Key River Fish Habitat Assessment

Executive Summary

The Eastern Georgian Bay Stewardship Council (EGBSC) received funding from Environment and Climate Change Canada to carry out a 32-month project to assess spawning, nursery, rearing, and foraging habitat in eight tributaries to eastern Georgian Bay, which included the Key River. Fish habitat assessments were focused on Walleye, Lake Sturgeon, and Sucker species, between the river mouths and the first major spawning area or barrier to fish passage.

Spawning bed enhancement work was completed at Ludgate and Portage Lake Outlet in fall 2015. Follow-up monitoring was completed in 2016 and a more detailed habitat assessment was carried out in 2017. During the 2017 spawning season, EGBSC visited Ludgate and Portage Lake Outlet seventeen (17) times between April 18 and June 20. Basic water chemistry measurements (water temperature, dissolved oxygen, pH, conductivity) were recorded on all site visits and were generally within the expected range for Canadian Shield waters.

Three stations were set up at Ludgate and four at Portage Lake Outlet to measure water velocity and water level fluctuations. All but one of the velocity measurements was under 2.0 m/s, and would likely not limit Walleye, Sucker, or Lake Sturgeon movement. Fish should be able to easily move throughout and past Ludgate, up to Portage Lake Outlet. It is unknown whether the rapids at Portage Lake Outlet serve as a barrier to fish passage further upstream.

Water levels at both sites fluctuated throughout the spawning and egg incubation periods. Despite this, the newly created habitat at both sites was observed to be functioning as intended with sufficient water depth over the habitat. A small amount of egg stranding was observed at Ludgate, however, upstream of the newly created habitat.

Fish observations were limited to two Walleye seen at Portage Lake Outlet during a regular site visit. No night surveys were conducted on the Key River in 2017. Based on egg mat deposition, it appears that Sucker either do not use these spawning beds, or do so in very small numbers. This is to be expected given the lack of finer substrate (i.e., sand, gravel) at the spawning beds. In terms of Walleye egg deposition, a total of 1,810 Walleye eggs were deposited on egg mats at Ludgate and 7,017 at Portage Lake Outlet. No signs of Lake Sturgeon were seen in the Key River.

Plankton samples were taken during the time when fry would likely be hatching. These composite samples were visually compared to samples collected from the other tributaries being assessed in 2017 – Naiscoot River and Pickerel River. The Key River downstream of the spawning beds was considered to have good plankton production.

In the fall of 2017, EGBSC was unable to measure transects across the spawning beds. Instead, a qualitative approach was taken in which the substrate that could be seen from the banks was described. As expected, most of the areas outlined as having suitable spawning substrate correspond with the areas where river rock was placed as part of EGBSC's 2015 spawning bed enhancement work.

To assess nursery, rearing, and foraging habitat available downstream of the spawning beds, ten (10) underwater surveys were conducted. Bathymetry, side scan sonar data, and aerial photography were also collected. Based on these surveys, there appeared to be some diversity in substrate in the

nearshore area including bedrock, cobble, sand, clay, and silt. Bedrock and clay were present most often in the surveys. Density of aquatic vegetation ranged from absent to abundant. Areas with no vegetation or sparse vegetation could potentially provide habitat for different life stages than areas with moderate to abundant vegetation. Only two of the ten (10) surveys had any wood structure to provide habitat and cover for fish. Overall, the shoreline of the Key River downstream of the spawning beds to the river's outlet into Georgian Bay is largely natural (88% natural, 12% altered). Some of the observed alterations included train and highway bridges, marinas, mown grass close to the shoreline, and docks.

Overall, EGBSC's assessment confirmed that the created habitat at Ludgate and Portage Lake Outlet are functioning as intended. Walleye are continuing to spawn at these sites, although in low numbers. EGBSC recommends further monitoring during the spawning and egg incubation periods on a three to five year basis, as results from restoration efforts take several years to be fully realized. It would be beneficial to re-visit Ludgate and Portage Lake Outlet in a year with low Georgian Bay water levels to assess accessibility of the spawning beds and degree of egg stranding. EGBSC also recommends further, detailed analysis of the side scan sonar data to supplement the observations from underwater surveys. EGBSC does not recommend any habitat restoration at these sites.

Table of Contents

Project Overview and Methodologies

In 2015, the Eastern Georgian Bay Stewardship Council (EGBSC) received funding from Environment and Climate Change Canada to carry out a 32-month project to assess spawning, nursery, rearing, and foraging habitat in eight tributaries to eastern Georgian Bay, within the Parry Sound District. Lake Sturgeon, Walleye, and Sucker species have been experiencing varying levels of decline in parts of eastern Georgian Bay. Accordingly, fish habitat assessments were focused on these species with the goals of: (1) determining whether there is sufficient habitat available; and (2) identifying and prioritizing opportunities for restoration. Assessments were carried out between the river mouths and the first major spawning area or barrier to fish passage.

EGBSC formed a collaborative working group to aid in the development of a field protocol for data collection. This group consisted of:

- Arunas Liskauskas, Dave Gonder, Chris Davis, and Stephen James – Upper Great Lakes Management Unit, Ministry of Natural Resources and Forestry
- Scott Finucan – Ministry of Natural Resources and Forestry
- Greg Mayne – Environment and Climate Change Canada
- Karl Schiefer – Aquatic Biologist consultant and EGBSC member
- David Bywater – Environmental Scientist, Georgian Bay Biosphere Reserve
- David Sweetnam – Executive Director, Georgian Bay Forever

Two main protocols were considered for this project. The first was the Ontario Stream Assessment Protocol (OSAP), which is a standardized method of measuring and collecting field data in the province of Ontario. This protocol is applicable to wadeable streams. The rivers being considered in this project were non-wadeable. Nevertheless, components of the OSAP protocol were used when assessing spawning beds in late summer and fall.

The other protocol considered for tributary classification was the Rosgen Classification system. This protocol is often used in stream restoration projects. However, the Rosgen Classification system was designed based on U.S. rivers and may not be appropriate for central Ontario rivers. Consequently, the Rosgen Classification was not used.

EGBSC completed broad habitat surveys on each river – Shebeshekong, Seguin, Magnetawan, Shawanaga, Key, Pickerel, Naiscoot, Sucker Creek – to record the location and evaluate the amount and quality of habitat available. During assessments, EGBSC also considered whether there were habitat limitations from human or natural stressors and identified any potential restoration opportunities.

As part of the broad habitat assessments, the following information was collected on each river:

- Basic water quality parameters (pH, conductivity, dissolved oxygen)
- Water temperature
- Water velocity
- Water level fluctuations
- Aerial photographs
- Underwater photographs and videos

- Substrate type
- General size of habitat
- Accessibility of spawning areas during different flow regimes
- Potential limitations or indicators of stress
- Opportunity for restoration

For the assessments, EGBSC used a combination of methods to collect data and brought in standardized protocols where possible. The project advisory team helped guide the technical aspects of this project to ensure the data collected was not only valuable but useable for other work and reports.

To collect high quality imagery of the sites, EGBSC purchased and used a DJI Phantom 3 Advanced quadcopter.

Three software programs were used as part of this project. Pix4D was used to create orthomosaics from the drone photography. Reefmaster was used to map bathymetry and side scan sonar data that was collected using a Lowrance unit. Finally, QGIS 2.18 was used for mapping.

In addition to gathering field data, EGBSC also collected background information and local knowledge when possible. The information that can be shared is provided in the Background Information section.

Background Information

The Key River is situated north of the Magnetawan River and south of the Pickerel and French Rivers (Figure 1). The Key River falls within the Henvey Inlet-Key River quaternary watershed draining an area of 197 km^2 (Figure 2). The river and its watershed are situated in the ancestral and traditional territory of the Anishinabek people.

Figure 1. Location of the Key River in relation to Parry Sound and Pointe au Baril

Figure 2. Henvey Inlet-Key River quaternary watershed

There are two spawning areas located between the Key River outlet to Georgian Bay and Portage Lake. The lower spawning site (hereafter referred to as Ludgate) is situated approximately 15 km east of the Key River outlet, at the train bridge at Ludgate, immediately downstream of the Little Key River outlet. The upper spawning area (hereafter referred to as Portage Lake Outlet) is located approximately 820 m further upstream from Ludgate, at the outlet from Portage Lake (Figure 3).

The area immediately around the Ludgate spawning bed is owned by CN rail, the rest is a mix of private property and Henvey Inlet Reserve. The closest village to the spawning areas was Ludgate, now a ghost town. The village of Ludgate started as a small railway station to serve the lumber industry. At its peak, Ludgate was a small sawmill village that provided homes for loggers and railway workers. The town was eventually abandoned. In the 1900s, logs were floated down the Key River to Georgian Bay. Key Harbour was built at the mouth of the Key River in 1908 for the purpose of building a shipping facility and iron refineries. The iron refineries were never built, but the shipping facility operated between 1909 and 1916. It was re-opened in 1929, and a fishery was also created. In 1938, shipping stopped, but the fishery remained. Tourism inspired the building of small cottages and lodges in the late 1950s.

With the development of the railway, the outlet to Portage Lake was moved and a new channel constructed. Prior to development, the original outlet from Portage Lake contained abundant, high quality spawning habitat for Walleye and Lake Sturgeon. Spawning habitat in the new channel was not as extensive as the habitat in the old channel, or of as high quality. Overall, the new channel resulted in a loss of fish habitat (J. Smitka, personal communication, 2014).

Figure 3. Location of Ludgate and Portage Lake Outlet spawning beds

The Ministry of Natural Resources and Forestry's (MNRF) Upper Great Lakes Management Unit (UGLMU) assessed Walleye populations in the Key River in 1985 and 1998. Although it is difficult to suggest any trend-through-time data from two years of monitoring, differences between the results from the two years suggested that the Key River stock was severely stressed. In addition, genetic diversity in the Key River stock was lower than in tributaries farther north (A. Liskauskas, personal communication, 2014). A stock with higher genetic diversity may be more resilient to stressors and environmental changes.

Historic and more recent observations of the Key River spawning areas revealed that lower water levels in Georgian Bay interfered with the success of Walleye spawning at Portage Lake Outlet (J. Smitka, personal communication, 2014) which is the preferred spawning area (Henvey Inlet First Nation, personal communication, 2015). Portage Lake Outlet contains the most suitable Walleye spawning habitat, and habitat at the lower site is quite limited (J. Smitka, personal communication, 2014). Jerry Smitka, Key River Area Association (KRAA) member and retired Ontario Ministry of Natural Resources fisheries biologist, has been visually monitoring the Key River site for many years. He has observed a steady decline in the number of Walleye spawning at the site and a decline in the number of eggs deposited.

In 2003, Jerry Smitka and volunteers created appropriately sized substrate in the Portage Lake outlet by blasting and reconfiguring the north channel to create riffles and pools that would help fish advance farther up the Portage Lake outlet and add additional spawning habitat. Although the restoration in 2003 helped to create additional habitat and improve spawning, it was concluded that smaller rock material was needed to allow fish access to the entire channel (J. Smitka, personal communication, 2016).

In September 2014, EGBSC partnered with the KRAA and the UGLMU and submitted a project proposal to Environment Canada's Lake Simcoe/South-eastern Georgian Bay Clean-Up Fund and the MNRF's Land Stewardship and Habitat Restoration Fund to carry out a restoration project at Portage Lake Outlet and Ludgate. The project idea was supported by other organizations, communities, and agencies including: French River Delta Association; Henvey Inlet First Nation; Georgian Bay Association; Municipality of Killarney; MNRF Parry Sound District; Patricia Chow-Fraser, Professor, McMaster University; and Charles McKinney, Technical Assistant.

The restoration goals for the Key River project were to:

- Increase the amount of spawning area available and improve the quality of habitat
- Vary depths of rock placement to help ensure an adequate level of water over the spawning beds throughout Walleye spawning and egg incubation
- Make a positive contribution towards a well-balanced and productive fish community and aquatic ecosystem
- Promote a healthy and naturally sustainable Walleye population

Project construction took place in fall 2015. River rock between 6 cm and 25 cm was barged to the spawning beds and placed using a small excavator. The rock was placed at a variety of depths to try and ensure that some amount of spawning habitat would be available during a variety of water levels. Large boulders were used in specific locations to help influence flow direction, the speed of water flow, and to create resting areas (Figures 4 and 5).

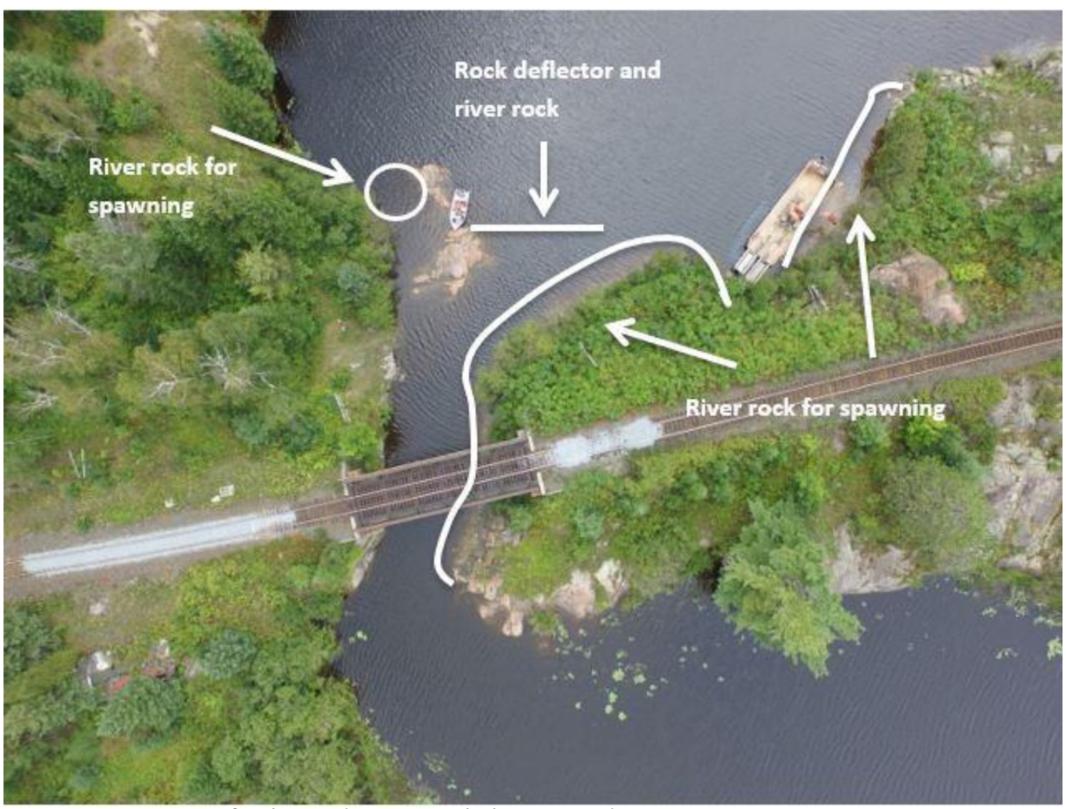


Figure 4. Locations of enhanced spawning habitat at Ludgate

Figure 5. Location of enhanced spawning habitat at Portage Lake Outlet

A total of 400 m^2 of new habitat was created between the two sites – 250 m^2 at Ludgate and 150 m^2 at Portage Lake Outlet.

EGBSC has monitored Ludgate and Portage Lake Outlet each spring since the restoration work and has confirmed that the created habitat is functioning as designed.

Spring Spawning Assessments

In 2017, EGBSC began spring field work on the Key River on April 18 and ended on June 20. During this period, both spawning beds (Ludgate and Portage Lake Outlet) were visited seventeen (17) times, approximately every three to four days, whenever possible. Towards the end of the Walleye and Sucker spawning period (end of May, early June), site visits were less frequent.

Water Chemistry

A YSI PROPLUS metre was used to measure basic water quality parameters on each site visit – water temperature, dissolved oxygen, conductivity, and pH. These parameters were selected because of the influence they can have on fish and fish activity, and to see if the levels recorded indicated any potential issues.

Water temperature is extremely important to fish. Aside from water velocity, water temperature is the main stimulus for spawning. For Walleye, spawning males begin to move towards spawning areas when water temperatures reach 2 to 5˚C. Spawning takes place through a variety of temperatures, but peak spawning typically occurs at 7 to 8˚C (Kerr et al., 1997). Conversely, spawning activity typically ceases once water temperatures reach 10 to 11˚C (Kerr et al., 1997). For Sucker species, spawning takes place between 10 and 16˚C (Hasnain et al., 2010). For Lake Sturgeon, main spawning activity occurs between 13 and 18˚C (Scott & Crossman, 1998). Water temperature also influences the speed and success of egg incubation. Optimal water temperature for egg incubation is 12.2˚C for Walleye, 14.5 ˚C for Lake Sturgeon, 15˚C for White Sucker, and 12.5˚C for Longnose Sucker (Hasnain et al., 2010).

Fish require dissolved oxygen to breathe. Fast flowing, cold water has higher dissolved oxygen concentrations than slow moving, warm water. Cold water can hold more oxygen as it rolls through rapids, which incorporates air from the atmosphere into the water. Dissolved oxygen is typically highest in early spring and declines as water temperatures increase and velocity slows.

The pH of water refers to how alkaline or acidic the water is, and is ranked on a scale of 0 to 14. pH will influence how soluble and available nutrients and heavy metals are in a system. pH can also influence fish health and reproductive success. In general, Walleye do best in waterbodies with a pH ranging between 6.0 and 9.0. Reproductive success can be jeopardized at pH levels below 6.0.

Conductivity measures the ability of water to pass an electrical current and is influenced by geology. For example, a clay substrate will have a high conductivity because of a greater amount of ions in the water. Rivers within the Parry Sound District typically have low conductivity, but conductivity can be significantly affected by stormwater runoff, and a sudden increase or decrease can indicate issues in a waterbody.

For complete water chemistry data, refer to Appendix A.

Ludgate

As illustrated in Figure 6, water temperature at Ludgate increased from 6.3°C on April 18 to 21.0°C on June 20. Several small drops in temperature were observed, with the largest being a drop of 2.3°C from May 31 to June 5. The greatest number of Walleye eggs were found on egg mats at Ludgate between

April 22 and 25 when water temperatures were between roughly 8 to 10°C. Dissolved oxygen levels dropped from 12.00 mg/L at the start of the study period (April 18) to 8.10 mg/L at the end (June 20), fluctuating throughout that period. The highest level was recorded on May 2 (12.20 mg/L) and reached a low of 7.32 mg/L on June 5. All but one pH recorded at Ludgate was above 6.0. The highest pH was 7.58 on June 20 and the lowest pH recorded was 4.31 on May 2. EGBSC staff noted on the field sheet that the pH reading on the YSI was jumping up and down considerably on May 2 before finally settling on 4.31. It is possible that this reading does not reflect the true pH on that day. Aside from May 2, the pH readings are mildly acidic and typical for Canadian Shield watersheds.

Figure 6 illustrates changes in temperature, dissolved oxygen, and pH over the spawning and egg incubation periods. Overall, pH remained relatively stable, while temperature and dissolved oxygen followed a fairly typical pattern for spring.

Conductivity was also recorded between April 18 and June 20 (Figure 7). Conductivity measurements ranged from 35.5 uS/cm on May 22 to 68.9 uS/cm on June 20.

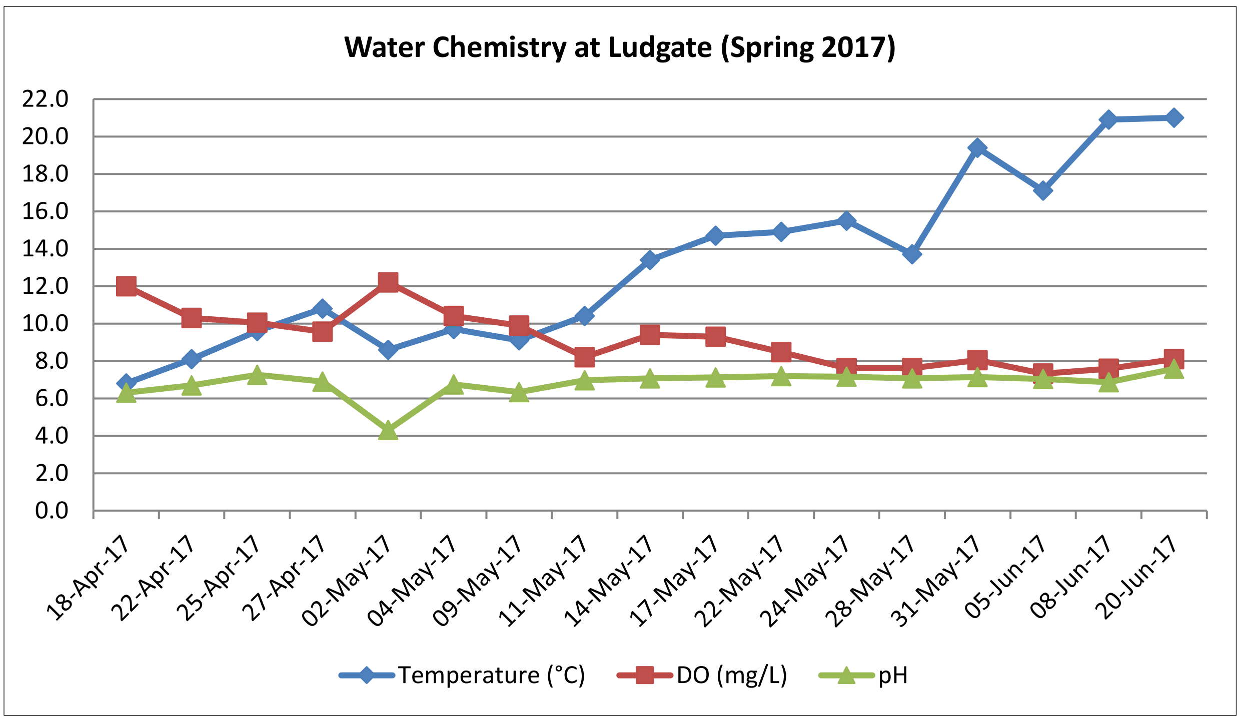


Figure 6. Water temperature (°C), dissolved oxygen (mg/L), and pH measurements taken at Ludgate in spring 2017

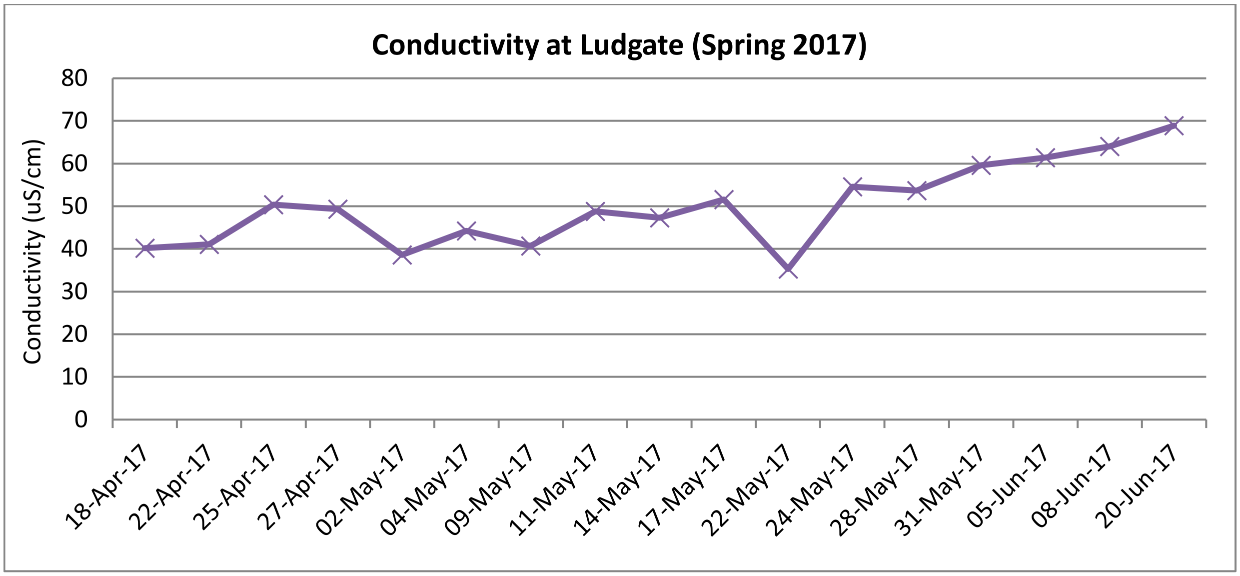


Figure 7. Conductivity measurements (uS/cm) taken at Ludgate in spring 2017

Portage Lake Outlet

Water temperature at Portage Lake Outlet increased from 6.7°C on April 18 to 20.9°C on June 20 (Figure 8). Similar to Ludgate, several small drops in temperature were observed with the largest being a drop from May 31 to June 5 (19.3°C to 17.5°C, a drop of 1.8°C). The greatest number of Walleye eggs were found on egg mats at Portage Lake Outlet between April 22 and 27 when water temperatures were between roughly 8 to 10°C. Dissolved oxygen levels dropped fairly consistently throughout the study period. The highest level was recorded on April 18 (12.53 mg/L) and the lowest level of 7.99 mg/L was recorded on June 5. All pH levels recorded at Portage Lake Outlet were above 6.0. The lowest pH was 6.15 on April 22. The highest pH recorded was 11.01 on May 2, the same day that the abnormally low pH was recorded at Ludgate. Aside from the May 2 reading, the pH readings are mildly acidic and typical for Canadian Shield watersheds.

Figure 8 illustrates changes in temperature, dissolved oxygen, and pH over the spawning and egg incubation periods. Overall, pH remained relatively stable, while temperature and dissolved oxygen followed a typical pattern for spring.

Conductivity was recorded between April 18 and June 20, and exhibited a fairly steady increasing trend. Measurements recorded at Portage Lake Outlet ranged from a low of 50.5 uS/cm on April 18 to a high of 82.7 uS/cm on June 20 (Figure 9).

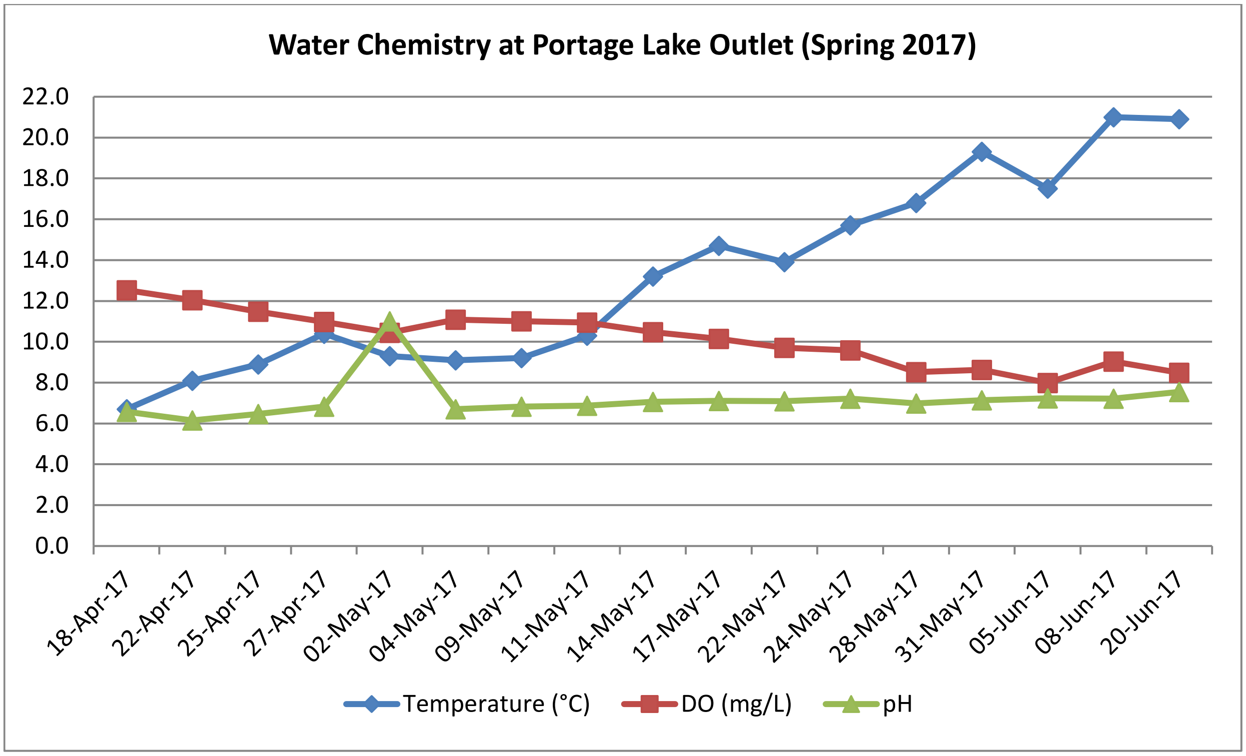


Figure 8. Water temperature (°C), dissolved oxygen (mg/L), and pH measurements taken at Portage Lake Outlet in spring 2017

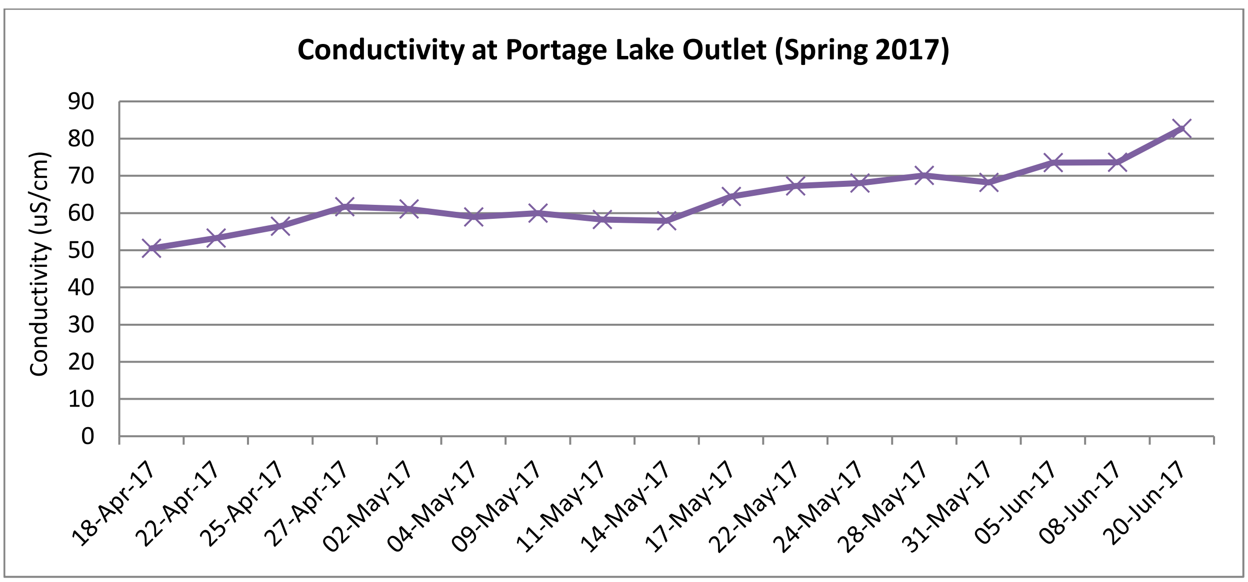


Figure 9. Conductivity measurements (uS/cm) taken at Portage Lake Outlet in spring 2017

Water Velocity

Water velocity has an influence on fish spawning. Species such as Walleye spawn in areas of fast-moving water, during the spring freshet. Walleye prefer velocities less than 2.0 m/s (Kerr et al., 1997). Lake

Sturgeon generally spawn in conditions with a minimum velocity of 0.5 m/s to a maximum of 1.5 m/s (Golder Associates Ltd., 2011), and White Sucker typically spawn in velocities ranging from 0.14 m/s to 0.9 m/s (Twomey et al., 1984). Water velocity is typically high during the spawning period and declines over time.

Water velocity was measured with a Marsh McBirney Flo-mate 2000 flow meter to investigate whether there were areas where the flow would be too fast for fish to swim through. Mean velocity was measured at 60% of the water depth.

Ludgate

Three stations were established at Ludgate to collect information on water velocity and water level fluctuations from April 18 to June 8 (Figure 10). Figure 11 displays velocity measurements recorded at stations 1 and 2.

Figure 10. Water velocity (1 and 2) and depth stations (3) at Ludgate

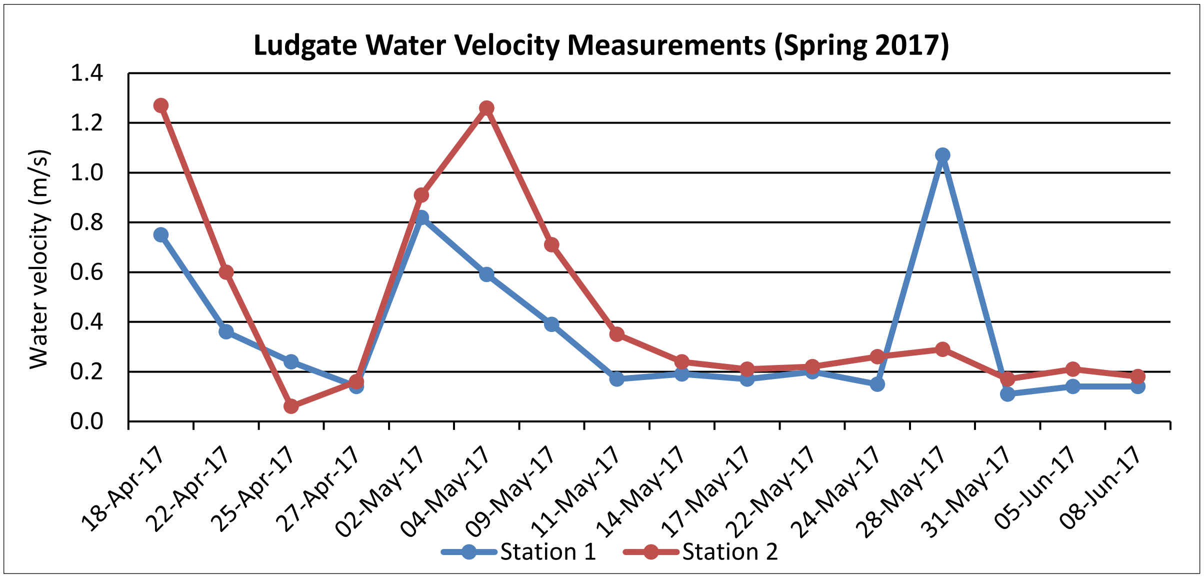


Figure 11. Water velocity measurements at Ludgate in spring 2017

At station 1, the highest velocity was 1.07 m/s on May 28. The lowest velocity was 0.11 m/s recorded on the next site visit on May 31. The highest velocity at station 2 was 1.27 m/s recorded on April 18 while the lowest was 0.06 m/s recorded two site visits later on April 25. None of the velocities recorded at either station would prevent fish from accessing or spawning at the site.

Portage Lake Outlet

Four stations were established at Portage Lake Outlet to collect information on water velocity and water level fluctuations from April 18 to June 20 (Figure 12). Velocity measurements recorded at all stations are displayed in Figure 13.

At station 1, the highest velocity recorded was 3.51 m/s on May 11 (highest overall velocity for both stations), the next highest velocity was 0.94 m/s on April 18. The lowest velocity recorded at station 1 was 0.17 m/s on April 25. The highest velocity recorded at station 2 was 1.92 m/s on May 9, while the lowest velocity recorded was 0.28 m/s on April 18. Only the May 11 velocity at station 1 would potentially prevent fish from accessing, or spawning at, the site.

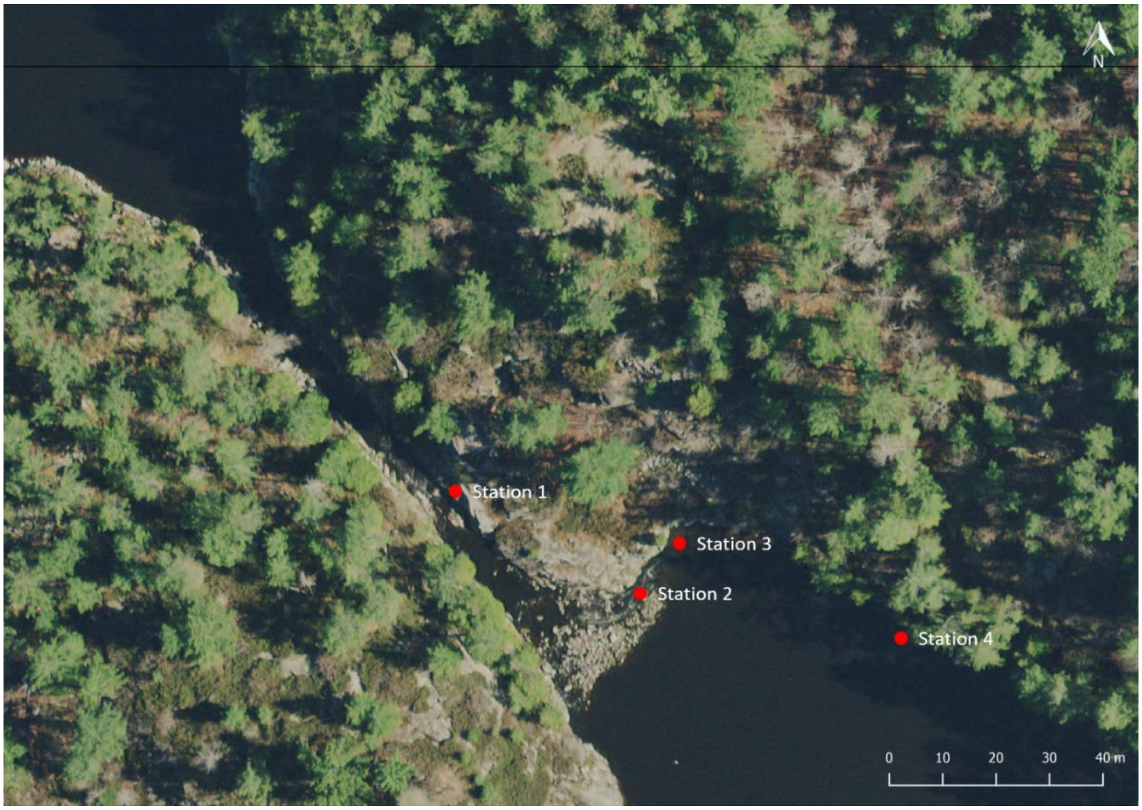


Figure 12. Water velocity (1 and 2) and depth stations (3 and 4) at Portage Lake Outlet

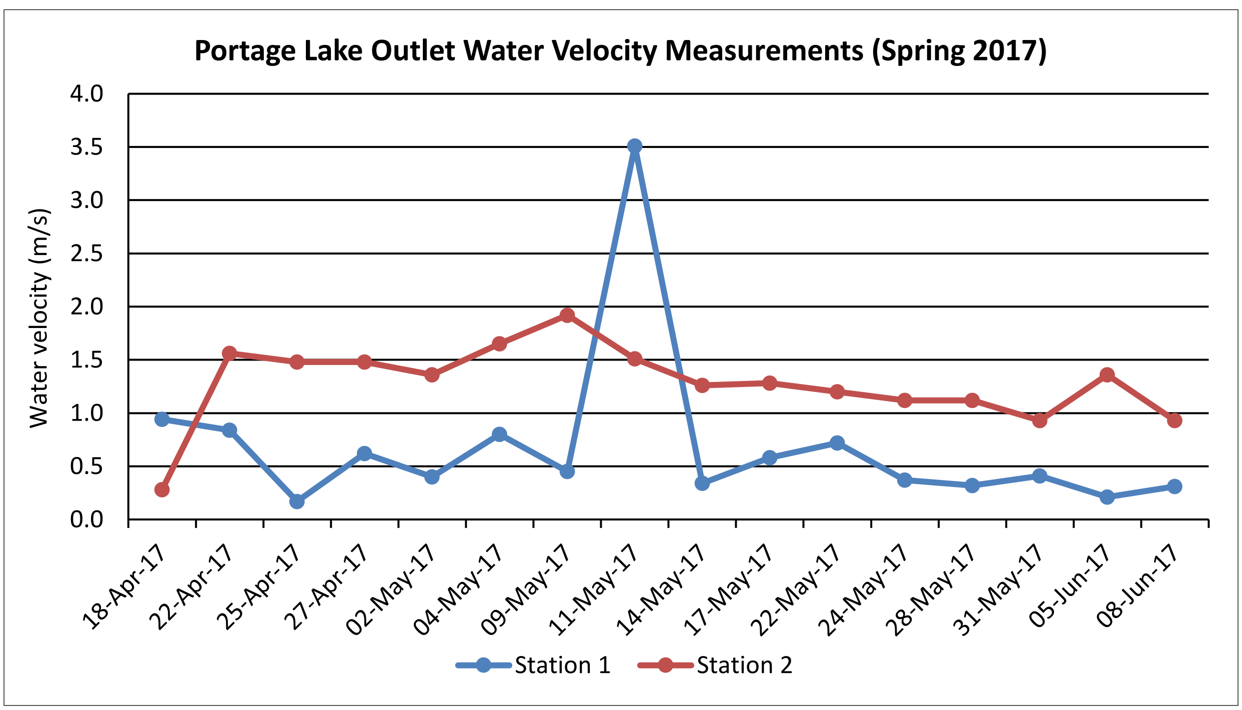


Figure 13. Water velocity measurements at Portage Lake Outlet in spring 2017

Water Level Fluctuations

Water levels were recorded at several stations (Figures 10 and 12) to understand how water levels change throughout spawning and egg incubation, and how they change along the spawning bed. Typically, when the spring freshet begins, water levels are high. Water levels subsequently decline over the following months. If water levels decline rapidly after the spawning period, deposited eggs may be left out of water and will not hatch.

Complete water level and velocity data can be found in Appendix B.

Ludgate

At Ludgate, water levels fluctuated greatly throughout the spawning and egg incubation periods. Figure 14 illustrates the changes in water level from April 18 to June 20. The water level station at Ludgate was very close to, or at, Georgian Bay water level and was therefore influenced by wind and seiche effects typical of eastern Georgian Bay.

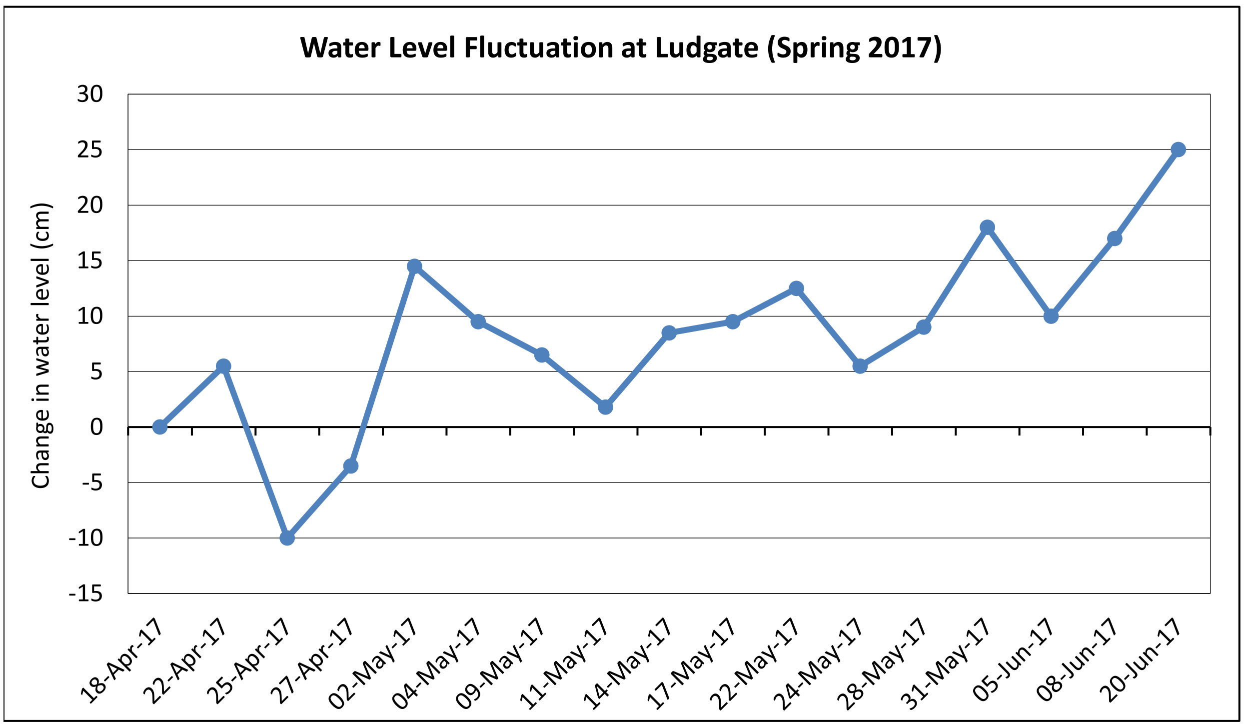


Figure 14. Water level fluctuations at Ludgate. Measurements on the first site visit served as the benchmark against which future measurements were compared (i.e., water level up or down compared to the first site visit).

Portage Lake Outlet

Similar to Ludgate, water levels at Portage Lake Outlet fluctuated a great deal between site visits throughout the spawning and egg incubation periods. Both stations followed a similar pattern of water level rise and decrease. Figure 15 illustrates the changes in water level from April 18 to June 20.

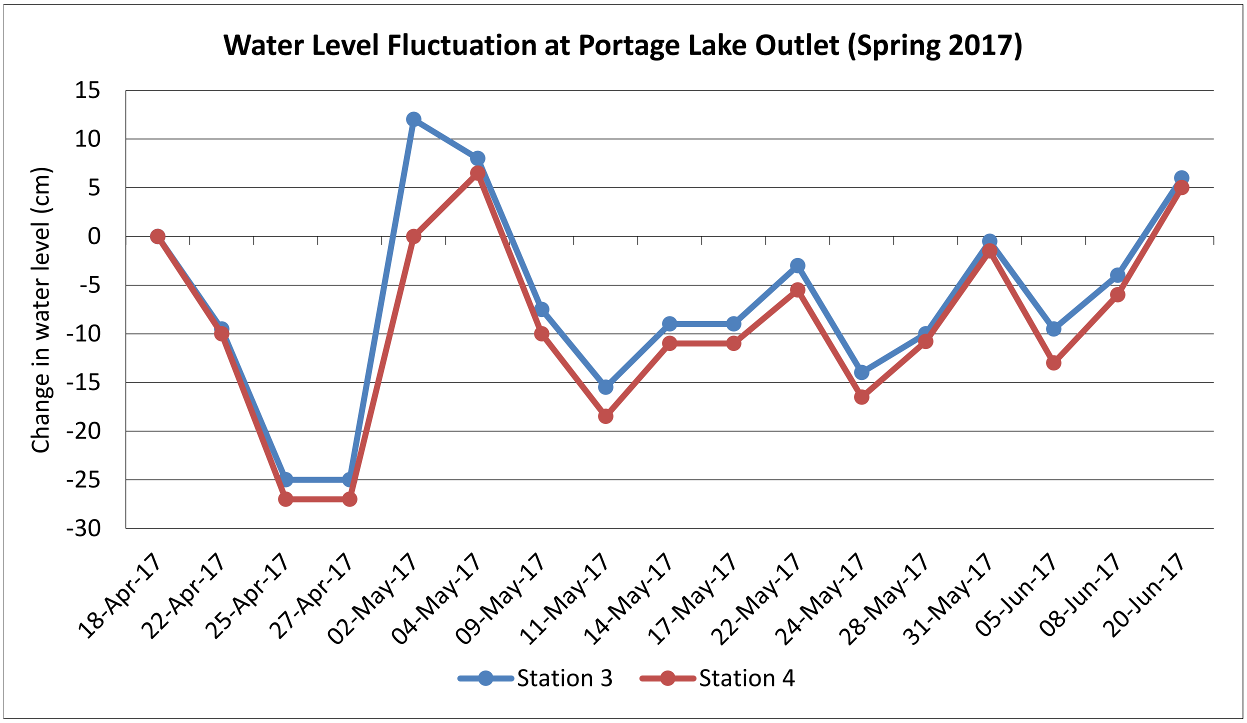


Figure 15. Water level fluctuations at Portage Lake Outlet measured at stations 3 and 4. Measurements on the first site visit served as the benchmark against which future measurements were compared (i.e., water level up or down compared to the first site visit).

Aerial Photographs

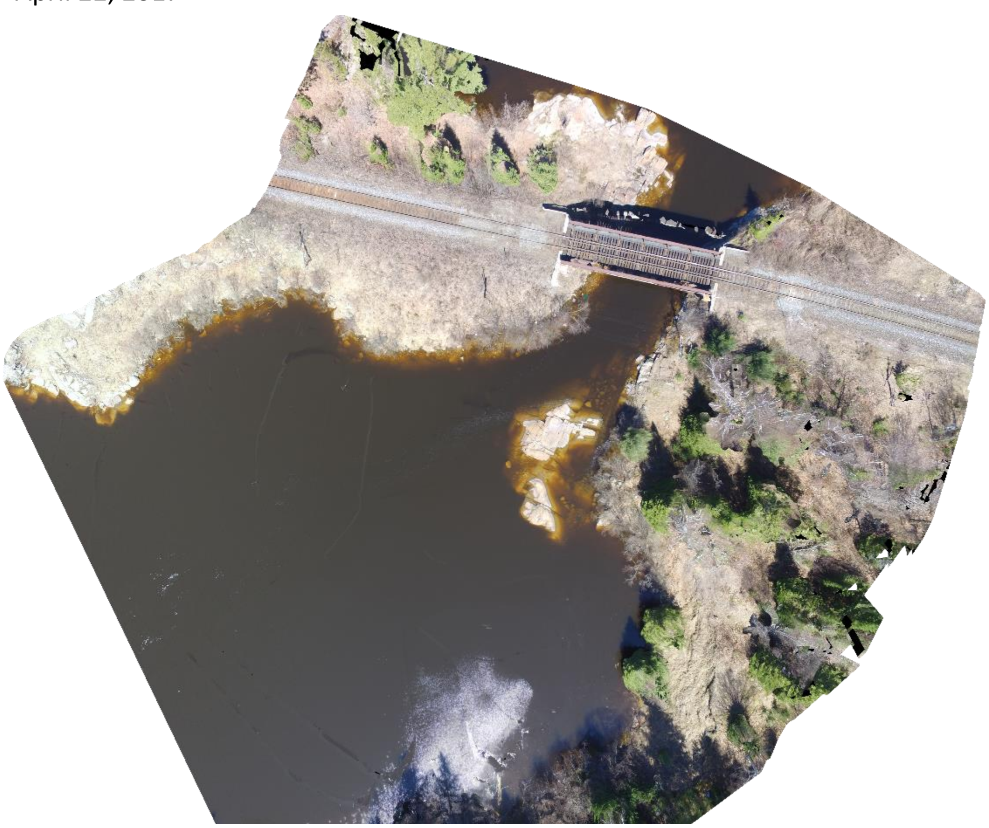
An important component of the spawning bed assessments was taking a series of drone photographs during the spawning and egg incubation period to help evaluate how the spawning area changed throughout the spring freshet. During each visit, weather permitting, EGBSC staff flew a drone to capture photos of the spawning bed. Multiple photos were taken during each flight and then stitched together using Pix4D software to create an orthomosaic showing the entire spawning bed for each visit.

The following orthomosaics illustrate changes in water levels at both spawning beds from April 18 to June 20. The images show that the created habitat remained underwater at both sites, which is crucial for successful egg incubation. A small number of eggs were observed stranded out of water at Ludgate, upstream of the train bridge and the created habitat. At Portage Lake Outlet, the middle of the lower end of the rapids, where the flow splits to the right and left banks, experienced a notable drop in water level leaving most of the rock out of water.

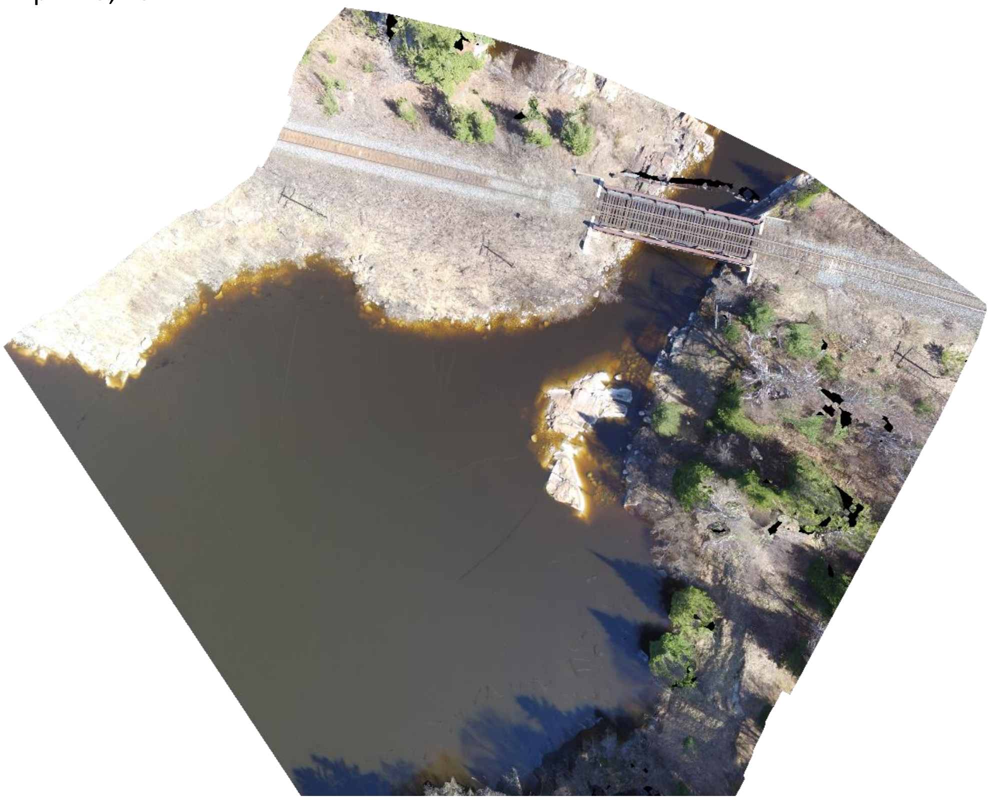
Ludgate

April 18, 2017

April 22, 2017

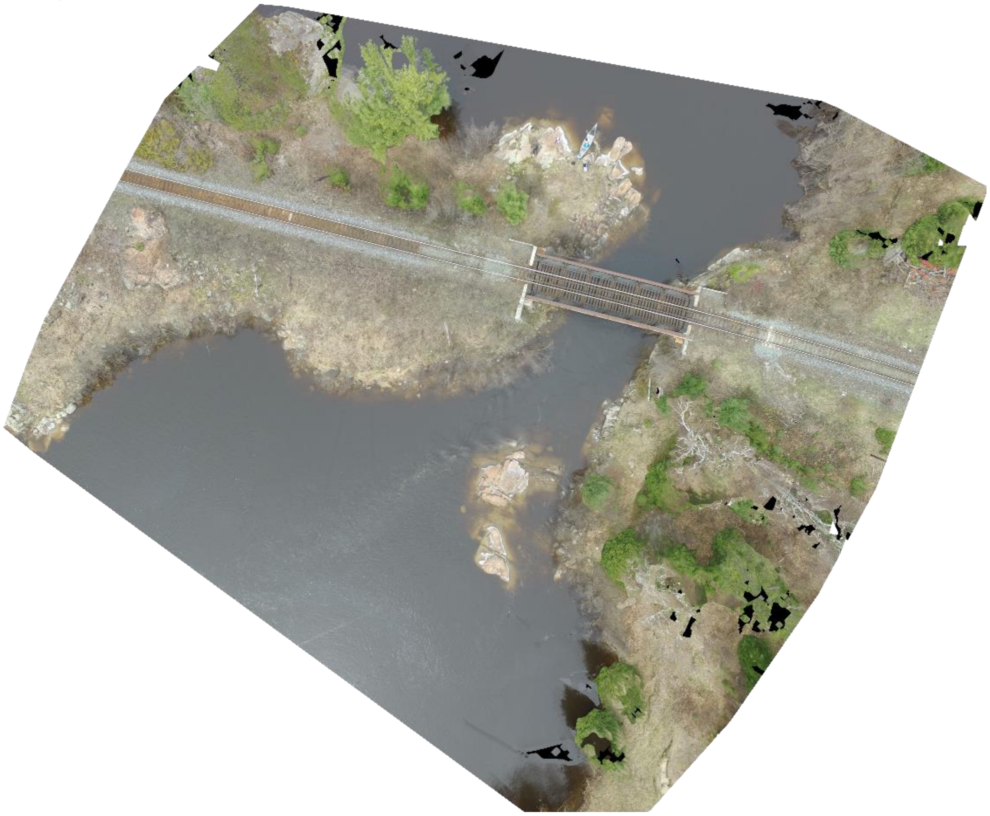


April 25, 2017

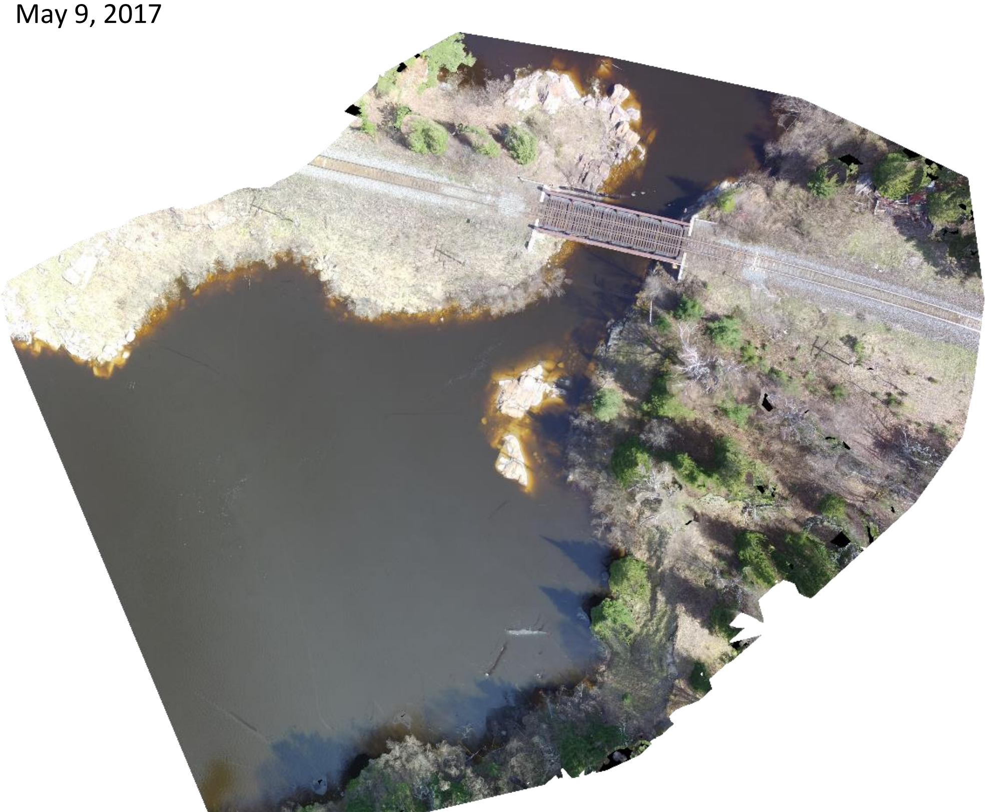


May 2, 2017 – unable to fly drone

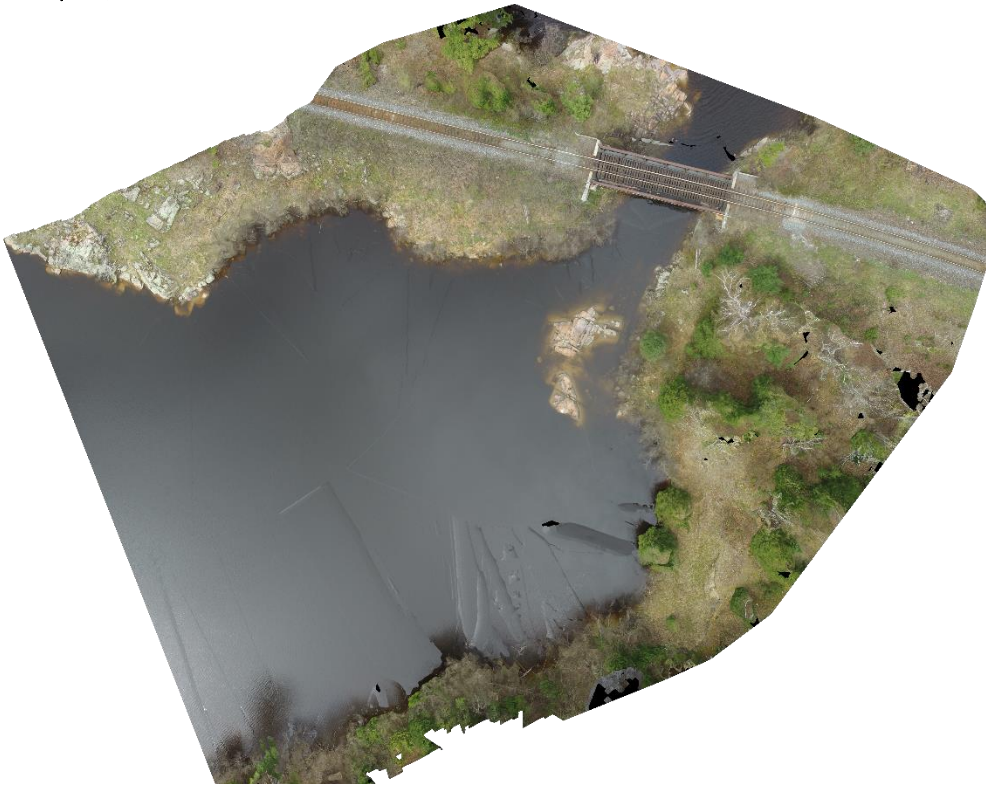
May 4, 2017



May 9, 2017



May 14, 2017



May 17, 2017

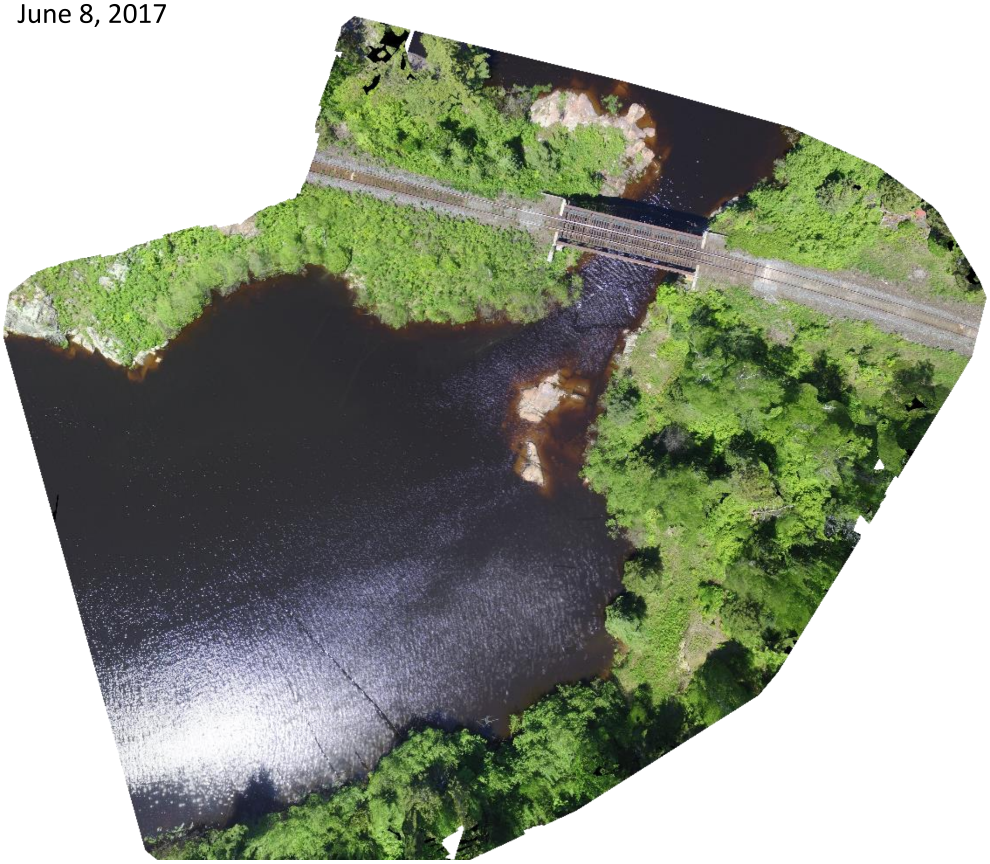
May 22, 2017

May 28, 2017

May 31, 2017 – unable to fly drone

June 5, 2017

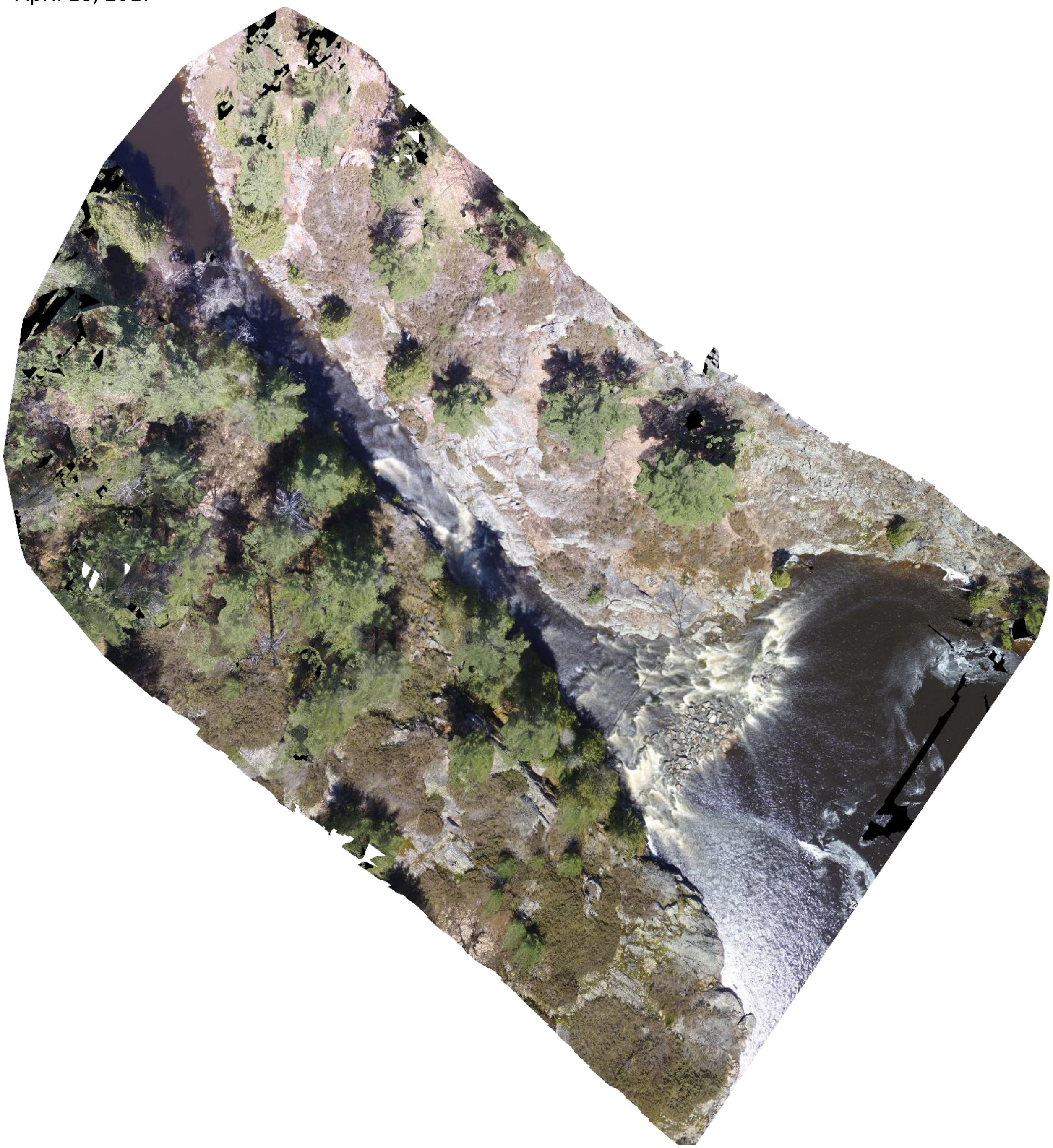
June 8, 2017



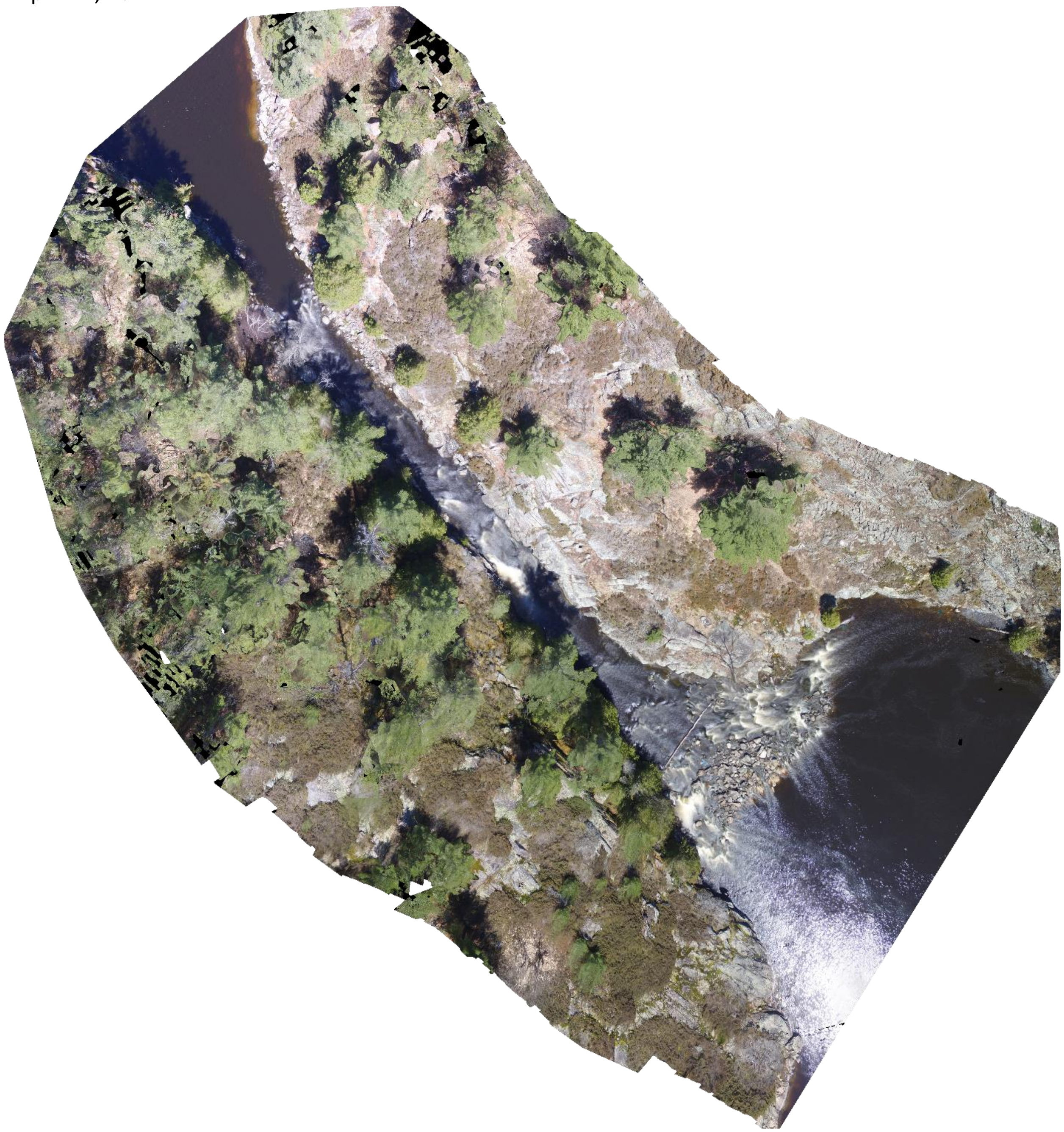
June 20, 2017

Portage Lake Outlet

April 18, 2017



April 22, 2017



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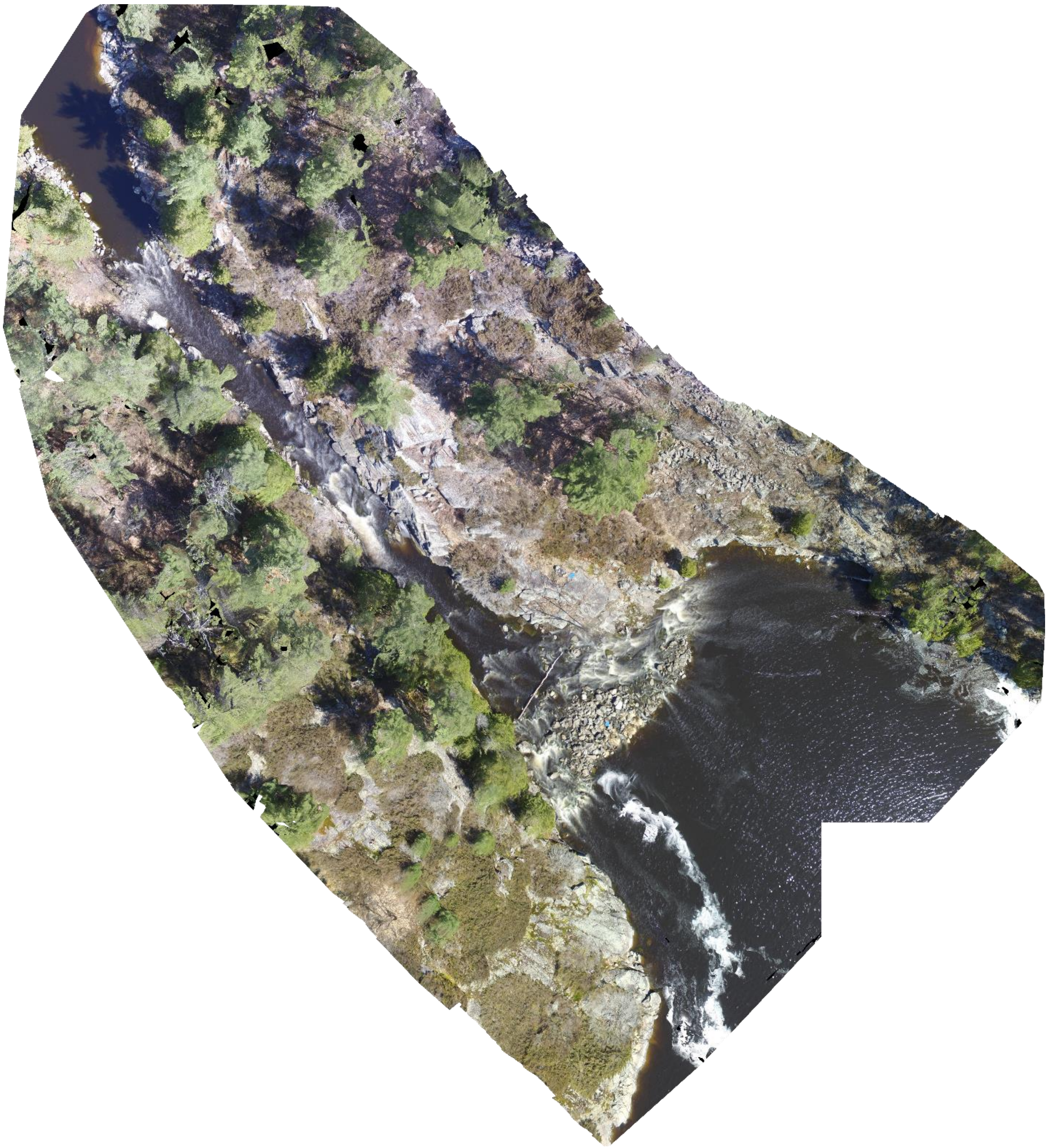
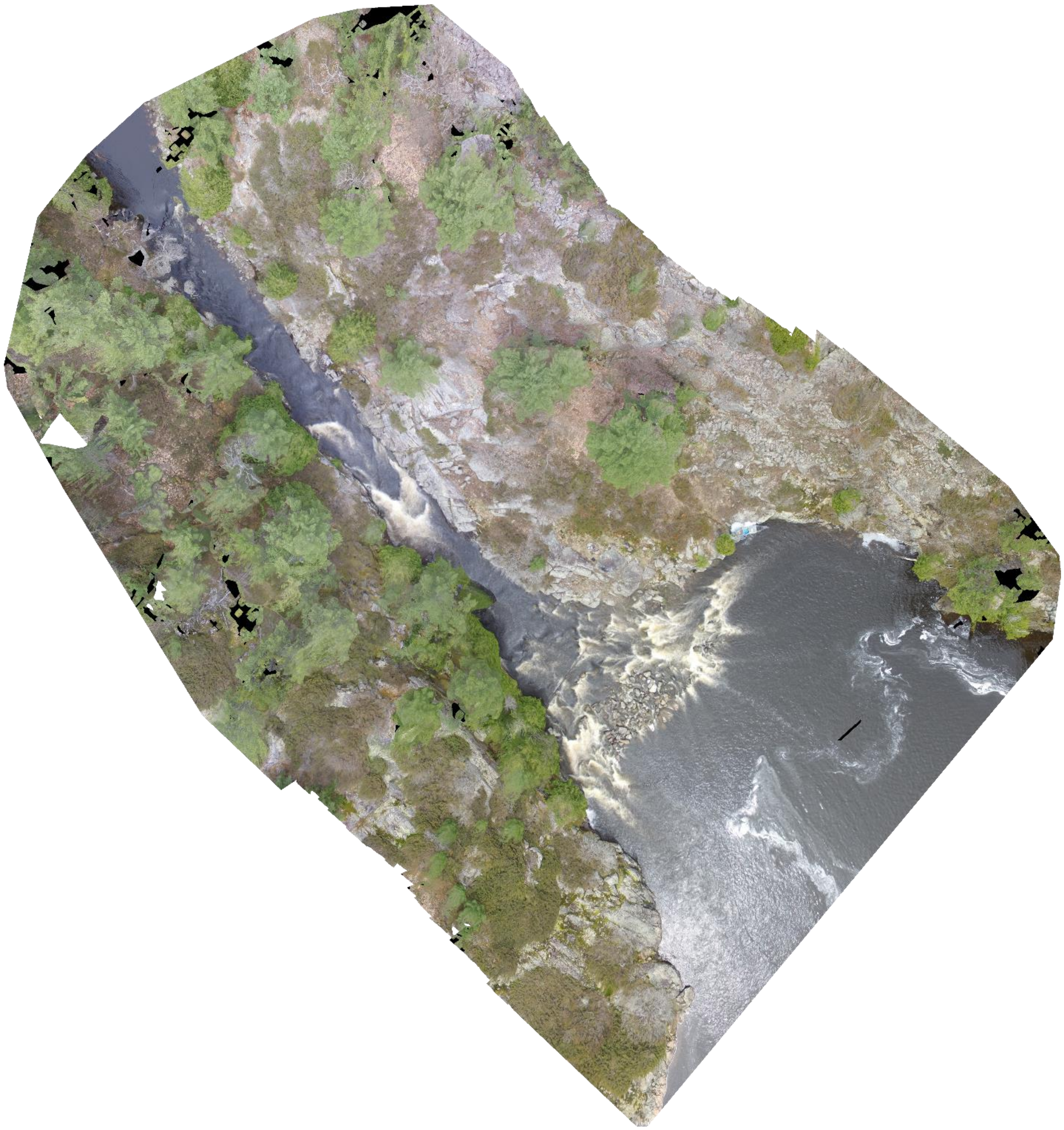
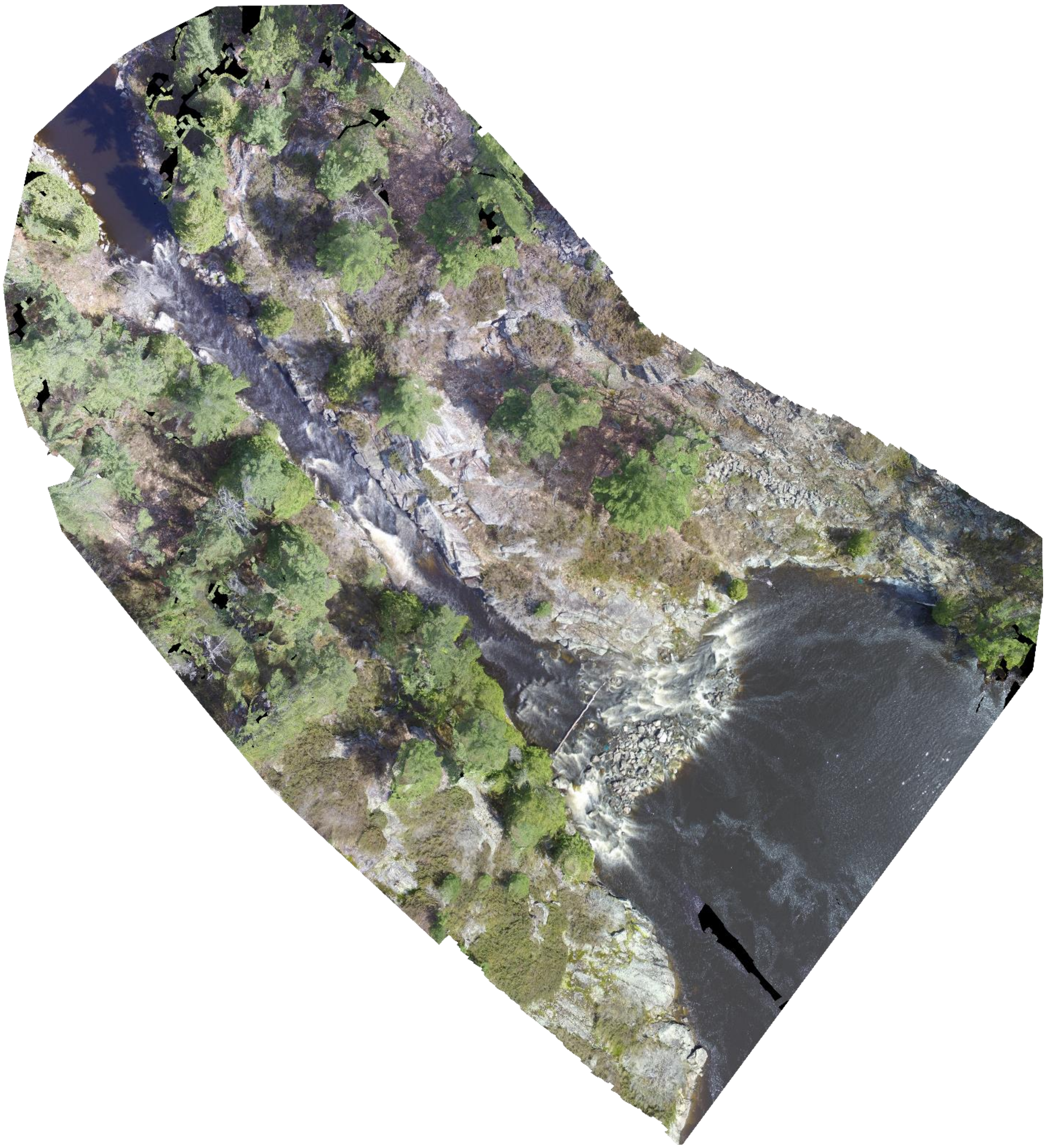


May 4, 2017



May 9, 2017



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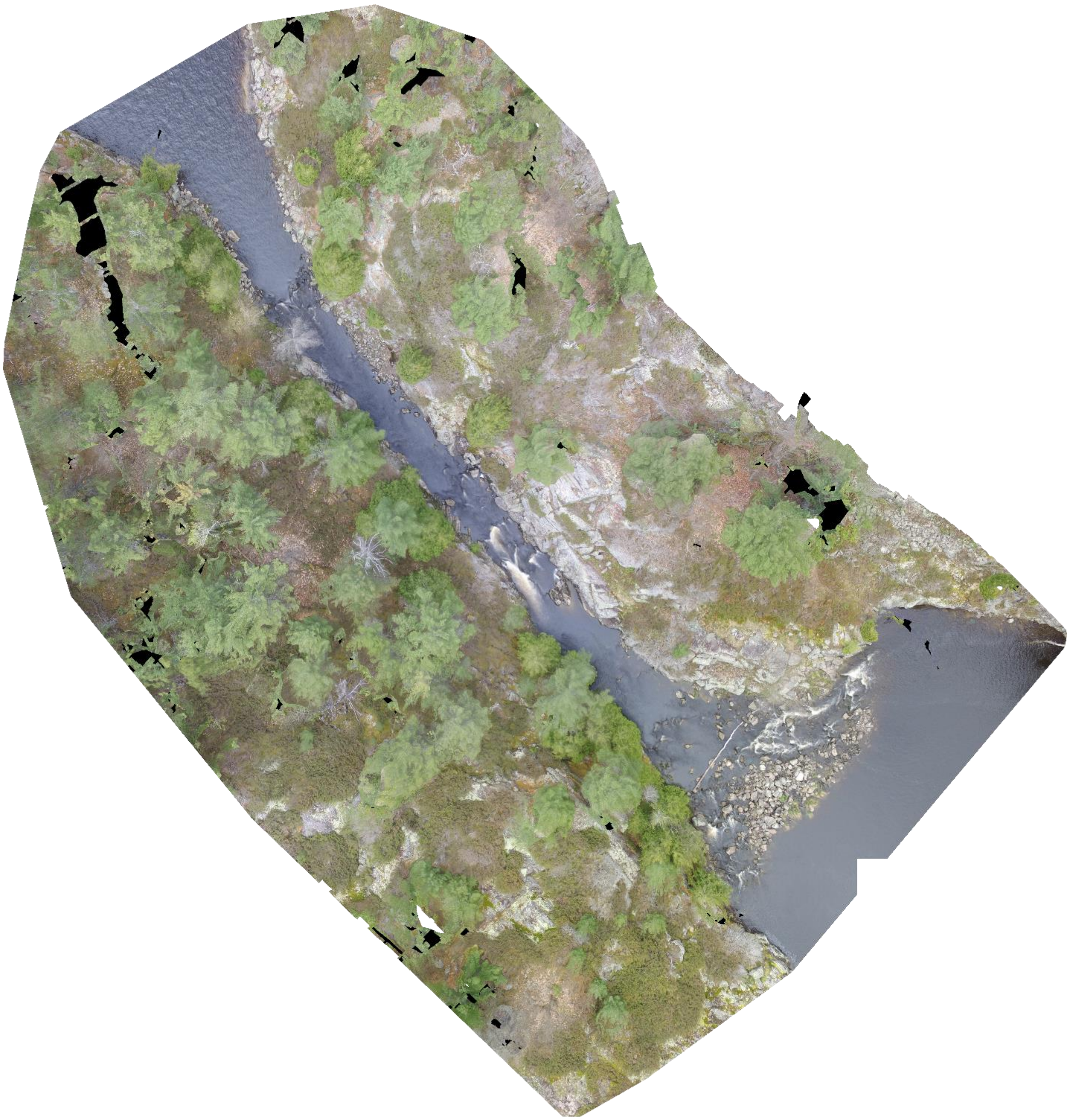

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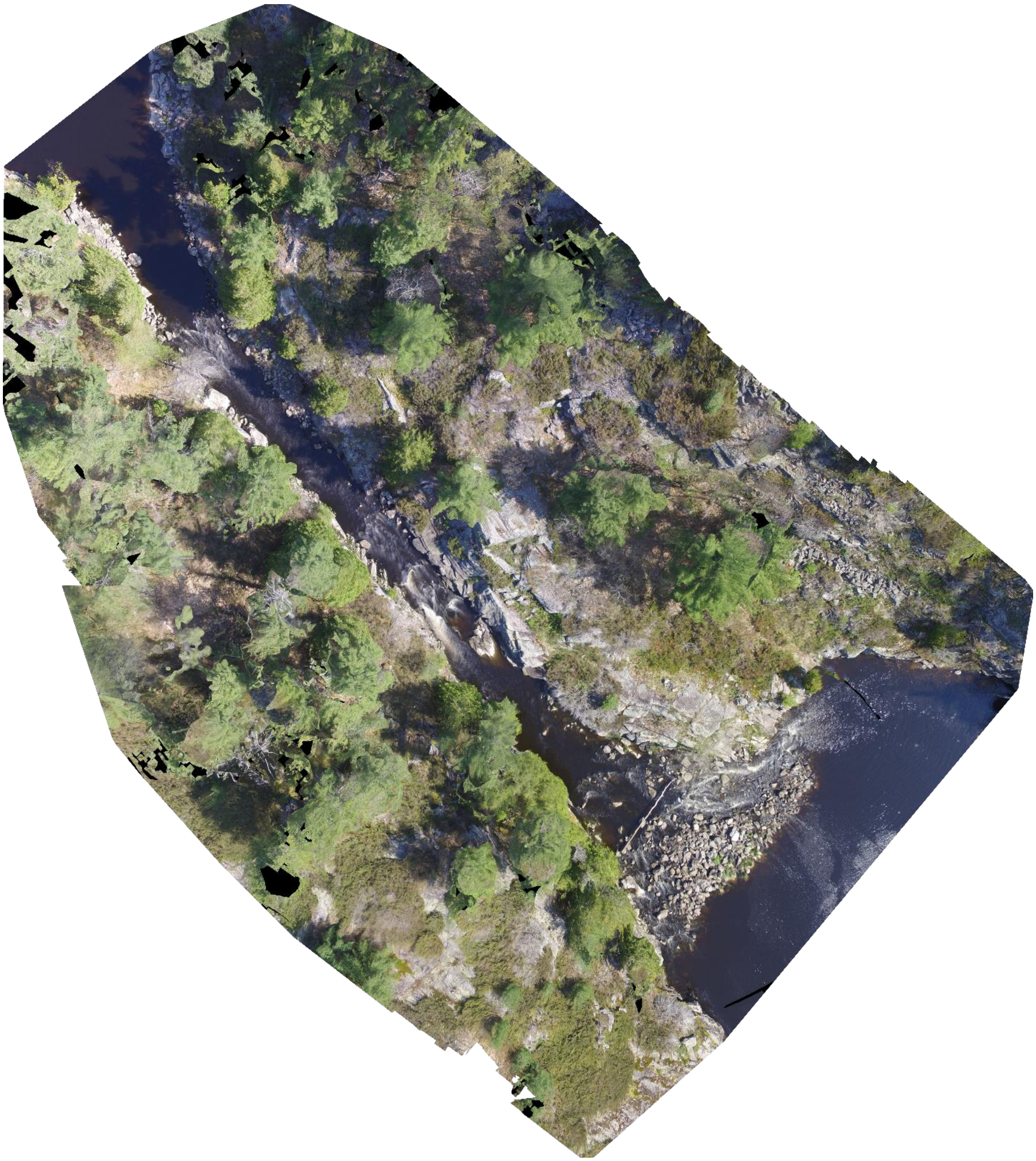

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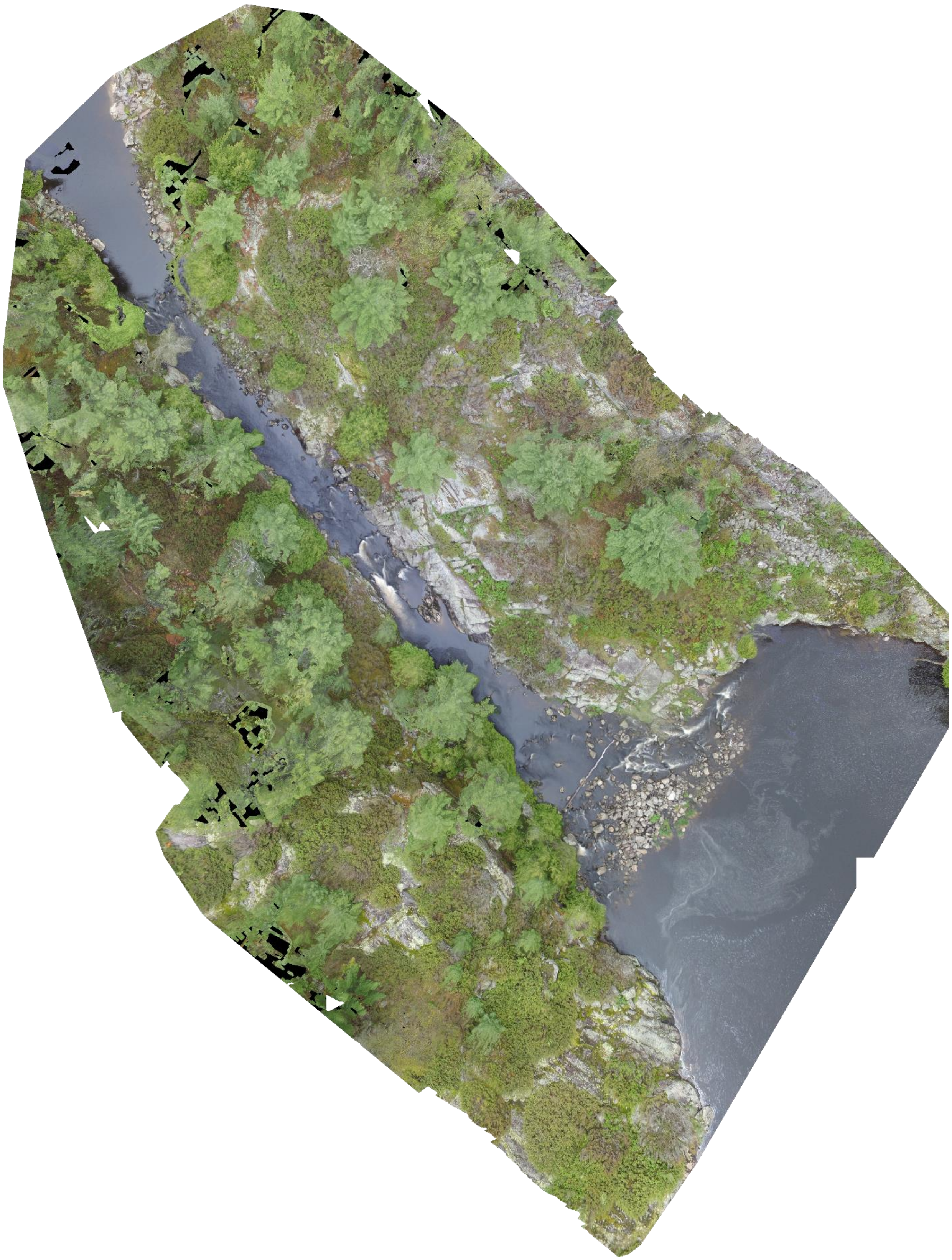

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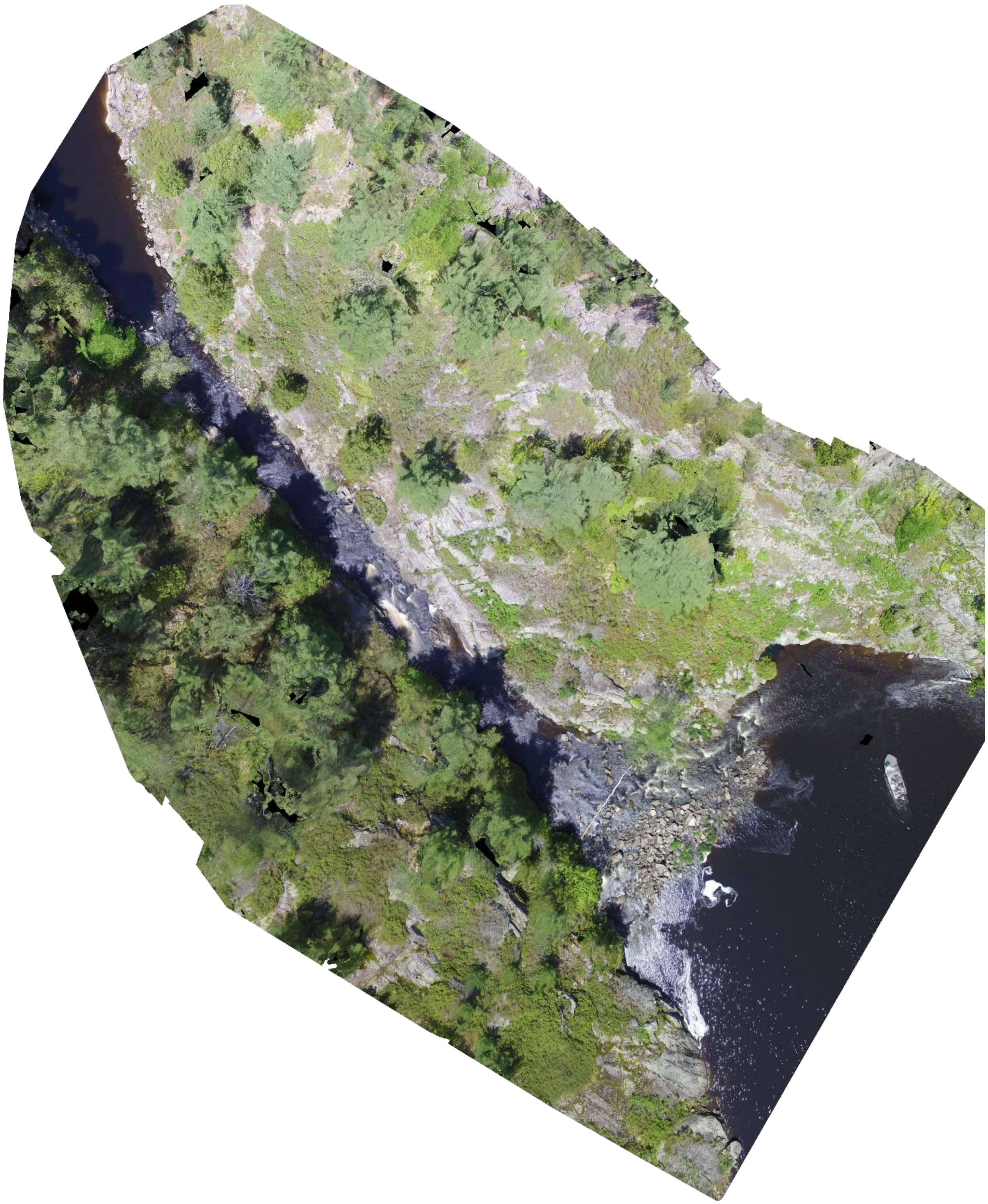
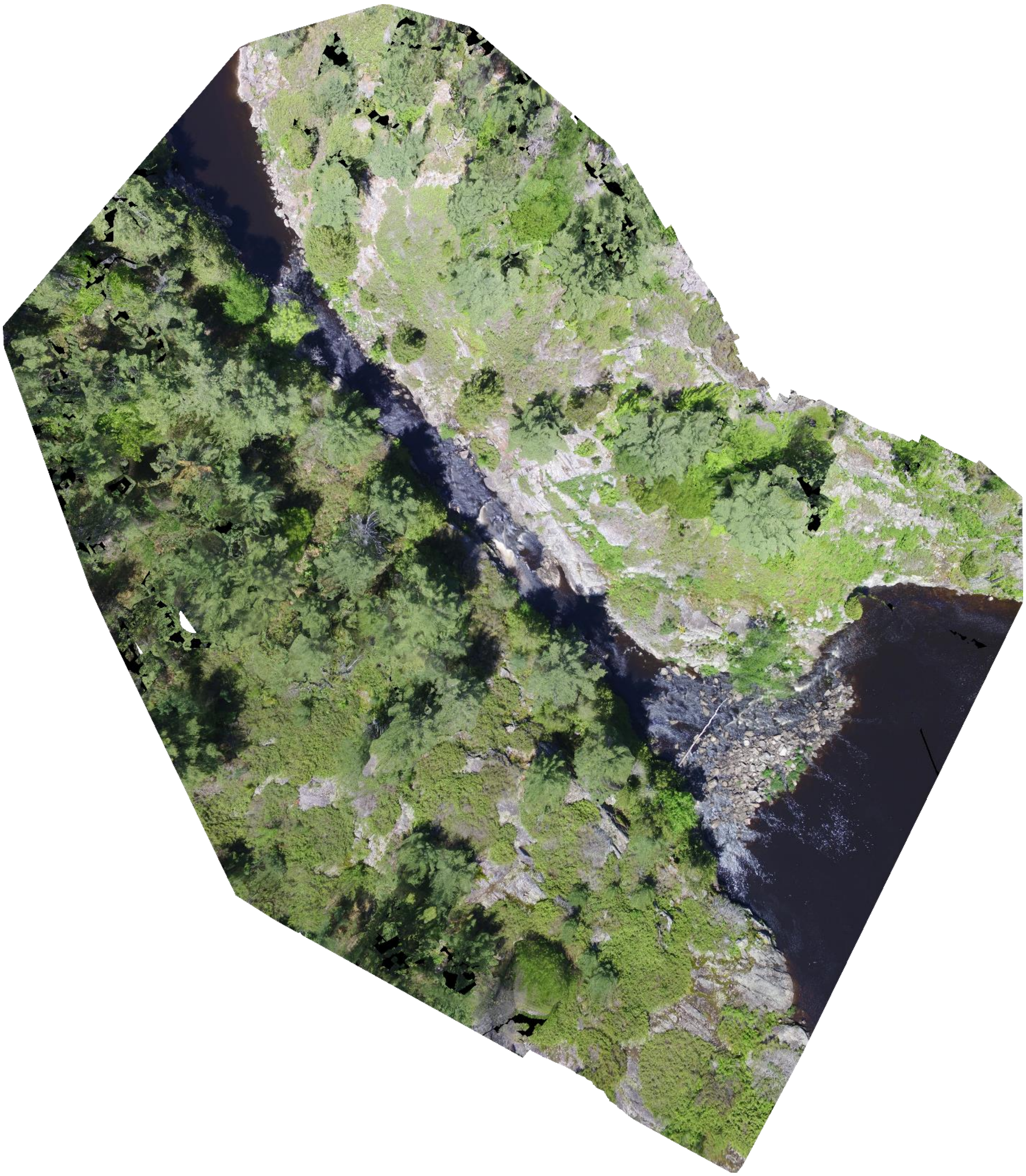


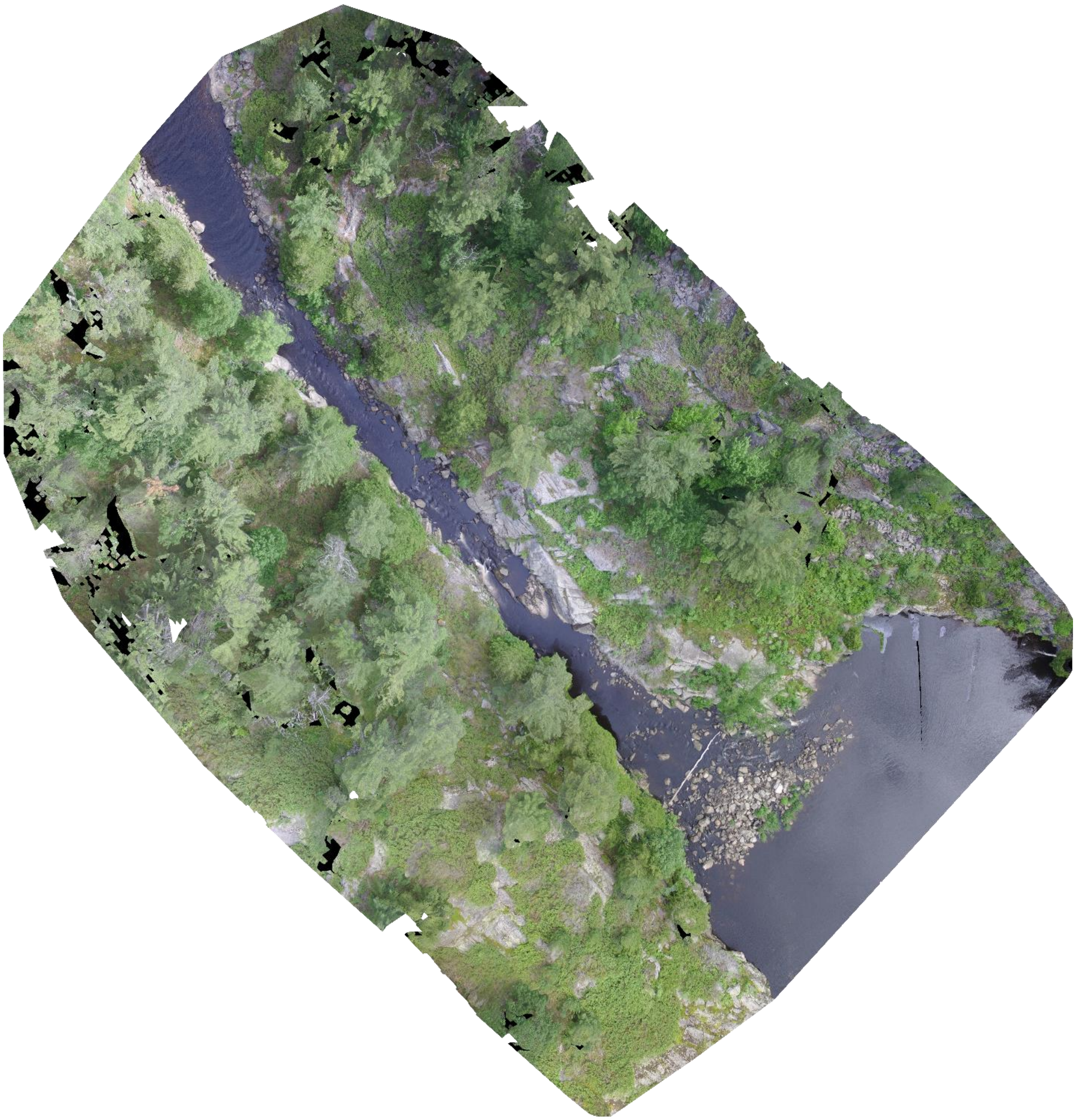
May 31, 2017 – unable to fly drone

June 5, 2017

June 8, 2017



June 20, 2017



Fish Observations

Ludgate

No fish were observed at Ludgate during regular site visits and no night surveys were conducted at the Key River in 2017.

Portage Lake Outlet

On April 18, two Walleye were observed at Portage Lake Outlet at noon. EGBSC staff spotted the fish at the egg mat 2 location just prior to installing the egg mat. No other fish were observed during regular site visits and no night surveys were conducted at the Key River in 2017 (refer to Appendix C for a complete list of fish and egg observations).

Egg Deposition

Ludgate

EGBSC set four egg mats at Ludgate to help assess the amount, type, and location of egg deposition (Figure 16). Egg mats were only placed on a small portion of the spawning bed, and therefore, only represent a small portion of the entire spawning area. Based on size, eggs could be differentiated between Walleye and Sucker species, but it was not possible to identify the Sucker eggs to species level. Had Lake Sturgeon eggs been deposited, they would have also been distinguishable by size and colour.

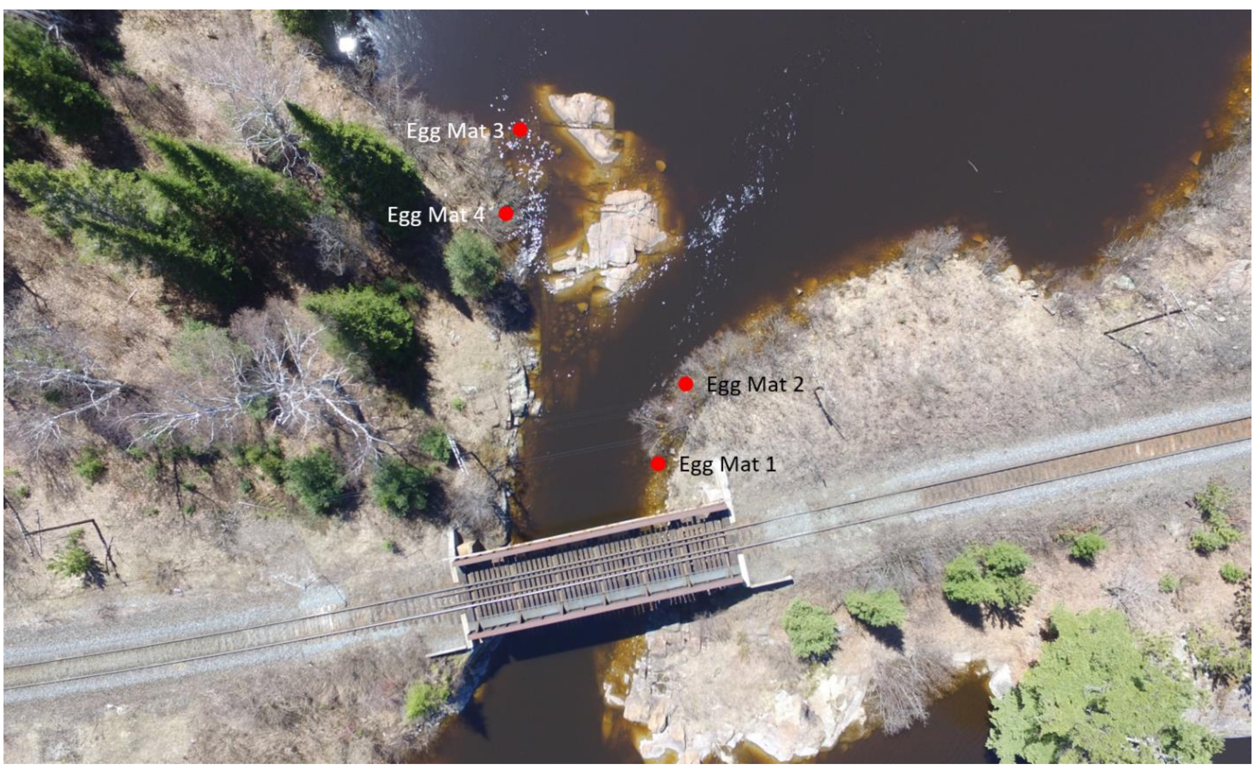


Figure 16. Location of egg mats installed at Ludgate in 2017

Egg mats were installed at various times throughout the study period (see Appendix C for more detail). Egg deposition on the mats was quite low. From April 18 to June 20, a total of 1,840 Walleye eggs were counted and no Sucker eggs were observed. Egg mat 2 had the greatest total number of Walleye eggs (863). Egg mat 1 had the next highest Walleye egg count at 722. No eggs were counted on egg mat 4 which was installed later in the season, on May 14.

In addition to the eggs counted on egg mats, Walleye eggs were also seen in the substrate upstream of egg mat 1 on April 25. On April 27, Walleye eggs were observed in the substrate again, some upstream of the train bridge. Some of the eggs observed on April 27 were in very shallow water or already stranded out of water (Figure 17).

Figure 17. Walleye eggs in very shallow water at Ludgate on April 27, others were already stranded out of water

Portage Lake Outlet

Four egg mats were set at Portage Lake Outlet to help assess the amount, type, and location of egg deposition (Figure 18). Egg mats were only placed on a small portion of the spawning bed, and therefore, only represent a small portion of the entire spawning area. Based on size, eggs could be differentiated between Walleye and Sucker species, but it was not possible to identify the Sucker eggs to species level. Had Lake Sturgeon eggs been deposited, they would have also been distinguishable by size and colour.

Figure 18. Location of egg mats installed at Portage Lake Outlet in 2017

Egg mats were installed at various times throughout the study period (see Appendix C for more detail). Egg deposition on the mats at Portage Lake Outlet was higher than at Ludgate. From April 18 to June 20, a total of 7,017 Walleye eggs and only 1 Sucker egg were counted. Egg mat 2 had the greatest total number of Walleye eggs (6,594). Egg mat 1 had the only Sucker egg. No eggs were counted on egg mat 4 which was installed later in the season on May 17.

In 2017, egg mats were set at a total of seven spawning areas on three rivers – Naiscoot River (two spawning beds), Pickerel River (three spawning beds), and Key River (two spawning beds). Table 1 compares the total Walleye and Sucker egg counts for these sites.

Table 1. Comparison of egg mat totals at all spawning beds assessed in 2017

Eggs	Naiscoot River		Key River		Pickerel River		
	Naiscoot Dam	Harris Branch	Ludgate	Portage Lake Outlet	Trestle Gully	Bailey Bridge	Squaw Rapids
Walleye	0	11	1,840	7,017	86	9,374	667
Sucker	0	184	0	1	0	67	0

Plankton Sampling

Once eggs incubate and hatch, fish enter their larval stage. Larval Walleye have limited mobility and typically move by drifting with water flow and wave action. Shortly after hatching, Walleye need to feed on zooplankton to ensure survival, growth, and development. The availability of zooplankton is a major factor in surviving this life stage. To help evaluate the amount of zooplankton downstream of the Key River spawning beds, EGBSC conducted several plankton tows using a 12" diameter, 153 micron plankton net.

EGBSC did not identify and count the zooplankton in the samples. Only a visual observation of the samples could be made and compared with the two other rivers sampled in 2017.

Ludgate

On June 8, three plankton samples were taken downstream of Ludgate and combined to create one composite sample (Figure 19). Based on the composite sample, the waters downstream of Ludgate can be described as having good plankton production.

Figure 19. Ludgate composite plankton sample (June 8, 2017)

Portage Lake Outlet

On May 30 and June 8, three plankton samples were taken downstream of Portage Lake Outlet and combined to create one composite sample each time (Figures 20 and 21). Based on the composite samples, the waters downstream of Portage Lake Outlet can also be described as having good plankton production.

Figure 20. Portage Lake Outlet composite plankton sample (May 22, 2017)

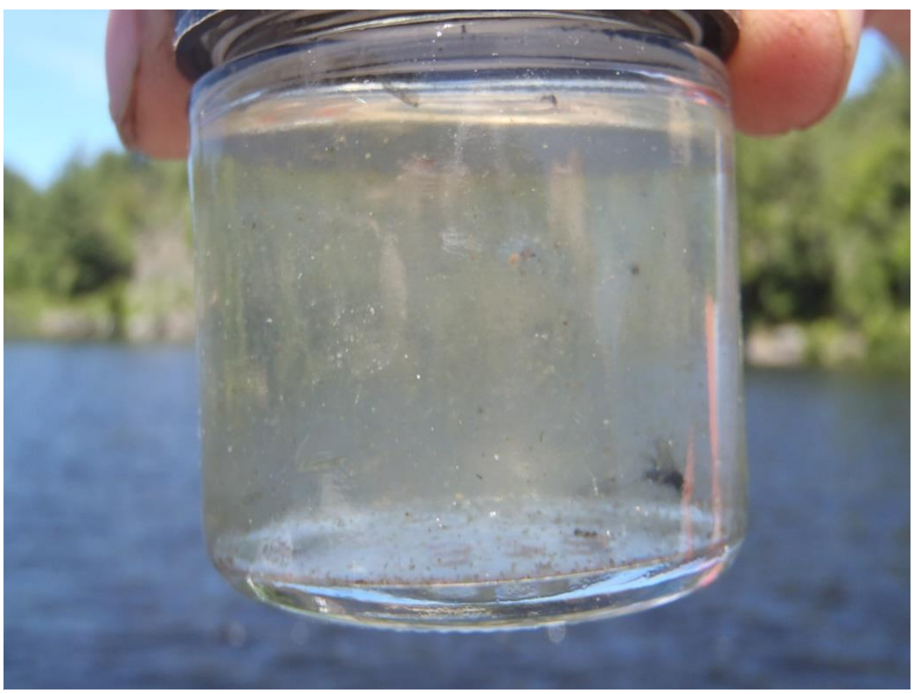


Figure 21. Portage Lake Outlet composite plankton sample (June 8, 2017)

Spawning Bed Measurements

Reproductive success for Walleye, Lake Sturgeon, and White Sucker is optimized when water depth, velocity, and appropriately sized substrate are present at the same location within a spawning area. The optimal substrate size for Walleye egg incubation ranges from gravel (0.2 to 6.4 cm) to cobble (6.4 to 25 cm) (Kerr et al., 1997). The optimal substrate size for Lake Sturgeon ranges from 10 to 60 cm in diameter (Golder Associates Ltd., 2011). White Sucker spawn on a clean bottom of coarse sand to gravel ranging from 2 to 16 mm in size (Twomey et al., 1984). Optimal depth for spawning Walleye ranges from 30 to 100 cm (Kerr et al., 1997) and 10 to 200 cm for Lake Sturgeon spawning (Golder Associates Ltd., 2011).

In the fall of 2017, EGBSC attempted to measure transects across the Ludgate and Portage Lake Outlet spawning beds with the intent of identifying areas "ideal" for spawning for Walleye, Lake Sturgeon, and Sucker species. Transects were to be completed later in the season, when it was hoped that it would be safe to wade across most, or parts of, the spawning beds. However, water levels were still high enough that transects could not be safely measured across the spawning beds. Instead, a qualitative approach was taken in which the substrate that could be seen from the banks was described. Depth measurements at bankfull were not possible without being able to stretch a tape measure across the entire channel. Furthermore, any velocity data collected would not have been the same as during the spawning season.

Ludgate

Substrate visible from the banks was recorded at Ludgate. Figure 22 outlines the areas considered to have substrate suitable for Walleye and Lake Sturgeon. As expected, most of the areas outlined in Figure 22 correspond with the areas where river rock was placed as part of EGBSC's 2015 spawning bed enhancement work (see Background Information). Very little substrate observed at Ludgate was considered ideal for Sucker.

Portage Lake Outlet

Substrate visible from the right bank at Portage Lake Outlet was recorded. Figure 23 illustrates the area with substrate considered ideal for Walleye and Lake Sturgeon. Similar to Ludgate, this area corresponds with the area of focus for EGBSC's spawning bed enhancement work in 2015. No substrate smaller than cobble was observed in a large enough quantity to constitute an area of ideal Sucker spawning substrate.

Figure 22. Areas of ideal spawning substrate observed at Ludgate

Figure 23. Area of ideal spawning substrate observed at Portage Lake Outlet

Nursery, Rearing, and Foraging Habitat

Until they become mobile, newly hatched fry of most riverine spawning species are dispersed largely according to water currents. In lake environments, wind-driven current can be a major factor in dispersing fry. Accordingly, the availability of nursery habitat in the downstream (or down-wind) vicinity of spawning sites is an important factor in reproductive success.

EGBSC completed surveys downstream of Portage Lake Outlet and Ludgate to determine if there is habitat – nursery, rearing, and foraging – for Walleye, Lake Sturgeon, and Sucker fry. To assess nursery, rearing, and foraging habitat, EGBSC combined bathymetry and side scan sonar data, as well as, underwater survey data. The purpose of the underwater surveys was to help ground truth what was being displayed from the sonar data. In addition, EGBSC compared the length of natural shoreline (unaltered) downstream of the spawning beds to the length of altered shoreline. Natural shorelines are critical for maintaining water quality and fish habitat. Natural shorelines help to slow runoff from roads, houses, and other areas of development, improving water filtration and filtering nutrients before they reach the watercourse. Natural vegetation along watercourses helps to create shade and moderate temperature. Natural debris (branches, leaves, etc.) that fall into the water are a source of food for aquatic insects, which in turn, are a source of food for certain fish, such as White Sucker.

There were a number of challenges associated with gathering and interpreting the data collected. First, there is very little information on nursery, rearing, and foraging habitat for Sucker species. More information is available for Walleye and Lake Sturgeon, but it is quite vague. For example, adult Walleye are described as being found between 2 to 10 m depth, this wide range makes it challenging to focus in on specific habitat. EGBSC focused survey efforts in the nearshore area at depths of approximately 1.5 m. Second, once eggs hatch, the larvae drift downstream, according to currents and wind. It is not possible to say how far the larvae drift, and this distance would vary river by river. Third, side scan sonar data was collected to help identify the type of substrate present in the river and identify areas with vegetation and boulders (.sl2 files are available upon request). However, in some areas, interpretation of the side scan data was very difficult making it challenging to discern between different types of substrate. In the areas where the substrate was not clear, that information was not used in determining fish habitat due to a lack of confidence in interpretation. Finally, the fourth challenge was integrating all of the data collected.

Underwater Surveys

Underwater videos were taken by snorkelling for 100 m approximately every 1 km, using a GoPro camera. In total, EGBSC carried out ten (10) underwater surveys. Each survey location has been identified in Figure 24. Bathymetry maps are presented in Appendix D.

Surveys were started a considerable distance downstream of both the spawning beds and Highway 69 due to concerns over water quality in these areas. A potential blue-green algae bloom in these areas was reported to the Ministry of Environment and Climate Change at the same time that field work was scheduled to take place on the Key River. Accordingly, snorkel surveys were conducted further downstream. Visibility at some of the survey locations was still impacted by the presence of algae in the water column.

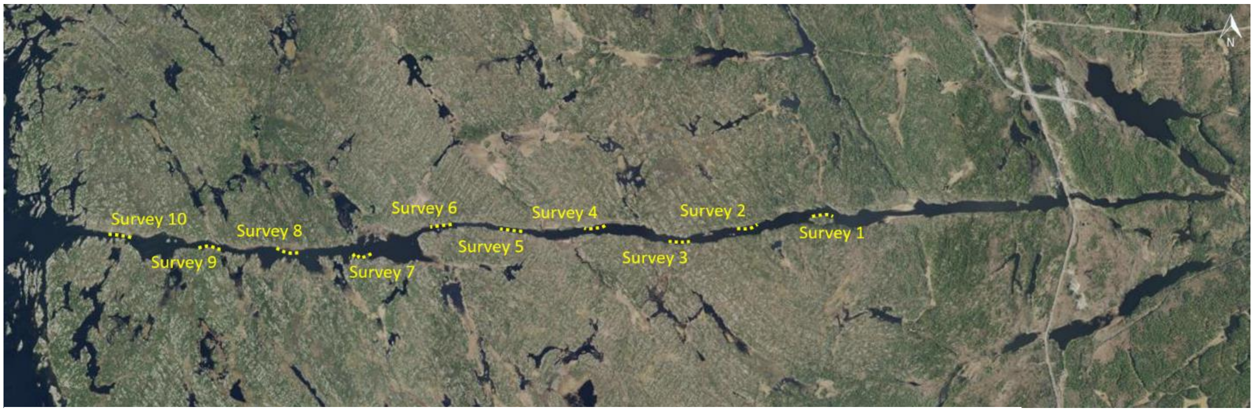


Figure 24. Underwater survey locations downstream of Highway 69 on the Key River

For each underwater survey, types of substrate and aquatic vegetation, as well as, abundance of aquatic vegetation and woody debris (sticks, branches, logs) were recorded. Aquatic vegetation and woody debris offer cover for fish at various life stages and provide cover for predatory fish to ambush their prey. Classifications and definitions of abundance are detailed in Table 2. Each of the underwater surveys is summarized in Table 3.

Table 2. Definitions of aquatic vegetation and wood structure abundances

Abundance	Sparse	Moderate	Abundant
Aquatic vegetation	Observed in small, inconsistent patches	Observed consistently along the substrate, camera moves easily through the area	Consistent and thick, difficult to move camera through the area
Wood structure	1-2 branches or sticks	2 logs and/or several branches or sticks (<10)	>3 logs and/or >10 branches

Table 3. Summary of findings from underwater surveys

Survey	Substrate	Woody Debris	Aquatic Vegetation	Notes
1	Could not see – very poor visibility due to algae	Absent	Absent	Dense algae in water column
2	Bedrock	Absent	Absent	Dense algae in water column
3	Bedrock, sand, rocks	Absent	Moderate	
4	Muck	Sparse	Abundant vegetation until very end at steep cliff face	
5	Bedrock for 3/4 of the survey, clay for 1/4	Absent	Sparse	
6	Mainly clay some muck	Sparse	Moderate	
7	Muck wherever vegetation was, elsewhere 60% muck, 40% bedrock	Absent	Abundant	Some low-lying marsh
8	Muck, clay/silt/organic matter	Absent	Abundant	
9	Bedrock, only soft by plants	Absent	Sparse	
10	Sand for 3/4 of survey, turned to muck with a bit of sand for final 1/4	Absent	Small section moderate, sparse everywhere else	Floating docks along survey

The following list of aquatic vegetation (submergent, emergent, and floating) was recorded from the ten (10) surveys: Wild Rice, Water Celery, filamentous algae, Floating Heart, Pipewort, White Water Lily, Pickerelweed, Bladderwort, and Sedges. White Water Lily was the most dominant species, observed in six of the ten (10) surveys. Algae was present in the water column for all surveys.

Shoreline Characteristics

Along each of the ten (10) underwater surveys, shoreline characteristics were also recorded and photographed. The Key River, downstream of the spawning bed to the outlet, has predominantly natural shoreline (88% natural, 12% altered) (Figures 25-29). Observed alterations included train and highway bridges, marinas, mown grass close to the shoreline, and docks. The natural shoreline along the surveys consisted mainly of bedrock cliffs, gently sloped bedrock with forest set back, pockets of wetland, and flooded alders. Photos of the shoreline from each survey can be found in Appendix E. It is important to note that surveys did not cover the entire length of the shoreline, therefore, they do not represent all possible alterations or types of natural shoreline.

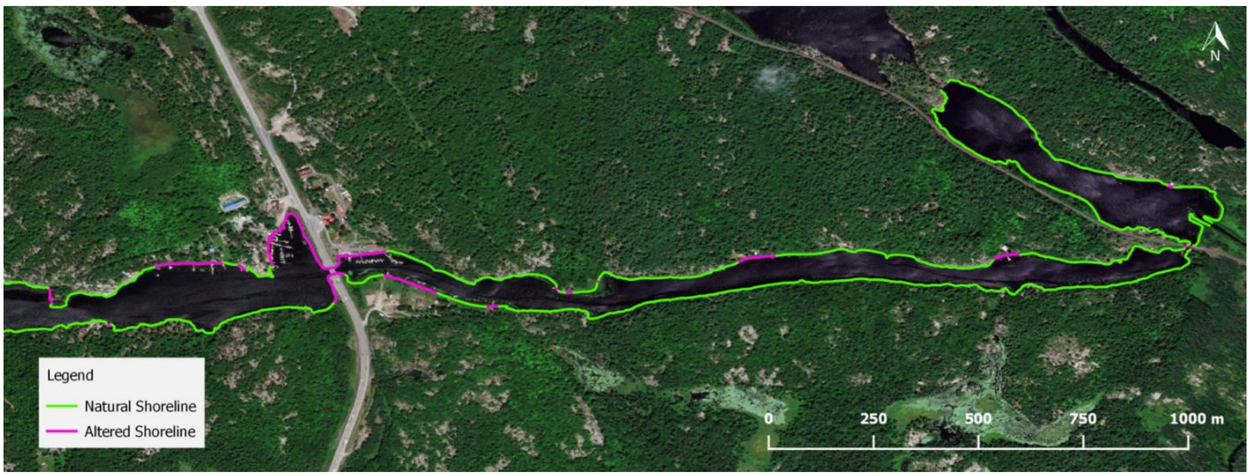


Figure 25. Natural and altered shoreline downstream of Portage Lake Outlet and Ludgate

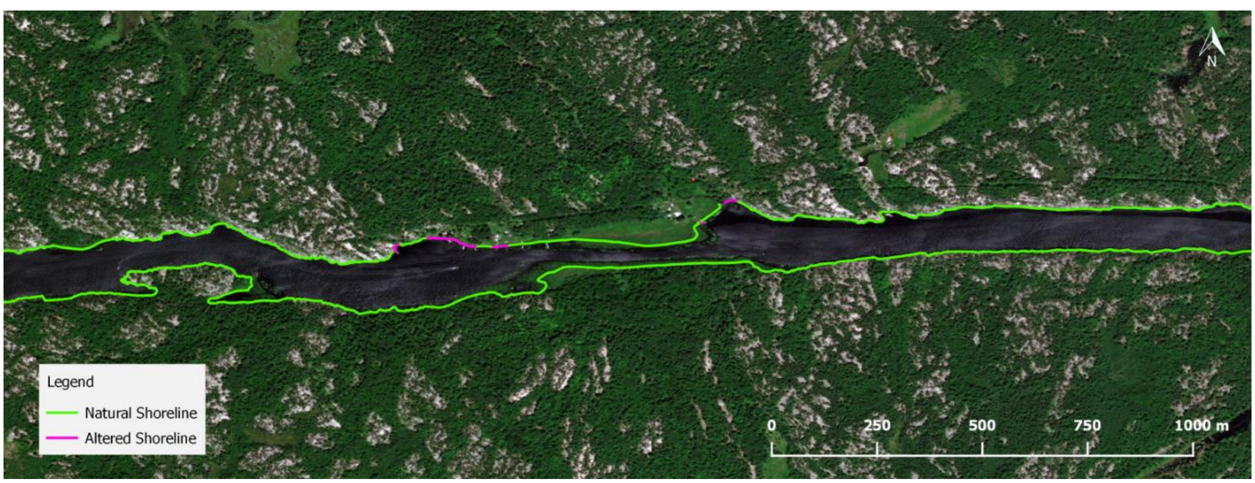


Figure 26. Natural and altered shoreline downstream of Portage Lake Outlet and Ludgate

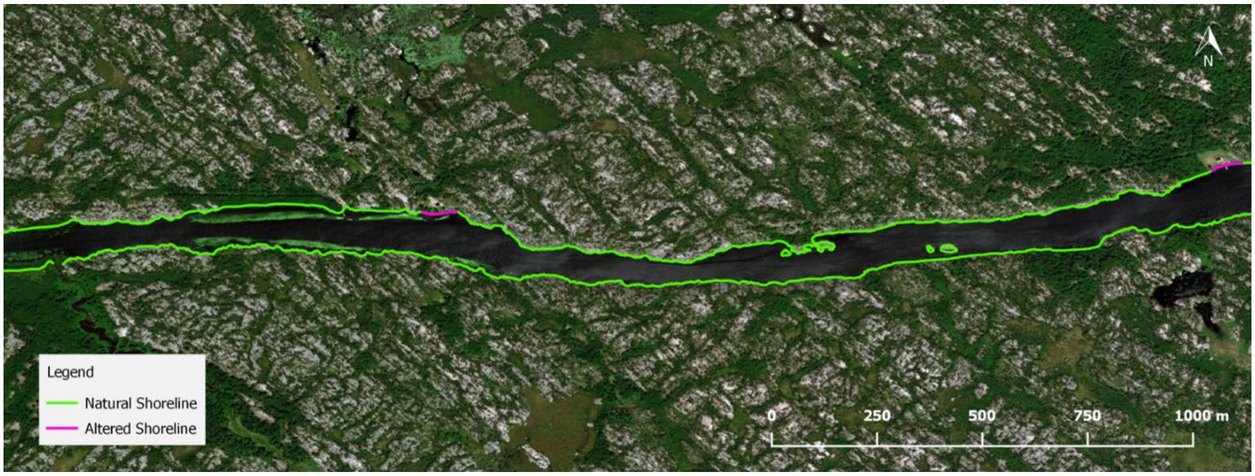


Figure 27. Natural and altered shoreline downstream of Portage Lake Outlet and Ludgate

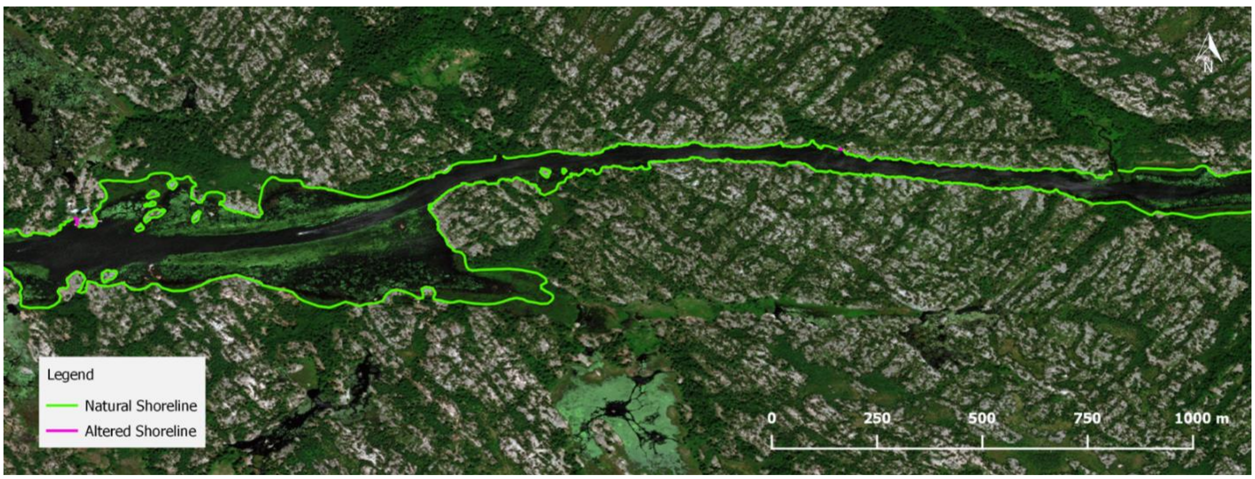


Figure 28. Natural and altered shoreline downstream of Portage Lake Outlet and Ludgate

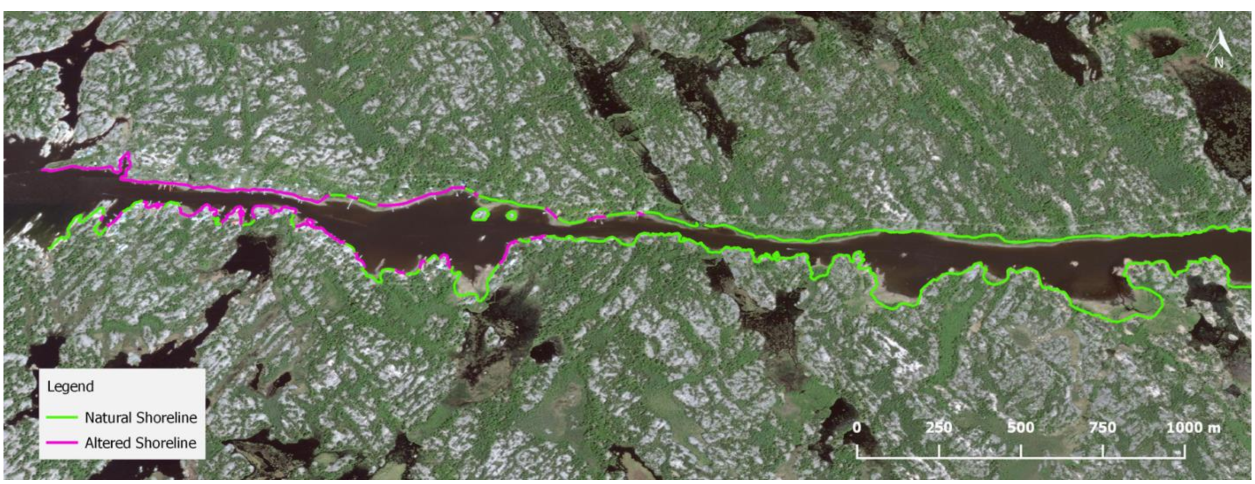


Figure 29. Natural and altered shoreline downstream of Portage Lake Outlet and Ludgate

Shoreline substrate was also recorded and photographed for each of the surveys. Only the shoreline substrate that was visible was recorded. Table 4 lists the shoreline characteristics of each survey.

Table 4. Shoreline characteristics along the underwater surveys

Survey	Shoreline Characteristics
1	Bedrock shoreline
2	Bedrock cliffs
3	Sloping bedrock
4	Lots of vegetation transitioning back to bedrock and ending with a vertical bedrock face
5	Steep bedrock
6	Mainly low-lying Alders along fringe
7	Sloped bedrock and some low-lying marsh
8	Bedrock cliffs
9	Gradually sloping bedrock
10	Sandy beach with mown grass to water, floating docks

In addition to substrate, shoreline vegetation that could be identified was recorded for each survey (Table 5). No terrestrial or aquatic invasive species were observed along the surveys.

Table 5. Shoreline vegetation observed along the underwater surveys

Survey	Shoreline Vegetation
1	Moss, Birch spp., Cedar, Polypody Fern, Jack Pine, Sweet Gale, Red Pine, Meadowsweet, Juniper
2	Cedar, White Pine, Juniper, White Birch
3	Cedar, Juniper, White Birch, Sweet Gale, Moss, Lichen, Jack Pine, Red Pine
4	Alder spp., Poplar spp., Red Oak, White Spruce, Sumac, Ash spp., Pine spp., Juniper, Goldenrod spp., Meadowsweet, Sweet Gale, Sedge spp., White Birch
5	Jack Pine, Juniper, Moss, Cherry saplings, Birch spp., Ferns, Goldenrod spp.
6	Sweet Gale, Alder spp., Trembling Aspen, White Pine, Red Oak, Meadowsweet, Common Cattail, Pickerelweed, Blue Flag Iris
7	Alder spp., Meadowsweet, Juniper, Grass spp., Goldenrod spp., Red Pine, Jack Pine, White Pine, Common Cattail, Poplar spp., Sweet Gale
8	Juniper, Birch spp., Jack Pine, White Pine, Meadowsweet, Bulrush spp., Common Cattail, Aster spp., Goldenrod spp.
9	White Pine, Jack Pine, Grass spp., Goldenrod spp., White Birch, Meadowsweet, Aster spp., Juniper, Poplar spp., Moss
10	Goldenrod spp., Sumac, White Pine, Jack Pine, White Birch, Sweet Gale

Discussion and Recommendations

Water chemistry measurements that were monitored (water temperature, dissolved oxygen, pH, and conductivity) were generally normal and typical of what one would expect from a Canadian Shield watershed. However, on May 2, pH measurements at both Ludgate and Portage Lake Outlet were abnormal. pH at Ludgate measured 4.31, well below all other pH measurements at the site throughout the study period. At Portage Lake Outlet, pH measured 11.01 on the same day, well above all other pH measurements at that site. Field notes indicate that the YSI was behaving irregularly on May 2 and that the accuracy of these measurements was questionable. Aside from abnormal pH measurements on May 2, there were no other indications of water quality having any adverse effects on fish spawning or egg incubation.

Water level fluctuations were observed at Ludgate and Portage Lake Outlet throughout the spawning and egg incubation periods. At Ludgate, eggs were seen deposited in the substrate just upstream of the train bridge where the water became very shallow, and in some cases, in places where the water had receded below the substrate leaving the eggs stranded. While most eggs were observed in areas that stayed underwater for the entire egg incubation period, the potential for egg stranding is still a concern. Importantly, the newly created habitat at both sites was observed to be functioning as intended with sufficient water depth over the habitat.

Water velocity measured at Ludgate stations did not exceed 1.27 m/s and would not be expected to impede fish movement through or past the spawning bed. At Portage Lake Outlet, all but one of the recorded water velocities were below 1.92 m/s. One velocity measurement at the uppermost station reached 3.51 m/s. The next highest velocity measurement at that same station was 0.94 m/s which suggests there may have been even a small difference in the placement of the flow metre to elicit a vastly different velocity measurement. It is unknown whether the rapids at Portage Lake Outlet serve as a barrier to fish passage further upstream.

No night surveys were conducted on the Key River in 2017. Species observed during regular monitoring were recorded. In 2017, two Walleye were observed at Portage Lake Outlet as egg mats were being installed. At Ludgate, a total of 1,810 Walleye eggs were deposited on egg mats and at Portage Lake Outlet, that number was 7,017. Overall, based on visual observations and egg mat deposition, there appears to be a low number of Walleye spawning at the Key River and seemingly no Sucker or Lake Sturgeon. Although it is still too early to make conclusions about the impact on Walleye, both enhanced spawning beds were functioning as intended. It was a positive sign to see that the overwhelming majority of observed egg deposition at Portage Lake Outlet occurred in the newly created habitat, where there would be sufficient water depth for eggs to successfully incubate.

Downstream of the spawning beds to the Key River outlet into Georgian Bay, the majority of the shoreline is natural, although there are some marinas and lodges/cottage resorts. Underwater surveys were dominated by bedrock substrate with much finer substrate (e.g., clay, silt, sand) as the next dominant substrate. Wood structure was quite sparse while aquatic vegetation varied from sparse to abundant. Plankton samples indicated good plankton production downstream of the spawning beds. No obvious stressors or limiting factors were identified with regard to nursery, rearing, or foraging habitat.

The Key River assessment in 2017 marked the second consecutive year of monitoring at the two Key River spawning beds following restoration in 2015. EGBSC recommends further monitoring during the spawning and egg incubation periods in the future on a three to five year basis, as results from restoration efforts take several years to be fully realized. It would be beneficial to re-visit Ludgate and Portage Lake Outlet in a year with low Georgian Bay water levels to understand if low Georgian Bay water levels change accessibility of the spawning beds or the degree of egg stranding. EGBSC also recommends further, detailed analysis of the side scan sonar data to supplement the observations from underwater surveys and provide more in-depth insights into nursery, rearing, and foraging habitat (.sl2 files available upon request).

Acknowledgements

We would like to thank the Key River Area Association for the opportunity to present our work at their Annual General Meeting and to continue to post our project information on their website for members to read.

We would also like to thank Henvey Inlet First Nation community members for providing background information about the spawning beds.

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- Scott Finucan – Ministry of Natural Resources and Forestry
- Greg Mayne – Environment and Climate Change Canada
- Karl Schiefer – Aquatic Biologist consultant and EGBSC member
- David Bywater – Environmental Scientist, Georgian Bay Biosphere Reserve
- David Sweetnam – Executive Director, Georgian Bay Forever

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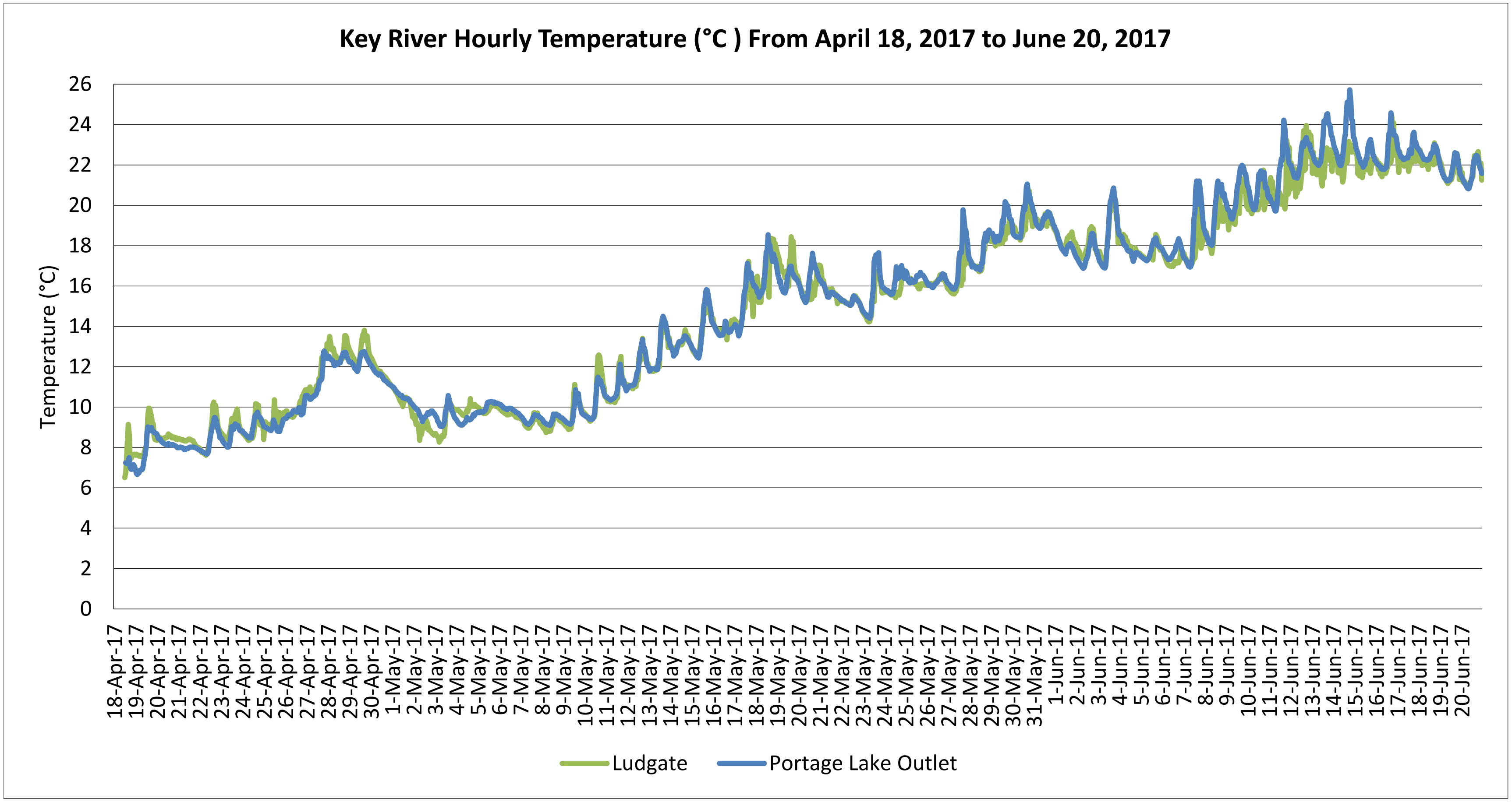
Appendix A – Water Chemistry

Water Chemistry – Ludgate, 2017

Date	Time	Temperature (°C)	DO (mg/L)	DO (%)	pH	Conductivity
18-Apr-17	11:09	6.8	12.00	98.6	6.30	40.2
22-Apr-17	11:57	8.1	10.30	87.3	6.70	41.1
25-Apr-17	11:03	9.6	10.04	87.8	7.26	50.4
27-Apr-17	10:50	10.8	9.56	86.2	6.90	49.3
02-May-17	11:20	8.6	12.20	88.4	4.31	38.6
04-May-17	2:35	9.7	10.41	91.5	6.74	44.2
09-May-17	10:50	9.1	9.89	86.5	6.34	40.7
11-May-17	10:27	10.4	8.20	73.4	6.97	48.8
14-May-17	2:55	13.4	9.39	90.1	7.07	47.3
17-May-17	10:13	14.7	9.30	91.4	7.12	51.6
22-May-17	10:45	14.9	8.47	83.9	7.19	35.3
24-May-17	11:30	15.5	7.61	76.0	7.15	54.6
28-May-17	2:30	13.7	7.61	81.4	7.07	53.7
31-May-17	2:10	19.4	8.04	87.4	7.14	59.6
05-Jun-17	11:30	17.1	7.32	76.2	7.04	61.4
08-Jun-17	2:22	20.9	7.59	94.5	6.87	64.0
20-Jun-17	10:25	21.0	8.10	91.0	7.58	68.9

Water Chemistry – Portage Lake Outlet, 2017

Date	Time	Temperature (°C)	DO (mg/L)	DO (%)	pH	Conductivity
18-Apr-17	12:55	6.7	12.53	102.4	6.58	50.5
22-Apr-17	12:27	8.1	12.04	102.0	6.15	53.3
25-Apr-17	11:55	8.9	11.48	99.1	6.46	56.4
27-Apr-17	10:30	10.4	10.98	98.2	6.82	61.7
02-May-17	12:20	9.3	10.45	91.2	11.01	61.1
04-May-17	1:55	9.1	11.08	96.3	6.70	58.9
09-May-17	10:20	9.2	11.00	95.7	6.83	60.0
11-May-17	9:55	10.3	10.95	97.7	6.87	58.2
14-May-17	2:26	13.2	10.47	100.0	7.06	57.9
17-May-17	9:49	14.7	10.15	99.7	7.11	64.4
22-May-17	10:20	13.9	9.71	96.9	7.09	67.3
24-May-17	11:05	15.7	9.58	95.2	7.22	68.0
28-May-17	2:05	16.8	8.51	87.7	6.99	70.1
31-May-17	1:50	19.3	8.62	94.0	7.14	68.2
05-Jun-17	11:10	17.5	7.99	83.5	7.24	73.5
08-Jun-17	1:50	21.0	9.03	100.7	7.21	73.6
20-Jun-17	9:55	20.9	8.49	96.6	7.54	82.7



Key River Hourly Temperature (°C) From April 18, 2017 to June 20, 2017
Temperature (°C)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
18-Apr-17
19-Apr-17
20-Apr-17
21-Apr-17
22-Apr-17
23-Apr-17
24-Apr-17
25-Apr-17
26-Apr-17
27-Apr-17
28-Apr-17
29-Apr-17
30-Apr-17
1-May-17
2-May-17
3-May-17
4-May-17
5-May-17
6-May-17
7-May-17
8-May-17
9-May-17
10-May-17
11-May-17
12-May-17
13-May-17
14-May-17
15-May-17
16-May-17
17-May-17
18-May-17
19-May-17
20-May-17
21-May-17
22-May-17
23-May-17
24-May-17
25-May-17
26-May-17
27-May-17
28-May-17
29-May-17
30-May-17
31-May-17
1-Jun-17
2-Jun-17
3-Jun-17
4-Jun-17
5-Jun-17
6-Jun-17
7-Jun-17
8-Jun-17
9-Jun-17
10-Jun-17
11-Jun-17
12-Jun-17
13-Jun-17
14-Jun-17
15-Jun-17
16-Jun-17
17-Jun-17
18-Jun-17
19-Jun-17
20-Jun-17
Ludgate
Portage Lake Outlet

Appendix B – Water Level and Velocity

Water Level Data – Ludgate, 2017

Benchmark	Date	Depth (cm)
3	18-Apr-17	22
3	22-Apr-17	16.5
3	25-Apr-17	32
3	27-Apr-17	25.5
3	02-May-17	7.5
3	04-May-17	12.5
3	09-May-17	15.5
3	11-May-17	20.2
3	14-May-17	13.5
3	17-May-17	12.5
3	22-May-17	9.5
3	24-May-17	16.5
3	28-May-17	13
3	31-May-17	4
3	05-Jun-17	12
3	08-Jun-17	5
3	20-Jun-17	3

Water Level Data – Portage Lake Outlet, 2017

Benchmark	Date	Depth (cm)
3	18-Apr-17	66
3	22-Apr-17	75.5
3	25-Apr-17	91
3	27-Apr-17	91
3	02-May-17	54
3	04-May-17	58
3	09-May-17	73.5
3	11-May-17	81.5
3	14-May-17	75
3	17-May-17	75
3	22-May-17	69
3	24-May-17	80
3	28-May-17	76
3	31-May-17	66.5
3	05-Jun-17	75.5
3	08-Jun-17	70
3	20-Jun-17	60
4	18-Apr-17	103
4	22-Apr-17	113
4	25-Apr-17	130
4	27-Apr-17	130
4	02-May-17	103
4	04-May-17	96.5
4	09-May-17	113
4	11-May-17	121.5

4	14-May-17	114
4	17-May-17	114
4	22-May-17	108.5
4	24-May-17	119.5
4	28-May-17	113.8
4	31-May-17	104.5
4	05-Jun-17	116
4	08-Jun-17	109
4	20-Jun-17	98

Velocity Data (m/s) – Ludgate, 2017

Date	Station 1	Station 2
18-Apr-17	0.75	1.27
22-Apr-17	0.36	0.6
25-Apr-17	0.24	0.06
27-Apr-17	0.14	0.16
02-May-17	0.82	0.91
04-May-17	0.59	1.26
09-May-17	0.39	0.71
11-May-17	0.17	0.35
14-May-17	0.19	0.24
17-May-17	0.17	0.21
22-May-17	0.2	0.22
24-May-17	0.15	0.26
28-May-17	1.07	0.29
31-May-17	0.11	0.17
05-Jun-17	0.14	0.21
08-Jun-17	0.14	0.18

Velocity Data (m/s) – Portage Lake Outlet, 2017

Date	Station 1	Station 2
18-Apr-17	0.94	0.28
22-Apr-17	0.84	1.56
25-Apr-17	0.17	1.48
27-Apr-17	0.62	1.48
02-May-17	0.4	1.36
04-May-17	0.8	1.65
09-May-17	0.45	1.92
11-May-17	3.51	1.51
14-May-17	0.34	1.26
17-May-17	0.58	1.28
22-May-17	0.72	1.2
24-May-17	0.37	1.12
28-May-17	0.32	1.12
31-May-17	0.41	0.93
05-Jun-17	0.21	1.36
08-Jun-17	0.31	0.93

Appendix C – Visual Observations

Visual Observations – Portage Lake Outlet, 2017

Date	Observation Method	Fish Species
18-Apr-17	Visual (day)	Walleye – 2

Egg Mat Counts – Ludgate, 2017

Egg Mat	Date Set	Date Counted	Sucker Eggs	Walleye Eggs	Notes
1	18-Apr-17	22-Apr-17	0	40	full mat count
2	18-Apr-17	22-Apr-17	0	180	4" grid used to count (extrap.)
3	18-Apr-17	22-Apr-17	0	225	4" grid used to count (extrap.)
1	22-Apr-17	25-Apr-17	0	585	2" counts (extrap.)
2	22-Apr-17	25-Apr-17	0	664	4" grid used (extrap.)
3	22-Apr-17	25-Apr-17	0	23	full mat count
1	25-Apr-17	27-Apr-17	0	15	full mat count
2	25-Apr-17	27-Apr-17	0	2	full mat count
3	25-Apr-17	27-Apr-17	0	2	full mat count
1	27-Apr-17	02-May-17	n/a	n/a	too deep
2	27-Apr-17	02-May-17	n/a	n/a	too deep
3	27-Apr-17	02-May-17	n/a	n/a	too deep
1	27-Apr-17	04-May-17	n/a	n/a	couldn't find, reset
2	27-Apr-17	04-May-17	n/a	n/a	couldn't find, reset
3	27-Apr-17	04-May-17	n/a	n/a	too deep, still there
1	04-May-17	09-May-17	0	7	most US
2	04-May-17	09-May-17	0	6	DS ~7-8m from EM1
3	27-Apr-17	09-May-17	0	3	south side
1	09-May-17	11-May-17	0	61	walleye
2	09-May-17	11-May-17	0	7	walleye
3	09-May-17	11-May-17	0	2	walleye
1	11-May-17	14-May-17	0	1	walleye
2	11-May-17	14-May-17	0	4	walleye
3	11-May-17	14-May-17	0	0	
1	14-May-17	17-May-17	0	13	walleye
2	14-May-17	17-May-17	0	0	
3	14-May-17	17-May-17	0	0	
4	14-May-17	17-May-17	0	0	
1	17-May-17	22-May-17	n/a	n/a	couldn't find, reset
4	17-May-17	22-May-17	0	0	
1	22-May-17	24-May-17	0	0	
4	22-May-17	24-May-17	0	0	
1	24-May-17	28-May-17	0	0	
4	24-May-17	28-May-17	0	0	
1	28-May-17	31-May-17	0	0	
4	28-May-17	31-May-17	0	0	
1	31-May-17	05-Jun-17	0	0	

4	31-May-17	05-Jun-17	0	0	site abandoned, no flow
1	05-Jun-17	08-Jun-17	0	0	
1	08-Jun-17	20-Jun-17	0	0	
		TOTAL	**0**	**1840**	

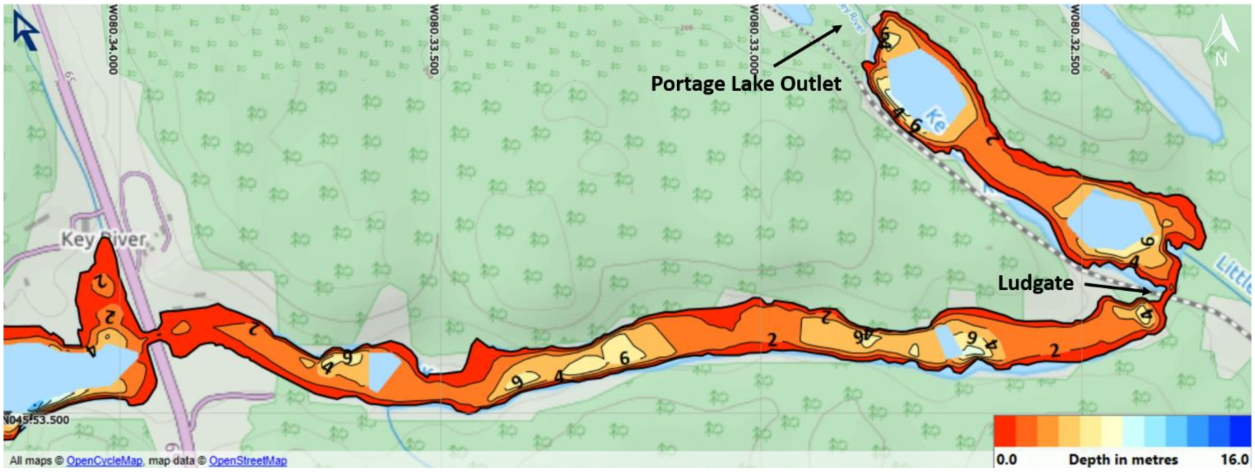
Egg Mat Counts – Portage Lake Outlet, 2017

Egg Mat	Date Set	Date Counted	Sucker Eggs	Walleye Eggs	Notes
1	18-Apr-17	22-Apr-17	0	10	appears numerous eggs wedged deeply in mat, possibly some smelt eggs - lots of caddisflies
2	18-Apr-17	22-Apr-17	0	5025	4" grid used to count (extrap.)
3	18-Apr-17	22-Apr-17	0	146	4" grid used to count (extrap.)
1	22-Apr-17	25-Apr-17	0	0	found out of water, reset
2	22-Apr-17	25-Apr-17	0	0	found out of water, reset
3	22-Apr-17	25-Apr-17	0	146	4" grid used, walleye & smelt eggs
1	25-Apr-17	27-Apr-17	0	0	535135, 5082891
2	25-Apr-17	27-Apr-17	0	1256	full mat count
3	25-Apr-17	27-Apr-17	0	115	full mat count
1	27-Apr-17	02-May-17	0	3	full mat count
2	27-Apr-17	02-May-17	n/a	n/a	too deep and murky
3	27-Apr-17	02-May-17	n/a	n/a	too deep and murky
1	02-May-17	04-May-17	1	0	reset ~2m US and ~2m closer to RB
2	27-Apr-17	04-May-17	n/a	n/a	too deep and murky
3	27-Apr-17	04-May-17	n/a	n/a	too deep and murky
1	04-May-17	09-May-17	0	0	
2	27-Apr-17	09-May-17	0	53	at base of rapids
3	27-Apr-17	09-May-17	n/a	n/a	couldn't find, set new mat
1	09-May-17	11-May-17	0	2	walleye
2	09-May-17	11-May-17	0	237	walleye
3	09-May-17	11-May-17	0	1	walleye
1	11-May-17	14-May-17	0	0	found out of water
2	11-May-17	14-May-17	0	15	walleye eggs
3	11-May-17	14-May-17	n/a	n/a	couldn't find, set new mat
1	14-May-17	17-May-17	0	0	
2	14-May-17	17-May-17	0	0	
3	14-May-17	17-May-17	0	0	
2	17-May-17	22-May-17	0	8	at boat parking site - walleye
4	17-May-17	22-May-17	0	0	at flow stn 1
2	22-May-17	24-May-17	0	0	
4	22-May-17	24-May-17	0	0	
2	24-May-17	28-May-17	0	0	
4	24-May-17	28-May-17	0	0	
2	28-May-17	31-May-17	0	0	
4	28-May-17	31-May-17	0	0	
2	31-May-17	05-Jun-17	0	0	
4	31-May-17	05-Jun-17	0	0	
2	05-Jun-17	08-Jun-17	0	0	

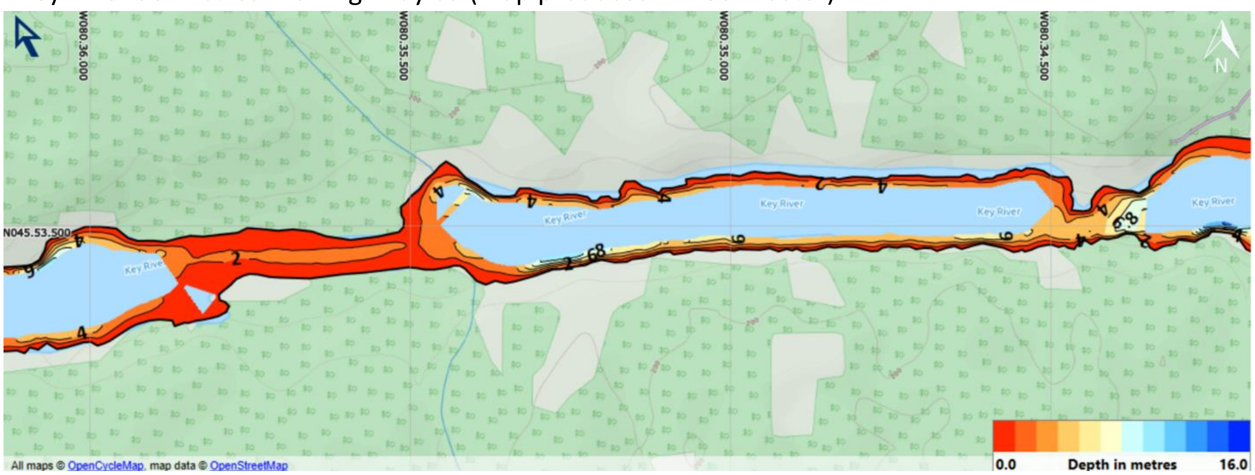
4	05-Jun-17	08-Jun-17	0	0	
2	08-Jun-17	20-Jun-17	0	0	
4	08-Jun-17	20-Jun-17	0	0	
TOTAL			**1**	**7,017**	

Appendix D – Bathymetry Maps

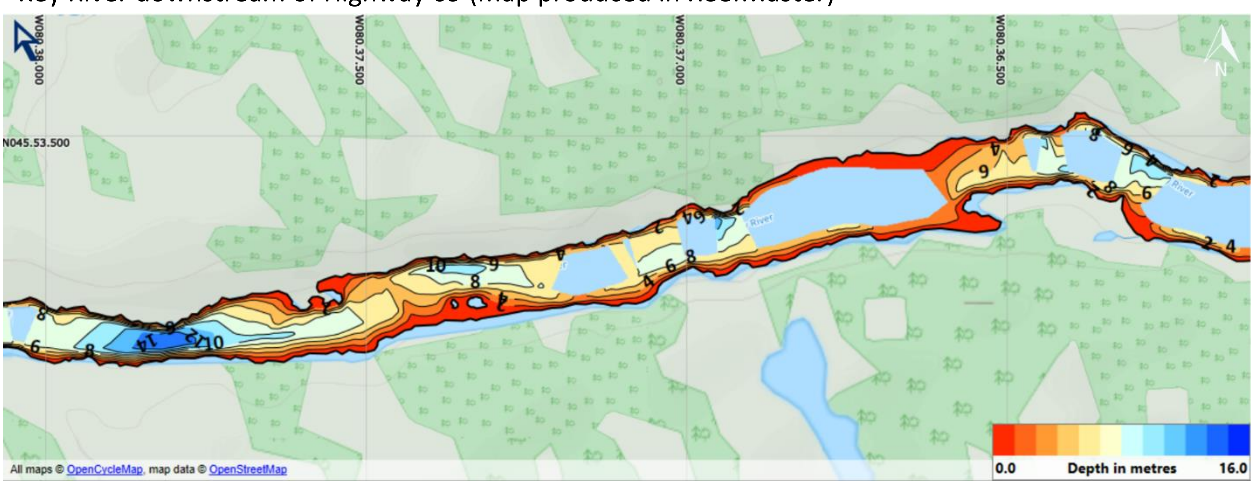
Key River downstream of Portage Lake Outlet and Ludgate (map produced in ReefMaster)



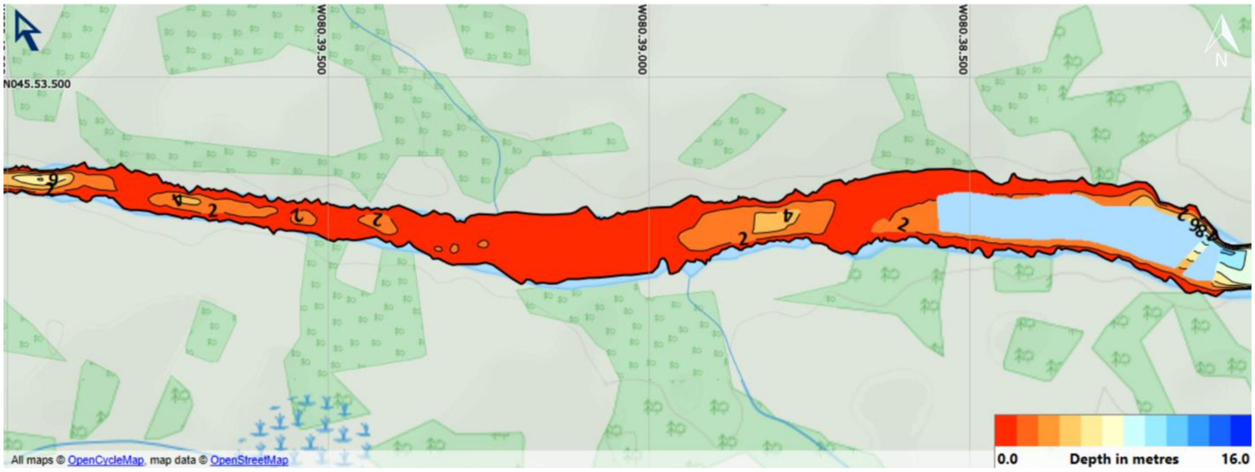
Key River downstream of Highway 69 (map produced in ReefMaster)



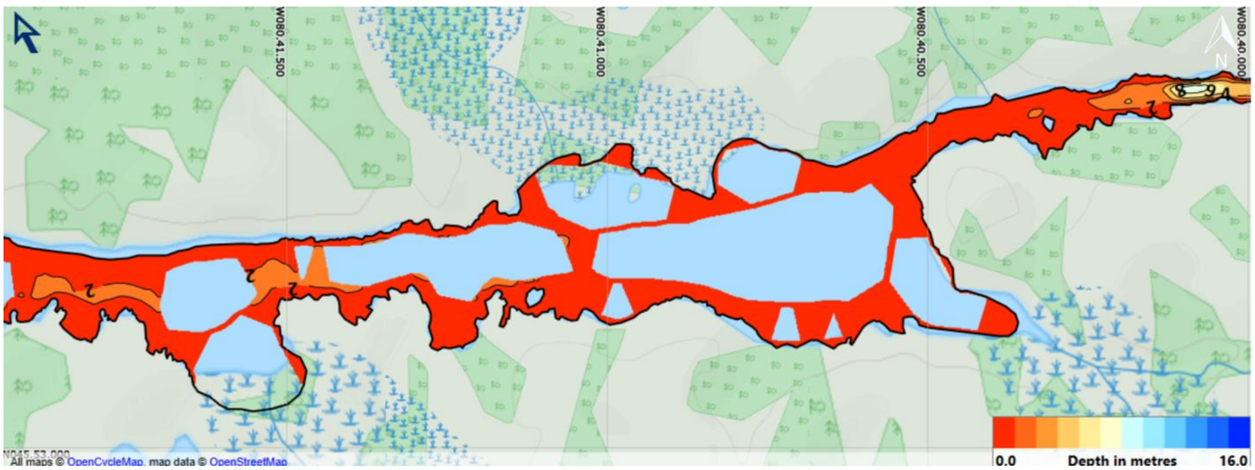
Key River downstream of Highway 69 (map produced in ReefMaster)



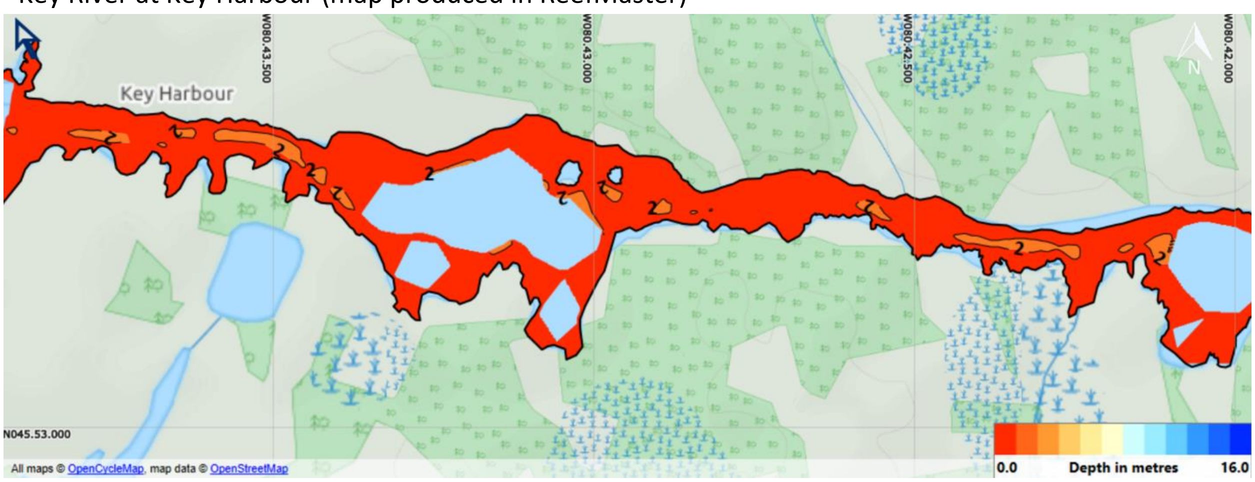
Key River downstream of Highway 69 (map produced in ReefMaster)



Key River upstream of Key Harbour (map produced in ReefMaster)



Key River at Key Harbour (map produced in ReefMaster)



Appendix E – Shoreline Photos

Underwater Surveys – shoreline photos

Survey 1

Survey 2

Survey 3

Survey 4

Survey 5

Survey 6

Survey 7

Survey 8

Survey 9

Survey 10