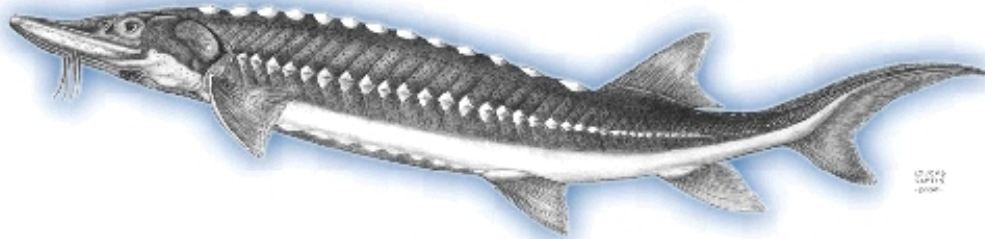


NECHAKO WHITE STURGEON HABITAT MANAGEMENT PLAN

NECHAKO
RIVER **WHITE STURGEON**



RECOVERY INITIATIVE

August 2008

TABLE OF CONTENTS

TABLE OF CONTENTS	2
1. INTRODUCTION	3
2. BACKGROUND	4
3. OBJECTIVES	6
4. SCOPE OF HABITAT MANAGEMENT PLAN	6
4.1 <i>GEOGRAPHIC SCOPE</i>	6
4.2 <i>BIOLOGICAL SCOPE</i>	7
4.3 <i>MANAGEMENT SCOPE</i>	7
5. DATA AND DATA GAPS	7
6. HABITAT MANAGEMENT PLAN	7
6.1 <i>SPAWNING HABITAT</i>	7
6.2 <i>EGG HABITAT</i>	9
6.3 <i>LARVA HABITAT</i>	9
6.4 <i>0+ JUVENILE HABITAT</i>	11
<i>i. Bird Sanctuary</i>	11
<i>ii. Historic Back Channels</i>	11
<i>iii. Juvenile Over-wintering Habitat</i>	11
6.5 <i>OVER-WINTER HABITAT, JUVENILE TO ADULT AGE STURGEON</i>	12
6.6 <i>MONITORING AND EVALUATION</i>	12
7. APPROACH	13
8. PRELIMINARY WORKPLAN 2009-2012	14
9. REFERENCES	15

1. Introduction

The Nechako white sturgeon population is listed as an endangered species by COSEWIC and is protected under Schedule 1 of the Federal Species at Risk Act (SARA). The Recovery Plan for Nechako White Sturgeon (NWSRI 2004) provides information on the status of the Nechako stock group. The Recovery Plan includes information such as what is known about the distribution and movements, genetics and stock structure, growth, condition, maturation, survival, food and feeding, spawning behaviour, habitat, early life history and recruitment of this stock group.

Priority recovery activities outlined in the Recovery Plan include the need to gather biological data on Nechako sturgeon as it relates to adult stock status and productivity, determination of essential habitats for each life history phase, and genetic baseline data. Also identified were the needs for assessments of stock status to ensure sources of adult mortality are being controlled, conservation fish culture is effective, and natural recruitment is re-established.

In order to achieve the desired conservation status of a healthy and naturally reproducing population, targets are identified in the Recovery Plan. These targets are benchmarks by which progress toward recovery will be measured.

The recovery of Nechako white sturgeon requires a two-pronged approach that combines: 1) conservation aquaculture with, 2) the investigation and restoration of habitat, which will be the focus of this document.

The first approach was initiated in 2006 with the Conservation Aquaculture Program, which is designed to build a founder population with the objectives of: 1) preservation of existing genetic diversity and, 2) restoration of a healthy population size that when established can use habitats remediated or restored by this plan. The aquaculture program in of itself does not resolve the fundamental issue of natural in-river recruitment, but will provide the stop-gap until the problem is solved¹.

The second approach to sturgeon recovery is outlined in this Habitat Management Plan, which combines active investigation of habitat requirements, with a continually increasing scale of habitat rehabilitation, habitat enhancement and where needed, habitat creation projects that work towards the conservation of Nechako white sturgeon through natural in-river recruitment.

¹ It should also be noted that currently the Nechako population is estimated to be below 500 individuals. Because of this, random genetic drift is now an issue (i.e., random loss of rare alleles) such that even if recruitment failure was stopped immediately, genetic loss through random breeding would still need to be mitigated through conservation fish culture.

2. Background

The Nechako River itself is one of the largest tributaries to the Fraser River, which drains 25% of the total river discharge in BC. The Nechako River is 290 km in length and has an average annual discharge of $9 \times 10^9 \text{ m}^3$ (Dorcy and Griggs 1991). The Nechako Watershed covers an area of $52,000 \text{ km}^2$ and drains into the Fraser River at Prince George. Of this area, $32,000 \text{ km}^2$ are drained by the Nechako River and the remainder by the Stuart and Nautley rivers. The Nautley River is the largest tributary to the Nechako River upstream of Vanderhoof and has a drainage area of $6,000 \text{ km}^2$. There are numerous large lakes and rivers throughout the basin. Much of the water from the upper Nechako River watershed is diverted westward into the Kemano River for hydroelectric generation.

The drainage area above Kenney Dam is $14,000 \text{ km}^2$. A significant portion of this area is in the Tahtsa Range (Coast Mountains). The Tahtsa sub-basin supplies 70 to 80% of the average runoff at Vanderhoof (Rood and Neill 1987).

The impoundment of water into the Nechako Reservoir and the resultant spillway releases have significantly altered the hydrology of the Nechako River system since 1952. A major dam in the Nechako Canyon and nine saddle dams created the reservoir. The reservoir is 90,000 ha in size and includes Knewstubb, Nataalkuz, Tetachuck, Ootsa, Whitesail and Tahtsa lakes, and Tahtsa and Intata reaches.

Water is released from the reservoir through two separate structures. Water released for power generation exits westward through the Tahtsa system into an underground tunnel to the powerhouse in Kemano then into the Kemano River. On the eastern end of the reservoir water is released through the Skins Lake Spillway. Flows released from the spillway pass through the Cheslatta River, Cheslatta Lake, and Murray Lake and enter the Nechako River at Cheslatta Falls. Cheslatta Falls is 9 km downstream of Kenney Dam. The only flow in the Nechako River between Kenney Dam and Cheslatta Falls is from local natural inflow. Releases from the Skins Lake Spillway have varied significantly since its construction. In the last two decades, releases from the spillway have contributed $62 \text{ m}^3/\text{s}$ mean annual flow to the Nechako River. The inflow to the reservoir since 1952 has averaged $195 \text{ m}^3/\text{s}$.

Seven distinct reaches have been classified in the 142 km section of the Nechako River from Cheslatta Falls to Vanderhoof (Rood and Neill 1987). Reaches 1 through 4 are upstream of the Nautley River that drains Fraser Lake as well as Francois Lake via the Stellako River. The Nautley River contributes $30 \text{ m}^3/\text{s}$ mean annual flow to the Nechako River. Reaches 5 to 7 lie in the area between the Nautley River and Vanderhoof.

The hydrological regime of the system has shaped the habitat of each of these seven reaches. Reaches 1 through 6 of the Nechako River are incised and generally confined by bedrock (Rood and Neill 1987). Prior to flow regulation floodplain and back-channels predominate in reaches 4 and 7 while in the remaining reaches floodplain is fragmentary. The substrate in these reaches is generally boulder with cobbles and gravel locally abundant. Reach 4 is predominantly sand substrate. There are also accumulations of sand in reaches 2, 5 and 7. Only Reach 2 has been identified as a source of sediment input (Rood and Neill 1987).

The Nechako River was naturally a fairly sediment-poor system due to the presence of headwater lakes, with bank erosion historically providing the greatest sediment inputs (Rood and Neill 1987). Impoundment initially led to sediment inputs due to erosion in the Murray Cheslatta system caused by the introduction of spillway flows. Additional large inputs of sediment occurred when the Cheslatta Fan formed as a result of two avulsions of the Cheslatta River, one in 1961 and a second in 1972 (in the Nechako Canyon just upstream of Cheslatta Falls). Approximately 0.9M m^3 of material was deposited in the Nechako River of which about half was transported downstream (Hay & Company 2000). The fate of this sediment has not been well studied however, Rood and Neill (1987) identified a decline in active side channels during the period when the avulsions occurred. Sediment inputs from Reach 2 and the Cheslatta avulsions as well as low base flows may also have contributed to the presently shallow channel, as river depth is generally less than 2 m although deep pools are not uncommon.

In the 45 km from Vanderhoof to the confluence with the Stuart River, the Nechako River typically has a low gradient and is slow moving within a confined, meandering channel. There are several small tributaries and one set of rapids (Hulatt Rapids) 15 km upstream of the Stuart River. The river here is generally deeper than that upstream of Vanderhoof. The Stuart River contributes a mean annual flow of $128\text{ m}^3/\text{s}$ and has a drainage area of $20,000\text{ km}^2$, including several large lakes (Stuart, Trembleur and Takla). The Stuart River enters the Nechako River approximately 90 km upstream from the Nechako-Fraser confluence.

A program of monitoring sturgeon populations across the Fraser Basin conducted from 1995 to 1999 provided the first documented evidence of the decline of the Nechako population and results of the program provided the bulk of information used to develop the NWSRI Recovery Plan. There have been studies since that time to further assess spawning, distribution and early life history; assessments of juvenile abundance; distribution of critical habitat; and information on the distribution and biology of white sturgeon in the Stuart River system.

In most years since 2004, Nechako white sturgeon spawning² has been detected in the Vanderhoof area and/or fertilized eggs have been collected in the river at that location. Laboratory and field experiments have shown that early life history phases of Nechako white sturgeon are very sensitive to substrate type and quality. In addition, a 2-dimensional flow model has been developed that provides insight into the potential relationship between spawning habitat, egg and larval habitat, and flow.

Studies done to date indicate that the Vanderhoof area may contain, and likely historically contained, critical habitat for multiple life history phases of Nechako white sturgeon. As such, this Habitat Management Plan considers options for restoring or recreating conditions in the Vanderhoof area that are suitable for survival of white sturgeon at each of four life phases. In addition, over-winter habitat requirements for all ages of sturgeon is also considered.

3. Objectives

Achieving natural recruitment for the Nechako white sturgeon is a fundamental goal for recovery of this population. The objectives of this Habitat Management Plan are 1) to identify habitat management options that are supported by available data; 2) map a course of action for collecting the additional information needed to design and then; 3) implement habitat management activities that will achieve recovery of Nechako white sturgeon. Over the past eight years the Nechako White Sturgeon Recovery Initiative (NWSRI) has gathered a substantial amount of information on the spawning, early life history, and status of Nechako white sturgeon. While it is recognized that information gaps exist, and addressing these gaps is important, it is critical that progress on habitat remediation be made before the population becomes extirpated. The information already available provides a substantial foundation for development of measures, which can be adapted as new information is learned.

4. Scope of Habitat Management Plan

4.1 Geographic Scope

Nechako white sturgeon are known to utilize the Nechako Watershed up to Takla Lake, Fraser Lake, and the Nechako River mainstem from Prince George to upstream of Fort Fraser. There are no reports of sturgeon in the Nechako Reservoir or upstream of Fraser Lake in the Stellako and Francois system or Endako River. The NWSRI will continue periodic monitoring of the sturgeon population across the entire known geographic distribution range.

² 2004 is the first year spawning was detected through a directed study, however it is strongly suspected based upon a retrospective analysis of telemetry movements that spawning has taken place annually at least for the last 10-15 years and likely longer. (Triton 2008).

4.2 Biological Scope

The focus of this Habitat Management Plan is on habitat requirements for the spawning, egg, larvae and 0+ juvenile life phases of Nechako white sturgeon and on over-wintering habitat needs.

4.3 Management Scope

This Plan focuses on habitat management directed at achieving natural in-river recruitment. The general approach is to combine ongoing research with an active program of habitat rehabilitation, habitat enhancement, habitat creation and maintenance activities or structures. Such a program would combine small to large habitat modifications and engineering of the river channel, with ongoing monitoring to evaluate the species' habitat use patterns in both unaltered areas and sites where experimental habitat modification have been made for recruitment restoration.

5. Data and Data Gaps

This Habitat Management Plan provides consideration for specific habitat management options related to all life history phases of Nechako white sturgeon. More specifically these life phases are: spawning, egg, larva, and 0+ juvenile phase and over-wintering habitat needs. Each life phase is introduced separately in the following section of the report with a brief explanation of the data available and assumptions made. Additional studies and projects that are required in order to fill critical data gaps are also presented.

6. Habitat Management Plan

Achieving appropriate habitat conditions that considers all life-phases is the goal.

6.1 Spawning Habitat

In most years since 2004, sturgeon have been detected spawning near Vanderhoof in an area locally called the bird sanctuary reach. Spawning has been observed predictably in the spring when water temperature reaches about 14 °C in or near the Vanderhoof area, between mid May and mid June. It is possible that there are other spawning areas in the watershed (e.g. Braeside location) but no other has yet been confirmed. There is some data to suggest that sturgeon exhibit spawning site fidelity so this area may be important in both a historic and present-day context.

Water velocity appears to be a primary factor in the selection of spawning locations, with high velocity being preferred. Spawning events have been recorded at sites with a velocity of 0.96 m/s that was reached at a discharge of 100 m³/s (2004 & 2006) and 1.03 m/s at 456 m³/s (2007). Historically, during the spawning period, high velocity reaches likely occurred upstream of Vanderhoof, with the bird sanctuary reach being

predominantly a lower velocity depositional zones containing braided gravel bars. High velocity reaches tend to have cleaner and larger type substrate that sturgeon eggs can adhere to. Larval hiding and feeding habitats, on the other hand, might be found in areas of high gravel density.

In order to positively affect recruitment it is assumed that spawning habitat needs to be suitably located in or upstream of egg and larvae habitat, and 0+ juvenile habitat.

Flow modelling indicates that in order to promote a higher velocity zone upstream of a predominantly lower velocity zone within the current spawning area, thus creating a suitable spatial distribution of spawning, egg depositional, larval hiding/feeding and 0+ juvenile habitats, the discharge would need to exceed 450-500 m³/s at the location. Spring flow rates exceeded this level at this location annually before construction of the Kenney Dam. Current low level flooding in the community of Vanderhoof begins at a discharge of about 500 m³/s.

Since 1981, the average spring flow at the current spawning location at Vanderhoof has been approximately 170 m³/s with a recorded variation (since 1981) of 100 m³/s to 529 m³/s. At discharge rates lower than 450-500 m³/s, high velocity areas (potential spawning areas) occur throughout the bird sanctuary reach. However, at these discharge rates, the high velocity sites selected for spawning may not be suitably associated with the appropriate egg and larval habitat. This may promote spawning in locations that are too distant from suitable egg, larvae, and juvenile habitats, resulting in unnaturally high rates of egg, larvae and/or juvenile mortality, and subsequent juvenile recruitment failure.

Further, habitats and substrates in the Vanderhoof spawning area have been altered by the Nechako River's regulated discharge regime and other factors, which are believed to have degraded the suitability of substrates in this area (for the purposes of sturgeon spawning, incubation, etc.), further impacting recruitment success.

Given these barriers, habitat manipulation that promotes the occurrence of a high velocity reach upstream of the predominantly low velocity bird sanctuary reach containing clean gravels will be considered.

Data Needs:

- Determination of factors influencing white sturgeon spawning locations in the Nechako River;
- Model of historic hydrograph and thermograph relationship for discharges between 600-1200 m³/s;
- Analysis of substrate quality and quantity in the existing sturgeon spawning zones and upper bird sanctuary;
- Examination of current discharge and substrate condition and dynamics in the Vanderhoof area;

- Identification of substrate composition of islands in the bird sanctuary reach;
- Investigation of velocity and discharge dynamics in the existing and a modified sturgeon spawning zone.

6.2 Egg Habitat

White sturgeon eggs are adhesive; they sink quickly once released and adhere to the substrate. Fertilization occurs within the water column immediately upon release. Favourable egg habitat is likely comprised of relatively clean substrate that is stable at normal spring flows (historical above 500-700 m³/s) and has abundant interstitial spaces. A rough substrate with interstitial spaces creates a near-zero velocity boundary layer at the substrate level, which may be critical for white sturgeon egg and larval life phases. In order to effect successful recruitment it is assumed that egg habitat will need to be in the same location as spawning habitat and at or upstream of larval habitat and upstream of juvenile habitat.

The spawning area will be modified to ensure that flow velocity would be high enough to maintain clean substrate (prevent deposition of fine sediments) for the duration of the egg and possibly the larval stages. If monitoring of sedimentation in this reach indicates an ongoing sediment load problem, then regular (annual) cleaning through mechanical means may be required. Initial cleaning of the substrate will be conducted in order to remove fines accumulated within the substrate. This may include cleaning using hydraulic pressure or machinery. Alternatively, efforts to control upstream sediment sources through upstream channel modification to promote storage of fines could be used to prevent or reduce the need for annual cleaning. In this circumstance, significant effort will need to be expended to identify upstream sediment sources and then create the appropriate structures to trap and control this sediment before it reaches the spawning and bird sanctuary reaches.

Data Needs:

- Analysis of optimal habitat conditions (i.e., substrate size and condition) for sturgeon eggs and larvae;
- Determination of potential substrate cleaning methods;
- Monitoring of ongoing sedimentation;
- Determination of potential avenues for modification of river hydraulics to promote development and maintenance of egg habitat at or downstream of spawning habitat.

6.3 Larva Habitat

White sturgeon eggs hatch after 7-12 days, depending on temperature. Upon hatch sturgeon enter a larval phase that lasts between 30 and 40 days, depending on temperature and rate of development. After hatch their yolk is absorbed during the internal (endogenous) feeding phase and then at 10-15 days they transition to the

external (exogenous) feeding phase as yolk reserves are depleted. At 30 – 40 days post-hatch, larvae undergo a metamorphosis into the adult body form and enter the juvenile phase.

Survival during the larval period is critical to successful recruitment, but factors affecting survival at this stage are still being actively investigated. Recent work on the Nechako River has shown the importance of interstitial habitats (clean gravel with spaces) throughout the larval phase, and the absence of such habitat (i.e., the current state of the Nechako River) has been clearly demonstrated to decrease survival. In addition, as exogenous feeding begins, food abundance is also clearly important. However, the precise habitats occupied at this stage and how they contribute to survival still require further investigation.

Larvae are poor swimmers and appear to have very limited ability to search for appropriate habitat other than diving downward from where they hatch. Most eggs are likely in crevices (in the near-zero velocity substrate zone) already so it may be that upon hatching, larvae simply burrow down further into the substrate. Larvae emerge once the yolk sac is absorbed and development into a feeding and free-swimming juvenile stage is complete.

Pre-feeding larvae exposed to any velocity will use yolk sac reserves intended for growth and development before development is complete, and will therefore be more susceptible to predation if they are not in suitable cover provided by substrate. Newly hatched larvae that do not immediately enter the substrate have been observed to drift downstream and re-enter the substrate if the opportunity is encountered. Habitat for the newly hatched pre-feeding stage larvae is assumed to be at the same location as egg incubation and, in optimal spawning and egg habitat, is present for some distance downstream. The availability of suitable larvae habitat downstream of the egg deposition zone may be important in order for those larvae that are swept into the current to have an opportunity to regain cover in the substrate.

Habitat needs for larvae may be similar to those for spawning and egg phases, but likely extend further downstream as downstream drift is regularly observed at the feeding stage. Habitat remediation or creation for this stage would therefore be concentrated within the bird sanctuary reach, downstream of the spawning zone located immediately upstream and would be similar to that used for spawning and incubation.

Data Needs:

- Length of time to hatch and time to emergence of sturgeon larva under in-river conditions;
- Post-feeding sturgeon larvae flow and habitat preferences;
- Food requirements for sturgeon larvae;
- Growth rates under natural conditions;
- The effects of various factors (e.g., food, habitat, predation) on larval survival rates;

- Investigation of velocity and discharge dynamics in bird sanctuary reach.
- Determination of potential avenues for modification of river hydraulics to promote development and maintenance of larvae habitat at or downstream of egg habitat.

6.4 0+ Juvenile Habitat

Relatively little is known about the early juvenile phase from 40 days to 1-year old. There are anecdotal reports of 0+ juveniles using shallow muddy back channels in the Fraser River, and there is a general assumption that this age group uses slow moving side channel habitat. Assuming this is also the case in the Nechako River, the Vanderhoof area would provide important habitat for this life phase. Age 0+ juvenile sturgeon are likely subject to high predation from salmonids, char, pikeminnow, and possibly larger white sturgeon. For this reason it is assumed that for the first year juvenile sturgeon may avoid the deeper mainstem of the river. Further investigation is required to confirm this assumed pattern and better define habitat use at this stage.

There are three potential areas where habitat management activities will be investigated. These areas are the bird sanctuary, historic back channels and over-wintering holes.

i. Bird Sanctuary

A network of islands presently exists at this site that are only submerged under flood level flows higher than 500-700 m³/s. However, they could function as white sturgeon habitat if they were lowered in elevation such that they are inundated at normal spring discharges. This type of island configuration would create abundant habitat that is warm, shallow and with a lower density of larger piscivorous fish. Lowering the elevation of the islands will increase channel width and therefore also reduce velocity, creating the zero-velocity-rearing areas preferred by post-emergent larvae and 0+ juvenile sturgeon.

ii. Historic Back Channels

The Nechako River at Vanderhoof has a large amount of back channels and a floodplain area that is located immediately downstream of the proposed (and historic) spawning zone/reach. Most of this habitat is non-functional at current typical spring discharge levels. Lowering the elevation of these areas so that they function at a lower discharge level will be investigated. There are four candidate locations where this type of habitat modification will be examined: in the bird sanctuary reach itself, on the south side of the bird sanctuary, immediately downstream of the bridge, and near the municipal sewage lagoons.

iii. Juvenile Over-wintering Habitat

Over-wintering sites proximal to juvenile summer habitat may be important for 0+ juveniles in order for them to avoid predation from other fish including larger sturgeon. It

is possible that over the past 50 years of managed flows, the presence of these over-wintering holes has been reduced or eliminated. These types of habitat features can be formed naturally and maintained by events such as high river discharge and ice jams, which are now relatively rare. Monitoring of juvenile habitat use and survival will guide decisions regarding this work. The need for suitable over-wintering holes immediately downstream of the bird sanctuary will be investigated.

Data Needs:

- Tracking habitat use of post-emergent juvenile sturgeon;
- Food requirements and habitat use for 0+ juvenile sturgeon;
- Analysis of structure and stability of existing sturgeon over-wintering sites for 0+ juvenile sturgeon.

6.5 Over-winter Habitat, Juvenile to Adult Age Sturgeon

Sections of river which are relatively deep (5-15 meter deep) adjacent to the thalweg (average 2-4 meters deep) are known to be used by adult sturgeon as over-wintering locations. There are a number of such habitat types downstream of Vanderhoof whose exact location is known. However, to-date no systematic and thorough mapping of these habitat types has been done. It is not known how important these habitat types are for sturgeon, considering the abundance of lakes in the watershed that also could be used as over-wintering habitat. It is not known if the abundance and quality of these habitat types has changed since flow regulation in the Nechako River began. An assessment of over-winter habitat availability and quality needs to be done to begin to understand the potential importance of this habitat type.

Data Needs:

- Mapping of over-wintering habitat in the Nechako River;
- Assessment of size, depth and condition of over-wintering habitat;
- Analysis of change in quantity and quality of over-wintering habitat.

6.6 Monitoring and Evaluation

This plan is based on the premise that adaptable management will be applied throughout the process. Monitoring and evaluation programs are not explicitly described in this Habitat Management Plan. However, it is assumed that short and long-term monitoring and evaluation of the population and habitats, through the Nechako White Sturgeon Recovery Initiative, will serve to ensure a continual refinement of knowledge and necessary actions.

7. Approach

The proposed work plan below provides a sequential approach to data collection, laboratory testing and in-stream habitat management activities. Undertaking this plan will require an iterative method that combines further investigation of key questions (i.e., habitat requirements of feeding larvae), habitat restoration (e.g., substrate modifications for spawning, egg and larval stages) and monitoring to verify results. The initial habitat restoration would be completed in conjunction with release of eggs/larvae produced through conservation fish culture, but this would shift to focus on the habitat requirements to achieve successful recruitment from wild spawning toward the end of this plan.

8. Preliminary Workplan 2009-2012

Year of Work	Task:	Estimated Cost:
2009-2011	Monitoring and tracking of adult sturgeon spawners to confirm habitat preferences.	\$200,000 year 1 \$60,000 / year
2009-2012	Assess habitat use of post-emergent juvenile sturgeon.	\$200,000 year 1 \$100,000 / year
2009	Model of historic hydrograph and thermograph relationship for discharges between 600-1200 m ³ /s.	\$20,000
2009	Analysis of substrate quality and quantity in the existing spawning area and upper Bird Sanctuary.	\$150,000
2009-2010	Velocity and discharge dynamics in the existing and a modified sturgeon spawning chute and Bird Sanctuary Reach (nhc model).	\$100,000
2009-2011	Analysis of optimal substrate size and condition for egg and larva habitat.	\$100,000/yr.
2009	Determination of potential substrate cleaning methods.	\$70,000
2009-2011	Optimal design of a Spawning Channel and Bird Sanctuary Reach.	\$150,000
2009	Length of time to hatch and time to emergence for sturgeon larvae under in-river conditions	\$50,000
2010	Discharge and substrate condition and dynamics in the Vanderhoof area.	\$50,000
2009	Substrate composition of islands in the Bird Sanctuary.	\$30,000
2009-2010	Post-emergent sturgeon larvae flow and habitat preferences.	\$120,000
2009-2011	Food requirements for sturgeon larvae.	\$150,000
2011	Fine sediment source evaluation and upstream diversion/ storage and removal structures.	\$2,500,000
2012	Substrate cleaning and modification in spawning chute	\$750,000
2010-2011	Modification of Bird Sanctuary reach	\$2,500,000
2012	Sturgeon spawning zone modification	\$2,500,000
2009--2011	Food requirements for 0+ juvenile sturgeon.	\$120,000
2011	Analysis of structure and stability of existing sturgeon over-wintering holes.	\$50,000
2012	Juvenile habitat creation	\$2,000,000
TOTAL	<i>Includes one time and annual costs listed above. Does not include cost of hatchery program or other research and monitoring costs.</i>	\$12,430,000

9. REFERENCES

Dorcey, A.H.J., and J.R. Griggs (*Editors*). 1991. *Water in sustainable development: exploring our common future in the Fraser River basin*. Westwater Research Centre, University of British Columbia, Vancouver, B.C.

Hay & Company Consultants, Inc. 2000. Options for passing flows through the Cheslatta Fan. Prepared for NFCP. Report # MENV-022.

Nechako White Sturgeon Recovery Initiative. 2004. Recovery Plan for Nechako White Sturgeon. Prepared by Golder Associates Ltd. 82 pp + App.

Rood, K.M., and C.R. Neill. 1987. A study of some aspects of the geomorphology of the Nechako River. Prepared for Fisheries and Oceans Canada, Vancouver, BC.

Triton Environmental Consultants Limited. 2008. Nechako White Sturgeon Database Summary. Prepared for Ministry of Environment. Prepared by Greg Sykes. 194 pp.