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Mabel Lake Water: Preliminary Source Water Assessment

Prepared for: Regional District of North Okanagan
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Executive Summary

Regional District of North Okanagan (RDNO) operates a 26 m deep drinking water intake in Mabel Lake that is located near the outflow into Shuswap River. Elevated turbidity occurred at the intake during early 2020 and a study was initiated to determine the source of the turbidity. As the study began, divers inspecting the intake found that the intake had rotated such that the screens were lying on the lake bottom, likely disturbing the sediment and increasing turbidity and bacteria counts in the raw water. The intake was temporarily repaired on August 31, 2020 with final upgrades to the intake completed on June 15, 2021.

This study briefly evaluated source water quality and found that Mabel Lake source water quality was high on both sampling trips. The study focused primarily on mapping water currents and delineating an intake protection zone (IPZ). The IPZ was created using a two-hour buffer such that the highest risk activities can be excluded and allow RDNO at least two hours of reaction time from an event that could impair water quality.

The activities that present the greatest risk to source water quality and intake infrastructure relate to boating and freshet impacts, particularly via Lusk Creek.

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1.0 Introduction

1.1 Mabel Lake Overview

Mabel Lake is a large, deep lake with low nutrient concentrations. It is approximately 33 km long, up to 2.5 km wide and has a surface area of 59 km². It averages 110 m deep with a maximum depth 192 m in the southern half of the lake. Mabel Lake is both fed by and drains into the Shuswap River. Source water for Mabel Lake Water Utility is extracted from an intake located at 26 m depth and approximately 200 m from shore.

1.2 Study Background

In 2014, the drinking water intake in Mabel Lake was extended to a depth of 26 m. This extension provided improved water quality until 2020. On May 23, 2020, increased turbidity readings (>1 NTU) caused RDNO to issue a Water Quality Advisory. For several hours on June 23, 2020, turbidity increased to >5 NTU, initiating a Boil Water Notice. Summer 2020 exhibited water quality fluctuation for longer than historically recorded. In addition to turbidity, Total Coliform and *E. coli* counts were also elevated.

On Aug 5, 2020, divers discovered that the intake had fallen over and was resting on the bottom of the lake. After further investigation it was surmised that the intake likely fell over because it needed additional support due to its location on the sloped lake bottom. The intake was put back upright on Aug 31, 2020 and on Jun 15, 2021 a permanent refit of the intake was implemented with better anchoring of both the intake and pipeline.

The Regional District of North Okanagan (RDNO) was interested in determining an intake protection zone and contracted Larratt Aquatic Consulting (LAC) to perform a study at Mabel Lake during 2020/21.

1.3 Study Purpose

The proposed study involved water quality and algae sampling, and a drogue study program in Mabel Lake. Water quality samples around the intake are used to check for possible inputs of turbidity and bacteria to the intake and the drogue study is used to understand the movement of water currents at variable depths.

1.4 Study Design

Chemistry samples were sent to Caro Labs in Kelowna. Water chemistry parameters are listed in Table 1. Algal samples were identified to species by LAC, along with cell density and biovolume calculations. In addition, drogue currents were analyzed by LAC.

Table 1: Water chemistry parameters

Parameter	Units	Detection Limit
Turbidity	NTU	0.1
Coliforms, Total	MPN/100 mL	1
E. coli	MPN/100 mL	1

Sampling focused on four areas in Mabel Lake: Lusk Creek, the current intake, near the boat launch, and at the river outlet west of the boat launch (Figure 1). In each area water chemistry

was collected and additional algae collection and drogue runs were performed near the current intake and boat launch (Figure 1).

Figure 1: Map of Mabel Lake sampling program

Figure 2: Photograph of drogue floats near current intake

2.0 Methods

Water Quality

Water quality samples were collected either by hand directly below the surface or in a low-metals Van Dorn bottle-sampler for deep samples. Samples were transposed into bottles provided by CARO Environmental Laboratories (Caro Labs). The filled sample bottles were placed on chipped ice and delivered to Caro Labs in Kelowna, B.C. within 8 hours of collection. Samples were analysed according to current Standard Methods.

Algae

Algae samples were collected near the current intake. Algae was taken from 0 m and 25m. These samples were stored in a dark, iced cooler until analyzed by LAC.

Drogues

Drogues are weighted baskets connected to a float via a rope of specific length such that they can be used to track water currents at a given depth. During this study, drogues were deployed at depths of 5 m, 10 m, 20 m, and 30 m around the intake location. The drogues results are used to define the proposed intake protection zone.

3.0 Results

3.1 Bathymetry and Water Currents

A bathymetric survey was conducted around the intake. The survey revealed a large shallow bench area to the north and west of the intake that experiences heavy boating activity and contains a large marina (Figure 3). While powerboating in water <8 m is not advised because of the risk of sediment disturbance, there are strong currents near the outflow to Shuswap River that would likely restrict the potential for impacts to the water intake. Depth increases quickly along the axis of the pipeline below 10 m. This is beneficial because it means that plumes of sediment that are disturbed upslope of the intake should largely pass below the screens (in their correct position) and continue down the slope to deeper water.

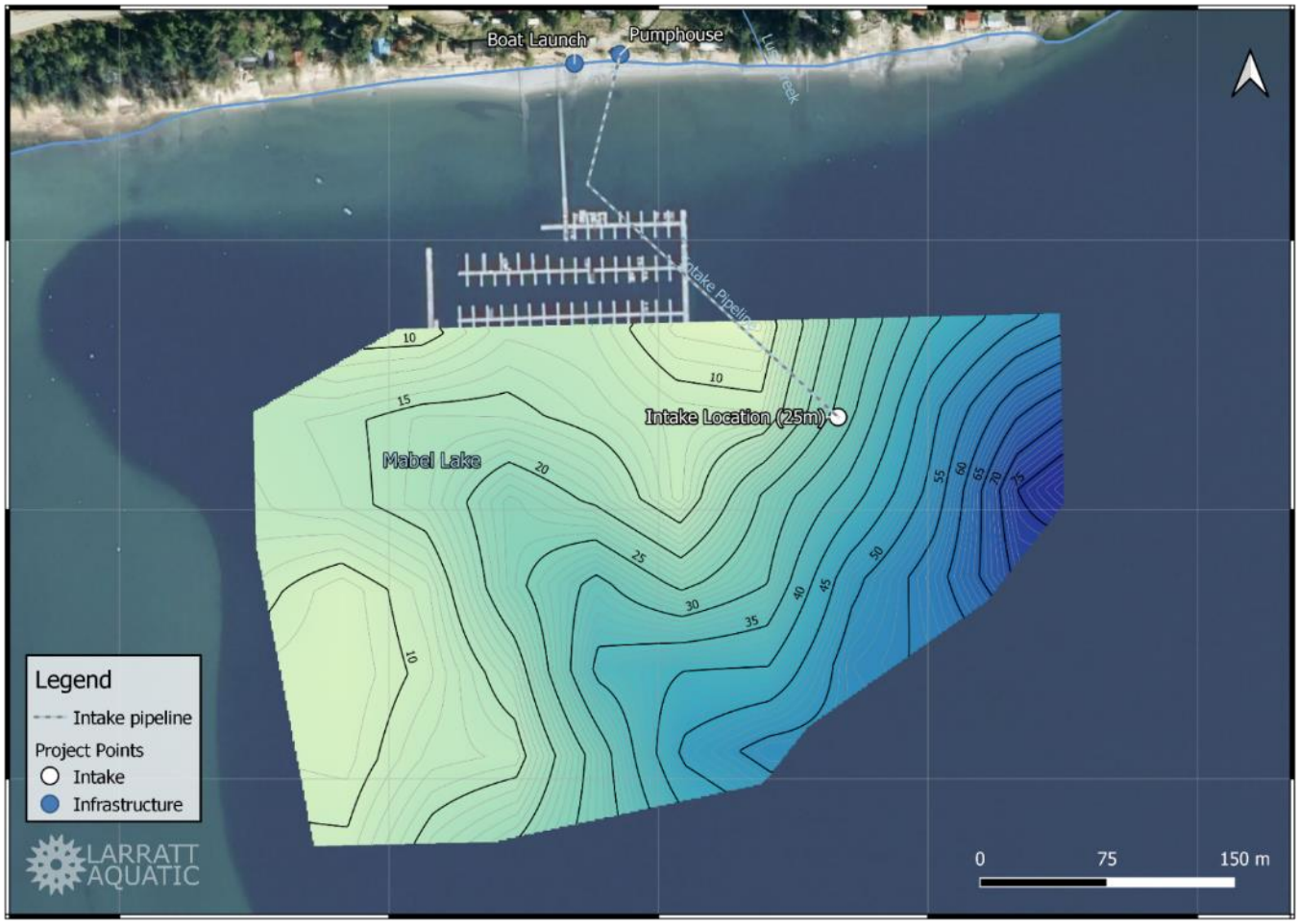


Figure 3: Bathymetry of Mabel Lake around intake

Drogues were used to measure water currents at the intake on two occasions. On both occasions, the surface drogues (5 m) moved quickly towards the outflow into the Shuswap River. Deeper drogues (>20m) moved more slowly and were recorded travelling in multiple directions (Figure 4). It is likely that winds blowing along the N-S axis of the lake create an area of turbulent water currents within the bay that the intake is located within. This could mean that contaminants that sink below the surface may linger within the bay, settling out of the water column.

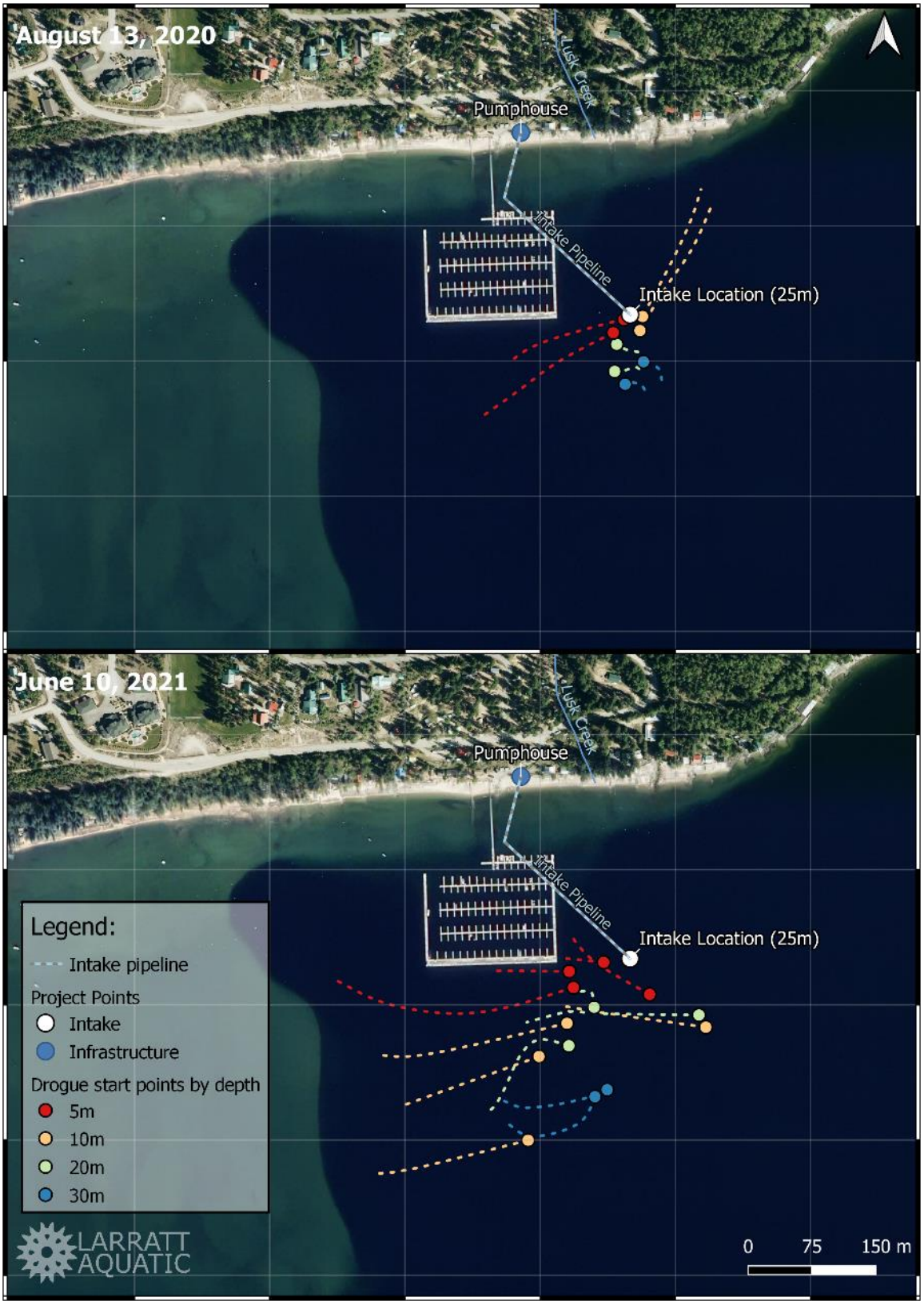


Figure 4: Drogues at Mabel Lake intake

Note: Drogues started at points and traveled away along dashed lines.

3.2 Lake Profiles

Water temperature in Mabel Lake varied from 20 °C at the surface to 5.1 °C at 35 m on Aug 13, 2020 and 13.6 °C at the surface to 5.1 °C at 35 m on Jun 10, 2021 (Figure 5). Dissolved oxygen was high throughout the water column on both dates but there was evidence of significant algal activity at the thermocline on Aug 13, 2020 (Figure 5).

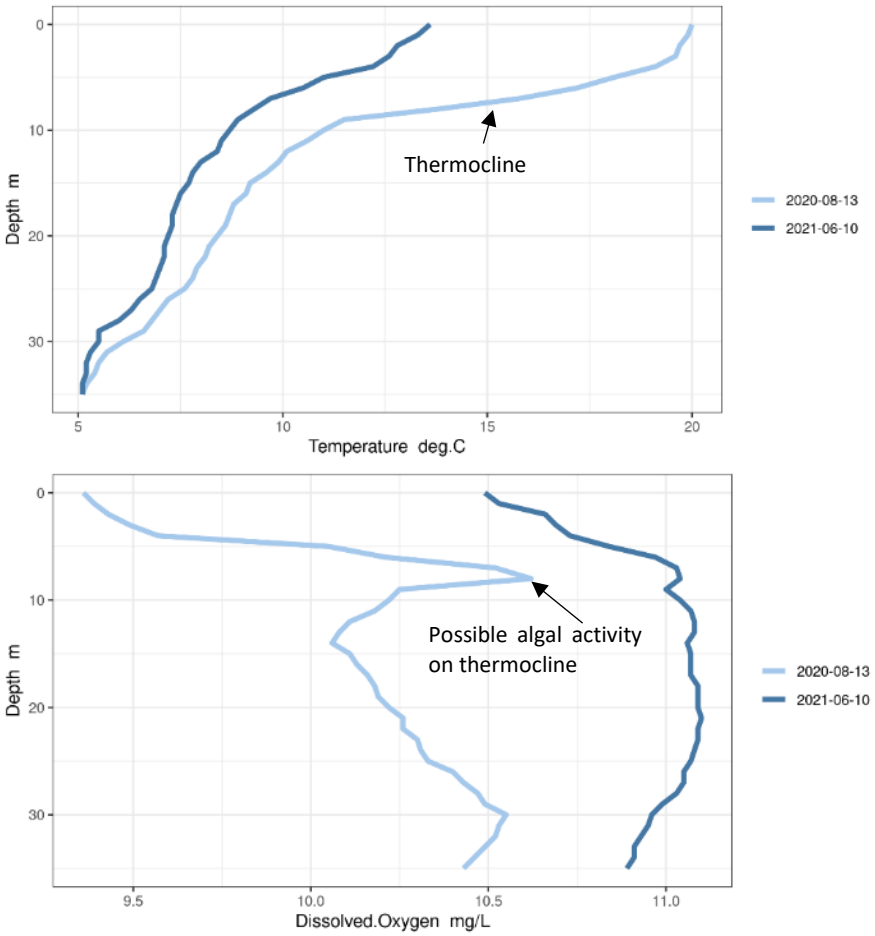


Figure 5: Temperature and dissolved oxygen profiles from Mabel Lake near the intake during sample trips

Water clarity was high on both trips but was greater during the August 2020 trip (9.8 m) than the June 2021 trip (7.4 m) because the August trip occurred during the clear phase of the lake which is after the effects of freshet have passed and spring algal activity has diminished (Figure 6). The June trip occurred during freshet.

3.3 Water Chemistry

Water chemistry samples were collected at four sites on each sampling trip for bacteria and turbidity. On Aug 13, lake bacteria and turbidity readings were low measuring <1 CFU/100mL of *E. coli* and 0.48 NTU at the surface. However, nearby Lusk Creek had elevated turbidity (5.1 NTU) and bacteria (942 units/100mL of total coliforms and 2 units/100mL of *E. coli*). The sediment near the intake was also sampled for bacteria to determine the risk from resuspended sediment. The sample contained moderate bacteria counts measuring 2100 units/100mL of total coliforms and

36 units/100mL of *E. coli*. The intake has 2 m of clearance above the sediment that should protect against most sediment resuspension events.

3.4 Algae

Algae samples were collected near the intake location from the surface and the intake depth (26 m) on Aug 13, 2020 and Jun 10, 2021. Densities during both trips were low, an expected result given the high water-clarity on both trips (Figure 6). A mixture of diatoms, flagellates, and cyanobacteria were noted but densities were too low to adversely affect water quality (Figure 6).

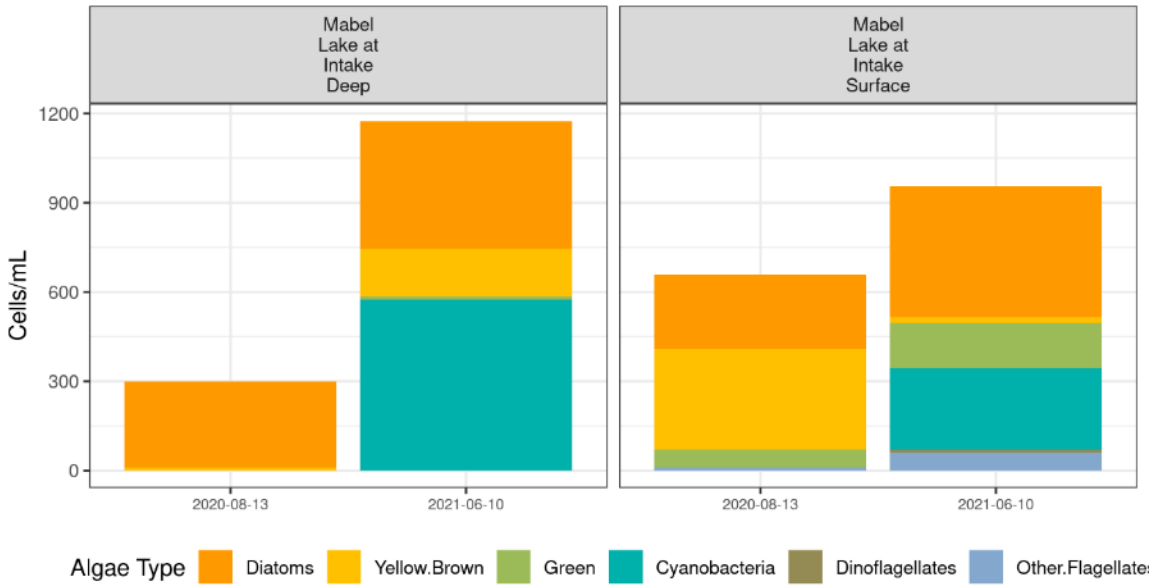


Figure 6: Algae densities in Mabel Lake at the intake

3.5 Intake Inspection

The intake was inspected using an ROV on June 10, 2021. The survey captured the pipeline from 8 m depth down to the intake screens at 26 m below the surface. The intake has good clearance above the sediment (~2 m); the screens were in good condition, and the intake was held in a vertical position using straps attached to an anchor east of the intake. Shortly after the inspection, on June 15, divers performed additional works on the intake to permanently anchor the screens vertically and to better anchor the pipeline which had risen off the lake bottom in some locations.

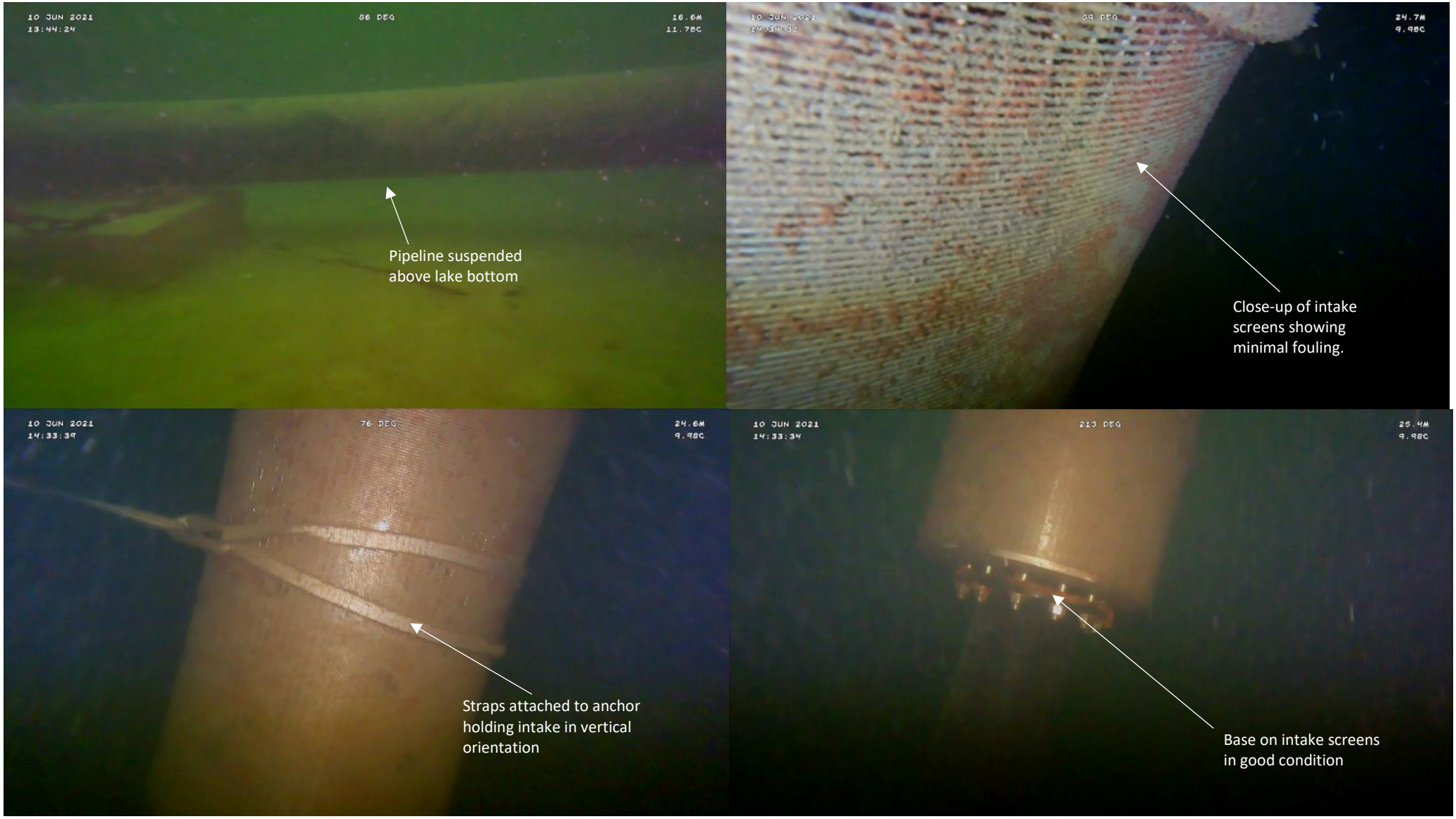


Figure 7: Images of intake and pipeline captured by ROV on Jun 10, 2021

4.0 Intake Protection Zone

The goal of this study was to briefly summarize water quality at the intake and to propose an intake protection zone (IPZ). An IPZ is an area where protection of the intake and source water quality takes precedence over all other activities. It is understood that activities within a much larger area than the proposed IPZ have the potential to negatively impact the intake but the common practice is to create a buffer of two hours around the intake. The IPZ can also be used as an information gathering tool; registering the area with Front Counter BC allows a water supplier to receive notifications about potential developments near their intake and then work collaboratively with stakeholders to mitigate potential risks to source water quality.

The distance around the intake that water could travel within 2 hours was delineated by using water currents data from this study (red zone in Figure 4). An extended area was highlighted as an area of vulnerability along the shoreline where risk factors that are likely to affect the intake but at time-scales greater than 2-hours travel time from the source to the intake (blue zone in Figure 8). This combined area is the proposed IPZ (orange area in Figure 8).

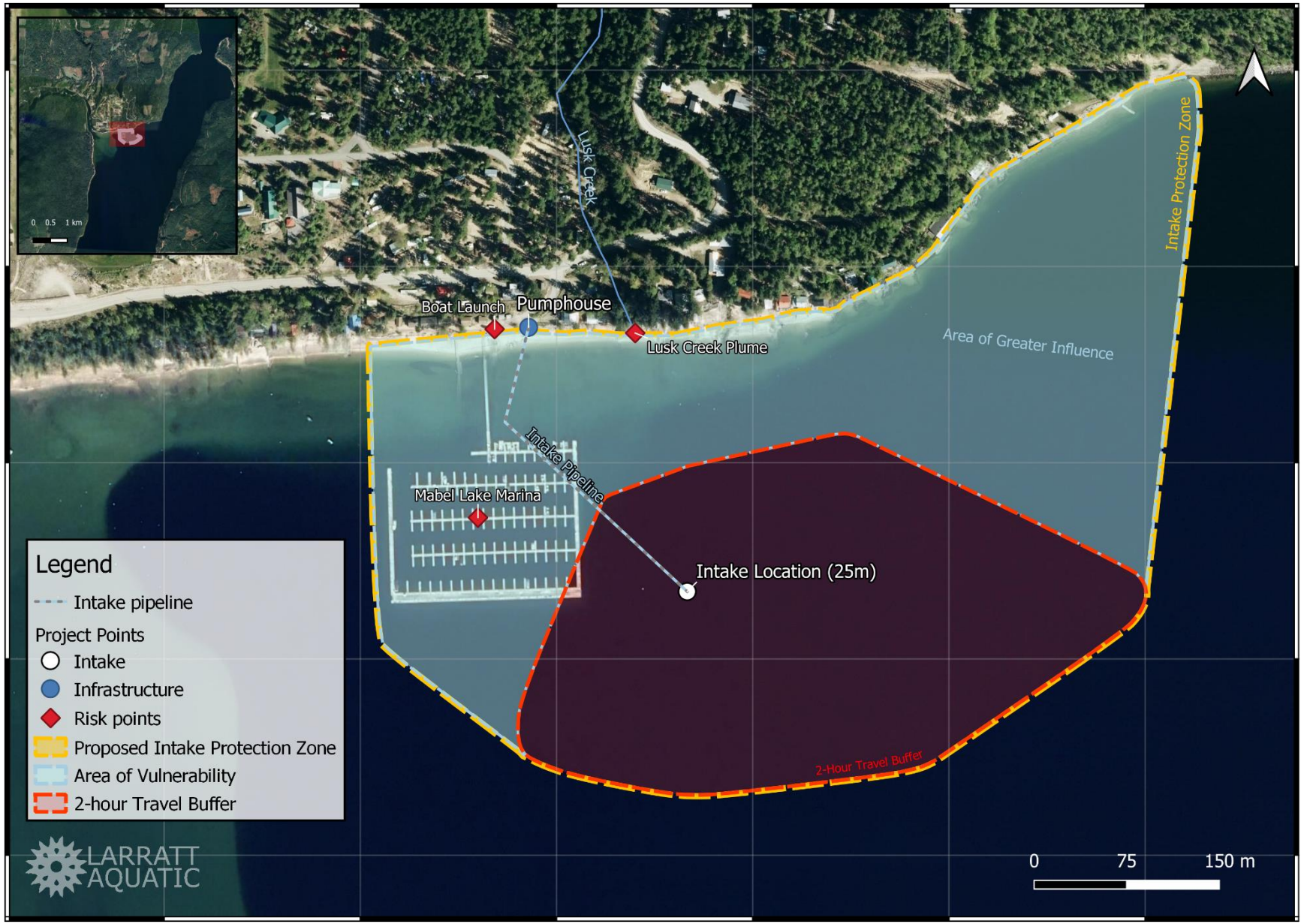


Figure 8: Map of proposed intake protection zone

5.0 Risk Ranking and Conclusions

The initial cause of elevated turbidity and bacteria counts in the raw water was identified by divers as a damaged intake prior to the start of the study. The study provided information on the quality of Mabel Lake source water around the intake. Current water data from around the intake was used to delineate an intake protection zone that would provide at least 2-hours of response time for RDNO. The main risks to the intake are summarized in Table 2 with the highest risks associated with boating activities, shoreline septic, and freshet flows.

The IPZ will be helpful by establishing the intake as a preeminent use where activities have the greatest potential to affect the intake. The IPZ also serves as a vital tool for education and communication with stakeholders. As the IPZ includes offshore and shoreline activities, it should be registered with Front Counter BC and the RDNO planning department to provide the RDNO Utilities Department with notifications if a development is planned for within or on the land adjacent to the IPZ in the future.

Table 2: Risk Ranking Table

Risk Name	Description	Rating	Within IPZ?	How will IPZ Help?
Marina & Boating	There is a large marina within the proposed IPZ and significant boating activity was noted during sampling trips.	Very High	Yes	Education of boaters about intake presence and their role.
Boat launch	Public boat launch adjacent to the marina is a potential risk from introduction of invasive species, garbage, fuel spills.	High	No	Education of boaters about intake presence and their role.
Lusk Creek	Lusk Creek is a small creek that drains Lusk Lake into Mabel Lake approximately 200 m from the intake. Residences on septic and golf course abut the creek. Lusk Lake should buffer upstream impacts and outside of freshet, creek flow is very low.	High during freshet, low during remainder of the year.	Yes	The mouth of Lusk Creek lies within of the IPZ. The IPZ should be used as an educational tool for properties that abut the creek on the potential for negative impacts to the intake, which is their drinking water source.
Flooding	Mabel Lake water level is unregulated. Flooding within all or part of its watershed could negatively impact water quality	High	Yes-entire lake	Education of property owners with goal of ensuring areas susceptible to flooding are free of harmful chemicals
Shoreline Septic	Many residences in the Mabel Lake community are on private septic systems.	Moderate (normally), High (during flood or in event of failing septic system)	Yes	The IPZ should be used as an educational tool for shoreline properties on the potential for negative impacts to the intake from poorly maintained septic fields, particularly in the event of flooding

Appendices

Appendix 1: Water Quality Data

Site	Date	Turbidity	Total Coliforms	*E. coli*
Lusk Lk Creek	2021-06-10	0.57	1990	15
Surface Mabel	2021-06-10	0.5	8	1
Deep Mabel	2021-06-10	0.34	12	<1
Launch Mabel	2021-06-10	0.47	2	<1
River Mouth	2021-06-10	0.52	9	2
Lusk Lk Creek	2020-08-13	5.09	942	2
Surface Mabel	2020-08-13	0.48	1	<1
Deep Mabel	2020-08-13	0.73	<1	<1
Launch Mabel	2020-08-13	0.33	8	<1
Rivermouth	2020-08-13	0.51	43	<1
Mabel Lake Sediment	2020-08-11	NA	2100	36

Appendix 2: Field Meter Data from Mabel Lake at Intake

Site	Profile.Type	Day	Month	Year	Date	Secchi	Bottom	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Mabel.Lake.Intake	Temperature	13	8	2020	2020-08-13	9.8	35	20	19.9	19.7	19.6	19.1	18.1	17.2	15.8	13.8	11.5	11	10.6	10.1	9.9	9.6	9.2	9.1	8.8	8.7	8.6	8.4	8.2	8.1	7.9	7.8	7.6	7.2	7	6.8	6.6	6.1	5.7	5.5	5.4	5.2	5.1			
Mabel.Lake.Intake	Temperature	10	6	2021	2021-06-10	7.4	38.1	13.6	13.3	12.8	12.6	12.2	11	10.5	9.7	9.3	8.9	8.7	8.5	8.4	8	7.8	7.7	7.5	7.4	7.3	7.3	7.2	7.1	7.1	7	6.9	6.8	6.5	6.3	6	5.5	5.5	5.3	5.2	5.2	5.1	5.1	4.9	4.7	4.6
Mabel.Lake.Intake	Dissolved.Oxyger	13	8	2020	2020-08-13			103	103.1	103.1	103.5	103.3	106.4	106.1	106.1	102.7	94.1	92.6	91.4	89.8	89	88.2	87.9	87.8	87.5	87.6	87.4	87.3	87.1	86.8	86.7	86.6	86.4	86	85.8	85.8	85.6	84.9	84	83.5	82.9	82.4	81.8			
Mabel.Lake.Intake	Dissolved.Oxyger	10	6	2021	2021-06-10			101	100.7	100.7	100.6	100.1	98.3	98.3	97.1	96.3	95	94.8	94.6	94.5	93.4	93	92.8	92.4	92.1	92.1	92.1	91.9	91.7	91.6	91.3	90.9	90.9	89.8	89.4	88.7	87.2	86.9	86.6	86.1	85.9	85.8	85.4	84.7	84	83.7
Mabel.Lake.Intake	Dissolved.Oxyger	13	8	2020	2020-08-13			9.36	9.39	9.43	9.49	9.57	10.05	10.21	10.52	10.62	10.25	10.22	10.18	10.11	10.08	10.06	10.11	10.13	10.16	10.18	10.19	10.22	10.26	10.26	10.3	10.31	10.33	10.4	10.43	10.47	10.49	10.55	10.53	10.52	10.49	10.46	10.43			
Mabel.Lake.Intake	Dissolved.Oxyger	10	6	2021	2021-06-10			10.49	10.53	10.66	10.69	10.73	10.84	10.97	11.03	11.04	11	11.04	11.07	11.08	11.08	11.06	11.07	11.07	11.07	11.09	11.09	11.09	11.1	11.09	11.09	11.08	11.07	11.05	11.05	11.03	10.99	10.96	10.95	10.93	10.91	10.91	10.89	10.84	10.82	10.8
Mabel.Lake.Intake	Conductivity	13	8	2020	2020-08-13			97.4	97.1	97	96.6	97	94.3	93.9	96.9	92	93.2	92.6	91.5	92.8	94.1	95.1	95.8	96	96.6	96.7	97.2	98	99.7	99.1	100.7	101.3	101.8	104.1	105.4	107.1	106.8	108.8	108.9	109.4	109.6	110	110.1			
Mabel.Lake.Intake	Conductivity	10	6	2021	2021-06-10			93.3	92.8	93.5	93.5	95	96	97.5	98.7	102.4	102.6	102	100.9	101.3	104.8	105.1	105.4	105.8	106	106.8	106.6	106.7	106.4	107.3	106.6	107.3	107.1	107.9	108	108.7	109.4	109.3	110	109.9	110.4	110.5	110.8	112	112	111.9
Mabel.Lake.Intake	Conductivity.Adju	13	8	2020	2020-08-13			88.1	87.6	87.1	86.6	86	81.9	80	79.8	72.4	69.2	67.7	66.3	66.4	66.9	67.1	66.9	66.8	66.7	66.7	66.7	67	67.7	67	67.8	68	68	68.7	69	69.9	69.3	69.5	68.7	68.6	68.5	68.3	68.2			
Mabel.Lake.Intake	Conductivity.Adju	10	6	2021	2021-06-10			73	72.1	71.6	71.4	71.8	70.3	70.4	69.8	71.7	71.1	70.2	69.1	69.2	70.7	70.5	70.6	70.5	70.3	70.7	70.6	70.4	70	70.6	69.9	70.1	69.9	69.7	69.4	69.2	68.7	68.5	68.7	68.4	68.6	68.5	68.6	69	68.5	68.3
Mabel.Lake.Intake	TDS	13	8	2020	2020-08-13			63	63	63	63	63	61	61	63	60	61	60	59	60	61	62	62	62	63	63	63	64	65	64	65	66	66	68	68	70	69	71	71	71	71	71	72			
Mabel.Lake.Intake	TDS	10	6	2021	2021-06-10			61	60	61	61	62	62	63	64	67	67	66	66	66	68	68	68	69	69	69	69	69	69	70	69	70	70	70	70	71	71	71	71	71	72	72	72	73	73	73
Mabel.Lake.Intake	Salinity	13	8	2020	2020-08-13			0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05			
Mabel.Lake.Intake	Salinity	10	6	2021	2021-06-10			0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

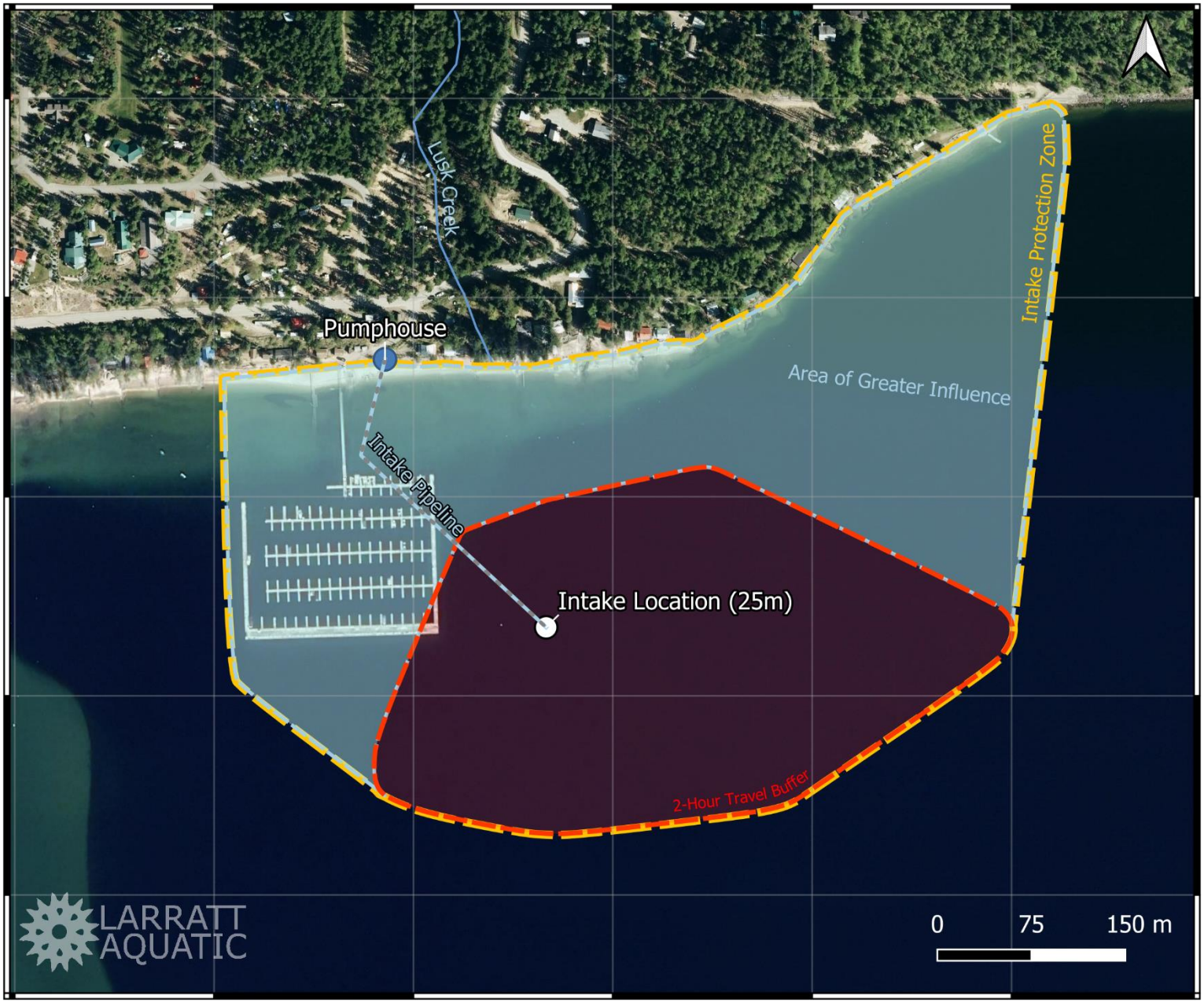
Appendix 3: Master Taxonomy Table

Sample.Type	Site	Date	Depth	Depth.Num	Diatoms	Yellow.Brown	Green	Cyanobacteria	Dinoflagellates	Other.Flagellates	Total.Cells
Whole	Mabel Lake at Intake	2020-08-13	Surface	0	250	340	60	0	0	10	660
Whole	Mabel Lake at Intake	2020-08-13	Deep	25	290	10	0	0	0	0	300
Tow	Mabel Lake at Intake	2020-08-13			7%	93%	0%	0%	0%	0%	100%
Whole	Mabel Lake at Intake	2021-06-10	Surface	0	440	20	150	275	10	60	955
Whole	Mabel Lake at Intake	2021-06-10	Deep	25	430	160	10	575	0	0	1175
Tow	Mabel Lake at Intake	2021-06-10			62%	38%	0%	0%	0%	0%	100%

Raw taxonomic data is available upon request.

Appendix 4: Intake Protection Zone Map for Information Distribution

The following simplified version of the Intake Protection Zone map has been created as a potential educational tool for working with stakeholders.



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