Keeyask Generation Project

PRELIMINARY DRAFT

Physical Environment Monitoring Plan

KEEYASK
Hydropower Limited Partnership

April 2013

KEEYASK GENERATION PROJECT
PHYSICAL ENVIRONMENT
MONITORING PLAN

DRAFT

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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(*Drafters Note: general location map to be inserted)*. The Program includes a collection of plans grouped in the following categories: Environmental Protection Plans, Environmental Management Plans, and Environmental Monitoring Plans.

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.

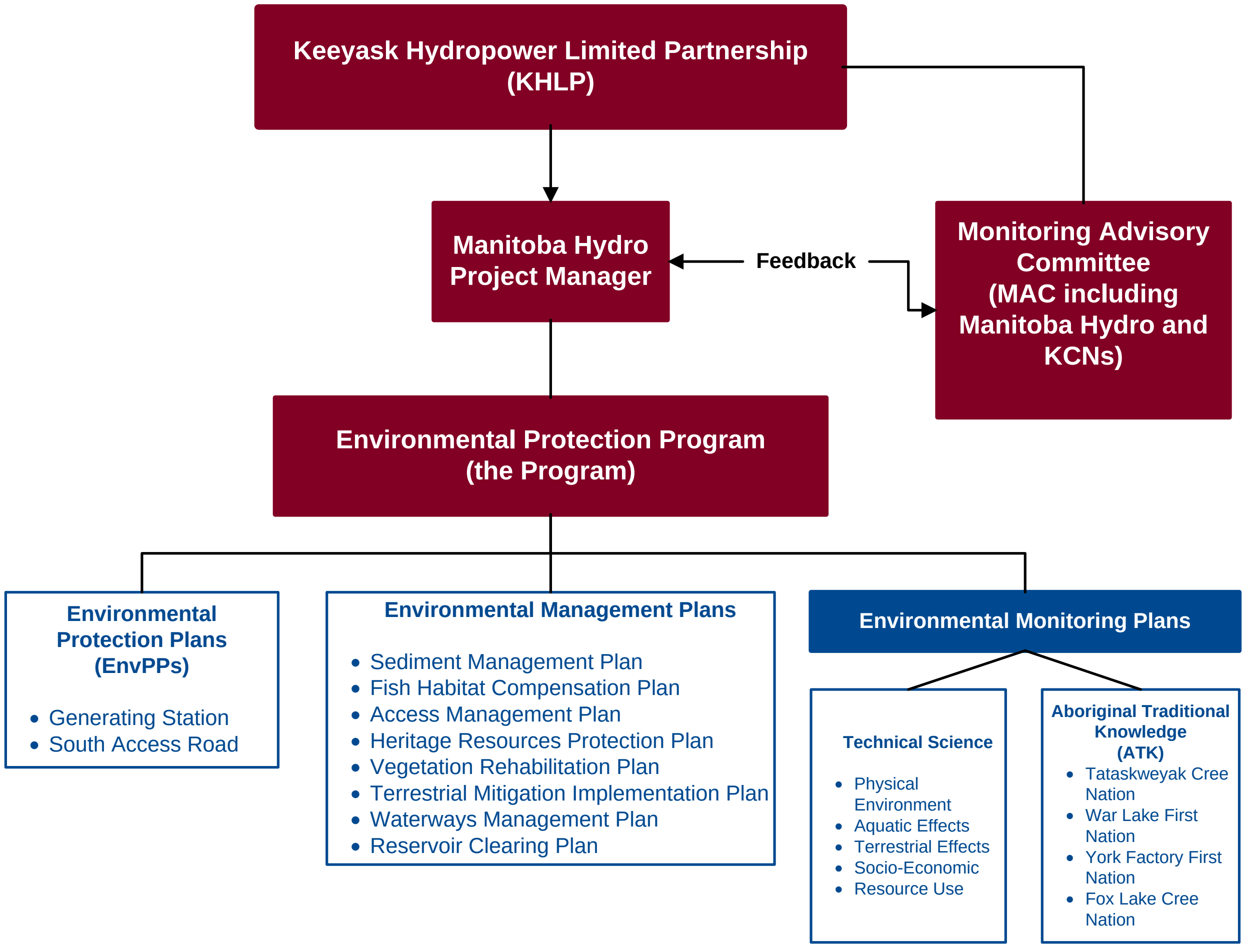

Figure 1: Environmental Protection Program

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 Officer 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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LIST OF ABBREVIATIONS

ADCP	acoustic doppler current profiler
AEMP	Aquatic Environment Monitoring Plan
ASL	above sea level
DIC	dissolved inorganic carbon
DO	dissolved oxygen
DOC	dissolved organic carbon
EIS	environmental impact statement
FSL	full supply level
GHG	greenhouse gas
GPS	geographic positioning system
GS	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
PIC	particulate inorganic carbon
POC	particulate organic carbon
PEMP	Physical Environment Monitoring Plan
PE SV	Physical Environment Supporting Volume
TC	total carbon
TIC	total inorganic carbon
TDG	total dissolved gas
TOC	total organic carbon
TEMP	Terrestrial Environment Monitoring Plan
TSS	total suspended sediment
VSS	volatile suspended solids

1.0 INTRODUCTION

1.1 BACKGROUND

This document describes the Physical Environment Monitoring Plan (PEMP) that will be implemented by the Keeyask Hydropower Limited Partnership (KHLP)[1] during the construction and operation of the Keeyask Generation Project (the Project). Manitoba Hydro will implement the PEMP on behalf of the KHLP. The Project consists of a 695-megawatt (MW) hydroelectric generating station at Gull Rapids on the lower Nelson River, immediately upstream of Stephens Lake, approximately 180 km northeast of Thompson, 60 km northeast of Split Lake, and 30 km west of Gillam (Map 1-1). A complete description of the Project components and preliminary construction schedule may be found in the Project Description section (Sec. 4) of the *Keeyask Generation Project: Response to EIS Guidelines* (the Keeyask EIS).

The Keeyask EIS and the associated Physical Environment Supporting Volume (PE SV) submitted to the regulators presented predicted effects of the Project on a number of components of the physical environment. The KHLP committed to monitoring in the Keeyask EIS (Chapter 8) for the following key physical environment components:

- surface water and ice-regimes,
- shoreline erosion processes (mineral soil and peat)
- sedimentation, and
- greenhouse gas.

The PEMP will support other monitoring programs, particularly the Aquatic Effects Monitoring Plan (AEMP), by monitoring the following additional items: woody debris, surface water temperature and dissolved oxygen, and total dissolved gas pressure. Regulatory reporting for the PEMP will present the results of monitoring for the key physical environment components. Some monitoring activities have been scheduled within ongoing programs (e.g., existing hydrometric monitoring program), while others will be conducted on an “as required” basis (e.g., focused monitoring for specific construction activities).

Subsequent to the submission of the EIS, additional commitments and requirements for physical environment monitoring were identified through:

[1] The Keeyask Hydropower Limited Partnership is comprised of four limited partners and one general partner. The limited partners are Manitoba Hydro, Cree Nation Partners Limited Partnership (CNP; controlled by the Tataskweyak Cree Nation [TCN] and War Lake First Nation [WLFN]), York Factory First Nation Limited Partnership (controlled by YFFN), and Fox Lake Cree Nation Keeyask Investments Inc. (controlled by FLCN). The four communities together are referred to as the Keeyask Cree Nations (KCNs). The general partner is 5900345 Manitoba Ltd., a corporation wholly owned by Manitoba Hydro.

- *[DRAFTING NOTE: this list to be developed once regulatory processes are completed, may include commitments identified with the KCNs, federal review process, CEC recommendations, other regulatory requirements (e.g., licences), etc.]*

1.2 KEEYASK CREE NATIONS PERSPECTIVES

The Keeyask Cree Nations (KCNs) prepared their own Environmental Evaluation Reports documenting their traditional knowledge with respect to the Project environment and have evaluated 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 during operation, which may affect navigation safety, 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. Reservoir clearing and waterways management are not components of the PEMP.
  - The PEMP includes provision for communicating information pertaining to debris management to the Monitoring Advisory Committee (MAC) as described in Section 7.2. The MAC is a committee that includes representatives of the KCNs and Manitoba Hydro as described in the JKDA (Sched. 4-7).
- 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 (see Sec. 4.2.2.1). The AEMP also includes water quality monitoring.
- Potential negative effects of erosion.
  - The PEMP includes erosion, reservoir expansion and sedimentation monitoring to identify effects of the Project related to erosion (see 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.
  - As described in the JKDA, a fundamental operating feature of the Keeyask Project is that the open-water hydraulic zone of influence will not affect levels on Split Lake. The Adverse Effects Agreements in place between Manitoba Hydro and both TCN and YFFN include a description of the process to address a breach of this fundamental operating feature.
  - The PEMP includes water level and ice-regime monitoring to identify Project effects due to flooding and operation of the reservoir (see 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 area (see Sec. 3.3.3), which will allow for the monitoring of changes to and development of islands. This information will support studies related to caribou under the Terrestrial Environment 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 (see Sec. 5). The consideration of broad based regional climate change issues is beyond the scope of the PEMP.
- The effectiveness of planned mitigation and compensation measures (e.g., constructed fish spawning areas).
  - Monitoring under the PEMP will support the AEMP and other monitoring activities designed to confirm environmental effects of the Project and assess the effectiveness of planned mitigation and compensation works.

1.3 MONITORING OBJECTIVES

The PEMP will measure a number of physical environment parameters during the construction and operational phases of the Project to:

- document actual conditions that may be compared with predictions in the EIS,
- identify unanticipated effects,
- support monitoring of the effectiveness of mitigation and compensation measures, particularly those related to the aquatic environment,
- support development of other mitigation and compensation measures or remedial actions should they be required,
- confirm compliance with regulatory requirements including project approvals and applicable environmental regulations, and
- provide data and information for other monitoring programs and communication with the MAC.

This document outlines the following:

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

1.4 SCOPE OF PHYSICAL ENVIRONMENT MONITORING PLAN

1.4.1 Environmental Protection Program

As noted in the Preface, the Keeyask Environmental Protection Program is comprised of the following components:

- environmental protection plans,
- environmental management plans, and
- environmental monitoring plans.

The different monitoring plans, including the PEMP, are interrelated to varying degrees since they all deal with aspects of the Project's effects on the environment. The PEMP is closely connected with the AEMP and the Sediment Management Plan for In-stream Construction (SMP).

Both the PEMP and SMP involve monitoring of suspended sediments in the waterway, which may be affected by construction and operation of the Project. The SMP will only be implemented during the construction phase of the Project (SMP, Sec. 1). The SMP involves real-time monitoring of turbidity as a proxy for TSS so that mitigation can be implemented as soon as possible if in-stream construction activity causes TSS increases that exceed specified thresholds. While data collected through the PEMP may be used to identify in-stream construction effects, the PEMP is not intended to provide real-time measurement of Project effects as in-stream work is occurring to monitor if TSS increases exceed specified thresholds. Real-time monitoring of TSS during in-stream construction is entirely within the scope of the SMP. Similarly, the PEMP is not designed to fulfil any part of monitoring that might be required with respect to the environmental protection plans (i.e., for the GS, South Access Road, or others that may be developed).

Predicted effects of the Project on the physical environment were reported in the Keeyask EIS and these results were used by other study groups to assess the significance of Project effects on Valued Environmental Components (VECs). Chapter 6 of the Response to EIS Guidelines discusses the effects assessments for the VECs while Appendix 6C of that chapter includes a table listing the VECs considered. Mitigation and compensation measures were identified in various study areas to address Project effects on VECs. Similar to the approach taken in the EIS, the scope of the PEMP is to measure the actual effects of the Project on the physical environment during construction and operation for the parameters identified in this monitoring plan. Monitoring results may be compared with baseline data and predictions in the EIS where appropriate. It is beyond the scope of the PEMP to assess: actual effects on VECs; the effectiveness of mitigation and compensation measures; or the need for additional mitigation and compensation measures. Data collected through the PEMP will be provided to the other environmental monitoring groups (aquatic, terrestrial, socio-economic, resource use, ATK) as needed to support their monitoring efforts and their assessment of actual Project effects on the VECs within their study areas, including the effectiveness of or need for mitigation and compensation measures.

1.4.2 Temporal Scope

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

- *Pre-construction*: The period prior to the start of construction. Provides the baseline conditions of relevant physical environment parameters in the study area before it is affected by the Project. This monitoring has been completed and is reported in the Physical Environment Supporting Volume (as part of the Keeyask EIS) and related technical memoranda.
- *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.
- *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 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.

1.4.3 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 the monitoring activity will occur during operation within the main reservoir area up to about 20 km upstream of the Keeyask GS, 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 monitoring may also take place downstream of Stephens Lake during certain periods of construction to determine if Project effects on suspended sediment are observed further downstream as expected. Some monitoring activities will occur at locations over the entire open water hydraulic zone of influence, while others may be focused on specific localized areas to measure certain specific Project effects.

Project effects differ spatially within the open water hydraulic zone of influence and monitoring is planned to capture these effects in different representative areas. Several terms are used to describe different areas of the post-Project environment, and some of these areas may be roughly described by reference to peat transport modeling zones defined for the peatland disintegration studies (Map 1-3). 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 peat transport 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. These generally correspond to peat transport zones 4 through 13 (Map 1-3). 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), from about 20-45 km upstream of the GS. Flooding is generally limited in this area. The downstream end of this area is near the downstream end of the hatched portion of peat transport zone 1 (Map 1-3).
- *Entrance to Gull Lake (reservoir):* The upstream end of Gull Lake just downstream from the upstream riverine area.
- *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 GS and approximately defines the entrance to Stephens Lake.
- *Stephens Lake:* The lake area downstream of the entrance to Stephens Lake to the Kettle GS. The south arm of the lake between the proposed Keeyask GS and Kettle GS generally represents the mainstem area of this reservoir.

The descriptions above are meant to provide general descriptions of different parts of the overall PEMP 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.

1.4.4 Scope Review & 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. Planned monitoring, including any adjustments, would be discussed with the MAC.

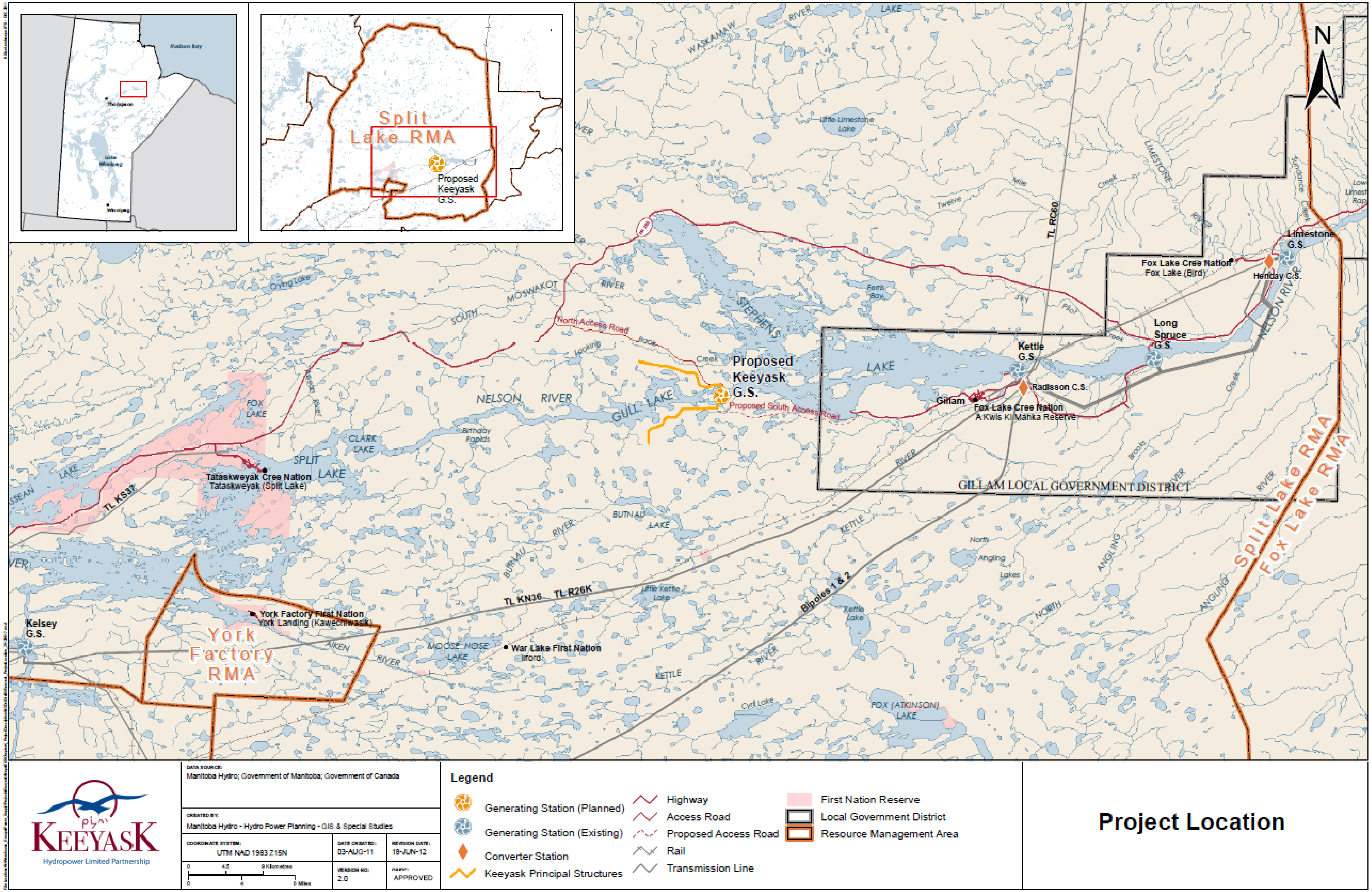
During the construction period, the annual plan for PEMP monitoring activity will consider previous results as well as the planned level of in-stream work activity during the monitoring period. During the initial period of operation, the scope of the program will be reviewed after the third and fifth year of monitoring results have been obtained. 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) 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.

1.5 SAFETY

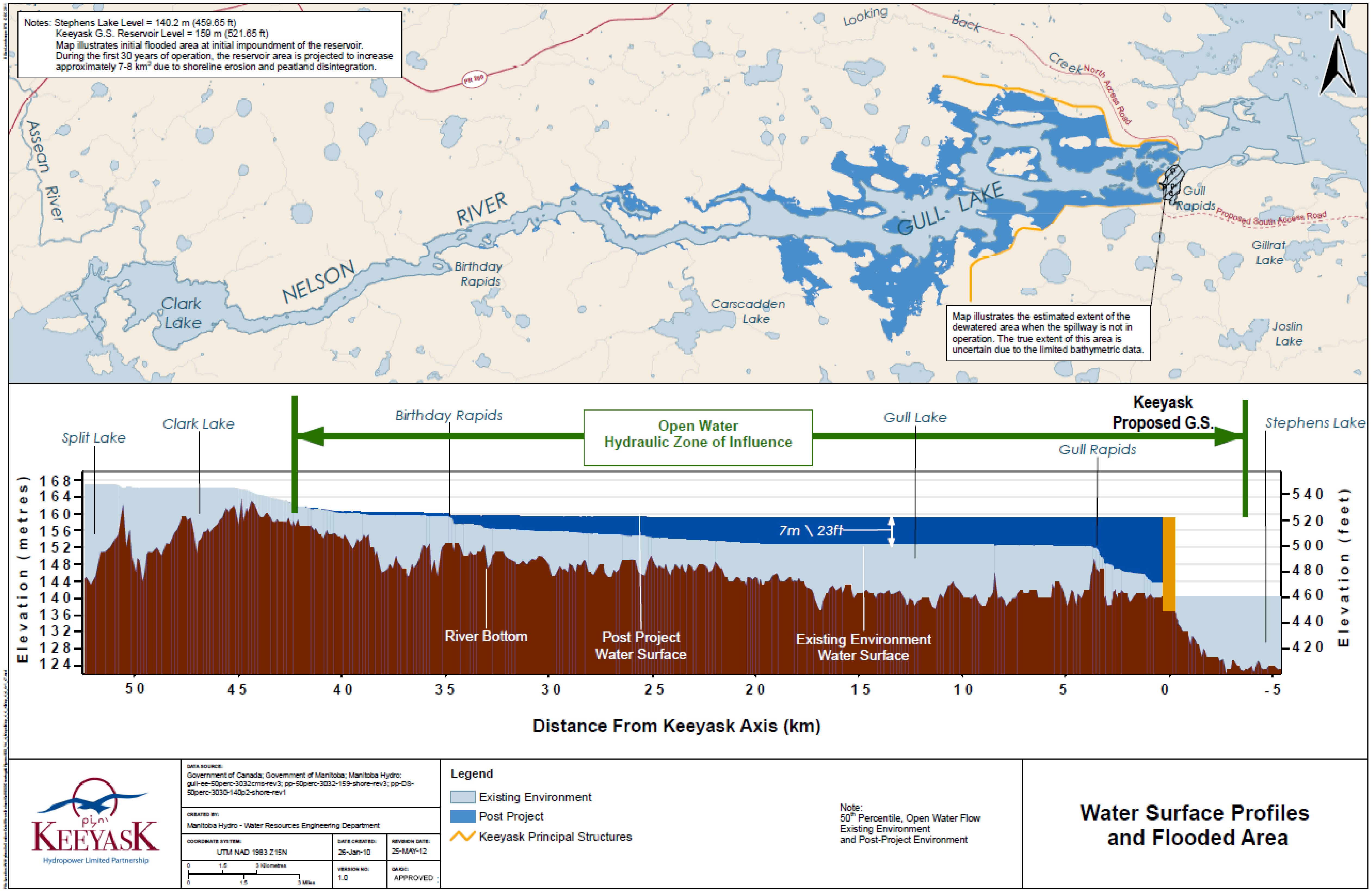
The safety of equipment, property and, most importantly, personnel is of primary importance in the performance of all PEMP activities. All applicable federal and provincial acts and regulations will be followed. Work activities undertaken to implement the PEMP will be performed in accordance with Manitoba Hydro corporate safety and occupational health rules, policies and procedures, as well as applicable contractor and consultant safety and health programs.

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 may 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. In accordance with the section of The Workplace Safety and Health Act dealing with the right to refuse dangerous work (C.C.S.M. c. W210, 43(1)), 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.



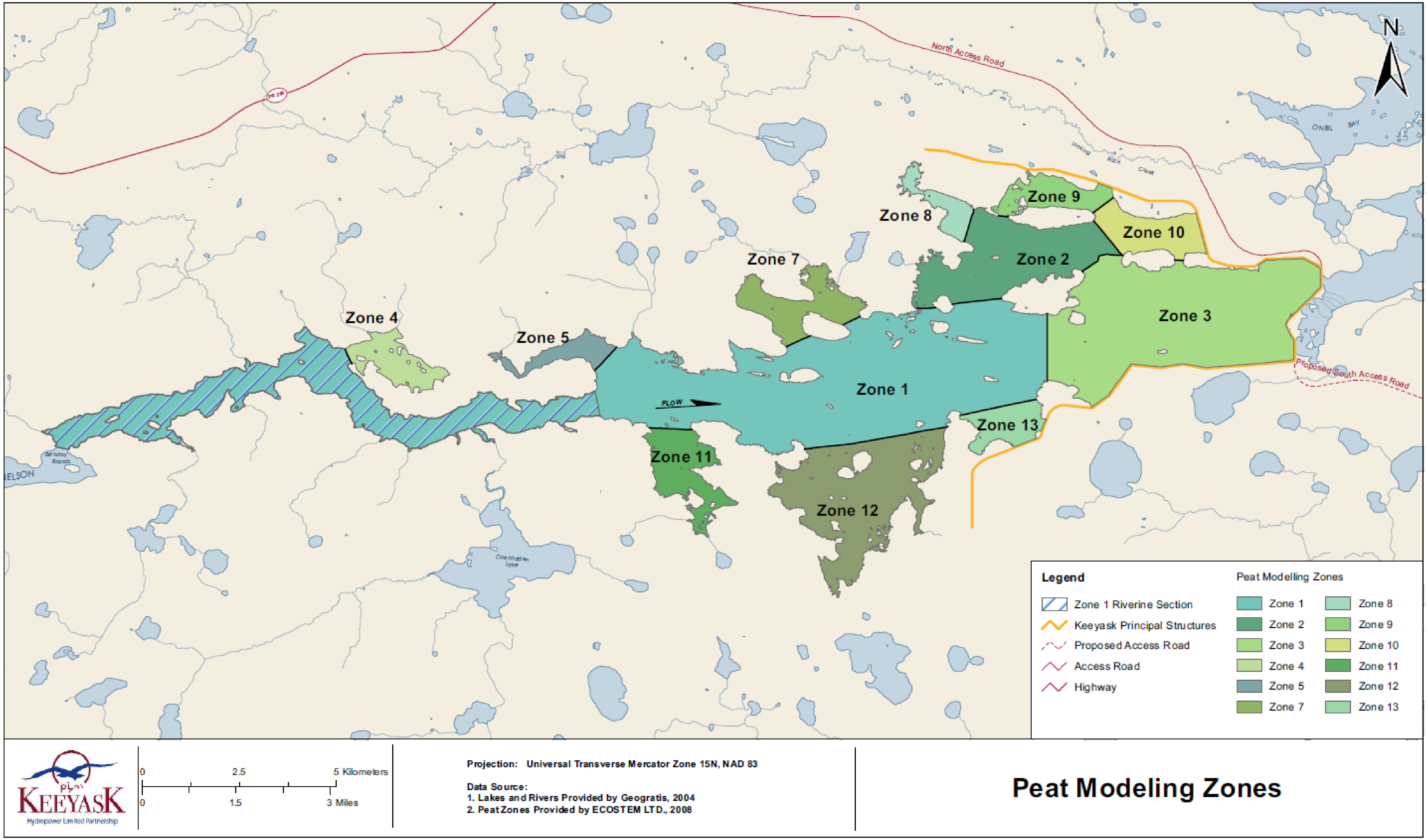
(source: PD SV, Map 1-1)

Map 1-1: General Project Location



(source: PE SV, Figure 4.4-4)

Map 1-2: Water Surface Profiles and Flooded Area



(source: PE SV, Map 7. 2-3)

Map 1-3: Peat Transport Modeling Zones Defined in the Keeyask EIS

2.0 SURFACE WATER AND ICE-REGIMES

2.1 BACKGROUND

This section describes surface water and ice regime monitoring that will be carried out during construction and initial operation of the Project. The water regime and ice parameters include:

- water level,
- depth / bottom elevation,
- water velocity, and
- ice cover development.

Water level monitoring and reporting under the PEMP will occur over the initial operating period. It is expected that some water level monitoring will take place over the long-term operation of the Project for operational purposes, however that monitoring is beyond the scope of the PEMP. Water level data will be used to confirm expected changes resulting from construction and operation of the Project, and to support other monitoring programs.

Water levels have been and are currently recorded on Split Lake upstream of the Project's predicted open water hydraulic zone of influence and downstream on Stephens Lake. This monitoring is expected to continue during construction and operation of the Keeyask Project and, where data are available, the Keeyask water regime monitoring program will utilize this information if required.

Monitoring and measurement of depth/bottom elevation, water velocity and ice cover development will take place after the reservoir is impounded or after the generating station is fully operational (i.e., all generators in service). Water velocity and depth/bottom elevation will be monitored to provide specific information required for the AEMP (e.g., for habitat assessment). Ice cover development under different flow conditions will be monitored to confirm predicted effects of the Project on the development of an ice cover upstream and downstream of the Project.

2.2 KEEYASK LICENSING AND REGULATORY REQUIREMENTS

This section to be completed when requirements from regulatory and licensing processes are defined.

2.3 CONSTRUCTION PERIOD WATER LEVELS

2.3.1.1 Monitoring Methods

Water levels will be measured throughout the year using automated water level recorders installed and operated according to Manitoba Hydro's protocols for water level monitoring sites. Operation of the sites includes routine maintenance visits to check monitoring equipment. The sites may be set up as temporary or permanent monitoring locations as required, depending on future requirements such as regulatory or operational needs.

2.3.1.2 Locations, Frequency and Duration

Continuous water level monitoring is planned for the following locations during the entire construction period (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, and
- upstream of Gull Rapids (downstream end of Gull Lake, likely near the ice boom).

As required, water level data will also be obtained from other monitoring sites on Split Lake and Stephens Lake if available (see inset map, Map 2-1). Levels are currently monitored by Manitoba Hydro on the Aiken River at York Landing and by Manitoba Hydro and Water Survey of Canada on Split Lake at the Split Lake community. 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. Operation and maintenance of these additional sites is beyond the scope of the Keeyask PEMP.

2.4 OPERATING PERIOD

2.4.1 Water Level

2.4.1.1 Monitoring Methods

Monitoring methods will be the same as during construction, using automated water level recorders installed and operated according to Manitoba Hydro's protocols, which include routine maintenance visits to check monitoring equipment. The sites may be set up as temporary or permanent monitoring locations as required.

2.4.1.2 Locations, Frequency and Duration

Continuous water level monitoring during the initial operating period (i.e., after impoundment) will continue at the same locations that will be monitored 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 (at the generating station).

The first five sites are the same as during construction, however the specific locations may need to be adjusted for the sites at Birthday Rapids and on Gull Lake due to water level changes resulting from reservoir impoundment. During operation, water levels at the downstream end of the reservoir will likely be measured at or near the generating station. As with construction period monitoring, available water level data will be obtained from other monitoring sites on Split Lake and Stephens as required to support monitoring of Project effects.

As noted above (Sec. 1.2), the KCNs expressed concerns about the potential for the Project to affect water levels on Split Lake. A fundamental operating feature of the Keeyask Project is that Split Lake water levels will not be affected by the Project during open water conditions (JKDA, Art. 7.2.2(a)). Water level data will be used to verify this fundamental operating feature.

While it is anticipated that some of the PEMP sites may continue to be monitored over the long term (e.g., during the operating life of the generating station), monitoring and reporting requirements for purposes of the PEMP will be shorter. Water level monitoring under the PEMP is planned to take place during the initial operating period. This duration is expected to be sufficient to capture a range of flow and operating conditions to characterize changes and variations in water levels due to the Project. However, potential requirements for longer term monitoring will be considered when the scope of ongoing PEMP monitoring is assessed at the end of the initial operating period (see Sec. 1.4.4).

2.4.2 Bed Elevation and Water Depth

The preparation of reservoir depth charts is a commitment under the Waterways Management Program, as described in the JKDA (Sched. 11-2, Item 4.2(c)). These depth charts will be prepared to support safe navigation on the new reservoir and to identify safe navigation routes for users of the waterway.

It is anticipated that the AEMP will require more detailed bed elevation and depth data in specific areas than may be provided in the depth charts prepared under the Waterways Management Program. The measurement of bed elevation and water depth under PEMP would be restricted to site-specific monitoring in support of the AEMP where greater resolution may be required.

2.4.2.1 Monitoring Methods

Bed elevation data will be collected using Manitoba Hydro's 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. Areas to be mapped will be traversed in a systematic pattern designed to collect the depth data at the resolution required for the AEMP studies. Specific requirements during the operation phase will be defined in conjunction with the AEMP studies group. Results will be shared with the group implementing the Waterways Management Program, as they may use the information in the depth maps to be prepared as part of that program.

2.4.2.2 Locations, Frequency and Duration

It is anticipated that the measurement of bed elevation and water depth at site-specific locations upstream of the Project would primarily occur 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 can occur prior to impoundment since downstream water levels on Stephens Lake are controlled by the Kettle GS. Sites to be measured are expected to include planned or potential aquatic habitat compensation areas such as planned spawning habitats downstream of the GS (Map 2-2). Specific areas to be monitored will be identified based on the requirements of the AEMP studies group.

The need for subsequent follow-up bed elevation and water depth measurements, or measurements at new locations, will be determined based on requirements identified by the AEMP studies group.

2.4.3 Water Velocity

Water velocity, in addition to water level fluctuation and depth, is a physical parameter that is relevant to the assessment of aquatic habitat. Velocity monitoring will be performed as part of the PEMP to support the work of the AEMP studies group for post-Project habitat monitoring purposes.

2.4.3.1 Monitoring Methods

Water velocity will be measured using Acoustic Doppler Current Profiler (ADCP) technology to measure velocity across the depth of the water column. Monitoring will be done according to Manitoba Hydro procedures for ADCP flow measurement. The methods employed may be adapted depending on changes in technology and potential identification of improvements in processes used to collect velocity data. Velocities will be measured along transects across the specific habitat areas at sufficient density to adequately characterize velocities in the habitat area to meet the needs of the AEMP studies group.

2.4.3.2 Locations, Frequency and Duration

Velocity measurements will be obtained at site-specific locations upstream and downstream of the Project. Sites to be measured are expected to include planned or potential aquatic habitat compensation areas such as planned spawning habitats downstream of the GS (Map 2-2). Specific areas to be monitored will be identified based on the requirements of the AEMP studies group.

Within the upstream open water hydraulic zone of influence, monitoring will be performed to capture a range of flow conditions (e.g., once at low, median and high all season flows). Measurement at different reservoir water levels may also be required if substantial differences in velocity are anticipated based on the reservoir level. Some of this monitoring could occur before all the generating units in the powerhouse are operating.

Downstream of the generating station, particularly in the area of constructed sturgeon and whitefish spawning habitats, water velocity monitoring will occur after the generating station is fully operating in order to capture actual operating flows from the powerhouse and spillway. Downstream monitoring will be performed to capture velocities under a range of discharge conditions (e.g., low, median and high all season flows) and generating unit operations.

Velocity measurements would not occur on a scheduled basis (e.g., annually) since the range of conditions to be measured is largely dependent upon the inflows to this reach of the lower Nelson River (i.e., discharge from Split Lake) and the operation of the Keeyask GS. As such, it is anticipated that monitoring will be planned in response to projected and actual flow conditions. For this reason, the duration of the water-velocity monitoring program is uncertain.

Depending on the results obtained and specific requirements of the AEMP study group, it may not be necessary to obtain velocity measurements at all locations under the entire range of flow and operating conditions. The data collected may support conclusions with respect to flow and operating conditions not yet measured. For this reason, the PEMP and AEMP teams will assess the need for further velocity monitoring at specific sites as data are obtained and processed.

2.4.4 Ice-Regime

The Project will change the upstream ice-regime through creation of the reservoir and will alter the downstream ice-regime between the GS and the entrance to Stephens Lake. Ice-regime monitoring will be performed to verify the expected development of a thinner, smoother ice-cover on the reservoir and advancement of the ice front upstream of Birthday Rapids each year. Downstream monitoring will be performed to verify that a thinner, smoother ice cover develops between the GS and Stephens Lake relative to conditions without the Project. It will also confirm that a large hanging ice-dam no longer develops in the downstream area when the Project is in place.

The KCNs have expressed concern about the potential for the Project to affect Split Lake water levels and ice conditions in the winter (see Sec. 1.2). As noted in Sec. 2.4.1.2, water level data from the PEMP and other monitoring sites will be used to assess whether or not the Project affects Split Lake water levels and subsequently Split Lake ice conditions.

2.4.4.1 Monitoring Methods

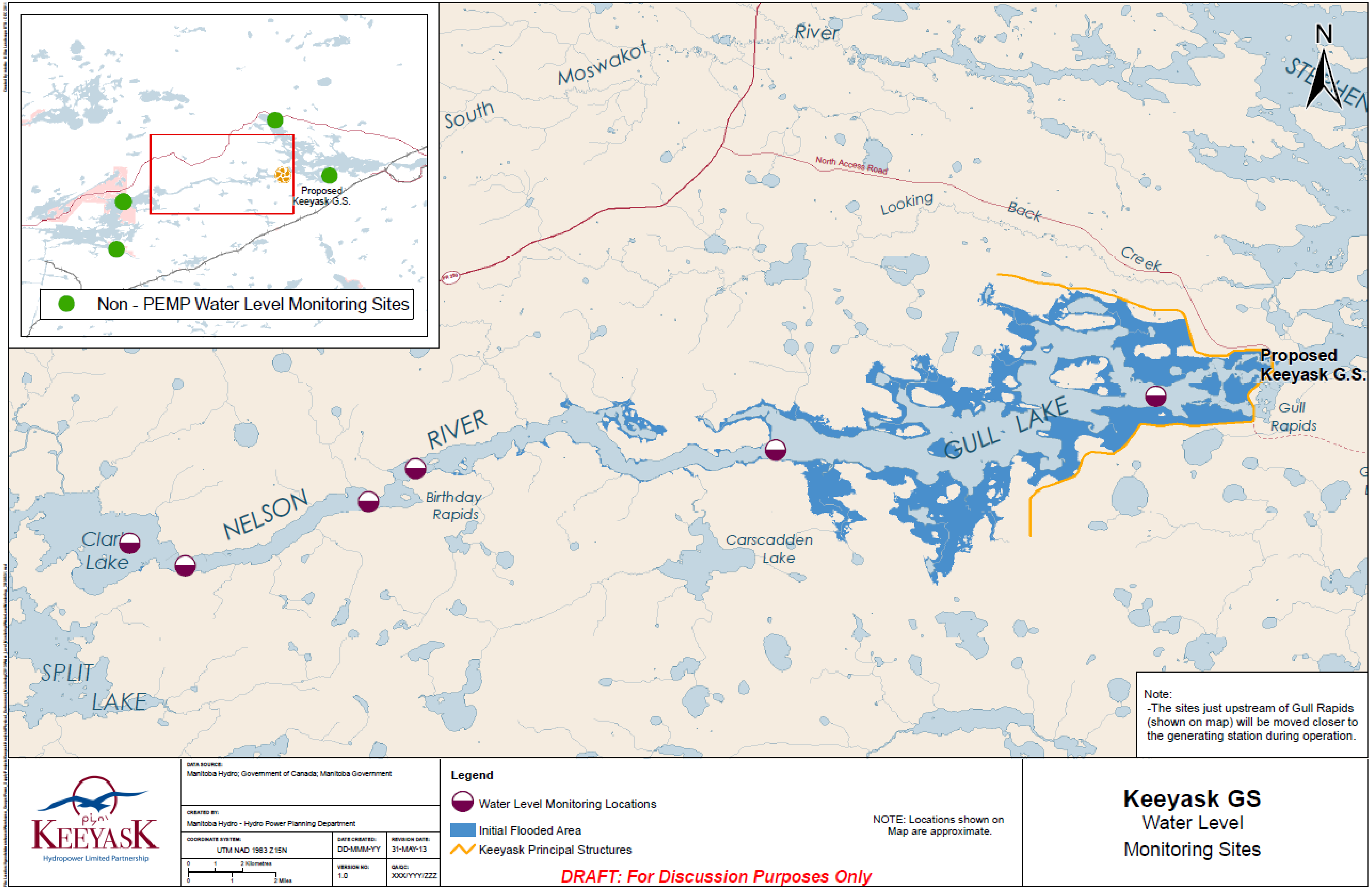
The location of the advancing ice front will be identified, either by visual observation or satellite imagery. Ice thickness and water level will be measured by drilling holes through the ice cover at various locations so that thickness and water level can be measured. Measurements at a number of locations can then be used to generate a profile of ice thickness and water level. Water level measurements may also be used to verify data obtained from continuous water level recorders (see Sec. 2.4.1). Ice cover measurements may be limited based on safety considerations.

A component of the Waterways Management Program during operation is “installing and monitoring regularly the condition of safe ice trails” (JKDA, Sched. 11-2, Sec. 4.2(g)). Work under this management program may include collection of information such as ice thickness that may be used in the ice-regime monitoring. Therefore, if practicable, the ice-regime monitoring will be coordinated with the work of the waterways management group.

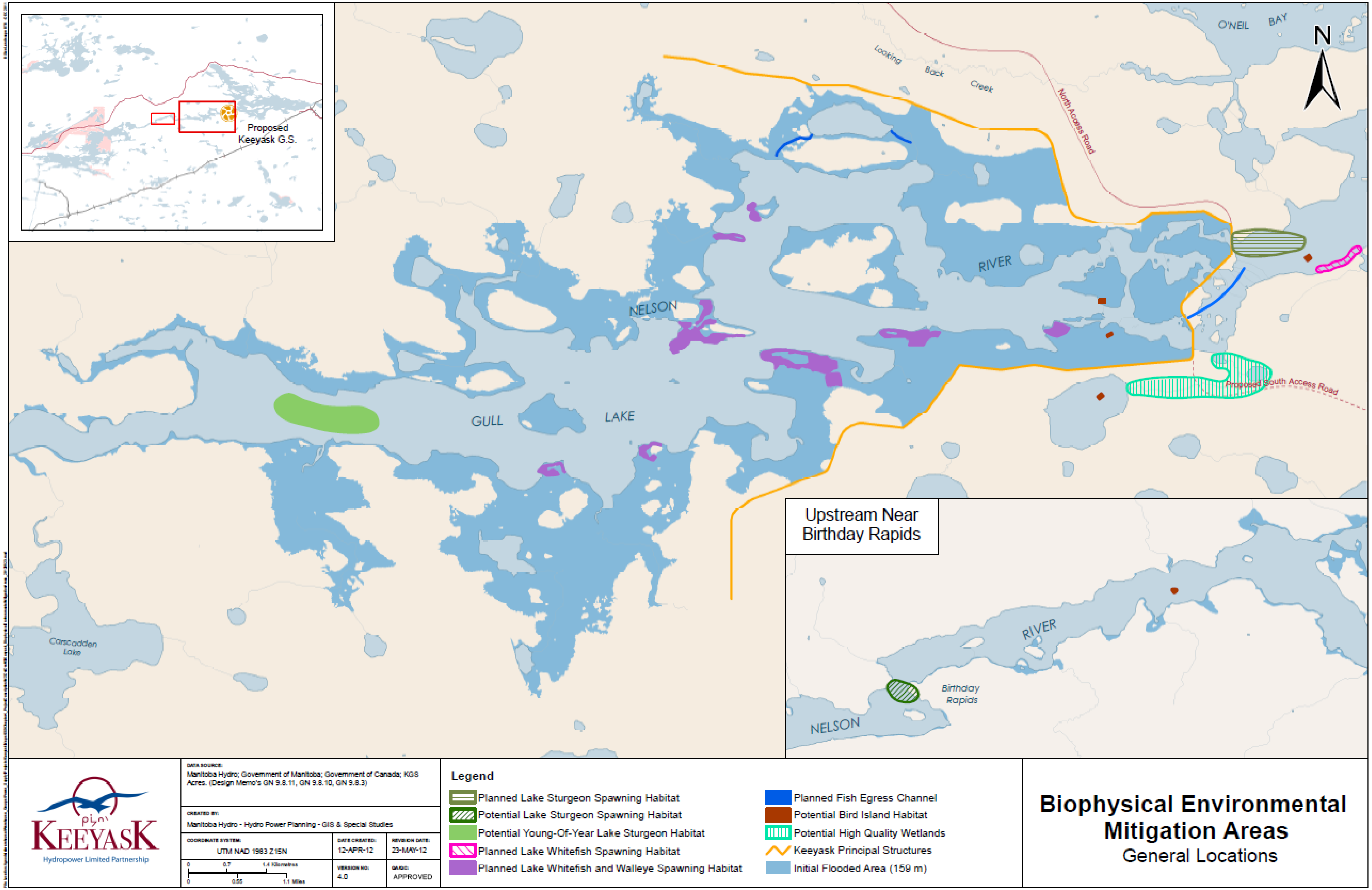
2.4.4.2 Locations, Frequency and Duration

Once freeze-up is sufficiently initiated (likely about mid-November) the location of the upstream ice front will be periodically identified (up to once a month) and photographed. The development of the upstream ice cover on the reservoir and in the upstream riverine section will also be monitored periodically (up to once a month). At multiple locations on the mainstem, ice thickness and spot water levels will be measured to identify how the ice cover is developing over time. Ice thickness and spot water levels will also be periodically measured at multiple sites downstream of the generating station to the entrance to Stephens Lake.

Ice-regime monitoring is planned to occur each winter in the first three winters after reservoir impoundment at which time the need for additional monitoring will be assessed.



Map 2-1: Water Level Monitoring Sites



(source: PD SV, Figure 2-22)

Map 2-2: Biophysical Environmental Mitigation and Compensation Areas (General Locations)

3.0 SHORELINE EROSION & PEATLAND DISINTEGRATION

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 processes. While some erosion monitoring is proposed for the construction period, most of the monitoring activity is planned for the operating phase after impoundment when the largest Project effects will occur. Erosion monitoring will include shorelines comprised of inorganic mineral materials (e.g., sand, silt, clay) as well as organic (peat) material. Peatland disintegration results in peat entering the water due to resurfacing of flooded peat (i.e., peat floating up from the bottom) and break down of floating and shoreline peatlands. Erosion and peatland disintegration processes are relevant to other monitoring activities because it contributes sediment to the waterway. This has implications for other physical environment factors such as sediment deposition and suspended sediment. It also relates to factors being monitored in other programs such as water quality (e.g., nutrients, metals, mercury), which is part of the AEMP. This component of the PEMP includes monitoring:

- reservoir expansion and reservoir area,
- peat resurfacing, and
- shoreline classification.

Approximately 45 km^2 of land will be flooded when the reservoir is impounded and most of this area is covered in peat material. The largest Project effects in terms of shoreline erosion (i.e., mineral erosion and peatland disintegration) is 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 is predicted to be lower in years 2-5 after impoundment and gradually declines to a lower and more stable long-term rate. Initially, mineral/bedrock and peat shorelines are expected to represent about 30% and 60% of the total post-Project shoreline length respectively. The proportion that is mineral/bedrock or mineral overlain by peat is expected to increase over time as mineral material becomes exposed due to disintegration of shoreline peatlands.

3.2 CONSTRUCTION PERIOD

During construction, water level increases within Gull Rapids at certain times during in-stream construction may result in the erosion of some shorelines (SMP, Sec. 2.3.1), introducing suspended sediment into the river. The Project is not expected to substantively affect shorelines outside of Gull Rapids prior to final reservoir impoundment to FSL, particularly because Gull Lake water levels are expected to remain within the range of historic water levels. The SMP will monitor suspended sediment increases due to shoreline erosion within Gull Rapids during in-stream construction and mitigation measures may be implemented if necessary as described in the SMP. Because the effects of shoreline erosion within Gull Rapids are considered under the SMP and other effects are expected to be limited, the monitoring of shoreline erosion during construction will consist of mapping the top-of-bluff location based on high-resolution aerial imagery (colour air photo or satellite) obtained at:

- the start of construction (2014), and
- prior to reservoir impoundment to FSL (2019).

Changes in shoreline position (edge of peat for peat shorelines, top-of-bluff for mineral banks) may then be identified for the period between pre-Project environmental studies and start of construction, which provides additional baseline information on shoreline erosion rates. Photos at the start of construction and before reservoir impoundment will provide an indication of changes during construction. The pre-impoundment imagery will be acquired over an area large enough to encompass post-Project shorelines: i.e., it will capture the flooded area, which will have largely been cleared of vegetation through the Reservoir Clearing Plan (JKDA, Sched. 11-1). The pre-impoundment and planned post-impoundment images (see Sec. 3.3.3) may also be used to estimate the actual area flooded by the Project.

3.3 OPERATING PERIOD

3.3.1 Shoreline Classification

The Keeyask EIS predicts that the nature of the reservoir shoreline will gradually change as mineral bank erosion and peatland disintegration occur. As noted above, initially there will be a higher proportion of peat shorelines than mineral shorelines. Ongoing peatland disintegration will expose mineral materials that typically erode at a slower rate. Thus, the relative amount of mineral shoreline is expected to increase over time. Additionally, erosion would no longer occur where shoreline erosion exposes bedrock. Periodically, shoreline properties such as material type (e.g., peat or mineral), estimated bluff height and slope will be re-classified so that the changing nature of shorelines may be identified. If monitoring identifies erosion that is much greater than expected, the potential cause will be investigated if deemed necessary by the MAC or if required to support other monitoring programs (e.g., AEMP, TEMP). The assessment would use data collected by the PEMP and other monitoring programs as applicable (e.g., ecosite mapping from the TEMP).

3.3.1.1 Monitoring Methods

Shoreline classification will be done using several information sources that may include;

- GPS referenced shoreline video,
- GPS referenced still photos,
- Remote sensing (e.g., air photo, satellite imagery, or LiDAR) and,
- field verification.

It is anticipated that much of the information required to classify shorelines can be obtained from videos, photos and remote sensing, however additional field surveys may be required for verification.

3.3.1.2 Locations, Frequency and Duration

The classification of shorelines will encompass the length of the open-water hydraulic zone of influence (Map 1-2). The collection of onsite information to support shoreline classification (e.g., video, photos) should be timed to occur as close as possible to the time aerial imagery is acquired so that both sets of information represent conditions at approximately the same point in time.

Shoreline classification will be done in the first open water season following reservoir impoundment to establish the initial shoreline condition.

Reclassification of the shorelines will then occur in the fifth and tenth year after impoundment to measure the change in shoreline composition. The spatial scope for reclassification in the fifth and tenth years may be limited to the main reservoir area from the GS to the upstream end of the reservoir where substantial changes in shoreline location and/or bank attributes are expected to occur. Depending on observed changes in top-of-bluff position (Sec. 3.3.2), reclassification may be limited to specific sites where greater erosion is occurring and the nature of the shoreline material is more likely to have changed.

3.3.2 Reservoir Expansion and Reservoir Area

The shoreline erosion assessment in the Keeyask EIS predicted that the reservoir area may increase by approximately 7-8 km^2 in the first 30 years of operation, with the highest rates of change occurring in the first five years of operation. Monitoring will be performed to verify the rate of reservoir expansion and the change in reservoir area during operation. The Keeyask EIS predicts that floating and mobile peat (i.e., peat that may be transported away from where it originates) will generally accumulate in backbay areas and aerial imagery may be used verify where mobile peat accumulates (PE SV Sec. 7.4.2.3).

3.3.2.1 Monitoring Methods

Overall reservoir expansion and change in area will be determined based on mapping the shoreline position (edge of peat for peat shorelines, top-of-bluff for mineral banks) from colour aerial photography, which may include LiDAR and/or satellite imagery. Imagery will be of sufficient resolution to allow the shoreline position to be identified. Changes in shoreline position between years will be identified. If necessary, field surveys may be performed to verify mapping where uncertainty exists in the shoreline position or, if required, to investigate areas where unanticipated high rates of reservoir expansion occur.

3.3.2.2 Locations, Frequency and Duration

Monitoring of reservoir expansion will encompass the length of the open-water hydraulic zone of influence from the outlet of Clark Lake to just downstream of the Project (Map 1-2).

Colour aerial photographs of sufficient resolution to map the shoreline will be obtained in the first open water season following impoundment to identify the initial shoreline position (edge of peat for peat shorelines, top-of-bluff for mineral banks) in the operating period. Satellite imagery will subsequently be obtained in the second, fifth and tenth open water seasons after impoundment. Aerial photographs may be obtained in the tenth year rather than satellite imagery.

The change in reservoir shoreline will be mapped to identify where reservoir expansion is occurring, which may then be compared with predicted rates of expansion reported in the EIS. Monitoring requirements during the long-term operation period will be assessed after the tenth year of operation.

Additional satellite imagery may be obtained in intervening years if there is an identified need. The PEMP will co-ordinate imagery collection with the other study groups (AEMP, TEMP), which may also require this type of information.

3.3.3 Peat Resurfacing

The Keeyask EIS included predictions of the amount of peat that would resurface (i.e., flooded peat that floats to the surface). The greatest amount of peat resurfacing, about two thirds of all resurfacing, is expected to occur in the first year after impoundment and is not expected to occur beyond year ten. Resurfaced peat is the primary source of organic sediment loading to the reservoir in the first year of operation and contributes to floating peat that may be transported within the reservoir. Much of the peat that resurfaces may subsequently sink back to the bottom, potentially after being transported to another location. Monitoring will attempt to characterize how much resurfacing occurs.

3.3.3.1 Monitoring Methods

[Drafting Note: The method(s) for monitoring resurfacing remains to be determined but may include one or more sources of information: e.g., satellite imagery, still photographs, video (ground level, helicopter), aerial photographs, field observations (e.g., waterways management program)].

3.3.3.2 Locations, Frequency and Duration

The spatial scope for monitoring peat resurfacing is the newly flooded areas of the reservoir, primarily the flooded terrestrial areas from the GS to about 20 km upstream at the entrance to the reservoir (see Map 1-2).

Monitoring of peat resurfacing is proposed during the period of reservoir impoundment in 2019 and in the first three to five years of operation after impoundment. The frequency of monitoring activity for peat resurfacing will be greater early in the monitoring period when the greatest amount of resurfacing is expected to occur. As the rate of additional resurfacing is expected to decline in the following years, the frequency of monitoring activity will likewise be reduced. Monitoring activity will be adjusted based on observations.

4.0 SEDIMENTATION

4.1 BACKGROUND

This section of the PEMP 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:

- turbidity,
- total suspended solids (TSS) and other water quality parameters,
- 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. 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. Other effects, such as changes in substrate composition, may only be discernible over longer periods as sediment is deposited over time.

While effects of the Project on suspended sediments (mineral and organic) 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 because it can be measured over extended periods using automated probes, unlike suspended sediment concentrations that can only be measured from discrete water samples. Turbidity probes can be installed at a monitoring site to continuously measure turbidity (i.e., take readings at regular, frequent time intervals) and store the readings on internal memory. Continuous turbidity will be monitored in addition to discrete turbidity and suspended sediment sampling to provide a more complete picture of the variation in water transparency over an extended period. This can provide useful information to understand how infrequent events such as high winds affect turbidity, which may not be captured by discrete water sampling.

4.2 CONSTRUCTION PERIOD

4.2.1 Continuous Turbidity Monitoring

4.2.1.1 Monitoring Methods

Continuous turbidity monitoring will be performed according to protocols developed by Manitoba Hydro, 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. The probes will measure turbidity (and temperature) at a predetermined frequency and store the measurements internally. Field crews will perform routine maintenance checks on the probes approximately every three weeks. These checks include using another probe to obtain discrete turbidity readings at a site before removing the continuous probe. Water samples will be obtained before removing the continuous probe and will be sent to a laboratory to test for total suspended solids (TSS) and other water quality parameters (see Sec. 4.2.2). The continuous turbidity probe would then be removed so that data may be downloaded and the probe may be cleaned and recalibrated. The probe would be redeployed in the water once the maintenance is complete. A second set of water samples and discrete turbidity readings would be obtained after the probe is put back in the water. Additional discrete in-situ measurements such as dissolved oxygen would also be obtained at the same time.

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. The probe may also be deployed on the riverbed, under the ice, for the entire winter season if ice conditions prevent it from being suspended from the ice surface (e.g., ice too thick). In this case, the probe would be installed prior to or soon after the ice cover forms and would be recovered at the start of the following open water season, remaining in place near the bottom over the winter. Maintenance visits cannot be performed with this deployment method since the probe would be inaccessible under the ice.

4.2.1.2 Locations, Frequency and Duration

Continuous turbidity monitoring was performed as part of the baseline EIS studies. Monitoring during construction will be performed during periods of in-stream work, where possible, at the same locations that were monitored during the baseline studies, or at a subset of these locations. Locations where monitoring is expected 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 GS.

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 performed downstream of the Kettle GS at the following locations:

- just upstream of the Long Spruce GS, and
- just upstream of the Limestone GS.

The locations of the 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 tailrace channel summer level cofferdam 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.

In addition to monitoring during open-water periods when in-stream construction activities occur, winter monitoring is also proposed for a subset of the open water sites. Winter monitoring may be performed for the sites at:

- upstream end of Gull Lake,
- upstream of Gull Rapids (near ice boom), and
- entrance to Stephens Lake.

This monitoring could occur each winter, however the need to conduct monitoring each winter will be assessed on an ongoing basis depending on observed results.

4.2.2 Discrete TSS and Water Quality

4.2.2.1 Monitoring Methods

Monitoring will be performed according to protocols developed by Manitoba Hydro, 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 unless the water is shallow, in which case the sample would be collected at mid-depth. Two water samples would be obtained at each depth. Samples will be shipped to an accredited lab to test for:

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

The Keeyask EIS predicted that organic suspended sediments would increase due to flooding of terrestrial areas and ongoing peatland disintegration. The effects are expected to be greatest in the first years of operation and decrease over time as the rate of peatland disintegration declines. Water quality testing under PEMP will include measuring the following parameters related to organic carbon in order to monitor Project effects with respect to organic sediments:

- volatile suspended solids (VSS),
- total carbon (TC),
- total organic carbon (TOC),
- dissolved organic carbon (DOC),
- particulate organic carbon (POC),
- total inorganic carbon (TIC),
- dissolved inorganic carbon (DIC), and
- particulate inorganic carbon (PIC).

The parameter VSS provides an indication of the fraction of TSS that is organic matter. The carbon parameters provide a characterization of the organic and inorganic carbon fractions of the suspended and dissolved solids. The TC concentration is the sum of the TOC and TIC fractions (TC = TOC + TIC), which in turn are the sum of the respective organic and inorganic dissolved and particulate concentrations (TOC = DOC + POC, and TIC = DIC + PIC).

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.

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. Environmental baseline studies included discrete monitoring at ten sites from Clark Lake to the entrance of Stephens Lake, with three to five sampling points across the width of the channel at each site (Map 4-1). Baseline monitoring did not indicate substantive lateral variability at these sites, therefore the number of sampling points at each site may be reduced. Four of these sites are at the same location where continuous turbidity monitoring will be performed:

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

The additional discrete monitoring sites that were monitored during the baseline studies are in the following locations (Map 4-1):

- just upstream of Birthday Rapids,
- just downstream of Birthday Rapids,

- upstream of Gull Lake
- central area of Gull Lake
- north of Caribou Island, and
- south of Caribou Island.

Discrete monitoring sites will be sampled two to four times per open water season at about the same time that routine maintenance checks are being done at the continuous turbidity sites. Sampling will be performed each year during construction until the reservoir is impounded.

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 protocols developed by Manitoba Hydro, which are briefly described below and may be revised from time to time.

Bed-load measurements will be carried out at sampling points using a standard bed-load sampler. Five separate bed-load samples will be collected at each sampling point. Samples that yield sufficient material will be laboratory tested to obtain the grain size gradations.

Where possible, a bed material grab sample will also be collected at each sampling point when bed-load sampling is performed. These samples will be analyzed at an accredited laboratory to obtain grain size gradation. Bed material sampling under the bed-load monitoring program 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 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 potential fish habitat compensation may be implemented (see PD SV, Table 6-2). The second monitoring site is near an area identified by the aquatic studies group 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 for the Keeyask 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 monitoring results.

4.2.4 Sediment Deposition and Substrate

4.2.4.1 Scope

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

4.2.4.2 Monitoring Methods

Depending on the monitoring location, sediment deposition and substrate monitoring may involve one or more of the following activities:

- obtaining sediment grab samples,
- installing sediment traps,
- collecting substrate imagery, and
- obtaining sediment core samples.

Sediment grab samples will be obtained according to Manitoba Hydro protocols for sediment sampling. Samples will be collected using a standard sampler designed to collect samples of surface sediments (e.g., ponar sampler). Depending on substrate conditions it may not be possible to obtain sediment grab samples (e.g., rocky bottom).

If possible (e.g., water velocity not too high), sediment traps will also be placed at two monitoring sites (see Sec. 4.2.4.3 for locations) during each year of construction. Sediment collected in the traps will be removed two times each year and the samples will be lab tested to determine sediment volumes and particle size gradations.

Results from sediment trap monitoring must be considered in conjunction with other sediment data that will be collected because sediment collected in the trap may not provide a complete representation of the sedimentation environment. An important aspect of the sedimentation regime in areas of flow is that finer material, which may be deposited when water velocities are low, may later be re-suspended and transported away from the site when 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. Thus, the characteristics and amount of sediment collected in the trap will not necessarily represent the actual sediment type and net rate of deposition on the bed. To develop a more complete understanding of the sediment regime, results from the analysis of sediment collected by the traps cannot be considered in isolation. Instead, they must be assessed within the context of results from substrate sampling, water quality (TSS) sampling, and substrate imagery where imagery is obtained.

In addition to the sediment traps and grab samples, underwater video may be obtained at a number of locations at each monitoring site. Video may be used to identify the nature of the substrate and determine if visible changes are occurring over time, which may be useful where sediment grab samples cannot be obtained. Where possible, and if required, sediment cores may also be obtained using a suitable coring method considering water depth, flow and substrate type. The need for coring will be determined based on results from sediment grab sampling.

4.2.4.3 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. The substrate in this area was identified in the Keeysk EIS as coarse material (e.g., gravel, cobble, boulder), therefore it may not be possible to obtain sediment grab or core 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. Several sampling positions will be measured in each location.

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. Since in-stream construction activities are planned to occur during the open water period, sampling 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. If sediment sampling suggests the substrate has changed, sediment cores may also be collected at each monitoring location at the end of the construction monitoring period, just prior to reservoir impoundment.

In addition to the above sampling, substrate imagery (video or photos) will be collected at the monitoring locations using an underwater camera. The imagery will help identify if the bed materials visibly changed over time, which may be useful where suitable sediment samples cannot be obtained. Imagery will be collected at each site at the start and end of the construction period. The downstream site will also have imagery collected following major in-stream construction activities that may cause larger increases in sediment transported downstream of the Project (e.g., initial spillway operation and Stage II river diversion).

4.3 OPERATING PERIOD

Predictions were made in the Keeyask 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. 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 resurfacing occurs. Resurfacing is expected to be much lower in the second and following years after impoundment. Correspondingly, organic suspended sediment is expected to be much lower in the second year and is expected to decrease over time.

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.

4.3.1 Continuous Turbidity Monitoring

4.3.1.1 Monitoring Methods

Continuous turbidity monitoring during operation will follow the same protocols 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 during open water conditions will be done at or near the locations that will be monitored during construction, which are (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 GS.

Additional continuous turbidity monitoring will be done in the open-water season at two or three representative backbay sites that will be identified on the north side of the reservoir plus two or three representative sites on the south side of the reservoir. Sites will be located in backbays where the largest effects on suspended sediment (mineral plus organic) are expected to occur. These sites will be in locations that are terrestrial prior to impoundment and will be flooded when the reservoir is raised to full supply level in 2019. Monitoring will be done during each open water season in the first five years after impoundment, at which time the requirements for ongoing continuous turbidity monitoring during the remainder of the initial operating period will be assessed. Note the summary schedule (Appendix A) assumes some continuous monitoring would be likely to occur over the entire initial operating period.

Where possible, winter turbidity monitoring will also be performed during operation at three of the sites that will be monitored during open water conditions:

- upstream end of Gull Lake
- upstream of Keeyask GS, 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.

4.3.2 Discrete TSS and Water Quality

4.3.2.1 Monitoring Methods

Discrete monitoring during operation will follow the same protocols used in the construction period monitoring (see Sec. 4.2.2.1). This will include collection of dissolved oxygen and temperature data, which will be provided to the aquatic studies group.

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

Discrete sampling sites will be established in those flooded backbays where continuous turbidity is not being monitored.

Discrete monitoring sites will be sampled two to four times per open water season 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, at which time the need for ongoing monitoring during the initial operating period will be assessed. Note the summary schedule (Appendix A) assumes some continuous monitoring would be likely to occur in each year of the initial operating period.

4.3.3 Bed-load Monitoring

4.3.3.1 Monitoring Methods

Bed-load monitoring during operation will follow the same protocols 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 monitoring during construction at the upstream end of the reservoir 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 program for the reservoir is intended to develop a general understanding of substrate changes across a range of different depositional environments within the reservoir.

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 protocols used for the construction period monitoring (see Sec. 4.2.4.2).

Mineral sedimentation analyses reported in the Keeyask EIS (PE SV, Sec. 7) indicated that material derived from shoreline erosion would primarily settle within a couple hundred metres of the shore. Therefore, additional deposition monitoring in the reservoir will involve the collection of sediment samples along transects extending perpendicular from the shoreline edge up to approximately 400 m offshore (e.g., at approximately 5, 50, 100, 200 and 400 m offshore). Sediment grab samples will be obtained (e.g., using a ponar sampler) along each transect to identify the substrate type (mineral, organic), deposition depth and, where mineral material is present, to collect samples for laboratory grain size analysis. In addition to the nearshore sediment transects, sediment sampling will be performed at a number of offshore locations within mainstem areas of the reservoir representing flooded areas of the original river channel. The sampling is intended to identify changes in surface substrate over time (e.g., organic to mineral; course mineral to fine) and rates of deposition. The potential requirement to obtain sediment cores will be determined based on results from the grab sampling program.

4.3.4.2 Locations, Frequency and Duration

Deposition and substrate monitoring will be performed 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.Monitoring will take place at these two locations each year during the first five years of operation.

The scope will be reviewed after three years. Where possible, depending on site conditions, the monitoring will include:

- obtaining sediment grab samples twice each year, once at the beginning of the open water season and once near the end,
- deploying sediment traps that will be in place over the entire year, with collected sediment samples being removed twice each year, once at the beginning of the open water season and once near the end,
- obtaining substrate imagery (video) once each open water season.

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, if required, will be obtained in the fifth year.

Nearshore sedimentation transects will be established both in newly flooded backbays and along the reservoir mainstem while a number of offshore sampling sites will also be established. Potential monitoring locations are shown on Map 4-2 and include:

- up to eight sites in back-bays on the south side of the reservoir,
- up to twelve sites in back-bays on the north side of the reservoir,
- up to four sites along the south side of the reservoir mainstem,
- up to six sites along the north side of the reservoir mainstem, and
- five offshore sites along the original thalweg of the river (not including the site at the upstream end of the reservoir discussed above).

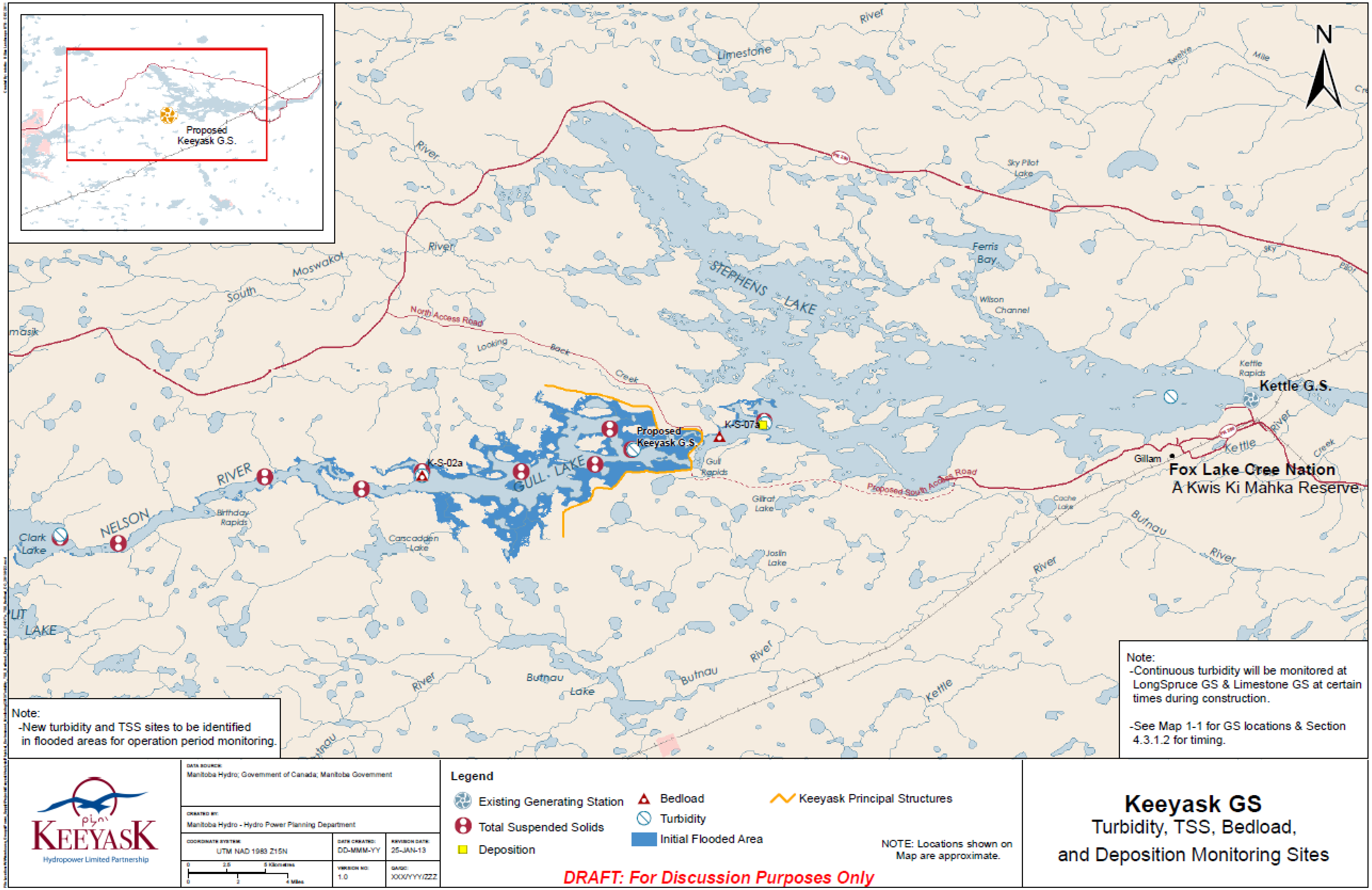
Because the actual configuration of the newly formed reservoir shoreline cannot be known before the reservoir is formed, monitoring in the first year will include confirmation of the ability to monitor the proposed locations (e.g., is it accessible). Locations will be adjusted as required based on actual conditions.

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

- year 1 (first open water season after impoundment) to identify baseline sediment type and collect mineral samples if present,
- year 2, to identify sedimentation during approximately the first sedimentation prediction period (year 1),
- year 5, to identify sedimentation during the second prediction period (year 2-5), and
- year 10, to identify sedimentation over the first 5 years of the third prediction period (year 6-15).

The proposed monitoring periods correspond to years in which aerial imagery is to be collected. The scope of any long-term monitoring will be determined based on observed results and may include reduced frequency of sampling and monitoring of fewer sites.

The need for site-specific sediment deposition and substrate monitoring at additional sites under the PEMP in support of specific habitat monitoring requirements under the AEMP will be determined in conjunction with the AEMP study team.



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

Map 4-2: Deposition and Substrate Monitoring Sites

MAP TO BE DEVELOPED ONCE LOCATIONS IDENTIFIED

5.0 GREENHOUSE GAS

The Keeyask Reservoir Greenhouse Gas Monitoring Program (Program) has been in place since 2008 to measure existing conditions and will continue up to the start of Keeyask construction. The purpose of the Program is to enable the comparison of pre- and post-impoundment aquatic greenhouse gas (GHG) concentrations to document changes resulting from the Project.

The chemical, morphological, and biological processes that create and exchange GHGs in reservoirs are similar to those of naturally occurring aquatic systems. Some of these processes may be altered during reservoir creation from the flooding of terrestrial ecosystems. 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 (CO2) and methane (CH4) 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 10 years following impoundment. It is anticipated that the Keeyask reservoir will behave in a similar manner. That is, somewhat elevated GHG concentrations are expected within the first few years after impoundment, returning to levels similar to reference levels within ten years. Reference levels that have been measured as part of the existing Program include aquatic GHG concentrations on the Nelson River upstream of the future reservoir, pre-project baseline concentrations in the Gull Lake area as well as concentrations in nearby reference lakes.

5.1 MONITORING METHODS

The following monitoring methodologies are being used in the current GHG Program and would also be used in future monitoring. They are recognized approaches for studying CO2 and CH4 gas concentrations and have been utilized internationally by independent researchers, government and industry.

Temporal monitoring will involve the use of continuous GHG monitoring systems to record the daily, seasonal and annual variability of greenhouse gas concentrations in the surface waters. These devices will measure CO2, CH4 and O2 partial pressures at the water surface every three hours and store the data in an electronic data logger. Partial pressure measurements will be converted into dissolved gas concentrations that may be used to estimate GHG emission rates.

Spatial, point in time field sampling has also been conducted as part of the existing Program and will be employed as part of the GHG monitoring during Keeyask construction and operation. Point sampling will be performed at various locations to assess spatial variability of aquatic GHG partial pressures and gas concentrations, upstream and downstream of the proposed generating station site, within the proposed reservoir, and at reference lakes. Two techniques that have been and will be used in spatial measurements are: CO2, and CH4 sensors (consistent with temporal measurements) as well as floating gas chambers.

Reservoir GHG monitoring methodologies, locations and frequency will be continually assessed throughout the duration of the monitoring program and will be revised as appropriate to optimize the data collection Program.

5.2 CONSTRUCTION PERIOD

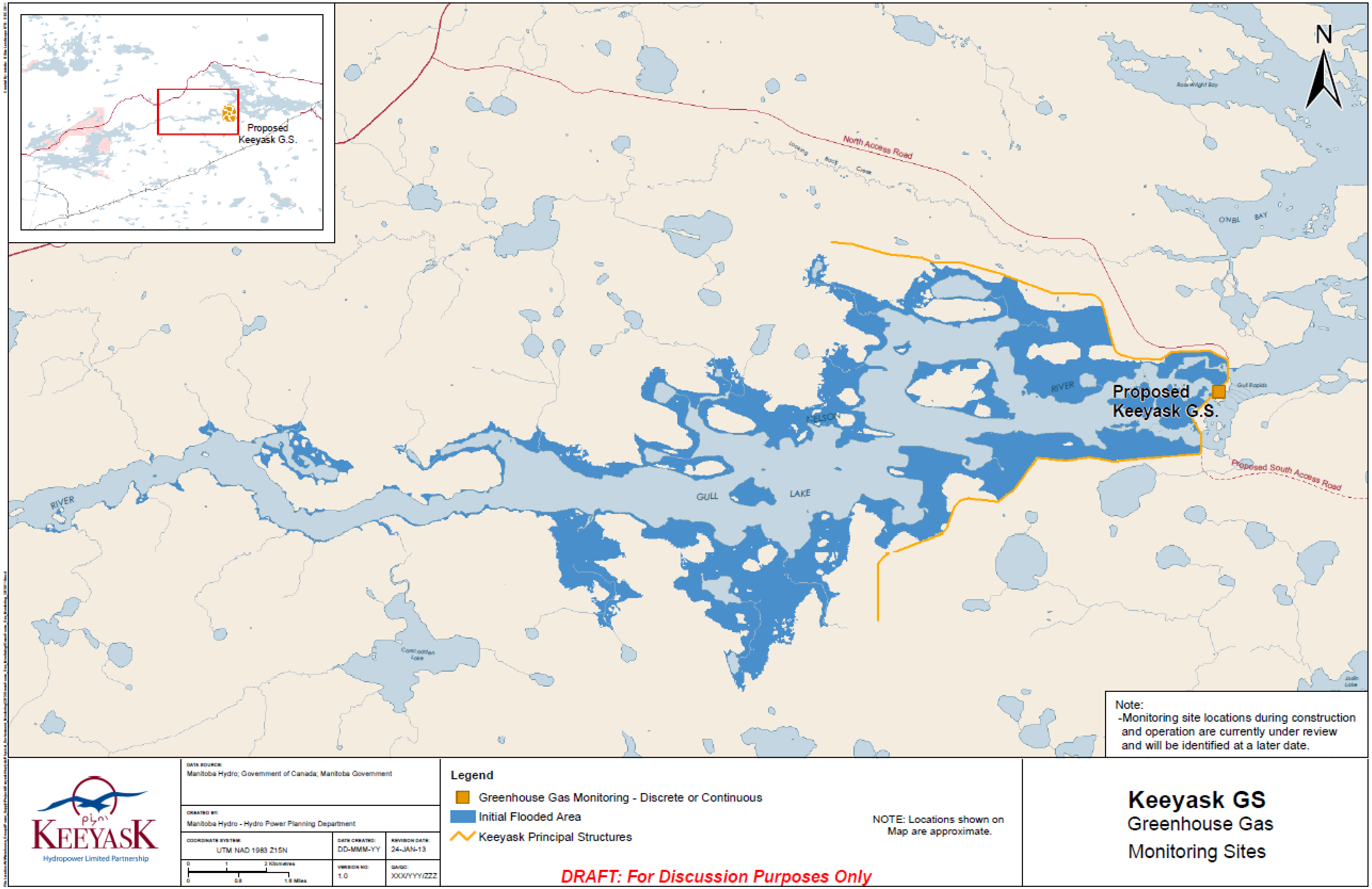
Continuous and discrete monitoring of aquatic GHG concentrations is planned to take place during the construction period and will strive to coincide with the pre-impoundment sampling locations within the proposed reservoir, and at upstream and downstream sites along the Nelson River.

5.3 OPERATING PERIOD

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.

A continuous GHG monitor will be installed in the Keeyask powerhouse and will be the primary monitoring site. The unit will monitor aquatic GHG concentrations of the reservoir. An additional continuous GHG monitor will be installed on the Nelson River upstream of the flooded area. Continuous GHG monitoring is planned for ten years following the final in-service date.

Additional seasonal continuous and spatial sampling of aquatic GHG partial pressures and gas concentrations is planned to measure changes due to reservoir impoundment.



Map 5-1: Greenhouse Gas Monitoring Sites

6.0 ANNUAL MONITORING REPORT

Each year an annual monitoring report will be produced and submitted to the regulator. The annual report will summarize the PEMP 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, 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.

The reporting period for the annual monitoring report will typically be from <date> of a given year to <date> of the next calendar year and will be submitted to the regulator on <date> of each year.

[*Drafting Note: reporting period and submission date of annual reports to be identified following the Project's regulatory review process*]

7.0 MONITORING IN SUPPORT OF OTHER PROGRAMS

In addition to the primary monitoring activities described in Sections 2 through 6, the PEMP will also include the gathering of information and data related to:

- debris management,
- surface water temperature and dissolved oxygen, and
- Total Dissolved Gas (TDG) pressure.

These additional monitoring activities will not be included as part of the annual PEMP report to the regulator. Rather, the information and data will be provided as required to other monitoring programs for use in their studies and would be reported within those studies where used.

7.1 MONITORING OF DEBRIS MANAGEMENT

The PEMP will obtain information pertaining to debris management activities performed under the Waterways Management Program so that it may be communicated to representatives of the KCNs on the MAC as well as other monitoring programs that may have a need for the information. The PEMP is not responsible for implementation of the Waterways Management Program or any of the activities and deliverables required as part of that program.

7.1.1 Waterways Management Program Overview

Management of woody debris currently takes place along the Nelson River downstream of Split Lake to and including Stephens Lake. Since 2003, the program has kept records on the amount of woody debris removed; classifying it based certain criteria related to size (large or small) and type (new, old or caused by beavers). It is anticipated that the program will continue to include recording of relevant information on debris removal and other activities undertaken in the implementation of the program during the construction and operating periods of the Project.

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

7.1.2 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). Two person boat patrols will continue to operate upstream of the Project and on Stephens Lake during construction. The PEMP will obtain information on the types and quantities of debris removed by the boat patrols and summarize the information for reporting to the MAC.

7.1.3 Operating Period

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 impoundment, with less management activity required from year's six to ten, and less required again after year ten (JKDA, Sched. 11-2).

Information to be obtained for the PEMP from the Waterways Management Program that will be communicated to the MAC may include:

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

The PEMP will summarize the information and report it to the MAC and other monitoring programs as required.

7.2 SURFACE WATER TEMPERATURE AND DISSOLVED OXYGEN

The PEMP includes collection of surface water temperature and DO data in support of AEMP studies. While this data is obtained as a part of the PEMP, work within the aquatic studies may involve further analysis and characterization of the data as it pertains to Project effects on the aquatic environment.

7.2.1 Monitoring Methods

Dissolved oxygen monitoring will be performed in accordance with Manitoba Hydro procedures for continuous and discrete measurement of DO using in-situ loggers. Typically, a continuous monitoring site will utilize two DO loggers that measure DO and water temperature at a preset frequency and store measurement data internally. The sampling frequency of the loggers would be set short enough to identify daily DO changes (i.e., diurnal variations). One logger would be positioned near the water surface while the second would be positioned near 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 monitoring shows that little vertical difference occurs. As with the continuous turbidity monitoring, the protocol for continuous DO monitoring includes routine maintenance visits to check and recalibrate the equipment, and to download the stored data.

Discrete DO and water temperature will also be measured in conjunction with discrete water sampling that will take place under the continuous turbidity and discrete TSS/water quality components of the sedimentation monitoring (Sec. 4). These discrete DO and temperature data will be provided to the AEMP team for use in the monitoring of aquatic effects.

7.2.2 Construction Period

The Project is not predicted to affect DO and water temperature conditions during construction prior to reservoir impoundment because water levels are predicted to remain within the limits of existing high water levels (PE SV, Sec. 9.4.1.1). DO concentrations measured within the Project's open water hydraulic zone of influence (Map 1-2) are typically high (i.e., at or near saturation) throughout the water column and these conditions are not expected to change during construction. Therefore, monitoring during construction will not include the use of continuous DO probes. Monitoring will be comprised of DO and water temperature measurements obtained during discrete water sampling that will take place as part of the sedimentation monitoring (see Sec. 4). Data collected during discrete water sampling will be provided to the AEMP study team.

7.2.3 Operating Period

The Project is predicted to affect DO and water temperature conditions within flooded backbays while little effect is anticipated along the reservoir mainstem and in the water discharged downstream. Monitoring during operation will include continuous monitoring at sites within the study area as well as discrete measurements during maintenance visits and in association with discrete sampling as part of the sedimentation monitoring.

7.2.3.1 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 7-1):

- 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 two or three representative backbay sites that will be identified on the north side of the reservoir plus two or three representative sites on the south side of the reservoir. These sites will be in locations that are terrestrial prior to impoundment and will be flooded when the reservoir is raised to full supply level in 2019. Monitoring in the flooded areas will be performed using two loggers, with one near the surface and one near the bottom. Sites will be located in backbays where the largest effects on DO and water temperature are expected to occur. It is expected that the DO monitoring sites will be placed at or near the locations of continuous turbidity monitoring sites that are to be established in flooded backbays. As noted above, discrete DO measurements will be obtained at other locations in association with discrete monitoring performed as part of the sedimentation monitoring work.

Continuous DO and water temperature monitoring will be peroformed 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 and methods for ongoing continuous DO monitoring will be assessed in conjunction with the AEMP studies group to ensure continued collection of data required for the study of Project effects on the aquatic environment.

7.2.3.2 Winter Period

Winter monitoring will be performed to verify expected Project effects on DO and temperature during the ice-covered period. This will involve discrete measurements of DO and temperature, and collection of water samples for laboratory analysis, at various points through the depth of the water column to identify any vertical variance in DO and temperature.

Monitoring will be performed at the same sites where continuous DO is monitored during the open water periods and at backbay sites where DO is measured as part of the discrete TSS/water quality sampling under the sediment monitoring component of the PEMP.

This monitoring will be performed two times in the first winter after impoundment: once soon after freeze-up 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 AEMP studies team to consider requirements for winter monitoring in subsequent years.

7.3 TOTAL DISSOLVED GAS PRESSURE

Atmospheric gases such as oxygen, carbon dioxide and nitrogen are dissolved in surface waters. The amount of 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%. As described in the AEMP (Sec 5.2.3) TDG super-saturation can occur when air bubbles in the water discharged from the GS are forced into solution in the water, particularly downstream of the spillway where turbulent flow can entrain air bubbles. TDG pressure is an important parameter with respect to fish health because super-saturation can cause adverse physiological effects called gas bubble trauma in fish (see AEMP, Sec. 5.2.3.1).

The PEMP includes monitoring of TDG pressure in the vicinity of the GS to support the AEMP requirements for monitoring effects of the Project on the fish community. TDG data collected under the PEMP will be provided to the AEMP study team, which will report the results as part of the AEMP report on fish community monitoring.

7.3.1 Monitoring Methods

TDG monitoring will be performed using an electronic probe designed to measure in-situ TDG pressure. TDG pressure will be measured using one or more sensors deployed at several depths below the water surface to identify vertical variations in TDG. Additional parameters including DO, atmospheric pressure and water temperature may 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 required, it may also be possible to deploy TDG probes to obtain continuous TDG measurements (i.e., readings at a specified fixed interval over an extended period). Manitoba Hydro will develop a formal monitoring procedure for TDG measurement, which may be based on procedures used in other jurisdictions (e.g., U.S. Army Corps of Engineers Plan of Action for Dissolved Gas Monitoring 2010-2014).

7.3.2 Construction Period

TDG monitoring will not occur during construction, as there was no identified need for monitoring in this period.

7.3.3 Operating Period

7.3.3.1 Discrete TDG Monitoring

Upstream of the GS, discrete TDG measurements will be obtained at several points across the width of the reservoir to provide background conditions before the water is discharged downstream through the powerhouse and spillway (Map 7-1). The sampling points will be located a sufficient distance upstream of the GS to ensure the safety of the monitoring crew.

Downstream of the GS, discrete TDG measurements will be obtained as close to the structures as possible and potentially over several kilometres downstream of the powerhouse, spillway and confluence of the spillway and powerhouse flows (Map 7-1). Sampling will generally be done along several transects across the width of the flow and parallel to the flow direction in the reach between the GS and the entrance to Stephens Lake (i.e., up to about 3-4 km downstream). The exact extent of downstream sampling will be determined based on observed TDG values. Monitoring immediately downstream of the structures will be contingent upon worker safety since this area may have high water velocities and very turbulent flow conditions.

7.3.3.2 Continuous TDG Monitoring

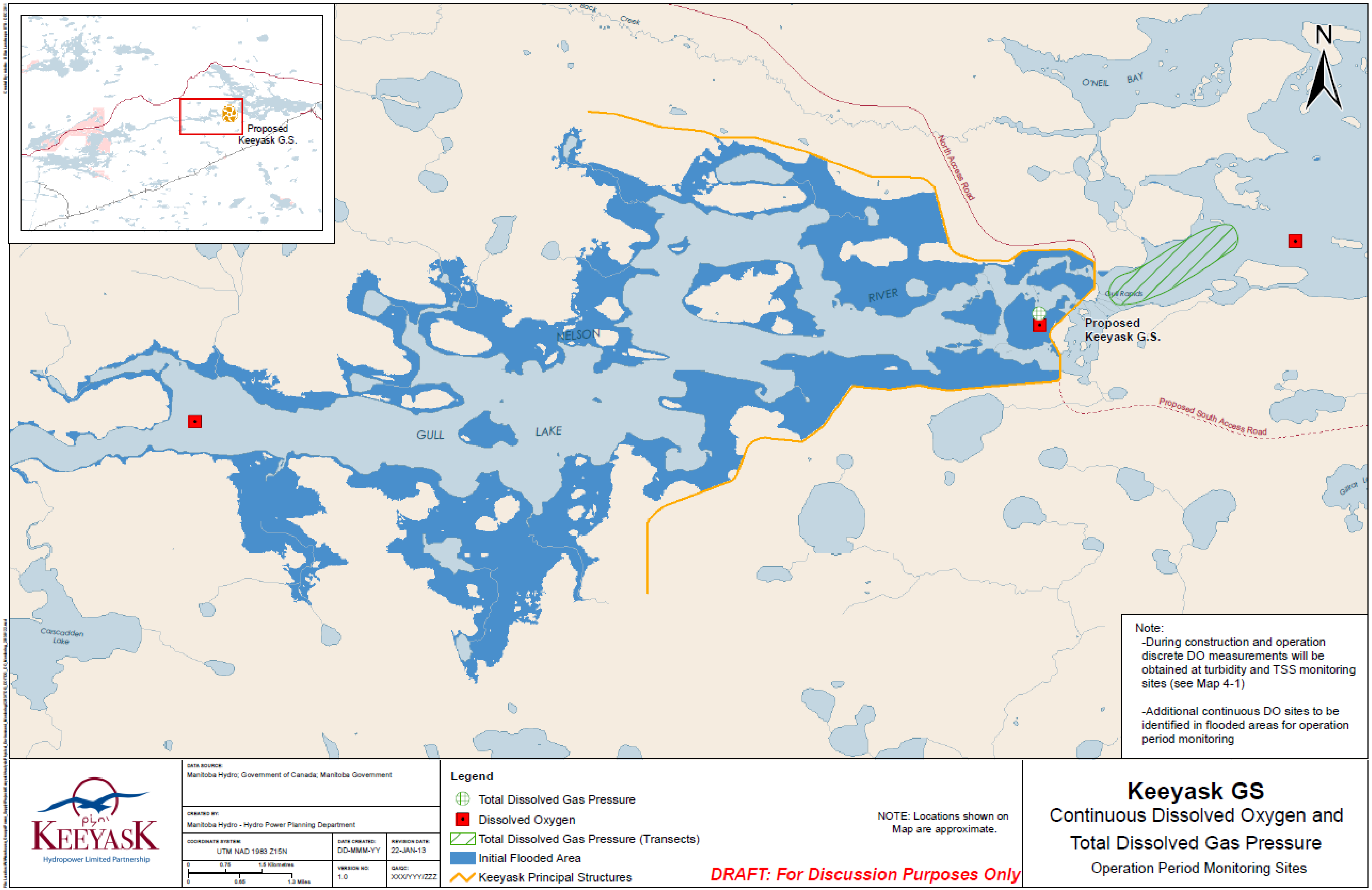
As noted above, TDG sensors may be deployed in the field to obtain continuous TDG readings at a fixed interval over an extended period. Measurement data would be stored on internal memory for later download by monitoring crews. The need for, practicality and potential locations for continuous TDG monitoring will be assessed in conjunction with the AEMP studies team and based on initial monitoring results from the discrete sampling program.

7.3.3.3 Timing, Frequency and Duration

TDG monitoring will be performed in conjunction with AEMP studies of gas bubble trauma in the fish community (see AEMP, Sec 5.2.3). The effects of the Project on TDG concentrations downstream will depend upon the amount of flow in the Nelson River and the relative contribution of discharges from the powerhouse and spillway to the total flow discharged downstream. For this reason, the timing of TDG monitoring will depend upon Nelson River flow conditions and the operation of the Keeyask GS, particularly relating to periods of spillway discharge and variable gate openings. In order to quantify the actual effects of the Project as it will be operated over the long term, the AEMP study of gas bubble trauma, and consequently TDG monitoring, will be conducted after all of the powerhouse turbines are in service.

TDG monitoring will be conducted in the first open water period after all of the powerhouse turbines are in service. Monitoring will be performed at least once each during periods of low and intermediate flow on the Nelson River, when there is no discharge from the spillway. Monitoring will also be required during periods of higher Nelson River flows when there are low, intermediate and high discharges through the spillway. Because of the ramping and frequent variability of spillway flows within and between days, the AEMP studies will take place over periods of three or four days, during which time TDG monitoring will also be required. In the event that continuous TDG monitoring is employed, the duration of the continuous monitoring during different flow conditions will be determined in conjunction with the requirements of the AEMP study team.

The duration of the TDG monitoring after operation begins cannot be determined since it is dependent upon the occurrence of Nelson River flow conditions ranging from low to high, which are not known a-priori. The need for monitoring in any year will be determined based on projected flow conditions; however, the actual performance of monitoring will depend upon flow conditions that actually occur. The PEMP and AEMP study teams will work together to review monitoring results to determine if modifications to the sampling program are required.



Map 7-1: Dissolved Oxygen and Total Dissolved Gas Monitoring Sites

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APPENDIX A

SUMMARY OF PROPOSED MONITORING SCHEDULE

FIGURE A1-1:

SUMMARY OF PROPOSED MONITORING SCHEDULE

CONSTRUCTION PERIOD[1]

	0		1		2		3		4		5
	2014	2014/15	2015	2015/16	2016	2016/17	2017	2017/18	2018	2018/19	2019
Season	S	W	S	W	S	W	S	W	S	W	S
WATER & ICE REGIME											
Water Level	X	X	X	X	X	X	X	X	X	X	X
Depth / Bed Elevation[2]											
Water Velocity											
Ice Cover											
SHORELINE EROSION & PEATLAND DISINTEGRATION											
Peat Resurfacing											X
Shoreline Classification											
Reservoir Area / Expansion											X
Imagery (aerial photos / satellite)[3]	X										X
SEDIMENTATION											
Continuous Turbidity	X	X	X	X	X	X	X[4]	X	X	X	X[4]
Discrete TSS/water quality	X		X		X		X		X		X
Bed Load	X		X		X		X		X		X
Deposition / Substrate	X		X		X		X		X		X
GREENHOUSE GAS											
At the GS											
Upstream/Downstream[5]	X		X		X		X		X		X
MONITORING IN SUPPORT OF OTHER PROGRAMS											
Debris Management	X		X		X		X		X		X
Dissolved Oxygen[6,7]	X		X		X		X		X		X
Total Dissolved Gas											

OPERATING PERIOD[1]

	1			2		3			4		5			6		7		8		9		10		
	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
Season	W	S	W	S	W	S	W		S	W	S	W		S	W	S	W	S	W	S	W	S	W	
WATER & ICE REGIME																								
Water Level	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																			
SHORELINE EROSION & PEATLAND DISINTEGRATION																								
Peat Resurfacing		X		X		X																		
Shoreline Classification		X									X											X		
Reservoir Area / Expansion		X		X							X											X		
Imagery (aerial photos / satellite)[3]		X		X							X											X		
SEDIMENTATION																								
Continuous Turbidity	X	X	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		
Bed Load		X		X		X			X		X													
Deposition / Substrate		X		X		X			X		X											X		
GREENHOUSE GAS																								
At the GS	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	
Upstream/Downstream[5]		X		X		X			X		X			X		X		X		X		X		
MONITORING IN SUPPORT OF OTHER PROGRAMS																								
Debris Management		X		X		X			X		X			X		X		X		X		X		
Dissolved Oxygen[6,7]	X	X		X		X			X		X			X		X		X		X		X		
Total Dissolved Gas				F		F			F		F			F		F		F		F		F		

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

5 - scope of upstream / downstream GHG monitoring under development

6 - during construction discrete DO readings will be obtained with discrete TSS/water quality sampling and continuous Tu maintenance

7 - the need for additional winter monitoring to be determined after the first winter of operation

APPENDIX B

GLOSSARY

Above sea level (ASL) Elevation: Elevations are referenced to Geodetic Survey of Canada, Canadian Geodetic Vertical Datum 1928, GSofC, 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 inorganic carbon (DIC): The inorganic carbon in a water sample passed through a filter (typically a 0.45 micron filter).

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.

Ecosite type: A classification of site conditions that have important influences on ecosystem patterns and processes. Site attributes that were directly or indirectly used for habitat classification included moisture regime, drainage regime, nutrient regime, surface organic layer thickness, organic deposit type, mineral soil conditions and permafrost conditions.

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

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 carbon (TC): A measure of all the carbon, inorganic and organic, in a water sample.

Total inorganic carbon (TIC): All the inorganic carbon in a water sample.

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*.