Keeyask Generation Project

Environmental Impact Statement

Supporting Volume

Aquatic Environment

Hydropower Limited Partnership

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APPENDICES

APPENDIX 4A
LOWER TROPHIC LEVEL METHODS
1997–2006

4A.1 PHYTOPLANKTON METHODS

4A.1.1 PHYTOPLANKTON COMMUNITY VARIABLES

A number of phytoplankton community variables were measured in the study area to address potential effects of the Keeyask GS on the aquatic environment. The rationale for inclusion of each of these is provided below.

4A.1.1.1 Chlorophyll *a*

Chlorophyll *a* is a green pigment found in plants, including aquatic plants and algae (small, plant-like organisms). Measurement of chlorophyll *a* in water is commonly used as an indicator of the amount of algae growing in the water (*i.e.*, phytoplankton). However, this method is not very sensitive and does not provide any information on the type of phytoplankton present. Furthermore, because the chlorophyll *a* content varies between species of phytoplankton, the concentration of chlorophyll *a* may not accurately represent the absolute quantity of phytoplankton present.

The detailed approach and methods for chlorophyll *a* sampling conducted between 2001 and 2005 as part of the water quality program are presented in Appendix 2C.

4A1.1.2 Phytoplankton Community Composition and Biomass

Phytoplankton (algae) are small, aquatic, plant-like organisms that are most often found suspended or entrained in the water column. Growth of phytoplankton depends on the amount of available light, nutrients, and water temperature. Many other aquatic organisms rely on phytoplankton, directly or indirectly, as a food source. Consequently, changes in phytoplankton abundance or composition can result in changes to invertebrate and fish populations. For these reasons, phytoplankton biomass and species composition were determined for lakes sampled in the study area. Studies often include taxonomic identification and enumeration of phytoplankton to more accurately assess algal biomass. The following detailed approach and methods are limited to sampling conducted to describe phytoplankton community composition and biomass.

4A.1.2 PHYTOPLANKTON COLLECTION AND ANALYSIS

Samples for the identification and enumeration of phytoplankton were collected at a depth of approximately 0.10 metres (m) in conjunction with the water quality program. In the open water season, phytoplankton biomass and species composition were assessed at the following sites in the study area (Section 2.0, Map 2-2):

- Three sites in 1999: Site A (also known as TRIB-1) on the Nelson River upstream of Birthday Rapids; and sites B and C (also known as GL-1 and GL-2, respectively) in Gull Lake;
- Thirteen sites in 2001: five sites in Split Lake (SPL-3,-4,-6,-7, and -8); one site in Clark Lake (CL-1); two sites in Assean Lake (AL-1 and AL-2); one site on the Nelson River downstream of Birthday Rapids (NR-2); two sites in Gull lake (GL-1 and GL-2); and two sites in Stephens Lake (STL-1 and STL-2); and
- Thirteen sites in 2002: six sites in Split Lake (SPL-3,-4,-5,-6,-7, and -8); one site in Clark Lake (CL-1); two sites in Assean Lake (AL-1 and AL-2); two sites in Gull lake (GL-1 and GL-2); and two sites in Stephens Lake (STL-1 and STL-2).

As the phytoplankton community measured in surface waters can vary during the growing season due to changes in physical conditions and succession of algal species, sampling was conducted several times during each of the open water seasons. A summary of the sampling periods is a follows:

- 1999: early October;
- 2001: March; early June; early July; mid-August; and mid-September; and
- 2002: March; June; July; August; and September/October.

During the ice-cover season, phytoplankton identification and enumeration were performed on samples collected in March of 2001 and 2002 at the following sites (Section 2.0, Map 2-2):

- In 2001, samples were collected at four sites in Split Lake (SPL-3, SPL-4, SPL-6, and SPL-8); both sites in Assean Lake (AL-1 and AL-2); and one site on Stephens Lake (STL-1); and
- In 2002, samples were collected at the same sites as the previous year, plus: two additional sites in Split Lake (SPL-5, and -7); one site in Gull lake (GL-2); and one additional site in Stephens Lake (STL-2).

Immediately after collection, samples were preserved with Lugol's solution and sent to ALS Laboratory Group (formerly Enviro-Test Laboratories, Winnipeg, MB) for analysis.

Algal cells were identified and counted in 10 millilitres (mL) of sample at 156X and 500X magnification (Utermohl technique modified by Nauwerck 1963). Cell biovolume (10 cells per species) was determined by applying the geometric formula best fitted to the cell shape (Vollenweider 1968). Phytoplankton biomass in milligrams per cubic metre [mg/m^3] wet weight was determined from total sample biovolume (cubic micrometres [μm^3]) assuming a specific gravity of one for cellular mass.

The relative abundance of phytoplankton biomass was calculated for the major algal classes. The fraction of phytoplankton reported as 'small chrysophytes' by ALS was not incorporated into estimates of total phytoplankton biomass for 2001 and 2002, as these measurements may include TSS and/or large particles in addition to phytoplankton (B. Bayer *pers. comm.* 2001). In order for comparisons to be made between years, the portion of the phytoplankton biomass that was attributable to 'small chrysophytes' was also removed from the samples processed in 1999. Additionally, the phytoplankton analysis in this document is restricted to the nanoplankton (those algae with maximum dimension greater than 2 μm)

and larger organisms. While the picoplankton fraction (those algae with a maximum dimension between 0.2 and 2.0 μm) was not accounted for, phytoplankton in this size range likely do not comprise a significant amount (less than 10%) of the algal biomass in the study area.

4A.1.3 DATA PRESENTATION

Phytoplankton community composition and biomass data from 1999, 2001 and 2002 study programs are presented in Zrum and Bezte (2003), Badiou and Cooley (2004), and Badiou and Cooley (2005), respectively.

4A.2 AQUATIC MACROPHYTE METHODS

4A.2.1 AQUATIC MACROPHYTE COMMUNITY VARIABLES

The aquatic macrophyte field program consisted of a number of components with the overall objective being to provide a description of aquatic plants in terms of relative abundance, composition, and distribution within study area waterbodies. General information on aquatic plant abundance, composition, and distribution in all reaches was obtained in conjunction with aquatic habitat surveys (Section 3.2; Appendix 3A). Detailed methods for the aquatic macrophyte field program conducted in each of the study area reaches are provided below.

4A.2.2 SPLIT LAKE AREA

4A.2.2.1 Split Lake (Including the York Landing Arm)

Quantitative surveys of aquatic macrophytes were not undertaken in Split Lake as part of the Keeyask environmental studies. Information on aquatic plant abundance, species composition, and distribution (*i.e.*, location of areas supporting rooted plants visible from the surface) was recorded during the boat-based bathymetric and aquatic habitat mapping survey conducted in September, 1997, and June, 1998, as part of the TEMA program (Kroeker 1999). Information was transcribed directly onto field maps, and included species composition and relative densities; plants were identified on-site. General distribution information was represented as polygons in the geographic information system (GIS) based on these observations (Map 3-4), *i.e.*, Map 3-4 shows general areas where rooted aquatic macrophytes were most abundant within Split Lake at the time of the surveys.

The presence and relative abundance (*i.e.*, low, high density) of aquatic macrophytes was also noted in conjunction with sediment-dwelling macroinvertebrate and fish community studies conducted in 1997 and 1998 to supplement the above information.

Clark Lake was surveyed as part of the Keeyask environmental studies.

4A.2.2.2 Assean Lake

Quantitative surveys of aquatic macrophytes were not undertaken in Assean Lake as part of the Keeyask environmental studies. The presence of aquatic macrophytes was noted in conjunction with sediment-dwelling macroinvertebrate and fish community studies conducted in 2001, 2002, and 2004.

4A.2.3 KEEYASK AREA

4A.2.3.1 Aquatic Macrophyte Surveys

Aquatic macrophyte abundance, species composition, and distribution (*i.e.*, location of areas supporting rooted plants visible from the surface) was described during the 2001 boat-based aquatic habitat survey within the Keeyask area (Clark Lake to downstream of Gull Rapids). As aquatic plant distribution differs over time in response to inter-annual variation in water levels and other growing conditions, this information was supplemented with observations during the 2003 walking and the 2006 aerial surveys of the Nelson River between Birthday and Gull rapids to better delineate aquatic plant distribution.

4A.2.3.1.1 2001

Information on aquatic plant abundance, species composition, and distribution was recorded during the boat-based bathymetric and aquatic habitat mapping survey conducted from late July to late August, 2001. Information was transcribed directly onto field maps, and included species composition and relative densities; plants were identified on-site. Distribution information was digitized into the GIS as polygons based on these observations (Map 4A-1).

4A.2.3.1.2 2003

Fifteen aquatic macrophyte beds were identified and mapped at 17 locations in the Nelson River between Birthday and Gull rapids (including Gull Lake) during late August, 2003. The average depths of these macrophyte beds ranged from 0.26 to 1.36 m. Aquatic macrophyte beds were mapped based on the abundance of macrophytes within a bed; individual plants or small groupings of plants were not mapped. A Trimble ProXR with a TSC1 datalogger for sub-metre accuracy was used to record data. Because 2003 was a low water year, the perimeters of macrophyte beds were walked and depths were taken manually (with a metre stick) and recorded in metres. The data collected in the field was then downloaded into Trimble Pathfinder Office v2.90. Trimble Pathfinder point files were exported as ArcView Shape files and imported into ArcGIS®. Polygons were digitized and presented as maps displaying the location of the macrophyte beds (Map 4A-1).

4A.2.3.1.3 2006

An aerial survey was conducted between Birthday and Gull rapids in August 2006, and aquatic macrophyte bed locations were recorded on maps. Based on these observations, the edges of the plant beds were delineated and these polygons were digitized into the GIS using ArcGIS® (Map 4A-1).

4A.2.3.2 Aquatic Macrophyte Abundance and Composition

Detailed sampling to describe aquatic plant abundance and composition at selected sites was conducted in 2001 and 2002 between Birthday and Gull rapids and in 2003 and 2004 for Clark Lake to Gull Rapids in conjunction with the plant-dwelling macroinvertebrate program (2001–2004) (Section 4A.4.3).

4A.2.3.2.1 2001 and 2002

Sampling Period and Locations

Five areas were sampled in early September 2001 (14 sites total), and in late August 2002 (15 sites total), to describe aquatic plant abundance and composition (Map 4A-2):

- Pahwaybanic Bay (Area 1), located approximately 8.2 kilometres (km) downstream of Birthday Rapids, off the mainstem of the Nelson River;
- John Garson Bay (Area 2), located approximately 11.4 km upstream of Gull Rapids, off the mainstem of the Nelson River;
- Kahpowinic Bay (Area 3), located approximately 15.5 km downstream of Birthday Rapids, off the mainstem of the Nelson River;
- Tub Bay (Area 4), located approximately 4.6 km upstream of Gull Rapids, off the mainstem of the Nelson River; and
- Gull Lake at Caribou Island (Area 5), located approximately 8.0 km upstream of Gull Rapids.

Sample collection and field measurements

Within each area, three sites were selected to represent specific aquatic habitats, including a shoreline site, a mid-bay site, and an outer-bay site; the exception was John Garson Bay where only two sites were sampled. Within each site, random locations with abundant aquatic vegetation and water depth no greater than 2 m were sampled in replicate; one sample was taken from the left side of the boat and one from the right. At each site, universal transverse Mercator (UTM) coordinates were taken with a navigation quality Global Positioning System (GPS) unit and water depth was measured using a weighted rope graduated to the nearest 0.10 m.

Aquatic macrophytes and associated epiphytic invertebrates were collected with a custom designed sampler constructed of industrial acrylonitrile butadiene styrene (ABS) grade material. The frame measured 0.6 x 0.7 m in depth, 1.4 m in height, with a surface area of 0.42 m^2, and had an attached 1.5 m cod-end. The sampler was placed into the water with the retractable cutter blade engaged and lowered to the bottom, disturbing the aquatic vegetation as little as possible. The cutter blade and attached cod-end were then pulled across the bottom of the sampler, severing the rooted macrophytes above the sediment surface. All plants and associated invertebrates were retained within the sampler.

Once the sampler was pulled to the surface, macrophytes were thoroughly rinsed. Replicate samples were kept separated and macrophytes were put into labelled bags. The rinse water was sieved through a 500 μm sieve to collect epiphytic invertebrates, which were then fixed in 10% formalin. Macrophyte

samples were frozen immediately and transported to North/South Consultants Inc. (NSC) laboratory (Winnipeg, MB) for further processing.

Laboratory and Data Analysis

In 2001 and 2002, macrophytes were thawed in the laboratory in cold water, identified to the lowest taxonomic group (usually genus or species), and sorted. Macrophyte samples were sorted and identified based on Fassett 1957, Scoggan 1978–1979, Johnson *et al.* 1995, and Flora of North America Editorial Committee 2000. Species level identification of certain aquatic macrophyte samples was difficult due to the time of year samples were collected (*i.e.*, lack of flowering parts in early fall). Consequently, these macrophytes were sorted into groups with similar appearances, and are referred to as *Potamogeton* sp. 1, *Potamogeton* sp. 2, and *Potamogeton* sp. 3. Any macrophyte material that could not be identified was grouped as unidentified.

The wet weight (g) of macrophyte samples was determined by weighing plant material in pre-weighed aluminum pans. Samples were subsequently dried in a Fisher Scientific Isotemp drying oven for approximately 24 hours (h) at a temperature of 106°C and a dry-weight (g) was determined for each plant group (g dry-weight/group). Dried samples were discarded. Aquatic macrophyte biomass (g dry-weight of group/m^2) was determined using the following formula: dry-weight of group per sample (g) / surface area of sampler (0.42 m^2).

4A.2.3.2.2 2003 and 2004

Sampling Period and Locations

Aquatic macrophyte sampling was conducted in mid- to late August 2003, and mid-August in 2004, to describe aquatic plant abundance and composition (Map 4A-2 and Map 4A-3).

Macrophyte beds in the Keeyask area were identified and stratified (shallow: 1.0–1.5 m; moderate: 1.5–2.0 m; and, deep: 2.0–2.5 m) using bathymetric survey data collected in 2001 and aerial photos from 08 July 2003. For ease of sampling, the study area was divided into eight areas and each area was then further divided into zones as follows:

- Pahwaypanik Bay (Area 1: Zones 1 to 4);
- John Garson Bay (Area 2: Zones 1 to 4);
- Kahpowinik Bay (Area 3: Zones 1 to 4);
- Tub Bay (Area 4: Zones 1 to 4);
- Gull Lake – Caribou Island (Area 5: Zones East and West);
- Gull Lake – John Kitch Bay (between Morris Point and John Kitchekeesik Point) (Area 6: Zones East and West);
- Small bay to the east of Rabbit Creek (Area 7: Zones 1 to 4); and
- Clark Lake (Area 8: Zones 1 to 4).

A set of random sampling sites were generated for each zone using the Random Point Generator utility in ArcGIS®. Three sites per zone were generated for the areas in Gull Lake (for a total of 12 sampling sites) and two sites per zone were generated for all other areas (for a total of 48 sites). These randomly generated sites were then mapped on a 1:15,000 scale digital ortho-imagery. Field crews used a handheld GPS unit to locate and sample the selected sites.

In both study years, sampling was attempted at 60 sites. In 2003, nine of these sites could not be sampled due to low water levels, while four sites could not be sampled due to high water levels. Only 64% of the sites sampled contained macrophytes. In 2004, seven of these sites could not be sampled due to high water levels and only 60% of the sites sampled contained macrophytes.

Sample Collection and Field Measurements

All sampling locations were accessed by boat. Two subsamples were collected at each site: one off the port side of the boat (Sample A) and a second off the starboard side (Sample B). Water depth was measured at the port and starboard side of the boat with a weighted rope graduated to the nearest 0.10 m; an average depth was later calculated for each site. If aquatic macrophytes were found to be absent from a randomly pre-selected site, field crews measured water depth and noted the absence of plants.

Aquatic macrophytes and associated epiphytic invertebrates were collected with a custom designed sampler constructed of industrial ABS grade material. The frame measured 0.6 x 0.7 m in depth, 1.4 m in height, with a surface area of 0.42 m^2, and an attached 1.5 m, 400 μm mesh cod-end. The sampler is functional to water depths of less than 2.5 m. As a result, deeper sites were not sampled. To disturb the aquatic vegetation as little as possible, the sampler was lowered into the water with the cutter blade retracted until it reached the sediment. The cutter blade was then pulled across the bottom of the sampler, severing the rooted macrophytes above the sediment surface. All plants and associated invertebrates were retained within the sampler (Photo 4A-1).

Once the sampler was pulled to the surface, macrophytes were removed by hand, placed in a Ziploc bag and a whole wet weight was taken (to the nearest gram) with a Kilotech PC 2000A digital scale. The macrophytes were then placed in a 500 μm mesh-bottom bucket with a 400 μm mesh-bottom bucket directly below it and rinsed thoroughly to remove epiphytic invertebrates. After rinsing, macrophyte samples were placed in a salad spinner and spun to remove excess moisture, placed in labelled Ziploc bags and weighed again. Any water collected from the spinning process was added to the rinse buckets to retain all invertebrates. Subsamples A and B were processed separately. Macrophyte samples were transported to the field laboratory, frozen and then transported to the NSC laboratory (Winnipeg, MB) for further processing.

Due to low water levels in 2003, some sites were located in areas no longer wetted, or only partially wetted. Although these sites were dry or in very little water, some still contained aquatic plants. These plants were collected by placing the sampler over the plants and hand grabbing all vegetation contained within the area of the sampler. There were no duplicate samples taken at these hand-grabbed sites. Aquatic macrophyte data from these sites were not used to determine abundance and composition for the EIS; however, the presence of aquatic plant species contributed to the list of aquatic macrophyte taxa observed in the study area, 1997–2006.

Source: North/South Consultants Inc., 2004

Photo 4A-1: Aquatic environmental studies team member with aquatic macrophyte sampler containing plants and associated macroinvertebrates

Laboratory and Data Analysis

Macrophytes were thawed in cold water and rinsed again using the 500 and 400 μm mesh-bottom buckets to collect any epiphytic invertebrates missed during field processing. Macrophytes were sorted under a 3X desktop magnifier with lamp and identified to the lowest taxonomic group possible (usually genus or species). Macrophyte identification was based on Fassett (1957), Scoggan (1978–1979), Johnson *et al.* (1995), Flora of North America Editorial Committee (2000), Lahring (2003), and personal communications with J. Krindle (2002). Scientific names were updated according to the Integrated Taxonomic Information System (ITIS). Any macrophyte material that could not be identified was grouped as unidentified.

In 2003, species level identification of certain aquatic macrophytes (genus *Potamogeton*) was difficult due to the late sampling period and the loss of flowering parts that aid in identification. Consequently, these macrophytes were sorted into groups of similar appearances and are referred to as *Potamogeton* spp.

The wet weight (g) of each macrophyte group was determined by weighing plant material in pre-weighed aluminum pans with a Mettler PM480 Delta Range digital scale to the nearest 0.001 g. Samples were subsequently dried in a Fisher Scientific Isotemp drying oven for approximately 24 h at a temperature of 106°C, and a dry-weight (g) was determined for each macrophyte group. Dried samples were discarded once processed. Aquatic macrophyte biomass (g/m^2) was determined by dividing the dry weight of the macrophyte group per sample (g) by the surface area of the sampler (0.42 m^2).

Subsamples (A and B) were averaged for each site, and this value was used in the calculations to determine percent composition and relative density of the aquatic plant community for each area as presented in the EIS. If aquatic macrophytes were absent from randomly pre-selected sites, these sites were not used for the EIS as these data were used for the purposes of describing the composition and relative density of the plant community where plants were present.

4A.2.3.3 Drifting Aquatic Macrophyte Biomass and Composition

Drift traps were used to sample extensive areas of rapids where sampling by other methods (*e.g.*, dredge or air lift sampler) was otherwise not feasible due to logistical (*e.g.*, water depths and water velocities too high for effective sampling) or safety concerns (*i.e.*, high flows immediately upstream and downstream of Gull Rapids). Drifting aquatic plants and algae were sampled using drift traps at various locations selected along the Nelson River mainstem during the 2003 and 2004 open water seasons to gain an overall understanding of the spatial and temporal differences in abundance and distribution of biomass within the study area, and provide the basis for assessing potential changes in production from specific areas (*i.e.*, Birthday Rapids, Gull Rapids, Stephens Lake) associated with the Project.

4A.2.3.3.1 Sampling Period and Locations

Drift traps were set in the Nelson River, upstream and downstream of Birthday Rapids, and upstream and downstream of Gull Rapids, between June and October in 2003 and 2004.

Two types of drift nets were used: 1) surface set drift nets (floated at the surface of the water); and 2) bottom-set drift nets (set on the river bottom). Drift trap nets consisted of a 3 m long, 954 micrometre (µm) Nitex screen bag with a 43 centimetres (cm) by 85 cm opening that tapered into a 9 cm diameter removable ABS pipe cod-end. Weather permitting, drift traps were left in the water for 24 h. When possible, floating and bottom-set drift traps were set adjacent to each other at each sampling location.

Drift traps were set at Birthday Rapids in July, August, and September, 2003, and in July and August, 2004. Both a floating and a bottom-set trap were positioned at two locations immediately upstream of the rapids (sites A1-F, A1-S, A2-F, and A2-S) and immediately downstream of the rapids (sites B1-F, B1-S, B2-F, and B2-S) resulting in a total of eight traps (Map 4A-4). Four traps, two floating and two bottom-set, were set at two locations upstream of Gull Rapids (sites C1-F, C1-S, C2-F, and C2-S), in July, August, and September 2003, and in July and August 2004, and downstream of Gull Rapids in Stephens Lake (sites D1-F, D1-S, D2-F, and D2-S) in June, July, August, September, and October 2003, and in July and September 2004 (Map 4A-4 and Map 4A-5).

4A.2.3.3.2 Sample Collection and Field Measurements

The floating drift traps consisted of two 1.83 m (6 feet) long by 15.24 cm (6 ") diameter L-shaped ABS pontoons attached to each side of the opening of the drift trap with sideline (Photo 4A-2). Pontoons were attached to one another using two crossbars with one crossbar at each end of the pontoon; the opening of the drift trap was in line with the 90° angle of each of the pontoons, with the cod-end floating freely at the far end. Pontoons were anchored to the river bottom using either a king anchor or a cinder block to ensure the traps remained in position. Similar to the bottom-set traps, these floating traps were all positioned facing into the current. To retrieve the floating traps, the boat approached the crossbar at the end of the pontoons. With the boat continuing to move forward toward the pontoons, study team members grabbed the crossbar located at the end of the pontoons, and hauled both pontoons and the drift trap into the bow of the boat.

Source: North/South Consultants Inc.

Photo 4A-2: Floating drift trap set to quantify aquatic invertebrate and plant biomass in the study area

The opening of each bottom-set drift trap was inserted into a metal frame weighing approximately 25 kg (55 pounds), which kept it anchored to the river bottom and open, facing the current (Photo 4A-3). These drift traps were set in either shallow (less than 1 m) or deep (greater than 1 m) water. For all sets in 2003, and deep water sets in 2004, drift trap frames were attached to a large anchor that was tied to the lower edge of the frame by approximately 20 m of sideline and two large floats were tied through two loops on either side of the metal drift trap frame with at least 10 m of excess line, depending on the depth of the drift trap. For shallow water sets in 2004, drift net frames were anchored to shore with

approximately 5 m of rope tied to the lower edge of the drift net frame; to retrieve the drift net, the rope attached to shore was pulled in, and the contents of the drift net were emptied. To retrieve bottom-set drift traps (all sets in 2003 and deep water sets in 2004), a boat was positioned near the floats attached to either side of the drift trap frame. Each float was then grabbed by a study team member and the lines were pulled into the boat simultaneously. As the lines were retrieved, the frame rose upward and pivoted on the anchor. Once at the surface, the drift trap frame was placed on the bow of the boat and contents of the Nitex screen bag were washed towards the cod-end. The ABS cod-end container was emptied into sample jars and rinsed at least once before the drift trap was reset.

Source: North/South Consultants Inc.

Photo 4A-3: Bottom-set drift trap set to quantify aquatic invertebrate and plant biomass in the study area

To estimate the volume of water travelling through each drift trap, water velocity was measured with a Model 1210, Price Type 'AA' Current Meter. The Price Meter consists of a bucket-wheel mounted on a vertical axis which revolves when suspended in flowing water. Audible sounds are used to count the

number of revolutions per second, which were converted to metres/second. The Price Meter was weighted and bracket-mounted to the bow of the boat and lowered with a pulley, airline cable, and integrated winch system. In 2004 only, water velocities were not taken at a number of drift trap locations downstream of Gull Rapids; data for sites without water velocity data were described qualitatively and were not included in quantitative analyses.

The location of each velocity reading was recorded geospatially with the use of a hand-held GPS unit. Water depths were measured at each drift trap location using a weighted metred rope.

HOBO® Water Temperature Pro data loggers (tidbit thermometers) were used to record water temperature in the Nelson River at two locations in 2003 (Gull Lake, downstream of Birthday Rapids, and at Stephens Lake, downstream of Gull Rapids) and three in 2004 (downstream of Birthday Rapids, upstream of Gull Rapids, and in Stephens Lake downstream of Gull Rapids). Each tidbit thermometer was set at a depth of approximately 3–5 m below the water surface and recorded water temperature (± 0.1°C) at 6-hour intervals daily from 28 May-04 October 2003, in Gull Lake, 28 May-14 October 2003, in Stephens Lake, 14 June-17 October 2004, downstream of Birthday Rapids, 16 June-18 October 2004, upstream of Gull Rapids, and 10 June-19 October 2004, in Stephens Lake.

4A.2.3.3.3 Laboratory and Data Analysis

Drift net contents were transferred into sample jars, fixed in 10% formalin, and shipped to the NSC laboratory (Winnipeg, MB) for processing. In the laboratory, all samples were sieved using a 355 µm mesh, rinsed with water, and sorted under a 3X desktop magnifier with lamp. Samples were sorted and identified in their entirety for lake sturgeon and lake sturgeon eggs. Following this initial sort, samples were sub-sampled, when necessary, using a Folsom plankton splitter with a 4 litre capacity and twin 'boat' receptacles. Samples were then sorted for larval fish and fish eggs, macrophytes, and invertebrates. All macrophytes were grouped and identified to genus and species, when possible. Scientific names used follow the ITIS classification. Sample processing, taxonomy, and quality assurance were completed in accordance with NSC procedures (Section 4A.5). Aquatic plant samples were dried in a Fisher Scientific Isotemp® drying oven for approximately 24 h at 106°C. Dry weight (g) was determined by weighing each plant group in pre-weighed aluminum pans with a Mettler PM480 Delta Range® digital scale to the nearest 0.001 g. Dried samples were discarded once processed. Plant biomass was calculated with the formula: [dry weight of plant $_{(mg)}$ x 100] divided by [time $_{(seconds)}$ x drift trap height $_{(metres)}$ x drift trap width $_{(metres)}$ x water velocity $_{(metres/second)}$].

4A.2.4 STEPHENS LAKE AREA

4A.2.4.1 Aquatic Macrophyte Surveys

Areas of Stephens Lake that were historically inundated (habitats flooded by the Kettle dam at the first full supply level attained first in 1971) were surveyed more intensively in 2005 and 2006, years with higher than average water levels, to describe the existing aquatic habitat in previously flooded areas and assist in the development of a predictive aquatic macrophyte model to support the impact assessment for the future reservoir. Species composition, abundance and distribution of vascular macrophytes and the variables that influence habitat preference (*i.e.*, water depth, slope, and substratum) were extensively documented to support model development (Cooley and Dolce 2008). Aquatic macrophyte beds were not delineated as they were for Clark Lake and the Keeyask area and, as such, the description of plant bed distribution throughout Stephens Lake is qualitative and based on field observations.

4A.2.4.1.1 Aerial Survey

An aerial survey was conducted in late July 2005, along the western shoreline of Stephens Lake to determine macrophyte bed locations and to direct the subsequent boat-based sampling program. Aerial video was captured along 72 km of shoreline using a GPS linked system (Red Hen Systems Inc., Fort Collins, Colorado) mounted on a Bell Jet Ranger helicopter. Aerial frame surveys were conducted at about 100 m above the lake surface. The locations of the macrophyte beds were recorded on maps.

4A.2.4.1.2 Boat-Based Survey

From late July to early August, 2005, 525 sites were visited by boat in the vicinity of Ross Wright and O'Neil bays in Stephens Lake and presence/absence macrophyte data and aquatic habitat information were collected (Cooley and Dolce 2008). Macrophyte species were identified and at each location water depth, bottom slope, and substratum type were recorded. Water depth (± 5 cm) was measured at the center of each plant stand using an incremented 5 m aluminium probe. Slope of the substratum was determined using the change in depth over a known distance using the aluminium probe, or a scientific-grade vertical echosounder operating at 50 kilohertz (Quester Tangent Corporation), coupled with Trimble Pro XR differential (sub-metre) GPS. Substratum type at the location of the macrophyte bed was classified based on texture or compaction with the probe, and/or with a 'Petit' Ponar dredge (bottom dredge sampler).

In early August 2006, sampling was directed to areas where plants were recorded as absent in 2005. Information from the first field survey was used to locate areas where plants were absent and boat-based sampling was used to collect depth, slope, and substratum information. Effort was stratified within the preferred water depth range observed in 2005, as well as above and below this depth range.

4A.2.4.2 Aquatic Macrophyte Abundance and Composition

Quantitative surveys of aquatic macrophyte abundance and composition were undertaken in 2005 and 2006 (Map 4A-6). In late July, 2005, macrophyte samples were collected at 22 of the 525 habitat sites in the vicinity of Ross Wright and O'Neil bays and processed for further analysis at NSC (Winnipeg, MB). All sites visited in 2005 were chosen randomly from the sample of sites known to have macrophytes present with the intent to provide a relatively large sample. In early August 2006, seven sites were sampled within the same area as 2005. Sites visited in 2006 were chosen by a stratified random sampling design so that half the sample sites were located in areas where plants were not observed during the 2005 helicopter survey. This method was employed to verify that aerial and boat-based observations were in agreement at sites where macrophytes were recorded as absent from the helicopter.

Sample collection and field measurements, and laboratory and data analysis were conducted as for the Keeyask area in 2003 and 2004. The only difference in methods was that rinse water was sieved through a 400 μm sieve only.

4A.2.4.3 Drifting Aquatic Macrophyte Biomass and Composition

Drift traps were used to sample extensive areas of rapids where sampling by other methods (*e.g.*, dredge or air lift sampler) was otherwise not feasible due to logistical (*e.g.*, water depths and water velocities too high for effective sampling) or safety concerns (*i.e.*, high flows immediately upstream and downstream of Gull Rapids). Drifting aquatic plants and algae were sampled using drift traps at various locations selected along the Nelson River mainstem during the 2003 and 2004 open water seasons to gain an overall understanding of the spatial and temporal differences in abundance and distribution of biomass within the study area, and provide the basis for assessing potential changes in production from specific areas (*i.e.*, Birthday Rapids, Gull Rapids) associated with the Project.

Drift traps were set downstream of the Kettle GS, in the Long Spruce reservoir, in July, August, and September 2003, and in late June, July, and September 2004. Four traps, two floating and two bottom-set drift traps were set at two locations in each study year (Map 4A-5).

Sample collection and field measurements, and laboratory and data analysis were conducted as for the Keeyask area in 2003 and 2004. As for locations downstream of Gull Rapids in 2004, water velocities were not taken at a number of drift trap locations downstream of the Kettle GS; data for sites without water velocity data were described qualitatively and were not included in quantitative analyses.

4A.2.5 ACCESS ROAD AREA

Field sampling was conducted by a two-person crew to assess the quality of fish habitat in streams crossed by the proposed access road in October 2004 (Map 1-4). For each stream crossed by the proposed access road, a reach extending approximately 100 m upstream and 200 m downstream of the

proposed right-of-way (ROW) was assessed. Fish habitat characteristics including stream cover were recorded.

Cover was classified as the total percent of wetted stream area that consisted of cover to the nearest 5% including deep pool, large organic debris, boulder, in-stream vegetation (*i.e.*, aquatic plants), over-stream vegetation, and cut-bank.

Aquatic plant abundance, composition, and distribution (other than percent-cover) were not assessed during the October 2004 stream habitat assessment.

4A.2.6 DATA PRESENTATION

Aquatic macrophyte abundance, community composition, and distribution data from 2001–2006 study programs are presented in Dolce and Sotiropoulos (2004a, 2004b), Gill (2007a, 2007b), Burt and Dolce (2008), Cooley and Dolce (2008), Dolce and Burt (2008), and Mazur and Savard (2008).

4A.3 ZOOPLANKTON METHODS

4A.3.1 ZOOPLANKTON COMMUNITY VARIABLES

Zooplankton community abundance, composition, and distribution were measured in study area lakes to address potential effects of the Keeyask GS on the aquatic environment.

Zooplankton (*e.g.*, Cladocera, Copepoda) are very small animals without backbones (invertebrates) living in the water column and are consumed by larval, juvenile, and adult (*e.g.*, cisco) fish. The availability and quality of food (*e.g.*, amount and kinds of phytoplankton), the number of predators (*e.g.*, other invertebrates, fish), and water residence time affect the abundance of zooplankton; in rapidly flushed lakes and rivers little zooplankton biomass accumulates except in areas where there is little water movement.

4A.3.2 ZOOPLANKTON COLLECTION AND ANALYSIS

Samples for the identification and enumeration of zooplankton were collected in conjunction with the water quality sampling program. In the open water season, zooplankton abundance and species composition were assessed at the following lake sites in the Keeyask area (Section 2.0, Map 2-2):

- 15 sites in 2001: eight sites in Split Lake (Sp.L.-1, Sp.L.-2, Sp.L.-3, Sp.L.-4, Sp.L.-5, Sp.L.-6, Sp.L.-7, and Sp.L.-8); one site in Clark Lake (C.L.-1); two sites in Assean Lake (A.L.-1 and A.L.-2); two sites in Gull Lake (G.L.-1 and G.L.-2); and two sites in Stephens Lake (St.L.-1 and St.L.-2); and
- 13 sites in 2002: six sites in Split Lake (Sp.L.-3, Sp.L.-4, Sp.L.-5, Sp.L.-6, Sp.L.-7, and Sp.L.-8); one site in Clark Lake (C.L.-1); two sites in Assean Lake (A.L.-1 and A.L.-2); two sites in Gull Lake (G.L.-1 and G.L.-2); and two sites in Stephens Lake (St.L.-1 and St.L.-2).

As zooplankton abundance and community composition can vary during the season due to changes in environmental conditions (*e.g.*, water temperature, availability, and quality of food) sampling was conducted during four sampling periods (early to mid-June, early to mid-July, mid- to late August, and mid-September to early October) with the exception of sites Sp.L.-1, Sp.L.-2, and Sp.L.-5, which were only sampled in early June 2001, and sites Sp.L.-8 and C.L.-1, which were only sampled in June, July, and August 2002.

Samples were collected at both standing water (*i.e.*, secluded bays that remain relatively isolated from the flow in the Nelson River) and flowing water ('mainstem') sites in the lakes investigated, as the abundance of zooplankton is closely related to water residence time.

In 2001, zooplankton were collected in vertical, bottom to surface tows with a 63 μm mesh, 0.25 m diameter, 1.00 m long conical net during the first three sampling periods, and a 63 μm mesh, 0.22 m diameter, 1.30 m long conical net in the fourth sampling period. In 2002, zooplankton were collected in vertical, bottom to surface tows with a 63 μm mesh, 0.22 m diameter, 1.3 m long conical net during all four sampling periods. In both years, the net, weighted with a PVC cod-end (collecting cup), was lowered to the bottom and then slowly retrieved by hand. Upon removal from the water, captured zooplankton were rinsed from the net into the cod-end, washed into a labelled jar, and fixed in 10% formalin. Depth and number of tows were recorded to permit estimation of the total volume of water filtered for each sample. Samples were transported to the laboratory at NSC (Winnipeg, MB) and transferred to 70% ethanol for storage.

Zooplankton were identified to species using standard references, including Edmondson (1959), Pennak (1978), Smith and Fernando (1978), and Balcer *et al.* (1984). Cladocera were identified to species and enumerated. Copepoda were counted as Cyclopoida and Calanoida copepodites, and Cyclopoida and Calanoida adults; only adults were identified to species. When possible, at least 200 individuals were counted in each sample. Large samples were sub-sampled depending on the density of organisms in each sample. Larger and/or relatively rare specimens were enumerated for the entire sample prior to sub-sampling.

An estimate of density of each taxon captured in each tow was calculated as the number of individuals per cubic metre of water filtered (individuals/m^3). Volume of water filtered was calculated by multiplying the net mouth area by the water column depth for each vertical tow conducted. Depth of the tow was adjusted to account for the length of the net as the net mouth did not reach the lake bottom, *i.e.*, depth of the tow was equal to the total water column depth minus the length of the net. All filtered volumes were considered estimates, however, due to the assumption that each tow filtered either a perfectly vertical cylinder of water, or filtered water at an exact observed angle.

4A.3.3 DATA PRESENTATION

Zooplankton community composition and abundance data from 2001 and 2002 study programs are presented in Juliano and Zrum (2003, 2004).

4A.4 AQUATIC MACROINVERTEBRATE METHODS

4A.4.1 AQUATIC MACROINVERTEBRATE COMMUNITY VARIABLES

The aquatic macroinvertebrate field program consisted of a number of components with the overall objective being to provide a habitat-based description of macroinvertebrate communities (sediment-dwelling, plant-dwelling, and drifting) in terms of abundance, composition, and distribution within study area waterbodies. Detailed methods for each of the macroinvertebrate field programs are provided below.

4A.4.2 SEDIMENT-DWELLING MACROINVERTEBRATES

Detailed sampling to describe the habitat-based abundance, composition and distribution of sediment-dwelling aquatic macroinvertebrates in the study area waterbodies was conducted between 1997 and 2006.

4A.4.2.1 Sampling Period and Locations

Sediment-dwelling macroinvertebrates were collected during both the open water and ice-covered seasons in the Split Lake area (Map 4A-7), the Keeyask area (Map 4A-8), and the Stephens Lake area (Map 4A-9). The number and type of macroinvertebrates in a lake continually fluctuate during the summer months as organisms reproduce and as some (particularly aquatic insects) periodically mature and emerge from the water as adults. However, populations tend to be more stable in fall and winter months permitting the population to be better represented by samples collected during these time periods.

Sediment-dwelling macroinvertebrate sampling was conducted in the fall (September-October) at the following locations:

- Nine sites in 1999: two transects with three sites each on Gull Lake; two sites on the Nelson River between Birthday and Gull rapids; and one site on the Nelson River between Gull Lake and Gull Rapids;
- Twenty-one sites in 2000 (as part of York Factory First Nation and Manitoba Hydro program): two transects with three sites each near the mouth of the Aiken River; three transects with three sites each off the Aiken River near the main body of Split Lake; and two transects with three sites each equidistance between the transects near the mouth of the Aiken River and the transects near the main body of Split Lake;

- Seventy-nine sites in 2001: 11 sites on Split Lake; nine sites on Split Lake in the York Landing Arm; eight sites on Clark Lake; 13 sites on Assean Lake; 17 sites on Gull Lake; and 21 sites on Stephens Lake;
- One hundred and two sites in 2002: 11 sites on Split Lake; 17 sites on Split Lake at York Landing Arm; eight sites on Clark Lake; 17 sites on Assean Lake; 26 sites on Gull Lake; and 31 sites on Stephens Lake;
- Fifty-one sites in 2004: four sites on Clark Lake; four sites on Assean Lake; nine sites on Gull Lake; 10 sites on Stephens Lake; and three sites at each of five stream crossings along the access road ROW (Map 1-4); and
- Thirty sites in 2006: 15 sites in each of Ross Wright and O'Neil bays in Stephens Lake.

During the ice-covered season (January-March), samples were collected at the following locations:

- Twenty-nine sites in 1997 (as part of TEMA program): 29 sites on Split Lake;
- Forty-one sites in 1998 (as part of TEMA program): 41 sites on Split Lake;
- Twenty-six sites in 2001: 15 sites on Split Lake and 11 sites on Assean Lake; and
- Twenty-six in 2002: 15 sites on Split Lake and 11 sites on Assean Lake.

4A.4.2.2 Sample Collection and Field Measurements

The distribution of sediment-dwelling macroinvertebrates within a waterbody can be highly variable and abundance can vary even among similar habitat types. Therefore, to achieve a better estimate of overall composition and abundance, and to facilitate inter-annual comparisons, sampling areas were chosen to encompass the range of conditions within each study area waterbody (*i.e.*, shallower and deeper water areas, areas with and without water movement, areas with mineral- or organic-based substrata, areas with and without aquatic macrophytes).

A hand-held navigational GPS was used to determine UTM co-ordinates at sites. Access to all sampling locations was by boat during the open water season and by snowmobile with sleds during the ice-covered season.

With the exception of the 2004 samples collected at stream crossings along the access road ROW, samples were collected using a 'tall' Ekman dredge (0.023 m^2 opening) with attached lead weights. Generally, four dredge samples were taken at each site to determine within-site organism variability. During the open water season, replicate samples were separated spatially around the boat (*i.e.*, port, starboard, bow, and stern) to ensure that sampling disturbances from one dredge did not affect another sample (Photo 4A-4). Each Ekman sample was retrieved to the surface and carefully sieved through a 500 μm mesh rinsing bag or bucket on-site (Photo 4A-5). Invertebrates retained by the screen were transferred to plastic jars and fixed with 10% formalin. Fixed samples were shipped to the NSC laboratory (Winnipeg, MB) for processing. Total water depth and water transparency measurements were also made at each sampling site. Water depth was measured with a weighted metred rope and water

transparency was measured using a Secchi disk; a metal disc coloured white and black for contrast. The average of the depth below the water surface at which point the disc would disappear on lowering and reappear on raising was recorded.

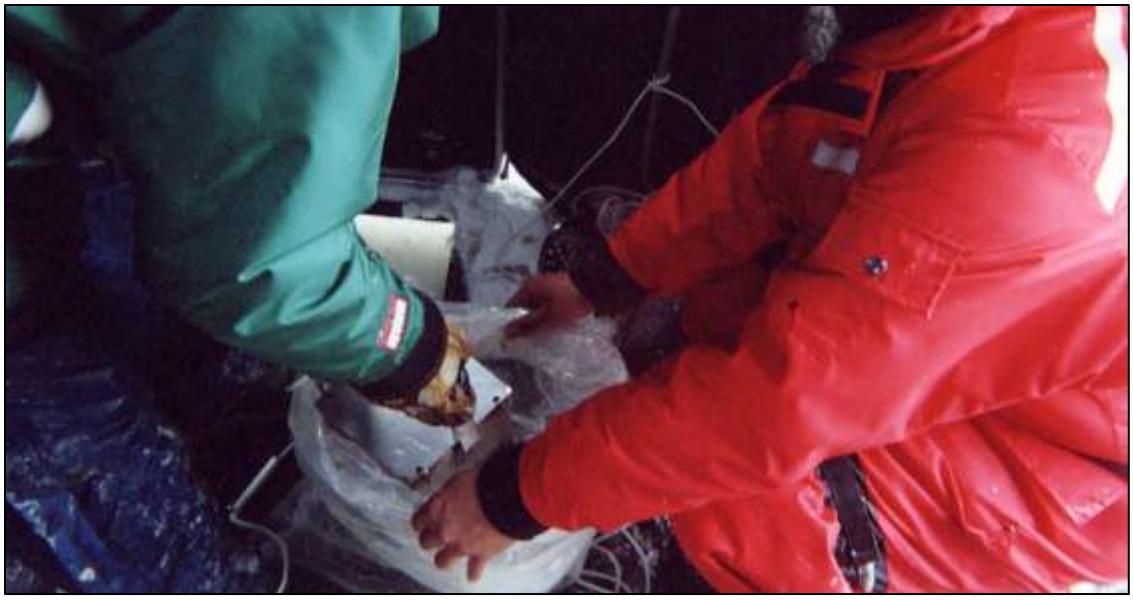
Source: North/South Consultants Inc., 2009

Photo 4A-4: Sampling of sediment-dwelling macroinvertebrates from a boat using a Ponar dredge

Source: North/South Consultants Inc., 2000

Photo 4A-5: A sieved sample from an Ekman dredge

During the ice-cover season access to water at sampling sites was through holes drilled with a gas-powered ice auger. A separate 30 cm diameter hole was drilled for each Ekman sample. To ensure that sampling disturbances in one hole did not affect another, each hole was not less than 1 m apart from another and all holes were within a 3 m radius at each site. Water depth was measured at each sampling site with a weighted, metred rope (accurate within ± 0.1 m). Ice thickness and relative water velocity were determined at a subset of sites. Ice thickness was measured with a metre stick that had a metal flange fastened to one end (accurate within ±0.1 m).The sample was retrieved to the surface of the ice and carefully placed in a plastic bag (Photo 4A-6). The Ekman samples were placed in a cooler to avoid or limit freezing and then processed the same day. Each Ekman was carefully sieved through a 500 µm mesh rinsing bag and invertebrates retained by the screen were transferred to plastic jars and fixed with 10% formalin. Fixed samples were shipped to the NSC laboratory (Winnipeg, MB) for processing.



Source: North/South Consultants Inc., 2001

Photo 4A-6: Aquatic environmental studies team members on the ice placing a retrieved sample from the Ekman dredge into a plastic bag

In winter of 1997 and 1998 water velocity was measured at selected sites using a Model 622, Price Type 'AA' Current Meter at 60 to 80% of the water depth. Relative water velocity was estimated in the field during all other years, with the exception of 2000 and 2006, according to the following criteria:

- LOW – sample collection possible, sampling equipment reaches the bottom sediment with minimal or no angle;
- MED – sample collection possible, sampling equipment pulled by water current and reaches the bottom sediment at an angle; or
- HIGH – sample collection not possible.

An additional Ekman sample was taken at each site and sub-sampled with a 5 cm diameter core tube (0.002 m^2 surface area) to provide a sample of approximately 100 mL of sediment. These sediment sub-samples were frozen and sent to the laboratory at NSC (Winnipeg, MB) for organic content and particle size analyses.

The aquatic invertebrate community was sampled near the proposed access road ROW during the October 2004, sampling period. Beginning at the downstream end of the reach, working upstream, aquatic invertebrates were collected in each reach of all stream crossings using a D-ring kick net with a 0.5 m x 0.5 m opening and 500 μm mesh. Samples were collected by placing the kick net on the bottom of the stream with the opening facing upstream and kicking the substratum upstream of the kick net, allowing the water to carry the debris including aquatic invertebrates into the net. Three samples were collected per stream crossing; one at the centreline reach and one each at the upstream and downstream

extent of the broad area reach. Samples were fixed in 10% formalin and shipped to the NSC laboratory (Winnipeg, MB) for identification of invertebrates.

4A.4.2.3 Laboratory and Data Analysis

In Winnipeg, samples were rinsed with water, transferred to 70% ethanol, stained with Rose Bengal to facilitate removal of organisms, and sorted under a 3X desktop magnifier with lamp. Invertebrates were identified to major group (subclass, order, or family) and quantified by an invertebrate taxonomist for all samples except those collected along the access road ROW where samples were analyzed for presence/absence only. A Leica Mz125 microscope (maximum 100X magnification) and reference texts from Merritt and Cummins (1996), Peckarsky *et al.* (1990), and Clifford (1991) were used for identification. Scientific names used followed the ITIS classification. Sample processing, taxonomy, and quality assurance were completed in accordance with NSC procedures (Section 4A.5).

Abundance of benthic invertebrates was calculated by dividing the total number of invertebrates per sample by the area of the sampler (0.023 m^2). In addition, the total number of taxa was determined by identifying groups to the lowest practical taxonomic level as presented in the table below:

Phylum, Subphylum or Class	Major Group	Taxonomic Level of Identification
Annelida	Oligochaeta; Hirudinea	Subclass
Crustacea	Ostracoda	Class
	Amphipoda	Family
	Diplostraca	Order
Arachnida	Acari	Subclass
	Araneae	Order
Mollusca	Bivalvia; Gastropoda	Family
Platyhelminthes	-	Phylum
Insecta	Megaloptera; Odonata; Coleoptera; Hemiptera; Ephemeroptera; Trichoptera; Plecoptera; Diptera (excluding Chironomidae)	Family
	Chironomidae	Subfamily

Total organic content was determined from the sediment samples by weight loss after sample combustion at 500ºC for 12 h ("ashing"). Particle size analysis was done according to the procedures for silty sediments outlined in Holme and McIntyre (1984). These data were used to supplement substrata information (*i.e.*, the quantification of bottom substrata types) obtained during aquatic habitat surveys (Section 3.0).

4A.4.3 PLANT-DWELLING MACROINVERTEBRATES

Detailed sampling to describe the habitat-based abundance, composition and distribution of plant-dwelling aquatic macroinvertebrates (epiphytic invertebrates) was conducted in 2001 and 2002 between Birthday and Gull rapids, in 2003 and 2004 for Clark Lake to Gull Rapids, and in 2005 and 2006 in Stephens Lake in conjunction with the aquatic macrophyte abundance and composition program in the study area waterbodies (2001–2006).

4A.4.3.1 2001 and 2002

Sampling period and locations, sample collection and field measurements, and laboratory and data analysis in 2001 and 2002 were the same as for Section 4A.2.3.2.1 (Map 4A-2); details specific to the plant-dwelling macroinvertebrate samples follow.

In the laboratory, epiphytic invertebrate samples were transferred to 70% ethanol, sorted under a 3X desktop magnifier with lamp, identified to major groups, and enumerated. Any remaining invertebrates found on macrophytes in the lab that were not initially rinsed off in the field were included in the analysis. Epiphytic invertebrate abundance (individuals/m^2) was determined using the following formula: individuals per sample / surface area of sampler (0.42 m^2).

4A.4.3.2 2003 and 2004

Sampling period and locations, sample collection and field measurements, and laboratory and data analysis in 2003 and 2004 were the same as for Section 4A.2.3.2.2 (Map 4A-2 and Map 4A-3); details specific to the plant-dwelling macroinvertebrate samples follow.

Epiphytic invertebrate samples were sorted under a 3X desktop magnifier with lamp and invertebrates were transferred to 70% ethanol. Any remaining invertebrates found on macrophytes in the laboratory that were not initially rinsed and placed into bottles in the field were included in the analysis. Invertebrates were identified to major group using a Leica Mz125 microscope (maximum 100X magnification) and enumerated with reference texts by Clifford (1991), McCafferty (1998), and Merritt and Cummins (1996). Scientific names used followed the ITIS classification. Sample processing, taxonomy, and quality assurance were completed in accordance with NSC procedures (Section 4A.5).

Epiphytic invertebrate abundance (individuals/m^2) was calculated by dividing the number of invertebrates per sample by the surface area of the sampler (0.42 m^2). To determine total number of taxa in 2003, epiphytic invertebrate groups were identified to the lowest practical taxonomic level as presented in the following table:

Phylum, Subphylum or Class	Major Group	Taxonomic Level of Identification
Annelida	Oligochaeta; Hirudinea	Subclass
Crustacea	Ostracoda	Class
	- all other Crustacea	Order
Arachnida	Acari	Subclass
Mollusca	Bivalvia	Family
	Gastropoda	Class
Hydrozoa	-	Class
Insecta	Odonata; Coleoptera; Hemiptera; Ephemeroptera; Trichoptera; Diptera	Family

In 2004, epiphytic invertebrate groups were identified to the lowest practical taxonomic level as presented in the following table:

Phylum, Subphylum or Class	Major Group	Taxonomic Level of Identification
Annelida	Oligochaeta; Hirudinea	Subclass
Crustacea	Ostracoda	Class
	Amphipoda	Family
Arachnida	Acari	Subclass
Mollusca	Bivalvia	Family
	Gastropoda	Family
Hydrozoa	-	Class
Insecta	Coleoptera; Hemiptera; Ephemeroptera; Trichoptera; Diptera	Family
	Chironomidae	Subfamily

The double sieving method allowed for a comparison of catch efficiency between mesh sizes. The 500 µm mesh retained between 56.1 and 87.1% of the total invertebrates captured in samples. Chironomidae and Oligochaeta accounted for the majority of invertebrates that passed through the 500 µm mesh and were retained by the 400 µm mesh. The invertebrate fraction retained by the 500 µm mesh only was used as the data for the EIS to be directly comparable to the methods employed for the sediment-dwelling macroinvertebrate samples collected.

4A.4.3.3 2005 and 2006

Sampling period and locations, sample collection and field measurements, and laboratory and data analysis in 2005 and 2006 were the same as for Section 4A.2.4.2 (Map 4A-6); details specific to the plant-dwelling macroinvertebrate samples follow.

Epiphytic invertebrate samples were sorted under a 3X desktop magnifier with lamp and invertebrates were transferred to 70% ethanol. Any remaining invertebrates found on macrophytes in the laboratory that were not initially rinsed and placed into bottles in the field were included in the analysis. Invertebrates were identified to major group using a Leica Mz125 microscope (maximum 100X magnification) and enumerated with reference texts by Clifford (1991), McCafferty (1998), and Merritt and Cummins (1996). Scientific names used followed the ITIS classification. Sample processing, taxonomy, and quality assurance were completed in accordance with NSC procedures (Section 4A.5).

Epiphytic invertebrate abundance (individuals/m^2) was calculated by dividing the number of invertebrates per sample by the surface area of the sampler (0.42 m^2). To determine total number of taxa, epiphytic invertebrate groups were identified to the lowest practical taxonomic level as presented in the following table:

Phylum, Subphylum or Class	Major Group	Taxonomic Level of Identification
Annelida	Oligochaeta; Hirudinea	Subclass
Crustacea	Ostracoda	Class
	- all other Crustacea	Order
Arachnida	Acari	Subclass
Mollusca	Bivalvia	Family
	Gastropoda	Class
Hydrozoa	-	Class
Insecta	Megaloptera; Odonata; Coleoptera; Hemiptera; Ephemeroptera; Trichoptera; Diptera	Family

Rinse water was sieved through a 400 μm sieve only. These data were compared to those from the 500 μm sieve fraction collected for the sediment-dwelling macroinvertebrate program in Stephens Lake. Based on information collected in the Keeyask area in 2003 and 2004, it is recognized that chironomids and oligochaetes may be proportionately over-represented in the plant-dwelling samples in comparison to those collected to describe the sediment-dwelling community in the same type of habitat.

4A.4.4 DRIFTING MACROINVERTEBRATES

Drift traps were used to sample tributaries and extensive areas of rapids where sampling by other methods (*e.g.*, dredge or air lift sampler) was otherwise not feasible due to logistical (*e.g.*, water depths and water velocities too high for effective sampling) or safety concerns (*i.e.*, high flows immediately upstream and downstream of Gull Rapids). Drifting macroinvertebrates were sampled using drift traps at various locations selected along the Nelson River during the 2001 to 2004 open water seasons to gain an overall understanding of the spatial and temporal differences in abundance and distribution of biomass within the Keeyask area, and provide the basis for assessing potential changes in production from specific areas (*i.e.*, Birthday Rapids, Gull Rapids) associated with the Project.

4A.4.4.1 2001 and 2002

Invertebrate drift sampling was conducted between 23 May and 08 July 2001, and 15 June and 20 July 2002, at various locations selected to represent current conditions within the study area. Sampling locations included the Nelson River mainstem between Birthday and Gull rapids, the Nelson River mainstem between Gull Rapids and Stephens Lake, and tributaries of the Nelson River between Clark Lake and Gull Rapids, including Assean River, and Nap, Portage, and Two Goose creeks (Map 4A-4, Map 4A-5 and Map 4A-10).

As part of a lake sturgeon fisheries investigation in the study area, six drift traps, set in the reach of the Nelson River mainstem between Birthday and Gull rapids 24 June-08 July 2001, and 25 June-20 July 2002, and five drift traps, set at the base of Gull Rapids in Stephens Lake between 19 June and 08 July 2001, and between 28 June and 20 July 2002, were sampled for drifting invertebrates.

Two drift traps were set in the Assean River, located approximately 7 km upstream of Clark Lake. The traps were set between 27 May and 24 June 2001, and between 15 June and 12 July 2002, approximately 100 m downstream from the first series of rapids.

In each of Nap, Portage, and Two Goose creeks, individual drift traps were set to sample drifting invertebrates from 27 May to 24 June 2001, and from 15 June to 20 July 2002. Drift traps were set in fast flowing areas approximately 30 m, 90 m, and 150 m from the mouths of the creeks, respectively.

Physical characteristics were measured at each drifting invertebrate sampling site in the Nelson River mainstem though not in the Nelson River tributaries. Physical characteristics included water depth, relative water velocity, and substrate composition and compaction. Water depth was measured using a staff gauge (± 1 cm) or weighted metred rope. Relative water velocity was estimated in the field as low, medium, or high. Substratum composition and compaction were qualitatively assessed at the time drift nets were installed.

Drift samples were collected from the Nelson River mainstem and Stephens Lake using 'large' drift nets (43 x 85 cm opening; 3 m length; 954 µm Nitex mesh). Traps were anchored to the river bottom and oriented directly into the current. Contents of the drift nets, set over 24-hour periods, were collected weekly between 19 June and 08 July 2001, and between 25 June and 20 July 2002.

Within the tributaries of the Nelson River between Clark Lake and Gull Rapids 'small' drift nets (15 x 15 cm opening; 1 m length; 500 μm Nitex mesh) were deployed to collect drifting invertebrates. Traps were oriented directly into the current with the mouth of the trap positioned approximately 10 cm below the surface of the water. As water levels receded, traps were moved to areas of higher water velocity and suitable depth in order to maximize the efficiency of the trap. Contents of the drift nets, set over 24-hour periods, were collected weekly between 27 May and 24 June 2001, and between 15 June and 20 July 2002.

All drift samples were fixed using 10% formalin and shipped to the NSC laboratory (Winnipeg, MB) for processing. In the laboratory, samples were rinsed with water, transferred to 70% ethanol, stained with Rose Bengal to facilitate removal of organisms, and sorted under a 3X desktop magnifier with lamp. Aquatic invertebrates were identified to major group (*i.e.*, subclass, order, or family) and their presence/absence recorded. All samples were retained and archived at NSC should further analyses be required.

4A.4.4.2 2003 and 2004

Sampling period and locations, sample collection and field measurements, and laboratory and data analysis in 2003 and 2004 were the same as for Section 4A.2.3.3 and Section 4A.2.4.3 (Map 4A-4 and Map 4A-5); details specific to the drifting macroinvertebrate samples follow.

Drifting invertebrates were enumerated and identified to major group (*i.e.*, subclass, order, or family) using a Leica Mz125 microscope (maximum 100X magnification). Scientific names used follow the ITIS classification. All fish and invertebrate samples were stored in 70% ethanol and are retained at NSC should further analysis be required. Sample processing, taxonomy, and quality assurance were completed in accordance with NSC procedures (Section 4A.5). Invertebrate drift density was calculated with the formula: [number of individuals x 100] divided by [time $_{(s)}$ x drift trap height $_{(m)}$ x drift trap width $_{(m)}$ x water velocity $_{(m/s)}$].

4A.4.5 DATA PRESENTATION

Aquatic macroinvertebrate abundance, community composition, and distribution data from 1997-2006 study programs are presented in Lawrence and Fazakas (1997), Fazakas and Zrum (1999), Zrum and Neufeld (2001), Zrum and Bezte (2003), Zrum and Kroeker (2003), Dolce and Sotiropoulos (2004a, 2004b), Juliano and Neufeld (2004, 2005), Sotiropoulos and Neufeld (2004), Gill (2007a, 2007b), Neufeld (2007), Capar (2008), Burt and Dolce (2008), Cooley and Dolce (2008), Dolce and Burt (2008), and Mazur and Savard (2008).

4A.5 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

4A.5.1 SAMPLE PROCESSING

Sorting aquatic samples involves removing aquatic macroinvertebrates and plant material from the organic and inorganic material within each sample.

4A.5.1.1 Sorting Samples

- All sorting is conducted with a 3X desktop magnifier with lamp.
- All sorted samples are checked by a second laboratory technician.
- Any additional invertebrates/plant materials collected during the quality assurance/quality control (QA/QC) process are combined with the original sample, but counted separately.
- Sorting efficiency must be greater than or equal to 95% or the sample must be re-sorted.

4A.5.2 VERIFICATION OF TAXONOMIC IDENTIFICATION

NSC taxonomists communicate with external taxonomic specialists to ensure accuracy and consistency.

4A.5.2.1 Sample Identification

- Samples are identified to the appropriate taxonomic level by an in-house or external taxonomist. Ten percent of these samples are randomly selected and sent to an external taxonomy specialist for QA/QC. The accuracy of the sample subset is assessed for identification and enumeration.
- All uncertain and unknown invertebrates/plants are sent to an external specialist.
- Incorrect identifications and/or enumeration discrepancies are noted on the laboratory datasheet.
- The target overall accuracy level is 90% for invertebrate/plant identification and enumeration. The external taxonomists' corrected identification and enumeration values are used where discrepancies exist.
- All samples that fall outside the target accuracy level will be re-identified and/or re-enumerated.

4A.5.3 DATA PROCESSING

Data processing involves entering data from laboratory data sheets into an MS Excel data template. Data templates include project name, study area, site locations, site labels, sampling date, sampling gear, taxa, life stages, and enumeration list. After raw data are entered into the template spreadsheet, a second technician verifies all entered data and formulae. A final verification is conducted by the report author.

4A.6 ASSESSMENT METHODS

A quantitative habitat-based model was developed to estimate the abundance of sediment- and plant-dwelling macroinvertebrates in the newly created Keeyask reservoir at four time steps post-impoundment for comparison with abundance in the existing Keeyask area (upstream of the GS). The model used the mean abundance (individuals/m^2) of macroinvertebrates from baseline studies in the study area as an estimate of macroinvertebrate abundance at defined habitat types in the existing environment and as a predictor of macroinvertebrates in the same habitat types post-Project. An abundance estimate was generated for some habitat types that were not sampled because of constraints in the methods (*e.g.*, medium water velocity habitats) or because they were uncommon in the existing environment (*e.g.*, deep water, organic substrate habitats) using surrogate values from similar habitat types that were sampled or other comparable areas in northern Manitoba (*e.g.*, Wuskwatim area, Stephens Lake). The main steps in model development and application, in sequence, were:

1. Estimate macroinvertebrate abundance in defined habitat types in the existing environment;
2. Determine the area of each habitat type in the Keeyask area (upstream of the GS) existing environment (Section 3.2.4.1; Appendix 3D);
3. Develop area estimates for defined habitat types in Year 30 post-Project (Section 3.2.4.2; Appendix 3D);
4. Modify the Year 30 habitat areas in the downstream, more lacustrine portion of the reservoir for the intermediate time steps (*i.e.*, years 1, 5, and 15) to account for shoreline erosion, peat disintegration and transport, and loss and subsequent establishment of aquatic plant beds (Appendix 3D);
5. Estimate suitable habitat areas in the intermittently exposed zone (IEZ) (Appendix 3D);
6. Modify abundance estimates at the intermediate time steps in response to predicted changes in DO and TSS concentrations (Section 2.5.2.2); and
7. Use the model to estimate the abundance of sediment- and plant-dwelling macroinvertebrates in the newly created Keeyask reservoir at four time-steps post-impoundment.

4A.6.1 ESTIMATE ABUNDANCE IN DEFINED HABITAT TYPES IN THE EXISTING ENVIRONMENT

Study area locations sampled for sediment- and plant-dwelling macroinvertebrates (Section 4A.4.2 and Section 4A.4.3) were classified according to water depth and velocity, substrate compaction and composition, and the presence or absence of rooted aquatic vegetation.

Habitat-specific abundance estimates were determined for the sediment- and plant-dwelling macroinvertebrate communities sampled in the Keeyask area (Table 4A-1 and Table 4A-2).

Of the 21 habitat types present in the Keeyask area existing environment or predicted to be present in the post-impoundment environment, 15 were not sampled for sediment-dwelling macroinvertebrates and one for plant-dwelling macroinvertebrates during baseline data collection in the Keeyask area. An abundance estimate was generated for some habitat types that were not sampled because of constraints in the methods (*e.g.*, medium water velocity habitats) or because they were uncommon in the existing environment of the study area (*e.g.*, deep water, organic substrate habitats) using surrogate values from similar habitat types that were sampled or other comparable areas in northern Manitoba (*e.g.*, Wuskwatim area, Stephens Lake).

4A.6.2 CALCULATE THE AREA OF EACH HABITAT TYPE IN THE EXISTING ENVIRONMENT

The area of each habitat type was estimated for the Nelson River between the outflow of Clark Lake and the Keeyask GS location in the existing environment using Manitoba Hydro's shoreline data (the spatial extent of habitat types was modelled at 95th percentile flow conditions) (Section 3.2.4.1; Appendix 3D).

4A.6.3 ESTIMATE AREA OF EACH HABITAT TYPE IN YEAR 30 POST-PROJECT

The area of each habitat type was estimated for the Nelson River between the outflow of Clark Lake and the site of the Keeyask GS in Year 30 post-Project using the predicted shoreline at a water level elevation at the face of the dam of 158 m ASL for MOL or at 159 m ASL under 95th percentile flow conditions for FSL (Section 3.2.4.2; Appendix 3D).

4A.6.4 MODIFY THE YEAR 30 HABITAT AREAS FOR INTERMEDIATE TIME STEPS

The predicted Year 30 habitat areas were modified to characterize reservoir evolution and associated changes to the proportional distribution of each habitat type during the intermediate time steps (Years 1, 5, and 15) to account for:

- Expansion of the Keeyask reservoir over the time series due to shoreline erosion and peatland disintegration;
- Reduction in the area of organic substrates (*i.e.*, peat) in shallow areas over time due to peatland disintegration and transport; and
- Loss and subsequent establishment of aquatic plants beds (Appendix 3D).

These area estimates were used to provide a comparison between habitat conditions in the existing Keeyask area (upstream of the GS) and habitat changes in the reservoir over time.

4A.6.5 ESTIMATE SUITABLE HABITAT AREAS IN THE INTERMITTENTLY EXPOSED ZONE

Depending on the mode of operation, (peaking or base loaded), a portion of shallow water habitats in each of Year 1, 5, 15, and 30 time steps (Appendix 3D) may be more or less dewatered on a frequent or infrequent basis. Intermittent dewatering is expected to somewhat reduce the suitable habitat in those frequently exposed areas that would be available to aquatic macroinvertebrates. Estimates and assumptions regarding the effect of mode of operation on suitable shallow water habitat areas are described in Appendix 3D.

4A.6.6 MODIFY ABUNDANCE ESTIMATES AT THE INTERMEDIATE TIME STEPS

Aquatic macroinvertebrate abundance and community composition in aquatic habitats in the downstream portion of the Keeyask reservoir (reaches 5–9A, Map 3-5; Appendix 3D) are expected to be affected by predicted changes in DO (Years 1 and 5 time steps) and TSS (Year 1 time step only) concentrations post-impoundment. No similar effects are expected in the upstream reaches 2A–4 (Map 3-5; Appendix 3D). Analysis and discussion of DO and TSS changes post-impoundment are presented in Section 2.5.2.2.

Predicted changes to DO and TSS have potential negative consequences on aquatic macroinvertebrate abundance and community composition in affected areas. Consequently, modifications to abundance estimates to account for potential negative effects were undertaken. The abundance modifications were confined to those portions of each habitat type that would be in the lower reaches (*i.e.*, 5-9A) of the reservoir.

4A.6.6.1 Dissolved Oxygen

Based on DO modelling results (Section 2.5.2.2), some aquatic habitats, primarily those located in newly flooded terrestrial areas, would be of reduced value to aquatic macroinvertebrates because of near bottom hypoxic conditions created by the increased oxygen demand associated with disintegrating peat and organic substrates. Areas predicted to be more severely affected by reduced DO concentrations (bottom

DO concentration less than 2 mg/L) were associated with off-current habitats characterized by standing water with soft, organic-based substrates. The total area of habitats with DO concentration less than 2 mg/L was proportionally allocated to those habitat types. Areas predicted to be less severely affected by reduced DO concentrations (bottom DO concentration greater than or equal to 2 mg/L but less than or equal to 6.5 mg/L) included shallow water, low velocity habitats and areas of deep, standing water habitat.

Habitat-specific abundance estimates were modified to account for low DO effects on aquatic macroinvertebrate behaviour (*i.e.*, avoidance of low DO areas) and survival:

- Where DO was less than 2 mg/L at the bottom, habitat was considered not suitable for aquatic macroinvertebrates and the habitat-specific abundance estimated was conservatively set to zero for the low DO affected portion of the habitat;
- Where DO was greater than or equal to 2 mg/L but less than or equal to 6.5 mg/L at the bottom, habitat was considered less suitable and the habitat-specific abundance estimate was conservatively reduced by 50% for the low DO affected portion of the habitat; and
- Where DO was greater than 6.5 mg/L at the bottom, it was assumed that there would be no DO related negative effects on aquatic macroinvertebrates (chronic objective for the protection of aquatic life is 6.5 mg/L).

4A.6.6.2 Total Suspended Solids

Total suspended solids are predicted to increase in the first year following impoundment (Section 2.5.2.2). The majority of the increase in TSS is predicted to come from peat disintegration processes and thus result in a large organic component of the TSS. Depending on location, average increase in TSS is expected to range from:

- Less than 5 mg/L in mainstem lotic Zones 1, 2, and 3;
- 8–22 mg/L in lentic habitats found in Zones 4, 5, 10, 12, and 13;
- 40–86 mg/L in lentic habitats found in Zones 7, 8, 9, and 11.

Elevated organic TSS levels are predicted to persist for only a few hours at certain locations (*e.g.*, Zone 5), but would extend for days to weeks or months in other locations. TSS increases are also likely to exceed the predicted average increases on occasion because of re-suspension of bottom organic material and site-specific increases in shoreline erosion due to wind/wave events. On other occasions, TSS concentrations are likely to be below the predicted range of average concentrations. By the end of the first year after impoundment, TSS increase is expected to drop sharply as the source of particulates diminishes (Section 2.5.2.2).

Prolonged (*i.e.*, months), low to moderate increases in suspended fine sediments (assuming silt/clay fraction is suspended) beyond the current range of concentrations may affect aquatic macroinvertebrates in the following ways: abrasion of/deposition on respiratory surfaces (*i.e.*, gills) (*e.g.*, a reduction in certain types of mayflies); interference of food intake for filter-feeders (*e.g.*, a reduction in certain types of

caddisflies and fingernail clams); and increased rates of invertebrate drift due to changes in feeding efficiency and behaviour (*e.g.*, a temporary reduction in aquatic insect abundance in areas exposed to increases in TSS). DFO (Birtwell 1999) indicates that sediment increases resulting from placer mining operations in the 25–100 mg/L range would pose a "Low Risk" to fish habitat.

Considering the range of concentrations predicted to occur over an approximate one year period in the Keeyask reservoir, and the guidance provided by DFO that relate to the risks to fish habitat, it is suggested that TSS effects in the Keeyask area (upstream of the GS) could result in a 10% reduction in aquatic habitat productivity that would persist for one year. It is suggested that this reduction be conservatively applied across all shallow, low velocity and standing water habitat types plus all deep, standing water habitat types in the lower reaches (5–9A) of the reservoir. The short-term (one-year) reduction in habitat use/productivity related to increases in TSS concentration is in addition to the predicted decreases in habitat production/use by aquatic macroinvertebrates as a result of depressed DO concentrations that would accompany shoreline erosion and peat disintegration processes, including organic and mineral sedimentation, peat resurfacing and the formation of peat islands.

In summary, predicted increases in TSS in the first year of impoundment are expected to affect aquatic macroinvertebrates in the newly impounded reservoir. Although newly wetted aquatic habitat would be undergoing colonization by benthic macroinvertebrates in Year 1 (predominantly chironomids, which are rapid colonizers and more tolerant of low DO and increased TSS concentrations), it was assumed that the abundance estimates for all Year 1 shallow, standing water and low velocity habitats, plus all deep-standing water habitats, would be reduced by 10% as a result of increased TSS concentrations. TSS effects are predicted to be greatest Year 1, declining rapidly thereafter (Section 2.5.2.2).

4A.6.7 USE THE MODEL TO ESTIMATE THE POST-PROJECT ABUNDANCE OF AQUATIC MACROINVERTEBRATES

The model was used to evaluate the potential effects of reservoir creation and operation on the Keeyask area (upstream of the GS) aquatic macroinvertebrate community. The model estimates changes to sediment- and plant dwelling macroinvertebrate abundance associated with predicted habitat changes resulting from flooding and ongoing operation of the GS.

Using mean abundance estimates for each habitat type (individuals/ha), a total abundance estimate per habitat type (*i.e.*, individuals/hectare multiplied by the total habitat area) was calculated at each time step for each mode of operation (*i.e.*, 158 m ASL base loaded, 159 m ASL base loaded, and weekly cycling [peaking] between 158 m and 159 m ASL), taking into account the habitat modifications described in Section 4A.6.4, Section 4A.6.5, and Section 4A.6.6 (Table 4A-1 and Table 4A-2).

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Table 4A-1: Habitat-type-specific total sediment-dwelling macroinvertebrate abundance in the existing environment (EE) and at post-Project (PP) time steps under different operating scenarios

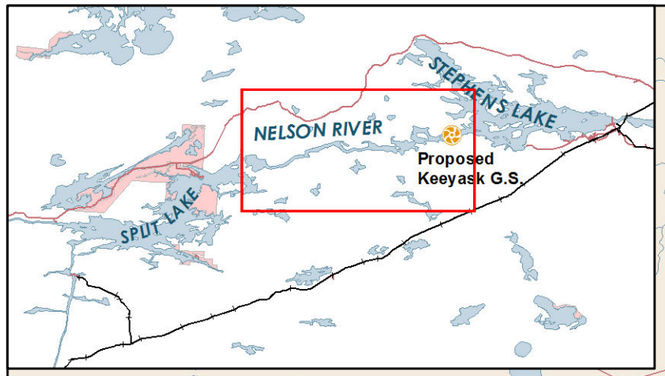
Total Abundance (individuals/ habitat type)	EE[1]	Year 1 PP			Year 5 PP			Year 15 PP			Year 30 PP		
		Peaking Mode[2]		Base Loaded[3]	Peaking Mode		Base Loaded	Peaking Mode		Base Loaded	Peaking Mode		Base Loaded
Classification[6]		MOL[4]	FSL[5]		MOL	FSL		MOL	FSL		MOL	FSL	
Total	4.5E+10	1.1E+11	1.2E+11	1.3E+11	1.1E+11	1.2E+11	1.4E+11	1.3E+11	1.5E+11	1.8E+11	1.2E+11	1.5E+11	1.8E+11
S-L-h-M-N	1.4E+09	2.1E+08	2.7E+08	3.3E+08	2.5E+08	3.2E+08	3.9E+08	2.7E+08	3.5E+08	4.3E+08	2.8E+08	3.7E+08	4.6E+08
S-L-s-M-N	4.1E+09	1.5E+09	1.7E+09	1.9E+09	2.1E+09	2.4E+09	2.8E+09	2.4E+09	2.9E+09	3.4E+09	2.6E+09	3.2E+09	3.8E+09
S-L-s-M-P	8.5E+08	2.3E+06	2.6E+06	3.0E+06	2.3E+06	2.6E+06	3.0E+06	3.1E+07	4.0E+07	5.0E+07	1.3E+08	1.8E+08	2.3E+08
S-M-h-M-N	3.2E+09	8.1E+08	9.3E+08	1.1E+09	8.4E+08	9.8E+08	1.1E+09	8.4E+08	9.8E+08	1.1E+09	8.4E+08	9.9E+08	1.1E+09
S-St-s-M-N	2.2E+10	7.0E+09	9.0E+09	1.1E+10	2.4E+10	3.1E+10	3.8E+10	3.0E+10	4.1E+10	5.2E+10	3.7E+10	5.1E+10	6.5E+10
S-St-s-M-P	8.3E+09	2.0E+06	5.4E+07	1.1E+08	2.0E+06	5.4E+07	1.1E+08	3.0E+08	7.7E+08	1.2E+09	1.5E+09	3.8E+09	6.0E+09
S-St-s-O-N	0.0E+00	3.1E+10	4.0E+10	5.0E+10	1.2E+10	1.9E+10	2.6E+10	1.8E+10	3.4E+10	4.9E+10	6.7E+09	1.9E+10	3.1E+10
S-St-s-O-P	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.7E+08	4.3E+08	6.9E+08	8.7E+08	2.3E+09	3.7E+09
D-St-s-M-N	5.7E+08	2.3E+10	2.3E+10	2.3E+10	2.6E+10	2.6E+10	2.6E+10	2.8E+10	2.8E+10	2.8E+10	2.8E+10	2.8E+10	2.8E+10
D-L-s-M-N	4.0E+09	4.5E+10	4.5E+10	4.5E+10	4.5E+10	4.5E+10	4.5E+10	4.5E+10	4.5E+10	4.5E+10	4.5E+10	4.5E+10	4.5E+10
D-St-s-O-N	0.0E+00	4.0E+08	4.9E+08	4.9E+08	4.4E+08	5.5E+08	5.5E+08	9.0E+08	1.0E+09	1.1E+09	9.0E+08	1.0E+09	1.1E+09

1. At the 95th percentile flow.
2. Assumes weekly cycling.
3. Assumes no cycling (i.e., Full Supply Level [FSL] with no intermittently exposed zone [IEZ]).
4. Minimum Operating Level – no IEZ.
5. Includes IEZ.
6. Classification Codes:
   Depth S=shallow, D=deep; **Velocity** M=medium, L=low, St=standing; **Compaction** h=hard, s=soft; **Composition** M=mineral, O=organic; **Vegetation** N=no plants, P=plants

Table 4A-2: Habitat-type-specific total plant-dwelling macroinvertebrate abundance in the existing environment (EE) and at post-Project (PP) time steps under different operating scenarios

Total Abundance (individuals/ habitat type)	EE[1]	Year 1 PP			Year 5 PP			Year 15 PP			Year 30 PP		
		Peaking Mode[2]		Base Loaded[3]	Peaking Mode		Base Loaded	Peaking Mode		Base Loaded	Peaking Mode		Base Loaded
Classification[6]		MOL[4]	FSL[5]		MOL	FSL		MOL	FSL		MOL	FSL	
Total	9.0E+08	6.9E+05	5.2E+06	9.8E+06	6.9E+05	5.2E+06	9.8E+06	4.1E+07	9.5E+07	1.5E+08	2.0E+08	4.7E+08	7.4E+08
S-L-s-M-P	1.9E+08	5.2E+05	6.0E+05	6.7E+05	5.2E+05	6.0E+05	6.7E+05	6.9E+06	9.2E+06	1.1E+07	2.9E+07	4.0E+07	5.1E+07
S-St-s-M-P	7.1E+08	1.7E+05	4.6E+06	9.1E+06	1.7E+05	4.6E+06	9.1E+06	2.6E+07	6.6E+07	1.1E+08	1.3E+08	3.2E+08	5.2E+08
S-St-s-O-P	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	8.0E+06	2.0E+07	3.1E+07	4.0E+07	1.0E+08	1.7E+08

1. At the 95th percentile flow.
2. Assumes weekly cycling.
3. Assumes no cycling (*i.e.*, Full Supply Level [FSL] with no intermittently exposed zone [IEZ]).
4. Minimum Operating Level – no IEZ.
5. Includes IEZ.
6. Classification Codes:
   Depth S=shallow; **Velocity** L=low, St=standing; **Compaction** s=soft; **Composition** M=mineral, O=organic; **Vegetation** P=plants.



N

Ross Wright Bay

STEPHENS LAKE

O'Neil Bay

Looking Back Creek

PR 280

Effie Creek

Hidden Creek

Pond 13

Caribou Island

Gull Rapids

Two Goose Creek

Trickle Creek

GULL LAKE

NELSON RIVER

Fork Creek

Birthday Rapids

Nap Creek

Portage Creek

Rabbit Creek

Seebeesis Creek

Clark Lake

Long Rapids

Carscadden Lake

Legend

- 2001 Macrophytes
- 2003 Macrophytes
- 2006 Macrophytes

Note: Shows 95th percentile inflow

KEEYASK Hydropower Limited Partnership

0 2.5 5 7.5 10 Kilometres

0 1.25 2.5 3.75 5 Miles

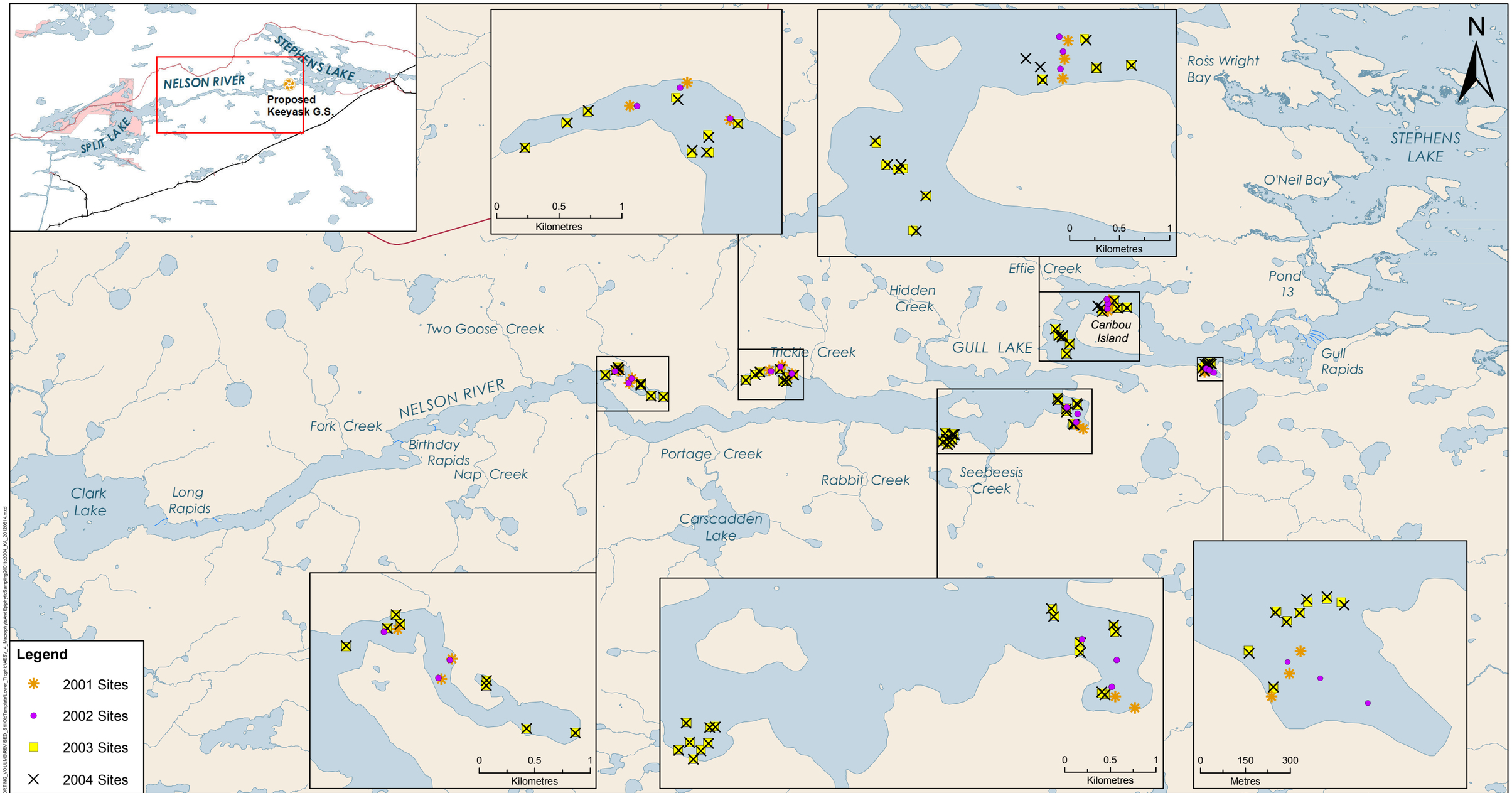
Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000
Stephens Lake Shoreline - Quickbird@Digitalglobe, 2006
Nelson River Shoreline modelled by Manitoba Hydro

Macrophyte Bed Distribution

Existing Environment - Reaches 2A to 11

File Location: G:\EIS\Keeyask\Publish_MXD's\SUPPORTING_VOLUME\REVISED_Stills\Template\Aquatic_Habitat\AESV_1_MacrophyteBedDistribution_EE_Reach2aAto11_20120910.mxd

Map 4A-1



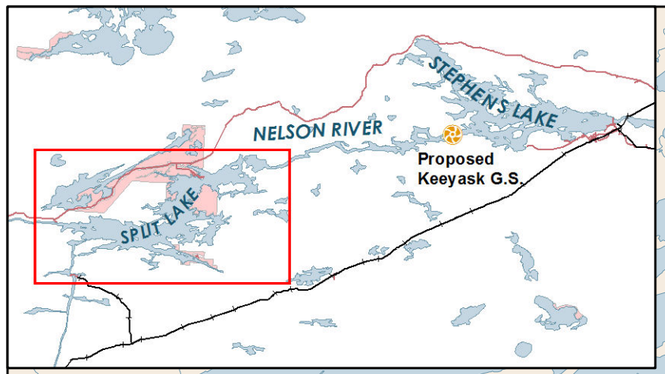
Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000
Stephens Lake Shoreline - Quickbird@Digitalglobe, 2006
Nelson River Shoreline modelled by Manitoba Hydro

Macrophyte and Epiphytic Sampling 2001-2004

Keeyask Area

File Location: G:\EIS\Keeyask\Publish_MXDs\SUPPORTING_VOLUME\REVISED_SIBOOTemplate\Lower_Trophic\AESV_4_Macrophyte\AnnEpiphyticSampling2001to2004_KA_20120914.mxd

Map 4A-2



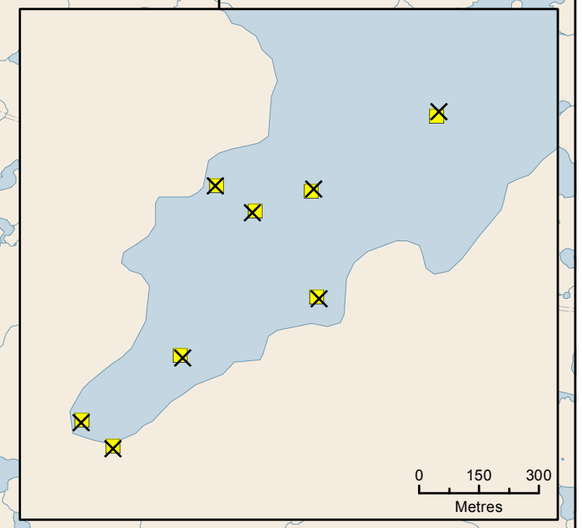
N

Clark Lake

PR 280

Burntwood River

SPLIT LAKE



Grass River

Kelsey G.S.

Ripple River

Aiken River

Legend

- 2003 Sites
- 2004 Sites

KEEYASK
Hydropower Limited Partnership

0 5 10 Kilometres
0 2.5 5 Miles

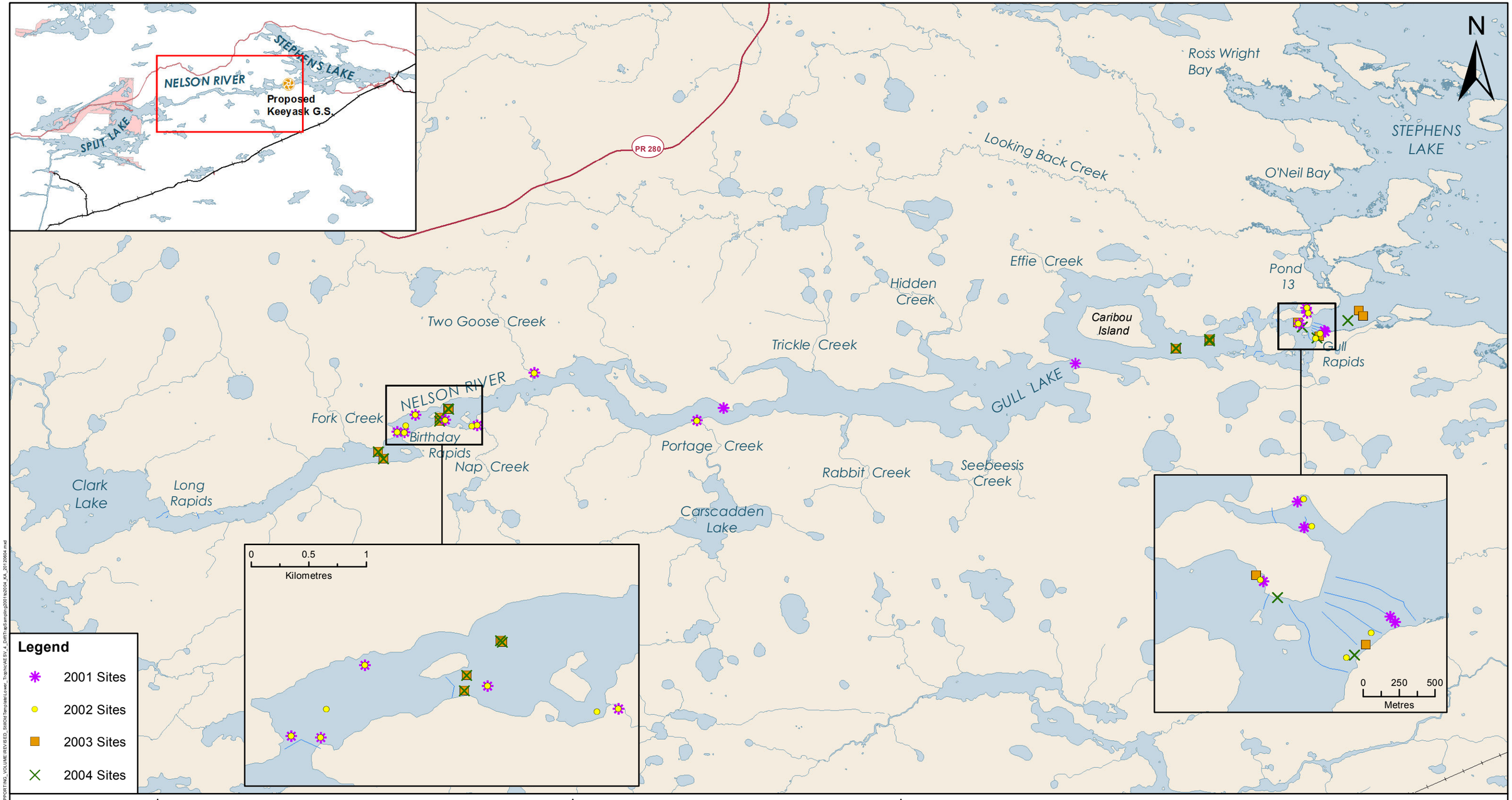
Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Macrophyte and Epiphytic Sampling 2003-2004

Split Lake Area

Map 4A-3

File Location: G:\ES\Keeyask\Publish_MX\Dist\SUPPORTING_VOLUME\REVISED_SIMOs\Temp\aliki\Lower_Trophic\AES\V_4_Macrophyte\ArcEpiphyte\GIS\maps\p2003_2004_SL_20120605.mxd



N

Ross Wright Bay

O'Neil Bay

STEPHENS LAKE

Callan Island

Cabin Island

Stratford Island

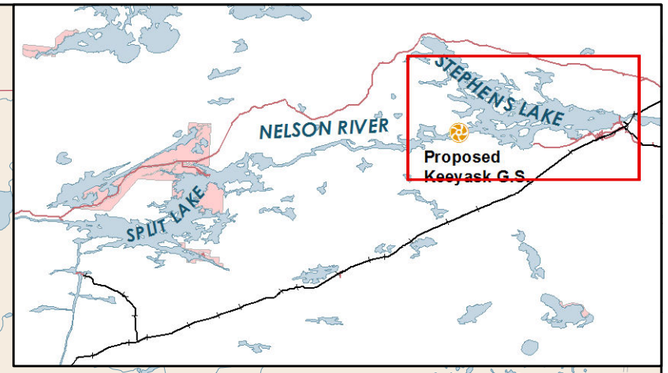
Ferris Bay

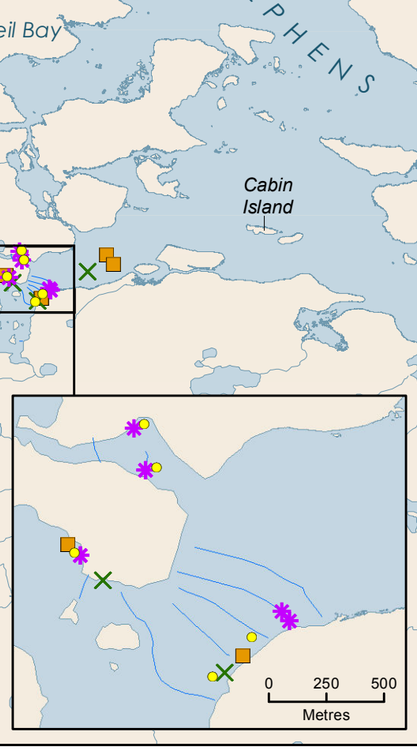
Wilson Channel

Butnau Dam

Kettle G.S.

PR 280





Legend

- 2001 Sites
- 2002 Sites
- 2003 Sites
- 2004 Sites

KEEYASK Hydropower Limited Partnership

0 5 10 Kilometres

0 2 4 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000,
Stephens Lake Shoreline-Quickbird@Digitalglobe, 2006
Nelson River Shoreline modelled by Manitoba Hydro

Drift Trap Sampling 2001-2004

Gull Lake, Gull Rapids and Downstream of the Kettle Generating Station

File Location: G:\EIS\Keeyask Publish_MX\ArcIS\SUPPORTING_VOLUME\REVISED_Stitch\Template\Lower_Trophic\AESV_4_Drift\Trap&sample\p2001to2004_Gull_Rapids_DSK.mxd\5_20120909.mxd