Keeyask Generation Project

Physical Environment Monitoring Plan

KEEYASK
Hydropower Limited Partnership

Manitoba Conservation and Water Stewardship Client File 5550.00
Manitoba Environment Act Licence No. 3107

October 2015

KEEYASK GENERATION PROJECT
PHYSICAL ENVIRONMENT
MONITORING PLAN

Prepared by

Keeyask Hydropower Limited Partnership

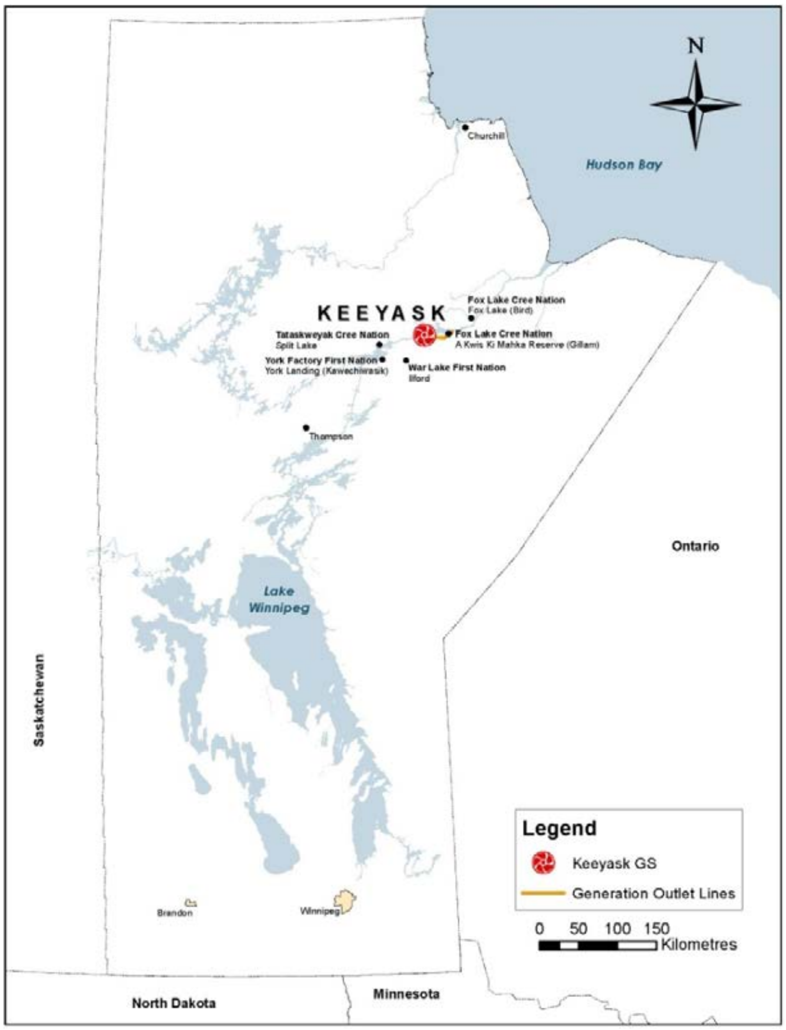
Winnipeg, Manitoba

October 2015

PREFACE

KEEYASK ENVIRONMENTAL PROTECTION PROGRAM

An Environmental Protection Program (the Program) has been developed to mitigate, manage and monitor potential environmental effects described in the *Keeyask Generation Project: Response to EIS Guidelines* during the construction and operation phases of the Keeyask Generation Project (the Project) shown on Map 1. The Program includes a collection of plans grouped in the following categories: Environmental Protection Plans, Environmental Management Plans, and Environmental Monitoring Plans.



Map 1: Location of Keeyask Generation Project

Figure 1 lists all of the plans included in the Program. It also demonstrates how the Program will be managed. The Keeyask Hydropower Limited Partnership (the Partnership) has delegated authority to Manitoba Hydro to manage construction and operation of the Project including implementation of the Program. The organizational structure of the Partnership for this aspect of the Project includes a Monitoring Advisory Committee (MAC), which includes participants from each of the Keeyask Cree Nations (KCNs) and Manitoba Hydro. Manitoba Hydro will be guided on the implementation of the Program by the MAC, the Partnership Board of Directors and ongoing discussion with Regulators.

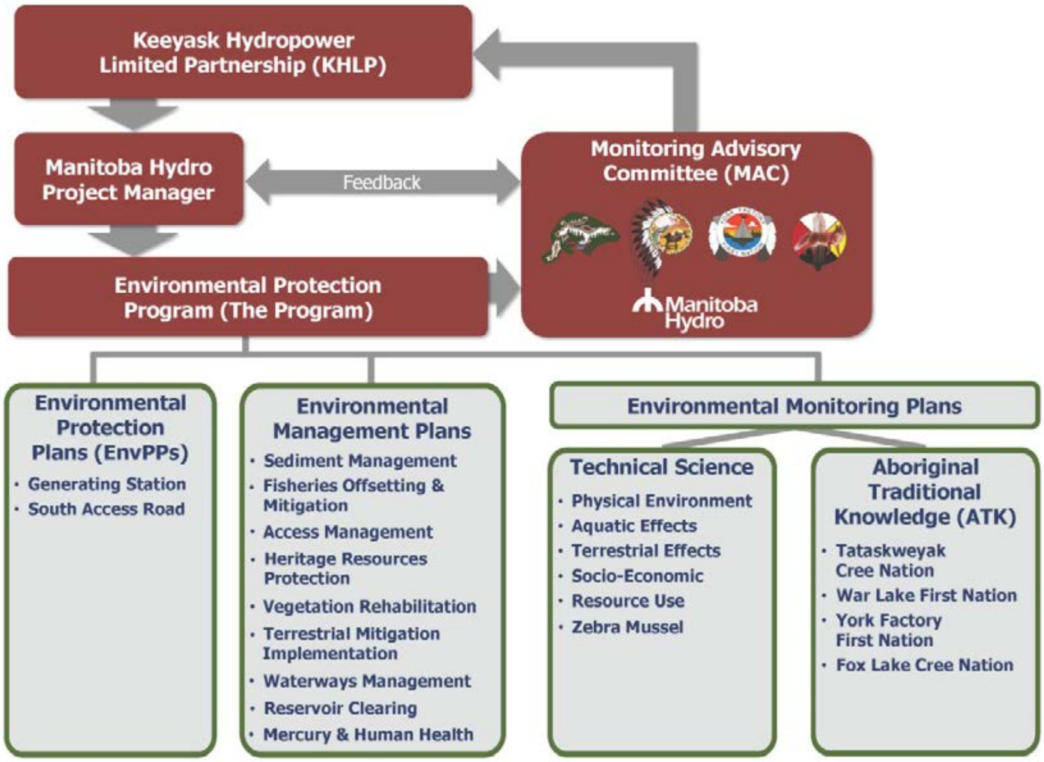


Figure 1: Environmental Protection Program

The Environmental Protection Plans (EnvPPs) provide detailed, site-specific environmental protection measures to be implemented by the contractors and construction staff to minimize environmental effects from construction of the generating station and south access road. They are designed for use as reference documents providing the best management practices to meet or exceed regulatory requirements. EnvPPs are organized by construction activity, highlighting measures to reduce the impact of a specific work activity (e.g., tree clearing or material placement in water). Contractors' compliance with the EnvPPs is a contractual obligation. Under Manitoba Hydro's construction site management, a Site Environmental Lead will be responsible for monitoring compliance and determining when corrective actions are required.

The Environmental Management Plans focus on minimizing effects on specific environmental parameters. They outline specific actions that must be taken during construction and in some cases into the operational phase to mitigate Project effects. The management plans include monitoring to determine success of the actions taken and to determine other actions that need to be undertaken (adaptive management). Implementation of these plans will involve Manitoba

Hydro's staff, the KCNs, specialized consultants and contractors under the direction of the Project Manager.

The Environmental Monitoring Plans are designed to measure the actual effects of the Project, test predictions or identify unanticipated effects. During the course of the environmental assessment, numerous requirements for monitoring were identified. There will be both technical science monitoring and Aboriginal Traditional Knowledge (ATK) monitoring undertaken. The technical science monitoring will be conducted by Manitoba Hydro and specialized consultants contracted by Manitoba Hydro, who will in turn hire members of the KCNs to work with them to fulfil the monitoring activities. Manitoba Hydro will also have contracts with each of the KCNs to undertake ATK monitoring of the project.

The activities that occur and the results generated from the Environmental Protection Program will be discussed at MAC meetings. The MAC is an advisory committee to the Partnership Board of Directors and will review outcomes of the programs and, if appropriate provide advice and recommendations to the Partnership on additional monitoring or alternative mitigation measures that may be required. The MAC will provide a forum for collaboration among all partners. On behalf of the Partnership, the MAC will also ensure that the outcomes of the Environmental Protection Program are communicated more broadly on an annual basis to Members of the KCNs, regulators and the general public.

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ADCP	acoustic doppler current profiler
AEMP	Aquatic Effects Monitoring Plan
ASL	above sea level
DO	dissolved oxygen
DOC	dissolved organic carbon
EIS	environmental impact statement
FSL	full supply level
GHG	greenhouse gas
GPS	geographic positioning system
G.S.	generating station
JKDA	Joint Keeyask Development Agreement
KCNs	Keeyask Cree Nations
KHLP	Keeyask Hydropower Limited Partnership
MAC	Monitoring Advisory Committee
PD SV	Project Description Supporting Volume
POC	particulate organic carbon
PEMP	Physical Environment Monitoring Plan
PE SV	Physical Environment Supporting Volume
TC	total carbon
TDG	total dissolved gas
TOC	total organic carbon
TEMP	Terrestrial Effects Monitoring Plan
TSS	total suspended sediment

1.0 INTRODUCTION

1.1 BACKGROUND

This document describes the Physical Effects Monitoring Plan (PEMP) for the Keeyask Generation Project (the Project), a 695 megawatt (MW) hydroelectric generating station and associated facilities at Gull Rapids on the lower Nelson River in northern Manitoba immediately upstream of Stephens Lake. The Project will be located entirely within the Split Lake Resource Management Area. The Project is approximately 725 kilometres (km) northeast of Winnipeg, 35 km upstream of the existing Kettle Generating Station, where Gull Lake flows into Stephens Lake, 60 km east of the community of Split Lake, 180 km east-northeast of Thompson and 30 km west of Gillam (Map 1-1).

The *Keeyask Generation Project: Response to EIS Guidelines* (EIS), and *Physical Environment Supporting Volume* (PE SV) completed in June 2012, provide a summary of predicted effects, planned mitigation and monitoring for the Project. The PEMP provides details on monitoring and follow-up related to the physical environment based on the assessment and feedback received through the regulatory process. Monitoring and follow-up activities focus on effects to key components of the physical environment to:

- Determine if EIS predictions of effects on the physical environment are correct and to identify unanticipated effects.
- Support other monitoring programs (e.g., aquatic and terrestrial) that will monitor Project effects and determine the effectiveness of mitigation/offsetting measures.

The environmental components that will be monitored under the PEMP include the following:

- surface water (level/depth) and **ice-regimes**,
- shoreline **erosion** and reservoir expansion over time,
- **sedimentation** (related to water quality, sediment transport and deposition),
- greenhouse gas emissions,
- woody **debris**,
- surface water temperature and **dissolved oxygen** (related to water quality and aquatic habitat), and
- total dissolved gas pressure.

This document outlines the following:

- objectives of the monitoring,
- temporal and spatial **scope** of monitoring,

- the requirements and schedule of monitoring during construction and the period of initial operation, and
- monitoring program deliverables and reporting requirements.

During the construction and operation phases, monitoring results will be reviewed to determine whether adjustments need to be made to either the temporal and/or spatial scope of monitoring activities. The teams managing and implementing other Keeyask monitoring activities (e.g., the aquatic monitoring team responsible for the Aquatic Effects Monitoring Plan (AEMP)) may identify a need for additional PEMP monitoring in support of their monitoring objectives. This may result in the expansion of planned monitoring activities or additional monitoring that is not currently anticipated.

1.2 KEEYASK CREE NATIONS PERSPECTIVES

Alongside the Response to EIS Guidelines, the Partnership also submitted to regulators the three Environmental Evaluation Reports prepared independently by the **Keeyask Cree Nations (KCNs)**. These reports document the KCNs traditional knowledge with respect to the Project environment and provide an evaluation of the proposed development from their worldview. The evaluations carried out by the KCNs identified a number of concerns pertaining to the **effects** of the Project on the physical environment. These concerns were summarized in the Keeyask EIS (Sec. 6.3.2) and are noted below along with components of the Project and the PEMP that will help address concerns expressed by the KCNs:

- Woody debris that may result due to **flooding** and erosion in the Keeyask reservoir, which may affect navigation safety, resource use, shoreline access and general aesthetics.
- The **Joint Keeyask Development Agreement (JKDA)** includes a Reservoir Clearing Plan (JKDA, Sched. 11-1) and Waterways Management Program (JKDA, Sched. 11-2) to address the KCNs' concerns regarding debris.
- The PEMP includes provision for communicating information pertaining to debris management undertaken by the Waterways Management Program.
- Changes to **water quality** due to erosion and flooding, including suspended **sediments**, within the **reservoir** and downstream.
- The PEMP includes measurement of suspended sediments and other water quality parameters (Sec. 4). The AEMP includes a comprehensive water quality monitoring program.
- Potential negative effects of erosion.
- The PEMP includes erosion, reservoir expansion and sedimentation monitoring to identify effects of the Project related to erosion (Sec. 3 and 4). The PEMP will also support the monitoring of Project effects on the aquatic and terrestrial environments due to erosion.

- Changing water levels and **flows**, including uncertainty regarding the potential to affect water levels and ice conditions on Split Lake upstream of the predicted open water **hydraulic zone of influence**.
- A fundamental operating feature of the Keeyask Project is that the operation of the Keeyask G.S. will not affect water levels on Split Lake during open water conditions (i.e., the open-water hydraulic zone of influence will not affect Split Lake). The PEMP includes water level and ice-regime monitoring to identify Project effects due to flooding and operation of the reservoir (Sec. 2). Water level data will be used to confirm that there are no unanticipated Project effects on Split Lake water levels.
- Concern that caribou calving habitat will be reduced due to flooding of islands and uncertainty as to whether new islands will form as replacement calving habitat.
- The PEMP includes monitoring of reservoir expansion and reservoir area (Sec. 3), which will allow for the monitoring of changes to and development of islands. This information will support studies related to caribou under the Terrestrial Effects Monitoring Plan (TEMP).
- Concern that future climate change will be a major factor in the future physical landscape.
- The PEMP includes monitoring of greenhouse gases produced from the reservoir (Sec. 5). The consideration of broad based regional climate change issues is beyond the scope of the PEMP.
- The effectiveness of planned **mitigation** and offsettingmeasures (e.g., constructed fish spawning areas).
- The PEMP will support the AEMP and other monitoring activities designed to confirm the effectiveness of planned mitigation and offsetting measures.

1.3 SCOPE OF PHYSICAL ENVIRONMENT MONITORING PLAN

1.3.1 TEMPORAL SCOPE

For the purposes of the PEMP, the periods over which Project related monitoring will occur are defined as:

- **CONSTRUCTION:** For the purposes of the PEMP, the construction phase is assumed to cover the period from the start of construction in 2014 until the reservoir is impounded to the **full supply level** (FSL) of 159 m **above sea level** (ASL) in 2019, although construction activity continues up to 2022 (see PD SV).

- **INITIAL OPERATION:** The first ten years of the operating phase, which is assumed to start following reservoir **impoundment** to FSL, which is when the major effects on the physical environment will begin. Construction activity will continue for more than two years after impoundment before the Project is entirely completed.
- **LONG-TERM OPERATION:** The ongoing operation following the initial operating period.

The following sections of the PEMP describe monitoring activities during the construction and initial operating phases of the Project. A summary schedule of proposed monitoring activities during construction and the initial operating periods is provided in Appendix A.

The need for and scope of monitoring in the long-term operation phase will be assessed after the initial operating period based on:

- results obtained in the initial operating period,
- regulatory requirements, and
- the long-term needs of other monitoring programs.

Relative to monitoring in the first ten years of operation, it is anticipated that long-term monitoring activities will be reduced in terms of frequency and spatial extent, or possibly discontinued for some program components.

1.3.2 SPATIAL SCOPE

The spatial extent of PEMP monitoring is largely determined by the extent of the Project's open water hydraulic zone of influence (Map 1-2). The bulk of monitoring activities will occur during operation within the main reservoir area up to about 20 km upstream of the Keeyask G.S., as this is where the majority of the flooding and related Project effects will occur. However, some monitoring will occur just upstream of the open water hydraulic zone of influence in Clark Lake, to identify background conditions, and downstream into Stephens Lake to measure downstream effects of the Project. Some sediment monitoring will also take place downstream of Stephens Lake to Limestone G.S. during certain periods of construction to determine if Project effects on suspended sediment are observed further downstream as expected. The spatial scope of monitoring activities varies depending on the parameters and timing considered as described further in Sections 2 through 8 of this plan.

Project effects differ spatially within the open water hydraulic zone of influence and monitoring is planned to capture these effects in different representative areas. Because the bulk of the monitoring activities are planned within the reservoir area between Birthday Rapids and the G.S. this area has been divided into 13 zones for reference purposes to indicate where monitoring will occur (Map 1-3). These zones are the same as the zones defined for the peatland disintegration modeling reported in the EIS (PE SV, Sec. 7, Map 7.2-3). Several terms are also used to describe different areas of the **post-Project** environment, and some of these areas may be roughly described by reference to the monitoring zones. Terms used to describe different areas within the PEMP monitoring area include:

- ***Mainstem***: The part of the reservoir through which most of the flow travels. For Keeyask, this generally corresponds to monitoring zones 1 (unhatched area), 2 and 3. The mainstem covers the original Nelson River area plus immediately adjacent flooded areas (compare Map 1-2 and Map 1-3).
- ***Backbays***: Relatively shallow bays formed due to flooding of terrestrial areas corresponding to monitoring zones 4 through 13. These areas generally have low water velocities and limited mixing with the mainstem flow.
- *Upstream* ***riverine*** *area*: The river **reach** between Clark Lake and the entrance to Gull Lake (reservoir) at the downstream end of the hatched portion of monitoring zone 1. This reach extends from about 20 km to 45 km upstream of the G.S. Flooding is generally limited in this area.
- *Entrance to Gull Lake (reservoir):* The upstream end of Gull Lake, which is at the upstream end of the unhatched portion of zone 1.
- *Entrance to Stephens Lake:* The downstream extent of the Project's open water hydraulic zone of influence (Map 1-2) is approximately 3 km downstream of the G.S. and approximately defines the entrance to Stephens Lake.
- *Stephens Lake:* The lake area downstream from the entrance to Stephens Lake to the Kettle G.S. The south arm of the lake between the proposed Keeyask G.S. and Kettle G.S. generally represents the mainstem area of this reservoir.

The descriptions above are meant to provide general descriptions of different parts of the overall physical environment monitoring area. While they are useful for identifying different parts of the monitoring area, they are not intended to define fixed boundaries between different areas.

1.3.3 Scope Review and Long-Term Monitoring

The PEMP has been developed as an adaptive plan; it is expected that results of monitoring will be regularly reviewed and monitoring adjusted based on the results. This may involve adjusting the number or location of sites being monitored, the frequency or duration of monitoring activities, as well as the spatial extent of the monitoring.

During the construction period, the annual plan for physical environment monitoring activities will consider previous results as well as the planned level of in-stream work activity during the monitoring period. During the initial period of operation, the scope of the program activities will be reviewed after fifth year of monitoring results have been obtained, although a few activities will be reviewed after year 3 as noted in the following sections of the plan. The review will consider if adjustments should be made to optimize the monitoring program over the remainder of the initial operating period. Notwithstanding the specific program review in years three and five, adjustments may be proposed at other times based on monitoring results. Proposed adjustments would take into consideration any regulatory requirements and the needs of other monitoring programs (e.g., AEMP).

At the end of the initial operating period (i.e., the first ten years after impoundment) the requirements for physical environment monitoring in the long-term operating period will be assessed. This assessment will take into consideration the monitoring results from the initial operating period, observed Project effects relative to predictions in the Keeyask EIS, regulatory requirements, and the needs of other monitoring programs. The output of this review will be a revised PEMP for a period of time (e.g., 10 years) following the initial operating period, which will include subsequent reviews of monitoring requirements.

1.4 SAFETY

The safety of equipment, property and, most importantly, personnel is of primary importance in the performance of all PEMP activities. Monitoring during construction and operation will require field crews and equipment to operate in potentially challenging environments. During open water seasons there may be a number of potential hazards, particularly due to high water velocities and turbulent flow conditions that exist in some areas (e.g., near rapids). In winter, thin ice and near freezing water temperatures may pose a risk. PEMP monitoring activities may be adjusted or cancelled at certain times and locations based on safety considerations. Field crews will have the discretion to determine whether or not any planned activity poses an unacceptable risk to the safety of people or equipment based on conditions encountered in the field.

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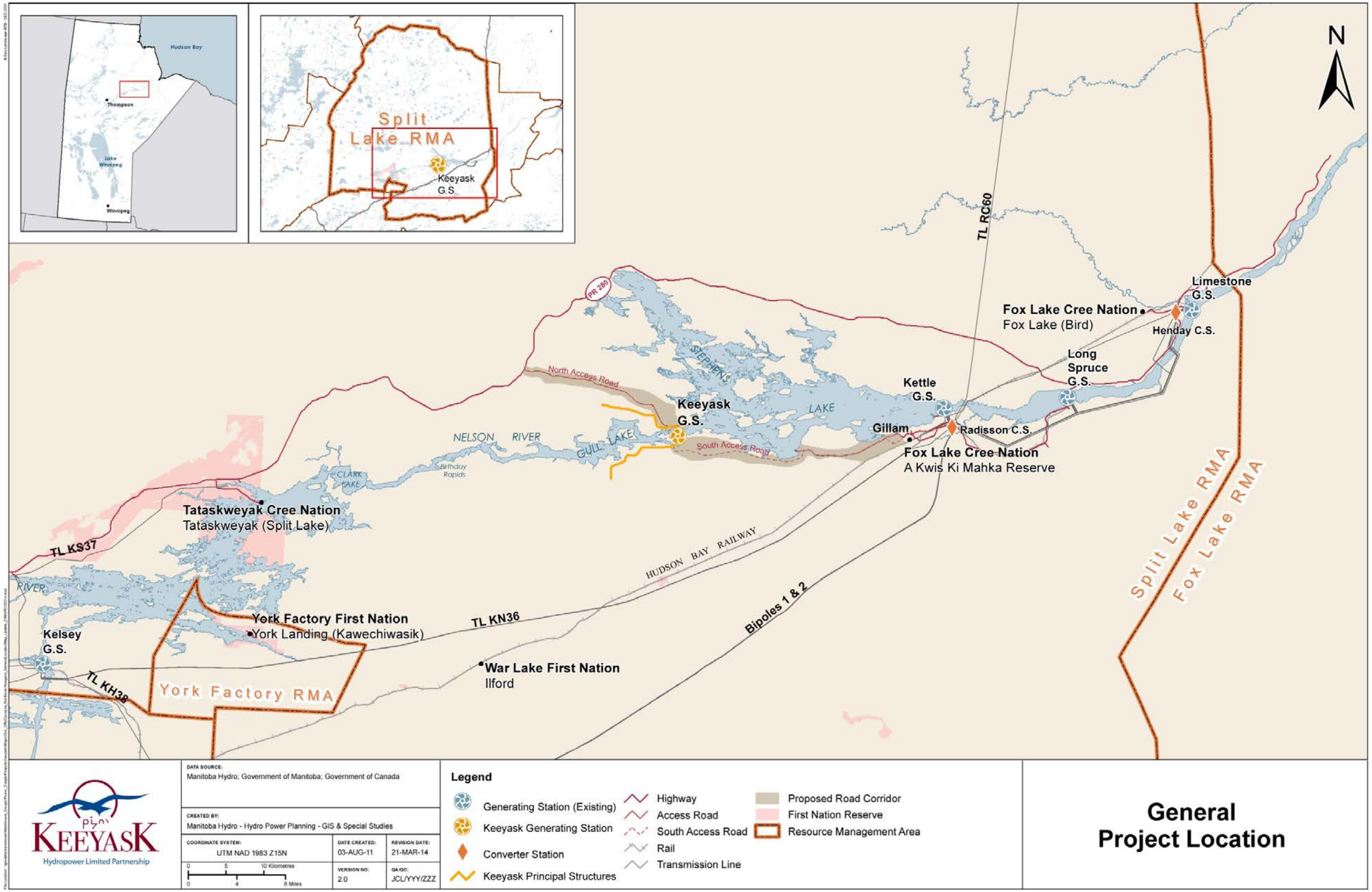

Map 1-1: **General Project Location**

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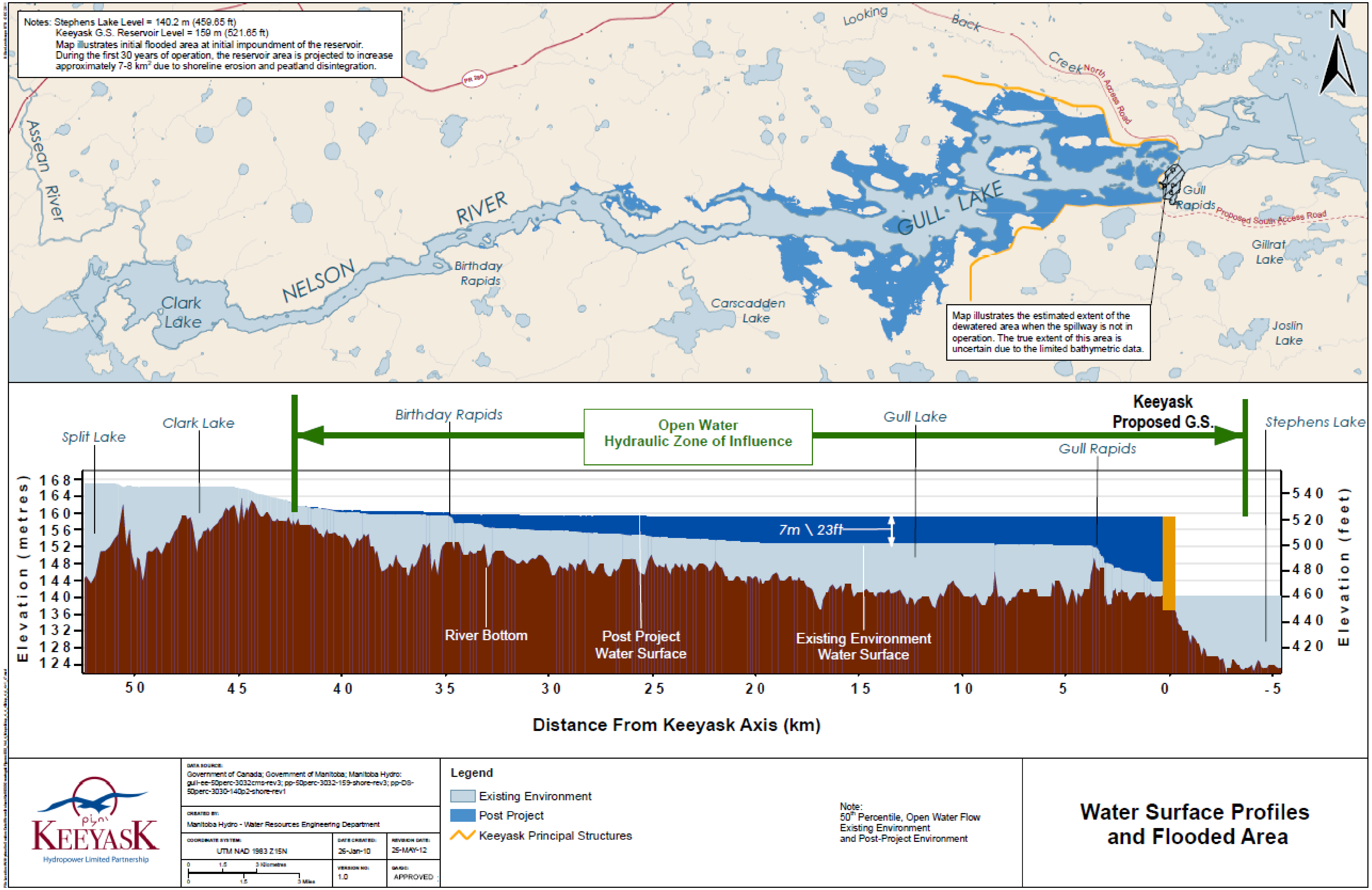

(source: PE SV, Figure 4.4-4)

Map 1-2: Water Surface Profiles and Flooded Area

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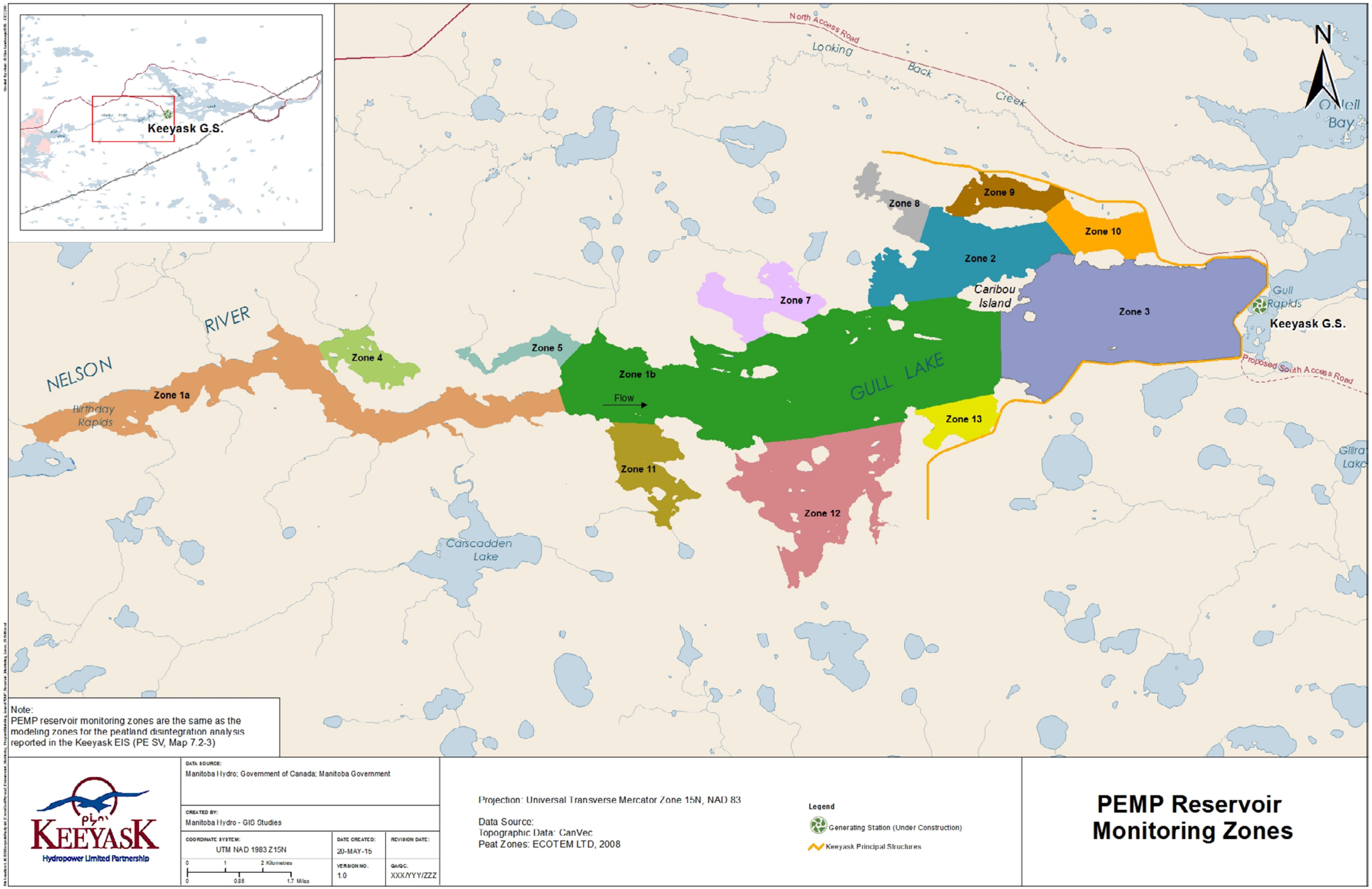

Map 1-3: **PEMP Reservoir Monitoring Zones – Birthday Rapids to Keeyask Generating Station**

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2.0 SURFACE WATER AND ICE-REGIMES

2.1 BACKGROUND

This section describes surface water and ice regime monitoring during construction and operation of the Project. The **water regime** and ice parameters include:

- water level,
- water depth / river and lakebottom elevation,
- water velocity, and
- ice cover.

The objectives of the water and ice regime monitoring include:

- Determining water level regime and verifying expected changes in water levels resulting from the Project;
- Confirming that there are no unanticipated Project effects on Split Lake water levels;
- Determining water depth/bottom elevation and velocity information to support monitoring being performed under the AEMP;
- Measuring ice conditions to support understanding of winter water levels, which may be affected by ice processes; and
- Confirming that future ice conditions during operation are consistent with predicted effects reported in the EIS.

Water regime monitoring, particularly water level measurement, is important not only to identify effects of the Project relative to pre-Project conditions but also to support monitoring of other Project effects through other monitoring programs like the AEMP. It is also relevant to understanding and interpreting results that may be observed from other monitoring activities such as erosion and suspended sediment monitoring.

2.2 CONSTRUCTION PERIOD

2.2.1 WATER LEVELS

2.2.1.1 MONITORING METHODS

Manitoba Hydro will install and operate automated water level recorders at the monitoring sites listed below to obtain hourly water level data throughout the year during construction. Monitoring will typically use a gas (nitrogen) bubbler system that uses gas back-pressure to determine water depth. The equipment will be connected to a logging system to record the data for later download. Operation of the automated water level gauges includes routine maintenance visits to check that monitoring equipment is operating properly.

2.2.1.2 LOCATIONS, FREQUENCY AND DURATION

Water levels will be monitored continuously throughout the year during the construction period at the following locations (Map 2-1):

- Clark Lake (upstream of outlet),
- downstream of Clark Lake outlet,
- upstream of Birthday Rapids,
- downstream of Birthday Rapids,
- upstream end of Gull Lake, and
- upstream of Gull Rapids.

Because the Clark Lake site is located upstream of the expected open-water hydraulic zone of influence (Map 1-2), data from this location will be used to verify that Project's backwater effect for open-water conditions does not extend upstream of the Clark Lake outlet and into Split Lake as expected. In addition, water levels on Split Lake will also be considered using water level data collected at either or both of the existing gauges at the Split Lake community, which are operated by Manitoba Hydro and Water Survey of Canada. Water level data from existing sites on Stephens Lake may also be used if required to support PEMP objectives. On Stephens Lake, Manitoba Hydro currently monitors water levels at a site in the northwest arm of the lake and a site near the Butnau Dam on the south shore of the lake.

2.2.2 BED ELEVATION AND WATER DEPTH

Water depth and bed elevations will not be monitored during the construction period.

2.2.3 WATER VELOCITY

Water velocity will not be monitored during the construction period.

2.2.4 ICE REGIME

The EIS indicated that on average without the Project a complete ice cover does not form upstream of Gull Rapids to Clark Lake in about 1 out of 3 years due to higher flow conditions (PE SV, Sec. 4). It also predicted that an ice cover would form each year during construction due to the installation of an ice boom just upstream of Gull Rapids. Monitoring will verify this expected change in ice processes.

2.2.4.1 MONITORING METHODS

The spatial extents of the ice cover will be visually identified from satellite imagery that is freely available from internet databases (e.g., Landsat). Satellite imagery will be supplemented with visual observations (photographs) from the Project area.

2.2.4.2 LOCATIONS, FREQUENCY AND DURATION

The extent of the ice cover from the Split Lake community water level gauge to the entrance to Stephens Lake will be monitored up to twice a month when satellite imagery is available during periods of ice cover for the construction period. Photographs will generally be taken in conjunction with other regular field work such as water level gauge maintenance or water quality/turbidity monitoring in the area.

2.3 OPERATING PERIOD

2.3.1 WATER LEVEL

2.3.1.1 MONITORING METHODS

As in the construction period, water levels will be monitored using automated gauges installed and operated by Manitoba Hydro to obtain hourly water level data.

2.3.1.2 LOCATIONS, FREQUENCY AND DURATION

Continuous water level monitoring during the *initial operating period* (i.e., 10 years after impoundment) will continue at the same general locations as during construction (Map 2-1):

- Clark Lake (upstream of outlet),
- downstream of Clark Lake,
- upstream of Birthday Rapids,
- downstream of Birthday Rapids,
- upstream end of Gull Lake (i.e., the reservoir), and
- downstream end of reservoir (near the generating station).

Specific locations may be adjusted when the reservoir is impounded to prevent equipment loss or damage. Water level data from either one or both of the existing gauges at the Split Lake community will also be used to support monitoring of PEMP monitoring objectives and verify any potential effects from the Project on Spit Lake. The collection of hourly water level data will allow for the identification of water level variations resulting from operation of the Keeyask G.S.

The initial operating period is expected to be sufficient duration to capture a range of flow and operating conditions to confirm water levels and variations due to the Project. The Keeyask operating licence will require reservoir water-level monitoring at the G.S. over the long term and this data would be available for PEMP and other monitoring purposes. Therefore, monitoring under PEMP is not required at the powerhouse beyond year 10. The need for longer term monitoring at the other PEMP water level monitoring sites will be reviewed at the end of the initial operating period to determine if further monitoring is required, taking into consideration the needs of other Keeyask monitoring activities.

2.3.2 BED ELEVATION AND WATER DEPTH

2.3.2.1 MONITORING METHODS

Bed elevation data will be collected using standard methods for the collection of **bathymetry** information. This typically involves acoustic sonar measurement techniques linked with a geographic positioning system (GPS) to collect accurate positional data for mapping purposes. In general, the sonar system measures water depth to the bed below the sonar unit while the GPS measures the elevation and horizontal position of the sonar system. Thus the bed elevation at a specific location may be calculated by deducting the depth from the sonar elevation and the results can then be used to map bed elevation.

2.3.2.2 LOCATIONS, FREQUENCY AND DURATION

It is anticipated that the measurement of bed elevation and water depth would primarily occur at site-specific locations upstream of the Project within the reach between Birthday Rapids and the generating station during the open water season following reservoir impoundment.

Measurements at specific sites downstream of the generating station could occur prior to impoundment because downstream water levels on Stephens Lake are controlled by the Kettle G.S. operations rather than Keeyask G.S. operations.

Specific areas that support objectives of the AEMP will be identified by the aquatic monitoring team. Sites to be measured are expected to include planned or potential aquatic habitat offsetting areas such as planned spawning habitats to be constructed downstream of the G.S. (Map 2-2). The need for subsequent follow-up monitoring or measurements at additional sites will be determined based on the results of aquatic effects monitoring as identified by the aquatic monitoring team.

2.3.3 WATER VELOCITY

Water velocity, in addition to water level fluctuation and depth, is a physical parameter that is relevant to the assessment of erosion, sedimentation and aquatic habitat. Velocity monitoring will be undertaken to support post-Project aquatic habitat monitoring. Additional measurement may also be done to support erosion and sedimentation studies if results of those monitoring components indicate a need for velocity information to interpret sediment transport and deposition results.

2.3.3.1 MONITORING METHODS

Water velocity will be measured using Acoustic Doppler Current Profiler (ADCP) or similar technology to measure velocity across the depth of the water column. Velocities will be measured along transects and grids covering the areas of sensitive habitat and aquatic habitat offsetting areas.

2.3.3.2 LOCATIONS, FREQUENCY AND DURATION

Velocity measurements will be obtained at locations upstream and downstream of the Project that include sensitive habitats and planned or potential aquatic habitat offsetting areas such as spawning habitats downstream of the G.S. (Map 2-2). To provide additional information for aquatic monitoring, four velocity transects will be obtained across the width of the reservoir that will include both the main channel and backbay areas. The transects will be approximately evenly spaced along the length of the reservoir from the G.S. to approximately 20 km upstream. The final locations of the monitoring transects identified by the aquatic monitoring team based on actual reservoir conditions following impoundment.

Velocity measurements will generally be taken under low, average and high flow conditions (e.g., approximately 5th, 50th, 95th percentile flows) to understand the range of velocities in the sensitive habitat areas. The aquatic monitoring team will identify whether or not velocities need to be measured at any particular site under all three flow conditions based on observations and specific habitat monitoring requirements. Because monitoring will depend on flow conditions, the specific duration of this activity is uncertain.

2.3.4 ICE-REGIME

The EIS (PE SV, Sec. 4) reported that without the Project, the reach upstream of Gull Rapids to Split Lake does not develop a complete ice cover approximately one year in every three years. Rough and thick ice develops at the entrance to Gull Lake when there is an ice cover, and also develops at the entrance to Stephens Lake each year. With the Project, it is predicted that an upstream ice cover will develop each year, generally sooner than without the Project, and that it may also extend further upstream. A thinner, smoother lake ice cover is expected to develop over a larger area of Gull Lake while a rough, thick ice cover will no longer form at the entrance to Stephens Lake. In spring, the ice break up period when levels transition from higher winter levels to lower equivalent open water levels, for the same flow, will occur more rapidly than without the Project. Monitoring is proposed to verify the expected changes in ice cover development due to the Keeyask G.S.

2.3.4.1 MONITORING METHODS

The spatial extents of the ice cover through the winter season will be identified from satellite imagery that is freely available from internet databases (e.g., Landsat). This imagery will be supplemented with visual observations (e.g., photos).

Ice thickness and water level will be measured by drilling holes through the ice cover at a number of locations to generate a cross section of ice thickness and water level along the length of the reservoir. Ice cover measurements may be limited based on safety considerations such as ice thickness.

2.3.4.2 LOCATIONS, FREQUENCY AND DURATION

The extent of the ice cover from the Split Lake community water level gauge to the entrance to Stephens Lake will be monitored up to twice a month when satellite imagery is available during periods of ice cover. Photographs will generally be taken in conjunction with other regular fieldwork such as water level gauge maintenance or water quality/turbidity monitoring in the area.

The initial operating period is expected to be sufficient duration to capture a range of conditions to confirm ice effects due to the Project. The need for longer term ice monitoring will be reviewed at the end of the initial operating period to determine if further monitoring is required.

Ice thickness and **spot water levels** will be measured at locations spaced approximately every 5 km along the mainstem in monitoring zones 1, 2, and 3 from the G.S. to approximately

20 km upstream at the entrance to Gull Lake (Map 2-1). This monitoring will identify how the ice cover develops and breaks up during the winter season. Ice thickness and spot water levels will also be measured at two sites located 2 and 4 km downstream of the G.S. in the entrance to Stephens Lake (Map 2-1). Ice measurements will be made approximately every 4 to 6 weeks when ice conditions allow in the first three winters after reservoir impoundment at which time the need for additional monitoring will be assessed.

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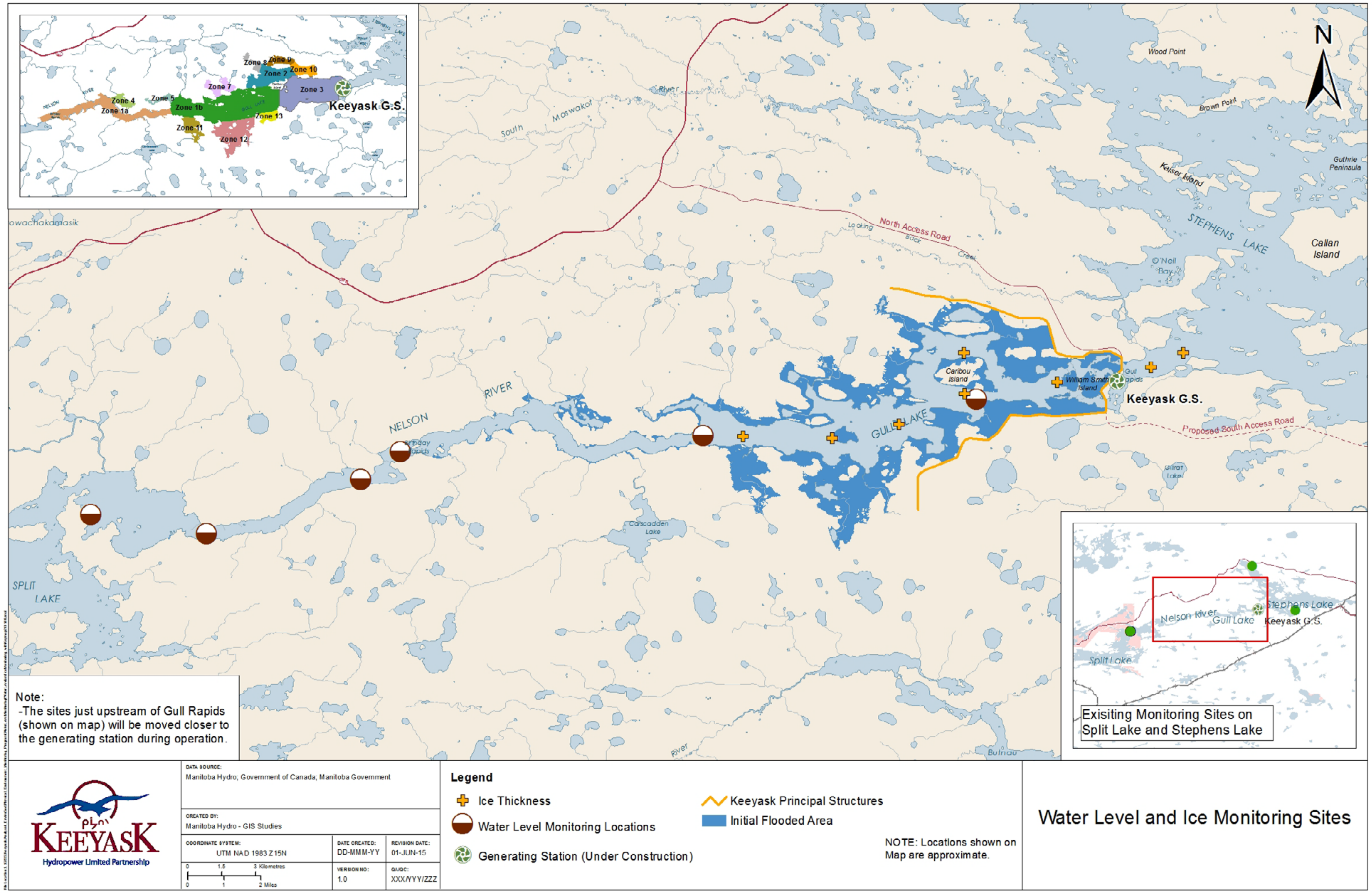

Map 2-1: Water Level and Ice Monitoring Sites

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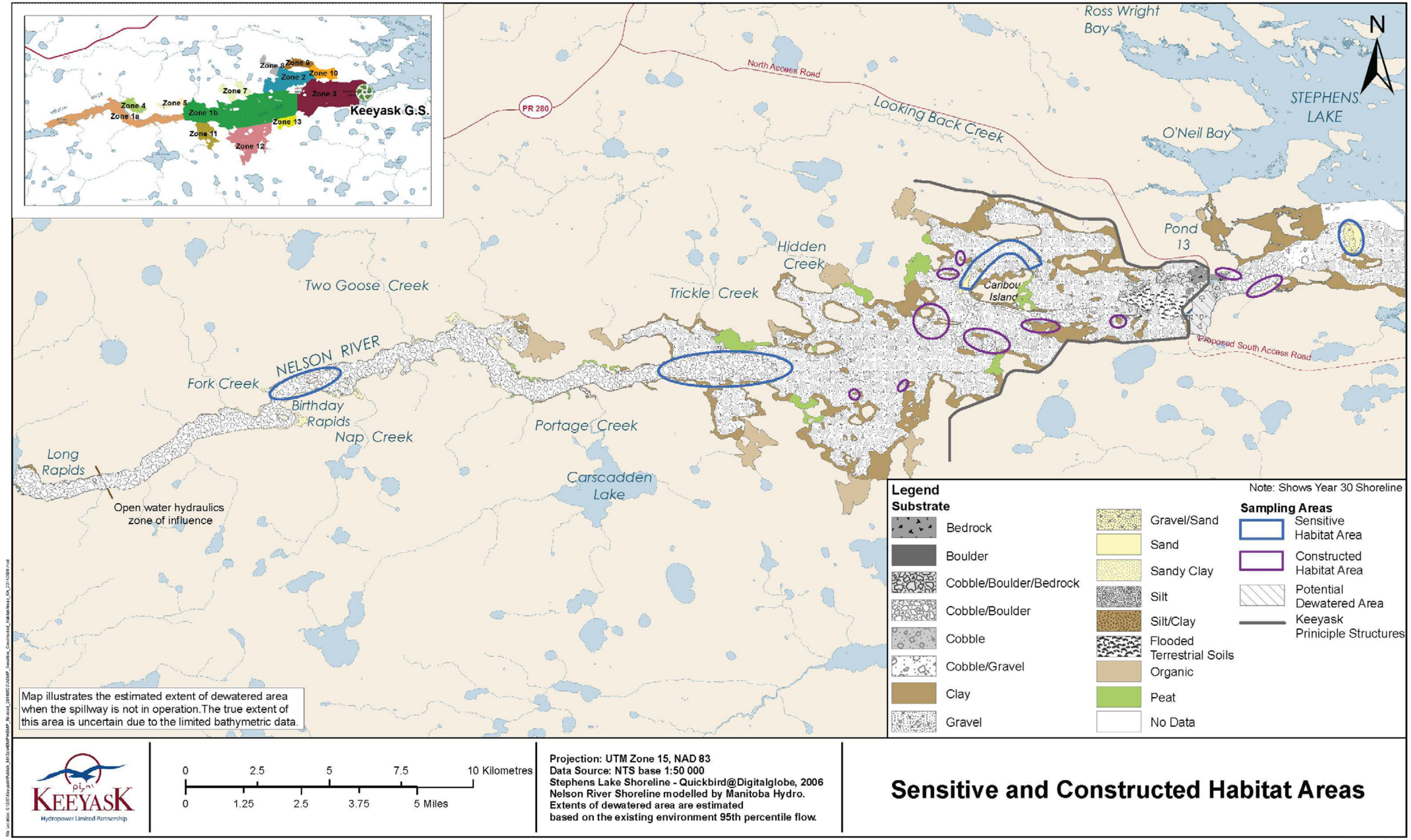

(source: AEMP, Map 3-3)

Map 2-2: **Sensitive and Constructed Habitat Areas in the Aquatic Environment (General Locations)**

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3.0 SHORELINE EROSION AND RESERVOIR EXPANSION

3.1 BACKGROUND

This section of the PEMP describes monitoring planned during the construction and operation phases of the Keeyask Project related to shoreline erosion and peatland disintegration processes. In general, shoreline erosion refers to the recession of mineral (e.g., sand, clay) banks while peatland disintegration refers to the breakdown of peat soils, which may be present along shorelines or as floating peat mats in the reservoir. Floating peat mats will occur where flooded peat breaks away from the bottom and resurfaces as a floating mat or where floating peat at the shore breaks off. These mats may sink to the bottom near where they form or may be transported to other areas by wind and currents. These mats may be broken down while floating.

Approximately 45 km^2 of land will be flooded when the reservoir is impounded and most of this area is covered in peat material. Compared with pre-Project conditions, the largest increases in shoreline erosion and peatland disintegration rates are predicted to occur within the Gull Lake area of the reservoir during impoundment and in the first year of operation. The rate of reservoir expansion due to shoreline erosion and peatland disintegration is predicted to be lower in years 2-5 after impoundment, compared with the first year, and then gradually decrease in subsequent years to a lower and more stable long-term expansion rate. About two-thirds of the initial reservoir shoreline is expected to made up of peat that may disintegrate rapidly resulting in high rates of shore recession. Mineral shorelines that generally recede less rapidly, and non-eroding bedrock and dykes, form about one-quarter and one-tenth of the initial shoreline respectively.

The objectives of the shoreline erosion and reservoir expansion monitoring include:

- measuring reservoir area and expansion over time,
- confirming predictions related to rates of shoreline erosion, peatland disintegration and reservoir expansion, and
- identifying the amount and locations of peat resurfacing.

3.2 CONSTRUCTION PERIOD

3.2.1.1 MONITORING METHODS

The PEMP monitoring of shoreline erosion during construction will consist of mapping the shoreline position (edge of peat for peat shorelines, top-of-bluff for mineral banks) prior to the start of construction and before full impoundment of the reservoir. High-resolution satellite imagery to be obtained before construction and impoundment will be used to identify the shoreline position at each time. While shoreline recession is an ongoing process, large changes are not anticipated during construction. The pre-construction and pre-impoundment shorelines will be compared to determine if any substantial changes in shoreline positions occurred during construction prior to impoundment.

3.2.1.2 LOCATIONS, FREQUENCY AND DURATION

Two sets of high resolution satellite images will be obtained, one at the start of construction (2014) and another before reservoir impoundment (2019). Each set of satellite imagery will be acquired over an area large enough to cover the extent of the open water hydraulic zone of influence. It will encompass the extent of the future post-Project shorelines, extending from Clark Lake to the G.S. (i.e., it will capture the flooded area), plus several kilometres downstream of the G.S. covering the entrance to Stephens Lake.

3.3 OPERATING PERIOD

3.3.1.1 MONITORING METHODS

Shoreline erosion monitoring will consist of mapping the shoreline position (edge of peat for peat shorelines, top-of-bluff for mineral banks) based on high-resolution aerial imagery (colour air photo or satellite). This work will be done in conjunction with the mapping planned within the AEMP and TEMP with respect to shorelines and reservoir area. Field verification may be required in areas where the shoreline position is not apparent in the imagery. Additionally, ground based surveys may also be completed to obtain detailed elevation profiles if other monitoring programs (e.g., TEMP) identify a need for detailed elevation data at a specific site. The shoreline position and rates of reservoir expansion will be compared with predictions presented in the Keeyask EIS (PE SV, Section 6).

3.3.1.2 LOCATIONS, FREQUENCY AND DURATION

Imagery will be acquired over an area large enough to encompass post-Project shorelines in the open water hydraulic zone of influence. The imagery will extend from Clark Lake to the

G.S. to capture the flooded area to monitor shoreline erosion and reservoir expansion and will extend up to five kilometres downstream of the G.S. to capture the entrance to Stephens Lake.

Consistent with the TEMP, the shoreline location will be mapped in years 1, 3, 5 and 10 after impoundment. The need for and frequency of additional monitoring beyond year 10 will be assessed at the end of the initial operating period. If the rates of shoreline recession and reservoir expansion are consistent with predictions in the EIS (PE SV, Section 6) then additional monitoring would not be proposed unless specifically required for other monitoring programs. Rates and locations of peat resurfacing will be monitored in conjunction with planned mapping done under the TEMP and AEMP based on imagery.

Additional monitoring as noted in the AEMP (Table 3-4) to understand origins and pathways of sediment at sensitive young-of-year sturgeon habitat sites may be triggered if silt accumulation is observed at the habitat sites. This work would only occur if the specifically identified as a requirement by the aquatic monitoring team.

4.0 SEDIMENTATION

4.1 BACKGROUND

This section describes monitoring planned during the construction and operation phases of the Keeyask Project related to sedimentation processes. The sedimentation processes are closely linked with mineral bank erosion and peatland disintegration, which cause sediment to enter the water body. This component of the PEMP includes monitoring for:

- turbidity,
- total suspended solids (TSS)
- organic sediment,
- bed-load, and
- sediment deposition and substrate.

The largest overall effects of the Project on sedimentation are predicted to occur after impoundment of the reservoir. Once the reservoir is filled, the mass of sediment entering the waterway will be greater than occurs without the Project due to shoreline erosion and peatland breakdown, although the effects are not uniform throughout the reservoir. The highest total sediment loading is predicted to occur in the first year after impoundment and declines over time to a lower, more stable long-term rate, corresponding to the anticipated decline in rates of shoreline recession and peatland disintegration over time. Within the reservoir mainstem, suspended sediment concentrations are expected to be lower than observed in the existing environment due to reduced flow velocities, which results in sediment deposition within the reservoir. The sediment regime upstream of Birthday Rapids is not expected to change because flooding is limited in this area and shorelines are largely non-eording bedrock. Other effects, such as changes in substrate composition, may only be discernible over longer periods as sediment is deposited over time.

The objectives of the sedimentation monitoring include:

- confirming sediment transport and deposition predictions; and
- supporting water quality and aquatic habitat monitoring components of the AEMP .

4.2 CONSTRUCTION PERIOD

4.2.1 CONTINUOUS TURBIDITY MONITORING

4.2.1.1 MONITORING METHODS

While effects of the Project on **concentrations** of suspended sediments (mineral and organic) in the water were assessed in the EIS, the effects on turbidity, a measure of the water's transparency, were not. Turbidity increases as transparency decreases with higher concentrations of suspended sediment. Turbidity will be monitored as it can be measured continuously using automated probes whereas suspended sediment concentrations can only be measured from discrete water samples tested in a laboratory. Turbidity will be monitored continuously in addition to discrete turbidity and suspended sediment sampling to provide a more complete picture of the range of variation in water transparency over an extended period. Continuous data can also provide an understanding of how turbidity is affected by short, infrequent events such as wind storms, which data are unlikely to be captured by discrete water sampling.

Continuous turbidity monitoring will be performed according to Manitoba Hydro standard procedures, which are briefly described below and may be revised from time to time. Under open water conditions, turbidity probes would be placed in the water at a depth of approximately 2 m below the surface or at mid-depth if total depth is less than 4 m. The probes will measure turbidity at a predetermined frequency, typically taking readings every few minutes.

Field crews will perform routine maintenance checks on the probes in conjunction with the discrete TSS monitoring. These checks include using another probe to obtain discrete turbidity readings at a site before removing the continuous probe and after it is placed back in the water to verify the continuous data. Discrete water samples will also be obtained before removing the continuous probe and will be sent to a laboratory to test for TSS and other water quality parameters (see Sec. 4.2.2 for additional information).

For winter monitoring, the probe may be placed through the ice so that it is suspended in the water column but remains accessible for maintenance purposes. Alternatively, the probe may be deployed on the riverbed, under the ice, for the entire winter season if ice conditions would prevent it from being suspended from the ice surface (e.g., areas where ice is known to get very thick or unstable). In this case, the probe would be installed prior to or soon after the ice cover forms and would be recovered the following open water season, remaining in place near the bottom over the winter. Maintenance visits cannot be performed with this deployment method because the probe would be inaccessible under the ice and would not be recovered until open water conditions return in spring.

4.2.1.2 LOCATIONS, FREQUENCY AND DURATION

Continuous turbidity monitoring will be completed during open water (typically June to September) and ice covered seasons (typically January to April). During periods of ice formation and breakup it will not be monitored.

Locations where open water monitoring is planned to take place are (Map 4-1):

- Clark Lake (upstream of outlet),
- upstream end of Gull Lake,
- upstream of Gull Rapids (near ice boom),
- entrance to Stephens Lake, and
- Stephens Lake near the Kettle G.S.

In years when there may be Project effects due to in-stream construction that could cause measureable changes further downstream, additional continuous turbidity monitoring will undertaken downstream of the Kettle G.S. at the following locations:

- just upstream of the Long Spruce G.S., and
- just upstream of the Limestone G.S.

The locations of the Kettle, Long Spruce and Limestone generating stations are shown on Map 1-1. This additional monitoring will occur in 2017 at the start of Stage II river diversion when flow is first passed through the spillway and when upstream water levels increase in Gull Rapids due to the construction of the south dam upstream cofferdam. Monitoring will also occur in 2019 when the powerhouse/tailrace cofferdam below the powerhouse is removed. These additional sites would be monitored over a period starting prior to the activity that may cause the suspended sediment increase and ending after the activity is completed. The actual timing of this monitoring will be adjusted if the construction schedule changes.

Winter monitoring is also proposed for a subset of the open water sites. Winter monitoring will be performed at the following sites:

- Clark lake,
- upstream end of Gull Lake, and
- entrance to Stephens Lake.

The exact location at which monitoring occurs may vary within these general areas between years based on local ice conditions observed at the time of monitoring.

4.2.2 DISCRETE TSS AND WATER QUALITY

4.2.2.1 MONITORING METHODS

Monitoring will be performed according to Manitoba Hydro procedures, which are briefly described below, and may be revised from time to time.

Where possible, discrete (in-situ) water samples will be obtained at the 20% and 80% depth locations in the water column as measured from the surface. However, samples will not be obtained at less than 0.3 m below the surface or above the bottom, therefore in shallow water of 1.5 m depth or less one sample would be collected at mid-depth. Sampling would be the same in winter except that sampling positions would be at 20% and 80% of water depth below the bottom of the ice rather than the total depth. Sampling would be at mid-depth if there is less than 1.5 m of water under the ice. Note that discrete sampling at the continuous turbidity sites is the same except that the upper sample will instead be obtained at the same depth (typically 2m) as the continuous logger rather than at the 20% depth position. Samples will be shipped to an accredited lab to test for:

- TSS, and
- Grain size distribution of suspended sediment.

Because the Project will flood terrestrial areas largely comprised of organic peat material, the discrete water sampling during construction includes testing for suspended and dissolved organic carbon. Although effects on organic carbon in the water are not expected prior to impoundment, the construction period monitoring will include measuring the following parameters to provide additional pre-impoundment data:

- total organic carbon (TOC),
- dissolved organic carbon (DOC),
- particulate organic carbon (POC),

This is consistent with the water quality monitoring component of the AEMP which includes laboratory testing for TOC and DOC (AEMP, Table 2-2). The third parameter, POC, can be calculated from the other two (i.e., TOC = DOC + POC).

In addition to laboratory testing for the parameters noted above, the following discrete measurements would also be obtained in the field:

- water depth,
- turbidity,
- water temperature, and
- dissolved oxygen concentration (see Section 8).

4.2.2.2 Locations, Frequency and Duration

Discrete sampling will be performed at a number of locations in addition to the samples collected during routine maintenance at the continuous turbidity sites. The sites will be consistent with those monitored during the baseline studies and includes ten sites from Clark Lake to the entrance of Stephens Lake, with up to to five sampling points across the width of the channel at each site (Map 4-1). The sampling locations are:

- Clark Lake,
- just upstream of Birthday Rapids,
- just downstream of Birthday Rapids,
- upstream of Gull Lake
- entrance to Gull Lake
- central area of Gull Lake
- north of Caribou Island, and
- south of Caribou Island.
- upstream of Keeyask G.S., and
- the entrance to Stephens Lake.

Discrete monitoring sites will be sampled four times per open water season (i.e., approximately monthly) each year during the construction period. During ice-covered periods, discrete TSS samples be collected at continuous turbidity monitoring sites as a part of maintenance visits.

4.2.3 Bed-load Monitoring

Bed-load refers to sediment that is transported along the bottom by rolling, sliding and bouncing, and is typically comprised of larger particles that are too heavy to be suspended in the water column under a given flow condition. Bed-load sampling will be performed to measure the amount of material being transported along the bed and will include obtaining sediment samples at the monitoring locations.

4.2.3.1 Monitoring Methods

The sampling program will be carried out according to Manitoba Hydro procedures, which are briefly described below and may be revised from time to time.

Bed-load measurements will be obtained using a Helley-Smith style sampler configured as a cable suspended, steel frame with fins to orient a 3 inch by 3 inch opening into the flow. The sampler is placed on the river/lake bed so that material moving along the bottom may captured in a sample collection bag attached to the opening. Five separate bed-load samples will be collected at each sampling point by placing the sampler on the bottom for a duration of 5 minutes each time. Each sample collected will be submitted for laboratory and will be tested to obtain the grain size gradation if the sample is large enough to perform the test.

At each sampling point where bed-load sampling is performed a **bed material** grab sample will also be collected if possible using a ponar grab sampler. These samples will be submitted for laboratory analysis to obtain grain size gradation. Bed material sampling undertaken as part of the bed-load monitoring is in addition to any bed material sampling required as part of the deposition monitoring described in Section 4.2.4.

4.2.3.2 LOCATIONS, FREQUENCY AND DURATION

Bed-load monitoring will be performed along a transect perpendicular to the main flow at two locations (Map 4-1):

- near the entrance to Gull Lake, and
- near the entrance to Stephens Lake.

The entrance of Gull Lake is an area where increased deposition may occur during the operation phase. Monitoring during construction will provide baseline information on bed material being transported into Gull Lake during the period of in-stream construction prior to impoundment. The site will be located near an area where a potential fish habitat offsetting measure may be implemented (see Fisheries Offsetting and Mitigation Plan). The Stephens Lake site is near an area identified as important habitat for Lake Sturgeon.

Bed-load sampling will be performed at five monitoring points located perpendicular across the main flow at each monitoring site. Each site will be sampled twice per year in the open water season during construction. Additional bed-load sampling may be performed at the downstream site during initial spillway operation and Stage II river diversion when larger predicted increases in transported sediment may occur. Baseline bed-load monitoring conducted for the EIS frequently found that adequate bed-load samples could not be obtained because of low bed-load rates. Therefore, the need for and frequency of bed-load sampling during construction will be assessed based on the success of sampling efforts. If no samples are collected in the first two years, bedload monitoring will not be done again until just before impoundment.

4.2.4 SEDIMENT DEPOSITION AND SUBSTRATE

Monitoring of sediment deposition and substrate has been identified as a requirement in support of aquatic habitat monitoring in the AEMP. The monitoring described below pertains to the deposition and substrate monitoring at two specific sites.

4.2.4.1 MONITORING METHODS

Deposition and substrate monitoring during construction will involve:

- obtaining sediment grab samples, and
- installing sediment traps.

Sediment grab samples will be obtained using a standard sampler (e.g., ponar sampler) designed to collect samples from the top of the sediment layer on the lake bed. At both sediment trap positions discussed below, sediment grab samples will be obtained from four locations around the trap, generally within about 10 m of the trap location. It may not be possible to obtain sediment grab samples where the substrate is hard or very coarse such as areas with bed rock or boulders.

If possible (e.g., water velocity not too high), a sediment trap will also be placed at two monitoring sites (see Sec. 4.2.4.3 for locations) during each year of construction. A sediment trap generally consist of one or more open-ended plastic tubes approximately 10 cm in diameter that are designed to sit on the lake bed with the tube standing vertically. Sediment settling through the water column enters the open end of the tube and is retained in it until the tube is recovered. Sediment collected in the traps will be removed two times each year and the material will be lab tested to determine the sediment mass and particle size gradation to identify the nature of sediments that may potentially deposit at that location.

An important aspect of the sedimentation regime is that finer material that may be deposited at lower flows when water velocities are low may be re-suspended and transported away from the site when flow and water velocities are higher. While a sediment trap may collect fine sediments, it does not allow for re-suspension of those sediments from the collection chambers. The characteristics and amount of sediment collected in the trap can indicate the potential sediment available for deposition but may not necessarily represent the actual sediment type and net deposition rate at the site. Therefore, results from sediment trap monitoring will be considered in conjunction with results from sediment grab sampling as the material collected from the bed reflects actual deposition and transport conditions.

4.2.4.2 LOCATIONS, FREQUENCY AND DURATION

Deposition and substrate monitoring will be performed at two locations (Map 4-1):

- the entrance to Gull Lake, and
- the entrance to Stephens Lake.

The first site is located at the upstream end of Gull Lake in an area where increased deposition may occur during the operation phase because of lower water velocities resulting from increased water levels. The substrate in this area was identified in the EIS as coarse material (e.g., gravel, cobble, boulder), therefore it may not be possible to obtain sediment grab samples at this location. Monitoring at this site during construction will help identify the deposition environment before it is affected due to reservoir impoundment. The second monitoring site will be downstream of the Project at the entrance to Stephens Lake, which the EIS showed as having a sandier type of substrate.

Sediment grab samples will be obtained twice each year, once at the beginning of the open water season and again near the end of the season when the traps are recovered. As in-stream construction activities are generally planned to occur during the open water period, sampling downstream at these times may help determine if substrates are affected due to construction activities.

Sediment traps will be deployed at both monitoring locations throughout the entire year in each year of the construction period. The sediment samples collected in each trap will be removed for grain size analysis twice a year: once near the beginning of the open water season and once near the end. Collected samples will then represent the open water period when in-stream construction activities are planned to occur and the winter period when no in-stream construction activity is expected to take place.

4.3 OPERATING PERIOD

Predictions were reported in the EIS with respect to post-Project effects on mineral and organic suspended solids (PE SV, Sec. 7). Generally, mineral suspended solids are predicted to be lower in the mainstem area compared with pre-Project conditions due to increased deposition resulting from reduced flow velocities. The bulk of the area being flooded by the Project (Map 1-2) is comprised of peatlands. As a result, organic suspended sediment is expected to be elevated in newly flooded backbays primarily due to peat resurfacing, particularly in the first year of operation after impoundment when the greatest amount of peat resurfacing occurs. Resurfacing is expected to be much lower in the second and following years after impoundment, with the rate of resurfacing declining over time. Correspondingly, organic suspended sediment is expected to be much lower in the second year and is expected to decrease over time (PE SV, Sec. 7, Table 7.4-5).

Predictions were also made regarding expected rates of sediment deposition in different areas of the reservoir. The highest predicted rates occur in the nearshore areas of flooded backbays. The expected rates are generally highest in the first year of operation and decrease to a lower, steady rate over the long-term as rates of peatland disintegration and mineral erosion also decline.

4.3.1 CONTINUOUS TURBIDITY MONITORING

4.3.1.1 MONITORING METHODS

Continuous turbidity monitoring during operation will follow the same procedures used in the construction period monitoring (see Sec. 4.2.1.1).

4.3.1.2 LOCATIONS, FREQUENCY AND DURATION

Continuous turbidity monitoring during the operating period under open water conditions will be carried out at or near the mainstem locations that will be monitored during construction (Map 4-1):

- Clark Lake (upstream of outlet),
- upstream end of Gull Lake,
- upstream of Keeyask dam,
- entrance to Stephens Lake, and
- Stephens Lake near the Kettle G.S.

Additional continuous turbidity monitoring will be done in the open-water season within backbays that AEMP is focussing on for overall water quality and habitat monitoring, which are identified as Zones 4, 8, 11 and 12 on Map 1-3. These backbays will be substantially formed through the flooding of terrestrial peatlands and represent areas where the largest sedimentation effects are expected to occur due to erosion and peatland disintegration.

On the north side of the reservoir, a continuous turbidity site will be established within Zone 4 and another in Zone 8. On the south side of the reservoir, a continuous turbidity site will be established within Zone 11 while two sites will be established in Zone 12, which is the largest backbay.

Monitoring will be done during each open water season in the first five years after impoundment, at which time the requirements for ongoing monitoring will be assessed taking into consideration the requirements of the AEMP. This period of monitoring is expected to provide turbidity data over a wide range of open water flows and levels for a variety of weather conditions. The results will provide an understanding of the variability in sediment conditions, as indicated by turbidity, over the open water season in general and in response to events like rain or wind storms that can cause large turbidity changes over short periods. After year 5, the results will be reviewed to determine if turbidity has been observed across a wide enough range of conditions to provide an understanding of the variability in turbidity and thus the sediment environment within the study area. Monitoring may be continued beyond year 5 at one or more sites if additional data is needed to better characterize the variability in turbidity conditions. Note that the summary schedule (Appendix A) shows continuous monitoring occurring over the entire 10-year initial operating period based on the conservative assumption that additional monitoring may be required at one or more locations.

Winter turbidity monitoring will also be performed at four sites during operation:

- Clark Lake,
- upstream end of Gull Lake,
- upstream of Keeyask G.S., and
- entrance to Stephens Lake.

Winter monitoring will be performed over the first three years of operation and results will be assessed to determine if further winter monitoring is warranted. In comparison with open water turbidity conditions, it is anticipated that winter turbidity would typically be lower and much less variable. If monitoring results confirm that conditions are as anticipated and similar each winter then it not be performed beyond the third winter. Winter monitoring is not proposed for the backbays because the primary sources of sediment in these areas are erosion, peat breakdown and wave re-suspension, processes that would not be active when there is an ice cover.

4.3.2 Discrete TSS and Water Quality

4.3.2.1 Monitoring Methods

Discrete monitoring of TSS, particle size and organic carbon during operation will follow the same methods used in the construction period monitoring (see Sec. 4.2.2.1) and will include collection of dissolved oxygen and temperature data. All discrete data will be provided to the aquatic monitoring team for consideration in conjunction with the broader water quality monitoring that is part of the AEMP.

4.3.2.2 Locations, Frequency and Duration

Discrete sampling will be done at or near the same locations that will be monitored during the construction period (Map 4-1):

- Clark Lake,
- just upstream of Birthday Rapids,
- just downstream of Birthday Rapids,
- upstream of Gull Lake
- entrance to Gull Lake
- central area of Gull Lake

- north of Caribou Island, and
- south of Caribou Island.
- upstream of Keeyask G.S.
- one site in each of Zones 5, 9, 20 and 13, and
- two sites in Zone 7.

The first nine sites are located along the mainstem of the Nelson River within the boundary of the pre-Project waterway shorelines. Within the reservoir area, these locations include monitoring in Zones 1, 2 and 3. The final six sites will be established in those flooded backbays where continuous turbidity is not being monitored (Map 4-1).

Discrete monitoring sites will be sampled four times per open water season (i.e., approximately monthly), typically at the same time that routine maintenance checks are being done at the continuous turbidity sites. The sites will be monitored each year during the first five years after impoundment, if monitoring results confirm that conditions are similar to those predicted it will be discontinued. Note that the summary schedule (Appendix A) assumes some continuous monitoring would occur for the entire 10-year initial operating period and TSS samples would continue to be collected at those locations.

Specific discrete sampling is not proposed during the winter period. However, discrete measurements will be obtained during routine maintenance of turbidity loggers during deployed in the winter.

4.3.3 Bed-load Monitoring

4.3.3.1 Monitoring Methods

Bed-load monitoring during operation will follow the same methods used in the construction period monitoring (see Sec. 4.2.3.1).

4.3.3.2 Locations, Frequency and Duration

Bed-load monitoring during operation will be performed at the same two locations that will be monitored during construction (Map 4-1):

- near the entrance to Gull Lake, and
- near the entrance to Stephens Lake.

Bed-load sampling will be performed twice per year in the open water season at each site during the first five years after the reservoir is impounded. The duration of monitoring may be reduced if sampling routinely produces inadequate material samples for laboratory testing.

4.3.4 SEDIMENT DEPOSITION AND SUBSTRATE

Monitoring during operation will include the continuation of the construction monitoring using sediment traps at the upstream end of the reservoir (Gull Lake) and the entrance to Stephens Lake, plus additional sediment monitoring within the reservoir.

After reservoir impoundment, much of the reservoir will change over time as shoreline erosion, peatland disintegration, changing flows and water levels, and other processes add and distribute sediment. Changes in substrate over time will be quite variable around the reservoir’s shoreline (approximately 250 km of shoreline) and in deeper offshore areas due to site-specific influences. It is not reasonably practicable to characterize deposition and substrate changes across all the different potential conditions in the reservoir because a vast number of sampling sites would be required. The planned deposition and substrate sampling monitoring focuses on the backbays of Zones 4, 8, 11 and 12 (Map 1-3), which are key areas of the reservoir identified for monitoring in the AEMP, as well as monitoring along the mainstem in Zones 1, 2 and 3.

4.3.4.1 MONITORING METHODS

Deposition and substrate monitoring at the upstream end of Gull Lake and the entrance to Stephens Lake will follow the same methods used for the construction period monitoring (see Sec. 4.2.4.2). This will include year round deployment of sediment traps and collection of sediment grab samples twice per year.

Mineral sedimentation analyses reported in the EIS (PE SV, Sec. 7) indicated that material derived from shoreline erosion would primarily settle within a couple hundred metres of the shore while disintegrated peat is similarly expected to settle near where it originates. Therefore, nearshore deposition monitoring in the reservoir will involve the collection of sediment cores at 5 points along transects extending perpendicular from the shoreline edge up to approximately 400 m offshore. The shoreline edge will be at the 159 m FSL elevation and samples will be taken at approximately 5, 50, 100, 200 and 400 m offshore. Cores will generally be obtained by pushing a coring tube into the substrate and extracting an intact sample. The core will be visually inspected to identify the substrate types (mineral, organic) and deposition layers to determine the depth of deposited material. Where the deposited sediment is mineral material a sample will be obtained for laboratory grain size analysis.

In addition to the nearshore sediment transects, sediment sampling will be performed at a number of deepwater offshore locations within mainstem areas of the reservoir representing flooded areas of the original river channel. Substrate samples will be obtained using a sampler designed to collect bottom substrates (e.g., ponar sampler). The sampling is intended to identify changes in surface substrate over time (e.g., organic to mineral; course mineral to fine) and, to the extent practicable based on the sampling method, rates of deposition.

4.3.4.2 LOCATIONS, FREQUENCY AND DURATION

Deposition and substrate monitoring using sediment traps will be performed each year during the first five years of operation at the same two locations that will be monitored during the construction period (Map 4-1):

- at the upstream end of the reservoir (Gull Lake), and
- the entrance to Stephens Lake.

After year five of operation, the results from the construction and operation period monitoring will be compared to identify changes in the sediment deposition conditions. The potential need for sediment core samples from these two locations will be assessed based on results from the first four years of monitoring and requirements identified by the aquatic monitoring team. If required, cores would be would be obtained in the fifth year.

Nearshore sedimentation transect sites will be established both in newly flooded backbays and along the reservoir mainstem while a number of offshore sampling sites will also be established. The backbay sites are located Zones 4, 8, 11 and 12, which are key areas of focus for monitoring under the AEMP. Monitoring locations include (Map 4-2):

- four sites in Zone 4 (2 north side, 2 south side),
- four sites in Zone 8 (2 north side, 2 south side),
- four sites in Zone 11 (2 east side, 2 west side),
- six sites in Zone 12 (3 east side, 3 west side),
- four sites along the south side of the reservoir mainstem,
- six sites along the north side of the reservoir mainstem, and
- five deepwater sites along the original thalweg of the river

Because the exact configuration of the newly formed reservoir shoreline will be known only once the reservoir is impounded, monitoring in the first year will include the identification of final monitoring locations based on actual conditions.

The EIS predicts that sediment deposition rates will be highest in the first year after impoundment when the greatest rate of reservoir expansion occurs and will gradually decrease over time (PE SV Sec. 7). By year 10 after impoundment, the deposition rates are expected to have reduced to a rate that is likely to be near a rate that may be maintained over the longer term operation.

The nearshore deposition transects and offshore sampling points will be monitored through the collection of sediment cores and grab samples in the following periods after impoundment:

- year 1 (first open water season after impoundment) to identify initial sediment types at the start of operation and to collect mineral samples if present,

- year 2 to identify sedimentation during approximately the first sedimentation prediction period (year 1 of operation),
- year 5 to identify sedimentation during the second prediction period (years 2-5), and
- year 10, to identify sedimentation over the first 5 years of the third prediction period (years 6-15).

The scope of any long-term monitoring will be determined based on observed results from the first 10 years (e.g., decreasing and stabilizing rates as expected) and considering any requirement to support ongoing aquatic studies. If required, longer term monitoring is likely to be done at reduced frequency because discernible changes may take longer to develop at lower deposition rates. It may also focus on fewer sites that are representative of general deposition conditions or support other monitoring activities (e.g., aquatic habitat).

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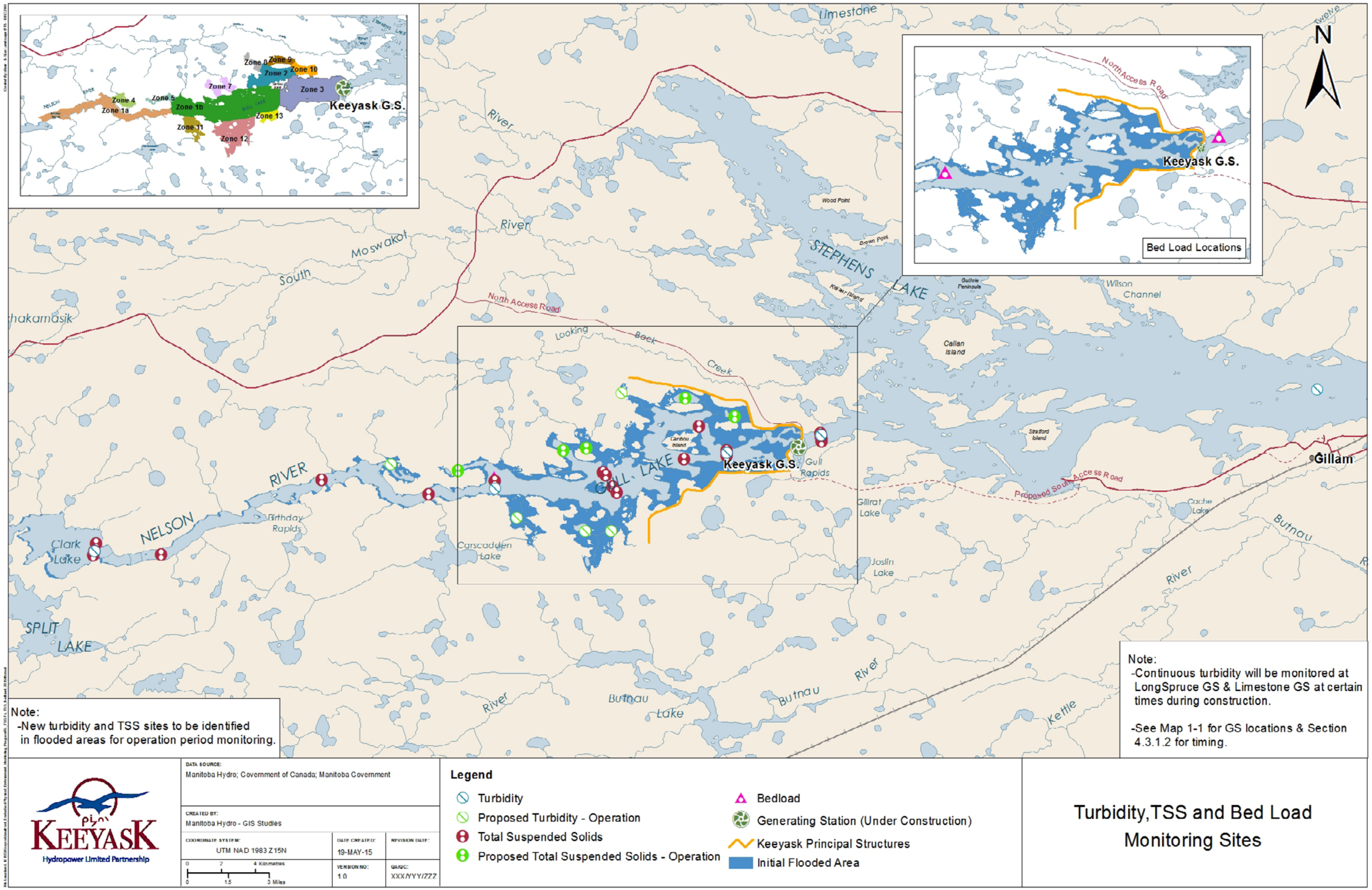

Map 4-1: Suspended Sediment and Bed-load Monitoring Sites

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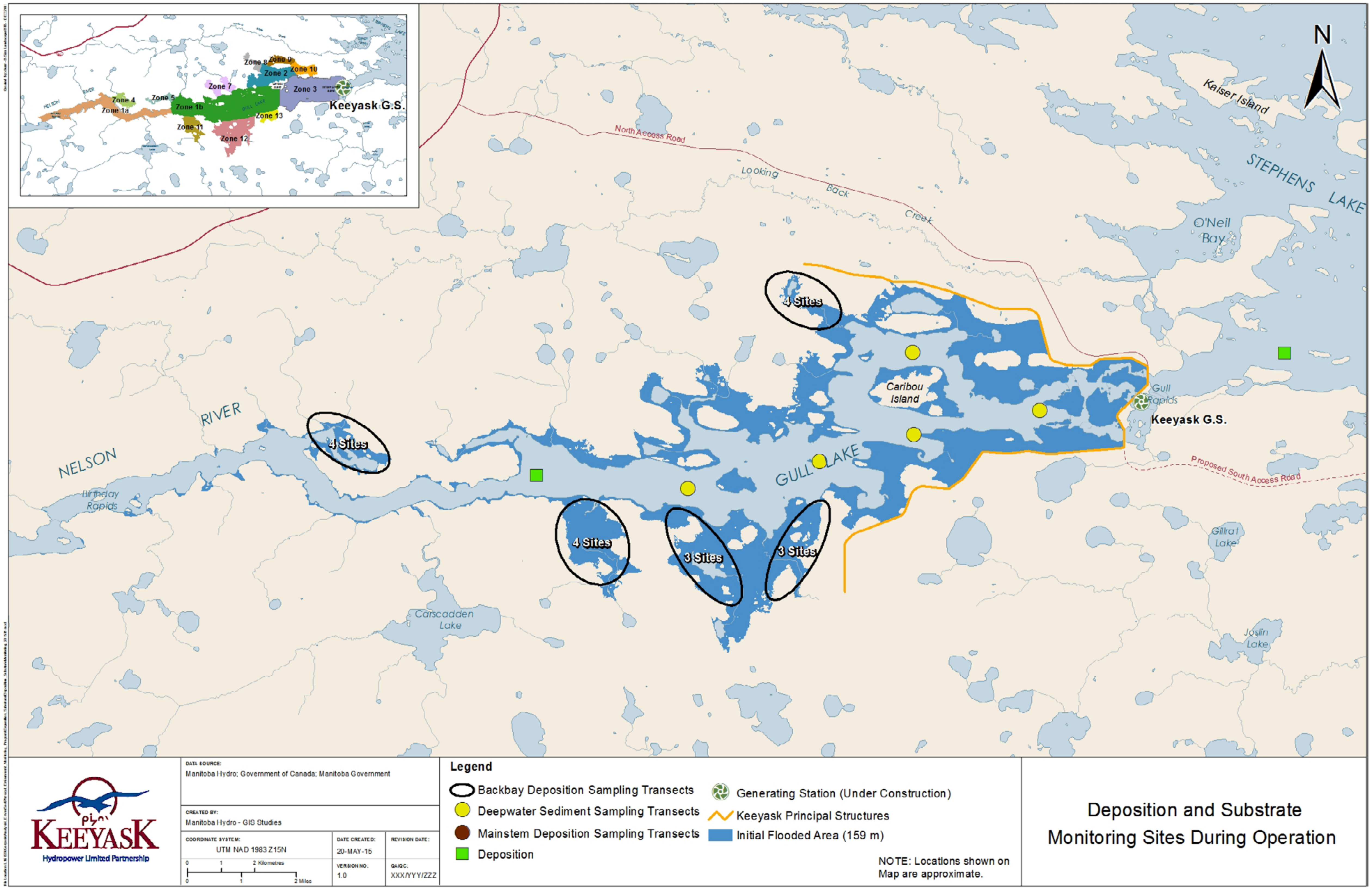

Map 4-2: Deposition and Substrate Monitoring Sites

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5.0 GREENHOUSE GAS

5.1 BACKGROUND

The processes that create and exchange Greenhouse Gases (GHG) in reservoirs are similar to those of naturally occurring aquatic systems. As a result of flooding, a portion of the readily available organic matter in the flooded soils, plant material, and wood decomposes and emits GHGs, primarily in the form of carbon dioxide (CO_2) and methane (CH_4) gases.

Studies indicate that GHG emissions from boreal hydroelectric reservoirs increase shortly after flooding and return towards levels similar to those of natural water bodies within a period of approximately 10 years following impoundment. It is anticipated that the Keeyask reservoir will behave in a similar manner; GHG concentrations are expected to be elevated within the first few years after impoundment, returning to levels similar to reference levels within ten years. Reference levels have been measured as part of Manitoba Hydro's Reservoir GHG Monitoring Program, which includes aquatic GHG concentrations on the Nelson River upstream and downstream of the future reservoir, pre-project baseline concentrations in the Gull Lake area as well as concentrations in nearby reference lakes.

The primary purpose of GHG monitoring during the operating period will be to document that GHG concentrations behave as expected; increasing initially and returning to concentrations similar to reference levels in the subsequent years.

5.2 CONSTRUCTION PERIOD

5.2.1 MONITORING METHODS

During construction two types of monitoring methodologies will be used consistent with the methodologies employed during Keeyask baseline monitoring, which include:

- measuring partial pressures of carbon dioxide (pCO_2) and methane (pCH_4) in surface water, and
- directly measuring the flux (release) of CO_2 and CH_4 from surface water to the atmosphere.

These measurement techniques provide multiple lines of evidence for documenting aquatic GHG emissions prior to flooding and creating the Keeyask reservoir.

Partial pressure measurements will be obtained from discrete, in-situ sampling at several locations throughout the waterway, and continuously monitoring at a location within the future reservoir and at a downstream location (Map 5-1). Discrete and continuous partial pressure measurements will be obtained by using a combination of semiconductor, infrared and laser CO_2 and CH_4 sensors.

Surface water partial pressure measurements of CO_2 and CH_4 will be converted to fluxes of GHGs emanating from the surface water to the atmosphere using the Thin Boundary Layer equation (difference in gas concentration between water and air) and a Mass Transfer Coefficient (MTC) based on wind speed and water body surface area.

Monitoring methodologies and technologies will be continuously evaluated and amended as appropriate. Direct measurements of CO_2 and CH_4 fluxes from the surface to the atmosphere may also be obtained using CO_2 and CH_4 sensors installed within a floating chamber device and/or mounted on an Eddy Covariance Tower.

5.2.2 LOCATIONS, FREQUENCY AND DURATION

Monitoring is planned to be conducted upstream, within, and downstream of the future Keeyask reservoir during the construction period. The planned monitoring locations are illustrated in Map 5-1. These locations are selected to correspond with the Keeyask baseline GHG monitoring sites to facilitate pre and post impoundment comparisons of monitoring results.

Discrete sampling will be conducted during the open water season to measure potential differences in GHG concentrations and fluxes that are related to spatial variation within the waterway. Surface water partial pressures and direct fluxes will be measured at these locations using the methodologies described in the section above.

Automated systems that are designed to continuously monitor CO_2 and CH_4 partial pressures will be installed in the main channel during the open water season. They will record natural differences in partial pressures that occur over time, including trends within the season and variations in different years. The monitors will be mounted on a floating deck at an upstream site and a downstream site (Map 5-1).

Baseline data has been collected over a number of years prior to construction and will continue during construction in open water seasons when three major phases of construction occur:

- 2014 – the first year of construction when all flow is diverted to the south channel of Gull Rapids,
- 2017 – when the south channel is closed off and all flow passes through the partially completed spillway,and
- 2019 – when the reservoir will be impounded to full supply level (159 m ASL).

5.3 OPERATING PERIOD

5.3.1 MONITORING METHODS

Monitoring methodologies are planned to be consistent with those used during the construction monitoring period. Methodologies will include measuring partial pressures of carbon dioxide (pCO_2) and methane (pCH_4) in surface water and directly measuring the flux of CO_2 and CH_4 from surface water to the atmosphere.

Partial pressures will be obtained using continuous monitors and discrete sampling. Monitoring methodologies and technologies will be continuously evaluated and amended as appropriate. The direct measurements of GHG fluxes may also be obtained using a floating chamber device and/or Eddy Covariance Towers, consistent with the construction period sampling.

5.3.2 LOCATIONS, FREQUENCY AND DURATION

A continuous CO_2 and CH_4 partial pressure monitor will be installed in the Keeyask powerhouse and will be the primary monitoring site. The unit is planned to operate each year for the first ten (10) years following reservoir impoundment.

Continuous monitoring of CO_2 and CH_4 partial pressures is also planned for the following locations during the open water season (Map 5-2). Continuous direct flux measurements may also be conducted at these sites.

- Zone 3 – mainstem channel
- Zone 10 or alternatively, Zone 12 or Zone 13 – flooded backbay areas that will have organic substrates
- Clark Lake – measuring background conditions upstream of the open water hydraulic zone of influence.

During operation, discrete sampling will be conducted at the discrete locations sampled during the construction period (Map 5-1) as well as at the continuous monitoring sites described above (Map 5-2). Discrete sampling may also be conducted within other back bay areas, such as Zones 4, 8 11 and 12.

The monitoring locations are designed to assess the GHG concentrations within the main channel, in the flooded back bay areas, and upstream of the open water hydraulic zone of influence. They correspond with the locations sampled during the baseline and construction monitoring periods and allow for comparison of changes relative to pre-flooding conditions. The continuous and discrete GHG monitoring within the waterways are planned to occur for the first three years after impoundment during the open water season.

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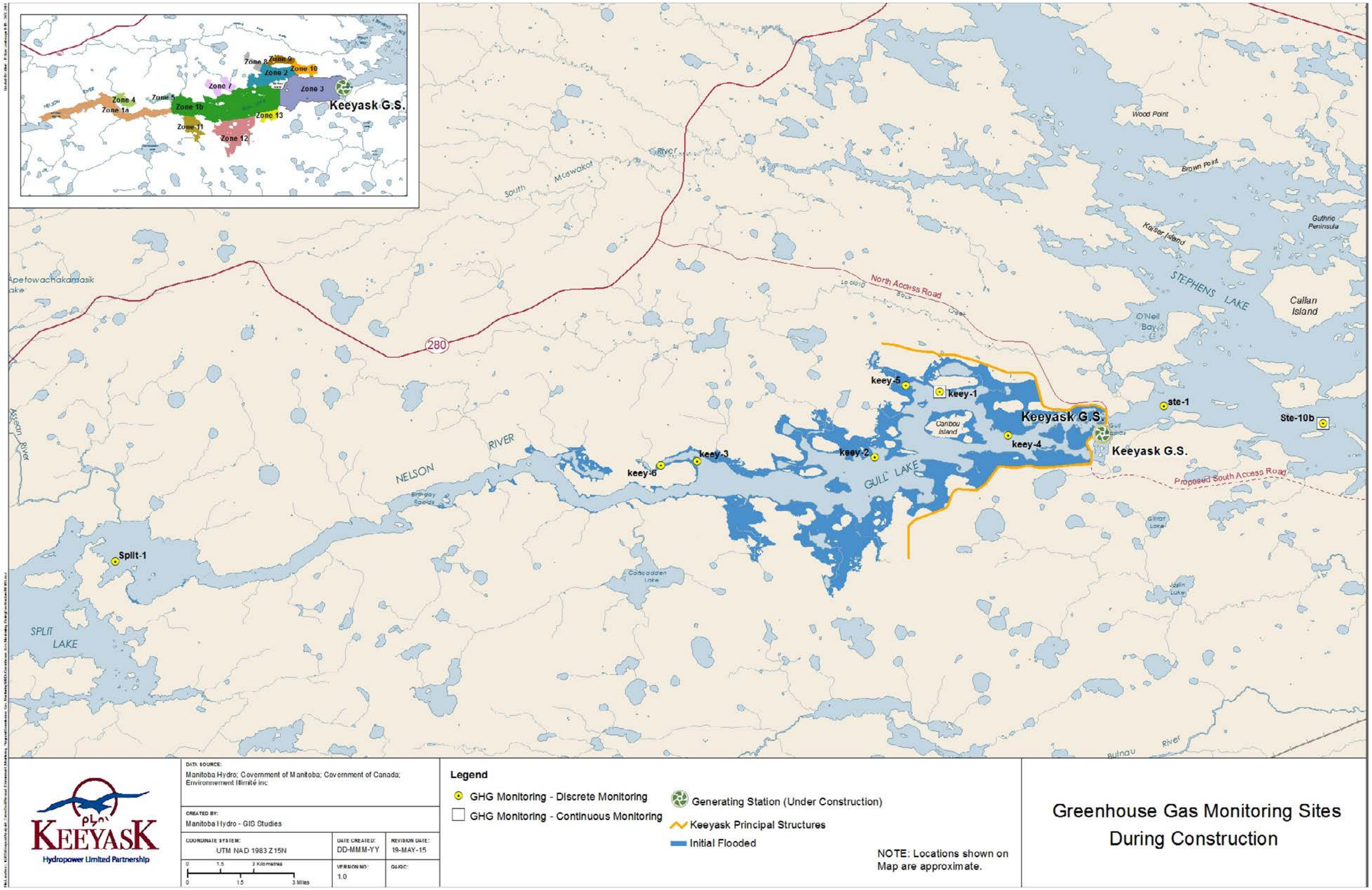

Map 5-1: Greenhouse Gas Monitoring Sites During Construction

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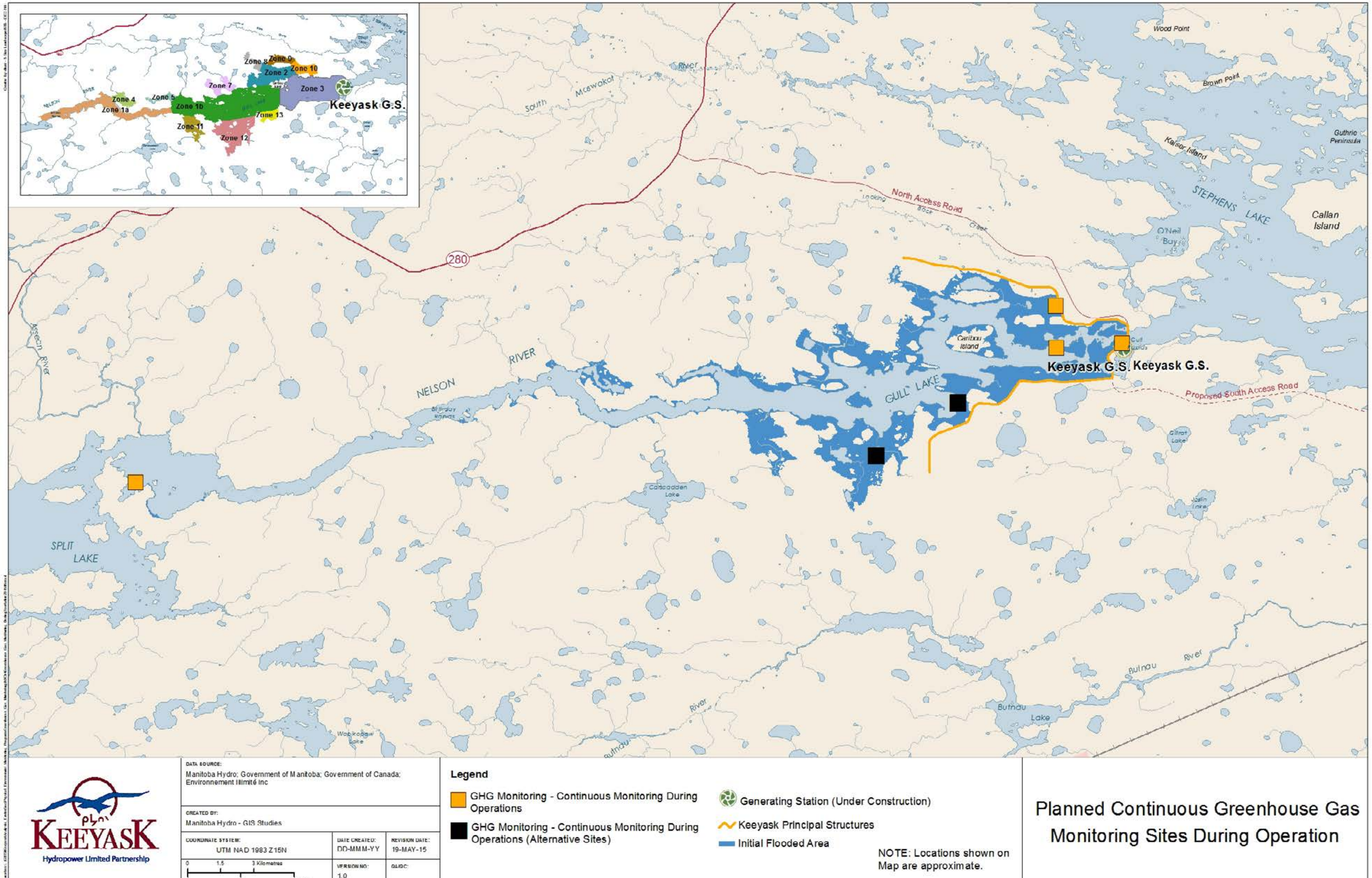

Map 5-2: **Planned Continuous Greenhouse Gas Monitoring Sites During Operation**

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6.0 DEBRIS

6.1 BACKGROUND AND WATERWAYS MANAGEMENT PROGRAM OVERVIEW

The PEMP will obtain information pertaining to debris management activities performed under the Keeyask Waterways Management Program (WMP). Details on the implementation of the WMP are provided in the WMP document and are not provided here because the WMP is not implemented as a component of the PEMP. The objective of the monitoring activity under PEMP is to verify the amount of debris being collected and that measures have been taken to reduce the risk to navigation and other activities due to water borne woody debris, and to report on this activity to the MAC.

Manitoba Hydro currently operates debris management programs that are implemented locally on various water bodies including the Nelson River downstream of Split Lake to and including Stephens Lake. Since 2003, records have been kept on the amount of woody debris removed in this local area; classifying it based certain criteria related to size (large or small) and type (new, old or caused by beavers). Woody material greater than 1 m (3 feet) long and material more than 10 cm (4 inches) in diameter is considered large debris, while woody material less than 1 m (3 feet) long and material less than 10 cm (4 inches) in diameter is considered as small. Debris caused by beavers is evident by the characteristic teeth marks resulting from being felled while debris having green woody material is considered to be new, and anything else would be considered as old debris. The WMP will continue to include recording relevant information on debris removal and other activities undertaken in the Keeyask area during the construction and operating periods of the Project.

Current debris management activities will continue during the construction period, which is considered phase one in the implementation of the Keeyask Waterways Management Program (JKDA, Sched. 11-2, item 4.1). Phase two of the WMP describes activities to be undertaken after impoundment of the reservoir (JKDA, Sched. 11-2, item 4.2). In this phase, the WMP will employ a larger work force performing waterways management activities upstream of the G.S. while a boat patrol continues to manage debris on Stephens Lake under the existing management program for northern Manitoba. A variety of activities will be undertaken in different time periods after impoundment including: collection of floating debris, preparing reservoir depth charts, and constructing and maintaining landing sites.

6.2 CONSTRUCTION PERIOD

The Project is not expected to substantively affect debris conditions during the construction period prior to reservoir impoundment (PE SV, Sec. 10.4.1) since water levels are expected to generally remain within the range observed prior to construction. The Keeyak WMP will operate a boat partrol to manage debris in the open water hydraulic zone of influence upstream of the Project, which would generally cover the reach from Clark Lake to Gull Rapids. Existing debris management activities that are not part of the Project would continue being performed on Stephens Lake during construction.

6.3 OPERATING PERIOD

Project construction includes clearing trees and other vegetation from the areas that will be flooded when the reservoir is impounded, as described in the Reservoir Clearing Plan, which is one of the Project's environmental management plans (see Preface, Fig. 1). While clearing mitigates the large amount of debris that would otherwise be generated due to flooding, some debris will still be produced due to impoundment as well as shoreline erosion and peatland disintegration during operation. The largest debris effects are expected to occur in the first five years of operation due to flooding of the reservoir and because this is when the highest rates of peat resurfacing and reservoir expansion occur. Accordingly, the greatest level of activity under the Waterways Management Program will be during the initial three to five years of operation after impoundmen. Less management activity expected from year's six to ten, and less again after year 10/ (JKDA, Sched. 11-2).

The PEMP will report on the following:

- types and quantities of floating debris removed,
- locations of debris accumulation,
- substantial debris removal activities (e.g., removal of beached debris), and
- substantial debris prevention activities (e.g., tree clearing along eroding shorelines).

7.0 TOTAL DISSOLVED GAS PRESSURE

7.1 BACKGROUND

Atmospheric gases such as oxygen, carbon dioxide and nitrogen are dissolved in surface waters. The amount of Total Dissolved Gas (TDG) in the water depends on a number of factors including water temperature and atmospheric air pressure. For a given set of conditions, the TDG pressure in the water attempts to reach an equilibrium with the atmospheric pressure, at which point the TDG would be at 100% saturation. Dissolved gas super-saturation represents a condition where excess gases are dissolved in the water and the degree of saturation is greater than 100%. High levels of super-saturation (i.e., typically more than 110%) can cause adverse physiological effects in fish.

High TDG super-saturation may result downstream of a spillway where there is a plunging flow into a deep pool that produces air bubbles. If water pressure is high enough gases from these bubbles may be forced into solution in the water, raising the TDG pressure. Elevated TDG would not be expected as a result of flow through a powerhouse since this flow does not entrain a large amount of air bubbles that might contribute to TDG increases downstream. The EIS (PE SV Sec. 9) presented the prediction that the Project would not cause high levels of TDG super-saturation. The design of the Project reduces the potential to entrain dissolved gases and promotes off-gassing of excess TDG: i.e., low plunge height, rounded spillway to reduce turbulence, shallow up-sloping tailrace.

While excessive TDG supersaturation is not anticipated, monitoring will be performed to verify this prediction.

7.2 CONSTRUCTION PERIOD

TDG monitoring will not occur during construction as downstream flow conditions representative of long-term operation will not occur until the spillway is complete and all generating units are on line.

7.3 OPERATING PERIOD

7.3.1 MONITORING METHODS

Monitoring will be performed using an electronic probe designed to obtain discrete in-situ measurements of TDG pressure. Additional parameters including DO, atmospheric pressure and water temperature will also be measured. Barometric pressure data from the Environment Canada weather station at Gillam may be used in place of in-situ air pressure data.

If discrete monitoring finds high TDG super-saturation (>110%) downstream of the G.S., a TDG probe may be deployed downstream to obtain continuous readings over an extended period. Readings would be obtained at a fixed interval sufficient (e.g., several minutes) so that average hourly saturation values may be calculated. Continuous monitoring would measure changes over time, which may identify how TDG super-saturation relates to variable G.S. and spillway operation if this cannot be identified from results of discrete monitoring.

7.3.2 LOCATIONS, FREQUENCY AND DURATION

As noted, TDG monitoring will not begin until all the powerhouse turbines are in service, and would not be performed until the first open water period after this occurs. The specific timing of TDG monitoring will depend upon projected and actual Nelson River flow conditions and the operation of the Keeyask G.S., particularly relating to periods of spillway discharge.

Monitoring will take place under the following operating conditions:

- When river flow is such that there is no flow through the spillway and most (5 or more) of the turbines are operating to verify that powerhouse operation does not elevate TDG.
- Once when river flow is high (i.e., approximately 95^{th} percentile or higher) and there is high flow through the powerhouse and the spillway is in operation.

If in either flow condition the discrete, in-situ monitoring does not detect excess levels of TDG super-saturation (>110%), then no further monitoring would take place as the results would confirm the expectation that the Project would not cause high TDG pressure. Additionally, monitoring when there is no spillway discharge may not be performed if monitoring at high flow with spillway discharge occurs first and does not detect any excess TDG super-saturation. Since spillway flow is more likely to cause high TDG, then if this effect is not detected when the spillway is operating the results would indicate that it is not likely to occur when the spillway is not operating.

If excess TDG super-saturation is observed, further monitoring would take place to determine the conditions that cause high TDG (e.g., flow range, variation in station operation). The PEMP and aquatic monitoring teams would work together to review monitoring results to determine how long additional sampling may be required to capture the range of conditions and when to end monitoring if TDG returns to lower levels.

7.3.2.1 DISCRETE TDG MONITORING

Upstream of the G.S., vertical TDG profiles (i.e., through the water column depth) will be obtained at a sampling transect across the width of the reservoir (Map 7-1). Profiles will be obtained approximately every 500 metres along the transect to provide background conditions before the water is discharged downstream through the powerhouse and spillway. The sampling transect will be located upstream of hazard bouys demarcating the hazardous water zone upstream of the dam to ensure the safety of the monitoring crew.

Downstream of the Project, sampling will be done both across the width of the flow in the reach between the G.S. and the entrance to Stephens Lake (i.e., up to about 4 km downstream). The first sampling transect across the width of the channel will be located as close to the structures as possible based on safety considerations. Downstream transects across the width will be completed every 500 metres up to approximately 4 km downstream. Vertical TDG profiles will be recorded at five equally spaced sites at each transect. The downstream extent of monitoring may be extended if in-situ results show that TDG levels are still high (>110% saturation) at about 4 km downstream. In this case additional transects and would be added approximately every 500 m downstream until in-situ readings are below 110% to determine extent of elevated TDG.

7.3.2.2 CONTINUOUS TDG MONITORING

If discrete TDG monitoring detects high TDG pressures and results are not sufficient to identify the conditions causing elevated TDG, a TDG sensor may be deployed in the field to obtain continuous readings (i.e., readings at a fixed interval over an extended period). The continuous sensor would be located downstream of the G.S. The specific location would be determined based on where elevated TDG are observed so that it can be sited in a location where it captures the variation in TDG from low to high levels. The need for continuous TDG monitoring will be assessed in conjunction with the aquatic monitoring team based on monitoring results from the discrete sampling program.

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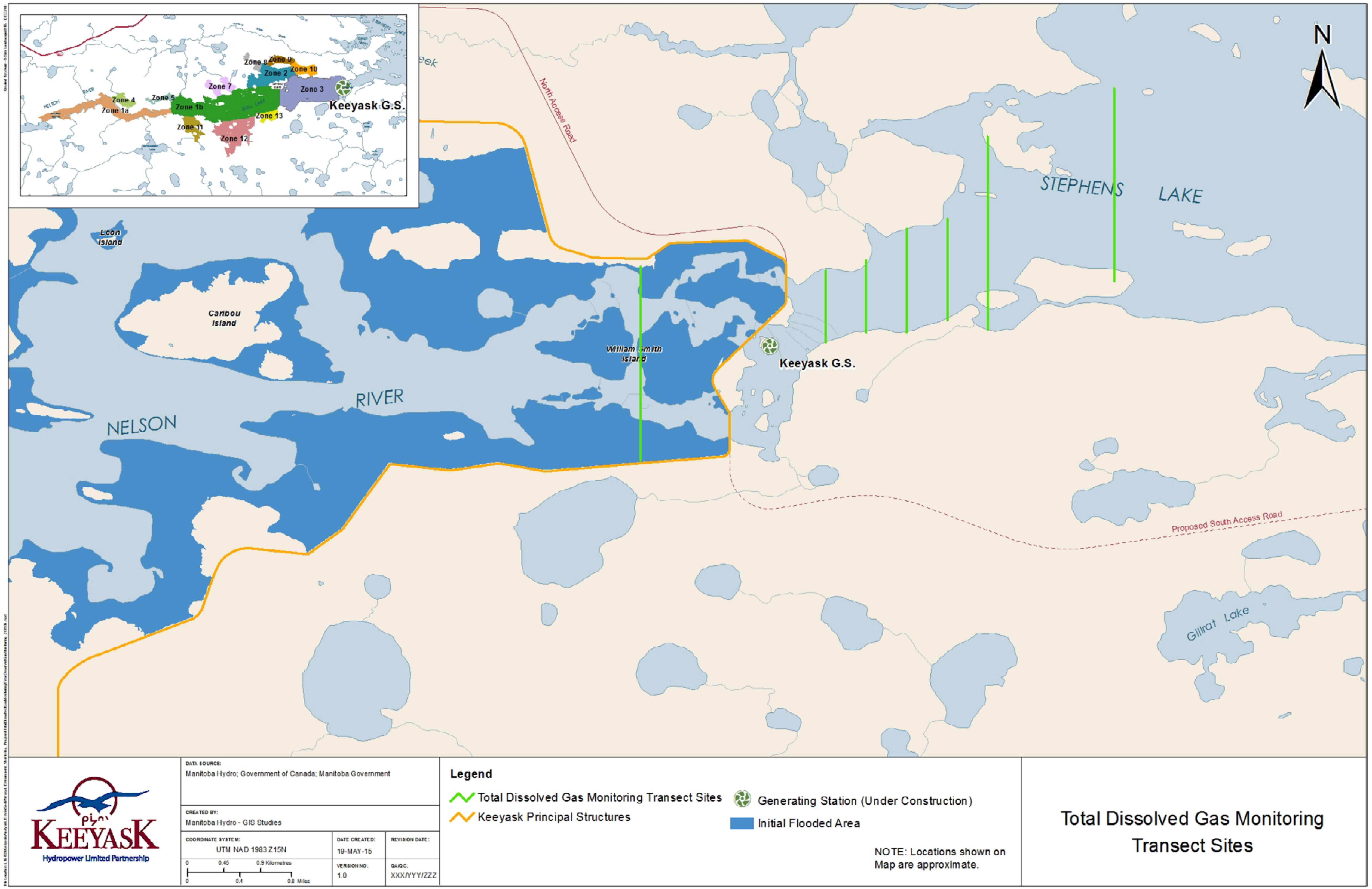

Map 7-1: **Total Dissolved Gas Monitoring Transect Sites**

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8.0 SURFACE WATER TEMPERATURE AND DISSOLVED OXYGEN

8.1 BACKGROUND

Dissolved oxygen is an important water quality parameter because aquatic organisms require DO to live and may adversely affected if DO concentrations drop too low. As with TDG, the surface water attempts to maintain an equilibrium concentration of oxygen dissolved in the water and the water is fully (100%) saturated at equilibrium. Because the DO saturation concentration is temperature dependent, the water temperature must be known in order to understand how a particular DO concentration relates to the saturation concentration at the time of sampling. DO saturation concentration and water temperature are inversely related so that as temperature increases the saturation concentration decreases.

DO in the water is consumed due to biological and chemical processes in the water and is replenished through oxygen transfer at the air/water interface or mixing with inflowing water having higher DO. Concentrations can drop to very low levels where oxygen is not replenished as fast as it is consumed. In the existing environment, DO levels are typically at or near saturation throughout the open water hydraulic zone of influence due to low oxygen demands and well mixed conditions. The Project will create shallow backbays that are not as well mixed with the mainstem flow. The decay of flooded and suspended organic material in these backbays will create oxygen demands that are higher than demands in the existing environment.

The EIS (PE SV, Sec. 9) predicted that with the Project DO concentrations would remain at or near saturation in the reservoir mainstem (Zones 1, 2, 3) and the upstream riverine area. In flooded backbays (zones 4-13), DO concentrations are generally expected to remain near saturation because average wind conditions provide sufficient replacement of oxygen that is consumed. However, during infrequent low wind periods, DO concentrations can drop well below saturation. This may be exacerbated by warmer backbay water temperatures that reduce the saturation concentration. In winter, when ice prevents reaeration, DO concentrations are expected to drop to low levels over the course of the winter.

The PEMP includes collection of surface water temperature and DO data in support of AEMP studies. Similar to sediment monitoring, the DO monitoring will include both discrete in-situ monitoring as well as continuous monitoring using electronic probes. Monitoring will include collection While this data is obtained as a part of the PEMP, work within the AEMP will involve further analysis and characterization of the data as it pertains to Project effects on overall water quality the aquatic environment.

8.2 CONSTRUCTION PERIOD

8.2.1 CONTINUOUS MONITORING

The Project is not predicted to affect DO and water temperature conditions during construction prior to reservoir impoundment (PE SV, Sec. 9.4.1.1), therefore continuous DO monitoring will not occur during construction.

8.2.2 DISCRETE MONITORING

8.2.2.1 MONITORING METHODS

Monitoring will consist of in-situ DO and water temperature measurements obtained using an electronic DO probe. Measurements will be obtained at the same time as other discrete water sampling that will take place as part of the sedimentation monitoring (see Sec. 4.2). Data collected during discrete water sampling will be provided to the aquatic monitoring team.

8.2.2.2 LOCATIONS, FREQUENCY AND DURATION

Discrete DO and water temperature will be measured during the construction period in conjunction with discrete water sampling that will take place under the continuous turbidity and discrete TSS components of the sedimentation monitoring (Sec. 4.2). Measurements will be obtained when turbidity loggers at the following sites are maintained (see Map 4-1 for continuous turbidity locations) in open water conditons:

- Clark Lake (upstream of outlet),
- upstream end of Gull Lake,
- upstream of Gull Rapids (near ice boom),
- entrance to Stephens Lake, and
- Stephens Lake near the Kettle G.S.

In addition, discrete data will also be collected when TSS (Sec. 4.2.2) sampling is performed at the following locations in open water conditions (see Map 4-1 for discrete TSS locations):

- Clark Lake,
- just upstream of Birthday Rapids,
- just downstream of Birthday Rapids,
- upstream of Gull Lake

- entrance to Gull Lake
- central area of Gull Lake
- north of Caribou Island, and
- south of Caribou Island.
- upstream of Keeyask G.S., and
- the entrance to Stephens Lake.

In winter, discrete DO and water temperature will be obtained when routine maintenance is performed at the following continuous turbidity sites:

- Clark Lake,
- upstream end of Gull Lake, and
- entrance to Stephens Lake.

8.3 OPERATING PERIOD

8.3.1 CONTINUOUS MONITORING

8.3.1.1 MONITORING METHODS

Continuous DO monitoring will be performed in accordance with Manitoba Hydro procedures. Typically, a continuous monitoring site will utilize two DO loggers that measure DO and water temperature at a preset frequency over an extended period. The sampling frequency of the loggers would be set short enough to obtain hourly average concentrations in order to identify DO changes during the course of a day (e.g., diurnal variations). One logger would be positioned no less than 0.3 m below the water surface while the second would be positioned no less than 0.3 m from the bottom. This arrangement allows for identification of vertical differences in DO concentration and water temperature within the water column. A single DO logger may be used in locations where little vertical difference would be expected (e.g., upstream riverine area) or where monitoring shows there is little vertical difference. Continuous DO monitoring includes routine maintenance visits to check and recalibrate the equipment.

8.3.1.2 LOCATIONS, FREQUENCY AND DURATION: OPEN WATER PERIOD

Continuous DO and water temperature monitoring under open water conditions will be performed at three mainstem sites where continuous turbidity will also be measured (Map 8-1):

- upstream end of Gull Lake,

- upstream of Keeyask dam, and
- entrance to Stephens Lake.

A single logger will be employed at the upstream end of Gull Lake and the entrance to Stephens Lake because the water column is well mixed at these sites. The water column is expected to be well mixed at the site just upstream of the dam, but this will be verified by initially using two loggers at this site. If monitoring confirms the site is well mixed, then one logger may be used in subsequent monitoring periods.

Additional continuous DO and water temperature monitoring will be done in the open-water season at backbay locations in Zones 4, 8, 11 and 12 (Map 8-1) where continuous turbidity is also being monitored. These sites will be in locations that are largely terrestrial prior to impoundment and will be flooded when the reservoir is raised to full supply level and are the areas where the largest effects on DO and water temperature are expected to occur. Monitoring in the flooded areas will be performed using two loggers, with one near the surface and one near the bottom.

A continuous DO monitoring site will also be established during the open water season in a backbay (O'Neil Bay) on Stephens Lake northeast of the G.S., which was previously monitored in 2008 and 2009 (PE SV Sec. 9). Two DO loggers (top and bottom) will be placed at this location, which will allow for comparison of DO conditions between backbays in the newly formed Keeyask reservoir and conditions in the backbay of a reservoir formed about four decades earlier.

Continuous DO and water temperature monitoring will be performed during the open water season in the first five years after impoundment in order to capture a range of operating and atmospheric conditions. The need for ongoing continuous DO monitoring after year 5 will be assessed in conjunction with the aquatic monitoring team to ensure continued collection of data required for the study of Project effects on the aquatic environment. If additional monitoring is proposed, it may be performed at fewer representative sites.

8.3.1.3 LOCATIONS, FREQUENCY AND DURATION: WINTER PERIOD

Continuous DO and water temperature monitoring is not planned during the winter period. Discrete monitoring is planned as discussed in the following section.

8.3.2 DISCRETE MONITORING

8.3.2.1 MONITORING METHODS

Discrete monitoring during operation will be performed in the same manner as construction monitoring.

8.3.2.2 LOCATIONS, FREQUENCY AND DURATION: OPEN WATER PERIOD

Discrete DO and water temperature readings will be obtained at the same times and locations as discrete TSS/turbidity samples (Sec. 4.3.2), which will be obtained four times per year at the following locations (see Map 4-1):

- Clark Lake,
- just upstream of Birthday Rapids,
- just downstream of Birthday Rapids,
- upstream of Gull Lake
- entrance to Gull Lake
- central area of Gull Lake
- north of Caribou Island, and
- south of Caribou Island.
- upstream of Keeyask G.S.,
- the entrance to Stephens Lake,
- one site in each of Zones 5, 9, 20 and 13, and
- two sites in Zone 7.

The first nine sites are located along the mainstem of the Nelson River within the boundary of the pre-Project waterway shorelines. Within the reservoir area, these locations include monitoring in Zones 1, 2 and 3. The final six sites will be established in those flooded backbays where continuous turbidity is not being monitored (Map 4-1).

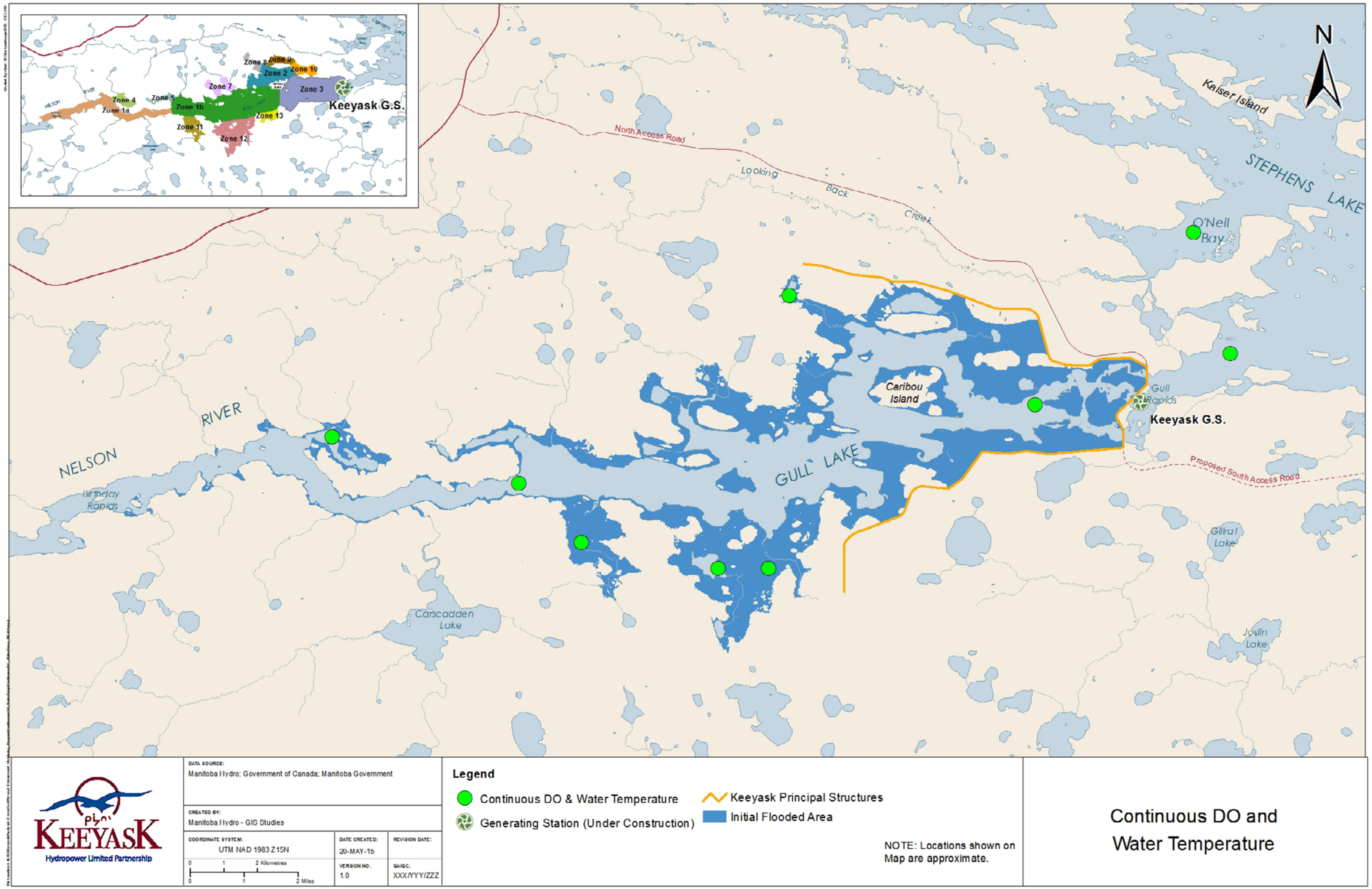
8.3.2.3 LOCATIONS, FREQUENCY AND DURATION: WINTER PERIOD

Winter monitoring will be performed to verify predicted Project effects on DO in winter. It is anticipated that mainstem DO will remain at or near saturation while backbay DO concentrations decline to low levels over the course of the winter. A probe will be used to obtain discrete measurements o points through the depth of the water column (typically 1 m interval) to identify any vertical variance in DO and temperature.

Monitoring will be performed at the same locations where continuous DO is monitored during the open water periods (Map 8-1). In addition, measurements will also be obtained at the six backbay sites in Zones 5, 9, 20, 13 and 7 (2 sites) where discrete DO and water are measured during open water periods in conjunction with discrete TSS monitoring (see Map 4-1).

This monitoring will be performed two times in the first winter after impoundment: once soon after freeze-up (likely December) and again in the latter part of the winter season when low DO conditions are likely to have fully developed (likely February or March).

Results will be reviewed in conjunction with the aquatic monitoring to consider requirements for winter monitoring in subsequent years. Additional monitoring may not occur after the first year if results are as anticipated with high DO in the mainstem and low DO in backbays.



Map 8-1: **Continuous Dissolved Oxygen and Water Temperature Monitoring Sites**

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9.0 ANNUAL MONITORING REPORT

Each year an annual monitoring report will be produced and submitted to the regulator as per Environment Act Licence No. 3107 (July 2, 2014) issued to the KHLP by the Province of Manitoba. The report will be distributed to the Partners and will be available to support all other monitoring activities (aquatic, terrestrial, etc.) as required. The annual report will summarize the physical environment monitoring that took place and new data collected within the last reporting period with respect to:

- surface water and ice-regimes,
- shoreline erosion and peatland disintegration,
- sedimentation,
- debris management, and
- greenhouse gas monitoring.

As appropriate, new data will be presented along with corresponding data collected in previous monitoring periods so that the new information may be considered within the context of previous monitoring results. Tables, charts and maps will be used to present the monitoring results, depending on the method considered most appropriate for the information. The report will also highlight notable variations or occurrences observed in the data, discuss analysis of the results if additional analyses are performed, and compare results with baseline data and predictions from the Keeyask EIS as appropriate. Although debris monitoring is primarily undertaken to provide information to the Partner communities through the MAC, the annual report will also highlight debris management activities noted in Section 6.

The reporting period for the annual monitoring report will typically be from April 1of a given year to March 31of the next calendar year and will be submitted to the regulator by June 15 of each year.

10.0 REFERENCES

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APPENDIX A

SUMMARY OF PROPOSED MONITORING SCHEDULE

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FIGURE A1-1: SUMMARY OF PROPOSED MONITORING SCHEDULE	2014	2014/15	2015	2015/16	2016	2016/17	2017	2017/18	2018	2018/19	2019	2019/20	2020	2020/21	2021	2021/22	2022	2022/23	Review Scope of Monitoring Program	2023	2023/24	2024	2024/25	Review Scope of Monitoring Program	2025	2025/26	2026	2026/27	2027	2027/28	2028	2028/29	2029	2029/30	Define Scope of Long-Term Monitoring Program
	CONSTRUCTION PERIOD[1]											OPERATING PERIOD[1]																							
	0		1		2		3		4		5		1		2		3			4		5			6		7		8		9		10		
Season	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W		S	W	S	W		S	W	S	W	S	W	S	W	S	W	
Surface Water and Ice Regimes																																			
Water Level	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	
Depth / Bed Elevation[2]													X																						
Water Velocity													F		F		F			F		F			F		F		F		F		F		
Ice Cover		X		X		X		X		X		X		X		X																			
Shoreline Erosion & Reservoir Expansion																																			
Imagery (aerial photos / satellite)[3]	X										X		X				X					X													
Reservoir Area / Expansion											X		X				X					X													
Sedimentation																																			
Continuous Turbidity	X	X	X	X	X	X	X[4]	X	X	X	X[4]	X	X	X	X	X	X	X		X	X	X	X												
Discrete TSS/water quality	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X												
Bed Load	X		X		X		X		X		X		X		X		X			X		X													
Sediment Traps	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X												
Nearshore Deposition													X		X								X										X		
GREENHOUSE GAS																																			
Keeyask GS Powerhouse													X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	
Upstream/Downstream	X						X				X		X		X					X							X						X		
Debris																																			
Debris quantification	X		X		X		X		X		X		X		X		X			X		X			X		X		X		X		X		
Total Dissolved Gas																																			
TDG													F		F		F			F		F													
Dissolved Oxygen																																			
Discrete DO	X		X		X		X		X		X	X	X		X		X			X		X													
Continuous DO													X		X		X			X		X													

NOTES:

X - monitoring planned in the period, some components of some activities will not occur each year

F - depends on flow conditions, would not occur each year

1 - construction assumed to end and operation begin once reservoir impounded to full supply level in 2019 although construction / decommissioning activity occurs until 2022 (see PD SV Fig. 3-1)

2 - planned in first year of operation, may occur in later years based on need

3 - satellite imagery may be obtained in intervening years based on need

4 - continuous turbidity at Longspruce GS and Limeston GS

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APPENDIX B

GLOSSARY

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Above sea level (ASL) Elevation: Elevations are referenced to Geodetic Survey of Canada, Canadian Geodetic Vertical Datum 1928, G.S.ofC, CGVD28, 1929 Adjustment.

Backbay: Area in a river or stream isolated from the main flow where water velocities are typically low or nonexistent.

Bathymetry: The area and water depth of a lake or river.

Bed-load: Measure of moving particles over the bed by rolling, sliding or saltating (*i.e.*, bounce, jump or hop).

Bed elevation: Elevation of the river or lake bed in metres above sea level.

Bed material: Soil material that makes up the bed of the river or lake.

Bedrock: A general term for any solid rock, not exhibiting soil-like properties, that underlies soil or other surficial materials.

Cobble: Rocks larger than gravel but smaller than boulders, having a particle diameter between 64 and 256 mm.

Compensation: Compensation is the replacement of natural habitat, increase in the productivity of existing habitat, or maintenance of productivity by artificial means.

Concentration: The density or amount of a material suspended or dissolved in a fluid (aqueous) or amount of material in a solid (*e.g.*, sediments, tissue).

Debris: Any material, including floating or submerged items (*e.g.*, driftwood, plants), suspended sediment or bed-load, moved by flowing water.

Decomposition: The process by which organisms, including bacteria and fungi, break down organic matter.

Deposition: Settling of sediment particles on the river/lake bottom.

Dissolved organic carbon (DOC): The inorganic carbon in a water sample passed through a filter (typically a 0.45 micron filter).

Dissolved oxygen: The concentration of oxygen dissolved in water, expressed in mg/l or as percent saturation, where saturation is the maximum amount of oxygen that can theoretically be dissolved in water at a given altitude and temperature.

Effect: Any change that the Project may cause in the environment. More specifically, a direct or indirect consequence of a particular Project impact [ref]. The impact-effect terminology is a statement of a cause-effect relationship (see **Cause-effect linkage**). A terrestrial habitat example would be 10 ha of vegetation clearing (*i.e.*, the impact) leads to habitat loss, permafrost melting, soil conversion, edge effects*, etc*. (*i.e.*, the direct and indirect effects).

Environment: The components of the Earth, including a) land, water and air, including all layers of the atmosphere, b) all organic and inorganic matter and living organsisms, and c) the interacting natural systems that include components referred to in a) and b) (Canadian

Environmental Assessment Agency). Or (a) air, land, and water, or (b) plant and animal life, including humans (MEA).

Environmental assessment (EA): Process for identifying project and environment interactions, predicting environmental effects, identifying mitigation measures, evaluating significance, reporting and following-up to verify accuracy and effectiveness leading to the production of an Environmental Assessment report. EA is used as a planning tool to help guide decision-making, as well as project design and implementation (Canadian Environmental Assessment Agency).

Environmental effect: In respect of a project, a) any change that the project may cause in the environment, including any change it may cause to a listed wildlife species, its critical habitat or the residences of individuals of that species, as those terms are defined in subsection 2(1) of the Species at Risk Act, b) any effect of any change referred to in paragraph a) on i) health and socio-economic conditions, ii) physical and cultural heritage, iii) the current use of lands and resources for traditional purposes by Aboriginal persons, or iv. any structure, site or thing that is of historical, archaeological, paleontological or architectural significance, or any change to the project that may be caused by the environment; whether any such change or effect occurs within or outside Canada (*Canadian Environmental Assessment Act*).

Environmental Impact Assessment (EIA): see *Environmental Assessment*. (Canadian Environmental Assessment Agency).

Erosion: A natural process, which is either naturally occurring or anthropogenic in origin, by which the Earth's surface is worn away by the actions of water and wind.

Existing environment: The present condition of a particular area; generally assessed prior to the construction of a proposed project.

Flooding: The rising of a body of water so that it overflows its natural or artificial boundaries and covers adjoining land that is not usually underwater.

Flow: Motion characteristic of fluids (liquids or gases); any uninterrupted stream or discharge.

Full supply level (FSL): The normal maximum controlled level of the forebay (reservoir).

Generating station (G.S.): A complex of structures used in the production of electricity, including a powerhouse, spillway, dam(s), transition structures and dykes.

Gravel: An accumulation of loose or unconsolidated, rounded rock fragments larger than sand, and between 10 and 100 mm in diameter; rock larger than sand but smaller than cobble having a particle diameter between 2 and 64 mm.

Greenhouse gas (GHG): Gases, *e.g.*, methane, carbon dioxide, chlorofluorocarbons emitted from a variety of sources and processes, said to contribute to global warming by trapping heat between the earth and the atmosphere. Or (a) carbon dioxide, (b) methane,(c) nitrous oxide, (d) hydrofluorocarbons, (e) perfluorocarbons, (f) sulphur hexafluoride, (g) any other gas prescribed by regulation (MEA).

Habitat: The place where a plant or animal lives; often related to a function such as breeding, spawning, feeding*, etc*.

Hanging ice dam: A deposit of ice, typically at the downstream end of rapids that builds up through the winter by accumulating frazil ice, which then partially blocks the flow of water and causes water levels upstream to rise.

Hydraulic Zone of Influence (HZI): Reach of river over which water levels and water level fluctuations caused by the operation of a particular project are measurable within the accuracy required for operation and license compliance.

Ice front: Where ice pans and ice sheets encounter an existing ice cover, such as at a lake, they accumulate, and the cover advances upstream. The upstream end of an advancing ice cover is called the ice front. If flow velocities at the ice front are low enough, the ice cover continues to advance upstream through the accumulation of these sheets and pans.

Ice regime: A description of ice on a water body (*i.e.*, lake or river) with respect to formation, movement, scouring, melting, daily fluctuations, seasonal variations*, etc*.

Impoundment: The containment of a body of water by a dam, dyke, powerhouse, spillway or other artificial barrier.

In situ: In place; undisturbed. An *in situ* environmental measurement is one that is taken in the field, without removal of a sample to the laboratory.

Joint Keeyask Development Agreement (JKDA): An agreement between Tataskweyak Cree Nation and War Lake First Nation operating as Cree Nation Partners, and, York Factory First Nation, and Fox Lake Cree Nation, and, The Manitoba Hydro-Electric Board regarding the partnership, ownership, development and operation of the Keeyask Project.

Keeyask Cree Nations (KCN): Tataskweyak Cree Nation (TCN) at Split Lake; York Factory First Nation (YFFN) at York Landing; War Lake First Nation (WLFN) at Ilford; and Fox Lake Cree Nation (FLCN) at Bird and Gillam.

Keeyask Generation Project: The Keeyask Generation Project (the Project) is a proposed 695–MW hydroelectric generating station located near Gull Rapids on Nelson River in the Province of Manitoba.

Mainstem: The unimpeded, main channel of a river.

Mineral soil: Naturally occurring, unconsolidated material that has undergone some form of soil development as evidenced by the presence of one or more horizons and is at least 10 cm thick. If a surface organic layer (*i.e.*, contains more than 30% organic material or 17% organic carbon by weight) is present, it is less than 20 cm thick.

Mitigation: A means of reducing adverse Project effects. Under CEAA, mitigation is "the elimination, reduction or control of the adverse environmental effects of the project, and includes restitution for any damage to the environment caused by such effects through replacement, restoration, compensation or any other means."

Monitoring: Measurement or collection of data to determine whether change is occurring in something of interest. The primary goal of long term monitoring of lakes and rivers is to understand how aquatic communities and habitats respond to natural processes and to be able to distinguish differences between human-induced disturbance effects to aquatic ecosystems and those caused by natural processes. *Or* A continuing assessment of conditions at and surrounding the action. This determines if effects occur as predicted or if operations remain within acceptable limits, and if mitigation measures are as effective as predicted.

Nearshore: Aquatic habitat occurring at the interface between a lake or stream and adjacent terrestrial habitat; usually includes aquatic habitat up to 3 m in depth; shallow underwater slope near to shore.

Offshore: Aquatic habitat not adjacent to terrestrial habitat; usually includes aquatic habitat greater than 3 m in depth.

Organic: The compounds formed by living organisms.

Parameter: Characteristics or factor; aspect; element; a variable given a specific value.

Particulate organic carbon (POC): The inorganic carbon in the residue retained on a filter (typically a 0.45 micron filter) when a water sample is filtered.

Peat: Material consisting of non-decomposed and/or partially decomposed organic matter, originating predominantly from plants.

Peat resurfacing: Process whereby all or portions of a peat mat that was submerged by flooding detaches and floats to the water surface.

Peatland disintegration: Processes related to flooded peat resurfacing; breakdown of non-flooded and resurfaced peatlands and peat mats; and, peat formation on peatlands and peat mats that have hydrological connections to a regulated area.

Post-project: The actual or anticipated environmental conditions that exist once the construction of a project has commenced.

Powerhouse: Structure that houses turbines, generators, and associated control equipment, including the intake, scroll case and draft tube.

Project: Keeyask Generation Project.

Reach: A section, portion or length of stream or river.

Reservoir: A body of water impounded by a dam and in which water can be stored for later use. The reservoir includes the forebay.

Riverine: Relating to, formed by, or resembling a river including tributaries, streams, brooks, *etc*.

Scope: An activity that focuses the assessment on relevant issues and concerns and establishes the boundaries of the environmental assessment (Canadian Environmental Assessment Agency).

Sediment core: A sample of sediment obtained by driving a hollow tube into the bed and withdrawing it with its contained sample or core.

Sediment trap: Small cylindrical tube placed along the bottom of a water body to “trap” or capture a representative sample of deposited sediment.

Sediment(s): Material, usually soil or organic detritus, which is deposited in the bottom of a waterbody.

Sedimentation: A combination of processes, including erosion, entrainment, transportation, deposition and the compaction of sediment.

Shore: The narrow strip of land in immediate contact with the sea, lake or river.

Spillway: A concrete structure that is used to pass excess flow so that the dam, dykes, and the powerhouse are protected from overtopping and failure when inflows exceed the discharge capacity of the powerhouse.

Spot water level: A single, surveyed measurement of the water surface elevation at a location at a specific point in time.

Substrate(s): the material forming the streambed; also solid material upon which an organism lives or to which it is attached. See also bed material.

Suspended sediment concentration: Measure of the amount of sediment in a unit of water usually expressed in terms of milligrams of dry sediment measured down to approximately 1 micron (0.001 mm) in a litre of water.

Top-of-bluff: The location of the interface between the undisturbed upland and the eroding bluff where the ground surface slopes sharply towards the lakeshore.

Total organic carbon (TOC): All the organic carbon in a water sample.

Total suspended solids (TSS): Solids present in water that can be removed by filtration consisting of suspended sediments, phytoplankton and zooplankton.

Transect: A line located between points and then used to investigate changes in attributes along that line.

Valued environmental component (VEC): Any part of the environment that is considered important by the proponent, public, scientists or government involved in the assessment process. Importance may be determined based on cultural values or scientific concern.

Volatile Suspended Solids (VSS): The portion of total suspended solids that are lost on ignition (heating to 550°C), which gives an approximation of the amount of organic matter present in the suspended solids.

Water quality: Measures of substances in the water such as nitrogen, phosphorus, oxygen and carbon.

Water regime: A description of water body (*i.e.*, lake or river) with respect to water levels, flow rate, velocity, daily fluctuations, seasonal variations*, etc*.