1L opaque
4	SWMP 03 (1m) (PHOS +pH)		"	14:30						x	x	x	2		2x120ml
5	SWMP 03 (5m) (PHOS + pH)		"	14:20						x	x	x	2		2x120ml
6	SWMP 03 (10m) (PHOS + pH)		"	14:10						x	x	x	2		2x120ml
7															
8															
9															
10															

LABORATORY USE ONLY

CUSTODY SEAL Y / N		COOLER TEMPERATURES
Present	Intact	
N/A		6.5.4

COOLING MEDIA PRESENT: (Y) / N

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)
Pat	2019/08/16	16:12	JM PEDRO TACE	2019/08/17	09:57

B968256_COC

736

Your Project #: 1300017
Site Location: ENOS LAKE WQ
Your C.O.C. #: 08475263

Attention: Jamieson Atkinson

BC Conservation Foundation
Nanaimo
#1-7217 Lantzville Road
Lantzville , BC
Canada V0R 2H0

Report Date: 2019/12/03
Report #: R2819234
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B999708
Received: 2019/11/20, 08:45

Sample Matrix: Water
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
pH @25°C (3)	3	N/A	2019/11/21	BBY6SOP-00026	SM 22 4500-H+ B m
Orthophosphate by Konelab (low level)	3	N/A	2019/11/21	BBY6SOP-00013	SM 23 4500-P E m
Total Phosphorus Low Level Total (1)	3	2019/11/25	2019/11/26	AB SOP-00024	SM 23 4500-P A,B,F m
Chlorophyll A in Water Subcontract (2)	3	N/A	2019/12/03		

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by BV Labs Calgary Environmental
(2) This test was performed by Sub Burnaby to ALS Winnipeg
(3) The CCME method requires pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the CCME holding time. Bureau Veritas Laboratories endeavours to analyze samples as soon as possible after receipt.

Bureau Veritas Laboratories Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

Your Project #: 1300017
Site Location: ENOS LAKE WQ
Your C.O.C. #: 08475263

Attention: Jamieson Atkinson
BC Conservation Foundation
Nanaimo
#1-7217 Lantzville Road
Lantzville , BC
Canada V0R 2H0

Report Date: 2019/12/03
Report #: R2819234
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B999708
Received: 2019/11/20, 08:45

Encryption Key

AUTHORIZED REPORT
RAPPORT AUTORISÉ

Bureau Veritas Laboratories
03 Dec 2019 15:50:36

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Customer Solutions, Western Canada Customer Experience Team
Email: customersolutionswest@bvlabs.com
Phone# (604) 734 7276

==========

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BV Labs Job #: B999708
Report Date: 2019/12/03

BC Conservation Foundation
Client Project #: 1300017
Site Location: ENOS LAKE WQ
Sampler Initials: PH

RESULTS OF CHEMICAL ANALYSES OF WATER

BV Labs ID		WY7546	WY7547	WY7548	
Sampling Date		2019/11/19 12:40	2019/11/19 12:40	2019/11/19 12:40	
COC Number		08475263	08475263	08475263	
	UNITS	SWMP 03 (1M) CHLORO A	SWMP 03 (3M) CHLORO A	SWMP 03 (10M) CHLORO A	QC Batch
Internal Sublet Analysis					
Subcontract Parameter	N/A	ATTACHED	ATTACHED	ATTACHED	9695693

BV Labs ID		WY7549	WY7550	WY7551		
Sampling Date		2019/11/19 12:40	2019/11/19 12:40	2019/11/19 12:40		
COC Number		08475263	08475263	08475263		
	UNITS	SWMP 03 (1M) (PHOS+PH)	SWMP 03 (5M) (PHOS+PH)	SWMP 03 (10M) (PHOS+PH)	RDL	QC Batch
Misc. Inorganics						
pH	pH	7.81	7.78	7.77	N/A	9680642
Anions						
Orthophosphate (P)	mg/L	0.0028	0.0018	0.0028	0.0010	9681052
Nutrients						
Total Phosphorus (P)	mg/L	0.0049	0.0058	0.0049	0.0010	9684785

RDL = Reportable Detection Limit
N/A = Not Applicable

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BV Labs Job #: B999708
Report Date: 2019/12/03

BC Conservation Foundation
Client Project #: 1300017
Site Location: ENOS LAKE WQ
Sampler Initials: PH

GENERAL COMMENTS

Results relate only to the items tested.

Bureau Veritas Laboratories Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

BV Labs Job #: B999708
Report Date: 2019/12/03

QUALITY ASSURANCE REPORT

BC Conservation Foundation
Client Project #: 1300017
Site Location: ENOS LAKE WQ
Sampler Initials: PH

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
9680642	pH	2019/11/21			101	97 - 103			0.14	N/A		
9681052	Orthophosphate (P)	2019/11/21	101	80 - 120	94	80 - 120	0.0012, RDL=0.0010	mg/L	16	20		
9684785	Total Phosphorus (P)	2019/11/26	101	80 - 120	100	80 - 120	<0.0010	mg/L	4.8	20	95	N/A

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

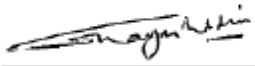
Bureau Veritas Laboratories Burnaby: 4606 Canada Way V5G 1K5 Telephone(604) 734-7276 Fax(604) 731-2386

BV Labs Job #: B999708
Report Date: 2019/12/03

BC Conservation Foundation
Client Project #: 1300017
Site Location: ENOS LAKE WQ
Sampler Initials: PH

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Ghayasuddin Khan, M.Sc., P.Chem., QP, Scientific Specialist, Inorganics

Rob Reinert, B.Sc., Scientific Specialist

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Maxxam
A Bureau Veritas Group Company

CHAIN OF CUSTODY RECORD

Burnaby: 4606 Canada Way, Burnaby, BC V5G 1K5, Toll Free (800) 665-8566

COC #: 08475263

BBY FCD-00077/05

Page 1 of 1

Invoice Information	Report Information (if differs from invoice)	Project Information (where applicable)	Turnaround Time (TAT) Required
Company Name: R1307 BC Conservation Fundation	Company Name:	Quotation #: B30709	✓ Regular TAT 5 days (Most analyses)
Contact Name: Jamieson Atkinson	Contact Name:	P.O. #/ AFE#:	PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS
Address: #1 - 7217 Lantzville Road	Address:	Project #: 1300013	Rush TAT (Surcharges will be applied)
Lantzville, BC PC: V0R 2H0	PC:	Site Location: Enos Lake WQ	☐ Same Day ☐ 2 Days
Phone: (250) 327 -1155	Phone:	Site #:	☐ 1 Day ☐ 3 Days
Email: jatkinson@bccf.com; phalinowski@bccf	Email:	Sampled By: Patricia Halinowski	Date Required:

Regulatory Criteria	Special Instructions
☐ BC CSR Soil ☐ BC CSR Water	☐ Return Cooler
☐ CCME (Specify) ☐ Other (Specify)	☐ Ship Sample Bottles (Please Specify)
☐ Drinking Water ☐ BC Water Quality	

SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

Analysis Requested

Rush Confirmation #:

LABORATORY USE ONLY

CUSTODY SEAL Y / N (Present / Intact) | COOLER TEMPERATURES: N/A | 0.5, 6

COOLING MEDIA PRESENT: Y / N

	Sample Identification	Lab Identification	Date Sampled (YYYY/MM/DD)	Time Sampled (HH:MM)	Matrix	Chlorophyll A	E.coli	Dissolved Metals (incl. Hardness)	Dissolved Nutrients Only	Field Preserved	Orthophosphate (DP)	pH	# OF CONTAINERS SUBMITTED	HOLD - DO NOT ANALYZE	COMMENTS
1	SWMP 03 (1m) CHLORO A		2019/11/19	12:40		x							1		1 x 1L opaque
2	SWMP 03 (5m) CHLORO A		2019/11/19	12:40		x							1		1 x 1L opaque
3	SWMP 03 (10m) CHLORO A		2019/11/19	12:40		x							1		1 x 1L opaque
4	SWMP 03 (1m) (PHOS +pH)		2019/11/19	12:40						x	x	x	2		2x120ml
5	SWMP 03 (5m) (PHOS + pH)		2019/11/19	12:40						x	x	x	2		2x120ml
6	SWMP 03 (10m) (PHOS + pH)		2019/11/19	12:40						x	x	x	2		2x120ml
7															
8															
9															
10															

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)
Patricia H	2019/11/19	15:60	JMARKHAM MOY	2019/11/20	8:45

B999708_COC

Appendix 2

Limnologist's Report

Enos Lake Protection and Monitoring Program:

Review of 2019 Water Quality Data

From PGL, 2016

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

PO Box 7

Lantzville, B.C.

V0R 2H0

By: John Deniseger

December 2019

Summary

Year 3 of the BCCF's Enos Lake annual water quality monitoring program was completed in 2019. 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 2019, and compares them to water quality targets for Enos Lake.

Overall, 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. Previous data suggested that Enos Lake is at least mesotrophic to eutrophic, likely leaning toward eutrophic, while phosphorus concentrations and hypolimnetic dissolved oxygen levels did not appear to meet the water quality targets.

In 2019, Enos Lake appeared to be less productive than in previous years, likely as a result of the relatively cooler, wetter summer conditions. In 2019, the total phosphorus target was met, while hypolimnetic dissolved oxygen levels did not meet the water quality target. Chlorophyll a and phosphorus data indicated oligotrophic to mesotrophic conditions, while secchi readings continued to indicate eutrophic conditions. Overall, the data suggests that Enos Lake may have been mesotrophic in 2019.

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 water quality sampling has been carried out since 2006, there has not been a standardized sampling program in place until 2017. Sampling history prior to 2017 is further outlined in Nordin (2017). The 2018 data is reviewed in Deniseger (2018).

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 2019 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.

Four data points were provided in 2019 (all at station 03):

February 28 1.5 m

May 9 2.3 m

August 18 2.8

September 10 2.5 m

November 19 2.75 m

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 2018, only 5 data points were collected, ranging from 2.0 to 3.5 m.

In 2019, 5 data points were collected, exhibiting a narrow range from 1.5 to 2.8 m, with an average of 2.4 meters. Average summer secchi depth of less than 3 meters are normally indicative of a eutrophic lake. While the data is limited, it would appear to suggest that Enos Lake is a eutrophic lake. However, more frequent data (monthly) collection is needed to more thoroughly assess Enos Lake.

2.2 Temperature

Field data collection in 2019 included temperature, dissolved oxygen, conductivity and redox potential profiles taken quarterly at station 03.

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 2019. The late February profile shows the lake to be effectively isothermal, unstratified and mixing. The lake was likely recently "ice free" as February was characterized by a prolonged period of drier, colder weather. Not surprisingly, the temperatures were slightly cooler than in 2018. By May, the profile indicates strong stratification with an 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. In early September, the upper 4 meters of Enos Lake were greater than 20 C, with a thermocline that continues to be deeper and more compressed. The strong thermocline is continuous at least from mid-spring through early fall, effectively isolating the deeper waters of the lake. In November, the lake was once again isothermal, unstratified and mixing. It would have been interesting to have additional temperature profile data immediately following the early August rain event. 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 2019

Profile - Site SWMP-03				
	2/28/2019	**5/9/2019**	**9/10/2019**	**11/19/2019**
Depth (m)	Temp. (°C)	Temp. (°C)	Temp. (°C)	Temp. (°C)
1	3.9	17	20.8	9.2
2	3.8	16.3	20.7	9.1
3	3.8	12.7	20.7	9.1
4	3.8	12.9	20.4	9.1
5	3.8	8	17	9.1
6	3.8	6.1	11.5	9.1
7	3.7	5.4	8.7	9.1
8	3.6	5.2	7.1	9
9	3.5	5	6.5	9
10	3.6	5	6.3	8.9
11		5.1		8.6

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 3.5 to 3.9 C (see table 2.2). Dissolved oxygen levels were high, consistently greater than 12.0 mg/L, ranging from 91.2 to 96.9 saturation. This reflects isothermal conditions and subsequent mixing throughout the water column.

The May sampling indicates a stratified lake with a thermocline between 2 and 6 meters deep, with significant oxygen depletion below 9 meters and greater than 90% saturation above 5 meters.

The September 2019 profile indicates a relatively warm layer of surface water down to 4 meters, with a deeper, steep thermocline down to 8 meters. The September dissolved oxygen data may reflect an equipment or calibration issue as the data is consistently lower than would be reasonably expected, particularly above the thermocline. Regardless, the data is still of value as it illustrates trends with depth. Oxygen levels are higher above the thermocline, decreasing quickly below the thermocline, with likely oxygen depletion at depth.

The November profile reflects isothermal conditions with dissolved oxygen levels greater than 9 mg/L at depths to 8 meters, and dissolved saturation ranging from 81.9 to 85.2%. However, with increasing depth, oxygen levels continued to decrease, down to 5.46 mg/L or 46.7 % saturation at 11 meters. This may indicate that the thermocline has only recently broken down, so that mixing and oxygen replenishment at depth has not yet been completed.

Table 2.2 Enos Lake Dissolved Oxygen concentration profiles for 2019

Profile - Site SWMP-03				
	2/28/2019	**5/9/2019**	**9/10/2019**	**11/19/2019**
Depth (m)	D.O. (mg/L)	D.O. (mg/L)	D.O. (mg/L)	D.O. (mg/L)
1	12.69	10.01	6.74	9.73
2	12.71	10.05	6.45	9.80
3	12.70	10.03	6.48	9.73
4	12.70	10.30	6.06	9.79
5	12.62	11.84	4.02	9.70
6	12.54	11.11	2.72	9.42
7	12.51	9.81	0.63	9.60
8	12.49	9.84	0.11	9.25
9	12.33	8.12	0.09	8.73
10	12.04	3.01	0.09	7.18
11		0.42		5.46

Table 2.3 Enos Lake Dissolved Oxygen saturation profiles for 2019 (from Standard Methods for the examination of water and wastewater)

Profile - Site SWMP-03 dissolved oxygen (% saturation)				
	2/28/2019	**5/9/2019**	**9/10/2019**	**11/19/2019**
Depth (m)	D.O. (%saturation)	D.O. (%saturation)	D.O. (%saturation)	D.O. (%saturation)
1	96.9	103.2	74.9	84.6
2	96.3	102.6	71.7	85.2
3	96.2	94.6	72.0	84.6
4	96.2	97.2	67.3	85.1
5	95.6	100.3	41.4	84.3
6	95.0	89.5	27.0	81.9
7	94.8	77.9	5.4	83.5
8	94.6	77.5	0.9	79.7
9	92.7	63.4	0.7	75.3
10	91.2	23.5	0.7	61.9
11		3.3		46.7

In the epilimnion layer (above the thermocline), the water quality target for dissolved oxygen is greater than 5 mg/L. This target was met. Below the thermocline in the hypolimnion, the target is 2 mg/L. This target was not met during the late spring and likely not met through the summer (May through September).

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. Due to equipment unavailability, no conductivity profile was collected as part of the May sampling.

The profile for late February when the lake was not stratified showed an increasing trend with depth, ranging from 140.3 to 163.2 µS/cm. In September, conductance ranged from 128 to 156.8 µS/cm, with the highest readings at depth. In November, conductance was consistently at 118 µS/cm throughout the water column to a depth of 7 meters, before gradually increasing to a high of 135.7 µS/cm at 11 meters.

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 2019

Profile - Site SWMP-03			
	2/28/2019	9/10/2019	11/19/2019
Depth (m)	Conductivity (µS/cm)	Conductivity (µS/cm)	Conductivity (µS/cm)
1	140.3	147.4	118.0
2	143.1	147.3	118.0
3	146.5	147.3	118.0
4	148.6	146.6	118.0
5	152.5	131.5	118.0
6	154.5	128	118.0
7	157.1	131	118.0
8	159.0	146.9	118.1
9	161.5	153.5	118.4
10	163.2	156.8	119.3
11			135.7

2.5 pH

Enos Lake pH data is summarized in tables 2.5(a) and 2.5 (b) below

Due to equipment issues, no field pH data was collected as part of the February and May sampling. However, lab measurement of pH was added at 3 depths (1, 5 and 10 m) for each of the 4 sampling days. This helped to fill in data gaps, while also providing a "check" on field data.

There are issues with the limited pH data collected in the field in 2019. The September data appears to be too low at all depths. The November field data appears to be much better, as confirmed by the lab pH data. The source of the problem could be related to equipment maintenance and malfunction issues or field calibration and sampling procedures.

The November field pH data and all of the lab pH data appears to be fairly typical of east coast Vancouver Island lakes.

Table 2.5(a) Enos Lake pH profiles for 2019 – lab data

Site SWMP-03				
	2/28/2019	5/9/2019	8/16/2019	11/19/2019
Depth (m)	pH (pH units)	pH (pH units)	pH (pH units)	pH (pH units)
1	7.68	7.83	7.29	7.81

5	7.73	7.86	7.23	7.78
10	7.63	7.85	7.22	7.77

Table 2.5 (b) Enos Lake pH profiles for 2019

Profile - Site SWMP-03		
	9/10/2019	**11/19/2019**
Depth (m)	pH (pH units)	pH (pH units)
1	7	7.48
2	7.1	7.6
3	7.13	7.72
4	7.1	7.81
5	6.09	7.87
6	5.95	7.92
7	6.02	7.93
8	6.09	7.93
9	6.18	7.9
10	6.21	7.78
11		7.54

2.6 Redox

Redox potential (sometimes referred to as ORP) measures the lake's ability to "cleanse" itself and break 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 be a challenge. 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 2019, redox data was collected in September and November. However, the November data is obviously erroneous and has not been used in the data analysis in this report. It is likely that the redox probe needs replacement.

Table 2.6 Enos Lake redox potential profiles for 2019

Profile - Site SWMP-03		
	9/10/2019	11/19/2019
Depth (m)	Redox (mV)	Redox (mV)
1	111	-22
2	114.2	-19
3	112.8	-13.5
4	120.2	-9.8
5	136.2	-6
6	131.4	-1.3
7	124.3	1.2
8	-184.2	5.8
9	-247.3	9
10	-268.3	9.8
11		-12
12		

The redox potential data collected in 2019 is shown above in Table 2.6. The September data supports the dissolved oxygen data indicating an oxygen deficit at depth due to an accumulation of decaying organic matter on the lake bottom. Enos Lake is not able to sufficiently replenish oxygen to meet the oxygen demand at depth.

The equipment should be sent in for full servicing and assessment (potential probe replacement).

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.

The 2019 data had an annual mean of 4.54 ug/L, which was less than 50% of the 2017 and 2018 averages of 10.55 and 10.2 ug/L, respectively. It should be noted that there was no data collected in late February. However, it is highly unlikely that this would have increased the annual mean significantly.

General trophic status classification 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. While the annual means for 2017 and

2018 were both indicative of a eutrophic lake, Enos Lake's mean concentration of 4.54 ug/L in 2019 is characteristic of a mesotrophic or moderately productive lake.

Table 2.7 Enos Lake chlorophyll a data for 2019

SWMP-03 - chlorophyll a ug/L			
	5/9/2019	**8/16/2019**	**11/19/2019**
Depth (m)			
1	3.96	3.01	4.29
5	8.1	4.0	2.92
10	7.78	5.4	1.41
Daily mean	**6.61**	**4.14**	**2.87**
Annual mean	**4.54**		

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. This target was met in 2019. The 2019 annual average of 7.3 ug/L was less than 50% of the 2017 and 2018 averages of 19 and 16.6 ug/L. This supports the lower chlorophyll a value found in 2019.

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. 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.

Another method of assessing 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 oligotrophic in 2019 but mesotrophic in both 2017 and 2018.

Table 2.8 Enos Lake total phosphorus data for 2019

Site SWMP-03 - total Phosphorus ug/L				
	2/28/2019	5/9/2019	8/16/2019	11/19/2019
Depth (m)				
1	18.4	6.1	4.1	4.3
5	11.1	3.0	3.0	5.8
10	3.3	11.0	13.6	4.3
Annual mean	7.3			

Table 2.9 Enos Lake orthophosphate data for 2019

Site SWMP-03 - Orthophosphate ug/L				
	2/28/2019	5/9/2019	8/16/2019	11/19/2019
Depth (m)				
1	2.1	<1	2.1	2.8
5	2.2	<1	2.8	1.8
10	2.4	<1	2.2	2.8

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.

Chlorophyll a, total phosphorus and secchi depth are fundamental indicators used to assess lake trophic status. While more secchi depth data should be collected on a monthly basis, the 2017, 2018 and 2019 data suggest that Enos Lake is eutrophic.

Mean annual average chlorophyll a data for both 2017 and 2018 also classifies Enos Lake as eutrophic. While the phosphorus levels indicate that Enos Lake may be considered mesotrophic, the phosphorus target of 12 ug/L was not met in 2018 or 2017. In 2019, Enos Lake appears to have been less productive as chlorophyll a classified the lake as mesotrophic. Total phosphorus levels classified Enos Lake as oligotrophic, while the phosphorus target of 12 ug/L was met.

Table 3.1 Year to year status of key indicators and targets

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

During the summer months, dissolved oxygen levels below the thermocline did not meet the target of 2 ug/L. While the redox data for 2018 and 2019 is limited, the dissolved oxygen levels can be used to gain some insight into lake processes with respect to redox. Spring through summer, the dissolved oxygen levels at depth were very low, virtually anoxic. It is highly likely that the redox potential at depth would have been less than 100 mV or potentially negative, confirmation that reducing conditions were present at the sediment water interface. Reducing conditions are typically indicative of internal loading – the release of phosphorus from the sediments into the water column. In 2018, this would explain the relatively higher concentrations of total phosphorus at depth, particularly in late summer. While the higher concentrations at depth, typical of internal loading, continued in 2019, they were substantially lower than in 2017 and 2018.

Weather patterns in mid-summer 2019 were atypical for the east coast of Vancouver Island. The prolonged summer drought typical of the area, did not occur as temperatures were somewhat cooler and substantial rains occurred in early August. It is likely that the August rain increased flows through the lake, resulting in additional flushing and mixing of the lake, at least over the short term. This may explain the lower total phosphorus and chlorophyll a values for 2019, particularly below the thermocline. While this may have benefitted the lake's overall health in 2019, it is not something that can be relied on over the long term, as significant summer rain is unusual for the area.

The apparent decrease in productivity in 2019 highlights the importance of continuing the Enos Lake monitoring program over the long term. Seen in isolation, an individual year's data may lead to incorrect conclusions. Year to year variability is to be expected. Trends over time lead to better management decisions, particularly when factoring in the impacts of climate change.

Enos Lake's 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. In 2019, the target for total phosphorus was met, while the target for dissolved oxygen at depth was not met. Overall, Enos Lake appears to have been less productive in 2019 than in previous years, based on the data available, suggesting that the lake may have been mesotrophic.

4.0 Recommendations

The annual portion of the monitoring program relies on two components: field profile data and lab data (chlorophyll a and phosphorus). A portion of the field data, particularly pH and redox, is questionable or erroneous. Field calibration methodology should be reviewed and enhanced. It is possible that one or more probes are due for replacement. Continuing the collection of lab pH data as part of the sampling program should be standard practice. Increasing Secchi depth data collection to year-round on a monthly basis is also recommended.

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.

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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