# Keeyask Generation Project

## Aquatic Effects Monitoring Plan

# Development of Nearshore and Aquatic Macrophyte Habitat Report

**AEMP-2024-13**

KEEYASK

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Manitoba Environment Act Licence No. 3107

**2023 -2024**

# KEEYASK GENERATION PROJECT

## AQUATIC EFFECTS MONITORING PLAN

REPORT #AEMP-2024-13

## DEVELOPMENT OF NEARSHORE AND AQUATIC MACROPHYTE HABITAT IN THE KEEYASK STUDY AREA, 2023

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. Monitoring results provide information to assess the accuracy of predictions, information to determine the actual effects of construction and operation of the GS on the environment, and whether 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, and water levels were 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 commissioning of the final of seven turbines completed on March 9, 2022.

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

Nearshore habitats are important to aquatic plants and animals including fish because they are shallow enough to allow light to reach the bottom, which allows plants to grow. Aquatic plants provide food, cover, and spawning habitat for many kinds of fish. Many fish species prefer shallow nearshore habitats compared to deep offshore areas including jackfish (Northern Pike) and smaller-bodied forage fish (minnows).

Impoundment of the Keeyask reservoir in fall 2020 flooded areas upstream of the GS and changed many types of habitats including nearshore areas. Areas that were nearshore habitats before flooding became deeper, offshore areas. New nearshore areas will develop in shallow water areas (less than 3 m deep) that used to be on land. The development of these areas into healthy nearshore habitats will depend on factors like water level, the type of soil present before flooding, and how much soil and sediment is washed away (erosion) or left behind (deposited) by water. It is not clear how fast these areas will develop into places that will support the growth of aquatic plants and other aquatic life.

This report presents the results of nearshore and aquatic plant monitoring in the Keeyask reservoir in 2023, the third open-water season after flooding.

**Why is the study being done?**

Monitoring of nearshore habitats is being done to answer three questions:

*How will nearshore habitat develop in the Keeyask reservoir?*

This question is important because some large-bodied fish species (including jackfish), small-bodied fish species (minnows), and many young fish use nearshore habitats for rearing, feeding, and spawning. It is important that these habitat types develop in the reservoir after flooding.

*How will aquatic plant habitat develop in the Keeyask reservoir?*

Aquatic plants are important for many aquatic species. Most of the areas in the Keeyask reservoir that are shallow and receive enough light at the bottom for plants to grow are now flooded land. It is important that these flooded terrestrial habitats change into suitable habitats for aquatic plants to grow.

*How accurate were the predictions in the EIS Aquatic Effects Supporting Volume?*

This question is important because it will help us to understand how nearshore habitat develops in flooded areas. Detailed studies of how fast nearshore habitats develop in northern Manitoba have not been done in the past. It was predicted that many nearshore areas in the Keeyask reservoir will turn into areas where rooted aquatic plants can grow.

**What was done?**

Substrate composition (what the bottom is made of), and aquatic plant presence were monitored in nine newly flooded shallow areas upstream of the Keeyask and three shallow areas downstream in Stephens Lake (map below). Stephens Lake is an old reservoir and is considered an example of what the Keeyask reservoir will look like over time. Aquatic plants were collected using a sampling rake (pictured below) and identified. The distribution of aquatic plants was mapped by interpreting images from a satellite and acoustic data from a boat-based sonar.

**Aquatic plants as seen from the boat (left), sampled using the rake (middle), and identified by species (right) in the Keeyask reservoir in 2023.**

Substrates and water depth were mapped using a sonar system. Substrate type was confirmed at each site by using a Ponar dredge to grab a sample of the bottom pictured below) or a sounding line (to hear or feel if the bottom is rocky or soft). A few Ponar grab samples were also sent to the lab to confirm classifications done in the field.

**Substrates sampled with a Ponar dredge (left) showing sand (middle) and organics (right) from the Keeyask reservoir in 2023.**

**What was found?**

Substrates in nearshore areas of the Keeyask reservoir were mostly made up of soft mud (like silt and clay) and some organic (plant) matter. Rooted aquatic plants were found at eight of the nine sampling areas in the Keeyask reservoir including areas that were on land before flooding. Fourteen species of aquatic plants were found including eleven rooted and three free-floating (not including algae). Plant beds were generally larger in the sampling areas in the Keeyask reservoir than in Stephens Lake. More aquatic plants were found in the flooded backbays in the Keeyask reservoir than in the areas close to the main part of the river.

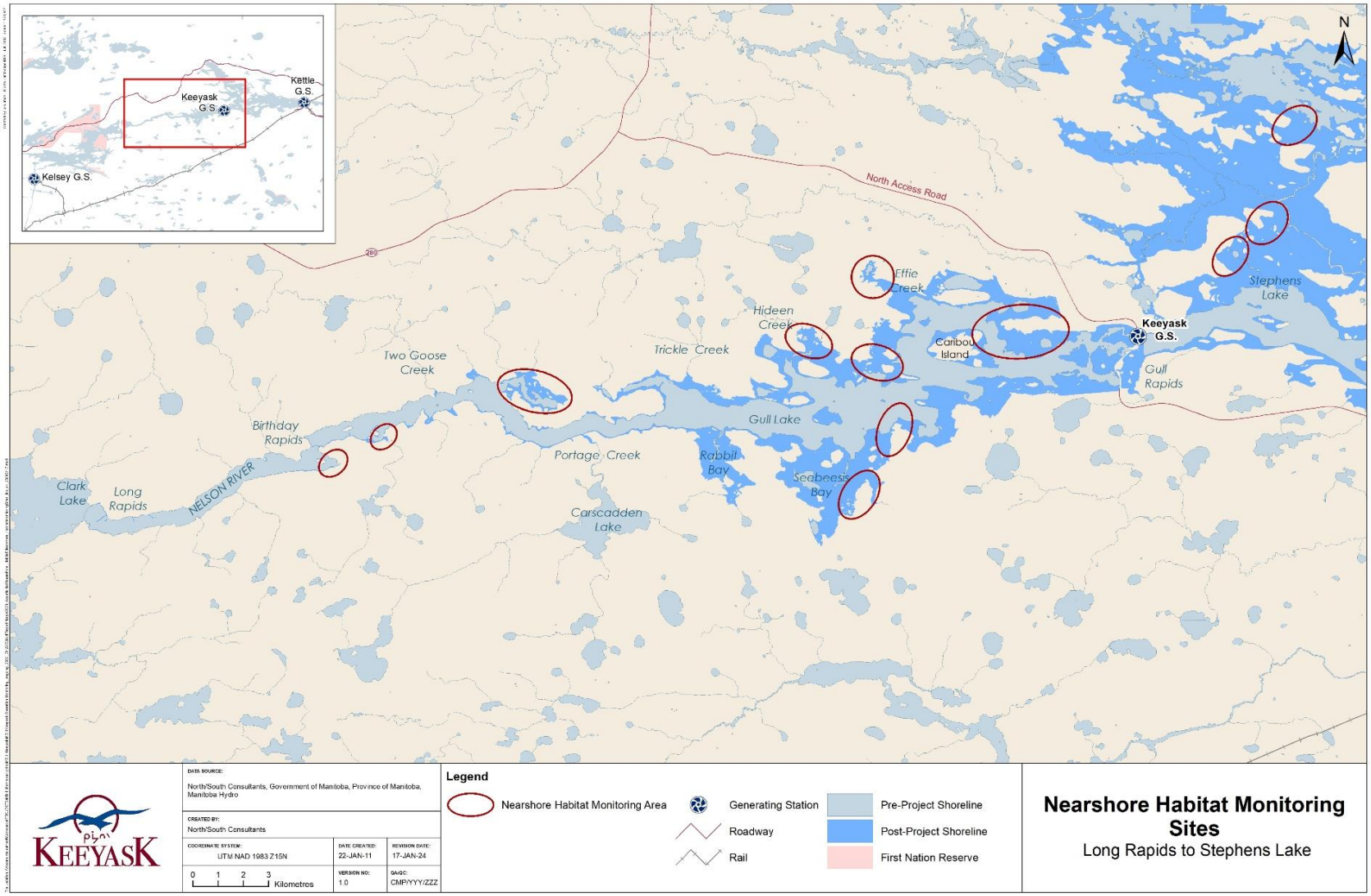
One area sampled in the Keeyask reservoir in 2023 showed little aquatic plant growth. This area was in the lower part of Gull Lake near the Keeyask GS. This area had lots of floating peat (the surface layer of soil that contains partly decayed plants) that makes conditions unsuitable for rooted aquatic plants. This peat will break down over time and it is likely that plants will eventually grow in this area.

**What does it mean?**

Sampling in 2023 was the third year after the Keeyask reservoir was flooded. Rooted aquatic plants were found at most shallow water sites sampled in the Keeyask reservoir, including in the flooded backbays on areas that used to be land. Large areas of organic substrates were found in the Keeyask reservoir, but mud, sand, and rock were also found. The EIS predicted that aquatic plants would not grow in many areas of the Keeyask reservoir until 15 years after flooding because plants were not expected to grow on organic substrates and areas of peat were expected to take a long time to break down. However, rooted plants were found growing on organic substrates showing that aquatic vegetation would regrow in the Keeyask reservoir more quickly than what was originally thought.

**What will be done next?**

Nearshore habitat and aquatic macrophyte monitoring was conducted every year in the first three years following reservoir impoundment to document early conditions and changes. Going forward, changes are expected to occur more slowly, and monitoring will be conducted every three years (next in 2026). Surveys will be repeated using the same methods to describe changes to nearshore habitats as the Keeyask reservoir ages over the long-term.




**Map showing sites surveyed for nearshore habitat monitoring, August 2023.**

# ACKNOWLEDGEMENTS

We would like to thank Manitoba Hydro for the opportunity and resources to conduct this study.

Kelvin Kitchekeesik, Melvin Cook, and Patrick Connell Jr. of Tataskweyak Cree Nation (TCN) are thanked for their local expertise and assistance in conducting the field work. We would also like to thank Douglas Kitchekeesik and Gordon Cook of TCN for arranging logistic support and personnel needed to conduct the fieldwork.

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# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF MAPS

# LIST OF PHOTOS

# LIST OF APPENDICES

# 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 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 licencing process for the Project, an Aquatic Effects Monitoring Plan (AEMP) was developed detailing the monitoring activities of various components of the aquatic environment including the focus of this report, nearshore habitat monitoring during the operation phase 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 changes 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 nearshore habitats and aquatic macrophyte growth.

Data collected in shallow water areas (less than 3 m) is recording changes in flooded areas that develop into new nearshore and macrophyte habitat as the Keeyask reservoir ages. Comparable data are being collected in Stephens Lake, which is considered a proxy for the Keeyask reservoir several decades after flooding.

Impoundment of the Keeyask reservoir was completed on September 5, 2020. Sampling in the Keeyask reservoir in 2023 represented the third year of sampling after impoundment. The key questions identified in the AEMP for this monitoring component are:

- *How will nearshore habitat develop in the Keeyask reservoir?*
- *How will aquatic macrophyte habitat develop in the Keeyask reservoir?*
- *How accurate were the predictions in the EIS?*

This report provides results based on data collected in August 2023, three years following impoundment and builds on results of surveys in 2021 and 2022 (Dolce *et al*. 2022, Dolce Blanchard and Hrenchuk 2023).). These results describe the initial flooded condition within the

Keeyask reservoir. Development of nearshore and macrophyte habitat is expected to be slow and may take up to 15 years, depending on site conditions. Surveys will be repeated over time to describe changes as the Keeyask reservoir ages.

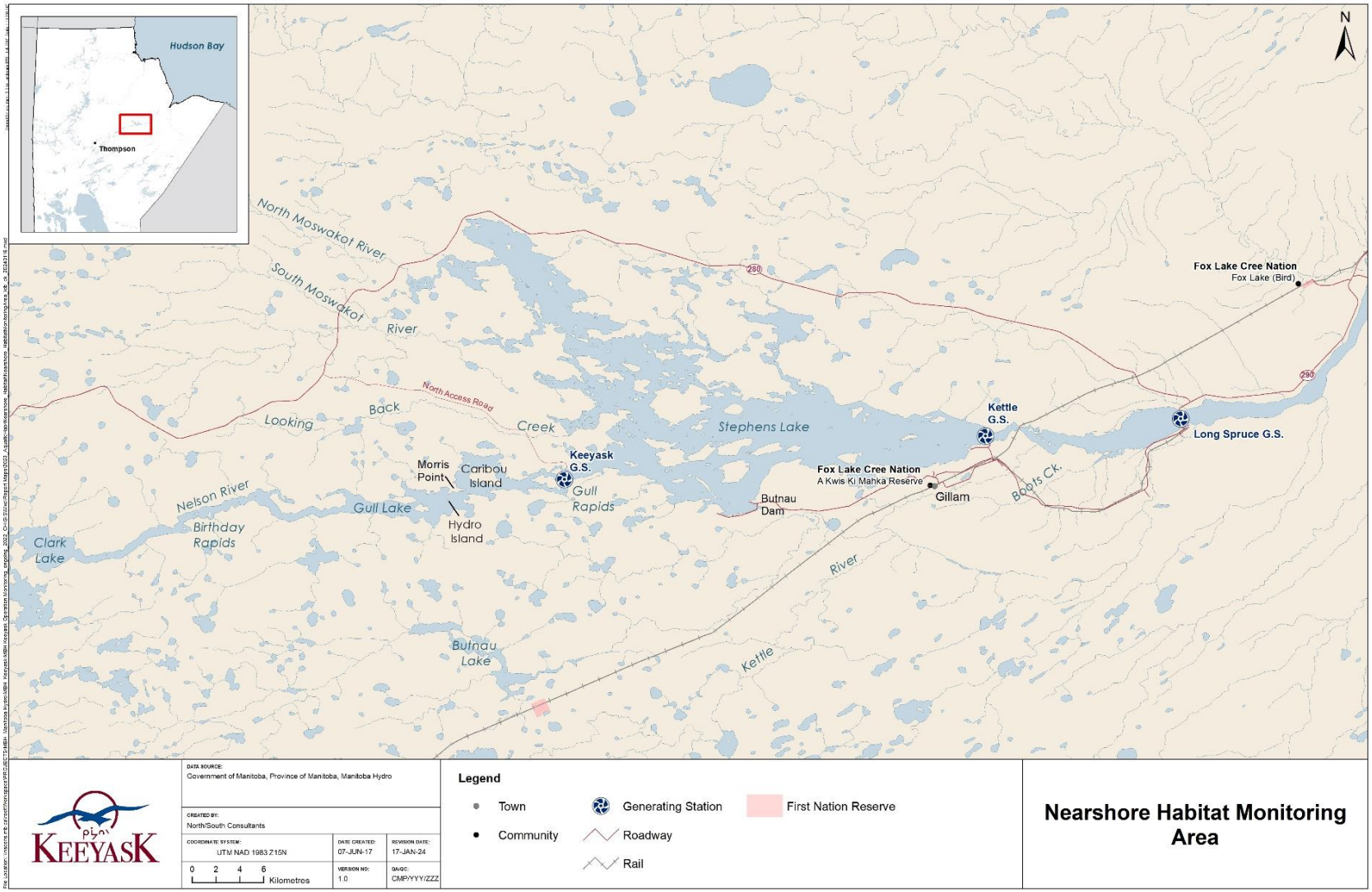
# 2.0 STUDY SETTING

The study area encompasses an approximately 50 km long reach of the Nelson River from Birthday Rapids to the north arm of Stephens Lake (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. Birthday Rapids is located approximately 10 km downstream of Clark Lake and 30 km upstream of 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, this portion of the Keeyask reservoir is still referred to 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.




**Map 1:** **Map of the Nelson River showing the site of the Keeyask Generating Station and the nearshore habitat monitoring study setting.**

# 3.0 METHODS

## 3.1 SAMPLE DESIGN

Sampling areas for nearshore habitat monitoring were selected to represent the range of inundation experienced in the Keeyask reservoir from very little change in depth immediately upstream of Birthday Rapids to areas of maximum depth increase in the lower reservoir (Map 2). Sites were also selected to include both shallow flooded habitat in the uppermost sections of flooded tributaries and areas nearer to the mainstem (Map 3). Sampling was initially intended to target shallow areas (<3 m in depth post-Project) but was extended to deeper habitats to include previous littoral areas that were inundated after impoundment. Four of the nearshore sampling areas (as defined by reservoir zones) were located in zones 4, 7, 8 and 12 (Map 4) which are also sampled in the water quality, benthic invertebrate, and fish monitoring programs to provide an integrated study of the development of the aquatic environment in newly flooded terrestrial habitat. Three reference sites from previously flooded areas in Stephens Lake were also sampled (MS10, MS11, and MS12; Map 3). Monitoring of nearshore habitat conditions in this area are to provide context for future habitat conditions for the flooded Keeyask reservoir sites after several decades of impoundment.

Nearshore habitat was characterized using a combination of satellite imagery, boat-based sonar surveys, and point measurements at sites within the sampling areas. As described in Section 3.2, satellite remote sensing was used to generate shorelines of the new reservoir and delineate boundaries between turbid waters associated with the mainstem of the reservoir and humic water associated with tributaries. Satellite imagery was also used to map the extent of aquatic plants unless the water was too turbid. As described in Section 3.3, each sampling area was surveyed using sonar to obtain information on water depth, substrate, and plants in the water column. Selected sites within the sampling areas were sampled for substrate (Section 3.4), macrophytes (Section 3.5), and measurement of light extinction (Section 3.6).

## 3.2 SATELLITE REMOTE SENSING

Moderate/high resolution satellite images were used to track reservoir-scale changes over time using optical and microwave electromagnetic frequencies. These changes include shoreline position and the presence of aquatic plant beds, as well as the boundaries of turbid water masses (*i.e.*, water masses with high suspended sediment concentration) and humic water masses (*i.e.*, water masses high in dissolved organic carbon concentration).

Reservoir shorelines specific to the nearshore sampling areas were determined using high-resolution (50cm) Jilin-1 (Satellite Imaging Corporation) multispectral (red, green, blue, and near-infrared) satellite image data collected in August 2023 and classifying the imagery into land and

water pixels by using a near-infrared image band thresholding technique. The resulting wetted area classification was converted to a vector product and manually edited to remove additional misclassified water areas.

The estimated extent of aquatic plants was determined by an unsupervised image classification using the four optical bands of the satellite imagery with land masked out to delineate where macrophytes were present at or near the surface of the nearshore habitat areas. It should be noted that this method cannot distinguish between floating and rooted plants. Where water was too turbid for light to penetrate the water column, acoustic plant detections from the BioSonics data (Section 3.3) were used to delineate plant bed extent.

Turbid and non turbid water masses within the reservoir were determined using the European Space Agency's (ESA) Sentinel-2 Level-2A optical images obtained from the ESA Copernicus Open Access Hub website (https://scihub.copernicus.eu/). Images of the Keeyask study area were captured three times during the 2023 open-water season (spring, summer, and fall) and were analyzed using ESA's SNAP satellite image processing software and ArcGIS software. Areas were classified as humic (high in dissolved organic carbon), mixed (a transition class between humic and turbid water masses), or turbid (expected to be high in TSS) according to their optical properties. Humic water appears very dark in the imagery, turbid water is bright, and mixing is obvious between the two. ArcGIS was then used to map and summarize the areas of these three water mass types.

## 3.3 WATER DEPTH, SUBSTRATE, AND PLANT MAPPING

A BioSonics MX 200 kHz single-beam echosounder sonar was used to characterize the substrate and calculate water depth within each nearshore habitat area. The echosounder was also used to delineate areas of plant beds where satellite imagery was not effective. An initial transect was navigated parallel to the shoreline through the whole sampling area. A second 'zig-zag' patterned transect was conducted travelling between nearshore and offshore crossing the first transect. At some locations, shallow water and/or the presence of terrestrial debris or peat mats prevented access to portions of the sampling area.

BioSonics Visual Aquatic software was used to calculate water depth across each transect. Bottom depth in the field is 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). Substrate grab samples (Section 3.4) were used to validate acoustic bottom typing data.

The presence of plants was determined according to a higher acoustic signal than the background water column without plant presence and was used to delineate the edges of plant beds. BioSonics Visual Aquatic software has analysis capabilities for detection of plants in the water column based on acoustic signal threshold (*i.e*. -70 dB), minimum plant length *(i.e*. 20 cm) and the maximum depth at which you would expect plants. However, sometimes aquatic plants cannot be distinguished from flooded terrestrial vegetation or suspended peat due to their similar acoustic responses.

Summary habitat maps (depth, substrate, and plant bed extent) of each nearshore sampling area were produced using the BioSonics classified acoustic data and the satellite imagery was used to determine the extent of plant beds described in Section 3.2. The mapped shoreline created using satellite imagery (Section 3.2) was used as a boundary for the bathymetric interpolation produced in ArcGIS software. Three maps were created:

1) Bathymetric maps were produced using the depths from the BioSonics acoustic data collected during sampling from 2021 to 2023. Depth data for the three years was standardized to the 2023 water level, which approximately equates to water levels associated with a median or 50$^{th}$ percentile inflow. Where the survey boat could not access portions of a sampling area, bathymetry was interpolated to the nearby shoreline boundary.
2) Substrate maps were also produced from the three years of acoustically classified data. ArcGIS software was used to interpolate a continuous substrate surface. Where sections of a sampling area could not be accessed, substrate was indicated as not mapped.
3) Maps of the extent of plant beds in 2023 was produced using the high-resolution satellite imagery described in Section 3.2. Where water was too turbid for light to penetrate the water column, acoustic plant detections from the BioSonics data were used to delineate plant bed extent.

## 3.4 SUBSTRATE SAMPLING

Substrate samples were collected in each of the nearshore habitat sampling areas in the Keeyask reservoir and Stephens Lake (Map 3). In 2021, prior to the first year of field surveys, each sampling area was marked with a grid of points. Sampling sites within each sampling area were randomly selected from this grid of points. Each selected point was sampled if access was possible (access was not possible at some sites due to shallow water or the presence of floating peat or terrestrial vegetation). In 2022, additional sites were selected that would be accessible. In 2023 these sites were then revisited again, to have comparable sites between years. Water depth was recorded at each site. Weather conditions and water temperature were recorded once in each sampling area.

Substrate grab samples were collected using a petite Ponar (0.023 m$^2$ surface area) dredge sampler. Primary, secondary, and tertiary substrate types were identified at each sampling site and classified using a 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.

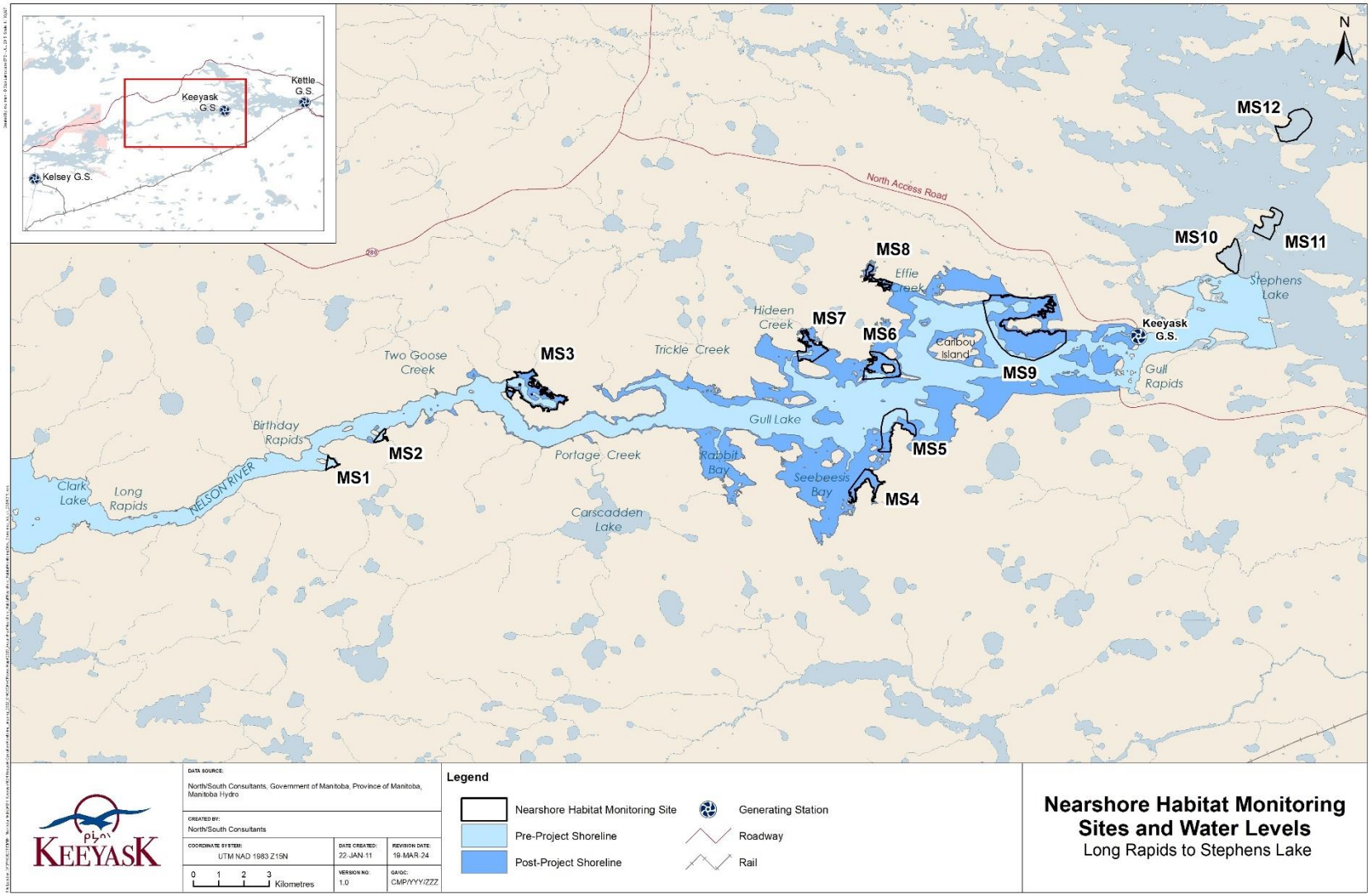
**Table 1: Modified Wentworth scale of material size used to classify substrate *in situ* (after Wentworth 1922).**

| 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 |

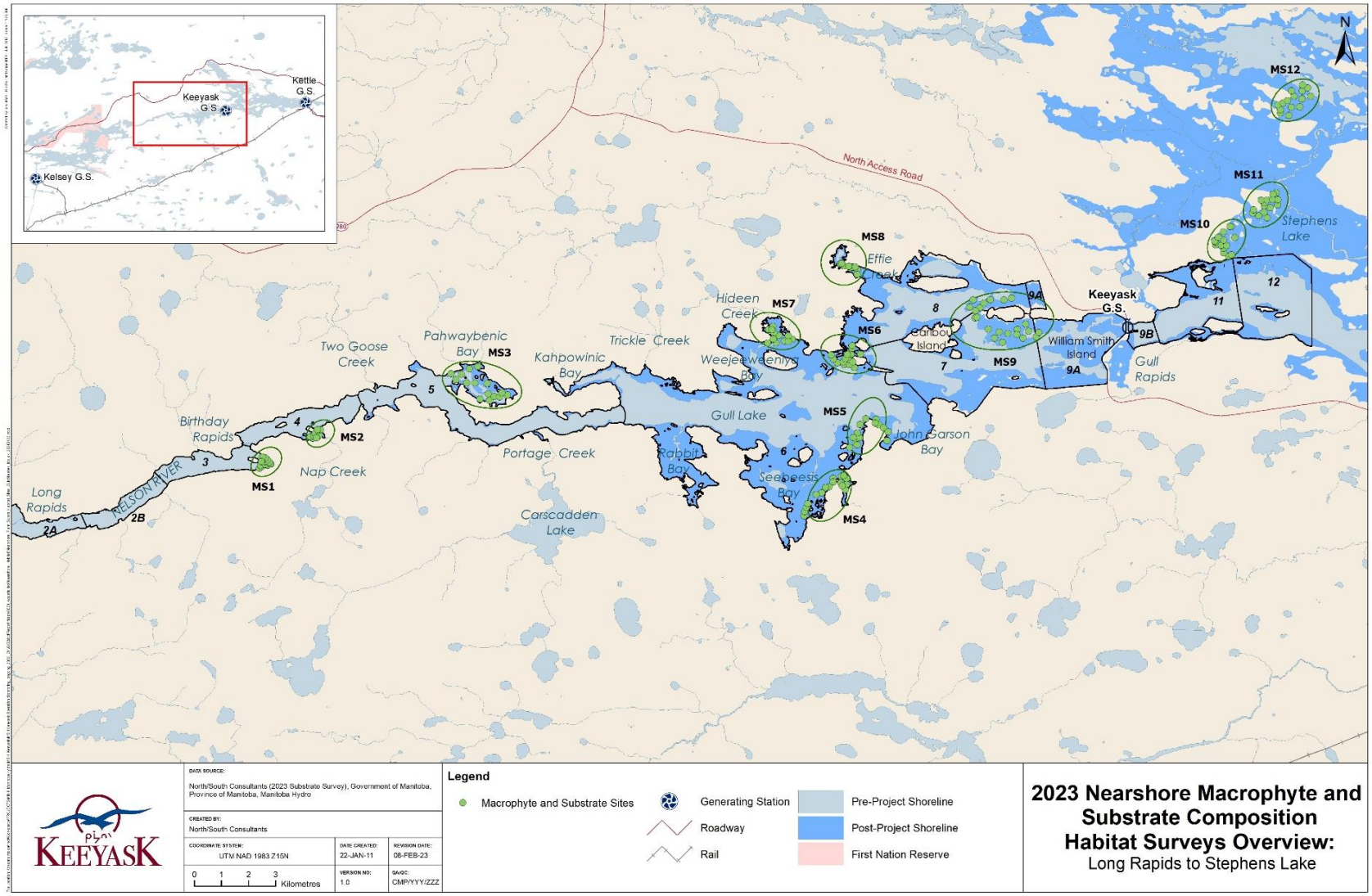
## 3.5 MACROPHYTE SAMPLING

Plant samples were collected at the same sites selected for substrate sampling (Section 3.4, Map 3).

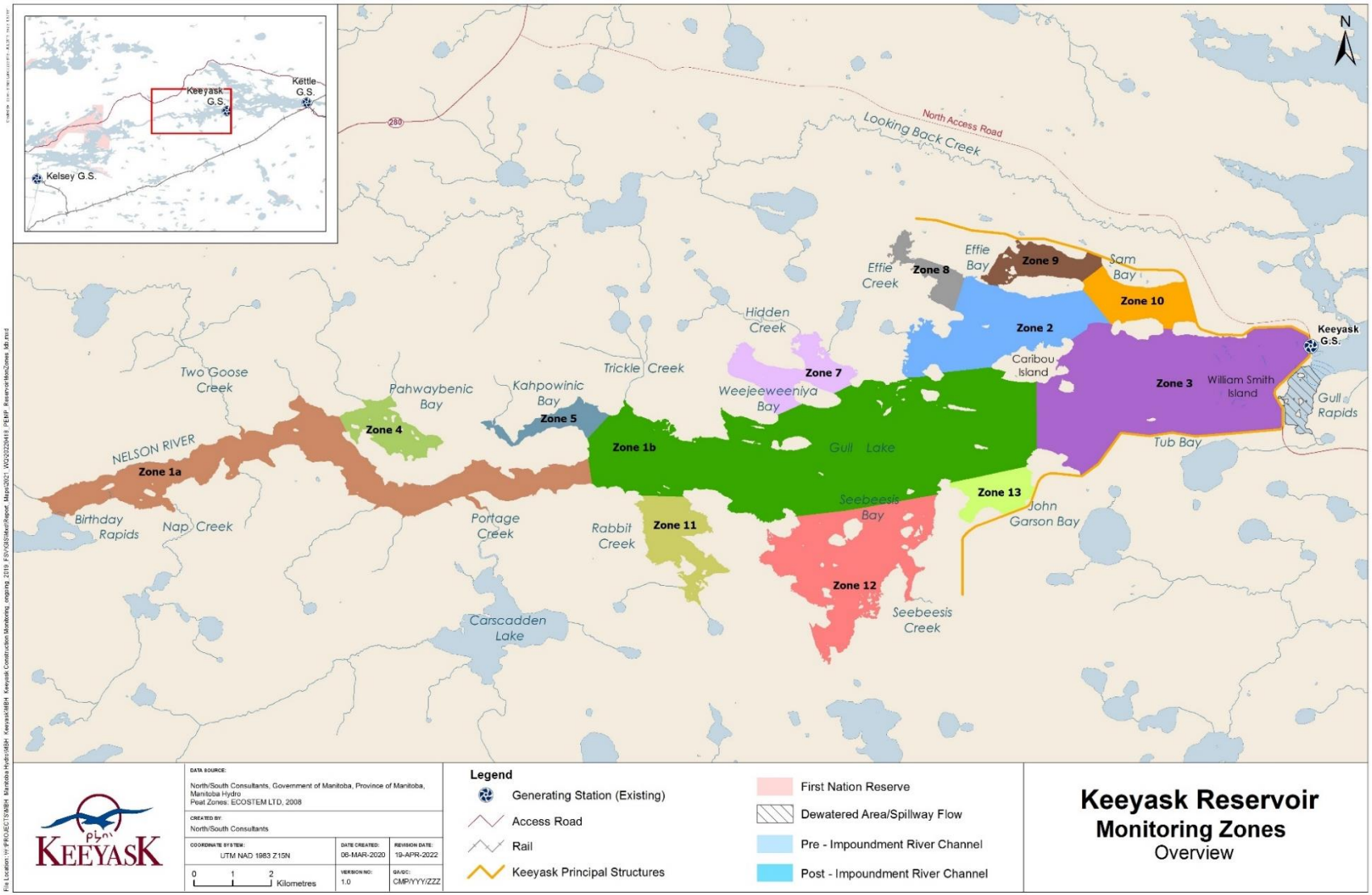
A weighted rake sampler was used at each site to assess the presence of submerged aquatic plants and obtain a sample for species identification. The rake sampler consisted of a double headed rake, constructed back-to-back with hose clamps and U-bolts with a heavy braided rope (10 m long) to assist in keeping the rake along the bottom (Photo 1). The amount of each species within the sample was estimated as sparse, common, or abundant (Figure 1). Macro-algae (*Chara* spp. and *Nitella* spp.), filamentous algae, aquatic mosses, and free-floating vascular plants (*Lemna* spp.) were also recorded if observed.




**Map 2: Map outlining the nearshore habitat monitoring areas within the Keeyask study area.**




**Map 3: Locations of nearshore substrate and aquatic macrophyte sampling sites for the nearshore aquatic habitat monitoring surveys in 2023.**




**Map 4: Keeyask reservoir backbay areas (zones) – zones 4, 7, 8, and 12 were sampled for substrate, aquatic macrophytes, and light extinction as part of the nearshore aquatic habitat monitoring surveys in 2023.**

| Fullness Rating | Coverage | Description |
|---|---|---|
| 1 |  | Only few plants. There are not enough plants to entirely cover the length of the rake head in a single layer. |
| 2 |  | There are enough plants to cover the length of the rake head in a single layer, but not enough to fully cover the tines. |
| 3 |  | The rake is completely covered and tines are not visible. |

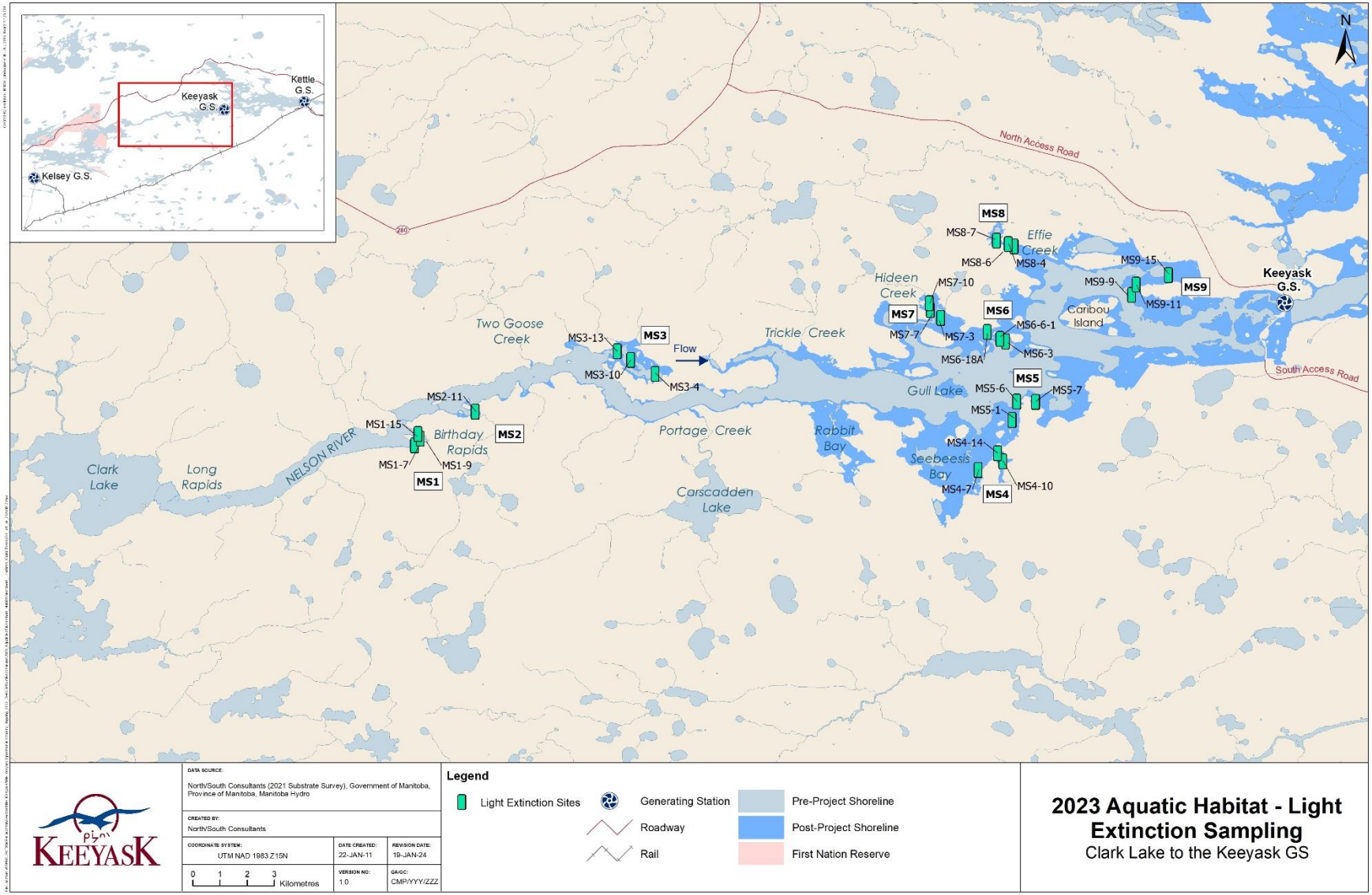
**Figure 1: Plant density based on rake collection (0 - absent; 1 - sparse; 2 - common; and 3 - abundant; Hauxwell *et al.* 2010).**

**Photo 1: Image of the weighted double headed rake sampler.**

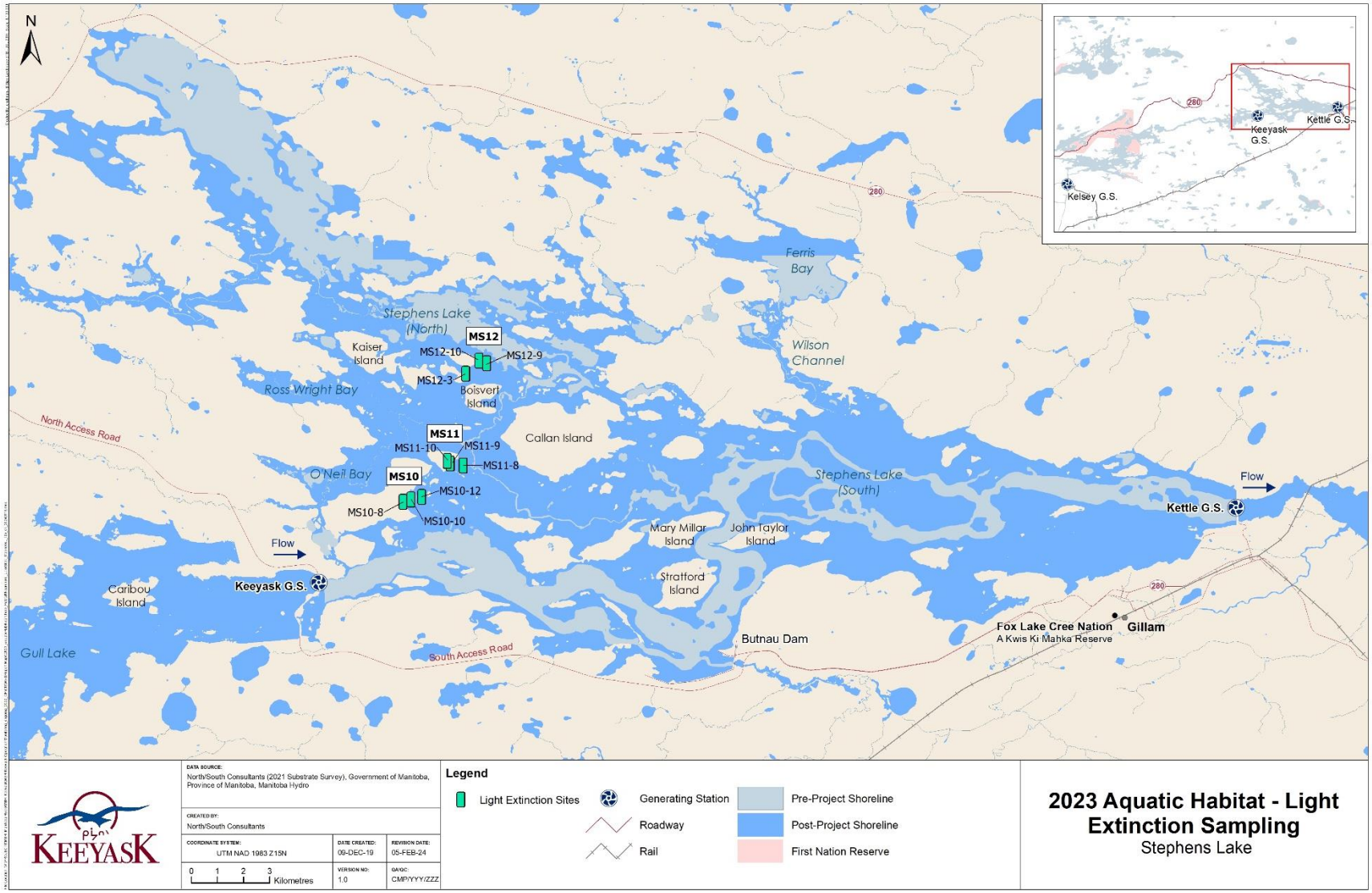
## 3.6 LIGHT EXTINCTION SAMPLING

A light profile measurement was taken using a LI-1400 data logger (LI-COR) at three (MS3-MS12) or four (MS1-MS2) sites in each sampling area (maps 5 and 6). There are three sensors associated with the LI-COR: terrestrial sensor (air); spherical sensor (underwater); and the flat sensor (underwater). The air sensor was placed on a flat surface in direct sunlight, close to the surface of the water. Both underwater sensors were lowered in the water on the sunny side of the boat. Light readings were recorded just below the water surface and at 10 cm vertical increments until the point of light extinction was reached. At that point, the LI-COR was lowered an additional 20 cm to ensure that all readings had been recorded.

Photosynthetically active radiation (PAR) extinction was calculated by determining the ratio of terrestrial to spherical sensors at each depth, relative to the surface. Outliers were removed to ensure the percent of PAR began at the water surface was 100%.




**Map 5: Light extinction sampling sites in the Keeyask reservoir, 2023.**




**Map 6: Light extinction sampling sites in Stephens Lake, 2023.**

# 4.0 RESULTS

## 4.1 OVERVIEW OF RESERVOIR

Satellite remote sensing data from the Copernicus/European Space Agency were used to map the Keeyask reservoir showing shoreline and water mass boundary positions for the spring (June 14), summer (August 21), and fall (October 10) of 2023 (Map 7).

The open-water area within the Keeyask reservoir decreased over the open-water season, measuring (8,932 ha), summer (8,524 ha), and fall (8,256 ha) periods (Table 2). Inflows were highest in the spring and lowest during the fall. Floating peat islands, that first appeared in spring 2021 and became abundant by fall 2021, were present throughout the 2023 open-water period, seen as small green island areas within backbays in Map 8.

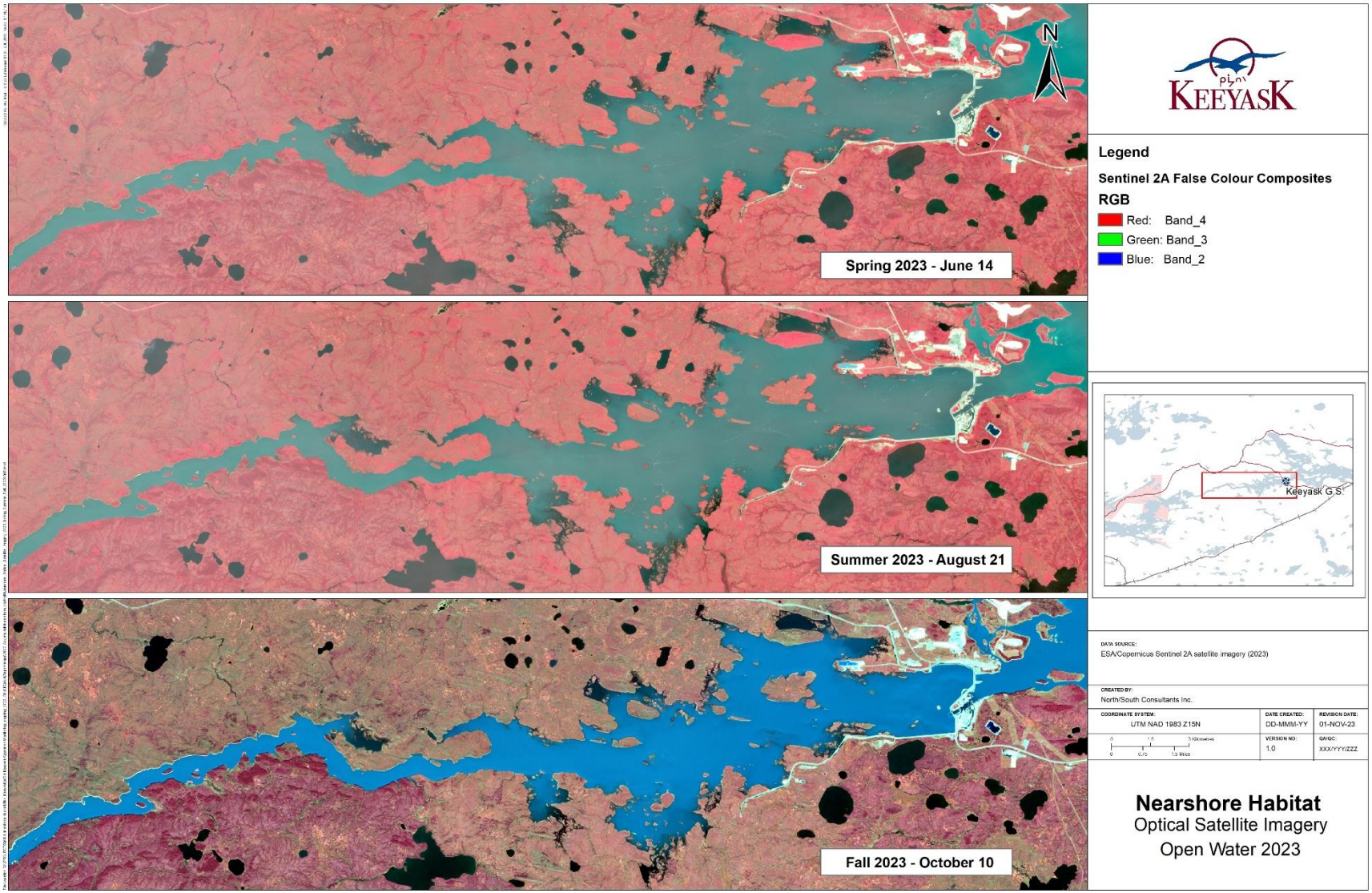
Turbid water masses were predominant throughout the mainstem of the Nelson River and into the Keeyask reservoir in spring, summer, and fall (Map 9). The Keeyask reservoir backbays contained the highest proportion of humic water. A clear transition of mixed water could be seen between the humic and turbid water masses. As was seen in 2021 and 2022, the fall had the highest amount of turbid water (7,118 ha) and the lowest amount of humic and mixed water masses. However, in August, mixed water masses extended to the ends of the flooded reservoir backbays.

**Table 2: Summary of reservoir humic, mixed, and turbid water mass areas (spring, summer, and fall 2023) derived from the analysis of optical (Sentinel-2) satellite remote sensing data.**

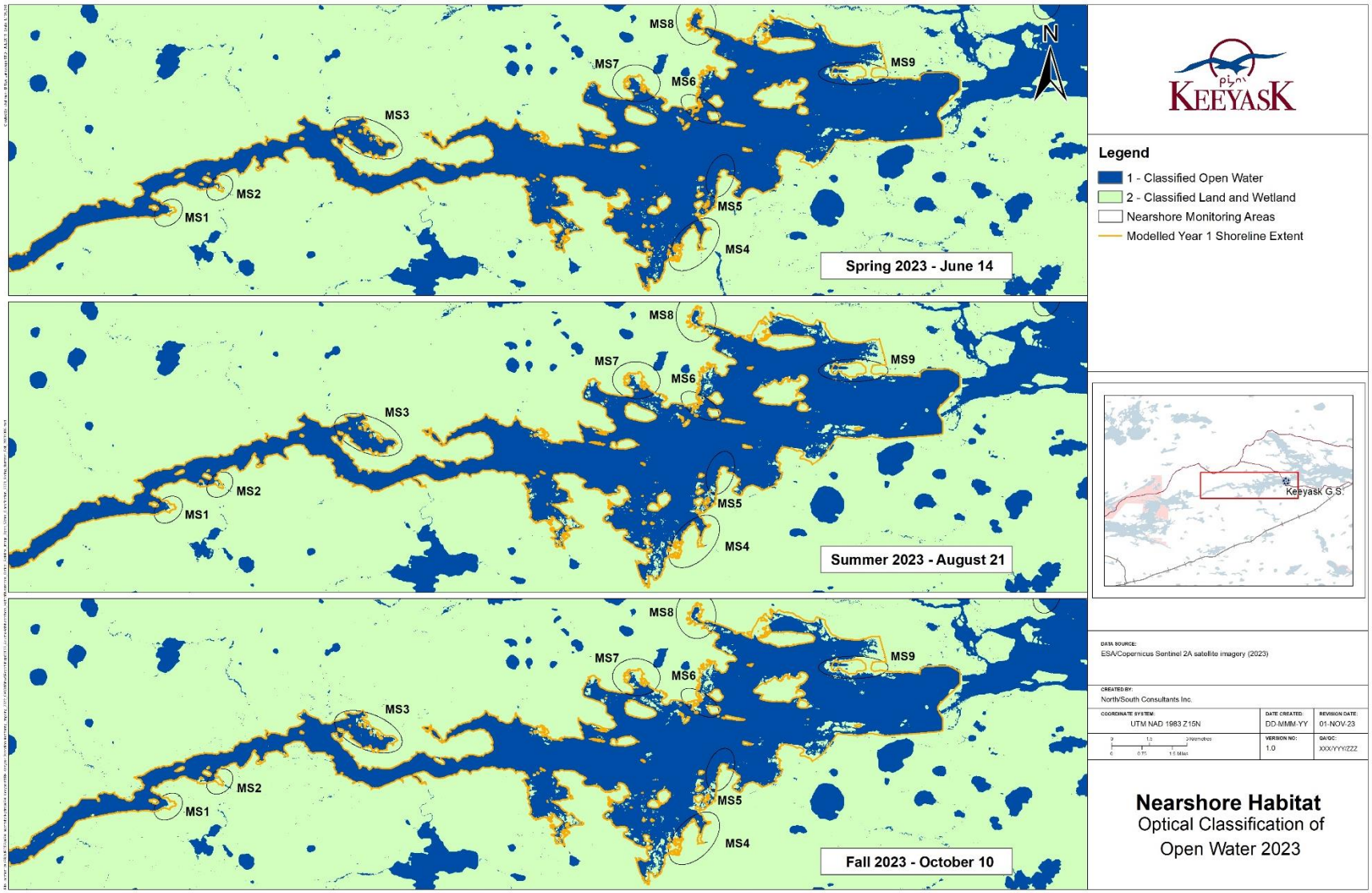
| Image Date | Inflow (cms)[2] | Water Level (m)[2] | Estimated Area (ha)[1] | | | |
|---|---|---|---|---|---|---|
| | | | Open-Water Area | Humic Water | Mixed Water | Turbid Water |
| 14-Jun | 3,272 | 158.90 | 8,932 | 1,316 | 1,367 | 6,249 |
| 21-Aug | 2,984 | 158.71 | 8,524 | 932 | 480 | 7,112 |
| 10-Oct | 1,991 | 158.62 | 8,256 | 688 | 449 | 7,118 |

1 - Area of reservoir is estimated from open-water classification from Keeyask GS upstream to Long Rapids at the boundary of Reach 2A and 2B.

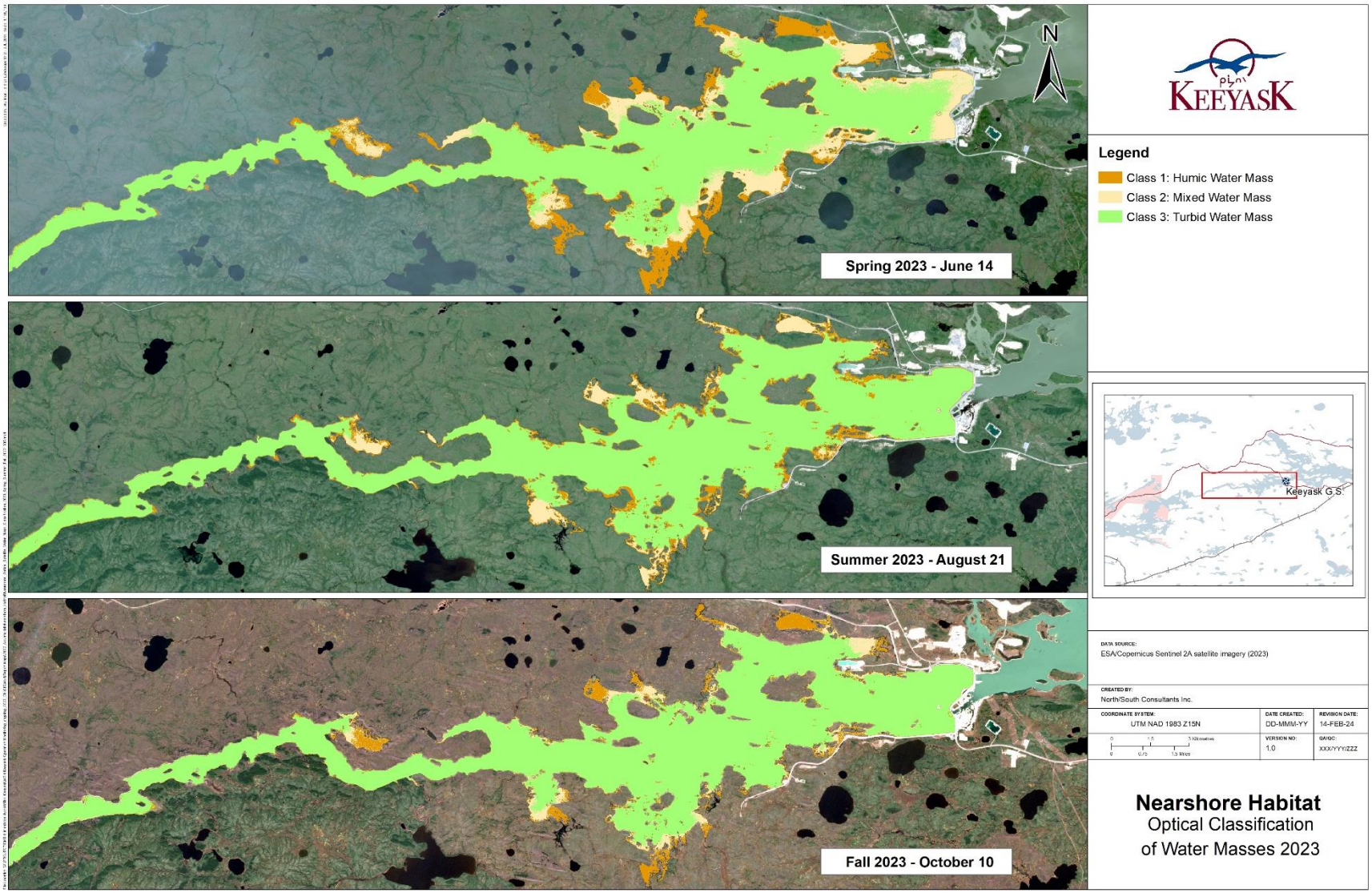
2 - Estimated daily mean inflow and daily mean water level provided by Manitoba Hydro




**Map 7: Sentinel-2 optical satellite imagery false colour near infrared composites of the Keeyask reservoir showing shoreline and turbid (blue) and humic (black) water mass boundary positions during spring, summer, and fall, 2023.**




**Map 8:** **Map showing results of the optical near infrared band land and water threshold masking analysis and classification for spring, summer, and fall, 2023, and relative to year 1 modelled shorelines (orange).**




**Map 9: Map showing results of the optical supervised classification of humic, mixed, and turbid water mass analysis and classification for spring, summer, and fall, 2023.**

## 4.2 NEARSHORE HABITAT SURVEYS

The mean, minimum and maximum depths in each nearshore sampling area were calculated for the polygon representing previously wetted habitat (*i.e.*, within the 95th percentile shoreline of the pre-Project environment) and the newly flooded terrestrial habitat polygon (*i.e.*, between the pre-Project shoreline and the shoreline determined from August 2023 satellite imagery) (Table 3).

Results of aquatic plant collection in each sampling area, including a qualitative estimate of abundance for each species, are provided in Appendix 1.

### 4.2.1 UPSTREAM OF BIRTHDAY RAPIDS (MS1)

#### 4.2.1.1 2023 SAMPLING

Mean water surface elevation was 160.16 m at site MS1 at the time of sampling on August 22, 2023 (Map 3; Table 3). Depth in the area of the pre-impoundment shoreline ranged from 1.08–10.22 m. Depth in flooded, previously terrestrial areas was not measured in 2023.

**Table 3: Minimum, maximum, and mean depth (m), and water levels as measured at each nearshore habitat monitoring site, 2023. Water surface elevations were taken from Manitoba Hydro gauges located upstream of Birthday Rapids (05UF770), downstream of Birthday Rapids (05UF771), Upstream of Gull Lake (05UF587), Gull Lake (05UF596), and Stephens Lake (05UF586).**

| Location | Date | Area | Pre-Impoundment Shoreline | | | Flooded Shoreline (Previously Terrestrial) | | | Mean Water Surface Elevation (m)[1] |
|---|---|---|---|---|---|---|---|---|---|
| | | | Depth | | | Depth | | | |
| | | | Mean (m) | Min (m) | Max (m) | Mean (m) | Min (m) | Max (m) | |
| Keeyask reservoir | 22-Aug-23 | MS1 | 2.91 | 1.08 | 10.22 | - | - | - | 160.16 |
| | 22-Aug-23 | MS2 | 4.17 | 1.60 | 7.84 | 2.25 | 1.52 | 2.77 | 159.12 |
| | 23-Aug-23 | MS3 | 4.12 | 2.54 | 4.72 | 3.05 | 1.14 | 4.14 | 159.11 |
| | 23-Aug-23 | MS4 | - | - | - | 2.31 | 0.96 | 5.16 | 158.67 |
| | 22-Aug-23 | MS5 | 8.40 | 5.29 | 12.82 | 2.97 | 0.96 | 6.33 | 158.66 |
| | 15-Aug-23 | MS6 | 6.74 | 4.96 | 7.11 | 2.11 | 0.96 | 6.68 | 158.55 |
| | 15-Aug-23 | MS7 | 5.70 | 4.37 | 6.50 | 3.12 | 0.96 | 5.87 | 158.55 |
| | 15-Aug-23 | MS8 | - | - | - | 2.12 | 0.96 | 4.16 | 158.55 |
| | 19-Aug-23 | MS9 | 5.96 | 3.68 | 9.00 | 3.28 | 0.96 | 5.81 | 158.57 |
| Stephens Lake | 20-Aug-23 | MS10 | 3.81 | 1.14 | 8.77 | - | - | - | 140.44 |
| | 20-Aug-23 | MS11 | 3.33 | 1.24 | 9.06 | - | - | - | 140.44 |
| | 21-Aug-23 | MS12 | 3.74 | 0.96 | 8.15 | - | - | - | 140.36 |

1 – Water surface elevations were taken from stations located at least 7 km upstream of the Keeyask GS. The immediate Keeyask forebay is held between 158 and 159, while more variation in elevations occurs farther upstream.

Substrate was sampled at 13 of 14 sites within the area (Table 4). One site (MS1-10) was too shallow to access with a boat at the time of sampling due to low water levels. Most sites were classified as soft compact clay with a mix of organics and/or sand (Photo 2). The acoustic classification model indicated that the area was dominated by organic/flooded terrestrial substrates (68%) followed by silt/sand (9%), gravel/sand (8%), and silt/clay (7%; Table 5). Substrate was collected for PSA at three sites in the area (MS1-7, MS1-9, and MS1-15) which consisted largely of sand, silt, and clay (Table 6).

Aquatic plants were observed at ten sampling sites, which ranged in depth from 0.1–1.1 m (Table A1-1). Five species of aquatic macrophytes were present, the most abundant of which was Richardson pondweed (*Potamogeton richardsonii*) and Sago pondweed (*Stuckenia pectinata*).

**Photo 2: Substrate collected upstream of Birthday Rapids (MS1) in 2023, showing clay mixed with sand and organics.**

**Table 4: Locations and results of substrate grab type validation sampling and post-survey class verification in the area upstream of Birthday Rapids (MS1), 2023.**

| 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 | % | | |
| MS1-1 | petite Ponar | 22-Aug | 331895 | 6241967 | 1.1 | moderate | clay | 80 | organic | 10 | silt | 10 | mud | clay/organic/silt |
| MS1-2 | petite Ponar | 22-Aug | 332002 | 6242025 | 0.3 | soft | organic | 50 | sand | 50 | - | - | organic | organic/sand |
| MS1-3 | petite Ponar | 22-Aug | 331943 | 6242058 | 2.4 | moderate | organic | 50 | sand | 50 | - | - | organic | organic/sand |
| MS1-4 | petite Ponar | 22-Aug | 332200 | 6242071 | 0.5 | soft | clay | 80 | sand | 20 | - | - | mud | clay/sand |
| MS1-6 | petite Ponar | 22-Aug | 332119 | 6242099 | 0.9 | soft | clay | 80 | organic | 10 | sand | 10 | mud | clay/organic/sand |
| MS1-7 | petite Ponar | 22-Aug | 332323 | 6242111 | 0.5 | soft | clay | 80 | organic | 20 | - | - | mud | clay/organic |
| MS1-8 | petite Ponar | 22-Aug | 332313 | 6242122 | 0.1 | soft | clay | 80 | sand | 20 | - | - | mud | clay/sand |
| MS1-9 | petite Ponar | 22-Aug | 332108 | 6242205 | 1 | soft | clay | 80 | organic | 20 | - | - | mud | clay/organic |
| MS1-10 | petite Ponar | 22-Aug | 332266 | 6242180 | 0.4 | - | - | - | - | - | - | - | - | - |
| MS1-11 | petite Ponar | 22-Aug | 331981 | 6242321 | 3.7 | hard | boulder | 100 | - | - | - | - | rock | boulder |
| MS1-12 | petite Ponar | 22-Aug | 332192 | 6242264 | 0.6 | soft | clay | 80 | organic | 20 | - | - | mud | clay/organic |
| MS1-13 | petite Ponar | 22-Aug | 332120 | 6242347 | 0.7 | soft | clay | 80 | organic | 20 | - | - | mud | clay/organic |
| MS1-15 | petite Ponar | 22-Aug | 332017 | 6242379 | 1.1 | moderate | gravel | 80 | clay | 20 | - | - | rock | gravel/clay |
| MS1-19A | petite Ponar | 22-Aug | 331970 | 6242205 | 8.3 | hard | boulder | 100 | - | - | - | - | rock | boulder |

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

**Table 5: Results of acoustic classification of single beam data collected from the Keeyask reservoir and upper Stephens Lake, 2023.**

| Area | Date | Total Samples | Acoustic Substrate Classification Composition (% Membership) | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Organics | Mud | Sand | | Rock | | | | |
| | | | Organics/FT[1] | Silt/Clay | Silty Sand | Sand | Gravel/Sand | Gravel | Cobble | Bedrock/Boulder | |
| | | | Class 1 | Class 2 | Class 3 | Class 4 | Class 5 | Class 6 | Class 7 | Class 8 | |
| MS1 | 22-Aug-23 | 1035 | 68 | 7 | 9 | 4 | 8 | 3 | <1 | - | 100 |
| MS2 | 22-Aug-23 | 1038 | 17 | 32 | 23 | 9 | 17 | 1 | - | - | 100 |
| MS3 | 23-Aug-23 | 5366 | 62 | 20 | 3 | 5 | 10 | - | - | - | 100 |
| MS4 | 23-Aug-23 | 1505 | 28 | 28 | 24 | 14 | 6 | - | - | - | 100 |
| MS5 | 22-Aug-23 | 2236 | 45 | 24 | 6 | 9 | 16 | <1 | - | - | 100 |
| MS6 | 15-Aug-23 | 3965 | 59 | 19 | 9 | 6 | 6 | <1 | - | - | 100 |
| MS7 | 15-Aug-23 | 2435 | 33 | 27 | 12 | 14 | 15 | - | - | - | 100 |
| MS8 | 15-Aug-23 | 1360 | 47 | 21 | 11 | 13 | 9 | - | - | - | 100 |
| MS9 | 19-Aug-23 | 6303 | 29 | 25 | 14 | 15 | 18 | <1 | - | - | 100 |
| MS10 | 20-Aug-23 | 2484 | 58 | 18 | 5 | 5 | 14 | - | - | - | 100 |
| MS11 | 20-Aug-23 | 3260 | 63 | 18 | 6 | 5 | 8 | - | - | - | 100 |
| MS12 | 21-Aug-23 | 2876 | 46 | 16 | 14 | 14 | 10 | <1 | - | - | 100 |
| **Summary** | | **33863** | **46** | **21** | **11** | **9** | **11** | **2** | **<1** | **-** | **100** |

1 – Flooded terrestrial.

**Table 6: Results of particle size analysis (conducted at ALS Laboratories) from samples collected upstream of Birthday Rapids (MS1), 2023.**

| Area Name | Date | Area Code | Habitat | Field Site No. | Inorganic Carbon (%) | CaCO3 Equivalent | Total Carbon by Combustion (%) | Total Organic Carbon (%) | % Sand (2.0-0.05 mm) | % Silt (0.05-2µm) | % Clay (<2 µm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keeyask Reservoir | 22-Aug-2023 | MS1 | nearshore | MS1-7 | 0.463 | 3.86 | 10.6 | 10.1 | 5.0 | 71.0 | 24.0 | Silt Loam |
| Keeyask Reservoir | 22-Aug-2023 | MS1 | nearshore | MS1-9 | 1.47 | 12.2 | 3.68 | 2.21 | 43.4 | 42.2 | 14.3 | Loam |
| Keeyask Reservoir | 22-Aug-2023 | MS1 | nearshore | MS1-15 | 2.36 | 19.7 | 3.25 | 0.890 | 75.6 | 16.3 | 8.0 | Sandy Loam |

#### 4.2.1.2 2021-2023 SUMMARY

Sampling area MS1 is located upstream of Birthday Rapids, near the upstream extent of flooding caused by impoundment of the Keeyask reservoir (Map 2). As such, most of this sampling area is located within habitat that was wetted prior to impoundment, with only small areas of flooded terrestrial habitat at the back (*i.e.,* eastern extent) of the bay.

In 2021, the majority of shoreline sites in MS1 were inaccessible by boat due to low water levels and could not be sampled. Farther away from shore, all sites were composed of either mud or rock (Map 10). By 2022, the nearshore sites were accessible and were composed largely of flooded terrestrial vegetation, organics, and mud. In 2023, acoustic mapping indicated that the majority of the substrate in MS1 was comprised of organics, although mud (*i.e.,* clay and silt) was also present. Hard substrates were consistent at the deeper sites through the three-year period, with rock and sand comprising 27% of the sampled area in 2023 (Table 7).

Flooding due to impoundment within MS1 was minimal, however, sampling in each of the three years occurred under differing flow conditions (5$^{th}$ percentile in 2021, 95$^{th}$ percentile in 2022, and 50$^{th}$ percentile in 2023) which caused differences in water levels (Manitoba Hydro 2022, 2023, 2024). Mean water surface elevation at this site measured 159.76 m in 2021, 162.52 m in 2022, and 160.16 m in 2023. Despite these changes in water levels, rooted aquatic macrophytes were observed in all three sampling years (Map 11). In 2021, aquatic plants were present at four sites consisting of three plant species (*i.e.,* Richardson pondweed, Sago pondweed, Long-leaf pondweed [*Potamogeton nodosus*]). In 2022 and 2023, aquatic plants were present at ten sites. Ten plant species were identified in 2022, the most abundant of which was Richardson pondweed and Smartweed (*Persicaria* spp.). Five plant species were identified in 2023, consisting mostly of Richardson and Sago pondweed (Table A1-1).

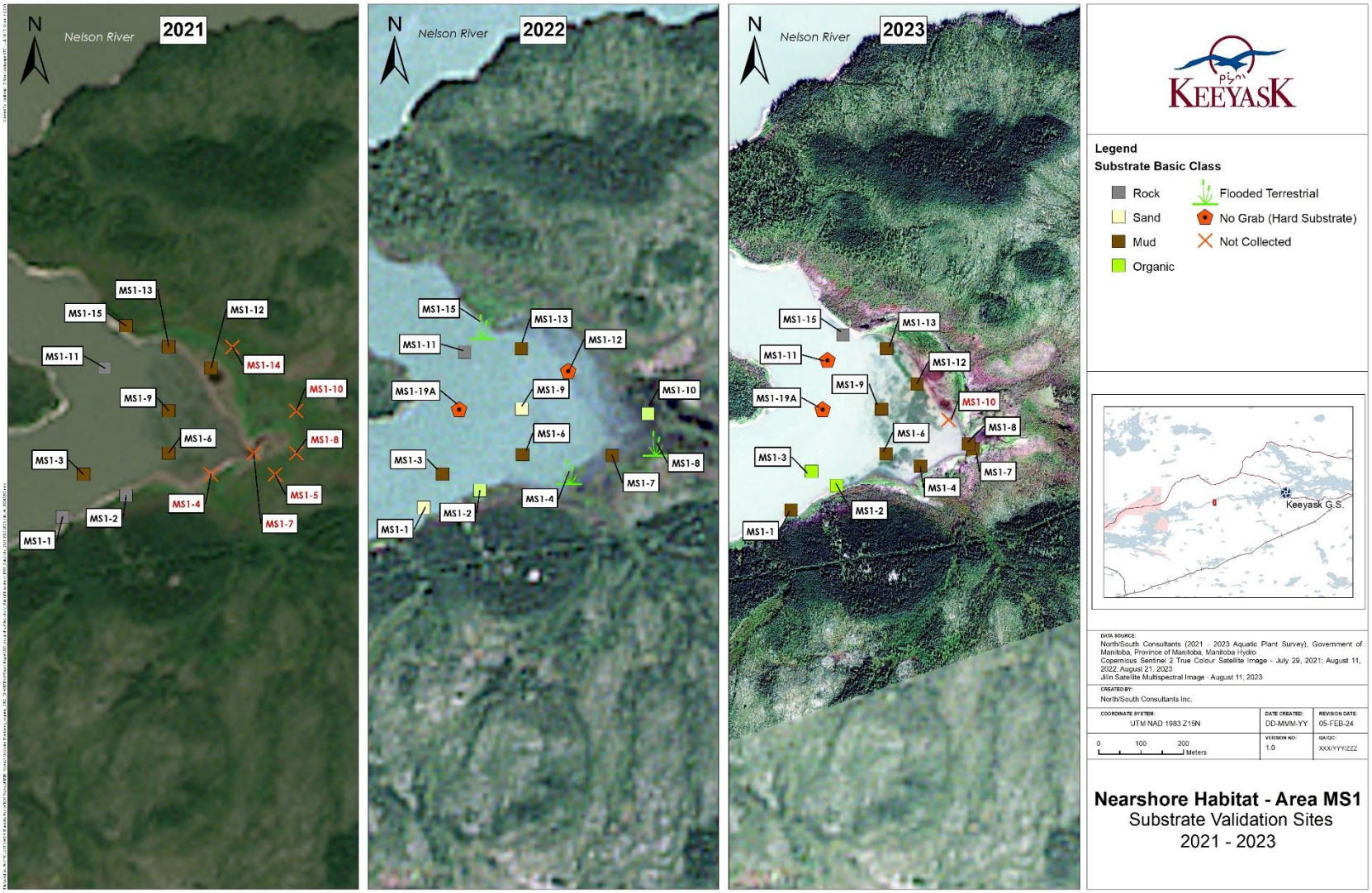
In the third year following reservoir impoundment, plant beds were present throughout much of MS1, comprising approximately 29% of the sampling area (Map 12). Plant beds were visible at the water surface throughout much of the sampling site (photos 3 and 4). Generally, light penetrated to a greater depth in 2022 compared to either 2021 or 2023. Although most sites were shallow (approximately 1 m deep) and more than 20% of surface light reached the bottom, light extinction sampling at a single deeper (*i.e.,* >3.5 m) site suggests that little (<10% of surface) light penetrates to 2.5 m of depth (Figure 2). In all three sampling years, this area was dominated by Nelson River mainstem turbid (high TSS) water with very little humic water present (Section 4.1), which can limit penetration of photosynthetically active radiation (*i.e.*, light; Map 9).

**Table 7: Total area occupied by each substrate type as measured by acoustic surveys in the Keeyask reservoir upstream of Birthday Rapids (MS1) 2023.**

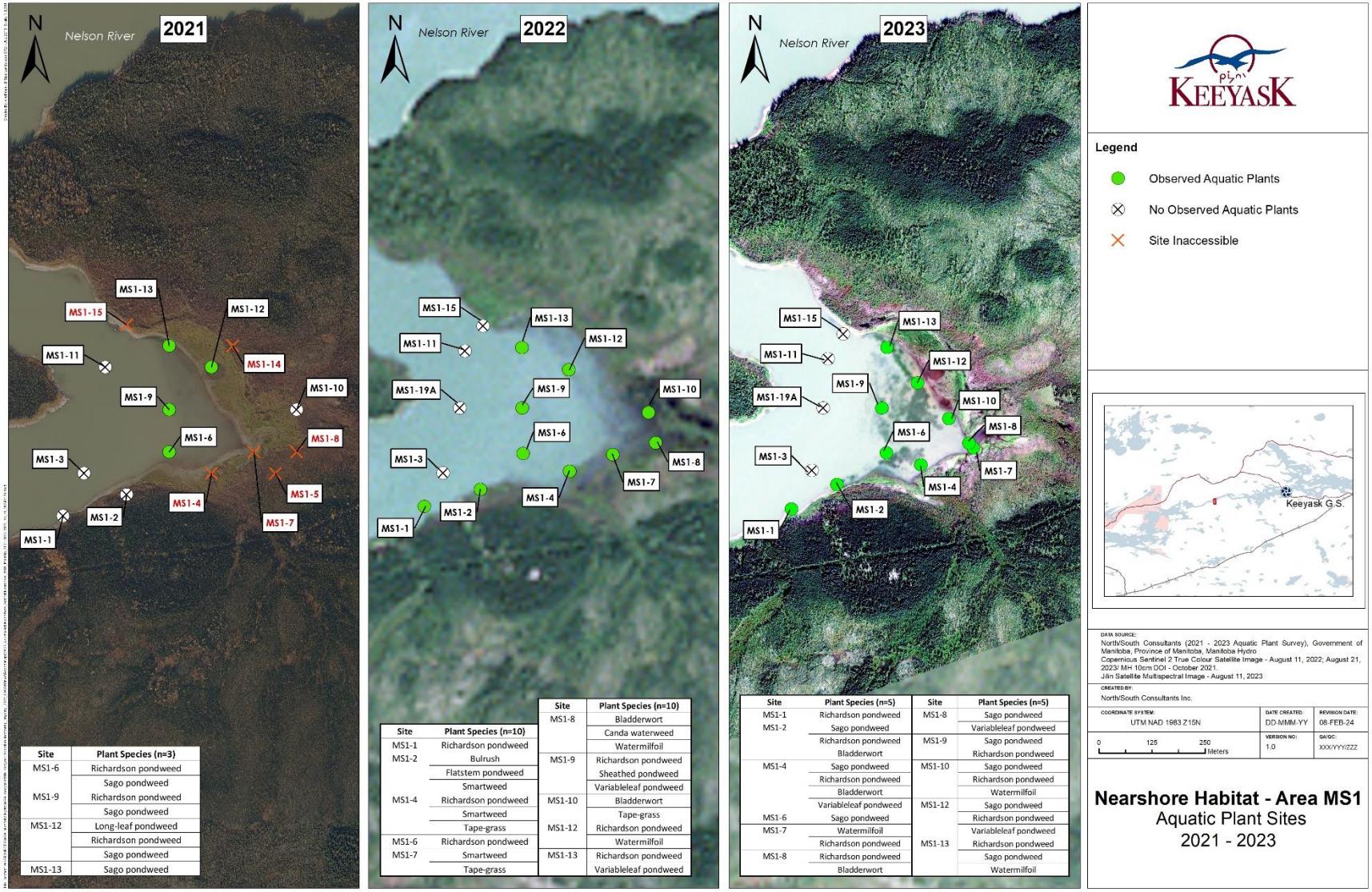
| MS1 | Area ($m^2$) | % of Total Area |
|---|---|---|
| Organic | 73,223 | 53 |
| Mud | 20,588 | 15 |
| Silty Sand | 5,899 | 4 |
| Sand | 23,579 | 17 |
| Rock | 14,035 | 10 |
| **Sum** | **137,324** | **100** |

**Photo 3: Aerial view of plant beds visible at the surface of the water upstream of Birthday Rapids (MS1; from the eastern edge looking west to the river mainstem) in 2023.**

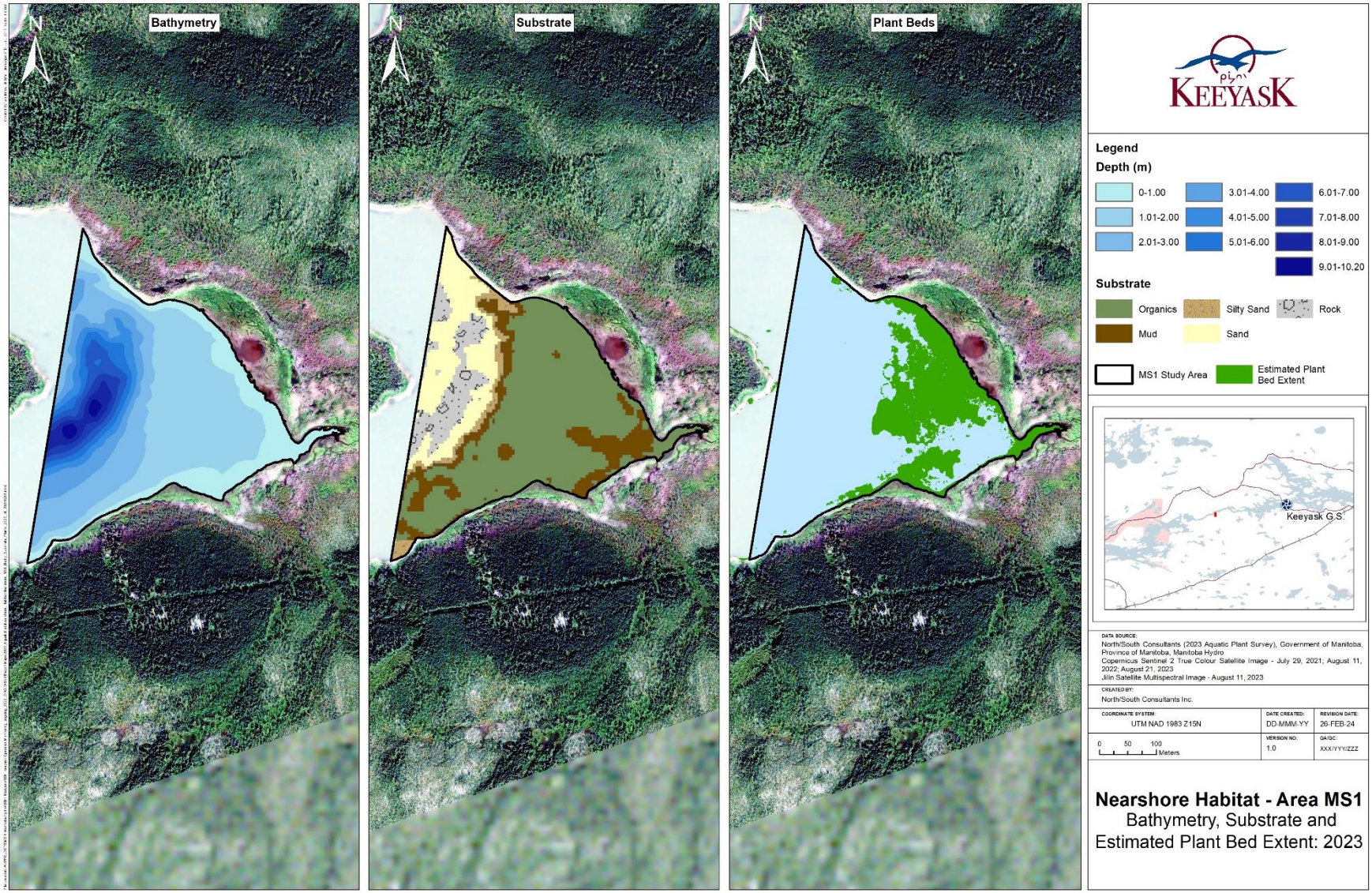
**Photo 4: Plant beds visible at the surface of the water upstream of Birthday Rapids (MS1) in 2023.**




**Map 10: Basic substrate class results of sediment grabs taken at sampling sites in the area upstream of Birthday Rapids (MS1), August 2021-2023.**




**Map 11: Macrophytes collected from the area upstream of Birthday Rapids (MS1) over three sampling years, August 2021-2023.**




**Map 12: Bathymetry, substrate, and plant beds in the area upstream of Birthday Rapids (MS1) in the third year (*i.e.,* 2023) following impoundment of the Keeyask reservoir.**

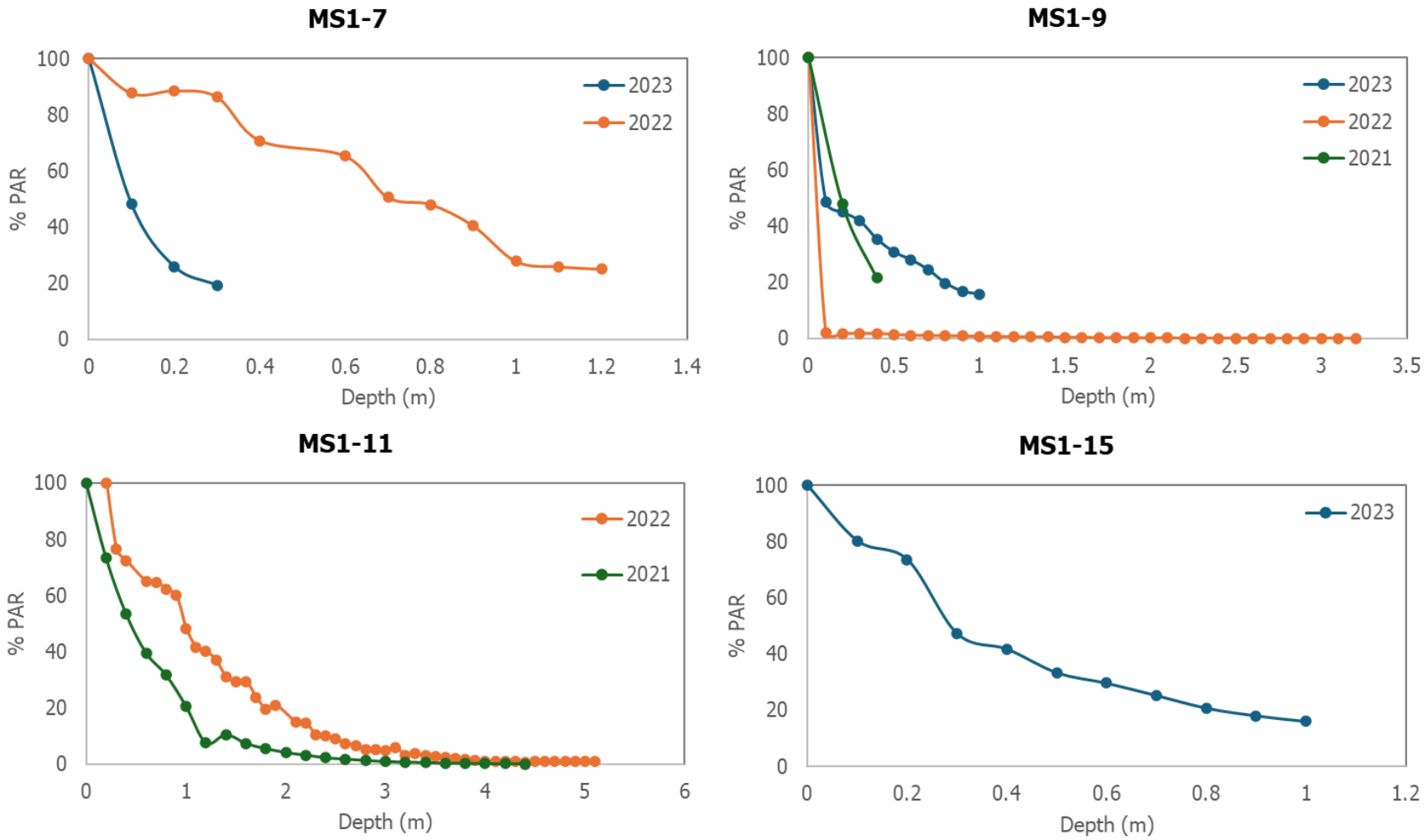



**Figure 2: The percent of photosynthetically active radiation (PAR) with depth at four sites in the area upstream of Birthday rapids (MS1), measured with a LI-1400 data logger (LI-COR), 2021-2023.**

## 4.2.2 DOWNSTREAM OF BIRTHDAY RAPIDS (MS2)

### 4.2.2.1 2023 SAMPLING

Mean water surface elevation was 159.12 m at site MS2 at the time of sampling on August 22, 2023 (Map 3; Table 3). Depth in flooded, previously terrestrial areas ranged from 1.52–2.77 m. Depth in the pre-impoundment shoreline ranged from 1.60–7.84 m.

Substrate was sampled at eight sites within the area (Table 8). Three sites were classified as hard rock, four as mud where clay was the dominant substrate, and one as organic. Substrate could not be collected from a single site with moderate compaction (MS2-17A). The acoustic classification model indicated that the area was dominated by silt/clay substrate (32%) followed by silty sand (23%; Table 5). PSA analysis was conducted at three sites, sand was classified as the dominant substrate at two sites, whereas clay was dominant at one (Table 9).

Plants were observed at two sampling sites at 1.5 and 6.5 m deep (Table A1-2). Three species were present including Watermilfoil (*Myriophyllum* spp.), Canada waterweed (*Elodea canadensis*), and Sago pondweed (*Stuckenia pectinate*; Photo 5).

**Photo 5: Aquatic plants collected from the Keeyask reservoir (MS2) in 2023, showing Watermilfoil (left), Sago pondweed (middle), and Canada waterweed (right).**

**Table 8: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir downstream of Birthday Rapids (MS2), 2023.**

| 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 | % | | |
| MS2-4 | petite Ponar | 22-Aug | 333871 | 6243063 | 2.4 | soft | clay | 80 | silt | 10 | sand | 10 | mud | clay/silt/sand |
| MS2-5 | petite Ponar | 22-Aug | 333777 | 6243117 | 4.8 | hard | clay | 100 | - | - | - | - | mud | clay |
| MS2-7 | petite Ponar | 22-Aug | 333915 | 6243141 | 6.5 | hard | boulder | 100 | - | - | - | - | rock | boulder |
| MS2-8 | petite Ponar | 22-Aug | 334051 | 6243114 | 3.3 | moderate | clay | 70 | gravel | 20 | silt | 10 | mud | clay/gravel/silt |
| MS2-11 | petite Ponar | 22-Aug | 334123 | 6243201 | 1.5 | soft | silt | 80 | gravel | 10 | sand | 10 | mud | silt/gravel/sand |
| MS2-12 | petite Ponar | 22-Aug | 333966 | 6243241 | 4.5 | hard | boulder | 100 | - | - | - | - | rock | boulder |
| MS2-13 | petite Ponar | 22-Aug | 334154 | 6243380 | 2.2 | soft | organic | 50 | clay | 50 | - | - | organic | organic/clay |
| MS2-14 | petite Ponar | 22-Aug | 334038 | 6243376 | 4.8 | hard | boulder | 100 | - | - | - | - | rock | boulder |
| MS2-17A | petite Ponar | 22-Aug | 334004 | 6243089 | 3.4 | moderate | - | - | - | - | - | - | - | - |

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

**Table 9: Results of particle size analysis (conducted at ALS Laboratories) from samples collected downstream of Birthday Rapids (MS2), 2023.**

| Area Name | Date | Area Code | Habitat | Field Site No. | Inorganic Carbon (%) | CaCO3 Equivalent | Total Carbon by Combustion (%) | Total Organic Carbon (%) | % Sand (2.0-0.05 mm) | % Silt (0.05-2µm) | % Clay (<2 µm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keeyask Reservoir | 22-Aug-2023 | MS2 | nearshore | MS2-8 | 1.93 | 16.1 | 3.72 | 1.79 | 53.0 | 29.9 | 17.1 | Sandy Loam |
| Keeyask Reservoir | 22-Aug-2023 | MS2 | nearshore | MS2-13 | 1.57 | 13.0 | 2.87 | 1.30 | 17.1 | 40.4 | 42.4 | Silty Clay |
| Keeyask Reservoir | 22-Aug-2023 | MS2 | nearshore | MS2-11 | 1.02 | 8.53 | 4.35 | 3.33 | 47.4 | 38.2 | 14.4 | Loam |

### 4.2.2.2 2021-2023 SUMMARY

Sampling area MS2 is located on the south shore of the Nelson River downstream of Birthday Rapids, at the outlet of Nap Creek (Map 2). Flooding due to impoundment of the Keeyask reservoir was minimal in this area, largely confined to areas close to shore and the outlet of Nap Creek.

In 2021, most sites sampled were farther from shore and cobble and gravel were the dominant substrate types at the majority of sites in MS2 (Map 13). In 2022, more sites closer to shore were sampled and organic and flooded terrestrial substrates were found. The fewest sites were sampled for substrate in 2023. Grabs were collected from four sites, all of which were comprised of mud. In all three years, soft substrates were found closer to shore (including mud and organics), and hard substrates (including rock) were found farther from shore. In 2023, sand and rock substrates comprised 60% of the study area, while organics and mud were only found in 18% (Table 10).

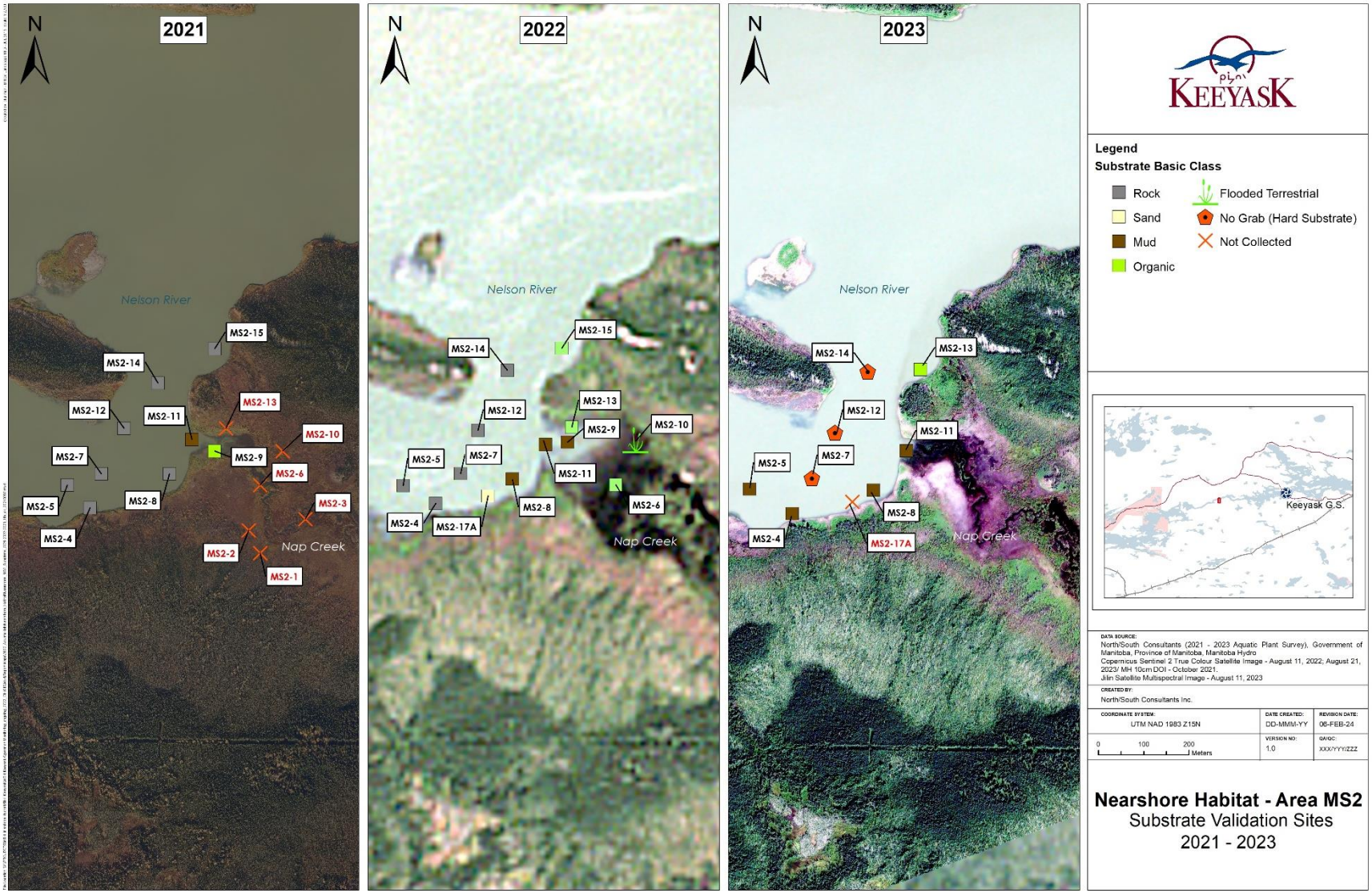
The aquatic macrophyte community in MS2 has changed over the first three years following reservoir impoundment (Map 14). A single semi-aquatic plant species (*i.e.,* Wild celery) was present at one site in 2021. In 2022, three rooted aquatic plant species were identified at two sites including Variableleaf pondweed (*Potamogeton gramineus*), Water buttercup (*Ranunculus spp.*), and Tapegrass (*Vallisneria* spp.). Three different rooted aquatic macrophyte species including Watermilfoil, Canada waterweed, and Sago pondweed were found at two sites in 2023 (Table A1-2).

In the third year following reservoir impoundment, plant beds were sparse in MS2, existing only at the outlet of Nap Creek at the very end of the bay and comprising only 10% of the total study area (Map 15; Photo 6). The lack of extensive plant beds is likely due to the presence of hard substrates, which are found near to shore. Further, little shallow water is present, dropping to depths greater than 3 m close to shore. Light extinction sampling suggests that only between 1 and 3% of surface light is present at this depth, while approximately 20% permeates to depths of 1 m (Figure 3). In all three years, this area was dominated by Nelson River mainstem turbid (high TSS) water with very little humic water, except for the shallow outlet area of Nap Creek, which tends to limit penetration of photosynthetically active radiation (*i.e.*, light; Map 9).

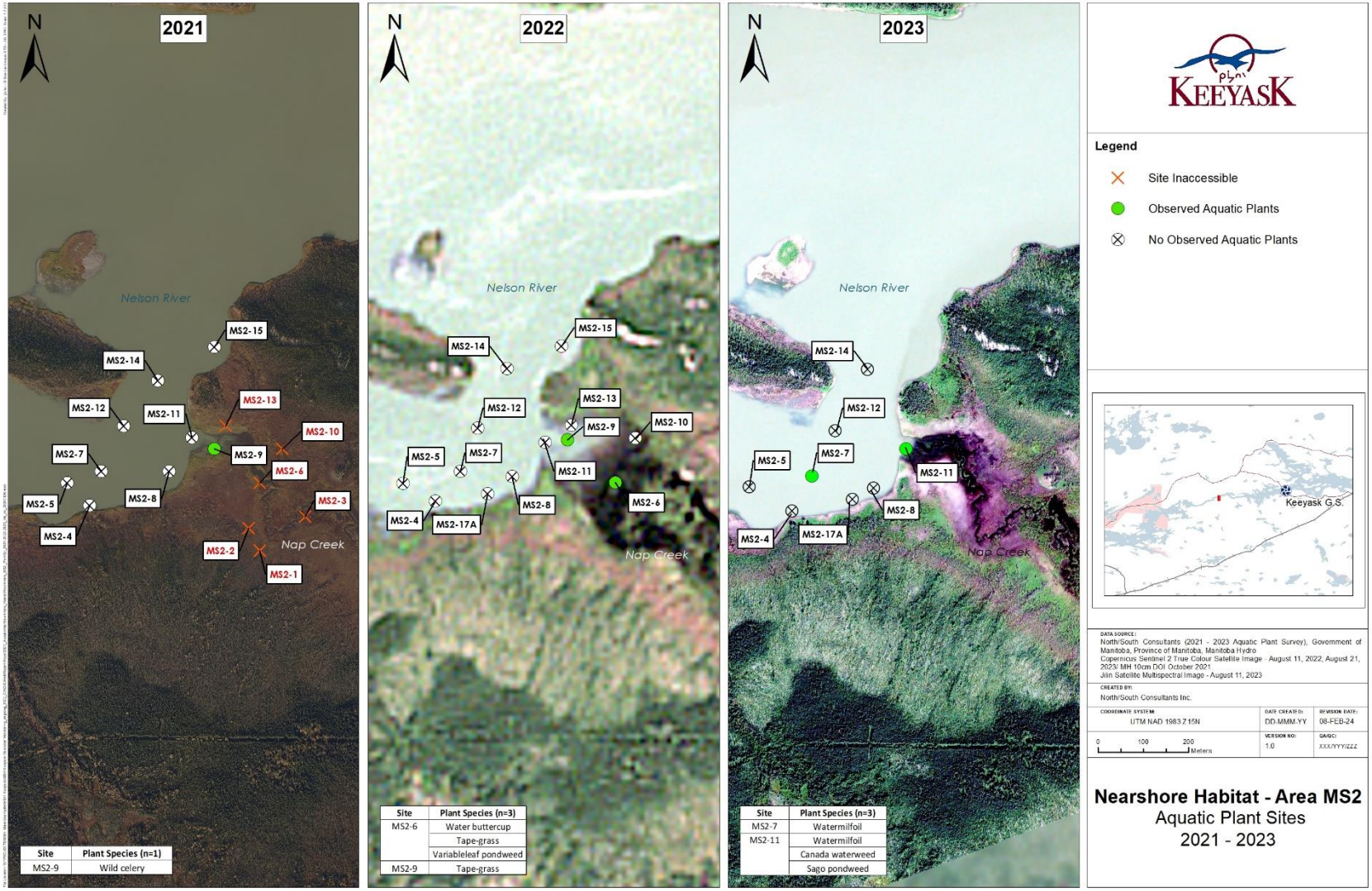
**Table 10: Total area occupied by each substrate type as measured by acoustic surveys in the Keeyask reservoir downstream of Birthday Rapids (MS2), 2023.**

| MS2 | Area ($m^2$) | % of Total Area |
|---|---|---|
| Organic | 3,913 | 3 |
| Mud | 16,679 | 15 |
| Silty Sand | 14,918 | 13 |
| Sand | 40,239 | 35 |
| Rock | 28,759 | 25 |
| No Data | 10,093 | 9 |
| **Sum** | **114,600** | **100** |

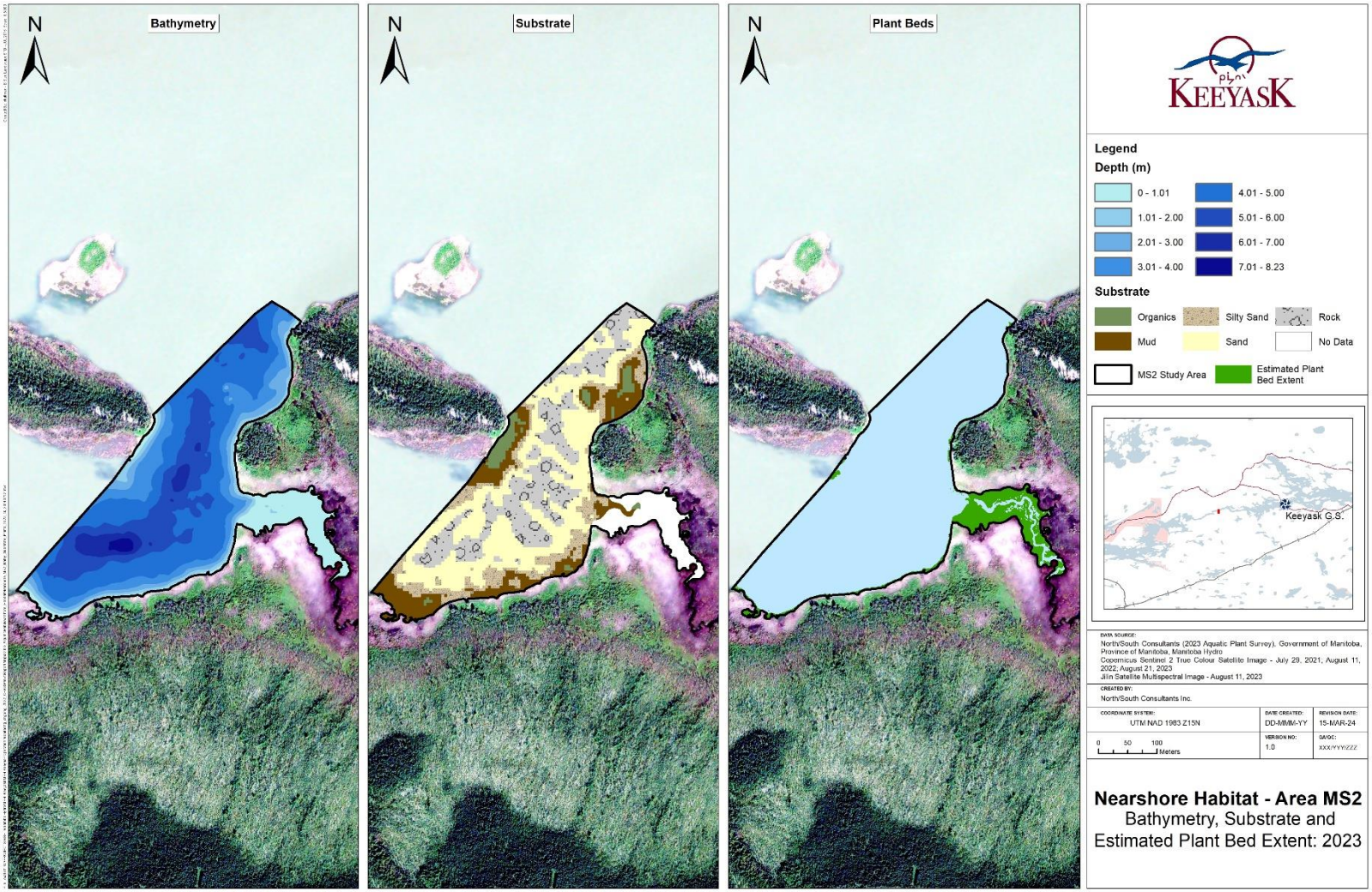
**Photo 6: Plant beds visible at the surface of the water at the mouth of Nap Creek (MS2) in 2023.**




**Map 13: Basic substrate class results of sediment grabs taken at sampling sites in the area downstream of Birthday Rapids (MS2), August 2021-2023.**




**Map 14: Macrophytes collected from the area downstream of Birthday Rapids (MS2) over three sampling years, August 2021-2023.**




**Map 15: Bathymetry, substrate, and plant beds in the area downstream of Birthday Rapids (MS2) in the third year (*i.e.,* 2023) following impoundment of the Keeyask reservoir.**

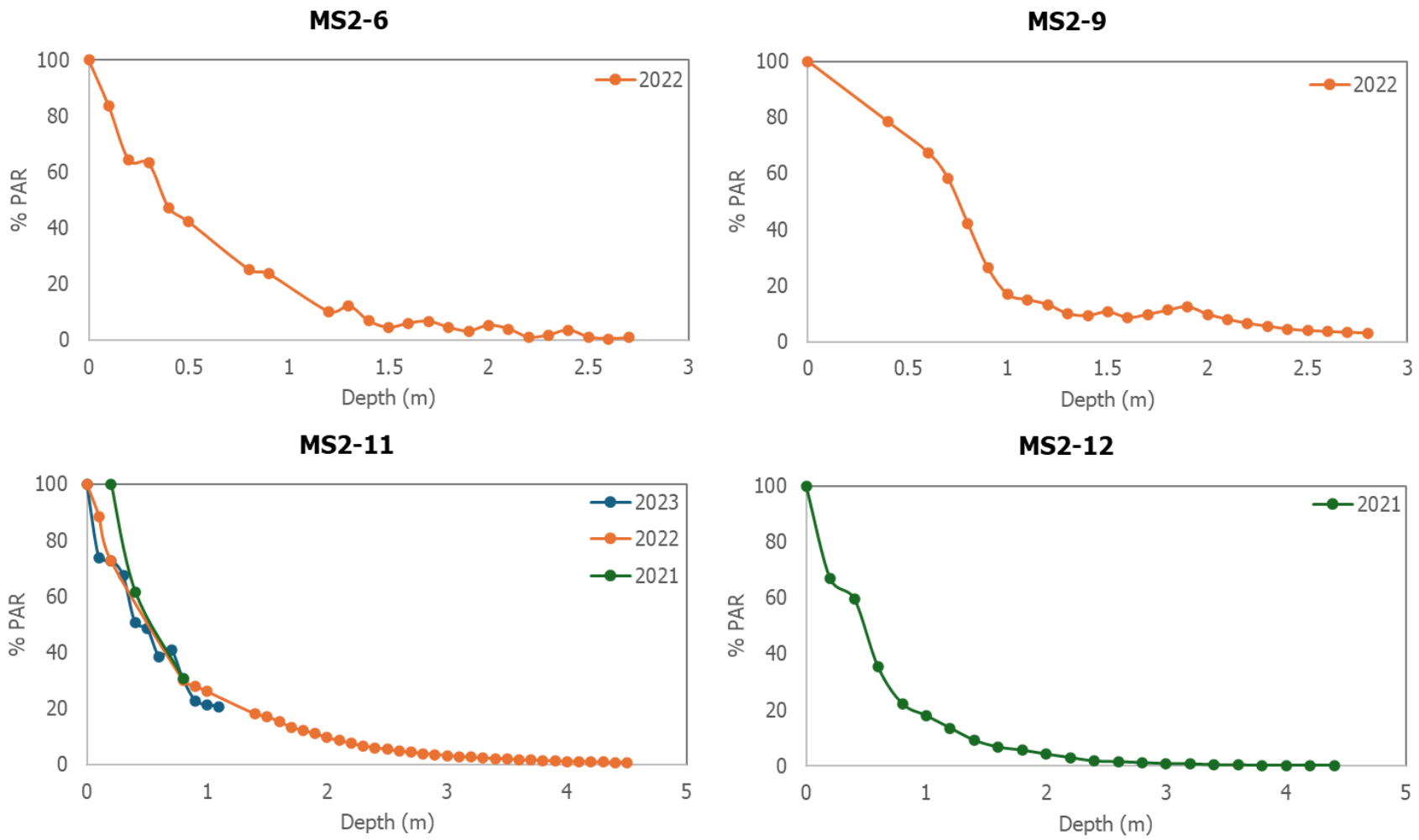



**Figure 3: The percent of photosynthetically active radiation (PAR) extinction with depth at four sites in the area downstream of Birthday rapids (MS2), measured with a LI-1400 data logger (LI-COR), 2021-2023.**

## 4.2.3 KEEYASK RESERVOIR BACKBAY ZONE 4 (MS3)

### 4.2.3.1 2023 SAMPLING

Mean water surface elevation was 159.11 m at site MS3 on August 23, 2023 (Map 3; Table 3). Depth in flooded, previously terrestrial areas ranged from 1.14–4.14 m. Depth in the pre-impoundment shoreline ranged from 2.54–4.72 m.

Fifteen sites were sampled for substrate (Table 11). Organics were the dominant substrate at 11 sites (Photo 7), while the remaining four sites were comprised of mud (*i.e.,* clay and silt). The acoustic classification model indicated that the area was dominated by organics and flooded terrestrial (62%) followed by silt and clay (20%; Table 5). PSA analysis was conducted at three sites, and silt was classified as the dominate substrate at all three (Table 12).

Aquatic plant species were observed at five sites that ranged in depth from 0.7–3.0 m (Table A1-3). Four species of aquatic plants were observed. Bladderwort (*Utricularia spp.*) and Watermilfoil were most abundant while Water knotweed (*Persicaria amphibia*) and Canada waterweed were present but sparse.

**Photo 7: Substrate collected from the Keeyask reservoir backbay Zone 4 (MS3) in 2023, showing organics.**

**Table 11: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir in backbay Zone 4 (MS3), 2023.**

| 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 | % | | |
| MS3-1 | petite Ponar | 23-Aug | 340391 | 6244464 | 3 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS3-2 | petite Ponar | 23-Aug | 340039 | 6244515 | 3.5 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS3-3 | petite Ponar | 23-Aug | 340555 | 6244613 | 3.9 | soft | organic | 90 | clay | 10 | - | - | organic | organic/clay |
| MS3-4 | petite Ponar | 23-Aug | 340755 | 6244591 | 4.1 | soft | organic | 70 | clay | 30 | - | - | organic | organic/clay |
| MS3-5 | petite Ponar | 23-Aug | 341038 | 6244664 | 1.3 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS3-6 | petite Ponar | 23-Aug | 340338 | 6244704 | 3.9 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS3-7 | petite Ponar | 23-Aug | 340843 | 6244736 | 1.6 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS3-9 | petite Ponar | 23-Aug | 339543 | 6245101 | 3.7 | soft | clay | 80 | organic | 20 | - | - | mud | clay/organic |
| MS3-10 | petite Ponar | 23-Aug | 339847 | 6245110 | 1.6 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS3-11 | petite Ponar | 23-Aug | 340301 | 6245082 | 0.7 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS3-12 | petite Ponar | 23-Aug | 339152 | 6245226 | 1.3 | soft | organic | 50 | clay | 50 | - | - | organic | organic/clay |
| MS3-13 | petite Ponar | 23-Aug | 339354 | 6245423 | 4.2 | soft | clay | 90 | silt | 10 | - | - | mud | clay/silt |
| MS3-14 | petite Ponar | 23-Aug | 339645 | 6245622 | 3.7 | soft | clay | 80 | silt | 20 | - | - | mud | clay/silt |
| MS3-15 | petite Ponar | 23-Aug | 339955 | 6245709 | 1.6 | moderate | organic | 50 | clay | 50 | - | - | organic | organic/clay |
| MS3-17A | petite Ponar | 23-Aug | 338966 | 6245444 | 4.1 | moderate | clay | 80 | silt | 20 | - | - | mud | clay/silt |

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

**Table 12: Results of particle size analysis (conducted at ALS Laboratories) from samples collected from the Keeyask reservoir backbay Zone 4 (MS3), 2023.**

| Area Name | Date | Area Code | Habitat | Field Site No. | Inorganic Carbon (%) | CaCO3 Equivalent | Total Carbon by Combustion (%) | Total Organic Carbon (%) | % Sand (2.0-0.05 mm) | % Silt (0.05-2µm) | % Clay (<2 µm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keeyask Reservoir | 23-Aug-2023 | MS4 | nearshore | MS4-7 | 0.485 | 4.04 | 35.1 | 34.6 | 1.1 | 91.9 | 7.0 | Silt |
| Keeyask Reservoir | 23-Aug-2023 | MS4 | nearshore | MS4-10 | 0.495 | 4.13 | 27.8 | 27.3 | 2.1 | 29.4 | 68.5 | Heavy Clay |
| Keeyask Reservoir | 23-Aug-2023 | MS4 | nearshore | MS4-14 | 0.532 | 4.43 | 31.5 | 31.0 | 2.9 | 75.6 | 21.5 | Silt Loam |

### 4.2.3.2 2021-2023 SUMMARY

Sampling area MS3 is located within the farthest upstream flooded backbay (Zone 4), located within the middle Keeyask reservoir (maps 2 and 4). Flooding was more extensive within this area compared to the two upstream sites, although was largely limited to the edges of the bay (Photo 8). The middle of the bay contains habitat that was wetted prior to impoundment.

Substrates within MS3 changed over the first three years following impoundment. In 2021, all eleven sites sampled contained substrates classified as soft compact mud (Map 16). By 2022, most sites contained organic substrates, although mud (*i.e.,* silt and clay) was still found throughout the backbay. By 2023, the majority of sampling sites contained organic substrates, while mud was only sampled at the mouth. Substrate mapping in 2023 indicated that the sampling area was dominated both by organic (37%) and mud (48%) substrates (Table 13).

Few aquatic plants were found within MS3 in 2021, while the number of species and overall abundance was greater in both 2022 and 2023 (Map 17). Three rooted aquatic plant species (Duck celery [*Vallisneria* spp.], Long-leaf pondweed, and Watermilfoil) were observed at only two sites in 2021. Rooted aquatic plants were found at the same five sites in both 2022 and 2023. In both years, Bladderwort and Watermilfoil were most abundant (Table A1-3).

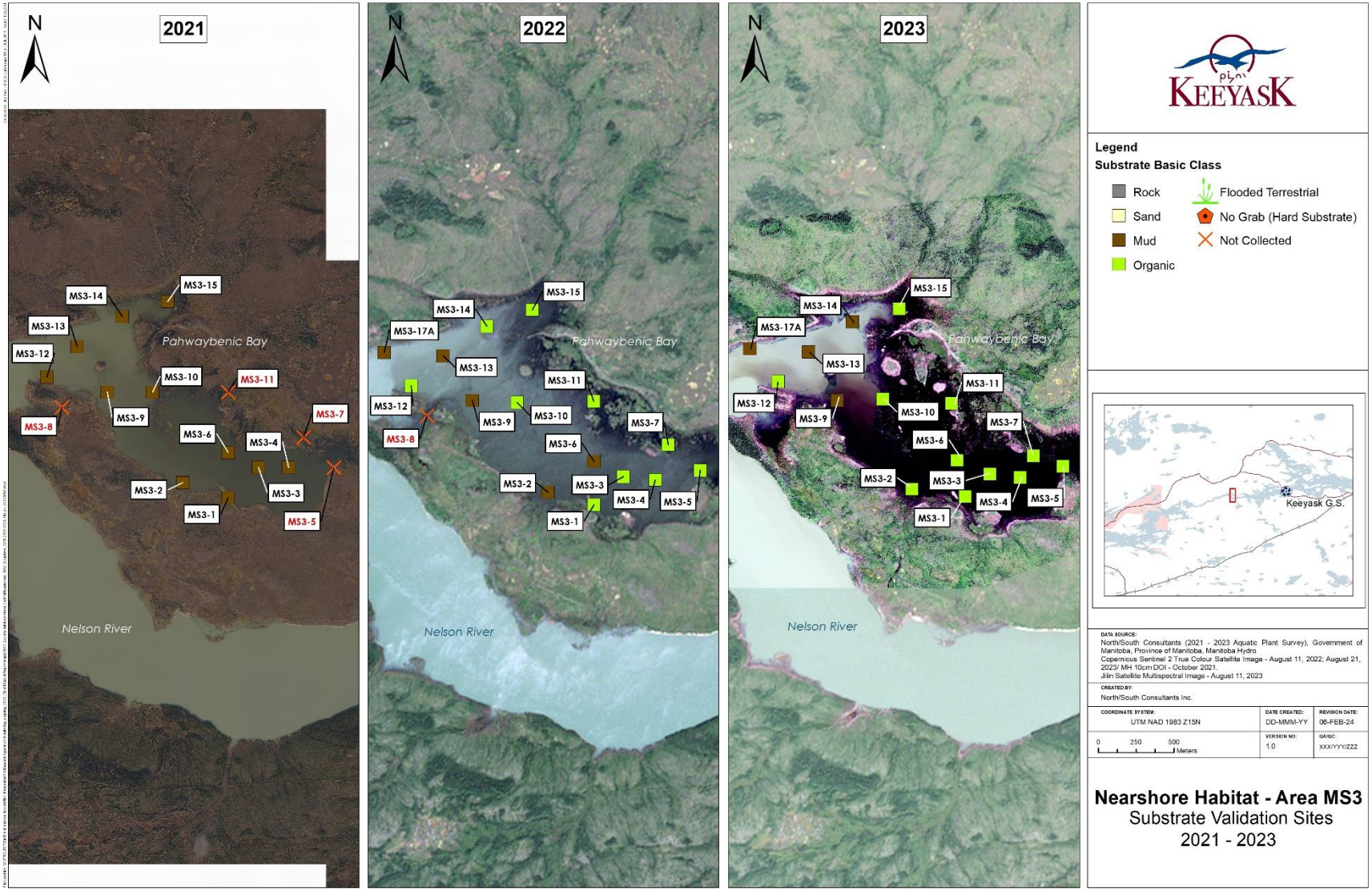
In the third year following reservoir impoundment, plant beds were present within approximately 28% of the sampling area in MS3 (Map 18; photos 8 and 9). The majority of plant beds were present along the shorelines where shallow water was present. No plant beds were present in the middle of the backbay where deep (*i.e.,* > 3.01 m) water is present. In all years, light extinction sampling suggests that little (<6% of surface) light penetrates to 2.5 m of depth, while at 1 m, between 16 and 31% of surface light may be present (Figure 4).

**Table 13: Total area occupied by each substrate type as measured by acoustic surveys in the Keeyask reservoir flooded backbay Zone 4 (MS3), 2023.**

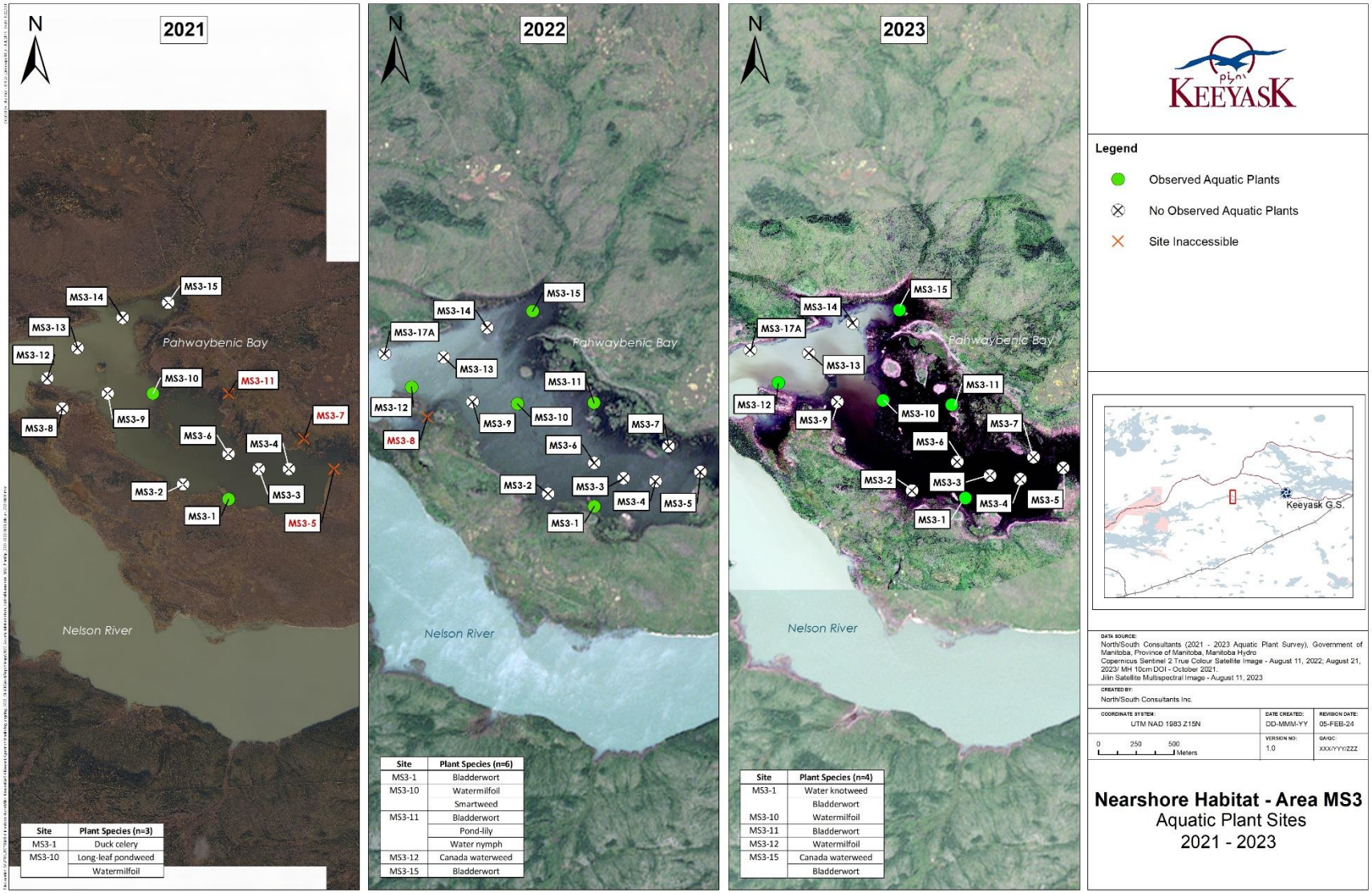
| MS3 | Area ($m^2$) | % of Total Area |
|---|---|---|
| Organic | 609,736 | 37 |
| Mud | 786,583 | 48 |
| Silty Sand | 153,533 | 9 |
| Sand | 8,419 | 1 |
| Rock | 100 | 0 |
| No Data | 89,590 | 5 |
| **Sum** | **1,647,961** | **100** |

**Photo 8: Flooded terrestrial habitat at the edges of flooded reservoir backbay Zone 4 (MS3) in 2023.**

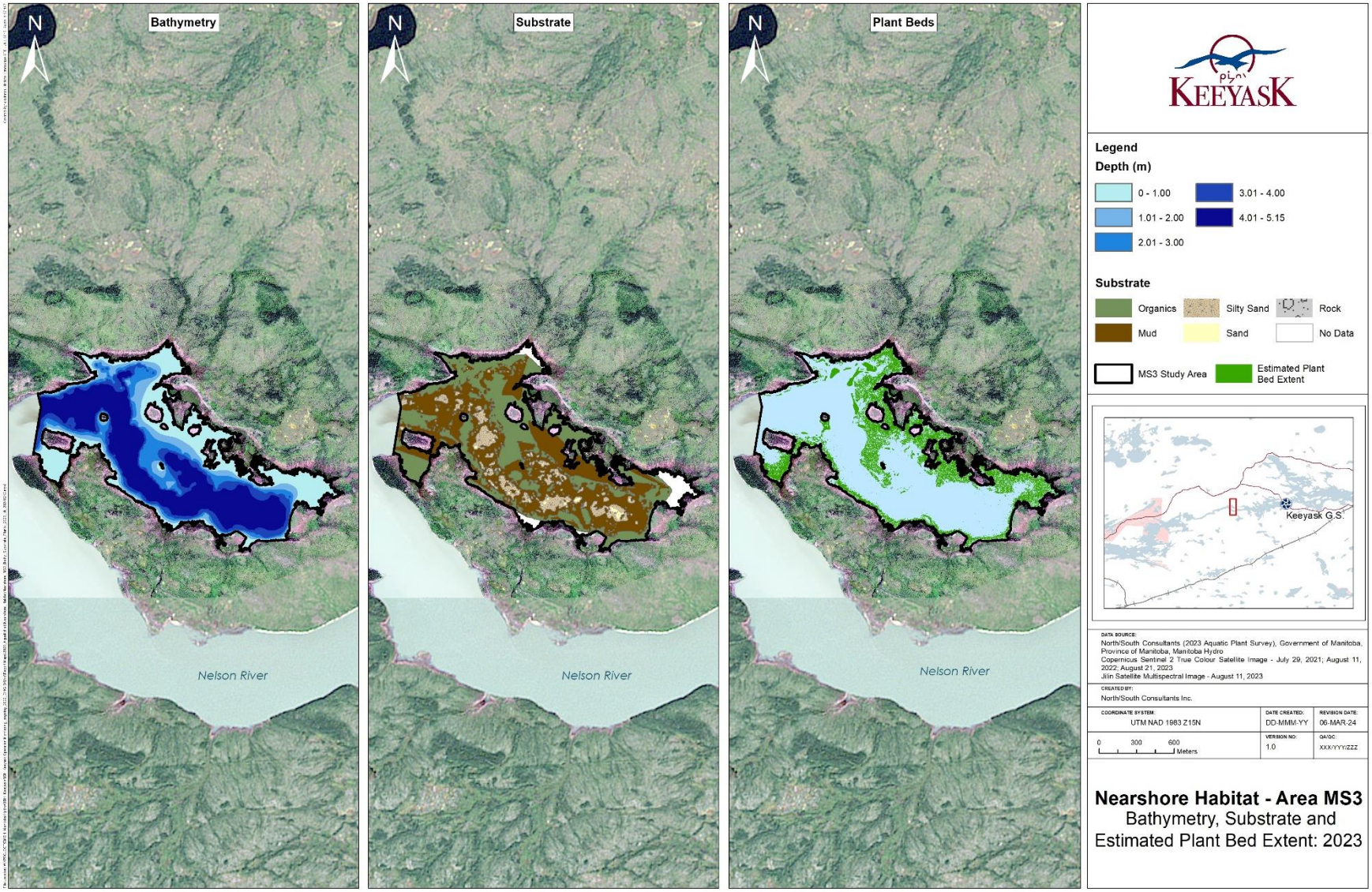
**Photo 9: Plant beds visible at the surface of the water in the Keeyask reservoir backbay Zone 4 (MS3) in 2023.**




**Map 16: Basic substrate class results of sediment grabs taken at sampling sites in the Keeyask reservoir in backbay Zone 4 (MS3), August 2021-2023.**




**Map 17: Macrophytes collected from the Keeyask reservoir in backbay Zone 4 (MS3) over three sampling years, August 2021-2023.**




**Map 18: Bathymetry, substrate, and plant beds in the Keeyask reservoir backbay Zone 4 (MS3) in the third year (*i.e.,* 2023) following impoundment of the Keeyask reservoir.**

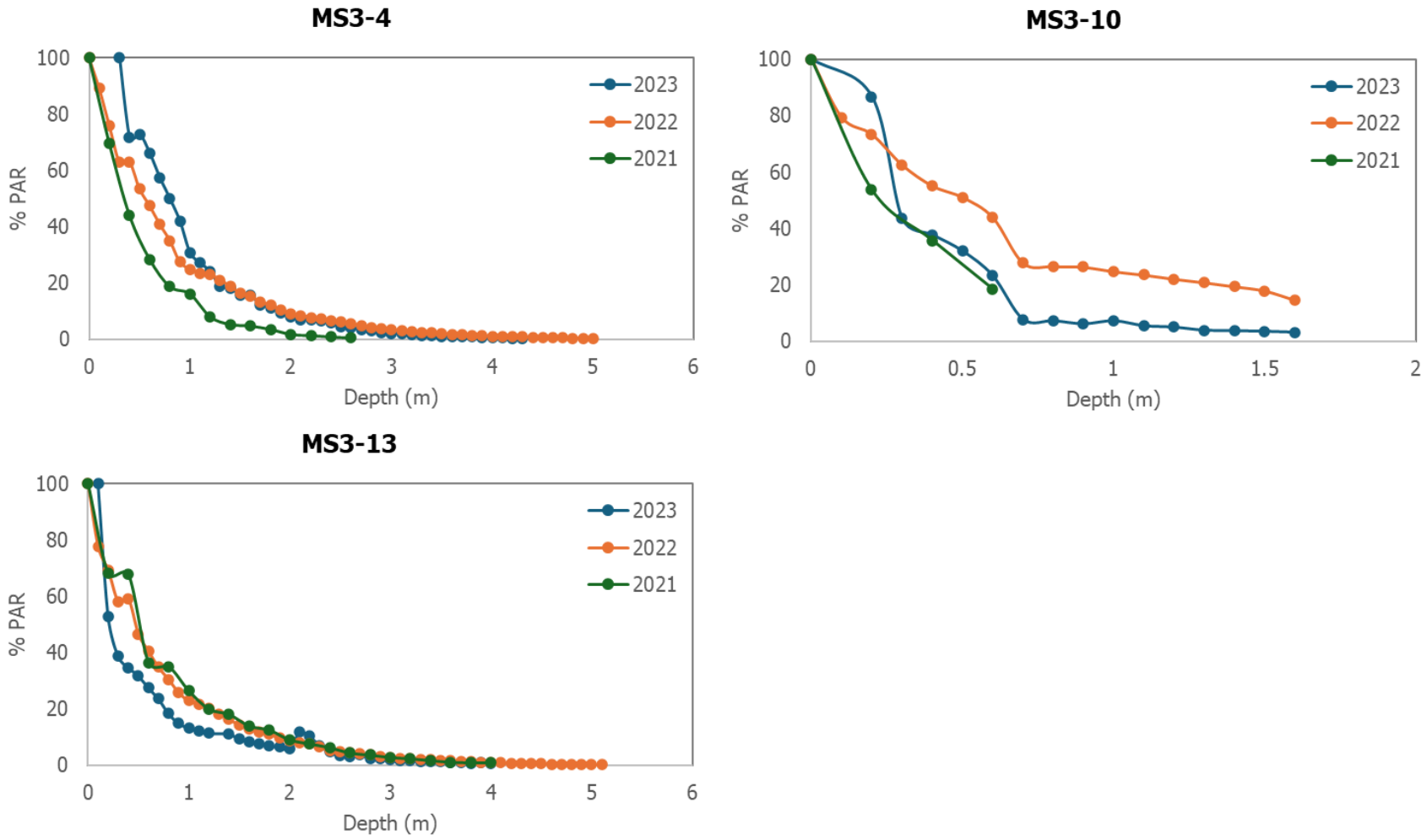



**Figure 4:** **The percent of photosynthetically active radiation (PAR) extinction with depth at three sites in the Keeyask reservoir in backbay Zone 4 (MS3), measured with a LI-1400 data logger (LI-COR), 2021-2023.**

## 4.2.4 KEEYASK RESERVOIR BACKBAY ZONE 12 (MS4)

### 4.2.4.1 2023 SAMPLING

Mean water surface elevation was 158.67 m at site MS4 on August 23, 2023 (Map 3; Table 3). Depth in the flooded terrestrial area ranged from 0.96–5.16 m. No existing (*i.e.*, pre-flooded area) shorelines were present as the entire site was located within a flooded area.

Substrates were sampled at 17 sites. All sites were classified as organic, as the entire sampling area is located within a flooded bay (Table 14). The acoustic classification model indicated that the area was dominated by organics and silt/clay, each comprising 28% of the area (Table 5). PSA analysis was conducted at three sites that were classified as silt and clay (Table 15).

Aquatic plant species were observed at 14 sites ranging in depth from 0.3–1.6 m (Table A1-4). Five species of aquatic plants were observed. Star duckweed (*Lemna trisulca*) was the most abundant and was present at 14 sites (Photo 10). Bladderwort, Watermilfoil, Flat-stemmed pondweed (*Potamogeton zosteriformis*), Canada waterweed, and Whitewater buttercup (*Ranunculus aquatilis*) were present but sparse.

**Photo 10: Star duckweed collected using a rake sampler from the Keeyask reservoir backbay Zone 12 (MS4) in 2023.**

**Table 14: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir in backbay Zone 12 (MS4), 2023.**

| 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 | % | | |
| MS4-7 | petite Ponar | 23-Aug | 352633 | 6241056 | 1.1 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-8 | petite Ponar | 23-Aug | 353505 | 6241166 | 0.5 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-9 | petite Ponar | 23-Aug | 352904 | 6241279 | 0.9 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-10 | petite Ponar | 23-Aug | 353547 | 6241371 | 1.4 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-11 | petite Ponar | 23-Aug | 353344 | 6241427 | 0.3 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-12 | petite Ponar | 23-Aug | 353050 | 6241589 | 2.5 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-13 | petite Ponar | 23-Aug | 353556 | 6241579 | 1 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-14 | petite Ponar | 23-Aug | 353357 | 6241664 | 3 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-15 | petite Ponar | 23-Aug | 353445 | 6241690 | 1.6 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-16A | petite Ponar | 23-Aug | 352779 | 6241256 | 0.9 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-17A | petite Ponar | 23-Aug | 353050 | 6241456 | 0.9 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-18A | petite Ponar | 23-Aug | 352430 | 6240984 | 1.4 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-20A | petite Ponar | 23-Aug | 353398 | 6241316 | 0.9 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-21 | petite Ponar | 23-Aug | 351990 | 6240201 | 0.9 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-22 | petite Ponar | 23-Aug | 352008 | 6240367 | 0.9 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-23 | petite Ponar | 23-Aug | 352068 | 6240517 | 1 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS4-24 | petite Ponar | 23-Aug | 352120 | 6240650 | 1.5 | soft | organic | 100 | - | - | - | - | organic | organic |

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

**Table 15: Results of particle size analysis (conducted at ALS Laboratories) from samples collected from the Keeyask reservoir backbay Zone 12 (MS4), 2023.**

| Area Name | Date | Area Code | Habitat | Field Site No. | Inorganic Carbon (%) | CaCO3 Equivalent | Total Carbon by Combustion (%) | Total Organic Carbon (%) | % Sand (2.0-0.05 mm) | % Silt (0.05-2µm) | % Clay (<2 µm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keeyask Reservoir | 23-Aug-2023 | MS4 | nearshore | MS4-7 | 0.485 | 4.04 | 35.1 | 34.6 | 1.1 | 91.9 | 7.0 | Silt |
| Keeyask Reservoir | 23-Aug-2023 | MS4 | nearshore | MS4-10 | 0.495 | 4.13 | 27.8 | 27.3 | 2.1 | 29.4 | 68.5 | Heavy Clay |
| Keeyask Reservoir | 23-Aug-2023 | MS4 | nearshore | MS4-14 | 0.532 | 4.43 | 31.5 | 31.0 | 2.9 | 75.6 | 21.5 | Silt Loam |

### 4.2.4.2 2021-2023 SUMMARY

Sampling area MS4 is located within the flooded reservoir backbay Zone 12, along the south shore of Gull Lake (maps 2 and 4). Prior to impoundment, much of Zone 12 was terrestrial habitat, with small creeks leading to inland ponds. Flooding was extensive within this area, and much of the backbay consists of flooded terrestrial vegetation and peatland (Photo 11). Sampling was conducted entirely within a flooded portion of Zone 12 that was terrestrial prior to reservoir impoundment. As such, organic substrate composed of detritus and loose, broken-down plant matter was predominant in all three years (Map 19; Photo 12). Substrate mapping in 2023 showed that approximately 23% of the sampling area was comprised of organic substrate, while 43% contained mud; however, 31% of the study area could not be mapped due to the presence of floating peat islands (Table 16).

The abundance and diversity of aquatic plants within MS4 has increased over the first three years following reservoir impoundment, although free-floating species continued to dominate into 2023 (Map 20). In 2021, two plant species (Bladderwort and Richardson pondweed) were present at three sampling sites. Richardson pondweed was the only rooted aquatic species present. In 2022, the number of sampling sites that contained aquatic plants increased to ten. Six species of aquatic plants were present at four sites, including three species of rooted plants (Canada Waterweed, Richardson pondweed, and Watermilfoil). Five aquatic plant species were present in 2023, of which Star duckweed (a free-floating species) was dominant (Table A1-4). However, four species of rooted aquatic macrophytes were also present at four sites (Canada waterweed, Flat-stemmed pondweed, Watermilfoil, and Whitewater buttercup).

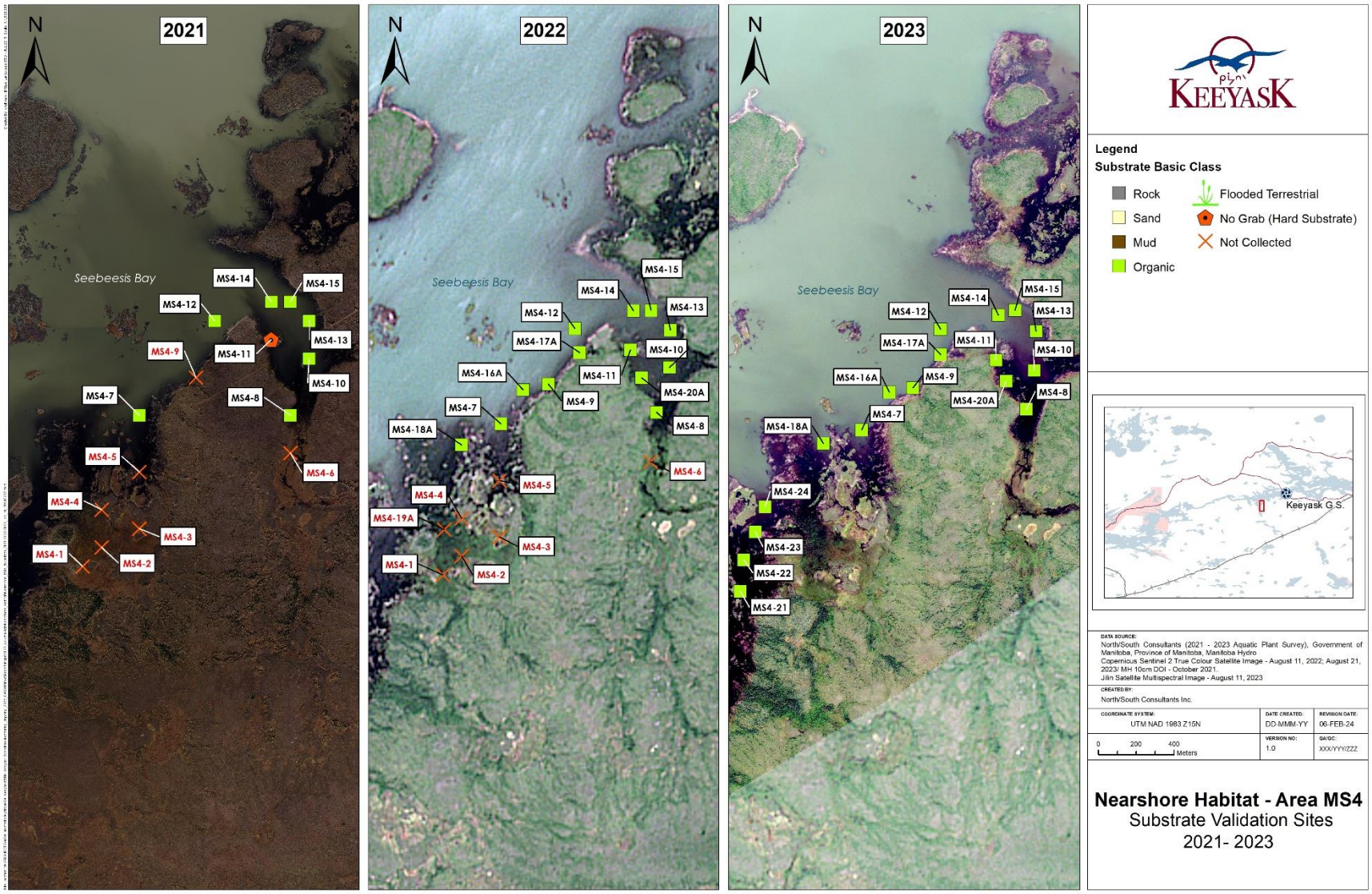
In the third year following reservoir impoundment, plant beds were present throughout much of MS4, occupying approximately 66% of the study area (Map 21). Light extinction sampling suggests that between 12 and 32% penetrates to 1 m of depth (Figure 5). Beyond this, light attenuates quickly and between only 5 and 6% of surface light penetrates to 2 m. Despite this, plant beds were present in areas measuring greater than 2 m in depth.

**Table 16: Total area occupied by each substrate type as measured by acoustic surveys in the Keeyask reservoir flooded backbay Zone 12 (MS4), 2023.**

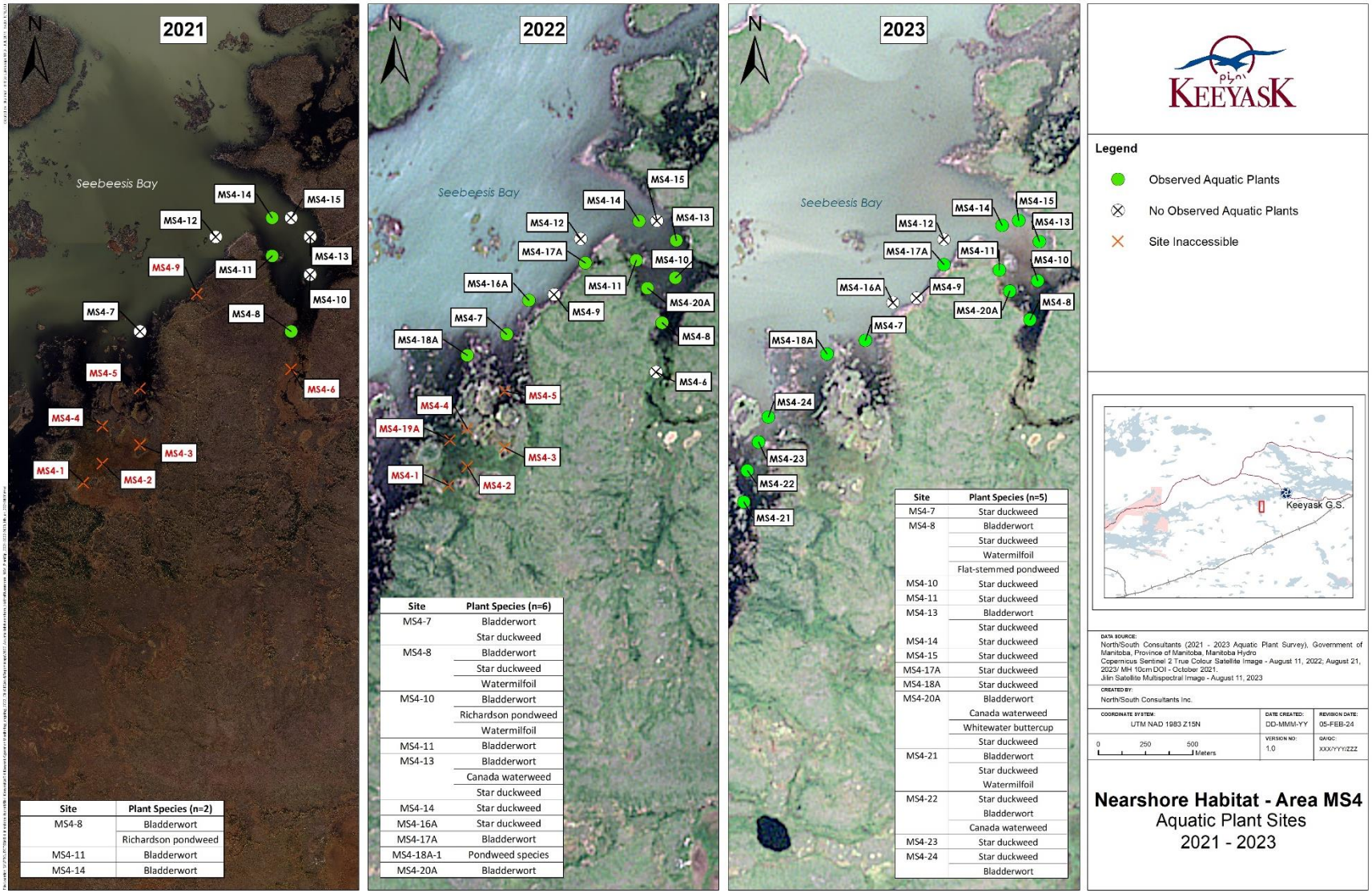
| MS4 | Area ($m^2$) | % of Total Area |
|---|---|---|
| Organic | 130,582 | 23 |
| Mud | 238,484 | 43 |
| Silty Sand | 14,355 | 3 |
| Sand | 555 | 0 |
| Rock | 0 | 0 |
| No Data | 172,752 | 31 |
| **Sum** | **556,729** | **100** |

**Photo 11: Flooded terrestrial habitat and peat islands in the Keeyask reservoir backbay Zone 12 (MS4) in 2023.**

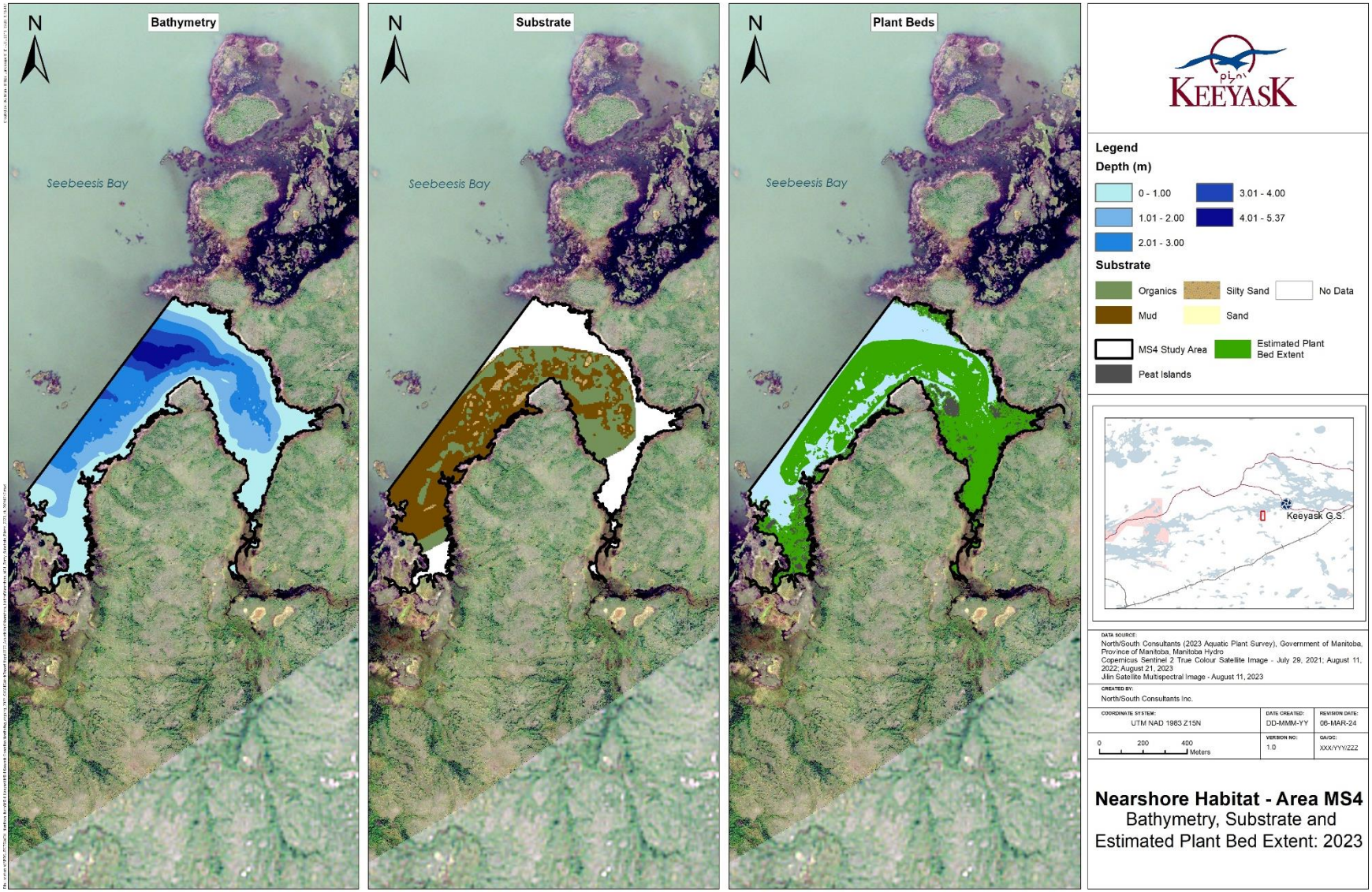
**Photo 12: Substrate collected in the Keeyask reservoir backbay Zone 12 (MS4) in 2023 showing organic, flooded terrestrial substrate.**




**Map 19: Basic substrate class results of sediment grabs taken at sampling sites in the Keeyask reservoir in backbay Zone 12 (MS4), August 2021-2023.**




**Map 20: Macrophytes collected from the Keeyask reservoir in backbay Zone 12 (MS4) over three years of sampling, August 2021-2023.**




**Map 21: Bathymetry, substrate, and plant beds in the Keeyask reservoir backbay Zone 12 (MS4) in the third year (*i.e.,* 2023) following impoundment of the Keeyask reservoir.**

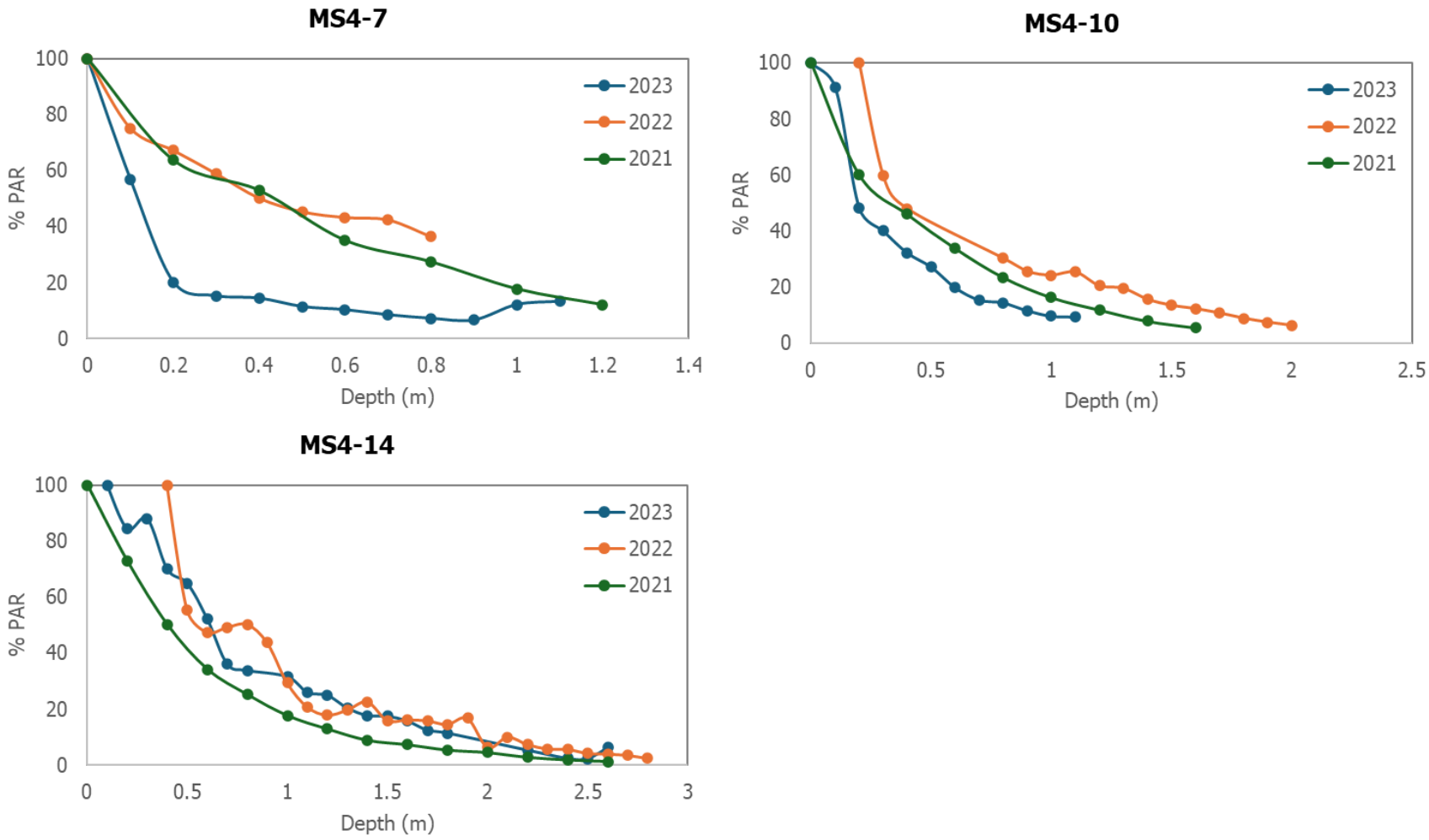



**Figure 5: The percent of photosynthetically active radiation (PAR) extinction with depth at three sites in the Keeyask reservoir in backbay Zone 12 (MS4), measured with a LI-1400 data logger (LI-COR), 2021-2023.**

## 4.2.5 SOUTH SHORE OF GULL LAKE (MS5)

### 4.2.5.1 2023 SAMPLING

Mean water surface elevation was 158.66 m at site MS5 on August 22, 2023 (Map 3; Table 3). Depth in flooded, previously terrestrial areas ranged from 0.96–6.33 m. Depth in the pre-impoundment shoreline ranged from 5.29–12.82 m.

Substrate was collected from 13 of 14 sites (Table 17). Most sites were classified as soft or moderate organic, while clay was present at three sites. The acoustic classification model indicated that the area was dominated by organics (45%) and silt/clay (24%; Table 5). PSA analysis was conducted at three sites and were classified as silt and silt loam (Table 18).

Plants were observed at five sampling sites ranging in depth from 0.5–1.9 m (Table A1-5). Two aquatic plant species were observed: Bladderwort and Watermilfoil (Photo 13).

**Photo 13: Watermilfoil collected using a rake sampler on the south shore of Gull Lake (MS5) in the Keeyask reservoir in 2023.**

**Table 17: Locations and results of substrate grab type validation sampling and post-survey class verification in the south shore of Gull Lake (MS5), 2023.**

| 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 | % | | |
| MS5-1 | petite Ponar | 21-Aug | 353888 | 6242891 | 2 | moderate | organic | 100 | - | - | - | - | organic | organic |
| MS5-4 | petite Ponar | 21-Aug | 354043 | 6243079 | 1.5 | moderate | organic | 100 | - | - | - | - | organic | organic |
| MS5-5 | petite Ponar | 21-Aug | 353952 | 6243265 | 2.4 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS5-6 | petite Ponar | 21-Aug | 354053 | 6243568 | 8.2 | hard | - | - | - | - | - | - | - | - |
| MS5-7 | petite Ponar | 21-Aug | 354749 | 6243565 | 1.7 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS5-9 | petite Ponar | 21-Aug | 354265 | 6243780 | 5.1 | moderate | organic | 50 | clay | 50 | - | - | organic | organic/clay |
| MS5-10 | petite Ponar | 21-Aug | 354644 | 6243760 | 2.5 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS5-18A | petite Ponar | 21-Aug | 353802 | 6243093 | 2.3 | moderate | organic | 100 | - | - | - | - | organic | organic |
| MS5-19 | petite Ponar | 21-Aug | 353667 | 6242721 | 0.5 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS5-20 | petite Ponar | 21-Aug | 353939 | 6242822 | 1.9 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS5-21 | petite Ponar | 21-Aug | 354612 | 6243625 | 1.2 | soft | organic | 50 | clay | 50 | - | - | organic | organic |
| MS5-22 | petite Ponar | 21-Aug | 354919 | 6243459 | 1.6 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS5-23 | petite Ponar | 21-Aug | 355089 | 6243305 | 0.5 | moderate | clay | 80 | organic | 20 | - | - | mud | mud |
| MS5-24 | petite Ponar | 21-Aug | 355042 | 6242976 | 0.5 | soft | organic | 100 | - | - | - | - | organic | organic |

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

**Table 18: Results of particle size analysis (conducted at ALS Laboratories) from samples collected from the south shore of Gull Lake (MS5), 2023.**

| Area Name | Date | Area Code | Habitat | Field Site No. | Inorganic Carbon (%) | CaCO3 Equivalent | Total Carbon by Combustion (%) | Total Organic Carbon (%) | % Sand (2.0-0.05 mm) | % Silt (0.05-2µm) | % Clay (<2 µm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keeyask Reservoir | 21-Aug-2023 | MS5 | nearshore | MS5-1 | 0.495 | 4.12 | 42.1 | 41.6 | 4.5 | 91.9 | 3.6 | Silt |
| Keeyask Reservoir | 21-Aug-2023 | MS5 | nearshore | MS5-7 | 2.77 | 23.1 | 17.1 | 14.3 | 2.0 | 84.0 | 14.0 | Silt Loam |
| Keeyask Reservoir | 21-Aug-2023 | MS5 | nearshore | MS5-9 | 1.99 | 16.6 | 7.34 | 5.35 | 9.7 | 81.8 | 8.5 | Silt |

### 4.2.5.2 2021-2023 SUMMARY

Sampling area MS5 is located on the south shore of Gull Lake in the Keeyask reservoir, extending into the eastern portion of flooded backbay Zone 12 and the western portion of Zone 13 (maps 2 and 4). Most of the sampling area is located within the mainstem of the river where flooding was minimal (Photo 14). However, sites located at the mouth of each flooded backbay are located within areas of flooded terrestrial vegetation (Photo 15). As such, sites within these areas were classified as organic, composed of detritus and loose, broken-down plant matter in all three sampling years (Map 22). Deeper sites located within the Nelson River mainstem were only sampled in 2021 and 2022, after which they were determined to be too deep (measuring greater than 8.0 m in depth) to support aquatic plant life. These sites were comprised of mud (*i.e.,* clay and silt) or rock (*i.e.,* cobble) substrates. Substrate mapping in 2023 showed that approximately 10% of the sampling area was comprised of organic substrate, while 23% contained mud; however, 30% of the study area could not be mapped due to shallow water (Table 19).

The distribution of rooted aquatic macrophytes has increased within MS5 over the first three years following reservoir impoundment (Map 23). No aquatic plants were observed in 2021, even at the shallow sites located close to shore. In 2022, two species of free-floating aquatic plants (Bladderwort and Star duckweed) were found at two sampling sites. Five sampling sites contained aquatic plants in 2023, including a single species of rooted macrophyte (Watermilfoil; Table A1-5). In both years, sites with aquatic plants were shallow (maximum depth 2.6 m) and located close to shore (maps 23 and 24)

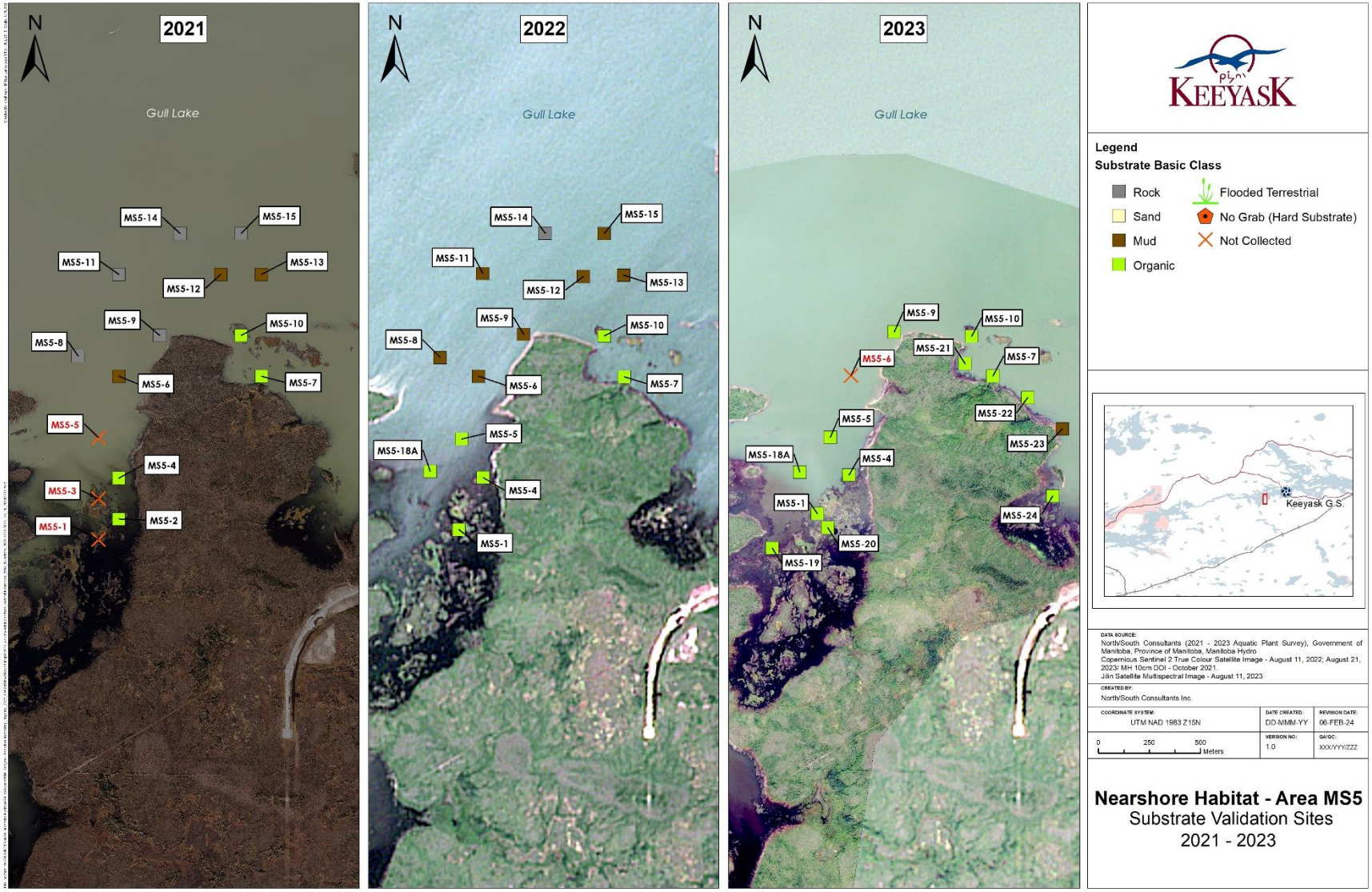
In the third year following reservoir impoundment, plant beds were present although sparse, occupying approximately 19% of the study area (Map 24). Plant beds were generally limited to areas closer to shore as well those farther from the mainstem. Light extinction sampling suggests that little light (between <1 and 10% of surface) penetrates to 2 m of depth (Figure 6), although light penetrated to a greater depth in 2022 compared to 2021 or 2023. Between 12 and 37% of surface light reached a depth of 1 m.

**Table 19: Total area occupied by each substrate type as measured by acoustic surveys in the Keeyask reservoir on the south shore of Gull Lake (MS5), 2023.**

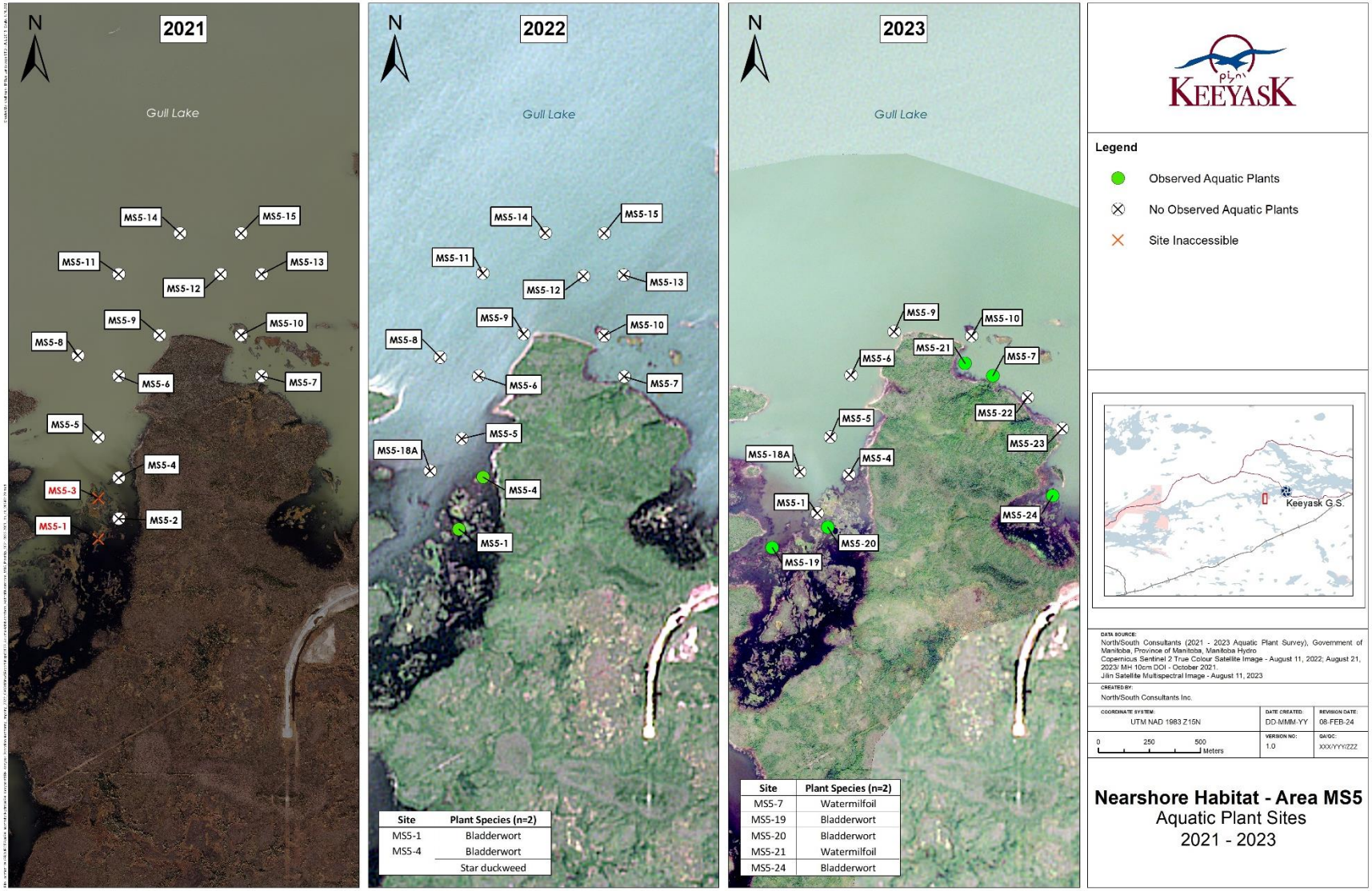
| MS5 | Area ($m^2$) | % of Total Area |
|---|---|---|
| Organic | 105,039 | 10 |
| Mud | 243,006 | 23 |
| Silty Sand | 161,072 | 15 |
| Sand | 203,181 | 19 |
| Rock | 38,567 | 4 |
| No Data | 326,960 | 30 |
| **Sum** | **1,077,825** | **100** |

**Photo 14: Portion of the sampling area on the south shore of Gull Lake (MS5) showing little flooded area in 2023.**

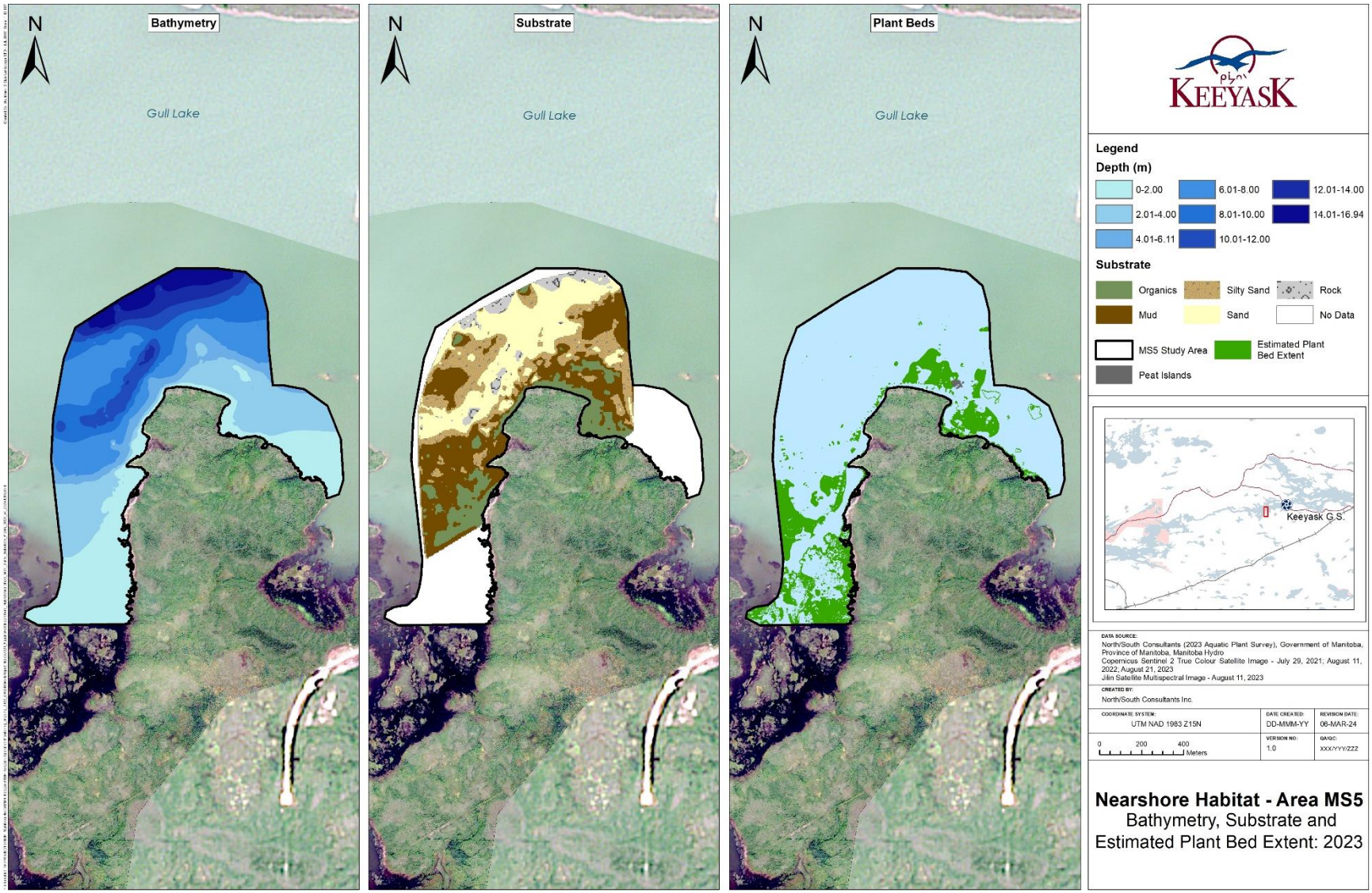
**Photo 15: Areas of flooded terrestrial vegetation located within the sampling area on the south shore of Gull Lake (MS5) in 2023.**




**Map 22: Basic substrate class results of sediment grabs taken at sampling sites along the south shore of the Keeyask reservoir (MS5), August 2021-2023.**




**Map 23: Macrophytes collected from the south shore of the Keeyask reservoir (MS5) over three sampling years, August 2021-2023.**




**Map 24: Bathymetry, substrate, and plant beds along the south shore of the Keeyask reservoir (MS5) in the third year (*i.e.,* 2023) following impoundment of the Keeyask reservoir.**

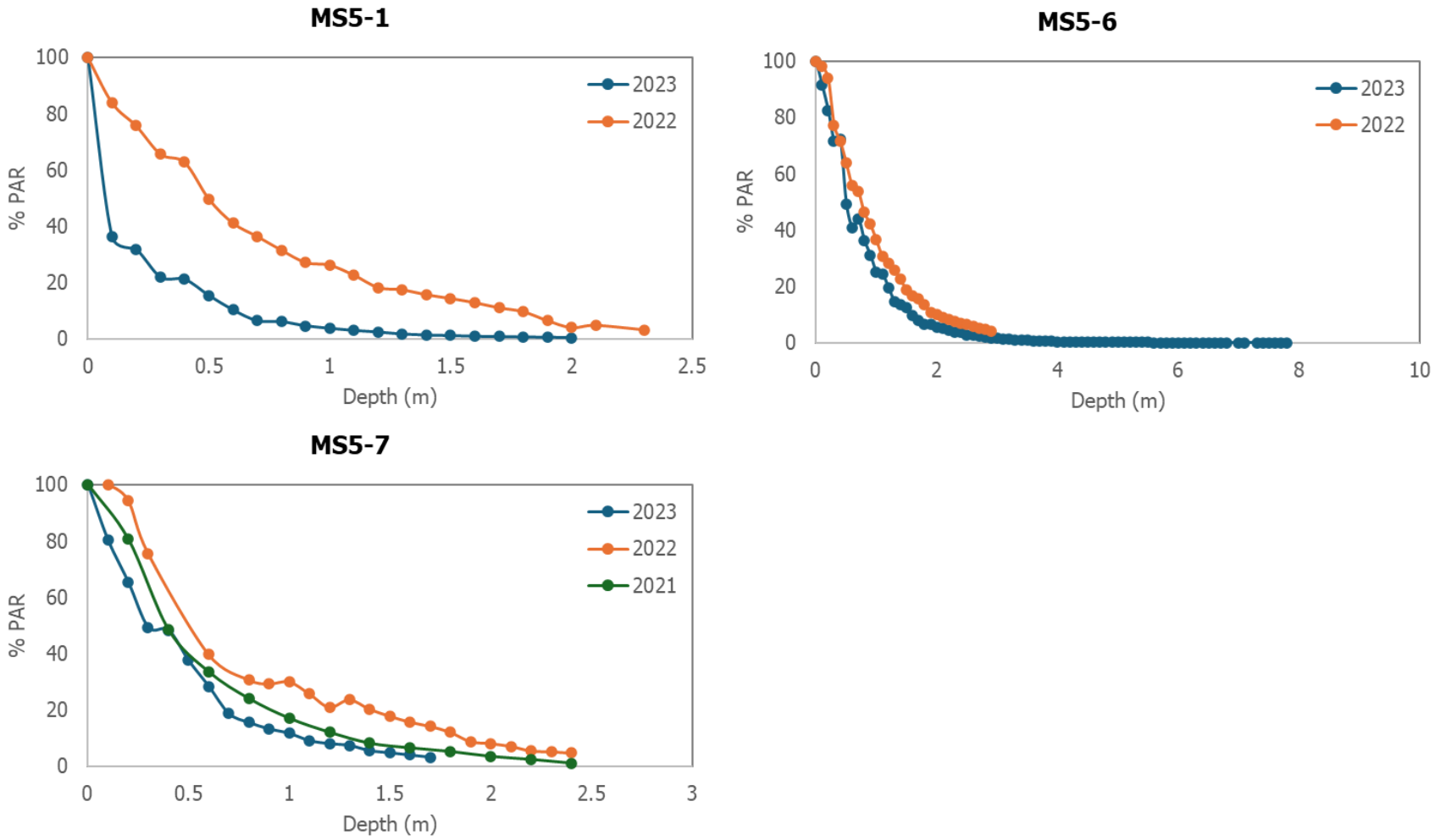



**Figure 6: The percent of photosynthetically active radiation (PAR) extinction with depth at three sites on the south shore in the Keeyask reservoir (MS5), measured with a LI-1400 data logger (LI-COR), 2021-2023.**

## 4.2.6 NORTH SHORE OF GULL LAKE (MS6)

### 4.2.6.1 2023 SAMPLING

Mean water surface elevation was 158.55 m at site MS6 on August 15, 2023 (Map 3; Table 3). Depth in flooded, previously terrestrial areas ranged from 0.96–6.68 m. Depth in the pre-impoundment shoreline ranged from 4.96–7.11 m.

Substrate was collected from 15 sites (Table 20). Most sites were classified as organic substrate with some silt and clay. The acoustic classification model indicated that the area was dominated by soft substrates including organic (59%) and silt/clay (19%; Table 5). PSA analysis was conducted at three sites that were classified as silt loam and silt (Table 21).

Aquatic plants were observed at six sampling sites, ranging in depth from 0.3–1.0 m (Table A1-6). Two aquatic plant species were observed; Watermilfoil was present at all six sites, and Star duckweed (Photo 16) was present at one site.

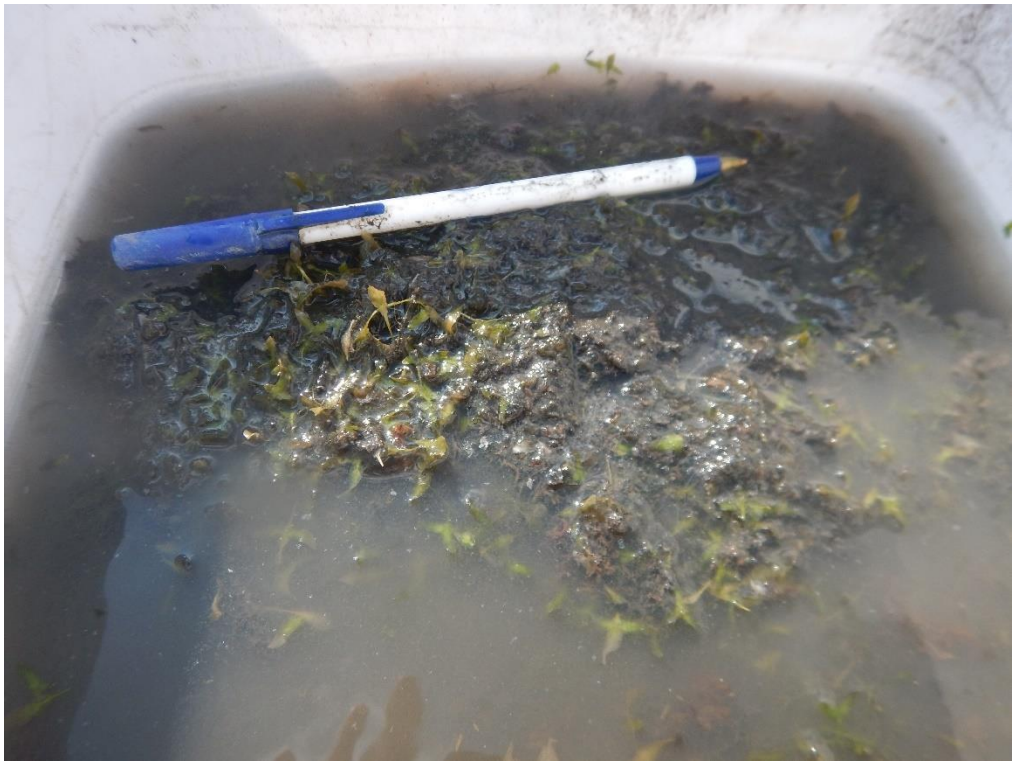


**Photo 16: Star duckweed located within the sampling area on the north shore of Gull Lake (MS6) in 2023.**

**Table 20: Locations and results of substrate grab type validation sampling and post-survey class verification in the north shore of the Keeyask reservoir (MS6), 2023.**

| 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 | % | | |
| MS6-1 | petite Ponar | 15-Aug | 353849 | 6245671 | 6.3 | soft | organic | 85 | clay | 15 | - | - | mud | organic/clay |
| MS6-2 | petite Ponar | 15-Aug | 353452 | 6245781 | 4.5 | soft | organic | 80 | clay | 10 | silt | 10 | mud | organic/clay/silt |
| MS6-3 | petite Ponar | 15-Aug | 353656 | 6245782 | 5.5 | soft | clay | 60 | organic | 30 | silt | 10 | mud | clay/organic/silt |
| MS6-4 | petite Ponar | 15-Aug | 353218 | 6245842 | 0.6 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS6-5 | petite Ponar | 15-Aug | 353069 | 6245981 | 0.5 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS6-6 | petite Ponar | 15-Aug | 353439 | 6245877 | 1 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS6-7 | petite Ponar | 15-Aug | 353650 | 6245977 | 1.2 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS6-8A | petite Ponar | 15-Aug | 353725 | 6246167 | 1.3 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS6-10A | petite Ponar | 15-Aug | 353508 | 6245996 | 0.4 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS6-11 | petite Ponar | 15-Aug | 353581 | 6246158 | 1 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS6-12 | petite Ponar | 15-Aug | 354065 | 6246167 | 4.2 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS6-14 | petite Ponar | 15-Aug | 353753 | 6246373 | 0.5 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS6-17B | petite Ponar | 15-Aug | 353760 | 6246478 | 0.3 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS6-18A | petite Ponar | 15-Aug | 352975 | 6246134 | 0.7 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS6-20A | petite Ponar | 15-Aug | 353782 | 6245880 | 0.8 | soft | organic | 100 | - | - | - | - | organic | organic |

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

**Table 21: Results of particle size analysis (conducted at ALS Laboratories) from samples collected from the north shore of Gull Lake (MS6), 2023.**

| Area Name | Date | Area Code | Habitat | Field Site No. | Inorganic Carbon (%) | CaCO3 Equivalent | Total Carbon by Combustion (%) | Total Organic Carbon (%) | % Sand (2.0-0.05 mm) | % Silt (0.05-2µm) | % Clay (<2 µm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keeyask Reservoir | 15-Aug-2023 | MS6 | nearshore | MS6-3 | 1.20 | 9.97 | 10.3 | 9.10 | 18.2 | 76.7 | 5.1 | Silt Loam |
| Keeyask Reservoir | 15-Aug-2023 | MS6 | nearshore | MS6-6 | 0.622 | 5.18 | 41.5 | 40.9 | 4.6 | 94.0 | 1.4 | Silt |
| Keeyask Reservoir | 15-Aug-2023 | MS6 | nearshore | MS6-18A | 0.403 | 3.36 | 39.8 | 39.4 | 6.9 | 79.6 | 13.5 | Silt Loam |

### 4.2.6.2 2021-2023 SUMMARY

Sampling area MS6 is located on the north shore of Gull Lake in the Keeyask reservoir, directly opposite from MS5 (Map 2). Most of the sampling area is located on flooded terrestrial habitat. In all three sampling years, substrates within the majority of sites were classified as organic, composed of detritus and loose, broken-down plant matter (Map 25). In 2023, the dominant substrate was classified as organic at two sites (MS6-1, MS6-2), previously classified as mud (*i.e.,* clay and silt) in 2021 and 2022. Large amounts of rafted peat with terrestrial debris including logs were observed within the area in 2023 (photos 17 and 18). Substrate mapping in 2023 showed that approximately 27% of the sampling area was comprised of organic substrate, while 22% contained mud; however, 48% of the study area could not be mapped due to the presence of floating peat islands (Table 22).

Although few species have been found in this area, the distribution of rooted aquatic macrophytes has increased over the first three years following reservoir impoundment (Map 26). No aquatic plant species were present in 2021, but two terrestrial species (Labrador tea [*Rhododendron groenlandicum*] and Horsetail *[Equisetum* spp.]) were present in low abundance. In 2022, two free-floating aquatic species (Star duckweed and Bladderwort) were observed at four sites, while unidentified algae were collected from an additional four sites. In 2023, aquatic plants were found at six sites, the majority of which were rooted Watermilfoil (Table A1-6).

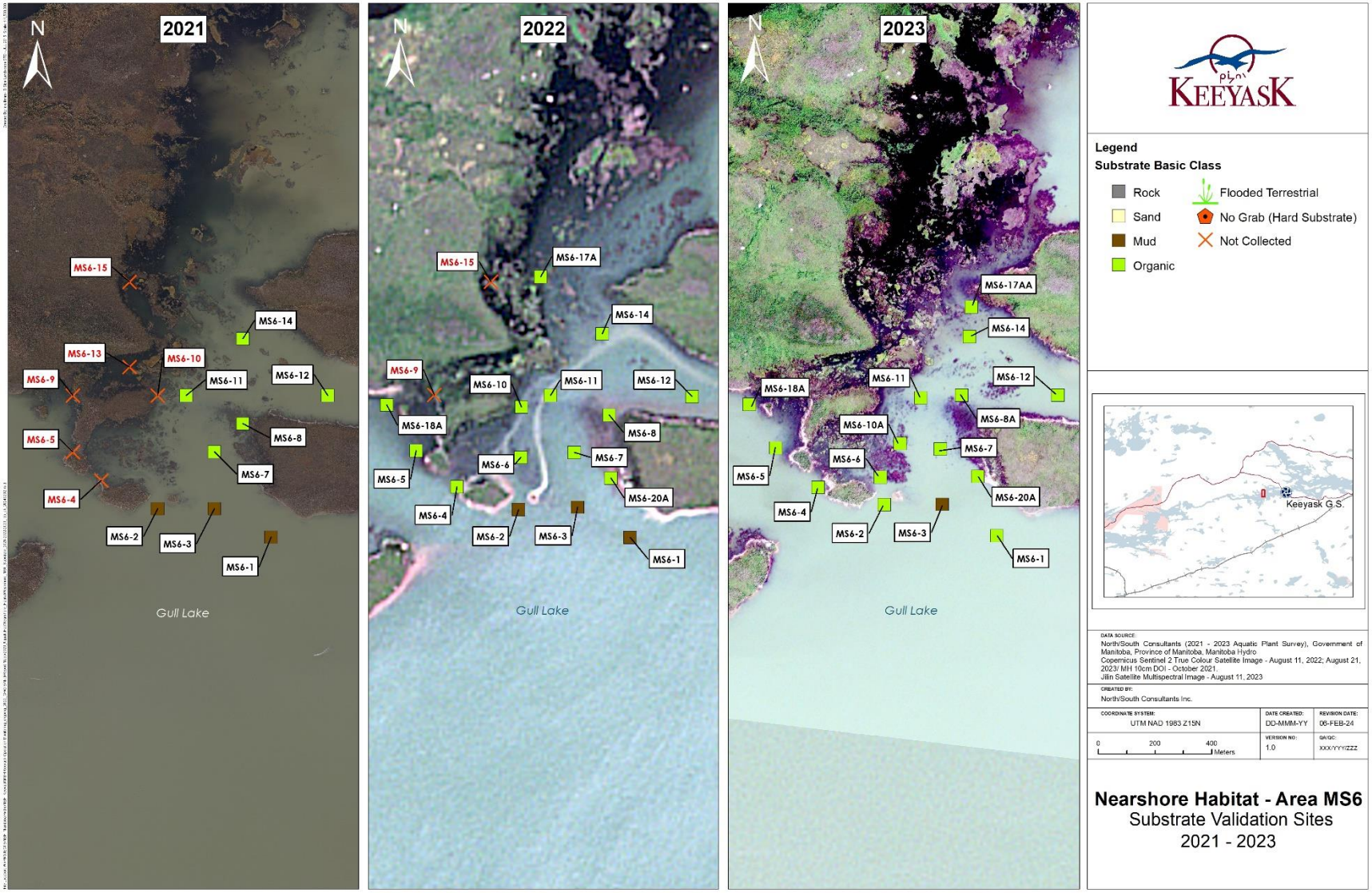
In the third year following reservoir impoundment, plant beds occurred within approximately 28% of the sampling area, largely within the shallower portions measuring less than 1 m in depth (Map 27). Light extinction sampling suggests that little light (between 2 and 8% of surface) penetrates to a depth of 2 m (Figure 7), although light extinction was only measured at a single deeper site. At the remaining two sites (measuring between 0.6 and 1 m deep), between 18 and 79% of surface light reached the bottom.

**Table 22: Total area occupied by each substrate type as measured by acoustic surveys in the Keeyask reservoir on the north shore of Gull Lake (MS6), 2023.**

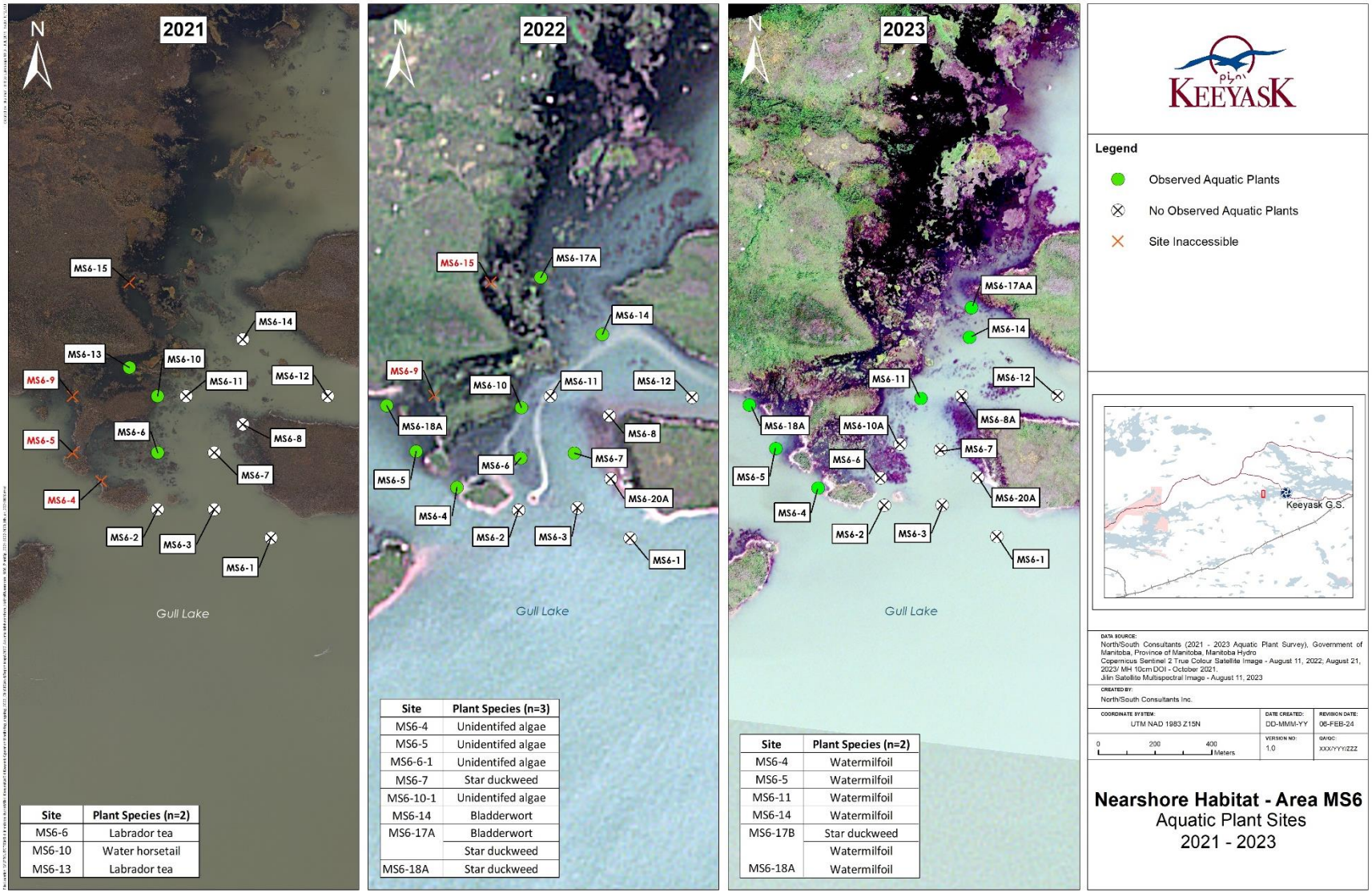
| MS6 | Area ($m^2$) | % of Total Area |
|---|---|---|
| Organic | 248,049 | 27 |
| Mud | 197,769 | 22 |
| Silty Sand | 27,350 | 3 |
| Sand | 6,325 | 1 |
| Rock | 0 | 0 |
| No Data | 438,170 | 48 |
| **Sum** | **917,662** | **100** |

**Photo 17: Peat and terrestrial debris observed on the north shore of Gull Lake (MS6) in 2023.**

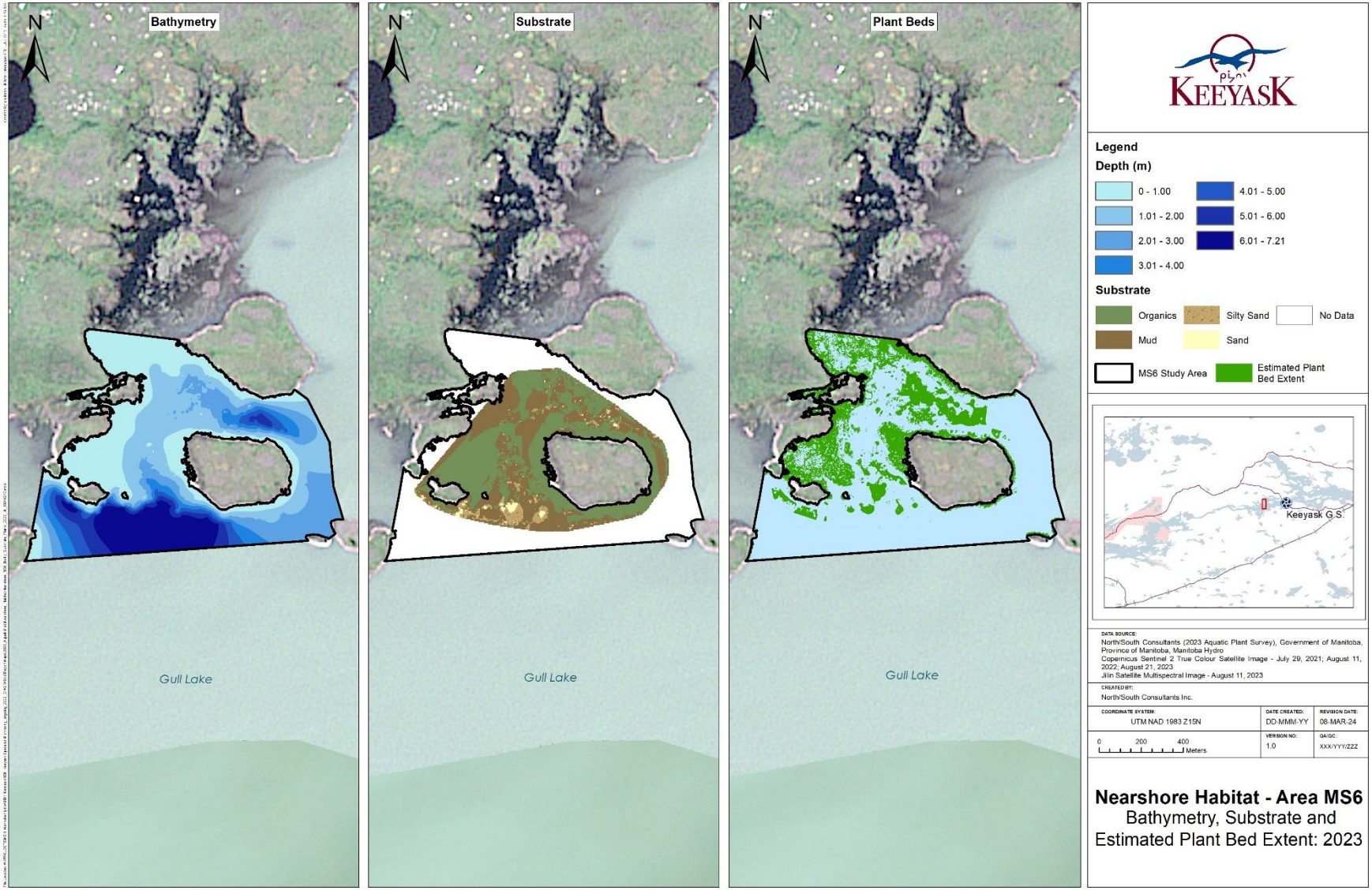
**Photo 18: Rafted peat and terrestrial debris observed on the north shore of Gull Lake (MS6) in 2023.**




**Map 25: Basic substrate class results of sediment grabs taken at sampling sites along the north shore of the Keeyask reservoir (MS6), August 2021-2023.**




**Map 26: Macrophytes collected from the north shore of the Keeyask reservoir (MS6) over three sampling years, August 2021-2023.**




**Map 27: Bathymetry, substrate, and plant beds along the north shore of the Keeyask reservoir (MS6) in the third year (*i.e.*, 2023) following impoundment of the Keeyask reservoir.**

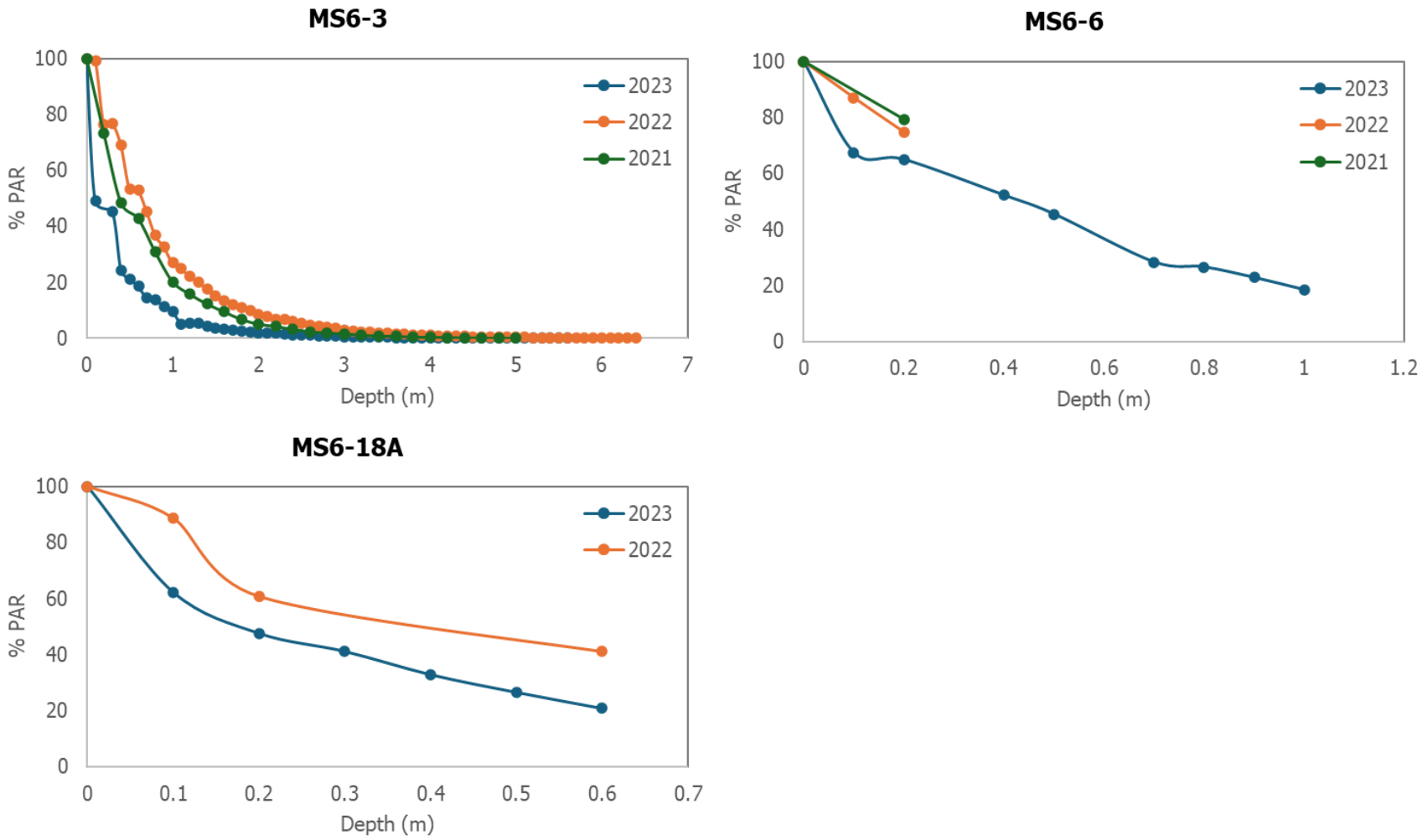



**Figure 7:** **The percent of photosynthetically active radiation (PAR) extinction with depth at three sites on the north shore in the Keeyask reservoir (MS6), measured with a LI-1400 data logger (LI-COR), 2021-2023.**

## 4.2.7 KEEYASK RESERVOIR BACKBAY ZONE 7 (MS7)

### 4.2.7.1 2023 SAMPLING

Mean water surface elevation was 158.55 m at site MS7 on August 15, 2023 (Map 3; Table 3). Depth in flooded, previously terrestrial areas ranged from 0.96–5.87 m. Depth in the pre-impoundment shoreline ranged from 4.37–6.50 m.

Substrates were collected at 13 sites (Table 23). All sites were classified as organic, including detritus and loose, broken-down plant matter, as the entire area was located within a flooded bay. The acoustic classification model indicated that the area was dominated by soft substrates including organic (33%) and silt/clay (27%). Rocky substrates were also present including gravel/sand (15%; Table 5). PSA analysis was conducted at three sites that were classified as silt and silt loam (Table 24).

Aquatic plants were observed at nine sampling sites, which ranged in depth from 0.2–1.8 m (Table A1-7). Eight aquatic plant species were identified, the most common of which was Watermilfoil. Bladderwort, Star duckweed, and Lily species (*Nuphar* spp.) were present at multiple sites but in small numbers. Sedges (*Carex* spp.), Water arum (*Calla palustris*), Bryophytes (terrestrial mosses), and water nymph (*Najas* spp.) were also observed (Photo 19).

**Photo 19: Aquatic plants collected from the Keeyask reservoir backbay Zone 7 (MS7) in 2023, including Lily species, Star duckweed, Watermilfoil, and Bryophytes (including terrestrial mosses and leafy liverworts).**

**Table 23: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir, backbay Zone 7 (MS7), 2023.**

| 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 | % | | |
| MS7-1 | petite Ponar | 15-Aug | 350643 | 6246572 | 1.8 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS7-2 | petite Ponar | 15-Aug | 350945 | 6246573 | 5.5 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS7-3 | petite Ponar | 15-Aug | 351263 | 6246654 | 2.3 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS7-4 | petite Ponar | 15-Aug | 351552 | 6246712 | 0.2 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS7-5 | petite Ponar | 15-Aug | 351059 | 6246848 | 1.9 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS7-6A | petite Ponar | 15-Aug | 350731 | 6247022 | 0.5 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS7-7 | petite Ponar | 15-Aug | 350875 | 6246946 | 0.3 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS7-8 | petite Ponar | 15-Aug | 351399 | 6246843 | 1 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS7-9 | petite Ponar | 15-Aug | 350676 | 6247072 | 1.4 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS7-10 | petite Ponar | 15-Aug | 350842 | 6247190 | 1.5 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS7-16A | petite Ponar | 15-Aug | 350796 | 6247062 | 1.8 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS7-18A | petite Ponar | 15-Aug | 351407 | 6246628 | 2.7 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS7-19 | petite Ponar | 15-Aug | 350855 | 6246728 | 1.5 | soft | organic | 100 | - | - | - | - | organic | organic |

1 – Class verified with sidescan imagery post-survey.

**Table 24: Results of particle size analysis (conducted at ALS Laboratories) from samples collected from the Keeyask reservoir backbay Zone 7 (MS7), 2023.**

| Area Name | Date | Area Code | Habitat | Field Site No. | Inorganic Carbon (%) | CaCO3 Equivalent | Total Carbon by Combustion (%) | Total Organic Carbon (%) | % Sand (2.0-0.05 mm) | % Silt (0.05-2µm) | % Clay (<2 µm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keeyask Reservoir | 15-Aug-2023 | MS7 | nearshore | MS7-3 | 0.426 | 3.55 | 26.0 | 25.6 | 1.7 | 79.5 | 18.8 | Silt Loam |
| Keeyask Reservoir | 15-Aug-2023 | MS7 | nearshore | MS7-7 | 0.452 | 3.77 | 36.9 | 36.4 | <1.0 | 93.8 | 5.6 | Silt |
| Keeyask Reservoir | 19-Aug-2023 | MS7 | nearshore | MS7-10 | 0.333 | 2.77 | 29.2 | 28.9 | <1.0 | 98.0 | 1.4 | Silt |

### 4.2.7.2 2021-2023 SUMMARY

Sampling area MS7 is located within the flooded reservoir backbay Zone 7, along the north shore of Gull Lake (maps 2 and 4). The backbay is split into east and west portions by an island, and MS7 is located entirely within the eastern portion of the bay. Prior to flooding, part of MS7 was located within an off-system pond. Flooding was extensive within this area, and much of the backbay consists of flooded terrestrial vegetation (Photo 20). Sampling was conducted entirely within a flooded portion of Zone 7 that was terrestrial prior to reservoir impoundment. As such, organic substrate, composed of detritus and loose broken-down plant matter, was found at each sampling site in all three sampling years (Map 28). Substrate mapping in 2023 showed that approximately 23% of the sampling area was comprised of mud, while 15% contained silty sand; however, 52% of the study area could not be mapped due to shallow depths and the presence of plant beds that disrupted the acoustic signals (Table 25).

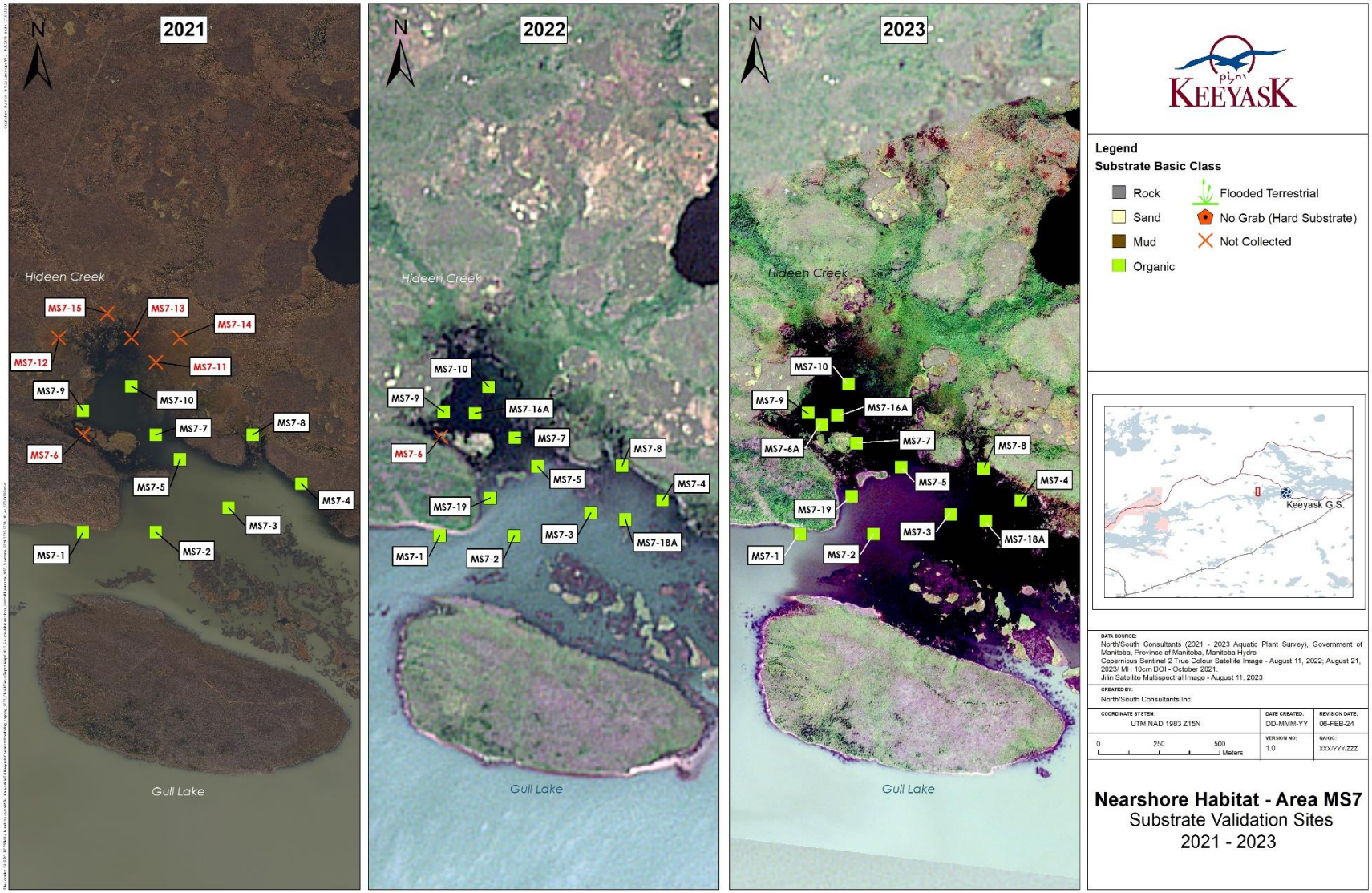
The abundance and diversity of aquatic macrophytes in MS7 has increased over the first three years following reservoir impoundment (Map 29). In 2021, six plant species were observed at six sites sampling sites, including two terrestrial species (Smartweed [*Polygonum pensylvanicum*] and Horsetail) and three rooted species (Duck celery, Pond-lily [*Nuphar* spp.], and Water horsetail [*Equisetum fluviatile*]). In 2022, nine plant species were present at the same six sites including a mixture of aquatic plants, terrestrial plants, unidentified algae, and terrestrial moss (*Sphagnum* spp.). Five species of aquatic macrophytes were present at nine sites in 2023, the most common of which was Watermilfoil (Table A1-7). Free-floating Bladderwort and rooted Pond-lily were present in all three sampling years.

In the third year following reservoir impoundment, plant beds were present throughout much of MS7, occupying approximately 41% of the study area (Map 30). Light extinction sampling suggests that as much as 10% of surface light can penetrate to 2.5 m, the deepest area sampled (Figure 8). As observed in other areas, light penetrated to a greater depth in 2022 compared to 2021 or 2023.

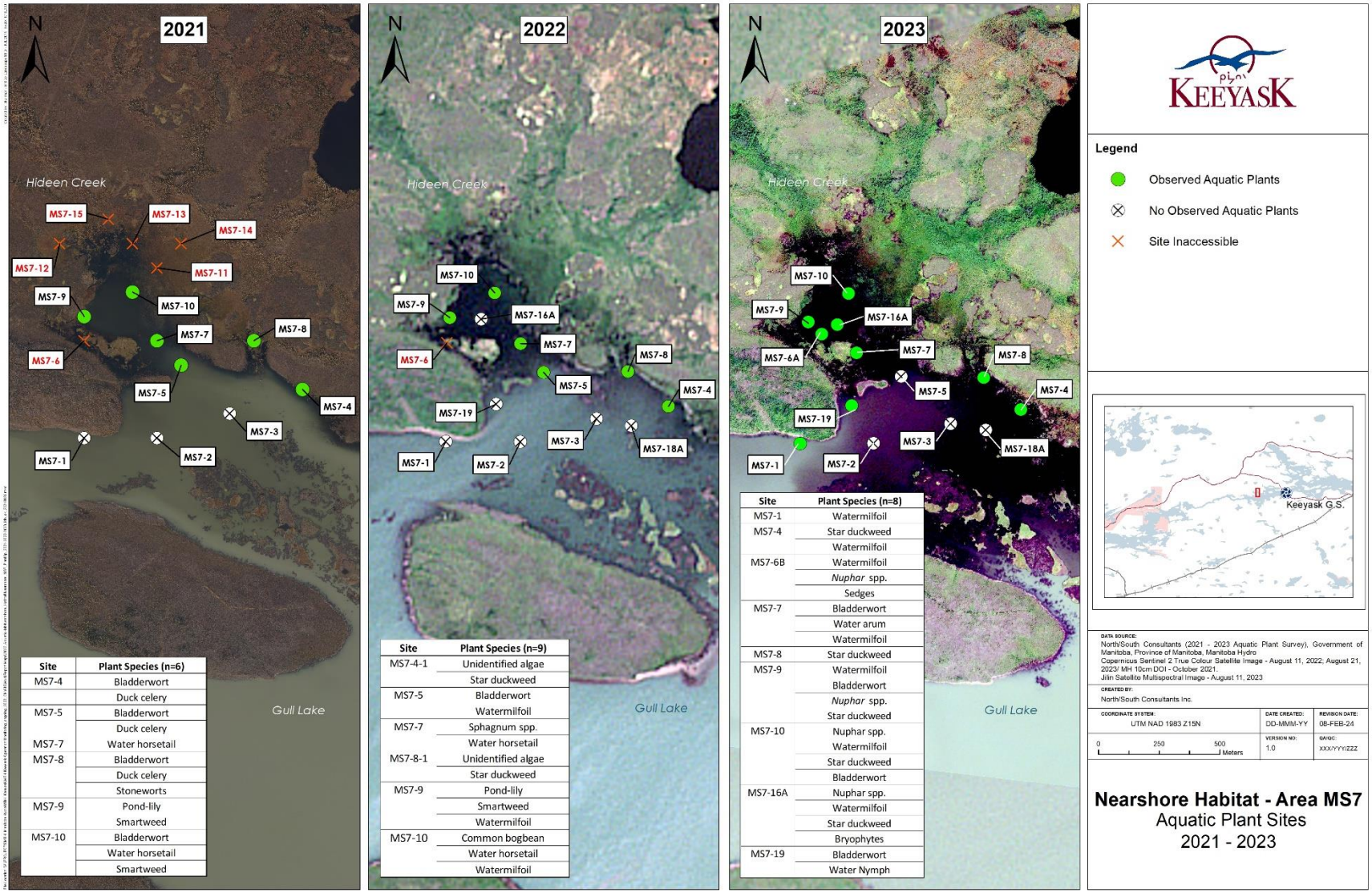
**Table 25: Total area occupied by each substrate type as measured by acoustic surveys in the Keeyask reservoir flooded backbay Zone 7 (MS7), 2023.**

| MS07 | Area ($m^2$) | % of Total Area |
|---|---|---|
| Organics | 57,144 | 9 |
| Mud | 146,272 | 23 |
| Silty Sand | 93,831 | 15 |
| Sand | 13,950 | 2 |
| Rock | 0 | 0 |
| No Data | 335,415 | 52 |
| **Sum** | **646,612** | **100** |

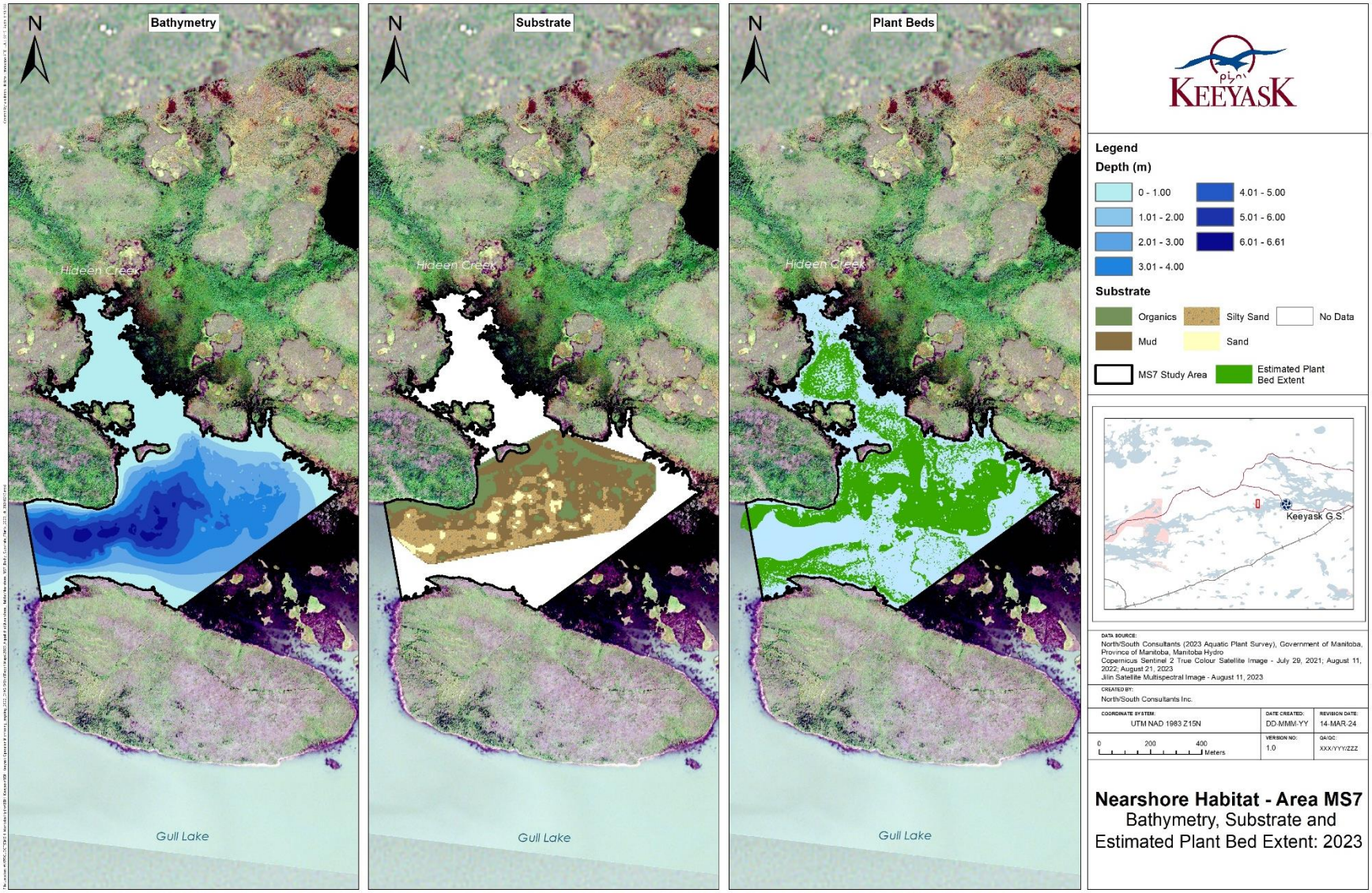
**Photo 20: Flooded terrestrial vegetation observed in the Keeyask reservoir backbay Zone 7 (MS7) in 2023.**




**Map 28: Basic substrate class results of sediment grabs taken at sampling sites in the Keeyask reservoir, backbay Zone 7 (MS7), August 2021-2023.**




**Map 29: Macrophytes collected from the Keeyask reservoir in backbay Zone 7 (MS7) over three sampling years, August 2021-2023.**




**Map 30: Bathymetry, substrate, and plant beds in the Keeyask reservoir backbay Zone 7 (MS7) in the third year (*i.e.,* 2023) following impoundment of the Keeyask reservoir.**

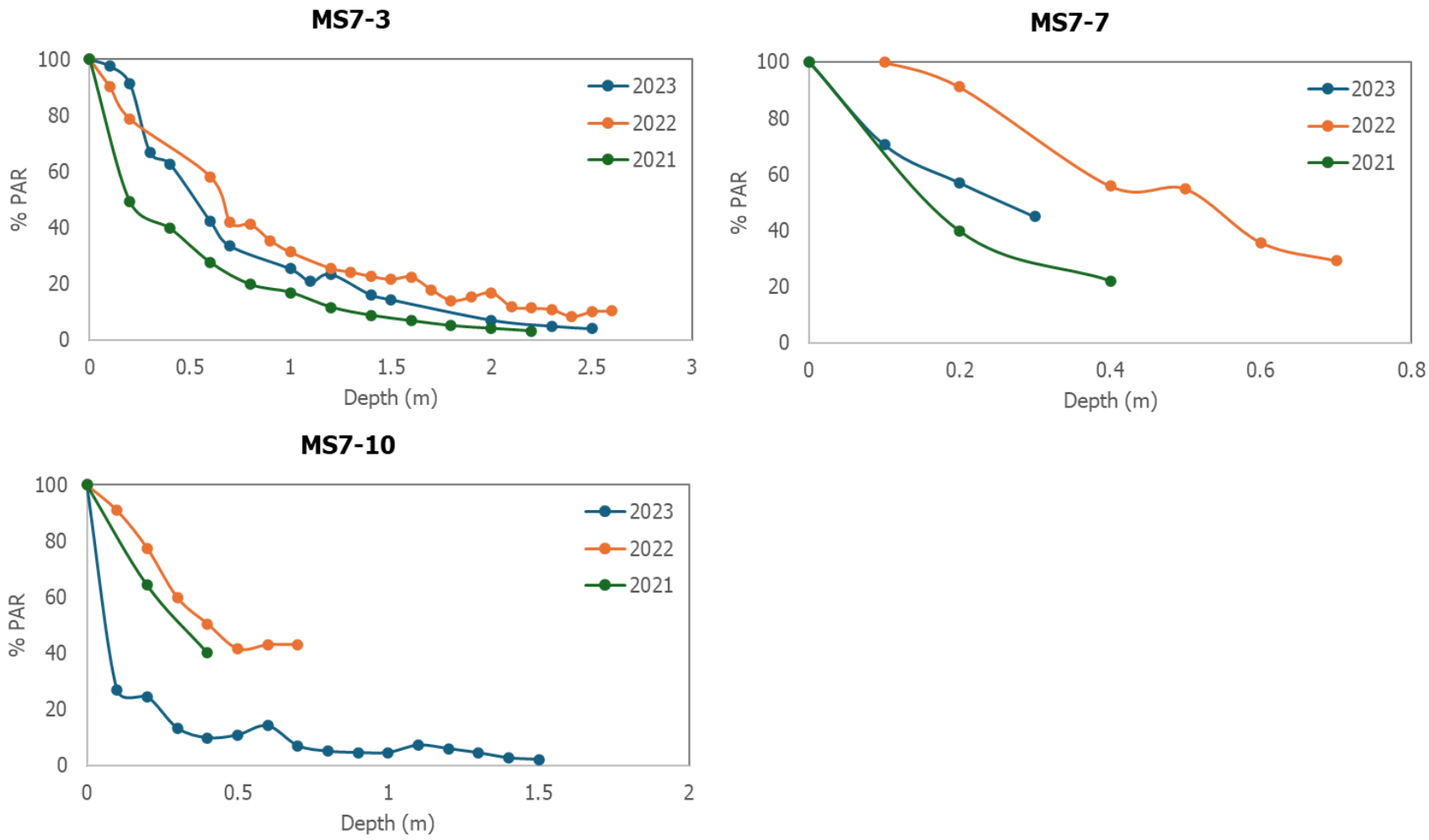



**Figure 8:** **The percent of photosynthetically active radiation (PAR) extinction with depth at three sites in the Keeyask reservoir, backbay Zone 7 (MS7), measured with a LI-1400 data logger (LI-COR), 2021-2023.**

## 4.2.8 KEEYASK RESERVOIR BACKBAY ZONE 8 (MS8)

### 4.2.8.1 2023 SAMPLING

Mean water surface elevation was 158.55 m at site MS8 on August 15, 2023 (Map 3; Table 3). Depth in the flooded terrestrial area ranged from 0.96–4.16 m. No existing (*i.e.*, pre-flooded) shorelines were present as the entire site was located within a flooded area.

Substrates were collected at nine sites (Table 26). Because the area was located within a flooded bay, the substrate at each site was composed of organic matter including detritus and loose, broken-down plant matter. The acoustic classification model indicated that the area was dominated by organic (47%), silt/clay (21%), and sand (13%) substrates (Table 5). PSA analysis was conducted at three sites that were composed of silt loam and heavy clay (Table 27).

Aquatic plants were observed at seven sampling sites, which ranged in depth from 0.1–1.9 m (Table A1-8). Nine aquatic plant species were observed. Bladderwort and Watermilfoil were the most abundant and were each present at six of seven sites. Star duckweed, Canada Waterweed, Water nymph, Hornwort (*Ceratophyllum* spp.), Flat-stemmed pondweed (*Potamogeton zosteriformis*), Whitewater buttercup (*Ranunculus aquatilis*), and Water knotweed (*Persicaria amphibia;* Photo 21) were also present and found in sparse abundance.

**Photo 21: Water knotweed collected from the Keeyask reservoir backbay Zone 8 (MS8) in 2023.**

**Table 26: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir, backbay Zone 8 (MS8), 2023.**

| 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 | % | | |
| MS8-3 | petite Ponar | 19-Aug | 353709 | 6249328 | 0.2 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS8-4 | petite Ponar | 19-Aug | 353958 | 6249289 | 1.9 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS8-5 | petite Ponar | 19-Aug | 353445 | 6249414 | 0.6 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS8-6 | petite Ponar | 19-Aug | 353752 | 6249367 | 1.9 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS8-7 | petite Ponar | 19-Aug | 353314 | 6249502 | 0.1 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS8-16A | petite Ponar | 19-Aug | 353869 | 6249380 | 1.4 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS8-17A | petite Ponar | 19-Aug | 353968 | 6249113 | 0.7 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS8-19A | petite Ponar | 19-Aug | 353641 | 6249399 | 0.1 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS8-20A | petite Ponar | 19-Aug | 353373 | 6249510 | 0.7 | soft | organic | 100 | - | - | - | - | organic | organic |

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

**Table 27: Results of particle size analysis (conducted at ALS Laboratories) from samples collected from the Keeyask reservoir backbay Zone 8 (MS8), 2023.**

| Area Name | Date | Area Code | Habitat | Field Site No. | Inorganic Carbon (%) | CaCO3 Equivalent | Total Carbon by Combustion (%) | Total Organic Carbon (%) | % Sand (2.0-0.05 mm) | % Silt (0.05-2µm) | % Clay (<2 µm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keeyask Reservoir | 19-Aug-2023 | MS8 | nearshore | MS8-4 | 0.589 | 4.91 | 38.7 | 38.1 | 2.9 | 21.8 | 75.3 | Heavy Clay |
| Keeyask Reservoir | 19-Aug-2023 | MS8 | nearshore | MS8-6 | 4.52 | 37.7 | 30.2 | 25.7 | <1.0 | 85.6 | 13.7 | Silt Loam |
| Keeyask Reservoir | 19-Aug-2023 | MS8 | nearshore | MS8-7 | 0.619 | 5.16 | 39.7 | 39.1 | 4.5 | 74.0 | 21.5 | Silt Loam |

### 4.2.8.2 2021-2023 SUMMARY

Sampling area MS8 is located within the flooded reservoir backbay Zone 8 (maps 2 and 4). Prior to impoundment, much of Zone 8 was terrestrial habitat, with a small central creek (named Effie Creek) leading to an inland pond. Sampling was conducted largely within the flooded portion of Zone 8 that was terrestrial prior to reservoir impoundment, although some sampling sites were located within the former Effie Creek (Photo 22). As such, organic substrate composed of detritus and loose, broken-down plant matter was predominant in all three years (Map 31). Substrate mapping in 2023 showed that approximately 32% of the sampling area was comprised of organic substrate, while only 3% contained mud; however, 63% of the study area could not be mapped due to shallow depths and the presence of floating peat (Table 28).

The abundance and diversity of aquatic macrophytes in MS8 has increased over the first three years following reservoir impoundment and the number of rooted aquatic macrophytes has increased (Map 32). Two plant species were observed at four sites in 2021, including one species of terrestrial plant (Smartweed) and one species of non-rooted aquatic plant (Bladderwort). No rooted aquatic macrophytes were observed. In 2022, six plant species were identified at seven sampling sites, including two terrestrial species (Smartweed and Horsetail) and three aquatic plant species (Bladderwort, Watermilfoil, and Star duckweed). One species of rooted aquatic macrophyte (Watermilfoil) was observed. In 2023, nine plant species were collected from seven sites, including one terrestrial plant (Smartweed) and eight aquatic plant species (Table A1-8). Five species of rooted aquatic macrophytes were also present (Canada waterweed, Flat-stemmed pondweed, Watermilfoil, Water nymph, and Whitewater buttercup).

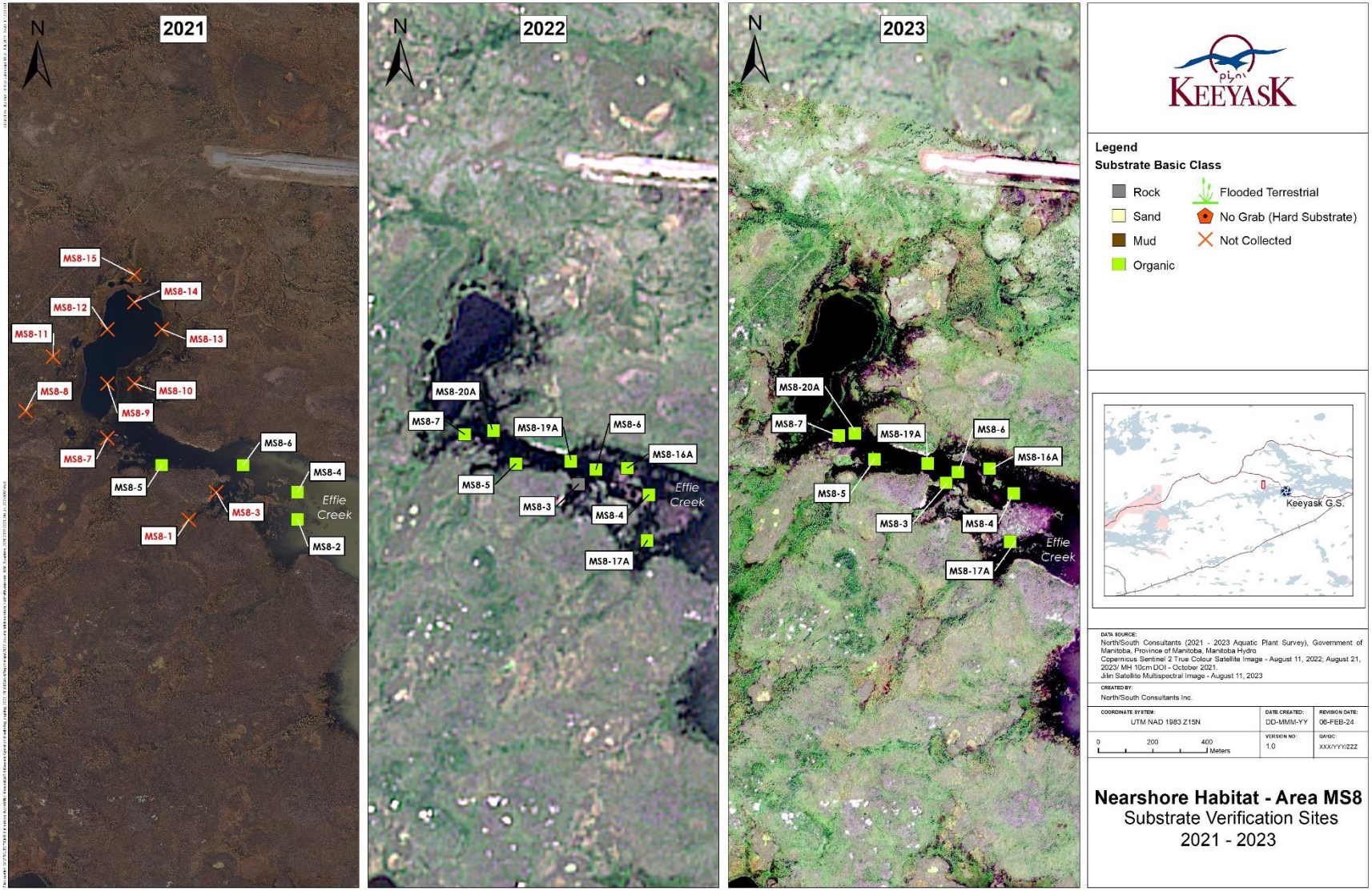
In the third year following reservoir impoundment, plant beds were present throughout much of MS8, occupying approximately 42% of the study area (Map 33; Photo 23). Plant beds were largely limited to the shallower areas along the shore measuring less than 2.5 m in depth, although some beds were found in deeper areas. Light extinction was measured at two sites greater than 2 m deep and only between <1% and 3% of surface light was present at 2 m of depth (Figure 9). Between 5 and 35% of surface light was present at 1 m of depth.

**Table 28: Total area occupied by each substrate type as measured by acoustic surveys in the Keeyask reservoir flooded backbay Zone 8 (MS8), 2023.**

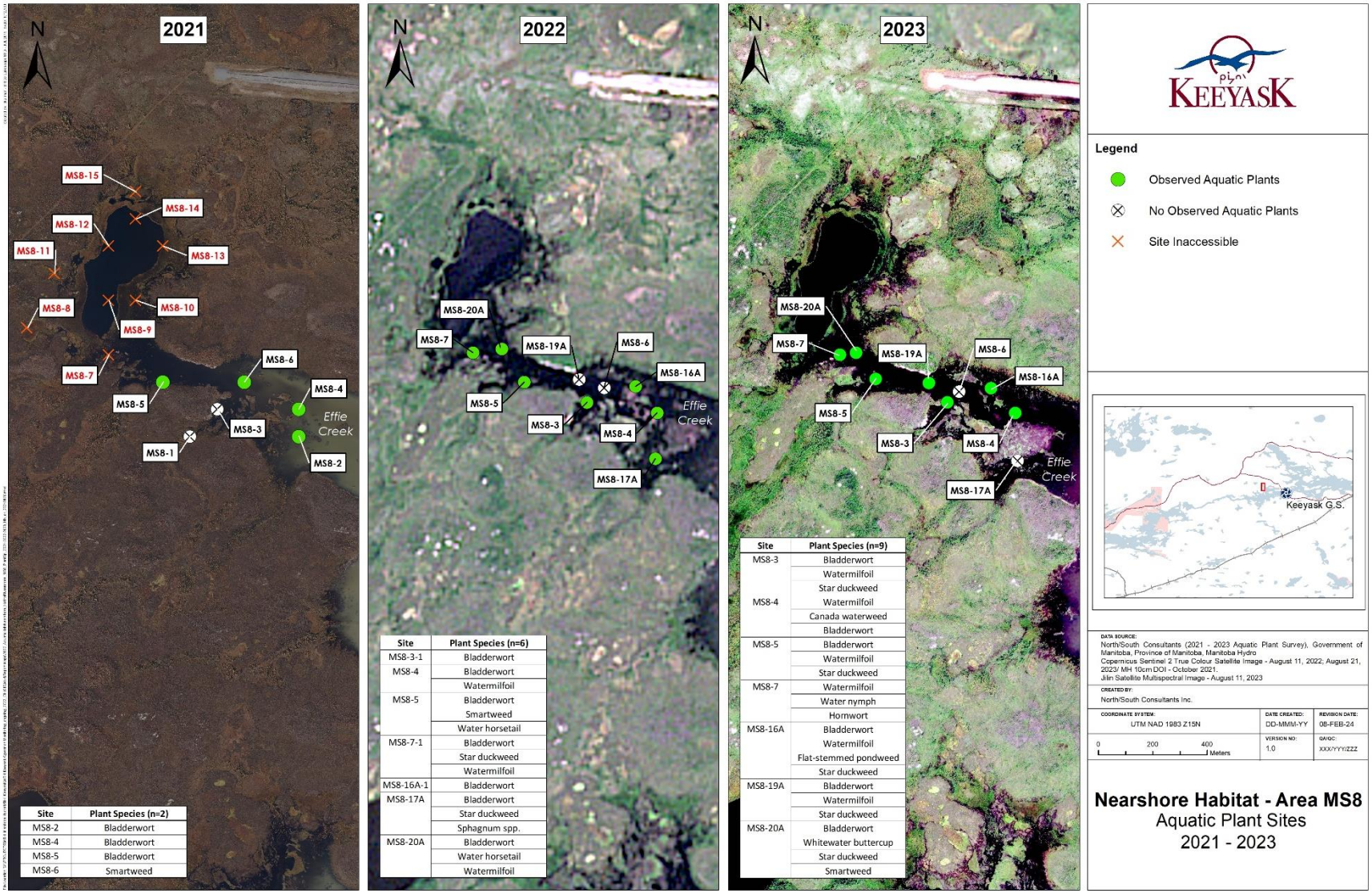
| MS8 | Area ($m^2$) | % of Total Area |
|---|---|---|
| Organic | 77,072 | 32 |
| Mud | 7,151 | 3 |
| Silty Sand | 4,569 | 2 |
| Sand | 650 | 0 |
| Rock | 0 | 0 |
| No Data | 153,439 | 63 |
| **Sum** | **242,881** | **100** |

**Photo 22: Flooded terrestrial habitat within the Keeyask reservoir backbay Zone 8 (MS8) in 2023.**

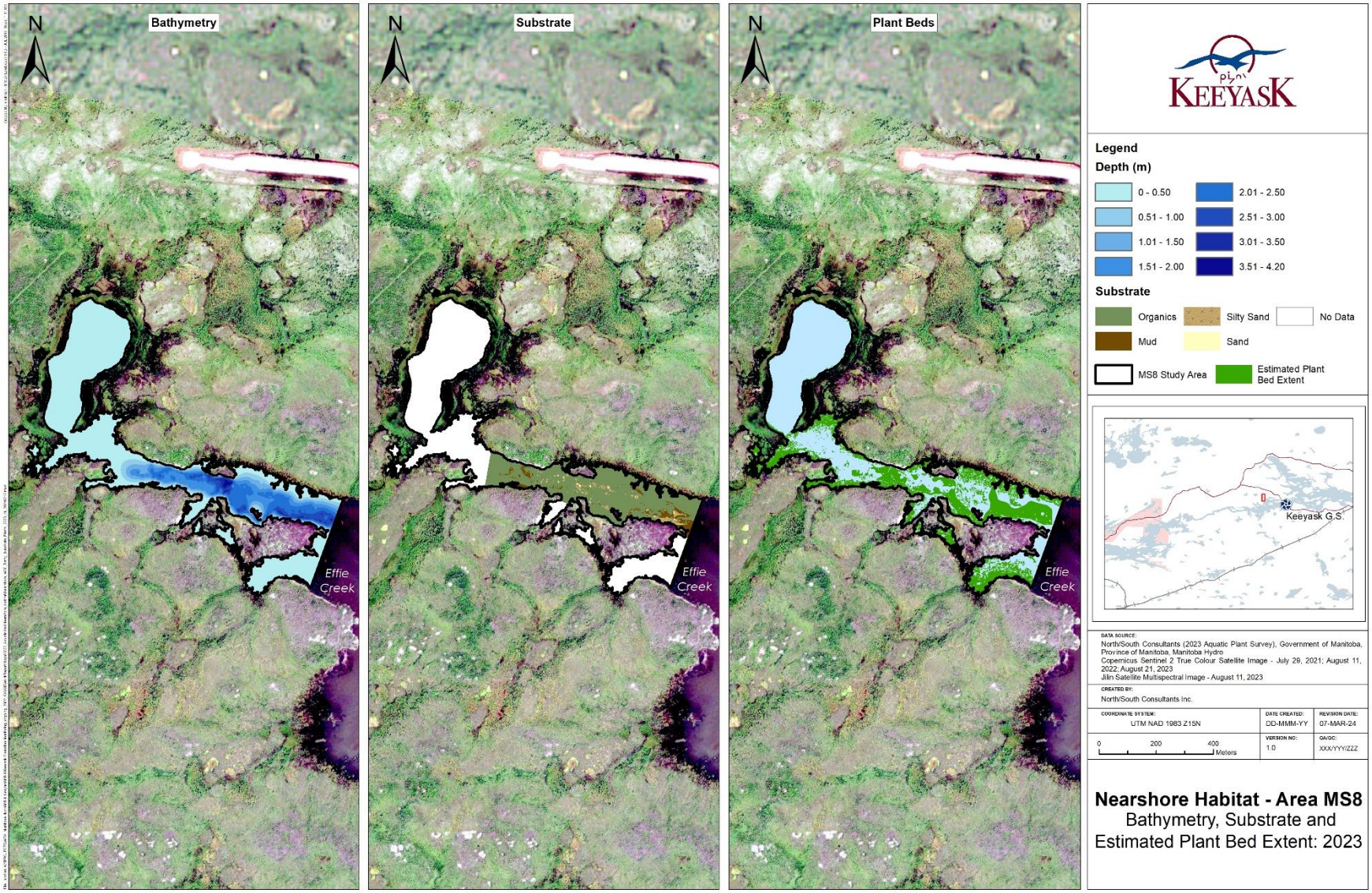
**Photo 23: Aquatic macrophyte beds observed in the Keeyask reservoir backbay Zone 8 (MS8) in 2023.**




**Map 31: Basic substrate class results of sediment grabs taken at sampling sites in the Keeyask reservoir, backbay Zone 8 (MS8), August 2021-2023.**




**Map 32: Macrophytes collected from the Keeyask reservoir in backbay Zone 8 (MS8) over three sampling years, August 2021-2023.**




**Map 33: Bathymetry, substrate, and plant beds in the Keeyask reservoir backbay Zone 8 (MS8) in the third year (*i.e.,* 2023) following impoundment of the Keeyask reservoir.**

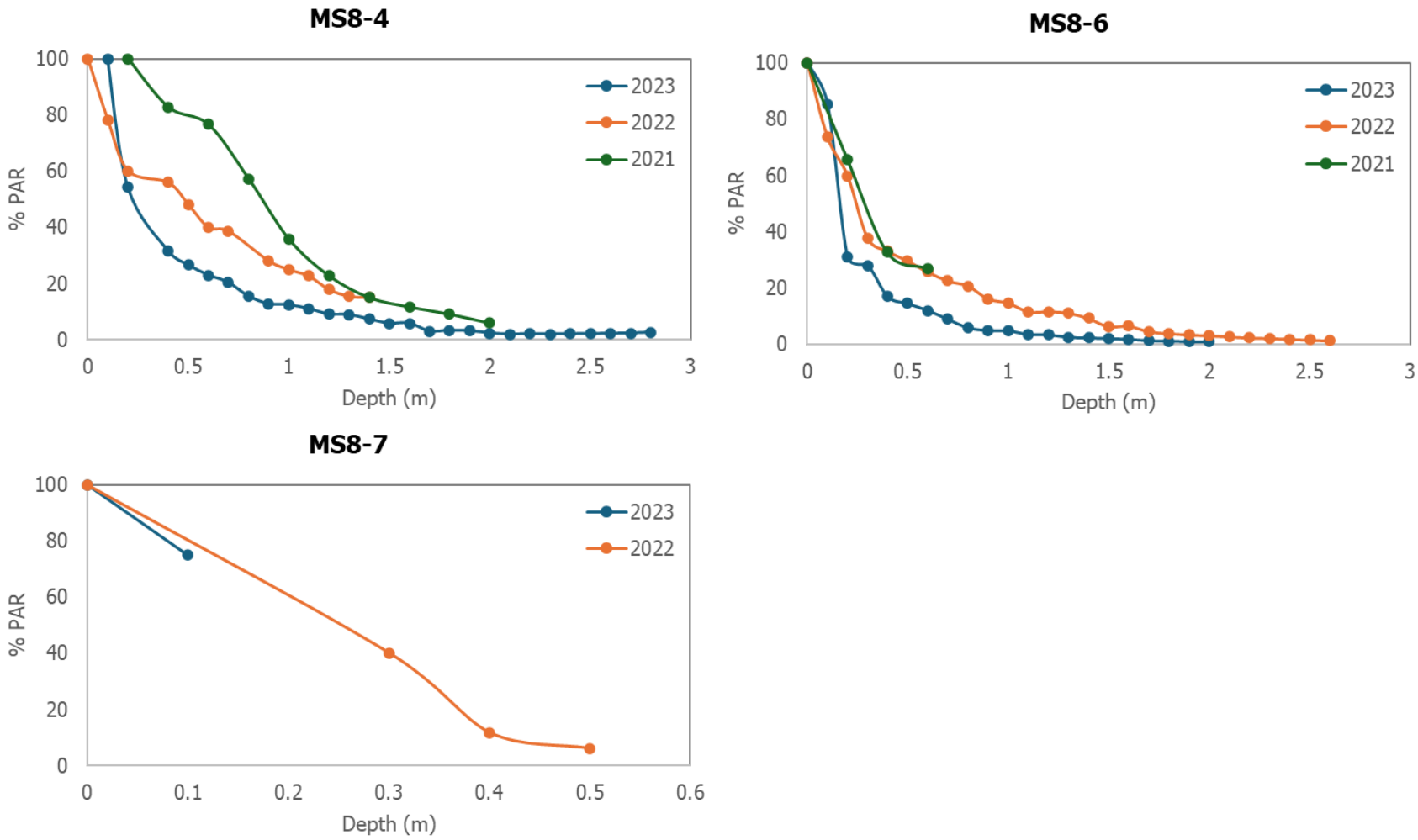



**Figure 9:** **The percent of photosynthetically active radiation (PAR) extinction with depth at three sites in the Keeyask reservoir, backbay Zone 8 (MS8), measured with a LI-1400 data logger (LI-COR), 2021-2023.**

# 4.2.9 LOWER GULL LAKE (MS9)

## 4.2.9.1 2023 SAMPLING

Mean water surface elevation was 158.57 m at site MS9 on August 19, 2023 (Map 3; Table 3). Depth in flooded, previously terrestrial areas ranged from 0.96–5.81 m. Depth in the pre-impoundment shoreline ranged from 3.68–9.0 m.

Substrate was collected 21 of 22 sites (Table 29). Most sites were classified as organic substrates including detritus and loose, broken-down plant matter, but clay and silt were also present. The acoustic classification model indicated that the area was dominated by soft substrates including organic (29%) and silt/clay (25%). Rocky substrates including gravel/sand, sand, and silt/sand were also present comprising 18%, 15%, and 14%, respectively (Table 5). PSA analysis was conducted at three sites which were classified as silt and silt loam (Table 30).

Star duckweed was the only aquatic plant species observed and was present only at a single site (Table A1-9; Photo 24).

**Photo 24: Small amounts of Star duckweed collected from the Keeyask reservoir in lower Gull Lake (MS9) in 2023.**

**Table 29: Locations and results of substrate grab type validation sampling and post-survey class verification in the Keeyask reservoir in lower Gull Lake (MS9), 2023.**

| 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 | % | | |
| MS9-1 | petite Ponar | 16-Aug | 359295 | 6246600 | 5.2 | soft | organic | 50 | clay | 50 | - | - | organic | organic/clay |
| MS9-2 | petite Ponar | 16-Aug | 360062 | 6246752 | 4.2 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS9-3 | petite Ponar | 16-Aug | 360545 | 6246801 | 4.2 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS9-4 | petite Ponar | 16-Aug | 359004 | 6246756 | 3.3 | soft | clay | 100 | - | - | - | - | mud | clay |
| MS9-5 | petite Ponar | 16-Aug | 359184 | 6246978 | 2.7 | moderate | organic | 80 | clay | 10 | silt | 10 | organic | organic/clay/silt |
| MS9-6 | petite Ponar | 16-Aug | 360643 | 6246966 | 4.2 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS9-7 | petite Ponar | 16-Aug | 359848 | 6247073 | 3.3 | moderate | organic | 100 | - | - | - | - | organic | organic |
| MS9-8 | petite Ponar | 16-Aug | 360154 | 6247272 | 2.8 | moderate | organic | 100 | - | - | - | - | organic | organic |
| MS9-9 | petite Ponar | 16-Aug | 358291 | 6247502 | 6.4 | soft | clay | 80 | silt | 20 | - | - | mud | clay/silt |
| MS9-10 | petite Ponar | 16-Aug | 358091 | 6247900 | 2.2 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS9-11 | petite Ponar | 16-Aug | 358461 | 6247874 | 2.1 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS9-12 | petite Ponar | 16-Aug | 358217 | 6248169 | 4.9 | soft | organic | 50 | clay | 50 | - | - | organic | organic/clay |
| MS9-13 | petite Ponar | 16-Aug | 358850 | 6248170 | 3.2 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS9-14 | petite Ponar | 16-Aug | 359354 | 6248168 | 5.6 | moderate | - | - | - | - | - | - | - | - |
| MS9-15 | petite Ponar | 16-Aug | 359639 | 6248231 | 4 | soft | organic | 80 | clay | 20 | - | - | organic | organic/clay |
| MS9-16 | petite Ponar | 16-Aug | 359501 | 6246931 | 2.4 | moderate | organic | 80 | clay | 20 | - | - | organic | organic/clay |
| MS9-17 | petite Ponar | 16-Aug | 359823 | 6246890 | 4 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS9-18 | petite Ponar | 16-Aug | 360257 | 6247009 | 5.5 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS9-19 | petite Ponar | 16-Aug | 358781 | 6247083 | 1.9 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS9-20 | petite Ponar | 16-Aug | 358358 | 6247518 | 5.7 | soft | organic | 50 | clay | 50 | - | - | organic | organic/clay |
| MS9-21 | petite Ponar | 16-Aug | 358305 | 6247757 | 3.2 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS9-22 | petite Ponar | 16-Aug | 358621 | 6248043 | 3.4 | soft | organic | 100 | - | - | - | - | organic | organic |

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

**Table 30: Results of particle size analysis (conducted at ALS Laboratories) from samples collected from the Keeyask reservoir in lower Gull Lake (MS9), 2023.**

| Area Name | Date | Area Code | Habitat | Field Site No. | Inorganic Carbon (%) | CaCO3 Equivalent | Total Carbon by Combustion (%) | Total Organic Carbon (%) | % Sand (2.0-0.05 mm) | % Silt (0.05-2µm) | % Clay (<2 µm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keeyask Reservoir | 16-Aug-2023 | MS9 | nearshore | MS9-9 | 1.87 | 15.6 | 4.64 | 2.77 | 19.7 | 73.1 | 7.2 | Silt Loam |
| Keeyask Reservoir | 16-Aug-2023 | MS9 | nearshore | MS9-11 | 0.834 | 6.95 | 36.8 | 36.0 | 6.7 | 82.2 | 11.0 | Silt |
| Keeyask Reservoir | 16-Aug-2023 | MS9 | nearshore | MS9-15 | 0.452 | 3.76 | 35.4 | 34.9 | <1.0 | 88.3 | 11.1 | Silt |

### 4.2.9.2 2021-2023 SUMMARY

Sampling area MS9 is located entirely within a previously terrestrial area on the north shore within lower Gull Lake (Map 2). Large amounts of flooded terrestrial habitat and peat were present in 2023 (Photo 25). As such, most sites were classified as organic substrates including detritus and loose, broken-down plant matter in all three years (Map 34). A single site (MS9-9) in 2021 was classified as sand and silt. In 2023, 19 sites were classified as organic, and MS9-9 was classified as mud (*i.e.,* clay and silt). Substrate mapping in 2023 showed that only 6% of the sampling area was comprised of organic substrate, while 22% contained mud; however, 35% of the study area could not be mapped due to the presence of floating peat islands (Table 31).

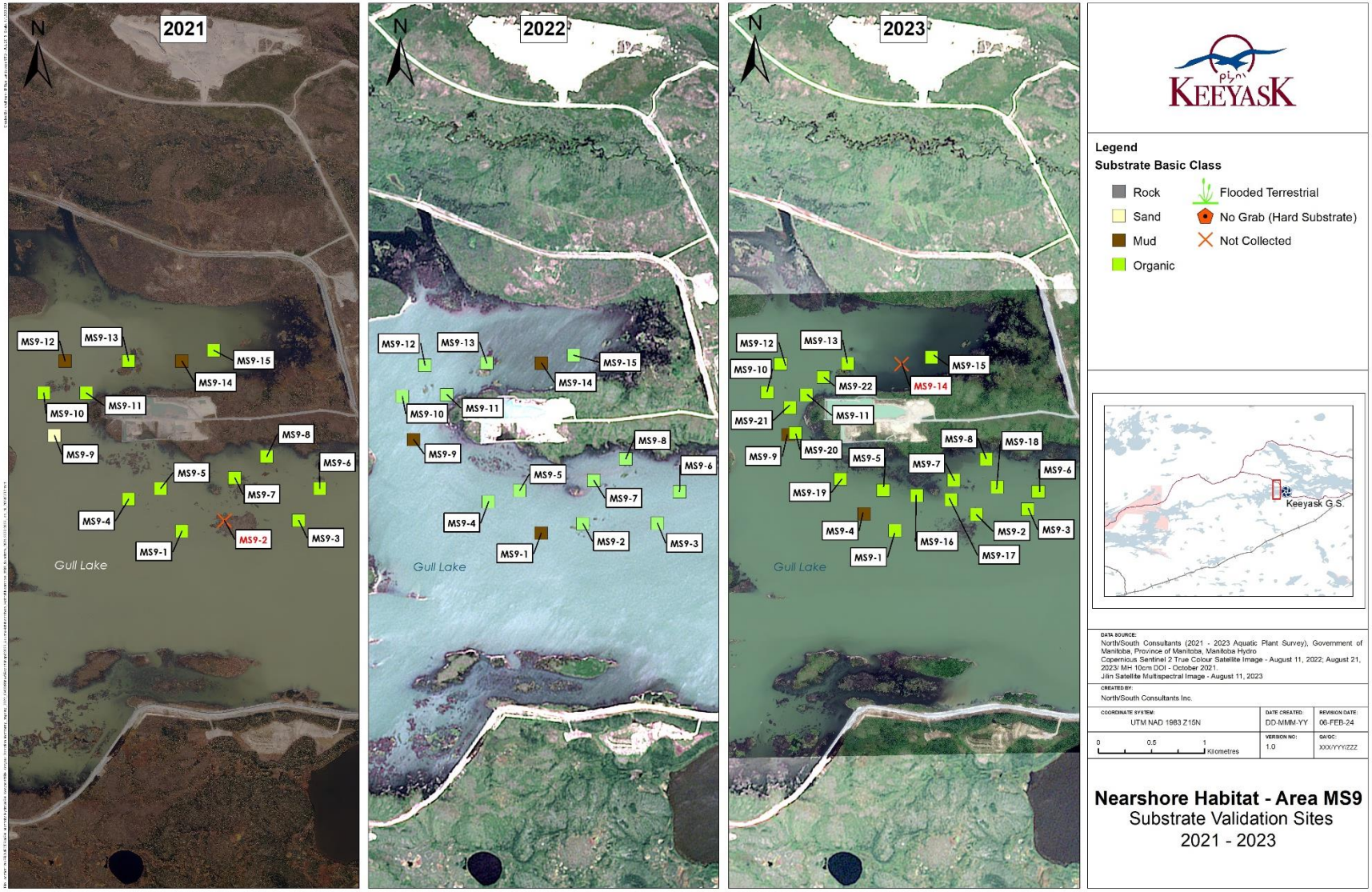
No plant species were observed in this area in 2021 or 2022. A single species of free-floating aquatic plant (Star duckweed) was found at a single site in 2023 (Map 35; Table A1-9).

Although mapping (*i.e*. boat-based acoustic plant detection) suggests that 27% of this area is covered with aquatic macrophyte beds, these are areas of algae and peat rather than established aquatic macrophytes (Map 36). Light extinction sampling suggests that little light (between 4 and 7% of surface) penetrates to 2 m of depth; this was consistent in all three sampling years (Figure 10). Between 15 and 23% of surface light was present at 1 m of depth.

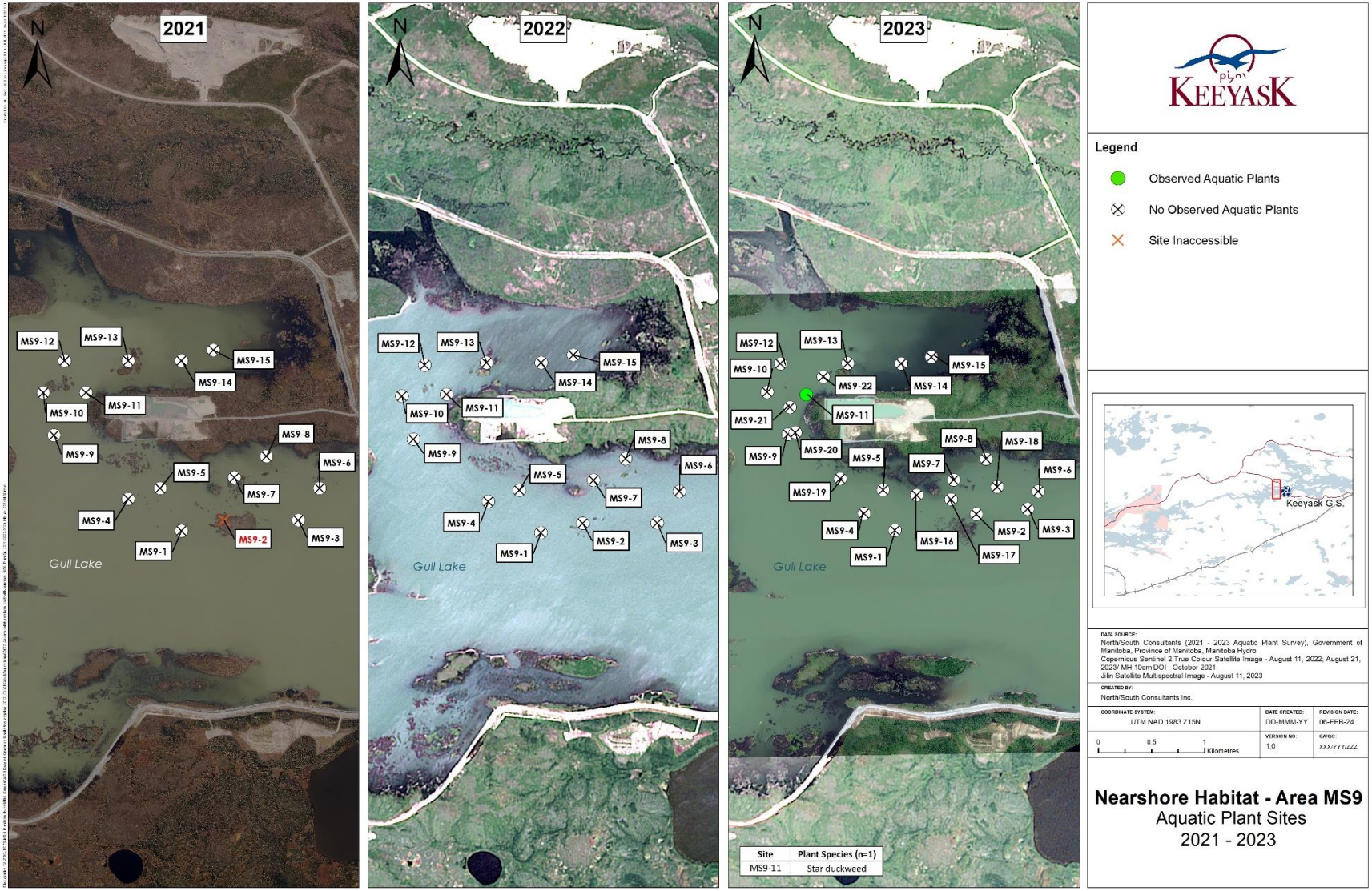
**Table 31: Total area occupied by each substrate type as measured by acoustic surveys in the Keeyask reservoir in lower Gull Lake (MS9), 2023.**

| MS9 | Area ($m^2$) | % of Total Area |
|---|---|---|
| Organic | 303,979 | 6 |
| Mud | 1,050,672 | 22 |
| Silty Sand | 965,382 | 20 |
| Sand | 513,736 | 11 |
| Rock | 270,200 | 6 |
| No Data | 1,683,646 | 35 |
| **Sum** | **4,787,615** | **100** |

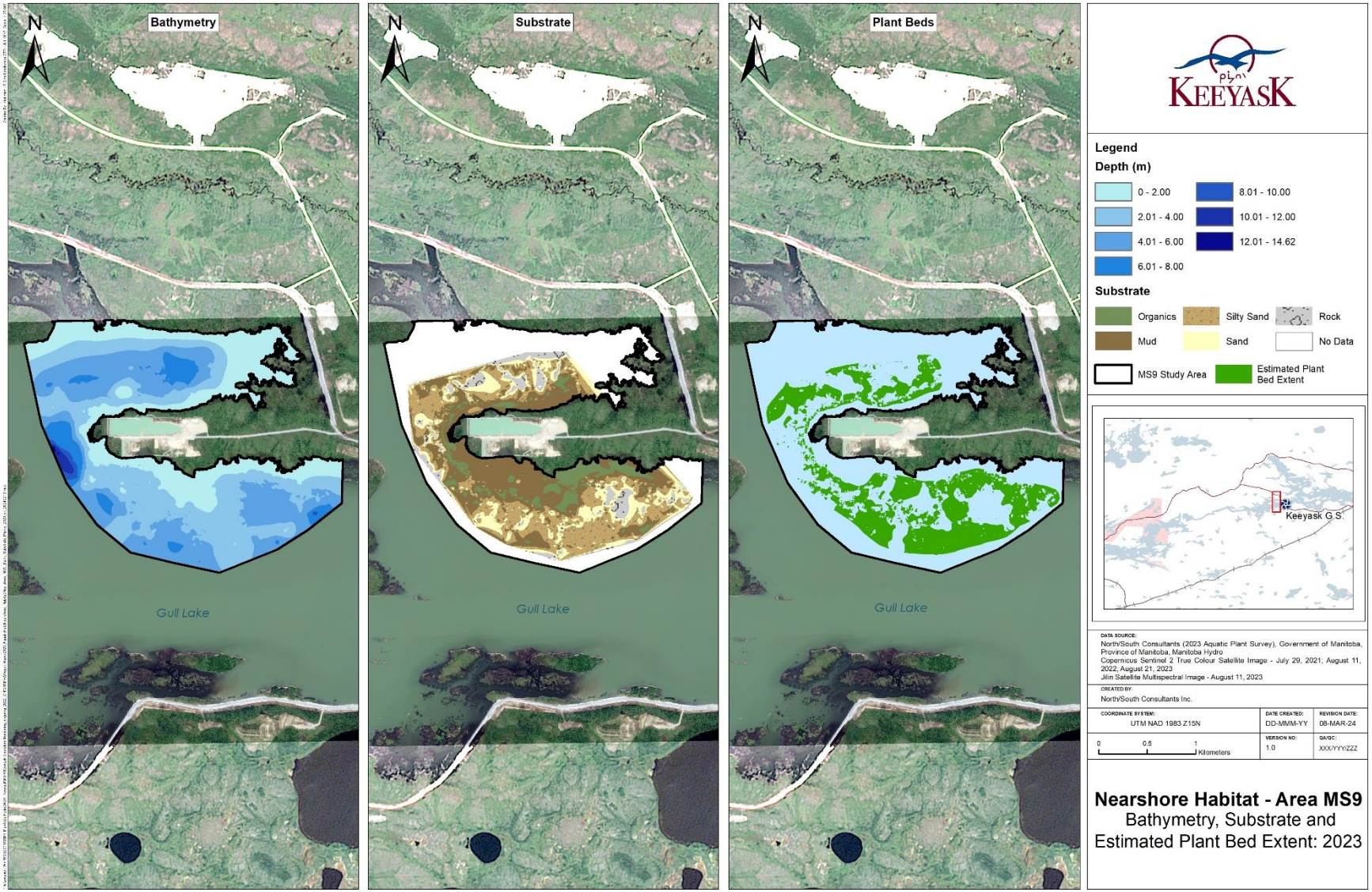
**Photo 25: Large amounts of flooded terrestrial habitat including peat in the Keeyask reservoir in lower Gull Lake (MS9) in 2023.**




**Map 34: Basic substrate class results of sediment grabs taken at sampling sites in the lower Keeyask reservoir (MS9), August 2021-2023.**




**Map 35: Macrophytes collected from the lower Keeyask reservoir (MS9) over three sampling years, August 2021-2023.**




**Map 36: Bathymetry, substrate, and plant beds in the lower Keeyask reservoir (MS9) in the third year (*i.e.,* 2023) following impoundment of the Keeyask reservoir.**

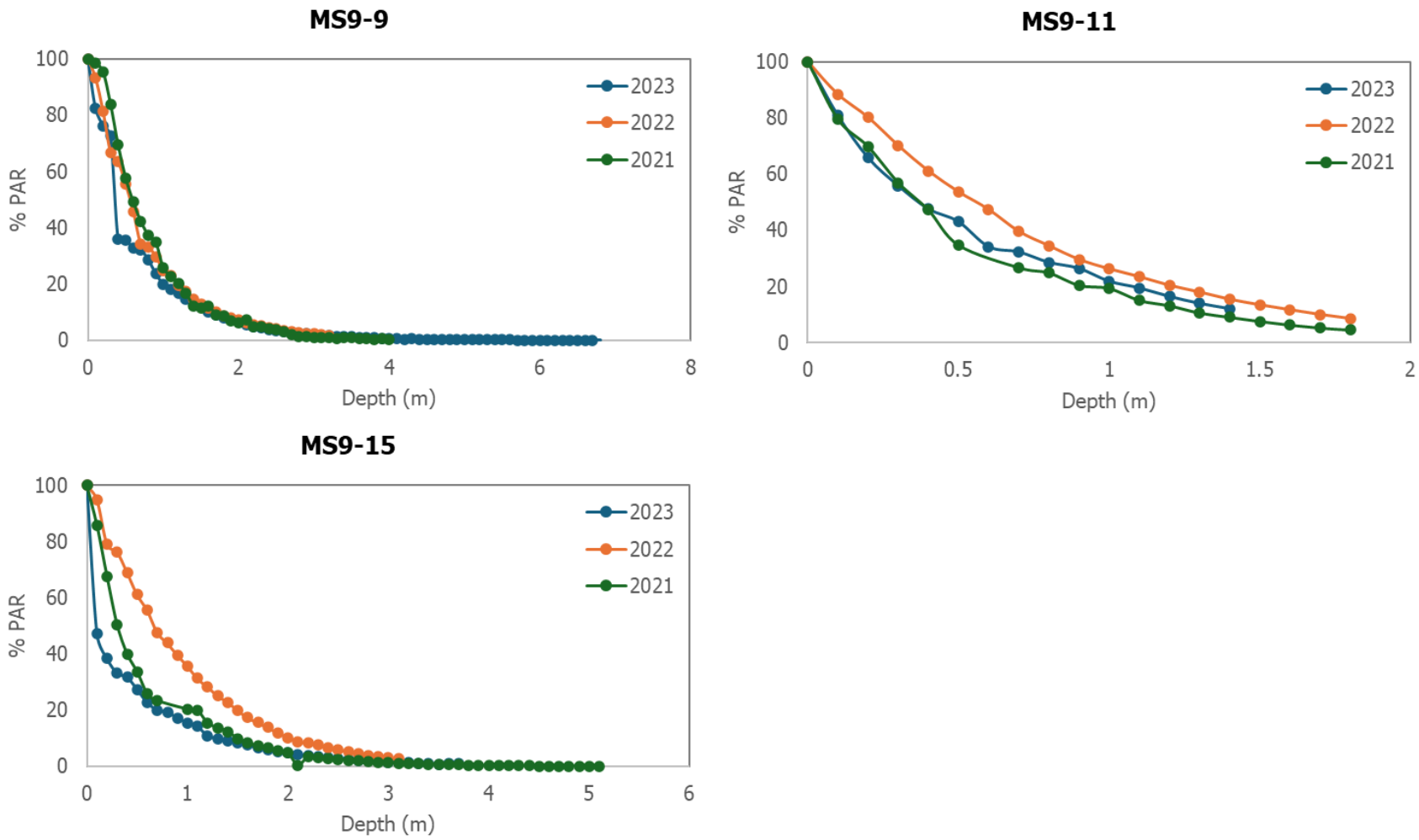



**Figure 10: The percent of photosynthetically active radiation (PAR) extinction with depth at three sites in the lower Keeyask reservoir (MS9), measured with a LI-1400 data logger (LI-COR), 2021-2023.**

# 4.2.10 STEPHENS LAKE (MS10)

## 4.2.10.1 2023 SAMPLING

Mean water surface elevation was 140.44 m at site MS10 on August 20, 2023 (Map 3; Table 3). Depth in the sampling area ranged from 1.14–8.77 m.

Substrate was collected at 15 sites (Table 32). Substrate at most sites was comprised of mud (*i.e.,* clay and silt) and sand. The acoustic classification model indicated that the area was dominated by soft substrates including organic (58%) and silt/clay (18%), whereas 15% of the area was comprised of gravel/sand (Table 5). PSA analysis was conducted at three sites which were classified as loamy sand, silt, and silt loam (Table 33). Silty sand and sand were located at the deepest areas in this nearshore habitat area.

Aquatic plant species were observed at six sites ranging in depth from 0.5–1.9 m (Table A1-10). Four species of rooted aquatic macrophytes were present including Richardson pondweed, Sago pondweed (Photo 26), *Stuckenia* spp., and Whitewater buttercup. Plant density ranged from abundant to sparse.

**Photo 26: Sago pondweed collected from Stephens Lake (MS10) in 2023.**

**Table 32: Locations and results of substrate grab type validation sampling and post-survey class verification in Stephens Lake (MS10), 2023.**

| 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 | % | | |
| MS10-1 | petite Ponar | 21-Aug | 367647 | 6249775 | 0.3 | moderate | clay | 50 | sand | 50 | - | - | mud | clay/sand |
| MS10-2 | petite Ponar | 21-Aug | 367453 | 6249901 | 0.9 | soft | clay | 80 | silt | 20 | - | - | mud | clay/silt |
| MS10-3 | petite Ponar | 21-Aug | 367748 | 6249826 | 1.7 | moderate | clay | 80 | sand | 20 | - | - | mud | clay/sand |
| MS10-4 | petite Ponar | 21-Aug | 367454 | 6250067 | 1.9 | moderate | clay | 50 | sand | 50 | - | - | mud | clay/sand |
| MS10-5 | petite Ponar | 20-Aug | 367158 | 6250183 | 0.5 | soft | sand | 100 | - | - | - | - | sand | sand |
| MS10-6 | petite Ponar | 20-Aug | 367371 | 6250171 | 1.7 | moderate | clay | 50 | sand | 50 | - | - | mud | clay/sand |
| MS10-7 | petite Ponar | 21-Aug | 367568 | 6250166 | 2.1 | moderate | clay | 80 | silt | 10 | gravel | 10 | mud | clay/silt/gravel |
| MS10-8 | petite Ponar | 20-Aug | 367153 | 6250276 | 0.6 | soft | sand | 100 | - | - | - | - | sand | sand |
| MS10-9 | petite Ponar | 21-Aug | 367134 | 6250331 | 0.6 | soft | sand | 90 | organic | 10 | - | - | sand | sand/organic |
| MS10-10 | petite Ponar | 21-Aug | 367459 | 6250366 | 2.9 | moderate | clay | 90 | sand | 10 | - | - | mud | clay/sand |
| MS10-11 | petite Ponar | 20-Aug | 367252 | 6250468 | 1.2 | moderate | clay | 70 | sand | 20 | organic | 10 | mud | clay/sand/organic |
| MS10-12 | petite Ponar | 21-Aug | 367866 | 6250463 | 7.8 | soft | clay | 50 | silt | 25 | sand | 25 | mud | clay/silt/sand |
| MS10-13 | petite Ponar | 21-Aug | 367450 | 6250674 | 2.2 | moderate | clay | 70 | organic | 20 | silt | 10 | mud | clay/organic/silt |
| MS10-14 | petite Ponar | 21-Aug | 367749 | 6250867 | 3.5 | moderate | clay | 75 | silt | 20 | organic | 5 | mud | clay/silt/organic |
| MS10-15 | petite Ponar | 21-Aug | 367396 | 6250874 | 0.9 | moderate | clay | 60 | silt | 30 | organic | 10 | mud | clay/silt/organic |

1 – Class verified with sidescan imagery post-survey.

**Table 33: Results of particle size analysis (conducted at ALS Laboratories) from samples collected from Stephens Lake (MS10), 2023.**

| Area Name | Date | Area Code | Habitat | Field Site No. | Inorganic Carbon (%) | CaCO3 Equivalent | Total Carbon by Combustion (%) | Total Organic Carbon (%) | % Sand (2.0-0.05 mm) | % Silt (0.05-2µm) | % Clay (<2 µm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stephens Lake | 20-Aug-2023 | MS10 | nearshore | MS10-8 | 1.99 | 16.6 | 2.85 | 0.860 | 82.1 | 8.3 | 9.6 | Loamy Sand |
| Stephens Lake | 20-Aug-2023 | MS10 | nearshore | MS10-10 | 2.77 | 23.1 | 4.59 | 1.82 | 10.8 | 82.7 | 6.5 | Silt |
| Stephens Lake | 20-Aug-2023 | MS10 | nearshore | MS10-12 | 2.66 | 22.2 | 4.52 | 1.86 | 20.9 | 69.3 | 9.8 | Silt Loam |

### 4.2.10.2 2021-2023 SUMMARY

Sampling area MS10 is located approximately 6 km downstream of the Keeyask GS in an off-current area previously flooded by impoundment of the Kettle GS (completed in 1974; Map 2). Water levels in this area are generally controlled by operation of the Kettle GS, but extreme flow changes (*e.g.*, during commissioning in 2021) can also affect levels. In 2021, extremely low water levels made some sites closest to shore inaccessible. However, substrates changed little over the three sampling years, and were comprised of mud (*i.e.,* clay and silt) or sand (Map 37; Photo 27). Substrate mapping in 2023 showed that 43% of the sampling area was comprised of mud, while 17% contained silty sand (Table 34).

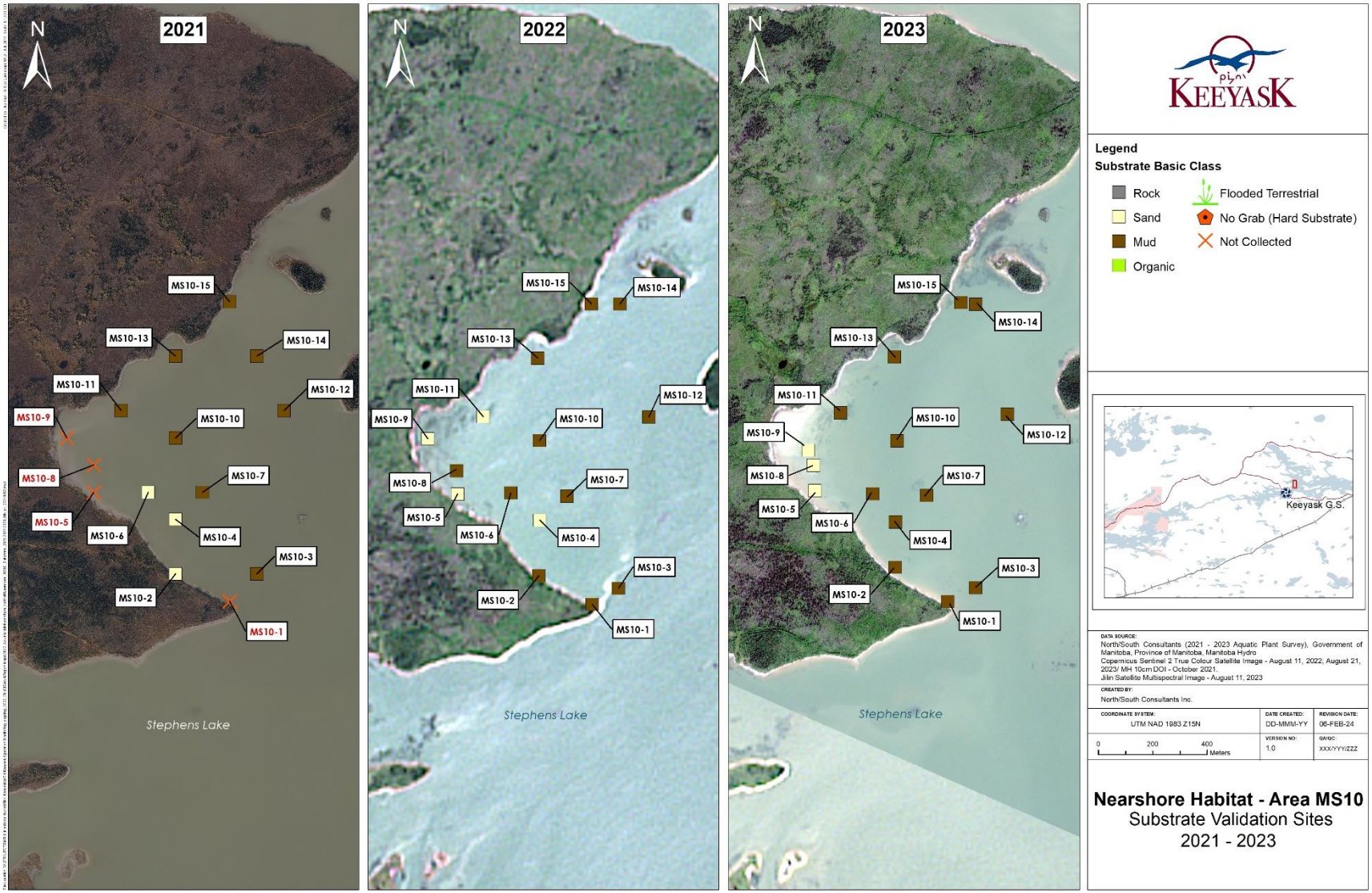
Changes in abundance and distribution of plants were observed over the three sampling years (Map 38). Water level fluctuations due to Keeyask GS powerhouse commissioning combined with low flows limited plant growth in 2021. Only two rooted aquatic plant species (Richardson and Sago pondweed) were identified at three sites. Water levels were more stable in 2022 and the same two rooted species and one free-floating species (Star duckweed) were observed at four sites. By 2023, six sites contained four species of rooted aquatic plants including Richardson and Sago pondweed, *Stuckenia* spp., and Whitewater buttercup (Map 38; Table A1-10).

In 2023 plant beds were present in 15% of the sampling area largely close to shore (Map 39). As in the Keeyask reservoir, light extinction sampling suggests that little light (between <1 and 10% of surface) penetrates to 2 m of depth, while between 13 and 54% of surface light was found at 1 m (Figure 11).

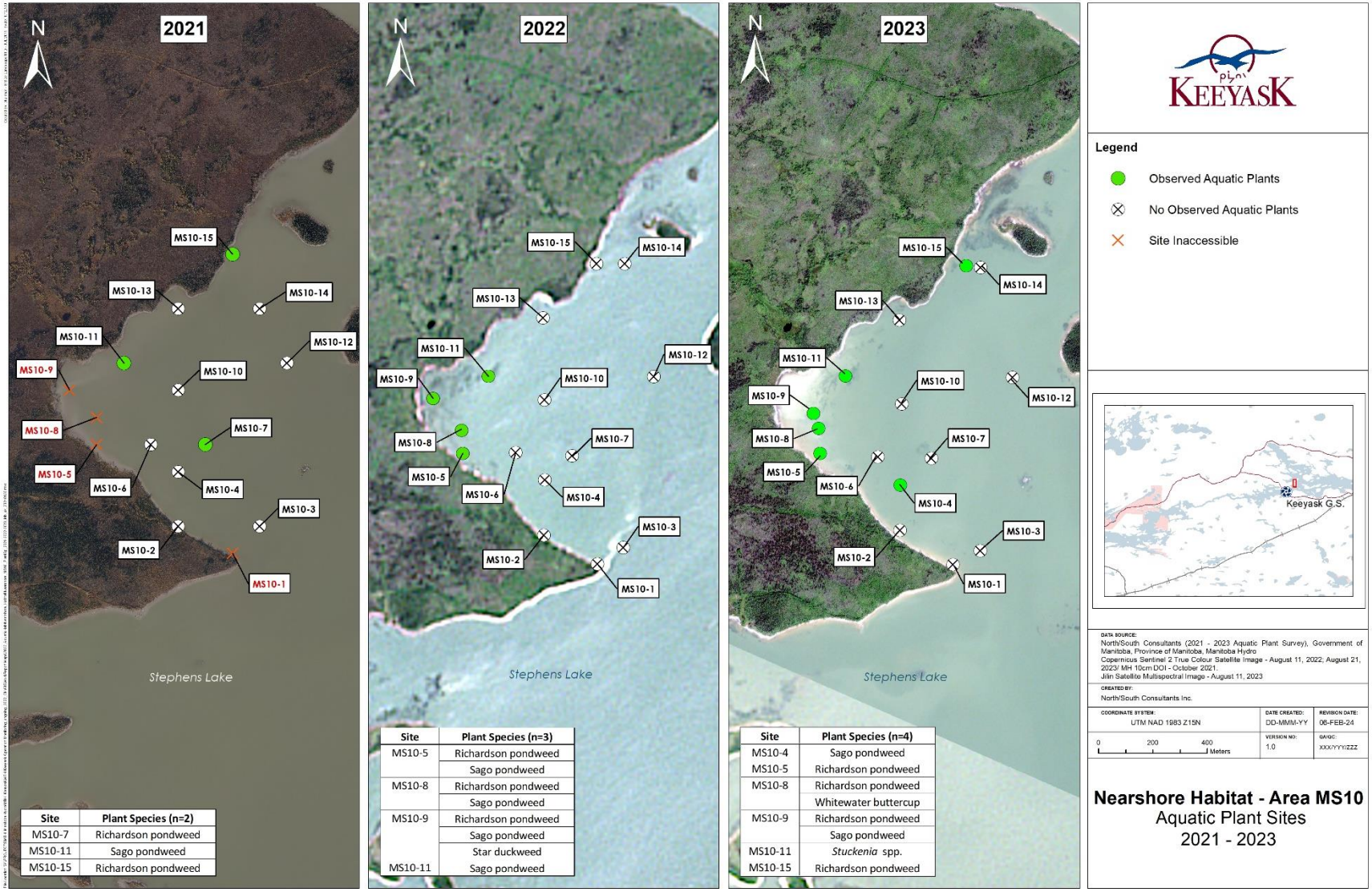
**Table 34: Total area occupied by each substrate type as measured by acoustic surveys in Stephens Lake (MS10), 2023.**

| MS10 | Area ($m^2$) | % of Total Area |
|---|---|---|
| Organic | 199,561 | 27 |
| Mud | 312,055 | 43 |
| Silty Sand | 124,659 | 17 |
| Sand | 20,525 | 3 |
| Rock | 125 | 0 |
| No Data | 76,195 | 10 |
| **Sum** | **733,120** | **100** |

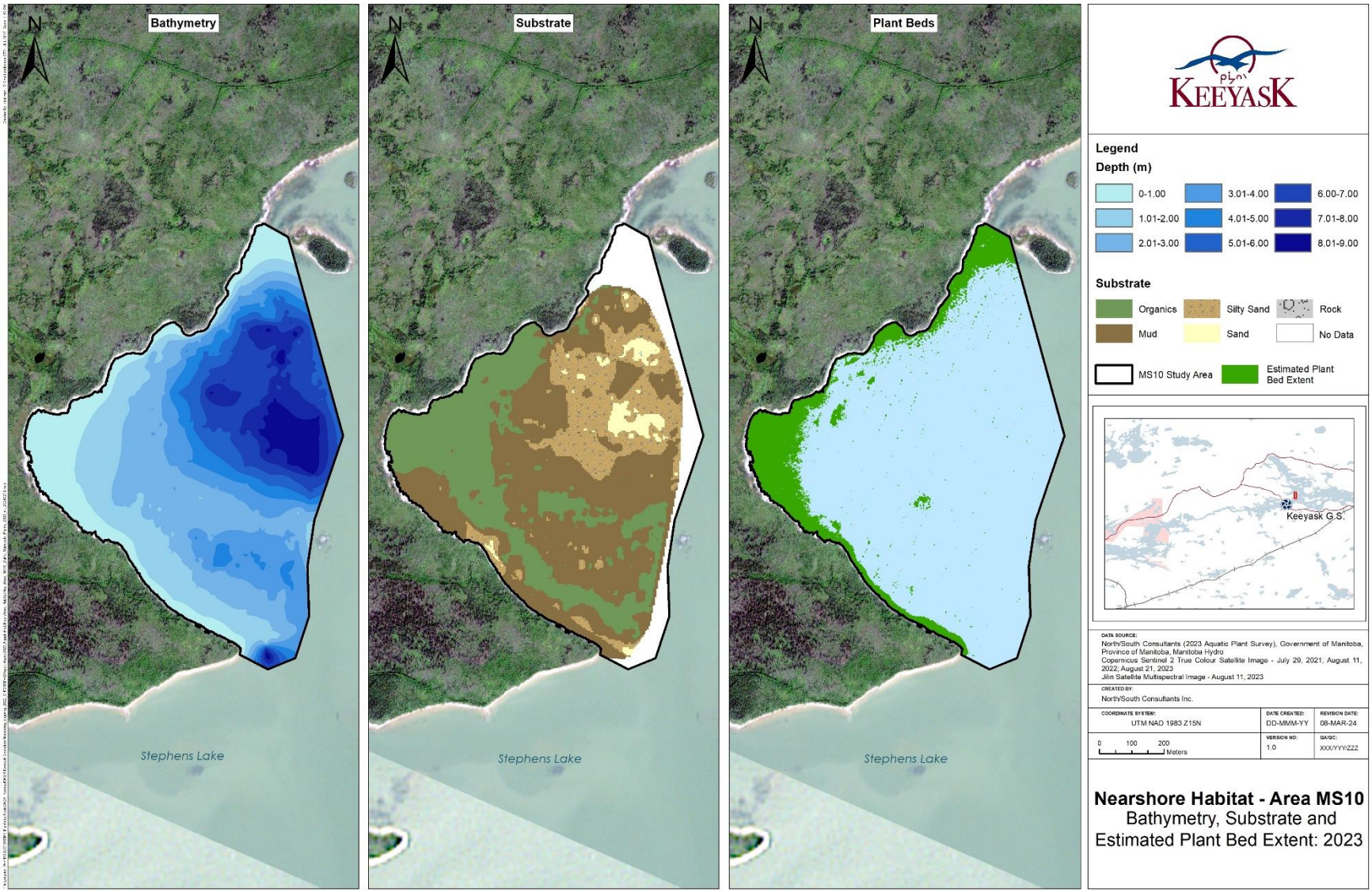
**Photo 27: Substrate collected in Stephens Lake (MS10), showing sand substrate.**




**Map 37: Basic substrate class results of sediment grabs taken at sampling sites in Stephens Lake (MS10), August 2021-2023.**




**Map 38: Macrophytes collected from Stephens Lake (MS10) over three sampling years, August 2021-2023.**




**Map 39: Bathymetry, substrate, and plant beds in Stephens Lake (MS10) in 2023.**

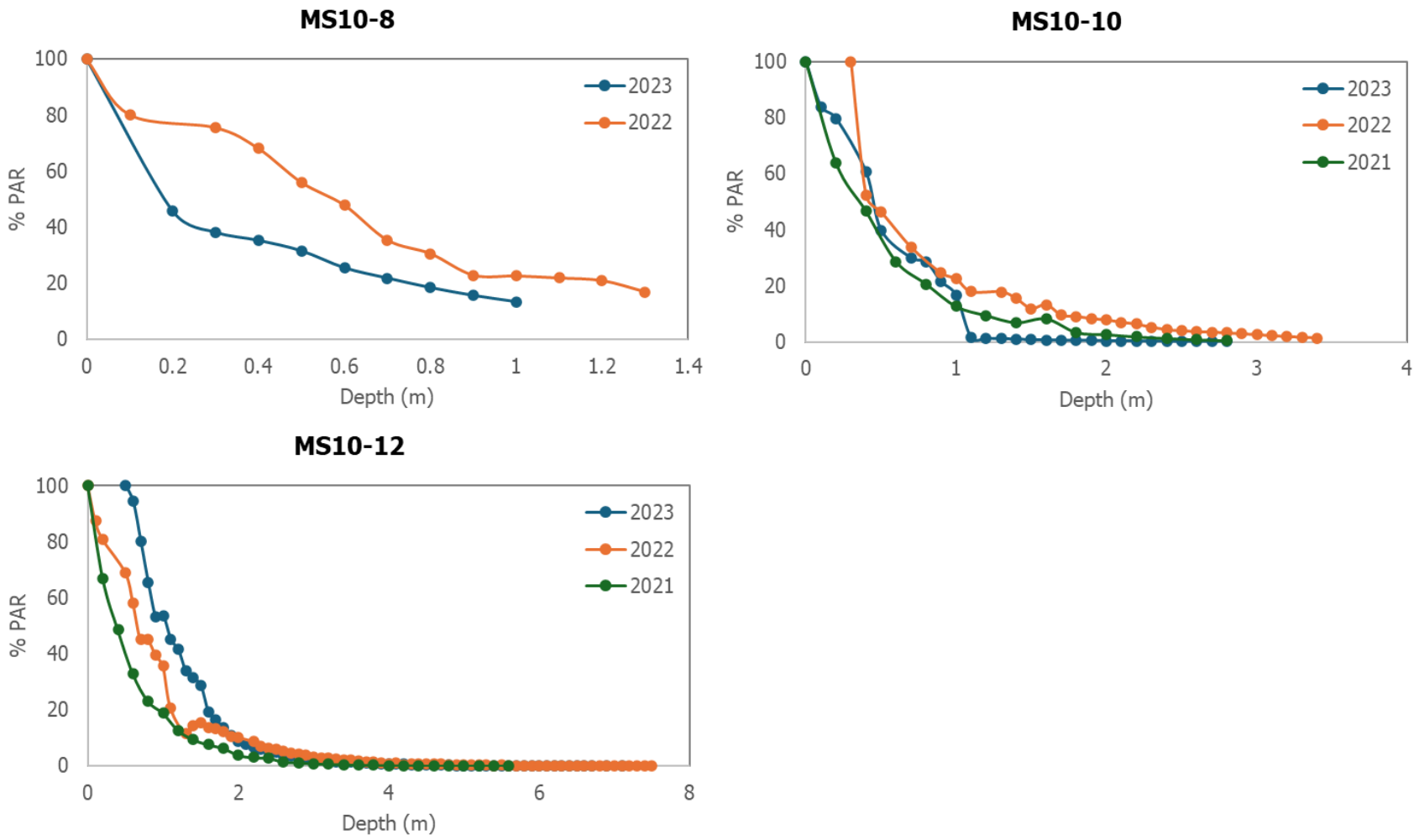



**Figure 11: The percent of photosynthetically active radiation (PAR) extinction with depth at three sites in Stephens Lake (MS10), measured with a LI-1400 data logger (LI-COR), 2021-2023.**

# 4.2.11 STEPHENS LAKE (MS11)

## 4.2.11.1 2023 SAMPLING

Mean water surface elevation was 140.44 m at site MS11 on August 20, 2023 (Map 3; Table 3). Shoreline depth ranged from 1.24–9.06 m.

Substrate was collected at 15 sites (Table 35). Most sites (n=13) were classified as mud and were made up largely of clay with some silt and organics. One site was comprised entirely of sand, and another of cobble and sand. The acoustic classification model indicated that the area was dominated by soft substrates including organic (63%) and silt/clay (18%), although some areas of gravel/sand (8%) were also present (Table 5). PSA analysis was conducted at three sites which were classified as silty loam, silt, and loam (Table 36).

Aquatic plant species were observed at four sites ranging in depth from 0.6–2.8 m (Table A1-11). Seven species of rooted aquatic macrophytes were present: Richardson pondweed (Photo 28), Sago pondweed, Sheathed pondweed (*Stuckenia vaginata),* Water Knotweed (*Persicaria amphibia*), Watermilfoil, Water nymph, and Whitewater buttercup (Photo 29). One species of terrestrial plant (Smartweed) was also found.

**Photo 28: Richardson pondweed collected from Stephens Lake (MS11) in 2023.**

**Table 35: Locations and results of substrate grab type validation sampling and post-survey class verification in the Northern portion of Stephens Lake (MS11), 2023.**

| 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 | % | | |
| MS11-1 | petite Ponar | 20-Aug | 369056 | 6251187 | 4.1 | soft | clay | 80 | silt | 10 | organic | 10 | mud | clay/silt/organic |
| MS11-2 | petite Ponar | 20-Aug | 368754 | 6251263 | 3.2 | moderate | clay | 70 | gravel | 20 | sand | 10 | mud | clay/gravel/sand |
| MS11-3 | petite Ponar | 20-Aug | 368532 | 6251356 | 1.2 | hard | clay | 80 | sand | 20 | - | - | mud | clay/sand |
| MS11-4 | petite Ponar | 20-Aug | 368949 | 6251387 | 1.8 | moderate | clay | 80 | organic | 20 | - | - | mud | clay/organic |
| MS11-5 | petite Ponar | 20-Aug | 368564 | 6251484 | 0.6 | soft | sand | 100 | - | - | - | - | sand | sand |
| MS11-6 | petite Ponar | 20-Aug | 369168 | 6251566 | 1.7 | moderate | clay | 80 | organic | 20 | - | - | mud | clay/organic |
| MS11-7 | petite Ponar | 20-Aug | 368952 | 6251636 | 1.8 | soft | clay | 80 | organic | 20 | - | - | mud | clay/organic |
| MS11-8 | petite Ponar | 20-Aug | 369449 | 6251664 | 2.9 | soft | clay | 50 | sand | 40 | organic | 10 | mud | clay/sand/organic |
| MS11-9 | petite Ponar | 20-Aug | 368954 | 6251744 | 2.0 | moderate | clay | 80 | silt | 10 | organic | 10 | mud | clay/silt/organic |
| MS11-10 | petite Ponar | 20-Aug | 368846 | 6251837 | 0.8 | soft | clay | 80 | silt | 10 | organic | 10 | mud | clay/silt/organic |
| MS11-11 | petite Ponar | 20-Aug | 369060 | 6251848 | 1.3 | moderate | clay | 60 | organic | 30 | silt | 10 | mud | clay/organic/silt |
| MS11-12 | petite Ponar | 20-Aug | 369262 | 6251863 | 2.8 | soft | clay | 90 | silt | 10 | - | - | mud | clay/silt |
| MS11-13 | petite Ponar | 20-Aug | 369454 | 6251862 | 5.9 | soft | clay | 80 | silt | 10 | organic | 10 | mud | clay/silt/organic |
| MS11-14 | petite Ponar | 20-Aug | 369390 | 6252107 | 7.4 | soft | clay | 80 | silt | 10 | organic | 10 | mud | clay/silt/organic |
| MS11-15 | petite Ponar | 20-Aug | 369280 | 6252057 | 1.2 | hard | cobble | 80 | sand | 20 | - | - | rock | cobble/sand |

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

**Table 36: Results of particle size analysis (conducted at ALS Laboratories) from samples collected from Stephens Lake (MS11), 2023.**

| Area Name | Date | Area Code | Habitat | Field Site No. | Inorganic Carbon (%) | CaCO3 Equivalent | Total Carbon by Combustion (%) | Total Organic Carbon (%) | % Sand (2.0-0.05 mm) | % Silt (0.05-2µm) | % Clay (<2 µm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stephens Lake | 20-Aug-2023 | MS11 | nearshore | MS11-8 | 2.27 | 18.9 | 3.91 | 1.64 | 30.1 | 67.4 | 2.5 | Silt Loam |
| Stephens Lake | 20-Aug-2023 | MS11 | nearshore | MS11-9 | 0.192 | 1.60 | 6.80 | 6.61 | 6.6 | 81.1 | 12.3 | Silt |
| Stephens Lake | 20-Aug-2023 | MS11 | nearshore | MS11-10 | 1.81 | 15.0 | 4.36 | 2.55 | 44.6 | 34.0 | 21.4 | Loam |

### 4.2.11.2 2021-2023 SUMMARY

Sampling area MS11 is located approximately 8 km downstream of the Keeyask GS in an off-current area previously flooded by impoundment of the Kettle GS (completed in 1974; Map 2). Like MS10, this area is impacted by water level changes associated with operation of both the Kettle and Keeyask GSs and extremely low water levels in 2021 made some sites closest to shore inaccessible. However, in all three years, most sites were comprised of mud (*i.e.,* clay and silt) with sand also present at some sites (Map 40). Cobble was present at a single site in both 2021 and 2023. Substrate mapping in 2023 showed that 40% of the study area was comprised of mud, while 10% contained silty sand (Table 37).

Like what was observed in MS10, water level fluctuations due to Keeyask GS powerhouse commissioning combined with low flows limited plant growth in MS11 in 2021; however, aquatic plant communities grew in abundance and distribution over the three sampling years (Map 41). Only two rooted aquatic plant species (Richardson and Sago pondweed) were found at a single sampling site in 2021. In 2022, three aquatic plant species (Richardson, Sago, and Sheathed pondweed) were identified at four sites. By 2023, four sites contained seven species of rooted aquatic plants including Richardson, Sago, Sheathed, and Variableleaf pondweed, Watermilfoil, Water nymph, and Whitewater buttercup (Map 41; Table A1-11). One terrestrial species (Smartweed) was also found (Photo 29).

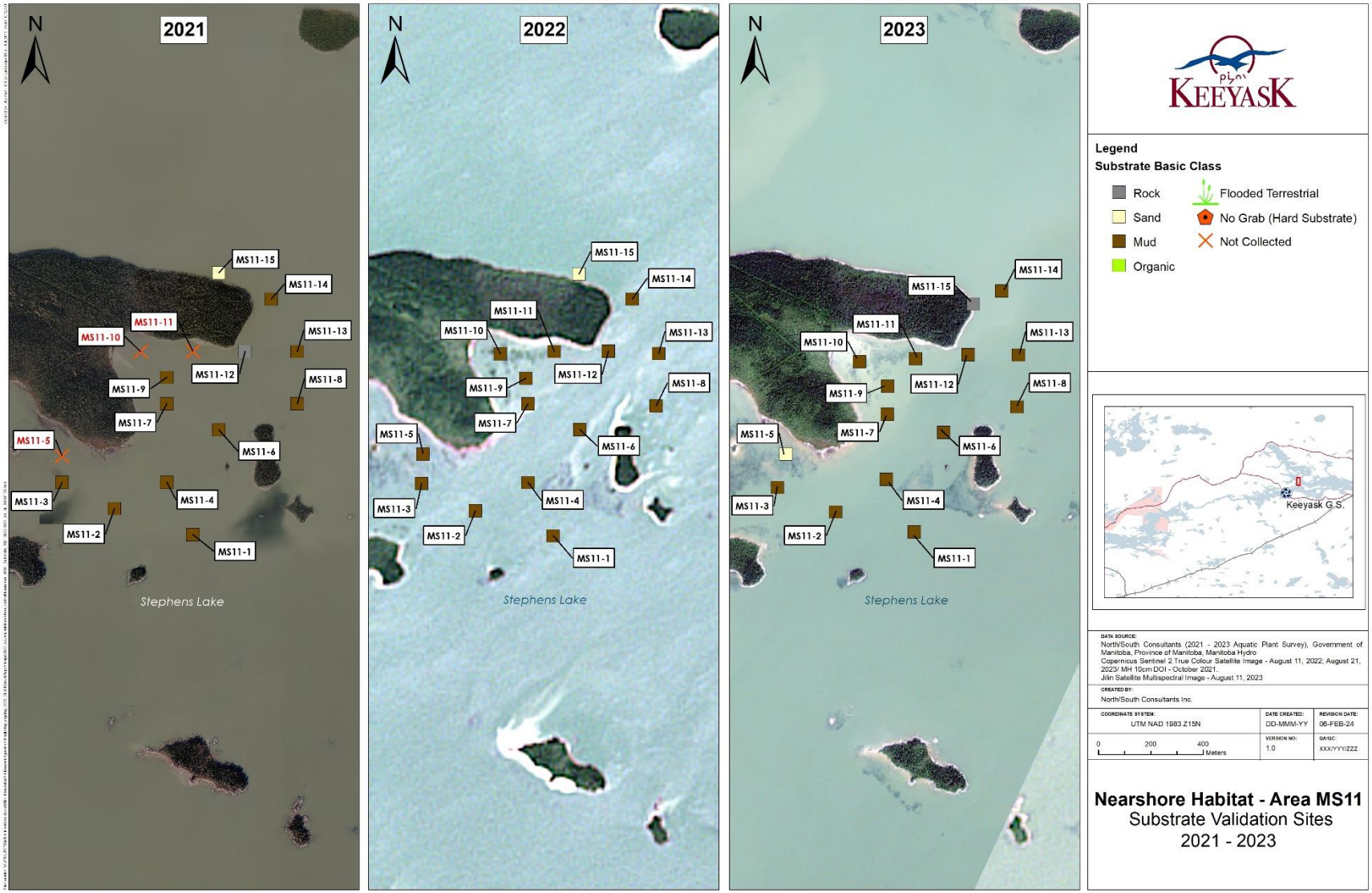
In 2023, plant beds comprised approximately 17% of the sampling area and were present largely in areas close to shore (Map 42; Photo 30). Light extinction sampling suggests that little light (between 2 and 10%) penetrates to 2 m of depth, although only one of three sampling sites was deeper than this (Figure 12). At the remaining two sampling sites (measuring between 1.2 and 1.9 m deep), between 4 and 13% of surface light reached the bottom.

**Table 37: Total area occupied by each substrate type as measured by acoustic surveys in Stephens Lake (MS11), 2023.**

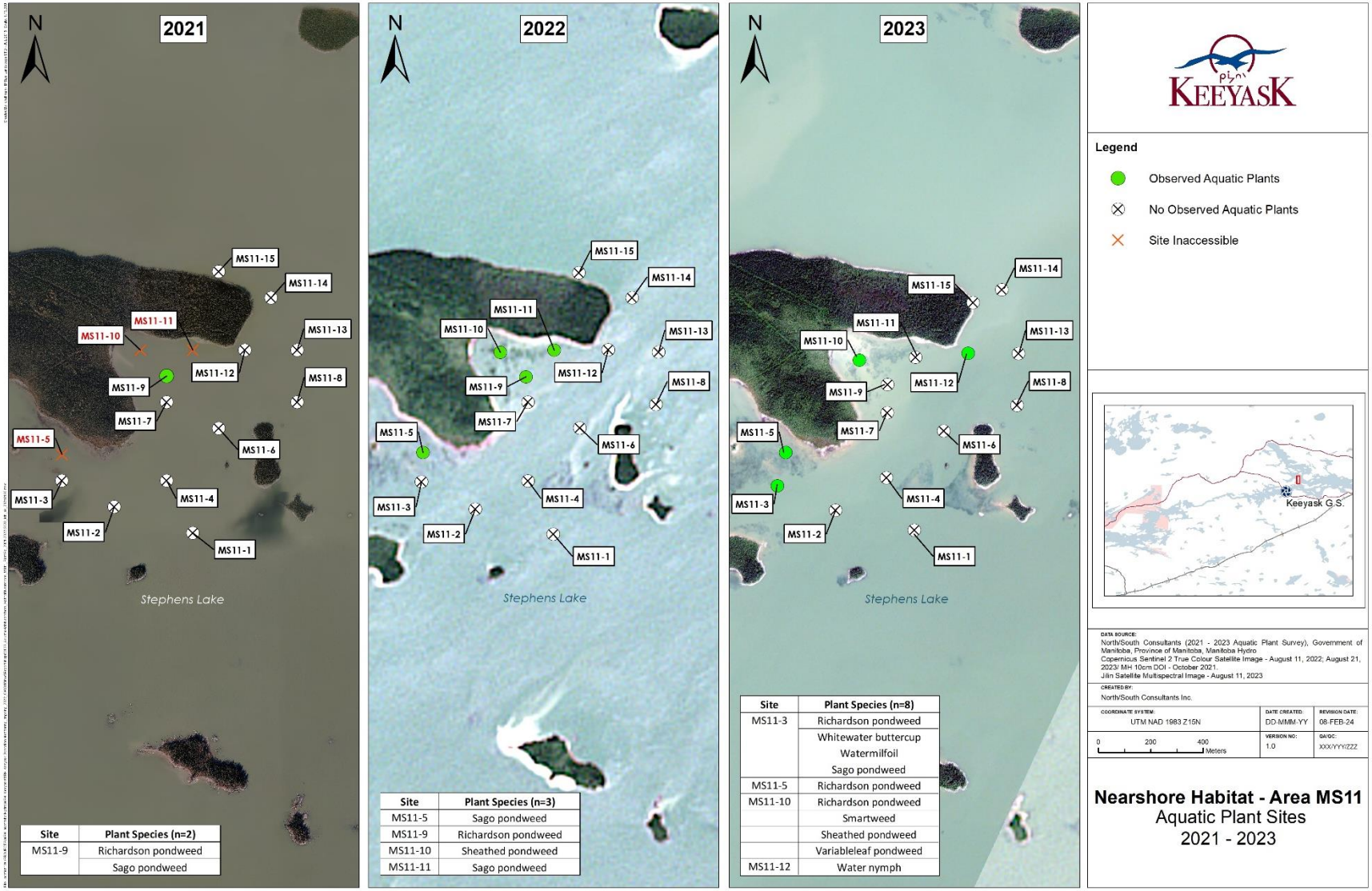
| MS11 | Area ($m^2$) | % of Total Area |
|---|---|---|
| Organic | 246,775 | 36 |
| Mud | 273,058 | 40 |
| Silty Sand | 66,071 | 10 |
| Sand | 4,125 | 1 |
| Rock | 375 | 0 |
| No Data | 89,149 | 13 |
| **Sum** | **679,554** | **100** |

**Photo 29: Aquatic plants collected in Stephens Lake (MS11) in 2023.**

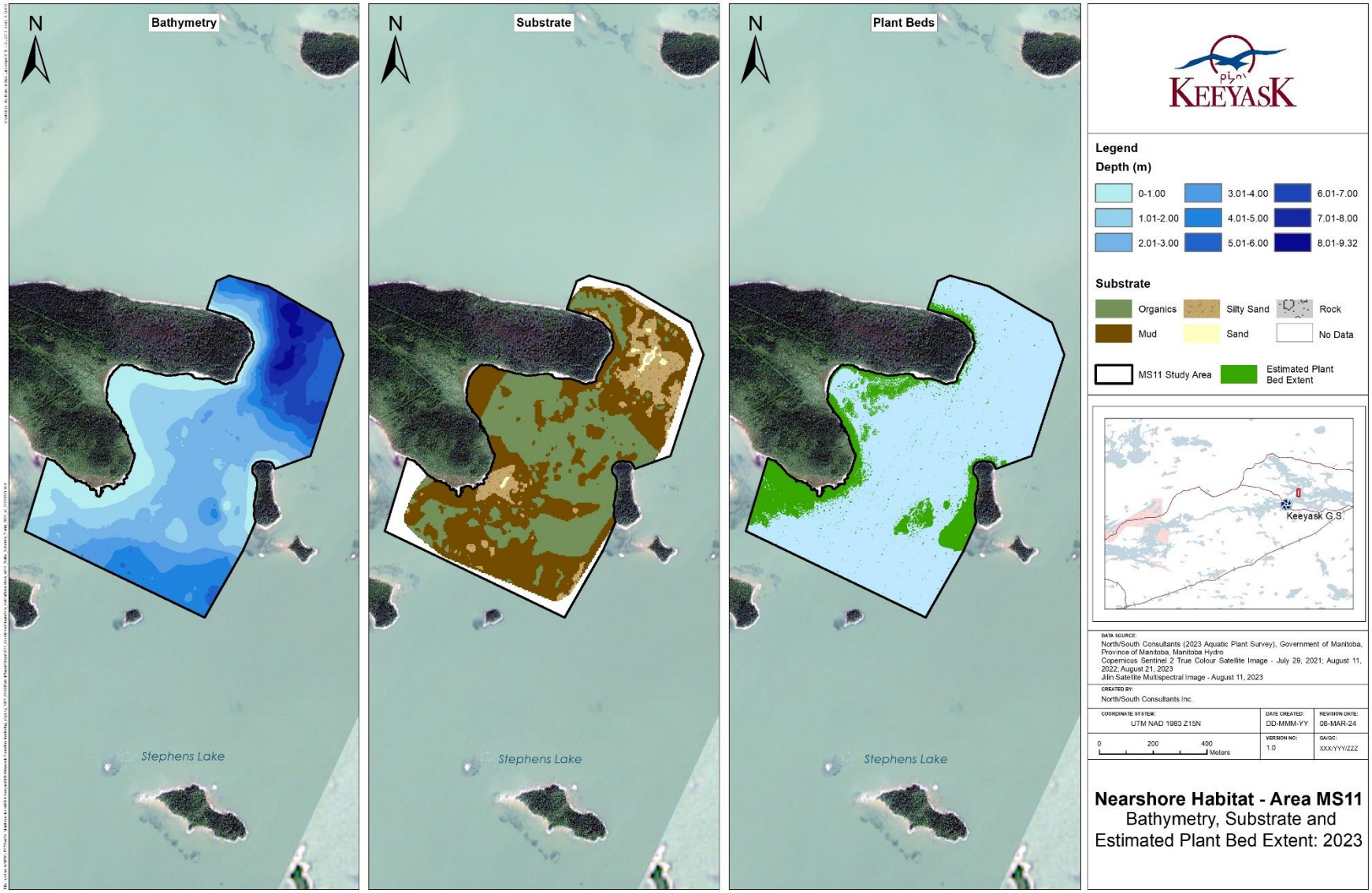
**Photo 30: Aquatic plant beds seen at the water surface in Stephens Lake (MS11) in 2023.**




**Map 40: Basic substrate class results of sediment grabs taken at sampling sites in Stephens Lake (MS11), August 2021-2023.**




**Map 41: Macrophytes collected from Stephens Lake (MS11) over three sampling years, August 2021-2023.**




**Map 42: Bathymetry, substrate, and plant beds in Stephens Lake (MS11) in 2023.**

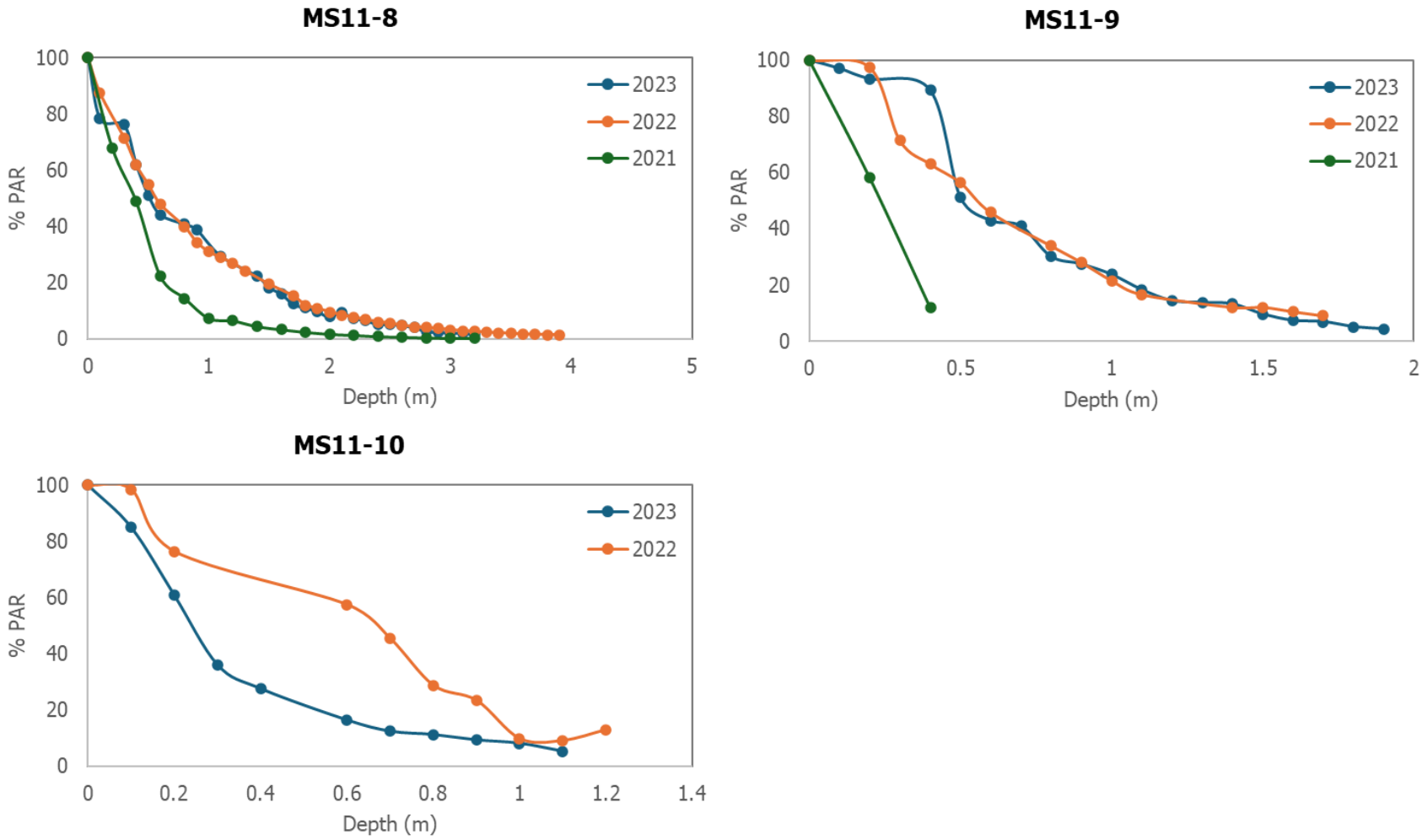



**Figure 12: The percent of photosynthetically active radiation (PAR) extinction with depth at three sites in Stephens Lake (MS11), measured with a LI-1400 data logger (LI-COR), 2021-2023.**

# 4.2.12 STEPHENS LAKE (MS12)

## 4.2.12.1 2023 SAMPLING

Mean water surface elevation was 140.36 m at site MS12 on August 21, 2023 (Map 3; Table 3). Shoreline depth ranged from 0.96–8.15 m.

Substrate was collected at 15 sites (Table 38). This area was dominated by soft compact mud (*i.e.,* clay and silt). Organic matter was also present at 11 sites, consisting of detritus and decomposing vegetation (Photo 31). The acoustic classification model indicated that the area was dominated by soft substrates including organic (46%), and silt/clay (16%), sand was also prominent in the area with silt/sand, sand and gravel/sand comprising 14%, 14%, and 10%, respectively (Table 5). PSA analysis was conducted at three sites which were classified as silt loam and silt (Table 39).

One aquatic plant species (Richardson pondweed) was found at one site at a depth of 0.5 m (Table A1-12).

**Photo 31: Organic sediment collected from Stephens Lake (MS12) in 2023.**

**Table 38: Locations and results of substrate grab type validation sampling and post-survey class verification in the Northern portion of Stephens Lake (MS12), 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 | % | | |
| MS12-1 | petite Ponar | 21-Aug | 369859 | 6254962 | 1.9 | soft | clay | 55 | organic | 25 | silt | 10 | mud | clay/organic/silt |
| MS12-2 | petite Ponar | 21-Aug | 369552 | 6255056 | 1.7 | soft | clay | 55 | organic | 25 | silt | 10 | mud | clay/organic/silt |
| MS12-3 | petite Ponar | 21-Aug | 369551 | 6255173 | 2 | soft | organic | 100 | - | - | - | - | organic | organic |
| MS12-4 | petite Ponar | 21-Aug | 369956 | 6255266 | 2.5 | soft | clay | 75 | silt | 20 | organic | 5 | mud | clay/silt/organic |
| MS12-5 | petite Ponar | 21-Aug | 370259 | 6255273 | 4.5 | soft | clay | 75 | silt | 20 | organic | 5 | mud | clay/silt/organic |
| MS12-6 | petite Ponar | 21-Aug | 369455 | 6255355 | 1 | soft | organic | 90 | silt | 10 | - | - | organic | organic/silt |
| MS12-7 | petite Ponar | 21-Aug | 369645 | 6255429 | 0.5 | soft | organic | 50 | clay | 25 | silt | 25 | organic | organic/clay/silt |
| MS12-8 | petite Ponar | 21-Aug | 369804 | 6255505 | 0.4 | soft | clay | 60 | organic | 40 | - | - | mud | clay/organic |
| MS12-9 | petite Ponar | 21-Aug | 370352 | 6255569 | 5 | soft | clay | 80 | silt | 15 | organic | 5 | mud | clay/silt/organic |
| MS12-10 | petite Ponar | 21-Aug | 370054 | 6255672 | 1.6 | soft | organic | 60 | clay | 20 | sand | 20 | organic | organic/clay/sand |
| MS12-11 | petite Ponar | 21-Aug | 370660 | 6255672 | 5.3 | soft | clay | 80 | silt | 20 | - | - | mud | clay/silt |
| MS12-12 | petite Ponar | 21-Aug | 369958 | 6255872 | 2.6 | soft | organic | 75 | silt | 25 | silt | 25 | organic | organic/silt |
| MS12-13 | petite Ponar | 21-Aug | 370357 | 6255868 | 7 | soft | clay | 80 | silt | 20 | - | - | mud | clay/silt |
| MS12-14 | petite Ponar | 21-Aug | 370560 | 6255971 | 7.4 | soft | clay | 80 | silt | 20 | - | - | mud | clay/silt |
| MS12-15 | petite Ponar | 21-Aug | 370364 | 6256079 | 7.8 | soft | clay | 80 | silt | 20 | - | - | mud | clay/silt |

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

**Table 39: Results of particle size analysis (conducted at ALS Laboratories) from samples collected from Stephens Lake (MS12), 2023.**

| Area Name | Date | Area Code | Habitat | Field Site No. | Inorganic Carbon (%) | CaCO3 Equivalent | Total Carbon by Combustion (%) | Total Organic Carbon (%) | % Sand (2.0-0.05 mm) | % Silt (0.05-2µm) | % Clay (<2 µm) | Texture |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stephens Lake | 21-Aug-2023 | MS12 | nearshore | MS12-3 | 0.838 | 6.99 | 27.5 | 26.7 | <1.0 | 78.4 | 20.6 | Silt Loam |
| Stephens Lake | 21-Aug-2023 | MS12 | nearshore | MS12-9 | 1.55 | 12.9 | 9.18 | 7.63 | <1.0 | 90.1 | 9.3 | Silt |
| Stephens Lake | 21-Aug-2023 | MS12 | nearshore | MS12-10 | 1.75 | 14.6 | 7.88 | 6.13 | 16.5 | 78.1 | 5.3 | Silt Loam |

### 4.2.12.2 2021-2023 SUMMARY

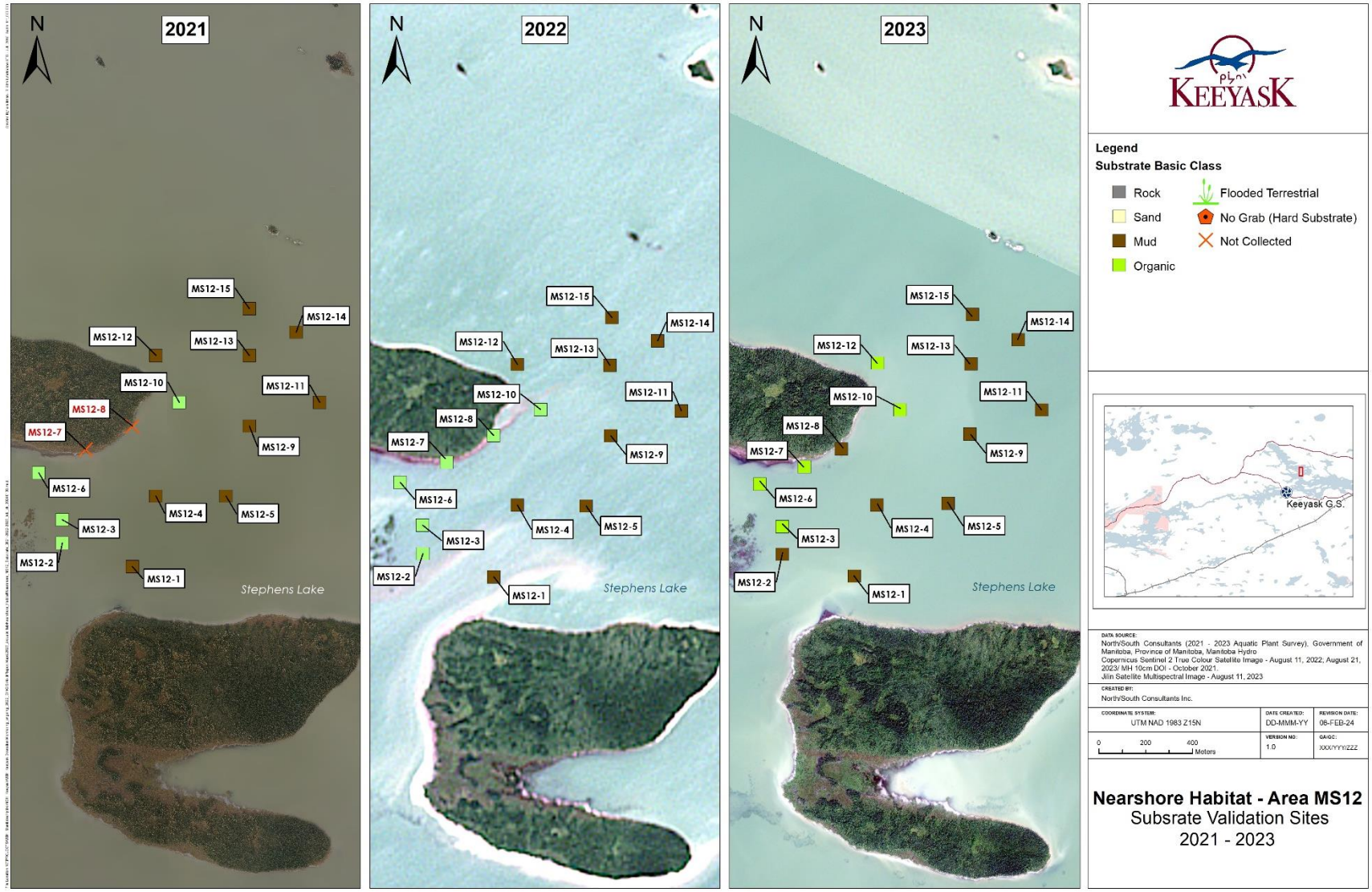
Sampling area MS12 is located approximately 9 km downstream of the Keeyask GS in the north arm of Stephens Lake (approximately 7 km north of the main channel of the river; Map 2). This area was extensively flooded during impoundment of the Kettle GS (completed in 1974). Like the other two sampling areas located on Stephens Lake, this area is impacted by water level changes associated with operation of both the Kettle and Keeyask GSs and extremely low water levels in 2021 made some sites closest to shore inaccessible. Clay was the dominant substrate type at most sites in all three years (Map 43). Organic matter, consisting of detritus and decomposing vegetation, was also present at four (2021) and five (2022 and 2023) sites in the area. Substrate mapping in 2023 showed that 16% of the study area was comprised of organic, while 35% contained mud (*i.e.,* clay and silt; Table 40).

Unlike the other sampling areas in Stephens Lake, few aquatic macrophytes were found in area MS12 in any sampling year. No plant species were observed in 2021, although the site where plants were found in 2022 and 2023 was not accessible due to low water (Map 44). One aquatic plant species was observed at a single site in both 2022 and 2023. Cattail (*Typha* spp.) was observed in 2022 and Richardson pondweed was observed in 2023.

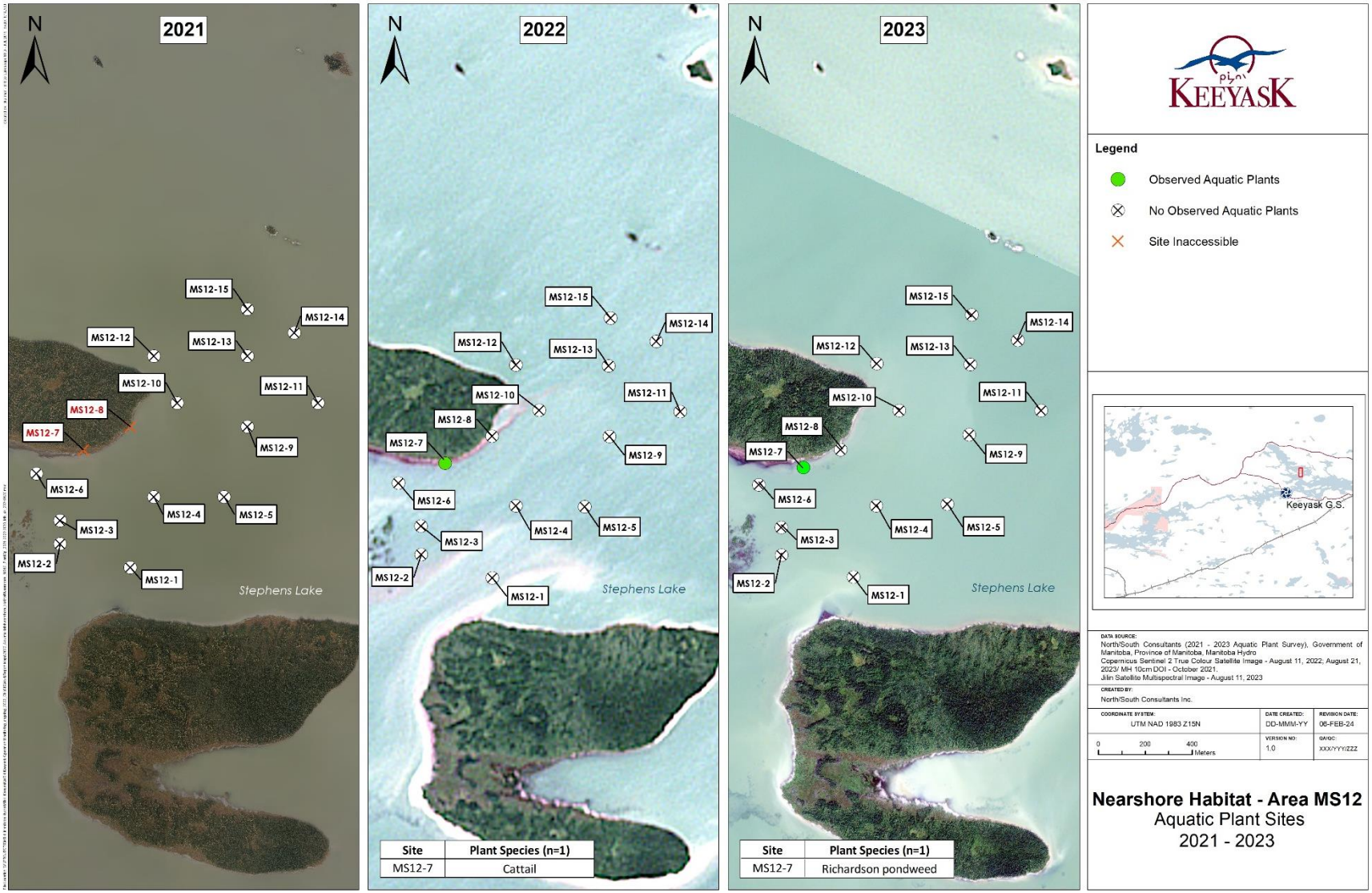
In 2023, plant beds were virtually not existent within MS12, comprising only 1% of the study area despite shallow areas measuring less than 2 m (Map 45). Light extinction sampling suggests that little light (between 4 and 11% of surface) penetrates to 2 m of depth (Figure 13). Between 7 and 40% of surface light was measured at 1 m of depth, varying greatly between years with 2022 higher than either 2021 or 2023.

**Table 40: Total area occupied by each substrate type as measured by acoustic surveys in Stephens Lake (MS12), 2023.**

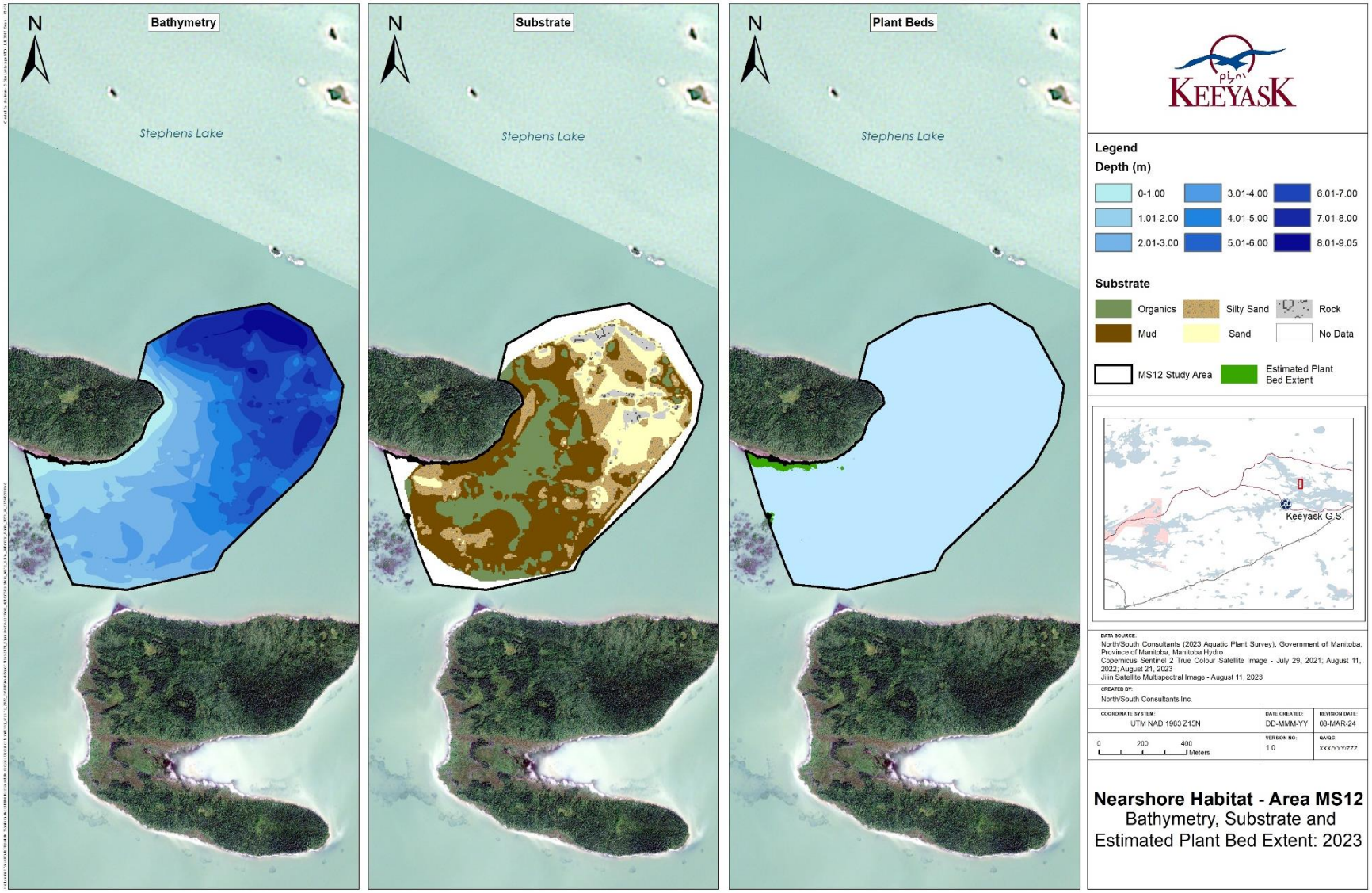
| MS12 | Area ($m^2$) | % of Total Area |
|---|---|---|
| Organic | 175,310 | 16 |
| Mud | 373,884 | 35 |
| Silty Sand | 182,309 | 17 |
| Sand | 131,625 | 12 |
| Rock | 35,150 | 3 |
| No Data | 170,936 | 16 |
| **Sum** | **1,069,214** | **100** |




**Map 43: Basic substrate class results of sediment grabs taken at sampling sites in Stephens Lake (MS12), August 2021-2023.**




**Map 44: Macrophytes collected from Stephens Lake (MS12) over three sampling years, August 2021-2023.**




**Map 45: Bathymetry, substrate, and plant beds in Stephens Lake (MS12) in 2023.**

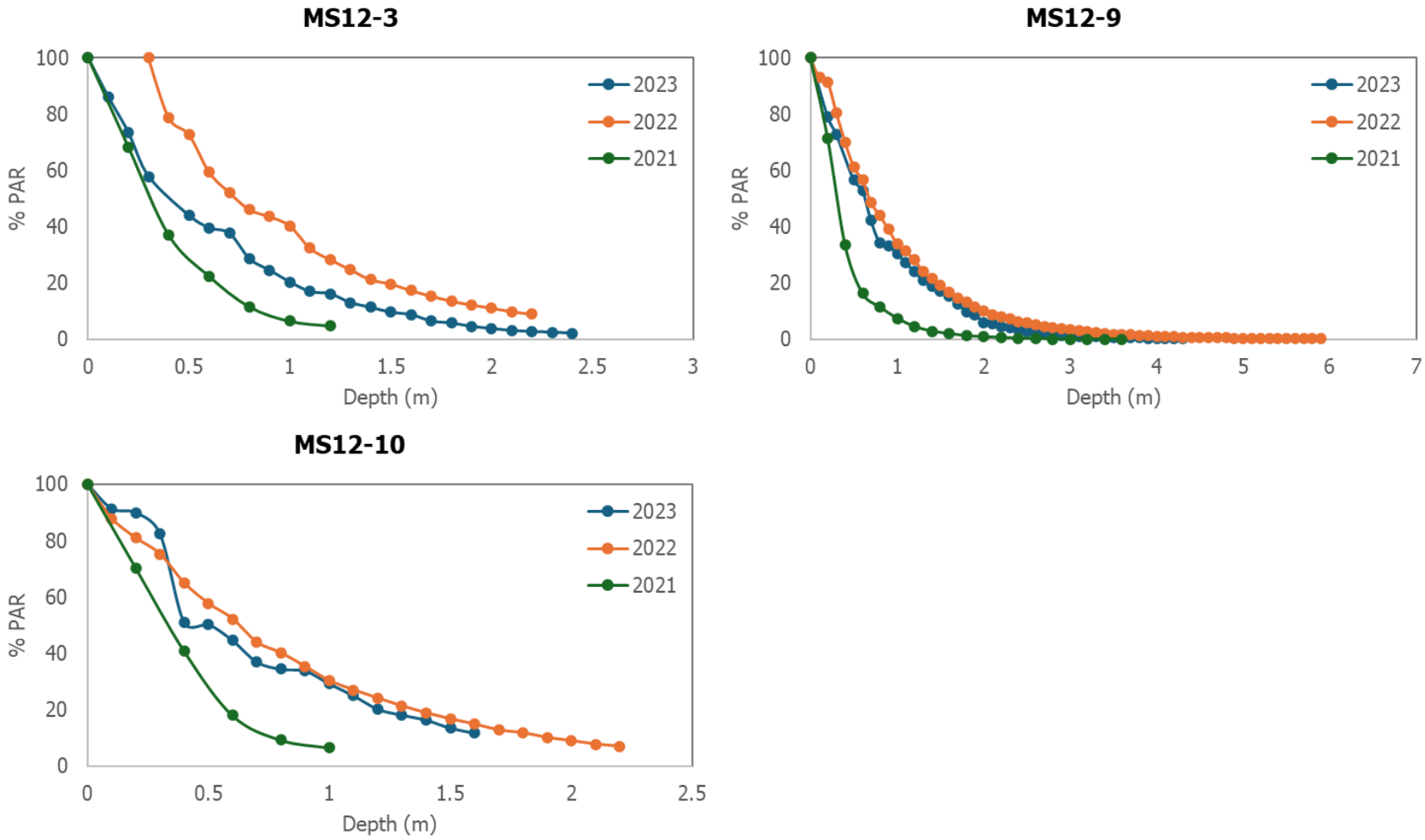



**Figure 13: The percent of photosynthetically active radiation (PAR) extinction with depth at three sites in Stephens Lake (MS12), measured with a LI-1400 data logger (LI-COR), 2021-2023.**

# 5.0 DISCUSSION

The primary objective of nearshore habitat monitoring is to monitor changes in shallow flooded areas that will develop into new nearshore and aquatic macrophyte habitat as the Keeyask reservoir ages. The development of nearshore habitat and areas suitable for aquatic macrophytes within the Keeyask reservoir depends primarily on changes in water level, exposure, the type and distribution of inorganic and organic soils and floating peat following impoundment, light availability in the water column (which is related in part to the boundary between humic (from local drainage high in dissolved organics) and turbid (Nelson River high TSS mainstem) water), and the deposition of mineral and organic sediments. Nearshore areas were sampled within nine areas in the Keeyask reservoir and in the first three years following reservoir impoundment to observe how these areas have developed and to determine if aquatic macrophytes have begun to colonize newly flooded areas. Sampling was also conducted in three areas in Stephens Lake to provide comparison to nearshore habitat and aquatic plant distribution in an established reservoir.

Sampling occurred during differing flow conditions. In August 2021, river discharge (as measured at the outflow from Split Lake) was near or lower than 5$^{th}$ percentile flows (Manitoba Hydro 2022). In contrast, near record high flows were observed in August 2022, measuring between 95$^{th}$ and 100$^{th}$ percentile (Manitoba Hydro 2023). Near median flows (50$^{th}$ percentile) were observed in 2023 (Manitoba Hydro 2024). These differences in inflows caused the largest changes in water levels in the farthest upstream site (MS1), while water levels in the remaining sites were moderated by regulation of the Keeyask reservoir.

## 5.1 KEY QUESTIONS

Key questions identified in the AEMP for nearshore aquatic habitat monitoring are addressed below.

*How will nearshore habitat develop in the Keeyask* reservoir*?*

Development of nearshore habitat in the first three years following impoundment has differed between sampling areas within the Keeyask reservoir, depending on location, level of flooding, and proportion of flooded terrestrial habitat. Flooding was minimal in the two farthest upstream areas (MS1 and MS2), located immediately upstream and downstream of Birthday Rapids. As such, most of these sampling areas were within habitat that was wetted prior to impoundment, containing only small areas of flooded terrestrial habitat along the boundaries. Substrates changed little at these sites over the first three years following impoundment, with soft substates located close to shore (including clay and silt) and hard substrates located farther from shore.

Greater changes in substrates were observed over the three-year sampling period within sampling area MS3, the farthest upstream flooded reservoir backbay sampled. Flooding was largely limited to the edges of the bay, and the middle of the backbay contained habitat that was

wetted prior to impoundment. In 2021, the majority of sites contained silt and clay substrates. By 2023, sampling sites were dominated by organic matter. These substrates were largely comprised of flooded terrestrial vegetation and peat. Because this area has no tributaries or flow, this broken-down vegetation has not been carried away. Mapping indicated that approximately 37% of the substrate in the sampling area was comprised of organic matter by 2023.

The remaining six sampling areas were located largely or completely within flooded terrestrial habitats. Three are located within flooded reservoir backbays (MS4, MS7, and MS8) while three are located close to the main river channel (MS5, MS6, and MS9). As expected, organic substrate composed of detritus and loose, broken-down plant matter was predominant in each of these areas, with no changes in composition occurring over the three sampling years. Inorganic substrates, largely silt and clay, were also present each year. This is different than what was seen in Stephens Lake. Each of the three sampling areas in Stephens Lake were terrestrial habitats that were flooded when the Kettle GS reservoir was impounded nearly 40 years ago. Substrates within two of these areas were largely composed of clay, silt, and sand with little organic matter present. However, organic substrates were present in the most northern sampling area (MS12), increasing in prevalence over the three sampling years. This shows that long-term flooded habitats may develop mineral substrates or remain organic. It is expected that substrates in the six sampling areas in the Keeyask reservoir will continue to develop.

Large amounts of peat were observed within several (four of nine including MS4, MS6, MS8, and MS9) of the nearshore sampling areas in the Keeyask reservoir in 2023 and satellite remote sensing data indicated that floating peat islands first observed in 2021 have persisted within the flooded backbays, increasing in size and number over time. Peat islands were first evident in spring 2021 and increased in size and number over the 2021 open-water period, decreasing the overall open-water area within the Keeyask reservoir. The same pattern was observed in both 2022 and 2023. The open-water area of the reservoir decreased from 9,190–8,777 ha over the open-water period in 2021, 8,893–8,691 ha in 2022, and 8,932–8,256 ha in 2023. Peat islands can impede the growth of rooted plants within backbays.

*How will aquatic macrophyte habitat develop in the Keeyask reservoir?*

Like nearshore habitats, the development of aquatic macrophyte communities in the three years following reservoir impoundment differed based on sampling location. Flooding was minimal in the farthest upstream sampling area (MS1), however, water levels differed between sampling years due to differing river inflows. Mean water surface elevation at this site differed as much as 2.76 m (between 2021 and 2022). Despite these fluctuations, rooted aquatic macrophytes were observed in all three years following impoundment, although they were more widespread and diverse in both 2022 and 2023 than in 2021. Plant beds were present in approximately 29% of the area in 2023, occupying shallow areas at the end of the bay.

Flooding was also minimal in the sampling area located downstream of Birthday Rapids (MS2), although more change was seen in this area over the three sampling years than in MS1. A single semi-aquatic plant species (Wild celery) was found in 2021, while three rooted aquatic species were found in both 2022 and 2023. Aquatic plants were sparse in this area in all three sampling

years, largely due to the nature of the site rather than impacts of impoundment. This area consists mainly of rocky substrates, which are found near the shoreline. Further, little shallow water is present, dropping to depths greater than 3 m close to shore, with little light penetrating deeper than 1 m. Plant beds were present only within the entrance of Nap Creek (located at the end of the backbay), comprising only 10% of the total study area.

Despite little change observed in the substrate in each of the four sampled flooded reservoir backbays (zones 4 [MS3], 7 [MS7], 8 [MS8], and 12 [MS4]; maps 3 and 4), the distribution and variety of aquatic plants increased by year in all four areas. In 2021, four species of rooted aquatic macrophytes (Long-leaf and Richardson pondweed, Pond lily, and Watermilfoil) were found at seven of the 60 flooded backbay sites sampled. However, free-floating Bladderwort was the most common aquatic plant species observed and was found at ten sites. By 2022, rooted aquatic plants were more prevalent, and between two and four species were found in each sampling area at a total of 13 of the 58 flooded backbay sites sampled. Free-floating aquatic plant species (Bladderwort and Star duckweed) continued to be prevalent and were found at 22 sites. By 2023, rooted aquatic macrophytes were present at 23 of 54 backbay sites sampled. These included a total of eight species, with three to six species found in each of the four flooded backbays. Free-floating aquatic plants (Bladderwort, Star duckweed, and Hornwort) were also abundant and were present at 31 sites. In all three years, rooted aquatic plants were more abundant in MS7 (flooded backbay Zone 7) than in any of the other three backbays. Part of this sampling area is located within what was a pond pre-impoundment, and it is likely several species were present prior to flooding and have persisted. However, the abundance and diversity of aquatic plant species (both rooted and free-floating) increased in each of the four flooded reservoir backbays in the first three years following reservoir impoundment.

By 2023, plant beds were established within each of the four flooded backbays, ranging from 28% (in Zone 4; MS3) to 66% (in Zone 12; MS4) of each sampling area. Plant bed extent was largely limited by depth with the majority of growth in areas less than 2 m deep. Plant beds were present over both organic and mud substrates.

The abundance of aquatic macrophytes was lowest in the sampling areas located close to the mainstem in the Keeyask reservoir (MS5, MS6, and MS9) in Gull Lake in all three sampling years. However, the distribution of aquatic plants increased over time at two of the sites (MS5 and MS6). No aquatic plants were observed at either site in 2021, only free-floating species (Bladderwort and Star duckweed) were observed in 2022, and rooted Watermilfoil was found at both sites in 2023. Plant beds were more limited than within the flooded backbay sampling areas, only comprising between 19 (in MS5) and 28% (in MS6) of each area. Both areas contain narrow bands of shallow water habitat (*i.e.,* less than 3 m deep) located close to shore. Light extinction sampling suggests that little light penetrates below 2 m, limiting the overall area available for macrophyte growth. As these sites are close to the mainstem, flows are higher than in the backbay sites and they are also exposed to wave-action which may further limit plant growth. Floating peat, which can impede plant growth, was observed at one of the sites (MS6).

Aquatic macrophytes have not yet established at the sampling area located farthest downstream in Gull Lake (MS9). A single species of free-floating aquatic macrophyte (Star duckweed) was

found at a single site over the three years of sampling. This sampling area is located fully on what was terrestrial habitat prior to impoundment and large amounts of peat were observed throughout this area in 2022. Floating peat islands observed via satellite remote sensing increased in size and number over the 2023 open-water period. As this area is located close to the main flow in the lower portion of the Keeyask reservoir, it is likely that floating peat islands drift from farther upstream and settle in the shallow areas, impeding plant growth. The EIS predicted that plant growth may be limited in this area due to the composition of the pre-impoundment topography. Further monitoring will indicate whether aquatic macrophytes establish in this area.

The three sampling areas in Stephens Lake (Map 3) are a proxy for what nearshore habitat in the Keeyask reservoir will develop into in the future. These sites displayed both the variation that can be expected among sites in the Keeyask reservoir in the future, as well as between year variation in plant abundance. Few aquatic macrophytes were found in area MS12 in any sampling year; no aquatic plants were observed in 2021 and only a single species was present in each of 2022 and 2023. This is the farthest site from the Keeyask GS, located in the north arm of Stephens Lake. This area was extensively flooded during impoundment of the Kettle GS and still contains terrestrial debris that has not broken down. Substrates contained a large amount of organic matter, and it is possible that this site does not support a large abundance of aquatic macrophytes. Rooted aquatic macrophytes were found in both of the more southerly sampling areas (MS10 and MS11), although abundance and distribution changed over time. Few aquatic plants were found in either area during sampling in 2021 (only present at four of the 30 sites sampled). Low water levels combined with water level fluctuations due to Keeyask GS powerhouse commissioning may have limited plant growth in 2021 (Dolce Blanchard *et al*. 2022). However, water levels were more stable in 2022 and plants were more widespread, with two rooted species recorded at the sampling areas (Dolce Blanchard and Hrenchuk 2023). By 2023, between four and seven species of aquatic macrophyte were found in each sampling area. Plant beds were small in 2023, only comprising between 1 (in MS12) and 17% (in MS11) of each total sampling area.

*How accurate were the predictions in the EIS?*

Overall, nearshore and aquatic macrophyte habitats in the Keeyask reservoir appear to be developing faster than what was predicted in the EIS. It was predicted that macrophyte habitat in nearshore areas of the Keeyask reservoir may take up to 15 years to develop, depending on site conditions. However, rooted macrophytes have established in the Keeyask reservoir by the third year following impoundment. Over the first three years post-impoundment, rooted aquatic plants were found within eight of the nine nearshore areas sampled in the Keeyask reservoir, including in sites that were previously terrestrial habitats. Observed species were similar to those found in the reference areas in Stephens Lake, although the diversity was often greater within areas in the Keeyask reservoir. Plant beds were also generally larger in the Keeyask reservoir than in Stephens Lake, occupying a larger proportion of the majority of the sampling areas.

The EIS predicted that when aquatic macrophytes did establish in the Keeyask reservoir (*i.e.,* by 15 years following impoundment) Richardson pondweed would be found in the nearshore areas located close to the Keeyask reservoir mainstem, while Watermilfoil would establish within the flooded reservoir backbays. By the third year following reservoir impoundment, Watermilfoil was

the only rooted aquatic macrophyte observed in any of the three nearshore areas located near the Keeyask reservoir mainstem. In contrast, eight different species of rooted aquatic species were present within the flooded backbays (including both Richardson pondweed and Watermilfoil) in 2023. Although the composition of these communities will likely change over time, this further suggests that the aquatic plant community within flooded areas of the Keeyask reservoir was more diverse and abundant by the third year following impoundment than predicted would be the case so soon after impoundment.

Substrates within the nearshore habitats more closely resemble what was predicted in the EIS. Immediately after flooding, it was predicted that substrates in the nearshore areas would be heterogeneous, composed of flooded terrestrial habitat, especially at the ends of the flooded backbays. In these areas, where humic waters predominate, it was predicted that silt sediments would not develop as the only source of silt was expected to be deposition from turbid waters in the main reservoir. Organic and flooded terrestrial substrates were the most common substrate type and were found in each of the sampling areas in the Keeyask reservoir; however, other substrate types were also present. Clay and silt were found at several sites in each area, including in those that were located entirely on pre-impoundment terrestrial habitats and within flooded backbays. There appears to be more mixing of water masses within the backbays than predicted. In both spring and fall of 2023, much of each flooded reservoir backbay contained humic water, with small amounts of turbid or mixed water within the middle of each bay. However, in August, mixed water masses extended to the ends of each bay. The same was observed in 2021. Because of this, it is likely that silt deposition occurs within each backbay from the turbid water of the reservoir mainstem.

Nearshore habitat and aquatic macrophyte monitoring was conducted annually in the first three years following reservoir impoundment to document early conditions and changes. Going forward, changes are expected to occur at a reduced rate; thus monitoring will be conducted every three years (next in 2026). Surveys will be repeated using the same methods to document changes to nearshore habitats as the Keeyask reservoir ages over the long-term.

# 6.0 SUMMARY AND CONCLUSIONS

The primary objective of nearshore habitat monitoring is to monitor changes in shallow flooded areas that will develop into new nearshore and aquatic macrophyte habitat as the Keeyask reservoir ages. Sampling over the first three years after impoundment occurred during a range of flow conditions. In August 2021, river discharge (as measured at the outflow from Split Lake) was near or lower than 5$^{th}$ percentile flows. In contrast, near record high flows were observed in August 2022, measuring between 95$^{th}$ and 100$^{th}$ percentile, while near median flows (50$^{th}$ percentile) were observed in 2023.

Key questions addressed through aquatic habitat monitoring during Keeyask GS operation are:

- *How will nearshore habitat develop in the Keeyask reservoir?*
- *How will aquatic macrophyte habitat develop in the Keeyask reservoir?*
- *How precise were the predictions in the EIS?*

Overall, nearshore, aquatic macrophyte habitats in the Keeyask reservoir appear to be developing faster than what was predicted in the EIS. It was predicted that macrophyte habitat in nearshore areas of the Keeyask reservoir may take up to 15 years to develop, depending on site conditions. It was further predicted that when aquatic macrophytes did establish in the Keeyask reservoir, Richardson pondweed would be found in the nearshore areas located close to the Keeyask reservoir mainstem, while Watermilfoil would establish within the flooded reservoir backbays. Rooted macrophytes have established in the Keeyask reservoir by the third year following impoundment, including in sites that were previously terrestrial habitats. By the third year following reservoir impoundment, Watermilfoil was the only rooted aquatic macrophyte observed in any of the three nearshore areas located near the Keeyask reservoir mainstem and not Richardson pondweed as predicted. In contrast, eight different species of rooted aquatic vegetations were present within the flooded backbays (including both Richardson pondweed and Watermilfoil).

Substrates within the nearshore habitats more closely resemble what was predicted in the EIS. Immediately after flooding, it was predicted that substrates in the nearshore areas would be heterogeneous, composed of flooded terrestrial habitat, especially at the ends of the flooded backbays. In these areas, where humic waters predominate, it was predicted that silt sediments deposition, originating from the turbid waters of the main reservoir, would not occur. Organic and flooded terrestrial substrates were the most common substrate type and were found in each of the sampling areas in the Keeyask reservoir; however, other substrate types were also present. Clay and silt were found at several sites in each area, including in those that were located entirely on pre-impoundment terrestrial habitats and within flooded backbays.

Nearshore habitat and aquatic macrophyte monitoring was conducted annually in the first three years following reservoir impoundment to document early conditions and changes. Going forward, changes are expected to occur at a reduced rate, thus monitoring will be conducted every three years (next in 2026). Surveys will be repeated using the same methods to document changes to nearshore habitats as the Keeyask reservoir ages over the long-term.

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# APPENDICES

# APPENDIX 1:
# AQUATIC MACROPHYTE OBSERVATIONS FROM THE KEEYASK RESERVOIR AND STEPHENS LAKE, 2023.

**Table A1-1: Aquatic macrophyte observations in the Keeyask reservoir upstream of Birthday Rapids (MS1), 2023.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS1-1 | 331895 | 6241967 | 1.1 | Yes | Potamogeton richardsonii | Richardson pondweed | Abundant |
| MS1-2 | 332002 | 6242025 | 0.3 | Yes | Stuckenia pectinata | Sago pondweed | Common |
| | | | | | *Potamogeton richardsonii* | Richardson pondweed | Sparse |
| | | | | | *Utricularia* spp. | Bladderwort | Sparse |
| MS1-3 | 331943 | 6242058 | 2.4 | No | - | - | - |
| MS1-4 | 332200 | 6242071 | 0.5 | Yes | *Stuckenia pectinata* | Sago pondweed | Common |
| | | | | | *Potamogeton richardsonii* | Richardson pondweed | Sparse |
| | | | | | *Utricularia* spp. | Bladderwort | Sparse |
| | | | | | *Potamogeton gramineus* | Variable-leaf pondweed | Sparse |
| MS1-6 | 332119 | 6242099 | 0.9 | Yes | *Stuckenia pectinata* | Sago pondweed | Abundant |
| MS1-7 | 332323 | 6242111 | 0.5 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| | | | | | *Potamogeton richardsonii* | Richardson pondweed | Sparse |
| MS1-8 | 332313 | 6242122 | 0.1 | Yes | *Potamogeton richardsonii* | Richardson pondweed | Common |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Sparse |
| | | | | | *Stuckenia pectinata* | Sago pondweed | Sparse |
| | | | | | *Potamogeton gramineus* | Variable-leaf pondweed | Sparse |
| MS1-9 | 332108 | 6242205 | 1.0 | Yes | *Stuckenia pectinata* | Sago pondweed | Abundant |
| | | | | | *Potamogeton richardsonii* | Richardson pondweed | Sparse |
| | | | | | *Stuckenia pectinata* | Sago pondweed | Common |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Common |
| | | | | | *Potamogeton richardsonii* | Richardson pondweed | Common |
| MS1-10 | 332266 | 6242180 | 0.4 | Yes | *Stuckenia pectinata* | Sago pondweed | Common |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Common |
| | | | | | *Potamogeton richardsonii* | Richardson pondweed | Common |

**Table A1-1: Continued.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS1-11 | 331981 | 6242321 | 3.7 | No | - | - | - |
| MS1-12 | 332192 | 6242264 | 0.6 | Yes | *Stuckenia pectinata* | Sago pondweed | Abundant |
| | | | | | *Potamogeton richardsonii* | Richardson pondweed | Sparse |
| | | | | | *Potamogeton gramineus* | Variable-leaf pondweed | Sparse |
| MS1-13 | 332120 | 6242347 | 0.7 | Yes | *Potamogeton richardsonii* | Richardson pondweed | Common |
| | | | | | *Stuckenia pectinata* | Sago pondweed | Sparse |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Sparse |
| MS1-15 | 332017 | 6242379 | 1.1 | No | - | - | - |
| MS1-19A | 331970 | 6242205 | 8.3 | No | - | - | - |

**Table A1-2: Aquatic macrophyte observations in the Keeyask reservoir downstream of Birthday Rapids (MS2), 2023.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS2-4 | 333871 | 6243063 | 2.4 | No | - | - | - |
| MS2-5 | 333777 | 6243117 | 4.8 | No | - | - | - |
| MS2-7 | 333915 | 6243141 | 6.5 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| MS2-8 | 334051 | 6243114 | 3.3 | No | - | - | - |
| MS2-11 | 334123 | 6243201 | 1.5 | Yes | *Myriophyllum* spp. | Watermilfoil | Common |
| | | | | | *Elodea canadensis* | Canada waterweed | Common |
| | | | | | *Stuckenia pectinata* | Sago pondweed | Sparse |
| MS2-12 | 333966 | 6243241 | 4.5 | No | - | - | - |
| MS2-14 | 334038 | 6243376 | 4.8 | No | - | - | - |
| MS2-17A | 334004 | 6243089 | 3.4 | No | - | - | - |

**Table A1-3: Aquatic macrophyte observations in the Keeyask reservoir flooded backbay Zone 4 (MS3), 2023.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS3-1 | 340391 | 6244464 | 3.0 | Yes | *Utricularia* spp. | Bladderwort | Common |
| | | | | | *Persicaria amphibia* | Water knotweed | Common |
| MS3-2 | 340039 | 6244515 | 3.5 | No | - | - | - |
| MS3-3 | 340555 | 6244613 | 3.9 | No | - | - | - |
| MS3-4 | 340755 | 6244591 | 4.1 | No | - | - | - |
| MS3-5 | 341038 | 6244664 | 1.3 | No | - | - | - |
| MS3-6 | 340338 | 6244704 | 3.9 | No | - | - | - |
| MS3-7 | 340843 | 6244736 | 1.6 | No | - | - | - |
| MS3-9 | 339543 | 6245101 | 3.7 | No | - | - | - |
| MS3-10 | 339847 | 6245110 | 1.6 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| MS3-11 | 340301 | 6245082 | 0.7 | Yes | *Utricularia* spp. | Bladderwort | Abundant |
| MS3-12 | 339152 | 6245226 | 1.3 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| MS3-13 | 339354 | 6245423 | 4.2 | No | - | - | - |
| MS3-14 | 339645 | 6245622 | 3.7 | No | - | - | - |
| MS3-15 | 339955 | 6245709 | 1.6 | Yes | *Elodea canadensis* | Canada waterweed | Abundant |
| | | | | | *Utricularia* spp. | Bladderwort | Sparse |
| MS3-17A | 338966 | 6245444 | 4.1 | No | - | - | - |

**Table A1-4: Aquatic macrophyte observations in the Keeyask reservoir flooded backbay Zone 12 (MS4), 2023.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS4-7 | 352633 | 6241056 | 1.1 | Yes | *Lemna trisulca* | Star duckweed | Common |
| MS4-8 | 353505 | 6241166 | 0.5 | Yes | *Utricularia* spp. | Bladderwort | Common |
| | | | | | *Lemna trisulca* | Star duckweed | Common |
| | | | | | *Myriophyllum spp.* | Watermilfoil | Sparse |
| | | | | | *Potamogeton zosteriformis* | Flat-stemmed pondweed | Sparse |
| MS4-9 | 352904 | 6241279 | 0.9 | No | - | - | - |
| MS4-10 | 353547 | 6241371 | 1.4 | Yes | *Lemna trisulca* | Star duckweed | Abundant |
| MS4-11 | 353344 | 6241427 | 0.3 | Yes | *Lemna trisulca* | Star duckweed | Abundant |
| MS4-12 | 353050 | 6241589 | 2.5 | No | - | - | - |
| MS4-13 | 353556 | 6241579 | 1.0 | Yes | *Utricularia* spp. | Bladderwort | Abundant |
| | | | | | *Lemna trisulca* | Star duckweed | Sparse |
| MS4-14 | 353357 | 6241664 | 3.0 | Yes | *Lemna trisulca* | Star duckweed | Abundant |
| MS4-15 | 353445 | 6241690 | 1.6 | Yes | *Lemna trisulca* | Star duckweed | Abundant |
| MS4-16A | 352779 | 6241256 | 0.9 | No | - | - | - |
| MS4-17A | 353050 | 6241456 | 0.9 | Yes | *Lemna trisulca* | Star duckweed | Abundant |
| MS4-18A | 352430 | 6240984 | 1.4 | Yes | *Lemna trisulca* | Star duckweed | Abundant |
| MS4-20A | 353398 | 6241316 | 0.9 | Yes | *Utricularia* spp. | Bladderwort | Abundant |
| | | | | | *Elodea canadensis* | Canada waterweed | Sparse |
| | | | | | *Ranunculus aquatilis* | Whitewater buttercup | Sparse |
| MS4-21 | 351990 | 6240201 | 0.9 | Yes | *Utricularia* spp. | Bladderwort | Common |
| | | | | | *Lemna trisulca* | Star duckweed | Common |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Common |
| MS4-22 | 352008 | 6240367 | 0.9 | Yes | *Lemna trisulca* | Star duckweed | Common |
| | | | | | *Utricularia* spp. | Bladderwort | Common |
| | | | | | *Elodea canadensis* | Canada waterweed | Common |
| MS4-23 | 352068 | 6240517 | 1.0 | Yes | *Lemna trisulca* | Star duckweed | Abundant |
| MS4-24 | 352120 | 6240650 | 1.5 | Yes | *Lemna trisulca* | Star duckweed | Abundant |
| | | | | | *Utricularia* spp. | Bladderwort | Sparse |

**Table A1-5: Aquatic macrophyte observations in the Keeyask reservoir south shore of Gull Lake (MS5), 2023.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS5-1 | 353888 | 6242891 | 2.0 | No | - | - | - |
| MS5-4 | 354043 | 6243079 | 1.5 | No | - | - | - |
| MS5-5 | 353952 | 6243265 | 2.4 | No | - | - | - |
| MS5-6 | 354053 | 6243568 | 8.2 | No | - | - | - |
| MS5-7 | 354749 | 6243565 | 1.7 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| MS5-9 | 354265 | 6243780 | 5.1 | No | - | - | - |
| MS5-10 | 354644 | 6243760 | 2.5 | No | - | - | - |
| MS5-18A | 353802 | 6243093 | 2.3 | No | - | - | - |
| MS5-19 | 353667 | 6242721 | 0.5 | Yes | *Utricularia* spp. | Bladderwort | Abundant |
| MS5-20 | 353939 | 6242822 | 1.9 | Yes | *Utricularia* spp. | Bladderwort | Abundant |
| MS5-21 | 354612 | 6243625 | 1.2 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| MS5-22 | 354919 | 6243459 | 1.6 | No | - | - | - |
| MS5-23 | 355089 | 6243305 | 0.5 | No | - | - | - |
| MS5-24 | 355042 | 6242976 | 0.5 | Yes | *Utricularia* spp. | Bladderwort | Abundant |

**Table A1-6: Aquatic macrophyte observations in the Keeyask reservoir north shore of Gull Lake (MS6), 2023.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS6-1 | 353849 | 6245671 | 6.3 | No | - | - | - |
| MS6-2 | 353452 | 6245781 | 4.5 | No | - | - | - |
| MS6-3 | 353656 | 6245782 | 5.5 | No | - | - | - |
| MS6-4 | 353218 | 6245842 | 0.6 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| MS6-5 | 353069 | 6245981 | 0.5 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| MS6-6 | 353439 | 6245877 | 1.0 | No | - | - | - |
| MS6-7 | 353650 | 6245977 | 1.2 | No | - | - | - |
| MS6-8A | 353725 | 6246167 | 1.3 | No | - | - | - |
| MS6-10A | 353508 | 6245996 | 0.4 | No | - | - | - |
| MS6-11 | 353581 | 6246158 | 1.0 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| MS6-12 | 354065 | 6246167 | 4.2 | No | - | - | - |
| MS6-14 | 353753 | 6246373 | 0.5 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| MS6-17b | 353760 | 6246478 | 0.3 | Yes | *Lemna trisulca* | Star duckweed | Abundant |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Sparse |
| MS6-18A | 352975 | 6246134 | 0.7 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| MS6-20A | 353782 | 6245880 | 0.8 | No | - | - | - |

**Table A1-7: Aquatic macrophyte observations in the Keeyask reservoir flooded backbay Zone 7 (MS7), 2023.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS7-1 | 350643 | 6246572 | 1.8 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| MS7-2 | 350945 | 6246573 | 5.5 | No | - | - | - |
| MS7-3 | 351263 | 6246654 | 2.3 | No | - | - | - |
| MS7-4 | 351552 | 6246712 | 0.2 | Yes | *Lemna trisulca* | Star duckweed | Abundant |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Sparse |
| MS7-5 | 351059 | 6246848 | 1.9 | No | - | - | - |
| MS7-6A | 350731 | 6247022 | 0.5 | Yes | *Myriophyllum* spp. | Watermilfoil | Abundant |
| | | | | | *Nuphar spp.* | Lily | Sparse |
| | | | | | *Carex* spp. | Sedges | Sparse |
| MS7-7 | 350875 | 6246946 | 0.3 | Yes | *Utricularia* spp. | Bladderwort | Common |
| | | | | | *Calla palustris* | Bog arum | Common |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Sparse |
| MS7-8 | 351399 | 6246843 | 1.0 | Yes | *Lemna trisulca* | Star duckweed | Abundant |
| MS7-9 | 350676 | 6247072 | 1.4 | Yes | *Myriophyllum* spp. | Watermilfoil | Common |
| | | | | | *Utricularia* spp. | Bladderwort | Sparse |
| | | | | | *Nuphar* spp. | Lily | Sparse |
| MS7-10 | 350842 | 6247190 | 1.5 | Yes | *Nuphar* spp. | Lily | Common |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Sparse |
| | | | | | *Lemna trisulca* | Star duckweed | Sparse |
| MS7-16A | 350796 | 6247062 | 1.8 | Yes | *Nuphar* spp. | Lily | Common |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Sparse |
| | | | | | *Lemna trisulca* | Star duckweed | Sparse |
| | | | | | Bryophytes | liverworts, hornworts and mosses | Sparse |
| MS7-18A | 351407 | 6246628 | 2.7 | No | - | - | - |
| MS7-19 | 350855 | 6246728 | 1.5 | Yes | *Utricularia* spp. | Bladderwort | Common |
| | | | | | *Najas* spp. | Water nymph | Common |

**Table A1-8: Aquatic macrophyte observations in the Keeyask reservoir flooded backbay Zone 8 (MS8), 2023.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS8-3 | 353709 | 6249328 | 0.2 | Yes | *Utricularia* spp. | Bladderwort | Common |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Common |
| | | | | | *Lemna trisulca* | Star duckweed | Sparse |
| MS8-4 | 353958 | 6249289 | 1.9 | Yes | *Myriophyllum* spp. | Watermilfoil | Common |
| | | | | | *Elodea canadensis* | Canada waterweed | Sparse |
| | | | | | *Utricularia* spp. | Bladderwort | Sparse |
| MS8-5 | 353445 | 6249414 | 0.6 | Yes | *Utricularia* spp. | Bladderwort | Abundant |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Sparse |
| | | | | | *Lemna trisulca* | Star duckweed | Sparse |
| MS8-6 | 353752 | 6249367 | 1.9 | No | - | - | - |
| MS8-7 | 353314 | 6249502 | 0.1 | Yes | *Myriophyllum* spp. | Watermilfoil | Common |
| | | | | | *Najas* spp. | Water nymph | Sparse |
| | | | | | *Ceratophyllum* spp. | Hornwort | Sparse |
| MS8-16A | 353869 | 6249380 | 1.4 | Yes | *Utricularia* spp. | Bladderwort | Common |
| | | | | | *Potamogeton zosteriformis* | Flat-stemmed pondweed | Sparse |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Sparse |
| | | | | | *Lemna trisulca* | Star duckweed | Sparse |
| MS8-17A | 353967 | 6249113 | 0.7 | No | - | - | - |
| MS8-19A | 353641 | 6249399 | 0.1 | Yes | *Utricularia* spp. | Bladderwort | Common |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Common |
| | | | | | *Lemna trisulca* | Star duckweed | Sparse |
| MS8-20A | 353373 | 6249510 | 0.7 | Yes | *Utricularia* spp. | Bladderwort | Common |
| | | | | | *Lemna trisulca* | Star duckweed | Sparse |
| | | | | | *Ranunculus aquatilis* | Whitewater buttercup | Sparse |
| | | | | | *Persicaria amphibia* | Water knotweed | Sparse |

**Table A1-9: Aquatic macrophyte observations in the Keeyask reservoir in lower Gull Lake (MS9), 2023.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS9-1 | 359295 | 6246600 | 5.2 | No | - | - | - |
| MS9-2 | 360062 | 6246752 | 4.2 | No | - | - | - |
| MS9-3 | 360545 | 6246801 | 4.2 | No | - | - | - |
| MS9-4 | 359004 | 6246756 | 3.3 | No | - | - | - |
| MS9-5 | 359184 | 6246978 | 2.7 | No | - | - | - |
| MS9-6 | 360643 | 6246966 | 4.2 | No | - | - | - |
| MS9-7 | 359848 | 6247073 | 3.3 | No | - | - | - |
| MS9-8 | 360154 | 6247272 | 2.8 | No | - | - | - |
| MS9-9 | 358291 | 6247502 | 6.4 | No | - | - | - |
| MS9-10 | 358091 | 6247900 | 2.2 | No | - | - | - |
| MS9-11 | 358461 | 6247874 | 2.1 | Yes | *Lemna trisulca* | Star duckweed | Abundant |
| MS9-12 | 358217 | 6248169 | 4.9 | No | - | - | - |
| MS9-13 | 358850 | 6248170 | 3.2 | No | - | - | - |
| MS9-14 | 359354 | 6248168 | 5.6 | No | - | - | - |
| MS9-15 | 359639 | 6248231 | 4.0 | No | - | - | - |
| MS9-16 | 359501 | 6246931 | 2.4 | No | - | - | - |
| MS9-17 | 359823 | 6246890 | 4.0 | No | - | - | - |
| MS9-18 | 360257 | 6247009 | 5.5 | No | - | - | - |
| MS9-19 | 358781 | 6247083 | 1.9 | No | - | - | - |
| MS9-20 | 358358 | 6247518 | 5.7 | No | - | - | - |
| MS9-21 | 358305 | 6247757 | 3.2 | No | - | - | - |
| MS9-22 | 358621 | 6248043 | 3.4 | No | - | - | - |

**Table A1-10: Aquatic macrophyte observations from Stephens Lake (MS10), 2023.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS10-1 | 367647 | 6249775 | 0.3 | No | - | - | - |
| MS10-2 | 367453 | 6249901 | 0.9 | No | - | - | - |
| MS10-3 | 367748 | 6249826 | 1.7 | No | - | - | - |
| MS10-4 | 367454 | 6250067 | 1.9 | Yes | *Stuckenia pectinata* | Sago pondweed | Abundant |
| MS10-5 | 367158 | 6250183 | 0.5 | Yes | *Potamogeton richardsonii* | Richardson pondweed | Abundant |
| MS10-6 | 367371 | 6250171 | 1.7 | No | - | - | - |
| MS10-7 | 367568 | 6250166 | 2.1 | No | - | - | - |
| MS10-8 | 367153 | 6250276 | 0.6 | Yes | *Potamogeton richardsonii* | Richardson pondweed | Abundant |
| | | | | | *Ranunculus aquatilis* | Whitewater buttercup | Sparse |
| MS10-9 | 367134 | 6250331 | 0.6 | Yes | *Potamogeton richardsonii* | Richardson pondweed | Abundant |
| | | | | | *Stuckenia pectinata* | Sago pondweed | Sparse |
| MS10-10 | 367459 | 6250366 | 2.9 | No | - | - | - |
| MS10-11 | 367252 | 6250468 | 1.2 | Yes | *Stuckenia* spp. | Pondweed | Abundant |
| MS10-12 | 367866 | 6250463 | 7.8 | No | - | - | - |
| MS10-13 | 367450 | 6250674 | 2.2 | No | - | - | - |
| MS10-14 | 367749 | 6250867 | 3.5 | No | - | - | - |
| MS10-15 | 367696 | 6250874 | 0.9 | Yes | *Potamogeton richardsonii* | Richardson pondweed | Abundant |

**Table A1-11: Aquatic macrophyte observations from Stephens Lake (MS11), 2023.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS11-1 | 369056 | 6251187 | 4.1 | No | - | - | - |
| MS11-2 | 368754 | 6251263 | 3.2 | No | - | - | - |
| MS11-3 | 368532 | 6251356 | 1.2 | Yes | *Potamogeton richardsonii* | Richardson pondweed | Common |
| | | | | | *Ranunculus aquatilis* | Whitewater buttercup | Common |
| | | | | | *Myriophyllum* spp. | Watermilfoil | Sparse |
| | | | | | *Stuckenia pectinata* | Sago pondweed | Sparse |
| MS11-4 | 368949 | 6251387 | 1.8 | No | - | - | - |
| MS11-5 | 368564 | 6251484 | 0.6 | Yes | *Potamogeton richardsonii* | Richardson pondweed | Abundant |
| MS11-6 | 369168 | 6251566 | 1.7 | No | - | - | - |
| MS11-7 | 368952 | 6251636 | 1.8 | No | - | - | - |
| MS11-8 | 369449 | 6251664 | 2.9 | No | - | - | - |
| MS11-9 | 368954 | 6251744 | 2.0 | No | - | - | - |
| MS11-10 | 368846 | 6251837 | 0.8 | Yes | *Potamogeton richardsonii* | Richardson pondweed | Abundant |
| | | | | | *Persicaria amphibia* | Water knotweed | Sparse |
| | | | | | *Stuckenia vaginata* | Sheathed pondweed | Sparse |
| MS11-11 | 369060 | 6251848 | 1.3 | No | - | - | - |
| MS11-12 | 369262 | 6251863 | 2.8 | Yes | *Najas* spp. | Water nymph | Common |
| MS11-13 | 369454 | 6251862 | 5.9 | No | - | - | - |
| MS11-14 | 369390 | 6252107 | 7.4 | No | - | - | - |
| MS11-15 | 369280 | 6252057 | 1.2 | No | - | - | - |

**Table A1-12: Aquatic macrophyte observations from Stephens Lake (MS12), 2023.**

| Site | Location | | Water Depth (m) | Plant Presence | Aquatic Plant Species | | |
|---|---|---|---|---|---|---|---|
| | Easting | Northing | | | Scientific Name | Common Name | Abundance |
| MS12-1 | 369859 | 6254962 | 1.9 | No | - | - | - |
| MS12-2 | 369552 | 6255056 | 1.7 | No | - | - | - |
| MS12-3 | 369551 | 6255173 | 2.0 | No | - | - | - |
| MS12-4 | 369956 | 6255266 | 2.5 | No | - | - | - |
| MS12-5 | 370259 | 6255273 | 4.5 | No | - | - | - |
| MS12-6 | 369455 | 6255355 | 1.0 | No | - | - | - |
| MS12-7 | 369645 | 6255429 | 0.5 | Yes | *Potamogeton richardsonii* | Richardson pondweed | Abundant |
| MS12-8 | 369804 | 6255505 | 0.4 | No | - | - | - |
| MS12-9 | 370352 | 6255569 | 5.0 | No | - | - | - |
| MS12-10 | 370054 | 6255672 | 1.6 | No | - | - | - |
| MS12-11 | 370660 | 6255672 | 5.3 | No | - | - | - |
| MS12-12 | 369958 | 6255872 | 2.6 | No | - | - | - |
| MS12-13 | 370357 | 6255868 | 7.0 | No | - | - | - |
| MS12-14 | 370560 | 6255971 | 7.4 | No | - | - | - |
| MS12-15 | 370364 | 6256079 | 7.8 | No | - | - | - |