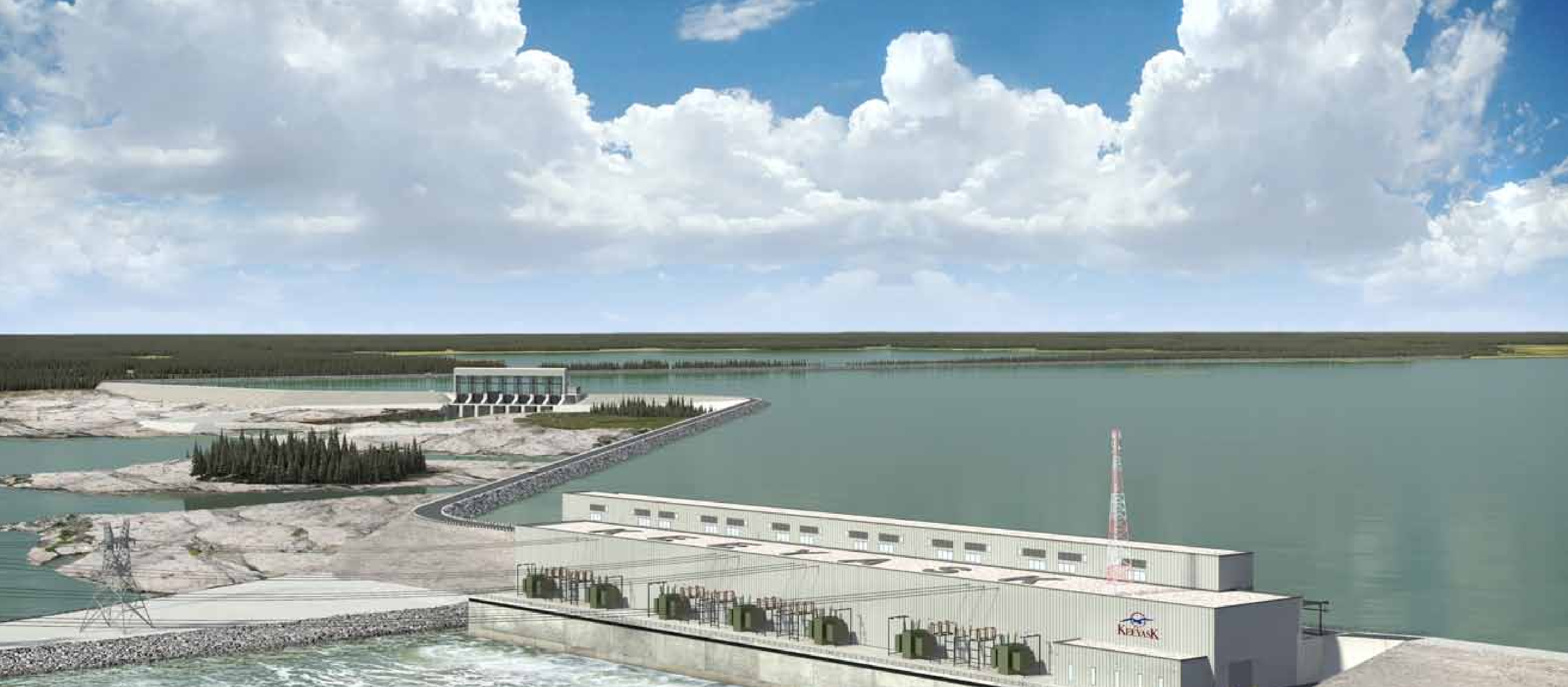
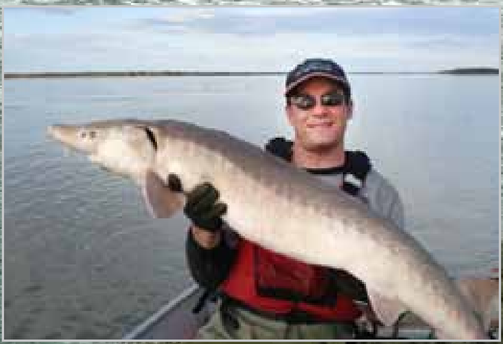
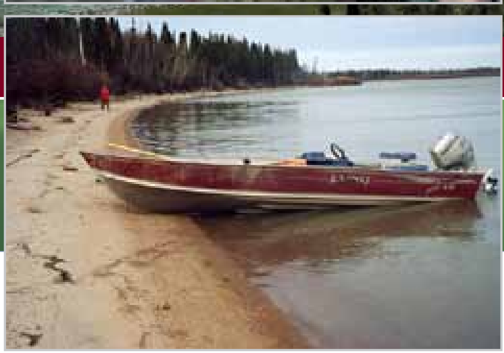




Keeyask Generation Project

Environmental Impact Statement



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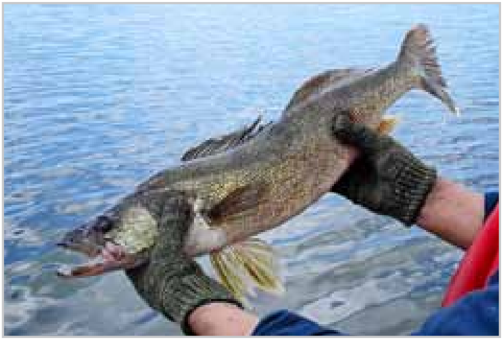

KEEYASK

Hydropower Limited Partnership

June 2012

APPENDICES

APPENDIX 5A
GENERAL ECOLOGY OF VEC FISH SPECIES

5A.1 WALLEYE

Walleye (Photo5A-1) spawn in the spring, generally close to ice break-up (water temperature 6 to 9°C), with lake populations spawning either in tributary streams or within the lake itself (Ford *et al*. 1995). Spawning typically occurs in streams or shallow inshore areas (water depth less than 2 metres [m]) over gravel, boulder, or rubble substrates where water flow is adequate for oxygenation and removal of waste products (*i.e.*, at the base of rapids, falls, or riffles in streams or wind-swept shorelines in lakes) (McPhail and Lindsey 1970; Scott and Crossman 1998). Less commonly, walleye have been observed spawning over organic substrate and dead vegetation in northern Manitoba (Manitoba Hydro and NCN 2003), and over dead vegetation in marshes in Wisconsin (Priegel 1970). Walleye may not spawn in some years when water temperature is not favourable (Scott and Crossman 1998). Male walleye generally become sexually mature at two to four years of age and at approximately 340 mm, and females at three to six years of age and at approximately 370 millimetres [mm] (Scott and Crossman 1998). Walleye may live to 20 years in northern waters (Scott and Crossman 1998).

Source: North/South Consultants Inc.

Photo 5A-1: Walleye / pickerel / okaow / *Sander vitreus*

It has been suggested that most female walleye release the majority of their eggs in just one night of spawning (Scott and Crossman 1998). The eggs are released, settling into gaps along the spawning substrate, and usually hatch within 12–18 days (Scott and Crossman 1998). Young walleye move into the upper levels of the open water approximately 10–15 days after hatching (Scott and Crossman 1998).

Walleye are tolerant of a wide range of environmental conditions, but generally prefer large, shallow, semi-turbid lakes. The species tends to prefer turbid slow moving water in lakes and rivers, often remaining near the bottom (Scott and Crossman 1998). They seek cover from sunlight under banks, sunken trees, rocky outcrops, weed beds, and by moving into deeper or more turbid waters during the day (Ryder 1977; Scott and Crossman 1998). As a result, walleye undergo diel changes in activity, moving into shallows at night to feed and retreating to cover during the day. During summer, walleye move into deeper water, possibly to avoid warming lake temperature, or in response to prey movements (Bodaly 1980; Ford *et al.* 1995; Scott and Crossman 1998). Summer movements generally do not exceed 8 km, but movements of 100 km or more have been observed (Magnin and Beaulieu 1968, cited in Scott and Crossman 1998). Young-of-the-year walleye exhibit strong schooling tendencies and may segregate themselves from juvenile and adult walleye by using different microhabitats to avoid cannibalism. Winter habitat preferences are similar to those in summer, with the exception of an avoidance of strong currents (Scott and Crossman 1998).

Walleye are opportunistic feeders. Young-of-the-year walleye feed predominantly on a variety of invertebrates and smaller fish species, including their conspecifics when other forage species are not readily available (Scott and Crossman 1998). As they mature, walleye become predominantly piscivorous, although they will still take advantage of various insect hatches and crayfish (Priegel 1963).

Walleye use sub-carangiform locomotion. A 200 mm long walleye switches from a sustained swimming speed (which can be maintained indefinitely) to a prolonged swimming speed (which can be maintained for a period of time up to 30 minutes) at a water velocity of approximately 0.5 metres per second [m/s] and moves from a prolonged swimming speed to a burst swimming speed (which can be maintained for a period of time up to 10 seconds) at a velocity of about 0.9 m/s (Katopodis 1993; Appendix 5E). A 500 mm long walleye makes the same changes at approximately 0.85 and 1.4 m/s. The pooled critical velocity (velocity at which fish moves from sustained to prolonged swimming) for 54 walleye of various sizes was found to be 0.56 m/s (Katopodis and Gervais 1991; Appendix 5E).

Walleye populations are vulnerable to overexploitation, as they are highly sought after in domestic, commercial, and recreational fisheries. Walleye are also sensitive to effects to spawning habitat, which is often limited to a few locations.

5A.2 NORTHERN PIKE

Northern pike (Photo 5A-2) begin to spawn shortly after ice break-up at water temperatures of 4 to 11°C. Spawning occurs during the day in shallow (less than 0.5 m deep) water over heavily vegetated floodplains of rivers, marshes, and bays of larger lakes (Diana *et al.* 1977; Casselman and Lewis 1996). In northern populations, the age of sexual maturity is reached at five years for males and six years for females, and at approximately 400 mm in length for both sexes (Scott and Crossman 1998).

Source: North/South Consultants Inc.

Photo 5A-2: Northern pike / jackfish / unchwapayo / *Esox lucius*

Northern pike eggs typically hatch within 12–14 days at typical spawning temperatures but can hatch in as little as 4–5 days at higher water temperatures (between 17.8 and 20°C) (Scott and Crossman 1998). Once hatched, young northern pike are inactive for 6–10 days and are often found attached during this period to vegetation by way of adhesive glands (Scott and Crossman 1998).

Northern pike inhabit vegetated areas of lakes and slow meandering rivers (McPhail and Lindsey 1970; Scott and Crossman 1998). Juvenile northern pike prefer habitats in quiet bays with adequate vegetation cover for both ambushing prey and seeking shelter from predators, such as larger northern pike (Chapman and Mackay 1990). Holland and Huston (1984) found that young northern pike were ten times more abundant in emergent vegetation and three times more abundant in submergent vegetation than in unvegetated areas. Adult northern pike prefer areas less than 5 m in depth for most of the year, moving into deeper water to overwinter (Diana *et al.* 1977; Inskip 1982; Scott and Crossman 1998). As an ambush predator, northern pike require cover (logs, weeds, stumps, boulders) to capture their prey (Inskip 1982), and are most commonly found in moderately vegetated areas along the interface between vegetation and open water (Inskip 1982; Randall *et al.* 1996; Casselman and Lewis 1996). Grimm (1989) suggested that waterbodies must contain more than 25% submerged macrophytes for a northern pike dominated fish community to exist.

Northern pike are opportunistic feeders and will feed on whatever is readily accessible, including aquatic invertebrates, fish, ducklings, mice, and other small mammals (Lawler 1965). After the yolk is absorbed, the diet of northern pike consists mainly of larger zooplankton and some immature aquatic insects (Scott and Crossman 1998). By the time YOY northern pike reach about 50 to 60 mm, fish comprise most of the diet, including their conspecifics (Scott and Crossman 1998; Hunt and Carbine 1951; Frost 1954).

Northern pike locomotion is generally considered somewhere between that of anguilliform and sub-carangiform swimming, and they display sustained and prolonged swimming speeds less than those of walleye (Katopodis and Gervais 1991). Critical velocity is 0.38 m/s for the species (Katopodis and Gervais 1991; Appendix 5E).

Given their preference for vegetated habitat, northern pike are particularly sensitive to any disturbance to aquatic macrophyte beds.

5A.3 LAKE WHITEFISH

Lake whitefish (Photo 5A-3) spawn during fall once water temperatures drop below 8°C (Scott and Crossman 1998). Spawning is known to occur in both lakes (Ford *et al*. 1995) and rivers (Scott and Crossman 1998). In lakes, lake whitefish generally spawn in water less than 5 m deep (Ford *et al*. 1995; Anras *et al*. 1999), with depths as shallow as 1.5 m having been documented (Weagle and Baxter 1974). In rivers, water depth for lake whitefish spawning may be as shallow as 1 m (Green and Derksen 1987). A wide variety of substrates are used for spawning, typically ranging from large boulders to gravel and sand (Lawrence and Davies 1978; Fudge and Bodaly 1984; Anras *et al*. 1999); the use of silt substrates with emergent vegetation has also been documented (Bryan and Kato 1975). Lake whitefish reach sexual maturity between ages six and seven, and at approximately 360 mm in length. Lake whitefish do not necessarily spawn every year (Scott and Crossman 1998).

Source: North/South Consultants Inc.

Photo 5A-3: Lake whitefish / whitefish / atikameg / *Coregonus clupeaformis*

Lake whitefish eggs incubate over winter, and hatch between March and May (Scott and Crossman 1998). After emerging from the substrate, larvae are planktonic for a period that may last several weeks. Initially located near spawning grounds, they soon become widely distributed by wind and currents. During their larval period, lake whitefish have little control over their direction of movement, although they are able to control their buoyancy, typically rising to the surface in the evening and descending again in the morning (Cucin and Faber 1985, cited in Richardson *et al.* 2001).

Post-larval juveniles remain in shallow water where they can use a variety of substrates, provided cover is available (Ford *et al.* 1995). Young-of-the-year lake whitefish generally move from shallow inshore water to deeper water by early summer (Scott and Crossman 1998). Adult lake whitefish typically occur in deep, cold-water lakes, where they are found at depths greater than 10 m over a wide variety of substrates. Lake whitefish are a demersal species, spending most of their time near bottom; however, they have been observed moving into shallow water habitats periodically, usually at night, to feed (Anras *et al.* 1999). Lake whitefish are a schooling species, with large schools often found in a very small area. While movements greater than 150 km have been observed, movements by the species are typically considerably shorter (Scott and Crossman 1998).

Lake whitefish are typically bottom feeders, but pelagic feeding and surface feeding have been observed (Scott and Crossman 1998). Benthic invertebrates are the preferred dietary item (primarily small clams and amphipods), but fish, zooplankton, and terrestrial invertebrates are also consumed. The diet of YOY lake whitefish consists mainly of zooplankton until they move to deeper water later in the open-water season, at which point they consume more benthic invertebrates and fish eggs (Scott and Crossman 1998; Becker 1983).

As a species that uses sub-carangiform locomotion, lake whitefish swimming speeds are very similar to those of walleye, with shifts from sustained to prolonged swimming and from prolonged to burst swimming at comparable velocities (described in Appendix 5E). Critical velocity for lake whitefish is 0.55 m/s (Katopodis and Gervais 1991; Appendix 5E).

Lake whitefish prefer cold water and, consequently, are sensitive to increases in water temperature at depth, as well as oxygen depletion. Spawning areas are particularly vulnerable, as eggs remain on the substrate for the entire winter where they are vulnerable to water level fluctuations (eggs may become exposed and frozen if water levels decline significantly between late fall and late winter), oxygen depletion, and sedimentation. Lake whitefish may also be affected by changes in the abundance of benthic invertebrates, which are their primary food source.

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APPENDIX 5B
FISH COMMUNITY AND MOVEMENTS METHODS

5B.1 FIELD DATA COLLECTION AND ANALYSIS

A summary of fish community and movement studies conducted between 1997 and 2006 is presented in Table 5B-1. The field program was grouped into eight primary components (although activities among the components often overlapped), as follows:

- Habitat-based community assessment;
- Spring spawning habitat;
- Fall spawning habitat;
- Overwintering habitat;
- Tributary use;
- Drifting biomass;
- Stream crossing assessment; and
- Fish movements.

5B.1.1 HABITAT-BASED FISH COMMUNITY ASSESSMENT

This study was conducted to provide a replicable, habitat-based description of the fish community of study area waterbodies. Habitat types fished are described fully in Section 3.0. In summary, fish habitat was classified based on water depth, water velocity, substrate compaction, substrate composition, and presence of aquatic macrophytes (Section 3.0). These habitat classifications were further grouped into biologically meaningful habitat types in order to describe rearing and foraging habitat in the study area (Table 5B-2). These general habitat classifications were also applied in the post-Project to the Keeyask reservoir (Table 5B-3). The gear types used as part of the habitat-based assessment included standard gang index gill nets, boat electrofishing, small mesh index gill nets, and seine nets. In all waterbodies, sites were chosen to sample available habitat types, with emphasis on the most common habitat types. If a site spanned a composite of habitat types, the overall designation for that site was the dominate habitat type.

Standard gang index gill nets, which are the standard sampling gear used by Manitoba Fisheries Branch, were used to inventory lentic fish communities (Assean Lake, Split Lake, Clark Lake, portions of the Nelson River between Clark and Gull lakes, Gull Lake, and Stephens Lake). Index gill nets were set in each waterbody over two or three summers between 1999 and 2004 (Photo 5B-1). These results were combined with the results of similar studies conducted in Split and Clark lakes in 1997 and 1998 (Fazakas and Lawrence 1998; Fazakas 1999), the York Landing arm of Split Lake in 1999 (Mota and MacDonell 2000), and in Stephens Lake in 1999 (Bretecher and MacDonell 2000). Index gangs consisted of six panels (22.9 × 1.8 m) with stretched mesh sizes ranging from 1.5" (38 mm) to 5.0" (127 mm).

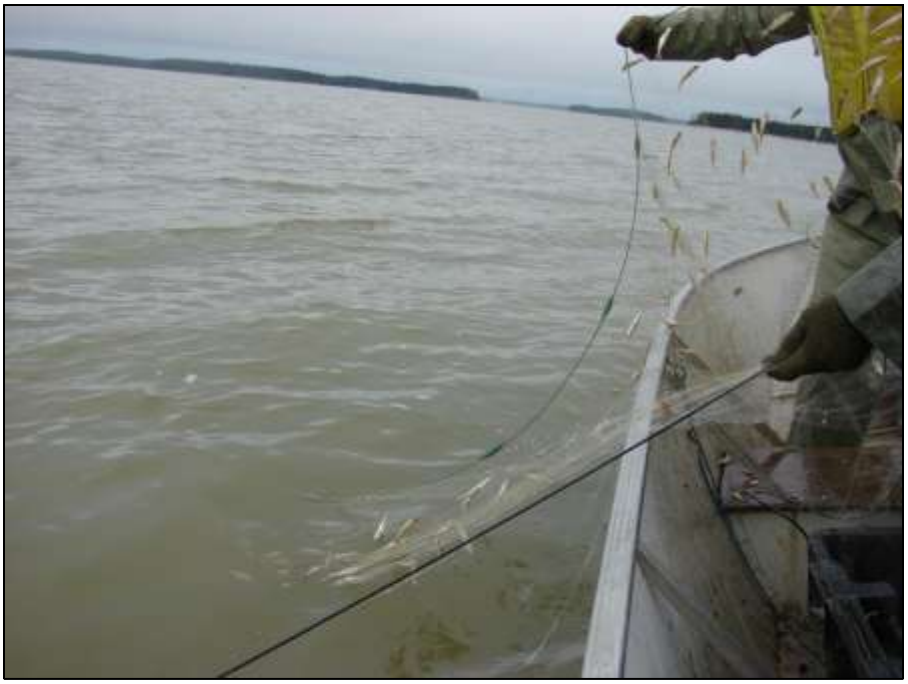
Source: North/South Consultants Inc.

Photo 5B-1: Aquatic environmental studies crew checking a standard gang index gill net in the study area

During late summer in 2003 and 2004, the fish community in the Keeyask area was also sampled with boat-based electrofishing, particularly in areas with medium to high velocities that could not be fished effectively using gill nets. These surveys were conducted using a Smith-Root (Type VIA) electrofishing system powered by a 5,000 W portable generator and mounted to a 5.5 m long aluminum boat with a 175 horsepower inboard Sport Jet-Drive motor. The electrofishing unit was run between 707–884 V, 3–6 A, 60 pulses per second, and a pulse width of 3–6 milliseconds. Because of gear-specific difference in the relative abundance of fish species sampled by electrofishing compared to gill nets, the habitat-specific electrofishing data has not been included in the discussion of fish use of habitat in the Keeyask area.

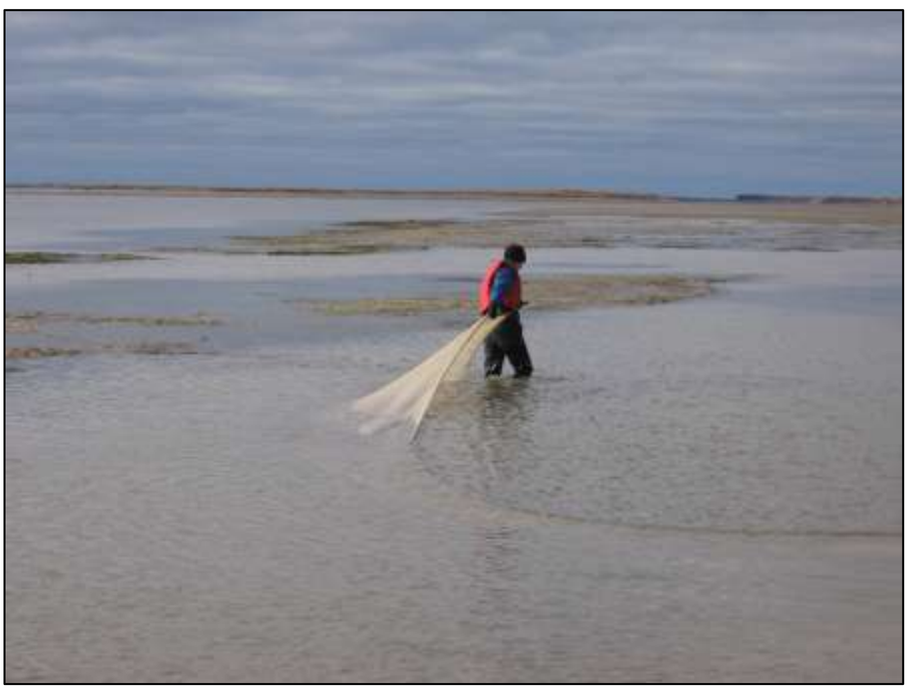
Small mesh index gill nets were used to sample the forage fish community (forage fish included all fish species that remain small-bodied in adult stage, such as rainbow smelt) of the same waterbodies surveyed with standard gangs (Photo 5B-2). These gill nets consisted of three panels (10.0 × 1.8 m) with stretched mesh sizes ranging from 16 to 25 mm.

Seine nets were also used to sample forage fish during the summer in Gull Lake, in the Nelson River below Birthday Rapids, and in Gull Rapids in 2002 and 2003, and in Clark Lake in 2004 (Photo 5B-3). Seine nets consisted of a 15 m long by 1.5 m deep panel of 4 mm mesh.



Source: North/South Consultants Inc.

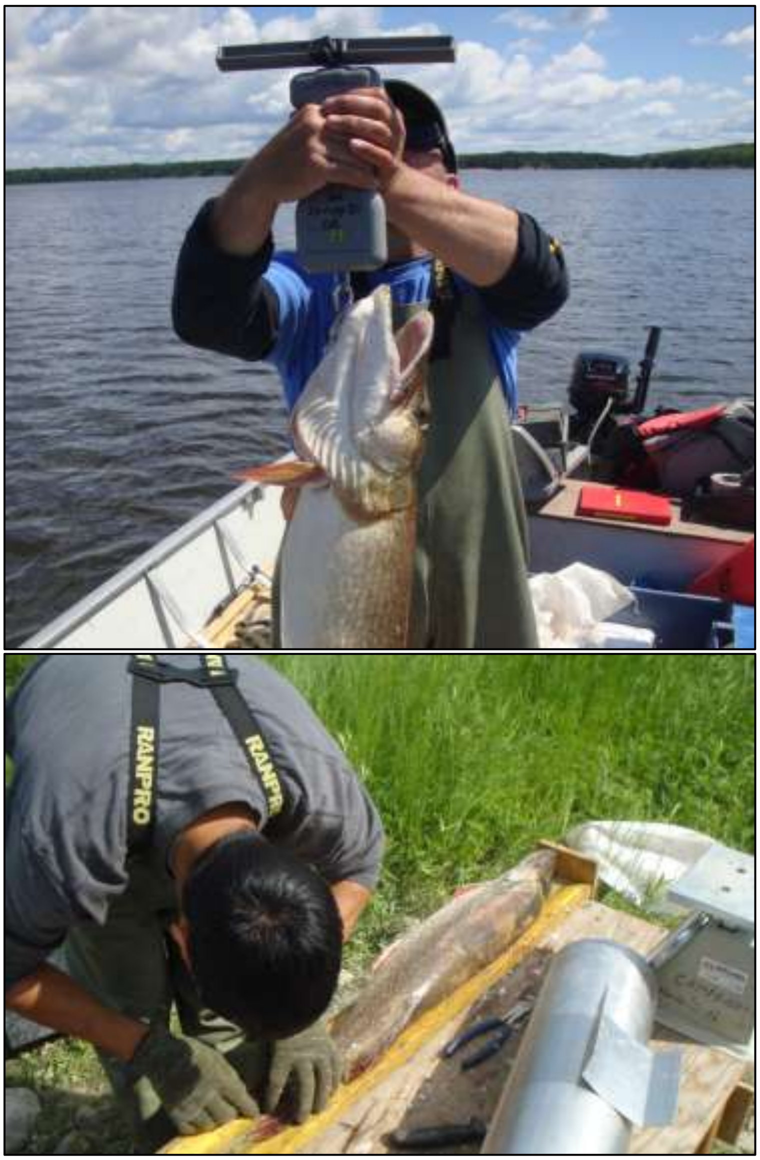
Photo 5B-2: Forage fish caught in a small mesh index gill net in the study area



Source: North/South Consultants Inc.

Photo 5B-3: Pulling a seine net to sample the fish community in the littoral zone

In addition to providing an assessment of fish species composition, relative abundance (%), and CPUE data, information on fish size, condition, and sex and state of maturity were also obtained from fish captured (Photo 5B-4). Catch-per-unit-effort was expressed in different units for each gear type: for standard gangs, number of fish captured in a 100 m net set for 24 hours (h); for small mesh gangs, number of fish captured in 30 m net set for 24 h; and for seine nets, number of fish captured in a 10 m haul. Dietary and age data were obtained from VEC fish species captured as part of the index gillnetting programs. Fish captured in standard gang index gill nets were examined for DELTs. Fish captured were classified as YOY based on the following length limits: 120 mm for walleye; 150 mm for northern pike; and 100 mm for lake whitefish.



Source: North/South Consultants Inc.

Photo 5B-4: Aquatic environmental studies team members processing fish captured as part of fish community studies

A specific survey was conducted in Stephens Lake to provide information to develop models to infer fish species distribution in the proposed Keeyask reservoir. Fish were sampled in Stephens Lake using two types of gill nets (small mesh index gill nets, as described above, and nets consisting of two panels [22.9 × 1.8 m] of 38 and 51 mm mesh). Both types of gill nets were set at sites representing specific habitats in both the main basin of the lake and in Ross Wright and O'Neil bays in the summer of 2005. Size and diet information were recorded for large-bodied species.

5B.1.2 SPRING SPAWNING HABITAT

This study was conducted to provide information on spawning locations for walleye, northern pike, and white sucker. A variety of gear types were employed from mid-May to early July from 2001 to 2006 throughout the study area to capture adults of the target species, including short duration (2–4 h) sets of tagging gill nets (51–127 mm mesh), boat electrofishing (Smith-Root Type VIA electrofishing system and 5.5 m aluminum boat), angling (barbless hooks and heavy test line), snaring (common snare wire attached to long pole), hoop nets (1.2 m diameter opening and 25 mm mesh; Photo 5B-5), and dip nets (0.6 m opening with fine mesh net). Fish captured were assessed for sexual maturity to help assess the location of spawning habitat.

Source: North/South Consultants Inc.

Photo 5B-5: Hoop net set in the study area

Larval drift traps (Burton and Flannagan 1976) were also employed during this time period to identify potential spawning habitat in tributaries (Photo 5B-6; small trap [15 × 15 cm opening with 500 micrometre (µm) collecting net]; Assean River, North Moswakot River, South Moswakot River, Portage Creek, Nap Creek, Fork Creek, Two Goose Creek, Gull Rapids Creek, Pond 13) and the mainstem (large trap [43 × 85 cm opening with 950 µm collecting net]; below First Rapids, Birthday Rapids, and Gull Rapids, and in Gull Lake). Kick nets (0.5 m diameter D-ring frame and 500 µm collecting net) were used to sample fish eggs in Gull Rapids Creek and Pond 13 during May 2005 and 2006.

Potential spawning sites were also assessed through tracking of radio-tagged and acoustic-tagged fish as described in the Fish Movements section below.

Source: North/South Consultants Inc.

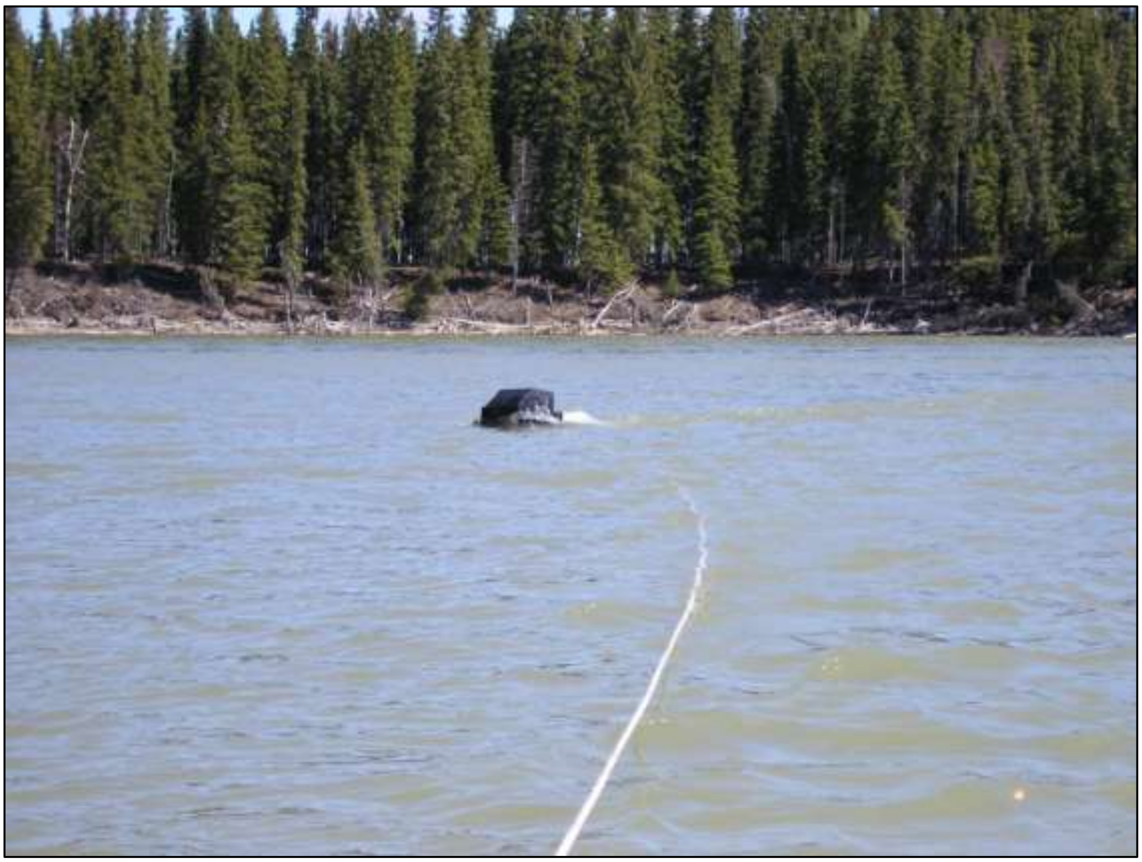
Photo 5B-6: Setting a drift trap to capture drifting larval fish and eggs

5B.1.3 FALL SPAWNING HABITAT

This study was conducted to provide information on spawning locations for lake whitefish. Adult lake whitefish were captured throughout the study area from late September to mid-October from 2001–2004 using short duration (2–4 h) sets of tagging gill nets (51–127 mm mesh) and hoop nets (as described above). Any lake whitefish captured were assessed for sexual maturity to help assess the location of spawning habitat.

At the onset of the open water season (usually mid-May to early June, 2001–2006), sampling was conducted to capture larval lake whitefish as they emerged from the substrate. A modified neuston sampler (Mason and Philips 1986; Mota *et al.* 2000; 45 × 45 cm opening with 500 µm collecting net) was used from 2001–2004 in lentic habitats (Clark Lake, Stephens Lake, Gull Lake; Photo 5B-7), while drift traps (as described for the spring spawning study) were used to sample lotic habitats.

Potential spawning habitats were also assessed through tracking of radio- and acoustic-tagged lake whitefish as described in the Fish Movements section below.



Source: North/South Consultants Inc.

Photo 5B-7: Performing a neuston tow to capture drifting larval fish

5B.1.4 OVERWINTERING HABITAT

This study was conducted to provide information on potential overwintering habitat in areas where it was felt that the Project could potentially adversely affect some characteristic of overwintering habitat (*e.g.*, water velocity, dissolved oxygen). Fish implanted with radio-tags were tracked periodically during the winter months from 2001 to 2004 to identify overwintering habitat for VEC species as described in the Fish Movements section below.

5B.1.5 TRIBUTARY USE

This study was conducted to assess fish use of several study area tributaries. The fish communities of these tributaries, including streams and rivers flowing into Split Lake (Aiken, Mistuska, Ripple Rivers), Clark Lake (Assean, Hunting, and Crying Rivers), Gull Lake and the upstream section of the Nelson River (Portage, Two Goose, Nap, Fork, Sam Bay, Gull Rapids, and Pond 13 Creeks), and Stephens Lake (North and South Moswakot Rivers), were sampled during spring and fall as part of the spawning studies using a variety of gear types (*e.g.*, hoop nets, gill nets, and drift traps). In addition to the data collected during these programs, additional surveys were conducted in the Keeyask area.

Backpack electrofishing was used to assess the fish community in eight of the tributary creeks (Nap, Two Goose, Portage, Trickle, Rabbit, Ox Bay, Effie, and Gull Rapids Creeks) of the Nelson River between Birthday Rapids and Stephens Lake due to their small size (Photo 5B-8). Fish species composition and abundance was assessed within 50 to 100 m sections of each stream during the spring and/or fall of 2002 and 2003 using a backpack electrofisher. Catch-per-unit-effort was expressed as the number of fish caught per 100 seconds of fishing effort.

Source: North/South Consultants Inc.

Photo 5B-8: Aquatic environmental studies team member conducting a backpack electrofishing survey in the study area

The fish communities of two small headwater lakes in the Keeyask area, Carscadden Lake and Little Gull Lake, were assessed during August 2002 using seine nets (as described earlier) and index gill nets (standard gangs and small mesh, as described earlier).

Comparisons of CPUE among tributaries and lakes could not be made because of the variety of gear types used and associated differences in CPUE calculations. Instead, comparisons were made using the relative abundance of fish species in the catches.

5B.1.6 DRIFTING BIOMASS

Drift traps were set during the open water season to describe, both spatially and temporally, the abundance and distribution of fish biomass drifting in the study area, and to provide the basis for assessing potential changes in production from specific areas (*i.e.*, Birthday Rapids, Gull Rapids) associated with the Project. Large drift traps (as described earlier) were set once overnight at sites located above and below Birthday Rapids, above and below Gull Rapids, and below the Kettle GS at monthly intervals over the open water season (June-October) in 2003 and 2004. Drifting fish biomass in 2003 was expressed quantitatively as drift density (number of fish/cubic metre).

5B.1.7 ACCESS ROADS STREAM CROSSINGS ASSESSMENT

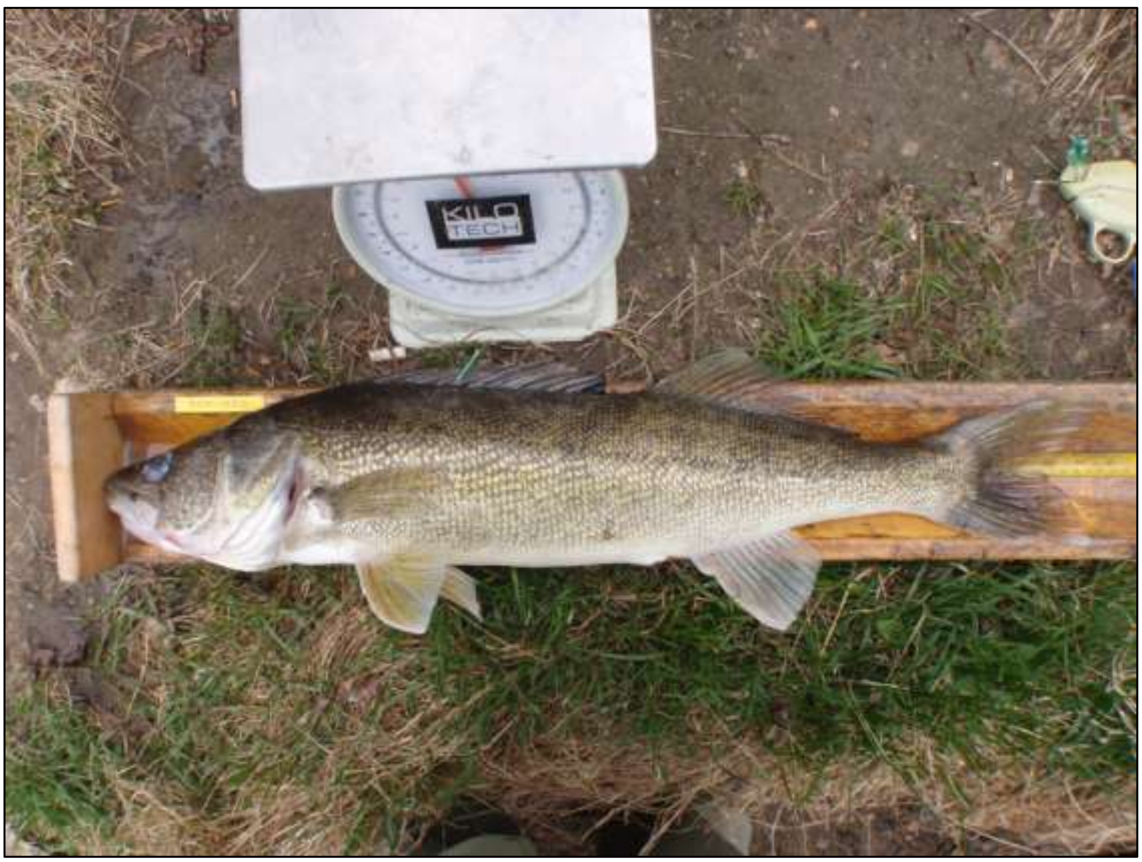
This study was conducted to assess fish use of streams crossed by the North and South Access Roads. Data on fish species composition and abundance during the open-water season were obtained from 20 to 100 m long sections of five stream crossings in fall 2004 and/or spring 2005 and from Gull Rapids Creek Lake during July 2005. Due to the small size of the streams, it was not possible to assess fish populations in winter with gill nets. A variety of gear types were used to sample fish including: electrofisher (boat or backpack unit, as described earlier); gill nets (standard gang index gill nets, as described earlier, and one panel [22.9 × 1.8 m] of 38 or 95 mm mesh); seines (as described earlier); hoop nets (large net as described earlier and smaller, 0.6 m diameter opening and 25 mm mesh); and kick nets (as described earlier).

To provide information on the potential of these waterbodies to overwinter fish, the three crossings that were accessible in March 2005 and the two north access road crossings in February 2009 were sampled for flowing water. In March 2005, DO was measured at the unnamed tributary of the South Moswakot River approximately 1 km upstream of the crossing location at the outlet of a small headwater pond due to poor access at the crossing location.

5B.1.9 FISH MOVEMENTS

This study was conducted to: a) gain a general understanding of VEC species' movements within the study area; b) assess whether fish move upstream and/or downstream through Long Rapids, Birthday Rapids, and Gull Rapids; and c) document concentrated movements of fish that can be used to identify important habitat, such as spawning locations. Information on fish movements was obtained from recaptures of large numbers of Floy®-tagged fish and through repeated tracking of a relatively small number of radio-tagged and acoustic-tagged fish.

Fish were marked with individually numbered plastic Floy® FD-94 T-bar anchor tags throughout the study area between 1999 and 2005 (Photo 5B-9). These tags were applied between the basal pterygiophores of the dorsal fin using a Dennison Mark II tagging gun. A total of 15,180 fish were tagged, including 5,472 walleye, 7,995 northern pike, and 1,713 lake whitefish. The majority of individuals (8,158 fish) were tagged in Reach 1 (the Split Lake Reach). Fish selected to receive tags were captured using a variety of gear types (*e.g.*, gill nets, hoop nets, electrofishing, angling, snaring) at numerous locations throughout the study area. The recapture of marked fish was recorded during all North/South Consultants fisheries programs conducted in the study area, including those focused on lake sturgeon (as described in Section 6.0), as well as any recaptured further downstream (*e.g.*, Conawapa GS Environmental Studies Program, Lower Nelson River Aquatic Studies). The return of Floy®-tags (or tag numbers), and the associated catch information (*i.e.*, where and when fish were captured), from local fishers was promoted using posters offering rewards in Split Lake, Gillam, and Thompson.



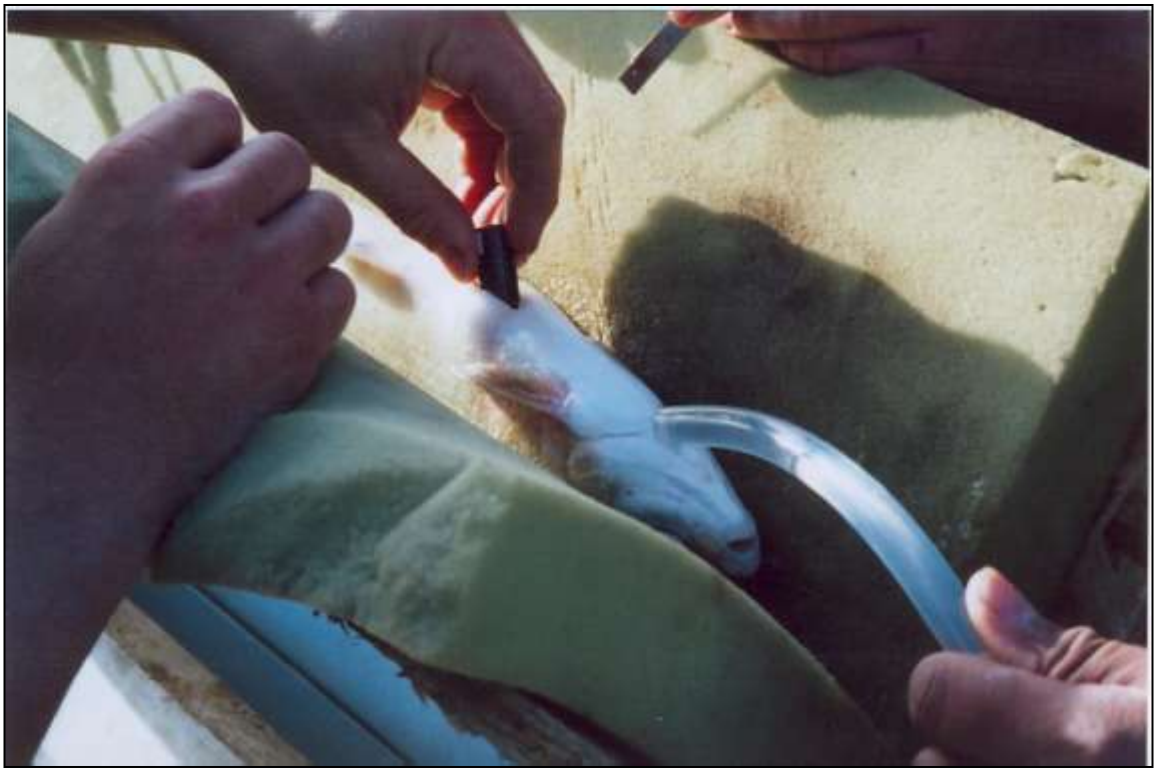
Source: North/South Consultants Inc.

Photo 5B-9: A walleye marked with a Floy®-tag as part of fish movement studies

Thirty walleye, 14 northern pike, and 10 lake whitefish captured in Gull Lake (44 fish) or Stephens Lake (10 fish) were tagged with radio-transmitters (model MCFT-3A, Lotek Engineering Inc., Newmarket, Ontario) in the spring or fall of 2001 (Photo 5B-10). Radio-tagged fish were relocated from the air periodically between June 2001 to February 2004 using a helicopter equipped with a Lotek model SRX-400 receiver and a single 'yagi' antenna. An additional 20 lake whitefish were implanted in 2001 with acoustic-transmitters (model V16-4H-01-SHK1-R256, Vemco Ltd., Shad Bay, NS) in Gull Lake (10 fish) or Stephens Lake (10 fish; Photo 5B-11). These fish were tracked from June to October of 2001–2004 using 10 Vemco VR1 and VR2 submersible stationary receivers (positioned near the upstream and downstream sides of both Birthday Rapids and Gull Rapids) and by manual tracking by boat using a Vemco VR-60 ultrasonic receiver.

Source: North/South Consultants Inc.

Photo 5B-10: Aquatic environmental studies team member surgically inserting a radio tag into a walleye (note gill irrigation removed temporarily while photo was taken)



Source: North/South Consultants Inc.

Photo 5B-11: Aquatic environmental studies team member surgically inserting an acoustic tag into a lake whitefish

5B.2 IMPACT ASSESSMENT ANALYSIS

A habitat evaluation model was developed to estimate potential fish use of habitats at various time steps after impoundment for comparison with habitat use in the existing Upstream Keeyask Area. The before-and-after comparison was based on the change in area and proportion of aquatic habitat types and associated CPUE of each of the VEC species and VEC fish communities. The main steps in model development and application, in sequence, were:

1. Estimate fish use of different habitat types in the existing environment;
2. Calculate the area of each habitat type in the Upstream Keeyask Area existing environment (Appendix 3D);
3. Estimate area of the habitat types in Year 30 post-Project (Appendix 3D);
4. Modify the Year Thirty habitat areas for intermediate time steps (Years 1, 5, and 15) (Appendix 3D);
5. Estimate useable habitat areas in the Intermittently Exposed Zone (Appendix 3D);
6. Modify fish use metrics at the intermediate time steps; and

7. Model potential fish use of habitats and change habitat value and area in the Upstream Keeyask Area at each time step.

1. Estimate Fish Use of Different Habitat Types in the Existing Environment

Study area locations sampled with gill nets during summer 1997 and 1998 (Fazakas and Lawrence 1998; Fazakas 1999), 2001–2003, and 2004 (Clark Lake only) were classified according to water depth and velocity, substrate compaction and composition, and the presence or absence of rooted aquatic vegetation.

Based on the study area catch records, a habitat-specific CPUE was calculated for each VEC fish species as well as for the large-bodied and forage fish species assemblages by averaging the site-specific values of standard gang and small mesh index gill nets (Table 5B-4). Assean Lake catch data were not included in the calculation of habitat-specific CPUEs as this lake was found to have a substantially different fish community composition than other study area waterbodies.

Of the 21 habitat types present in the Upstream Keeyask Area existing environment or predicted to be present in the post-impoundment environment, nine had not been sampled during the study area sampling conducted between 1997 and 2004 due to their absence or scarcity in the study area waterbodies. In these cases, a CPUE value was estimated using surrogate values from similar habitat types that were sampled and professional judgment. For example, CPUE values for habitats with organic substrates, which were not sampled previously in the study area, were generated by discounting the corresponding soft mineral substrate habitat CPUE by 50% based on low CPUE values observed in water bodies characterized by an abundance of organic matter, such as Notigi Lake (Table 5-2).

No high velocity habitats (velocity more than 1.5 metres per second) were sampled in study area sampling between 1997 and 2004 owing to methodological challenges and safety concerns. Consequently, the CPUE values for the corresponding medium velocity habitat types were used as surrogates for the two high velocity habitats. However, the medium velocity CPUE values were discounted by 75% based on an assumption that fish use of high velocity habitats would be that much lower.

2. Calculate the Area of Each Habitat Type in the Existing Environment

The areas of habitat types present in the existing environment were calculated using geographic information system analysis and are shown in Appendix 3D.

3. Estimate Area of the Habitat Types in Year 30 post-Project

Estimates of specific habitat areas were based on a habitat model described in Section 3. Areas of each of the Year 30 post-Project habitat types are provided in Appendix 3D.

4. Modify the Year 30 Habitat Areas for Intermediate Time Steps (Years 1, 5, and 15)

Change to aquatic habitats in the existing environment and the evolution and expansion of habitats in the reservoir that are predicted to occur due to shoreline erosion, peat disintegration and sediment transport processes along with the loss and subsequent development over time of aquatic plant beds, were described for Year 1, 5, 15, and 30 time steps and tabulated (Appendix 3D). These area estimates were used to provide a comparison between habitat conditions in the existing Upstream Keeyask Area environment with habitat changes in the reservoir over time.

5. Estimate Useable Habitat Areas in the Intermittently Exposed Zone

Depending on the mode of operation, (peaking mode or base loaded), shallow water habitats at each Year 1, 5, 15, and 30 time step (Table 3D-1) may be more or less exposed to air on a frequent or infrequent basis. Intermittent exposure to air would have the effect of reducing the area of shore zone habitats that would be useable by fish and also would affect the biological productivity in those exposed areas. Estimates and assumptions regarding the effect of mode of operation on useable shallow water habitat areas are described in Appendix 3D.

6. Modify Fish Use Metrics at Intermediate Time Steps

It is anticipated that fish use of aquatic habitats in the downstream portion of the Keeyask reservoir (Reaches 5–9A in Map 3-26) would be affected by predicted changes in the dissolved oxygen (DO) and TSS concentrations in the early years post-impoundment. No similar effects are expected in the upstream reaches 2A-4 (Map 3-26). Analysis and discussion of DO and TSS predictions post-impoundment is presented in Water and Sediment Quality (Section 2).

Predicted changes to DO and TSS have potential negative consequences on fish use of habitats and habitat productivity. Consequently, modifications to the fish use metric (CPUE) to account for potential negative effects were undertaken. The CPUE modifications were confined to those portions of each habitat type that would be in the lower reaches (5–9A) of the reservoir.

Dissolved Oxygen

The DO regime was modelled as critical week bottom summer values in Year 1 and Year 5 (described in Section 2). Based on modelling results, some aquatic habitats, primarily those located in newly flooded terrestrial areas, would, under conditions specified in the model, be of reduced foraging value to fish 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 dissolved oxygen concentrations (bottom DO less than 2 mg/L) were associated with off-current habitats characterized by standing water with soft organic substrates. The total area of habitats with DO less than 2 mg/L was proportionally allocated to those habitat types. Areas predicted to be less severely affected by reduced dissolved oxygen concentrations (bottom DO greater than or equal to 2 mg/L but less than or equal to 6.5 mg/L) also included shallow water low velocity habitats as well as areas of deep, standing water habitat.

Habitat-specific fish use metrics (CPUE) used in Step 7 to follow, were modified to account for DO effects on fish behaviour (*i.e.*, avoidance of low DO areas), mortality (of eggs), and growth:

- Where DO was greater than or equal to 2 mg/L at the bottom, habitat was considered not useable by fish and the habitat-specific CPUE was set to zero for the 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 CPUE was reduced by 50% for the DO stressed portion of the habitat; and

- Where DO was more than 6.5 mg/L at the bottom, it was assumed that there would be no DO related negative effects on fish use of habitats.

Total Suspended Solids

Total suspended solids are predicted to increase in the first year following impoundment of the Keeyask reservoir (Section 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 (Map 2-22);
- 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 increase 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).

Increases in TSS of the aforementioned magnitude and duration are expected to have a short-term effect on the fish community as follows:

- By preventing or reducing the successful development of eggs and larvae of certain fish species (*e.g.*, northern pike) that might spawn in shallow lentic environments;
- By altering fish use of habitats and their movements within the reservoir; and
- By reducing the availability and catchability of food.

EIFAC (1964) guidelines for the protection of inland fisheries suggest that waters with chronic TSS concentrations in the 25–80 parts per million (mg/L) range should support good to moderate fisheries with yields "somewhat diminished" relative to waters with less than 25 parts per million TSS.

DFO (in Government of Canada 1993) indicates that sediment increases resulting from placer mining operations in the 25–100 mg/L range would pose a "Low Risk" to fish and their habitat.

In New Zealand, Hayes *et al.* (1992) concluded that TSS concentrations in the range of 20–40 mg/L had little effect on the fish community of a shallow water lake when compared to a similar lake with TSS levels of 5 mg/L. Numerous indices (CPUE, condition, size) were higher in the turbid lake and also were higher in the turbid portions of the clear lake.

Considering the range of concentrations predicted to occur over an approximate one year period in the Keeyask reservoir, and the guidance provided by the EIFAC and DFO that relate to the risks to fish and fish habitat, it is suggested that TSS effects in the Upstream Keeyask Area could result in a 10%

reduction in fish habitat productivity that would persist for one year. It is suggested that this reduction be 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 fish as a result of depressed DO 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 fish and fish use of habitats in the newly impounded reservoir. It was assumed that the forage value and fish use of 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 levels.

The fish use metric (CPUE) of habitats used in Step 7 (to follow) was decreased by 10% at all Shallow-Standing water and Low velocity habitats, plus all Deep-Standing water habitats. TSS effects are not predicted beyond Year 1 (Section 2).

7. Model Change in Fish Use of Habitats and Habitat Value and Area in the Upstream Keeyask Area at Each Time Step

Two approaches, both based on an assumption that CPUE data reflect fish use of habitats in which they were caught, were used to evaluate the potential effects of reservoir creation and operation on the Upstream Keeyask Area fish community. The first approach predicts change to fish density (CPUE) associated with predicted habitat changes resulting from flooding and ongoing operation of the generating station. The second approach evaluates changes in area and suitability of habitats available to and used by VEC species. Both approaches use CPUE data described in Step 1.

Change in Fish Use of Habitats

Using CPUE data for each habitat type (Table 5B-4 from Step 1), a weighted mean CPUE ($CPUE_w$) was calculated for each VEC at each time step for each mode of operation (*i.e.*., 158 m above sea level [ASL] base loaded, 159 m ASL base loaded, and weekly cycling [peaking] between at 158 m and 159 m ASL).

$$CPUE_w = (\Sigma\ [Area_{hab} \times CPUE_{hab}]) \div (\Sigma\ Area_{hab})$$

where: $CPUE_w$ = weighted mean CPUE for Upstream Keeyask Area;

$Area_{hab}$ = useable area (ha) of each habitat type (as per Step 5); and

$CPUE_{hab}$ = mean CPUE for each habitat type (modified as required per Step 6).

The calculated $CPUE_w$ values for each Year 1, 5, 15, and 30 time steps are presented in Table 5B-5.

Change in Habitat Value and Area

A habitat ranking procedure, described in the following paragraphs, was used to predict potential changes in fish use of (value) and quantity of (area) fish habitat in the Upstream Keeyask Area as a result of creation and operation of the Project. The ranking of habitat value involved the calculation of a Relative Abundance Index (RAI) for each habitat type using fish CPUE data from habitat-based summer gillnetting at waterbodies in the study area. The validity of the model is based on an assumption that fish density associated with a habitat type would increase with increasing habitat suitability. CPUE data have been used elsewhere to model habitat suitability (Gallaway *et al.* 1999; Morris and Ball 2006) or to validate habitat evaluations that have employed Habitat Suitability Indices (HSI), assuming one should expect a close correspondence between CPUE data and HSI values (Brown *et al.* 2000).

The CPUE-based approach involved assigning each habitat type (T) in the pre- and post-Project environments (Section 3) an RAI_T value. Then, by multiplying the area of the habitat (H_T) by its RAI_T, a Weighted Suitable Habitat Area for each habitat type ($WSHA_T$) for each VEC.

For each VEC, the RAI_T was calculated by dividing the CPUE associated with a specific habitat type ($CPUE_T$) by the maximum habitat-specific CPUE ($CPUE_{MAX}$) observed in study area waterbodies for that VEC.

1. $RAI_T = CPUE_T/CPUE_{MAX}$

The ratio of $CPUE_T$ to $CPUE_{MAX}$ provides a value between 0 and 1 that was then used to calculate the Weighted Suitable Habitat Area ($WSHA_T$) of a habitat type (H_T) by multiplying its area by its RAI_T.

2. $WSHA_T = H_T \text{ (ha)} \times RAI_T$

The individual $WSHA_T$ of all habitat types in the existing Upstream Keeyask Area were then summed to provide a total WSHA value for each VEC.

3. Total existing environment WSHA = Σ all existing environment $WSHA_T$

The same procedure was followed for each habitat type predicted to be present in the Year 1, 5, 15, and 30 post-Project environments. The ratio of predicted (post-Project) WSHA to existing (pre-Project) WSHA was calculated for each VEC at each post-Project time step to estimate Project effects on the potential fish use of combined fish habitats in the Upstream Keeyask Area.

4. Post-Project WSHA/Existing WSHA = gain/loss in potential fish use of habitats (*i.e.*, productive capacity).

Results of the predicted changes in habitat value and area are presented in Table 5B-6.

Detailed Steps

Detailed steps that were taken to calculate a Weighted Suitable Habitat Area (WSHA) for each VEC (walleye, northern pike, lake whitefish, white sucker, rainbow smelt, large-bodied fish combined, and forage fish combined) follow.

Upstream Keeyask Area Existing Environment

1. Calculated the areas (ha) of each habitat type: H_1, H_2, H_3, ….. H_{20}) in the Upstream Keeyask Area existing environment (Appendix 3D).
2. Derived the CPUE statistic of the VEC for each habitat type in the pre-Project Upstream Keeyask Area (compiled from summer gillnetting data from study area waterbodies).
3. Calculated the VEC-specific Relative Abundance Index (RAI) of each of the habitat types in the existing environment. This involved:
    a. Using the CPUE for each habitat type, calculating a VEC-specific RAI for each habitat (H) by dividing the CPUE for a specific habitat type by the maximum CPUE observed or estimated in that habitat. Thus, $RAI_{H1} = CPUE_{H1}/CPUE_{MAX}$.
    b. Repeating this calculation for each habitat type to obtain RAI_{H1}, RAI_{H2}, RAI_{H3}, …. RAI_{H20}).
4. Calculated the VEC-specific Weighted Suitable Habitat Area (WSHA) for each habitat type by multiplying each habitat area (H) by its RAI value:

    $WSHA_1 = H_1 \text{ (ha)} \times RAI_{H1}$

    $WSHA_2 = H_2 \text{ (ha)} \times RAI_{H2}$

    ….

    ….

    $WSHA_{20} = H_{20} \text{ (ha)} \times RAI_{H20}$.
5. Calculated the VEC-specific Weighted Suitable Habitat Area in the Upstream Keeyask Area by summing habitat-specific WSHAs for all habitat types in the existing environment (*i.e.*, Total $WSHA = WSHA_1 + WSHA_2 + WSHA_3 + \ldots WSHA_{20}$.
6. Steps 1 through 5 were repeated for each VEC.

Upstream Keeyask Area Post-Project Environment

The same procedure was applied to each VEC species for each proposed operating scenario in the post-Project environment for each of the Year 1, 5, 15, and 30 time steps:

- Peaking between 158 and 159 m ASL;
- Base loaded at 158 m ASL; and
- Base loaded at 159 m ASL.

When calculating the RAI (Step 3 above) in the post-Project environment, the CPUE associated with certain habitats were modified prior to performing the calculation:

- To account for depressed DO conditions in Years 1 and 5, portions of certain habitats in the reservoir were assigned a CPUE of 0, were discounted 50%, or were not modified (described in Step 6 – Modification of Fish Use Metrics for Intermediate Time Steps).
- To account for elevated TSS condition in Year 1, the CPUE of certain habitats in the reservoir was reduced by 10% (described in Step 6 – Modification of Fish Use Metrics for Intermediate Time Steps).

The proportional change in the Weighted Suitable Habitat Area for each VEC species was determined by dividing the post-Project WSHA by the WSHA in the existing environment of the Upstream Keeyask Area.

5B.3 REFERENCES

5B.3.1 LITERATURE CITED

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Table 5B-1: Summary of approach and methods used for fish community and movement studies in the Keeyask area, 1997–2008[1]

Study	Objective	Method	Equipment	Location[2]	Time of Sampling	Number of Sites[3]
Habitat-based fish community assessment	To provide replicable habitat-based description of the fish community of study area water bodies.	a) standard gang index gill nets	6 panels (22.9 × 1.8 m) of 38, 51, 76, 95, 108, and 127 mm stretched twisted nylon/monofilament mesh	SPL	Aug 1997-98, 2001-02, 2004	106
				NR	Oct 1999; Aug 2001-02	32
				GR	Aug 2002-03	9
				STL	Aug 1999, 2002-03	85
		b) small mesh index gill nets	3 panels (10 × 1.8 m) of 16, 20, and 25 mm stretched twisted nylon mesh	SPL	Aug 2001-02, 2004	52
				NR	Aug 2001-02	48
				GR	Aug 2002-03	8
				STL	Aug 2002-03	39
		c) boat electrofishing	5.5 m aluminum boat with inboard motor and Smith-Root Type VIA electrofishing system	NR	Aug-Sep 2003-04	93
		d) seine nets	1 panel (15 × 1.5 m) of 4 mm mesh	SPL	Aug 2004	7
				NR	Sep 2001; Aug 2002-03	52
				GR	Aug 2003	2
		e) aquatic habitat modelling	i) small mesh index gill nets as described above; and ii) 2 panels (22.9 × 1.8 m) of 38 and 51 mm stretched twisted nylon mesh	STL	Jul-Aug 2005	92
Spring spawning habitat	To identify habitat used for spawning by northern pike, walleye, and white sucker.	a) drift traps	i) 43 × 85 cm opening with 950 µm Nitex collecting net (large);or ii) 15 × 15 cm opening with 500 µm Nitex collecting net (small)	SPL	May-Jul 2001-02	i) 6 ii) 2
				NR	May-Jul 2001-04	i) 39 ii) 10
				GR	Jun-Jul 2001-04; May 2006	i) 3 ii) 4
				STL	May-Jun 2003	i) 0 ii) 7
		b) gill nets	i) 1-4 panels (22.9 × 1.8 m) of 51, 76, 95, 108, 127 and/or 140 mm stretched twisted nylon mesh; or ii) 1 panel (10 × 1.8 m) of 25 mm stretched twisted nylon mesh	SPL	May-Jun 2002-04	i) 101 ii) 0
				NR	May-Jun 2001-04	i) 118 ii) 0
				GR	May-Jul 2001-04; May 2005-06	i) 43 ii) 0
				STL	May-Jul 2001; Jun 2003-04	i) 33 ii) 2
		c) hoop nets	1.2 m diameter opening and 25 mm mesh	SPL	May-Jul 2001-04	12
				NR	May-Ju1 2001-02	4
				GR	May 2006	1
				STL	May-Jun 2003	4
		d) kick nets	0.5 m diameter D-ring frame and 500 µm Nitex collecting net	GR	May 2005-06	9
		e) dip nets	0.6 m opening and fine mesh net	STL	May 2006	6
		f) boat electrofishing	as described above	NR	May 2001; Jun 2002	29
		g) snaring	single loop of pliable brass wire attached to a long pole	SPL	Jun 2002; May 2003	5
		h) angling	barbless hook and heavy test line	SPL	May-Jun 2002-03	16
				NR	May-Jun 2001	6
				GR	Jun 2003	1
		i) radio telemetry	individually coded Lotek radio transmitters (model MCFT-3A) and helicopter tracking with SRX-400 receiver	NR, GR, STL	May-Jun 2002-03	44

Table 5B-1: Summary of approach and methods used for fish community and movement studies in the Keeyask area, 1997–2008[1]

Study	Objective	Method	Equipment	Location[2]	Time of Sampling	Number of Sites[3]
Fall spawning habitat	To identify habitat used for spawning by lake whitefish.	a) neuston sampler	45 × 45 cm opening with 500 µm Nitex collecting net	SPL	Jun 2004	6
				NR	May/Jun 2001-04	54
				STL	Jun 2001-04	62
		b) drift traps	i) 43 × 85 cm opening with 950 µm Nitex collecting net (large); or ii) 15 × 15 cm opening with 500 µm Nitex collecting net (small)	SPL	May-Jul 2001-02	i) 6 ii) 2
				NR	May-Jul 2001-04	i) 39 ii) 10
				GR	Jun-Jul 2001-04; May 2006	i) 33 ii) 4
				STL	May-Jun 2003	i) 0 ii) 7
		c) gill nets	2-4 (22.9 × 1.8 m) panels of 76, 95, 108, and/or 127 mm stretched twisted nylon mesh	SPL	Sep-Oct 2002, 2004	74
				NR	Sep-Oct 2001-04	258
				GR	Sep-Oct 2001-03	31
				STL	Sep-Oct 2002-03	129
		d) hoop nets	as described above	SPL	Sep-Oct 2001-02, 2004	7
				STL	Sep-Oct 2002-03	6
		e) radio telemetry	as described above	NR, GR, STL	Sep-Oct 2001-02	10
		f) acoustic telemetry	as described above	NR, GR, STL	Sep-Oct 2001-03	20
Overwintering habitat	To identify habitat used for overwintering by northern pike, walleye, and lake whitefish.	a) radio telemetry	as described above	NR, GR, STL	Jan-Mar 2002; Nov-Apr 2002-03	54
Tributary use	To assess the fish community of tributary water bodies (rivers, streams, lakes).	a) drift traps	15 × 15 cm opening with 500 µm Nitex collecting net (small)	SPL	May-Jun 2001-02	2
				NR	May-Jul 2001-03	10
				GR	May 2006	4
				STL	May-Jun 2003	7
		b) gill nets	1-4 panels (22.9 × 1.8 m) of 51, 76, 95, 108, and/or 127 mm stretched twisted nylon mesh	SPL	May, Sep-Oct 2002; May-Jun 2003; Jun, Sep-Oct 2004	66
				GR	Jun 2004; May 2005-06; Aug-Sep 2006	9
				STL	Sep-Oct 2002-03; May-Jun 2003; Jun 2004	116
		c) hoop nets	as described above	SPL	May-Jul 2001-04; Sep-Oct 2001-02, 2004	25
				NR	May-Ju1 2001-02	4
				GR	May 2006	1
				STL	Sep-Oct 2002-03; May-Jun 2003; Jun 2004	11
		d) backpack electrofisher	Smith Root backpack unit	NR	Jun-Jul 2002-03; Sep 2002-03	28
				GR	Sep 2003	3
		e) index gill nets (small mesh and standard gang)	as described above	NR	Aug 2002	2
		f) seine nets	as described above	NR	Aug 2002	2
Drifting biomass	To describe the abundance and distribution of drifting fish in specific areas during the open-water season.	a) drift traps	43 × 85 cm opening with 950 µm Nitex collecting net (large)	NR	Jul-Sep 2003, Jul-Sep 2004	6
				GR	Jun-Oct 2003, Jul-Oct 2004	4
				STL	Jul-Sep 2003, Jun-Sep 2004	2
Stream crossing assessment	To assess fish use of streams crossed by the Keeyask Access Road.	a) backpack/boat electrofisher	as described above	SC	Oct 2004; May 2005	8
		b) kick nets	as described above	SC	Oct 2004; May 2005	8
		c) hoop nets	i) as described above; or ii) 0.6 m diameter opening and 25 mm mesh	SC	May 2005	i) 1 ii) 2
		d) gill nets	1 panel (22.9 × 1.8 m) of 38 or 95 mm stretched twisted nylon mesh	SC	Oct 2004	1
		e) seine nets	as described above	SC	Jul 2005	1
		f) standard gang index gill net	as described above	SC	Jul 2005	1

Table 5B-1: Summary of approach and methods used for fish community and movement studies in the Keeyask area, 1997–2008[1]

Study	Objective	Method	Equipment	Location[2]	Time of Sampling	Number of Sites[3]
Fish movement	To assess general movement patterns of northern pike, walleye, and lake whitefish.	a) radio telemetry	as described above	NR, GR, STL	Jun 2001-Feb 2004	54
		b) acoustic telemetry	as described above	NR, GR, STL	Jun-Oct 2001-03	20
		c) mark and recapture	individually numbered Floy®-tag attached between fin membranes of dorsal fin	SPL	2001-04	8158
				NR	1999, 2001-04	2732
				GR	2001-05	2437
				STL	2001-05	1853

1. In addition to the programs described in this table, Floy®-tagged northern pike, walleye, and lake whitefish were captured incidentally in gill nets set to specifically target lake sturgeon from 2001–2008; the methods for these programs is described in Section 6.
2. SPL = Split Lake area; NR = Keeyask area: Nelson River between Clark Lake and Gull Rapids; GR = Keeyask area: Gull Rapids and downstream, riverine portion of Stephens Lake; STL = Stephens Lake area; SC = Keeyask access road stream crossings.
3. For radio/acoustic telemetry and mark/recapture methods, the number represents the number of fish marked rather than the number of sites sampled.

Table 5B-2: Description of general habitat types used to describe foraging and rearing habitat used by fish in the Keeyask area in the existing environment

Waterbody	General Habitat Type	Description[2]
Assean Lake	East basin	• Smaller basin (1,123 ha) with a mix of shallow and deep water with primarily low velocity, soft mineral-based substrates (fine silt, clay), and macrophyte beds abundant in shallow marshy bays and shore.
	West basin	• Larger basin (6,310 ha) with a mix of shallow and deep water with primarily low velocity, soft mineral-based substrates (fine silt, clay), and macrophyte beds abundant in shallow marshy bays.
	Channel	• Narrow channel with a mix of shallow and deep water with low velocity, soft mineral-based substrates, and a scarcity of macrophyte beds.
Split/Clark Lakes	Nearshore lacustrine	• Primarily shallow water with standing to low velocity, a combination of soft and hard mineral-based substrates (primarily fine silt, clay), and macrophyte beds abundant in some areas.
	Offshore lacustrine	• Primarily deep water with low velocity, a combination of soft and hard mineral-based substrates (primarily fine silt, clay), and a scarcity of macrophyte beds.
Nelson River[1]	Nearshore lacustrine	• Areas of Gull Lake with primarily shallow water with low velocity, a combination of soft (silt, clay) and hard (gravel, cobble, boulder) mineral-based substrates, and few macrophyte beds.
	Offshore lacustrine	• Areas of Gull Lake with primarily deep water with low velocity, hard (gravel, cobble, boulder) mineral-based substrates, and a scarcity of macrophyte beds.
	Riverine	• Areas of the Nelson River with a combination of shallow and deep water, primarily with low to medium[3] velocity, hard (cobble, boulder) mineral-based substrates, and a scarcity of macrophyte beds.
	Backbay	• Primarily shallow water with standing to low velocity, soft (silt, clay) mineral-based substrates, and abundant macrophyte beds.
Stephens Lake North	Nearshore lacustrine	• Areas of the north arm of the lake with primarily shallow water with low velocity, a combination of soft and hard mineral-based substrates, and macrophyte beds.
	Offshore lacustrine	• Areas of the north arm of the lake with primarily deep water with low velocity, a combination of soft and hard mineral-based substrates, and a scarcity of macrophyte beds.

Table 5B-2: Description of general habitat types used to describe foraging and rearing habitat used by fish in the Keeyask area in the existing environment

Waterbody	General Habitat Type	Description[2]
Stephens Lake South	Nearshore lacustrine	• Areas of the old Nelson River channel with primarily shallow water, with low to medium velocity, a combination of soft and hard mineral-based substrates, and macrophyte beds.
	Offshore lacustrine	• Areas of the old Nelson River channel with primarily deep water with low to medium velocity, a combination of soft and hard mineral-based substrates, and a scarcity of macrophyte beds.

1. Nelson River between Clark Lake and Gull Rapids, including Gull Lake.
2. Based on habitat classification system described in Section 3.0.
3. Areas with high water velocity (more than 1.5 m/s) were excluded as suitable foraging/rearing habitat because at water velocities more than 1.5 m/s fish of all lengths would employ burst swimming and endurance would be limited to 10 seconds or less.

Table 5B-3: Description of general habitat types used to describe foraging and rearing habitat used by fish in the Keeyask reservoir post-Project

Waterbody	General Habitat Type	Description[1]
Keeyask reservoir	Backbay reservoir	• Locations off of upper reservoir with shallow, standing water, a combination of soft (silt, clay) mineral-based substrates and organic deposition, and an abundance of macrophyte beds.
	Riverine reservoir	• Areas of the upper reservoir with a combination of shallow and deep water, primarily with low to medium[2] velocity, hard (cobble, boulder) mineral-based substrates, and a scarcity of macrophyte beds.
	Nearshore lentic reservoir	• Areas of the reservoir with shallow, standing water, a combination of soft (silt, clay) mineral-based substrates and organic deposition/peat, and an abundance of macrophyte beds.
	Offshore lentic reservoir	• Areas of the reservoir with deep, standing water, primarily soft (silt) mineral-based substrates, and a scarcity of macrophyte beds.
	Nearshore lotic reservoir	• Areas of the reservoir with shallow, low velocity water, soft (silt, clay) mineral-based substrates, and few macrophyte beds.
	Offshore lotic reservoir	• Areas of the reservoir with deep, low velocity water, a combination of soft (silt) and hard (cobble, boulder) mineral-based substrates, and a scarcity of macrophyte beds.

1. Based on habitat classification system described in Section 3.0.
2. Areas with high water velocity (more than 1.5 m/s) were excluded as suitable foraging/rearing habitat because at water velocities more than 1.5 m/s fish of all lengths would employ burst swimming and endurance would be limited to 10 seconds or less.

Table 5B-4: Mean habitat-specific catch-per-unit-effort (CPUE[1]) in the existing environment during summer

Habitat Classification					Habitat-Specific CPUE				
Depth	**Velocity**	**Compaction**	**Composition**	**Vegetation**	**NRPK[2]**	**WALL[2]**	**LKWH[2]**	**Tot-LB[2]**	**Tot-FF[3]**
deep	high	hard	mineral	no plants	0.7	1.7	0.0	4.2	4.6
deep	low	hard	mineral	no plants	6.1	4.2	1.4	21.5	65.0
deep	low	soft	mineral	no plants	3.0	12.8	4.7	34.2	41.7
deep	medium	hard	mineral	no plants	2.8	6.6	0.1	16.9	18.2
deep	medium	soft	mineral	no plants	2.3	5.0	0.0	12.8	16.0
deep	standing	hard	mineral	no plants	9.3	2.0	0.3	13.1	86.6
deep	standing	soft	mineral	no plants	4.6	6.0	0.9	20.7	55.5
deep	standing	soft	organic	no plants	2.3	3.0	0.5	10.4	27.8
shallow	high	hard	mineral	no plants	1.3	1.5	0.2	4.4	2.8
shallow	low	hard	mineral	no plants	12.4	7.1	0.9	26.4	30.3
shallow	low	soft	mineral	no plants	9.8	5.4	0.2	20.0	26.6
shallow	low	soft	mineral	plants	12.1	1.3	0.1	18.5	42.0
shallow	low	soft	organic	no plants	4.9	2.7	0.1	10.0	13.3
shallow	medium	hard	mineral	no plants	5.4	5.9	0.8	17.6	11.4
shallow	medium	soft	mineral	no plants	4.3	4.5	0.2	13.3	10.0
shallow	medium	soft	organic	no plants	2.1	2.2	0.1	6.7	5.0
shallow	standing	hard	mineral	no plants	15.7	11.5	13.7	43.3	168.3
shallow	standing	soft	mineral	no plants	12.4	8.7	3.2	32.8	147.8
shallow	standing	soft	mineral	plants	19.8	0.2	2.5	36.9	155.5
shallow	standing	soft	organic	no plants	6.2	4.3	1.6	16.4	73.9
shallow	standing	soft	organic	plants	9.9	0.1	1.2	18.5	77.7
				Mean	**7.0**	**4.6**	**1.6**	**19.0**	**51.4**

1. Red font indicates habitat types that were not sampled directly and where CPUE values were determined using surrogates or professional judgment.
2. Using standard gang index gill nets (NRPK = northern pike; WALL = walleye; LKWH = lake whitefish; Tot-LB = all large-bodied fish).
3. Using small mesh index gill nets (Tot-FF = all forage fish).

Table 5B-5: Weighted mean catch-per-unit-effort ($CPUE_W$) using standard gang index gill nets (#fish/100m/24h) and small mesh index gill nets (#fish/30m/24h) in the Upstream Keeyask Area during summer in the existing environment (EE) and four post-Project (PP) time steps for three operation modes (Base loaded at 158 and 159 m above sea level [ASL], and peaking between 158 and 159 m ASL)

Species	EE	Year 1 PP			Year 5 PP			Year 15 PP			Year 30 PP		
		Base Loaded		Peaking	Base Loaded		Peaking	Base Loaded		Peaking	Base Loaded		Peaking
		158	159		158	159		158	159		158	159	
Area (ha)	4979	8342	9532	9532	8342	9717	9717	8342	9974	9974	8342	10156	10156
Standard gangs													
Northern pike	6.1	3.8	4.1	3.9	4.7	5.0	4.5	5.3	6.0	5.2	5.6	6.4	5.5
Walleye	5.3	5.5	5.7	5.6	6.7	6.4	6.0	7.2	7.0	6.5	7.3	7.1	6.5
Lake whitefish	1.3	1.4	1.5	1.4	1.7	1.7	1.6	1.8	1.9	1.7	1.9	2.0	1.8
Total catch	19.2	17.7	18.5	17.9	21.5	20.9	19.7	23.3	23.5	21.5	23.9	24.3	22.0
Small mesh gangs													
Forage fish	53.2	41.9	44.8	42.3	52.4	55.2	50.1	59.5	66.9	58.3	61.8	71.2	61.0

Table 5B-6: Weighted suitable habitat area (WSHA; ha) in the Upstream Keeyask Area during summer in the existing environment (EE) and four post-Project (PP) time steps for three possible modes of operation (base loaded at 158 and 159 m above sea level [ASL], and peaking between 158 and 159 m ASL), and the ratio of predicted post-Project to existing WHSA (*i.e.*, PP/EE)

		WSHA											
		Year 1PP			Year 5PP			Year 15 PP			Year 30 PP		
Species	EE	Base Loaded		Peaking	Base Loaded		Peaking	Base Loaded		Peaking	Base Loaded		Peaking
		158	159		158	159		158	159		158	159	
Walleye	2247	3979	4264	4123	4358	4842	4602	4680	5484	5083	4750	5659	5206
Northern pike	1573	1870	2160	2016	1989	2439	2215	2249	3020	2635	2346	3308	2827
Lake whitefish	492	1019	1120	1070	1019	1178	1099	1108	1378	1243	1137	1458	1298
Large-bodied fish	2353	4133	4480	4309	4146	4684	4417	4500	5415	4959	4605	5714	5161
Forage fish	1593	2429	2802	2617	2596	3186	2892	2946	3963	3456	3063	4294	3680

		Proportional Increase in WSHA											
		Year 1 PP			Year 5 PP			Year 15PP			Year 30 PP		
Species	EE	Base Loaded		Peaking	Base Loaded		Peaking	Base Loaded		Peaking	Base Loaded		Peaking
		158	159		158	159		158	159		158	159	
Walleye	1.0	1.8	1.9	1.8	1.9	2.2	2.0	2.1	2.4	2.3	2.1	2.5	2.3
Northern pike	1.0	1.2	1.4	1.3	1.3	1.6	1.4	1.4	1.9	1.7	1.5	2.1	1.8
Lake whitefish	1.0	2.1	2.3	2.2	2.1	2.4	2.2	2.3	2.8	2.5	2.3	3.0	2.6
Large-bodied fish	1.0	1.8	1.9	1.8	1.8	2.0	1.9	1.9	2.3	2.1	2.0	2.4	2.2
Forage fish	1.0	1.5	1.8	1.6	1.6	2.0	1.8	1.8	2.5	2.2	1.9	2.7	2.3

APPENDIX 5C
BIOLOGICAL INFORMATION OF VEC FISH SPECIES CAPTURED DURING INDEX GILLNETTING PROGRAM IN THE STUDY AREA

5C.1 WALLEYE

5C.1.1 SPLIT LAKE AREA

Walleye captured with index gill nets set in Clark, Split, and Assean lakes ranged from 65 to 611 mm in length (Table 5C-1). Mean lengths were generally similar among the three waterbodies ranging from 345 mm at Split Lake to 364 mm at Clark Lake. Fish from all three lakes were generally in the same condition. The sub-sample of walleye aged from all three waterbodies ranged from 1–17 years.

Very few walleye captured in standard gang index gill nets set in either Split/Clark or Assean lakes between 2001 and 2004 had external DELTs (less than 0.5% of the catch; Table 5C-2). In Split/Clark lakes, three of the walleye captured exhibited fin deformities, while a single walleye captured in Assean Lake had a tumour.

The majority of walleye (more than 95%) captured in Clark, Split, and Assean lakes as part of the index gillnetting programs conducted between 2001 and 2004 whose stomachs contained food items had consumed fish. The most frequently consumed fish species by walleye in Clark and Split lakes was rainbow smelt, which occurred in 31 and 58% of stomachs that contained fish, respectively. As expected, given that rainbow smelt were not captured in gillnetting surveys of Assean Lake, none of the walleye captured in Assean Lake had consumed rainbow smelt. The most frequently consumed fish species in this lake was yellow perch, which occurred in 28% of stomachs that contained fish. Less than 5% of walleye had invertebrate remains in their stomach.

5C.1.2 KEEYASK AREA

5C.1.2.1 Nelson River between Clark Lake and Gull Rapids

Walleye captured with standard gang index gill nets in the Keeyask area ranged from 66 to 686 mm in length during the summer of 2001 and 2002 (Table 5C-1). Fish captured in the river upstream of Gull Lake were generally the same size and condition as fish captured in Gull Lake. The sub-sample of walleye aged ranged from 1–26 years.

None of the walleye captured in standard gang index gill nets in Gull Lake or the stretch of the Nelson River above Gull Lake in 2001 and 2002 displayed any external DELTs (Table 5C-3).

The majority of walleye (more than 95%) captured in the Keeyask area as part of the index gillnetting programs in 2001 and 2002 whose stomachs contained food items had consumed fish. During the fall of 1999, walleye had fed exclusively on fish. In both spring and fall, the most frequently consumed fish species was rainbow smelt, which occurred in 52% of stomachs that contained fish. About 5% of walleye had invertebrate remains in their stomach.

5C.1.2.2 Gull Rapids

Walleye captured with index gill nets set in the Nelson River below Gull Rapids in 2002–2003 ranged from 234 to 570 mm in length (Table 5C-1). The mean length and condition of fish captured in 2003 was greater than observed in 2002.

External DELTs were observed on a single walleye that was captured in standard gang index gill nets set in the Nelson River below Gull Rapids (Table 5C-3). This fish showed signs of fin erosion.

The majority of walleye (more than 90%) captured below Gull Rapids as part of the 2002–2003 index gillnetting programs whose stomachs contained food items had consumed fish. The most frequently consumed fish species was rainbow smelt, which occurred in 40% of stomachs that contained fish. Approximately 20% of walleye had invertebrate remains in their stomach.

5C.1.3 STEPHENS LAKE AREA

Walleye captured with index gill nets set in Stephens Lake (excluding the riverine portion immediately downstream of Gull Rapids) in 2002 and 2003 ranged from 108 to 633 mm in length (Table 5C-1). The mean length and condition factor of the catch was generally similar among years. The sub-sample of walleye aged ranged from 2– 22 years.

Several of the walleye captured in standard gang index gill nets set in Stephens Lake had external DELTs (about 1% of the catch; Table 5C-4). The most frequently observed DELT category was tumours, which was observed on six walleye. Four walleye had fin deformities and another two fish showed signs of fin erosion.

The majority of walleye (more than 90%) captured in Stephens Lake (excluding the reach immediately below Gull Rapids) as part of the 2002–2003 index gillnetting programs whose stomachs contained food items had consumed fish. The most frequently consumed fish species by walleye in Stephens Lake was rainbow smelt, which occurred in 30% of stomachs that contained fish. Approximately 30% of walleye had invertebrate remains in their stomach.

5C.2 NORTHERN PIKE

5C.2.1 SPLIT LAKE AREA

Northern pike captured in index gill nets set in Clark, Split, and Assean lakes ranged from 140 to 1,090 mm in length (Table 5C-5). The mean length of fish from Split Lake (470 mm) was smaller than in Clark Lake (518 mm) or Assean Lake (544 mm). The condition of northern pike was relatively constant among years and lakes, with annual average condition factors ranging from 0.69 to 0.79. The sub-sample of northern pike aged from all three waterbodies ranged from 1–15 years.

Only one of the northern pike captured in standard gang index gill nets set in Split/Clark Lake had an external DELT; a fin deformity. DELTs were not observed on any of the northern pike captured in Assean Lake (Table 5C-2).

Northern pike captured in index gill nets set in Clark, Split, and Assean lakes set during the summers of 2001 to 2004 fed primarily on fish, as is common for the species. The most frequently consumed fish species by northern pike in Clark and Split lakes was rainbow smelt, which occurred in 58 and 45% of stomachs that contained fish, respectively. As expected, given that rainbow smelt were not captured in gillnetting surveys of Assean Lake, none of the northern pike captured in Assean Lake had consumed rainbow smelt. The most frequently consumed fish species in this lake was yellow perch, which occurred in 21% of stomachs that contained fish. Northern pike captured in all three lakes frequently consumed crayfish; this prey item occurred in 16–51% of northern pike stomachs that contained food.

5C.2.2 KEEYASK AREA

5C.2.2.1 Nelson River between Clark Lake and Gull Rapids

Northern pike captured with standard gang index gill nets in the Gull Lake reach ranged from 171 to 1,017 mm in length (Table 5C-5). Fish captured in the river upstream of Gull Lake were generally the same size and condition as fish captured in Gull Lake. The sub-sample of northern pike aged ranged from 1–15 years.

Only one of the northern pike captured in standard gang index gill nets set in Gull Lake and the upstream reach of the Nelson River had a DELT (Table 5C-3). This fish had a tumour on its head.

The majority of northern pike (81%) captured as part of the index gillnetting program in Gull Lake and the stretch of the Nelson River upstream during the fall of 1999 and the summers of 2001 and 2002 whose stomachs contained food items had consumed fish. In both seasons, the most frequently consumed fish species was rainbow smelt, which occurred in 41% of stomachs that contained fish. During the summer, about 34% of the northern pike had invertebrate remains in their stomach. The most frequently consumed invertebrate group at this time was crayfish. In contrast to the mainstem, fewer of the northern pike captured in Carscadden Lake had fed on fish (67% of fish with stomach contents). The only species of prey fish that could be identified in these stomachs were yellow perch and a single burbot. Many northern pike in Carscadden Lake also consumed invertebrate prey (58%).

5C.2.2.2 Gull Rapids

Northern pike captured in index gill nets set immediately below Gull Rapids from 2002 to 2003 ranged from 236 to 687 mm in length (Table 5C-5). There was little difference in the size of fish between years (471–479 mm); however, the condition factor of northern pike captured in 2003 (0.89) was somewhat higher than that observed in 2002 (0.72).

None of the northern pike captured in standard gang index gill nets set in the Nelson River below Gull Rapids exhibited external DELTs (Table 5C-3).

Northern pike captured in index gill nets set immediately below Gull Rapids during summer from 2002 to 2003 fed primarily on fish. Approximately 67% of the northern pike captured whose stomachs contained food items had eaten fish. Northern pike had consumed at least three species of fish (white sucker, rainbow smelt, and sculpins), in addition to a number of unidentified fish remains. Northern pike frequently consumed crayfish; this prey item occurred in 44% of northern pike stomachs that contained food.

5C.2.3 STEPHENS LAKE AREA

Northern pike captured in index gill nets set in Stephens Lake in 2002 and 2003 ranged from 123 to 998 mm in length (Table 5C-5). The condition factor of northern pike was relatively constant between years, with an overall mean of 0.74. The sub-sample of northern pike aged ranged from 1–19 years.

Four northern pike captured in standard gang index gill nets set in Stephens Lake had external DELTs (less than 0.5% of the catch; Table 5C-4). These northern pike displayed deformities; two of the fin and two of the head.

Northern pike captured in index gill nets set in Stephens Lake from 2002–2003 fed primarily on fish. Approximately 55% of the northern pike captured whose stomachs contained food items had eaten fish, of which the most frequently consumed species was rainbow smelt (35% of stomachs that contained fish). Northern pike also frequently consumed crayfish (36% of stomachs that contained food).

5C.3 LAKE WHITEFISH

5C.3.1 SPLIT LAKE AREA

Lake whitefish captured with index gill nets set in Clark, Split, and Assean lakes ranged from 129 to 565 mm in length (Table 5C-6). The mean length of fish captured in Split Lake (372 mm) and Assean Lake (396 mm) were similar. Although the mean length of lake whitefish from Clark Lake (349 mm) was lower than in Split or Assean lakes, this result could be due to the small number of fish sampled from that lake. The mean condition of lake whitefish ranged from 1.44 at Clark Lake to 1.57 at Split Lake. The sub-sample of lake whitefish aged from all three waterbodies ranged from 1–24 years.

None of the lake whitefish captured in standard gang index gill nets set in either Split/Clark or Assean lakes displayed external DELTs (Table 5C-2).

Lake whitefish captured as part of the index gillnetting program in Clark, Split, and Assean lakes between 2001 and 2004 had fed almost exclusively on aquatic invertebrates. The most frequently consumed invertebrates included snails (Gastropoda), clams (Bivalvia), and clam shrimp (Laevicaudata/Spinicaudata/Cyclestherida). Two fish in Assean Lake and two fish in Split Lake had fish remains in their stomachs (yellow perch and emerald shiner).

5C.3.2 KEEYASK AREA

5C.3.2.1 Nelson River between Clark Lake and Gull Rapids

Lake whitefish captured during the summer of 2001 and 2002 with standard gang index gill nets in the Gull Lake reach ranged from 136 to 592 mm in length (Table 5C-6). Fish captured in the river above Gull Lake were about the same size and condition as fish captured in Gull Lake. The sub-sample of lake whitefish aged ranged from 1–25 years.

An external DELT (a deformed fin) was observed on one of the lake whitefish captured in standard gang index gill nets set in Gull Lake and upstream in the Nelson River (Table 5C-3).

Lake whitefish captured as part of the index gillnetting program in the Gull Lake reach during the fall of 1999 and the summers of 2001 and 2002 had fed almost exclusively on aquatic invertebrates. In both seasons, the most frequently consumed invertebrates included mayflies (Ephemeroptera), snails (Gastropoda), and clams (Bivalvia). Only 3% of the lake whitefish had fish remains in their stomachs.

5C.3.2.2 Gull Rapids

No lake whitefish were captured during the summer index gillnetting program from which biological data could be derived. As lake whitefish move to the base of Gull Rapids from Stephens Lake during fall, biological data for those fish (described in the Stephens Lake area) could be used to describe Gull Rapids lake whitefish.

5C.3.3 STEPHENS LAKE AREA

Lake whitefish captured with index gill nets set in Stephens Lake in 2002 and 2003 ranged from 124 to 569 mm in length (Table 5C-6). The mean condition factor of lake whitefish captured in both years was 1.77. The sub-sample of lake whitefish aged ranged from 1–25 years.

None of the lake whitefish captured in standard gang index gill nets set in Stephens Lake exhibited external DELTs (Table 5C-4).

Lake whitefish captured as part of the index gillnetting program in Stephens Lake (2002–2003) had fed almost exclusively on aquatic invertebrates. The most frequently consumed invertebrates were mayflies (Ephemeroptera), snails (Gastropoda), and clam shrimp (Laevicaudata/Spinicaudata/Cyclestherida). Only one lake whitefish had fish remains in its stomach. FLCN Members have similarly reported that lake whitefish in Stephens Lake feed on insects and small fish (FLCN 2010 Draft).

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Table 5C-1: Mean size, condition, and age, by waterbody and year, of walleye captured in standard gang index gill nets set in the study area during summer, 1997–2004

Waterbody	Year	Fork Length (mm)				Weight (g)				Condition Factor (K)				Age (y)			
		n[1]	Mean	Std[2]	Range	n	Mean	Std	Range	n	Mean	Std	Range	n	Mean	Std	Range
Split Lake	1997	505	318	95	65–600	503	477	396	25–3500	503	1.13	0.21	0.450–3.29	91	6.7	3.7	2–17
	1998	470	314	93	125–576	469	460	403	15–2650	469	1.11	0.17	0.48–1.78	147	6.5	3.3	2–15
	2001	693	372	60	170–596	684	718	376	50–2450	684	1.27	0.24	0.76–3.56	104	6.3	3.0	2–15
	2002	226	387	68	171–611	214	834	443	49–3000	214	1.30	0.21	0.93–3.37	109	6.3	3.2	1–14
	All Years	1894	345	86	65–611	1870	601	421	15–3500	1870	1.19	0.23	0.48–3.56	451	6.5	3.3	1–17
Clark Lake	1997	45	350	96	163–460	45	618	370	25–1150	45	1.16	0.14	0.51–1.50	8	8.6	4.2	2–16
	1998	60	338	97	147–548	60	566	457	25–1995	60	1.11	0.18	0.56–1.51	16	6.9	3.0	3–10
	2001	74	390	87	181–570	73	877	578	66–2400	73	1.25	0.14	0.98–1.53	18	8.1	4.3	2–14
	2002	20	388	93	152–554	20	844	477	35–2225	20	1.22	0.13	0.92–1.42	12	6.9	4.2	1–14
	2004*	25	355	134	162–555	23	770	751	32–2300	23	1.25	0.32	0.67–1.68	25	6.0	4.2	2–16
	All Years	224	364	100	147–570	221	726	536	25–2400	221	1.19	0.19	0.51–1.68	79	7.1	4.0	1–16
Assean Lake	2001	657	355	84	150–535	657	602	419	15–1900	657	1.12	0.14	0.24–1.71	122	6.8	4.1	2–16
	2002	738	349	79	135–560	734	564	382	24–1975	734	1.14	0.27	0.51–3.70	125	7.2	3.6	1–16
	All Years	1395	352	81	135–560	1391	582	400	15–1975	1391	1.13	0.22	0.24–3.70	247	7.0	3.9	1–16
Nelson River (including Gull Lake)	2001	359	407	101	156–587	359	1077	722	25–2800	358	1.30	0.20	0.53–2.74	128	6.8	4.4	2–18
	2002	242	446	101	66–686	242	1395	825	3–4750	242	1.33	0.16	0.88–1.72	134	8.5	5.2	1–26
	All Years	601	422	103	66–686	601	1205	780	3–4750	600	1.31	0.18	0.53–2.74	262	7.7	4.9	1–26
Gull Rapids	2002	48	408	57	315–554	47	972	465	375–2275	47	1.31	0.12	0.99–1.55	-	-	-	-
	2003	46	435	64	234–570	44	1407	530	275–2725	44	1.55	0.12	1.36–1.82	-	-	-	-
	All Years	94	421	61	234–570	91	1182	541	275–2725	91	1.43	0.17	0.99–1.82	-	-	-	-
Stephens Lake	2002	658	396	96	108–633	529	995	678	85–3050	529	1.24	0.13	0.69–1.90	120	9.8	4.9	2–20
	2003	581	438	86	147–621	571	1211	668	25–3700	571	1.28	0.17	0.69–1.80	128	10.1	4.8	2–22
	All Years	1239	416	94	108–633	1100	1107	681	25–3700	1100	1.26	0.15	0.69–1.90	248	10.0	4.9	2–22

1. Number of fish measured.
2. Standard deviation.
* Only sites that were fished in previous years were analyzed.

Table 5C-2: Frequency of occurrence (%) of deformities, erosion, lesions, and tumours (collectively referred to as DELTs) observed on VEC fish species captured in standard gang index gill nets set in the Split Lake area from 2001–2004

Species	DELT Category	Assean Lake			Split/Clark Lakes			
		2001	2002	Mean	2001	2002	2004	Mean
Lake whitefish	Deformity	0	0	0	0	0	0	0
	Erosion	0	0	0	0	0	0	0
	Lesion	0	0	0	0	0	0	0
	Tumour	0	0	0	0	0	0	0
		(308)	(239)	(547)	(65)	(85)	(2)	(152)
Northern pike	Deformity	0	0	0	0	0.3 (1*)	0	0.1 (1)
	Erosion	0	0	0	0	0	0	0
	Lesion	0	0	0	0	0	0	0
	Tumour	0	0	0	0	0	0	0
		(235)	(195)	(430)	(338)	(339)	(81)	(758)
Walleye	Deformity	0	0	0	0.4 (3)	0	0	0.3 (3)
	Erosion	0	0	0	0	0	0	0
	Lesion	0	0	0	0	0	0	0
	Tumour	0	0.1 (1)	0.1 (1)	0	0	0	0
		(657)	(738)	(1395)	(768)	(247)	(84)	(1099)

* The number in brackets represents the number of fish examined.

Table 5C-3: Frequency of occurrence (%) of deformities, erosion, lesions, and tumours (collectively referred to as DELTs) observed on VEC fish species captured in standard gang index gill nets set in the Keeyask area from 2001–2003

Species	DELT Category	Nelson River (including Gull Lake)			Reach below Gull Rapids		
		2001	2002	Mean	2002	2003	Mean
Lake whitefish	Deformity	0	1.6 (1*)	0.6 (1)	-	-	0
	Erosion	0	0	0	-	-	0
	Lesion	0	0	0	-	-	0
	Tumour	0	0	0	-	-	0
		(103)	(61)	(164)	(1)	(-)	(1)
Northern pike	Deformity	0	0	0	0	0	0
	Erosion	0	0	0	0	0	0
	Lesion	0	0	0	0	0	0
	Tumour	0	0.2 (1)	0.1 (1)	0	0	0
		(446)	(605)	(1051)	(18)	(21)	(39)
Walleye	Deformity	0	0	0	0	0	0
	Erosion	0	0	0	0	2.1 (1)	1.1 (1)
	Lesion	0	0	0	0	0	0
	Tumour	0	0	0	0	0	0
		(360)	(242)	(602)	(48)	(47)	(95)

* The number in brackets represents the number of fish examined.

Table 5C-4: Frequency (%) of deformities, erosion, lesions, and tumours (collectively referred to as DELTs) observed on VEC fish species captured in standard gang index gill nets set in the Stephens Lake area from 2001–2003

Species	DELT Category	Stephens Lake		
		2002	2003	Mean
Lake whitefish	Deformity	0	0	0
	Erosion	0	0	0
	Lesion	0	0	0
	Tumour	0	0	0
		(147)	(142)	(289)
Northern pike	Deformity	0	0.5 (4)	0.3 (4)
	Erosion	0	0	0
	Lesion	0	0	0
	Tumour	0	0	0
		(511)	(733)	(1244)
		(36)	(18)	(54)
Walleye	Deformity	0	0.7 (4)	0.3 (4)
	Erosion	0	0.3 (2)	0.2 (2)
	Lesion	0	0	0
	Tumour	0.2 (1)	0.9 (5)	0.5 (6)
		(658)	(581)	(1239)

* The number in brackets represents the number of fish examined.

Table 5C-5: Mean size, condition, and age, by waterbody and year, of northern pike captured in standard gang index gill nets set in the study area during summer, 1997–2004

Waterbody	Year	Fork Length (mm)				Weight (g)				Condition Factor (K)				Age (years)			
		n[1]	Mean	Std[2]	Range	n	Mean	Std	Range	n	Mean	Std	Range	n	Mean	Std	Range
Split Lake	1997	333	468	137	163–890	333	890	767	50–6600	333	0.69	0.12	0.31–2.19	81	4.3	1.9	1–12
	1998	275	469	137	200–852	275	916	761	50–5225	275	0.71	0.10	0.42–1.44	81	4.5	1.5	2–10
	2001	252	468	129	225–1015	251	951	836	85–8700	251	0.77	0.13	0.36–1.55	98	4.6	1.9	2–15
	2002	274	474	135	190–992	263	949	864	61–7400	263	0.73	0.17	0.23–2.75	101	5.0	2.6	1–12
	All Years	1134	470	135	163–1015	1122	924	804	50–8700	1122	0.72	0.14	0.23–2.75	361	4.6	2.0	1–15
Clark Lake	1997	77	496	157	200–890	77	1165	1063	25–6350	77	0.70	0.11	0.31–1.24	21	4.6	1.9	2–8
	1998	55	466	144	220–753	55	909	730	95–2950	55	0.71	0.08	0.57–0.92	17	4.4	1.9	2–8
	2001	86	493	133	140–758	86	1090	760	85–3300	86	0.79	0.34	0.45–3.61	27	4.5	2.2	1–9
	2002	64	542	136	232–881	64	1370	1020	173–6050	64	0.75	0.28	0.49–2.81	16	6.6	4.2	2–15
	2004*	55	614	129	215–925	22	1798	1005	500–4600	22	0.76	0.07	0.67–0.99	55	6.4	2.1	1–12
	All Years	337	518	148	140–925	304	1187	937	25–6350	304	0.74	0.23	0.31–3.61	136	5.5	2.6	1–15
Assean Lake	2001	234	546	155	231–1090	234	1414	1329	74–9400	234	0.69	0.11	0.23–1.70	128	5.6	2.5	2–14
	2002	194	543	167	220–1013	194	1465	1439	100–8050	194	0.70	0.09	0.40–1.09	119	6.3	3.2	1–13
	All Years	428	544	160	220–1090	428	1437	1379	74–9400	428	0.70	0.10	0.23–1.70	247	6.0	2.9	1–14
Nelson River (including Gull Lake)	2001	445	490	168	171–985	443	1245	1226	50–8250	443	0.79	0.20	0.26–2.82	125	5.6	2.8	2–13
	2002	646	539	152	218–1017	645	1494	1316	75–10050	645	0.77	0.11	0.21–1.92	171	6.6	3.5	1–15
	All Years	1091	519	160	171–1017	1088	1393	1285	50–10050	1088	0.78	0.15	0.21–2.82	296	6.1	3.3	1–15
Gull Rapids	2002	18	471	81	298–586	18	822	384	200–1500	18	0.72	0.05	0.59–0.79	3	2.7	0.6	2–3
	2003	21	479	92	236–687	21	1107	649	56–3150	21	0.89	0.14	0.43–1.09	-	-	-	-
	All Years	39	475	86	236–687	39	976	555	56–3150	39	0.81	0.13	0.43–1.09	-	-	-	-
Stephens Lake	2002	510	521	142	123–998	446	1238	1093	45–7875	446	0.72	0.07	0.50–1.11	123	6.7	4.0	1–15
	2003	731	507	132	179–971	727	1219	1030	14–7300	726	0.76	0.14	0.16–1.33	127	7.3	4.7	1–19
	All Years	1241	512	136	123–998	1173	1226	1054	14–7875	1172	0.74	0.12	0.16–1.33	250	7.0	4.4	1–19

1. Number of fish measured.
2. Standard deviation.
* Only sites that were fished in previous years were analyzed.

Table 5C-6: Mean size, condition, and age, by waterbody and year, of lake whitefish captured in standard gang index gill nets set in the study area during summer, 1997–2004

Waterbody	Year	Fork Length (mm)				Weight (g)				Condition Factor (K)				Age (years)			
		n[1]	Mean	Std[2]	Range	n	Mean	Std	Range	n	Mean	Std	Range	n	Mean	Std	Range
Split Lake	1997	130	362	70	209–534	129	822	524	100–2600	129	1.50	0.18	1.07–2.01	38	7.5	3.7	3–19
	1998	77	363	78	150–506	77	849	474	50–2040	77	1.55	0.16	1.02–1.97	28	6.8	2.5	4–13
	2001	63	366	109	139–551	62	995	655	32–2300	62	1.58	0.28	1.03–2.56	61	7.1	4.4	2–22
	2002	70	407	81	181–565	70	1309	654	65–3325	70	1.70	0.22	1.10–2.34	69	8.0	3.3	3–20
	All Years	340	372	84	139–565	338	961	596	32–3325	338	1.57	0.22	1.02–2.56	196	7.5	3.7	2–22
Clark Lake	1997	27	390	109	132–540	27	1099	785	25–2525	27	1.46	0.18	1.09–1.77	15	9.9	6.8	2–24
	1998	3	344	67	278–411	3	667	404	300–1100	3	1.48	0.09	1.40–1.58	3	5.3	1.2	4–6
	2001	2	275	193	138–411	2	720	962	39–1400	2	1.75	0.38	1.48–2.02	2	3.5	2.1	2–5
	2002	15	288	142	141–530	15	635	765	33–2200	15	1.37	0.24	1.08–1.87	15	5.7	6.2	1–23
	2004*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All Years	47	349	128	132–540	47	907	778	25–2525	47	1.44	0.21	1.08–2.02	35	7.4	6.4	1–24
Assean Lake	2001	308	390	77	132–531	308	1061	495	25–2450	308	1.57	0.20	0.79–2.10	133	5.3	2.9	2–16
	2002	239	403	65	129–542	236	1047	383	27–2175	236	1.51	0.27	1.10–3.85	119	7.3	3.2	1–20
	All Years	547	396	72	159–542	544	1055	449	25–2450	544	1.54	0.24	0.79–3.85	252	6.3	3.2	1–20
Nelson River (including Gull Lake)	2001	103	436	90	201–585	103	1653	886	125–4150	103	1.72	0.24	1.05–2.54	100	8.3	4.5	2–21
	2002	61	394	148	136–592	61	1592	1268	42–5525	61	1.76	0.49	0.95–4.47	57	9.3	7.2	1–25
	All Years	164	420	116	136–592	164	1630	1041	42–5525	164	1.74	0.35	0.954.47	157	8.6	5.6	1–25
Gull Rapids	2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All Years	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stephens Lake	2002	144	449	86	137–568	108	1682	732	32–3300	107	1.69	0.19	1.07–2.04	86	9.6	4.8	2–25
	2003	142	420	116	124–569	136	1809	1030	22–4400	136	1.84	0.35	0.93–2.54	121	10.2	5.8	1–25
	All Years	286	435	102	124–569	244	1753	911	22–4400	243	1.77	0.30	0.93–2.54	207	9.9	5.4	1–25

1. Number of fish measured.
2. Standard deviation.
* Only sites that were fished in previous years were analyzed.

Table 5C-7: Comparison of the frequency of occurrence (%*) of deformities, erosions, lesions, and tumours (DELTs) on large-bodied VEC species captured in selected northern Manitoba waterbodies

Waterbody	Study Year	Lake Whitefish	Northern Pike	Walleye
Study Area				
Split Lake	2001–2002	0.0 (0)	0.2 (1)	0.2 (1)
Clark Lake	2001–2004	0.0 (0)	0.0 (0)	1.7 (2)
Assean Lake	2001–2002	0.0 (0)	0.0 (0)	0.1 (1)
Nelson River	2001–2002	0.0 (0)	0.0 (0)	0.0 (0)
Gull Lake	2001–2002	0.8 (1)	0.2 (1)	0.0 (0)
Stephens Lake	2002–2003	0.0 (0)	0.3 (4)	1.0 (13)
Other				
Notigi Lake[1]	2001	0.0 (0)	0.8 (1)	0.0 (0)
Leftrook Lake[2]	2001	2.0 (3)	0.0 (0)	0.0 (0)
Wuskwatim Lake[3]	2000–2002	1.4 (4)	0.4 (1)	0.3 (2)
Rat River[4]	2004	0.0 (0)	0.0 (0)	0.5 (2)
Burntwood River[5]	2001–2002	0.0 (0)	0.0 (0)	0.4 (1)
Lower Nelson River[6]	2003	1.0 (1)	0.0 (0)	3.5 (3)

* The number of fish displaying DELT is shown in parentheses.

1. After Caskey and Mota (2003).
2. After MacDonald (2003).
3. After Mota and Jansen (2003) and Kroeker and Mota (2003).
4. Mota (2005).
5. Manitoba Hydro and NCN (2003).
6. After Johnson and MacDonell (2004).