Keeyask Generation Project

Adult Lake Sturgeon Movement Studies

Memorandum

Subject: Adult Lake Sturgeon Movements in the Clark Lake to Kettle Generating Station Reach of the Nelson River

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1.0 Purpose of memorandum

The purpose of this memorandum is to provide:

a) an overview of adult Lake Sturgeon movements and the significance of those movements in fulfilling their life history requirements;

b) a discussion of movements in the Clark Lake to Kettle GS reach of the Nelson River, based on information collected for the Environmental Impact Statement (EIS) and supplemented by additional information gained from Floy-tag recaptures since the EIS was produced and from an acoustic telemetry study initiated in 2011; and

c) a discussion on the implications of habitat fragmentation/loss of connectivity at Gull Rapids.

This discussion of Lake Sturgeon movements is limited to the adult life stage since subadult and juvenile Lake Sturgeon in the Nelson River and in other river systems are reported to move over a limited spatial extent (Holtgren and Auer 2004; Barth et al. 2011; Henderson et al. 2013; McDougall et al. 2013; McDougall et al. in press.).

An important issue for development of the Keeyask Generation Project (the Project) is the impact of the Project on adult Lake Sturgeon movements, in particular the importance of maintaining connectivity between populations upstream and downstream of the proposed generating station. Lake Sturgeon have been extensively studied as one component of the Keeyask Environmental Studies Program since 2001. The study area includes the Nelson River and lakes in the reach from the Kelsey Generating Station (GS) to the Kettle GS, as well as the lower sections of the Grass and Burntwood rivers (Map 1). Lake Sturgeon use of this area can be divided into three subsections:

- The Upper Split Lake area, consisting of Split Lake and upstream tributaries including the Nelson River below the Kelsey GS, the Grass River below Witchai Lake Falls, the Burntwood River below First Rapids and the Odei River from First Falls to the confluence with the Burntwood River. Habitat in this area will not be directly affected by development of the Keeyask GS;

- Below Clark Lake to Gull Lake, including Long Rapids and Birthday Rapids. Habitat in much of this reach will be substantially altered by the development of the Project; and

- Gull Rapids and the reach of the Nelson River up to and including Stephens Lake. Habitat at Gull Rapids will be lost when the Project is developed, and flows in the river channel downstream of the rapids will be affected, but habitat in Stephens Lake will not be altered. Sturgeon in Stephens Lake require habitat in Gull Rapids for spawning and utilize the riverine reach immediately downstream for foraging and rearing.

Lake Sturgeon movements have been studied by mark/recapture and acoustic and radio telemetry in the Clark Lake to Kettle GS reach of the Nelson River since 2001. A mark/recapture study (using Floy-tags) was conducted in Upper Split Lake area from 2001 to 2013. The main purpose of the mark/recapture study was to develop population estimates; however, information on movements was also recorded. A four-year telemetry study (both radio and acoustic), was conducted from 2001- 2004 and included a total of 31 fish. The main purpose of this study was to determine whether sturgeon moved upstream and/or downstream over Gull Rapids, although information on seasonal habitat use was also collected. More recently, in 2011, a second acoustic telemetry study was initiated as part of the pre-construction monitoring program. In this study, 60 adult Lake Sturgeon were tagged with acoustic transmitters (10 year life-span). The main objective of the study was to collect movement data on individual sturgeon prior to, during, and following construction of the Keeyask GS[1] to document effects of the Project on movements (Hrenchuk and Barth 2013).

2.0 Lake Sturgeon Movements and Life History Requirements

2.1 Background

Large Lake Sturgeon populations once existed in each of the three North American drainage basins (Great Lakes/St. Lawrence, Mississippi and Hudson Bay) (Houston 1987). Abundant populations inhabited large rivers such as the St. Lawrence, Ottawa, Nelson, Winnipeg, Saskatchewan, Hayes and Churchill, each of the Great Lakes and associated tributaries, Lake Winnipeg and associated tributaries, and smaller rivers such as the Red and Assiniboine in Manitoba. Aquatic macro-habitats within these waterbodies differ considerably and, based on historic accounts, it is apparent that Lake Sturgeon can thrive in a wide variety of macro-habitats ranging from fast-flowing deep rivers, to shallow prairie rivers, to large lakes.

In the scientific literature, the most commonly cited reasons for Lake Sturgeon decline are commercial harvest, and habitat alterations associated with dam construction and hydroelectric operations that destroyed spawning habitat, blocked movement between critical habitats, and altered water levels and flows that affected spawning, foraging and

[1] A decision has not been made to construct the Project, but monitoring was initiated to obtain pre-construction data on the same individuals that will be monitored during construction, should the Project proceed.

rearing habitats (Houston 1987; Auer 1996; Haxton 2003). Although dams and hydroelectric operations are commonly cited as having negative impacts on Lake Sturgeon populations and their habitats, the pathways by which the negative impacts ultimately affect populations are often poorly understood. The reasons for this are three-fold:

1) baseline data on Lake Sturgeon populations were not collected prior to past developments and therefore, it was/has not been possible to compare metrics such as abundance, age structure, and growth among populations pre- and post-development;

2) in areas where developments have occurred, many Lake Sturgeon populations had already been subject to intense commercial harvest. As such, abundance may already have been too low to facilitate detailed study; and

3) given that Lake Sturgeon inhabit a wide variety of macro-habitat types throughout their range, impacts of developments on populations may differ substantially between watersheds or even between proximate locations within a given watershed. As such, knowledge of species life-history within a river system may not always be directly transferrable to another system or population.

Over the past two decades, government agencies, First Nations, industry, and environmental groups have invested in efforts to conserve and rehabilitate Lake Sturgeon populations through managing harvest, stocking, mitigating impacts of prior developments, and developing a better understanding of the life history needs through scientific research (Peterson et al. 2007). With respect to the Keeyask Project, assessing current conditions and potential impacts is challenging due to issues associated with collecting data on depressed populations in a river system that is remote and logistically difficult to sample. Assessment of effects is further complicated because much of the established understanding of Lake Sturgeon is based on studies conducted in the Great Lakes/St. Lawrence drainage and, as discussed below, this knowledge may not be directly transferrable to Nelson River populations.

2.2 General Movement Patterns

Adult Lake Sturgeon movement patterns and movement extents have been described from many of the river systems and macro-habitat types throughout their range in North America (Hay-Chmielewski 1987; Fortin et al. 1993; Auer 1996; Rusak and Mosindy 1997; McKinley et al. 1998; Borkholder et al. 2002; Knights et al. 2002; Haxton 2003; Labadie 2011; Trested et al. 2011; Ecclestone 2012; Hrenchuk and Barth 2013; Shaw et al. 2013; McDougall et al. *in press*). Although movement patterns vary among and within river systems/watersheds, a general seasonal pattern can be described for this species. During spring, spawning adults move from overwintering areas to spawn in habitats characterized by fast-flowing water and clean substrates when water temperatures range from 9 – 18^{0}C (Harkness and Dymond 1961; Scott and Crossman 1973; Auer 1996; Rusak and Mosindy 1997; McKinley et al. 1998; Bruch and Binkowski 2002; Ambrose et al. 2010; Koga and MacDonell 2012). Non-spawning adults may accompany spawning adults to spawning grounds (Peterson et al. 2007). After spawning, adults disperse to forage during summer and fall (Auer 1996; Rusak and Mosindy 1997). Adults are habitat generalists utilizing a broad range of habitat types and prey, as their large size protects them from predators and allows them to forage on a variety of food types (Block 2001). Overwintering occurs in areas of deep water with low water velocities that may be in proximity to summer and fall foraging areas; the spatial extent of movements during winter is thought to be limited (Harkness and Dymond 1961; Scott and Crossman 1973; Rusak and Mosindy 1997; Labadie 2011; Shaw et al. 2012; McDougall et al. in press).

This generalized movement pattern is influenced in specific river systems by several biological (e.g., location and proximity to spawning areas), geomorphological (e.g., presence of rapids; habitat characteristics of the environment) and environmental factors (e.g., water levels, discharge, temperature). Perhaps the most important factor influencing the spatial extent of movements is the geographic distance between suitable spawning, foraging and overwintering habitat. As discussed below, this distance is highly variable among river systems. For example, in large stepped-gradient river systems, a diversity of habitats may exist in relatively short sections of river. In low-gradient systems, habitats appropriate for spawning and overwintering may be separated by large distances. Lake Sturgeon movements, therefore, need to be discussed in the context of the macro-habitat that a population occupies. Published scientific literature has not acknowledged the influence of macro-habitat on movement, and as a result the current paradigm is that adult Lake Sturgeon require vast amounts of unfragmented habitat to fulfill their life history requirements.

2.4 Examples of Lake Sturgeon Movements Relative to Macro-habitat

2.4.1 Low Gradient Macro-habitat

Lake Sturgeon populations that occupy rivers that consist primarily of low gradient macro-habitats (characteristic of some Great Lakes tributaries that support Lake Sturgeon) typically forage and overwinter in the lower reaches of the system and move to the upper reaches (the only locations where hydraulic conditions are suitable for spawning) to spawn. For example, Auer (1996) reported that “tagged, post spawning Lake Sturgeon immediately left the (Sturgeon River) river (69 km) and were recovered at distances of 265 km from the spawning site”. Many examples of Lake Sturgeon movement extents exhibited by populations in the Great Lakes are provided in Auer (1996), albeit with movement ranges varying from less than 10 km to more than 200 km. Based on observations made in these types of systems, Auer (1996) suggested that Lake Sturgeon require a barrier free 250-300 km combined river and lake range as a minimum distance to support self-sustaining populations.

In a similar relatively low gradient lake-tributary system, Rusak and Mosindy (1997) described the movements and seasonal habitat use of Lake Sturgeon in the Rainy River – Lake of the Woods watershed. These authors suggested that two discrete populations occupied this watershed, a “river” population that foraged and overwintered in the Rainy River near to spawning areas, and a “lake” population that foraged and overwintered in Lake of the Woods, necessitating upstream movements of approximately 50 – 70 km to spawning areas. As will be discussed below, similarities exist between results of this study, and studies conducted in the Clark Lake to Gull Lake reach of the Nelson River in terms of preference for “river” or “lake” environments.

2.4.2 Large Stepped Gradient Macro-habitat

Stepped gradient rivers are rivers in which short steep sections (typically rapids or waterfalls) alternate with lakes or low gradient river reaches (typical of Canadian Shield). Sturgeon typically spawn in the steep sections and forage and overwinter in the low gradient reaches. Some populations occur in large stepped-gradient river systems that contain substantive tributaries (e.g., St. Lawrence River populations and some populations in the Nelson River). These populations may spawn at both tributary and river mainstem sites. For example, the population in the reach of the Nelson River between the Limestone GS and Hudson Bay spawn at Lower Limestone Rapids (in the Nelson River mainstem) and in tributaries such as the Angling and Weir rivers. Similarly, Lake Sturgeon in the St. Lawrence and Ottawa River systems, spawn at both tributaries and mainstem sites (Fortin et al. 1993). Movements in these systems are highly variable and are largely dependent on the distance between the spawning area and foraging/overwintering area.

In stepped gradient systems where there are no tributaries that provide spawning habitat, spawning is restricted to mainstem sites. Habitat suitable for spawning may exist at multiple locations along the primary flow axis, but Lake Sturgeon generally congregate and spawn at a substantial set of falls, rapids or below some other impediment to upstream movement (e.g., a hydroelectric GS).

The distance required for Lake Sturgeon to complete their life cycle is the distance between the spawning site and foraging and overwintering areas. In stepped river systems, this distance may be quite small as suitable spawning, foraging and overwintering habitat may exist in close proximity. For example, in the Winnipeg River between the Pointe Du Bois GS and the Slave Falls GS, Lake Sturgeon complete their lifecycle in 10 km of riverine habitat. Lake Sturgeon populations in the Clark Lake to Stephens Lake reach of the Nelson River also inhabit a stepped gradient system, devoid of spawning tributaries, as discussed below.

3.0 Movements in the Clark Lake to Kettle GS Reach

This reach of the Nelson River is a large, stepped gradient macro-habitat. Spawning areas have been identified at Long Rapids, Birthday Rapids and Gull Rapids in the Nelson River mainstem (Map 1); the tributaries in this reach do not provide suitable sturgeon spawning habitat. Overwintering and foraging areas have been identified in Gull Lake and Stephens Lake. Further, based on acoustic telemetry data from the 2011 study, it is likely that some individuals overwinter between Birthday Rapids and Gull Lake.

Three general movement patterns between spawning and foraging/overwintering habitat have been identified for the sturgeon residing in the Nelson River between Clark Lake and Gull Rapids (Hrenchuk and Barth 2013). The first group displays year-round (spring, summer, fall, winter) affinity for the riverine portion of the Nelson River between Clark Lake and Gull Lake. Six of the 31 (19%) Lake Sturgeon tagged upstream of Gull Rapids in 2011 and 2012 were found exclusively in this reach after tagging. These results are similar to results of the acoustic telemetry study conducted between 2001 and 2004 during which 3 of 15 (20%) acoustically tagged Lake Sturgeon were found almost exclusively in this river reach over a four-year tracking period (Barth and Mochnacz 2004; Barth 2005; Barth and Murray 2005; Barth and Ambrose 2006). Fish in this group likely fulfill all of their life history of foraging, overwintering and spawning in less than 30 km of riverine habitat. The second group, which appears to represent a larger proportion of this population (22 of 31, or 71%, of the acoustically tagged fish in the 2011 study and 11 of 15, or 73%, of the acoustically tagged fish in the 2001 – 2004 study), displays fidelity for Gull Lake during summer, fall and winter, moving upstream only periodically. Upstream movements occur mainly during spring and both spawning and non-spawning fish may make this upstream movement. These fish move in the reach between Birthday Rapids and Gull Rapids, utilizing approximately 40 km of habitat (or less) to complete their life cycle. These results are similar to Rusak and Mosindy (1997) where adult Lake Sturgeon in the Rainy River –Lake of the Woods system exhibited fidelity for either a river or lake environment for foraging and overwintering, but spawned at similar sites in the Rainy River.

The third group is comprised of a smaller proportion of the tagged fish that deviate from the above patterns and undertake longer or one way movements, typically in summer or early fall. For example, one of the 31 (3%) Lake Sturgeon tagged in 2011 and 2012 moved from Gull Lake upstream at least as far as Clark Lake during summer and did not return in 2012 (Hrenchuk and Barth 2013). Similarly, of the 15 Lake Sturgeon included in the 2001 – 2004 acoustic telemetry study, 1 of the 15 (7%) tagged Lake Sturgeon moved downstream through Gull Rapids during summer and moved back upstream to Gull Lake the following summer (Barth and Murray 2005; Barth and Ambrose 2006). These movements do not follow the pattern of spring movements to spawning habitat followed by a return to foraging/overwintering habitat where most movements are within a relatively small area.

Downstream movement through Gull Rapids is infrequent for sturgeon inhabiting the Clark Lake to Gull Rapids reach. A total of 984 Floy-tags were applied in this reach between 2001 and 2012, and 402 recapture events occurred during this time (some fish were recaptured on multiple occasions). Of these 402 recapture events there were only eight records of sturgeon moving from areas upstream of Gull Rapids into Stephens Lake. Further, only 1 of the 46 (2%) (both 2001 and 2011 acoustic telemetry studies combined) Lake Sturgeon acoustically tagged upstream of Gull Rapids moved downstream into Stephens Lake. Considering that far more Lake Sturgeon currently reside in the Nelson River between Clark Lake and Gull Rapids than in Stephens Lake (Nelson and Barth 2012), and that more individuals have been marked with Floy-tags upstream of the rapids, it would be expected that recaptures would be more frequent if downstream movements were common. It should be noted that substantial gillnetting effort has been expended in Stephens Lake since 2001 to mark and recapture Lake Sturgeon (Hrenchuk 2013).

Data collected from Lake Sturgeon acoustically tagged in Stephens Lake during the open-water period in 2011 and 2012, and from 2001 – 2004, indicate that sturgeon frequently move to the base of Gull Rapids. Further, the data set from the 2011 study suggests that sturgeon utilize the 20 km reach from the base of Gull Rapids extending into the Stephens Lake along the old river channels[2] during spring, summer and fall (Hrenchuk and Barth 2013). For example, in the 2011 study, 19 of 29 (66%) tagged Lake Sturgeon have exhibited small-scale upstream and downstream movements from the base of Gull Rapids to 20 km downstream in Stephens Lake; movements into Lower Stephens Lake are infrequent (Hrenchuk and Barth 2013).

[2] Stephens Lake was formed when the Kettle GS impounded the Nelson River to Gull Rapids and the old river channels are still apparent in the southern section of the lake.

In terms of upstream movement through Gull Rapids, since inception of the 2011 study, 5 of the 29 (17%) sturgeon tagged in Stephens Lake (one in 2011 and four in 2012), have moved upstream through Gull Rapids. Similarly, in the 2001 to 2004 acoustic telemetry study, one of five (20%) Lake Sturgeon acoustically tagged in Stephens Lake, moved upstream over Gull Rapids and one of the 15 (7%) Lake Sturgeon tagged in Gull Lake moved downstream into Stephens Lake and moved back upstream in the year previous. These data may indicate that upstream movement from Stephens Lake through Gull Rapids to Gull Lake is more frequent relative to downstream movement from Gull to Stephens lakes; however, given the small absolute number of fish that moved, this result is tentative. In addition, because the number of adult Lake Sturgeon resident in Stephens Lake is small (i.e., 78 adult size Lake Sturgeon have been Floy-tagged in Stephens Lake since 2001 despite considerable gillnetting effort), the absolute number of upstream movements is small relative to the number of adults resident upstream of Gull Rapids.

The reason for the upstream movements over Gull Rapids is not readily apparent. The Lake Sturgeon's tendency to make asynchronous movements throughout the open-water season (Knights et al. 2002; Welsh and McLeod 2011; McDougall et al. in press.) complicates identification of migratory behaviour related to spawning as opposed to simply "random", perhaps exploratory, movements related to foraging. The timing of upstream movement through Gull Rapids suggests that the movements are not related to current year spawning, since each of the movements have occurred outside the spawning period (i.e., between mid-July and late-September) (Hrenchuk and Barth 2013). However, one acoustically tagged fish, identified as a female one year away from spawning when tagged in Stephens Lake in 2011, moved upstream through Gull Rapids in September 2011, and then moved upstream to Birthday Rapids presumably to spawn in spring 2012 (Hrenchuk and Barth 2013). This movement does not quite fit the description of two-step spawning migration described in Bemis and Kynard (1997), because although this fish moved through Gull Rapids closer to its spawning location the year prior to spawning, it remained resident in Gull Lake after spawning and has not returned to Stephens Lake.

In terms of downstream movement through Kettle GS, two of 29 (7%) Lake Sturgeon tagged in Stephens Lake in 2011 and 2012 moved downstream through the GS and were last located alive in Long Spruce Forebay (Hrenchuk and Barth 2013). There have been no other records of Lake Sturgeon marked upstream of the Kettle GS being recaptured downstream.

4.0 Implications of Fragmentation/Loss of Connectivity at Gull Rapids

As described in this memorandum, any discussion of Lake Sturgeon movements and fragmentation of habitat should consider the proximity of spawning areas to overwintering and foraging areas, as well as the geomorphology of the river system. In some areas, suitable foraging and overwintering habitat is far removed from the gradients required to create spawning habitat, and in other systems, such as in the Nelson River at Gull Rapids, they are not. As discussed in the Keeyask GS Response to EIS Guidelines, habitat to fulfill all life history stages will be present upstream and downstream of the GS, if planned constructed habitats function as intended. The majority of movements recorded during studies to date consist of movements from foraging and overwintering habitat to spawning habitat and vice versa and do not involve passing through Gull Rapids.

Construction of the Keeyask GS will disrupt existing movements over Gull Rapids by adult Lake Sturgeon; fish moving downstream from Gull Lake would need to pass either through the turbines or spillway and fish would not be able to move upstream, except through a trap and transport program or other fish passage mechanism.

As discussed in Section 3, only a small proportion of the Lake Sturgeon in Gull Lake move downstream to Stephens Lake. If a similar number of Lake Sturgeon move downstream after construction of the generating station, then losses to the total sturgeon population due to mortality during turbine or spillway passage would be minimal.

Also discussed in Section 3, approximately 20% of fish tagged in Stephens Lake move upstream over Gull Rapids; this represents a small absolute number of fish given that numbers of sturgeon in Stephens Lake are low (Nelson and Barth 2012). It is unlikely that the upstream population is dependent upon recruitment from the few fish that do ascend over Gull Rapids. What is lost, however, is gene flow from the downstream population to the upstream population. The importance of this upstream gene flow to

Lake Sturgeon populations is unknown. Given the persistence of Winnipeg River populations, maintaining gene flow does not appear to be critical in maintaining sustainable populations. It should also be noted that the proposed stocking program (Keeyask Generation Project Aquatic Environment Supporting Volume Appendix 1A, Part 2) will use the same brood stock for Gull and Stephens lakes; therefore in time these two stocks will be genetically the same.

The implications of blocking upstream movements on the Stephens Lake population are unclear. If sturgeon are moving upstream in advance of spawning the following year, it could be argued that sturgeon seeking to move upstream will not spawn, even with the creation of suitable spawning habitat downstream of the GS, if their movements are blocked. This has never been reported in the literature. In the Manitoba portion of the Winnipeg River, actively recruiting Lake Sturgeon populations persist within each of the five Winnipeg River impoundments and Lake Sturgeon conclusively spawn at the base of at least three of the six generating stations, and more likely five of six (McDougall et al. 2008; McDougall and MacDonell 2009; Hrenchuk 2011; McDougall 2011; Henderson and McDougall 2012). However, spawning has not been recorded immediately downstream of the Kettle, Long Spruce and Limestone GSs indicating that habitat may not always be suitable; it is also possible that the absence of spawning at these GSs is due to lack of adult spawning fish (Long Spruce and Kettle GSs), or because more suitable habitat exists further downstream (Limestone GS).

As discussed in Section 3, both the Lake Sturgeon groups in the Clark to Gull Rapids reach and the Gull Rapids to Stephens Lake reach included a small subset of individuals that exhibited an atypical movement in terms of leaving their “home range” and moving a greater distance to another location outside of the spawning period. It is noteworthy that, for individuals that did not leave the study area, the pattern of “typical” short distance foraging movements resumed in the new area. These atypical movements that are not between spawning and foraging/overwintering habitat have also been observed in other studies. Regardless of whether spawning, foraging and overwintering habitat is in close proximity or widely separated, there is individual variation, with some individuals displaying very strict affinity to small sections of river (core areas), while others move over relatively large spatial areas (Knights et al. 2002). For example, Priegel and Wirth (1974) suggested that individual Lake Sturgeon occupied established home ranges and rarely leave these home ranges areas except to spawn. Several other studies have suggested that Lake Sturgeon move over limited home range areas (Roussow 1957, Threader and Brousseau 1986). While results from the St. Lawrence and Ottawa river populations presented in Fortin et al. (1993) suggested that Lake Sturgeon rarely move from their home range with the exception of spawning, and that spawning movements may be extensive for some individuals. Sandilands (1987) reported movements of greater than 100 km for some individual Lake Sturgeon. As previously discussed, movement distances reported in Auer (1996) varied by population; however movement distances of greater than 265 km were reported.

Although these studies mention the distances covered by some individual fish, rarely do these authors discuss the prevalence or significance of these movements to the population. As a result, the proportion of Lake Sturgeon within a population that undertake long-distance movement and the importance of these movements for maintaining Lake Sturgeon populations (e.g., if they are important to maintain the transfer of genes) is unknown. In the case of the Keeyask Lake Sturgeon studies, data collected over the previous 13 years has provided a good indication of the proportion of the population that move long distances and the proportion that move through Gull Rapids.

In summary, the Keeyask GS may reduce the number of Lake Sturgeon that move from Gull Lake to Stephens Lake (either by reducing the number that attempt to move or increasing mortality of those that move). The GS would also prevent a small number of Lake Sturgeon from emigrating from the Stephens Lake population to join the upstream population. Based on existing numbers of fish that move, this change would not affect the long-term sustainability of either the upstream or downstream population. The likely implications for the upstream and downstream populations are:

a) a loss of individuals and genes (alleles) to the upstream population from the small number of individuals that would have immigrated from the downstream population;

b) a potential small loss of recruitment to the upstream population that would have resulted from contributions of downstream fish;

c) a small gain in numbers to the Stephens Lake population due to the prevention of upstream emigration; and/or

d) either result in an increased number of spawning sturgeon in Stephens Lake or a small reduction in recruitment if some fish seeking to move upstream do not spawn downstream of the station.

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