Keeyask Generation Project

Environmental Impact Statement

Supporting Volume

Aquatic Environment

KEEYASK

Hydropower Limited Partnership

June 2012

APPENDIX 1A - PART 2
KEEYASK LAKE STURGEON STOCKING STRATEGY

Lake Sturgeon (*Acipenser fulvescens*) Mitigation in the Keeyask Study Area:

Keeyask Lake Sturgeon Stocking Strategy

DRAFT: FOR DISCUSSION WITH FISHERIES AND OCEANS CANADA AND MANITOBA WATER STEWARDSHIP

North/South Consultants

April 2012

Table of Contents

List of Figures

List of Appendices

1.0 INTRODUCTION

The Keeyask Hydropower Limited Partnership[1] is planning to construct the Keeyask Generation Project on the Lower Nelson River at Gull Rapids starting in July 2014. Representatives of the Keeyask Cree Nations, Manitoba Hydro, and biologists working on the Project, have been working together to develop a suite of measures to mitigate effects of the development on the aquatic environment under the auspices of the Keeyask Aquatic Working Group, which was formed in mid-2008.

Development of the Keeyask Generating Station (GS) will affect lake sturgeon populations in the reach of the Nelson River between the Kelsey and Kettle GSs (Figure 1). To mitigate effects of the Keeyask GS on lake sturgeon, as well as support a broad-based recovery plan for this species, a mitigation package, comprised of habitat works and stocking, has been developed. Stocking is one of the most common mitigative strategies used to restore near-extirpated fish species from native environments and has been successfully employed for lake sturgeon in a number of locations throughout much of its range (Appendix 1). Stocking effectively improves recruitment by ensuring survival through the very young life history stages, thereby bypassing a significant portion of mortality that occurs in wild fish populations. The basic goal of any lake sturgeon stocking program is to establish, maintain or enhance a population within a designated area where suitable habitat exists.

1.1 BACKGROUND

Historically, the lake sturgeon was common throughout the Nelson River between Kelsey Rapids (now Kelsey GS) and Kettle Rapids (now the site of Kettle GS) as well as above and below these dams. Commercial exploitation of lake sturgeon in the upper Nelson River above Kelsey began in the early 1900s (MacDonell 1997). Over-harvest contributed to depleted sturgeon stocks throughout the province and the commercial fishery collapsed several times before it was closed permanently in 1992. In addition to commercial harvest, lake sturgeon numbers have declined at all locations on the Nelson River where the construction of generating stations has altered habitat for specific life history requirements such as spawning. Lake sturgeon populations remain in several portions of the Nelson River, including the reach between the Kelsey and Kettle dams, and also are present in the Burntwood River between First Rapids and Split Lake.

---

[1] The Keeyask Hydropower Limited Partnership is planning to construct the Keeyask Generation Project is comprised of four limited partners and one general Partner. The four limited partners are Manitoba Hydro, Cree Nation Partners Limited Partnership, York Factory First Nation Limited Partnership, and Fox Lake Cree Nation Keeyask Investments Inc. The Cree Nation Partners Limited Partnership is controlled by Tataskweyak Cree Nation (TCN) and War Lake First Nation (WLFN). The York Factory First Nation Limited Partnership is controlled by the York Factory First Nation (YFFN). Fox Lake Cree Nation Keeyask Investments Inc. is controlled by Fox Lake Cree Nation (FLCN). The general partner is 5900345 Manitoba Ltd., a corporation wholly owned by Manitoba Hydro.

Figure 1. Map of Kelsey to Kettle GS reach.

The lake sturgeon has been assessed as a "heritage species" in Manitoba and has been assessed as endangered, threatened or of special concern in western Canada (i.e., those in Manitoba, Saskatchewan, and Alberta) 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* (SARA), in which lake sturgeon in the Nelson River from Lake Winnipeg to Hudson Bay has been assessed as endangered and this reach is referred to as "Designatable Unit 3". As part of the SARA process, a Recovery Potential Assessment (RPA) has been prepared (DFO 2010). Within the RPA report, the Kelsey to Kettle reach of the Nelson River is listed as Management Unit (MU) 3.

1.2 OBJECTIVES

Maintaining or developing sustainable lake sturgeon populations in the Project area following development of the Keeyask GS is an important post-Project objective. In addition, the overall mitigation program developed for the Keeyask GS should consider the regional goal of recovery of lake sturgeon in the Nelson River, with the specific intent that development of the Keeyask GS should not preclude the recovery of lake sturgeon in the Nelson River, as set out in the DFO (2010) RPA.

During development of the stocking strategy, several information gaps were identified that need to be addressed before the strategy can be finalized. In addition, this strategy provides for an adaptive approach, as it is expected that all aspects of the strategy, including spawn collection, rearing and release, will be refined as additional information is obtained.

The program is comprised of three phases (note that conduct of these phases may overlap and that phases are not independent):

1. Planning phase – this phase provides the overall framework for the program, and refined the objectives to enable creation of a site-specific plan. During this phase, the need for additional information was identified and addressed through specific data collection programs. Specific activities included identification of:
    a. Target locations for stocking
    b. Target numbers, fish ages and duration of stocking program
    c. Source of brood stock
2. Pre-implementation phase – this phase addresses the practical issues related to implementation of the stocking program and includes investigations to address potential issues. It should be noted that additional requirements for field trials will likely be identified as investigations continue. Specific activities identified to date include:
    a. Assessment of brood stock collection
        i. Assessment of numbers of mature fish by spawning location
        ii. Assessment of the use of a hormone (Ovaprim) to facilitate collection of eggs and milt
    b. Assessment of rearing
        i. Investigations of potential lake sturgeon diseases and disease transmission
        ii. Evaluation of rearing conditions with respect to temperature and food supply
    c. Monitoring and assessment of post-release success
        i. Assessment of survival rates (to enable refinement of stocking target numbers)

    ii. Comparison of survival rates of fingerling and yearling fish
    iii. Measurement of movements from area of release

3. Implementation phase – this phase would mark the transition from a planning/information gathering program to implementation with the objective of supporting the sturgeon population in the directly affected area, and assisting in long-term recovery in the Keeyask region. A detailed plan for this phase will be developed after results of the planning and pre-implementation phase are available. However, it is recognized that the implementation phase would be comprised of three stages:
    a. Construction – during this phase, priority would be given to stocking into areas where spawning may be disrupted due to construction activities, in particular in Stephens Lake and, to a lesser extent, Gull Lake. The intent would be to improve recruitment during years when construction related activities may affect spawning success.
    b. Operation – this phase would comprise approximately the first two decades of operation, when the largest physical changes in the environment are expected. The effectiveness of habitat mitigation measures and stocking will be assessed during this phase based on results of monitoring programs aimed at determining recruitment success, and in particular contributions of hatchery-reared and wild fish to each cohort. Adjustments to the stocking program may be necessary based on results of monitoring.
    c. Long term – stocking in this phase would be designed to provide long-term sustainable populations within MU3. The need for and locations of stocking would depend on the results of monitoring to determine population status.

The following document is comprised of the following sections:

Section 2: Planning phase

Section 3: Pre-implementation phase

Section 4: Next Steps

2.0 PLANNING PHASE

The planning phase of the Keeyask lake sturgeon stocking strategy will address refining overall objectives of the stocking strategy, in terms of:

1. Identifying locations to stock;
2. Determining numbers and life stages of lake sturgeon to stock, and the duration of the program; and
3. Identifying sources of brood stock.

Several field investigations were undertaken in support of this phase, and, as discussed below, further refinements are expected as additional information is obtained. Input from the planning phase has been used to focus activities conducted during the pre-implementation phase (Section 3), which is focused on addressing issues related to the implementation of a lake sturgeon stocking strategy.

2.1 IDENTIFICATION OF TARGET LOCATIONS

As discussed in Section 1, lake sturgeon was historically abundant in the large river systems of northern Manitoba. Overall, waterbodies considered for mitigation as part of the Keeyask Project have been limited to northern Manitoba.

The broad river reaches selected for consideration within the stocking plan were ranked according to the degree of impact on the population that can be attributed to the development of Keeyask, as follows:

1. Direct effect of Keeyask GS on habitat/resident fish (Clark Lake to Stephens Lake reach);
2. Keeyask GS within same Management Unit (MU3 from Kelsey to Kettle GSs);
3. Keeyask GS within same Designatable Unit (Nelson River from Lake Winnipeg to Hudson Bay); and
4. Other locations in northern Manitoba.

Following selection of broad river reaches, potential locations within each reach were further evaluated with respect to the status of the current populations and availability of habitat to support all life history stages. The availability of habitat is important to support the goal of the stocking program, which is to establish self-sustaining populations.

2.1.1 Selection of River Reaches

The area that will be directly affected by the Keeyask Project is the reach of the Nelson River between Clark Lake and the inlet to Stephens Lake. The upstream portion of this reach, from Clark Lake to Gull Rapids, will become the reservoir of the Keeyask GS, while the lower portion will form the tailrace and immediate downstream environment of the GS. This downstream area is part of Stephens Lake. Habitat in this reach will be substantially altered, and habitat works are planned with the objective of providing requirements to support all life history stages. Stocking in this reach is considered the top priority for this stocking plan.

Management Unit 3 is the reach of the Nelson River between the Kelsey and Kettle GSs. Sturgeon use of this area can be broadly divided into three groups: Upper Split Lake (sturgeon use is concentrated in the Nelson River below the Kelsey GS, the Grass River and the Burntwood River to First Rapids), the Clark Lake to Gull Rapids reach, and Stephens Lake. Stocking in the Clark Lake to Gull Rapids reach and the area immediately downstream of the GS has already been identified as the top priority. Stocking in other portions of MU3 have been assigned a secondary priority level.

The Nelson River (DU3) was historically comprised of several sturgeon populations. The management units upstream of the Kelsey GS are currently being addressed by the Nelson River Sturgeon Management Board and so are not considered further in this plan. The Kelsey to Keeyask reach was considered above. The DFO (2010) RPA for the lower Nelson River identified the Long Spruce (MU4) and Limestone forebays (MU5) in assessing potential for recovery of lake sturgeon. For the purposes of this document, these forebays were assigned as the third priority of the stocking plan (subject to further evaluation of potential sturgeon habitat quality and availability). Downstream of the Limestone GS, the Nelson River supports a substantial population of lake sturgeon and stocking is not required.

With respect to other river systems in northern Manitoba, the Hayes and Churchill systems are both known to support sturgeon populations. The Hayes system is largely undisturbed by development, and therefore, stocking has not been considered for this area. The status of lake sturgeon in the Churchill River is not well known, though the river at the confluence of the Little Churchill River is known to support a population of lake sturgeon. Genetic evaluation has indicated that this is a distinct genetic stock (Cote *et al.* 2011). Given that this river is outside of the Designatable Unit and the stock is clearly distinct from that found in the Nelson River, stocking efforts will be focused on the Nelson River. If it is found that there is no potential for successful stocking projects in the Nelson River system, targeting other river systems would be revisited.

In summary, the Nelson River between the Kelsey and Limestone GSs was selected for further examination for suitability for stocking.

2.1.2 Selection of Locations within River Reaches

The overall analysis of broad river reaches identified the Nelson River between Kelsey and Limestone GSs as providing potential locations where population enhancements through stocking could contribute to the mitigation of effects of the Keeyask Project. This mitigation would ameliorate site-specific effects, as well as contribute to the recovery of the regional lake sturgeon stock. These areas were further examined to determine whether habitat was available to support all life history stages, such that a self-sustaining population could be established.

Lake sturgeon in the Kelsey to Kettle reach of the Nelson River occupy three general areas:

1. The Split Lake Area - includes the Nelson River from below Kelsey GS to the outlet of Split Lake and the Burntwood River from First Rapids to Split Lake;
2. The Keeyask Area - includes the reach of the Nelson River extending from the inlet of Clark Lake to the upstream end of Gull Rapids; and
3. The Stephens Lake Area (downstream of Gull Rapids to Kettle GS) (Figure 1).

Each of these areas currently supports a spawning population.

Studies conducted for the Keeyask Generation Project environmental assessment provided information regarding population size, existing habitat, success of current reproduction and relevant life history information for each of the three areas. These data were used as a basis for designing the stocking strategy for Keeyask. For example, key considerations for the design of the Keeyask stocking strategy such as the feasibility of collecting lake sturgeon gametes in the study area, locations to introduce hatchery reared fish, and the relative importance of each area for receiving hatchery reared fish, described later in this document, were based on these data.

Specific studies to address lake sturgeon populations in the Long Spruce and Limestone forebays were not conducted as part of the Keeyask technical studies; however, ATK from the Fox Lake Cree Nation (FLCN) indicates that sturgeon were present in these sections of the Nelson River prior to hydroelectric development but were substantially reduced following construction of the dams.

Split Lake Area

Lake sturgeon population estimates generated from mark and recapture data collected during EA studies (2001 – 2007) for the Split Lake Area ranged from 249 to 1,511 adult fish with the most recent estimate (2007) at 861. This area contains one known lake sturgeon spawning location, First Rapids on the Burntwood River. In addition, lake sturgeon are known to have historically spawned in Grass River below Witchai Lake Falls and in the Nelson River downstream of Kelsey Falls (now the Kelsey GS; MacDonell 1997). Despite substantial effort during EA studies, conclusive evidence of spawning or successful recruitment from either of these areas has not been found. However, based on the information collected during EA studies, it is clear that a remnant lake sturgeon population exists in this area.

In 2010, a coarse scale habitat inventory was conducted in the Split Lake Area, which included four rivers: a) the Burntwood River; b) the Odei River; c) the Nelson River downstream of Kelsey GS; and d) the Grass River (Henderson *et al.* 2011). Habitat suitable for spawning, rearing, and foraging for each life history stage (young-of-the-year (YOY), sub-adult (~200-833 mm) and adult (≥ 834 mm FL)) of the lake sturgeon was found in the Burntwood, Nelson, and Grass rivers. In the Odei River, however, the substrate was composed predominantly of fine particles (i.e., silt/clay) and water velocities were low, suggesting that suitable rearing habitat for YOY lake sturgeon may not exist. Although the Odei River may not provide habitat for YOY lake sturgeon, the presence of lake sturgeon from several age classes in the Burntwood River (Henderson *et al.* 2011) confirms that habitat suitable for each life history stage can be found in the Burntwood River downstream of First Rapids. In the Nelson and Grass rivers, EA studies have documented far fewer adult lake sturgeon (relative to the Burntwood River), despite the relatively high diversity of habitats. Given the diversity of habitat, historic reports of substantial sturgeon fisheries in both the Grass River and Nelson River downstream of Kelsey Falls, it is probable that suitable habitat for each life stage of the lake sturgeon exists in this area. Given that suitable habitat exists for each life stage of lake sturgeon in the Burntwood River, Nelson River near the Kelsey GS and the Grass River, these areas appear to be appropriate for stocking lake sturgeon.

Finally, it should be noted that the Keeyask GS Project is not expected to affect lake sturgeon habitat in the Split Lake area.

Keeyask Area: Clark Lake Inlet to Gull Rapids

Population estimates for the Nelson River between Birthday and Gull rapids (2001 to 2008) ranged from 344 to 1,275 adult fish with the most recent estimate (2008) at 643. This reach of the Nelson River contains two known sturgeon spawning locations: Long Rapids and Birthday Rapids. Based on EA studies, the lake sturgeon population in this reach of the Nelson River is considered to be remnant.

Habitat suitable for each life history stage of the lake sturgeon is believed to exist in this reach of the Nelson River as evidenced by captures of young-of-the-year (YOY), sub-adult, and adult fish. In addition, results from telemetry studies indicate that lake sturgeon over-winter within this reach of the Nelson River.

Construction of the Keeyask GS will alter water depth and flow conditions at Birthday Rapids as the upstream boundary of the open-water hydraulic zone of influence of the Project will be located between the outlet of Clark Lake and Birthday Rapids during open-water conditions. The alteration of water levels and flows at Birthday Rapids may render this area less suitable for spawning lake sturgeon. However, it is possible that lake sturgeon currently using Birthday Rapids for spawning will either continue to spawn at Birthday Rapids, or, move upstream to spawn at Long Rapids, which are not expected to be altered by the Project. Similar behaviours have been observed by adult lake sturgeon in Quebec (Richard Verdon *pers comm*). If monitoring indicates that sturgeon no longer spawn at Birthday Rapids, the potential to modify habitat immediately upstream will also be investigated.

Further to the habitat alteration at Birthday Rapids, construction of the Keeyask GS will also alter habitat between Birthday Rapids and the Keeyask GS. Habitat suitability index models were developed for three lake sturgeon life history stages based on the habitat (depth, water velocity and substrate) expected to exist in the Keeyask reservoir post-Project. Outputs from these models suggest that ample foraging habitat for sub-adult and adult lake sturgeon will exist post-Project; however, the models predict a net loss of YOY habitat. Creation of YOY habitat has been identified in the Keeyask mitigation plan. If monitoring data suggests that post-Project natural recruitment is poor, YOY habitat will be developed.

Stephens Lake

Too few sturgeon were captured in the Stephens Lake area during EA studies to generate a population estimate. Gull Rapids is the only location in the Stephens Lake area that possesses habitat characteristics suitable for lake sturgeon spawning. Catches of YOY, sub-adult and adult fish in Stephens Lake, particularly in the riverine reach downstream of Gull Rapids, indicate that at least some rearing and foraging habitat exists for these life stages in the present day environment. In addition, telemetry studies have shown that lake sturgeon over-winter in Stephens Lake.

Habitat suitability indices developed for YOY, sub-adult, and adult lake sturgeon indicate that there is currently little suitable YOY habitat in Stephens Lake. In addition, the Keeyask GS will eliminate all spawning habitat at Gull Rapids. In order to ensure that habitat suitable for each life history stage will exist following development of Keeyask, creation of a spawning structure downstream of the generating station powerhouse has been planned as a necessary mitigation action. Creation of a lake sturgeon spawning area has been accomplished downstream of the Rivière des Prairies GS in Quebec and this area has been successful in increasing the spawning success of lake sturgeon (Dumont *et al.* 2011). Further, habitat creation for young-of-the-year lake sturgeon is also being considered for an area downstream of the proposed spawning area. Should these habitat enhancement measures prove successful, then habitat suitable for each life stage of the lake sturgeon should remain in Stephens Lake post-Project.

Long Spruce and Limestone Forebays

Construction of the Long Spruce and Limestone GSs created the Long Spruce and Limestone forebays which have been in existence for approximately three and two decades, respectively. Although lake sturgeon populations within these forebays have not been studied extensively, similar to the Stephens Lake populations, lake sturgeon abundance appears to be too low to facilitate quantitative population estimates. In addition, it is unknown if natural recruitment of lake sturgeon is occurring within these two forebays. Young lake sturgeon (born after construction of the GSs) have been captured in both forebays, however, it remains unknown if these lake sturgeon are immigrants from areas further upstream in the Nelson River.

As previously discussed, a successful stocking program aimed at the long-term restoration of a naturally sustainable population must meet several criteria including: a) existence of habitat suitable for the growth of each life history stage in the vicinity of each release location; b) availability of spawning habitat for introduced fish to use once they reach sexual maturity; and c) a location where suitable numbers of brood stock, genetically similar to wild fish, can be collected. These criteria are discussed below in reference to the Long Spruce and Limestone GS forebays.

Habitat mapping of the Limestone and Long Spruce GS forebays indicated that the substrate was comprised almost entirely of coarse substrate such as bedrock, large boulders and cobble. Considering that rearing areas for larval and YOY lake sturgeon are thought to be composed of sand and gravel substrate, it is unknown if sufficient habitat suitable for the growth of each life history stage of the lake sturgeon exists within these forebays. Given the apparent lack of spawning lake sturgeon, it is difficult to determine the suitability of this habitat for larval sturgeon.

The second criterion, availability of spawning habitat, may also not be met in either forebay. Given the low abundance of spawning lake sturgeon however, it is difficult to assess the suitability or availability of spawning habitat. Successful spawning has not been documented below either GS and although lake sturgeon are known to spawn at the base of hydroelectric generating stations, the quality and quantity of habitat downstream of both the Long Spruce and Limestone GSs is smooth bedrock which lacks interstitial spaces sturgeon may need for successful egg incubation. Spawning areas may need to be created downstream of these GSs to provide stocked lake sturgeon a place to spawn.

The third criteria, that suitable numbers of brood stock with similar genetics exists to act as a donor population, could be met for these two areas. Lake sturgeon from the Nelson River downstream of Limestone GS would likely be the most suitable for brood stock for these two forebays.

In summary, because suitable habitat may not currently exist within the Long Spruce or Limestone forebays for each life history stage of the lake sturgeon, it was decided that lake sturgeon stocking into either of the forebays would not be included in the Keeyask stocking strategy. Any future consideration of lake sturgeon stocking in either of the Long Spruce and/or Limestone forebays would likely necessitate the creation of spawning and rearing habitats to support population recovery.

2.2 NUMBER OF FISH, AGE AT RELEASE AND DURATION OF STOCKING PROGRAM

The following section provides a rationale for the proposed number of fish stocked, age at release and duration of the stocking program required to meet the DFO (2010) RPA objective for MU3 (Kelsey GS to Kettle GS). The actual number of fish stocked and locations for stocking within MU3 will depend on ongoing monitoring and assessment, the age at which fish are stocked, and the success of spawn collection and rearing.

2.2.1 Number of Fish to Stock

The determination of the number of fish to stock within MU3 was based on stocking rates for lake sturgeon at the fall fingerling life stage. Stocking plans for older (i.e., yearling) or younger life stages would be adjusted according to expected survival rates for those stages.

Two approaches were followed to estimate the appropriate fall fingerling stocking density: 1) lake sturgeon stocking guidelines developed in Wisconsin; and 2) a recruitment model targeting reaching a specific adult spawning female population over the course of the program.

Wisconsin Guidelines

The Wisconsin Guidelines were developed based on Wisconsin rivers, which are smaller than the Nelson River. These guidelines suggest that fall fingerlings should be stocked at a rate of 80 fish/river mile (50 fish/river km). The river length in MU3 is 213 km; this was calculated by measuring river length from Kelsey GS to Kettle GS, plus the river length from First Rapids to a mid-point in the upper portion of Split Lake, plus the distance from the apex of the north arm of Stephens Lake to a mid-point in Stephens Lake. Based on the estimated river length, the Wisconsin Guidelines prescribe an annual fall fingerling stocking rate of 10,650 fish. As noted above, these guidelines are based on smaller rivers than the Nelson River; therefore, these estimates may be low.

Lake Sturgeon Recruitment Model

The DFO (2010) RPA provides a target number of a minimum number of 413 spawning females to achieve healthy, viable populations of lake sturgeon in each MU. To obtain an upper estimate on the number of sturgeon that could be stocked, targets for the release of fall fingerlings into the combined three reaches (Upper Split Lake, Nelson River between Clark Lake and Gull Rapids, and Stephens Lake) were developed based on a recovery target of 500 Adult Spawning Females (ASF) per year (which equates to 2500 ASF in the population based on females spawning every five years) within three generations (90 years) over the three areas combined.

The number of fall fingerlings required for stocking each year to achieve the ASF objective was derived through construction of a lake sturgeon life table with age, survival at age, and fecundity. The stocked cohorts were propagated through time using a matrix. For surviving spawning fish at each age over 25 years, a fecundity value was calculated based on literature values and a fecundity with age function was applied. The eggs that hatched and survived to fingerling stage were added to the population each year and the cycle repeated. The contribution of the existing population of "wild" adult spawning females to meeting the Management Unit ASF objective was not included in the recruitment model. Consequently, recruitment model results represent an over-estimate of the number of stocked fish required to meet the recovery target.

Three potential scenarios were explored and compared to determine the potential impact that ongoing harvest would have on the time to achieve the ASF objective (Figure 2). The stocking rate chosen for this comparison was the minimum rate that would achieve the ASF objective with both natural and fishing mortality factored into the adult survival rate.

1. **Unexploited Population** – This scenario (Figure 2 - top-most graph) assumes that only natural mortality (6.7%) would determine adult survival rates (i.e., no lake sturgeon fishing). Under these conditions, annual stocking of 19,722 fall fingerlings (includes both sexes at assumed 1:1 gender ratio) for 25 years would achieve the 2500 ASF objective in 32 years. Survival rates used in the model were as follows:
   - 0.300 annual survival of fall fingerlings;
   - 0.6998 annual survival of one-year olds; and
   - 0.933 annual survival for lake sturgeon older than two years of age (juvenile through all adult year classes).
2. **Exploited Population** – This scenario (Figure 2 – middle graph) shows how fishing mortality (in addition to natural mortality) would affect attainment of the ASF objective under the same stocking plan as above. No direct estimate of fishing mortality is available for the area. Therefore, an estimate of 8.3% was derived from the difference between the estimated population survival in the Nelson River between Clark Lake and Gull Rapids (85%) and the average adult survival provided by DFO (2010) (93.3%). Use of this estimate may result in an over-estimate of the effects of fishing mortality on the population as it was applied to the entire Kelsey to Keeyask reach, and fishing mortality in the other parts of the reach may be lower than in the Clark to Gull Rapids reach. Survival rates used in this run of the model were as follows:
   - 0.300 annual survival of fall fingerlings;
   - 0.6998 annual survival of one-year-olds;
   - 0.933 annual survival for year classes two through 24; and
   - 0.8496 annual survival for fish older than 24 years.

   The modelled results show that at the same stocking rate and duration (i.e., 25 years) as above, the 2500 ASF objective would be met at approximately year 45. However, within five years the ASF population would begin to decline, reaching 500 ASF by year 90 and continuing a slow decline thereafter.

3. **Exploited Population but with Enhanced Stocking to Maintain ASF Objective** – Survival rates at each life stage for this scenario (Figure 2 – bottom graph) are identical to those used in the middle graph. In this case, the ASF objective in the exploited population would be met the same as above (approximately 45 years). However, to sustain and grow the ASF population, stocking would be required for as long as annual fishing mortality remained at or above the estimated rate of 8.3%. In the example shown, continued stocking at a constant rate of 19,722 fall fingerlings would result in growth of the ASF population to approximately 3,900 fish by year 90. Stocking at this rate would meet and exceed the DFO RPA objective.

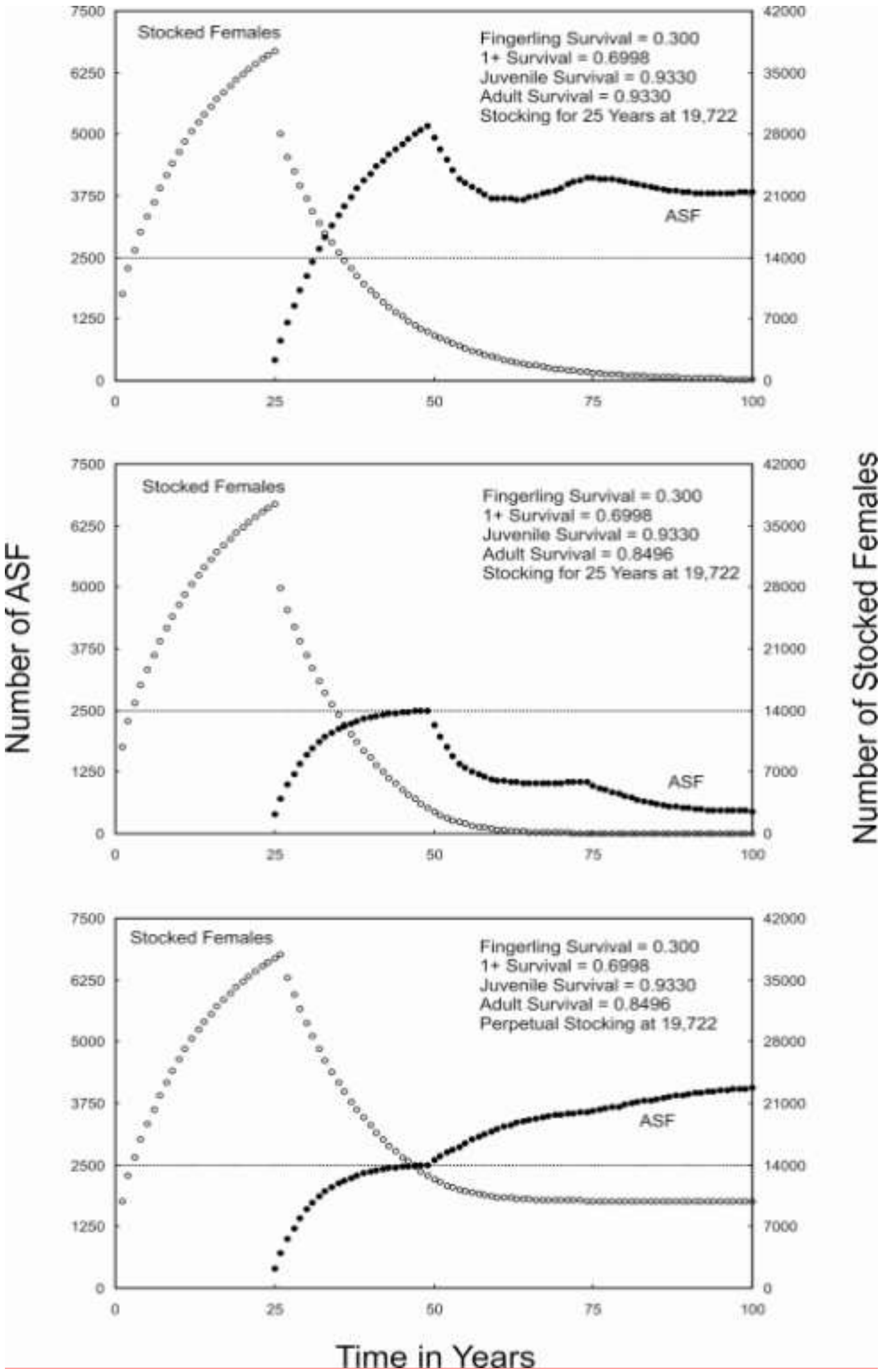

Figure 2. **Adult spawning female (ASF) population response to fall fingerling stocking: Upper graph – stocking with no harvest; Middle graph – stocking with harvest (8.3% fishing mortality); Lower graph – stocking to compensate for harvest.**

In the Exploited Scenario (i.e., assumes a constant annual 8.3% fishing mortality), to achieve the same objective in the same time frame as in the Unexploited Scenario, an annual stocking rate of 19,770 fall fingerlings would be required. However, to maintain the ASF population at or above the objective, ongoing stocking would be required in perpetuity providing fishing mortality remained at the current rate.

Of these three scenarios, it is recommended to use Scenario 3 as the basis for setting initial annual targets for stocking density. It is assumed that a sturgeon harvest on the Nelson River would continue since it is culturally important. It is important to note that lake sturgeon year-class strength and the proportion of the hatchery reared versus wild fish that comprise each year class will be monitored annually. Stocking rates would be modified based on monitoring results, to avoid either under or over-stocking.

Recommended Stocking Rate based on Fall Fingerling Stage

Using the Wisconsin Guidelines as a basis for determining the density of fish to be stocked, a fall fingerling stocking rate of 10,650 fish/year, annually over one generation or 25 years, would be recommended. However, stocking at this rate does not explicitly account for any assumed fishing mortality and may be too low considering the Wisconsin guideline was developed based on rivers smaller than the Nelson River.

Summary and Recommendation

The lake sturgeon recruitment model (Unexploited Scenario) indicates that, in the absence of fishing mortality, a stocking rate of 19,722/year for 25 years would achieve the ASF objective (DFO RPA) within 32 years. However, an analysis of how different rates of annual stocking affect the time (and cost) to achieve the long-term ASF objective indicates that stocking at a rate of 10,440/year for 25 years would attain the ASF objective in 45 years (Figure 3). This stocking rate appears to be the most cost-effective rate at which to stock fall fingerlings to achieve the DFO (2010) RPA objective within a reasonable period of time (i.e., within three generations). In the absence of fishing mortality, the ASF objective would be sustained over the long term at or above that level. This rate is essentially (and coincidentally) the same as the rate derived using the Wisconsin Guideline.

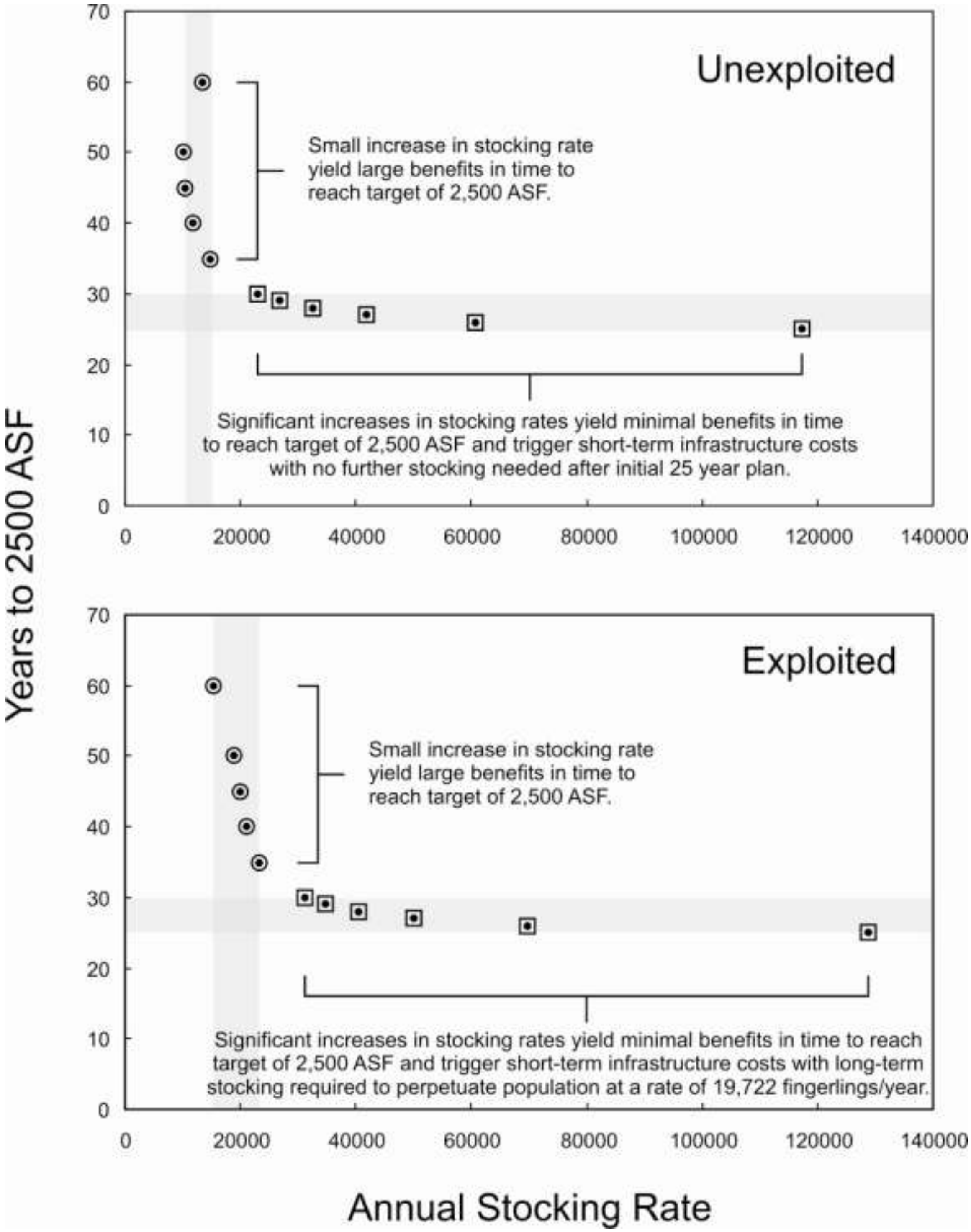

Figure 3. **Relationship between number of lake sturgeon fall fingerlings (male and female) stocked and time to meeting the adult spawning female objective.**

2.2.2 Age of Fish to Stock

Larvae (feeding stage; following yolk sac absorption), fall fingerlings (17 weeks old) and spring yearlings (1 year old) are the three life stages being considered for stocking. Advantages and disadvantages that are being considered in determining which life stages to stock are described below:

- Larval (feeding stage) fish have the advantage of lower rearing costs; however, mortality is considerably higher than older life stages due to starvation and predation once fish are released from the protective hatchery environment. Whether or not earlier life stage introduction to their receiving environment would result in higher future reproductive success is unknown, but it has been suggested that fish introduced at an early life stage would benefit in the long-term from effects of natural selection on maintaining desirable within-population genetic variation (Welsh *et al.* 2010). Habitat requirements of larval lake sturgeon are poorly understood, and further, uncertainties remain regarding the availability of this habitat following construction of the Keeyask GS. The number of larval sturgeon that are hatched in the hatchery may exceed the rearing requirement for fall fingerling and spring yearling release, as well as exceed the rearing capacity of the hatchery/rearing facility. Excess supply of larval lake sturgeon would be released into receiving reaches at locations in the same general area from which the gametes were sourced or where known YOY habitat is present.
- Fall fingerlings are the life stage released in many stocking programs as survival is higher relative to larval fish, and there are fewer uncertainties regarding the availability of suitable habitat. Crossman (2008) reported that recapture rates and dispersal distances were significantly higher for fish stocked at 17 weeks than for fish released at earlier ages. Additionally, given the uncertainty with the suitability of early young-of-the-year rearing habitat in the Keeyask reservoir, the release of fall fingerling may be more successful than the release of larvae. Although fall fingerlings cost more to raise than larvae/fry, the cost is significantly less than culturing the fingerlings over the winter. Literature sources suggest a first winter survival rate for fall released fingerlings of between 20 and 40% (Aloisi *et al.* 2006; Crossman *et al.* 2009).
- Spring yearlings would have the advantage of even higher survival relative to the earlier life stages and would be least likely to be limited by available foraging habitat in Stephens Lake and the newly created reservoir. Rearing costs would be the highest of the three life stages; however, the higher survival rate of one-year old lake sturgeon would also offset requirements to stock as many fall fingerlings to meet ASF recovery objectives. Other factors as noted by Welsh *et al.* (2010) (such as natural selection) need to be considered when making decisions on early versus later fish release.

The life stages proposed for stocking would depend on the availability of suitable habitat to support each life stage during and following construction of the Keeyask GS, the year-to-year variation in the supply of gametes, and consideration of survival rates versus rearing costs associated with each life stage. Population monitoring post-Project will play a key role in determining year-class strength and the relative contributions to each cohort from hatchery reared or wild fish. Monitoring will also be used to determine survival of each life stage of lake sturgeon released. These data will be used to fine-tune the stocking program by determining the optimal number, life stage and location to stock lake sturgeon.

2.2.3 Duration of Program

The Keeyask lake sturgeon stocking program is expected to be implemented for as long as required to achieve and maintain the stated DFO (2010) RPA objective for MU3. However, the focus and priorities attached to stocking program components are expected to change with time depending on Project phase (construction versus operation), habitat limitations, area-specific lake sturgeon population growth, and brood stock availability.

As discussed in Section 1.2, monitoring would be conducted during the pre-implementation and implementation phases of the stocking program to determine the effect on fish populations and avoid potential effects of overstocking. The duration of the program could vary depending on location and monitoring results as follows:

Short term – the aim of a short-term stocking program would be to prevent missing year classes in the sturgeon population in the Keeyask area during years of construction, as mitigation measures to support spawning and YOY rearing are refined. Therefore, stocking numbers and age at release would be modified once it is understood how the natural processes may have been affected by the project and how stocked lake sturgeon are surviving in the wild. A short-term stocking program would continue while the Keeyask GS is under construction.

Long term – the aim of a long-term stocking program would be to re-establish a sustainable population. Therefore, a long-term stocking program would continue through an entire generation (25 years). After 25 years, it is hoped that the number of naturally reproducing fish would be sufficient to sustain the population. For example, it is likely that the Stephens Lake area would be targeted with a 25-year program.

Permanent – as discussed in Section 2.2.1, the rates of exploitation in these areas may be sufficient to require stocking in perpetuity to support the populations. Monitoring would determine if densities are reaching levels that are too high; otherwise, stocking could continue for as long as mortality rates exceed a self-sustaining recruitment rate.

2.3 IDENTIFICATION OF "SOURCE" POPULATION

In order for a stocking program to be successful, a population of lake sturgeon must be identified from which gametes can be collected. Several factors must be considered when selecting a suitable source population:

1. The source population must be genetically similar, or as similar as possible, to the existing (remnant) population.
2. The population must be large enough to provide sufficient gametes and genetic variability.
3. It must be feasible to collect eggs and milt from the source population and transport fertilized eggs to a facility for rearing.

Cote *et al.* (2011) provided an analysis of the genetic structure of lake sturgeon from three river systems in northern Manitoba: the Nelson River from Sipiwesk Lake to the Nelson River Estuary; the lower Hayes River; and the Churchill River at the confluence with the Little Churchill. The study found that the Churchill River sturgeon were distinct from the other groups. Within the Nelson/lower Hayes group, there was evidence for four subpopulations: the Landing River (Nelson River); Kelsey/Grass and Burntwood (Split Lake); Birthday/Gull (Nelson River reach from Birthday Rapids to Kettle GS); and lower Nelson/Angling/Weir/lower Hayes rivers. The level of genetic difference among these four groups was low. The importance of conserving this genetic differentiation is unknown, but maintenance of existing genetic structure is the preferred approach in conservation genetics (Welsh *et al.* 2010). With respect to the Keeyask stocking strategy, a conservative approach to maintaining the existing genetic structure would require obtaining gametes and rearing lake sturgeon from the same resident lake sturgeon subpopulation for each area of interest for stocking. However, given the low level of difference found among the sites, an alternate, less conservative approach would be to consider the Nelson River below the Kelsey GS as a single population.

At least one known spawning location exists in each of the areas identified by Cote *et al.* (2011). However, in many cases, the total population and number of sturgeon spawning each year at some of these locations is small; pilot studies are being conducted to determine the feasibility of collecting gametes at these locations (Section 3.1). Even if spawn collection is feasible, the numbers of fish collected at some locations will be below recommended levels. Elliot *et al.* (2005) recommended that over 25 years, gametes should be collected from at least 250 different females. Although this goal would be difficult to achieve in the Keeyask area due to small populations, it would be feasible to collect eggs from a minimum of two different females annually. If the two females were crossed with a minimum of four males, this would ensure that genes from at least eight families were stocked annually. In addition, fish used for spawn collection will be marked for future identification to ensure that they can be recognized during subsequent spawn collection activities and not reused (i.e., the proposed plan would not retain adult sturgeon for use as brood stock).

It should be noted that, despite the small subpopulation size at some locations, none of the subpopulations had lower than expected genetic diversity and are considered genetically 'healthy' (Cote *et al.* 2011). In addition, recent work by Schueller and Hayes (2011) suggests that lake sturgeon have potentially lower minimum viable population sizes because the long-lived overlapping generations of lake sturgeon may buffer populations from inbreeding depression. Further, these authors suggest that populations between 80 and 150 individuals are required for long-term persistence. These studies, as well as additional genetic studies currently being planned for lake sturgeon in the Nelson River as part of Keeyask EA studies, will continue to contribute to refinement of this stocking strategy, specifically with regards to numbers of fish and numbers of families to stock.

With respect to the third consideration listed above, the collection of spawn is feasible (see Section 3.1) from each subpopulation. Therefore, given the uncertainties surrounding genetic mixing of stocks, the initial stocking plan would likely attempt to maintain the existing genetic structure and collect spawn from the same subpopulations as will be stocked. However, given uncertainties and difficulties associated with spawn collection, a second contingency strategy may be required. If the number of spawning fish is too small to support the above approach, then spawn will be collected at sites that are genetically the most similar to proposed stocking locations.

3.0 PRE-IMPLEMENTATION PHASE

This phase addresses the practical issues related to implementation of the stocking program and includes investigations to address potential issues. It should be noted that requirements for additional field trials will likely be identified as investigations continue.

Specific activities identified to date include:

1. Assessment of brood stock collection:
   - Assessment of numbers of mature fish at potential spawn collection locations;
   - Assessment of the use of hormones (e.g. Ovaprim) to facilitate collection of gametes; and
   - Field trials of gamete collection and fertilization.

2. Assessment of rearing:
   - Investigations of issues related to lake sturgeon disease and disease transmission;
   - Evaluation of the effect of water temperature on growth and survival rates; and
   - Evaluation of the effect of food type on growth and survival rates.

3. Assessment of post-release success:
   - Assessment of survival rates (refine stocking objectives);
   - Comparison of survival rates of fingerling and yearling fish; and
   - Measurement of movements from the area of release.

3.1 ASSESSMENT OF BROOD STOCK COLLECTION

Within the Kelsey to Kettle reach, spawning is known to occur at First Rapids on the Burntwood River, and at Long, Birthday and Gull rapids on the Nelson River. On the lower Nelson River downstream of the Kettle GS, spawning has been documented at the Lower Limestone Rapids, and the Weir and Angling rivers. Due to the estimated small annual female spawning population size in the area between the Kelsey and Kettle GSs, it is rare to catch a female lake sturgeon in spawning condition from which eggs can be readily expressed. Lake sturgeon are more abundant in the Nelson River below the Limestone GS. Collection of lake sturgeon for brood stock at Lower Limestone Rapids would be difficult given fluctuating water levels during moderate to low flow years. Further, spawn collection at the Angling River would also be difficult due to the low abundance of spawning lake sturgeon. Therefore, due to the high abundance of spawning fish, and their relative ease of capture, the Weir River provides the best opportunity to collect sturgeon gametes.

In spring 2010, field trials to capture spawning female lake sturgeon at First Rapids on the Burntwood River and at Birthday Rapids on the Nelson River did not yield any sturgeon from which eggs could be expressed. Given the relatively low numbers of spawning lake sturgeon, chances of capturing female lake sturgeon that would readily express eggs are low. One potential approach to spawn collection at these locations would be to inject a hormone that stimulates egg and milt production (e.g. Ovaprim), into fish that are maturing to spawn during the current year. Ovaprim is a commercially available hormone that contains gonadotropin releasing hormone and a dopamine inhibitor. This hormone is used to stimulate and induce ovulation in adult female lake sturgeon and spermiation in male sturgeon. As an example, it has been used successfully from 2008 to 2010 to induce spawning in female lake sturgeon in the Winnipeg River (C. Klassen *pers. comm.*) and has been used during lake sturgeon spawn taking operations in the Rainy River (J. Hunter *pers. comm.*). The benefits of using a hormone such as Ovaprim to induce spawning in lake sturgeon include:

1. Ensuring the collection of eggs and milt from wild spawning sturgeon;
2. The coordinated collection of eggs from ovulating females; and
3. Substantial increase in the volume of eggs collected from each female.

While the use of Ovaprim has proved successful for collecting eggs and milt from lake sturgeon, little is known regarding the effects of Ovaprim on adult lake sturgeon. Manitoba Hydro has engaged a physiologist from the University of Manitoba to examine the following:

1. The effect of Ovaprim on circulating blood and muscle levels of sex hormones, and the duration that these hormones persist in the blood and muscle;
2. The influence of Ovaprim administration on the endocrine stress response; and
3. The influence of Ovaprim administration on egg quality and fertilization success.

Through systematic analysis of plasma and muscle hormonal levels, egg and sperm quality and female and male condition following administration of Ovaprim, this study will determine the effects of Ovaprim on fish condition, gamete quality and viability.

Additionally, in spring 2011, the Nelson River Sturgeon Co-management Board (NRSB) conducted trials using Ovaprim during its spawn collection program on Nelson River near the mouth of the Landing River. Over 35,000 eggs were successfully collected, the largest number ever collected by the NRSB; without Ovaprim, the NRSB would likely have collected very few eggs and may not even have been able to fertilize them (D. MacDonald *pers. comm.*). Results of this initial field trial show that it is technically feasible to collect sturgeon gametes streamside using Ovaprim.

3.2 ASSESSMENT OF REARING

Sturgeon are presently reared in several hatcheries in the USA and Canada, including the Grand Rapids Hatchery in Manitoba. A new hatchery would be constructed in northern Manitoba to provide facilities to raise sturgeon for the Keeyask lake sturgeon stocking strategy. A new hatchery would be designed in consultation with individuals experienced in the design and operation of hatcheries.

Several issues specific to sturgeon culture have been identified at existing sturgeon hatcheries, including the transmission of disease, feeding of larval sturgeon after the yolk sac has been absorbed, and the effect of temperature on growth (fish held at low temperatures to reduce the transmission of disease grow very slowly).

Very little is known with respect to disease transmission among cultured lake sturgeon or the risks associated with transmission of diseases from cultured to wild fish. Manitoba Hydro is funding a study through the Department of Fisheries and Oceans (DFO) to improve the understanding of disease and disease transmission in lake sturgeon. The overall objective of this study is to generate a lake sturgeon infectious disease management plan that will work to prevent the spread of infectious diseases and minimize the incidence of disease in cultured lake sturgeon.

One measure that may work to reduce disease infection in cultured sturgeon is rearing sturgeon at low water temperatures. This measure is currently being employed at the Grand Rapids hatchery but further investigation is warranted as young fish grow more slowly at low temperatures.

The initiation of feeding of lake sturgeon immediately following absorption of the yolk sac and the switching of food types as the young fish grow may be associated with increased rates of mortality. Consultations with other hatchery operators and possible feeding trials in Manitoba will be used to identify an approach that achieves the optimum balance between mortality and cost. It should be noted that acceptable rates of mortality will vary depending on the success of initial egg collection and hatch.

3.3 ASSESSMENT OF POST-RELEASE

In order to monitor the success of any stocking program, hatchery reared fish must be marked prior to release. There are many challenges associated with marking very small fish; however, advances in technology are continually improving enabling smaller fish to be marked.

Several options currently exist for marking small fish and some of these are listed below:

1. Passively Integrated Transponder (PIT tags) – These are very small tags (8 mm now available) that have been successfully applied to fingerling lake sturgeon released into the Winnipeg River.
2. Scute removal – This has been done successfully in several white sturgeon stocking programs along the west coast of North America. A different scute, or combination of scutes, are removed from lake sturgeon annually allowing determination of the year the sturgeon was released as well as differentiation from wild sturgeon.
3. Coded wire tags – These are very small tags that can be inserted into lake sturgeon. A scanner is used to determine if a coded wire tag has been inserted into the fish; however, fish cannot be individually identified without removing it from the fish. Once removed, the tag can be read under a microscope to determine the tag number.
4. Visible Implant Elastomer – This is a plastic that is injected into the fish under the skin. It is visible for two to three years following implantation.

In addition to the techniques listed above, sturgeon raised to yearling size could be tracked with conventional telemetry tags.

The specifics of programs designed to monitor the survival of stocked lake sturgeon, and their behaviour relative to wild sturgeon, will be determined when hatchery-raised sturgeon are available, as specifics of the program would depend on the source of the brood stock and number of sturgeon.

4.0 NEXT STEPS (2012 – 2037)

With the planned date for the start of construction of the Keeyask GS in 2014, it is recommended that a preliminary lake sturgeon stocking trial be conducted as soon as possible (i.e., spring 2012). A preliminary stocking trial would have numerous benefits:

- Further refinement of spawn collection and rearing techniques;
- Identification of equipment needs and number of personnel required;
- Allow an opportunity to train KCN members how to collect gametes and rear lake sturgeon in a hatchery; and
- Allow participation by numerous individuals in the rearing and release (e.g., conservation and awareness program).

Following completion of the preliminary stocking trial and its successes/failures, refinements to this plan will be made to improve the success of the stocking plan.

Following completion of the trial stocking program in 2012, a ten-year plan to encompass the construction of the Keeyask GS would be developed.

5.0 REFERENCES

Aloisi, D., Gordon Jr., R.R., Starzl, N.J., Walker, J.L., and Brady, T.R. 2006. Genoa National Fish Hatchery lake sturgeon culture. Standard operating procedures. Department of the Interior, U.S. Fish and Wildlife Service, Great Lakes-Big Rivers Region. Region 3 Fisheries Data Series 2006-003. 19 pp.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2006. COSEWIC assessment and update status report on the lake sturgeon *Acipenser fulvescens* in Canada. Ottawa. Available at Available: http://dsppsd.pwgsc.gc.ca/collection 2007/ec/CW69-14-484-2007E.pdf. [accessed November 2011].

Cote, 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. 65 pp.

Crossman, J.A. 2008. Evaluating collection, rearing, and stocking methods for lake sturgeon (*Acipenser fulvescens*) restoration programs in the Great Lakes. Ph.D. Dissertation. Michigan State University, East Lansing, Michigan.Crossman, J. A., Forsythe, P.S., E. A. Baker, E.A., and Scribner, K.T. 2009. Overwinter survival of stocked age-0 lake sturgeon. Journal of Applied Ichthyology 25(5): 516-521 pp.

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

Dumont, P., D'amours, J., Thibodeau, S., Dubuc, N., Verdon, R., Garceau, S., Bilodeau, P., Mailhot, Y., and Fortin, R. 2011. Effects of the development of a newly created spawning ground in the Des Prairies River (Quebec, Canada) on the reproductive success of lake sturgeon (*Acipenser fulvescens*). Journal of Applied Ichthyology 27: 394-404 pp.

Elliott, R. F., Baker, E., Eggold, B., and Holtgren, M. 2005. Lake Michigan lake sturgeon rehabilitation plan-conservation genetics and rehabilitation stocking. Oral presentation. Proceedings of the Second Great Lakes Lake Sturgeon Coordination Meeting. November 9-10, 2004. Sault Ste. Marie, Michigan.

Henderson, L., Barth, C.C., MacDonald, J.E., and Garner, S.J. 2011. Results of a coarse scale habitat inventory in the upper Split Lake area, fall 2010. A draft report prepared for Manitoba Hydro by North/South Consultants Inc. 63 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.

Schueller, A.M., and Hayes, D.B. 2011. Minimum viable population size for lake sturgeon (Acipenser fulvescens) using an individual-based model of demographics and genetics. Canadian Journal of Fisheries and Aquatic Sciences 68: 62–73 pp.

Welsh, A. B., Elliot, R.F., Scribner, K.T., Quinlan, H.R., Baker, E.A., Eggold, B.T., Holtgren, J.M., C. C. Krueger, C.C., and May, B. 2010. Genetic guidelines for the stocking of lake sturgeon (*Acipenser fulvescens*) in the Great Lakes basin. Great Lakes Fishery Commission Miscellaneous Publication 2010-01. 55pp.

APPENDIX I

FEASIBILITY OF SUCCESS – WHAT IS KNOWN FROM ATTEMPTS AT STOCKING LAKE STURGEON IN OTHER LOCATIONS

OVERVIEW

Conservation-based lake sturgeon stocking programs have been conducted in numerous jurisdictions within the United States since the early 1980s (Menominee and St. Louis rivers, WI). Since then, each state bordering the Great Lakes, plus a number of other states that lake sturgeon historically occupied (Red River of the North, MN; Coosa River GA; Mississippi and Missouri rivers, MO), have implemented stocking programs with the aim of restoring self-sustaining populations. In Canada, lake sturgeon stocking initiatives have been undertaken in Quebec, Manitoba, and Saskatchewan.

Lake sturgeon stocking programs, at virtually each location that they have been attempted, have demonstrated the ability to culture and rear young sturgeon in either a hatchery or stream-side rearing facility. In addition, most programs have succeeded in releasing young fish into the wild and demonstrating adequate survival and growth of the released fish.

Recently, researchers studying a population of lake sturgeon comprised entirely of re-introduced stocked fish, found evidence of natural reproduction. Lake sturgeon (Lake Winnebago strain) were stocked into the St. Louis River, a tributary of Lake Superior, over a 25-year period starting in the early 1980's. Monitoring of this population prior to 2011 confirmed that the stocked fish were growing and that several age classes were present (Schram *et al.* 1999). Genetics analysis from fish naturally recruited in spring 2011 confirmed that these were Lake Winnebago strain fish and therefore, stocked fish had spawned approximately 30 years following the initial reintroduction of lake sturgeon into the river (R. Bruch *pers. comm.*). This is the first recorded evidence of natural reproduction in lake sturgeon resulting from stocked fish.

What follows are some examples of stocking plans and strategies that are being employed in other jurisdictions, as well as a brief summary of a few stocking programs that have been undertaken in North America, including Manitoba.

WHAT CAN BE LEARNED FROM EXISTING LAKE STURGEON STOCKING PROGRAMS

GUIDELINES FOR STOCKING

Stocking guidelines were developed for the rehabilitation of lake sturgeon in Michigan State watersheds (Elliot *et al.* 2004 in Quinlan et al. 2005). Guidance was provided for:

- **evaluating** the appropriateness (and success) of stocking;
- the selection of **donor populations**;
- the **collection of gametes**;
- **mating schemes**;
- **numbers to stock**; and
- **rearing and release** techniques.

Each of the items listed above (bold text) are described below.

Evaluation - Prior to initiating rehabilitation, the underlying reasons why a system is not populated or why a remnant population is at risk should be understood. Stocking should only be initiated when water quality and habitat are capable of supporting stocked fish. Furthermore, the system should be capable of supporting natural reproduction by the time stocked fish mature. Evaluation measures capable of documenting the success of rehabilitation actions should be planned and implemented prior to stocking.

Donor populations - should be selected based on similarities in genetic lineage, life history, and ecology between the donor population and the population being rehabilitated. A donor population also needs to be of sufficient size and genetic diversity to support gamete or larval collections. To protect the donor population, gamete collections should be made from no more than 5% of the annual adult spawning stock in any year, or should not exceed 10% of that population's annual production of eggs or larvae.

Collection of gametes and mating schemes - Over the period of rehabilitation (25 years), gametes should be collected from a minimum of 250 different females and 250-1250 males. Eggs from individual females should be divided equally among available males and fertilized 1:1. An alternative is to collect naturally deposited eggs or drifting larvae so that genes from as many families as possible contribute to the year class. Family contribution should be equalized throughout the rehabilitation or restoration process by rearing and stocking equal numbers from each contributing family.

The number of fish stocked - should be based on habitat availability and expected survival rates so that a minimum population of 750 mature adults (including males 15 years and older and females 20 years and older) that produces a minimum annual spawning run of 250 fish is established. All stocked fish should be permanently marked, and genetic analysis of parents and progeny should be conducted to document the genetic diversity of fish produced.

Rearing and release - Fish should be reared and released in a manner that imprints stocked fish to receiving waters. Streamside rearing, stocking of eggs or early stage larva, and within system transfers are examples. Sturgeon should be released at locations where wild fish of that life stage are known or would be expected to occur.

Elliot *et al.* (2005) note that although the guidelines listed above are still in draft form, Lake Michigan resource management agencies have and are taking actions to follow these guidelines for current reintroduction initiatives.

The question of timing of release (i.e., at what life stage/age) grapples with the trade-off between realizing significantly increased survival with age of released fish versus the cost and space required to rear older fish. The longer a fish is held and grown in a rearing facility, the greater the cost and the more extensive the facility requirement. There are also concerns that fish reared in hatcheries with a different water source to the waterbody in which they are stocked may not imprint to the location and thus move away. To address the imprinting issue, a number of agencies are moving to streamside rearing/grow-out facilities (SRF) that use water from the release location. However, the success and/or importance of imprinting are yet to be determined.

LAKE STURGEON REHABILITATION PLANS

A Lake Sturgeon Rehabilitation Plan for Lake Superior (Auer 2003) was among several considered in the development of the Keeyask lake sturgeon stocking plan. The following were among the recommendations that provided guidance for stocking plans:

- Stocking should be undertaken concurrent with exploitation controls and with habitat protection and restoration.
- Stocked fish should be of similar genetic origin as the extant wild population.
- Before a stocking program is implemented, fish-health issues should be considered to prevent introduction of unwanted pathogens.
- The capture of wild adults during spawning runs remains the most reasonable method of obtaining gametes for artificial propagation.
- To optimize the success of rehabilitation efforts, both larvae (15-30 mm) and fingerlings (100-250 mm) should be stocked.
- All stocked fingerling sturgeons should have a mark/tag to monitor stocking success.
- Spawning operations should follow a brood-stock management plan to maximize genetic variability. Wild brood stock should be bred and distributed following principles designed to maximize the genetic variability of the progeny and minimize genetic drift and inbreeding.
- The annual establishment of year-classes consisting of marked individuals at historic spawning sites and subsequent recruitment in three of every five years over a 20-year period will determine stocking success.

Stocking and genetic strategies should include:

- Regular evaluation of the impact that stocking lake sturgeons has on remnant populations;
- Ongoing assessment and determination of optimal stocking and survival rates; and
- Determining if lake sturgeons imprint on spawning habitat and, if so, at what life stage.

LAKE STURGEON CULTURE

The U.S. Fish and Wildlife Service and Department of Interior have published Standard Operating Procedures for lake sturgeon culture at the Genoa National Fish Hatchery in Genoa, WI. The culturing techniques described were originally adapted from methods developed by Wisconsin DNR at Wild Rose Fish Hatchery. The document provides guidance concerning gamete collection, egg transport, incubation, feeding through fry and fingerling growth stages, fish health concerns, environmental conditions in hatcheries, and release and distribution of reared fish. The document (FDS-2006-3) is available on-line at http://www.fws.gov/midwest/Fisheries/pubpolicy.html .

BRIEF REVIEW OF SELECTED LAKE STURGEON STOCKING PROGRAMS

Manitoba

In Manitoba, lake sturgeon have been stocked into the Assiniboine, Winnipeg, Saskatchewan and Nelson rivers. A brief review of the stocking history of each river is provided below.

Assiniboine River

Lake sturgeon were historically abundant in the Assiniboine River but believed to be completely extirpated by the early 1900's. Efforts to reintroduce lake sturgeon to the Assiniboine River began in 1996 (Appendix Table 1). The river was stocked each year from 1996 to 2008 with the exception of 1998, 2005 and 2007. Lake sturgeon stocked into the Assiniboine River were reared at either the

Whiteshell Hatchery or the Grand Rapids Hatchery, and released near Brandon, Manitoba. It should be noted that lake sturgeon from the Winnipeg, Saskatchewan and Nelson rivers were used to stock the Assiniboine River.

Although a study has not been conducted to formally assess the success of lake sturgeon stocking in the Assiniboine River, lake sturgeon are now commonly captured by anglers (B. Bruderlein, Manitoba Fisheries Branch). Anglers have reported catches of lake sturgeon each year since 1998, and at present, most of the lake sturgeon being captured are longer than 43 inches in length, with the largest reported measuring 60 inches. Because the stocked fish are likely at, or nearing sexual maturity, further study is necessary to determine if the stocked fish will begin to naturally reproduce in the river.

Winnipeg River

Lake sturgeon stocking in the Winnipeg River in Manitoba began in 1996 and has been conducted during most years until 2010 (Appendix Table 1). During this time, substantial numbers of lake sturgeon have been stocked, at various life stages, into the Manitoba portion of the Winnipeg River between the Pointe Du Bois GS and the MacArthur Falls GS (Appendix Table 1). Prior to 2008, lake sturgeon eggs and milt were collected without the aid of a hormone that would induce gamete release in ripe fish. However, in 2008 and 2009, a hormone was used as an aid to collect gametes.

Considerable research into various aspects of lake sturgeon stocking have been conducted in the Winnipeg River. Research to assess the survival, movement and growth of stocked lake sturgeon fingerlings and yearlings, as well as techniques to mark hatchery-reared fish were conducted by Cheryl Klassen (PhD candidate, University of Manitoba) from 2008 to 2010. Subsequently, in 2011, Gary Anderson (Professor, University of Manitoba), initiated a research project focused on assessing the physiological effects of hormone (Ovaprim) injection on adult lake sturgeon.

Despite the considerable amount of research conducted on lake sturgeon in the Winnipeg River, there is a limited understanding in terms of the role that stocking has had on present day lake sturgeon populations.

Nelson River

Lake sturgeon stocking in the Nelson River was conducted on an intermittent basis from 1994 to 2011 by the Nelson River Sturgeon Co-management Board and Manitoba Fisheries Branch (Appendix Table 1). Spawn collection generally occurred from a camp located at the Landing River, a tributary of the Nelson River located approximately 30 km upstream of the Kelsey GS. In spawn taking operations prior to 2011, both male and female lake sturgeon were held streamside in tanks until temperatures were appropriate for spawning. Once temperatures were appropriate, attempts were made to collect eggs and milt from these fish. Because success was limited using this technique, Ovaprim was used during spawn taking operations in 2011. During each year, fertilized eggs from the Landing River site were transported to the Grand Rapids Hatchery for rearing. Lake sturgeon were stocked by into the Nelson River in two general locations, in the Northeast channel and the west channel.

Similar to the other rivers stocked with lake sturgeon in Manitoba, it is difficult to determine the success of stocking efforts in the Nelson River. Annual monitoring of the lake sturgeon population in the Northeast channel of the river suggests that lake sturgeon abundance may be increasing and given that the abundance of younger fish in the catch has increased in the years since stocking commenced, stocking may have be responsible for these increases. In the western channel of the Nelson River, although a formal study has yet to take place, commercial and domestic fishermen have begun to catch lake sturgeon in their gill nets in the years since stocking began. Prior to stocking, lake sturgeon had not been captured for at least a decade. Although not conclusive, these sources of information suggest that the stocked fish may be responsible for these recent increases in catch (D.MacDonald *pers. comm.*).

Saskatchewan River

Lake sturgeon were stocked into the Saskatchewan River in 1999 and 2000, as well as from 2003 - 2007. Brood stock were collected below either the EB Campbell Dam or the Francois Findlay Dam on the Saskatchewan River by Saskatchewan Environment. Ovaprim was used during each year as an aid to collect lake sturgeon eggs. Fertilized lake sturgeon eggs were transported and subsequently reared in the Fort Qu'Appelle hatchery. Considerable numbers of lake sturgeon have been stocked into the Saskatchewan River as either fry or fingerlings (Appendix Table 1), however, the success of the lake sturgeon stocking program remains unknown.

Quebec

Eastmain River Stocking Program

In 2004, lake sturgeon fry and fingerlings were propagated in a field hatchery. This program produced 89,000 fry (2 cm), 25,000 fry (3 – 4 cm), and approximately 21,000 fingerlings (6 - 10 cm), and approximately the same number of young fish were introduced both upstream and downstream of the dam. A total of 88 adult sturgeon were also introduced upstream of the dam. Lake Sturgeon stocking efforts are continuing annually in the Eastmain River.

United States

Coosa River, Georgia

The Coosa River lake sturgeon population was extirpated sometime in the late 1950's or early 1960's. Over-fishing and pollution were identified as the main reasons for the sturgeon's demise in this river. Once most of the pollution sources were eliminated, a stocking program was developed to re-introduce lake sturgeon into the river. Wisconsin DNR provided fertilized lake sturgeon eggs to the State of Georgia, Wildlife Resources Division Summerville Hatchery, where they were raised prior to release.

The initial release of 1,100, six-inch (15 cm) fingerlings took place in 2002. Subsequently, between 2002 and 2008, 85,000 fingerlings were released into the river. Angler reports indicate that the stocked lake sturgeon are thriving. Lake sturgeon survival and growth was higher than expected based on the recapture and observed growth of over 350 tagged sturgeon. Lake sturgeon between 11" (28 cm) and 36" (90 cm) have been caught and released. In 2009, lake sturgeon over 40" (101 cm) and weighing up to 15 lbs (7 kg) were reported by anglers.

Genesee River, Rochester, New York

Phase I of the Genesee River lake sturgeon restoration project focused on the assessment of physical habitat parameters in the river and the evaluation of the suitability of the current aquatic habitat for lake sturgeon.

Phase II included "experimental stocking" of 900 juveniles (approx. 200 mm/44g) in 2003 and 1000 juveniles (approx. 170 mm/23g) in 2004. Recapture of marked fish indicate that:

- lake sturgeon were remaining in the river in good numbers;
- the habitat in which the fish were captured was gravelly to sandy and the sturgeon were generally occupying the deepest sections (6-10 m) of a given river reach;
- growth for the year classes was similar to growth in other systems (95-115 mm/year); and
- lake sturgeon diet was similar to that in other systems.

St. Louis River - tributary of Lake Superior (Lindgren and Schram 2008)

Lake sturgeon stocking in lower reaches of the St. Louis River began in 1983. Between 1983 and 2000, 762,000 fry, 143,000 fingerlings, and 500 yearlings have been stocked. More recently, 120,000 eggs in Astroturf nest boxes were placed at known historical spawning locations.

Marking of lake sturgeon during the re-habilitation project included: 81,134 marked with a coded wire tag, either in the snout or under a scute, or both; 990 marked with an external tag (50 also with a PIT tag); and 65 marked with a PIT tag under a dorsal scute (50 of which also had an external tag).

Gillnet catches of lake sturgeon in St. Louis Bay increased from zero (prior to stocking) to a maximum of 6.5 per set in 1996. An average of approximately two lake sturgeon per set was caught during 2000-2006 sampling. The mean length at capture of juveniles steadily increased over time (e.g., 1991 cohort increased from 18.5 cm to 101.3 cm mean length over 17 years).

Distribution and movement studies indicate that the stocked lake sturgeon remain in the St. Louis estuary for approximately five years. They then move into and remain in the western portion of Lake Superior for a number of years before returning to the estuary. Large sturgeon have been observed within the historical spawning area for a number of years (post-2006); however, natural reproduction has yet to be documented.

Spawning habitat enhancement works are being undertaken in previously disturbed areas in the St. Louis River.

Minnesota - Red River Basin: Appendix G – Restoration of Extirpated Lake Sturgeon (*Acipenser fulvescens*) in the Red River of the North Watershed (MDNR 2002)

In 2002, Minnesota DNR, in cooperation with USFWS and the White Earth Band, implemented a 20-year stocking plan with a goal of re-establishing a naturally reproducing population over the next 20-30 years. Lake sturgeon releases (fry and fingerlings) accomplished to date are shown in Appendix Table 1. Anglers are now catching the stocked fish. Further, results of test netting in 2011 suggest that the stocking efforts have been highly successful, so successful that the number of fish being stocked in future years are being reduced by half (R. Zortman, White Earth Band).

Michigan – Ontonagon River

Michigan Department of Natural Resources began stocking in 1998. Approximately 33,000 fall fingerlings have been stocked in the mainstem since 1998. Fillmore (2003) observed that juvenile lake sturgeon stocked in the Ontonagon River moved downstream and were most abundant near the river mouth.

Due to genetic concerns (lack of imprinting on native waters), a stream-side rearing facility (SRF) was constructed. Fish in the SRF were raised to fall fingerling stage using water from the Ontonagon River. Approximately 750 lake sturgeon were stocked in October 2007.

Appendix Table 1.

A summary of lake sturgeon life stages that have been released during a number of stocking programs in the United States and Canada with an indication of success.

Location	River/Lake	Year	Number/Life Stage	Success
Georgia	Coosa River	2002-2008	85,000/fingerlings	Juvenile growth and survival confirmed
New York	Genesee River	2003-2004	1,900 juveniles	Juvenile growth and survival confirmed (See summary notes)
	Cayuga Lake	1995-2004	3,732 age 0 and 1	1995 year-class (YC) male ripe in 2006. Mean TL of 1995 YC =1.12 m
	Oneida Lake	1995-1999	40,000 larvae 8,000 juveniles	High mortality of larvae (starvation). Rapid growth of juveniles. Age 8 males readily released sperm. Each YC has been recaptured
	Oswegatchie River	?	30,857 juveniles	Downstream movement pattern of newly released fish compared with naturalized fish
	St. Regis River	?	5,000 juveniles	LKST growing well
Wisconsin	St. Louis River	1983-2000 2000?	762,000 fry 143,000 fingerlings 500 yearlings 120,000 eggs in Astroturf nest boxes	LKST growing well. Large LKST observed on historical spawning grounds. No natural recruitment after 25 years.
	Yellow River	1995	10,000 fry 13,400 fingerlings	
	Upper Flambeau/Manitowish River	1993-2008	152,578 fry 56,946 fingerlings	Stocked fish are surviving and growing

Location	**River/Lake**	**Year**	**Number/Life Stage**	**Success**
	Menominee River	1982 1995-1999 and onward (2004?)	? 25,300 fingerlings 600 yearlings	
	Middle Wisconsin River	1997 - ? 2003	200,000 fingerlings Yearlings	1997 cohort still present in river and growing well
Michigan	Ontonagon River	1998-2004 2007 2008	Fingerlings Yearlings 723 fingerlings (SRF) 880 fingerlings (SRF)	Age 0 and yearling captured over soft substrates of sand and silt
	Cheboygan River watershed	2006	7,800 fingerlings	
	Black Lake	2007	1,000 fingerlings (SRF)	Plan is to release 65,000 fingerlings over 20 years. Target is 2,000 adult sturgeon in Black Lake.
Minnesota	Detroit Lake	1998-2008	25 sub-adults 1,671 yearlings 17,998 fingerlings 22,500 fry	Angler success indicates movement and growth of stocked lake sturgeon. As of 2011, numbers of fish stocked are being reduced by half.
	Round Lake	2004-2008	33,000 fingerlings	
	White Earth Lake	2004-2008	43,000 fingerlings	
	Otter Tail Lake	2002-2008	2,031 yearlings 37,000 fingerlings	
	Otter Tail River	1998-2008	172 sub-adults 250 yearlings 10,300 fingerlings	

Location	River/Lake	Year	Number/Life Stage	Success
	Buffalo River	2002-2008	350 yearlings 10,178 fingerlings	
	Roseau River	2004-2008	345,550 fry	
	Red Lake River	2004-2008	785,000 fry	
	St. Louis Bay	2000	7,980 fingerlings	
Manitoba	Nelson River	1994 - 2008	491 yearlings 15,974 fingerlings 1,025 fry	
	Winnipeg River	1996-2009	221 sub-adults 24,387 fingerlings	
	Nutimik Lake	1998-2008	4,950 fingerlings	
	Assiniboine River	1996-2008	5,000 fry 11,216 fingerlings 60 sub-adults	Angler success indicates that individuals have achieved a large size. Some individuals > 800 cm.
	Saskatchewan River	2003	67 fingerlings	
Saskatchewan	Saskatchewan River	1999-2007	157,000 fry 7,850 fingerlings	
Quebec	Eastmain River Riviere l'Eau Claire	2004	114,000 fry 21,000 fingerlings 88 adults	Plans to repeat over next few years

REFERENCES

AUER, N.A. [ED.]. 2003. A lake sturgeon rehabilitation plan for Lake Superior. Great Lakes Fish. Comm. Misc. Publ. 2003-02.

ELLIOT, R., BAKER, E., EGGOLD, B. and M. HOLTGREN. 2004. Overview of the Lake Michigan lake sturgeon rehabilitation plan conservation genetics and rehabilitation stocking section *In* Proceedings of the second Great Lakes lake sturgeon coordination meeting, November 9-10, 2004, Sault Ste. Marie, Michigan. Member of the U.S. Fish and Wildlife Service Great Lakes Basin Ecosystem Team Lake Sturgeon Committee (H. Quinlan, R. Elliott, E. Zollweg, D. Bryson, J. Boase, and J. Weisser).

FILLMORE, K.L. 2003. Master's Thesis. Habitat selection and movement of stocked juvenile lake sturgeon *Acipenser fulvescens* and benthic invertebrate distribution in the lower Ontonagon River, Michigan. Michigan Technological University. Houghton, MI.

LINDGREN J. P. and S. T. SCHRAM. 2008. Rehabilitation of lake sturgeon in the St. Louis River estuary and western Lake Superior. Power Point presentation. Minnesota Great Lakes Regional Collaboration Habitat and Species Workshop. December 16, 2008. Duluth, MN.

MINNESOTA DEPARTMENT OF NATURAL RESOURCES (MDNR). 2002. Appendix G - Restoration of extirpated lake sturgeon (Acipenser fulvescens) in the Red River of the North watershed. MDNR Fisheries Division. 10 pp.

SCHRAM, S.T., LINDGREN, J. and L.M. EVRARD. 1999. Reintroduction of Lake Sturgeon in the St. Louis River, Western Lake Superior. North American Journal of Fisheries Management 19: 815-823 pp.

APPENDIX 1B
KEEYASK GENERATION PROJECT
AQUATIC ENVIRONMENT STUDY
REPORT LIST

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
99-01	Remnant, R.A. and C.C. Barth. 2003. Results of Experimental Gillnetting on the Nelson River between Birthday and Gull Rapids, Manitoba, Fall 1999. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 75 pp. *Draft*.	Completed	Dec-03
99-02	Zrum, L. and C.L. Bezte. 2003. Water Chemistry, Phytoplankton, Benthic Invertebrate, and Sediment Data for Gull Lake and the Nelson River between Birthday Rapids and Gull Rapids, Manitoba, Fall, 1999. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 66 pp. *Draft*.	Completed	Dec-03
01-01	Zrum, L. and T.J. Kroeker. 2003. Benthic Invertebrate and Sediment Data from Split Lake and Assean Lake, Manitoba, Winter, 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 78 pp. *Draft*.	Completed	Dec-03
01-02	Barth, C.C., R.L. Bretecher, and J. Holm. 2004. Floy-tag Application and Recapture Information from the (Gull) Keeyask Study Area, 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 88 pp. *Draft*.	Completed	Nov-04
01-03	Barth, C.C., D.L. Neufeld, and R.L. Bretcher. 2003. Results of Fisheries Investigations Conducted in Tributaries of the Nelson River Between Birthday Rapids and Gull Rapids, Manitoba, Spring, 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 53 pp. *Draft*.	Completed	Dec-03
01-04	Juliano, K.M. and L. Zrum. 2003. Zooplankton Data from Split, Clark, Gull, Stephens, and Assean Lakes, Manitoba, 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 59 pp. *Draft*.	Completed	Dec-03
01-05	Dunmall, K.M., J. Holm, and R.L. Bretcher. 2003. Results of Index Gillnetting Studies Conducted in Assean Lake, Manitoba, Summer 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 70 pp. *Draft*.	Completed	Dec-03
01-06	Dolce, L.T. and M.A. Sotiropoulos. 2004. Aquatic Macrophyte and Associated Epiphytic Invertebrate Data Collected in Gull Lake and Portions of the Nelson River Between Birthday Rapids and Gull Rapids, Manitoba, Fall 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 56 pp. *Draft*.	Completed	Jan-04

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
01-07	Dunmall, K.M., J.E. MacDonald, and R.L. Bretecher. 2004. Results of Summer Index Gillnetting Studies Conducted in Split Lake and Clark Lake, and Spring Investigations of Adult and Larval Fish Populations in Portions of the Burntwood River, Grass River, and Nelson River flowing into Split Lake, Manitoba, 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 116 pp. *Draft*.	Completed	Feb-04
01-08	Remnant, R.A., N.J. Mochnacz, and J.E. MacDonald. 2004. Results of Fisheries Investigations Conducted in the Assean River Watershed, Manitoba, Spring and Fall, 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 106 pp. *Draft*.	Completed	Oct-04
01-10	Pisiak, D.J., T. Kroeker, and R.A. Remnant. 2004. Results of Summer Index Gillnetting Studies in Stephens Lake, Manitoba, and Seasonal Investigations of Adult and Larval Fish Communities in the Reach of the Nelson River between Gull Rapids and Stephens Lake, 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 110 pp. *Draft*.	Completed	Oct-04
01-11	Sotiropoulos, M.A. and L.J. Neufeld. 2004. Benthic Invertebrate, Sediment, and Drifting Invertebrate Data Collected from the Gull (Keeyask) Study Area, Manitoba, Spring - Fall 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 138 pp. *Draft*.	Completed	Oct-04
01-13	Remnant, R.A., C.R. Parks, and J.E. MacDonald. 2004. Results of Fisheries Investigations Conducted in the Reach of the Nelson River between Clark Lake and Gull Rapids (Including Gull Lake), 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 154 pp. *Draft*.	Completed	Oct-04
01-14	Barth, C.C. and N.J. Mochnacz. 2004. Lake Sturgeon Investigations in the Gull (Keeyask) Study Area, 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 146 pp. *Draft*.	Completed	Oct-04

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
01-15	Badiou, P.H., and H.M. Cooley. 2004. Water Chemistry, Phytoplankton, and Sediment Chemistry Data for the Nelson and Assean River Systems, Manitoba, 2001. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 210 pp. *Draft*.	Completed	Oct-04
02-03	Barth, C.C., L.J. Neufeld, and J.R. Olynik. 2003. Movements of Northern Pike, Walleye, and Lake Whitefish Tagged with Radio and Acoustic Transmitters in the Gull (Keeyask) Study Area, 2001/2003. Draft report prepared for Manitoba Hydro by North/South Consultants. 137 pp. *Draft*.	Completed	Dec-03
02-04	Juliano, K.M. and L. Zrum. 2004. Zooplankton Data from Split, Clark, Gull, Stephens, and Assean Lakes, and the Nelson River, Manitoba, 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 65 pp. *Draft*.	Completed	Jan-04
02-05	Holm, J., V.L. Richardson, and R.L. Bretecher. 2003. Results of Index Gillnetting Studies Conducted in Assean Lake, Manitoba, Summer 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 80 pp. *Draft*.	Completed	Dec-03
02-06	Hartman, E.J. and R.L. Bretecher. 2004. Results of Fisheries Investigations Conducted in the North Moswakot and South Moswakot Rivers, Manitoba, Fall 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 69 pp. *Draft*.	Completed	Jan-04
02-08	Mochnacz, N.J., C.C. Barth, and J. Holm. 2004. Results of Fisheries Investigations Conducted in the Aiken River and at the Mouth of the Ripple River, Manitoba, Spring 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 106 pp. *Draft*.	Completed	Mar-04
02-09	Holm, J. and R.A. Remnant. 2004. Results of Summer Index Gillnetting Studies Conducted in Split Lake and Clark Lake, and Spring Investigations of Adult and Larval Fish Communities in Portions of the Burntwood, Grass, and Nelson Rivers Flowing into Split Lake, Manitoba, 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 131 pp. *Draft*.	Completed	Apr-04

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
02-10	Dolce, L.T. and M.A. Sotiropoulos. 2004. Aquatic Macrophyte and Associated Epiphytic Invertebrate Data Collected in Gull Lake and Portions of the Nelson River between Birthday Rapids and Gull Rapids, Manitoba, Fall 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 57 pp. *Draft*.	Completed	Mar-04
02-12	Juliano, K.M. and L.J. Neufeld. 2004. Benthic Invertebrate and Sediment Data from Split Lake and Assean Lake, Manitoba, Winter 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 67 pp. *Draft*.	Completed	Dec-04
02-13	Juliano, K.M. and L.J. Neufeld. 2005. Benthic Invertebrate, Sediment, and Drifting Invertebrate Data Collected from the Gull (Keeyask) Study Area, Manitoba, Spring - Fall 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 161 pp. *Draft*.	Completed	Jan-05
02-14	Badiou, P.H. and H.M. Cooley. 2005. Water Chemistry, Phytoplankton, and Sediment Chemistry Data for the Nelson and Assean River Systems, Manitoba, 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 255 pp. *Draft*.	Completed	Feb-05
02-15	Johnson, M.W. 2005. Results of Fish Community Investigations Conducted in the Assean River Watershed, Manitoba, Spring and Fall 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 133 pp. *Draft*.	Completed	Feb-05
02-16	Pisiak, D.J. 2005. Results of Summer Index Gillnetting Studies in Stephens Lake, Manitoba and Seasonal Investigations of Adult and Larval Fish Communities in the Reach of the Nelson River between Gull Rapids and Stephens Lake, 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 179 pp. *Draft*.	Completed	Jan-05
02-17	Richardson, V.L. and J. Holm. 2005. Results of Fish Community Investigations Conducted in Tributary Systems of the Nelson River between Birthday Rapids and Gull Rapids, 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 98 pp. *Draft*.	Completed	Jan-05

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
02-18	Holm, J., V.L. Richardson, and C.C. Barth. 2005. Floy-tag Application and Recapture Information from the Gull (Keeyask) Study Area, 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 175 pp. *Draft*.	Completed	Feb-05
02-19	Barth, C.C. 2005. Lake Sturgeon Investigations in the Keeyask Study Area, 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 131 pp. *Draft*.	Completed	Feb-05
02-20	Johnson, M.W. and C.R. Parks. 2005. Results of Fish Community Investigations Conducted in the Reach of the Nelson River between Clark Lake and Gull Rapids, 2002. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 222 pp. *Draft*.	Completed	Aug-05
03-01	Ryland, D. and B. Watts. Fish Taste Studies for Tataskweyak Cree Nation. Draft report prepared for Manitoba Hydro by the University of Manitoba. 44 pp. *Draft*.	Completed	Jan-04
03-02	Ryland, D. and B. Watts. Fish Taste Studies for Fox Lake Cree Nation. Draft report prepared for Manitoba Hydro by the University of Manitoba. 43 pp. *Draft*.	Completed	Jan-04
03-03	Maclean, B.D. and D.J. Pisiak. 2005. Results of Fish Community Investigations Conducted at the Mouth of the Ripple River, Manitoba, Spring 2003. Year II. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 43 pp. *Draft*.	Completed	Feb-05
03-05	Badiou, P.H., H.M. Cooley, and T. Savard. 2005. Water Chemistry Data for the Lower Nelson River System, Manitoba, 2003. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 219 pp. *Draft*.	Completed	Dec-05
03-06	Murray, L., C.C. Barth, and J.R. Olynik. 2005. Movements of Radio- and Acoustic- Tagged Northern Pike, Walleye, and Lake Whitefish in the Keeyask Study Area: May 2002 to April 2003. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 125 pp. *Draft*.	Completed	Aug-05
03-08	Barth, C.C. and L. Murray. 2005. Lake sturgeon Investigations in the Keeyask Study Area, 2003. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 127 pp. *Draft*.	Completed	Oct-05

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
03-09	Pisiak, D.J. and E.J. Hartman. 2005. Results of Fish Community Investigations Conducted in the North Moswakot and South Moswakot Rivers, Manitoba, Spring and Fall 2003. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 157 pp. *Draft*.	Completed	Sep-05
03-11	Kroeker, D.S. and W. Jansen. 2005. Results of Fish Community Investigations Conducted in Tributaries of the Nelson River between Clark Lake and Gull Rapids, Manitoba, 2003. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 72 pp. *Draft*.	Completed	Jan-06
03-12	Maclean, B.D. and J.Holm. 2005. Results of Fish Community Investigations Conducted in the Mistuska River, Manitoba, Spring 2003. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 90 pp. *Draft*.	Completed	Sep-05
03-13	Maclean, B.D. and D.J. Pisiak. 2005. Results of Fish Community Investigations Conducted in the Aiken River, Manitoba, Spring 2003, Year II. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 108 pp. *Draft*.	Completed	Dec-05
03-14	Pisiak, D. 2005. Results of Summer Index Gillnetting Studies in Stephens Lake, Manitoba, and Seasonal Investigations of Fish Communities in the Reach of the Nelson River between Gull Rapids and Stephens Lake, 2003. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 313 pp. *Draft*.	Completed	Oct-05
03-15	Holm, J. 2006. Floy-tag Application and Recapture Information from the Keeyask Study Area, 2003. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 244 pp. *Draft*.	Completed	Sep-06
03-16	Dolce, L. T. and M.J. Burt. 2008. Aquatic Macrophyte and Associated Epiphytic Invertebrate Data Collected from the Keeyask Study Area, Manitoba, Late Summer 2003. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 111 pp. *Draft*.	Completed	Feb-08

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
03-17	Gill, G. 2007. Invertebrate Drift and Plant Biomass Data from the Nelson River at Birthday Rapids, Gull Lake, Gull Rapids, and Kettle Generating Station, Manitoba, Summer and Fall 2003. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 72 pp. *Draft*.	Completed	Nov-07
03-35	Maclean, B.D. and P. Nelson. 2005. Population and Spawning Studies of Lake Sturgeon (Acipenser fulvescens) at the Confluence of the Churchill and Little Churchill Rivers, Manitoba, Spring 2003. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 70 pp. *Draft*.	Completed	Jan-06
03-36	Bretecher, R.L., G.C. Dyck, and R.A. Remnant. 2007. Results of Fish Community Investigations Conducted in the Reach of the Nelson River Between Clark Lake and Gull Rapids (Including Gull Lake), 2003. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 275 pp. *Draft*.	Completed	Feb-07
03-37	Cooley, H.M. and M.W. Johnson. 2008. An Evaluation of Walleye Condition from Stephens Lake. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 59 pp. *Draft*.	Completed	Mar-08
04-03	Holm, J. 2005. Results of Fish Community Investigations Conducted in Clark Lake, 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 116 pp. *Draft*.	Completed	28-Oct-05
04-04	Badiou, P.H., T. Savard, and H.M. Cooley. 2007. Water Chemistry and Phytoplankton data for the Lower Nelson River System, Manitoba, 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 247 pp. *Draft*.	Completed	Jan-07
04-05	BARTH, C.C. and K. AMBROSE. 2006. Lake Sturgeon Investigations in the Keeyask Study Area, 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 105 pp. *Draft*.	Completed	Jan-06
04-06	Cooley, H.M. and T.G. Savard. 2008. Results of Greenhouse Gas Sampling in the Keeyask and Conawapa Study Areas: 2001-2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 76 pp. *Draft*.	Completed	Feb-08

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
04-07	T. Savard and H.M. Cooley. 2007. Turbidity Monitoring Data for Clark and Gull Lakes, Fall 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 51 pp. *Draft*.	Completed	Jan-07
04-08	Holm, J. 2007. Floy-tag Application and Recapture Information from the Keeyask Study Area, 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 148 pp. *Draft*.	Completed	Jan-07
04-09	Johnson, M.W. 2007. Results of Fish Community Investigations Conducted in the Reach of the Nelson River Between Clark Lake and Gull Rapids (Including Gull Lake), 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 159 pp. *Draft*.	Completed	Jan-07
04-10	Johnson, M.W. and C.C. Barth. 2007. Results of Fish Community Investigations in the Kettle and Butnau Rivers, Manitoba, Spring 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 59 pp. *Draft*.	Completed	Jan-07
04-11	Holm, J., H.M. Cooley, and E. Shipley. 2007. Trace Elements in Fish from the Keeyask Study Area: Fall 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 62 pp. *Draft*.	Completed	Feb-07
04-12	Johnson, M.W. and B.D. Maclean. 2007. Results of Fish Community Investigations Conducted in the Mistuska River, Manitoba, Spring 2004. Year II. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 87 pp. *Draft*.	Completed	Jun-07
04-13	Johnson, M.W. and B.D. Maclean. 2007. Results of Fish Community Investigations Conducted in the York Landing Arm of Split Lake and Its Major Tributaries, Manitoba, Fall 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 74 pp. *Draft*.	Completed	May-07
04-14	Pisiak, D.J. and B.D. Maclean. 2007. Population Studies of Lake Sturgeon (*Acipenser fulvescens*) in the Fox River, Manitoba, Summer 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 42 pp. *Draft*.	Completed	Apr-07

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
04-15	Neufeld, L. 2007. Benthic Invertebrate and Sediment, Data Collected from Littoral Zones in the Keeyask Study Area, Manitoba, Fall 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 92 pp. *Draft*.	Completed	Apr-07
04-16	MacDonald, J.E. 2007. Results of Fish Community Investigations in Gull Rapids and Stephens Lake, 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 113 pp. *Draft*.	Completed	May-07
04-17	Burt, M.J. and L.T. Dolce. 2008. Aquatic Macrophyte and Associated Epiphytic Invertebrate Data Collected from the Keeyask Study Area, Manitoba, Summer 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 130 pp. *Draft*.	Completed	Feb-08
04-18	Gill, G. 2007. Invertebrate Drift and Plant Biomass Data from the Nelson River at Birthday Rapids,Gull Rapids, and Kettle Generating Station, Manitoba, Summer and Fall 2004. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 91 pp. *Draft*.	Completed	Nov-07
05-02	Holm, J. 2007. Floy-tag Application and Recapture Information from the Keeyask Study Area, 2005. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 56 pp. *Draft*.	Completed	Apr-07
05-03	Murray, L. and C.C. Barth. 2007. Movements of Radio- and Acoustic- Tagged Northern Pike, Walleye, and Lake Whitefish in the Keeyask Study Area: May 2003 to August 2004 and a Summary of Findings from 2001-2005. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 111 pp. *Draft*.	Completed	Apr-07
05-04	Jansen, W. and N. Strange. 2007. Mercury Concentrations in Fish From the Keeyask Project Study Area for 1999-2005. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 168 pp. *Draft*.	Completed	Aug-07
05-05	Barth, C.C. and J.E. MacDonald. 2008. Lake Sturgeon Investigations in the Keeyask Study Area, 2005. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 63 pp. *Draft*.	Completed	Mar-08

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
05-06	Mazur, K.M. and T.G. Savard. 2008. Proposed Keeyask Access Road Stream Crossing Assessment, 2004 and 2005. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 68 pp. 83 pp. *Draft*.	Completed	Feb-08
06-02	Holm, J. 2007. Floy-tag Application and Recapture Information from the Keeyask Study Area, 2006. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 61 pp. *Draft*.	Completed	Apr-07
06-03	Savard, T. and H.M. Cooley. 2007. Dissolved Oxygen Surveys in the Keeyask Study Area: Winter 2005 and 2006. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 54 pp. *Draft*.	Completed	Apr-07
06-04	MacDonald, J.E. 2008. Lake Sturgeon Investigations in the Keeyask Study Area, 2006. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 110 pp. *Draft*.	Completed	Mar-08
06-05	Cassin, J. and R.A. Remnant. 2008. Results of Fish Spawning Investigations Conducted in Gull Rapids Creek, Pond 13, and Selected Tributaries to Stephens Lake, Spring 2005 and 2006. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 45 pp. *Draft*.	Completed	Mar-08
06-06	MacDonald, J.E. 2007. Fish community assessments of selected lakes within the Split Lake Resource Management Area, 2004-2006. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 145 pp. *Draft*.	Completed	Nov-07
06-07	Jansen, W. 2008. Infection Rate of the Parasite *Triaenophorus crassus* in Lake Whitefish from the Keeyask Study Area for 2003-2006. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 35 pp. *Draft*.	Completed	Mar-08
06-08	Cooley, P.M. and L. Dolce. 2008. Aquatic Habitat Utilization Studies in Stephens Lake: Macrophyte Distribution and Biomass, Epiphytic Invertebrates, and Fish Catch-Per- Unit-Effort in Flooded Habitat. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 75 pp. *Draft*.	Completed	Mar-08

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
06-09	Cooley, P.M. 2008. Carbon dioxide and methane flux from peatland watersheds and divergent water masses in a sub-arctic reservoir. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 45 pp. *Draft*.	Completed	Mar-08
06-10	Capar, L.N. 2008. Benthic Invertebrate Data Collected from O'Neil Bay and Ross Wright Bay in Stephens Lake, Manitoba, Fall 2006. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 34 pp. *Draft*.	Completed	Mar-08
06-11	Jansen, W. and N. Strange. 2009. Fish mercury concentrations from the Keeyask Project Study Area for 2006. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 68 pp. *Draft*.	Completed	Jul-09
06-12	Larter, J.L. and P.M. Cooley. 2010. Substratum and Depth Distribution in Flooded Habitat of Stephens Lake, Manitoba, Thirty-Five Years after Impoundment. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 57 pp. *Draft*.	Completed	Dec-10
06-13	Cooley, P.M., L. Dolce Blanchard, and J. Larter. 2009. The effect of local and regional watersheds on the spectral composition and attenuation of light and water quality parameters in the surface waters of Stephens Lake, Manitoba. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 51 pp. *Draft*.	Completed	May-09
08-01	MacDonald, J.E. 2009. Lake Sturgeon Investigations in the Keeyask Study Area, 2007-2008. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 116 pp. *Draft*.	Completed	Apr-09
08-02	Holm, J. 2009. Floy-tag Application and Recapture Information from the Keeyask Study Area, 2007 and 2008. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 63 pp. *Draft*.	Completed	Apr-09
09-01	Holm, J. 2010. Results of Index Gillnetting Studies Conducted in the Keeyask Study Area, Summer 2009. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 110 pp. *Draft*.	Completed	Oct-10
09-02	Holm, J. 2010. Floy-tag Application and Recapture Information from the Keeyask Study Area, 2009. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 48 pp. *Draft*.	Completed	Oct-10

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
09-03	Michaluk, Y. and J.E. MacDonald. 2010. Lake Sturgeon Investigations in the Keeyask Study Area, 2009. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 83 pp. *Draft*.	Completed	Dec-10
09-04	Savard, T. S. Hnatiuk-Stewart, and H.M. Cooley. 2010. Water Quality Data for the Lower Nelson River System, Manitoba, 2009. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 240 pp. *Draft*.	Completed	Jul-10
09-05	Jansen, W. 2010. Fish Mercury Concentrations in the Keeyask Study Area, 2009. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. 42 pp. *Draft*.	Completed	Dec-10
10-01	North/South Consultants Inc., 2011. Adult Lake Sturgeon Investigations in the Keeyask Study Area, Spring 2010. Keeyask Project Environmental Studies Program Report prepared for Manitoba Hydro. 78 pp. *Draft*	Completed	Dec-11
10-02	North/South Consultants Inc., 2011. Results of Lake Whitefish Spawning Surveys in Ferris Bay and the North and South Moswakot Rivers, Fall 2010. Keeyask Project Environmental Studies Program Report prepared for Manitoba Hydro. 51 pp. *Draft*	Completed	Nov-11
10-03	North/South Consultants Inc., 2011. Results of a Coarse Scale Habitat Inventory in the Upper Split Lake Area, Fall 2010. Keeyask Project Environmental Studies Program Report prepared for Manitoba Hydro. 75 pp. *Draft*	Completed	Dec-11
10-04	North/South Consultants Inc., 2011. Floy-tag Application and Recapture Information from the Keeyask Study Area, 2010. Keeyask Project Environmental Studies Program Report prepared for Manitoba Hydro. 53 pp. *Draft*	Completed	Dec-11
10-05	North/South Consultants Inc., 2011. Fish Community Assessment of Armstrong Lake,2010. Keeyask Project Environmental Studies Program Report prepared for Manitoba Hydro. 90 pp. *Draft*	Completed	Dec-11
10-06	North/South Consultants Inc., 2011. Benthic Invertebrate Surveys in Gull Lake and Stephens Lakes, Fall 2010. Keeyask Project Environmental Studies Program Report prepared for Manitoba Hydro. 78 pp. *Draft*	Completed	Dec-11

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
10-07	North/South Consultants Inc., 2011. Young-of-the-Year and Sub-Adult Lake Sturgeon Investigations in the Keeyask Study Area, Spring and Fall 2010. Keeyask Project Environmental Studies Program Report prepared for Manitoba Hydro. 60 pp. *Draft*	Completed	Dec-11
TBA	Ambrose, K.M. and R.A. Remnant. 2011. Results of fish community investigations in Armstrong Lake, Manitoba, 2010. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. *Draft*	In preparation	
TBA	Capar, L.N., and F. Schneider-Vieira. 2011. Results of benthic invertebrate sampling conducted in Gull and Stephens lakes, fall, 2010. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. *Draft*	In preparation	
TBA	Henderson, L. M., C. C. Bart, J.E. MacDonald, and S.J. Garner. 2011. Results of a coarse scale habitat inventory in the upper Split Lake area, fall 2010. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. *Draft*	In preparation	
TBA	Henderson, L.M. and C.C. Barth. 2011. Young-of-the-year and subadult lake sturgeon investigations in the Keeyask Study Area, 2010. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. *Draft*	In preparation	
TBA	Holm, J. 2011. Floy-tag application and recapture information from the Keeyask Study Area, 2010. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. *Draft*	In preparation	
TBA	MacDonald, J.E. and C.C. Barth. 2011. Lake sturgeon investigations in the Keeyask Study Area, Spring 2010. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. *Draft*	In preparation	
TBA	Michaluk, Y. J.E. MacDonald, and C. C. Barth. 2011. Results of lake whitefish spawning surveys in Ferris Bay and the North and South Moswakot rivers, fall, 2010. Draft report prepared for Manitoba Hydro by North/South Consultants Inc. *Draft*	In preparation	
TBA	North/South Consultants Inc., 2011. Adult Lake Sturgeon Investigations, 2011. Keeyask Project Environmental Studies Program Report prepared for Manitoba Hydro. *Draft*	In preparation	

Table 1B-1: Keeyask Generation Project aquatic environment study reports

Report Number	Report Title	Status	Date Completed
TBA	North/South Consultants Inc., 2011. Floy-tag Application and Recapture Information from the Keeyask Study Area, 2011. Keeyask Project Environmental Studies Program Report prepared for Manitoba Hydro. *Draft*	In preparation	
TBA	North/South Consultants Inc., 2011. Lake Sturgeon Telemetry Juvenile, 2011. Keeyask Project Environmental Studies Program Report prepared for Manitoba Hydro. *Draft*	In preparation	
TBA	North/South Consultants Inc., 2011. Young-of-the-year and Sub-Adult Lake Sturgeon Investigations in the Keeyask Study Area, Spring and Fall 2011. Keeyask Project Environmental Studies Program Report prepared for Manitoba Hydro. *Draft*	In preparation	