Teslin River Watershed Chinook Restoration Investigation

Prepared For
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EXECUTIVE SUMMARY

This project involved an investigation of potential Chinook salmon (*Oncorhynchus tshawytscha*) restoration options within the Teslin River watershed and included two general components: (1) a literature review of existing information on Chinook salmon in the watershed; and, (2) field assessments at a number of streams within the watershed to determine priorities for Chinook stock and/or habitat restoration options.

The literature review component of the project involved reading and compiling information from numerous studies conducted in the watershed including a data compilation report, community stewardship annual reports and studies targeted at the enumeration and spatial extent of Chinook spawning in the watershed. Based upon the literature review, 15 streams were visited during the field investigation component of the project and included the following:

- Tributaries to Teslin Lake including Deadman Creek and Brook's Brook.
- A tributary to Morley River (Hays Creek)
- Tributaries of the Nisutlin River (South Canol Road), including Rose River, Deer, Cottonwood, Coyote, Sidney, Evelyn, Murphy, 17 Mile and Moose creeks.
- Tributaries of the mainstem Teslin River including 4 Mile (Meadow) and 1 Mile creeks along the South Canol Road and Squanga Creek.

During the field assessments, a general description of the Chinook spawning and rearing habitat potential of each stream was recorded. For streams with existing stream crossings on the Alaska Highway and/or South Canol Road, a description of any fish passage limitations was also recorded. Water temperature loggers were deployed along with a time lapse camera in a primary stream of interest for Chinook restoration (Deadman Creek) and a control stream (Morley River). Three key opportunities for Chinook restoration within the Teslin River watershed were identified and include the following: (1) Chinook stock restoration in Deadman Creek, (2) Chinook habitat restoration in Hays Creek through improved fish passage at the existing Alaska Highway crossing, and (3) Chinook habitat restoration in Cottonwood Creek through improved fish passage at the existing South Canol Road crossing. The three candidate streams identified above currently appear to provide the best options for Chinook salmon restoration in the Teslin River watershed; however, there are other opportunities that could be further investigated at a later date. For example, exploring the use of in-stream Chinook egg incubation within other portions of the Teslin River watershed which are currently underutilized for spawning could provide a means to restore some stocks to levels which more closely resemble those observed historically.

ACKNOWLEDGEMENTS

Gillian Rourke (TTC Renewable Resources Coordinator) assisted with project logistics, provided advice on general project direction and administered the project on behalf of TTC. Korey Smith (TTC Game Guardian) provided valuable local knowledge during the field investigations and provided boat transport to Squanga Creek. Manon Fontaine (EDI) assisted with the compilation of existing reports within the literature review component of the project.

The field work component of this project was completed by Pat Tobler, Ben Schonewille and Scott Dilling of EDI with assistance from TTC Game Guardian Korey Smith.

AUTHORSHIP

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1 INTRODUCTION

The Teslin River watershed is located within the upper portion of the Yukon River Watershed and is fed by Teslin Lake, which is located approximately half within the Yukon and half within northern British Columbia (Map 1). There are a number of large rivers which flow into Teslin Lake which support spawning populations of Chinook salmon including the Nisutlin, Morley, Swift, Gladys, Jennings and upper Teslin rivers. Juvenile Chinook salmon rear throughout these watersheds and in numerous non-natal streams in other portions of the watershed including smaller, first order tributaries of Teslin Lake.

Chinook salmon are a very important resource for Teslin Tlingit Citizens, being both culturally significant and an important subsistence food source. In order to return to the Teslin River watershed, Chinook salmon must successfully migrate through every fishery on the mainstem Yukon River in both Alaska and Yukon; this is in addition to a multitude of environmental threats such as predators and changing water conditions along the length of the river. The sheer length of the Chinook salmon migration back to the Teslin watershed has long been understood by the Teslin Tlingit to make this portion of the run an important indicator of the overall health and strength of the Yukon River Chinook salmon run. The Teslin Tlingit Council (TTC) has been very proactive for many years in their Chinook conservation efforts within the Teslin River watershed; this has included complete fishing closures or harvest restrictions since 2009, and efforts to increase awareness around declining Chinook salmon stocks for over 15 years. TTC is guided by the 2010 *Teslin Tlingit Salmon Management Plan – A Plan to Address the Crisis of the Chinook Salmon Population Decrease*. A major component of TTC's long-term salmon management goals is to seek and opportunities for salmon and salmon habitat enhance, and to conduct such activities where possible.

Chinook salmon in the Teslin River watershed have one of the longest salmon migrations in North America with the headwaters of the Teslin River being nearly 3,000 km upstream from the Bering Sea. During 2002 and 2003 drainage Yuko River wide Chinook telemetry project, the longest distance travelled by a radio tagged Chinook was by a fish that was located in the Teslin River watershed. This individual was relocated in the McNeil River, a tributary of the upper Nisutlin River and had travelled nearly 2,700 km upstream from the tagging site on the lower Yukon River (Mercer and Eiler 2004). The Teslin River watershed is also a major spawning destination for Canadian-origin Chinook. During 2014, the Teslin River stock accounted for an estimated 28.2% of the border escapement; this is comparable to the 2007-2013 average of 24.7% (JTC 2015). Despite these numbers, the Teslin River watershed appears to be underutilized with low densities of spawners in spawning streams despite extensive suitable habitat.

A considerable amount of information has been collected on salmon stocks in the Teslin River watershed over the last 15 to 20 years. Of particular relevance to the current project, a habitat stewardship program was conducted in the watershed from 2003 through 2007 (Wilson 2004, 2005, 2006, 2007). This stewardship program provided a starting point for the current project due to the availability of baseline data and previous recommendations made in regards to potential Chinook restoration options in the watershed.

1.1 PROJECT OBJECTIVES

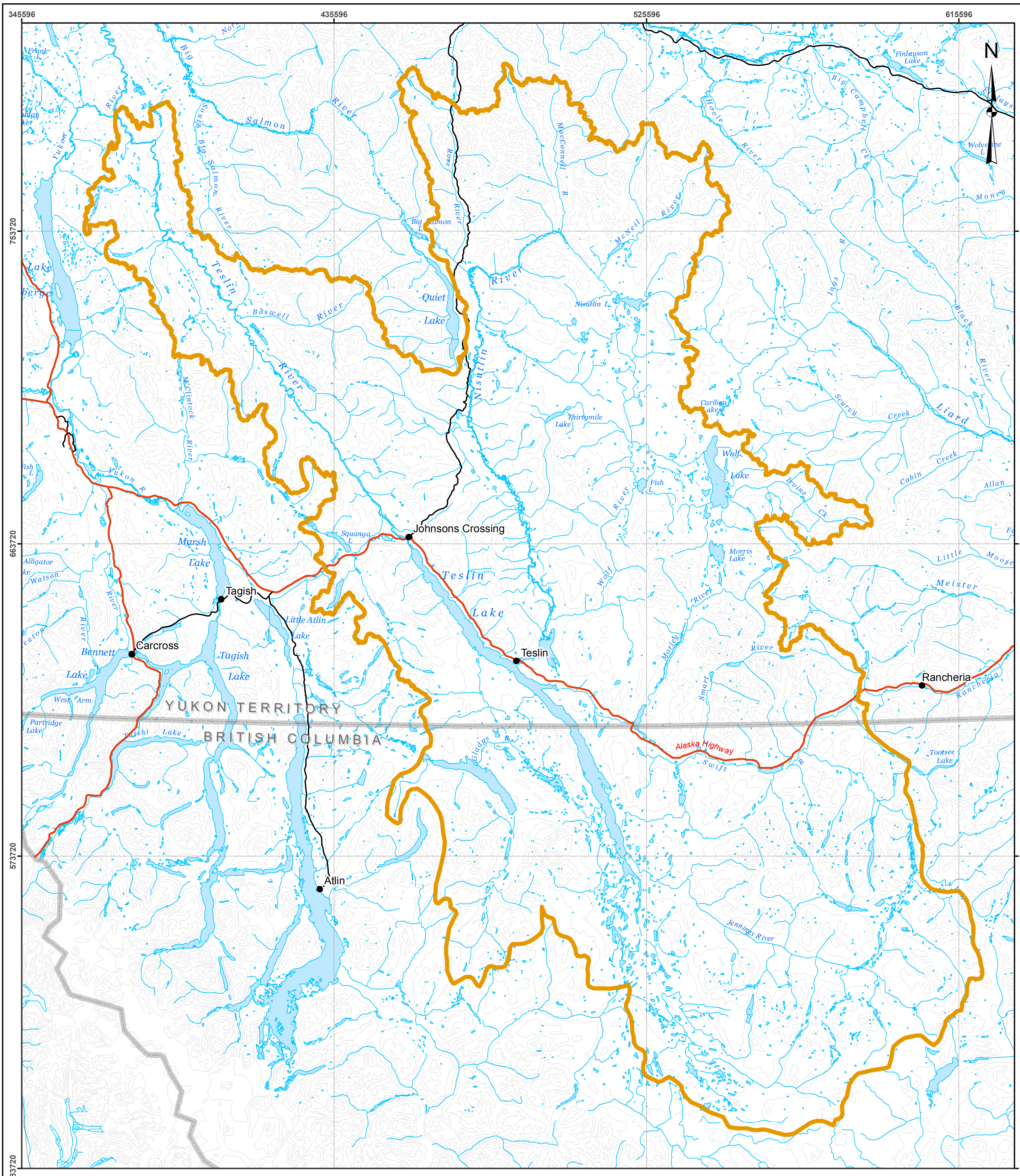
The project fits with TTC's long term objectives to conserve and restore Chinook populations within the Teslin River watershed. The objectives of the current project were to:

(1) compile existing information on salmon within the Teslin River watershed,

(2) conduct field assessments at a small number of streams to update the existing baseline information, and,

(3) outline next steps for a Chinook restoration project within the watershed.

This report is intended to provide a summary of the desktop and field components of the project while also providing details for a potential Chinook stock restoration project in the Teslin River watershed.



Legend

Teslin Watershed Boundary

Secondary Road

Highway

Overview Map of the Teslin River Watershed

Data Sources
1:250,000 and 1:1,000,000 Topographic Spatial Data (inset map) courtesy of Her Majesty the Queen in Right of Canada, Natural Resources Canada. All Rights Reserved.

1:1,000,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.Project data displayed is site specific.

Disclaimer
This document is not an official land survey and the spatial data presented is subject to change.

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Map Scale 1:1,100,000 (printed on 11 x 17)
Map Projection: NAD 1983 CSRS Yukon Albers

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2 METHODS

2.1 LITERATURE REVIEW

The literature review component of this project involved the review of existing reports on Chinook salmon in the Teslin River watershed including the data compilation reports completed previously by EDI, annual stewardship program reports, beaver management (Deadman Creek) reports, and various reports related to adult Chinook in the watershed (Table 1). Reports were reviewed and an emphasis was placed on determining the following information: (1) the identification of locations where Chinook were known to historically occur and are no longer found, and (2) areas where barriers to migration of adult or juvenile Chinook may present a habitat restoration opportunity.

The reports that were reviewed contain a combination of local/traditional knowledge (Tobler 2003) and a variety of assessments conducted by various consultants. Topics ranged from juvenile Chinook salmon habitat assessments (Wilson 2003, 2004, 2005, 2006, 2007) to studies on spawner distribution (Mercer 2004, 2005). It is also important to note that a thorough data compilation report for the watershed was completed in 2003 (Tobler 2004) which compiled and summarized all known information sources on salmon with the area.

Table 1. Summary of reports reviewed during the literature review component of the 2015 Teslin River Watershed Chinook Stock Restoration Investigation project.

Report Title	Report Citation
Salmon Information Gathering Workshop for the Teslin Tlingit Traditional Territory (2002)	Tobler 2003
Compilation and Mapping of Fisheries Information Within the Teslin Tlingit Traditional Territory (2003)	Tobler 2004
Restoration of Fish Passage at Selected Culverts on the South Canol Road (Phase 2)	Laberge Environmental Services 2002
Distribution and Abundance of Radio-tagged Chinook Salmon in the Canadian portion of the Yukon River Watershed as Determined by 2003 Aerial Telemetry Surveys	Mercer 2004
Distribution and Abundance of Radio-tagged Chinook Salmon in the Canadian portion of the Yukon River Watershed as Determined by 2004 Aerial Telemetry Surveys	Mercer 2005
Teslin River Chinook Sonar Project (2012)	Mercer 2013
Radio Telemetry Tracking of Chinook Salmon in the Canadian Portion of the Yukon River Watershed (2002)	Osborne and Mercer 2003
Chinook Salmon Assessment and Restoration/Enhancement Options for Selected Tributaries of the Teslin River	White Mountain Environmental Consulting 1997
Chinook Salmon Assessment and Restoration/Enhancement Options for Selected Tributaries of the Nisutlin River and Teslin Lake Drainages	White Mountain Environmental Consulting 1998
Teslin River Chinook Salmon Spawning Location Survey	White Mountain Environmental Consulting 2003
Beaver Management in Deadman Creek	Wilson 2003
Teslin River Sub-Basin Community Stewardship Program (2003)	Wilson 2004
Teslin River Sub-Basin Community Stewardship Program (2004)	Wilson 2005
Teslin River Sub-Basin Community Stewardship Program (2005)	Wilson 2006
Teslin River Sub-Basin Community Stewardship Program (2006)	Wilson 2007

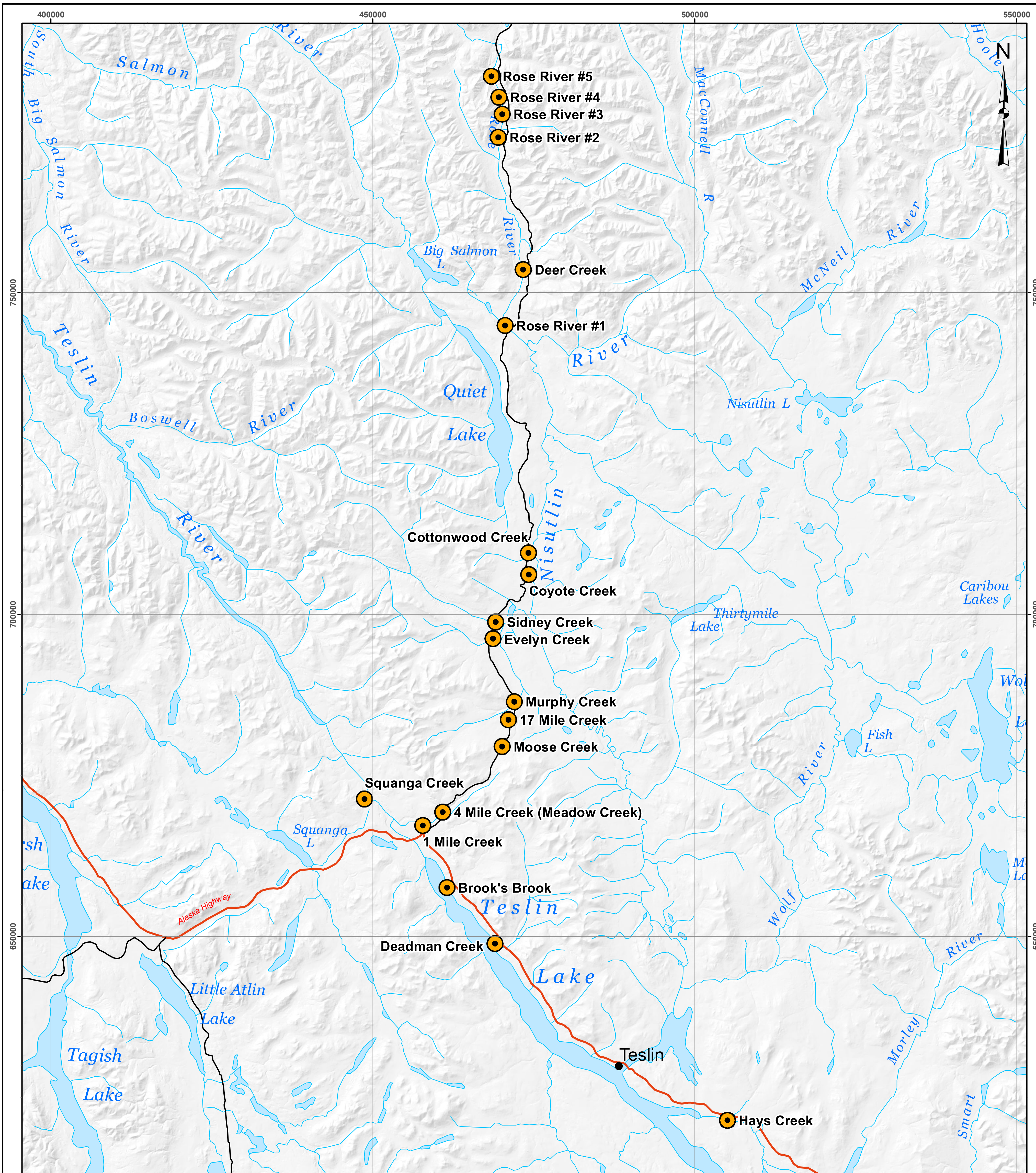
2.2 FIELD INVESTIGATIONS

The streams that were visited during field investigations associated with this project and the field activities conducted at each stream are summarized in Table 2. The field component for this project involved three days of on onsite investigation during mid-August at a number of streams to assess the potential for a Chinook restoration project, as well as follow up assessments on two of the streams during September and October to collect additional information (Deadman and Hays creeks; Table 2). The field sampling methods used during follow up investigations of Deadman and Hays Creek and the Morley River are further detailed in Sections 2.2.1 and 2.2.2 of this report.

Table 2. Summary of streams visited during the field component of the 2015 Teslin River Watershed Chinook Stock Restoration Investigation project.

Stream	Date Visited	Assessments Conducted
Deadman Creek	19 Aug 2015	General assessment of habitat & restoration potential and presence of adult Chinook; lower 0.8 km of stream.
	1 Sep 2015	Stream walk for Chinook spawning evidence; lower 2.3 km of stream.
	13 Sep 2015	Stream walk for Chinook spawning evidence; lower 2.3 km of stream.
	17 Oct 2015	Water temperature logger and time lapse camera install
Hays Creek	19 Aug 2015	General assessment of habitat & restoration potential and presence of adult Chinook. Assessed from highway crossing to the mouth.
	26 Sep 2015	Gee trapping for juvenile Chinook above and below Alaska Highway culvert
Morley River	19 Aug 2015	Observations near the bridge crossing site.
	17 Oct 2015	Water temperature logger and time lapse camera install
Brook's Brook	19 Aug 2015	General assessment of habitat & restoration potential - assessed from highway crossing to the mouth.
Rose River (crossings #1 - #5)	20 Aug 2015	General assessment of habitat & restoration potential – at crossing locations.
Deer Creek	20 Aug 2015	General assessment of habitat & restoration potential – at crossing location.
Cottonwood Creek	20 Aug 2015	General assessment of habitat & restoration potential – at crossing location.
Coyote Creek	20 Aug 2015	General assessment of habitat & restoration potential – at crossing location.
Sidney Creek	20 Aug 2015	General assessment of habitat & restoration potential – at crossing location.
Evelyn Creek	20 Aug 2015	General assessment of habitat & restoration potential – at crossing location.
Murphy Creek	20 Aug 2015	General assessment of habitat & restoration potential – at crossing location.
17 Mile Creek	20 Aug 2015	General assessment of habitat & restoration potential – at crossing location.
Moose Creek	20 Aug 2015	General assessment of habitat & restoration potential – at crossing locations.
4 Mile Creek	20 Aug 2015	General assessment of habitat & restoration potential – at crossing locations.
1 Mile Creek	20 Aug 2015	General assessment of habitat & restoration potential – at crossing locations.
Squanga Creek	21 Aug 2015	General assessment of habitat & restoration potential – from mouth extending 1.2 km upstream.

During the late August field investigations, each visited stream was assessed for general Chinook spawning and rearing habitat and potential barriers to migration for both juvenile and adult salmon. In the case of streams along the Alaska Highway and South Canol Road, the stream crossings were also investigated to determine if improvements to fish passage were necessary/warranted. At all streams that were visited, field personnel also investigated the streams for evidence of Chinook spawning including live adults, carcasses and/or redds.



Legend

- Habitat Investigation Sites
- Secondary Road
- Highway

Overview Map of Streams Visited During 2015 Field Investigations

Data Sources
1:250,000 and 1:1,000,000 Topographic Spatial Data (inset map) courtesy of Her Majesty the Queen in Right of Canada, Natural Resources Canada. All Rights Reserved.

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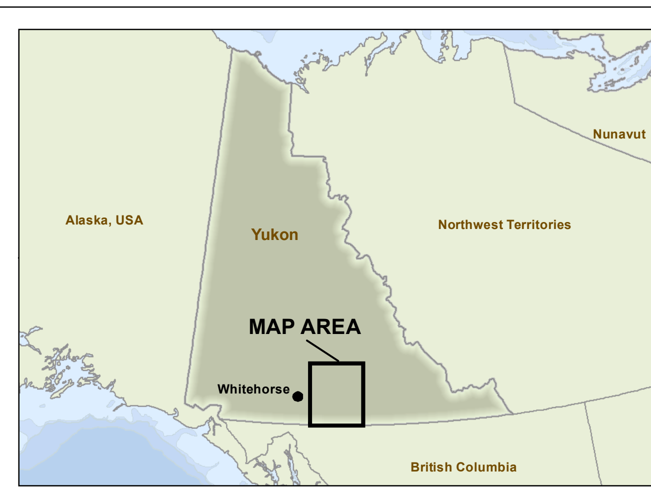
Map Scale 1:600,000 (printed on 11 x 17)
Map Projection: NAD 1983 CSRS Yukon Albers

Drawn: MS	Checked: MP/BSc	Date: 04/02/2016	FIGURE 2



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2.2.1 DEADMAN CREEK / MORLEY RIVER

On Deadman Creek, two follow up field investigations were conducted to search for evidence of Chinook spawning (early to mid-September) and a third investigation during mid-October was conducted to deploy water temperature loggers and a time lapse camera. One Tidbit V2 temperature logger was deployed to measure instream water temperatures on hourly intervals and was installed in a deep pool 225 m upstream of the Alaska Highway crossing (Photo 1). Two temperature loggers (Tibdit V2; hourly data collection) were also deployed within the gravel in the creek to determine if inter-gravel water flow is sufficient to allow for the survival of Chinook eggs and to determine if there are differences compared to surface water temperatures.

The methods used to install the inter-gravel temperature loggers closed followed the method developed by Burill et al. (2010) to monitor chum salmon egg incubation areas in the Tanana River of Alaska. In Deadman Creek, both inter-gravel loggers were deployed in pool outlet areas (potential Chinook spawning areas; Photo 1) and buried at depths of approximately 10 to 15 cm below the surface of the river bed. One inter-gravel temperature logger was deployed near the instream water temperature logger and the second was located 210 m upstream. A time lapse camera (Reconyx Hyperfire) was also installed near the temperature logger location shown in Photo 1 and was set to take a single photo every 15 minutes between noon and 2 pm each day. This camera will be retrieved in spring 2016, and the photos will provide information on ice formation during the early winter and the timing of breakup during the spring.

Photo 1. View of the lower portion of Deadman Creek showing locations of the instream (red arrow) and inter-gravel (green arrow) water temperature logger deployment sites (17 October 2015).

On Morley River, the same methods were used to deploy one instream water temperature logger, two inter-gravel water temperature loggers and a time lapse camera. These deployments were meant to serve as a control for Deadman Creek since the Morley is a well-documented Chinook spawning stream and has relatively warm surface water temperatures during the winter as compared to Deadman Creek which is relatively cool (von Finster 2015). In the Morley River, one inter-gravel logger was deployed in a glide habitat near the day use area 330 m upstream of the Alaska Highway crossing. A second inter-gravel logger along with an instream water logger and time lapse camera were also installed at a large pool directly downstream of the crossing.

2.2.2 HAYS CREEK

Following the initial investigation of Hays Creek on 19 August, a second follow up investigation was conducted on 26 September to sample the stream to determine the presence of juvenile Chinook upstream and downstream of the Alaska Highway crossing. Sampling was conducted using minnow traps baited with salmon roe as per the Yukon River Panel's protocol for sampling of juvenile Chinook (YRP 2007). A total of ten minnow traps were set in the stream with half of the traps upstream of the crossing and half of the traps downstream. Trap soak times ranged from 19.9 to 20.3 hours with an average of 20.2 hours. All fish captured in the traps were identified to species and any juvenile Chinook captured were measured for fork lengths.

3 RESULTS & DISCUSSION

3.1 LITERATURE REVIEW

The results of the literature review indicated that there are a number of candidate streams for Chinook restoration projects within the Teslin River watershed. A summary of these candidate streams is provided by geographic area in the following section. All of the candidate streams indicated below were visited during the field assessments with the exception of Swift River (Teslin River tributary).

3.1.1 DEADMAN CREEK

Deadman Creek is a tributary of Teslin Lake which crosses the Alaska Highway approximately 25 km northwest of the community of Teslin and flows into the lake downstream of the crossing. This stream was a focus of the Teslin River Sub-Basin Community Stewardship Program from 2003 to 2006 and field activities included monitoring the presence of juvenile Chinook, beaver dams and debris jams. Wilson (2003) conducted a project during 2001 to document potential barriers within the creek and to assess juvenile Chinook presence in the creek. Although some potential barriers were documented, juvenile Chinook were captured upstream of these barriers including a small number of individuals a considerable distance (8 km) upstream from Teslin Lake. It is important to note that Deadman Creek has high spring freshet flows that likely limit the consistent presence of beaver dams that span the entire channel(s) and could be barriers to juvenile and adult salmon migration into the stream. The stream has been well documented as a Chinook rearing and overwintering stream and there is local knowledge which indicates that Chinook used to spawn within the creek (Tobler 2004, Wilson 2007). During the final summary report for the stewardship program, Wilson (2007) suggests that the stream should be considered a high priority for monitoring obstructions and juvenile Chinook utilization. Given the easy access to the stream, the re-establishment of a spawning population of Chinook salmon in Deadman Creek could provide the opportunity to involve local community members in a 'hands-on' stock restoration project.

Much of the watershed was burned in a forest fire during the late 1950s after which the forest was replaced with deciduous vegetation growth. This provided an abundant food source for beavers, which likely allowed them to colonize the watershed. It is possible that this colonization could have led to restrictions to the access for spawners into the creek which may account for the recent lack of spawning observed within the stream.

3.1.2 HAYS CREEK

Hays Creek is a tributary of the Morley River which crosses the Alaska Highway approximately 20 km southeast of the community of Teslin; the creek flows into the river just over a kilometre downstream of the highway. The crossing at the highway includes a single culvert which has been identified as a probable barrier to juvenile Chinook due to a possible combination of velocities within the culvert and/or the cascade at the downstream end of the culvert (Tobler 2004, Wilson 2007). Past sampling information for juvenile Chinook also supports the assumption that the culvert is a barrier due to the presence of juveniles downstream of the culvert and the lack of upstream captures despite the presence of suitable rearing habitat (Wilson 2007).

3.1.3 STREAMS ALONG THE SOUTH CANOL ROAD

There are a number of small streams which cross the South Canol Road and either flow into the Teslin River (southern portion of the road) or Nisutlin River (northern portion of the road). Many of these streams are known rearing streams for juvenile Chinook with the larger streams (Sidney Creek, Rose River) being known or suspected spawning streams. Many of the rearing streams have documented barriers to the upstream migration of juveniles due either to beaver dams or stream crossing structures on the South Canol Road (Tobler 2004, Wilson 2007, White Mountain et al. 1998). The two most notable streams which have been previously identified (White Mountain et al. 1998, Laberge 2002) as priorities for fish passage improvements include Cottonwood Creek and Murphy Creek, both of which are tributaries of the Nisutlin River.

Cottonwood Creek flows into the Nisutlin River approximately 75 km upstream from the river mouth and has been well-documented as a juvenile Chinook rearing stream. The existing stream crossing is a perched culvert and is likely a complete barrier to all fish passage, although suitable rearing habitat is also located upstream of the crossing. Utilization of the stream by beavers has also been noted both upstream and downstream of the crossing; however, Laberge (2002) indicated that beaver dams previously documented downstream of the crossing appeared to have been breached due to high flows in the stream. On Murphy Creek, the stream crossing has been previously identified as a potential velocity barrier to juvenile Chinook passage. Sampling conducted by White Mountain et al. (1998) did document juvenile Chinook above the crossing, although the capture rate was considerably higher downstream.

3.1.4 SQUANGA CREEK

Squanga Creek is fed by Squanga Lake and flows into the mainstem Teslin River approximately 11 km downstream of Johnson`s Crossing, which is near the outlet of Teslin Lake. Approximately 400 m upstream from the Teslin River, the creek flows through a steep canyon which includes a number of chutes which collectively represent a barrier to all upstream fish passage. Previous assessments conducted downstream of the barriers have documented small numbers of Chinook spawners and moderate numbers of rearing juveniles (White Mountain et al. 1997). This stream could provide for a Chinook stock enhancement opportunity by introducing spawning Chinook above the barriers; however, this would pose some significant logistical challenges.

3.1.5 SWIFT RIVER (TRIBUTARY TO TESLIN RIVER)

Swift River is a clear water tributary which flows into the Teslin River approximately 55 km downstream of Johnson's Crossing. The Swift River originates from Swift and Rosy lakes and flows a distance of 32 kilometres downstream to the Teslin River. A considerable number of spawning Chinook are known to spawn in this river (i.e. 69 spawners were documented in 1997; White Mountain et al. 1997). The stream provides excellent habitat for juvenile Chinook throughout; however, during 1997, there was a large beaver dam located 3 km upstream from the Teslin River which likely restricts access for both juvenile and adult Chinook into upstream portions of the watershed (White Mountain et al. 1997). Local and traditional knowledge indicates that Chinook spawning historically occurred upstream to the outlet of Swift Lake based upon carcass observations (White Mountain et al. 1997). If this beaver dam is still present, its' removal could open up a considerable distance (6 km) of the stream to both juvenile and adult Chinook.

3.2 FIELD INVESTIGATIONS

The results the field investigations of each stream that was visited during this project are summarized in the following sections and representative photos of each stream are presented in Appendix A.

3.2.1 DEADMAN CREEK

The field investigations on Deadman Creek focused on the lower 2.3 km (linear distance) of the stream. There was evidence of beaver use in the stream (dam remnants of old dams and fresh cuttings), but there did not appear to be any barriers which would prohibit passage by adult or juvenile Chinook. The large beaver dam previously documented in the stream by Wilson (2003) was still present; however, the stream had formed a new channel around the dam through which adult and juvenile Chinook passage appeared to be possible. The active beaver dams (2) appeared to be located in off channel habitats; this may be in response to the volume of streamflow in the creek which may limit the presence of dams on the main channel. A small number of debris jams were also observed (Photo A1 in Appendix A), although these did not appear to constitute barriers to fish passage.

The portion of the stream that was investigated appeared to provide very suitable rearing habitat for juvenile Chinook with ample cover in the form of instream woody debris, overhanging vegetation and deep pools (Photo A2, Appendix A). The habitat for spawning Chinook also appeared suitable with deep holding pools in proximity to pool tailouts and glides which contained appropriately sized cobble/gravel bed materials that would provide suitable areas for Chinook salmon redd construction. Despite these habitat observations, no evidence of Chinook spawning (adults, carcasses or redds) was observed in the lower 2.3 km of the stream between 19 August and 13 September. Based upon the timing of Chinook elsewhere in the Teslin River watershed, this timing was appropriate to detect spawners and/or redds in Deadman Creek would they have been present.

Based upon the existing information on Chinook in Deadman Creek, the observations of the habitat during the 2015 field assessments, and the lack of observed spawning, this stream would likely provide an opportunity for a Chinook stock restoration project. Instream and inter-gravel temperature loggers that were deployed in the stream during October 2015 will be collected during the spring of 2016, and will provided additional data to provide insight to incubation conditions and better inform future restoration efforts on Deadman Creek. This same information will be available from a control stream (Morley River) where Chinook spawning currently occurs, and will provide a control for the data being collected in Deadman Creek during the winter of 2015/2016.

3.2.2 HAYS CREEK

The field investigation on Hays Creek during late August extended a linear distance of approximately 1 km, from the Alaska Highway crossing downstream to the Morley River. Within the portion of the stream that was assessed, the potential for Chinook spawning appeared to be relatively low due to a combination of inadequate bed material size (few cobbles; near the Morley River) and low frequency of pools (near the crossing). The habitat appeared to be more suitable for juvenile Chinook rearing (Photo A3, Appendix A) and existing information (Wilson 2007) from the portion of the stream upstream of crossing indicates that this is also the case further upstream.

The existing crossing includes a single culvert with gravel on the bottom. While velocities were not measured, at the time of survey, they did not appear to be excessive and should not restrict juvenile Chinook passage. However, there is a cascade ~ 5 m downstream of the culvert outlet that appears to be have been constructed as a tail water control structure. Based upon general observations of water velocities through/over the cascade, it would likely pose a barrier to the passage of juvenile Chinook at most flow levels (Photo A4, A5, Appendix A). As a follow up to this initial assessment, a limited amount of fish sampling (minnow trapping) was conducted upstream and downstream of the crossing on September 26. The number of juvenile Chinook captured was relatively low; however, the sampling did confirm that at least some juvenile Chinook are capable of passing through the existing culvert (Table 3). The single juvenile Chinook captured upstream of the culvert was relatively large (104 mm fork length; Photo 2) and this suggests that perhaps only the largest juveniles may be able to make it past the cascade. These inferences are based upon a very limited sample size of fish captured, and additional fish sampling would be required during the future to confirm this pattern.

Table 3. Summary of minnow trapping results on Hays Creek (26 September 2015).

Sampling Location	Trap	Set Duration (hours)	Fish Captured	Fork Lengths of Fish Captured (mm)
Upstream of Crossing	1	20.2	None	-
	2	20.1	None	-
	3	19.9	None	-
	4	20.1	None	-
	5	20.1	1 juvenile Chinook	104
Downstream of Crossing	1	20.1	None	-
	2	20.2	3 juvenile Chinook	80, 81, 80
	3	20.3	None	-
	4	20.3	None	-
	5	20.3	None	-

Photo 2. Juvenile Chinook captured upstream of the Alaska Highway crossing on Hays Creek (26 Sep 2015).

The results of the 2015 field assessments combined with the existing information on the stream suggest that Hays Creek would be a suitable candidate for a Chinook habitat restoration project. Improving fish passage at the existing culvert could be done by installing new rock lines below the cascade downstream of the culvert. This would reduce velocities over/within the cascade and would be expected to increase fish passage through the existing crossing. In order to inform such a restoration project, additional fish sampling upstream and downstream of the culvert is recommended.

3.2.3 BROOK`S BROOK

The field assessment on Brook's Brook extended linear distance of 300 m, from the existing Alaska Highway crossing downstream to Teslin Lake. a. The existing culvert at the crossing has baffles installed (Photo A6, Appendix A) and likely allows for the passage of adult and juvenile Chinook. The habitat within the stream appears to be better suited to juvenile Chinook rearing rather than adult spawning, due to lower flow volume and bed material composition (Photo A7, Appendix A). Downstream of the highway crossing, the stream has formed a new channel as the field assessment identified an abandoned stream channel and new section of channel where the stream flows through a vegetated area. One breached beaver dam and a small drop were observed near the outlet to Teslin Lake; however, neither of these appeared to be large enough to act as a barrier to juvenile Chinook.

3.2.4 ROSE RIVER

The Rose River parallels the South Canol Road for a considerable distance to the north of Quiet Lake and five of the existing stream crossings on the river were investigated during the 2015 field assessments. All five of the crossings that were investigated appeared to provide suitable passage[1] for juvenile and adult Chinook at observed flow levels with the exception of the #2 crossing which may present a velocity barrier to juveniles (Photo A8 – 14, Appendix A). The habitat appeared to be most suitable for Chinook spawning in the lower portions of the stream and rearing by juveniles would be expected to occur throughout the mainstem portions of the river observed. The crossings observed do not appear to provide any habitat restoration potential at the current time.

3.2.5 DEER CREEK

Deer Creek is a small tributary which flows into the Rose River 9.3 km upstream from the confluence with the Nisutlin River. The existing culvert at the Deer Creek crossing is perched (20 cm drop) and water velocities within the culvert may also be a barrier to juvenile fish at high flows (Photo A15, Appendix A). Sampling in this stream by White Mountain et al. (1998) did not capture any fish and it is not currently known if the stream is fish bearing. Given the small size of the stream and the limited potential for juvenile Chinook, habitat restoration in the form of fish passage improvements at the Deer Creek crossing should not be considered a high priority at this time.

3.2.6 COTTONWOOD CREEK

A tributary of the Nisutlin River, Cottonwood Creek was only investigated in the vicinity of the stream crossing during the 2015 field investigations. This stream does not appear to provide suitable habitat for Chinook spawning; however, the habitat for juvenile rearing is suitable and this has been confirmed by

[1] Note fish passage assessments were based on general observations by a biologist with extensive stream crossing assessment experience. Additional data would be required to confirm observations.

previous fish sampling. Laberge (2002) captured juvenile Chinook, burbot (*Lota* lota) and slimy sculpin (*Cottus* cognatus) downstream of the culvert with only slimy sculpin captured upstream. The outlet of the existing culvert at the crossing has been previously identified as a barrier to fish passage by White Mountain et al. (1998), Laberge (2002), Wilson (2007). This is consistent with the observations from the current field investigation - the culvert was observed to be perched by 40 cm, with a drop onto large rocks below the culvert (Photo A15, Appendix A). Downstream of this drop, there appeared to be remnants of rock lines in the stream; however, the rocks were not currently placed in a manner that would facilitate passage by juvenile Chinook at the current time (Photo A16, Appendix A)

Improvements to the existing stream crossing on Cottonwood Creek could provide an option for a Chinook habitat restoration project. As noted by Laberge (2002), the barrier is located in the lower portion of the watershed and is currently restricting access to the vast majority of this watershed, which appears to provide suitable rearing habitat for juvenile Chinook. Fish passage improvements could increase the available habitat for non-natal juvenile Chinook considerably (Photo A17, Appendix A). Laberge (2002) outlined a conceptual plan for addressing the fish passage issue without replacing the culvert; however, given the culvert was installed in the 1980 (according to Laberge 2002), discussions with Highways and Public Works may be warranted regarding the replacement of the existing structure with one designed for fish passage.

3.2.7 COYOTE CREEK

Coyote Creek is a tributary of the Nisutlin River and the presence of juvenile Chinook in the stream is not well understood; a limited amount of sampling during 2004 (Wilson 2007) did not capture any fish upstream or downstream of the culvert. The existing culvert does not appear to act as a barrier to fish passage (Photo A19, Appendix A); however, some bank scouring (which effects the road surface) was observed below the culvert which is likely due to backwatering in this area during high flows. While this area could be armoured to address the bank scouring/road issue, it is not a high priority from a fish habitat restoration perspective.

3.2.8 SIDNEY CREEK

The existing stream crossing on Sidney Creek is well designed and includes two large, well embedded culverts and a third smaller overflow culvert (Photo A20, Appendix A). These crossing structures appear to provide adequate fish passage for adult/juvenile Chinook and would be expected to do so across a wide range of flows. Although no Chinook restoration efforts appear to be required at the existing crossing at this time, other activities in the watershed such as placer mining may warrant future investigations into Chinook habitat restoration projects in the upper portions of the Sidney Creek watershed.

3.2.9 EVELYN CREEK

A tributary of Sidney Creek, Evelyn Creek is a known Chinook rearing stream and there are anecdotal reports of Chinook spawning (Wilson 2007). The existing stream crossing structure is a clear span bridge (Photo A21, Appendix A) and therefore, there are no concerns with fish passage at this crossing. Similar to

Sidney Creek, placer mining in the watershed may provide a rationale for Chinook habitat restoration opportunities.

3.2.10 MURPHY CREEK

Murphy Creek is a tributary of Sidney Creek that has been previously identified as a candidate for stream crossing improvements. However, during the 2015 field investigations, it was apparent that a new clear span bridge had recently been installed at the crossing (possibly during 2014; Photo A22, Appendix A) and as such there is no longer a fish passage concern at this crossing.

3.2.11 17 MILE CREEK

A tributary of Murphy Creek, 17 Mile Creek is a relatively small creek (Photo A23, Appendix A) with no prior data on juvenile Chinook rearing potential. The existing culvert at the South Canol Road is perched by 10 cm and likely contains a partial velocity barrier within the upper portion of the culvert (Photo A24). This stream crossing is a considerable distance upstream from the confluence with Murphy Creek (9 km) and as such the potential for juvenile Chinook rearing above the culvert is likely to be low overall.

3.2.12 MOOSE CREEK

A tributary of Murphy Creek, Moose Creek is a small stream with a culvert that is not perched (Photo A25, Appendix A). Velocities within the upper portion of the culvert likely result prevent juvenile Chinook from migrating through the culvert (Photo A26). This stream crossing is a considerable distance upstream from documented Chinook rearing habitat and as such the potential for juvenile Chinook is likely to be low overall.

3.2.13 4 MILE CREEK (MEADOW CREEK) AND 1 MILE CREEK

Tributaries of the Teslin River, 4 Mile and 1 Mile creeks are small streams (Photo A27-28, Appendix A) with culverts that contain velocities which may represent prevent juvenile Chinook from migrating through them. Although there is no existing information on juvenile Chinook within the streams, the distance downstream to the Teslin River (over 4 km) combined with observations of recent beaver activity suggest that the potential for juvenile Chinook within the vicinity of the stream crossings is relatively low. Fish sampling and culvert measurements (velocities, etc.) would provide more insight on these streams.

3.2.14 SQUANGA CREEK

Squanga Creek is a tributary of the Teslin River mainstem (Photo A29-31, Appendix A) and has been documented as a Chinook spawning and rearing stream (White Mountain et al. 1997). However, the amount of habitat which is accessible to adult Chinook is limited to a few hundred metres due to the presence of a number of chutes and cascades which act as a barrier to upstream migration of all fish (Photo A32). The 2015 field assessment indicated that the potential for Chinook spawning downstream of the barrier appeared to be fair due primarily to a limited amount of pools or resting areas for adult fish. No adult Chinook or evidence of spawning (carcasses, redds) were observed during the field assessment conducted on 21 August 2015.

Squanga Creek does not appear to provide an opportunity for Chinook restoration; however, it could serve as a potential Chinook habitat and/or stock enhancement opportunity by placing Chinook upstream of the barrier. Such measures are unlikely to be consistent with the current TTC salmon management goals and should not be given priority over Chinook stock and/or habitat restoration options in the Teslin River watershed.

3.3 INSTREAM INCUBATION OF CHINOOK SALMON

Due to the current state of the Chinook salmon runs in the Yukon River there has been increased attention regarding stock restoration techniques throughout the watershed. Hatchery supplementation has been part of that discussion; however, concerns and uncertainties of this technique are well documented (e.g. genetics, differences in fish size and development, disease; Naish et al. 2008). Given that no hatchery intervention has ever been completed on salmon in the Teslin Tlingit Traditional Territory, the runs can be considered to be completely natural aside from changes which have occurred over time due to harvest of the stock throughout the Yukon River. The decision to intervene with hatchery supplementation is not one to take lightly and all alternatives should be considered prior to implementation. The Teslin Tlingit Council has expressed concerns about hatcheries, and as such an alternative method is discussed below.

One such alternative to hatchery supplementation is on-site fertilization and in-stream incubation of Chinook eggs. The method involves the onsite collection of brood stock within the spawning stream and the on-site fertilization of the eggs without transport to a conventional hatchery. The fertilized eggs are then placed directly into the stream either in the form of a commercially available incubator (ex. Jordan Scotty salmonid incubator) of by some other means such as an 'artificial redd' where eggs are placed in the substrate in a manner which mimics natural salmon redd construction. Regardless of the deployment method used, the goal is to maximize egg fertilization rates which are relatively low in the wild and can be increased considerably through the use on-site fertilization. With increased fertilization rates and a decrease in egg predation, the outcome of this method is intended to increase egg to fry survival over natural conditions while providing a method that mimics natural conditions as closely as possible without hatchery intervention. Some of the most notable issues associated with conventional hatcheries are related to fish size and competition with wild fish. Both of these issues are non-existent with the concept of in-stream incubation as the eggs are allowed to incubate under natural conditions. However, in-stream incubation does have the potential to result in genetic consequences to the population by boosting the egg to fry survival of a subset of the population. This can be mitigated by using multiple adults for brood stock and ensuring that the stock restoration activities are conducted on a particular stock for the short term only (ie, maximum of two life cycles – 12 years) and are used for restoration only (ie, not used to maintain or enhance stocks).

The concept of in-stream incubation could be used on a stream to re-establish a spawning population or to restore a stock to levels which more closely represent historical levels. It is also important to note that such a restoration activity would require a considerable amount of time and effort to collect the brood stock, fertilize/deploy the eggs and monitor the effectiveness of the incubation. The outcome of such a restoration activity is not likely to produce as many fry as would be expected using a conventional hatchery; however, when the potential ecological risks are taken into consideration, in-stream incubation could provide a more balanced option for restoring Chinook stocks in the Teslin River watershed and elsewhere in the Yukon as compared to conventional hatchery augmentation.

4 CONCLUSION AND RECOMMENDATIONS

Based upon the literature review and field investigations conducted for this project, there are currently four key Chinook salmon restoration opportunities in the Teslin River watershed at this time. These include the following:

- Deadman Creek Chinook stock restoration, through potential reintroduction of a spawning population;
- Hays Creek juvenile Chinook habitat restoration, through fish passage improvements at the existing Alaska Highway crossing, and;
- Cottonwood Creek juvenile Chinook habitat restoration through fish passage improvements at the existing South Canol Road crossing.
- In-stream incubation of Chinook in streams within the Teslin River watershed which are no longer used for spawning or currently being underutilized by spawners.

The restoration of a Chinook spawning population should be considered the highest priority Chinook restoration option within the Teslin River watershed. Deadman Creek appears to be a suitable candidate stream for such a restoration activity and could provide opportunities for community involvement in a hands-on restoration project. Given the easy access to the creek, such a project could also provide for a valuable fisheries stewardship and training opportunities. Methods for such a restoration project could involve the use of in-stream egg incubation of Chinook eggs to reintroduce Chinook to the stream a method that does not involve conventional stocking methods (release of hatchery-reared fish). Additional assessment of incubation conditions in the creek (on-going), testing of instream incubation methods and development of a restoration plan are required prior to implementation of such a project. Monitoring of the success of the in-stream egg incubation could include a combination of direct measures of egg survival and indirect measures of juvenile presence in the stream in years following the implementation of the restoration activities. Permitting requirements for such a restoration project would likely include a fish collection license (DFO), fish introduction, transport and transplant permit (DFO/YG) and possibly a YESAB assessment.

Chinook habitat restoration projects through improvements to stream crossing structures on Hays and Cottonwood Creeks have the potential to restore access to habitats used for juvenile Chinook rearing. Both creeks would benefit from such activities, which could be completed by improving access into the existing culverts (i.e., new crossing structures not required). On Hays Creek, improvements to fish passage at the existing crossing could be achieved by strategic placement of large rock lines below the cascade downstream of the culvert outlet. The rock lines should be installed so that they back water the cascade, reducing the drop and water velocities. Prior to any such work additional assessment of the ability of juvenile fish to pass the existing cascade should be completed.

On Cottonwood Creek, it is likely that more extensive activities would be required to backwater the culvert (currently perched by 40 cm) and permit fish passage through the culvert. A Newbury Riffle may provide a suitable structure to achieve this goal and such structures have been used to successfully restore fish passage on other similarly sized streams in the Yukon. Before any such plan is developed, discussion with Highways and Public Works is recommended. The culvert was installed over 35 years ago and may be due for replacement.

Monitoring of the effectiveness of fish passage improvements could involve before/after sampling for fish presence upstream and downstream of the culverts. Permitting requirements for this type of restoration project would likely include a fish collection license (DFO), and depending upon the amount on in-stream work, a water license and YESAB assessment may also be required. Developing a detailed plan to improve fish passage at these crossings would require some additional study and discussion with other stakeholders (e.g. Yukon Highways).

During the conduct of this study there were a few other potential issues that should be investigated related to fish presence in relation to potential barriers.

- Beaver activity on the Swift River (lower Teslin River tributary) should be investigated to determine the current impact on Chinook migration (juveniles and adults).
- Fish sampling upstream and downstream stream crossings on the South Canol Road to determine the presence of juvenile Chinook and fish passage attributes of a number of stream crossings (including, but not limited to Deer, Coyote, Moose, 17 Mile, 4 Mile (Meadow) and 1 Mile Creeks).

In-stream incubation of Chinook salmon eggs in streams where Chinook were historically found or those which are currently underutilized could provide a method of restoring Chinook stocks in the Teslin River watershed without the use of convention hatchery supplementation methods. In-stream incubation may provide a more balanced approach which may allow for stock restoration objectives to be met without many of the ecological concerns associated with stocking of Chinook fry raised in a hatchery environment.

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APPENDIX A. PHOTOGRAPHS OF STREAMS VISITED DURING FIELD INVESTIGATIONS

Photo A1. Upstream view of debris jam in Deadman Creek (19 August 2015).

Photo A2. Downstream view of cover for juvenile Chinook in Deadman Creek (19 August 2015).

Photo A3. Upstream view of Hays Creek downstream of the Alaska Highway crossing (19 August 2015).

Photo A4. Downstream view of the cascade below the Hays Creek culvert (19 August 2015).

Photo A5. Upstream view of the cascade below the Hays Creek culvert (19 August 2015).

Photo A6. Upstream view of the Brook's Brook culvert (19 August 2015).

Photo A7. Upstream view of juvenile Chinook rearing habitat in Brook's Brook downstream of the crossing (19 August 2015).

Photo A8. Upstream view of the bridge at the Rose River crossing #1 (20 August 2015).

Photo A9. Downstream view of the Rose River #2 crossing (20 August 2015).

Photo A10. Downstream view of the Rose River #2 crossing (culvert inlets; 20 August 2015).

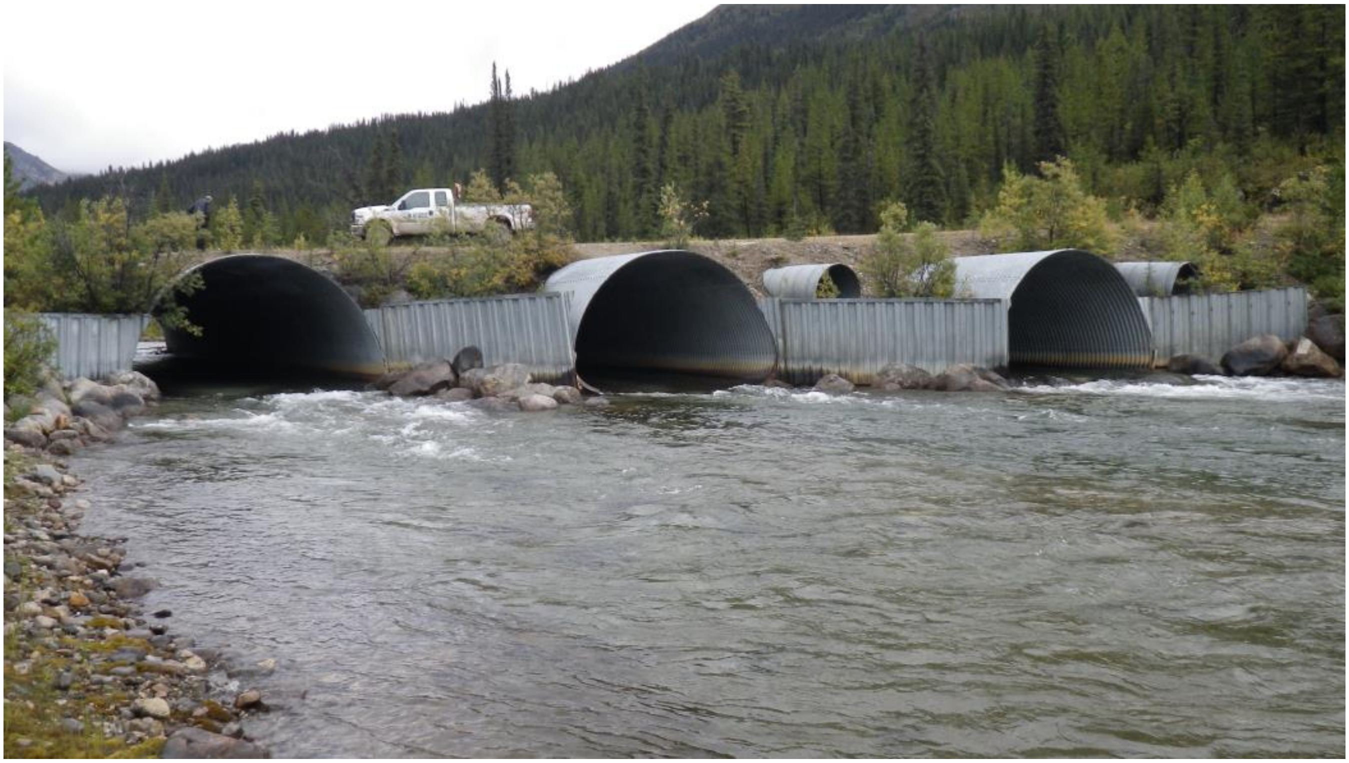

Photo A11. Upstream view of the Rose River #2 crossing (culvert outlets; (20 August 2015).

Photo A12. Upstream view of the Rose River #3 crossing (culvert outlet; 20 August 2015).

Photo A13. Upstream view of the Rose River #4 crossing (culvert outlet; 20 August 2015).

Photo A14. Upstream view of the Rose River #5 crossing (culvert outlets; 20 August 2015).

Photo A15. Overhead view of the Deer Creek culvert outlet (20 August 2015).

Photo A16. Upstream view of the perched culvert at the Cottonwood Creek (20 August 2015).


Photo A17. Downstream view of Cottonwood Creek below the South Canol Road crossing (20 August 2015).


Photo A18. Upstream view of Cottonwood Creek above the South Canol Road crossing (20 August 2015).


Photo A19. Upstream view of the Coyote Creek culvert (20 August 2015).


Photo A20. Upstream view of the Sidney Creek culverts (20 August 2015).

Photo A21. Cross channel view at the Evelyn Creek bridge (20 August 2015).

Photo A22. Cross channel view at the Murphy Creek bridge (20 August 2015).

Photo A23. Upstream view of 17 Mile Creek upstream of the South Canol Road (20 August 2015).

Photo A24. Upstream view inside the 17 Mile Creek culvert (20 August 2015).

Photo A25. Downstream view of Moose Creek downstream of the South Canol Road (20 August 2015).

Photo A26. Upstream view inside the Moose Creek culvert (20 August 2015).

Photo A27. Downstream view of 4 Mile Creek downstream of the South Canol Road (20 August 2015).

Photo A28. Downstream view of 1 Mile Creek downstream of the South Canol Road (20 August 2015).

Photo A29. Upstream view of Squanga Creek near the confluence with the Teslin River (21 August 2015).

Photo A30. Upstream view of Squanga Creek between the Teslin River and the barrier to fish passage (lower gradient portion; 21 August 2015).

Photo A31. Upstream view of Squanga Creek between the Teslin River and the barrier to fish passage (higher gradient portion; (21 August 2015).

Photo A32. Overhead view of falls on Squanga Creek which represent a total barrier to fish passage (21 August 2015).