Keeyask Generation Project

Environmental Impact Statement

Supporting Volume

Aquatic Environment

KEEYASK
Hydropower Limited Partnership

June 2012

SECTION 6
LAKE STURGEON

Hydropower Limited Partnership

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6.0 LAKE STURGEON

6.1 INTRODUCTION

The lake sturgeon (sturgeon/namayo/*Acipenser fulvescens*) is a long-lived species that was historically relatively abundant and widespread in Manitoba. Lake sturgeon currently inhabit the section of the Nelson River that will be impounded by the Keeyask Generating Station (GS), as well as areas immediately upstream to the Kelsey GS, including the Grass, Burntwood, and Odei rivers, and downstream to the Kettle GS. Lake sturgeon are present in the North and South Saskatchewan Rivers in Alberta, the Saskatchewan and upper Churchill Rivers in Saskatchewan, and the Saskatchewan, Churchill, Nelson, Hayes, Winnipeg, Pigeon, Red, and Assiniboine rivers in Manitoba. In Ontario, lake sturgeon inhabit the southern Hudson, James Bay, and Great Lakes drainages, including the freshwater portion of the St. Lawrence River. In the United States, lake sturgeon occur in the Mississippi, Lake Michigan, and Lake Superior drainage basins. Appendix 6A provides a detailed literature review of lake sturgeon ecology.

The lake sturgeon has often been referred to as a "living fossil" due to its retention of primitive characteristics, which include a cartilaginous skeleton, bony plates (or scutes), and the **heterocercal** tail typical of the shark family. Lake sturgeon are spring spawners that are slow to reach sexual maturity (14–16 years (y) of age for males and 24–26 y for females) and spawn relatively infrequently (every 2 y for males and every 4–7 y for females). These life history characteristics, in conjunction with a slow growth rate, made the lake sturgeon particularly vulnerable to over-exploitation by the commercial fishing industry during the late 19th and 20th centuries. Commercial harvest of lake sturgeon began in Manitoba during the late 1800s, with initial effort focusing on Lake Winnipeg. Commercial fishing for lake sturgeon in the Nelson River began in 1907 and the fishery first collapsed in 1911. The fishery was reopened in 1916 but collapsed several more times due to overfishing. The fishery was closed permanently in Manitoba in 1992. The characteristics that made lake sturgeon populations slow to recover following over-exploitation (*i.e.*, late age at maturity and low spawning periodicity) coupled with the preference for large river rapids for spawning also make this species sensitive to habitat alterations related to hydroelectric developments.

First Nations have identified lake sturgeon as a culturally important species. The lake sturgeon has been designated a heritage species in Manitoba and recently, western Canada lake sturgeon populations (*i.e.*, those in Manitoba, Saskatchewan, and Alberta) have been assessed as "endangered" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2006). Presently, the lake sturgeon is under consideration for listing under Schedule 1 of Canada's *Species at Risk Act*. Due to their cultural importance and COSEWIC status, this species was selected as a VEC in this impact assessment.

A brief description of the information sources, methods, and study area for the lake sturgeon assessment are provided in Section 6.2. The historic and current conditions of the lake sturgeon population in the study area are described in Section 6.3. Lake sturgeon abundance and habitat use are described for each of the study reaches followed by a description of lake sturgeon movements in the entire study area.

Project effects, including construction, operation, residual, and cumulative effects, and mitigation are described in Section 6.4 along with environmental monitoring and follow-up programs.

6.2 APPROACH AND METHODS

6.2.1 Overview to Approach

The approach taken for the lake sturgeon effects assessment was similar to the general approach taken for other aquatic environment components and was composed of two major steps:

- A description of the existing aquatic habitat conditions to provide the basis for assessing the potential effects of the Project on these components; and
- An effects assessment in which the predicted post-Project environment was described and changes from existing environment quantified.

An ecosystem-based approach was employed to assess the potential impacts of the Project on lake sturgeon, in which both direct and indirect pathways of effects were considered. Information presented incorporates findings from other aquatic components (*i.e.*, water quality, aquatic habitat, lower trophic levels, and other components of the fish community).

The spatial scale at which effects are described includes both areas directly affected by the project as well as a larger regional context.

The temporal scale of the assessment considers both the historic and existing environments, which are described using several sources of information, including local knowledge, existing published information, and studies conducted specifically as part of the environmental impact assessment of the Project. Environmental assessment studies for lake sturgeon were conducted from 2001–2008. Data from additional studies conducted in 2009 and 2010 were only used to address information gaps about the existing environment for sturgeon. The assessment also considered available information as to population trends of lake sturgeon to the future, if the Project is not constructed.

Potential Project-related effects on lake sturgeon were assessed based on habitat suitability index (HSI) models developed for the Keeyask area and comparisons to lake sturgeon populations in other reservoir environments. The information sources and impact assessment approaches are discussed below.

6.2.2 Study Area

The study area for lake sturgeon investigations extends along the Nelson River from the Kelsey GS in the southwest, downstream to Stephens Lake in the east (Map 1-1). The magnitude of physical change (*e.g.*, changes in water levels and flows) differs substantially among areas and, consequently, the study area for lake sturgeon was divided into three areas on the Nelson River:

- Split Lake area (Split Lake and adjoining water bodies, including Clark Lake and the lower reaches of the Grass, Odei, and Burntwood rivers). This area was included as it provides habitat for the regional lake sturgeon population and may be indirectly affected by movements of sturgeon from the directly affected Keeyask area (Map 6-1);

- Keeyask area (Nelson River extending from the outlet of Clark Lake to the inlet of Stephens Lake and tributary streams). For the purposes of discussion, this area has been further sub-divided into two reaches (Map 6-2):
  - Nelson River between Clark Lake and Gull Rapids, which includes the reservoir in the post-Project environment; and
  - Gull Rapids to approximately 4 kilometres (km) downstream, where water levels and flows will be affected by operation of the GS; and
- Stephens Lake area. This area is downstream of the hydraulic zone of influence (HZI) of the Project, but sturgeon rely on habitat at and immediately downstream of Gull Rapids (Map 6-3).

Overall sampling effort was highest in the Keeyask area because this is the area in which Project effects to sturgeon habitat are expected to be the greatest. For this reason, additional studies were required in this area in order to develop the Habitat Suitability Index (HSI) models used to assess predicted habitat changes on lake sturgeon.

6.2.3 Data and Information Sources

Section 1.5 summarizes the overall sources of information used for the Project, including technical studies, scientific publications and local knowledge. Specific sources of information used to characterize the environmental setting for lake sturgeon are detailed in this section.

6.2.3.1 Existing Published Information

A number of studies were conducted by the Province of Manitoba (Fisheries Branch) to collect harvest and biological data that would help set management quotas for the Nelson River commercial fishery for sturgeon prior to its closure in 1992 (Kooyman 1955; Sunde 1959, 1961; Sopuck 1987; Harkness 1980; Patalas 1988). Although the commercial fishery extended as far downstream as Kettle GS, these studies focused on the more heavily fished areas upstream of Kelsey GS such as Sipiwesk Lake. However, Patalas (1988) and MacDonell (1997) documented commercial quotas and yields for the management zone that encompassed what is now the study area. MacDonell (1997) provided an account of the history of the lake sturgeon fishery from the perspective of the **Bayline** communities of Pikwitonei, Thicket Portage, and Wabowden. The Nelson River Sturgeon Co-Management Board (NRSCB) was established in 1992 to assist with the management of the domestic fisheries in communities along the Nelson River from Norway House downstream to Split Lake. Macdonald (1998) reported on a 5-year (1992–1997) field program conducted by the NRSCB in this reach in order to establish a sustainable level of harvest. Biological data were collected from sturgeon as part of this program, and included information on fish captured in the Gull Lake area. The NRSCB has published a number of reports documenting its progress and activities since this time.

6.2.3.2 Keeyask Environmental Studies

Keeyask environmental studies focusing on lake sturgeon were conducted in the study area over an 8-year period (2001–2008). The field program consisted of four primary components as follows:

- Spring spawning;
- Summer/fall habitat use;
- Overwintering; and
- Movements.

For each component, a variety of gear types were used to sample lake sturgeon, including gill nets of various mesh sizes, drift traps, radio and acoustic telemetry, and Floy®-tags. Detailed approach and methods for these studies are presented in Appendix 6B.

Movement studies were conducted to gain a general understanding of lake sturgeon movements within the study area; to assess whether fish move upstream and/or downstream through Birthday Rapids and Gull Rapids; and to document concentrated movements of fish that can be used to identify important habitat, such as spawning locations. Information on movements through Gull Rapids was used to help determine whether fish passage might be required for the Keeyask Project. Lake sturgeon habitat use in the existing environment was described in part by calculating gillnet catch-per-unit-effort (CPUE) in various habitat types. The habitat classification system used for these calculations is provided in Appendix 6B.

Population estimates for adult lake sturgeon were developed from mark/recapture studies during spring in the Burntwood River between First Rapids and Split Lake, the Nelson River between Kelsey GS and Split Lake, and the Nelson River between Clark Lake and Gull Rapids. With sufficient numbers of tagged lake sturgeon and study duration, population models could estimate the proportion of lake sturgeon that were not returning to these reaches each year but were present elsewhere in the range of the population to provide an estimate of the total population in each area.

6.2.4 Assessment Approach

Impacts of the Project on lake sturgeon were assessed using two approaches:

- Habitat suitability index models predicting changes to lake sturgeon habitat in the Keeyask area; and
- Condition of sturgeon populations in Stephens Lake and other hydroelectric reservoirs.

Habitat-based CPUE analyses were based on three life stages:

- Young-of-the-year (YOY) — classified as lake sturgeon measuring approximately 150–200 millimetres (mm) long and are approximately 3 months old (captured in late summer/early fall);
- Sub-adults — classified as lake sturgeon measuring approximately 200–833 mm fork length (FL)and are approximately 1–15 y old; and

- Adults — lake sturgeon measuring greater than or equal to 834 mm FL[1].

Habitat Suitability Index models were developed in consultation with Fisheries and Oceans Canada (DFO; formerly known as the Department of Fisheries and Oceans) to estimate the amount of suitable lake sturgeon spawning habitat and foraging habitat (YOY, sub-adult, and adult) in the Keeyask area and upper Stephens Lake in the existing and post-Project environments. Development of these models is described in detail in Appendix 6D. Foraging adults (*i.e.,* non-spawners) and spawning adult fish in the Keeyask area were defined as follows:

- Non-spawners included summer and fall captures of adult fish (greater than or equal to 834 mm FL) only. This is because sexual maturity was not always evident for adults captured during spring.
- Spawning adults were deemed such based only on physical evidence of reproductive activity (*i.e.,* fish expressed gametes when pressure was applied to the abdomen).

Habitats in the Keeyask area and upper Stephens Lake were grouped into four HSI intervals representing varying degrees of the habitat's suitability for lake sturgeon:

HSI	Suitability
0.001 to < 0.25	Low
0.25 to < 0.50	Moderate
0.50 to < 0.75	High
0.75 to 1.0	Very High

HSI values were used to calculate the **weighted usable area** (WUA) of spawning and foraging habitat. Changes in WUA between the existing and post-Project environments were used to help assess the degree to which lake sturgeon habitat use would be altered by the Project (Section 6.4). It is important to note that WUAs presented in this document were used to determine the distribution of important sturgeon habitat in the area and provide a relative measure of the magnitude of potential impacts. WUAs should not be interpreted as an absolute measure of the amount of habitat available either pre- or post-Project. The spatial distribution of suitable habitat (*e.g.*, proximity of YOY foraging habitat to spawning grounds) was also taken into consideration in the assessment.

[1] The size distinction between sub-adult (less than 834 mm) and adult fish (greater than or equal to 834 mm) was adopted from lake sturgeon spawning at the Weir River (Holm *et al.* 2006) where a large number of fish can be captured in a smaller area over a short time period compared with the Keeyask area. This allows a greater number of lake sturgeon to be sexed by gamete extrusion providing a more representative dataset on fish size at maturity. It also corresponds well to the size of the smallest sexually mature fish (826 mm) captured in the study area during environmental studies.

6.3 ENVIRONMENTAL SETTING

6.3.1 Pre-1997 Conditions

Lake sturgeon formed an important part of the subsistence economy in the upper Nelson River prior to the arrival of European settlers (MacDonell 1997). Annual gatherings associated with the harvest of lake sturgeon also served to strengthen social and cultural traditions amongst the Cree communities (Socio-economic, Resource Use, and Heritage Resources Supporting Volume [SE SV] Section 1.2.3.1.1). The earliest quantitative records of lake sturgeon harvest are from the Hudson Bay Company archive and date back to 1832. The records pertain to the purchase of sturgeon isinglass (a gelatin from the swim bladders of fish) in the Norway House district (compiled by V. Petch; MacDonell 1997). From 1832 to 1891, the Hudson Bay Company purchased an average of 143 kilograms (kg) of isinglass (equivalent to approximately 40,612 kg of dressed sturgeon) at the Norway House post. This harvest was probably taken from Lake Winnipeg, its tributaries, and Playgreen Lake, but gives an indication of the extent of the lake sturgeon fishery before the "commercial fishery" began (MacDonell 1997).

Commercial production of lake sturgeon from Manitoba waters began in the late 1800s with the 1887 completion of the railroad linking Winnipeg to eastern markets (Sunde 1959). Initial effort focused on Lake Winnipeg and, although lake sturgeon were known to have been taken from the Nelson River by that time, all harvest from northern Manitoba was listed as Lake Winnipeg production (MacDonell 1997). Annual harvest of lake sturgeon from Lake Winnipeg reached nearly 80,000 kg by 1896 and by 1900, production had reached 445,000 kg (Patalas 1988; MacDonell 1997). Despite continued high prices and increased fishing effort, the sturgeon harvest from Lake Winnipeg declined rapidly and, by 1910, was only 13,700 kg (Patalas 1988). The fishery closed from 1911 to 1916, closed permanently in 1928, and never recovered.

Continued demand for lake sturgeon and the collapse of the Lake Winnipeg fishery led to increased harvesting on the Winnipeg, Saskatchewan, and Nelson Rivers. The commercial fishery on the upper Nelson River is cited by several authors as beginning in 1907 (Sunde 1961; Sopuck 1987; Patalas 1988) and by Tough (1987) as beginning in 1902. In this early part of the fishery, most of the harvest appears to have been taken from Lake Winnipeg downstream to (and including) Sipiwesk Lake. After a harvest of over 61,000 kg in 1902, production of the fishery declined to just over 3,000 kg by 1907 (Tough 1987 in MacDonell 1997). An annual average of only 6,400 kg was harvested from the Nelson River from 1908–1910 when concern over declining sturgeon stocks prompted a province-wide closure of the fishery from 1911 to 1916 (MacDonell 1997).

The Manitoba sturgeon fishery reopened in 1916 to meet demands resulting from World War I. The downstream extent of the fishery in the Nelson River increased with the completion of the Hudson Bay Railway to 9.6 km north of Gillam in 1917 (MacDonell 1997). The Nelson River fishery began in earnest that year, producing 57% of the total Manitoba production (119,000 kg; Patalas 1988). The fishery was opened all the way down to Kettle Rapids (now Kettle GS) in 1924, and to the Angling River in 1940. The fishery would undergo three more temporary closures between 1917 and 1970, after periods of high exploitation followed by collapse. During the periods the fishery was open (1917–1933, 1937–1946, 1953–1960), harvests ranged from one to 120 percent of the annual quota, but on average only reached 50% of the quota. After the third closure of the fishery (1947–1952), the downstream extent of the fishery varied; and after the fourth closure (1961–1969), five management zones were created between Lake Winnipeg and Port Nelson, with each zone having its own catch quota (MacDonell 1997).

Of the 58,168 kg of lake sturgeon harvested by the commercial fishery between 1970 and 1987, 83% of the total production was taken from the Sipiwesk Lake area (zones 2 and 3; Patalas 1988). Despite a relatively large annual quota for zones 1, 4, and 5 (4,500–4,700 kg combined), only 7.4% (4,305 kg) of the total production from 1970–1987 originated in Zone 4, the area that encompasses what is now the study area (Patalas 1988). Assuming an average weight of 9–18 kg (20–40 pounds) per fish[2], this harvest would equate to approximately 250–500 fish taken from the study area during this period.

The fishery was finally closed in 1992, when it was purchased from commercial fishers by the Department of Northern Affairs and the Manitoba Department of Natural Resources (MacDonell 1997). A province-wide ban on commercial fishing for lake sturgeon was implemented in the 1990s.

In addition to over-harvest, lake sturgeon in the Nelson River have been affected by hydroelectric development at rapids that were historic spawning sites, including the construction and operation of the Kelsey GS (1957), the Kettle GS (1966), and CRD/LWR (1976). The Bayline communities of Pikwitonei, Thicket Portage, and Wabowden reported abundant lake sturgeon below Kelsey GS prior to its development, in both the Nelson River mainstem and its tributaries (MacDonell 1997). In the 1930s and 1940s, lake sturgeon were sighted or captured at the base of Kelsey Rapids (now the site of Kelsey GS), the lower Grass River (including the base of Witchai Lake Falls), below First Rapids on the Burntwood River, where the Burntwood and Odei Rivers enter Split Lake, in the Odei River, and Gull Lake. Kelsey Rapids and Witchai Lake Falls were also believed by some fishermen to be spawning locations for sturgeon prior to Kelsey GS (MacDonell 1997).

Fox Lake Cree Nation Members stated that prior to hydro development, sturgeon were plentiful and were harvested by First Nations along the entire stretch of the lower Nelson River system, particularly at the mouths of the larger tributaries (FLCN 2008 Draft). Notable fishing locations included Kettle Rapids (now the site of Kettle GS; FLCN 2008 Draft), a former creek called Oskotowi Sipi (Moose Nose Lake area; FLCN 2009 Draft), and former rapids at "Indian Grave Channel" (FLCN 2009 Draft), which is located near the now flooded Moswakot Rivers/Nelson River junction in Stephens Lake (FLCN 2010 Draft). Rapids between Gull Rapids and Kettle GS (now flooded) were also important fishing areas for sturgeon (FLCN 2010 Draft). Lake sturgeon spawned at Kettle and Gull rapids, and the Butnau River provided important sturgeon habitat (FLCN 2009 Draft).

TCN members reported that both CRD and LWR caused a decline in lake sturgeon abundance (Split Lake Cree - Manitoba Hydro Joint Study Group 1996c). FLCN members stated that critical habitats were lost with each dam and fish could no longer move freely within their natural habitat as they were able to prior to dam construction (FLCN 2009 Draft). As each successive dam was built, there were fewer

[2]Average weight estimated from weight-frequency distribution for commercial catches from the Sipiwesk Lake area in 1953–1956 and 1987–1988 as presented in Patalas (1988).

sturgeon (FLCN 2009 Draft), and populations downstream of generating stations declined sharply following impoundment (FLCN 2010 Draft).

It is possible there were losses from the sturgeon population in the Kettle GS reservoir due to emigration of sturgeon during construction or immediately after in response to associated environmental disturbance. Tagging studies have confirmed downstream movement of lake sturgeon from the Long Spruce and Limestone reservoirs to the lower Nelson River following impoundment (North/South Consultants Inc. [NSC] 2012). These movements represent a loss to the reservoir populations, which can only be replaced by downstream movements from farther upstream.

Overall, there are now fewer sturgeon in Stephens, Gull, and Clark lakes (Split Lake Cree - Manitoba Hydro Joint Study Group 1996c). In response to directions from War Lake First Nation (WLFN) Elders, sturgeon are now harvested in lower quantities to preserve their populations (CNP, YFFN and FLCN 2011), and only the odd sturgeon is captured and used by the York Factory community (SE SV).

Published scientific information on lake sturgeon in the study area prior to 1997 is limited. From 1953–1956 and in 1959, biological data were collected by the Manitoba Fisheries Branch from lake sturgeon harvested at commercial fishing locations along the Nelson River, including Gull Lake (MacDonell 1997). However, these data were published for the fishery as a whole rather than individual locations (Kooyman 1955; Sunde 1959; Sunde 1961).

Studies providing biological data or population statistics on lake sturgeon for the post-Kelsey GS period were limited to the Sipiwesk Lake area (Sopuck 1987; Patalas 1988). The sturgeon population in Sipiwesk Lake likely uses the entire reach of the Nelson River from Eves/Whitemud falls to the Kelsey GS, spawning at several locations including in the Landing River and at various rapids and falls upstream of Sipiwesk Lake (McCart 1992). A field program conducted by the NRSCB in this reach of the Nelson River in order to establish a sustainable level of harvest concluded that large-scale changes to the available habitat did occur as a result of LWR (Macdonald 1998). However, habitat availability was not considered to be a limiting factor for the sturgeon in the area. In addition, no obvious year class failure attributable to the construction of Kelsey GS could be detected, though it was too early to detect any year class changes caused by Jenpeg GS (Macdonald 1998). Over-harvesting, both historical (primarily commercial) and at the time of publishing (domestic), were the biggest problems faced by the sturgeon stocks (Macdonald 1998). Because of the time required for sturgeon to reach sexual maturity and catchable size, impacts of previous hydroelectric developments would be slow to appear in the population (Macdonald 1998).

First Nations domestic fisheries continue to fish sturgeon on most water bodies that support fishable populations. In the Supreme Court Canada decision R. vs. Sparrow in 1990[3], gear and season restrictions

[3] In 1990, the Supreme Court of Canada issued a landmark ruling in the *Sparrow* decision. This decision found that the Musqueam First Nation has an Aboriginal right to fish for food, social and ceremonial purposes. The Court found that where an Aboriginal group has a right to fish for food, social and ceremonial purposes, it takes priority, after conservation, over other uses of the resource. The Supreme Court also indicated the importance of consulting with Aboriginal groups when their fishing rights might be affected.

similar to those of the commercial fishery were removed from the Treaty Indian domestic fishery. The NRSCB was established in 1992 to assist with the management of the domestic fisheries within communities along the Nelson River from Norway House downstream to Split Lake. The primary objective of the program was to provide non-regulatory harvest recommendations to domestic fishers that would balance subsistence and cultural needs of the community while protecting lake sturgeon populations in the Nelson River from further decline (NRSCB and InterGroup Ltd. 1999; InterGroup Ltd. 2005).

6.3.2 Current Conditions (Post-1996)

6.3.2.1 Overview and Regional Context

Presently, lake sturgeon occur throughout the study area in some of the larger rivers adjoining the Nelson River and in the riverine and lacustrine portions of the Nelson River. However, movements of lake sturgeon within the study area between the Split Lake, Keeyask, and Stephens Lake areas appear to be limited. Sturgeon were generally captured in the study area more often during spring, in part due to their congregation at spawning grounds. Lake sturgeon spawn in the spring, generally in a range of water depths in areas of swift current or rapids over gravel, cobble, and boulder-sized substrates. Spawning locations include First Rapids on the Burntwood River, Long Rapids, Birthday Rapids, Gull Rapids, and possibly high velocity areas in the Grass River and the vicinity of Kelsey GS. The entire reach of the Nelson River between Birthday and Gull Rapids, appears to be important foraging habitat for sturgeon. Lacustrine portions of the Nelson River (Split, Clark, Gull, and Stephens lakes) provide overwintering habitat in addition to foraging habitat.

Population estimates of adult lake sturgeon (greater than or equal to 834 mm FL) in the Keeyask area (Birthday Rapids to Gull Rapids only) and Split Lake Area are presented in Table 6-1. Estimates could not be generated for the Stephens Lake area due to the relatively small number of sturgeon captured during environmental studies. The variability among annual population estimates and the wide confidence range are due to several factors. The variable spawning interval for lake sturgeon results in many fish that are not captured during every sampling period; this effect is compounded by different spawning intervals between males and females. Given that the population estimate is only for adult-sized lake sturgeon, the annual population estimate fluctuates based on the recruitment of new individuals, which relates to spawning success and juvenile survival 20 to 30 years in the past when spawning populations were still changing in response to the commercial fishery. Finally, erratic return of tags from fish harvested in the domestic fishery and incomplete harvest information results in episodic updates to mortality estimates that can result in a disproportionate amount of mortality being recorded in one year.

During field studies, the highest average CPUE for lake sturgeon was in the Nelson River between Clark Lake and Gull Rapids and the lowest average CPUE was in Stephens Lake and in the Nelson River downstream of the Kelsey GS. Habitat suitable for each of the life history stages of lake sturgeon can currently be found in each of the three aforementioned areas.

Annual population estimates for the Keeyask area were generally much lower than estimates for other water bodies in northern and southern Manitoba (Table 6-1). Estimates for the adult population between

Birthday and Gull Rapids ranged from 344 to 1,275 fish. The most recent estimate for this area was 643 fish in 2008 (Table 6-1). Estimates for the adult population in the Split Lake area were also relatively low, ranging from 183 to 654 fish, and the most recent estimate (2009) at 585 fish. The sturgeon population in the Conawapa area (downstream of Limestone GS) is greater than either population in the study area, with an estimate of about 5,500 sturgeon. Estimates of lake sturgeon populations in the Winnipeg River between the Seven Sisters GS and Pointe du Bois GSs are also relatively high (Table 6-1).

Lake sturgeon investigations were conducted in the Split Lake, Keeyask, and Stephens Lake areas during the spring from 2001 to 2008, though not all three areas were sampled in all years. Information on lake sturgeon in each of these three areas is presented in Section 6.3.2.2 to Section 6.3.2.4. Information on lake sturgeon genetics, health, and movements are presented for the study area as a whole in Section 6.3.2.5, Section 6.3.2.6, and Section 6.3.2.7, respectively.

6.3.2.2 Split Lake Area

The Split Lake area (Map 6-1) was fished for lake sturgeon with large mesh gill nets during spring spawning investigations conducted at five locations from 2001–2008: 1) the Grass River; 2) the Nelson River near Kelsey GS downstream to Anipitapiskow and Sakitowak Rapids; 3) Split and Clark lakes; 4) the Burntwood River; and 5) the Odei River. Drift traps and egg collection mats were used to capture sturgeon eggs and larvae in the Burntwood, Odei, and Grass rivers as part of the spring spawning studies conducted in 2001, 2002, and 2007. In 2006, summer gillnetting was conducted in all of these areas except the Odei River. Large mesh gill nets were used to capture adult and sub-adult fish, and medium mesh gill nets were used to capture sub-adults and YOY fish to determine lake sturgeon use of the area outside the spawning season. Young lake sturgeon also would have been susceptible to capture in small mesh index gill nets and the smaller mesh sizes of standard gang index gill nets set in the Split Lake area as part of other Keeyask gillnetting studies conducted during five summers from 1997–2004, and summer 2009. Refer to Appendix 6B for details of the sturgeon sampling programs conducted in the Split Lake area and to Section 5 for other fish community studies.

Gillnetting CPUE data and habitat variables were examined at capture locations to identify habitat characteristics associated with foraging/rearing habitat. Spring captures of sub-adults (*i.e.,* known non-spawners) and summer/fall captures of all life stages were used as indicators of where, and in what types of habitat, lake sturgeon foraging might occur.

6.3.2.2.1 Distribution and Abundance

Spring

Lake sturgeon were captured at all five locations in the Split Lake area during spring spawning studies but were most abundant in the Burntwood River and the vicinity of Kelsey GS. Catches in the Burntwood River consisted mostly of adult fish captured below First Rapids, where many of the fish were likely congregating to spawn. Overall adult CPUE was higher in the Burntwood River (0.09 fish per 24 h) than all other locations (Table 6-2). Although sub-adult lake sturgeon were also captured during spring studies, the overall CPUE for each location was lower than for adults (0.03 fish/24 h or less). Only one sub-adult was captured in the Grass River whereas at least six were captured in each of the other water bodies.

Summer

Lake sturgeon were captured in the Kelsey GS vicinity and Split Lake during summer 2006, but not in the Grass or Burntwood rivers where fishing effort was limited (Table 6-2). Adult and sub-adult lake sturgeon were captured with equal frequency at both locations (0.01 fish/24 h). Overall CPUE during summer (0.02 fish/24 h; life stages and locations combined) was lower than the corresponding spring value for 2006 (0.04 fish/24 h). Two sub-adult and two adult lake sturgeon were captured in Split Lake during other fish community studies conducted during summer in 1997 and 2002 (Table 6-2). Two sub-adult lake sturgeon were also captured in standard index gill nets set in Clark Lake during summer 2009. One of these fish was estimated to be one year old based on its length (195 mm)[4]. These were the first recorded captures of lake sturgeon in Clark Lake during Keeyask environmental studies.

No YOY lake sturgeon were captured during sturgeon studies (Table 6-2), but a single YOY lake sturgeon was captured in Split Lake during other fish community gillnetting studies conducted during summer 2001.

6.3.2.2.2 Habitat

Spawning

The only location that was confirmed as a spawning site in the Split Lake area during the environmental studies was First Rapids on the Burntwood River. CNP resource users reported that lake sturgeon also spawn below First Falls on the Odei River (CNP Keeyask Environmental Evaluation Report). Historical spawning grounds in this area (Map 6-4; Appendix 6C) that may still be used by lake sturgeon include Witchai Lake Falls in the Grass River and the Nelson River downstream of the Kelsey GS (formerly Kelsey Rapids). Lake sturgeon do not appear to spawn in the rapids located upstream of the confluence of the Nelson River and Split Lake (Sakitowak and Anipitapiskow Rapids).

Between 2001 and 2007, numerous male lake sturgeon were captured downstream of First Rapids, some more than once, in maturing, ripe, or spent condition (Table 6-3). Recapture of the same spawning lake sturgeon below the rapids in different years indicates that some individuals return to this area to spawn. The capture of many fish whose maturity could not be determined suggests that non-spawners also use this area during spring. Larval drift traps set within 1 km downstream of First Rapids during spring 2001 and 2002 captured a total of 22 larval sturgeon, further indicating the use of these rapids by spawning sturgeon

One lake sturgeon showing evidence of spawning (a spent male) was captured in the Grass River during Keeyask environmental studies conducted in spring 2007 (Table 6-3). Two additional fish captured in the Grass River during spring were thought to be females preparing to spawn, as both were quite large (greater than 1,300 mm FL; 25–35 kg) and had distended abdomens and protruding urogenital openings.

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[4] Note that Keeyask sturgeon less than 200 mm in length are generally considered YOY fish when captured in fall. This fish was captured in mid-August 2009, and given the late ice break-up in 2009 this fish was not believed to have been spawned in 2009.

These fish were not included in Table 6-3 because their maturity status was not positively identified (*i.e.,* gametes were not extruded during examination).

The capture of two ripe males and one pre-spawn female in the vicinity of Kelsey GS suggest that lake sturgeon may also spawn in this area (Table 6-3). The Bayline communities of Pikwitonei, Thicket Portage, and Wabowden reported Kelsey Rapids (now the site of Kelsey GS) on the Nelson River and Witchai Lake Falls on the Grass River to be historic spawning locations for lake sturgeon (MacDonell 1997).

Spring habitat-based CPUE values for adult lake sturgeon tended to show where fish were congregating to spawn. Mean CPUE values were higher at fishing sites near rapids, sites in moderate velocity areas, and sites with hard substrates (Table 6-4).

Rearing

A single YOY lake sturgeon was captured in Split Lake during environmental studies focusing on other fish species (Table 6-2). It was captured in shallow, low velocity, soft substrate habitat near the confluence of the Burntwood and Nelson Rivers. Because young-of-the-year (YOY) lake sturgeon are difficult to capture, relatively little is known about this life stage. However, studies conducted in other river systems (Appendix 6A) suggest that suitable rearing habitat consists of gravel, sand, or silty sand substrate in areas of low velocity. Habitat in the Split Lake area is very diverse and appears to contain suitable conditions for YOY lake sturgeon. Although rearing sites have not been located in the Split Lake area, the capture of sub-adults indicates that successful recruitment is occurring.

Foraging

Sub-adults

Small numbers of sub-adult lake sturgeon were captured during spring almost every year in all water bodies except the Grass River (Table 6-2). During summer sturgeon studies, sub-adults were captured in the Kelsey GS vicinity and Split Lake. Sub-adults were also captured in Clark Lake during gillnetting studies focusing on other species. No sub-adults were captured in the Grass or Burntwood rivers during summer, but these water bodies were fished for sturgeon less extensively. The Odei River was not fished during summer.

Sub-adults were captured with equal frequency in lacustrine, riverine, and rapids habitat types (Table 6-5). Mean CPUE of sub-adults was slightly higher at deep water sites as compared to shallow sites; and at moderate velocity sites as compared to low velocity and standing water sites. Sub-adults were captured with equal frequency over soft and hard substrates.

Adults

During summer, fishing for adult sturgeon (*i.e.*, with large mesh gill nets) was only conducted in the Kelsey GS vicinity and Split Lake in deep (greater than 3 metres (m)) areas because outside the spawning season sturgeon are generally found in deeper water (Table 6-2). Adults were captured at both locations, with rapids habitat having a higher mean CPUE (0.03 fish/24 h) than riverine habitat (0.01 fish/24 h) and lacustrine habitat (less than 0.01 fish/24 h; Table 6-4). Correspondingly, mean CPUE was slightly higher at moderate velocity sites and sites with hard substrates than at sites with low velocity or soft substrates (Table 6-4).

Food Availability

Soft bottom substrates present in deep, standing and low water velocity habitats of the Split Lake area support a benthic invertebrate community dominated by *Pisidium* sp. clams, Amphipoda, Ephemeroptera (mayflies), and Chironomidae (midge) larvae (Table 4-23), which are all known forage items of lake sturgeon. Mean benthic invertebrate densities in these habitats were moderate (~3,500 individuals/square metre (m^2); Table 4-23) and within the range of densities observed in other northern Manitoba water bodies (Table 4-22).

Drifting invertebrates that settle on the substrate likely compose a large proportion of lake sturgeon diet in riverine and rapids habitat characterized by hard bottom substrates and low velocities. Drifting invertebrate studies were not conducted in the Split Lake area, but the drift composition is expected to be similar to that found in the Keeyask area, consisting primarily of Ephemeroptera, Trichoptera, Diptera, and Plecoptera (Section 6.3.2.3). Crayfish (Decapoda) are a common prey item of lake sturgeon and were present in some of the macroinvertebrate samples collected in the Split Lake area; however, because they were not a major taxonomic group in samples their abundance was not quantified (Table 4B-3).

Overwintering

Lake sturgeon overwintering habitat surveys were not conducted in the Split Lake area. During winter telemetry studies conducted in the Keeyask and Stephens Lake areas (Section 6.3.2.3 and Section 6.3.2.4), lake sturgeon were generally relocated in deep, low velocity habitat in the Nelson River from Birthday Rapids to Kettle GS. The Split Lake area contains ample habitat of this type and therefore likely contains sufficient overwintering habitat for lake sturgeon.

6.3.2.3 Keeyask Area

The Keeyask area (Map 6-2) was fished for lake sturgeon with large mesh gill nets during spring spawning investigations conducted at five locations between Clark Lake and Stephens Lake from 2001 to 2008: 1) Clark Lake to Birthday Rapids; 2) vicinity of Birthday Rapids; 3) vicinity of Birthday Rapids to Gull Lake; 4) Gull Lake; and 5) within and downstream of Gull Rapids. As part of the 2001–2004 investigations, drift traps were used to capture sturgeon eggs and larvae. Gillnetting was conducted during summer and fall with large mesh gill nets to capture adult and sub-adult fish, and medium mesh gill nets to capture sub-adult and YOY fish in order to determine lake sturgeon use of the area outside the spawning season.

The fall 2008 and 2009 gillnetting programs focused on capturing YOY and sub-adult lake sturgeon. The fall 2008 program was conducted between Birthday Rapids and Gull Rapids and in the downstream vicinity of Gull Rapids; the fall 2009 program was conducted downstream of Gull Rapids. Young lake sturgeon also would have been susceptible to capture in small mesh index gill nets and the smaller mesh sizes of standard gang index gill nets set in the Keeyask area as part of other Keeyask gillnetting studies conducted during fall 1999 and summer 2001–2003 and 2009. Refer to Appendix 6B for details of the sturgeon sampling programs conducted in the Keeyask area and to Section 5 for other fish community studies.

Gillnetting CPUE data and habitat variables were examined at capture locations to identify habitat characteristics associated with foraging/rearing habitat. Spring captures of sub-adults (*i.e.,* known non-spawners) and summer/fall captures (all life stages) were used as indicators of where, and in what types of habitat, lake sturgeon foraging might occur. Telemetry studies were conducted to locate important habitat for the species within the area.

6.3.2.3.1 Nelson River from Clark Lake to Gull Rapids

Distribution and Abundance

Spring

During spring in a given year, lake sturgeon were usually captured throughout the Nelson River between Clark Lake and Gull Rapids, and adult sturgeon accounted for most of the fish captured (Map 6-5; Table 6-6). Variation in annual CPUE could be attributed to differences in fishing locations among years and in timing of gillnetting studies (*e.g.*, late start-up in 2004 and 2008 may have missed the peak of the lake sturgeon pre-spawning aggregation). Annual mean CPUEs at Birthday Rapids were usually among the highest recorded in the study area. Overall CPUEs (life stages and years combined) were comparable for Birthday Rapids (0.23 fish/24 h) and Gull Lake (0.27 fish/24 h).

Between all four locations, adult sturgeon accounted for 85–90% of the overall spring CPUE. The highest overall CPUE for sub-adults was in Gull Lake (0.04 fish/24 h) and the lowest was between Clark Lake and Birthday Rapids (zero; Table 6-6).

Summer/Fall

Most summer and fall gillnetting for lake sturgeon was conducted in Gull Lake; catches consisted primarily of sub-adult sturgeon, but a few adults were also captured (Map 6-6; Table 6-6). Overall CPUE of adult fish captured in Gull Lake was approximately 10 times higher in spring than in summer. Catch-per-unit-effort of sub-adult lake sturgeon in Gull Lake was highest during fall (0.21 fish/24 h), followed by summer (0.08 fish/24 h), and spring (0.04 fish/24 h). Fifteen YOY lake sturgeon were captured in Gull Lake during fall 2008 (mean CPUE = 0.08).

Four adults and 20 sub-adults were captured between Birthday and Gull rapids during other Keeyask gillnetting studies conducted during summer and fall of 1999–2009 (Table 6-6). The sub-adult catch (number (n) = 15 fish) during the summer 2009 index gillnetting program included ten relatively small sturgeon (191–230 mm total length) believed to have hatched in spring 2008[5]. Based on these captures

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[5] Note that Keeyask sturgeon less than 200 mm in length are generally considered YOY fish when captured in fall. These fish were captured in mid-August 2009 and given the late ice break-up in 2009 were not believed to have been spawned in 2009.

and the 15 YOY captured in 2008 it appears that there was relatively high recruitment in this reach in 2008.

Habitat

Spawning

Lake sturgeon in the Nelson River between Clark Lake and Gull Rapids spawn primarily in the vicinity of Birthday Rapids as evidenced by the capture of numerous fish in spawning condition between 2001 and 2008 (Table 6-3, Map 6-4; Appendix 6C). Lake sturgeon congregate in the vicinity of the rapids in late May and early June at water temperatures of about 8–11 degrees Celsius (°C) and likely move into the rapids once water temperatures are suitable for spawning (11–17°C). Both spawning and non-spawning (the latter including both adults and sub-adults) fish appear to use Birthday Rapids during spring, as signs of sexual maturity were not evident for many of the fish captured there.

No lake sturgeon eggs or larvae were captured in drift traps set within and below Birthday Rapids. However, the capture of sub-adult fish between Birthday and Gull Rapids between 2001 and 2008 suggests that successful reproduction and recruitment has occurred.

Selection of spawning habitat upstream of Gull Lake in any particular year appears to be dictated in part by water level and flow conditions. In 2003, eight lake sturgeon that had been implanted with acoustic or radio transmitters in 2001 were relocated on at least one day at the inlet to Gull Lake at water temperatures between 6 and 12°C (see Section 6.3.2.7 for further details of telemetry studies). Three were relocated approximately 2.5 km downstream of Birthday Rapids in early June; one fish was recaptured in a gill net and identified as a pre-spawning male. None of these fish were detected by stationary receivers at the base of Birthday Rapids. All five lake sturgeon identified as being in spawning condition when captured in gill nets upstream of Gull Lake in 2003 were captured 2.0–2.5 km downstream of Birthday Rapids.

Gillnetting and larval drift studies indicated that lake sturgeon also spawn between Clark Lake and Birthday Rapids (Map 6-4; Appendix 6C). Long Rapids, which extends from the outlet of Clark Lake approximately 2.5 km downstream may provide suitable spawning habitat. Four male sturgeon were captured in this reach in pre-spawning or ripe condition in 2004 (Table 6-3). In addition, two larval lake sturgeon were captured in drift traps placed approximately 1 km upstream of Birthday Rapids the same year. It is likely that the larvae originated from spawning habitat at Long Rapids as other known or suspected spawning locations are well upstream of Split Lake.

Spring habitat-based CPUE values for adult lake sturgeon were highest in lacustrine habitat (0.23 fish/24 h), followed by rapids habitat (0.17 fish/24 h) and riverine habitat (0.14 fish/24 h; Table 6-7). Few adult fish captured in lacustrine and riverine habitat (*i.e.,* from Birthday Rapids to and including Gull Lake) were in spawning condition compared with the number captured near Birthday Rapids (Table 6-3 and Table 6-6). It is likely that many of the adults present in these lower velocity habitat types during spring were foraging.

Under 5th, 50th, and 95th percentile flow scenarios, HSI models for lake sturgeon spawning habitat in the existing environment indicate that there is a WUA of between 9 hectares (ha) and 12 ha from the outlet of Clark Lake down to Gull Rapids, with more spawning habitat available under lower flow conditions (Map 6-7 to Map 6-9; Appendix 6D). All usable habitat is located in reaches 2A and 2B between Clark Lake and Birthday Rapids and in the reach immediately downstream of Birthday Rapids (Reach 4). High suitability habitat (HSI greater than or equal to 0.5) accounts for 2–3 ha (Appendix 6D).

Rearing

Young-of-the-year lake sturgeon appear to have more specific habitat requirements compared to sub-adult and adult sturgeon which, by virtue of their larger size, can exploit a wider range of water velocities, substrates and larger prey for feeding. Young-of-the-year lake sturgeon show a preference for lower velocities with a sand or sand/gravel substrate (Appendix 6A).

Field studies have only located lake sturgeon rearing habitat in Gull Lake. Young-of-the-year lake sturgeon were captured north of Caribou Island (the lake's largest island) in habitats characterized by deep, low velocity water on soft substrates (Table 6-6 and Table 6-8, Map 6-10 to Map 6-13). Average water depth and velocity measured at YOY capture sites in 2008 ranged from 7.6 m to 10.4 m and 0.24 metres per second (m/s) to 0.51 m/s, respectively; substrate consisted primarily of sand with some silt/clay. The most frequently occurring prey items in a sub-sample of YOY sturgeon captured in 2008 were Ephemeroptera, Trichoptera (caddisflies), Chironomidae, and Plecoptera (stoneflies) larvae (Table 6-9). These are common diet items of YOY lake sturgeon captured in other locations (Appendix 6A).

Under 5th, 50th, and 95th percentile flow scenarios, HSI models for lake sturgeon rearing habitat in the existing environment indicate that there is a WUA of between 199 ha and 220 ha from the outlet of Clark Lake down to Gull Rapids (Map 6-14 to Map 6-16; Appendix 6D). High suitability habitat (HSI greater than or equal to 0.5) accounts for 54–64 ha. Most high or very high suitability habitat is located in the downstream portion of Gull Lake on the north side of Caribou Island, where YOY were captured during environmental studies. Due to the specific habitat requirements of larval lake sturgeon, survival of larvae hatched at Birthday Rapids likely depends on their being transported by the currents into this part of Gull Lake where velocities and substrates appear to be the most suitable for feeding.

Foraging

Sub-adults

Sub-adult lake sturgeon were captured throughout the Nelson River between Birthday Rapids and Gull Rapids, but mean CPUE was highest in lacustrine habitat (*i.e.,* Gull Lake; Table 6-10, Map 6-17). Sub-adults captured during sturgeon studies were captured more often at sites in deep (greater than 3 m) water, low to moderate velocities, and soft substrates than at shallow, standing water, hard substrate sites (Table 6-10, Map 6-18 to Map 6-20).

Over half of the sub-adult captures during summer and fall occurred in an area south of a small island in Gull Lake and extending along the lake's south shoreline (Map 6-17). This area is generally deep, of low to moderate water velocity, and has hard substrates. In fall 2008, water depth and velocity measured at a sub-adult capture site in this area ranged from 8–12 m and 0.27–0.52 m/s, respectively; substrate samples consisted mostly of gravel and cobble with some sand.

A large number of sub-adults were also captured north of Caribou Island at the same sites that YOY were captured (Map 6-17). The most frequently occurring prey items in a sub-sample of sub-adult sturgeon (325–559 mm FL) captured in Gull Lake during fall 2008 included Trichoptera, Ephemeroptera, and Plecoptera larvae (Table 6-9).

Under 5th, 50th, and 95th percentile flow scenarios, HSI models for sub-adult lake sturgeon foraging habitat in the existing environment show that there is a WUA of between 989 ha and 1,283 ha from the outlet of Clark Lake down to Gull Rapids (Map 6-21 to Map 6-23; Appendix 6D). Almost all high suitability habitat (HSI greater than or equal to 0.5), of which there are 625–867 ha, is located in Gull Lake.

Adults

Summer and fall fishing with large mesh gill nets was conducted almost entirely in Gull Lake as this is where summer and fall tracking surveys relocated a large proportion of the acoustic- and radio-tagged fish (of those that had been tagged and released between Birthday and Gull Rapids). Therefore, almost all summer/fall captures of adult sturgeon were in Gull Lake. Both the telemetry and gillnet capture data suggest that lacustrine habitat is important during summer and fall (Table 6-7, Map 6-6). The majority of fishing sites in Gull Lake were located in deep (greater than 3 m) water, low velocities, on hard substrates (Table 6-7).

Although most summer/fall relocations of acoustic- and radio-tagged adult sturgeon were within Gull Lake, many relocations also occurred in the riverine and rapids areas between Birthday and Gull Rapids, indicating that adults probably feed throughout this stretch of river (Map 6-24). Two adults were captured near Birthday Rapids during gillnetting studies: one during the summer/fall sturgeon studies and the other during other fish community gillnetting studies. Outside the spawning season, adult lake sturgeon are usually located in excess of 6 m of water in low to moderate velocities and over a wide range of substrate types (Appendix 6A).

Under 5th, 50th, and 95th percentile flow scenarios, HSI models for adult lake sturgeon foraging habitat in the existing environment indicate that there is a WUA of between 2,842 ha and 3,292 ha from the outlet of Clark Lake down to Gull Rapids (Map 6-25 to Map 6-27; Appendix 6D). Usable habitat is distributed throughout the reach and the majority has a high or very high suitability index under all three scenarios.

Food Availability

In sediment grab samples collected from deep, standing or low velocity, soft substrate areas in this reach during the open water season in 1999, 2001, and 2002, some of the preferred prey of lake sturgeon were the most abundant groups present. *Pisidium* sp. (clams), Gastropoda (snails), Trichoptera, Ephemeroptera, and Chironomidae larvae represented the majority of benthic invertebrates in the samples. Invertebrate densities were relatively low in deep, standing water habitat (917 individuals/m^2) compared to densities in deep, low velocity habitat (3,026 individuals/m^2; Table 4-27). The latter habitat type was the one in which the YOY sturgeon and many of the sub-adults were captured during fall 2008. The mean overall benthic invertebrate abundance for aquatic habitats sampled in the Keeyask area was 3,539 individuals/m^2, within the range of densities observed in other northern Manitoba water bodies (Table 4-22).

Drifting invertebrates that settle on the substrate likely compose a large proportion of lake sturgeon diet in riverine and rapids habitat characterized by hard bottom substrates and low velocities. In 2003 and 2004, aquatic insects (specifically Ephemeroptera, Trichoptera, and Diptera [mainly Chironomidae]) were the most abundant drifting invertebrates collected in drift traps, representing 86–98% of the total mean drift trap catch in the Keeyask area (Table 4-30). The greatest drifting invertebrate densities in the study area were observed upstream of Gull Rapids (at the downstream end of Gull Lake), followed by downstream of Birthday Rapids, downstream of Gull Rapids, and upstream of Birthday Rapids. Therefore, it appears that the majority of drifting invertebrates in the Keeyask area were produced between and including Birthday and Gull rapids (Section 4). Drifting invertebrate collections from the downstream vicinity of Birthday Rapids and the outlet of Gull Lake consisted primarily of Ephemeroptera, Trichoptera, Diptera, and Plecoptera (Table 4-30). Crayfish (Decapoda) are a common prey item of lake sturgeon and were present in some macroinvertebrate samples collected in the Keeyask area; however, because they were not a major taxonomic group in the samples their abundance was not quantified (Table 4B-3).

Overwintering

Relocations of both acoustic- and radio-tagged lake sturgeon during tracking surveys conducted from October to early May (2001–2004) indicate that sturgeon overwinter throughout the Nelson River from Birthday Rapids down to Gull Rapids in deep, low velocity habitat (Map 6-28).

6.3.2.3.2 Gull Rapids and Nelson River to Stephens Lake

Distribution and Abundance

Spring

Gull Rapids and the reach immediately downstream of the rapids (~4 km) do not appear to provide habitat for a large number of lake sturgeon compared to the reach of river from Birthday Rapids to, and including, Gull Lake (Table 6-6 and Table 6-11). In all years, adult lake sturgeon accounted for most or all of the spring catch. Adult lake sturgeon were captured both within and below Gull Rapids during spring (Map 6-29). Sub-adult CPUE in this area was 0.01 fish/24 h or less (Table 6-11).

Spring CPUE was generally higher in the area below Gull Rapids in years when fishing started earlier (2001, 2003, and 2006). Catch-per-unit-effort was higher within Gull Rapids than below the rapids in 2003. Reduced catches within and below the rapids in 2004 was likely the result of high debris levels, which hampered fishing.

Summer/Fall

No adult lake sturgeon were captured downstream of Gull Rapids during summer or fall sturgeon studies. A single sub-adult lake sturgeon was captured below Gull Rapids during summer, and 29 sub-adults and two YOY were captured during fall (Table 6-11). Sub-adult CPUE during fall was higher below Gull Rapids (0.41 fish/24 h) than in Gull Lake (0.21 fish/24 h; Table 6-6 and Table 6-11). Mean CPUE for YOY lake sturgeon was half as high below Gull Rapids (0.04 fish/24 h) as in Gull Lake (0.08 fish/24 h; Table 6-6 and Table 6-11, respectively).

Three adults and two sub-adults were captured during other Keeyask gillnetting studies conducted during fall 2001–2003 (Table 6-11).

Habitat

Spawning

Maturity assessments conducted during spring gillnetting studies indicate that lake sturgeon spawn in the vicinity of Gull Rapids. In the five years that sexual maturity was assessed, three pre-spawning females were captured below the rapids. Four of 11 lake sturgeon captured within the rapids in 2003 or 2004 were males that were maturing to spawn or spent (Table 6-3). Several more males were captured one or more times in pre-spawning or ripe condition below the rapids. Lake sturgeon seemed to congregate in the area immediately below the rapids in late May and early June and then move into the rapids once water temperatures were suitable for spawning. Water velocities and turbulence made the Gull Rapids area difficult to fish in terms of both safety and setting gill nets effectively; for this reason, the rapids proper were only fished in 2003 and 2004 (two relatively low flow years).

Despite the results of the maturity assessments, no larval lake sturgeon were captured downstream of Gull Rapids. It is assumed most of the spawning lake sturgeon captured in or near the rapids moved upstream from Stephens Lake as none of the lake sturgeon that were tagged upstream between Birthday and Gull Rapids were recaptured in spawning condition in the Gull Rapids vicinity (see Section 6.3.2.7).

Under 5th, 50th, and 95th percentile flow scenarios, HSI models for lake sturgeon spawning habitat in the existing environment show that there is a WUA of between 13 ha and 18 ha within and at the base of Gull Rapids, with more spawning habitat available under low flow conditions (Map 6-7 to Map 6-9; Appendix 6D). There is no spawning habitat available in the riverine reach (Reach 11) between the rapids and Stephens Lake. High quality habitat (HSI greater than or equal to 0.5) accounts for 1–4 ha of usable habitat. The model also suggests that there is more spawning habitat available at the base of the rapids than within them, due to the prevalence of excessively high velocities within the rapids proper (Map 3-8 and Map 3-17).

Rearing

Currently, lake sturgeon spawn within Gull Rapids and larvae drift downstream into lower velocity areas of the river or the western portion of Stephens Lake where an area of gravel/sand and sand has formed (Section 3). Lake sturgeon larvae have been reported to drift up to 60 km downstream of the spawning site (Appendix 6A). Therefore, larvae spawned further upstream may also be drifting downstream through Gull Rapids and settling in these areas. Most YOY gillnetting conducted during summer and fall was conducted in deep, hard substrate habitat as this was the most abundant habitat type in this reach, and shallow/soft substrate areas downstream of Gull Rapids are mostly in off-current bays which lack the velocity that appears to be typical of YOY habitat (Appendix 6A).

Two YOY lake sturgeon were captured along the south shore downstream of Gull Rapids during fall 2008 and 2009 (Table 6-11, Map 6-30). Both fish were captured in deep water, low or moderate velocities, and over a hard substrate (cobble/boulder; Table 6-8, Map 6-31 to Map 6-33). Stomach content analysis revealed that one of the YOY had consumed Chironomidae larvae and a variety of Ephemeroptera, Trichoptera, and Plecoptera larvae (Table 6-9). No YOY lake sturgeon were captured during other Keeyask gillnetting studies conducted downstream of the rapids during summer/fall from 2001–2003 (Table 6-11).

Under 5th, 50th, and 95th percentile flow scenarios, HSI models for lake sturgeon rearing habitat in the existing environment indicate that there is a WUA of between 35 ha and 40 ha in the reaches that include Gull Rapids and the portion of the river between the rapids and Stephens Lake (Map 6-14 to Map 6-16; Appendix 6D). Approximately 95% of the usable habitat lies between the base of Gull Rapids and Stephens Lake (*i.e.*, Reach 11). Although none of this habitat has a high suitability index (HSI greater than or equal to 0.5), three-month-old (approximately) YOY sturgeon were captured in this reach, suggesting that older YOY utilize what is thought to be less than optimal habitat or that YOY in this area are occupying microhabitats (*e.g.*, sand/gravel patches behind boulders) that were not detected at the scale that bottom typing sonar data were collected.

Foraging

Sub-adults

Sub-adult lake sturgeon were not documented within Gull Rapids in 2003 and 2004 (Table 6-11). However, gillnetting effort within the rapids was relatively limited due to difficult sampling conditions (high turbulence and flows). Telemetry studies relocated adult sturgeon within the Gull Rapids during summer, indicating that larger sturgeon, and possibly older sub-adults, forage there.

Several sub-adults were captured downstream of Gull Rapids during environmental studies (Table 6-11, Map 6-34). All sub-adult captures during sturgeon studies were in deep water over hard substrates (Table 6-10). Sub-adult CPUE was approximately four times higher at moderate velocity sites (0.15 fish/24 h) compared to low velocity sites (0.04 fish/24 h; Table 6-10, Map 6-35 to Map 6-37). Stomach contents from one sub-adult captured downstream of Gull Rapids during fall 2008 contained Ephemeroptera and Trichoptera larvae (Table 6-9).

Under 5th, 50th, and 95th percentile flow scenarios, HSI models for sub-adult lake sturgeon foraging habitat in the existing environment show that there is a WUA of between 178 ha and192 ha in the reaches that include Gull Rapids and the stretch of river between the rapids and Stephens Lake (Map 6-21 to Map 6-23; Appendix 6D). Most of the usable habitat (approximately 90%) lies between the base of Gull Rapids and Stephens Lake (*i.e.*, Reach 11).

Adults

Both spring gillnet capture data and biotelemetry movement data suggest that adult lake sturgeon use Gull Rapids for feeding. Most lake sturgeon captured within the rapids during spring (seven of 11 fish) did not appear to be in spawning condition, suggesting that they were there to feed. Multiple relocations of two radio-tagged adult lake sturgeon within Gull Rapids during summer suggest that lake sturgeon continue to use Gull Rapids as foraging habitat throughout summer (Map 6-24). No adult lake sturgeon were captured downstream of Gull Rapids during summer (Table 6-11). However, radio-tagged adult sturgeon were relocated downstream of Gull Rapids during summer and fall tracking surveys.

Under 5th, 50th, and 95th percentile flow scenarios, HSI models for adult lake sturgeon foraging habitat in the existing environment indicate that there is a WUA of between 610 ha and 630 ha in the reaches that include Gull Rapids and the stretch of river between the rapids and Stephens Lake (Map 6-25 to Map 6-27; Appendix 6D). The majority of usable habitat (approximately 65–70%) lies between the base of Gull Rapids and Stephens Lake (*i.e.*, Reach 11). Most of the usable habitat (551–576 ha) has a high or very high suitability index under all three flow scenarios.

Food Availability

It is likely that invertebrates that drift and settle on the substrate within and below the rapids are an important component of the diet of the lake sturgeon feeding in these areas. Based on drifting invertebrate collections from immediately above and below Gull Rapids, forage items available to sturgeon include mainly Ephemeroptera, Trichoptera, Diptera, Plectoptera, and Annelida (aquatic earthworms; Table 4-30). Production of drifting invertebrates from Gull Rapids is likely an important input to Stephens Lake; however, these rapids appear to produce overall fewer drifting invertebrates than does the Nelson River between Birthday Rapids and the downstream extent of Gull Lake (Section 4).

Overwintering

Although two lake sturgeon were relocated below Gull Rapids during late fall (Map 6-28), it is more likely that they overwinter in Stephens Lake as most relocations of acoustic- and radio-tagged lake sturgeon during late fall and winter were in the western portion of the lake (Section 6.3.2.7).

6.3.2.4 Stephens Lake Area

The Stephens Lake area was fished for lake sturgeon with large mesh gill nets concurrently with spring spawning investigations conducted at Gull Rapids in 2003, 2005, and 2006. In 2006, summer gillnetting was conducted with large mesh gill nets to capture adult and sub-adult fish, and medium mesh gill nets to capture sub-adults and YOY to determine lake sturgeon use of the area outside the spawning season. A habitat survey was conducted near the original Nelson River channel in the western portion of Stephens Lake (~5 km downstream of Gull Rapids) during summer 2009 to address information gaps on sturgeon rearing habitat in the existing environment. Because the survey indicated that this area contains substrates and velocities suitable for young sturgeon, this area was fished for YOY and sub-adults during fall 2009 and fall 2010. Young lake sturgeon also would have been susceptible to capture in small mesh index gill nets and the smaller mesh sizes of standard gang index gill nets set in Stephens Lake as part of other Keeyask gillnetting studies conducted during summer in 1999 and 2001–2003 (Section 5).

Gillnetting CPUE data were examined along with their respective habitat parameters at capture locations to identify habitat characteristics associated with rearing and foraging habitat. Telemetry studies were conducted to locate important habitat for the species within the area. Refer to Appendix 6B for further details of the lake sturgeon sampling programs conducted in the Stephens Lake Area and to Section 5 for other fish community studies.

6.3.2.4.1 Distribution and Abundance

Spring

Three of the five lake sturgeon gillnetting studies conducted in Stephens Lake were carried out at least in part during spring. Of the 11 sturgeon captured, eight were adults and three were sub-adults (Table 6-12). Low annual CPUEs (less than 0.01–0.04; all life stages combined) suggest that lake sturgeon population density in Stephens Lake is lower during spring than in other water bodies investigated in the study area. This may partly reflect spawning movements of fish out of Stephens Lake into the Gull Rapids area, as evidenced by Floy®-tag movement studies (Section 6.3.2.7).

No lake sturgeon were captured in the north arm of Stephens Lake or in the eastern portion of the lake upstream of Kettle GS despite sampling efforts during spring in 2005 and 2006.

Summer

During summer 2006, only two lake sturgeon (both adults) were captured in Stephens Lake. Both were captured along the south shore of an island located approximately 5 km downstream of Gull Rapids ("Cabin Island"; Table 6-12, Map 6-38). No lake sturgeon were captured in the north arm or in the eastern area of the lake upstream of Kettle GS.

Fall

No sturgeon were captured near the original Nelson River channel in the western portion of Stephens Lake during fall 2009 (Table 6-12). However, 32 individual sub-adult lake sturgeon were captured north of Cabin Island during fall 2010 (Table 6-12, Map 6-39).

6.3.2.4.2 Habitat

Spawning

Floy®-tag and telemetry studies indicate that sturgeon inhabiting Stephens Lake move between the lake and the Gull Rapids area (Section 6.3.2.7). It is assumed that Stephens Lake fish use the rapids for spawning (see Section 6.3.2.3.2) as no tributaries to Stephens Lake were identified as spawning habitat. A pre-spawning male captured near the rapids in 2001 was later recaptured in Stephens Lake.

Rearing

A habitat survey conducted during summer 2009 near the original Nelson River channel in the western portion of Stephens Lake indicated that there is a large area on the north side of Cabin Island with physical conditions considered suitable for YOY foraging (sand or sand/gravel substrate and low velocity). Gillnetting studies conducted in upper Stephens Lake during fall 2010 confirmed the presence of relatively young (two-year-old) lake sturgeon within this area (Map 6-39; see following section). These fish may have hatched at Gull Rapids (or further upstream) and drifted into this part of Stephens Lake, or may have previously occupied rearing habitat in the 4 km reach between Gull Rapids and Stephens Lake and moved downstream into the area north of Cabin Island to overwinter. Studies of YOY lake sturgeon in other systems have documented a pattern of downstream movement during fall, potentially to locate more suitable (lower) water velocities for overwintering (Appendix 6A). Prior to 2010, limited gillnetting had been conducted in this part of Stephens Lake with mesh sizes small enough, or in water deep enough, to capture YOY lake sturgeon. The absence of YOY from the gillnet catch in this area in 2010 may have been due to too few larval sturgeon being produced that year to be detected; to larval sturgeon not drifting into this portion of the lake; or to other biotic factors (*e.g.*, predation) that might make this area unsuitable for YOY.

Under 5th, 50th, and 95th percentile flow scenarios, HSI models for lake sturgeon rearing habitat in the existing environment indicate that there is a WUA of between 48 ha and 122 ha in upper Stephens Lake with more habitat available under higher flow conditions (Reach 12; Map 6-14 to Map 6-16; Appendix 6D). High suitability habitat (HSI greater than or equal to 0.5) accounts for 14–50 ha, with more habitat available under high flow conditions.

Foraging

The majority of lake sturgeon in Stephens Lake appear to forage within or nearby the original Nelson River channel in the western portion of the lake. During gillnetting studies conducted between 2001 and 2009, sub-adult lake sturgeon were only captured along this channel in the vicinity of Cabin Island at sites in deep water, low velocities, on soft substrates (Table 6-13). In 2010, a number of sub-adult sturgeon (n = 32) ranging in age from two to eight years old were captured north of Cabin Island at sites in deep, low velocity areas with sand (n = 24), silt (n = 6), and gravel/sand (n = 2) substrates (Map 6-40 to Map 6-42). Two- and three-year old fish accounted for 21 captures, 16 of which were found over sand substrate at depths of approximately 18 m.

Under 5th, 50th, and 95th percentile flow scenarios, HSI models for sub-adult lake sturgeon foraging habitat in the existing environment indicate that there is a WUA of between 228 ha and 286 ha in upper Stephens Lake with more habitat available under higher flow conditions (Reach 12; Map 6-21 to Map 6-23; Appendix 6D).

Most of the adult lake sturgeon (eight of ten fish) captured during spring and summer were also captured at sites located near Cabin Island (Map 6-38). Adult captures were at low velocity sites, irrespective of depth and substrate (Table 6-13).

Under 5th, 50th, and 95th percentile flow scenarios, HSI models for adult lake sturgeon foraging habitat in the existing environment indicate that there is a WUA of between 492 ha and 617 ha in upper Stephens Lake with more habitat available under higher flow conditions (Reach 12; Map 6-25 to Map 6-27; Appendix 6D).

Food Availability

Based on benthic invertebrate collections from deep, standing water, soft substrate habitat in Stephens Lake, food items available to lake sturgeon would include mainly Amphipoda, Chironomidae, Ephemeroptera, and Oligochaeta (Table 4-31). Mean benthic invertebrate abundance in this habitat type was moderate (~2,200–2,800 individuals/m²). Sediment grabs were not collected from deep, low velocity, soft substrate habitat in Stephens Lake; however, this habitat type is expected to have an invertebrate abundance similar to or higher than that observed in the comparable standing water habitat as this was the case in the Split Lake and Keeyask areas (Table 4-23 and Table 4-27, respectively). Crayfish (Decapoda) are a common prey item of lake sturgeon and were present in some drifting macroinvertebrate samples collected in Stephens Lake; however, because they were not a major taxonomic group in samples their abundance was not quantified (Table 4B-3).

Overwintering

Similar to open water foraging habitat, indications are that lake sturgeon overwintering habitat is closely associated with the original Nelson River channel in the western portion of the lake. During late fall/early winter, several sturgeon tagged with acoustic transmitters were detected in the vicinity of Cabin Island (Map 6-28 and Map 6-38). Two radio-tagged sturgeon were relocated a further 4 km downstream and one was relocated upstream of Kettle GS.

6.3.2.5 Genetics

A lake sturgeon genetics study was conducted in the region that includes the Keeyask and Conawapa GS study areas, the Hayes River, and the Churchill River. The study was conducted to assess levels of genetic diversity and population genetic structure among lake sturgeon in the region, to identify the degree of reproductive isolation among populations, and to provide baseline genetic data to help in the planning of recovery strategies that may involve stocking (Côté *et al.* 2011). The majority of lake sturgeon tissue samples were collected during spring spawning periods at known or suspected spawning locations. Results indicate that when the isolating effects of geographic distance and instream barriers are taken into consideration, fish captured from suspected or known spawning areas in the Split Lake area (Nelson River below Kelsey GS and First Rapids on the Burntwood River) represent one sub-population that is genetically distinct from that which spawns at Birthday Rapids and Long Rapids in the Keeyask area (the Birthday Rapids/Gull Lake sub-population). Too few lake sturgeon were captured in Stephens Lake to provide samples for the study; therefore, the degree of genetic differentiation between Stephens Lake fish and Birthday Rapids/Gull Lake fish is not known.

6.3.2.6 Health

Condition of lake sturgeon captured from each of the major sampling locations (Split Lake area, the Keeyask area above Gull Rapids, the vicinity of Gull Rapids, and Stephens Lake) during summer and fall are presented as general indicators of fish health. Mean condition factors from these four areas ranged from 0.74–1.01 (Table 6-14; Appendix 6E). Sub-adults captured in the Nelson River from Clark Lake to Gull Rapids and the Gull Rapids vicinity had the lowest mean condition factors (0.74 and 0.78, respectively). Condition factors for lake sturgeon from the Winnipeg River and several northern water bodies were tabulated for comparison with Keeyask fish. Condition factors for Keeyask fish were usually higher than in the Conawapa area (0.71–0.75) and, in all locations except the Nelson River from Clark Lake to Gull Rapids and the Gull Rapids vicinity, condition factors were similar to or higher than means for the Churchill, Fox, and Winnipeg Rivers.

6.3.2.7 Movements

Floy®-tags were applied to 871 lake sturgeon captured during Keeyask environmental studies between 1999 and 2008. An additional 62 lake sturgeon were tagged in Gull Lake by the Manitoba Fisheries Branch in 1995. A total of 272 fish were subsequently recaptured one or more times (Table 6-15). The overall recapture rate for individual fish was 29.2%.

Acoustic or radio transmitters were initially implanted in 32 lake sturgeon captured during spring 2001 to provide more detailed information on the frequency and timing of sturgeon movements (Table 6-16). One transmitter applied to a sturgeon captured between Birthday and Gull rapids was recaptured by a local resource user during summer 2001 and later returned to NSC. Therefore, this tag was omitted from all data analyses. A second transmitter applied to a sturgeon captured between Birthday and Gull rapids was returned by a local resource user during summer 2001 and re-applied to a sturgeon captured downstream of Gull Rapids during fall 2001. Therefore, as of spring 2002, transmitters were implanted in a total of 31 individual lake sturgeon: 11 fish captured immediately below Gull Rapids (six radio and five acoustic) and 20 fish captured between Clark Lake and Gull Rapids (five radio and 15 acoustic). All but one of these transmitters were relocated at least once during their three-year battery life expectancy (2001–2004).

6.3.2.7.1 Use of the Study Area

A total of 280 lake sturgeon were tagged in the Split Lake area during Keeyask environmental studies (Table 6-15, Map 6-43). Seventy-seven fish were subsequently recaptured and most recaptures of these fish occurred within the Split Lake area, usually within the same waterbody as the one in which they were tagged. Only one fish was recaptured outside the area, having moved a distance of approximately 50 km downstream into the Nelson River between Clark Lake and Birthday Rapids.

A total of 577 lake sturgeon were tagged in the reach of the Nelson River between Clark Lake and Gull Rapids (Table 6-15, Map 6-43). One hundred and sixty-six fish were subsequently recaptured, with most recaptures occurring within this reach. However, seven fish were recaptured in the Split Lake area, having moved a distance of 25–100 km upstream, and two were recaptured in the riverine stretch downstream of Gull Rapids (6–20 km downstream).

Twenty-seven of 66 lake sturgeon tagged in or immediately below Gull Rapids were subsequently recaptured, sometimes in multiple locations. Eight fish were recaptured outside the Gull Rapids vicinity between Clark Lake and Birthday Rapids (n = 1), between Birthday and Gull Rapids (n = 4), and in Stephens Lake (n = 3; Table 6-15, Map 6-43).

Ten tags were applied to lake sturgeon captured in the Stephens Lake area. Two of these fish were recaptured, both in the vicinity of Gull Rapids.

6.3.2.7.2 Movements Through Large Rapids

Floy®-tag and telemetry studies have shown that a proportion of lake sturgeon in each of the three major areas (Stephens Lake, Keeyask, and Split Lake areas) move between these areas and in doing so move through three sets of large rapids: Gull Rapids, Birthday Rapids, and Long Rapids. Movements of individual fish documented passing through these rapids and the potential significance of these movements are discussed in the following sections.

Gull Rapids

Movements through Gull Rapids were documented for nine lake sturgeon via recapture in gill nets (*i.e.,* Floy®-tag identification) and/or via relocations of acoustic or radio tags (*i.e.,* telemetry data). Five fish were tagged downstream of Gull Rapids, one was tagged within the rapids, and three were tagged between Gull Rapids and Birthday Rapids. Four of eight sturgeon were implanted with an acoustic or radio transmitter in addition to receiving Floy®-tags, allowing their movements to be assessed by stationary receivers or manual tracking (Table 6-16).

Fish tagged within or downstream of Gull Rapids

The five fish tagged downstream of Gull Rapids included two fish that received only Floy®-tags and three fish that received both a Floy®-tag and an acoustic or radio tag. Two lake sturgeon Floy®-tagged immediately below Gull Rapids in spring 2001 were recaptured upstream of these rapids in 2003 or 2004. One was recaptured between Gull Lake and Birthday Rapids and the other was recaptured between Birthday Rapids and Clark Lake, indicating it had moved through both Gull and Birthday rapids.

The lake sturgeon with acoustic tag 34 was relocated downstream of Gull Rapids several times in spring and summer 2001 and in spring and early summer 2002. It moved upstream through the rapids during the second week of July 2002 and was captured by a local resource user in Gull Lake later that week.

The lake sturgeon tagged with radio tag 149.560-2 was relocated below Gull Rapids in August 2001, within the rapids in July 2002, within and downstream of the rapids in summer 2003, and back downstream of the rapids in September 2003, the last time it was detected. This fish was captured by a local resource user in Gull Lake in 2006, indicating it had moved upstream through Gull Rapids between its last relocation in 2003 and its capture in 2006.

The lake sturgeon tagged with radio tag 149.620-1 moved through Gull Rapids in both directions. It was identified as a male maturing to spawn when it was captured downstream of Gull Rapids and implanted with a radio tag during spring 2001. It was then relocated downstream of the rapids several times from June to November 2001, within Stephens Lake in mid-May 2002, upstream of Gull Rapids in Gull Lake in fall 2002, within and downstream of Gull Rapids in spring and summer 2003, and finally downstream of Gull Rapids in fall 2003.

One lake sturgeon was Floy®-tagged within Gull Rapids during spring 2003 and was identified as a male maturing to spawn that year. It was recaptured in Gull Lake by a local resource user during summer 2004.

Fish tagged between Gull Rapids and Birthday Rapids

The three fish tagged between Gull Rapids and Birthday Rapids included two fish that received only Floy®-tags and one fish that received both a Floy®-tag and an acoustic tag.

Two lake sturgeon Floy®-tagged in Gull Lake during spring 2001 and spring 2003 were recaptured downstream of Gull Rapids during spring 2006. One of these fish had also been recaptured within Gull

Rapids in spring of 2003 and early summer 2004. Neither fish appeared to be in spawning condition at the time of any of their captures.

The lake sturgeon with acoustic tag 36 was tagged between Gull and Birthday rapids during spring 2001. It was relocated downstream of Gull Rapids several times during the summers of 2001 and 2002, upstream in Gull Lake during fall 2002 and again in spring, summer, and fall 2003. Acoustic Tag 36 was last relocated in Gull Lake during spring 2004 before the fish was captured by a local resource user in Gull Lake in summer 2004.

Birthday Rapids and Long Rapids

Eight sturgeon Floy®-tagged between Gull and Birthday rapids between 1995 and 2008 were recaptured one or more times upstream of Birthday Rapids between these rapids and Clark Lake (n = 1 fish), in Split Lake (n = 5), and the vicinity of Kelsey GS (n = 3; Table 6-15). Fish that moved into the Split Lake area also moved through Long Rapids. Eight additional sturgeon that were tagged with acoustic or radio transmitters moved through Birthday Rapids in both directions (Table 6-16); one of these fish was relocated in Clark Lake before moving back downstream, indicating successful passage through Long Rapids.

Importance of movements

Too few lake sturgeon were captured between Gull Rapids and Kettle GS during genetics studies (2005–2009) to assess whether the sturgeon residing in this area are genetically distinct from those residing in the Nelson River between Clark Lake and Gull Rapids (see Section 6.3.2.5). Floy®-tag recapture data and telemetry data suggest that between approximately 5 and 30% (respectively) of lake sturgeon from the Gull Rapids vicinity may move upstream through Gull Rapids into the Gull Lake area. Movements upstream through Gull Rapids are not believed to be related to spawning, at least in the year of capture, because: i) no sturgeon that were Floy®-tagged downstream of Gull Rapids during spring were recaptured upstream of the rapids later that same spring; ii) acoustic- and radio-tagged fish did not move through the rapids during spring and continue to upstream spawning sites; and iii) most fish recaptured in the Birthday Rapids vicinity (the closest location where fish moving upstream through Gull Rapids could go to spawn) appeared to have originated from the Gull Lake area where they were first captured and tagged.

Movements from the Gull Lake area downstream to the Gull Rapids vicinity also are not believed to be related to spawning. Only two lake sturgeon Floy®-tagged in the Gull Lake area were recaptured within or downstream of Gull Rapids during spring, despite the relatively high overall recapture rate (~25–30%) for fish tagged in the Gull Lake area. Additionally, neither of these fish was in spawning condition when they were recaptured downstream. The single acoustic-tagged lake sturgeon (acoustic tag 36) that moved from the Gull Lake area downstream to the Gull Rapids vicinity was only relocated there during summer months.

Genetic studies of lake sturgeon in the study area (see Section 6.3.2.5) indicate that fish captured from suspected or known spawning areas in the Split Lake area (Nelson River below Kelsey GS and First Rapids on the Burntwood River) and fish captured at Birthday and Long Rapids in the Keeyask area represent two sub-populations that are genetically distinct. Floy®-tag recapture data suggest that the incidence of sturgeon movement between the Split Lake and Keeyask areas is relatively low, supporting the notion that there is limited genetic exchange between the two sub-populations. Of 166 lake sturgeon tagged between Clark Lake and Gull Rapids and later recaptured, only seven fish (4.2%) were recaptured in the Split Lake area (Table 6-15). Of the 77 lake sturgeon tagged in the Split Lake area and recaptured, only one fish (1.3%) was recaptured in the Keeyask area (Table 6-15).

Movement studies of lake sturgeon have also reported them to remain mostly within the vicinity of where they were tagged, with the exception of spring spawning migrations or movements of a few fish over long distances (Appendix 6A). Some studies have reported the use of “core areas” or “activity centers,” locations heavily used and frequently returned to by sturgeon (Appendix 6A). In some cases, use of these core areas is accompanied by much farther ranging movements by a small percentage of fish. Floy®-tag recapture and telemetry data for lake sturgeon in the study area suggest that the river reach between Birthday and Gull rapids is part of the home range of some lake sturgeon that typically reside below Gull Rapids and, similarly, that the Gull Rapids vicinity is part of the home range of a comparatively smaller proportion of the lake sturgeon that reside in Gull Lake or between Gull Lake and Birthday Rapids.

6.3.2.8 Harvest

There is currently no commercial harvest permitted for lake sturgeon in the study area or elsewhere in Manitoba. However, lake sturgeon are harvested for domestic use by First Nation communities within the study area. Local resource users reported captures of 37 Floy®-tagged sturgeon from 1999–2009 for an approximate minimum harvest rate of 3.6% for the study area. Most of the reported recaptures by resource users were from either Split Lake or Gull Lake.

6.3.3 Current Trends/Future Conditions

Certain characteristics of the lake sturgeon’s life history, such as a variable spawning interval for males and females, long time to maturity, and longevity (greater than 60 y), make it difficult to determine current population trends over the relatively short period during which investigations were conducted. The presence of young fish indicates that recruitment is occurring. However, although habitat in the Clark Lake to Stephens Lake area currently supports all the life history requirements for lake sturgeon, population estimates are low, and the long-term sustainability of this population is uncertain. Numbers may be increasing in the Split Lake area, increasing the likelihood of the persistence of this population, if other factors (such as mortality) remain constant. The extremely small numbers of spawning sturgeon at Gull Rapids makes it unlikely that the Stephens Lake group is presently a self-sustaining population.

6.4 PROJECT EFFECTS, MITIGATION AND MONITORING

6.4.1 Construction Period

The following section considers potential effects on lake sturgeon related to the construction of the Keeyask GS. The assessment is based on construction-related effects to water quality (Section 2.5.1), physical attributes of aquatic habitat (Section 3.4.1), and lower trophic levels, particularly macroinvertebrates (Section 4.5.4.1).

Through the following pathways, the Project has the potential to affect lake sturgeon during construction:

- Relatively rapid changes in water levels and velocities in Gull Lake during Stage II construction;
- Disruption of spawning activity due to disturbance by construction activity and habitat loss/alteration;
- Alteration of aquatic habitat in Stephens Lake due to sediment deposition;
- Stranding of fish during cofferdam dewatering;
- Entrainment of fish in water intake pipes used for construction;
- Blasting effects; and
- Water quality effects from instream construction activities, malfunctions, or accidental spills.

Effects that begin during construction but are a permanent feature of operation (*e.g.*, flooding of terrestrial area) are considered under the operation period (Section 6.4.2).

6.4.1.1 Upstream of the Outlet of Clark Lake

Construction-related effects are not expected upstream of the outlet of Clark Lake as lake sturgeon in this reach will not be directly affected by construction of the Keeyask GS. Further, it is not expected that fishing activity, due to the presence of construction workers, will increase for populations upstream of the outlet of Clark Lake. Lake sturgeon may emigrate upstream from areas of habitat disturbance in the reach below Clark Lake, resulting in a small increase in the number of lake sturgeon in the Split Lake area. Over time, some lake sturgeon that move upstream may return downstream to the reservoir.

6.4.1.2 Downstream of the Outlet of Clark Lake

6.4.1.2.1 Changes to Water Quality

The following summarizes the potential impacts to lake sturgeon resulting from changes in water quality due to Project construction. A detailed discussion of potential effects of Project construction on water quality is found in Section 2.5.1. As discussed in Section 2.5.1, no impacts are expected as a result of accidental spills and releases of hydrocarbons and other hazardous materials due to safe handling and spill containment measures outlined in the Project Description (Project Description Supporting Volume [PD SV] Section 3.12). Consequently, accidental hydrocarbon spills and releases are expected to have no effect on lake sturgeon.

Effects of construction activities on total suspended solids (TSS) are described in detail in Section 2.5.1.1. No consequential effects on lake sturgeon are expected from the negligible to moderate increases in TSS predicted.

Wastewater effluent from the water treatment plant will be discharged into the main channel of the Nelson River. The effluent will meet Manitoba Conservation's Tier 1 Water Quality Standards for Secondary Treatment Technologies Discharging into Receiving Waters (as discussed in Section 2.5.1). Because the wastewater will meet or exceed Manitoba's standards for fecal coliform, biological oxygen demand, and total suspended solids, effluent inputs to the Nelson River will not have a detectable effect on lake sturgeon.

6.4.1.2.2 Sedimentation

Effects of construction activities on sedimentation are described in Section 3.4.1.4. Instream construction activities are predicted to result in the deposition of a 0.1–0.6 centimetre layer of sediment on the bottom of Stephens Lake; it is expected that this deposition will not result in a change in substrate composition (*e.g.*, sand will settle on existing areas of sand, silt will settle on existing areas of silt). Most of the deposition is predicted to occur near the entrance of Stephens Lake in an area approximately 4–6 km downstream of Gull Rapids that provides suitable habitat for YOY and sub-adult lake sturgeon (Section 6.3.2.3.2).

6.4.1.2.3 Blasting

Blasting will generally be conducted in accordance with DFO guidelines for the use of explosives in or near Canadian fisheries waters (Wright and Hopky 1998) to ensure compliance with various fish and fish habitat protection provisions of the Fisheries Act (including provisions to protect spawning beds during egg incubation).

6.4.1.2.4 Water Intake

During construction, water will be required for several uses including potable water for the camp and work areas, and water for mixing concrete. Intake pipes will be screened according to current end-of-pipe fish screening guidelines (DFO 1995) to minimize the entrainment and impingement of fish. Consequently, it is expected that water intakes will have no effect on lake sturgeon.

6.4.1.2.5 Mortality and Injury

Lake sturgeon may become stranded when dewatering occurs within cofferdams. Stranding will be mitigated through fish salvage operations that will involve the capture and release of fish back into the river.

There is a potential for increased fishing activity due to the presence of construction workers and increased access during Project. To reduce the effects of increased harvesting, the KCNs and Manitoba

Hydro, in consultation with Manitoba Conservation, will develop an Access Management Plan prior to construction. Given that construction workers will not be allowed to bring boats to the site and that fishing will not be allowed in the construction area, no potential for the harvest of lake sturgeon exists.

6.4.1.2.6 Loss and Alteration of Habitat in Footprint of Instream Structures

Cofferdam construction in the north and central channels and on the north bank of the south channel (Stage I Diversion) will eliminate lake sturgeon spawning and foraging habitat in the footprint of these structures and immediately downstream of them. Despite elevated flows and increased water velocity through the south channel during this phase, a reduced amount of spawning and foraging habitat is expected to remain in the vicinity of the islands along the south bank of this channel, where suitable habitat currently exists; however, it is not known whether sturgeon will use this habitat (Map 6-7 to Map 6-9). Given this uncertainty, construction processes, such as blasting and the release of TSS, will be managed on the basis that lake sturgeon are continuing to spawn in the south channel during construction, to allow for appropriate protection of sensitive early life stages.

Complete closure of the river through construction of cofferdams across the south channel (Stage II Diversion) will destroy remaining spawning and foraging habitat in the footprint of these structures. The cofferdams will not affect lake sturgeon in the Nelson River upstream of Gull Rapids as those fish use habitat upstream of the rapids.

In addition to effects to habitat, construction of the cofferdams has the potential to trap fish. This effect will be mitigated by conducting a salvage fishery of this area prior to dewatering. Cofferdam construction is not expected to affect the availability of foraging habitat (via effects to macroinvertebrates) in the reach between Gull Rapids and Stephens Lake (Section 4.5.4.1).

During construction of the North, Central, and South dams, river flows will be passed without regulation through sluiceways of the partially completed spillway (see Physical Environment Supporting Volume [PE SV] Section 4.4.1.4). Passage of flow through the spillway will result in negligible flows along the south bank of the south channel, rendering this area unsuitable for lake sturgeon spawning. Due to high, unregulated flows, habitat immediately downstream of the spillway is unlikely to be suitable for spawning or foraging. Slack water areas downstream of the central cofferdam and powerhouse area will not be suitable for spawning, but may provide some foraging habitat for lake sturgeon.

Spawning habitat losses in Gull Rapids are expected to be offset by the construction of spawning structures (Appendix 1A) downstream of the GS (see also Section 6.4.2.3.1). However, spawning structures would not be in place until construction of the GS is complete. Lake sturgeon stocking (Appendix 1A) in Stephens Lake will be implemented to offset potential recruitment losses during the construction period (see Section 6.4.2.4).

6.4.1.2.7 Net Effects of Construction with Mitigation

Lake sturgeon may move away from the construction area, either upstream into Split Lake or downstream into Stephens Lake during the construction period, in response to noise and other disturbance, and as water levels in the reservoir gradually rise during Stage I and Stage II river management (PE SV Section 4.4.1). Although adult and older sub-adult sturgeon that emigrate cannot be replaced, stocking will be used to maintain the total number of sturgeon and replace lost year classes if emigration results in reduced population numbers in the Keeyask area..

The lack of lake sturgeon spawning success downstream of the GS due to the loss of spawning habitat in Gull Rapids will be mitigated through stocking in Stephens Lake during the construction period. A more detailed description of the stocking program is provided in Section 6.4.2.4 and in Appendix 1A. The loss of foraging habitat within Gull Rapids is expected to have a minimal effect on lake sturgeon in Stephens Lake because there will still be sufficient foraging habitat in the reach between the GS and the lake and in the western portion of the lake near the original Nelson River channel (see also Section 6.4.2.3.1). Deposition predicted to occur near the entrance of Stephens Lake at suitable habitat for YOY and sub-adult lake sturgeon is unlikely to affect lake sturgeon use of this area (see also Section 6.4.2.3.1); however, monitoring will determine if lake sturgeon continue to use this habitat.

In summary, the following mitigation measures will be implemented to address construction effects on lake sturgeon:

- Avoidance of instream construction during sensitive spawning periods, where possible;
- Fish salvage prior to dewatering;
- Application of guidelines for end-of-pipe screening and blasting;
- Measures to reduce effects on water quality;
- Construction of spawning habitat downstream of the tailrace (see also Section6.4.2.3.1); and
- Stocking in both the reservoir and Stephens Lake.

6.4.2 Operation Period

Through the following pathways, the Project has the potential to affect lake sturgeon during operation:

- Increase in lake sturgeon movements upstream to Split and Clark lakes due to velocity changes as a result of impoundment (*e.g.*, reduction in velocity at Birthday Rapids);
- Habitat changes in the reservoir due to changes in water levels and flow that will result in the loss or alteration of existing habitat (riverine channels in Gull Lake, Birthday Rapids) and creation of new habitat;
- Creation of a barrier to upstream fish movement at Gull Rapids due to the presence of the GS;
- Changes in downstream movement of larval, juvenile and adult fish due to the creation of the reservoir and presence of the GS structures (*i.e.*, dam, spillway, trash racks and turbines);
- Loss of Gull Rapids;
- Alteration of habitat in the river channel between Gull Rapids and Stephens Lake;
- Potential for fish to become stranded after spillway operation; and

- Changes in harvest levels.

6.4.2.1 Upstream of Outlet of Clark Lake

6.4.2.1.1 Habitat

Aquatic habitat upstream of the outlet of Clark Lake (*i.e.,* Split Lake area) is predicted to not be affected by operation of the Project (Section 3.4.2.1). Therefore, the Project will not have any effect on habitat used by lake sturgeon in this reach for spawning, rearing, foraging, or overwintering.

6.4.2.1.2 Movements

Although movements of lake sturgeon from below Clark Lake into the Split Lake area have been documented (Section 6.3.2.7), sturgeon populations downstream of Clark Lake are not believed to rely on habitat in the Split Lake area and currently the incidence of movements upstream into the Split Lake area appears to be low. However, upstream movement of lake sturgeon in response to habitat disturbance in the Keeyask GS reservoir may occur as was observed with other fish species during impoundment of the Desaulniers River, Québec (Boucher 1982). Telemetry data suggest that Birthday and Long rapids currently are not a barrier to upstream movement of adult lake sturgeon. Emigration of lake sturgeon upstream is not expected to affect the current population in the Split Lake area as it contains ample habitat to support additional fish; over time, some lake sturgeon that move upstream may return downstream to the reservoir.

Habitat changes downstream of Clark Lake are not expected to affect sturgeon in the Split Lake area since they are not dependent on downstream habitat.

6.4.2.1.3 Health

Aquatic habitat and water quality upstream of the outlet of Clark Lake are not expected to be affected by operation of the Project (Section 3.4.2.1). Therefore, the Project is not expected to have any effect on the amount or quality of lake sturgeon foraging habitat (and therefore on the growth and condition of sturgeon) in this area.

6.4.2.1.4 Net Effects with Mitigation

The Project is predicted to have minimal impacts on lake sturgeon and no effect on their habitat in the Split Lake area. In the short-term, lake sturgeon abundance may increase slightly in this area as a result of lake sturgeon moving away from the Keeyask reservoir in response to habitat disturbances associated with impoundment. However, the rate of emigration to upstream areas is expected to be low as it is in the current environment because Long Rapids will remain unchanged. Over time, some lake sturgeon that move upstream may return downstream to the reservoir.

Although direct effects to lake sturgeon in the Split Lake area are predicted to be minimal, stocking of sturgeon (Appendix 1A) into suitable habitat at the upper end of Split Lake as part of a broader initiative to augment remnant populations is expected to increase the population in the long term.

6.4.2.2 Outlet of Clark Lake to Keeyask Generating Station

6.4.2.2.1 Applicability of Proxies

The reach of the Nelson River between Clark Lake and the Keeyask GS will undergo substantial changes in habitat post-impoundment. There are several examples of reservoirs where sturgeon populations are much lower than they appear to have been in the pre-impoundment river reach including: Stephens Lake (Section 6.3); Long Spruce reservoir; and Limestone reservoir. However, sturgeon numbers have been maintained in other reservoirs (*e.g.*, Nelson River above Kelsey GS, Winnipeg River between Slave GS and Pointe du Bois GS) or subsequent declines have been attributed to other factors (*e.g.*, harvest). The reasons behind the sustained presence or decline in a lake sturgeon population at a given reservoir are complex, and appear related to a variety of factors including: the availability of suitable habitat to support all life history functions; sturgeon immigration and emigration; and fishing mortality.

In general, Stephens Lake provides a reasonable proxy for the future Keeyask reservoir; however, use of this lake specifically to assess habitat suitability for lake sturgeon in the Keeyask reservoir is confounded by the lake's low sturgeon population density. Although the reasons for the current low numbers of lake sturgeon in Stephens Lake are not known, likely contributing factors include fishing mortality in combination with emigration and habitat changes during and following impoundment of the Kettle GS.

Field studies indicate that suitable habitat exists in Stephens Lake to support all life history stages of lake sturgeon. Lake sturgeon spawn at Gull Rapids, and sub-adult and adult sturgeon forage in the reach between Gull Rapids and the inlet to Stephens Lake, as well as in the original Nelson River channel in the western portion of the lake (Section 6.3.2.3 and Section 6.3.2.4). An area (50 ha) of habitat with suitable substrate, depth, and velocity for YOY is present, and is currently used by two to four year old (and possibly younger) sturgeon. There also appears to be rearing habitat in the reach between Gull Rapids and Stephens Lake proper[6]. Since habitat does not appear to be limiting, it is more likely that the small number of spawners, attributable at least in part to higher than sustainable fishing mortality over the past decades, is a major factor preventing the population from recovering to a density comparable to that currently occupying the reach between Clark Lake and Gull Rapids.

Limestone GS and Long Spruce GS reservoirs both contain "remnant" lake sturgeon populations, but certain physical features of these reservoirs limit their suitability as proxies for predicting conditions for lake sturgeon in the future Keeyask reservoir. Both Limestone and Long Spruce reservoirs are much shorter in length (16 and 23 km long, respectively) than the Keeyask reservoir (37 km) and are more homogenous with regards to habitat, being very deep with little littoral zone. At the conclusion of the Limestone Monitoring Program (1985–2003), there was no evidence that successful recruitment of lake sturgeon was occurring or would occur, within either waterbody (NSC 2012). Although many of the sturgeon captured are younger than the age of the reservoir, it remains unclear whether the young

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[6] Optimal rearing conditions (in particular, sand or sand/gravel substrates) were not detected at the level of detail used in sonar bottom-typing of this area; however, two YOY lake sturgeon were captured in this reach during environmental studies (Section 6.3.2.2).

sturgeon are a product of spawning within the reservoirs or are immigrants from upstream. The majority of lake sturgeon captured in these reservoirs are taken in the upper, more riverine areas. Researchers on the Winnipeg River have also found that sturgeon are most abundant in the upper reaches of reservoirs where conditions are more characteristic of riverine conditions (NSC 2012).

The following assessments are based firstly on habitat conditions predicted 30 years post-impoundment (Section 3) in conjunction with site-specific HSI models, and secondly, on habitat effects observed in other reservoirs, where applicable.

6.4.2.2.2 Habitat

Spawning Habitat

Environmental studies indicate that Birthday Rapids is an important spawning location for lake sturgeon in the reach of the Nelson River between Clark Lake and Gull Rapids. Alternative spawning habitat may be available in Long Rapids immediately downstream of Clark Lake (Section 6.3.2.3). Physical conditions in the Long Rapids area appear to meet depth, velocity, and substrate criteria for sturgeon spawning habitat. Evidence of sturgeon spawning activity at Long Rapids was documented during two of the four environmental studies conducted between Clark Lake and Birthday Rapids from 2001–2010. In some cases, lake sturgeon may only move upstream as far as the first set of rapids that provides suitable conditions for spawning, even if suitable habitat is also available further upstream (Section 6.3.2.3.1). Lake sturgeon in the Nelson River between Clark Lake and Gull Rapids do not appear to use Gull Rapids for spawning; therefore, the loss of Gull Rapids is not expected to affect spawning sturgeon between Clark Lake and the Keeyask GS.

The existing environment HSI model for lake sturgeon spawning habitat indicates that there is a WUA of between 9 and 12 ha from Clark Lake to Gull Rapids (Section 6.3.2.3.1). Birthday Rapids and Long Rapids and areas immediately downstream of them account for all of this area. Existing spawning habitat between Clark Lake and Birthday Rapids is not expected to be affected by the Project as flooding is not expected to extend that far upstream. However, increased water levels at Birthday Rapids due to impoundment may reduce the suitability of habitat in the rapids for spawning lake sturgeon; the post-Project HSI model suggests that these rapids will no longer be suitable for spawning due to the associated loss of white water (Map 6-44 to Map 6-46; Appendix 6D). Loss of spawning habitat due to flooding has been observed at the rapids on the Nelson River above the Kettle GS (FLCN 2008 Draft). However, some locations where increased water depth has resulted in the loss of white water but maintained appropriate velocity and substrate conditions have continued to support spawning lake sturgeon. For example, sturgeon appear to have continued to spawn in the Nelson River above the Kelsey GS following impoundment (Macdonald *pers. comm*. 2009). Therefore, it is possible that lake sturgeon will continue to use Birthday Rapids as a spawning area. Post-impoundment monitoring of spawning activity in this reach will be conducted to determine spawning success and, should monitoring indicate poor or no spawning success, contingency works to create suitable spawning habitat will be implemented. Contingency measures for the loss of Birthday Rapids as a spawning site are discussed further in Appendix 1A.

Changes to water quality are not expected to affect the suitability of spawning habitat in the riverine portion of the reservoir where lake sturgeon spawn as the analysis of sediment transport indicates that total suspended solids levels will decline post-impoundment and no consequential effects to other water quality parameters are expected (Section 2).

The current extent of predation on lake sturgeon eggs at their spawning grounds in the study area is not known. Predation by both lake sturgeon and other species is a source of mortality for lake sturgeon eggs in other systems (Appendix 6A). While the Project is predicted to change the composition of the fish community between Clark Lake and the Keeyask GS (Section 5), this change (increase in piscivorous fish species) is not expected to result in an increase in predation on lake sturgeon eggs.

Rearing Habitat (YOY)

Different life history stages of sturgeon appear to have different requirements for foraging habitat, with younger fish having more specific habitat needs than older fish (Appendix 6A). In the Nelson River between Clark Lake and Gull Rapids, YOY lake sturgeon were captured in deep, low velocity water over a mostly sand substrate in the downstream portion of Gull Lake on the north side of Caribou Island during environmental studies (Section 6.3.2.3.1). The existing environment HSI model for lake sturgeon rearing habitat show the reach between Clark Lake and Gull Rapids as having a WUA of between 199 and 220 ha (Section 6.3.2.3.1). However, almost all high quality habitat (HSI greater than or equal to 0.5; 54–64 ha) is located in the downstream portion of Gull Lake on the north side of Caribou Island, where YOY lake sturgeon were captured during environmental studies. The post-Project HSI model predicts a total rearing habitat WUA of between 445 and 637 ha. However, the amount of high quality rearing habitat for the reservoir is predicted to be lower (WUA=16–19 ha; Map 6-47 to Map 6-49; Appendix 6D). Furthermore, YOY access to the high quality habitat also is expected to be reduced given the increased area of the reservoir and the loss of moderate currents on which larvae currently rely to transport them to favourable rearing habitat in the lower end of Gull Lake. Because of this, it is uncertain whether the post-Project rearing habitat will be accessible to drifting larval sturgeon. Post-Project monitoring will be conducted to determine YOY distribution and abundance and, if necessary, contingency works to create sandy habitat suitable for YOY rearing in the reservoir would be implemented; contingency measures are discussed further in Appendix 1A.

Foraging Habitat (Sub-adult and Adult)

During the initial years post-impoundment, conditions over the newly flooded terrestrial habitat would not be optimal for lake sturgeon, which appear to favour deeper, more riverine, mineral substrate environments in the Nelson River (Section 6.3.2.3.1). Both sub-adult and adult lake sturgeon were captured or relocated via telemetry between Birthday Rapids and Gull Rapids, but were mainly found in Gull Lake (Section 6.3.2.3.1). In Gull Lake, sub-adults occupied a narrower range of conditions, favouring deep, low to moderate velocity areas. Adult sturgeon were also observed in the reach between Clark Lake and Birthday Rapids.

Lake sturgeon will continue to be able to use habitat in the former mainstem and Gull Lake that are not expected to experience the changes in water quality (Section 2.5.2.2) that are predicted for flooded shallow water lentic habitats (decreased dissolved oxygen, flooded terrestrial organics and episodic increases in suspended sediments). Over time, as the substratum evolves, lake sturgeon could begin to use flooded portions of the reservoir as conditions become suitable.

The long-term use of the reservoir by sub-adult and adult sturgeon was modeled separately. The post-Project HSI models predict a net gain of approximately 600–750 ha (WUA) of foraging habitat for sub-adults and a net gain of approximately 3,000–3,150 ha for adults (Map 6-50 to Map 6-55; Appendix 6D).

Currently, there appears to be a sufficient food supply for lake sturgeon between the outlet of Clark Lake and Gull Rapids (Section 6.3.2.3.1). Overall, benthic invertebrate abundance is expected to increase between Clark Lake and the Keeyask GS in both the short-term and long-term (Table 4-34), suggesting there will be an adequate food supply for both sub-adult and adult lake sturgeon post-Project.

The majority of the lake sturgeon captured in the Long Spruce and Limestone reservoirs are taken in the upper end of the reservoirs where conditions are more characteristic of riverine habitat (NSC 2012). These observations suggest that, while the amount of usable foraging habitat (*i.e.,* WUA) upstream of the Keeyask GS will be higher in the post-Project environment, not all this habitat may be selected by either sub-adult or adult fish.

Overwintering Habitat

Localized reductions in dissolved oxygen in nearshore zones may reduce the quality of habitat in off-current areas during winter, particularly in the first year post-impoundment (Section 2.5.2.2). However, these reductions are expected to have a limited effect on lake sturgeon overwintering habitat as ample well-oxygenated deep-water habitat will be available during winter.

6.4.2.2.3 Movements

Studies conducted to date have recorded incidental movements of lake sturgeon through Birthday Rapids and Gull Rapids (Section 6.3.2.7). Lower velocities and increased depth at Birthday Rapids may facilitate passage of lake sturgeon upstream through the rapids. It is possible that sturgeon will emigrate upstream or downstream away from the reservoir in response to habitat changes resulting from impoundment. Upstream emigration of other fish species was observed in the Desaulniers River, Québec (Boucher 1982), and downstream emigration was documented for lake sturgeon moving out of the Limestone reservoir within the first five years after impoundment (NSC 2012). Over time, some lake sturgeon that move upstream may return downstream to the reservoir. Although fish that permanently leave Gull Lake will not be replaced with the same age classes, conservation stocking will be used to maintain the total number of lake sturgeon in the reservoir. Details of the stocking program are provided in Appendix 1A.

Downstream movements of lake sturgeon through the Keeyask GS would represent a permanent loss to the population between Clark Lake and the Keeyask GS, as movements back upstream would be blocked by the dam. Implementation of upstream fish passage (Section 6.4.2.3) would mitigate the loss of lake sturgeon from the Keeyask reservoir.

The lake sturgeon population in the Keeyask reservoir will also potentially be affected by the loss of access to habitat in Stephens Lake and the barrier to the upstream movement of fish from Stephens Lake (*e.g.*, potential loss of inputs to the population from immigration). The effect of the GS as a barrier to movements in the context of Stephens Lake is discussed below in Section 6.4.2.3.2

6.4.2.2.4 Health

Growth and condition of many large-bodied fish species (including lake sturgeon) could increase after impoundment in response to increased primary and secondary production (Section 5.4.2).

6.4.2.2.5 Mortality and Injury

Improved road and waterway access has the potential to increase access to the Gull Lake area, and therefore opportunity for domestic harvest of lake sturgeon. Development of a lake sturgeon conservation awareness initiative to inform domestic resource users of the vulnerability of the lake sturgeon populations in the Keeyask reservoir and Stephens Lake will mitigate the potential for effects of increased harvest.

Downstream movement of lake sturgeon through the GS could result in injury or mortality due to turbine strikes. Turbine mortality would ultimately affect lake sturgeon downstream of the GS by reducing the number of immigrants entering the Stephens Lake population. Both the turbines and spillway will incorporate design features to reduce the risk of injury and mortality to fish (Appendix 1A).

6.4.2.2.6 Net Effects with Mitigation

Lake sturgeon require a range of habitat types to fulfill their life history requirements, including distinct habitat types for egg and larval development, and feeding of juveniles and adults. It has been suggested that a minimum of 250–300 km of barrier-free river and lake habitat are necessary to support a self-sustaining lake sturgeon population (Auer 1996). However, lake sturgeon have been documented thriving in much smaller reaches such as the Kelsey GS reservoir in the Nelson River; and the Seven Sisters and Slave Falls reservoirs in the Winnipeg River, MB (Macdonald 1998; NSC *unpubl. data*). Lake sturgeon have also been found to limit their movements to a relatively short reach of river even in the absence of physical barriers that would prevent movement further upstream or downstream (Appendix 6A). There are examples of other sturgeon species thriving in relatively short reaches of impounded river (*e.g.,* white sturgeon, *Acipenser transmontanus*, in the Bonneville and Dalles reservoirs on lower Columbia River; Kern *et al.* 2004, 2005; Oregon Department of Fish and Wildlife [ODFW] 2005).

The Keeyask area appears to contain habitat for sturgeon to fulfill all their life history functions, with two sets of rapids to provide spawning habitat, and 40 km of riverine and lacustrine environments that provide rearing, foraging, and overwintering habitat. Although the sturgeon population within this reach is relatively small, YOY, sub-adult, and adult fish have all been captured, indicating that successful recruitment is occurring.

Predicted changes to lake sturgeon habitat between Clark Lake and Gull Rapids include the potential loss of Birthday Rapids as a spawning site and the loss of riverine areas within Gull Lake associated with its conversion to a reservoir environment. It is possible that sturgeon will use spawning habitat in Long Rapids if conditions at Birthday Rapids are no longer suitable for spawning. Post-Project monitoring of spawning activity at these rapids will be conducted to determine spawning success and, should monitoring indicate poor or no success, contingency works to enhance shoreline areas at Birthday Rapids and create suitable spawning habitat will be implemented (Appendix 1A).

Riverine areas that will be lost from Gull Lake appear to be particularly important habitat for YOY and sub-adult lake sturgeon and there is uncertainty whether the combination of physical features that currently make these areas suitable to young sturgeon (particularly YOY) will be present in sufficient quantity to sustain the population in the post-Project environment. Although the amount of YOY habitat that will be available after impoundment is predicted to be similar in quantity to that which is currently present, the more highly suitable habitat is not expected to be accessible to drifting larval sturgeon in the post-Project environment. Predicted changes to the water regime in Gull Lake suggest that it may be necessary to create compensatory YOY habitat via strategic placement(s) of sand in the reservoir. However, prior to undertaking such compensation works, monitoring of physical parameters will be conducted to confirm substrate and velocity conditions that develop after impoundment. Physical environment monitoring would be conducted in conjunction with assessments of YOY and young sub-adult lake sturgeon distribution and abundance in relation to post-Project depth, velocity, and substrate conditions to refine locations where sand should be placed, if it is deemed necessary. Preliminary details of the sand placement strategy for the reservoir are provided in Appendix 1A.

The potential effect of loss of access to habitat in Stephens Lake/loss of immigrants from Stephens Lake is discussed below (Section 6.4.2.3.2).

Lake sturgeon abundance between Clark Lake and the Keeyask GS may decline in the short-term due to movements of lake sturgeon upstream into the Split Lake area or downstream (through the GS) into the Stephens Lake area in response to environmental disturbance associated with construction and initial operation. The status of small lake sturgeon populations in other reservoir environments such as the Kettle, Long Spruce, and Limestone reservoirs on the lower Nelson River (NSC 2012) and the Opinaca and Robert-Bourassa reservoirs in Québec (Hayeur 2001), suggest that a longer-term decline in lake sturgeon abundance may occur after impoundment. Therefore, in addition to the mitigation measures discussed above, a stocking plan has been developed to enhance the existing population in this reach and to compensate for potential population reductions. The stocking plan would be implemented prior to the start of construction, and would include the introduction of fall fingerlings (three to four months old) and spring yearlings to the reservoir. Stocking of fingerlings and yearlings by-passes the more vulnerable life stages, which have the most specific habitat requirements (eggs, larvae, and early YOY). Maintaining a viable population will prevent the long-term decline that seems to have occurred in some reservoirs, such as Stephens Lake. Details of the stocking plan as it pertains to this reach of the Nelson River as well as other locations in the study area are provided in Appendix 1A.

Domestic fishing mortality will be mitigated through the development of a conservation awareness program. Mortality and injury as a result of downstream movements through the powerhouse or over the spillway will be mitigated through the incorporation of design features to reduce mortality and injury (Appendix 1A)

6.4.2.3 Keeyask Generating Station to Kettle Generating Station

The following assessment is based on habitat conditions predicted 30 years post-impoundment (Section 3) in conjunction with site-specific HSI models (Appendix 6D).

6.4.2.3.1 Habitat

Spawning Habitat

Gull Rapids is the only known spawning location of lake sturgeon residing in Stephens Lake (Section 6.3.2.4). Members of CNP and FLCN are concerned that lake sturgeon spawning habitat will be lost at Gull Rapids (FLCN 2010 Draft; CNP Keeyask Environmental Evaluation Report) and those sturgeon that remain will be trapped between dams with less available habitat (CNP, YFFN and FLCN 2011). The existing environment HSI model for lake sturgeon spawning habitat indicates that there is a total WUA of between 13 ha and 18 ha (of which between 1.1 ha and 3.8 ha are high suitability habitat) within and at the base of Gull Rapids (Section 6.3.2.3.2). Construction of the GS will result in the loss of all potential spawning habitat in these areas (Map 6-44 to Map 6-46; Appendix 6D). There is currently no evidence of lake sturgeon from Stephens Lake moving upstream of Gull Rapids to spawn (Section 6.3.2.7), but the GS would block any such movements.

To compensate for the loss of spawning habitat, several areas will be developed to provide suitable spawning habitat (see Appendix 1A for a detailed description). A spawning structure will be constructed along the north bank immediately downstream of the tailrace. The structure will consist of a 3 ha area with a base comprised of cobbles and boulders with a minimum diameter of 0.1 m to allow for ample interstitial spaces for egg incubation, and clusters of three large (greater than 0.9 m) boulders spread over the structure to create off-current resting areas and turbulent flow. A range of depths (1–10 m) and velocities (0.5–1.5 m/s) will occur over the structure. During the lake sturgeon spawning and egg incubation period (late May to mid-July), operation of the GS will be constrained to include continuous operation of the two units immediately upstream of the structure to ensure adequate flows (PD SV Section 6.6). The structure will be monitored to determine whether successful spawning is occurring and, if not, it will be modified as required.

Lake sturgeon may, under some flow conditions, move upstream past the spawning structure and into the tailrace as has been observed below other GSs such as the Slave Falls GS and the Pointe du Bois GS on the Winnipeg River (McDougall *et al.* 2008a, b). To provide appropriate habitat, the north bank of the tailrace will be modified to create a shelf with coarse substrates and cuts in the wall of the tailrace will guide sturgeon moving at depth up towards the suitable substrate. Larval lake sturgeon that emerge from the spawning structures will be entrained in the flow from the powerhouse and transported downstream to rearing habitat that has been identified north of Cabin Island (Map 6-31 and Map 6-32 and see next section).

In addition, coarse materials from the remnants of the tailrace cofferdam will be spread to create conditions attractive to spawning fish in areas where interference with the outflow from the GS will not be a concern. The tailrace cofferdam extends from the transmission tower spur downstream and then to the north bank; locations where remnants will be left will be determined following further hydraulic modelling.

Lake sturgeon could also use habitat in the river below the spillway in years when the spillway is operating at sufficient discharges during the spawning and egg incubation period (estimated 20-30% of years; PD SV). During those years when discharge from the spillway appears adequate to attract spawning sturgeon, the spillway channel and immediate downstream river environment will be monitored to determine whether lake sturgeon are spawning in this area and, if so, attempts will be made to identify locations and timing of egg deposition. If eggs are deposited, spillway discharge would be maintained at levels sufficient to permit egg hatch and survival of larval fish until they emerge and drift from the site.

Egg survival and hatch success will not be affected by Project changes in water quality (Section 2.5.2). In addition, as mentioned above, the GS will be operated to provide adequate flows and minimize water level fluctuations during sturgeon spawning and egg incubation periods to promote spawning and prevent exposure of eggs or larvae. It is not expected that the Project will result in increased predation on sturgeon eggs since the species composition of the Stephens Lake fish community is not expected to change as a result of the Project.

Rearing Habitat (YOY)

Young-of-the-year lake sturgeon are generally found in shallow or deep water in areas of low velocity over a sand or sand/gravel substrate (Appendix 6A). The existing environment HSI model for lake sturgeon rearing habitat suggests that there is no high suitability habitat (HSI greater than or equal to 0.5) for YOY between Gull Rapids and Stephens Lake (Section 6.3.2.3.2). The capture of 3-month-old (approximate) YOY sturgeon over cobble/boulder substrate along the south shore between the rapids and the lake, suggests that older YOY can survive in what is thought to be less than optimal habitat, or that YOY in this area are occupying microhabitats (*e.g.,* sand/gravel patches behind boulders) that were not detected at the scale that bottom typing sonar data were collected (Section 3).

Habitat suitable for YOY sturgeon is present in the western portion of Stephens Lake north of Cabin Island (Section 6.3.2.4.2); analysis of post-Project sedimentation indicates that this area will not be subject to silt deposition during construction or operation (PE SV).

Because the number of lake sturgeon residing downstream of Gull Rapids is considerably reduced compared to historic levels, a stocking program will be implemented to avoid possible effects of a temporary reduction in rearing habitat should it occur (Appendix 1A) and potentially increase lake sturgeon abundance in Stephens Lake.

Post-Project monitoring of physical conditions (water velocity and substrate development) will be conducted in conjunction with an assessment of YOY and yearling distribution and abundance downstream of the Keeyask GS to ensure that there is sufficient rearing habitat. Should monitoring indicate that high quality rearing habitat is lacking, contingency works to create sandy habitat within the reservoir downstream of the GS would be implemented (Appendix 1A).

Foraging Habitat (Sub-adult and Adult)

Environmental studies conducted between Gull Rapids and Kettle GS indicate that both sub-adult and adult lake sturgeon forage primarily in riverine habitat downstream of Gull Rapids, particularly within or near the original Nelson River channel in the western portion of the reservoir (sections 6.3.2.3.2 and 6.3.2.4.2).

Sub-adult lake sturgeon were not documented within Gull Rapids during environmental studies; however, there is evidence that some adult sturgeon feed within Gull Rapids (Section 6.3.2.3). The footprint of the GS, the barrier to upstream movement that it creates, and de-watering of Gull Rapids, will eliminate or prevent access by Stephens Lake sturgeon, to all foraging habitat within the rapids.

The post-Project HSI sub-adult foraging habitat model predicts a loss of or loss of access to, approximately 8-10 ha (WUA) of sub-adult foraging habitat within and at the base of the rapids, and a gain of approximately 9–18 ha between the rapids and Stephens Lake. This amounts to a net gain of between 0–8 ha of sub-adult foraging habitat (Map 6-50 to 52; Appendix 6D) for Stephens Lake sub-adult lake sturgeon.

The post-Project HSI adult foraging habitat model predicts a loss of or loss of access to, approximately 143–157 ha (WUA) of adult foraging habitat within and at the base of the rapids, and somewhere between a loss of 3 ha and a gain of 21 ha of adult foraging habitat between the rapids and Stephens Lake. Depending on flow, the model predicts a net loss of or loss of access to, approximately 131–152 ha of adult foraging habitat (Map 6-503 to Map 6-555; Appendix 6D) for Stephens Lake adult lake sturgeon.

Mitigation has not been proposed to specifically address the reduction in available foraging habitat associated with the construction and presence of the Keeyask GS. Relatively few lake sturgeon access the Gull Rapids foraging habitat and suitable adult sturgeon foraging habitat is abundant in the approximately 28,000 ha Stephens Lake.

Overwintering Habitat

Lake sturgeon that reside downstream of Gull Rapids appear to overwinter primarily in Stephens Lake (Section 6.3.2.4). Overwintering habitat is likely closely associated with the original Nelson River channel in the western portion of the lake and will not be affected by operation of the GS.

6.4.2.3.2 Movements

The GS will block upstream movements of adult lake sturgeon from below the GS, and downstream movements from the reservoir, except for fish that pass over the spillway or past the turbines. Currently, adult lake sturgeon move upstream and/or downstream over Gull Rapids (Section 6.3.2.7); however, these movements do not appear to be related to the fulfillment of a particular life history function (*e.g.*, spawning). Access to habitat in the Gull Lake area does not appear to be critical to the lake sturgeon population downstream of Gull Rapids, and likewise, sturgeon in Gull Lake do not appear to require habitat in Stephens Lake. Consequently, provision of upstream and downstream passage at the GS would provide no clear benefit to either the Gull Lake or the Stephens Lake sturgeon populations.

The mitigation approach for potential effects of a physical barrier to upstream movement of either population is to provide habitat for all life history stages both upstream and downstream of the GS. The objective is to create/maintain self-sustaining populations in both areas. This approach avoids reliance on untested fish passage methods. (No fishways that successfully allow movement of lake sturgeon upstream and downstream past a facility the size of the, or in the climatic setting of Keeyask GS exist.) However, a need was identified to include upstream fish passage in the Project design to maintain existing connections among fish populations. This reflects a precautionary approach with respect to uncertainty regarding the importance of maintaining connections among populations. Provision of fish passage would provide lake sturgeon with access to a greater habitat area, including riverine habitat upstream of Birthday Rapids, and avoid creating a partially isolated population in Stephens Lake.

The phased approach to fish passage described in Appendix 1A will permit trial implementation of fish passage for lake sturgeon with minimal risk to the Stephens Lake population. Analyses conducted to date indicate that a trap/catch and transport program would be the most effective method to test the success of upstream passage and evaluate future options. Trap/catch and transport will also allow selection of lake sturgeon for upstream passage (for example, to avoid depleting the Stephens Lake population, only sturgeon that tags indicate originated from upstream of Gull Rapids may be transported). Implementation of the fish passage program will be conducted in close consultation with DFO and Manitoba Conservation and Water Stewardship (MCWS) and rely on monitoring to determine the success of the program and potential modifications.

Sturgeon moving downstream from the Keeyask reservoir would need to pass either over the spillway (when it is in operation) or past the trash racks and turbines. Effects to lake sturgeon would likely be similar to those of other fish (Section 5). Trash racks would physically exclude the largest sturgeon (greater than 1.4 m in fork length), though slightly smaller fish would likely not pass due to avoidance behaviour. Although experimental studies of turbine effects have not been conducted with lake sturgeon, studies of fish movements in the Limestone reservoir have recorded downstream passage by lake sturgeon both over the spillway and past the turbines.

During spillway operation, which is projected to occur minimally, relatively more fish may be entrained in the flow and move downstream than during normal GS operation due to high water velocities in the immediate reservoir upstream of the spillway.

In the long-term, blockage of downstream movements of sub-adult and adult lake sturgeon would reduce inputs to the downstream population through immigration. However, this effect is expected to be negligible given the current low rate of downstream movement (Section 6.3.2.7).

Creation of the Keeyask reservoir will reduce or eliminate the transport of larval lake sturgeon from the Clark Lake to Gull Rapids reach that have become entrained in the flow and carried downstream to Stephens Lake. The number of larval lake sturgeon presently entering Stephens Lake and the importance of this potential influx to the population is not known. Given that spawning sturgeon have not been captured in Gull Rapids in recent years, and that the majority of flow from spawning locations at Long and Birthday rapids moves along the south channel of the Nelson River where there are few low velocity areas for larval sturgeon to settle, it is likely that larval sturgeon may drift over Gull Rapids and into Stephens Lake. Stocking of fingerlings and yearlings into Stephens Lake, which is planned to augment the small population (see below), will also compensate for any reductions in the input of drifting larval lake sturgeon.

6.4.2.3.3 Health

Changes to the overall amount and quality of foraging habitat downstream of Gull Rapids are expected to be small relative to total available foraging habitat. No detectable effects to the condition of lake sturgeon are expected in the Keeyask GS to Kettle GS reach.

6.4.2.3.4 Mortality and Injury

At present, this reach is subject to domestic fishing but the number of sturgeon taken is not known. New road construction will increase access opportunities for domestic harvesters and thereby potentially increase lake sturgeon harvest. A lake sturgeon conservation awareness program for the Project will be developed in consultation with local domestic resource users and MCWS to highlight the sensitivity of populations in the Keeyask reservoir and immediately downstream.

There is no information available on turbine mortality rates for sturgeon. Turbine mortality rates for other VEC species are discussed in Section 5. Turbine design will include modifications to reduce the potential for injury and mortality of fish entrained in flows through the powerhouse (Appendix 1A).

Lake sturgeon downstream of the GS could become stranded in isolated pools that may form in portions of the south channel of Gull Rapids following spillway operation (Section 3.4.2.3). Measures to mitigate the effects of stranding will be implemented and include the design and construction of works to infill pools and/or create connecting channels between the pools and Stephens Lake (Appendix 1A).

6.4.2.3.5 Net Effects with Mitigation

Potential negative effects of the loss of spawning habitat are expected to be fully mitigated through the creation of compensatory spawning habitat constructed below the GS tailrace. A detailed description and diagram of the structure, its placement below the GS, and physical conditions required for the structure to be effective (*i.e.*, depth, velocity, and flow characteristics) are provided in Appendix 1A. Post-Project monitoring of spawning activity at the structure and of larval drift downstream of it, will be conducted to ensure that the structure is being used, that spawning is successful, and to determine whether any changes to the flow regime over the structure are required.

In addition to spawning habitat creation, during years when discharge from the spillway appears adequate to attract spawning sturgeon, and monitoring reveals spawning activity and egg deposition, the spillway discharge would be maintained at levels sufficient to permit egg hatch and survival of larval fish until they emerge and drift from the site.

To mitigate any potential effects related to substrate changes at identified YOY rearing habitats downstream of the Keeyask GS, post-Project monitoring of physical conditions (water velocity and substrate development) will be conducted in conjunction with an assessment of YOY and yearling distribution and abundance to ensure that there is sufficient rearing habitat. Should monitoring indicate that high quality rearing habitat is lacking, contingency works to create sandy habitat within Stephens Lake downstream of the GS would be implemented (Appendix 1A).

Stocking (Appendix 1A) of fall fingerling and yearling lake sturgeon will mitigate potential effects related to potential alteration of YOY rearing habitat and the loss of access to spawning habitat during the construction period and prior to creation of new spawning habitat. Stocking in Stephens Lake will also mitigate any potential effects related to the reduction or loss of downstream drift of larval lake sturgeon from upstream areas.

Potential effects of the barrier to upstream fish movements on the Stephens Lake sturgeon population created by the GS will be mitigated through the provision of an upstream fish passage (transport) system that would provide lake sturgeon with access to a greater habitat area but safeguard the small Stephens Lake adult spawning population.

Downstream movement of lake sturgeon through the GS could result in injury or mortality due to turbine strikes. Turbine mortality would ultimately affect lake sturgeon downstream of the GS by reducing the number of immigrants entering the Stephens Lake population. Both the turbines and spillway will incorporate design features to reduce the risk of injury and mortality to fish (Appendix 1A).

Potential stranding of lake sturgeon downstream of the GS in isolated pools following spillway operation will be avoided through the construction of connecting channels to allow fish escapement to Stephens Lake (Appendix 1A).

Potential negative effects of increased harvest on lake sturgeon as a result of improved access by domestic fishers will be mitigated through the implementation of a conservation awareness program directed at promoting lake sturgeon population growth.

6.4.2.4 Net Effects of Operation with Mitigation

Potential effects to lake sturgeon in the study area are primarily related to habitat losses or alteration associated with the presence and operation of the GS, and include the following:

- Potential reduction/degradation of spawning habitat at Birthday Rapids and complete loss of spawning habitat at Gull Rapids;
- Loss of natural lake sturgeon reproduction in Stephens Lake during the construction period;
- Complete loss of or loss of access to sub-adult and adult foraging habitat within Gull Rapids;
- Loss of access to YOY rearing habitat in Gull Lake;
- Decreased suitability of current "hot spots" for sub-adult sturgeon due to lower velocities and silt deposition throughout much of present-day Gull Lake;
- Potential stranding of lake sturgeon in isolated pools downstream of the spillway following spillway operation;
- Potential reduction/degradation of sub-adult and potential YOY rearing habitat between Gull Rapids and Stephens Lake, and in the western portion of Stephens Lake;
- Potential loss of sub-adult and adult sturgeon from the Gull Lake area due to emigration at impoundment; and

- Blockage of all upstream movements and creation of a significant barrier to downstream movement, including larval drift.

In summary, the following mitigation measures will be implemented to address operating effects on lake sturgeon:

- Monitoring to determine whether lake sturgeon continue to spawn at Birthday Rapids and, if not, placement of large structures along the shorelines to create turbulent flow to attract spawning fish;
- Monitoring of potential YOY habitat in the Keeyask reservoir and, if monitoring shows that juvenile recruitment is not successful, implementation of a program to create suitable habitat;
- Construction of spawning habitat downstream of the GS;
- Construction of channels to connect pools isolated after spillway operation to Stephens Lake to allow stranded fish to escape;
- A trap/catch and transport program for upstream fish passage. Downstream fish passage is being provided via the turbines and spillway, both of which incorporate design features to reduce the risk of injury and mortality to fish. The Project will be designed and constructed in a manner that would allow it to be retrofitted to accommodate other upstream and/or downstream fish passage options if required in the future; and
- Development of a lake sturgeon conservation awareness initiative to inform domestic resource users of the vulnerability of the lake sturgeon populations in the Keeyask reservoir and Stephens Lake.

Finally, implementation of a stocking program in the Kelsey to Kettle GS reach of the Nelson River. As discussed in Section 6.3.1, lake sturgeon were historically abundant in much of the lower Nelson River, but numbers have declined to the extent that they are currently assessed as endangered by COSEWIC and are being considered for listing under SARA. Given that construction of the Project will alter existing lake sturgeon habitat, and the uncertainties with respect to their use of constructed or altered habitats, it is proposed that stocking be used to support and enhance lake sturgeon populations within the Clark Lake to Stephens Lake reach of the Nelson River. Stocking would commence with the start of construction to compensate for the loss of natural recruitment that is expected to occur until compensatory spawning habitat has been provided. The stocking plan would include the introduction of fall fingerlings (three to four months old) and spring yearlings.

In addition, lake sturgeon will be stocked at off-site locations that currently provide habitat to support all life history functions where the current small populations are limiting the potential for recovery. To date, candidate sites have been identified in the upper Split Lake area, in the Nelson River below the Kelsey GS, the Grass River, and the Burntwood River below First Rapids (Map 1-1). A detailed description of the stocking program is provided in Appendix 1A. Principal points are provided below:

  - The stocking program will address effects of the Project, but be conducted in coordination with other regional recovery plans;

- The plan will be long-term, with a commitment by the Partnership to construct a hatchery and/or other facilities in northern Manitoba to provide the necessary infrastructure;
- Brood stock from the Nelson River will be selected based on genetic considerations, including numbers of individuals and genetic similarity to the target area;
- The program will be conducted in consideration of the need to maintain genetic diversity; and
- Target numbers and ages of fish stocked at each location will be determined based on the size and age structure of the existing population, the ability of the habitat to support additional fish, and recommended stocking rates and population targets developed elsewhere (*e.g.*, DFO 2010; Wisconsin stocking guidelines).

Stocking of lake sturgeon is one of the most effective means of recovering this species where adequate habitat is available (see Appendix 1A for details). Examples of successful conservation stocking programs include:

- The St. Louis River, a tributary of Lake Superior, where sturgeon were stocked from 1983 to 2000. Populations have increased in western Lake Superior and recently stocked sturgeon have been observed using historical spawning grounds on the St. Louis River;
- Red River of the North, a tributary of Lake Winnipeg, where a 20-year stocking plan has released fingerlings and fry across tributaries in Minnesota and lake sturgeon have been observed in the Red River to Lake Winnipeg; and
- Oneida Lake, New York, where lake sturgeon exhibited very high growth rates.

Lake sturgeon have also been stocked into the Saskatchewan, Assiniboine and upper Nelson rivers in Manitoba.

These mitigation measures have been discussed with DFO and MCWS. Additional measures that would be implemented prior to or during Project operation may be identified as a result of ongoing discussions regarding Project effects and mitigation between KHLP and these regulatory agencies.

6.4.3 Residual Effects

6.4.3.1 Construction Effects

Residual effects of the construction of the Keeyask Project are summarized in Table 6-17.

6.4.3.2 Operation Effects

Residual effects of the operation of the Keeyask Project are summarized in Table 6-18.

6.4.3.3 Summary of Residual Effects

The following are the residual effects on lake sturgeon once the appropriate mitigation measures are applied:

- Potential shift in spawning location from existing areas at or downstream of Birthday Rapids to other nearby habitat (*e.g.*, Long Rapids) (modification of the shoreline at Birthday Rapids may be required to create suitable spawning cues);
- Shift in use of YOY habitat from the river channel in Gull Lake to the river channel in the reservoir at the upstream end of Gull Lake (placement of suitable substrate may be required);
- Alteration of current preferred habitat for sub-adult lake sturgeon due to silt deposition throughout much of present-day Gull Lake. This will be offset by a general increase in the amount of habitat in the Nelson River between Clark and the GS;
- Shift in use of spawning habitat in Gull Rapids to constructed habitat in and near the tailrace;
- Replacement of larval lake sturgeon potentially entering Stephens Lake from spawning upstream of Gull Rapids with stocked fish; and
- An overall increase in the regional number of lake sturgeon due to augmentation of the currently depleted population by stocking.

The lake sturgeon response to the construction of the Project will result in moderate adverse effects over a medium spatial extent (lower reservoir and Stephens Lake) in the medium-term. In the long-term, no adverse effects to lake sturgeon numbers in the area directly affected by the Project are expected due to mitigation measures to provide habitat for all life history stages and the implementation of an extensive stocking program. An overall increase in the number of sturgeon in the Kelsey GS to Kettle GS reach of the Nelson River is expected in the long-term as a result of population augmentation due to stocking. There would be a commitment to extensive monitoring and adaptive management to modify and supplement stewardship as required to meet this goal. The adverse effects during construction are reversible (because the population will recover). The effects are continuous as they will last beyond the construction period. Finally, effects are of high ecological context due to the sensitivity of the species and the vulnerability of the population.

The technical lake sturgeon assessment is based on an analysis of their use of existing habitats and the habitat present post-Project, HSI models developed for the pre- and post-Project environments, and observations of lake sturgeon populations in a proxy reservoir (*i.e.*, Stephens Lake) and other reservoirs. These approaches provide moderate to high certainty regarding the prediction of adverse effects in the absence of mitigation. There is low to moderate certainty regarding the success of mitigation measures to create YOY habitat in the reservoir and moderate certainty regarding the success of mitigation measures to create spawning habitat in the reservoir and Stephens Lake. However, there is moderate to high certainty regarding effects to abundance following the implementation of a stocking program, resulting in an overall moderate to high certainty for the predicted increases in regional lake sturgeon numbers.

6.4.4 Environmental Monitoring and Follow-up

As described in Chapter 8 of the Keeyask Generation Project: Response to EIS Guidelines, Environmental Monitoring Plans are being developed as part of the Environmental Protection Program for the Project. The intent of the monitoring plans is to determine whether effects of the Project are as predicted and mitigation measures are functioning as intended. The monitoring plans will also provide for follow-up actions if effects are greater than predicted: the actions that would be taken depend on the nature and magnitude of the effect. The design of the monitoring plans will also consider uncertainties identified during the analysis and/or raised by the KCNs or during the regulatory review process.

An outline of monitoring planned for the lake sturgeon component of the aquatic environment is provided below. A detailed monitoring plan will be provided in the Aquatic Effects Monitoring Plan (AEMP). This document will provide a detailed description of the rationale, schedule, sampling locations and sampling methods for the technical monitoring that is proposed for the Project. This plan will be implemented in consultation with regulators, in particular DFO and MCWS, and it is expected that it will change based on regulatory review and on-going review of monitoring results. This monitoring plan will be implemented during the Project construction period and will continue into the operating period. Reports detailing the outcomes of monitoring programs will be prepared and submitted to regulators, to meet conditions of the Environment Act licence and other authorizations for the Project.

Monitoring of lake sturgeon movements will be conducted using long-term telemetry tags to address uncertainties with respect to their behavioural response to habitat disturbances during construction and the initial period of reservoir creation. In order to determine whether or not fish passage methods need to be modified, movements of lake sturgeon upstream and downstream of the GS will be monitored and their behaviour in the immediate vicinity of the GS will be observed. Monitoring for spawning activity and the presence of larval fish at locations where these would be expected to occur post-Project will be used to confirm whether or not the effects of construction and operation to spawning/rearing habitat occurred as predicted, and whether constructed habitat is functioning as intended. Sub-adult and adult lake sturgeon population size, relative abundance and condition (as well as other indicators of health) will be monitored to determine whether the reservoir and Stephens Lake provide suitable habitat for these life history stages. Stocked fish (or a subsample of) will be marked before they are released, and mark-recapture studies will be undertaken to determine their survival rates. Year-class strength in Gull and Stephens lakes will also continue to be monitored on an annual basis. In order to determine whether the predicted positive effects to the regional lake sturgeon population occur, sampling will be undertaken to estimate population size in the region (from the Kelsey GS to the Kettle GS). The frequency of each of these programs will vary; selected components will be monitored annually during instream construction and the first three years after FSL is reached, and then every three to five years for the following 20–30 years, depending on results. Monitoring of lake sturgeon populations will continue in conjunction with mitigation programs such as stocking until stocking and habitat mitigation create self-sustaining populations.

6.5 REFERENCES

6.5.1 Literature Cited

Auer, N.A. 1996. Response of spawning lake sturgeons to change in hydroelectric facility operation. Transactions of the American Fisheries Society 125: 66–77 pp.

Ambrose, K.M., Murray, L., Nelson, P.A., and MacDonell, D.S. 2008. Results of the 2006 fish community investigations focusing on lake sturgeon in the Conawapa study area. A report prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, MB. 217 pp.

Block, D. 2001. Growth estimates, habitat use and ecology of the lake sturgeon, Acipenser fulvescens Rafinesque, from Round Lake and mature reservoirs in the Winnipeg River. M.Sc. Thesis, Department of Zoology, University of Manitoba, Winnipeg, MB. 185 pp.

Boucher, R. 1982. Comportement des poissons du basin de la rivière Desaulniers après le remplissage du reservoir Desaulniers (territoire de la Baie James). Canadian Water Resources Journal 7(1): 215–228 pp.

CNP Keeyask Environmental Evaluation Report. 2012. Keeyask Environmental Evaluation: A report on the environmental effects of the proposed Keeyask Project on Tataskweyak Cree Nation and War Lake First Nation. January 2012. 78 pp. + appendices.

CNP, YFFN and FLCN. 2011. Keeyask Cree Nations and Manitoba Hydro Aboriginal Traditional Knowledge Workshop 2011. Workshop. Winnipeg, Manitoba, June 06, 2011.

Côté, G., Nelson, P.A., and Bernatchez, L. 2011. Population Genetics of Lake Sturgeon from the Churchill, Nelson, and Hayes Rivers. Draft report prepared for Manitoba Hydro. North/South Consultants Inc., Winnipeg, MB. 65 pp.

COSEWIC. 2006. COSEWIC Assessment and update status report on the lake sturgeon Acipenser fulvescens in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. Xi + 107 pp. http://publications.gc.ca/collections/collection_2007/ec/CW69-14-484-2007E.pdf [accessed May 27, 2012].

DFO (Department of Fisheries and Oceans). 1995. Freshwater intake end-of-pipe fish screen guideline. Communications Directorate, Department of Fisheries and Oceans. 28 pp.

DFO. 2010. Recovery potential assessment of lake sturgeon: Nelson River populations (Designatable Unit 3). Canadian Science Academy Secretariat, Science Advisory Report 2010/050. 24 pp.

FLCN (Fox Lake Cree Nation). 2008 Draft. Preliminary sturgeon TK study.

FLCN. 2009 Draft. Ninan – The Story of the Fox Lake Cree. Fox Lake Cree Nation, Manitoba.

FLCN. 2010 Draft. Keeyask traditional knowledge report. Fox Lake Cree Nation, Manitoba.

Harkness, W.J.K. 1980. Report on the sturgeon situation in Manitoba. MS Report No. 80–3. Manitoba Department of Natural Resources, Winnipeg, MB. 20 pp.

Hayeur, G. 2001. Summary of knowledge acquired in northern environments from 1970 to 2000. Hydro Québec, Montréal, QC. 110 pp.

Holm, J., Ambrose, K.M., MacDonell, D. 2006. Results of the 2004 fish community investigation focusing on lake sturgeon. A report prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, MB. 87 pp.

InterGroup Ltd. 2005. Nelson River Sturgeon Co-Management Board Ten Year Review: - Report on the Ten Year Review. Nelson River Sturgeon Co-Management Board, Thompson, MB. 37 pp.

Kendall, W.L. and Pollock, K.H. 1992. The Robust Design in capture-recapture studies: a review and evaluation by Monte Carlo simulation. In Wildlife 2001: Populations. Edited by D.R. McCullough and R.H. Barrett. Elsevier, London, UK. pp. 31–43 pp.

Kern, J.C., M.L. Hughes, and T.A. Rien. 2004. Report A. Evaluate the success of developing and implementing a management plan for white sturgeon in reservoirs between Bonnevile and McNary dams in enhancing production. In D.L. Ward, editor. Status and habitat requirements of white sturgeon populations in the Columbia River downstream from McNary Dam. Annual Progress Report to Bonneville Power Administration, Portland, OR.

Kern, J.C., M.L. Hughes, and T.A. Rien. 2005. Report A. Evaluate the success of developing and implementing a management plan for white sturgeon in reservoirs between Bonnevile and McNary dams in enhancing production. In D.L. Ward, editor. Status and habitat requirements of white sturgeon populations in the Columbia River downstream from McNary Dam. Annual Progress Report to Bonneville Power Administration, Portland, OR.

Kooyman, B. 1955. An analysis of data collected in 1953 and 1954 from the sturgeon fisheries on the Nelson and Churchill Rivers. Manitoba Department of Mines and Natural Resources, Winnipeg, MB. 8 pp.

Krebs, C.J. 1989. Estimating abundance: Mark and recapture techniques. In Ecological Methodology. Edited by C.M. Wilson and S. Pisano. Harper & Row Publishers, New York, NY. 15–63 pp.

Macdonald, D. 1998. Nelson River sturgeon studies 1993–1997: Five year report to the Nelson River Sturgeon Co-Management Board. Manitoba Department of Natural Resources, Winnipeg, MB. 44 pp.

MacDonell, D.S. 1997. The Nelson River lake sturgeon fishery from the perspective of the Bayline communities of Pikwitonei, Thicket Portage, and Wabowden. M.N.R.M. Thesis, Natural Resource Institute, The University of Manitoba, Winnipeg, MB. 173 pp.

Maclean, B.D. and Nelson, P.A. 2005. Population and spawning studies of lake sturgeon (Acipenser fulvescens) at the confluence of the Churchill and Little Churchill Rivers, Manitoba, spring 2003. A report prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, MB. 56 pp.

McCart, P. 1992. Nelson River sturgeon fishery: maximum sustainable yield and the impact of hydroelectric development. Aquatic Environments Limited, Spruce View, AB. 15 pp.

McDougall, C.A., Graveline, P., and MacDonell, D.S. 2008a. Preliminary investigations of lake sturgeon spawning and habitat utilization in the Slave Falls and Pointe du Bois reservoirs – 2006. A report prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, MB.

McDougall, C.A., MacDonell, D.S., Hudd, D.L., and Murray, L. 2008b. Results of Lake Sturgeon Studies in the Slave Falls Reservoir and Pointe du Bois Forebay – 2007. A report prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, MB. 236 pp.

Nelson River Sturgeon Co-Management Board (NRSCB) and InterGroup Ltd.. 1999. Five year review of the Nelson River Sturgeon Co-Management Program: Report on the five-year review. NRSCB, Thompson, MB. 18 pp.

NSC. 2012. Limestone Generating Station: Aquatic Environment Monitoring Programs. A Synthesis of Results from 1985 to 2003. A report prepared for Manitoba Hydro. 192 pp.

ODFW (Oregon Department of Fish and Wildlife). 2005. Oregon Native Fish Status Report Public Review Draft: Oregon White Sturgeon. Available from (http://www.dfw.state.or.us/fish/ONFSR/report.asp) [accessed June 15, 2011].

Patalas, J.W. 1988. The effects of commercial fishing on lake sturgeon (Acipenser fulvescens) populations in the Sipiwesk Lake area of the Nelson River, Manitoba, 1987–1988. MS Report No. 88–14. Manitoba Department of Natural Resources, Winnipeg, MB. 45 pp.

Pisiak, D.J. and Maclean, B. 2007. Population studies of lake sturgeon (Acipenser fulvescens) in the Fox River, Manitoba, summer 2004. A report prepared for Manitoba Hydro by North/South Consultants Inc., Winnipeg, MB. 42 pp.

Sopuck, R.D. 1987. A study of the lake sturgeon (Acipenser fulvescens) in the Sipiwesk Lake area of the Nelson River, Manitoba, 1976–1978. MS Report No. 87–2. Manitoba Department of Natural Resources, Winnipeg, MB. 59 pp.

Split Lake Cree – Manitoba Hydro Joint Study Group. 1996a. Analysis of change: Split Lake Cree Post Project Environmental Review. Split Lake Cree – Manitoba Hydro Joint Study Group; vol. 1 of 5.

Split Lake Cree – Manitoba Hydro Joint Study Group. 1996b. History and first order effects: Manitoba Hydro projects - Split Lake Cree Post Project Environmental Review. Split Lake Cree – Manitoba Hydro Joint Study Group; vol. 2 of 5.

Split Lake Cree – Manitoba Hydro Joint Study Group. 1996c. Environmental matrices: Summary of Manitoba Hydro impacts - Split Lake Cree Post Project Environmental Review. Support from William Kennedy Consultants Ltd. & InterGroup Consultants Ltd. Split Lake Cree - Manitoba Hydro Joint Study Group; vol. 3 of 5.

Sunde, L.A. 1959. The sturgeon fishery in Manitoba with recommendations for management: analysis of Nelson River data 1953–1956. Manitoba Department of Natural Resources, Winnipeg, MB. 27 pp.

Sunde, L.A. 1961. Growth and reproduction of the lake sturgeon (Acipenser fulvescens Rafinesque) of the Nelson River in Manitoba. M.Sc. Thesis, University of British Columbia, Vancouver, BC. 93 pp.

Tough, F. 1987. Native people and the regional economy of northern Manitoba: 1870-1930s. Ph.D. Thesis. York University.

Wright, D.G., and Hopky, G.E. 1998. Guidelines for the use of explosives in or near Canadian fisheries waters. Canadian Technical Report of Fisheries and Aquatic Sciences No. 2107. 38 pp.

6.5.2 Personal Communications

Macdonald, D. 2009. Fisheries Manager, Manitoba Water Stewardship, D. Ecological Services Division. Fisheries Branch, Northeastern Region. Thompson, MB. Telephone correspondence with Jaymie MacDonald, North/South Consultants Inc., Winnipeg, MB. October 29, 2009.

TABLES, FIGURES, AND MAPS

Table 6-1: Adult[1] lake sturgeon population estimates with 95% confidence limits for the study area and water bodies in Northern and Southern Manitoba

Location	Year	Estimate	95% Confidence Limits	
			Lower	Upper
Study Area[a]				
Keeyask Area (Birthday Rapids to Gull Rapids)	2001	406	330	638
	2002	344	246	666
	2003	550	429	861
	2004	481	316	876
	2005			
	2006	1,275	875	2,078
	2007			
	2008	643	384	1,178
Split Lake Area	2001	183	122	576
	2002	228	106	735
	2003	-	-	-
	2004	-	-	-
	2005	592	245	1815
	2006	505	325	947
	2007	654	527	975
	2008	-	-	-
	2009	585	478	824
Other Manitoba locations				
Conawapa Area (Nelson River below Limestone GS)[a]	2004-2005	5,467	3,768	8,018
Churchill River (confluence of Churchill and Little Churchill rivers)[2,b]	2003	1,812	1,304	2,320
Fox River (Rainbow Falls to Great Falls)[3,b]	2004	646	312	980
Winnipeg River (Seven Sisters-Slave Falls)[4,c]	1997	2,998-	1,143	13,101
Winnipeg River (Slave Falls-Pointe du Bois)[5,c]	2007	2,205	921	4,095

1. Adult fish were ≥ 834 mm fork length.
2. After Maclean and Nelson (2005).
3. After Pisiak and Maclean (2007).
4. After Block (2001).
5. Estimates from data collected during Pointe du Bois Modernization Project studies (2007-2009).
a. Estimated using the Robust Design (Kendall and Pollock 1992).
b. Estimated using the Peterson Method (described in Krebs 1989).
c. Estimated using the Jolly-Seber Method (described in Krebs 1989).

Table 6-2: Lake sturgeon catches (n) and mean catch-per-unit-effort (CPUE) in the Split Lake area, by location, season, and life stage, 2001–2008

Location	Season	Year	# Sites	# Fish	Adult		Sub-adult		YOY	
					n	Mean CPUE[1]	n	Mean CPUE	n	Mean CPUE
Grass River	Spring	2001	6	0	0	-	0	-	na[2]	-
		2002	3	2	2	0.06	0	-	na	-
		2005	2	0	0	-	0	-	na	-
		2006	6	2	1	0.01	1	0.01	na	-
		2007	32	10	10	0.03	0	-	na	-
		All Years	49	14	13	0.03	1	< 0.01	na	-
	Summer	2006	1 + 1[3]	0	-	-	-	-	0	-
Nelson River Downstream of Kelsey GS[4]	Spring	2001	23	7	6	0.03	1	0.02	na	-
		2002	13	2	1	0.01	1	0.01	na	-
		2005	7	4	3	0.03	1	0.02	na	-
		2006	33	21	12	0.01	9	0.02	na	-
		2007	33	49	30	0.05	19	0.02	na	-
		All Years	109	83	52	0.03	31	0.02	na	-
	Summer	2006	23 + 3	14	8	0.01	6	0.01	0	-
Split & Clark Lakes	Spring	2001	15	7	4	0.03	3	0.01	na	-
		2002	10	1	1	0.05	0	-	na	-
		2004	3	0	0	-	0	-	na	-
		2005	46	14	8	0.01	6	0.01	na	-
		2006	19	6	4	0.01	2	<0.01	na	-
		2007	13	10	6	0.04	4	0.02	na	-
		2008	5	0	0	-	0	-	na	-
		All Years	111	38	23	0.02	15	0.01	na	-
	Summer	2006	60 + 9	9	3	0.01	6	0.01	0	-

Table 6-2: Lake sturgeon catches (n) and mean catch-per-unit-effort (CPUE) in the Split Lake area, by location, season, and life stage, 2001–2008

Location	Season	Year	# Sites	# Fish	Adult		Sub-adult		YOY	
					n	Mean CPUE[1]	n	Mean CPUE	n	Mean CPUE
Burntwood River	Spring	2001	26	21	16	0.07	5	0.02	na[2]	-
		2002	30	16	14	0.10	2	0.02	na	-
		2005	21	15	14	0.09	1	0.01	na	-
		2006	16	37	34	0.11	3	0.01	na	-
		2007	27	59	54	0.10	5	0.01	na	-
		All Years	120	148	132	0.09	16	0.01	na	-
	Summer	2006	5 + 1[3]	0	0	-	0	-	0	-
Odei River	Spring	2005	6	2	-	-	2	0.07	na	-
		2007	13	22	18	0.07	4	0.01	na	-
		All Years	19	24	18	0.05	6	0.03	na	-
All Locations	Spring	2001	70	35	26	0.04	9	0.02	na	-
		2002	56	21	18	0.07	3	0.01	na	-
		2004	3	0	0	-	0	-	na	-
		2005	82	35	25	0.03	10	0.02	na	-
		2006	74	66	51	0.03	15	0.01	na	-
		2007	118	150	118	0.06	32	0.01	na	-
		2008	5	0	0	-	0	-	na	-
	Summer	2006	89 + 14	23	11	0.01	12	0.01	0	-
	Summer/Fall	1997-2009[5]	-	7	2	-	4	-	1	-

1. CPUE = # fish/24 h based on 45.7 m net. Adult CPUE calculated using only data from large mesh nets; sub-adult CPUE calculated using data from large and medium mesh; young-of-the-year (YOY) CPUE calculated using only data from medium mesh.
2. na = not applicable.
3. Large mesh gill nets + medium mesh gill nets.
4. Including its confluence with the Grass River.
5. Lake sturgeon catches during environmental studies focusing on other species.

Table 6-3: Spawning status of lake sturgeon captured in the study area during spring, 2001–2008

Area	Location	Male				Female[4]
		Maturity State[1]				Maturity State
		Maturing to spawn	Ripe	Spent	# Spawners[2,3]	Maturing to spawn
Split Lake	Burntwood River	18	11	8	**28**	-
	Grass River	-	-	1	**1**	-
	Nelson River downstream of Kelsey GS	-	2	-	**2**	1
Keeyask	Clark Lake to Birthday Rapids	1	3	-	**4**	-
	Birthday Rapids	16	14	3	**31**	4
	Birthday Rapids to Gull Lake	7	2	2	**10**	-
	Gull Lake	8	1	-	**9**	2
	Gull Rapids	1	-	3	**4**	-
	Downstream of Gull Rapids	10	1	-	**10**	3

1. Includes fish recaptured in multiple maturity states in the same year or fish recaptured in subsequent years.
2. Does not include recaptures of the same fish in the same location.
3. Maturity of six males (five between Birthday and Gull rapids and one downstream of Gull Rapids) was identified during surgical implantation of acoustic or radio transmitters in 2001.
4. Maturity of five females (three between Birthday and Gull rapids and two downstream of Gull Rapids) was identified during surgical implantation of acoustic or radio transmitters in 2001.

Table 6-4: Mean habitat-based catch-per-unit-effort (CPUE) of adult lake sturgeon in the Split Lake area during spring and summer

Habitat Characteristics[1]	Spring		Summer	
	# Sites	Mean CPUE[2]	# Sites	Mean CPUE
General Habitat Type				
Lacustrine	42	0.01	46	<0.01
Riverine	249	0.03	34	0.01
Rapids	117	0.09	9	0.03
Water Elevation				
Shallow	70	0.05	1	0.00
Deep	338	0.05	88	0.01
Water Velocity				
Standing	12	0.03	-	-
Low	243	0.03	71	<0.01
Moderate	153	0.07	18	0.02
Substrate Compaction				
Soft	179	0.03	40	<0.01
Hard	229	0.06	49	0.01

1. Habitat descriptions are provided in tables 6B-2 and 6B-3.
2. CPUE = # fish/24 h based on 45.7 m net. Adult CPUE calculated using only data from large mesh nets.

Table 6-5: Mean habitat-based catch-per-unit-effort (CPUE) of sub-adult lake sturgeon in the Split Lake area for all seasons combined

Habitat Characteristics[1]	# Sites	Mean CPUE[2]
General Habitat Type		
Lacustrine	94	0.01
Riverine	289	0.01
Rapids	128	0.01
Water Elevation		
Shallow	72	< 0.01
Deep	439	0.01
Water Velocity		
Standing	12	0
Low	325	0.01
Moderate	174	0.02
Substrate Compaction		
Soft	225	0.01
Hard	286	0.01

1. Habitat descriptions are provided in tables 6B-2 and 6B-3.
2. CPUE = # fish/24 h based on 45.7 m net. Sub-adult CPUE calculated using data from large mesh and medium mesh nets.

Table 6-6: Lake sturgeon catches (n) and mean catch-per-unit-effort (CPUE) in the Nelson River from Clark Lake to Gull Rapids, by location, season, and life stage, 2001–2008

Location	Season	Year	# Sites	# Fish	Adult		Sub-adult		YOY	
					n	Mean CPUE[1]	n	Mean CPUE	n	Mean CPUE
Clark Lake to Birthday Rapids	Spring	2003	12	1	1	0.02	0	-	na[2]	-
		2004	6	5	5	0.05	0	-	na	-
		2008	13	1	1	0.01	0	-	na	-
		All Years	31	7	7	0.02	0	-	na	-
Birthday Rapids (immediately below the rapids to ~ 2 km downstream)	Spring	2001	13	16	16	0.35	0	-	na	-
		2002	6	20	20	0.34	0	-	na	-
		2003	13	22	21	0.16	1	< 0.01	na	-
		2004	8	15	15	0.09	0	-	na	-
		2006	4	74	67	0.36	7	0.03	na	-
		2008	8	16	13	0.06	3	0.02	na	-
		All Years	52	163	152	0.22	11	0.01	na	-
	Summer	2006	3	1	1	0.01	0	-	na	-
Birthday Rapids to Gull Lake	Spring	2001	14	12	12	0.37	0	-	na	-
		2002	11	10	10	0.11	0	-	na	-
		2003	10	12	12	0.06	0	-	na	-
		2004	1	3	3	0.11	0	-	na	-
		2006	10	46	36	0.12	10	0.04	na	-
		2008	3	23	22	0.19	1	0.01	na	-
		All Years	49	106	95	0.18	11	0.01	na	-
	Summer	2006	3	0	0	-	0	-	na	-
	Fall	2002,03,08	0 + 1[3]	0	0	-	0	-	0	-
Gull Lake	Spring	2001	30	51	45	0.32	6	0.06	na	-
		2002	22	37	34	0.23	3	0.01	na	-
		2003	27	60	56	0.23	4	0.03	na[2]	-

Table 6-6: Lake sturgeon catches (n) and mean catch-per-unit-effort (CPUE) in the Nelson River from Clark Lake to Gull Rapids, by location, season, and life stage, 2001–2008

Location	Season	Year	# Sites	# Fish	Adult		Sub-adult		YOY	
					n	Mean CPUE[1]	n	Mean CPUE	n	Mean CPUE
Gull Lake (Continued)	Spring	2004	9	33	33	0.16	0	-	na	-
		2006	8	30	7	0.08	23	0.14	na	-
		2008	5	13	6	0.04	7	0.04	na	-
		All Years	101	224	181	0.23	43	0.04	na	-
	Summer	2006	15 + 4[3]	42	8	0.02	34	0.08	0	-
	Fall	2002,03,08	10 + 14	129	5	-	109	0.21	15	0.08
All Locations	Spring	2001	57	79	73	0.34	6	0.03	na	-
		2002	39	67	64	0.21	3	0.01	na	-
		2003	62	95	90	0.14	5	0.01	na	-
		2004	24	56	56	0.11	0	-	na	-
		2006	22	150	110	0.15	40	0.08	na	-
		2008	29	53	42	0.05	11	0.01	na	-
	Summer	2006	21 + 4	43	9	0.01	34	0.06	0	-
	Fall	2002,03,08	10 + 15	129	5	-	109	0.20	15	0.08
	Summer/Fall	1999-2009[4]	-	24	4	-	20	-	0	-

1. CPUE = # fish/24 h based on 45.7 m net. Adult CPUE calculated using only data from large mesh nets; sub-adult CPUE calculated using data from large and medium mesh; young-of-the-year (YOY) CPUE calculated using only data from medium mesh.
2. na = not applicable.
3. Large mesh gill nets + medium mesh gill nets.
4. Lake sturgeon catches during environmental studies focusing on other species.

Table 6-7: Mean habitat-based catch-per-unit-effort (CPUE) of adult lake sturgeon in the Keeyask area during spring and summer/fall

Habitat Characteristics[1]	Clark Lake to Gull Rapids				Gull Rapids			
	Spring		Summer/Fall		Spring		Summer	
	# Sites	Mean CPUE[2]	# Sites	Mean CPUE	# Sites	Mean CPUE	# Sites	Mean CPUE
General Habitat Type								
Lacustrine	100	0.23	25	0.01	-	-	-	-
Riverine	63	0.14	3	0	111	0.03	29	0
Rapids	70	0.17	3	0.01	23	0.04	-	-
Water Elevation								
Shallow	49	0.20	4	0	37	0.04	4	0
Deep	184	0.19	27	0.01	97	0.03	25	0
Water Velocity								
Standing	10	0.04	-	-	15	0.01	4	0
Low	213	0.20	30	0.01	85	0.02	22	0
Moderate	10	0.05	1	0	34	0.07	3	0
Substrate Compaction								
Soft	32	0.18	2	0	31	0.02	10	0
Hard	201	0.19	29	0.01	103	0.04	19	0

1. Habitat descriptions are provided in tables 6B-2 and 6B-3.
2. CPUE = # fish/24 h based on 45.7 m net. Adult CPUE calculated using only data from large mesh nets.

Table 6-8: Mean habitat-based catch-per-unit-effort (CPUE) of young-of-the-year lake sturgeon in the Keeyask area for all seasons combined

Habitat Characteristics[1]	Clark Lake to Gull Rapids		Gull Rapids	
	# Sites	Mean CPUE[2]	# Sites	Mean CPUE
General Habitat Type				
Lacustrine	18	0.07	-	-
Riverine	1	0	38	0.03
Water Elevation				
Shallow	-	-	1	0
Deep	19	0.06	37	0.03
Water Velocity				
Standing	-	-	2	0
Low	13	0.09	25	0.03
Moderate	6	0	11	0.04
Substrate Compaction				
Soft	5	0.23	1	0
Hard	14	0	37	0.03

1. Habitat descriptions are provided in tables 6B-2 and 6B-3.
2. CPUE = # fish/24 h based on 45.7 m net. YOY CPUE calculated using data from medium mesh nets.

Table 6-9: Diet items of sub-adult and young-of-the-year (YOY) lake sturgeon captured in Gull Lake and downstream of Gull Rapids during fall 2008

Diet Item[1]	Gull Lake				Gull Rapids	
	Sub-adult (n = 5)		YOY (n = 5)		Sub-adult (n = 1)	YOY (n = 1)
	n[2]	% FO[3]	n	% FO		
Crustacea						
Amphipoda (adult)			1	20		
Decapoda (adult)	1	20				
Bivalvia (adult)	1	20				
Insecta						
Diptera (Flies)						
Chironomidae (non-biting midge)						
Chironominae	1	20	3	60		1
Orthocladiinae	1	20				
Tanypodinae			1	20		
Ephemeroptera (may fly)						
Ephemeridae	2	40	1	20		
Heptageniidae	4	80	5	100	1	1
Baetidae			2	40		1
Ephemeroptera (unid.)	1	20	2	40		1
Trichoptera (caddis fly)						
Hydropsychidae	5	100	4	80	1	1
Trichoptera (unid.)			2	40		1
Plecoptera (stone fly)						
Perlodidae	2	40				
Plecoptera (unid.)	2	40	2	40		1
Insecta (unid.)			1	20		
Diptera (unid.) (pupa)	1	20				
Nemata (roundworm) (adult)			1	20		
Fish						
Cyprinidae (shiner)	1	20				
Fish remains					1	

1. Life stage of diet items is larval unless indicated otherwise.
2. n = number of fish.
3. % FO = % frequency of occurrence (percentage of stomachs in which diet item occurred).

Table 6-10: Mean habitat-based catch-per-unit-effort (CPUE) of sub-adult lake sturgeon in the Keeyask area for all seasons combined

Habitat Characteristics[1]	Clark Lake to Gull Rapids		Gull Rapids	
	# Sites	Mean CPUE[2]	# Sites	Mean CPUE
General Habitat Type				
Lacustrine	143	0.07	-	-
Riverine	67	0.01	178	0.07
Rapids	73	<0.01	23	0
Water Elevation				
Shallow	53	0.01	42	0
Deep	230	0.05	159	0.08
Water Velocity				
Standing	10	0.01	21	0
Low	256	0.04	132	0.04
Moderate	17	0.04	48	0.15
Substrate Compaction				
Soft	39	0.07	47	0
Hard	244	0.03	159	0.08

1. Habitat descriptions are provided in tables 6B-2 and 6B-3.
2. CPUE = # fish/24 h based on 45.7 m net. Sub-adult CPUE calculated using data from large mesh and medium mesh nets.

Table 6-11: Lake sturgeon catches (n) and catch-per-unit-effort (CPUE) within and downstream of Gull Rapids, by location, season, and life stage, 2001-2009

Location	Season	Year	# Sites	# Fish	Adult		Sub-adult		YOY	
					n	Mean CPUE[1]	n	Mean CPUE	n	Mean CPUE
Gull Rapids	Spring	2003	9	10	10	0.11	0	-	na[2]	-
		2004	14	1	1	< 0.01	0	-	na	-
		All Years	23	11	11	0.04	-	-	na	-
Downstream Gull Rapids	Spring	2001	19	24	22	0.06	2	< 0.01	na	-
		2002	15	4	4	0.02	0	-	na	-
		2003	20	17	15	0.03	2	0.01	na	-
		2004	8	5	5	0.01	0	-	na	-
		2005	24	6	4	0.02	2	< 0.01	na	-
		2006	25	14	14	0.04	0	-	na	-
		All Years	111	70	64	0.03	6	< 0.01	na	-
	Summer	2006	29 + 10[3]	1	0	-	1	0.01	0	-
	Fall	2008	0 + 12	8	-	-	7	0.25	1	0.05
		2009	0 + 16	23	-	-	22	0.53	1	0.03
		All Years	28	32	-	-	29	0.41	2	0.04
Locations Combined	Spring	2001	19	24	22	0.06	2	< 0.01	na	-
		2002	15	4	4	0.02	0	-	na	-
		2003	29	27	25	0.05	2	< 0.01	na	-
		2004	22	6	6	0.01	0	-	na	-
		2005	24	6	4	0.02	2	< 0.01	na	-
		2006	25	14	14	0.04	0	-	na	-
	Summer	2006	29 + 10	1	0	-	1	0.01	0	-
	Fall	2008	0 + 12	8	-	-	7	0.25	1	0.05
		2009	0 + 12	23	-	-	22	0.53	1	0.03
	Summer/Fall	2001-2003[4]	-	5	3	-	2	-	0	-

1. CPUE = # fish/24 h based on 45.7 m net. Adult CPUE calculated using only data from large mesh nets; sub-adult CPUE calculated using data from large and medium mesh; young-of-the-year (YOY) CPUE calculated using only data from medium mesh.
2. na = not applicable.
3. Large mesh gill nets + medium mesh gill nets.
4. Lake sturgeon catches during environmental studies focusing on other species.

Table 6-12: Lake sturgeon catches (n) and catch-per-unit-effort (CPUE) in the Stephens Lake area, by season and life stage, 2001–2010

Season	Year	# Sites	# Fish	Adult		Sub-adult		YOY	
				n	Mean CPUE[1]	n	Mean CPUE	n	Mean CPUE
Spring	2003	9	7	4	0.02	3	0.02	na[2]	-
	2005	48	2	2	< 0.01	-	-	na	-
	2006	47	2	2	< 0.01	-	-	na	-
	All Years	104	11	8	< 0.01	3	< 0.01	na	-
Summer	2006	30 + 5[3]	2	2	0.01	-	-	0	-
Fall	2009	0 + 6	0	-	-	-	-	-	-
	2010	0 + 10	32	na	na	32	0.55	0	-

1. CPUE = # fish/24 h based on 45.7 m net. Adult CPUE calculated using only data from large mesh nets; sub-adult CPUE calculated using data from large and medium mesh; young-of-the-year (YOY) CPUE calculated using only data from medium mesh.
2. na = not applicable.
3. Large mesh gill nets + medium mesh gill nets.

Table 6-13: Mean habitat-based catch-per-unit-effort (CPUE) of young-of-the-year (YOY), sub-adult, and adult lake sturgeon in the Stephens Lake area for all seasons combined

Habitat Characteristics[1]	YOY		Sub-adult		Adult	
	# Sites	Mean CPUE[2]	# Sites	Mean CPUE	# Sites	Mean CPUE
General Habitat Type						
Lacustrine	21	0	155	0.04	134	0.01
Riverine	-	-	-	-	-	-
Rapids	-	-	-	-	-	-
Water Elevation						
Shallow	-	0	35	0	35	<0.01
Deep	21	0	120	0.05	99	0.01
Water Velocity						
Standing	4	0	48	0	44	0
Low	17	0	107	0.05	90	0.01
Moderate	-	-	-	-	-	-
Substrate Compaction						
Soft	17	0	124	0.04	107	<0.01
Hard	4	0	31	0.02	27	0.02

1. Habitat descriptions are provided in tables 6B-2 and 6B-3.
2. CPUE = # fish/24 h based on 45.7 m net. Sub-adult CPUE calculated using data from large mesh and medium mesh nets. Adult CPUE calculated using data from large mesh nets only.

Table 6-14: Size and condition of lake sturgeon from the study area and other Manitoba water bodies during summer and fall

Location	Date	Life Stage[6]	Fork Length (mm)					Weight (g)					Condition Factor				
			n[7]	Mean	Std[8]	Min	Max	n	Mean	Std	Min	Max	n	Mean	Std	Min	Max
Winnipeg River[1]	July-Nov 2006-2008	Sub-adult +	895	573	154	245	1283	878	1869	2020	100	20412	878	0.82	0.09	0.51	1.14
Conawapa Area[2]	July 2006	Sub-adult +	81	991	193	547	1352	81	8067	4959	454	24945	81	0.71	0.12	0.28	1.08
	Aug 2006	Sub-adult +	65	904	196	300	1287	65	6218	3884	227	17237	65	0.71	0.12	0.35	1.10
	Sept 2005	Sub-adult +	84	1012	199	261	1322	83	8762	4315	75	18824	83	0.75	0.09	0.42	0.98
Fox River	July 2004	Sub-adult +	134	1036	205	310	1460	132	10555	5408	227	24955	131	0.84	0.11	0.56	1.22
Churchill River[3]	late June-early July 2003	Sub-adult +	299	1086	145	441	1401	258	11100	4200	5700	24700	258	0.83	0.11	0.45	1.45
Study Area[4]																	
Nelson River downstream of Kelsey GS	Aug-Sept 2006	Sub-adult	5	782	22	750	810	5	4699	680	3629	5443	5	0.98	0.09	0.86	1.10
		Adult	8	935	86	840	1044	8	7286	2706	4082	10886	8	0.86	0.15	0.62	1.08
Split Lake	Aug-Sept 2006	Sub-adult	6	573	138	353	785	5	2041	907	1361	3629	5	0.84	0.08	0.75	0.94
		Adult	3	967	107	845	1045	3	8165	3175	4990	11340	3	0.87	0.11	0.79	0.99
Nelson River (CL-GR)[5]	Aug-Oct 2002-2008	Sub-adult	142	604	143	244	832	85	1868	1141	110	5216	85	0.74	0.09	0.54	1.08
	Aug-Sept 2006	Adult	14	1041	163	840	1300	8	10512	5888	5443	19731	8	0.84	0.09	0.64	0.96
Gull Rapids	Aug-Sept 2006-2008	Sub-adult	8	592	107	428	738	7	1957	848	575	3100	7	0.78	0.09	0.63	0.90
Stephens Lake	Aug-Sept 2006	Adult	2	1205	120	1120	1290	2	18144	6415	13608	22680	2	1.01	0.09	0.97	1.06

1. Data collected during gillnetting studies conducted by North/South Consultants Inc. between Lamprey Rapids and the area immediately below Slave GS for the Pointe du Bois Modernization Project.
2. After Ambrose *et al.* (2008).
3. Churchill River at its confluence with Little Churchill River. After Maclean and Nelson (2005).
4. Values for fish captured during summer and fall studies.
5. Clark Lake to Gull Rapids.
6. 'Sub-adult +' refers to all fish over 200 mm fork length. For the study area, sub-adults were classified as those between 200 and 833 mm long and adults were classified as 834 mm or longer.
7. n = number of fish measured.
8. Std = standard deviation.

Table 6-15: Tagging and recapture locations of lake sturgeon marked with Floy®-tags during gillnetting studies conducted in the study area, 1995 and 1999–2008

			Number Recaptured/Location[2]													
			Split Lake Area						Nelson River from Clark Lake to Gull Rapids				Stephens Lake Area	Outside Study Area		
Tagging Area	**Location Code**	**Number Tagged[1]**	**1**	**2**	**3**	**4**	**5**	**Total[3]**	**6**	**7**	**8**	**Total[3]**	**9**		**Total Number Recaptured[4]**	**Recapture Rate (%)**
Split Lake area																
Burntwood River	1	120	40	2	1	4	-	45	-	-	-	0	-	-	45	37.5
Odei River	2	21	1	2	-	-	-	3	-	-	-	0	-	-	3	14.3
Kelsey GS	3	83	1	1	16	1	1	18	1	-	-	1	-	-	19	22.9
Split/Clark lakes	4	42	4	1	1	1	-	7	-	-	-	0	-	-	7	16.7
Grass River	5	14	-	-	2	1	-	3	-	-	-	0	-	-	3	21.4
Total Split Lake area		***280***						***76***				***1***	***0***	***0***	***77***	***27.5***
Keeyask area																
Nelson River between Clark Lake and Gull Rapids																
Clark Lake — Birthday Rapids	6	4	-	-	-	-	-	0	1	-	-	1	-	-	1	25.0
Birthday Rapids — Gull Rapids																
Keeyask Environmental Studies	7	511	-	-	3	4	-	6	1	143	2	145	-	-	149	29.2
Manitoba Fisheries Branch	7	62	-	-	-	1	-	1	-	15	-	15	-	-	16	25.8
Gull Rapids	8	66	-		-	-	-	0	1	4	23	26	3	0	27	40.9
Total Clark Lake - Gull Rapids		***643***						***7***				***187***	***3***	***0***	***193***	***30.0***
Total Stephens Lake Area	***9***	***10***	***-***		***-***	***-***	***-***	***0***	***-***	***-***	***2***	***2***	***0***	***0***	***2***	***20.0***
Total Keeyask Environmental Studies		**871**						**82**				**175**	**3**	**0**	**256**	**29.4**
Overall Total		**933**						**83**				**190**	**4**	**0**	**272**	**29.2**

1. Sixty-two sturgeon were tagged by the Manitoba Fisheries Branch in Gull Lake in 1995; the remainder were tagged throughout the study area between 1999 and 2008.
2. Does not include multiples recaptures of individual fish at the same location.
3. Does not include fish recaptured multiple times within the area at any time.
4. Does not include fish recaptured multiple times anywhere in the study area at any time.

Table 6-16: Summary of movements of lake sturgeon tagged with acoustic or radio transmitters in the study area, 2001–2004

				Movements								
	Number Tagged[1]			Remained Within[2]		Moved Over GR[3]		Moved Over BR[4]				
Year	BR – GR[5]	Below GR	Number Detected	BR-GR	Below GR	US	DS	Detected Within GR	US	DS	Entered STL	Left STL
2001	21	10	29	19	4	0	1[a]	0	5[c,d]	3[c]	5	-
2002	20	11	27	16	0	3[a,b]	0	1	1[e]	2[d,e]	7	4
2003	19	10	25	17	1	0	1[b]	2	3[c,f,g]	3[c,d,f]	1	1
2004	17	10	21	16	3	0	0	0	0	1[g]	1	-

1. Seven transmitters were returned by local resource users over the course of the study. The tag returned from a sturgeon tagged between Birthday and Gull rapids in summer 2001 was re-applied to a fish captured below Gull Rapids during fall 2001. One tag originally applied between Clark Lake and Gull rapids was recovered by a local resource user during the 2004 study so it does not appear in the table.
2. Fish considered to have remained with their tagging area had to have been relocated within that area in both the preceding and "current" year.
3. Superscripts indicate whether these movements were made by same or different fish (a = acoustic tag 36; b = radio tag 149.620 code 1 and acoustic tag 34).
4. Superscripts indicate whether these movements were made by same or different fish (c = acoustic tag numbers 39, 43, and 45; d = acoustic tag 48 and radio tag 149.720 code 4; e = acoustic tag 41; f = acoustic tag 40; g = acoustic tag 49).
5. Abbreviations as follows:
   BR-Birthday Rapids; GR-Gull Rapids; STL-Stephens Lake; DS-downstream; US-upstream.

Table 6-17: Residual effects on lake sturgeon: construction period

Environmental Effect	Mitigation	Residual Effect
Upstream of the Outlet of Clark Lake Emigration of lake sturgeon from the Keeyask reach immediately post-impoundment could increase the population in Split Lake.	None required.	A medium-term, small increase in the lake sturgeon population may occur within an area of medium extent (Split Lake).
Below Clark Lake to GS Sturgeon may emigrate from the Keeyask reach during construction during Stage I and Stage II river management.	Lake sturgeon stocking in the reservoir to compensate in part for loss of adult and sub-adult fish that move to other areas.	A medium-term, moderate change in the lake sturgeon population may occur within an area of medium extent (Keeyask reservoir).
Downstream of GS/Stephens Lake		
Loss of spawning habitat at Gull Rapids.	Stocking in Stephens Lake will commence during construction to offset construction period effects. Spawning habitat will be constructed post-construction (Table 6-18)	Short-term, small to moderate effects within a medium geographic area may be expected. However, replacement of natural recruitment with stocked fish will result in no apparent residual effects.
Construction activities and construction of cofferdams/GS structures will disturb spawning activity	To the extent possible, avoid in-water work during spawning periods	
The dewatering of areas inside of cofferdams has the potential to strand fish.	Fish salvage operations to capture and release fish prior to dewatering	
Potential sediment deposition at YOY and juvenile rearing habitat	No effect to habitat expected but will be confirmed by monitoring.	
Changes in water quality from a variety of construction activities has the potential to adversely affect fish health.	Measures to reduce effects on water quality	
Blasting activities have the potential to cause sensory disturbance, injury, and mortality to fish	Application of guidelines for blasting in or near water.	
Fish can become impinged/entrained by water intake pipes.	Application of guidelines for end-of-pipe screening	

Table 6-18: Residual effects on lake sturgeon: operation period

Environmental Effect	Mitigation	Residual Effect
Upstream of the Outlet of Clark Lake		
Lake sturgeon abundance may increase slightly due to potential increase in emigration from the new reservoir.	None required. See "Below Kelsey GS to Kettle GS" section below.	Small, medium-term, local increase in the lake sturgeon population may occur within an area of medium extent (Split Lake).
Below Clark Lake to GS		
Decrease in amount and suitability of spawning habitat at and below Birthday Rapids, though some portions of the rapids may remain suitable and Long Rapids will not be affected	Monitoring of spawning activity/success at and below Birthday Rapids. Create suitable habitat if required.	Shifts in areas of spawning, foraging, and YOY habitat use. Reduced number of fish entering Stephens Lake from upstream. No long-term decline in lake sturgeon abundance in the Keeyask reservoir or Stephens Lake.
YOY rearing habitat may no longer be accessible to larval lake sturgeon due to changes in flow regime in the reservoir.	Monitoring to determine YOY habitat presence and use. Create rearing habitat if required. Stocking of fall fingerlings and yearlings to offset potential effects of reduced YOY habitat availability.	
Decline in lake sturgeon abundance as a result of up and downstream emigration.	Stocking to offset potential effects of emigration. Implement upstream fish passage (trap/catch and transport) to offset potential downstream losses.	
Reduced rate of increase and potential decrease in abundance of lake sturgeon population resulting from increase in domestic harvest.	Development and promotion of a lake sturgeon conservation awareness program	

Table 6-18: Residual effects on lake sturgeon: operation period

Environmental Effect	Mitigation	Residual Effect
Downstream of GS/Stephens Lake		
Decrease in lake sturgeon reproduction in Stephens Lake resulting from destruction of spawning habitat at Gull Rapids	Construct spawning habitat below and in proximity to the tailrace. During years when lake sturgeon may be attracted to spillway flow for spawning, maintain spillway discharge to permit egg hatch and survival of pre-emergent larvae.	Over the long-term there will be a reduced number of lake sturgeon entering Stephens Lake from upstream and there will be a shift in the location of spawning habitat. YOY rearing habitat may shift with time. Overall, expect that population will maintained. Long-term moderate to large increase in lake sturgeon abundance in an area of medium extent (Stephens Lake) may occur as a result of stocking and lake sturgeon conservation and stewardship initiatives.
Decrease in potential lake sturgeon recruitment resulting from reduction or loss of larval lake sturgeon drift from upstream. Potential changes in rearing habitat.	Monitoring to confirm that YOY rearing habitat is not changing. Stocking of fall fingerling and yearling lake sturgeon to mitigate potential effects of loss of spawning habitat prior to creation of new spawning habitat and reduction or loss of downstream drift of larval lake sturgeon from upstream areas.	
Potential effects resulting from loss of access to upstream habitats	Provide upstream passage (trap/catch and transport) targeting downstream migrants.	
Decline in lake sturgeon abundance resulting from mortality/injury caused by fish moving downstream over the spillway or past the turbines.	Features will be incorporated into the design of the spillway and turbines to reduce risk of injury and mortality.	
Potential stranding of lake sturgeon following spillway use.	Construct connecting channels to allow fish escapement to Stephens Lake.	
Potential decrease in abundance of lake sturgeon population resulting from increase in domestic harvest due to improved access.	Development and promotion of a lake sturgeon conservation awareness program	

Table 6-18: Residual effects on lake sturgeon: operation period

Environmental Effect	Mitigation	Residual Effect
Below Kelsey GS to Kettle GS region	In addition to the various mitigation measures described above, including targeted stocking plans to address specific project impacts, a comprehensive stocking strategy will be implemented (Appendix 1A) to increase and maintain lake sturgeon populations in Split Lake, the Keeyask reservoir and Stephens Lake.	Overall, expect a long-term moderate to large increase in the lake sturgeon abundance over an area of large extent (Kelsey to Kettle reach).