Keeyask Generation Project

Aquatic Effects Monitoring Plan

Deep Water and Constructed Habitat Monitoring Report

AEMP-2023-14

KEEYASK

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KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING PLAN

REPORT #AEMP-2023-14

DEEP WATER AND CONSTRUCTED HABITAT MONITORING IN THE KEEYASK STUDY AREA, 2022

Prepared for

Manitoba Hydro

By

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SUMMARY

Background

The Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan to monitor the effects of construction and operation of the Keeyask Generating Station (GS) on the environment. Besides measuring the accuracy of the predictions made and actual effects of the GS on the environment, monitoring results will provide information on how construction and operation of the GS will affect the environment and if more needs to be done to reduce harmful effects.

Construction of the Keeyask GS began in mid-July 2014 and instream work was completed in 2020. The reservoir was impounded with water levels being raised to full supply level between August 31 and September 5, 2020. Commissioning of the powerhouse turbines was initiated after impoundment. They were brought into service one at a time with the final of seven turbines completed on March 9, 2022.

Aquatic habitat provides the environment in which aquatic organisms live. The monitoring of aquatic habitat after construction of the generating station is an important part of the overall plan to monitor the impacts of construction and operation of the Keeyask GS on aquatic life including fish. Some habitats are especially important for fish species to complete their life cycles, such as places to spawn, and places where larval fish can grow. Some of these habitats were lost or changed with reservoir impoundment and operation of the generating station.

Deep water, offshore areas provide important feeding and rearing habitat for many fish species including pickerel (Walleye), Lake Whitefish, and Lake Sturgeon. Substrate types (what the bottom is made of) in these offshore habitats are often important because fish species seek out certain areas. For example, juvenile Lake Sturgeon are found more in deep areas with sand or gravel substrates rather than with fine silty substrates.

Several studies were conducted in the Keeyask area before construction of the Keeyask GS that identified areas that were important for Lake Sturgeon (called sensitive habitats). These areas include places where young-of-the-year (YOY) Lake Sturgeon can grow (such as the channel around Caribou Island in lower Gull Lake) and areas where Lake Sturgeon spawn (such as at Long Rapids and Birthday Rapids (see map below). Impoundment of the Keeyask reservoir in fall 2020 changed water depth and flows at Birthday Rapids where Lake Sturgeon spawn. Flooding also changed depths and flows in areas important for YOY Lake Sturgeon to grow. Construction of the GS also eliminated Gull Rapids and changed flows downstream. It is expected that changes in flows upstream and downstream of the Keeyask GS will cause shifts in the types of substrates found in deep water areas.

Construction of the Keeyask GS also changed spawning habitats used by other fish species including pickerel and Lake Whitefish. Rocky spawning shoals were built upstream of the GS before reservoir impoundment to provide additional areas for these species to spawn after flooding (see map below). Several rocky areas were also created downstream of the GS to generate habitat diversity in areas where the substrate does not vary. These will create feeding areas for pickerel and other types of fish.

This report presents the results of habitat monitoring conducted at created spawning shoals and deep water sites, including areas identified as sensitive Lake Sturgeon habitats in the Keeyask reservoir and Stephens Lake during the second year post-impoundment.

Why is the study being done?

Habitat monitoring at deep water and constructed habitats is being done to answer several questions:

Will Birthday Rapids continue to provide spawning habitat for Lake Sturgeon?

This question is important because if Lake Sturgeon do not have a place to spawn, the population will decrease.

Will sand and gravel continue to be present in the river upstream and downstream of the GS where it is accessible to YOY Lake Sturgeon?

YOY Lake Sturgeon are commonly found in areas of low water velocity over sand and gravel bottom. Impoundment of the reservoir and operation of the GS will change flow patterns, which may change the areas where sand and gravel is present in the riverbed both upstream and downstream of the GS. It is important to determine the effect impoundment has on these habitats to ensure that YOY Lake Sturgeon have enough of the habitat that they need to survive and grow.

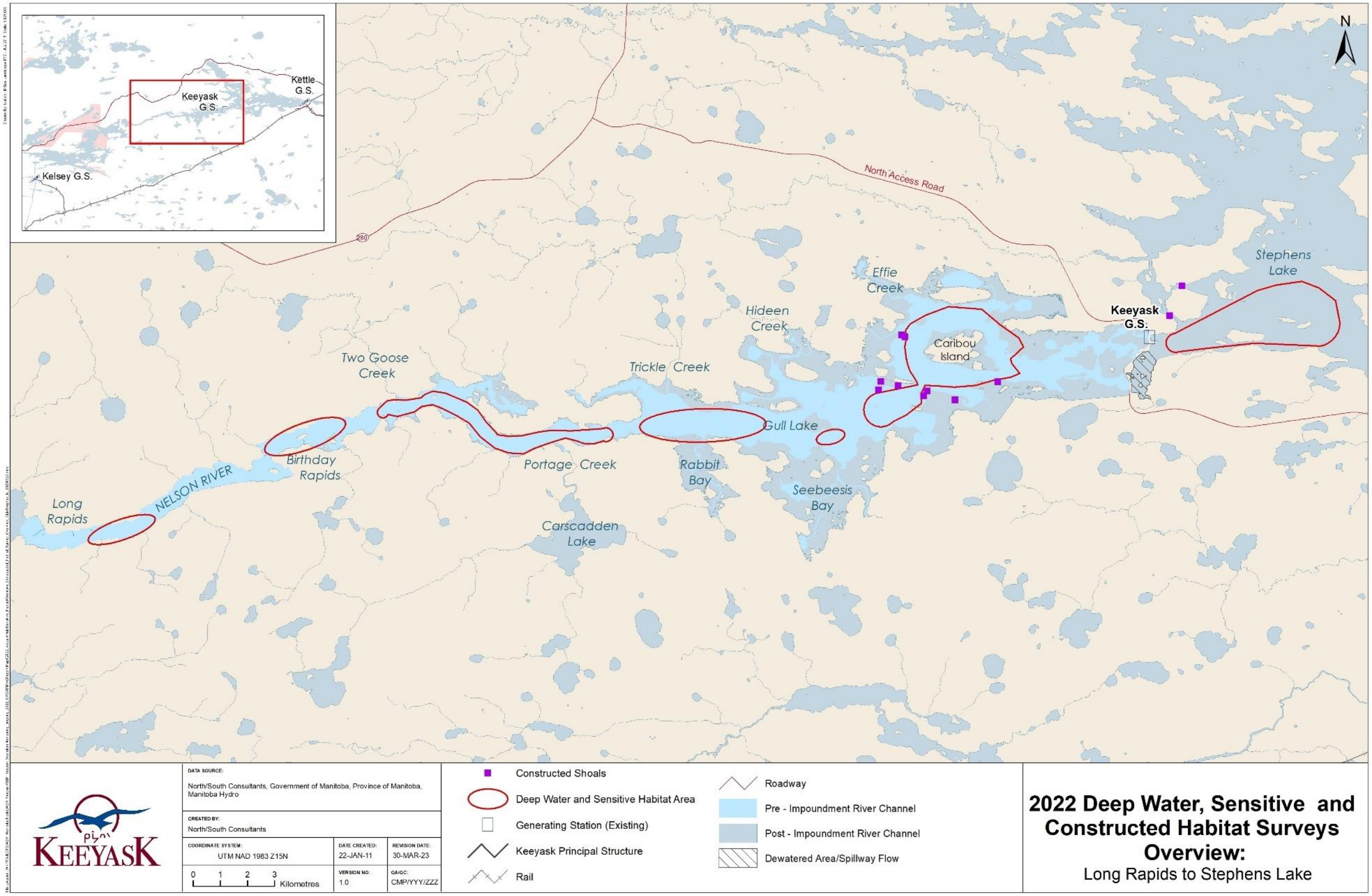
If sand and gravel are no longer present in the areas where they used to be, what are the substrates that develop in their place?

This question is important because it will help us to understand how rock, gravel, sand, and silt settle on the bottom of the reservoir and downstream of the Keeyask GS. Different species use different habitats, and knowing what substrates are there will help determine what types of fish will use these areas.

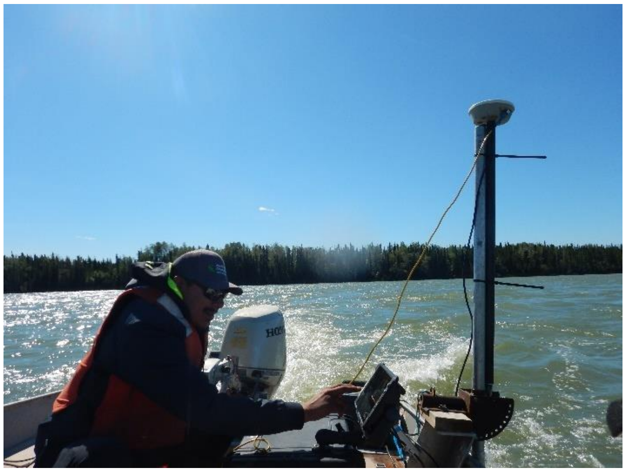
Habitat monitoring at constructed habitat is being done to answer an additional question:

Is the habitat at the constructed areas (i.e., water velocity and depth, and substrate) the same as how they were designed, or does it change over time?

This question is important to make sure that the shoals continue to provide the types of habitats that fish need to spawn and feed.



Map of the study area for the deep water and constructed habitat monitoring in the Keeyask reservoir and Stephens Lake in 2022.



Setup of acoustic equipment (left) and Ponar dredge substrate sampler (right) used to monitor deep water and constructed habitats in the Keeyask reservoir and Stephens Lake in 2022.

What was done?

Five sensitive habitat areas including four upstream of the Keeyask GS and one downstream were monitored in 2022. These included areas downstream of Long and Birthday rapids, at the Gull Lake entrance, in lower Gull Lake around Caribou Island, and in the upstream portion of Stephens Lake (see study area map above). Two deep water areas in the fast channel of the middle Keeyask reservoir and in upper Gull Lake were also sampled. Substrate composition (what the bottom is made of) information was collected and measurements of how deep and fast the water is were taken at each area. Substrate type was identified in each area by using a Ponar dredge (to grab a sample of the bottom), a sounding line (to hear or feel if the bottom is rocky or soft), and a sonar (to make a picture of the bottom).

Constructed habitats in the Keeyask reservoir and Stephens Lake were also monitored for water velocity and substrate. These included nine spawning shoals in the Keeyask reservoir and two rocky habitats in Stephens Lake (see map above). These areas were monitored in the same way as sensitive habitat, but because they were constructed in a certain way, a multibeam sonar was also used to get a more detailed picture of each shoal to see if they have remained the same.

What was found?

The areas downstream of Long Rapids and Birthday Rapids, as well as the middle of the Keeyask reservoir, mostly had hard rocky substrates including bedrock, boulder, and cobble. Water velocities were fast. The entrance to Gull Lake also had mostly rocky substrate but also had some areas of soft substrate (including sand, silt, and clay) farther downstream. Substrates returned to rock in an area of upper Gull Lake with high water velocities.

The area of lower Gull Lake around Caribou Island had a mix of substrates ranging from hard rock to soft mud. An area of sand was present in the middle of the channel to the north and east of Caribou Island. This sandy area was surrounded by mud (*i.e.*, silt and clay) in off-channel areas.

Upstream and downstream of this sandy area, the channel was generally rocky. Some silt was found on top of the sand near the downstream end.

Immediately downstream of the Keeyask GS, water velocities were fast, and substrates were rocky until about 3 km downstream where water velocities became more moderate and areas of sand and mud were found. Substrates in the sensitive Lake Sturgeon habitat between 4–7 km downstream of the Keeyask GS (an important place where YOY and juvenile Lake Sturgeon can grow) were different in the upstream and downstream parts. Hard rocky substrates were found mostly in the upstream portion, where the water velocity was greater. Farther downstream, the substrate largely consisted of a mix of silt, sand, and clay. Organic matter (broken down plants) was found on top of the substrates in this area in the spring, while some silt was deposited on top of the substrates in the summer.

Constructed habitat in the Keeyask reservoir and Stephens Lake were all found in areas of low water velocity. The constructed shoals were built of rock before the Keeyask reservoir was flooded. One shoal in the Keeyask reservoir showed small amounts of sand and organics on top of rock. Areas of the constructed shoals in Stephens Lake located closest to shore had mud and organic (broken down plant material) substrates instead of rock.

What does it mean?

Sampling in 2022 provides a second year of monitoring after flooding and is a starting point for studying the changes in substrates in deep water and constructed habitats in the Keeyask reservoir and Stephens Lake. Water velocities in some parts of the Keeyask reservoir have remained high after flooding including at Long Rapids, Birthday Rapids, the middle Keeyask reservoir, and the entrance to Gull Lake. The habitat downstream of Birthday Rapids was found to have high velocity with hard substrates. This combined with the capture of spawning Lake Sturgeon in the area in spring 2022 suggests that this area still provides spawning habitat. Sensitive juvenile and YOY Lake Sturgeon habitats in lower Gull Lake and upper Stephens Lake still contain sand substrates. Juvenile Lake Sturgeon were caught in both areas in 2021 and 2022 suggesting these areas still provide rearing habitat.

What will be done next?

The program will be repeated again in 2023. Data will be collected in the same areas and the same sites to monitor changes (*e.g.*, if fine sediments deposit over areas that are currently coarse sand, gravel, or cobble).

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

The Keeyask Generation Project (the Project) is a 695-megawatt (MW) hydroelectric generating station on the lower Nelson River in northern Manitoba. The GS is approximately 725 kilometres (km) northeast of Winnipeg, 35 km upstream of the existing Kettle Generating Station, 60 km east of the community of Split Lake, 180 km east-northeast of Thompson and 30 km west of Gillam. Construction of the GS began in July 2014 and the seven generating units were all in-service in March 2022.

The *Keeyask Generation Project: Response to EIS Guidelines*, completed in June 2012, provides a summary of predicted effects, and planned mitigation for the Project. Technical supporting information for the aquatic environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs, is provided in the *Keeyask Generation Project Environmental Impact Statement: Aquatic Environment Supporting Volume* (AE SV). As part of the licensing process for the Project, an *Aquatic Effects Monitoring Plan* (AEMP) was developed detailing the monitoring activities of various components of the aquatic environment for the construction and operation phases of the Project.

Aquatic habitat provides the environment in which aquatic biota live, as defined by water depth, velocity, substratum, and structure (including non-living and living [rooted plants] components). Aquatic habitat monitoring programs occur within the area of direct effect between the outlet of Clark Lake and approximately 7 km downstream of the GS. These programs were designed to record change over time in aquatic habitat that was altered by the Project, document the evolution of flooded terrestrial habitat into productive aquatic areas, and to assess conditions on structures constructed to offset habitat loss. A specific monitoring program was designed to assess the effects of the Project on deep water and constructed habitats.

Data collected in deep water areas (greater than 3 m) will be used to monitor change in substrate composition within offshore areas both upstream and downstream of the GS. Change in the distribution of the substrate in deep water is indicative of an alteration to the hydraulics and the ability of the river to transport materials along the bed. The evolution of substrate composition in deep water within the newly formed reservoir depends mostly on (new) water velocity patterns, and how the processes of erosion, transport, and deposition in the river channel maintain or alter the existing substrate. Potential effects on aquatic habitat downstream of the GS include the deposition of fine sediments over existing substrata. Monitoring areas include both sensitive Lake Sturgeon and constructed habitats.

Lake Sturgeon are a key component of the overall monitoring plan, chosen because they are important to local communities, and use a variety of habitats for spawning and foraging that will be substantially altered by the Project. Sensitive Lake Sturgeon habitats (*i.e.*, spawning and rearing habitats) were identified during baseline studies for the Project including areas that were used pre-Project and those predicted to be used post-Project. Sensitive Lake Sturgeon spawning habitats were identified at Long Rapids, Birthday Rapids, and the base of the Keeyask GS spillway. Sensitive Lake Sturgeon young-of-the-year (YOY) and sub-adult habitat was identified at Birthday Rapids, the entrance to Gull Lake, lower Gull Lake in the channel north of Caribou Island, and in Stephens Lake approximately 4–7 km downstream of the GS.

Constructed habitats were developed as an offsetting measure to account for some habitat loss caused by the Project and to increase the certainty that fish spawning habitat was available post-Project. In February and March 2018, three hectares of rocky spawning shoals were constructed in the future Keeyask reservoir to provide Lake Whitefish and Walleye spawning habitat immediately after impoundment (Map 1). Rockfill material was left in place at two temporary causeways (N5 and G3) in Stephens Lake to create shallow rocky habitat for fish and other aquatic species and a means of improving habitat diversity in these areas.

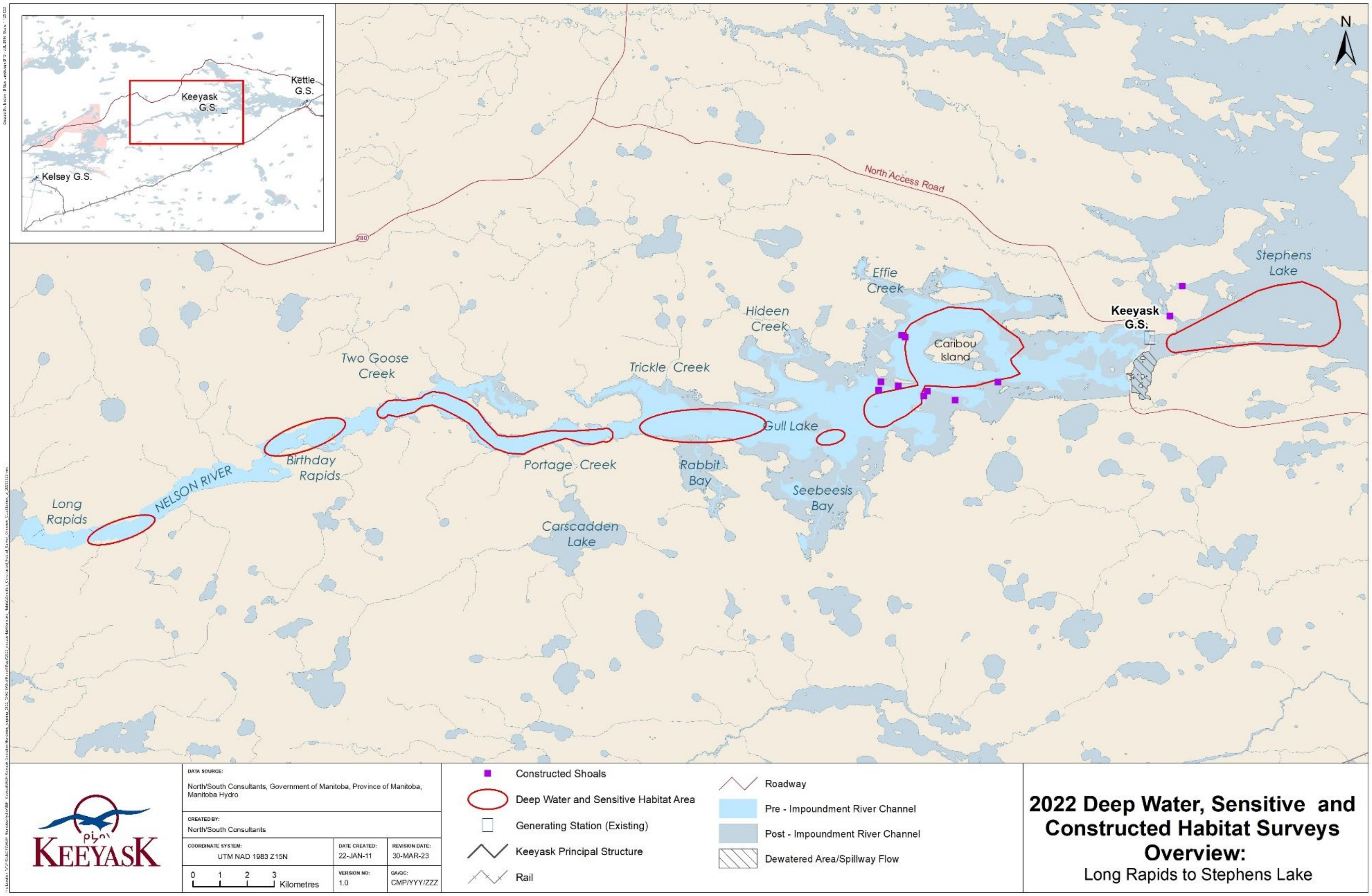
Monitoring of deep water areas is being conducted to address the following key questions, as described in the AEMP:

- *Will Long Rapids and Birthday Rapids and the area below the Keeyask GS continue to provide spawning habitat for Lake Sturgeon?*
- *How many years into the operation period will it take for substrate boundaries to form?*
- *How will substrate composition change over time in deep water areas in the Keeyask reservoir and Stephens Lake (including in the area of existing young-of-the-year [YOY] Lake Sturgeon habitats)?*
- *Will sand and gravel transport through the riverine reach of the reservoir and deposit downstream of Birthday Rapids and/or the entrance to Gull Lake to create suitable YOY Lake Sturgeon habitat?*
- *If sand and gravel do not deposit near the entrance to Gull Lake what are the substrate conditions that develop?*
- *How precise were the post-Project models that predicted the long-term deep water substrate distributions?*

Monitoring of constructed habitats is being conducted to address an additional key question:

- *Will monitoring data collected from the constructed spawning habitat (i.e., water velocity and depth, and substrate) in the reservoir confirm that the extent and surface area continue to meet design criteria over time?*

This report provides results based on data collected in August 2022, two years following impoundment. These results will be used to describe the initial flooded condition within the Keeyask reservoir and early operation within Stephens Lake. Changes to deep water substrates are expected to be slow and may take time to become apparent. Surveys will be repeated over time to describe the development of deep water habitats both upstream and downstream of the Keeyask GS.



Map 1: **Overview map of 2022 deep water and constructed aquatic habitat monitoring areas and sites.**

2.0 STUDY SETTING

The study area encompasses an approximately 110 km long reach of the Nelson River from Clark Lake to the upstream end of the Limestone Reservoir (Map 1). This section of river offers a diversity of physical habitat conditions, including a variety of substrate types, and variable water depths (range: 0–30 m) and velocities. Clark Lake is located immediately downstream of Split Lake, and approximately 42 km upstream of the Keeyask GS. Current is restricted to the main section of the lake, with off-current bays outside the main channel. The Assean River is the only major tributary to Clark Lake and flows into the north side. Downstream from the outlet of Clark Lake, the Nelson River narrows and water velocity increases for a 3 km stretch, known as Long Rapids. For the next 7 km, the river widens, and water velocity decreases. The area between Clark Lake and Birthday Rapids is referred to herein as the upper Keeyask reservoir.

Birthday Rapids is located approximately 10 km downstream of Clark Lake and 30 km upstream Keeyask GS and marks the upstream end of major water level changes because of impoundment by the Keeyask GS. The drop in elevation from the upstream to downstream side of Birthday Rapids was approximately 2 m prior to impoundment but is now nearly level, albeit a fast-flowing section of river. The 14 km reach of the Nelson River between Birthday Rapids and Gull Lake was characterized as a large and somewhat uniform channel with medium to high water velocities and a few large bays. This area is now within the Keeyask reservoir, though flooding was limited to mainly shoreline areas, and is referred to herein as the middle Keeyask reservoir.

Prior to impoundment, Gull Lake was a widening of the Nelson River, with moderate to low water velocity beginning approximately 20 km upstream the Keeyask GS. Water levels on Gull Lake increased by several metres following impoundment and flooding along the shoreline and small tributaries entering this reach was extensive. Although this area is larger than prior to impoundment, the portion of the Keeyask reservoir is referred to herein as Gull Lake.

Just below the Keeyask GS, the Nelson River enters Stephens Lake. Stephens Lake was formed in 1971 by construction of the Kettle GS. Construction of the Keeyask GS has altered the flow distribution immediately downstream of the station.

Construction of the Kettle GS flooded Moose Nose Lake (north arm) and several other small lakes that previously drained into the Nelson River, as well as the old channels of the Nelson River that now lie within the southern portion of the lake. Major tributaries of Stephens Lake include the North and South Moswakot rivers that enter the north arm of the lake. Looking Back Creek is a second order stream that drains into the north arm of Stephens Lake. Kettle GS is located approximately 40 km downstream of the Keeyask GS.

3.0 METHODS

Boat-based water velocity monitoring surveys were conducted between August 26 and 31, 2022. Substrate surveys were conducted between August 11 and 20, 2022. Additional habitat mapping and direct substrate sampling to obtain validation data were conducted in Stephens Lake on June 5 and 6 and September 16, 2022.

3.1 DEPTH AND VELOCITY

Depth and velocity data were collected by Manitoba Hydro using a SonTek M9 acoustic doppler current profiler (ADCP). Data were collected twice at each transect, from start to end bank and end bank to start bank. River Surveyor software was used to display cross sectional water velocities at each transect. Depth-averaged velocity was calculated at each transect using five second intervals (Figure 1).

Mean, minimum, and maximum depth and velocity were calculated for each survey area. ArcGIS mapping software was used to plot each transect and classify each as standing/lentic (<0.2 m/s); and low (0.2-0.5 m/s), moderate (0.5 – 1.5 m/s), high (1.5-2.5 m/s), and very high (>2.5 m/s) water velocity.

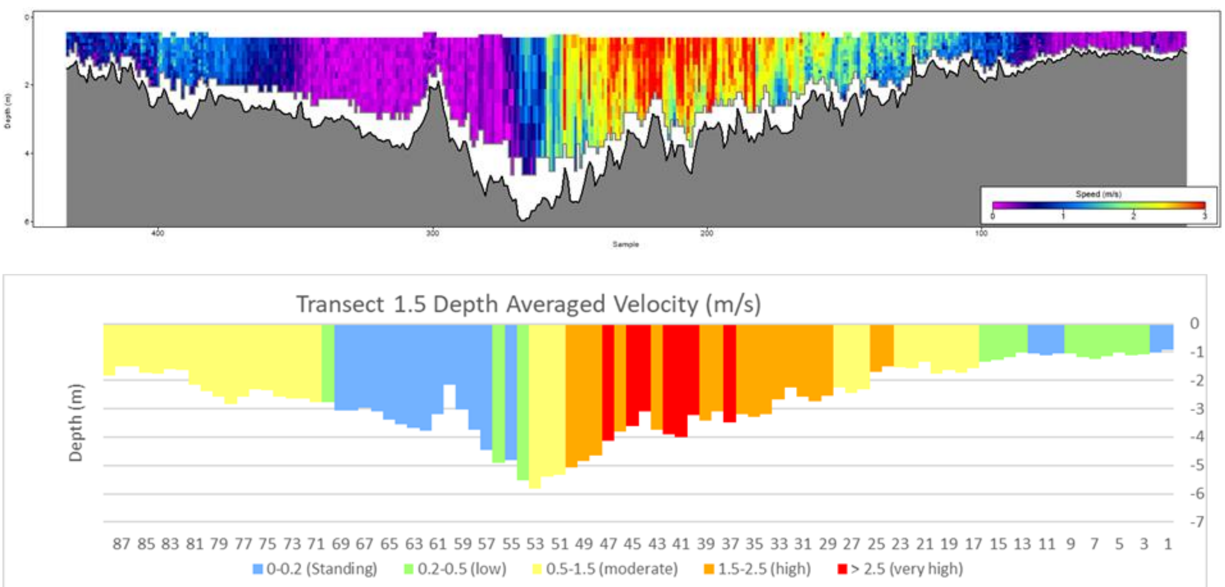


Figure 1: Full ADCP profile (top) sampled with the SonTek M9 ADCP and classified sub-sampled depth averaged velocity representation (bottom). Cross sections are viewed looking downstream (left to right bank).

3.2 SUBSTRATE

3.2.1 SUBSTRATE MAPPING

A Lowrance® Elite FS sonar/GPS echosounder was used to collect depth and bottom composition data as well as sidescan acoustic imagery at all sampling areas. Sidescan sonar image data have been shown to be effective in interpreting and mapping the substrate classes of benthic environments (Lucieer 2008; Kaeser *et al*. 2012; Fakiris *et al*. 2019). The system included a TotalScan™ transducer (83/200 kHz traditional sonar beams, as well as 455/800 kHz sidescan/down scan beams). Data were collected using a 50 m swath. Sidescan image mosaics of each of the survey areas were produced using SonarWiz 7. The raw image data and georeferenced image mosaics will be used to detect substrate boundary differences in future years of monitoring.

3.2.1.1 SUBSTRATE MAPPING AT DEEP WATER HABITATS

A BioSonics MX 200 kHz single-beam echosounder (SBES) was used to create substrate maps at each of the deep water habitat areas. A Trimble Pro XRT GNSS receiver using OmniSTAR real-time differential correction was used to provide positions for each sample accurate to less than a metre. Survey transects were navigated bank to bank (cross sections) or upstream to downstream (longitudinal transects) at boat speeds of less than 10 km/hr.

BioSonics Visual Aquatic software was used to calculate depth across each transect. Sound velocity corrections were completed using daily average water temperature from Manitoba Hydro's water temperature gauging station at Clark Lake. Bottom depth in the field was measured based on a signal threshold decibel (dB) level set in the BioSonics Visual Acquisition software. Depth was reanalyzed in Visual Aquatic software using a -55 dB rising level threshold to extract depth more accurately. The data were checked for signal error, pulse range omission, invalid depths, and acoustic waveform anomalies.

A model was created using Visual Habitat software which classed acoustic signals into types, based on the fact that different substrate types have different acoustic signals. Eight substrate classes were chosen including: organics (class 1), silt/clay (class 2), silt/clay/sand (class 3), sand (class 4), gravel/ sand (class 5), gravel (class 6), cobble (class 7), and bedrock/boulder (class 8).

3.2.1.2 SUBSTRATE MAPPING AT CONSTRUCTED HABITATS

A DSP Inc. 3DSS-IDX-450 combined sidescan sonar and multibeam echosounder was used to create substrate maps at each of the constructed habitat areas. This system was used to provide higher resolution imagery than at the deep water areas. Data were collected using a 100 m swath. The echosounder was coupled to a Septentrio dual antenna GNSS receiver to provide precise positions. These data were analyzed using SonarWiz software. The data were checked for anomalies and erroneous depth records which were filtered out of each file. Grids (to 0.25 m cell resolution) were created from the multibeam data which were imported into ArcGIS 10.8 software to create detailed maps of substrate and depth at each constructed habitat location.

3.2.1 DIRECT SAMPLING

Substrate grab samples were collected to validate the acoustic bottom typing data using a petite Ponar dredge (0.023 m^2 surface area). Primary, secondary, and tertiary substrate types were identified at each sampling site and classified using modified Wentworth scale and the percent composition of each type was estimated (*e.g.*, 50% clay, 30% silt, 20% sand; Table 1; Wentworth 1922). At several sites where fine or organic substrates were encountered, grab samples were preserved for particle size analysis (PSA) and organic content analysis, conducted at ALS Laboratories in Winnipeg, Manitoba. At locations where the Ponar could not be used (*e.g.*, in areas of high currents or rock bottom) a weighted sounding line was dragged across the substrate to differentiate between rock versus fine hard-packed substrates. The data obtained from Ponar dredge and weighted sounding line sampling is referred to as substrate validation in subsequent sections of this report.

Table 1: Modified Wentworth scale of material size used to classify substrate *in situ* (after Wentworth 1922).

Size Range	Wentworth Class	General Class	Basic Class
-	-	Bedrock	Rock
>256 mm	Boulder	Boulder	
64–256 mm	Cobble	Cobble	
32–64 mm	Very coarse gravel	Gravel	
16–32 mm	Coarse gravel		
8–16 mm	Medium gravel		
4–8 mm	Fine gravel		
2–4 mm	Very fine gravel		
1–2 mm	Very coarse sand	Sand	Sand
0.5–1 mm	Coarse sand		
0.25–0.5 mm	Medium sand		
125–250 µm	Fine sand		
62.5–125 µm	Very fine sand		
3.9–62.5 µm	Silt	Silt	Mud
0.98–3.9 µm	Clay	Clay	
-	-	Organic	Organic

4.0 RESULTS

4.1 DEEP WATER AND SENSITIVE HABITATS

Water velocity and substrate surveys were conducted within six areas in the Keeyask reservoir and one area in Stephens Lake in August 2022. Both water velocity and substrate surveys were conducted in four areas identified in the EIS as sensitive habitats, important for Lake Sturgeon. These include the areas downstream of Long and Birthday rapids (identified as important for Lake Sturgeon spawning), the entrance to Gull Lake (where slower water velocities may make the area important for Lake Sturgeon rearing), the area north of Caribou Island in lower Gull Lake (important rearing habitat for YOY and juvenile Lake Sturgeon), and Stephens Lake approximately 5–7 km downstream of the Keeyask GS (important rearing habitat for YOY and juvenile Lake Sturgeon).

Although lotic channels in the middle Keeyask reservoir and upper Gull Lake were not identified as important Lake Sturgeon habitats, substrate sampling was conducted in these areas to monitor change in substrate in deep water habitats over time. Substrate surveys in Stephens Lake were extended to include the area approximately 1.0–7.5 km downstream of the Keeyask GS.

4.1.1 LONG RAPIDS

4.1.1.1 DEPTH, WATER LEVEL, AND VELOCITY

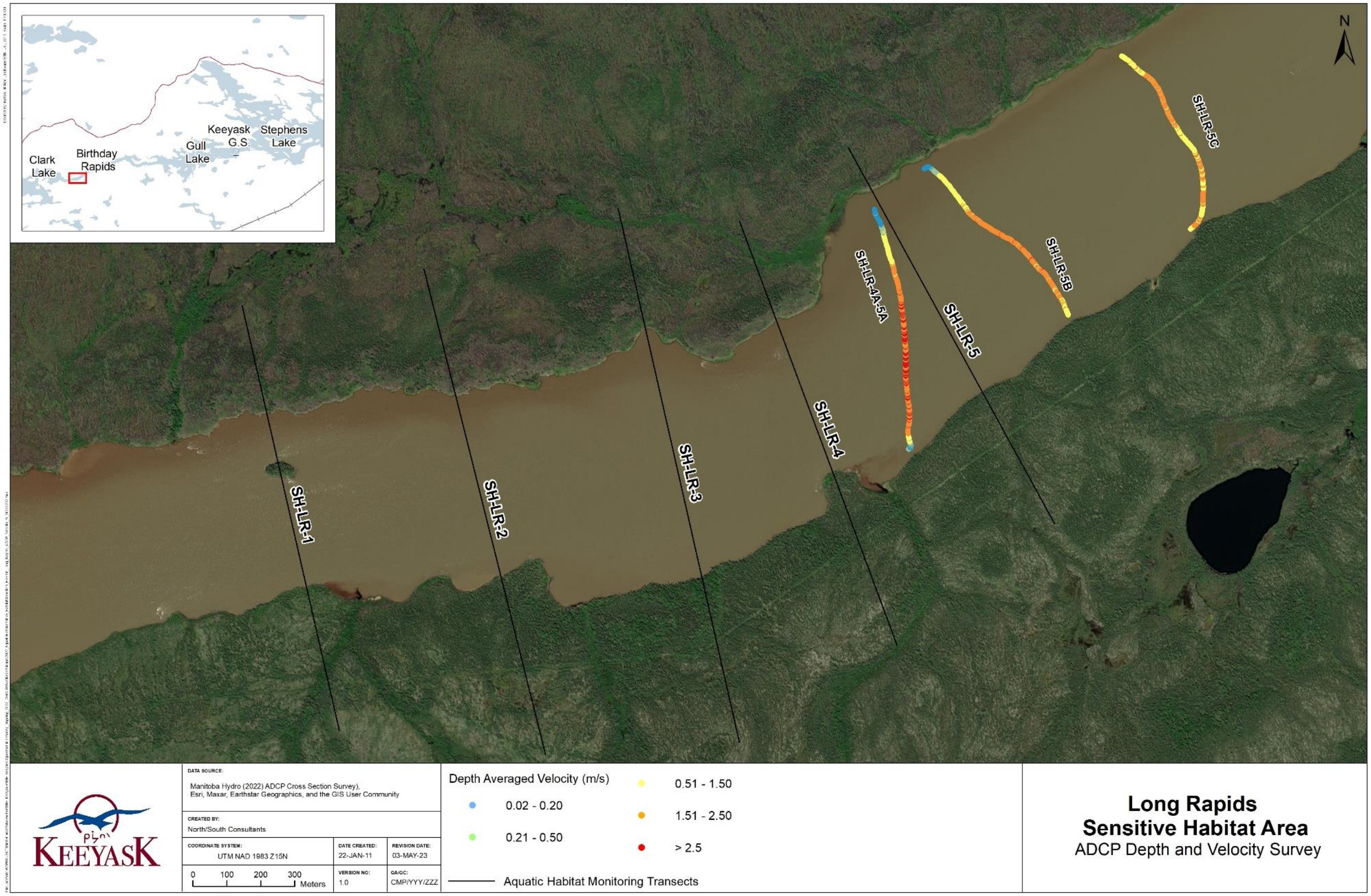
Boat-based ADCP depth and velocity surveys were conducted in the area extending approximately 2 km downstream of Long Rapids on August 31, 2022. Estimated mean Nelson River inflow on this date was high, measuring 6,366 m^3/s (Table 2). High flows caused turbulent water and unsafe boating conditions at the five pre-selected transects so three new transects were surveyed farther downstream (Map 2). Transect 4A-5A, located approximately halfway between Transects 4 and 5, was the farthest upstream surveyed.

Table 2: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the three cross sections surveyed at the Long Rapids sensitive habitat area with the SonTek M9 ADCP on August 31, 2022.

Transect ID	Date	Survey Distance (m)	Estimated Inflow (cms)[1]	Estimated WSE (m)[2]	Depth (m)			Velocity (m/s)		
					Min	Max	Mean	Min	Max	Mean
4A-5A	31-Aug-22	712	6,366	162.4	2.79	9.51	5.71	0.02	3.22	1.60
5B	31-Aug-22	620	6,366	162.4	3.89	9.84	7.20	0.02	3.10	1.54
5C	31-Aug-22	570	6,366	162.4	4.49	9.27	7.80	0.83	2.09	1.51
Summary					**2.79**	**9.84**	**6.95**	**0.02**	**3.22**	**1.55**

1 - Daily mean virtualized Split Lake outflow data provided by MBH.

2 - Water surface elevation (WSE) estimated from daily averages at MBH Gauging Station 05UF759 (150 m downstream of the Clark Lake Exit) and modelled post-Project water surface elevation data provided by MBH.



Map 2: Classified depth averaged velocity data resulting from ADCP transect surveys at the Long Rapids sensitive habitat area, 2022.

The area downstream of Long Rapids was characterized by high water velocities, moderating with distance from the rapids. Water velocities at Transect 4A-5A ranged from 0.02 to 3.22 m/s, with a mean cross section velocity of 1.60 m/s. The highest velocities were recorded in the centre of the river, with standing (lentic) and low water velocities along either bank (Figure 2). The two transects farther downstream were deeper (3.89 m–9.84 m) with more moderate water velocities. Transect 5B contained mostly high water velocities with some standing water along the left (south) bank. Water velocities were moderate or high across the entire river section in Transect 5C.

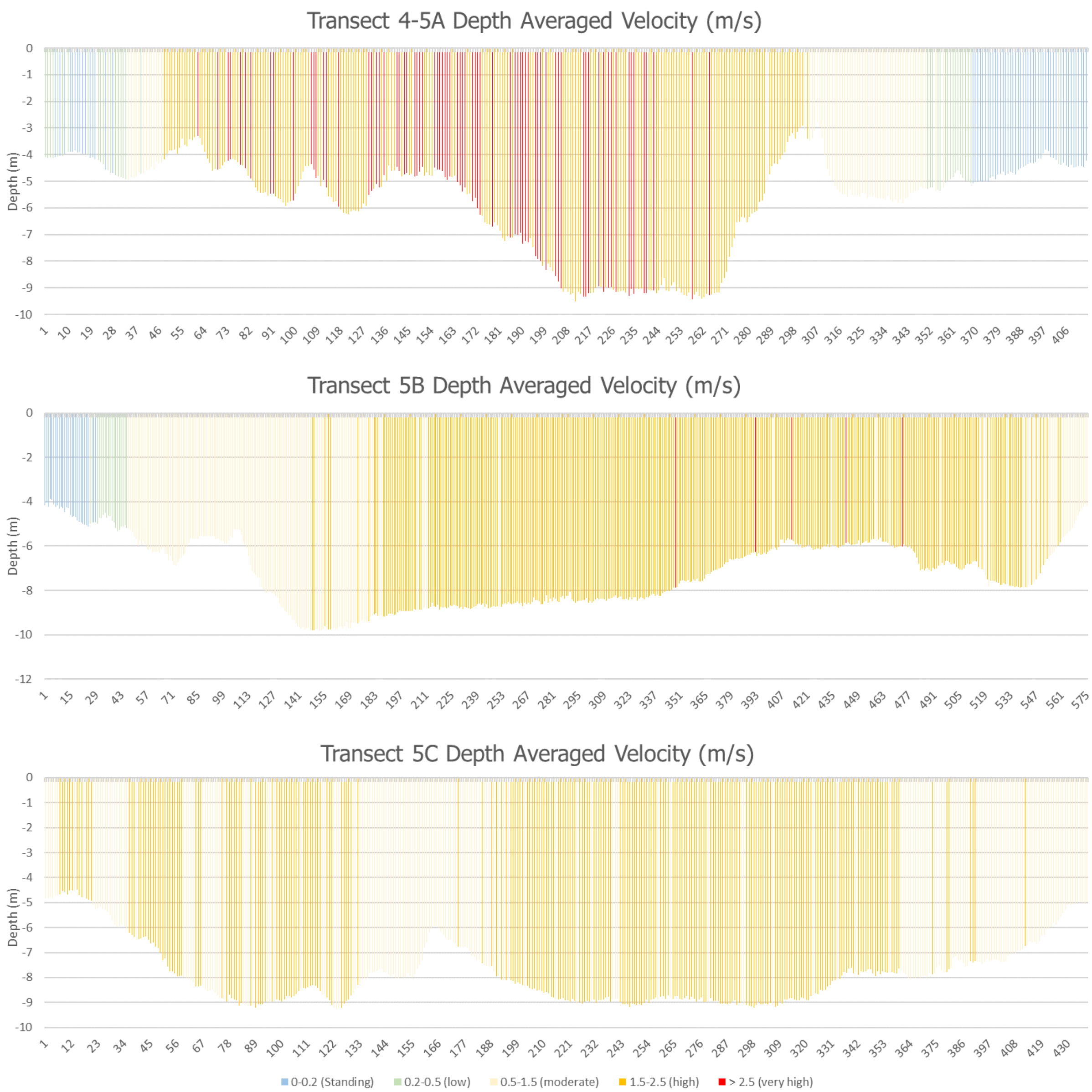


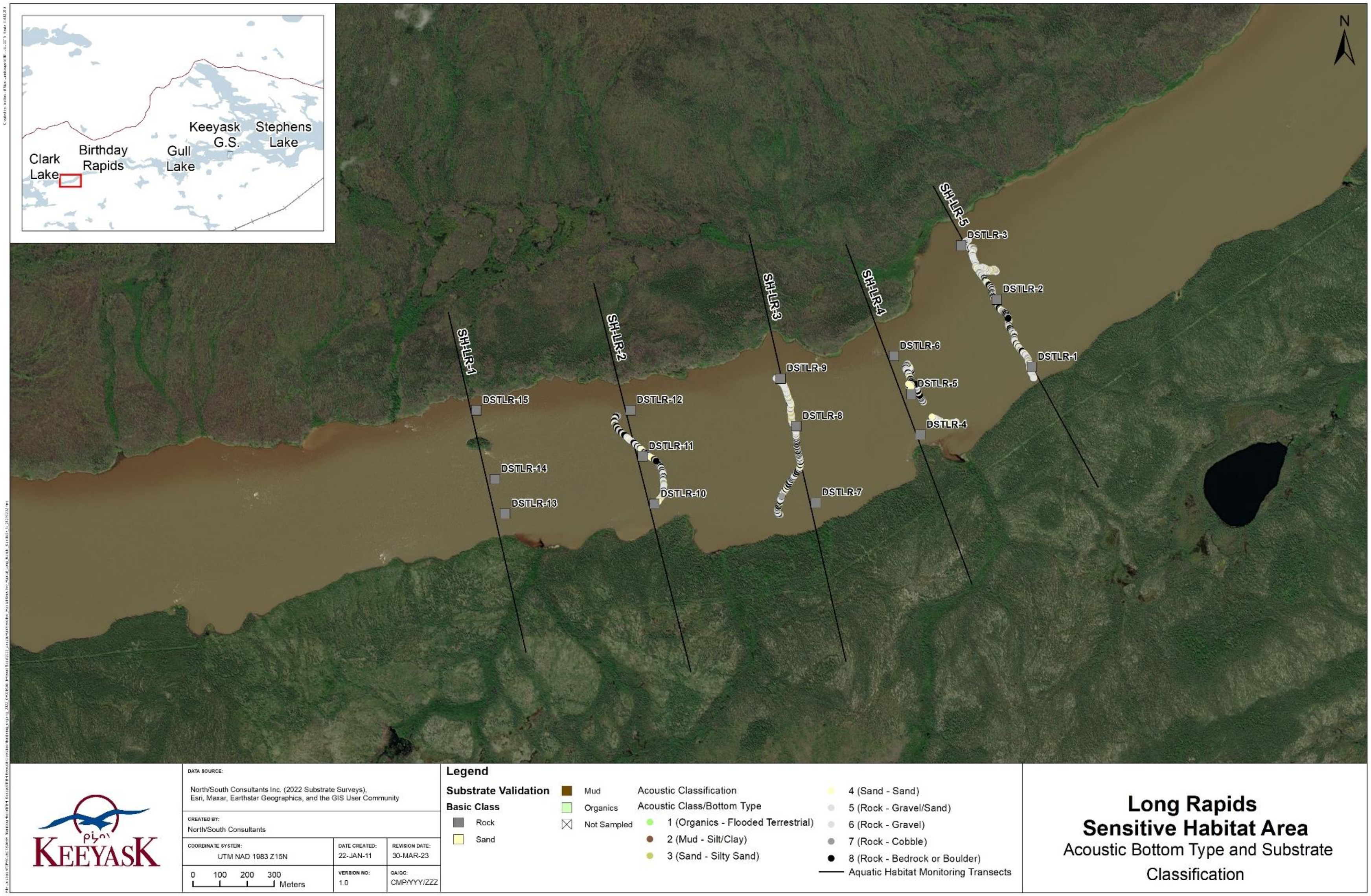
Figure 2: Classified sub-sampled depth averaged velocity representation of three transects sampled using an ADCP at the Long Rapids sensitive habitat area, 2022. Cross sections are viewed looking upstream (left to right bank).

4.1.1.2 SUBSTRATE

Substrate validation and single-beam acoustic surveys were conducted on August 11, 2022. High velocities throughout this reach and the prevalence of large, coarse substrate required the use of a weighted sounding line for determination of bottom types at all 15 sites. Hard substrates were found throughout the reach, classified as boulder and cobble (Table 4; Map 3). The acoustic substrate classification model indicated the area to be dominated by gravel/sand (34%), followed by bedrock/boulder (23%), and gravel (21%) (Table 3). No organics were observed.

Table 3: Results of acoustic classification of single beam data collected along transects at the Long Rapids sensitive habitat area, 2022.

Transect ID	Acoustic Substrate Classification Composition (% Membership)							
	Organics	Mud		Sand	Rock			
	organics/ FT	silt/ clay	silt/ clay/ sand	sand	gravel/ sand	gravel	cobble	bedrock/ boulder
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
1	-	-	-	-	-	-	-	-
2	-	-	4	9	32	22	7	27
3	-	<1	6	9	36	21	7	20
4	-	-	2	8	36	18	10	26
5	-	<1	4	8	32	25	12	18
Summary	**-**	**<1**	**4**	**9**	**34**	**21**	**9**	**23**



Map 3: **Classified acoustic bottom type data and substrate validation results from substrate transect surveys conducted at the Long Rapids sensitive habitat area, 2022.**

Table 4: Locations and results of field bottom type validation sampling and post-survey class verification at the Long Rapids sensitive habitat area, 2022.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
DSTLR-1	weighted sounding line	11-Aug-22	327149	6240365	4.5	hard	cobble	60	boulder	40	-	-	rock	cobble/boulder
DSTLR-2	weighted sounding line	11-Aug-22	327020	6240613	9.0	hard	boulder	100	-	-	-	-	rock	boulder
DSTLR-3	weighted sounding line	11-Aug-22	326889	6240812	5.0	hard	cobble	100	-	-	-	-	rock	cobble
DSTLR-4	weighted sounding line	11-Aug-22	326739	6240115	4.7	hard	boulder	100	-	-	-	-	rock	boulder
DSTLR-5	weighted sounding line	11-Aug-22	326705	6240265	9.0	hard	boulder	100	-	-	-	-	rock	boulder
DSTLR-6	weighted sounding line	11-Aug-22	326641	6240405	5.5	hard	boulder	100	-	-	-	-	rock	boulder
DSTLR-7	weighted sounding line	11-Aug-22	326354	6239865	7.0	hard	boulder	70	cobble	30	-	-	rock	boulder/cobble
DSTLR-8	weighted sounding line	11-Aug-22	326282	6240147	6.0	hard	boulder	90	cobble	10	-	-	rock	boulder/cobble
DSTLR-9	weighted sounding line	11-Aug-22	326223	6240322	4.5	hard	boulder	100	-	-	-	-	rock	boulder
DSTLR-10	weighted sounding line	11-Aug-22	325759	6239860	4.0	hard	cobble	100	-	-	-	-	rock	cobble
DSTLR-11	weighted sounding line	11-Aug-22	325716	6240036	7.0	hard	boulder	100	-	-	-	-	rock	boulder
DSTLR-12	weighted sounding line	11-Aug-22	325671	6240206	-	hard	cobble	100	-	-	-	-	rock	cobble
DSTLR-13	weighted sounding line	11-Aug-22	325209	6239824	5.0	hard	cobble	100	-	-	-	-	rock	cobble
DSTLR-14	weighted sounding line	11-Aug-22	325171	6239952	-	hard	cobble	100	-	-	-	-	rock	cobble
DSTLR-15	weighted sounding line	11-Aug-22	325103	6240205	-	hard	boulder	100	-	-	-	-	rock	boulder

1 – Class verified with digital images and sidescan imagery post-survey.

4.1.2 DOWNSTREAM OF BIRTHDAY RAPIDS

4.1.2.1 DEPTH, WATER LEVEL, AND VELOCITY

Boat-based ADCP depth and velocity surveys were conducted in the area extending approximately 3 km downstream of Birthday Rapids on August 27, 2022. Estimated mean Nelson River inflow was high, measuring 6,401 m^3/s (Table 5). High flows caused turbulent water and unsafe boating conditions close to Birthday Rapids, so surveys were conducted at five of eight transects (Map 4).

The water surface elevation at the time of the survey was estimated to be 160.65 m throughout the reach. The area downstream of Birthday Rapids was characterized by high water velocities, moderating with distance from the rapids. Depth ranged from 3.86 to 13.07 m.

Transect 4 was the farthest upstream transect sampled. This cross section contained mostly high to very high velocities with a small area of moderate to low velocity along the left (south) bank (Figure 3). Mean water velocity was 1.68 m/s, ranging from 0.18 to 3.15 m/s. Transect 5 crosses an island that has deep channels with high to very high velocities on either side. The remaining transects contained largely moderate or high water velocities with areas of low or standing velocities along both banks (Transect 6), left (south) bank (Transect 7), or right (north) bank (Transect 8).

Table 5: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the five cross sections surveyed in the Keeyask reservoir at the Birthday Rapids sensitive habitat area with the SonTek M9 ADCP on August 27, 2022.

Transect ID	Date	Sample Distance (m)	Estimated Inflow[1] (m^3/s)	Estimated WSE[2] (m)	Depth (m)			Velocity (m/s)		
					Min	Max	Mean	Min	Max	Mean
SH1-4	27-Aug-22	532	6,401	160.65	5.13	10.01	7.68	0.18	3.15	1.68
SH1-5	27-Aug-22	600	6,401	160.65	3.86	13.07	8.58	0.02	3.40	1.90
SH1-6	27-Aug-22	905	6,401	160.65	4.48	10.04	7.31	0.00	2.38	0.85
SH1-7	27-Aug-22	576	6,401	160.65	4.30	11.87	9.14	0.01	2.10	1.07
SH1-8	27-Aug-22	545	6,401	160.65	4.77	12.39	9.43	0.31	2.06	1.36
Summary					**3.86**	**13.07**	**8.26**	**0.00**	**3.40**	**1.35**

1 - Estimated or virtualized inflow provided by MBH.

2 - Water levels estimated from daily averages at MBH Gauging Station 05UF771 (175 m downstream of Birthday Rapids).

Map 4: **Classified depth averaged velocity data resulting from ADCP transect surveys in the Keeyask reservoir at the Birthday Rapids sensitive habitat area, 2022.**

Figure 3: Classified sub-sampled depth averaged velocity representation of five transects sampled using an ADCP at the Birthday Rapids sensitive habitat area, 2022. Cross sections are viewed looking upstream (left to right bank).

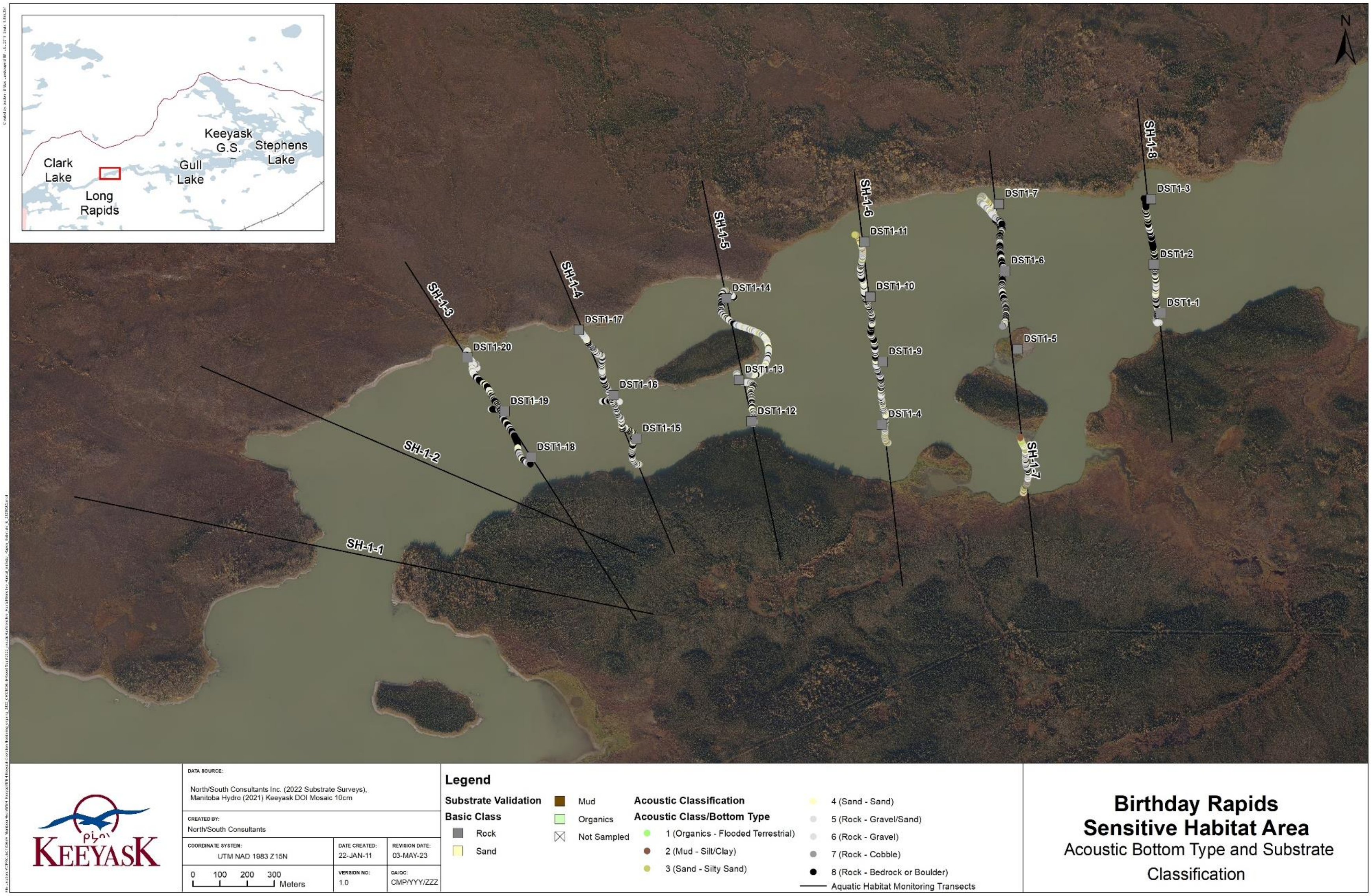
4.1.2.2 SUBSTRATE

Substrate validation and single-beam acoustic surveys were conducted on August 12, 2022. Due to very high water velocities that created unsafe boating conditions, substrate validation was not conducted within Transect 1 or 2 (Map 5).

High velocities throughout this reach and the prevalence of large, coarse substrate required the use of a weighted sounding line for confirmation of bottom types at all sites. Nineteen of the twenty-three substrate validation sites were sampled. Hard substrates were found throughout the reach, classified as boulder and cobble (Table 7). The acoustic classification model indicated the area to be dominated by bedrock/boulder (34%) followed by gravel/sand (21%), and gravel (18%) (Table 6).

Table 6: Results of acoustic classification of single beam data collected along transects in the Keeyask reservoir at the Birthday Rapids sensitive habitat area, 2022.

Transect ID	Acoustic Substrate Classification Composition (% Membership)							
	Organics	Mud		Sand	Rock			
	organics /FT Class 1	silt/ clay Class 2	silt/clay /sand Class 3	sand Class 4	gravel/ sand Class 5	gravel Class 6	cobble Class 7	bedrock /boulder Class 8
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	<1	10	18	23	13	35
4	-	-	-	11	24	21	10	34
5	-	<1	2	10	29	20	14	25
6	-	1	6	11	21	16	15	29
7	2	4	7	7	15	16	18	32
8	-	-	-	10	17	13	12	48
Summary	**2**	**2**	**4**	**10**	**21**	**18**	**14**	**34**



Map 5: **Classified acoustic bottom type data and substrate validation results from substrate transect surveys conducted in the Keeyask reservoir at the Birthday Rapids sensitive habitat area, 2022.**

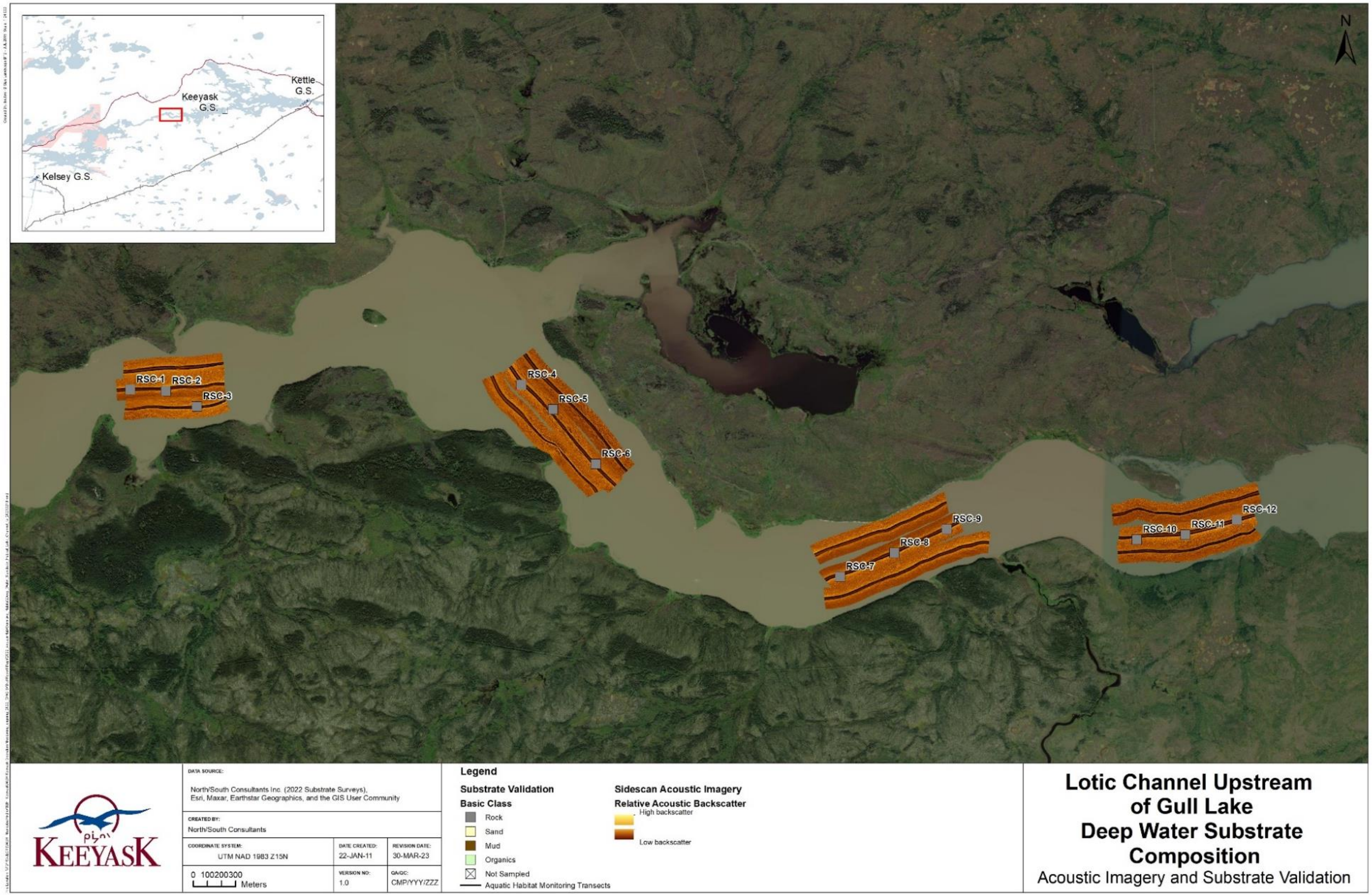
Table 7: Locations and results of field bottom type validation sampling and post-survey class verification in the Keeyask reservoir at the Birthday Rapids sensitive habitat area, 2022.

Site ID	Transect ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
								Substrate 1	%	Substrate 2	%	Substrate 3	%		
DST1-1	8	weighted sounding line	12-Aug-22	334386	6243723	6.8	hard	boulder	70	cobble	30	-	-	rock	boulder/cobble
DST1-2	8	weighted sounding line	12-Aug-22	334361	6243902	9.3	hard	boulder	70	cobble	30	-	-	rock	boulder/cobble
DST1-3	8	weighted sounding line	12-Aug-22	334350	6244143	12.7	hard	boulder	100	-	-	-	-	rock	boulder
DST1-4	7	weighted sounding line	12-Aug-22	333360	6243313	6.5	hard	boulder	60	cobble	40	-	-	rock	boulder/cobble
DST1-5	7	weighted sounding line	12-Aug-22	333859	6243590	2.5	hard	cobble	60	boulder	40	-	-	rock	cobble/boulder
DST1-6	7	weighted sounding line	12-Aug-22	333812	6243878	11.3	hard	boulder	100	-	-	-	-	rock	boulder
DST1-7	7	weighted sounding line	12-Aug-22	333790	6244125	6.2	hard	boulder	100	-	-	-	-	rock	boulder
DST1-8	6	not sampled	12-Aug-22	-	-	-	-	-	-	-	-	-	-	-	-
DST1-9	6	weighted sounding line	12-Aug-22	333363	6243544	6.8	hard	boulder	100	-	-	-	-	rock	boulder
DST1-10	6	weighted sounding line	12-Aug-22	333317	6243783	9.3	hard	boulder	60	cobble	40	-	-	rock	boulder/cobble
DST1-11	6	weighted sounding line	12-Aug-22	333295	6243985	6.2	hard	boulder	60	cobble	40	-	-	rock	boulder/cobble
DST1-12	5	weighted sounding line	12-Aug-22	332880	6243324	6.1	hard	boulder	100	-	-	-	-	rock	boulder
DST1-13	5	weighted sounding line	12-Aug-22	332833	6243477	5.3	hard	boulder	100	-	-	-	-	rock	boulder
DST1-14	5	weighted sounding line	12-Aug-22	332787	6243777	10.4	hard	boulder	60	cobble	40	-	-	rock	boulder/cobble
DST1-15	4	weighted sounding line	12-Aug-22	332456	6243260	6.2	hard	boulder	100	-	-	-	-	rock	boulder
DST1-16	4	weighted sounding line	12-Aug-22	332372	6243421	9.2	hard	boulder	100	-	-	-	-	rock	boulder
DST1-17	4	weighted sounding line	12-Aug-22	332244	6243661	4.6	hard	boulder	100	-	-	-	-	rock	boulder
DST1-18	3	weighted sounding line	12-Aug-22	332068	6243192	8.7	hard	boulder	100	-	-	-	-	rock	boulder
DST1-19	3	weighted sounding line	12-Aug-22	331971	6243361	9.4	hard	boulder	100	-	-	-	-	rock	boulder
DST1-20	3	weighted sounding line	12-Aug-22	331833	6243559	5.2	hard	boulder	100	-	-	-	-	rock	boulder
DST1-21	2	not sampled	12-Aug-22	-	-	-	-	-	-	-	-	-	-	-	-
DST1-22	2	not sampled	12-Aug-22	-	-	-	-	-	-	-	-	-	-	-	-
DST1-23	2	not sampled	12-Aug-22	-	-	-	-	-	-	-	-	-	-	-	-

1 – Class verified with digital images and sidescan imagery post-survey.

4.1.3 MIDDLE KEEYASK RESERVOIR

The middle Keeyask reservoir is not considered a sensitive Lake Sturgeon habitat but was sampled to monitor changes to substrates in deep water areas of the reservoir following impoundment. Substrate validation and single-beam acoustic surveys were conducted within four distinct areas of the middle Keeyask reservoir on August 18, 2022. Twelve substrate validation sites were sampled using a weighted sounding line (Table 8). Hard substrates were found, classified as boulder and cobble. Substrate mapping derived from analysis of sidescan image data confirmed boulder and cobble were present at each site (Map 6).



Map 6: **Map illustrating the results of substrate composition sampling sites and acoustic imaging in the lotic portion of the middle Keeyask reservoir, 2022. Lighter colours in the acoustic imagery indicate harder substrates while darker colours indicate softer substrates.**

Table 8: Locations and results of field bottom type validation sampling and post-survey class verification in the lotic portion of the middle Keeyask reservoir, 2022.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
RSC-1	weighted sounding line	18-Aug-22	335860	6244515	11.9	hard	boulder	100	-	-	-	-	rock	boulder
RSC-2	weighted sounding line	18-Aug-22	336112	6244506	11.7	hard	boulder	100	-	-	-	-	rock	boulder
RSC-3	weighted sounding line	18-Aug-22	336331	6244395	11.0	hard	boulder	100	-	-	-	-	rock	boulder
RSC-4	weighted sounding line	18-Aug-22	338626	6244550	12.2	hard	cobble	60	boulder	40	-	-	rock	cobble/boulder
RSC-5	weighted sounding line	18-Aug-22	338848	6244375	10.5	hard	cobble	60	boulder	40	-	-	rock	cobble/boulder
RSC-6	weighted sounding line	18-Aug-22	339151	6243990	11.9	hard	boulder	100	-	-	-	-	rock	boulder
RSC-7	weighted sounding line	18-Aug-22	340878	6243193	11.7	hard	cobble	60	boulder	40	-	-	rock	cobble/boulder
RSC-8	weighted sounding line	18-Aug-22	341262	6243362	12.7	hard	cobble	60	boulder	40	-	-	rock	cobble/boulder
RSC-9	weighted sounding line	18-Aug-22	341632	6243529	11.5	hard	cobble	60	boulder	40	-	-	rock	cobble/boulder
RSC-10	weighted sounding line	18-Aug-22	342975	6243455	10.6	hard	boulder	60	cobble	40	-	-	rock	boulder/cobble
RSC-11	weighted sounding line	18-Aug-22	343319	6243490	14.6	hard	cobble	60	boulder	40	-	-	rock	cobble/boulder
RSC-12	weighted sounding line	18-Aug-22	343682	6243595	13.1	hard	boulder	60	cobble	40	-	-	rock	boulder/cobble

1 – Class verified with digital images and sidescan imagery post-survey.

4.1.4 ENTRANCE TO GULL LAKE

It was predicted in the EIS that following impoundment of the Keeyask reservoir, decreased water velocities would lead to the deposition of sand downstream of the entrance to Gull Lake and that the area may become important for juvenile Lake Sturgeon rearing.

4.1.4.1 DEPTH, WATER LEVEL, AND VELOCITY

Boat-based ADCP depth and velocity surveys were conducted at nine transects in the area extending approximately 4.5 km downstream of the Gull Lake entrance on August 26 and 27, 2022 (Map 7). Estimated mean Nelson River inflow was high, measuring from 6,374 to 6,401 m^3/s (Table 9). The water surface elevation at the time of survey was estimated to be 159.56 m throughout the reach. Average water depths in the reach ranged from 1.60 to 21.30 m with a mean of 11.93 m. Maximum depths ranged from 14.84 (Transect 1) to 21.30 (Transect 5), making it one of the deeper areas surveyed.

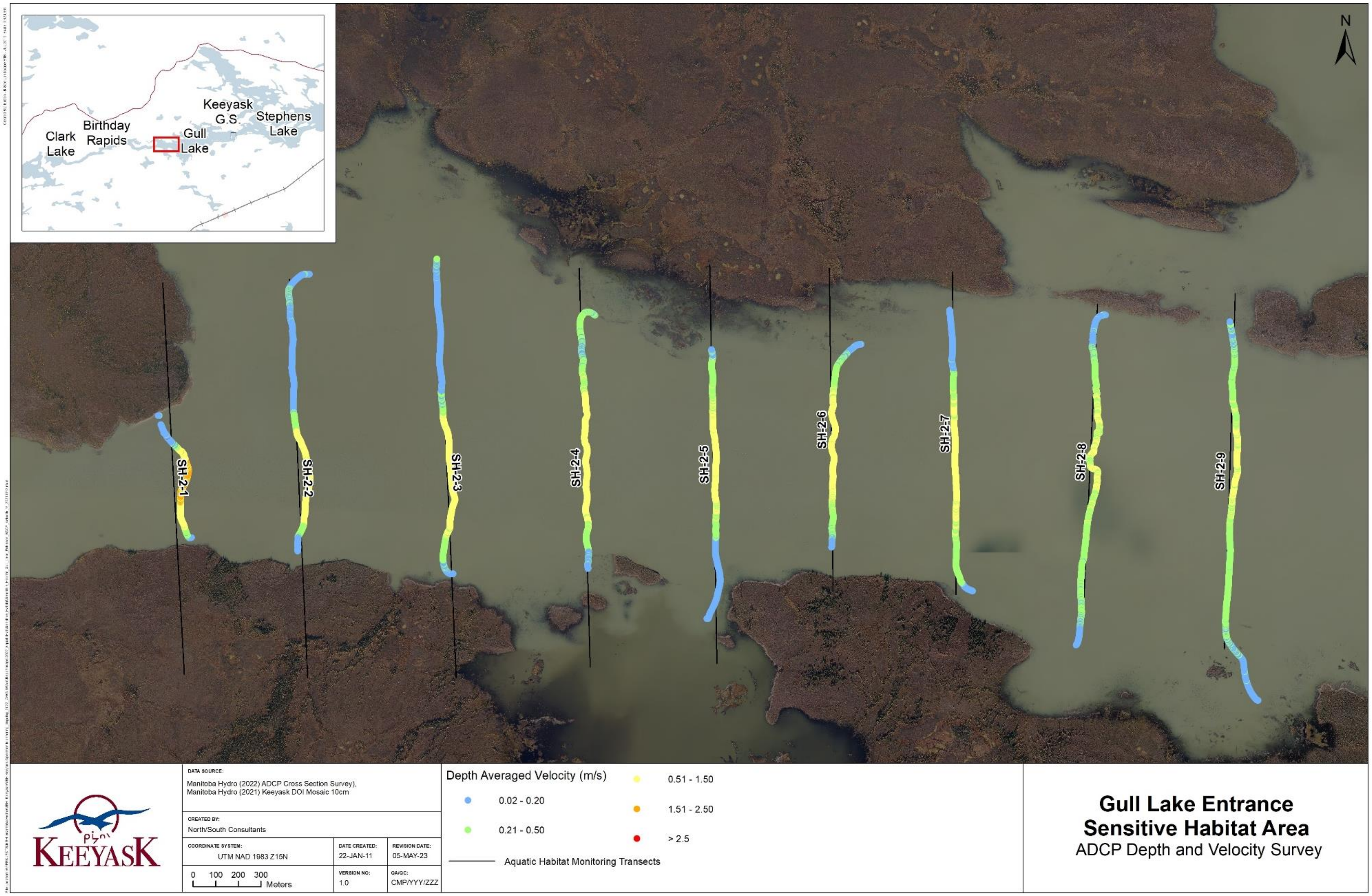
Table 9: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the nine cross sections surveyed in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area with the SonTek M9 ADCP on August 26 and 27, 2022.

Transect ID	Date	Sample Distance (m)	Estimated Inflow[1] (m^3/s)	Estimated WSE[2] (m)	Depth (m)			Velocity (m/s)		
					Min	Max	Mean	Min	Max	Mean
SH2-1	27-Aug-22	612	6,374	159.56	2.96	14.84	12.01	0.04	2.10	1.00
SH2-2	27-Aug-22	1,270	6,374	159.56	8.76	15.40	12.56	0.01	1.67	0.47
SH2-3	27-Aug-22	1,415	6,374	159.56	3.78	16.53	11.08	0.00	1.29	0.45
SH2-4	26-Aug-22	1,175	6,401	159.56	2.55	17.24	11.88	0.01	1.13	0.54
SH2-5	26-Aug-22	1,190	6,401	159.56	1.60	21.30	11.70	0.00	1.08	0.40
SH2-6	26-Aug-22	935	6,401	159.56	1.73	18.61	12.30	0.03	0.95	0.49
SH2-7	26-Aug-22	1,225	6,401	159.56	5.19	17.99	12.49	0.00	0.83	0.42
SH2-8	26-Aug-22	1,488	6,401	159.56	5.31	18.56	12.66	0.00	0.72	0.37
SH2-9	26-Aug-22	1,700	6,401	159.56	1.64	17.47	10.72	0.01	0.74	0.38
Summary					**1.60**	**21.30**	**11.93**	**0.00**	**2.10**	**0.46**

1 - Estimated or virtualized inflow provided by MBH.

2 - Water surface elevation (WSE) estimated from daily averages at MBH Gauging Station 05UF587 (750 m upstream of the Gull Lake entrance).

Water velocity along each transect was similar, with moderate to high water velocities in the middle of the channel (lessening with distance from the inlet) and areas of low and standing water along each shore (Figure 4). Transect 1 is located farthest upstream and had the highest water velocities, ranging from 0.04 to 2.10 m/s. Water velocity ranged from 0.01 to 0.74 m/s in the farthest downstream transect (Transect 9). Maximum water velocities were found roughly within the middle of the channel throughout the reach.



Map 7: **Classified depth averaged velocity data resulting from ADCP transect surveys in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2022.**

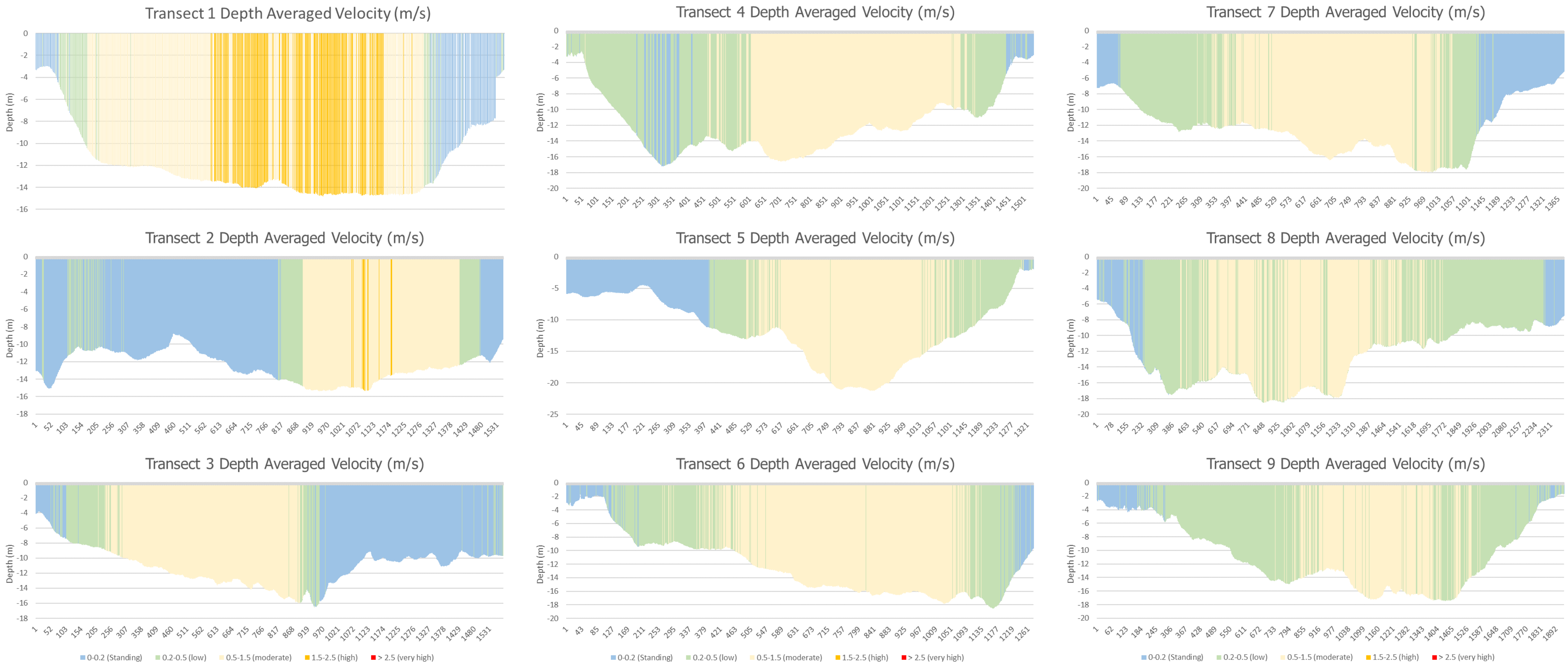


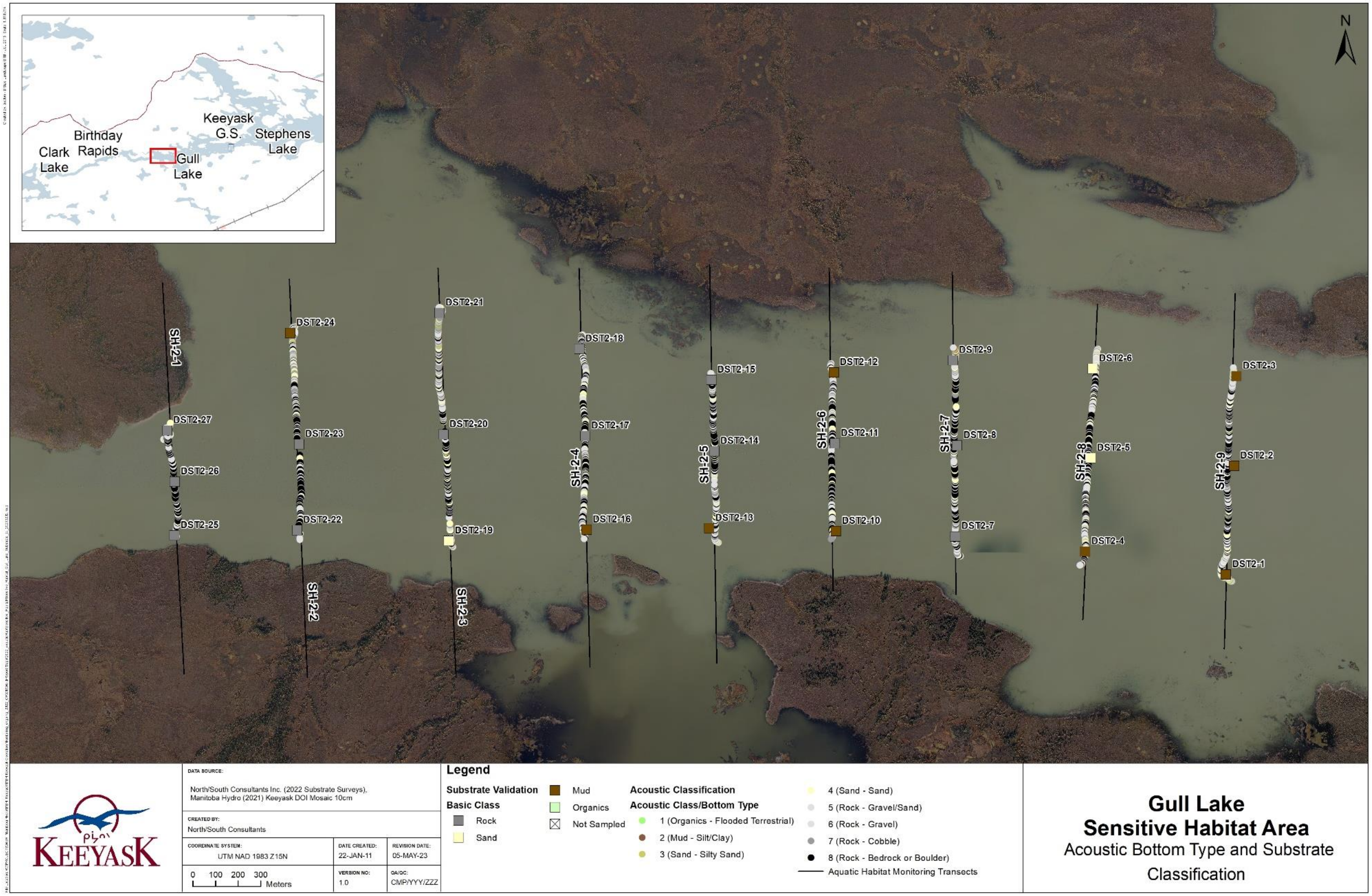
Figure 4: Classified sub-sampled depth averaged velocity representation of nine transects sampled using an ADCP in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2022. Cross sections are viewed looking upstream (left to right bank).

4.1.4.2 SUBSTRATE

Substrate validation and single-beam acoustic surveys were conducted on August 17, 2022. Twenty-seven substrate validation sites were sampled using either a petite Ponar or a weighted sounding line (Table 11). Substrates varied through the reach and consisted of clay, silt, sand, gravel, cobble, and boulder (Map 8). Samples from two sites (DST2-1 and DST2-3) were collected for PSA, which indicated silt was the dominant substrate in both areas (Table A-1). The acoustic classification model indicated the area was dominated by boulder/ bedrock (38%) followed by gravel/sand (22%) (Table 10). Small areas of sand were found throughout the reach, comprising 10% of the substrate in the area. No organics were observed.

Table 10: Results of acoustic classification of single beam data collected along transects in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2022.

Transect ID	Acoustic Substrate Classification Composition (% Membership)							
	Organics	Mud		Sand	Rock			
	organics /FT	silt/ clay	silt/ clay/ sand	sand	gravel/ sand	gravel	cobble	bedrock/ boulder
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
1	-	-	1	8	27	11	8	45
2	-	-	2	8	17	16	17	40
3	-	-	3	10	18	15	24	29
4	-	-	-	13	23	15	10	39
5	-	-	1	11	23	17	11	38
6	-	<1	<1	8	21	12	12	46
7	-	1	2	9	19	17	12	41
8	-	-	1	10	28	17	10	33
9	-	-	2	9	23	21	12	34
Summary	**-**	**1**	**2**	**10**	**22**	**16**	**13**	**38**



Map 8: **Classified acoustic bottom type data and substrate validation results from substrate transect surveys conducted in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2022.**

Table 11: Locations and results of field bottom type validation sampling and post-survey class verification in the Keeyask reservoir at the Gull Lake entrance sensitive habitat area, 2022.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
DST2-1	petite Ponar	17-Aug-22	349796	6243519	9.1	soft	clay	50	sand	25	silt	25	mud	clay/sand/silt
DST2-2	petite Ponar	17-Aug-22	349832	6243999	17.0	soft	silt	70	sand	30	-	-	mud	silt/sand
DST2-3	petite Ponar	17-Aug-22	349843	6244395	9.1	moderate	clay	40	silt	40	sand	20	mud	clay/silt/sand
DST2-4	petite Ponar	17-Aug-22	349174	6243620	8.9	moderate	clay	40	sand	30	silt	30	mud	clay/sand/silt
DST2-5	petite Ponar	17-Aug-22	349199	6244033	17.0	moderate	sand	70	clay	20	silt	10	sand	sand/clay/silt
DST2-6	petite Ponar	17-Aug-22	349208	6244428	16.3	hard	sand	70	silt	30	-	-	sand	sand/silt
DST2-7	petite Ponar	17-Aug-22	348600	6243687	11.6	moderate	silt	60	clay	40	-	-	mud	Silt/clay
DST2-8	petite Ponar	17-Aug-22	348608	6244089	13.0	moderate	gravel	85	sand	15	-	-	rock	gravel/sand
DST2-9	petite Ponar	17-Aug-22	348590	6244465	12.5	hard	cobble	100	-	-	-	-	rock	Cobble
DST2-10	petite Ponar	17-Aug-22	348073	6243710	15.0	moderate	silt	80	sand	20	-	-	mud	silt/sand
DST2-11	petite Ponar	17-Aug-22	348068	6244098	15.8	hard	gravel	95	sand	5	-	-	rock	gravel/sand
DST2-12	petite Ponar	17-Aug-22	348064	6244411	8.0	soft	clay	65	silt	35	-	-	mud	clay/silt
DST2-13	petite Ponar	17-Aug-22	347514	6243723	12.4	soft	clay	60	silt	40	-	-	mud	clay/silt
DST2-14	weighted sounding line	17-Aug-22	347536	6244064	20.6	hard	cobble	100	-	-	-	-	rock	cobble
DST2-15	weighted sounding line	17-Aug-22	347523	6244379	9.3	hard	cobble	100	-	-	-	-	rock	cobble
DST2-16	petite Ponar	17-Aug-22	346972	6243717	10.5	hard	silt	80	clay	20	-	-	mud	silt/clay
DST2-17	weighted sounding line	17-Aug-22	346966	6244131	12.9	hard	cobble	100	-	-	-	-	rock	cobble
DST2-18	weighted sounding line	17-Aug-22	346940	6244516	16.4	hard	cobble	100	-	-	-	-	rock	cobble
DST2-19	petite Ponar	17-Aug-22	346363	6243667	8.6	moderate	sand	60	silt	40	-	-	sand	sand/silt
DST2-20	weighted sounding line	17-Aug-22	346340	6244137	13.8	hard	cobble	100	-	-	-	-	rock	cobble
DST2-21	weighted sounding line	17-Aug-22	346322	6244674	9.6	hard	cobble	100	-	-	-	-	rock	cobble
DST2-22	weighted sounding line	17-Aug-22	345694	6243714	11.5	hard	cobble	100	-	-	-	-	rock	cobble
DST2-23	petite Ponar	17-Aug-22	345702	6244094	14.7	hard	cobble	100	-	-	-	-	rock	cobble
DST2-24	petite Ponar	17-Aug-22	345663	6244585	10.7	hard	silt	100	-	-	-	-	mud	silt
DST2-25	weighted sounding line	17-Aug-22	345151	6243691	5.5	hard	boulder	51	cobble	51	-	-	rock	boulder/cobble
DST2-26	weighted sounding line	17-Aug-22	345153	6243929	13.3	hard	boulder	50	cobble	50	-	-	rock	boulder/cobble
DST2-27	weighted sounding line	17-Aug-22	345119	6244155	9.3	hard	boulder	100	-	-	-	-	rock	boulder

1 – Class verified with digital images and sidescan imagery post-survey.

4.1.5 GULL LAKE LOTIC CHANNEL

Substrate validation and single-beam acoustic surveys were conducted within a lotic channel in upper Gull Lake on August 18, 2022. Three substrate validation sites were sampled using a weighted sounding line (Table 12). Hard substrates were found, classified as boulder and cobble. Substrate mapping derived from analysis of sidescan image data confirmed boulder and cobble were present at each site (Map 9).

Map 9: **Map illustrating the results of substrate composition sampling sites and acoustic imaging in the lotic portion of upper Gull Lake, 2022. Lighter colours in the acoustic imagery indicate harder substrates while darker colours indicate softer substrates.**

Table 12: Locations and results of field bottom type validation sampling and post-survey class verification in a lotic channel within upper Gull Lake, 2022.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition						Basic Class	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%		
RSC-13	weighted sounding line	18-Aug-22	351722	6243395	19.7	hard	cobble	100	-	-	-	-	rock	cobble
RSC-14	weighted sounding line	18-Aug-22	352198	6243439	18.7	hard	cobble	60	boulder	40	-	-	rock	cobble/boulder
RSC-15	weighted sounding line	18-Aug-22	352632	6243638	17.9	hard	cobble	60	boulder	40	-	-	rock	cobble/boulder

1 – Class verified with digital images and sidescan imagery post-survey.

4.1.6 CARIBOU ISLAND

4.1.6.1 DEPTH, WATER LEVEL, AND VELOCITY

Boat-based ADCP depth and velocity surveys were conducted in the area of Gull Lake approaching and surrounding Caribou Island on August 29 and 31, 2022 (Map 10). Estimated mean inflow was high, ranging from 6,366 to 6,445 m^3/s (Table 13). The water surface elevation at the time of the survey was estimated to be 159.03 to 159.04 m throughout the reach. Average water depths ranged from 0.61 to 20.81 m with a mean of 9.03 m.

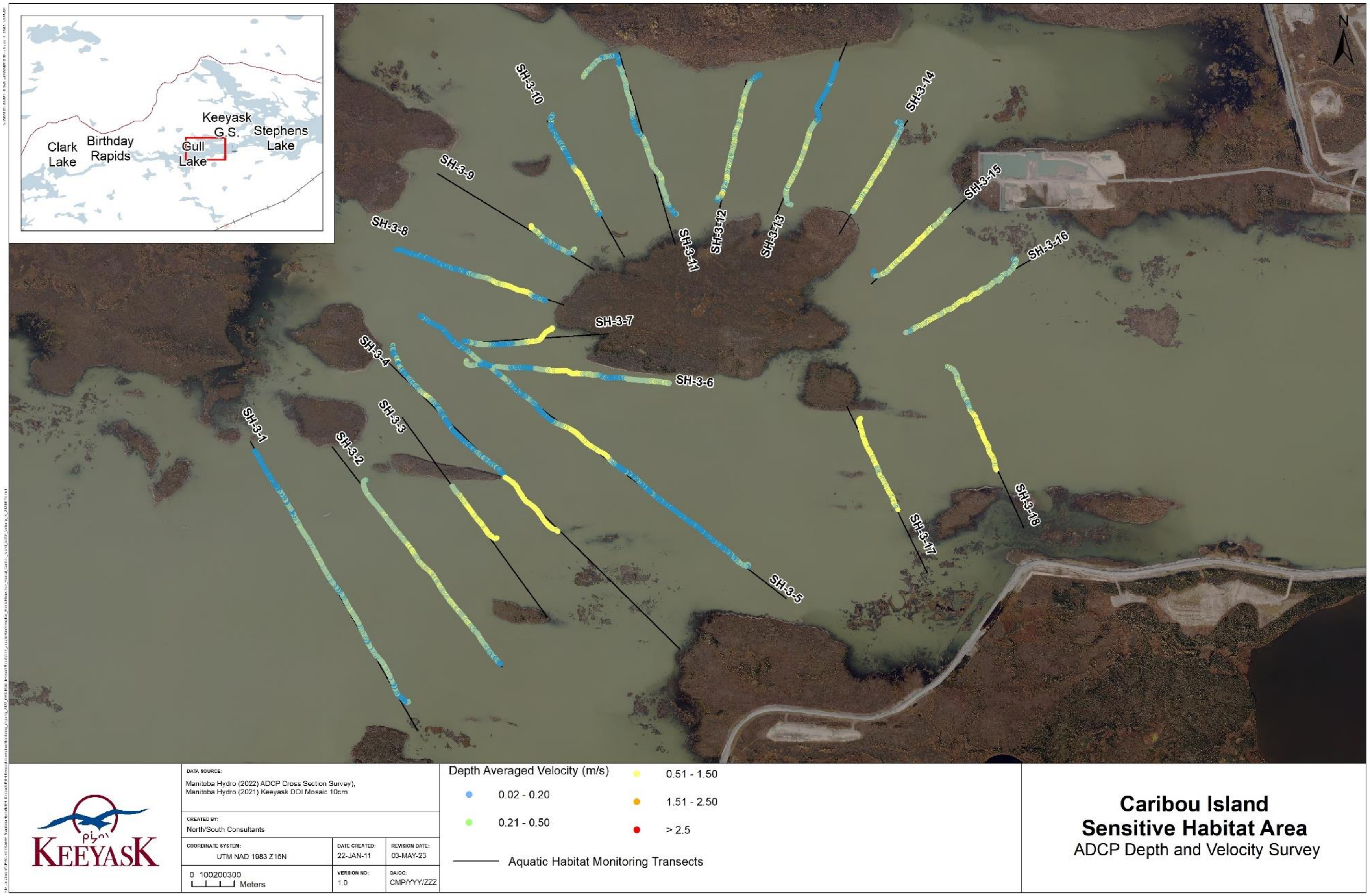
Table 13: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the 18 cross sections surveyed in the Keeyask reservoir at the Caribou Island sensitive habitat area with the SonTek M9 ADCP on August 29 and 31, 2022.

Transect ID	Date	Sample Distance (m)	Estimated Inflow[1] (m^3/s)	Estimated WSE[2] (m)	Depth (m)			Velocity (m/s)		
					Min	Max	Mean	Min	Max	Mean
SH3-1	31-Aug-22	2,100	6,366	159.03	4.46	19.28	10.01	0.00	0.60	0.25
SH3-2	31-Aug-22	1,680	6,366	159.03	2.10	20.81	10.48	0.07	0.73	0.40
SH3-3	31-Aug-22	520	6,366	159.03	5.70	18.65	13.79	0.36	0.85	0.56
SH3-4	31-Aug-22	1,831	6,366	159.03	0.61	20.52	7.59	0.02	1.44	0.45
SH3-5	31-Aug-22	2,953	6,366	159.03	1.46	19.10	9.06	0.00	1.07	0.23
SH3-6	31-Aug-22	1,501	6,366	159.03	6.53	16.39	9.56	0.00	0.87	0.36
SH3-7	31-Aug-22	774	6,366	159.03	2.18	15.62	9.20	0.01	1.14	0.43
SH3-8	31-Aug-22	1,156	6,366	159.03	3.70	14.30	9.04	0.01	1.02	0.31
SH3-9	29-Aug-22	406	6,445	159.04	5.97	12.99	8.86	0.01	1.09	0.31
SH3-10	29-Aug-22	930	6,445	159.04	4.04	17.52	8.86	0.00	1.03	0.31
SH3-11	29-Aug-22	1,280	6,445	159.04	1.97	16.12	7.99	0.00	0.87	0.28
SH3-12	29-Aug-22	927	6,445	159.04	6.55	16.04	8.79	0.01	1.62	0.37
SH3-13	29-Aug-22	1,068	6,445	159.04	3.47	15.12	8.89	0.00	0.92	0.27
SH3-14	29-Aug-22	746	6,445	159.04	1.24	15.24	7.80	0.04	1.48	0.43
SH3-15	29-Aug-22	755	6,445	159.04	2.39	14.64	9.20	0.02	2.01	0.51
SH3-16	29-Aug-22	991	6,445	159.04	1.96	13.25	7.47	0.01	1.23	0.45
SH3-17	29-Aug-22	743	6,445	159.04	1.55	17.72	7.54	0.06	1.50	0.67
SH3-18	29-Aug-22	859	6,445	159.04	7.22	17.97	11.28	0.05	1.59	0.64
Summary					**0.61**	**20.81**	**9.03**	**0.00**	**2.01**	**0.37**

1 - Estimated or virtualized inflow provided by MBH.

2 - Water levels estimated from daily averages at MBH Gauging Station 05UF596 (175 m downstream of Birthday Rapids).

The entire reach was characterized by areas of low to moderate water velocity surrounded by areas of standing water (Figure 5). Minimum water velocities ranged from 0.00–0.36 m/s (Transects 1 and 3, respectively) and maximum ranged from 0.60–2.01 m/s (Transects 1 and 14, respectively). Mean cross sectional water velocities ranged from 0.23–0.67 m/s.



Map 10: **Classified depth averaged velocity data resulting from ADCP transect surveys in the Keeyask reservoir in the area surrounding Caribou Island, 2022.**

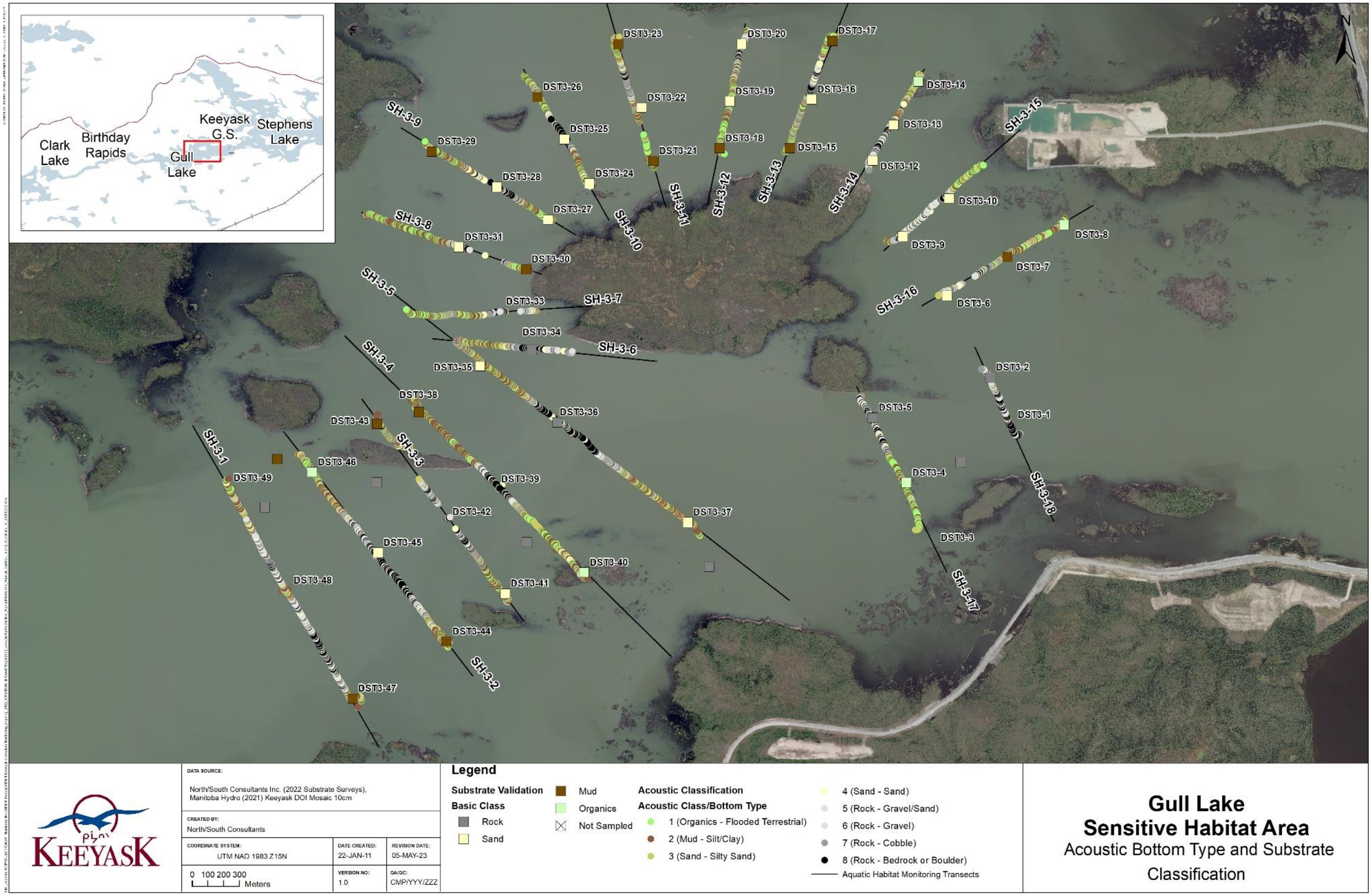
Figure 5: Classified sub-sampled depth averaged velocity representation of 18 transects sampled using an ADCP in the Keeyask reservoir at the Caribou Island sensitive habitat area, 2022. Cross sections are viewed looking upstream (left to right bank).

4.1.6.2 SUBSTRATE

Substrate validation and single-beam acoustic surveys were conducted on August 14, 2022. Substrate was sampled at 48 sites; a petite Ponar was used at 44 sites, while a weighted sounding line was used at four sites where a grab could not be collected with a petite Ponar due to rocky substrate (Table 14). Samples from ten sites were collected for PSA (Table A-1).

Substrates were varied throughout the reach, ranging from hard boulder to areas of soft silt. Sand was the dominant substrate type in six sites located within the middle of the channel to the north of Caribou Island, previously identified as important Lake Sturgeon rearing habitat (Map 11; Photo 1). Five of these sites were sampled for PSA which confirmed that sand was the predominant substrate from four (DST3-16, -22, -25, and -28). This area of sand was bordered on the upstream and downstream sides by areas of mud (*i.e.,* silt and clay). Silt deposition was evident at two of the six sites.

Photo 1: Substrate collected at site DST3-28 in the area of the Keeyask reservoir surrounding Caribou Island showing sand.



Map 11: **Classified acoustic bottom type data and substrate validation results from substrate transect surveys conducted in the Keeyask reservoir in the area surrounding Caribou Island, 2022.**

Table 14: Locations and results of field bottom type validation sampling and post-survey class verification in the Keeyask reservoir at the Caribou Island sensitive habitat area, 2022.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition								Basic Class	Silt Deposition Evident	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%			
DST3-01	weighted sounding line	14-Aug-22	358690	6245790	18.0	hard	cobble	100	-	-	-	-	-	-	rock	no	cobble
DST3-02	petite Ponar	14-Aug-22	358553	6246092	10.0	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST3-03	petite Ponar	14-Aug-22	358203	6245008	2.4	soft	organics	100	-	-	-	-	-	-	organic	no	organic
DST3-04	petite Ponar	14-Aug-22	358021	6245422	2.6	soft	organics	100	-	-	-	-	-	-	organic	no	organic
DST3-05	weighted sounding line	14-Aug-22	357807	6245836	16.1	hard	cobble	100	-	-	-	-	-	-	rock	no	cobble
DST3-06	petite Ponar	14-Aug-22	358280	6246613	11.0	soft	sand	65	silt	20	organics	10	clay	5	mud	yes	sand/silt/organics/clay
DST3-07	petite Ponar	14-Aug-22	358664	6246858	6.3	soft	silt	50	clay	30	sand	20	-	-	mud	yes	silt/clay/sand
DST3-08	petite Ponar	14-Aug-22	359023	6247063	3.1	soft	organics	60	silt	40	-	-	-	-	organic	yes	organic/silt
DST3-09	petite Ponar	14-Aug-22	357998	6246990	9.3	moderate	sand	90	silt	10	-	-	-	-	sand	yes	sand/silt
DST3-10	petite Ponar	14-Aug-22	358292	6247230	10.8	soft	sand	90	silt	10	-	-	-	-	sand	yes	sand/silt
DST3-12	petite Ponar	14-Aug-22	357806	6247471	10.6	moderate	organics	50	sand	50	-	-	-	-	sand	no	organics/sand
DST3-13	petite Ponar	14-Aug-22	357939	6247698	6.7	moderate	sand	100	-	-	-	-	-	-	sand	no	sand
DST3-15	petite Ponar	14-Aug-22	357282	6247551	7.5	soft	silt	60	sand	25	clay	15	-	-	mud	yes	silt/sand/clay
DST3-14	petite Ponar	14-Aug-22	358096	6247975	3.1	soft	organics	100	-	-	-	-	-	-	organic	No	organic
DST3-16	petite Ponar	14-Aug-22	357419	6247861	11.2	moderate	sand	80	silt	20	-	-	-	-	sand	yes	sand/silt
DST3-17	petite Ponar	14-Aug-22	357552	6248233	7.3	soft	clay	75	silt	25	-	-	-	-	mud	yes	clay/silt
DST3-18	petite Ponar	14-Aug-22	356835	6247550	7.0	soft	clay	75	silt	15	sand	10	-	-	mud	yes	clay/silt/sand
DST3-19	petite Ponar	14-Aug-22	356899	6247848	7.0	moderate	silt	80	sand	20	-	-	-	-	silt	yes	silt/sand
DST3-20	petite Ponar	14-Aug-22	356975	6248213	15.2	moderate	sand	75	silt	25	-	-	-	-	sand	yes	sand/silt
DST3-21	petite Ponar	14-Aug-22	356415	6247469	6.7	soft	clay	85	silt	15	-	-	-	-	mud	yes	clay/silt
DST3-22	petite Ponar	14-Aug-22	356339	6247808	8.0	moderate	sand	85	silt	10	clay	5	-	-	sand	yes	sand/silt/clay
DST3-23	petite Ponar	14-Aug-22	356190	6248213	9.5	soft	clay	80	silt	20	-	-	-	-	mud	yes	clay/silt
DST3-24	petite Ponar	14-Aug-22	356008	6247325	2.7	soft	organics	95	silt	5	-	-	-	-	organic	yes	organic/silt
DST3-25	petite Ponar	14-Aug-22	355848	6247608	13.4	moderate	sand	100	-	-	-	-	-	-	sand	no	sand
DST3-26	petite Ponar	14-Aug-22	355678	6247875	6.3	soft	clay	60	silt	25	sand	15	-	-	mud	yes	clay/silt/sand
DST3-27	petite Ponar	14-Aug-22	355744	6247096	6.5	soft	sand	35	clay	35	silt	30	-	-	sand	yes	sand/clay/silt
DST3-28	petite Ponar	14-Aug-22	355419	6247303	13.4	moderate	sand	100	-	-	-	-	-	-	sand	no	sand
DST3-29	petite Ponar	14-Aug-22	355006	6247529	6.8	soft	clay	85	silt	15	-	-	-	-	mud	yes	clay/silt
DST3-30	petite Ponar	14-Aug-22	355605	6246779	6.4	soft	clay	70	silt	25	organics	5	-	-	mud	yes	clay/silt/organic
DST3-31	petite Ponar	14-Aug-22	355178	6246921	12.8	soft	sand	60	gravel	30	silt	10	-	-	sand	yes	sand/gravel/silt
DST3-32	petite Ponar	14-Aug-22	354632	6247106	7.1	soft	clay	85	silt	15	-	-	-	-	mud	yes	clay/silt
DST3-33	petite Ponar	14-Aug-22	355442	6246511	14.8	hard	gravel	50	sand	50	-	-	-	-	rock	no	gravel/sand
DST3-34	petite Ponar	14-Aug-22	355640	6246268	14.1	hard	gravel	75	sand	25	-	-	-	-	rock	no	gravel/sand
DST3-35	petite Ponar	14-Aug-22	355313	6246165	7.5	moderate	sand	50	clay	40	silt	10	-	-	sand	yes	sand/clay/silt
DST3-36	weighted sounding line	14-Aug-22	355804	6245807	15	hard	cobble	100	-	-	-	-	-	-	rock	no	cobble
DST3-37	petite Ponar	14-Aug-22	356632	6245171	7.5	moderate	sand	45	clay	35	silt	20	-	-	sand	yes	sand/clay/silt
DST3-38	petite Ponar	14-Aug-22	354925	6245870	7.6	soft	clay	90	silt	10	-	-	-	-	mud	yes	clay/silt
DST3-39	weighted sounding line	14-Aug-22	355410	6245382	19.0	hard	cobble	100	-	-	-	-	-	-	rock	no	cobble

Table 14: Locations and results of field bottom type validation sampling and post-survey class verification in the Keeyask reservoir at the Caribou Island sensitive habitat area, 2022 (continued).

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition								Basic Class	Silt Deposition Evident	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%			
DST3-40	petite Ponar	14-Aug-22	355973	6244852	3.0	soft	organics	100	-	-	-	-	-	-	organic	no	organic
DST3-41	petite Ponar	14-Aug-22	355471	6244717	7.1	moderate	sand	70	silt	25	organics	5	-	-	sand	yes	sand/silt/organic
DST3-42	petite Ponar	14-Aug-22	355109	6245213	17.0	hard	gravel	90	sand	10	-	-	-	-	rock	no	gravel/sand
DST3-43	petite Ponar	14-Aug-22	354659	6245798	6.9	moderate	clay	45	sand	45	silt	10	-	-	mud	yes	clay/sand/silt
DST3-44	petite Ponar	14-Aug-22	355101	6244413	7.9	soft	clay	80	silt	15	organics	5	-	-	mud	yes	clay/silt/organic
DST3-45	petite Ponar	14-Aug-22	354663	6244978	16.4	moderate	sand	95	silt	5	-	-	-	-	sand	yes	sand/silt
DST3-46	petite Ponar	14-Aug-22	354246	6245490	2.5	soft	organics	100	-	-	-	-	-	-	organic	no	organic
DST3-47	petite Ponar	14-Aug-22	354502	6244050	7.5	soft	silt	100	-	-	-	-	-	-	mud	yes	silt
DST3-48	petite Ponar	14-Aug-22	354092	6244738	7.9	soft	sand	75	silt	25	-	-	-	-	sand	yes	sand/silt
DST3-49	petite Ponar	14-Aug-22	353711	6245388	7.4	soft	clay	90	silt	10	-	-	-	-	mud	yes	clay/silt

1 – Class verified with digital images and sidescan imagery post-survey.

The acoustic classification model indicated the area was dominated by mud (28% silt/clay and 13% silt/clay/sand) and organics (17%) (Table 15). Acoustic signatures for sand and gravel/sand were found in 6% and 9% of the reach, respectively. Rocky substrates including gravel (6%), cobble (12%) and bedrock/boulder (12%) were also found.

Table 15: Results of acoustic classification of single beam data collected along transects in the Keeyask reservoir at the Caribou Island sensitive habitat area, 2022.

Transect ID	Acoustic Substrate Classification Composition (% Membership)							
	Organics	Mud		Sand		Rock		
	organics/FT	silt/clay	silt/clay/sand	sand	gravel/sand	gravel	cobble	bedrock/boulder
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
1	6	20	10	9	15	13	12	14
2	10	24	12	7	11	9	9	19
3	16	30	9	5	9	6	14	12
4	19	38	17	5	6	2	5	8
5	9	35	17	4	6	2	14	14
6	9	25	14	5	13	5	14	14
7	21	28	16	4	3	5	18	4
8	28	41	12	3	2	3	7	4
9	27	34	12	5	1	3	11	9
10	19	36	13	7	2	4	7	11
11	22	30	16	1	2	2	24	3
12	26	29	11	3	5	5	17	5
13	19	21	18	4	5	2	25	7
14	8	19	16	9	19	9	9	12
15	13	14	5	11	21	13	14	10
16	13	27	18	5	7	8	17	5
17	27	21	11	8	12	3	3	16
18	-	-	1	9	27	15	6	43
Summary	**17**	**28**	**13**	**6**	**9**	**6**	**12**	**12**

4.1.7 STEPHENS LAKE

4.1.7.1 DEPTH, WATER LEVEL, AND VELOCITY

Boat-based ADCP depth and velocity surveys were conducted in the area extending from approximately 1.0–7.5 km downstream of the Keeyask GS on August 28, 2022. Estimated mean inflow was high, measuring 6,404 m^3/s (Table 16). The water surface elevation at the time of the survey was estimated to be 141.26 m throughout the reach. Average water depths ranged from 0.89 to 21.27 m with a mean of 12.77 m.

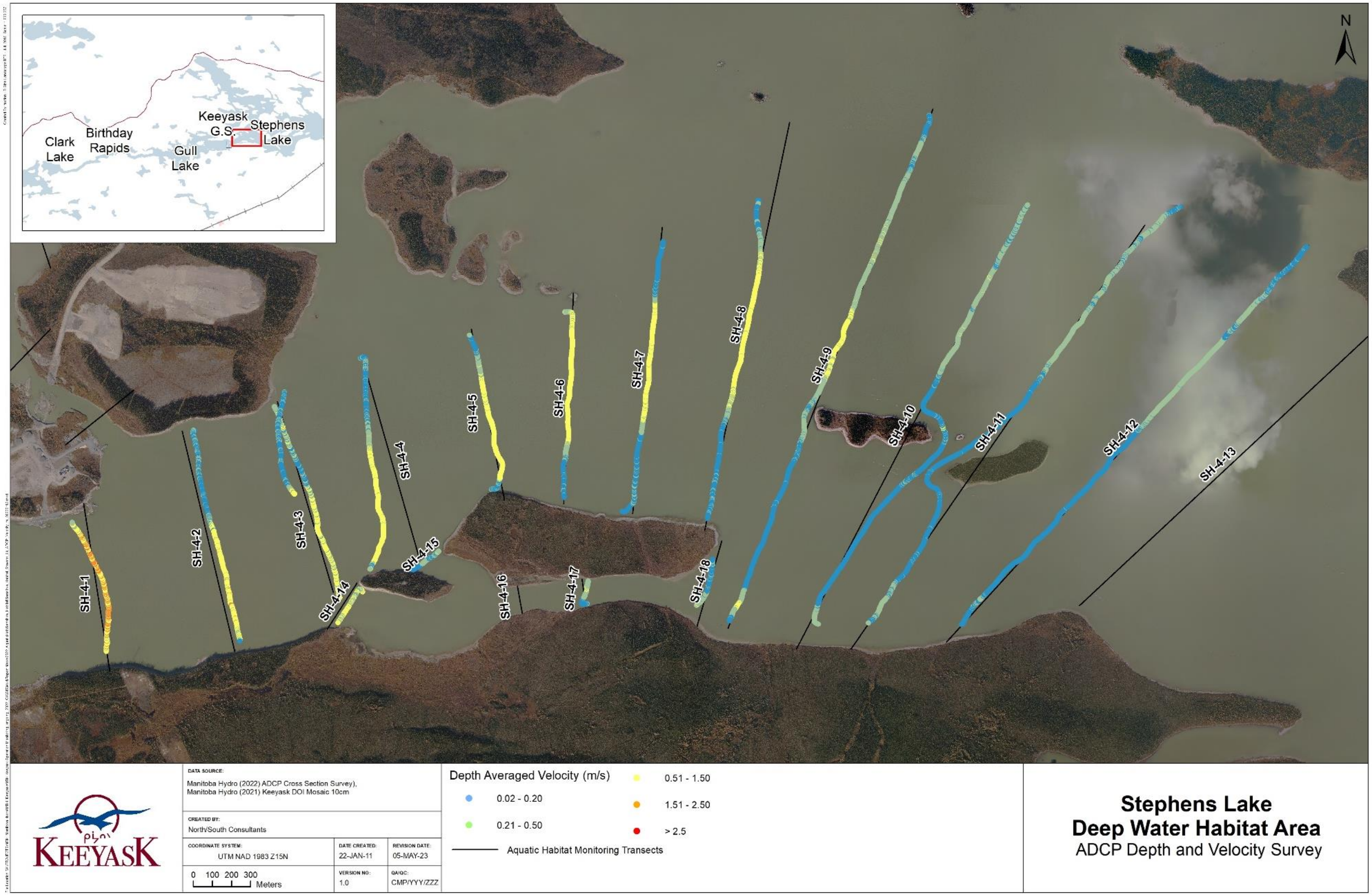
Transect 1 was the farthest upstream transect sampled in Stephens Lake, located approximately 1 km downstream of the Keeyask GS. This cross section contained moderate to very high velocities throughout (Figure 6). Mean water velocity was 1.44 m/s, ranging from 0.22 to 3.74 m/s. A channel of moderate water velocity extended approximately 6 km downstream (Transect 9), after which velocities became low (Map 12).

Table 16: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for the 16 cross sections surveyed in the Stephens Lake sensitive habitat area with the SonTek M9 ADCP on August 28, 2022.

Transect ID	Date	Sample Distance (m)	Estimated Inflow[1] (m^3/s)	Estimated WSE[2] (m)	Depth (m)			Velocity (m/s)		
					Min	Max	Mean	Min	Max	Mean
SH4-1	28-Aug-22	750	6,404	141.26	1.64	10.37	6.05	0.22	3.74	1.44
SH4-2	28-Aug-22	1,170	6,404	141.26	5.96	13.16	11.04	0.01	1.81	0.56
SH4-3	28-Aug-22	1,092	6,404	141.26	4.02	14.79	12.64	0.01	1.82	0.37
SH4-4	28-Aug-22	1,191	6,404	141.26	2.22	15.80	13.43	0.00	1.29	0.52
SH4-5	28-Aug-22	875	6,404	141.26	2.23	16.89	13.62	0.01	1.17	0.56
SH4-6	28-Aug-22	976	6,404	141.26	4.01	18.41	13.83	0.01	1.18	0.62
SH4-7	28-Aug-22	1,467	6,404	141.26	8.29	16.89	14.74	0.00	0.87	0.33
SH4-8	28-Aug-22	1,734	6,404	141.26	2.21	17.41	14.35	0.01	0.89	0.41
SH4-9	28-Aug-22	2,922	6,404	141.26	2.08	18.26	11.74	0.00	2.12	0.29
SH4-10	28-Aug-22	2,506	6,404	141.26	0.89	21.27	12.41	0.00	2.20	0.18
SH4-11	28-Aug-22	2,791	6,404	141.26	2.29	19.47	13.58	0.01	0.44	0.18
SH4-12	28-Aug-22	2,756	6,404	141.26	3.92	19.11	14.3	0.00	0.39	0.16
SH4-14	28-Aug-22	275	6,404	141.26	5.11	7.78	6.54	0.10	0.94	0.52
SH4-15	28-Aug-22	226	6,404	141.26	1.19	9.63	5.53	0.00	0.60	0.19
SH4-17	28-Aug-22	184	6,404	141.26	6.91	11.88	10.21	0.01	0.6.	0.29
SH4-18	28-Aug-22	319	6,404	141.26	1.63	9.88	5.30	0.03	0.55	0.25
Summary					**0.89**	**21.27**	**12.77**	**0.00**	**3.74**	**0.32**

1 - Estimated or virtualized inflow provided by MBH.

2 - Water levels estimated from daily averages at MBH Gauging Station 05UF709 (Stephens Lake).



Map 12: **Classified depth averaged velocity data resulting from ADCP transect surveys conducted in the upstream portion of Stephens Lake, 2022.**

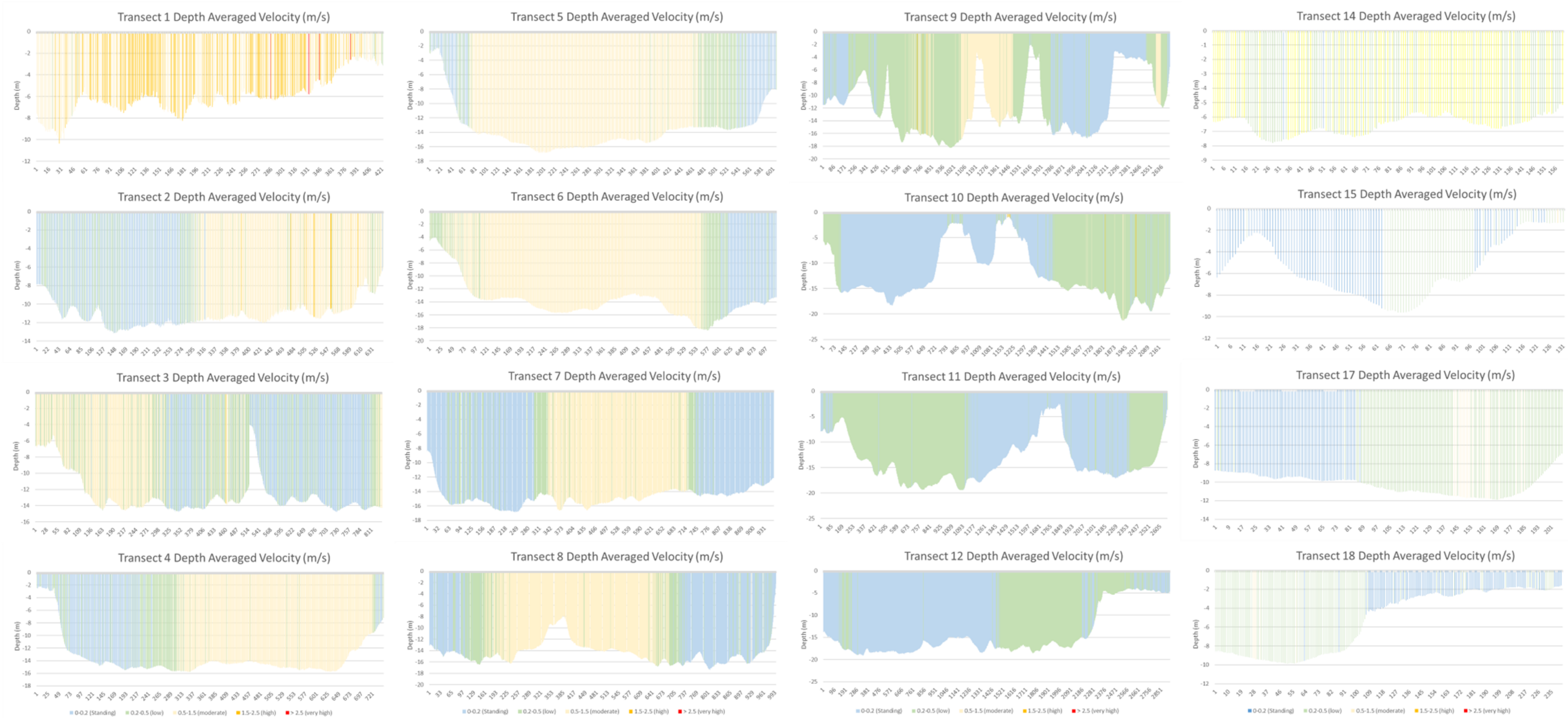


Figure 6: Classified sub-sampled depth averaged velocity representation of 16 transects sampled using an ADCP in Stephens Lake sensitive habitat area, 2022. Cross sections are viewed looking upstream (left to right bank).

4.1.7.2 SUBSTRATE

Substrate sampling in Stephens Lake was conducted in spring (June), summer (August), and fall (September) in 2022. Surveys were conducted in the area extending from approximately 1.0–7.5 km downstream of the Keeyask GS during August. A portion of this area approximately 5–7 km downstream of the Keeyask GS was identified in the EIS as important Lake Sturgeon YOY and rearing habitat. Because of its importance, additional substrate surveys were conducted in this area in June and September.

Spring substrate validation and acoustic surveys were conducted within the Stephens Lake sensitive habitat area on June 5 and 6, 2022. Twenty sites were sampled using a petite Ponar (Table 17). Sandy substrates were predominant (30–100%) at 11 sites within the reach (Map 13). PSA indicated that sand was the dominant substrate type at four of five samples collected (representing 49–67% of each sample) (Table A-1). Silt deposition was evident at the majority (n = 16) of sites. Organics, consisting of detritus and loose, broken-down plant matter (Photo 2), were evident at 12 sampling sites.

Photo 2: Substrate collected at site T4-4 in the upper Stephens Lake sensitive habitat area in June showing sand, clay, organics, and silt.

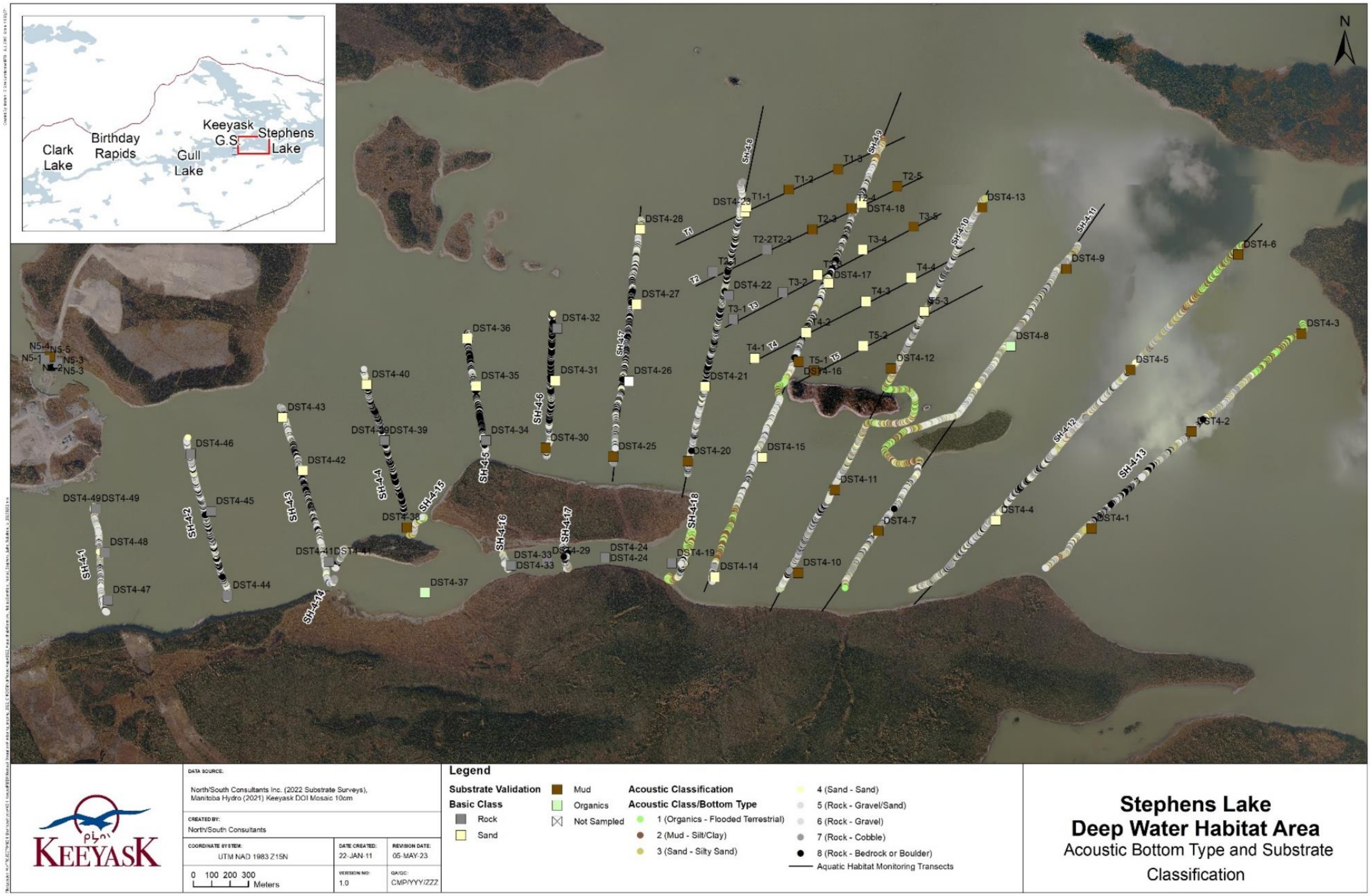
Table 17: Locations and results of field bottom type validation sampling and post-survey class verification in the Stephens Lake sensitive habitat area, June 2022.

Site ID	Transect ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition								Basic Class	Silt Deposition Evident	Class Verification[1]
								Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%			
T1-1	T1	petite Ponar	5-Jun-22	368451	6248897	-	soft	sand	30	clay	30	Silt	30	organics	10	sand	yes	sand/clay/silt/organics
T1-2	T1	petite Ponar	5-Jun-22	368673	6248996	-	soft	clay	40	silt	30	organics	30	-	-	mud	yes	clay/silt/organics
T1-3	T1	petite Ponar	5-Jun-22	368935	6249109	-	soft	organics	80	silt	15	clay	5	-	-	mud	yes	organics/silt/clay
T2-1	T2	petite Ponar	5-Jun-22	368259	6248530	-	hard	sand	100	-	-	-	-	-	-	sand	no	sand
T2-2	T2	petite Ponar	5-Jun-22	368532	6248658	-	soft	sand	40	clay	30	silt	30	-	-	sand	yes	sand/clay/silt
T2-3	T2	petite Ponar	5-Jun-22	368789	6248777	-	soft	sand	45	clay	45	gravel	10	-	-	sand	no	sand/clay/gravel
T2-4	T2	petite Ponar	5-Jun-22	369002	6248879	-	soft	clay	40	organics	40	silt	20	-	-	mud	yes	clay/organics/silt
T2-5	T2	petite Ponar	5-Jun-22	369260	6249006	-	soft	clay	40	organics	40	silt	20	-	-	mud	yes	clay/organics/silt
T3-1	T3	petite Ponar	5-Jun-22	368371	6248277	-	medium	organics	50	sand	20	clay	20	-	-	organics	no	organic/sand/clay
T3-2	T3	petite Ponar	5-Jun-22	368636	6248423	-	hard	sand	60	gravel	35	silt	5	-	-	sand	yes	sand/gravel/silt
T3-3	T3	petite Ponar	5-Jun-22	368835	6248526	-	soft	sand	30	clay	30	silt	30	organics	10	sand	yes	sand/clay/silt/organics
T3-4	T3	petite Ponar	5-Jun-22	369086	6248664	-	soft	sand	30	clay	30	silt	30	organics	10	sand	yes	sand/clay/silt/organics
T3-5	T3	petite Ponar	5-Jun-22	369348	6248793	-	soft	sand	40	clay	40	Silt	10	organics	10	sand	yes	sand/clay/silt/organics
T4-1	T4	petite Ponar	6-Jun-22	368493	6248069	-	soft	organics	85	silt	10	clay	5	-	-	organics	yes	organics/silt/clay
T4-2	T4	petite Ponar	6-Jun-22	368766	6248208	-	hard	cobble	85	gravel	5	sand	5	clay	5	rock	no	cobble/gravel/clay
T4-3	T4	petite Ponar	6-Jun-22	369085	6248371	-	soft	gravel	40	sand	30	clay	15	silt	15	rock	yes	gravel/sand/clay/silt
T4-4	T4	petite Ponar	6-Jun-22	369340	6248507	-	soft	sand	30	clay	30	organics	30	silt	10	sand	yes	sand/clay/organics/silt
T5-1	T5	petite Ponar	6-Jun-22	368821	6247996	-	soft	sand	40	clay	30	silt	30	-	-	sand	yes	sand/clay/silt
T5-2	T5	petite Ponar	6-Jun-22	369077	6248142	-	soft	sand	40	clay	40	silt	10	gravel	10	sand	yes	sand/clay/silt/gravel
T5-3	T5	petite Ponar	6-Jun-22	369414	6248318	-	soft	organics	40	clay	40	silt	20	-	-	organics	yes	organics/clay/silt

Map 13: **Map illustrating the results of substrate composition sampling sites and acoustic imaging for the Stephens Lake sensitive habitat area, June 2022. Lighter colours in the acoustic imagery indicate harder substrates while darker colours indicate softer substrates.**

Summer substrate validation and single-beam acoustic surveys were conducted throughout the reach of Stephens Lake between 1 and 7 km downstream of the GS on August 13 and 15, 2022. Seventy sites were sampled using a petite Ponar (at 60 sites) and a weighted sounding line (at ten sites) (Table 18). Hard rocky substrates (*e.g.,* boulder, cobble, gravel) were predominant (70–100%) within the upstream portion of the reach and along the south shore (Map 14). Sand was the predominant (40–100%) substrate at 13 sites (Photo 3) including seven sites previously sampled in spring within the sensitive habitat area (T1-1, T4-1, -2, -3, -4, T5-2 and -3). PSA indicated that sand was dominant at eight of nine representative sites sampled (representing 40.9–83.9% of each sample) (Table A-1). Silt deposition was evident at the majority (n = 41) of sites during the summer sampling period (Table 18).

Photo 3: Substrate collected at site DST4-14 in the upper Stephens Lake sensitive habitat area in August showing sand and silt.



Map 14: **Classified acoustic bottom type data and substrate validation results from substrate transect surveys conducted at the upstream portion and sensitive habitat area of Stephens Lake, August 2022.**

Table 18: Locations and results of field bottom type validation sampling and post-survey class verification conducted in the upstream portion of Stephens Lake, August 2022.

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition								Basic Class	Silt Deposition Evident	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%			
DST4-01	petite Ponar	13-Aug-22	370326	6247128	17.4	soft	silt	80	sand	10	organics	10	-	-	mud	yes	silt/sand/organics
DST4-02	petite Ponar	15-Aug-22	370871	6247655	20.6	soft	clay	70	silt	25	organics	5	-	-	mud	yes	clay/silt/organics
DST4-03	petite Ponar	15-Aug-22	371468	6248188	2.6	soft	silt	60	clay	20	organics	20	-	-	mud	yes	silt/clay/organics
DST4-04	petite Ponar	13-Aug-22	369803	6247172	17.6	moderate	silt	80	organics	10	sand	10	-	-	sand	yes	silt/sand/organics
DST4-05	petite Ponar	15-Aug-22	370537	6247992	16.3	soft	clay	100	-	-	-	-	-	-	mud	no	clay
DST4-06	petite Ponar	15-Aug-22	371124	6248619	3.5	soft	silt	60	clay	40	-	-	-	-	mud	yes	silt/clay
DST4-07	petite Ponar	13-Aug-22	369163	6247114	16.5	soft	silt	85	organics	10	clay	5	-	-	mud	yes	silt/organics/clay
DST4-08	petite Ponar	15-Aug-22	369884	6248120	18.9	soft	organics	75	silt	25	-	-	-	-	organics	yes	organics/silt
DST4-09	petite Ponar	15-Aug-22	370188	6248542	18.7	soft	clay	50	silt	40	organics	10	-	-	mud	yes	clay/silt/organics
DST4-10	petite Ponar	13-Aug-22	368726	6246886	14.0	moderate	silt	90	sand	10	-	-	-	-	mud	yes	silt/sand
DST4-11	petite Ponar	13-Aug-22	368927	6247338	15.5	soft	silt	90	sand	10	-	-	-	-	mud	yes	silt/sand
DST4-12	petite Ponar	15-Aug-22	369234	6247999	11.2	soft	clay	95	silt	5	-	-	-	-	mud	yes	clay/silt
DST4-13	petite Ponar	15-Aug-22	369729	6248876	16.0	moderate	silt	60	sand	40	-	-	-	-	mud	yes	silt/sand
DST4-14	petite Ponar	13-Aug-22	368273	6246864	11.5	moderate	sand	80	gravel	20	-	-	-	-	sand	no	sand/gravel
DST4-15	petite Ponar	13-Aug-22	368530	6247515	15.0	moderate	sand	60	silt	40	-	-	-	-	sand	yes	sand/silt
DST4-16	petite Ponar	13-Aug-22	368729	6248036	14.5	soft	silt	65	organics	15	sand	15	gravel	5	mud	yes	silt/organics/sand/gravel
DST4-17	petite Ponar	13-Aug-22	368892	6248463	17.5	soft	silt	50	sand	30	organics	15	clay	5	mud	yes	silt/sand/organics/clay
DST4-18	petite Ponar	13-Aug-22	369073	6248901	15.7	soft	silt	50	sand	40	organics	10	-	-	mud	yes	silt/sand/organics
DST4-19	petite Ponar	13-Aug-22	368038	6246938	8.9	moderate	gravel	50	sand	50	-	-	-	-	rock	no	gravel/sand
DST4-20	petite Ponar	13-Aug-22	368125	6247494	15.5	soft	silt	80	sand	20	-	-	-	-	mud	yes	silt/sand
DST4-21	petite Ponar	13-Aug-22	368219	6247901	16.6	soft	silt	80	organics	20	-	-	-	-	mud	yes	silt/organics
DST4-22	petite Ponar	13-Aug-22	368348	6248397	9.0	hard	cobble	90	boulder	10	-	-	-	-	rock	no	cobble/boulder
DST4-23	petite Ponar	13-Aug-22	368437	6248851	14.6	soft	silt	50	sand	40	organics	10	-	-	mud	yes	silt/sand/organics
DST4-24	weighted sounding line	13-Aug-22	367675	6246968	7.0	hard	cobble	100	-	-	-	-	-	-	rock	no	cobble
DST4-25	petite Ponar	13-Aug-22	367719	6247519	14.9	soft	silt	95	sand	5	-	-	-	-	mud	yes	silt/sand
DST4-26	petite Ponar	13-Aug-22	367804	6247930	15.7	-	-	-	-	-	-	-	-	-	-	no	-
DST4-27	weighted sounding line	13-Aug-22	367846	6248348	14.8	moderate	sand	100	-	-	-	-	-	-	sand	no	sand
DST4-28	petite Ponar	13-Aug-22	367866	6248757	13.2	soft	silt	70	organics	30	-	-	-	-	mud	yes	silt/organics
DST4-29	petite Ponar	13-Aug-22	367358	6246951	9.3	hard	-	-	-	-	-	-	-	-	rock	no	-
DST4-30	petite Ponar	13-Aug-22	367351	6247566	13.7	soft	silt	90	organics	10	-	-	-	-	mud	yes	silt/organics
DST4-31	petite Ponar	13-Aug-22	367403	6247933	13.2	moderate	sand	100	-	-	-	-	-	-	sand	no	sand
DST4-32	petite Ponar	13-Aug-22	367413	6248218	13.6	hard	gravel	100	-	-	-	-	-	-	rock	no	gravel
DST4-33	weighted sounding line	13-Aug-22	367162	6246927	8.0	hard	gravel	50	cobble	25	sand	25	-	-	rock	no	gravel/cobble/sand
DST4-34	petite Ponar	13-Aug-22	367025	6247607	13.7	hard	cobble	70	gravel	15	sand	15	-	-	rock	no	cobble/gravel/sand
DST4-35	petite Ponar	13-Aug-22	366972	6247903	15.0	moderate	sand	100	-	-	-	-	-	-	sand	no	sand
DST4-36	petite Ponar	13-Aug-22	366924	6248162	13.2	soft	silt	90	organics	10	-	-	-	-	mud	yes	silt/organics
DST4-37	petite Ponar	13-Aug-22	366694	6246778	10.1	soft	organics	100	-	-	-	-	-	-	organic	no	organics
DST4-38	petite Ponar	13-Aug-22	366595	6247133	10.2	soft	silt	45	sand	35	gravel	15	organics	5	mud	yes	silt/sand/gravel/organics

Table 18: Locations and results of field bottom type validation sampling and post-survey class verification conducted in the upstream portion of Stephens Lake, August 2022 (continued).

Site ID	Method	Date	UTM Easting	UTM Northing	Depth (m)	Compaction	Estimated Substrate Composition								Basic Class	Silt Deposition Evident	Class Verification[1]
							Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%			
DST4-39	weighted sounding line	13-Aug-22	366473	6247607	14	hard	cobble	40	sand	40	gravel	20	-	-	rock	no	cobble/sand/gravel
DST4-40	petite Ponar	13-Aug-22	366376	6247911	15.4	soft	organics	60	silt	40	-	-	-	-	organic	yes	organics/silt
DST4-41	petite Ponar	13-Aug-22	366169	6246947	6.0	hard	gravel	70	sand	30	-	-	-	-	rock	no	gravel/sand
DST4-41	weighted sounding line	13-Aug-22	366169	6246947	6.0	hard	cobble	70	gravel	20	sand	10	-	-	rock	no	cobble/gravel/sand
DST4-42	petite Ponar	13-Aug-22	366026	6247442	13.6	hard	sand	100	-	-	-	-	-	-	sand	no	sand
DST4-43	petite Ponar	13-Aug-22	365917	6247732	14.3	soft	silt	80	sand	15	clay	5	-	-	mud	yes	silt/sand/clay
DST4-44	weighted sounding line	13-Aug-22	365617	6246762	7.4	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-45	weighted sounding line	13-Aug-22	365527	6247221	10.0	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-46	petite Ponar	13-Aug-22	365416	6247534	12.4	soft	organics	95	sand	5	-	-	-	-	organic	no	organics/sand
DST4-47	weighted sounding line	13-Aug-22	364965	6246737	8.0	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-48	weighted sounding line	13-Aug-22	364949	6246997	6.5	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
DST4-49	petite Ponar	13-Aug-22	364902	6247235	3.9	hard	boulder	100	-	-	-	-	-	-	rock	no	boulder
T1-1	petite Ponar	13-Aug-22	368443	6248879	14.2	soft	sand	60	silt	20	organics	10	clay	10	sand	yes	sand/silt/organics/clay
T1-2	petite Ponar	13-Aug-22	368676	6248973	13.3	soft	silt	80	organics	20	-	-	-	-	mud	yes	silt/organics
T1-3	petite Ponar	13-Aug-22	368944	6249083	15.6	soft	silt	40	organics	40	sand	20	-	-	mud	yes	silt/organics/sand
T2-1	petite Ponar	13-Aug-22	368261	6248526	13.3	hard	gravel	60	sand	40	-	-	-	-	rock	no	gravel/sand
T2-2	weighted sounding line	13-Aug-22	368558	6248646	15.4	hard	cobble	90	sand	10	-	-	-	-	rock	no	cobble/sand
T2-3	petite Ponar	13-Aug-22	368804	6248756	17.0	soft	silt	80	organics	15	clay	5	-	-	mud	yes	silt/organics/clay
T2-4	petite Ponar	13-Aug-22	369018	6248871	14.3	soft	silt	75	organics	15	sand	10	-	-	mud	yes	silt/organics/sand
T2-5	petite Ponar	13-Aug-22	369267	6248990	14.0	soft	silt	60	organics	40	-	-	-	-	mud	yes	silt/organics
T3-1	petite Ponar	13-Aug-22	368372	6248267	14.0	moderate	gravel	100	-	-	-	-	-	-	rock	no	gravel
T3-2	petite Ponar	13-Aug-22	368644	6248413	12.0	hard	gravel	100	-	-	-	-	-	-	rock	no	gravel
T3-3	petite Ponar	13-Aug-22	368833	6248510	16.7	soft	sand	25	silt	25	organics	25	clay	25	sand	yes	sand/silt/organics/clay
T3-4	petite Ponar	13-Aug-22	369078	6248646	14.8	soft	sand	25	silt	25	organics	25	clay	25	sand	yes	sand/silt/organics/clay
T3-5	petite Ponar	13-Aug-22	369355	6248771	17.6	soft	silt	60	organics	35	clay	5	-	-	mud	yes	silt/organics/clay
T4-1	petite Ponar	13-Aug-22	368490	6248055	13.4	soft	sand	60	organics	30	silt	10	-	-	sand	yes	sand/organics/silt
T4-2	petite Ponar	13-Aug-22	368770	6248195	14.9	soft	sand	95	silt	5	-	-	-	-	sand	yes	sand/silt
T4-3	petite Ponar	13-Aug-22	369096	6248364	13.6	moderate	sand	100	-	-	-	-	-	-	sand	no	sand
T4-4	petite Ponar	13-Aug-22	369343	6248493	15.8	soft	sand	40	clay	40	silt	10	organics	10	sand	yes	silt/clay/organics
T5-1	petite Ponar	13-Aug-22	368812	6247986	9.6	soft	silt	60	organics	40	-	-	-	-	mud	yes	silt/organics
T5-2	petite Ponar	13-Aug-22	369080	6248122	13.4	moderate	sand	70	silt	20	organics	10	-	-	sand	yes	sand/silt/organics
T5-3	petite Ponar	13-Aug-22	369413	6248310	13.7	soft	sand	40	clay	40	silt	10	organics	10	sand	yes	sand/clay/silt/organics

1 – Class verified with digital images and sidescan imagery post-survey.

Acoustic classification was conducted a single time on August 13 (Table 19). The acoustic classification model indicated that all substrate types are found within the area, with only marginal difference in proportions. Bedrock/boulder composed the majority (25%) of the area, followed by cobble (21%), gravel/sand (16%), and gravel (15%). Silt/clay and organics each comprised 10% with sand and silt/clay/sand (each 7%) making up the lowest proportion of the substrate of the reach.

Acoustic imaging was conducted in the Stephens Lake sensitive habitat area on September 16, 2022. The upstream portion consisted of hard rocky substrates, whereas downstream fine substrate (silt/clay/sand) deposition was evident (Map 15).

Table 19: Results of acoustic classification of single beam data collected along transects in the Stephens Lake sensitive habitat area, August 2022.

Transect ID	Acoustic Substrate Classification Composition (% Membership)							
	Organics	Mud		Sand	Rock			
	organics/FT	silt/clay	silt/clay/sand	sand	gravel/sand	gravel	cobble	bedrock/boulder
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
1	2	2	3	9	29	25	16	13
2	-	-	<1	7	31	19	10	34
3	-	-	1	8	20	17	22	32
4	-	-	<1	5	14	10	14	57
5	-	-	-	6	16	13	6	59
6	-	-	<1	8	16	11	8	58
7	-	-	1	6	15	18	19	40
8	-	<1	1	8	22	17	19	34
9	6	12	6	7	19	16	16	18
10	10	10	10	6	12	12	30	10
11	5	10	12	8	14	13	35	4
12	6	11	10	7	10	12	36	8
13	10	13	11	7	7	9	32	11
14	-	2	6	10	17	19	38	8
15	19	24	19	5	12	13	8	-
16	10	7	8	5	16	14	28	13
17	-	6	5	7	15	20	27	20
18	24	22	20	6	5	8	8	7
Summary	**10**	**10**	**7**	**7**	**16**	**15**	**21**	**25**

Map 15: **Map illustrating the results of substrate composition sampling sites and acoustic imaging for the Stephens Lake sensitive habitat area, September 2022. Lighter colours in the acoustic imagery indicate harder substrates while darker colours indicate softer substrates.**

4.2 CONSTRUCTED HABITATS

4.2.1 KEEYASK RESERVOIR CONSTRUCTED HABITATS

Nine constructed shoal habitats were surveyed in the Keeyask reservoir in 2022 (Map 16). Water surface elevation was 159.04 m in the Keeyask reservoir at the time each shoal was surveyed (Table 20). Depths within the footprint of the shoal areas ranged between 2.63 and 6.29 m (Maps 17–25).

Table 20: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for cross sections surveyed at constructed shoal habitats in the Keeyask reservoir, 2022.

Area	Shoal	Date Surveyed	Estimated Area (m^2)	Water Surface Elevation[2] (m)	Depth (m)			Velocity[1] (m/s)		
					min	max	mean	min	max	mean
Keeyask reservoir	G-South	31-Aug-22	1,035	159.03	2.98	4.69	3.52	0.03	0.30	0.08
Keeyask reservoir	G-North	31-Aug-22	1,796	159.03	3.32	4.71	3.92	0.01	0.33	0.10
Keeyask reservoir	F-North	31-Aug-22	1,805	159.03	2.70	4.94	3.83	0.02	0.40	0.17
Keeyask reservoir	F-South	31-Aug-22	2,226	159.03	3.34	4.81	3.95	0.13	0.51	0.28
Keeyask reservoir	F-East	31-Aug-22	2,808	159.03	3.12	5.19	3.83	0.27	0.61	0.42
Keeyask reservoir	H-North	31-Aug-22	5,396	159.03	2.63	5.79	3.69	0.11	1.34	0.74
Keeyask reservoir	H-South	31-Aug-22	2,963	159.03	2.63	6.29	4.18	0.11	1.34	0.74
Keeyask reservoir	H-East	31-Aug-22	2,379	159.03	2.87	4.28	3.51	0.02	0.46	0.15
Keeyask reservoir	L	29-Aug-22	10,415	159.04	2.66	5.26	3.75	0.12	1.24	0.63

1. Velocity samples are averaged subsets of depth averaged ADCP velocity taken from the closest transect to each constructed shoal.

2. Daily mean water surface elevation from MBH gauge station Gull Lake (05UF596) or Stephens Lake (05UF709).

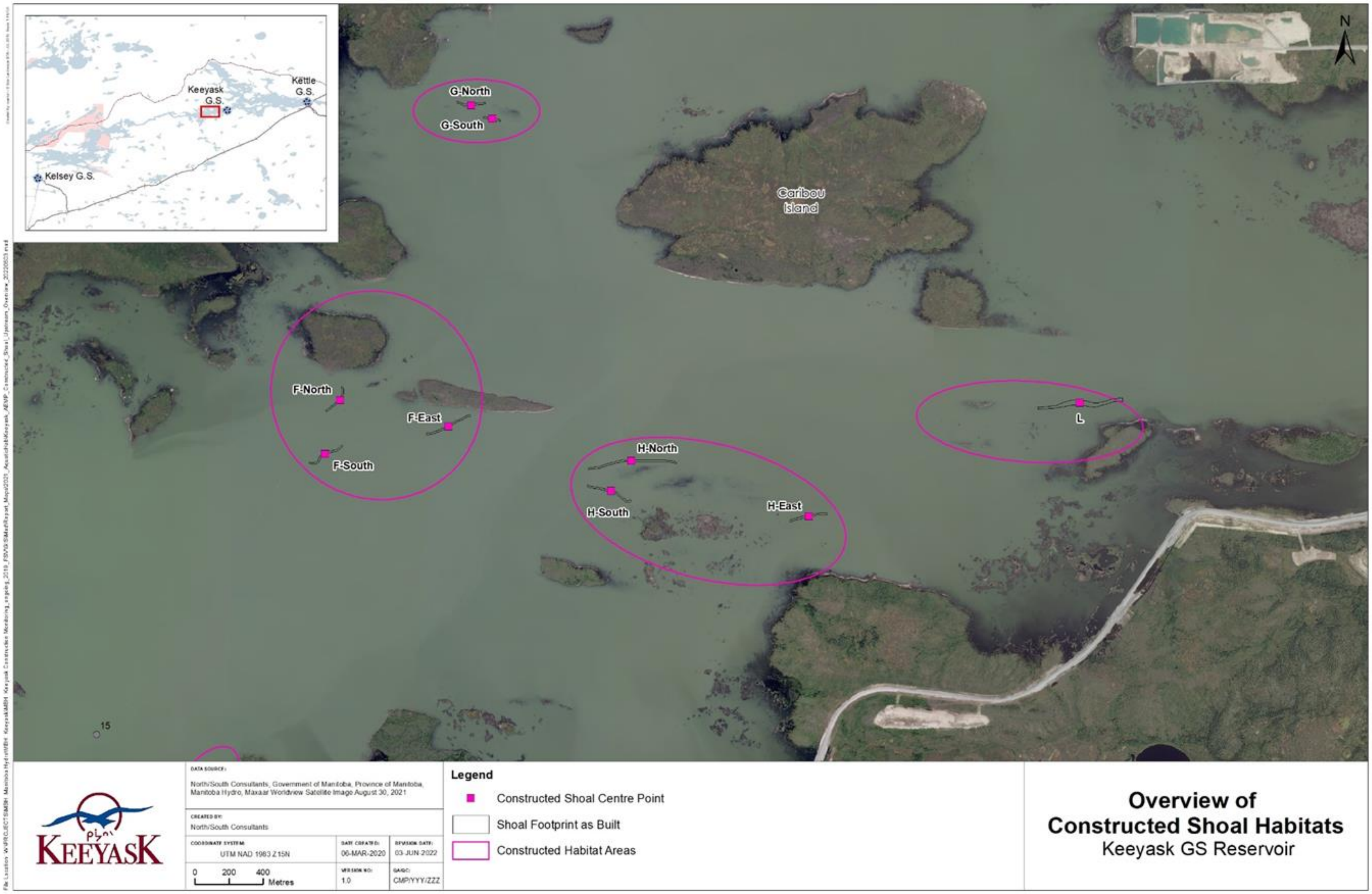
Boat-based ADCP depth and velocity surveys were not conducted directly on each shoal and water velocity was calculated as the depth averaged ADCP velocity taken from the closest transect (Table 20). Water velocity was generally low, ranging from an average of 0.08–0.74 m/s near each of the nine shoal habitats. Mean velocity was lowest near shoals G-South (0.08 m/s) and G-North (0.10 m/s) and highest near shoals H-South and H-North (0.74 m/s).

Substrate validation and single-beam acoustic surveys were conducted on August 14, 2022 (Maps 17–25). Substrate was sampled on each shoal using either a petite Ponar or a weighted sounding line (Table 21). Hard cobble substrate was observed at eight sites, with three of these sites consisting of 50% cobble and 50% boulder. A single site (F-North) contained small amounts of sand and organics overlying hard cobble and boulder substrates. These smaller substrates were present in small quantities (Photo 4).

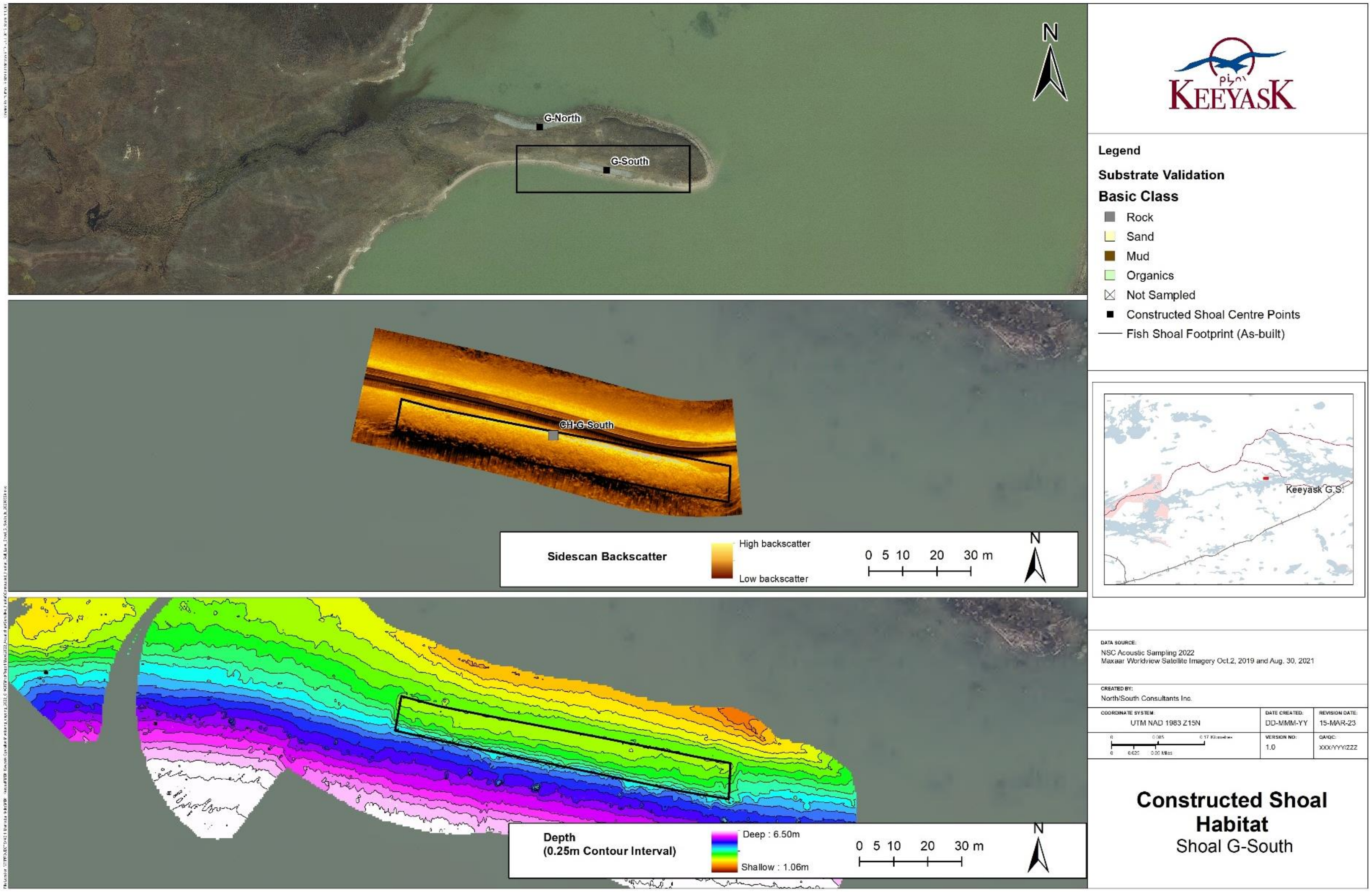
Photo 4: Small amounts of sand and organic substrates collected from constructed shoal F-North in the Keeyask reservoir, 2022. These substrates were overlying hard cobble and boulder.

Table 21: Locations and results of field bottom type validation sampling and post-survey class verification at the constructed habitats in the Keeyask reservoir, 2022.

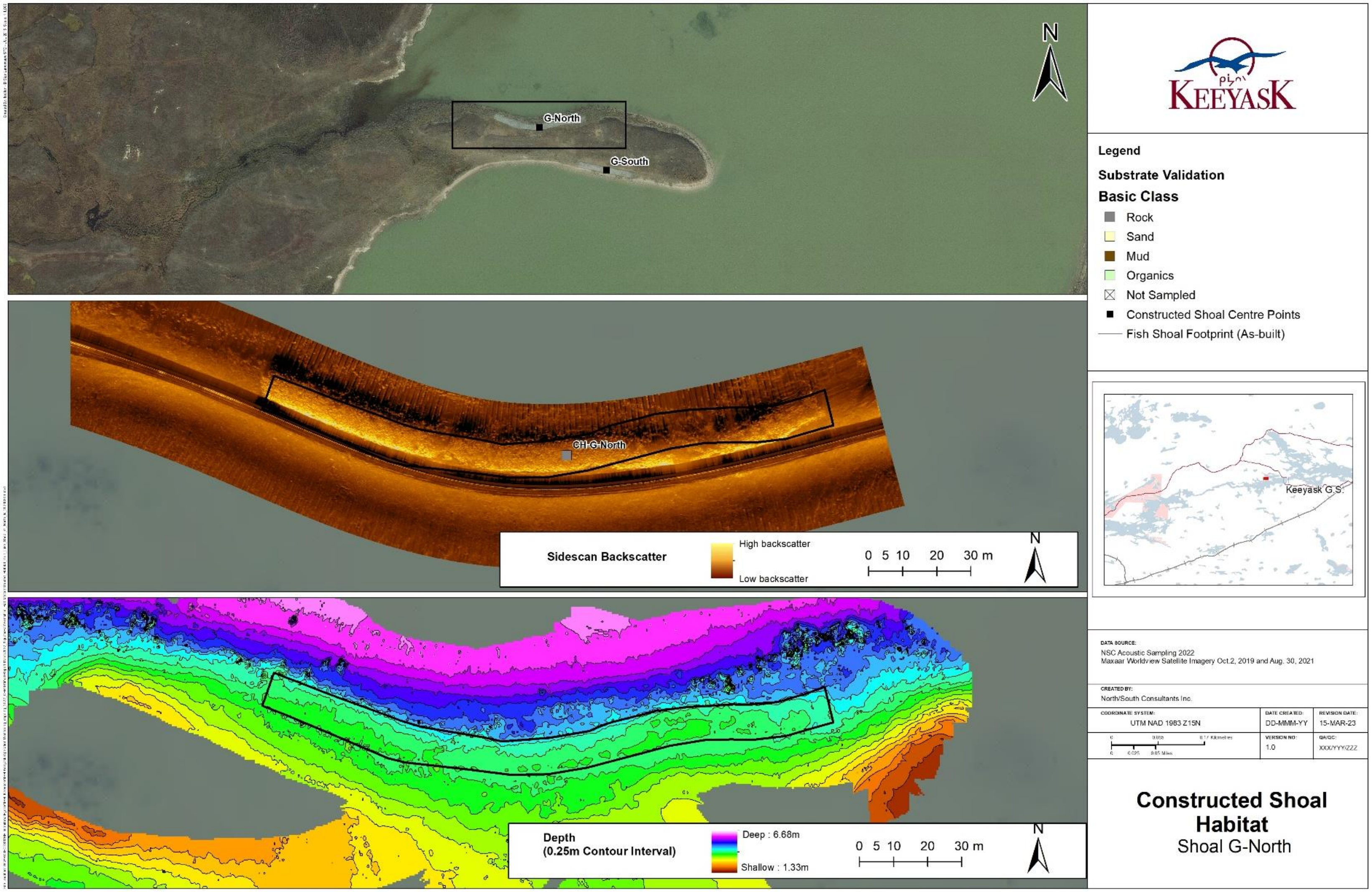
Shoal	Date	Site ID	Gear	Location		Depth (m)	Compaction	Estimated Sample Composition								Basic Class	Substrate Class Verification[1]
				Easting	Northing			Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%		
CH-G-South	14-Aug-22		weighted sounding line	354910	6247226	3.8	hard	cobble	100	-	-	-	-	-	-	rock	cobble
CH-G-North	14-Aug-22		weighted sounding line	354796	6247297	3.6	hard	cobble	50	boulder	50	-	-	-	-	rock	cobble/boulder
CH-F-North	14-Aug-22		petite Ponar	354024	6245573	3.8	hard	sand	75	organics	25	-	-	-	-	sand	sand/organic
CH-F-South	14-Aug-22		weighted sounding line	353947	6245263	3.7	hard	cobble	50	boulder	50	-	-	-	-	rock	cobble/boulder
CH-F-East	14-Aug-22		weighted sounding line	354663	6245413	5.0	hard	cobble	100	-	-	-	-	-	-	rock	cobble
CH-H-South	14-Aug-22		weighted sounding line	355609	6245045	3.9	hard	cobble	100	-	-	-	-	-	-	rock	cobble
CH-H-North	14-Aug-22		weighted sounding line	355733	6245212	2.0	hard	cobble	100	-	-	-	-	-	-	rock	cobble
CH-H-East	14-Aug-22		weighted sounding line	356768	6244889	3.0	hard	cobble	50	boulder	50	-	-	-	-	rock	cobble/boulder
CH-L	14-Aug-22		weighted sounding line	358366	6245555	3.0	hard	cobble	100	-	-	-	-	-	-	rock	cobble



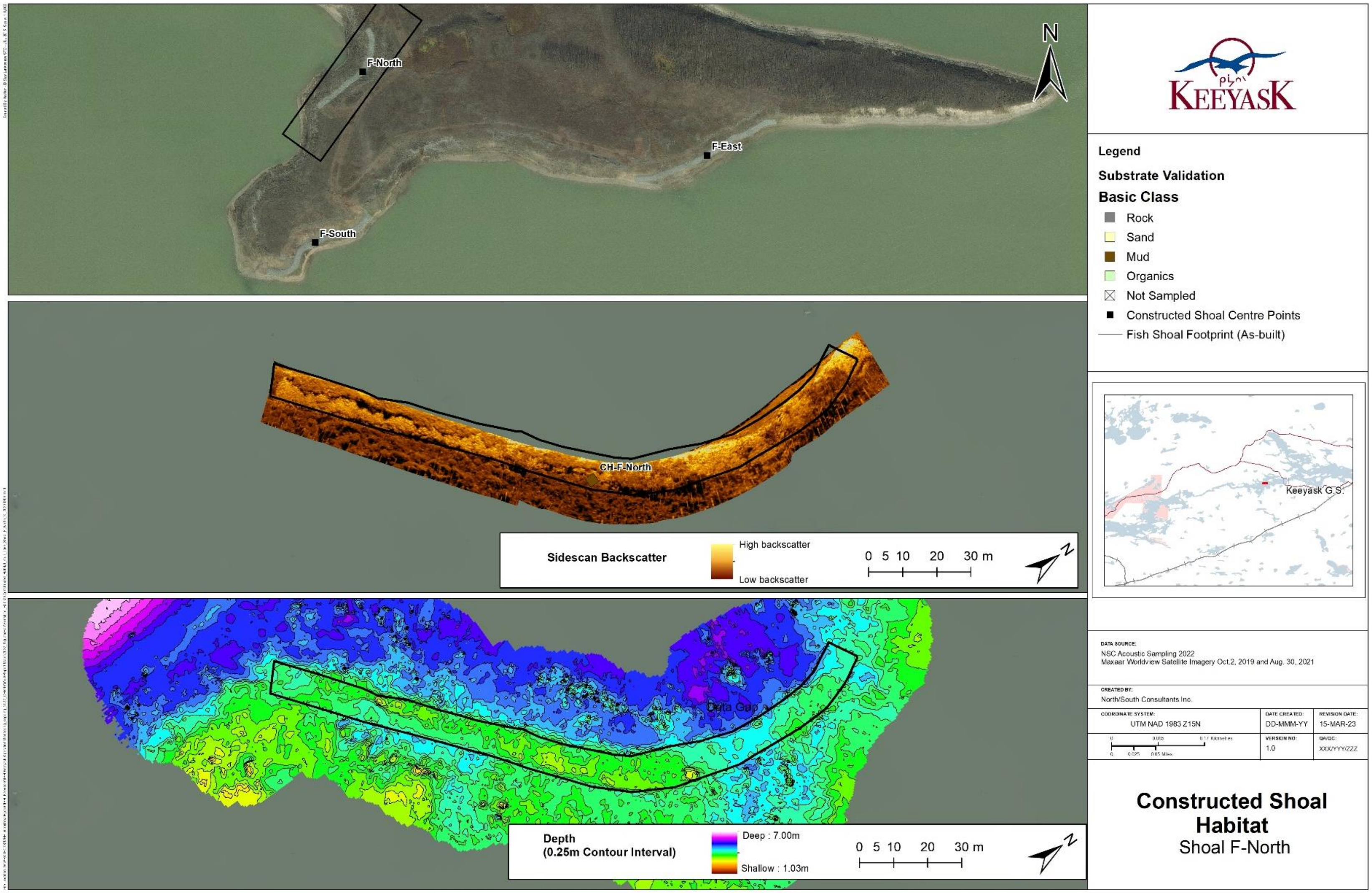
Map 16: **Map of 2022 Keeyask GS reservoir constructed habitat aquatic habitat monitoring sampling areas showing their locations following reservoir impoundment.**



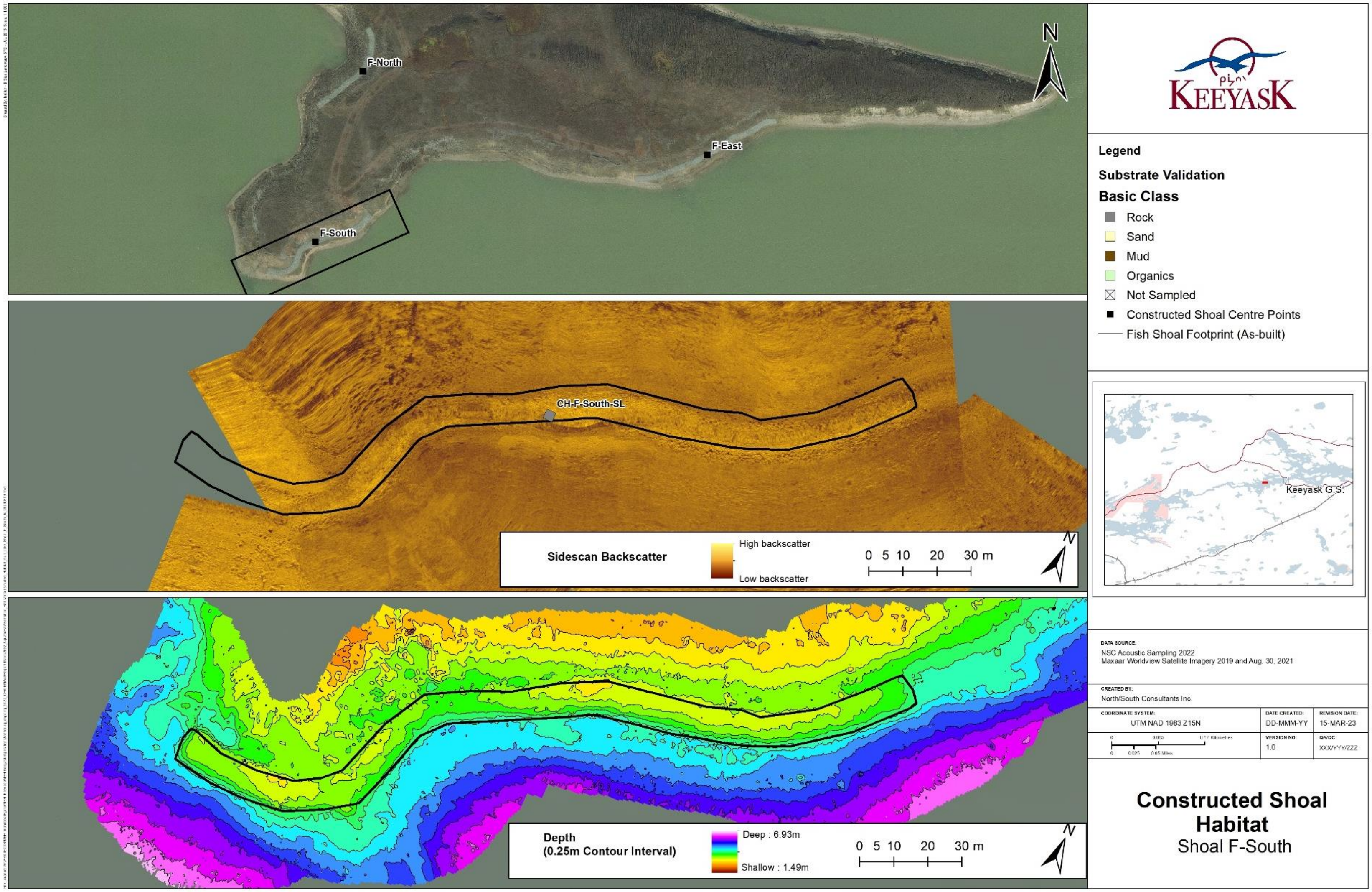
Map 17: Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the G-South shoal.



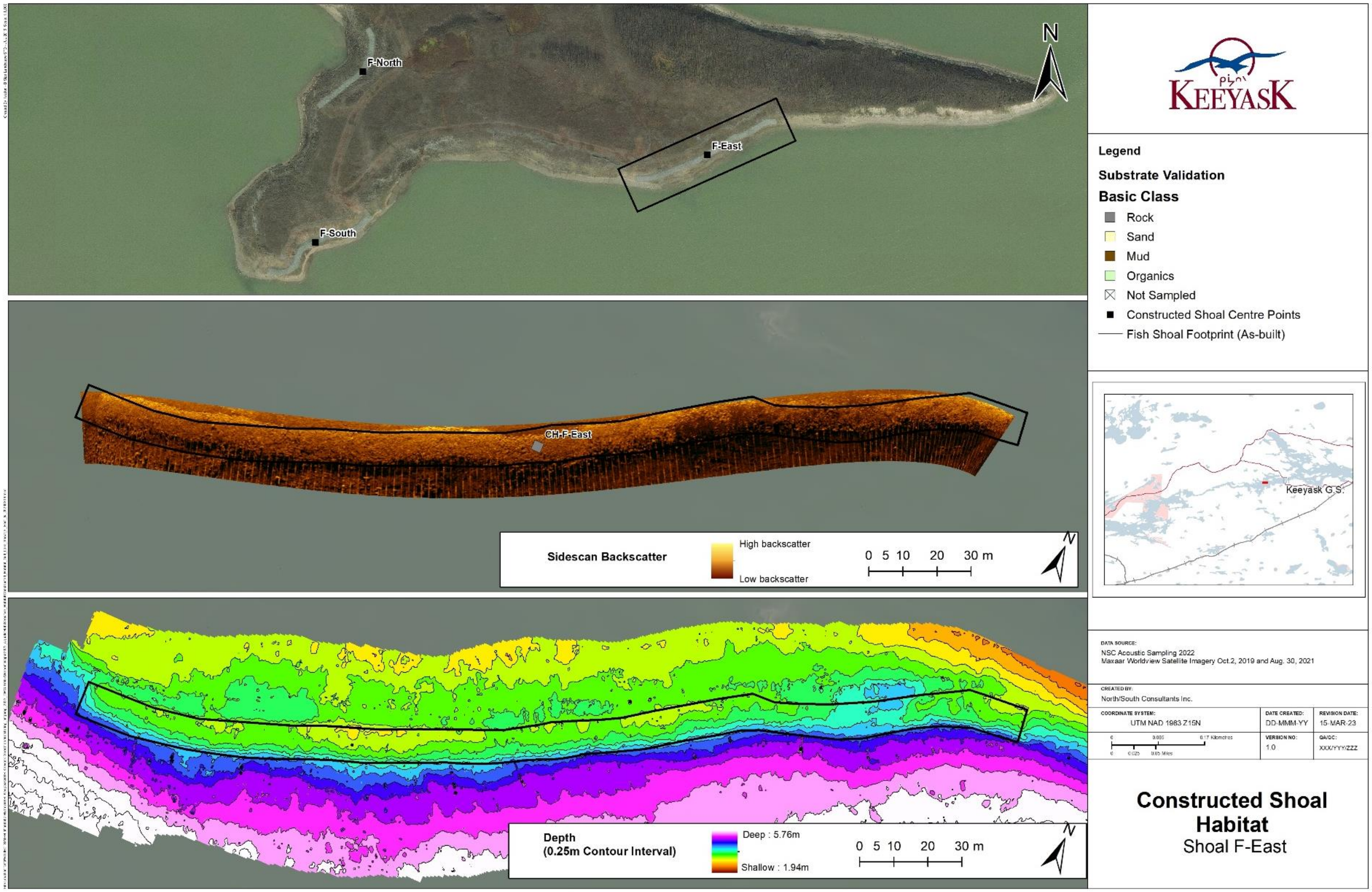
Map 18: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the G-North shoal.**



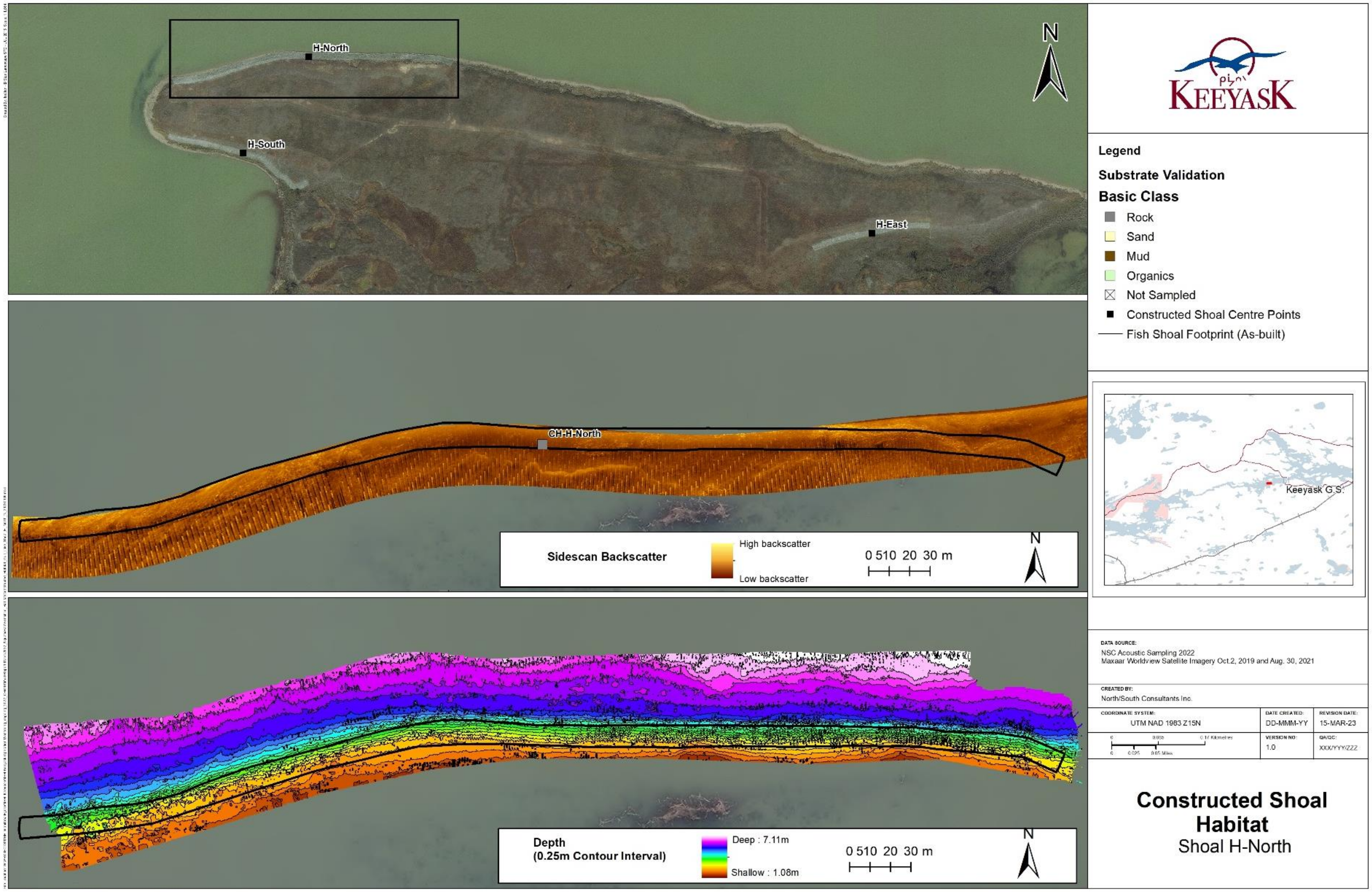
Map 19: Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the F-North shoal.



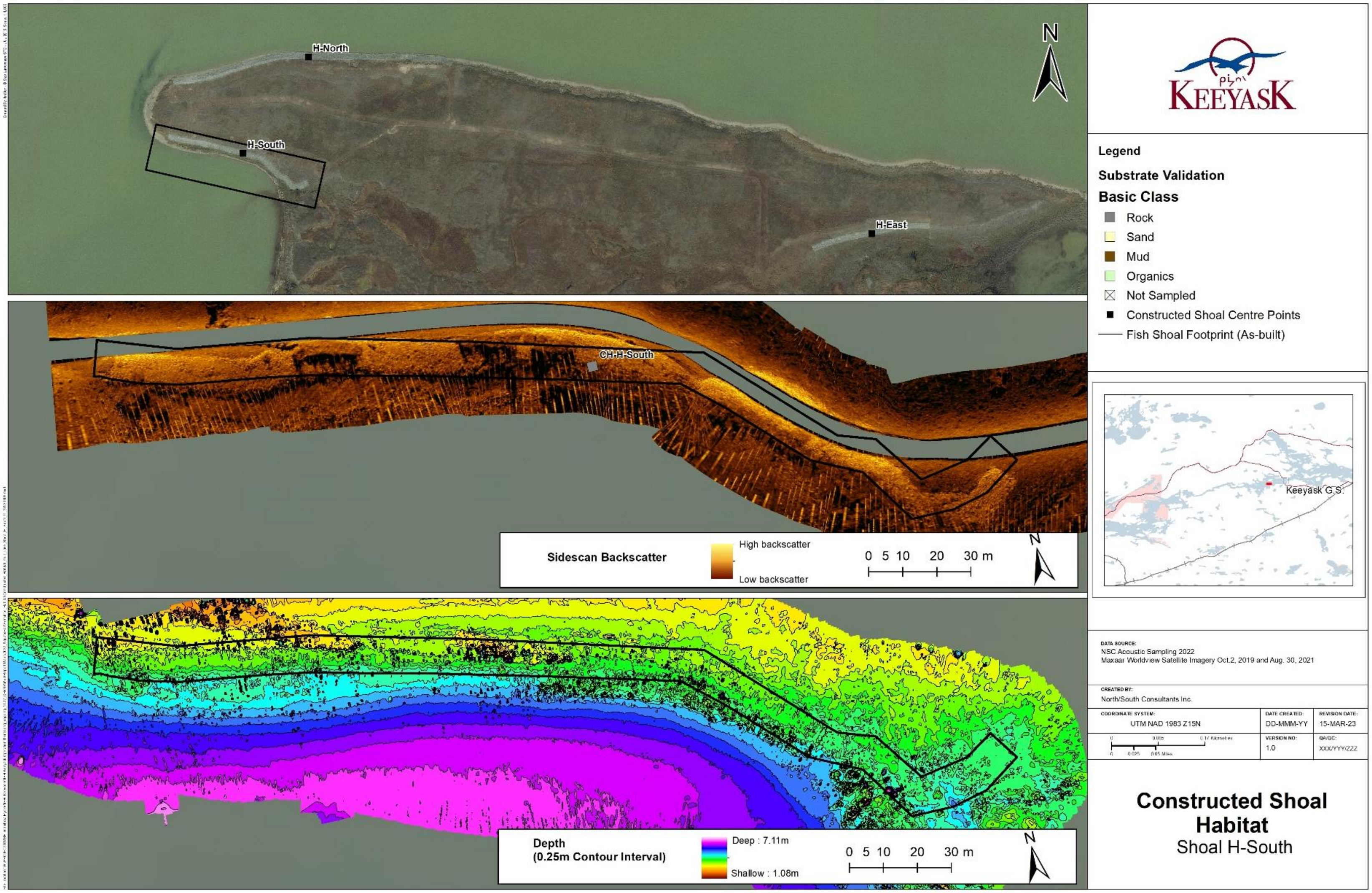
Map 20: Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the F-South shoal.



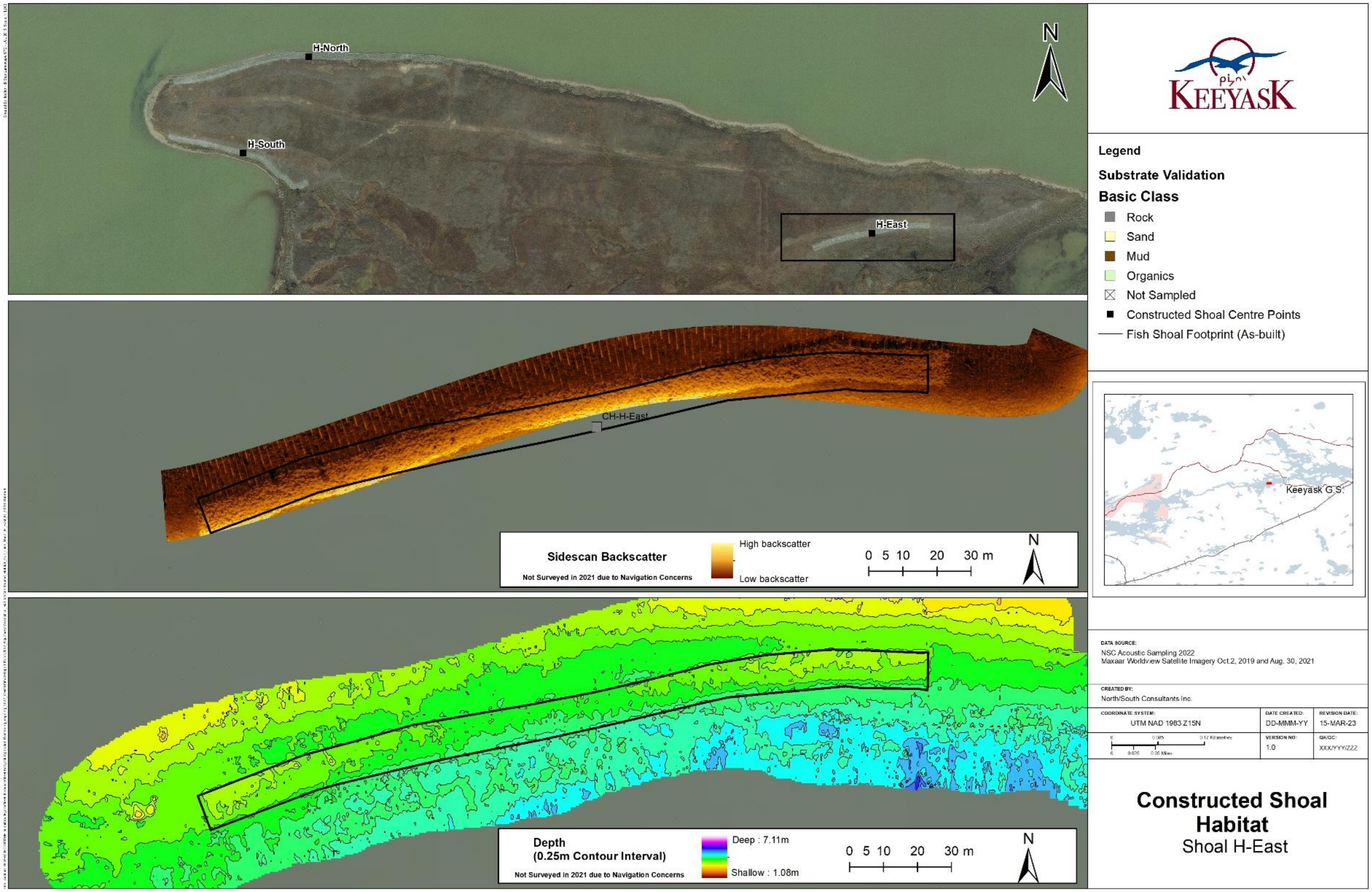
Map 21: Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the F-East shoal.



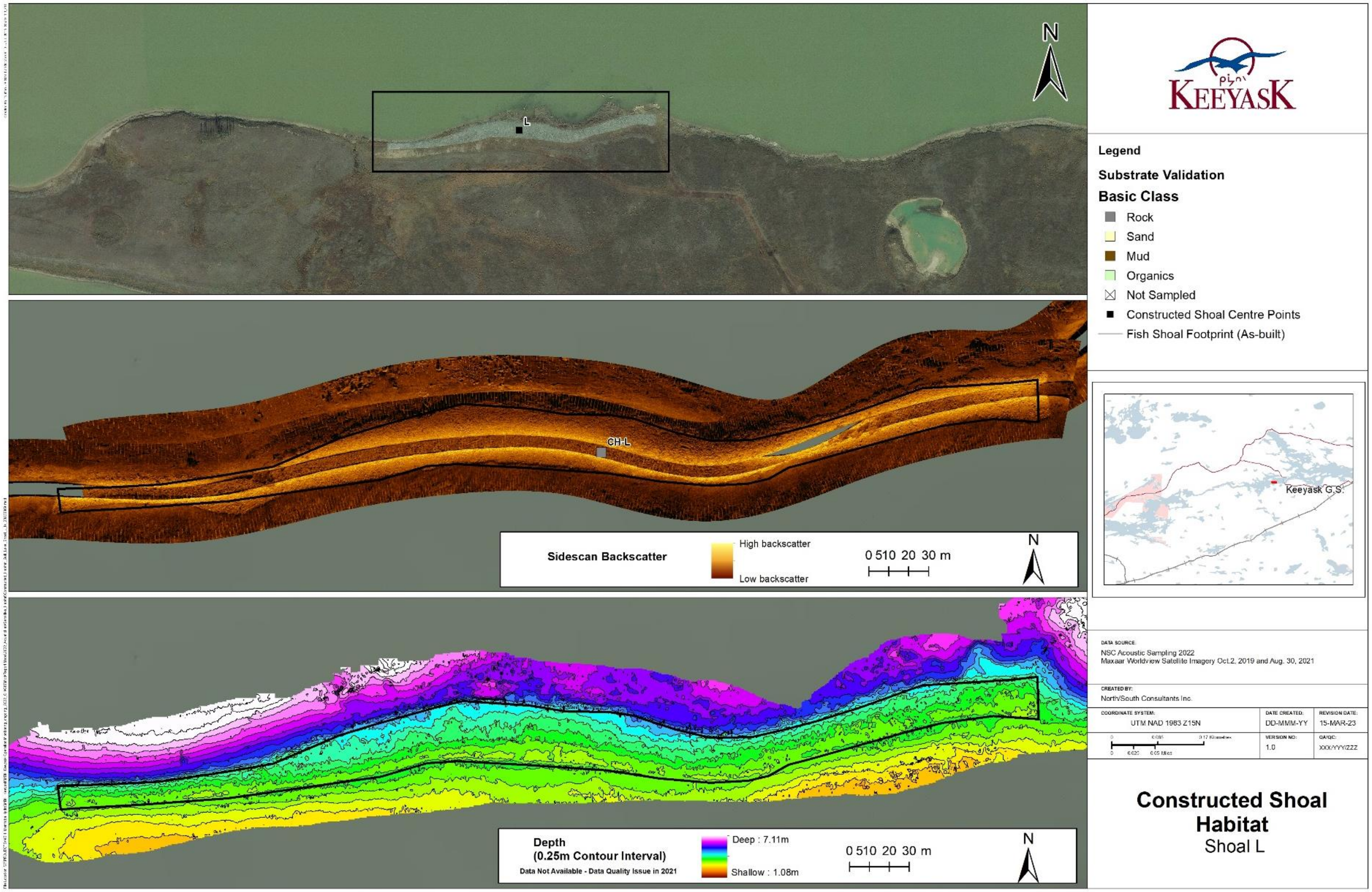
Map 22: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the H-North shoal.**



Map 23: Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the H-South shoal.



Map 24: **Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the H-East shoal.**



Map 25: Constructed shoal habitat survey showing the shoal location prior to impoundment (top), substrate survey results (middle), and survey depth and as-built footprint (bottom) at the L shoal.

4.2.2 CAUSEWAY CONSTRUCTED HABITATS

Two constructed shoal habitats were surveyed in Stephens Lake on August 28, 2022 at the sites of the former N5 and G3 causeways (Map 26). Water surface elevation was 141.26 m at the time each causeway was surveyed. Mean depths within the footprint of the shoal areas ranged from 1.76 m at G3 to 2.55 m at N5.

Water velocity was calculated as the depth averaged ADCP velocity taken from the closest transect to each constructed spawning shoal. Water velocity near the N5 causeway was low, ranging from 0.02 m/s to 0.81 m/s (Table 22). No ADCP transects were conducted n the vicinity of the G3 causeway, thus water velocity could not be estimated for this area.

Table 22: Minimum, maximum, and mean depth (m) and depth averaged velocity (m/s) for cross sections surveyed at constructed shoal habitats in Stephens Lake, 2022.

Area	Shoal	Date Surveyed	Estimated Area (m^2)	Water Surface Elevation[2] (m)	Depth (m)			Velocity[1] (m/s)		
					min	max	mean	min	max	mean
Stephens Lake	G3	28-Aug-22	-	141.26	1.50	2.65	1.76	-	-	-
Stephens Lake	N5	28-Aug-22	-	141.26	0.47	5.55	2.55	0.02	0.81	0.14

1. Velocity samples are averaged subsets of depth averaged ADCP velocity taken from the closest transect to each constructed shoal.

2. Daily mean water surface elevation from MBH gauge station Gull Lake (05UF596) or Stephens Lake (05UF709).

Substrate was sampled from five sites at the N5 causeway and three at the G3 causeway using a petite Ponar and a weighted sounding line (Maps 27 and 28). Hard rocky substrates (*e.g.*, boulder and cobble) were the dominate substrate at four of five sites at the N5 causeway and two of three sites at the G3 causeway. Silt (45%) and clay (40%) were the dominant substrates at a single site on the N5 shoal (N5-4) (Table 23; Photo 5). Organics composed 100% of the substrate at a single site on the G3 shoal (G3-3) (Table 23; Photo 6).

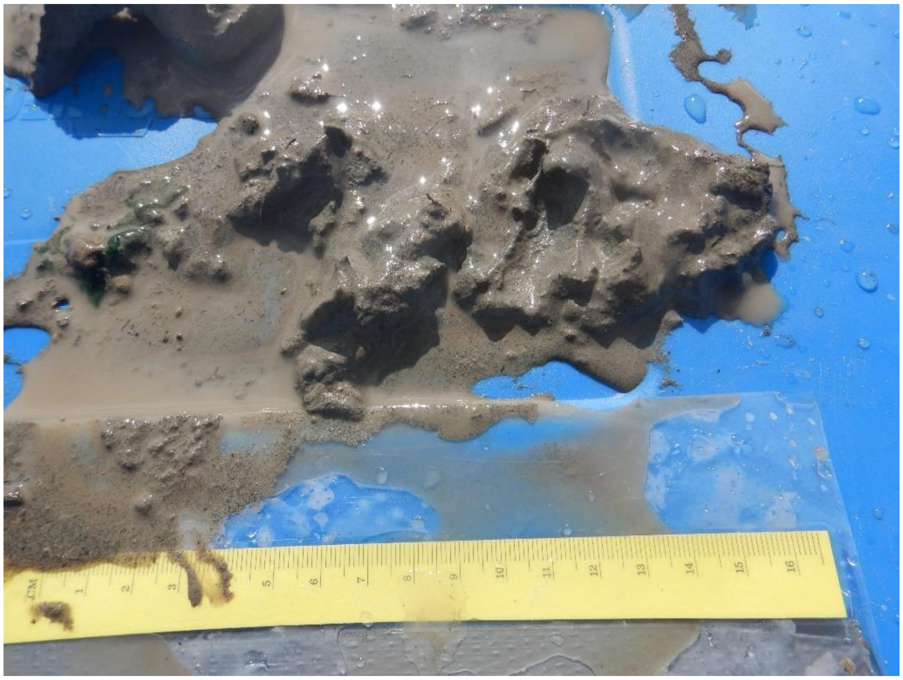
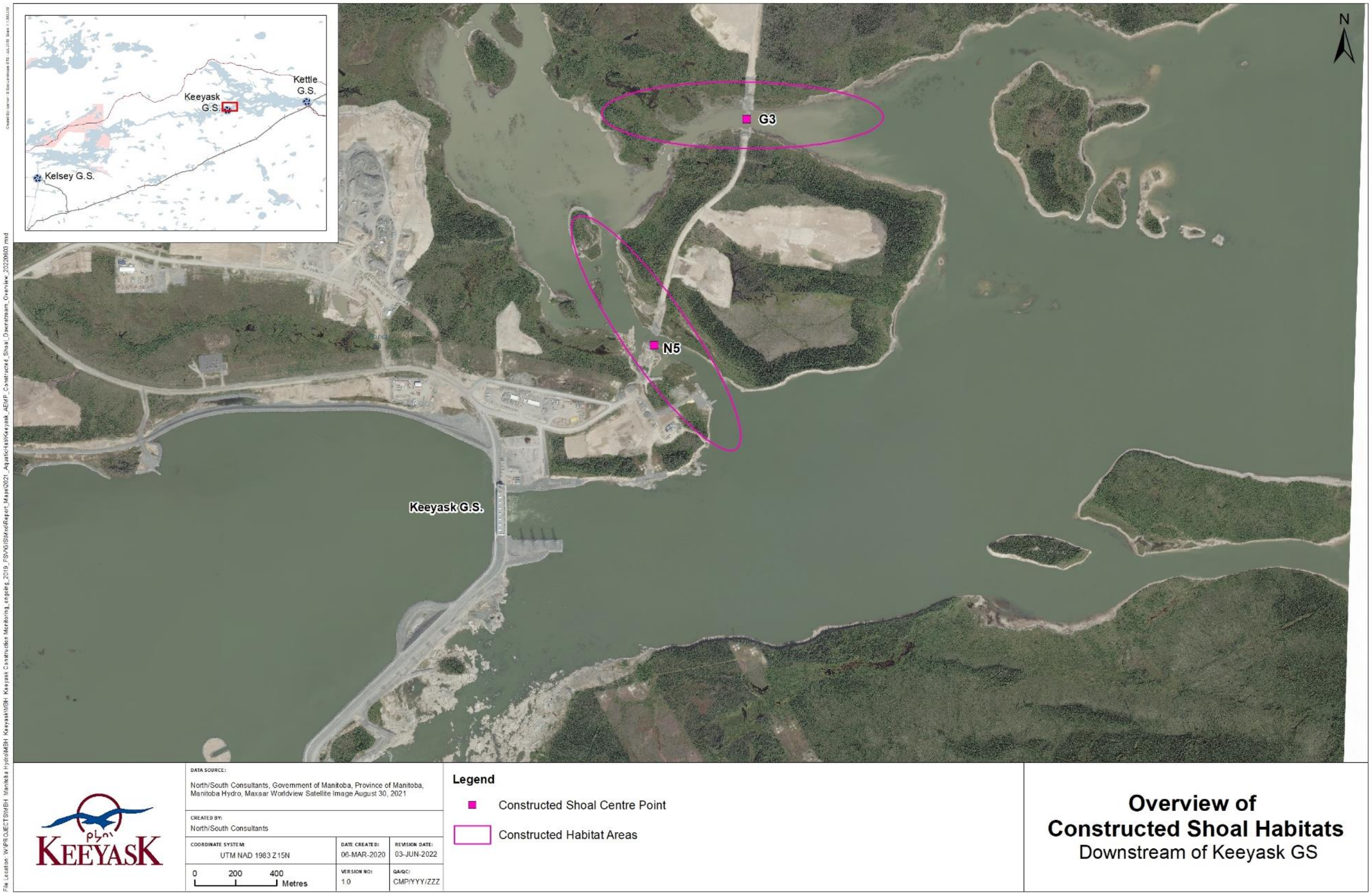
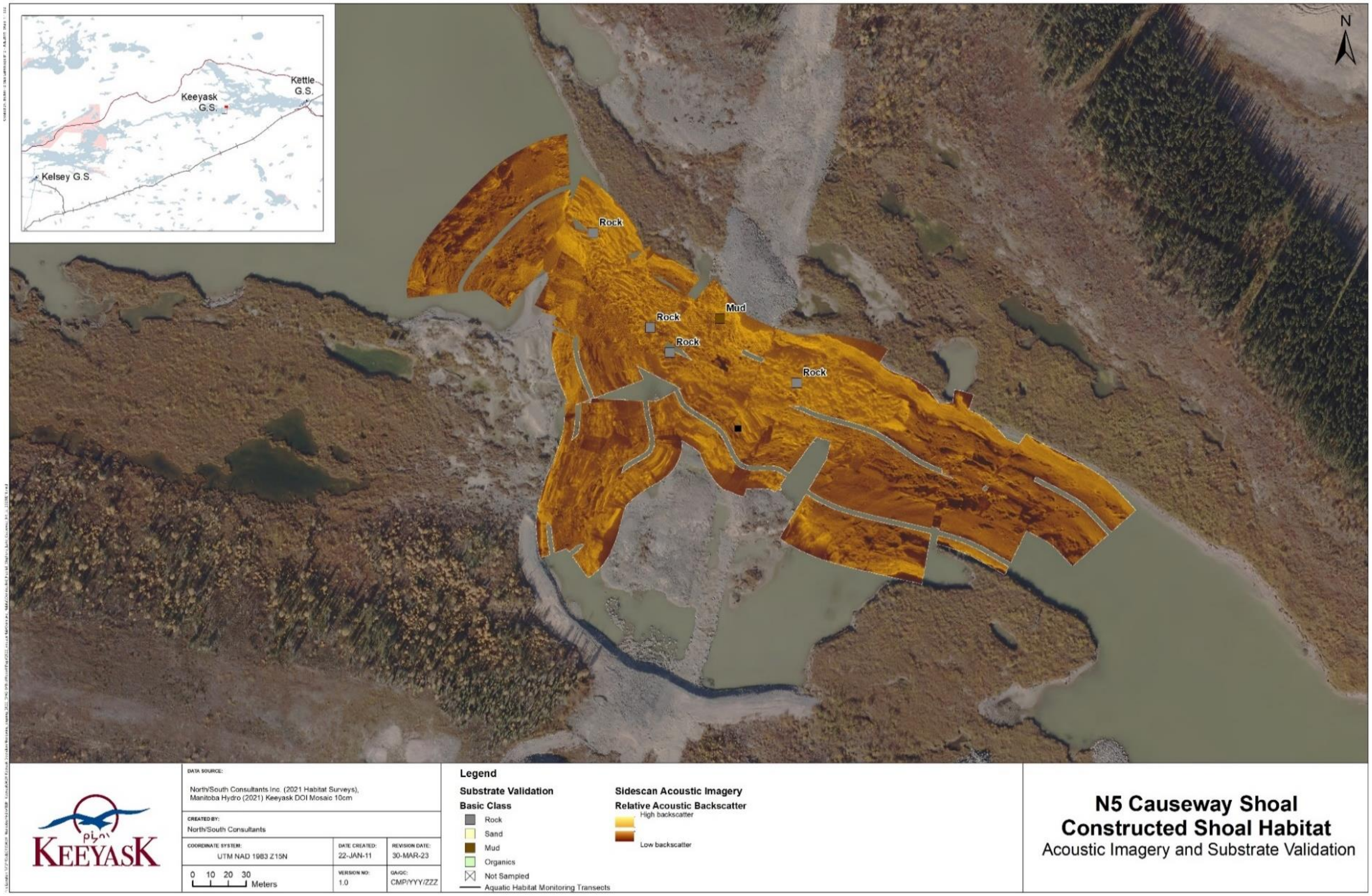


Photo 5: Silt and clay substrates collected from one sampling site located on the former N5 causeway, 2022.

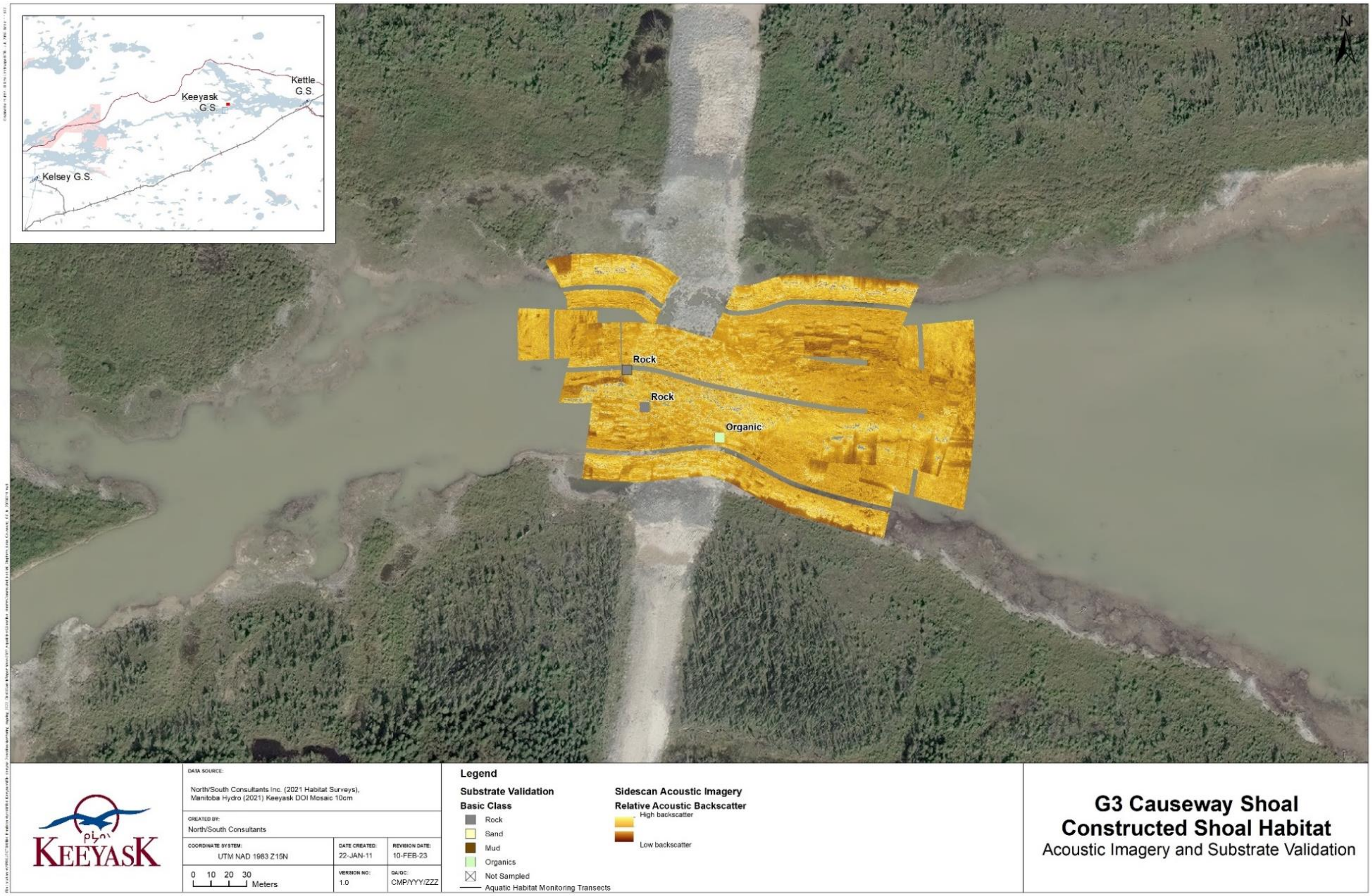
Photo 6: Organics collected from one sampling site located on the former G3 causeway, 2022.



Map 26: Map of 2022 Downstream of Keeyask GS constructed habitat aquatic habitat monitoring sampling sites.



Map 27: Map illustrating the results of substrate composition sampling sites and acoustic imaging for the N5 causeway shoal in Stephens Lake, 2022. Lighter colours in the acoustic imagery indicate harder substrates while darker colours indicate softer substrates.



Map 28: **Map illustrating the results of substrate composition sampling sites and acoustic imaging for the G3 causeway shoal in Stephens Lake, 2022. Lighter colours in the acoustic imagery indicate harder substrates while darker colours indicate softer substrates.**

Table 23: Locations and results of field bottom type validation sampling and post-survey class verification at the constructed habitats in Stephens Lake, 2022.

Shoal	Date	Site ID	Gear	Location		Depth (m)	Compaction	Estimated Sample Composition								Basic Class	Substrate Class Verification[1]
				Easting	Northing			Substrate 1	%	Substrate 2	%	Substrate 3	%	Substrate 4	%		
N5-1	10-Aug-22		weighted sounding line	364579	6248112	3.0	hard	cobble	60	boulder	30	gravel	5	sand	5	rock	cobble/boulder/gravel
N5-2	10-Aug-22		petite Ponar	364611	6248059	3.0	hard	cobble	100	-	-	-	-	-	-	rock	cobble
N5-3	10-Aug-22		weighted sounding line	364693	6248028	3.0	hard	boulder	95	cobble	5	-	-	-	-	rock	boulder/cobble
N5-4	10-Aug-22		petite Ponar	364650	6248064	3.0	soft	silt	45	clay	40	sand	10	organics	5	mud	silt/clay/sand
N5-5	10-Aug-22		petite Ponar	364622	6248045	2.0	hard	cobble	95	sand	5	-	-	-	-	rock	cobble/sand
G3-1	10-Aug-22		weighted sounding line	365080	6249108	2.0	hard	boulder	95	sand	5	-	-	-	-	rock	boulder/sand
G3-2	10-Aug-22		weighted sounding line	365090	6249087	3.0	hard	boulder	95	sand	5	-	-	-	-	rock	boulder/sand
G3-3	10-Aug-22		petite Ponar	365132	6249070	2.0	soft	organics	100	-	-	-	-	-	-	organic	organic

5.0 DISCUSSION

The primary objective of monitoring deep water and constructed habitats is to assess change in substrate composition in deep water areas (greater than 3 m) both upstream and downstream of the GS following GS construction and reservoir impoundment. Monitoring focussed on sites identified in the EIS as sensitive habitats for Lake Sturgeon (both spawning and rearing) and constructed habitats that were developed as an offsetting measure to account for some habitat loss caused by the Project. It was predicted in the EIS that substrate and habitat characteristics (such as depth and velocity) would change in these areas following reservoir impoundment and GS operation due to alteration in hydraulics and the ability of the river to transport materials along the riverbed. The evolution of substrate composition within the Keeyask reservoir and immediately downstream of the GS in Stephens Lake depends mostly on water velocity patterns and how the processes of erosion, transport, and deposition maintain or alter existing substrates.

5.1 DEEP WATER AND SENSITIVE HABITATS

Sensitive Lake Sturgeon habitats (*i.e.*, spawning and rearing habitats) identified during baseline studies for the Project were sampled in 2022. These included spawning habitats at Long Rapids and Birthday Rapids, and young-of-the-year (YOY) and sub-adult habitats at the entrance to Gull Lake, lower Gull Lake at the channel north of Caribou Island, and in Stephens Lake approximately 4–7 km downstream of the GS. Additional deep water habitats were monitored for substrate composition in the lotic portion of the middle Keeyask reservoir and the area of Stephens Lake between 1–4 km downstream of the GS to monitor changes over time.

It was predicted in the EIS that habitat characteristics at Birthday Rapids would change following reservoir impoundment (*e.g.*, slower water velocities and silt deposition) and the area may become unsuitable for Lake Sturgeon spawning. It was also predicted that Lake Sturgeon would then move upstream to Long Rapids to spawn. In 2022, substrates downstream of Long and Birthday rapids were generally hard, largely consisting of bedrock, boulder, and cobble, with no smaller substrates present. Water velocities were generally fast with areas of very high (>2.5 m/s) velocity in the farthest upstream transects. Spawning adult Lake Sturgeon were captured downstream of Birthday Rapids while no adult Lake Sturgeon were captured downstream of Long Rapids in spring 2022 (Ambrose *et al*. 2023). Further, movement monitoring studies using acoustic telemetry conducted in 2022 did not observe any Lake Sturgeon moving upstream to Long Rapids during the spawning period (Hrenchuk 2023). Together this suggests that, as in 2021, habitat characteristics at Birthday Rapids have remained suitable for Lake Sturgeon spawning and adult Lake Sturgeon do not appear to move upstream to spawn at Long Rapids.

It was predicted in the EIS that sand and gravel may deposit near the entrance to Gull Lake following reservoir impoundment and this may provide important YOY Lake Sturgeon habitat. As in 2021, water velocities at the entrance to Gull Lake in 2022 were moderate but were high within the upstream portion of this area. Here, substrates were generally hard, consisting of mainly boulder and cobble. Farther downstream, smaller substrates consisting of gravel, sand, clay, and silt were present. No juvenile or YOY Lake Sturgeon were captured here during monitoring in 2021 or 2022 (Burnett *et al*. 2022, 2023).

The lower portion of Gull Lake (*i.e.*, the area around Caribou Island) represents important Lake Sturgeon YOY and juvenile rearing habitat. It was predicted in the EIS that substrates may deposit on top of existing sand and gravel following impoundment, decreasing its suitability for juvenile Lake Sturgeon. In 2022, this area was characterized by areas of low to moderate water velocity surrounded by areas of standing water with minimal velocity. As in 2021, an area of sand was present within the middle of the channel to the north of Caribou Island, which was surrounded by mud (*i.e.*, silt and clay) in off-channel areas. Upstream and downstream of this sandy area the channel was generally rocky, and some silt deposition was evident downstream. Juvenile Lake Sturgeon continue to be captured in this area following impoundment, suggesting that the habitat has remained suitable (Burnett *et al*. 2022, 2023).

The area immediately downstream of the Keeyask GS was characterized by high water velocity and rocky substrate across the channel. Water velocities moderated approximately 3 km downstream of the GS and areas of sand and mud were present. Prior to the Project, a sensitive Lake Sturgeon habitat was identified approximately 4–7 km downstream of the GS site. This area contained sand substrate and was important for YOY and juvenile Lake Sturgeon. It was predicted in the EIS that fine sediments may deposit in this area, decreasing its suitability for juvenile Lake Sturgeon. As in 2021, areas of hard substrates, predominantly cobble, gravel, and sand, were found largely within the upstream portions of the reach in 2022. Farther downstream, sites largely consisted of a mix of silt, sand, and clay. Silt deposition was evident throughout the reach in summer, whereas organic matter consisting of detritus and broken-down plant material was predominant throughout the reach in spring. Despite this, juvenile Lake Sturgeon were captured in large numbers in this sensitive habitat area in the fall of 2022 (Burnett *et al*. 2023).

5.2 CONSTRUCTED HABITATS

Constructed habitats were developed as an offsetting measure to account for some habitat loss caused by the Project and to increase the certainty that fish spawning habitat was available post-Project. Rocky spawning shoals were constructed in the Keeyask reservoir to provide Lake Whitefish and Walleye spawning habitat immediately after impoundment. Rockfill material was left in place at two temporary causeways (N5 and G3) in Stephens Lake to create shallow rocky habitat for fish and other aquatic species as a means of improving diversity in these areas. Monitoring in 2021 indicated that each shoal was composed of boulders with no evidence of silt deposition. Monitoring in 2022 indicated that the predominant substrate at all nine shoals in the Keeyask reservoir was boulder and cobble. However, one shoal (F-North) showed deposition of small amounts of sand and organics over top of the rocky substrate near the middle portion of the shoal. In Stephens Lake, fine substrate (silt/clay/sand) was the dominant substrate at one site sampled on the N5 causeway along the north-east side closest to shore. Organic matter was found at one site on the G3 causeway along the south side closest to shore. However, hard substrates predominated at both causeway remnants.

5.3 NEXT STEPS

Sampling conducted in 2022 represents the second year of monitoring following impoundment of the Keeyask GS reservoir. Surveys will be repeated in 2023 using the same measures to describe changes to sensitive and constructed habitat areas as the Keeyask reservoir ages and as operation of the GS continues. A comprehensive report will follow that includes a detailed analysis of changes in deep water and constructed habitats in the three years following reservoir impoundment and provides responses to the key questions outline in the AEMP and included in the introduction of this report.

6.0 SUMMARY AND CONCLUSIONS

- Deep water and constructed habitats were sampled in 2022 to monitor change in substrate composition in deep water areas (greater than 3 m) both upstream and downstream of the GS.
- Deep water areas included sensitive Lake Sturgeon habitats (*i.e.*, spawning and rearing habitats) and deep water areas in the middle Keeyask reservoir and upper Stephens Lake.
  - It was predicted in the EIS that habitat characteristics at Birthday Rapids would change following reservoir impoundment and the area may become unsuitable for Lake Sturgeon spawning. It was also predicted that Lake Sturgeon would then move upstream to Long Rapids to spawn. In 2022, substrates downstream of Long and Birthday rapids were hard, consisting of bedrock, boulder, and cobble. No smaller substrates were found. Water velocities were generally fast in each area. Spawning adult Lake Sturgeon were captured downstream of Birthday Rapids in 2022 which suggests that habitat characteristics in this area were suitable for Lake Sturgeon spawning. No adult Lake Sturgeon were captured downstream of Long Rapids.
  - In 2022, the middle Keeyask reservoir contained hard substrates, classified as boulder and cobble and water velocities were high. This area is not considered as important for Lake Sturgeon but is being sampled to monitor how substrates in deep water areas of the Keeyask reservoir change over time.
  - It was predicted in the EIS that sand and gravel may deposit near the entrance to Gull Lake following reservoir impoundment and this may provide important YOY Lake Sturgeon habitat. However, water velocities have remained high in this area. Substrates were composed of boulder and cobble farther upstream and smaller substrates (gravel, sand, clay, and silt) farther downstream. No juvenile or YOY Lake Sturgeon were captured here during monitoring in 2021 or 2022. Substrates returned to boulder and cobble in the lotic channel in upper Gull Lake.
  - The lower portion of Gull Lake (*i.e.*, the area around Caribou Island) is characterized by areas of low to moderate water velocity surrounded by areas of standing water with minimal water velocities. It was predicted in the EIS that substrates may deposit on top of existing sand and gravel following impoundment, decreasing the suitability of the area for juvenile Lake Sturgeon. An area of sand was present within the middle of the channel to the north of Caribou Island. Some silt deposition was evident towards the downstream end of the sandy area. Juvenile Lake Sturgeon continue to be captured in this area following impoundment.
  - The area immediately downstream of the Keeyask GS was characterized by high water velocity and rocky substrate across the channel. Water velocities moderated approximately 3 km downstream of the GS and areas of sand and mud were present. Prior to the Project, a sensitive Lake Sturgeon area was located approximately 4–7 km downstream of the GS. This area contained sand substrate and was important for

YOY and juvenile Lake Sturgeon. It was predicted in the EIS that fine sediments may deposit in this area, decreasing its suitability for juvenile Lake Sturgeon. In 2022, substrate in the sensitive habitat area varied with larger substrates (cobble, gravel, and sand) found in upstream areas and smaller substrates (silt, sand, and clay) farther downstream. Broken-down plant material overlaid substrates in the spring, while silt deposition was evident in the summer. Despite this, juvenile Lake Sturgeon were captured in large numbers in this sensitive habitat area in both 2021 and 2022.

- All nine constructed spawning shoals in the Keeyask reservoir were composed of boulders and cobble. One (F-North) showed deposition of small amounts of sand and organics over top of the rocky substrate near the middle portion of the shoal.
- In Stephens Lake, one site on the N5 causeway remnant contained largely soft substrate (silt/clay/sand) deposition, while organic matter was found at a portion of the other (G3).
- Sampling in 2022 represents the second year of monitoring at sensitive, deep water, and constructed habitats. Surveys will be repeated in 2023 and a comprehensive report will follow that includes a detailed analysis of changes in deep water and constructed habitats in the three years following reservoir impoundment, including responses to key questions outlined in the AEMP.

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APPENDICES

APPENDIX 1: RESULTS OF PARTICLE SIZE ANALYSIS FROM SAMPLES COLLECTED IN DEEP WATER AREAS OF THE KEEYASK RESERVOIR AND STEPHENS LAKE, 2022.

Table A-1: Results of particle size analysis (conducted at ALS Laboratories) from samples collected at selected sites in the Keeyask reservoir at Gull Lake and Caribou Island sensitive habitat areas in August and in the Stephens Lake sensitive habitat area in June and August, 2022.

Date	Area Code	Area Name	Site ID	Inorganic Carbon (%)	$CaCO_3$ Equivalent	Total Carbon by Combustion (%)	Total Organic Carbon (%)	% Sand	% Silt	% Clay	Texture
								(2.0-0.05 mm)	(0.05-2 µm)	(<2 µm)	
17-Aug-22	DST2	Gull Lake	DST2-1	0.735	6.13	1.2	0.47	19.4	61.5	19.1	silt loam
17-Aug-22	DST2	Gull Lake	DST2-3	1.43	11.9	3.04	1.61	12.6	48.6	38.8	silty clay loam
14-Aug-22	DST3	Caribou Island	DST3-16	0.735	6.13	1.2	0.47	89.5	5.2	5.2	sand
14-Aug-22	DST3	Caribou Island	DST3-17	0.921	7.67	1.39	0.47	87.6	6.3	6.1	loamy sand
14-Aug-22	DST3	Caribou Island	DST3-19	1.78	14.9	3.97	2.19	15.6	61	23.3	silt loam
14-Aug-22	DST3	Caribou Island	DST3-22	0.911	7.59	1.92	1.01	82.5	9.3	8.2	loamy sand
14-Aug-22	DST3	Caribou Island	DST3-25	0.897	7.47	1.43	0.53	93	3.7	3.4	sand
14-Aug-22	DST3	Caribou Island	DST3-28	0.862	7.18	1.93	1.07	98.7	1.3	<1.0	sand
14-Aug-22	DST3	Caribou Island	DST3-31	1.44	12	3.02	1.58	74.7	14.8	10.5	sandy loam
14-Aug-22	DST3	Caribou Island	DST3-32	1.64	13.6	4.24	2.6	3.9	74.2	21.8	silt loam
14-Aug-22	DST3	Caribou Island	DST3-33	1.94	16.2	4.04	2.1	89.1	9.8	1.1	sand
14-Aug-22	DST3	Caribou Island	DST3-37	0.633	5.28	2.14	1.51	72	17.1	10.8	sandy loam
5-Jun-22	SH4	Stephens Lake	T3-3	1.47	12.3	6.59	5.12	44.5	45.7	9.8	loam
5-Jun-22	SH4	Stephens Lake	T3-4	1.45	12.1	5.83	4.38	55.5	38.3	6.1	sandy loam
5-Jun-22	SH4	Stephens Lake	T3-5	1.6	13.3	5.13	3.53	49	40.8	10.2	loam
6-Jun-22	SH4	Stephens Lake	T4-3	2.24	18.6	4.3	2.06	65.5	23.6	10.9	sandy loam
6-Jun-22	SH4	Stephens Lake	T5-3	1.35	11.2	3.85	2.5	67.2	17.2	15.6	sandy loam
13-Aug-22	DST4	Stephens Lake	DST4-4	1.54	12.8	5.01	3.47	40.9	28.9	30.2	clay loam
13-Aug-22	DST4	Stephens Lake	DST4-17	1.25	10.5	4.33	3.08	63.8	24.3	11.9	sandy loam
13-Aug-22	DST4	Stephens Lake	DST4-18	1.24	10.3	3.79	2.55	64.4	20.8	14.7	sandy loam
13-Aug-22	DST4	Stephens Lake	DST4-23	1.79	14.9	5.23	3.4	54.6	33.6	11.8	sandy loam
13-Aug-22	SH4	Stephens Lake	T3-3	1.23	10.2	3.84	2.61	68.8	20.9	10.3	sandy loam
13-Aug-22	SH4	Stephens Lake	T3-4	1.34	11.1	6.61	5.27	52.8	36.1	11.2	loam /sandy loam

Table A-1: Results of particle size analysis (conducted at ALS Laboratories) from samples collected at selected sites in the Keeyask reservoir at Gull Lake and Caribou Island sensitive habitat areas in August and in the Stephens Lake sensitive habitat area in June and August, 2022 (continued).

Date	Area Code	Area Name	Site ID	Inorganic Carbon (%)	$CaCO_3$ Equivalent	Total Carbon by Combustion (%)	Total Organic Carbon (%)	% Sand (2.0-0.05 mm)	% Silt (0.05-2 µm)	% Clay (<2 µm)	Texture
13-Aug-22	SH4	Stephens Lake	T3-5	1.38	11.5	6.93	5.55	40.5	47.3	12.2	Loam
13-Aug-22	SH4	Stephens Lake	T4-3	1.74	14.5	2.58	0.84	83.9	8.7	7.4	loamy sand
13-Aug-22	SH4	Stephens Lake	T5-3	1.24	10.3	3.81	2.57	72.1	17.3	10.5	sandy loam