

Klondike River Chinook Salmon Stock Restoration Plan Version 2.0



Prepared For

Yukon River Panel

c/o Pacific Salmon Commission
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EXECUTIVE SUMMARY

This Plan sets the stage for Chinook salmon restoration in the Klondike River watershed. During the development of the Plan, TH community members were engaged to determine their perspectives on Chinook restoration. This information was combined with existing information on Chinook salmon in the watershed to identify the types of restoration projects which may be considered over the short to medium term.

Tr'ondëk Hwëch'in (TH) citizens are physically, culturally and spiritually connected to the Yukon River salmon fishery. Tr'ondëk Hwëch'in, or people of the river, have historically focused their salmon harvest along the banks of the Yukon River and at the confluence of the Yukon and Klondike Rivers, or Tr'ochëk. TH has a vested interest in the health of salmon stocks found within their Traditional Territory and is committed to the restoration of Chinook stocks within their Traditional Territory, including the Klondike River. It is TH's hope that the continued and persistent involvement in restoration efforts will one day result in the return of healthy salmon stocks to this watershed.

The Klondike River watershed has experienced decades of major anthropogenic disturbances since the Gold Rush era in the late 1890s. Today placer mining continues to be a main economic activity of the Klondike region and it is unknown how the current escapement of Chinook in the watershed compares to pre-disturbance levels. This past disturbance, combined with a number of other factors (including accessibility), make the Klondike River watershed a priority for restoration within the TH Traditional Territory.

There is a considerable amount of existing information on the Klondike River Chinook stock. The 2009 to 2011 Klondike River sonar project provided information on spawner escapement which ranged from 1,181 to 5,147 spawners. Past research has also provided information on spawning distribution, habitat parameters and juvenile distribution and relative abundance. The continued monitoring of all life stages of Chinook will be important in the future, not only to monitor the health of the stock but also to inform the effectiveness of restoration efforts.

There are a number of potential restoration projects which may help to meet the watershed level objectives for restoration including: stewardship projects, habitat restoration, instream incubation, conventional hatcheries and streamside incubation. TH community members are in support of Chinook restoration within the Klondike River watershed; however, individuals were concerned about the scale of potential projects. Small scale projects (such as instream incubation) were deemed favorable as a starting point after which an increase in scale of the projects under consideration would be favorable. TH's medium to long term goal is to establish a streamside incubation facility, preferably in conjunction with the TH Teaching and Learning Farm.

TH is currently in the process of securing funding for a small instream incubation trial project on the Klondike River to determine the feasibility of this method in the watershed and to collection life history information which may be incorporated into future restoration projects. It is envisioned that additional restoration projects will be undertaken in the future at which time this Plan will be revised accordingly.



ACKNOWLEDGEMENTS

Tr'ondëk Hwëch'in (TH) would like to acknowledge our citizens who took time to complete our "*Chinook Salmon Survey*". The information and knowledge that you have shared with TH Fish and Wildlife Branch, in order to further our understanding of the TH connection to, and future vision for, Chinook salmon is greatly appreciated. We would also like to thank the many citizens who attend our community salmon meetings and provide us with valuable knowledge, insight and traditional stories that help to guide and direct us on the restoration planning efforts. Jody Mackenzie-Grieve (DFO) provided assistance in the compilation on existing hard copy and digital files in regards to salmon in the Klondike River watershed.

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AUTHORSHIP

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ACRONYMS AND ABBREVIATIONS

DDRRC.....	Dawson District Renewable Resources Council
DFO	Department of Fisheries and Oceans Canada
EDI	EDI Environmental Dynamics Inc.
TH	Tr'ondëk Hwëch'in
TH FA.....	Tr'ondëk Hwëch'in Final Agreement
TH TT.....	Tr'ondëk Hwëch'in Traditional Territory
TTC.....	Teslin Tlingit Council

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1 INTRODUCTION

This Plan is intended to set the stage for the restoration of Chinook salmon in the Klondike River watershed by combining information on Tr'ondëk Hwëch'in (TH) community perspectives with existing information and potential options for restoration projects in the watershed. The Plan is intended to be an evolving document and therefore future refinements will be made through communication with TH citizens, monitoring of the Chinook stock and lessons learned from restoration projects not only in the Klondike watershed, but elsewhere in the Yukon River watershed.

1.1 TR'ONDËK HWËCH'IN CONNECTION AND COMMITMENT

TH citizens are physically, culturally and spiritually connected to the Yukon River salmon fishery. Tr'ondëk Hwëch'in, or people of the river, have historically focused their salmon harvest along the banks of the Yukon River and at the confluence of the Yukon and Klondike Rivers, or Tr'ochëk. Under Chapter 16 of the Tr'ondëk Hwëch'in Final Agreement, TH is tasked with the responsibility of preserving and enhancing the renewable resources economy within the TH Traditional Territory (THTT). Under this direction, TH's connection to and reliance on subsistence and commercial salmon fisheries is integral to the health of the community. TH has a vested interest in the health of salmon stocks found within their Traditional Territory because fishing has been a main generator of income for TH citizens for decades as well as a significant contributor to the natural economy that has been woven into the fabric of TH culture. During recent times, Yukon River Chinook salmon populations have experienced significant declines and TH has made considerable effort to support their citizens through these difficult times. Culture camps that bring Elders and youth together are a venue that allows traditional knowledge to be shared and passed on to the next generation. These camps include activities that focus on all things salmon – harvesting techniques, preserving your catch, setting nets and special or traditionally used camping areas along the river, as well as spiritual practices, stories and songs that teach youth respect for the salmon. The Klondike River Chinook salmon have faced similar declines in populations for a number of decades as well. To address the loss of this healthy food source and traditional economy staple in the community, TH has been involved with efforts that support salmon restoration projects in our Traditional Territory. We hope that our continued and persistent involvement in restoration efforts will one day result in the return of healthy salmon stocks to this watershed.

In developing this restoration plan, Fish and Wildlife staff worked to obtain guidance and input from the TH community regarding the scale and scope of future projects that they would like to see in the THTT. Our goal was also to further investigate those research questions that were raised by the community during consultation sessions on the Klondike River Hatchery Feasibility Report (EDI 2010). A 'Chinook Salmon Survey' was created and distributed amongst members and the survey included questions about citizens' past, present and future connection to salmon, the cultural importance of the species, the importance of wild food to their family, along with a number of questions that gauged interest in varying types of restoration projects. The survey questions targeted information pertaining to restoration techniques and attempted to assess people's support for restoration in general, as well determining what scale restoration project (including temporal scale) is of interest to the community.



This information has been compiled and assessed, and TH has developed this Klondike River Chinook Salmon Restoration Plan with assistance from EDI. We view this Plan as a living document and have the intention to revisit the Plan regularly to make sure that it reflects community values and best practices that are learnt or observed over the next few years in the community with these restoration project efforts. It is our desire to have the Klondike River Chinook Salmon Restoration Plan determine the optimum approach for stock restoration for the Chinook salmon on the Klondike River for our community. This evolving process will succeed with data compilation and analysis, current site analysis and insight gained from other on-going restoration research in the Yukon River watershed. As this research is on-going in the Yukon and in its infancy in the THIT, we anticipate that greater direction for approach will be developed gradually as this project gains strength and momentum. Furthermore, TH recognizes the importance of exploring restoration options throughout the Yukon River watershed, in hopes of learning more about the unique life history strategies that our Yukon River Chinook salmon may employ and how they compare between tributary watersheds.

While past research has provided us with a substantial amount of data to consider, we believe that the development of the restoration plan has clearly defined a strategy for our next steps. This will enhance our understanding of future considerations by indicating those aspects of a potential restoration project that may require additional attention, further investigation and/or warrant precaution.

1.2 OVERVIEW OF THE KLONDIKE RIVER WATERSHED

The Klondike River watershed has experienced decades of major anthropogenic disturbances since the Gold Rush era. First signs of change came from the numerous placer mining operations located up Bonanza Creek; while relatively small in scale, the number of camps, people and gold seeking activities quickly increased exponentially. As the years passed and exploration efforts for placer gold expanded, Hunker Creek became an additional tributary to the Klondike River that was under intense exploration. Following the relatively manual labour era of pick, shovel and gold pan came an era that used machinery built to a scale that was capable of quickly altering the landscape in order to reach the gold-laden bedrock. Inherent in this changing landscape were alterations to the fish-bearing creeks and river channels that had carved their way through the land over countless centuries. Fluvial paths were moved from one side of the valley to the other and water flow was diverted or ponded, all of which had an enormous impact on the salmon that the TH Hän people had relied upon for so long. Today, the scars on the landscape tell the story of a much changed ecosystem that lost a considerable amount of fertile soils, lush riparian vegetation and trees, as well as long-established salmon spawning and rearing habitats. While this population of salmon has rebounded from the impacts of unregulated mining, we have been unable to go back in time to fully gauge the true or original carrying capacity of the Klondike River in its height of salmon production. And as time goes on, this remarkable species continues to face other regional and global challenges that continue to test the resiliency of the salmon. The strong connection that TH has maintained to this species over time is a testament to the resiliency of a culture intricately linked to salmon. It is the importance of maintaining this connection that is the catalyst to draft this restoration plan for Chinook salmon in the Klondike River.



Today placer mining continues to be a main economic activity of the Klondike region, however access to other economic activities, based on the natural economy, has been guaranteed to TH citizens under the Tr'ondëk Hwëch'in Final Agreement (TH FA). The objectives found in the TH FA: Chapter 16 clearly outline rights, roles and responsibilities for TH to uphold and to protect natural resources for future generations. The declines witnessed in the Yukon River Chinook salmon have been devastating to Tr'ondëk Hwëch'in people. This being said, the declines in the Klondike River Chinook salmon stock have been recognized as a plausible focus for restoration.

The benefits of targeting the Chinook stock on the Klondike River are many:

- The restoration project will target a fishery that has historically been relied upon by TH
- Closed system will allow easy determination of success of a restoration project
- Extensive research and data has been collected for this drainage
- A juvenile salmonid assessment program run annually by the DDRRC has a database containing information on adult spawning timing, juvenile rearing habitats, juvenile outmigration timings, and juvenile biological data (length/ weight)
- Easily accessible sites to continue data analysis of water quality, water quantity/ flow rates, water temperature, juvenile rearing habitat, juvenile success rates (including juvenile assessments of outmigration timings and documented size data for juveniles (i.e. length/ weight), redds/ adult spawning areas, and adult spawning timing due to Klondike Highway running adjacent to the river
- The lower portion of the river is conducive to re-deploying an adult assessment station (i.e. Didson sonar)
- Earlier studies, corroborated with our limited site investigation last year, indicate good potential for in-stream incubation sites
- Promising site conditions in channels running adjacent to the TH Teaching and Learning Farm, which will provide year-round access (on TH Settlement Land, guaranteeing access and tenure) along with necessary infrastructure including roads, power, water, outbuildings and trail to access the Klondike River. This reduces associated costs and provides the necessary requirements for a future project and its staff.

1.3 RESTORATION PLAN APPROACH

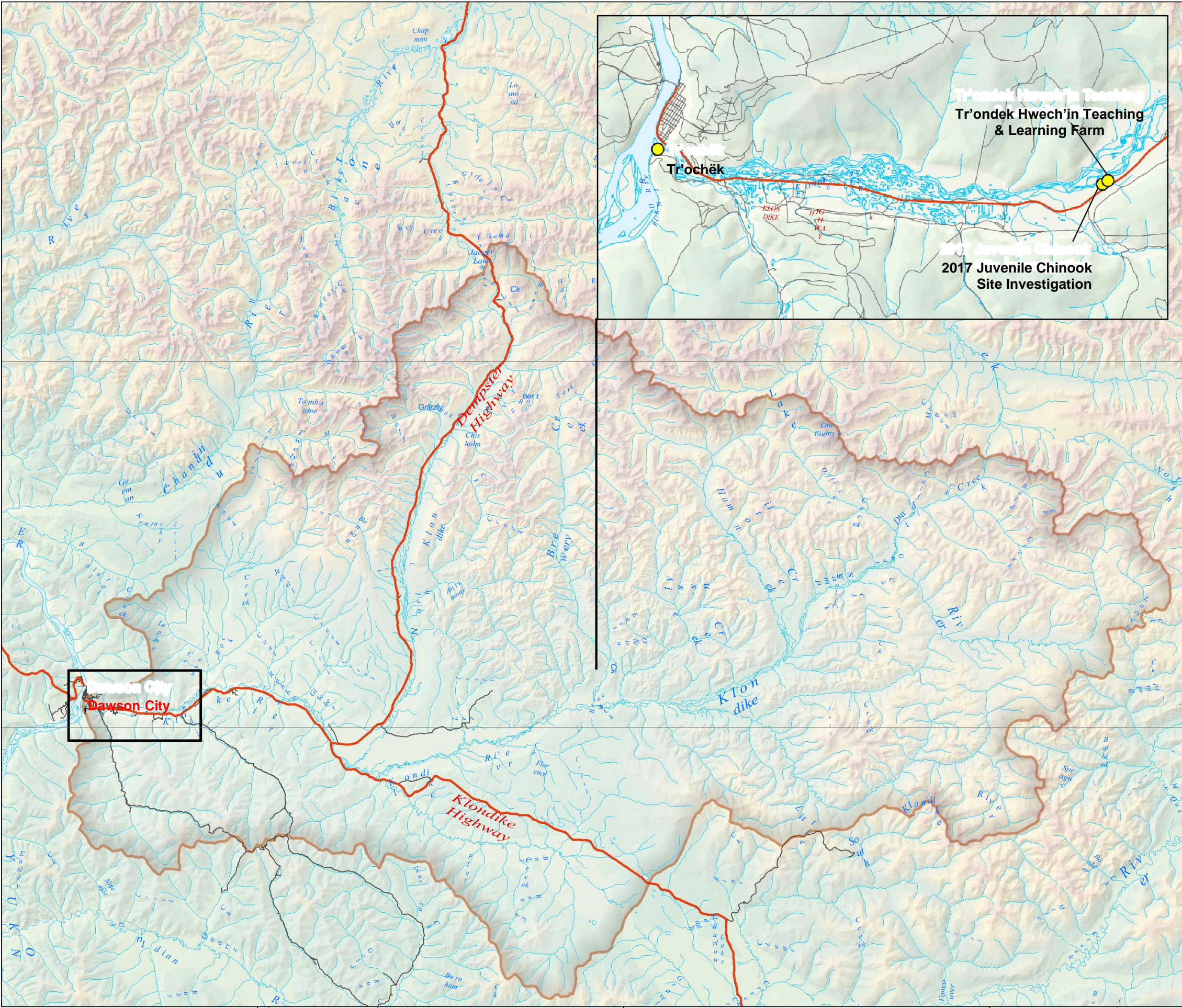
The Klondike River Restoration Plan has been developed to determine and Plan for the optimum approach to stock restoration of the Chinook salmon in the Klondike watershed. It was recognized at the onset of this project that the optimum approach to stock restoration would ultimately be determined by TH citizen input. Guidance and direction was gathered from the TH community through comments and stories collected at public meetings and a survey/ questionnaire that was distributed broadly amongst TH community members. Discussions included deliberations on types of restoration projects that would be considered, the location of a potential and future restoration project, the size and scale of project that would be amenable to citizens, as



well as guidance for acceptable timelines for a restoration project within the THTT. Once clear direction was obtained from citizen input and it was apparent that there is strong citizen support for some forms of salmon restoration on the Klondike River. The next step for development of the Plan included a thorough data and research compilation exercise. This compilation included a review of DFO's hard copy and digital files, Yukon River Panel project reports and other reports which have compiled existing information such as the TH Hatchery Feasibility Study (EDI 2010).

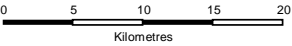
The potential for collaboration between a restoration project and the TH Farm is promising and contributes to TH's greater goals of food security, self-sufficiency and autonomy. During the 2017 and early 2018, a limited site investigation was conducted and we identified potential areas that may be suitable for in-stream egg incubation, further assessment of juvenile rearing habitat and (surface) ground water evaluation for temperature and flow parameters, as well as a site-specific water quality evaluation. This information was collected in channels flowing adjacent to, and downstream of, the TH Teaching and Learning Farm and has provided us with insight into opportunities of potential feasibility for future restoration projects directly adjacent to the TH Farm.

Critical to further development of recommendations stemming from this Plan, is incorporating considerations and insight gained from other on-going restoration research in the Yukon River watershed. We have been in communication with Teslin Tlingit Council (TTC) and have discussed numerous benefits of expanding on the current research for egg planting and in-stream incubation which TTC (through assistance with EDI) has been undertaking in Teslin River watershed over the past two years. TH recognizes that furthering research on this topic provides an opportunity to expand on these studies and to further our knowledge and understanding of the dynamics involved with in-stream egg incubation in systems that have either declining or extirpated stocks.



Overview of Klondike River Watershed

- Legend**
- Points of Interest
 - Secondary Access/Road
 - Highway
 - Watercourses
 - Waterbodies
 - Klondike River Watershed



Map Scale = 1:540,000 (printed on 11 x 17)
Map Projection: NAD 1983 UTM Zone 7N

Data Sources

1:250,000 Topographic Spatial Data (National Topographic Data Base [NTDB]), Department of Natural Resources Canada (NRCan), Earth Sciences Sector, Mapping Services Branch, Centre for Topographic Information, Sherbrooke. Provided by Geomatics Yukon, Corporate Spatial Warehouse, Yukon Government. Accessed in 2012.

Government of Canada. 2014b. National Road Network (Edition 12.0). Department of Natural Resources Canada (NRCan), Earth Sciences Sector. Provided by Geomatics Yukon, Corporate Spatial Warehouse, Yukon Government. Accessed in 2014. www.geomatics.yukon.ca.

Disclaimer

EDI Environmental Dynamics Inc. has made every effort to ensure this map is free of errors. Data has been derived from a variety of digital sources and, as such, EDI does not warrant the accuracy, completeness, or reliability of this map or its data.

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2 PLANNING

The planning component of this restoration Plan summarizes the TH citizen engagement component of the Plan development, current state of Chinook in the Klondike River watershed, provides watershed level objectives for restoration, summarizes existing information and identifies potential restoration projects and how they may be implemented.

2.1 TH CITIZEN ENGAGEMENT AND PROJECT SUPPORT

The Tr'ondëk Hwëch'in people have a strong connection to the land and all that it provides. Some of the strongest associations with healthy and traditional practices (identified by comments and stories brought forward at community meetings and by this survey) are the activities surrounding Chinook salmon harvest. For subsistence purposes, TH citizens rely greatly upon wild foods from the Traditional Territory (TT). The Chinook salmon has traditionally been a main part of the diet because it is an excellent source of vitamins, proteins and fats that provide essential nutrients to the community throughout the long cold winter months. This makes salmon a priority food that helps to maintain a healthy diet.

Comments gathered from the survey acknowledged the important role of Chinook salmon in helping maintain a healthy ecosystem. The dependence that bears, wolves, eagles and other wildlife have on the salmon was recognized through this traditional knowledge gathering exercise. Additionally, some citizens noted that the health of the trees along the river and the soils feeding the plants that grow along the river are also dependent on the salmon.

Many recounted memories of times when Chinook salmon once thrived in size and numbers; the runs were strong and the fish were much larger than what we currently see today. Changes to the run and the decreasing size was recognized by people talking about the effort and time it would take today, if they were fishing, to harvest the same amount for the freezers. Our people once fished Chinook salmon and would preserve the Chinook so they would last over the winter. Families preserved fish by freezing, smoking and canning the fish to make sure that there would be enough of it to last throughout the winter. They would share Chinook with other neighboring FN's, through trade, bartering or selling and fish was a staple at potlaches and celebrations.

The Chinook salmon are a part of TH culture and identity. While this sentence might be reiterated again and again, the importance of this statement should not be over looked. There are many traditional rituals, ceremonies and teaching stories that are practiced before, during and after the salmon run. TH people are excited about the salmon arriving and youth learn about the environmental indicators that the ancestors would look for to tell them the salmon are on their way. They would celebrate the coming of the first salmon by greeting them and letting the first ones pass and Elders talk of a time when these signs were so well known, and upon seeing the signs, people would bustle about and prepare for the coming harvest season; excitement and happiness was in the air. Once the harvesting of Chinook salmon begins, the boat landing in town is busy with people coming and going and boats travel up and down the river. On-the-land camps, such as First Fish Culture Camp, provides a venue where this knowledge and stories can be shared with the youth. The importance of keeping this knowledge alive and the importance of having the youth understand how



connected TH citizens have been to the salmon is a key focus of such camps. The camps also include feasts, dance and song, along with a long list of chores needed to be done to get ready for the coming harvest. A pervasive melancholy can be felt amongst the Elders and past fisherman who come to the camp during low-fish years. TH Elders and fisherman are supportive of holding these teaching camps and understand the many benefits, but discussion about the amount of knowledge you absorb when you participate “hands-on” in a harvest always occurs. It is for this reason, we conclude, that there is such widespread support for involvement with restoration projects. TH citizens want the salmon to come back in numbers that allow harvest and they want to see a time where the community is involved with a harvest that provides enough food to feed their community.

Restoration of the Chinook salmon is widely supported throughout the Tr’ondëk Hwëch’in Traditional Territory. We believe that all watersheds are important to providing support for healthy and sustainable stocks of Chinook salmon upon their return to the Yukon River. As noted in the surveys, important watersheds and tributaries to the Yukon River in the TH TT include the Klondike River, 40 Mile River, Chandindu River and 15 Mile River. Additionally, it is believed that all tributaries flowing into the Yukon River are equally important to help sustain viable Chinook stocks.

TH has worked extremely hard to inform the community on the benefits of the conservation measures that have been put in place for Chinook salmon. Since 2013, TH has requested their citizens to voluntarily withdraw from the harvest of Chinook salmon. This has been a notable sacrifice for TH citizens and everyone looks forward to the day that the harvesting of this iconic fish will be free from worry about long-term sustainability of the run. To honour the conservation efforts made by the Tr’ondëk Hwëch’in over the years TH partnered on the production of a video highlighting First Fish and conservation values that are shared during the camp. Most recently, TH put together a conservation campaign that developed educational banners to assist with sharing the story of the Chinook salmon with TH citizens, Dawson locals and tourists alike.

The conservation efforts that have been committed to over the years demonstrate the dedication that TH has to the Chinook salmon. The information we gathered during this exercise clearly indicate strong support by all to continue work on projects that will restore the salmon population and folks specifically support a restoration project for Chinook salmon on the Klondike River. Other key areas of interest were discussed as well, and while other watersheds were identified as priority, no areas other than the Klondike River could provide easy access close to town and close to the people who could assist with the project. Access to infrastructure that will be necessary to move forward with a restoration project was also uniquely available along the Klondike River. Citizens noted that the size of a restoration project is of concern, and generally people viewed larger projects with having more risk. Large scale hatcheries were commented on and not supported for the TH TT at this time; however, people were supportive of beginning with a small sized project, such as in-stream incubation, while continuing to collect data and information that will support advancing restoration projects in the future. TH citizens expressed interest in working towards developing a small scale incubation facility on the Klondike River to help increase numbers of Chinook salmon stocks in the near future. The size and scale of McIntyre Creek hatchery is used as a successful model that could also work in TH TT. It was also determined that many citizens would like to be involved in restoration project work and are excited to develop and expand this concept. Chinook salmon face many challenges (climate



change, over fishing, water quality) and have been exposed to long-term threats that have impacted their population by drastically reducing their numbers on the spawning grounds. The importance of education and planning for the future will result in a proactive approach to the issue of declining stocks.

2.2 CURRENT STATE OF SALMON IN THE KLONDIKE RIVER WATERSHED

TH has long been in conservation mode with respect to its subsistence harvesting practices of Chinook salmon. In 2013, an official General Assembly (GA) Resolution was passed regarding ‘Chinook Salmon Harvest Management’. GA Resolution #2013-03-02-01 supports the voluntary closure of all Chinook salmon fisheries in TH Traditional Territory for one life cycle of salmon. Subsequent years passed supportive Resolutions by Chief and Council that speak to specific circumstances of that year’s run, however since 2013 TH has requested citizens to voluntarily refrain from harvest. This request has resulted in an extremely limited harvest since the resolution was passed, and if salmon were harvested, the small amount of fish was enjoyed at special feasts or potlaches.

Based upon escapement information collected at the Klondike River Chinook sonar from 2009 to 2011 (Mercer 2010, 2011, 2012), the Klondike River stock accounted for 2.3 to 7.4% of the escapement measured at Eagle, Alaska. The Klondike River stock is included within the North Yukon Tributaries stock aggregate when determining stock percentage estimates upstream of the U.S./Canada border. This analysis is based upon genetic sampling conducted at the Eagle sonar site and from 2008 to 2015, the stock aggregate which includes the Klondike River ranged from 0.7 to 12.7% of the border escapement with an average of 5.7% (JTC 2017).

The Klondike River watershed experienced a notable and rapid disturbance during the Gold Rush from 1896-1899 which attracted over 30,000 people to the region and this disturbance continues to this day. The Gold Rush brought a rapid advancement of infrastructure to the Klondike watershed, primarily in the city of Dawson and the surrounding area (Neufeld 2016). Klondike River Chinook salmon also played a role in the Gold Rush as they helped feed many of the newcomers to the region and it has been noted that the discovery of gold at Bonanza Creek (previously known as Rabbit Creek) was due in part to Skookum Jim and George Carmack being drawn to the area due to a highly productive salmon fishery (Cox et al. 1997). The environmental impacts of mining in the area during that time were vast; although mining stress is substantially less than what it historically was, mining pressure is still evident in portions of the Klondike watershed.

In order to accommodate the rapidly increasing population, roads were established; sawmills were operating and subsequently leading to local deforestation; and dams and water management was developed to help satisfy the energy demands of the community and the associated mining activities (Neufeld 2016). A hydroelectric project was established during 1911 which diverted a considerable portion of the flows in the North Klondike River to a powerhouse on the mainstem Klondike River and was expanded in the following years to also divert a portion of the South Klondike River (Engineers Yukon 2018, Yukon Energy Corporation et al. 2018). The powerhouse which generated electricity using the diverted flow remained operational until 1966 when the last dredge was shut down and although the effect of this diversion of water on Chinook populations



is not well understood, it has been proposed that migratory and resident fish populations may have been severely impacted. Energy Exploration Limited (1982) indicated that as late as 1967, juvenile Chinook were being caught up in the turbines as there was no screening in place to prevent passage into the North Fork ditch and/or the turbines. The North Fork diversion and associated spillway also created a barrier to upstream migration of all fish species and the South Fork diversion ditch eliminated winter flows in a considerable portion of the channel between the South Fork intake and the North Fork confluence. These effects would have likely restricted adult and juvenile Chinook migration within the Klondike River watershed and may have resulted in considerable mortality of juveniles through turbine entrapment and/or desiccation and freezing of Chinook redds due to flow reductions.

Traditional knowledge collected by TH indicates very high population numbers occurred in the Klondike River during the 1980's. Considering information on potential impacts to the population from disturbance occurring up until the late 60's, this observance of a stock rebounding really gives us insight into the potential carrying capacity for the Klondike River.

2.3 WATERSHED LEVEL OBJECTIVES FOR CHINOOK RESTORATION

Watershed level objectives for Chinook salmon in the Klondike River watershed include the following:

1. Maintain cultural connectivity between the Tr'ondëk Hwëch'in in the Klondike River watershed and Chinook salmon by maintaining the health of the ecosystem to ensure adequate habitat is available for future increase in numbers of the stock.
2. Follow objectives established under the TH Final Agreement: Chapter 16 that will preserve and enhance the renewable resources economy through restoration efforts to address harvesting rights guaranteed under Chapter 16.
3. Investigate, trial and carry out projects aimed at the restoration of Chinook salmon stocks in the Klondike River watershed using approaches which are acceptable to Tr'ondëk Hwëch'in citizens.
4. Establish and maintain long term monitoring and assessments for all freshwater life history stages of Chinook salmon and their habitat in the Klondike River watershed including spawner escapement, juvenile habitat utilization, and juvenile out-flow timings and water quality.
5. Build capacity within the Tr'ondëk Hwëch'in community to develop and undertake Chinook salmon monitoring and restoration projects, as per TH FA, s.16.1.1.11, "*to enhance and promote the full participation of Yukon Indian People in renewable resources management*".
6. Collaborate with local, territorial, federal and international stakeholders to develop community driven salmon monitoring and restoration projects.
7. To reach a point of understanding where the carrying capacity of this river is well understood and historic stock numbers could be attained through advancing restoration initiatives.



2.4 EXISTING INFORMATION ON THE KLONDIKE RIVER STOCK

2.4.1 SPAWNER ESCAPEMENT

The most current and relevant information on Chinook spawner escapement comes from 2009 to 2011 when a DIDSON sonar was operated on the Klondike River 3.5 km upstream from the Yukon River. The total passage counts at the sonar ranged from a local of 803 during 2010 to a high of 5,147 during 2009 and 2011 being an intermediate count of 1,181 (Mercer 2010, 2011, 2012). The results of the 2003 and 2004 Yukon River wide Chinook telemetry projects can also be used to obtain a crude estimate of Klondike River escapement. During 2003, 6.8% of the tags passed the U.S./Canada border terminated in the Klondike River (Mercer and Eiler 2004) and 7.8% terminated in the watershed during 2004 (Mercer 2005). When compared to the total escapement upstream of the U.S./Canada border during these years, the estimated Klondike River escapement would have been 5,480 during 2003 and 3,780 during 2004. These are crude estimates based upon a relatively small sample size of radio tags entering the Klondike River however it is notable that these estimates are similar to the 2009 Klondike sonar estimate but considerably more than the 2010 and 2011 Klondike escapements. The Klondike River stock is known to migrate relatively early during the run and it is unclear how fisheries in the lower Yukon River may influence the numbers of Chinook which are destined for the Klondike River. In addition to the sonar and telemetry studies, there have been a number of additional Chinook spawning surveys completed on the Klondike River (DFO 2017). These surveys have enumerated the numbers and distribution of Chinook spawners and/or redds; however, they provide snapshots in time and do not provide an overall escapement count and are therefore not presented here.

The 2003 and 2004 aerial telemetry projects also provide information on the distribution of Chinook spawning within the Klondike River watershed. In both years, the highest proportion of radio tags were relocated upstream of the North Klondike River confluence (Table 1) with few tags located upstream of Brewery Creek. The North Klondike River contained tags during both years although the number was less than the mainstem Klondike River.

Table 1. Number of radio tags relocated in the Klondike River during 2003 and 2004 aerial telemetry projects (adapted from Mercer and Eiler 2004 and Mercer 2005).

Portion of the Klondike River Watershed	Number of Radio Tags Located		
	2003	2004	2003 and 204 Combined
Klondike River mainstem downstream of the North Klondike River confluence	7	2	9
North Klondike River mainstem	1	3	4
Klondike River mainstem upstream of the North Klondike River confluence	11	7	18



2.4.2 JUVENILE HABITAT UTILIZATION

A considerable amount of juvenile Chinook sampling has been completed in the Klondike River watershed for a variety of purposes. Past restoration and enhancement projects (Section 2.4.4) have conducted sampling in the mainstem Klondike River throughout the summer (YRCFA 2002) in an effort to document sizes and weights of naturally produced fry as a template for supplemental fry releases.

Areas with apparent groundwater inputs have been investigated in the Klondike River watershed in an effort to document the importance of these unique habitats for juvenile Chinook overwintering. Targeted sampling for juvenile Chinook has also been conducted throughout the year in two prominent groundwater fed channels (Viceroy and Germaine Creek) which have clearly documented the importance of these habitats for juvenile Chinook rearing and particularly, overwintering (DFO 2017). During March 2017, EDI undertook a fish overwintering assessment on the North Klondike and Klondike rivers on behalf of Oro Enterprises who have been conducting preliminary studies to inform the potential refurbishment and modernization of the North Klondike hydro-electrical project. This project involved sampling for juvenile Chinook in mainstem and groundwater fed side channels of both streams. Sampling in the mainstem North Klondike River captured a single juvenile Chinook and sampling in groundwater fed channels of the North Klondike did not capture any Chinook despite the conditions appearing to be highly suitable for overwintering (EDI 2017). In the Klondike River, no Chinook were captured in mainstem habitats; however, a considerable number were captured in side channels of the river which appeared to be influenced by groundwater inputs (EDI 2017a).

During the 2010 TH Hatchery Feasibility Study, EDI (2010) conducted a preliminary estimate of the carrying capacity of the Klondike River to support Chinook juveniles was determined to be just over 2 million fry. Based upon applicable bio-standards, a spawning escapement of 5,328 to 8,880 Chinook would be required to produce this number of fry (EDI 2010). Available information on modern escapement to the watershed are below these values and provide justification that the Klondike River could benefit from stock restoration and the habitat could support more juveniles than it currently does.

There is also evidence to support the theory that the Klondike River watershed provides rearing habitat for both natal and non-natal juveniles. Genetic sampling of juvenile Chinook captured in the Klondike River during August 2013 indicated that 66% of the 50 samples collected were of Klondike River origin with the remaining 34% comprised of Yukon River mainstem (28%), Mayo River (2%), Teslin River (2%) and Jennings River (2%) stocks (Mackenzie-Grieve 2014). These findings suggest that the Klondike River provides rearing habitat for not only natal stocks, but also from stocks further upstream in the Yukon River watershed.

The area known as the Klondike dredge ponds are a result of past mining disturbance on the Klondike River watershed and have been investigated on a number of occasions to determine their potential value to fish, including juvenile Chinook (EDI 2005, W.R. Ricks Consulting 2008). Improvements to the ponds (including maintaining connectivity to the river) have been proposed in the past as potential fish and fish habitat compensation options in the region (EDI 2005). Collectively, the dredge ponds include dozens of small to medium sized ponds which are of varying distances from the Klondike River. Some are known to contain fish



(including juvenile Chinook); however, the mechanisms of fish entry and exit from the ponds is not well understood but is likely very dynamic in nature. Ponds located nearer to the Klondike River typically have higher numbers of fish present which may indicate that they are transported into the ponds when flows in the river are high.

2.4.3 HABITAT MONITORING

Habitat monitoring information in the Klondike River watershed is mostly limited to water temperature data and flow data which provides value for monitoring potential changes to migration, spawning, rearing and overwintering habitat in the watershed. Continuous water temperature monitoring data is available for the North Klondike River (Viceroy Bridge) from August 5, 2011 to current (von Finster 2016) and also for the mainstem Klondike River from 2005 through 2009 (Leba 2012). In addition to these longer-term data series, there is additional water temperature available for a number of locations on a shorter term which were collected as a component of past Chinook restoration and enhancement projects in the watershed (see Section 2.4.4). There has also been a considerable amount of fish and fish habitat information collected for important groundwater fed habitats in the watershed, particularly the area known as the Viceroy Channel (North Klondike River) and the Germaine Creek channel (Klondike River; DFO 2017).

There are three year-round hydrometric monitoring stations located in the Klondike River watershed and an additional seasonal station (Environment Canada 2018) including:

- Klondike River above Bonanza Creek (09EA003; 1965-current),
- Klondike River at Rock Creek (seasonal; 09EA006; 2014-current),
- Little South Klondike River below Ross Creek (09EA005; 1981-current),
- North Klondike River near the mouth (09EA004; 1974-current).

2.4.4 PAST RESTORATION AND ENHANCEMENT PROJECTS

Beginning in 1989, TH partnered with Fisheries and Oceans Canada (DFO) through the Salmon Enhancement Program (SEP) and the Yukon River Commercial Fishing Association (YRCFA) to initiate a Chinook restoration project in the Klondike River watershed using streamside incubation boxes at a prominent groundwater site on the North Klondike River. The project was relatively small scale; however, it was successful in the consistent production of Chinook fry despite a number of technical challenges (EDI Environmental Dynamics Inc. 2010). The number of fry successfully raised by this project from 1990 to 1994 averaged 27,927 with a maximum of 33,434 during 1990 and a minimum of 17,458 during 1994; however, only a portion of these fish were released into the Klondike River (JTC 2017). Across the five year life span of the project, the majority of the fry produced were from the Tatchun Creek stock and were subsequently released back into Tatchun Creek. In all years combined, 31,664 Klondike River fry were produced and released back into the Klondike (JTC 2017).



The primary technical challenge associated with this project was the need to produce 2 gram juveniles for a May release date. In order to successfully produce Chinook fry, the eggs were first incubated in a moist incubator in Dawson City until near hatching, transported to the North Klondike incubation box for the winter before being live transported to the McIntyre Creek facility in Whitehorse for feeding/rearing and coded wire tagging (half tags) as 1 gram before being transported back to the North Klondike River for release in late June (EDI 2010). The project was discontinued during 1996 due to funding related issues; however, research and monitoring continued for a number of years to identify options for producing fry without the need for transporting fry between facilities. A number of potential options were considered including the use of surface water to increase summer water temperatures or a high-tech water recirculation and bio-filtration system (EDI 2010); however, these options were not pursued for a variety of reasons including potentially high costs, risk of disease transfer and/or the local capacity to operate such a facility.

During 2003, the Germaine Creek side channel on the Klondike River was the site of a bioengineering project aimed at being a fish habitat restoration project while also serving as a demonstration project of bioengineering methods in the Yukon (MMA et al. 2003). The side channel had been partially abandoned and contained exposed gravel bars and streambank clear of vegetation and was determined to be similar to many placer mines in the Klondike region. For this reason, it was determined that the use of the site to demonstration bioengineering methods could be used as remedial methods for placer mines in the future. Three bioengineering methods were used (gravel bar staking, live palisades and brush layers) with monitoring conducted annually until 2006. The results of the monitoring indicated that bioengineering can be used successfully in the Klondike region, with the gravel bar staking appearing to be the most successful of the methods used at the Germaine Creek site (MMA and PES 2007).

During 2006, the DDRRC initiated a stewardship project in the Dawson region which included the employment of a small number of high school students during the summer months to collect information on salmon and their habitat while also maintaining a cultural connection to the salmon (Taylor 2017). This project has served as a continuation of a stewardship program which began during the early 1990s and has paved the way for salmon research and monitoring in the Dawson region. Some of the past fieldwork conducted as a component of the DDRRC's project has helped contribute to Chinook restoration in the Klondike River. Annual fish salvages have been conducted along the Klondike River to move stranded juvenile Chinook from cut off pools and place them back in the river. From 2007 to 2017, a total of 2,983 juvenile Chinook have been salvaged from various locations with an average of 271 salvaged per year (Taylor 2017). The stewardship has also included a Public Involvement Day where the student stewardships inform the public about their field activities and the value of Klondike River salmon.



2.5 POTENTIAL PROJECTS FOR MEETING RESTORATION OBJECTIVES

In order to achieve the watershed level objectives for Chinook stock restoration in the Klondike River watershed, a three-pronged approach of monitoring/assessment, restoration projects and communication is needed. The restoration plan is intended to be an evolving document and therefore this approach will allow for the future refinement of the Plan through communication with TH citizens, monitoring of the Chinook stock and lessons learned from restoration projects not only in the Klondike watershed, but elsewhere in the Yukon River watershed.

2.5.1 MONITORING AND ASSESSMENT

Monitoring of the Klondike River Chinook stock is of utmost importance to restoration in the watershed. Over the long term, monitoring will provide information on the success of restoration projects and over the short and medium terms, will provide information to adapt restoration projects as necessary. Information of Chinook spawning, rearing and habitat exists for the Klondike River watershed; however, in a number of cases, there is a need to formally establish monitoring protocols in the watershed. This will set the stage for future long-term monitoring and provide the best possible information moving forward.

Monitoring the escapement of Chinook to the Klondike River through the use of DIDSON sonar is a priority for TH. The past operation of the Klondike River sonar from 2009 to 2011 clearly documented the suitability of the river for operating a DIDSON sonar and it is TH's goal to re-establish this stock enumeration project by 2020. Monitoring the spawning escapement in the watershed will not only track the overall health of the stock but in the long-term, would provide a means of determining the success of restoration efforts.

The Klondike River watershed provides rearing and overwintering habitat for natal and non-natal juveniles. Existing genetic sampling data indicates that approximately one-third of juvenile Chinook in the Klondike River during the summer months may be of non-natal origin and are from stocks further upstream in the Yukon River watershed. This information indicates that a formalized juvenile Chinook monitoring program in the Klondike River watershed would be beneficial in tracking changes in juvenile abundance over time. Such a monitoring project would require a study design to collect a meaningful data series of juvenile Chinook abundance and could be compared to Klondike River and/or Yukon River (Eagle, Alaska) escapement counts on an annual basis.

The current water temperature monitoring site on the North Klondike River and the four hydrometric monitoring stations in the watershed provide valuable information on water quantity and quality. Such information is important for tracking changes over time (including those resulting from climate change) and their implications for Chinook in the Klondike River watershed. The establishment of additional continuous water temperature monitoring stations on the mainstem Klondike River of use may also be of value to track seasonal water temperatures in locations known to provide important spawning and/or rearing habitat.



252 RESTORATION PROJECTS

There are a wide range of potential restoration projects which may be used to achieve the watershed level objectives of Chinook restoration in the Klondike watershed. Such projects include a wide range of intervention into the currently wild Klondike Chinook stock and the measurable benefit of such projects are equally varied. In broad terms, potential restoration projects can be separated into the following categories as presented and discussed in the following subsections: stewardship, habitat restoration, instream incubation, streamside incubation and conventional hatcheries. As per the recommendations of the Yukon Chinook Strategic Stock Restoration Initiative (SSRI; Connors et al. 2016), the proposed restoration options address three primary objectives including: (1) increase the likelihood of recovery of Yukon Chinook populations, (2) maintain or re-establish cultural connections to salmon, and (3) ensure actions are consistent with community values, involvement and capacity. For these reasons, the information gained from the TH community survey (Section 2.1) was used to provide context for the range of restoration projects which may be considered in the Klondike River watershed in the near future.

TH is currently in the process of securing funding for a small instream incubation trial project on the Klondike River to determine the feasibility of this method in the watershed and to collection life history information (development rates) which may be incorporated into future restoration projects. It is understood that instream incubation alone is unlikely to achieve the watershed level objectives for restoration as voiced by TH community. Based upon community input, it is TH's medium-term goal to have a streamside incubation project in the Klondike watershed, ideally in conjunction with the TH Teaching and Learning Farm.

2.5.2.1 Stewardship Projects

Stewardship projects are aimed at increasing the awareness and appreciation of Chinook salmon to indirectly contribute to the watershed level objectives for restoration. The Tr'ondëk Hwëch'in First Fish Culture Camp (Ayoub 2016) and the DDRRC Yukon River North Mainstem Project (Taylor 2017) are local examples of ongoing stewardship projects in the Dawson region. The First Fish project is aimed at maintaining a cultural connection to Yukon River salmon by teaching youth about a broad range of topics ranging from harvesting and processing salmon to conservation and fish biology. Such projects will continue to be key in achieving the restoration objectives for the Klondike watershed and there will likely be opportunities to combine future stewardship efforts with other restoration projects which may take place in the watershed such as habitat restoration, instream incubation and/or associated monitoring efforts. The DDRRC's stewardship project includes the employment of a small number of high school students during the summer months to collect information on salmon and their habitat while also helping to maintain a cultural connection to the salmon.

2.5.2.2 Habitat Restoration Projects

Habitat restoration projects are aimed at improving fish habitat with the objective of restoring habitats for spawning, rearing or overwintering which may have been adversely affected by past disturbance in the watershed with the goal of indirectly assisting in the restoration of stocks. Such projects may include the



construction of new fish habitat or improvements to existing habitat. Addressing barriers to upstream fish passage may also be considered a form of habitat restoration. The removal or remediation of natural (beaver dams) or anthropogenic (road crossings) have the potential to restore fish access to large portions of habitat in some instances.

Due to the extensive past disturbances in the Klondike River watershed, habitat restoration projects may have particular merit. Overwintering habitat may be a limiting factor for juvenile Chinook in the Klondike River watershed due to the harsh winter climate in the Dawson region and the potentially limited extent of areas strongly influenced by groundwater which provide valuable overwintering habitat. During 2004, the First Nation of Na-Cho Nyak Dun undertook a habitat restoration project on the lower Mayo River where groundwater fed side channels were deepened and enhanced for fish (Tobler and Schonewille 2005). Five years of biological and physical monitoring of this project indicated that the habitat restoration considerably increased the utilization by juvenile Chinook, particularly during the fall and winter when water temperatures were warmer than areas not influenced by groundwater (Tobler and Snow 2011). The lessons learned from this project and other habitat restoration projects could be used to identify potential habitat restoration projects in the Klondike River watershed. Preliminary field investigations in a groundwater fed side channel of the Klondike River near the TH Teaching and Learning Farm suggest that this site may be suitable for such a project (EDI 2018a); however, additional field investigations are likely required to better understand this area including the current extent of habitat utilization by juvenile Chinook. There are likely additional opportunities in the Klondike River watershed to develop small groundwater fed channels (Connors et al. 2016) and additional discussions with local biologists and TH members may aid in the identification of such candidate sites.

Beaver dams have the potential to limit access to both rearing and spawning habitats for Chinook. In some portions of the Yukon River watershed, beaver dams have the potential to limit access to spawning grounds; however, this does not appear a concern in the Klondike watershed where all known spawning locations are in large channels where beavers are unable to be constructed. Breaching of beaver dams is therefore another option of habitat restoration which can allow for increased juvenile Chinook habitat utilization and ultimately has the potential to allow for increased fry survival. This is particularly relevant in locations where beaver dams block access to important habitats, such as those used for overwintering. Breaching of dams can allow for juvenile to access the previously inaccessible habitats; however, some form of continued monitoring and management is often required. In order to limit the beavers from rebuilding the dams, they typically need to be killed and the site monitored for colonization by new individuals. This work requires a permit under the Yukon Wildlife Act and the permitting process has been efficient in the past (Connors et al. 2016). Beaver dam removal is a relatively low cost habitat restoration alternative which can be done largely with locally available capacity in the TH community. The success of the dam breaching can be straightforward by sampling with minnow traps upstream and downstream of the dams before and after breaching. It is important to emphasize that in the event the dam breaching is conducted, follow up site monitoring is required.

Quantifying the effectiveness of habitat restoration projects can be challenging but would provide a method to assist in the achievement of the watershed level objectives for stock restoration. For example, the numbers of juvenile Chinook using a rearing channel can be quantified; however, it may be difficult to make a direct



linkage to how this increased habitat utilization may result in more returning spawners. Habitat restoration projects which require in-stream excavation (groundwater channels) will have regulatory requirements and needs to be taken into consideration when planning such projects.

2.5.2.3 Instream Incubation Projects

Instream incubation projects are intended to provide a means of increasing fry production through intervention in the very early part of the Chinook life cycle. Whereas streamside incubation and hatcheries would intervene in the life cycle from egg fertilization to the fry stage, instream incubation would intervene at the egg fertilization stage only. This method is intended to capitalize on a higher egg fertilization rate compared to natural conditions but then allows the eggs and alevin to develop under natural conditions thus allowing the natural processes of development and natural selection to occur. This minimal amount of intervention in the life cycle may provide an appropriate level of risk which is minimal to wild stocks and therefore may be more preferred than more intrusive methods compared to conventional hatcheries. It may also be possible to integrate moist air incubation with an instream incubation project to increase egg survival and simplify some of the brood stock logistics. Such an approach would involve the development of fertilized eggs in the moist air incubator to the eyed-egg stage at which time they would be planted into the river.

The concept of instream egg incubation involves the collection of brood stock, followed by an onsite egg take/fertilization and subsequent planting into artificial redds construction of in place stream substrate. The eggs may be deployed into the artificial redds using a variety of commercially available incubation media such as Jordan-Scotty incubators or Whitlock-Vibert boxes. Eggs may also be directly planted into the artificial redds to mimic natural spawning or into custom made incubation trays to monitor development rates and survival through to emergence as fry. The overarching goal of instream incubation in the Klondike River watershed would be to increase egg to fry survival and ultimately process more fry than would be produced naturally. This is accomplished primarily by achieving a fertilization rate which is considerably higher than occurs naturally. In theory, this allows for a higher egg hatching rate which could translate into a higher number of fry produced (dependent upon habitat conditions). It is however problematic that estimates of egg to the emergent fry stage are not available for the Yukon River watershed (Bradford et al. 2009). Information from other watersheds is also limited, although information from other large rivers suggests a range of 30 to 40% emergence (Unwin 1986, Bennett et al. 2003, McMichael et al. 2005). Preliminary information from Teslin Tlingit Council's (TTC) Deadman Creek instream incubation project has documented emergence rates over 90% in the Morley River using a closed cell incubator containing natural substrate (EDI 2018b). These findings suggest that instream egg incubation can increase emergence rates considerably over natural conditions; however, further testing of the monitoring methods is required and would need to be tested on the Klondike River.

The Teslin Tlingit Council (TTC) began using instream incubation during 2016 to restore an extirpated Chinook spawning population into Deadman Creek. The project has also used instream incubation in a larger stream (Morley River) where natural Chinook spawning currently occurs to serve as a control for the ongoing work in Deadman Creek. A variety of open and closed incubation media have been used in this project to



date which provide estimates of egg survival to the hatching and emergence stages. This project has indicated that the method of instream incubation can be used in the Yukon River watershed to achieve very high egg hatching success and survival to the fry stage (over 90%) in locations where incubation conditions are suitable (EDI 2017b, 2018b).

There are a few drawbacks of using instream incubation as a restoration method, some of which can be at least in part be mitigated. Determining success to egg hatching stage is proven (as per the TTC project); however, providing a precise estimate of the number of fry produced can be challenging. Some new methods involving a close cell incubation tray currently being tested by the TTC project in the Morley River appear to be very positive in providing an indication of survival to emergence (EDI 2018b) and such methods could also be employed on the Klondike River. Instream incubation is often viewed as being suitable for small scale projects only (Connors et al. 2016); however, the lessons learned from the TTC project indicate that instream incubation may be possible on a larger scale provided that some of the methods of monitoring success continue to be developed and refined. Due to the handling and potential transport of eggs and milt, instream incubations projects require an Introduction, Transport and Transplant (ITT) permit from Fisheries and Oceans which also triggers a YESAB review. This process can take a number of months to complete and needs to be considered when planning such projects.

2.5.2.4 Conventional Hatcheries

Among the potential options for Chinook restoration, hatcheries are the most involved option and along with streamside incubation projects, involve the greatest amount of intervention in the Chinook life cycle. Hatcheries in general require a large capital investment, require a considerable amount of expertise to operate, and may pose considerable ecological risks to wild stocks. The TH Hatchery Feasibility Study conducted by EDI (2010) provided an estimate of \$1.3 million to construct a hatchery in the Rock Creek area with a conventional flow through design. Such a hatchery would provide year-round employment for 2-3 individuals and along ongoing regular costs, would require an annual operations budget of approximately \$300,000.

Hatcheries in general pose a risk to wild stocks due to genetic factors whereby the fitness of natural spawning and rearing can be rapidly and substantially reduced (Reisenbichler and Rubin 1999). These effects can occur because the overarching goal of a hatchery is to protect the eggs, alevin and fry at all live stages in an effort to maximize survival. This allows for very high survival rates compared to natural conditions; however, it also allows for a large number of eggs to survive which would have died in the wild due to natural factors. A very challenging component of operating a hatchery in the Yukon also involves the need to match the size of the supplemented fry to natural fry at the time of release. A critical uncertainty associated with hatcheries in the Yukon River watershed is determining the most appropriate rearing and release strategy (Connors et al. 2016) which may alter the size of returning adults and may change people's perspectives of the 'quality' of the returning adults.

The primary benefit of a hatchery over the other restoration options outlined here is that it allows for a known number of fry to be produced. Based upon these considerations, the use of conventional hatcheries should be viewed very carefully if under consideration for the Klondike River watershed. Should a hatchery be considered in the watershed, there are a number of strategies which may be used to reduce the adverse effects



to wild stocks, examples of such options outlined by Nickelson (2003) in a different watershed may include: avoiding large fry releases in areas with high numbers of natural fry, decreasing the number of fry released, or employing a strategy with smaller release groups spread temporally. The TH Hatchery Feasibility Study (EDI 2010) provides more detailed operation on how a hatchery could operate in the Dawson region including permitting requirements.

2.5.2.5 Streamside Incubation Projects

Streamside incubation projects are simply a small-scale application of hatchery technology without the large capital investment of a conventional hatchery. The past restoration project undertaken on the Klondike River is an example of a streamside incubation project, as is the McIntyre Creek facility in Whitehorse. These projects are typically much smaller than a conventional hatchery but operate on the same theory to maximize survival from the egg to fry life stages of the life cycle. Similar to conventional hatcheries, a considerable amount of expertise is required to manage and operate such a facility and this incurs a considerable amount of cost. The operation of a streamside incubation project in the Klondike River watershed would be a year-round commitment due to the timing of Chinook spawning in the watershed and the estimated release date of juveniles during the following summer.

The risks to the genetics of wild stocks and intraspecific competition may be similar between streamside incubation and conventional hatcheries (see Section 2.5.2.4). Some of the potential issues with size at release may be possible to mitigate with streamside incubation in part by allowing for the use of surface and groundwater sources at different times of year to match natural conditions.

The implementation of a streamside incubation project in the Klondike River watershed would be required to utilize a prominent groundwater source to ensure adequate water temperatures over the duration of the winter. Two such water sources are known to exist (Rock Creek channel and the former intake site on the North Klondike) and other sites may also be present. For example, the groundwater fed side channel adjacent to the TH Teaching and Learning Farm may be suitable and could provide a unique opportunity to establish a streamside incubation project in combination with the farm. Similar to a conventional hatchery, plans to develop a streamside incubation project in the Klondike River watershed should progress very carefully in order to assess and mitigate risks to the wild stocks currently found in the watershed.

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Communication with the local community is very important in order to achieve the watershed level objectives for Chinook restoration in the Klondike watershed. Increasing the awareness of Klondike River Chinook and the ongoing restoration activities is an integral part of this Plan. It is envisioned that a variety of methods may be used to communicate about Klondike Chinook restoration including annual open house events or articles in local print and electronic media. These methods will not only allow for the public to receive information but also for TH to receive feedback from community members. This feedback will be used to help identify



new potential restoration initiatives or to modify ongoing projects to more adequately address the watershed level objectives in the future.

2.6 PLAN FOR THE IMPLEMENTATION OF RESTORATION PROJECTS

The implementation of restoration projects will first begin with the identification of the project by local citizens and/or fisheries managers. The objectives of the project will be determined along with applicable performance measures to assess the success of the project in the future. Information will be collected to inform the potential project and may include a combination of field collected data, local/traditional knowledge and/or information available from published literature. Any new restoration projects will also be discussed with the TH community and any feedback incorporated into the project whenever possible.

2.7 RESTORATION PROJECT EVALUATION AND FEEDBACK

This restoration plan is intended to be adaptive as new information will be used to refine the Plan in the future. Many of the restoration approaches which may be used in the watershed are new, innovative approaches which require testing and monitoring to determine their effectiveness. As this information becomes available, this information will be incorporated with feedback from community members to revise the Plan accordingly. This may include new potential projects for achieving the watershed level objectives or modifications to ongoing projects.



3 PROJECT DEVELOPMENT – INSTREAM INCUBATION

The project development component of this restoration plan is intended to be completed for each restoration project under consideration to address the watershed level objectives for Chinook restoration in the Klondike River watershed. Given that this is the first version of the Plan, the project development component is limited to a pilot project involving the use of instream incubation for Chinook on the mainstem Klondike River and/or North Klondike River. TH is currently in process of securing funding for this pilot project through the Yukon River Panel's Restoration and Enhancement (R&E) Fund.

3.1 PROJECT NEED

The need for this project arises due to the desire to trial a project using instream incubation of Chinook to achieve the watershed level objectives of this Plan. The use of instream incubation to aid in Chinook stock restoration is a relatively new and innovative approach in the Yukon River watershed. This approach is desirable for a number of reasons including the small-scale approach, limited capital investment and the consideration that the methods do not require a year-round commitment. Instream incubation also poses a considerably lower amount of risk to wild stocks given that the level of intervention in the salmon life cycle is very limited and the developing eggs/alevin are subjected to natural conditions throughout their development.

The concept for the project is derived from Teslin Tlingit Council's (TTC) successful use of instream incubation of Chinook salmon on the Morley River and Deadman Creek in the Teslin River watershed. The results of the Morley River component of the TTC project are most relevant to the Klondike River due to more similarities between spawning and incubation habitats as opposed to Deadman Creek which is a much smaller stream. In the Morley River, TTC has documented that instream can increase egg to fry survival considerably over natural conditions and new, innovative methods are being developed to more accurately track the survival of the instream incubation work which may allow the scale of the project to be increased in the future (EDI Environmental Dynamics Inc. 2017b, 2018b).

In addition to increasing egg to fry survival, instream incubation has the potential to provide detailed information on timing of development in the Klondike River which may also be useful in the development of other restoration projects in the watershed (streamside incubation). Much of the existing information on the timing of egg and alevin development is based upon literature developed in a hatchery setting and recent data from TTC's project has indicated that development rates differ under natural conditions. This type of information is an indirect benefit of an instream incubation project and could help to conserve and restore Chinook stocks not only in the Klondike watershed, but elsewhere in the Yukon River watershed.



3.2 PROJECT OBJECTIVE

The current instream incubation project is intended to be a small-scale pilot project to determine the feasibility of its use the Klondike watershed. This is an important consideration for the following objectives which would be refined in the future if the trial is successful and the scope of the project modified. The specific objectives of the Klondike River instream incubation trial project are as follows:

- Conduct an aerial spawner/redd survey on the Klondike River to enumerate spawning activity and identify aggregations of spawners for brood stock collection.
- Determine the feasibility of collecting sufficient brood stock the Klondike watershed to deploy up to 15,000 fertilized Chinook eggs at up to 5 artificial redd sites on the Klondike River and/or North Klondike River using a combination of open and closed egg incubation media. Methods used to be similar to the TTC project (EDI 2017b, 2018b) and adapted to conditions on the Klondike River. Through discussion with DFO, there is potential for planting a small number of eggs in the groundwater fed side channel adjacent to the TH Farm to assess incubation conditions in this area.
- Conduct monitoring on a small number (3 or less) of natural redds to trial methods of obtaining an estimate of natural egg survival. This would be done when the eggs at eyed to allow for them to be 're-planted' into the substrate following enumeration.
- Conduct follow-up monitoring at the artificial redd sites during the following fall and winter to determine egg survival, hatching success and potentially emergence rate. Incidental information to be collected on development rates and habitat parameters (substrate, velocity, water temperatures).
- Integrate to trial project with local stewardship projects in the Dawson region including TH's First Fish Project and the DDRRC's Yukon River North Mainstem Stewardship project.
- Involve members of the TH Lands and Resources department in a hands on Chinook restoration project in the Klondike River watershed to provide training and capacity building through working alongside experienced fisheries biologists.
- Compile the results of the project into a technical report, discuss the results with the TH community and development a plan to continue the project in the event that the trial is successful.

In addition to these specific objectives, TH is also considering a number of ancillary component to this project including: establishing a juvenile Chinook monitoring program in the Klondike River watershed, re-establishing the Klondike River Chinook sonar, and conducted a desktop investigation into the future incorporation of a moist air incubation system to be used in combination with the instream incubation project.



3.3 PROJECT PERFORMANCE MEASURES

The performance measures outlined below are for the trial component of the instream incubation project only. It is envisioned that in the event that the trial is successful, the relevant performance measures would be adjusted accordingly. For example, the trial project is intended to test the feasibility of the proposed methods in the Klondike watershed only and it is not expected that a project of this scale would considerably increase the number of spawners returning to the Klondike River watershed. The performance measures for the instream incubation trial project include:

- The number eggs successfully collected from brood stock and fertilization onsite with an initial target of 15,000 eggs from up to 4 females and 8 males.
- The number of artificial redd sites established on the mainstem Klondike River and/or North Klondike River with a goal of 3 to 5 sites.
- The hatching success of eggs planted into the artificial redd sites through the use of open egg incubation media including (but possibly not limited to) Jordan-Scotty incubators and Whitlock-Vibert boxes.
- The emergence rate of Chinook fry as determined through the use of closed mesh bag incubators filled with natural or artificial substrate.
- The collection of Chinook spawning and incubation habitat information including: water temperature, substrate and velocity.

It is important to note that the ability to determine emergence rates may be dependent on the seasonal timing of this development. It is not well understood at what time of year this may occur and safety concerns associated with ice on the Klondike River may prohibit this component of the data collection.

3.4 CONNECTION TO THE BROADER RESTORATION PLAN

The instream incubation trial project will directly address a number of the watershed level objectives for Chinook restoration as laid out in this Plan. The project will trial a method of stock restoration which may provide a means of aiding in Chinook stock restoration with a level of risk which is less than some of the other available options and is appropriate given the views of TH citizens and perhaps more importantly, will provide relevant information which may be incorporated into other future restoration projects. There are some uncertainties associated with the project; however, it is envisioned that these may be able to be overcome during the trial project and that refinements to the project performance measures will be possible in the future once this new information is available.

The incorporation of the TH Lands and Resources staff into the field components of the project will provide training and capacity building opportunities to help set the stage for future Chinook restoration projects in the watershed. The project will also begin to collect monitoring information on Chinook spawning habitat



and some of the ancillary project components may also begin to coordinate monitoring of spawner escapement and/or juvenile abundance in the watershed.



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Klondike River Chinook Salmon Restoration Project: Field Report



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March 2018



Down to Earth Biology

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EXECUTIVE SUMMARY

The Tr'ondëk Hwëch'in (TH) have long been regarded as river people, relying on salmon as a primary source of protein and as a cultural cornerstone. In response to declines in returns of Chinook salmon, TH are beginning to focus their attention on Chinook restoration within their Traditional Territory. A Chinook stock restoration plan is currently under development for the Klondike River watershed and the current project was intended to collect information to inform potential restoration projects.

The specific objective of this project was to assess two groundwater fed side channels for their fish habitat potential and their suitability for future restoration projects. The sites investigated included a side channel adjacent to the TH Teaching and Learning Farm (the Farm Channel) and a side channel near Rock Creek (the Rock Creek channel). Each side channel was investigated on foot with fish habitat conditions recorded, in-situ water quality data collected and fish sampling conducted. Water quality sample for laboratory analysis were also collected from three sites in the Farm Channel and two temperature loggers were deployed in the Farm Channel to collect hourly water temperature data. The primary field investigation was conducted from July 27 to 29 with additional single day site visits conducted during September, February and March.

Stream investigations suggested that groundwater discharge was feeding both side channels as indicated by lower water temperatures compared to areas fed by the mainstem Klondike River. Fish captures in the Farm Channel were relatively low with 4 slimy sculpin and two burbot captured in 18 overnight minnow trap sets. Thirty-four juvenile Chinook, 1 burbot and 3 slimy sculpin were captured in 4 overnight trap sets in a nearby side channel of the Klondike River which flowed into the lower portion of the Farm Channel. An isolated pond connected to the lower portion of the Farm Channel also contained fish with 7 juvenile Chinook, 7 burbot and a single round whitefish captured in 3 overnight trap sets. At the time of the sampling, this pond appeared to be isolated from the Farm Channel due to beaver activity. In the Rock Creek channel, a beaver dam was ponding a considerable amount of water which appears to have changed the habitat conditions in the channel in which the substrate is dominated by fine materials. Minnow traps were set above and below the beaver dam with only the traps downstream of the dam capturing any fish (6 juvenile Chinook in 3 overnight trap sets).

The water quality in the Farm Channel appears to be conducive to use by fish, particularly during the winter months when water temperatures were near 1 °C and a considerable volume of groundwater flow was observed. This finding suggests that this channel likely provides overwintering habitat for juvenile Chinook and this location may be suitable for the development of Chinook restoration projects in the future. Continued monitoring of the habitat conditions and seasonal fish usage is recommended for the Farm Channel in future years to better understand the potential for Chinook habitat and/or stock restoration projects. The proximity to the TH Teaching and Learning Farm provides a unique opportunity for the development of such projects which can make use of existing access and infrastructure.



ACKNOWLEDGEMENTS

Funding for this project was provided by the Yukon River Panel's Restoration and Enhancement (R&E) Fund. Natasha Ayoub managed the project on behalf of the Tr'ondëk Hwëch'in and Jake Duncan of Dawson City provided local knowledge of Chinook salmon and in-kind project support.

AUTHORSHIP

This report was prepared by EDI Environmental Dynamics Inc. Staff who contributed to this project include:

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Hannah Gray B.Sc.GIS

The summer field assessments and juvenile fish sampling component of the fieldwork was completed by Petra Szekeres (EDI) and Natasha Ayoub (TH). Jake Duncan (EDI) completed the water sampling component of the fieldwork. Joel MacFabe (EDI) and Annina Altherr (EDI) completed the winter assessments and in-situ water quality measurements.



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1 INTRODUCTION

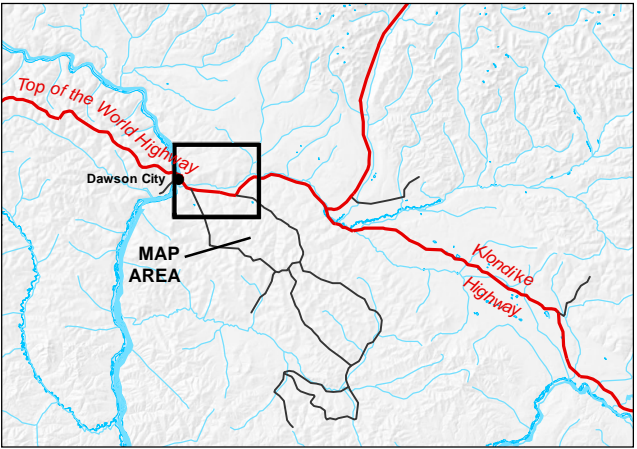
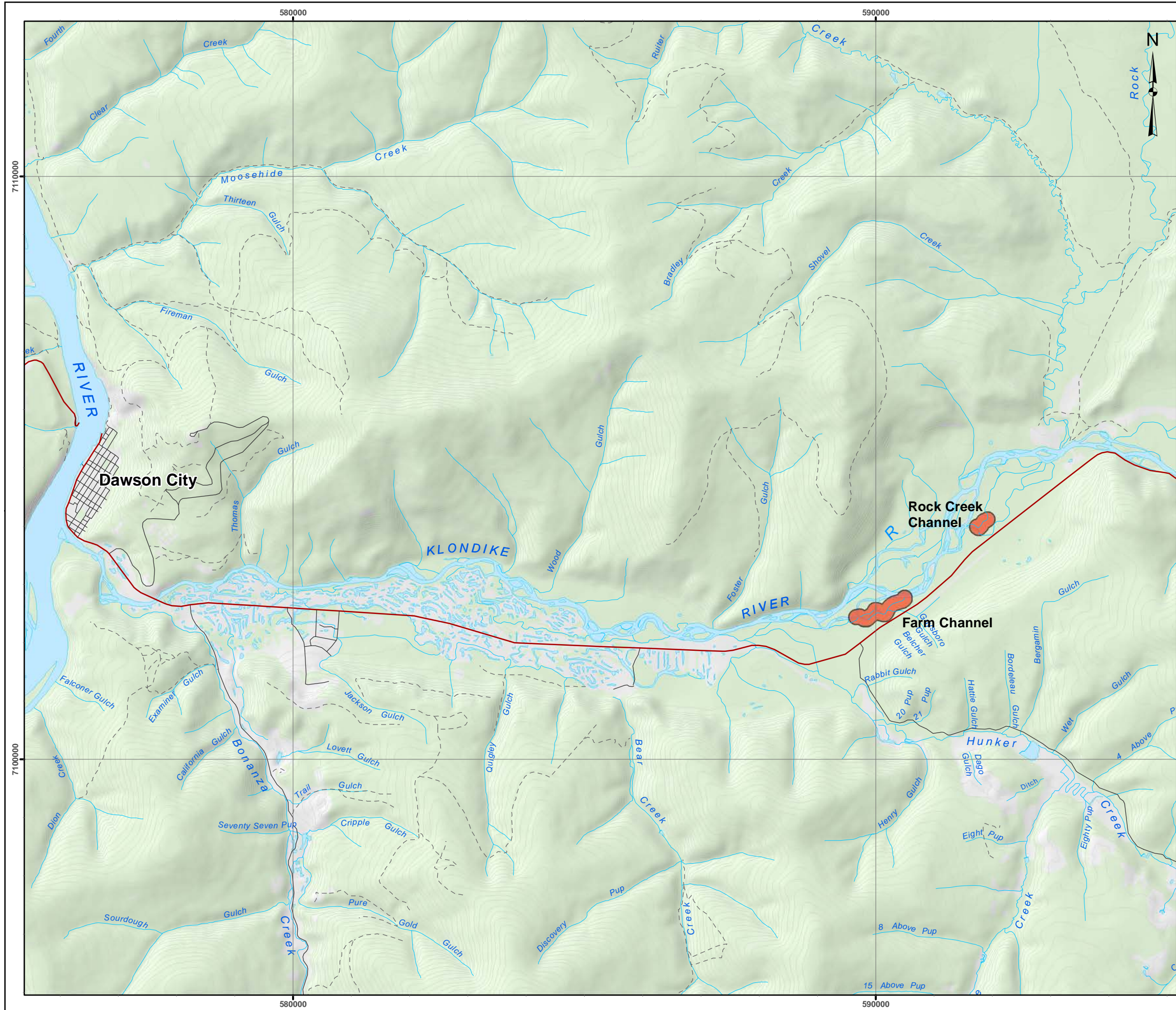
The Tr'ondëk Hwëch'in (TH) have long been regarded as river people, relying on salmon as a primary source of protein and as a cultural cornerstone. This was integral to their lifestyle for thousands of years, until the beginning of the Gold Rush which significantly altered the landscape and fish habitat, and increased fishing pressure on Chinook salmon beyond the subsistence fishing of the TH (Neufeld 2016). In recent years, the Chinook salmon return has been a cause for concern, with substantially fewer fish making the escapement from the Alaska side of the Yukon River. This has prompted the TH to prioritize the restoration of Chinook stocks in the TH Traditional Territory. The Klondike River was chosen as a priority for restoration due to a number of factors, including proximity to Dawson City, the cultural connection to the river, and past disturbances to the watershed.

A stock restoration plan for the Klondike River Chinook stock is currently under development and the current project was intended to support this plan through the collection and updating of fish and fish habitat information at two locations on the Klondike River (Figure 1). The primary site of interest was a groundwater fed tributary adjacent to the TH Teaching and Learning Farm (hereafter referred to as the 'Farm Channel'; Figure 1); this site is of particular interest to TH citizens as it is on TH Settlement Land and has existing access. A secondary site of interest is the 'Rock Creek groundwater fed channel' near the Klondike River campground. This site was previously identified as a site of interest with respect to potential Chinook restoration projects, due primarily to significant groundwater inputs (EDI 2010).

The goal of the current study was to investigate both the Farm Channel and the Rock Creek channel to determine the suitability of these locations for Chinook stock and/or habitat restoration projects. The specific objectives were:

- i) Identify potential sites for stock and/or habitat restoration projects.
- ii) Assessment of juvenile Chinook rearing habitat on both the Farm and Rock Creek channels.
- iii) Evaluation of water parameters (temperature, DO, pH, etc.) in the Farm Channel during summer and winter months, and in the Rock Creek channel during the summer.

The overarching rationale for pursuing a restoration strategy in the Klondike River is to re-establish a healthy Chinook salmon population, and aid in restoring the Chinook salmon stock in the system.



Legend

- Highway
- Secondary Road
- Trail

Study Extents

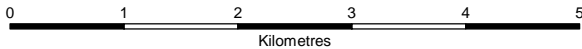
Overview of the Farm Channel and Rock Creek Channel field survey extent

Data Sources
1:50,000 and 1:1,000,000 Topographic Spatial Data courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Digital Elevation Model and 1:50,000 and 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. Data collected by EDI Environmental Dynamics Inc. (2017) was obtained using Garmin GPS technology.

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Map Projection: NAD 1983 UTM Zone 7N

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2 FARM CHANNEL INVESTIGATIONS

The unnamed side channel of the Klondike River near the TH Teaching and Learning Farm (‘the Farm Channel’) was assessed in July 2017 for fish presence and habitat conditions, as well as in-situ water quality parameters (YSI Pro Plus; temperature, pH, dissolved oxygen, and specific conductivity; Oakton T100 for measuring turbidity). Water quality was sampled and analyzed in September 2017, and an assessment of winter ice conditions and in-situ water quality was conducted in February and March 2018.

2.1 METHODS

2.1.1 STREAM INVESTIGATION

The length of the Farm Channel was investigated on foot between July 27 to July 29, 2017. The investigation included a small segment of the Klondike River upstream from the Farm Channel which was not connected to the Klondike River the during summer assessments. The entirety of the Farm Channel was investigated, as well as the side channel downstream of the TH Farm which connects the Farm Channel to the Klondike River (Figure 2). A man-made rectangular pond downstream of the side channel was also evaluated. Lastly, a dry side channel near the Farm Channel and Klondike River was also investigated. Any features of interest (e.g., algae accumulations) or evidence of past conditions (e.g., flooding) was recorded and had photo documented. In-situ water quality parameters were frequently measured at areas of interest. Three temperature loggers (HOBO Tidbit V2) were deployed in the vicinity of the confluence where the side channel flowed into the Farm Channel (Table 1).

Table 1. Temperature logger deployment stations, July 2017.

Location	Site Name	UTM Co-ordinates (Zone 7)	
		Easting	Northing
In the Farm Channel, 15 m upstream of the confluence	FC20	589995	7102551
In the side channel, 65 m upstream of the confluence	FC17	589986	7102627
In the Farm Channel, 25 m downstream of the confluence	FC22	589975	7102535

2.1.2 FISH SAMPLING

Fish sampling was conducted on the Farm Channel, the side channel, and the rectangular pond from July 27-28, 2017. Habitat suitability for juvenile Chinook was visually assessed, and gee-style minnow traps were set at various locations throughout the area. A total of 19 sites were sampled, and the number of traps per site varied from one to three (Table 2; Figure 2). The minnow trapping technique adhered to the Yukon River Panel protocol, whereby Yukon River salmon roe (chum, *Oncorhynchus keta*) was partitioned into a perforated thin plastic bag and attached inside the minnow trap to allow for the release of olfactory cues to attract nearby juvenile fish. Ideal minnow trap placement was specific to areas that appeared to be likely juvenile Chinook



salmon habitat, with adequate cover (e.g., wood debris) and slow flowing water. Each site was assigned a unique identifier, a GPS coordinate, and numerous photos were taken of each site (e.g., Photo 1; APPENDIX A). During deployment of minnow traps, in-situ water quality parameters were measured, and physical characteristics of the area recorded. Fish capture data was converted to a measure of catch per unit effort (number per 24 hours) to allow for comparisons between sites.

Table 2. Summary of fish sampling stations in the Farm Channel study area, July 2017.

Location	Site Name	UTM Co-ordinates (Zone 7)	
		Easting	Northing
Farm Channel	FC3	590431	7102711
	FC4	590409	7102706
	FC6	590377	7102697
	FC7	590343	7102688
	FC8	590314	7102674
	FC9	590278	7102665
	FC10	590230	7102627
	FC11	590210	7102600
	FC13	590162	7102489
	FC14	590097	7102497
	FC23	589935	7124810
	FC26	589767	7102408
	FC31	589705	7102451
Side channel	FC16	589985	7102560
	FC17	589986	7102627
	FC18	590066	7102712
	FC19	590093	7102736
Rectangle Pond	FC25	589855	7102385
Klondike River backwater	FC32	589661	7102427



Photo 1. Minnow trap set up on Farm Channel, July 2017.

2.1.3 WATER QUALITY

There were four water samples taken from Farm Channel in September 2017, at FC9, FC13, FC16, and FC23 (Table 3; Figure 2). In-situ water quality measurements were taken at all sites of interest,

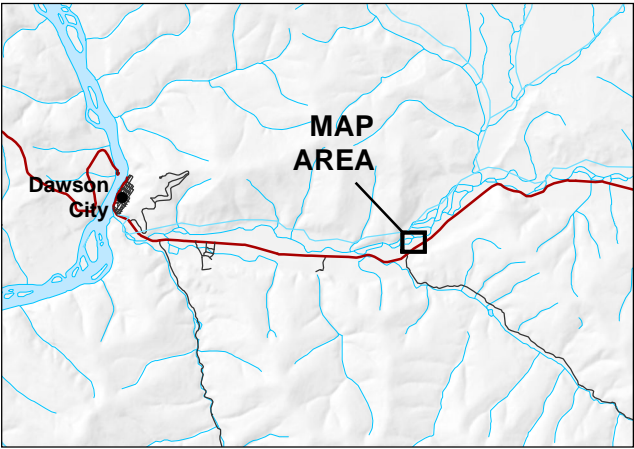
2.1.4 WINTER ASSESSMENT

A winter assessment was completed on the upstream portion of the Farm Channel on February 12 and 13, and March 13, 2018. Ice conditions and water flow was observed and recorded. The February in-situ water quality measurements were taken approximately at FC2, FC12, FC20, FC16, and FC22; the March winter assessment measured FC2, FC9, and FC12, where ice conditions allowed (Table 3). In the event of ice cover, the closest downstream open lead was used for the collection of water quality parameters. Aerial observations were also recorded during both winter assessments.



Table 3. Summary water quality stations in the Farm Channel study area September 2017, February 2018 and March 2018.

Site Name	Months Visited			UTM Co-ordinates (Zone 7)	
	September 2017	February 2018	March 2018	Easting	Northing
FC2		✓	✓	590454	7102726
FC9	✓		✓	590278	7102665
FC12		✓	✓	590198	7102567
FC13	✓			590162	7102489
FC16	✓	✓		589985	7102560
FC20		✓		589995	7102551
FC23	✓	✓		589935	7124810



- Legend**
- Fish Sampling Site
 - Site of Interest
 - Fish Sampling and Site of Interest
 - Highway
 - Secondary Road
 - Trail

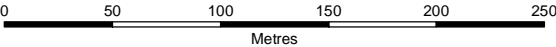
Fish sampling sites and sites of interest on the Farm Channel

Data Sources
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Digital Elevation Model and 1:50,000 and 1:1,000,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

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Map Scale = 1:3,500 (printed on 11 x 17)
Map Projection: NAD 1983 UTM Zone 7N

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Yukon government, 2018



2.2 RESULTS AND DISCUSSION

2.2.1 STREAM INVESTIGATION

The Farm Channel appeared to be primarily groundwater fed, originating from a groundwater seepage upstream of the TH Farm at Site FC2 (Figure 2; APPENDIX A Photo A-1). Along the Klondike River, there was evidence of flooding upstream from the Farm Channel (APPENDIX A Photo A-2 **Error! Reference source not found.**). From the Klondike River, deeper into the forest towards the groundwater seepage of Farm Channel, there was evidence of large logs being deposited, potentially from an ice jam on the Klondike River during a previous flood (APPENDIX A Photo A-3). These previous conditions suggest that the Farm Channel may be flooded and supplemented by the Klondike River at different times, likely a result of high flows on the Klondike River during spring breakup. Other evidence of flooding occurred further downstream on the Farm Channel, where there was evidence of undercut banks (APPENDIX A Photo A-4) two ‘blown-out’ beaver dams that went across the channel (e.g., APPENDIX A Photo A-5). Previous years’ satellite imagery on Google Earth Pro confirmed this observation, also confirming past beaver activity elsewhere in the channel. Beaver activity will need to be a consideration for planning potential restoration options for the Farm Channel, as beavers are known to alter Chinook salmon spawning and juvenile rearing habitat (Malison et al. 2016). Slightly downstream of this area, the water velocity appeared to slow, and a significant amount of algae was growing on the substrate (APPENDIX A Photo A-6). Eventually, there was a small channel which fed into the Farm Channel from the Klondike River (Photo 2; APPENDIX A Photo A-7). Leading up to this channel, the water temperature was an average of 7.0 °C (APPENDIX B), indicating that the largest contributing water source was likely groundwater, rather than surface water which would be expected to be warmer during the mid-summer. Substrate type was primarily made up of cobble and boulders throughout the channel, with areas of sediment and detritus build up in a number of locations.



Photo 2. Aerial photograph of Farm Channel and the side channel connecting to the Klondike River, July 2017. Image was opportunistically taken during another project in the same area.

The small side channel of the Klondike River leading into the Farm Channel was noticeably warmer, with a temperature of 12.7 °C (APPENDIX B) just above the confluence with the Farm Channel. The field crew investigated this side channel using the same methods as the Farm Channel. The substrate was dominated by silty sediment and organic debris, which resulted in very turbid water when disturbed (APPENDIX A Photo A-8, A-9). However, the side channel had good flow and appeared provide suitable rearing habitat for juvenile Chinook (APPENDIX A Photo A-10). Many fish were observed along its length from the Farm Channel upstream to the Klondike River. There was evidence to suggest that when water levels are higher, there are several inlets into the side channel from the Klondike River. At the present water level, there was one small portion where water flowed from the Klondike River into the side channel (APPENDIX A Photo A-11), and eventually into the Farm Channel. There was also evidence of large log jams at the inlet of the side channel (APPENDIX A Photo A-12).

The Farm Channel was assessed downstream of the side channel to the confluence with the Klondike River. The temperature directly downstream of the confluence was 7.7 °C (APPENDIX B). Directly below the confluence there was a considerable accumulation of algae on the substrate (APPENDIX A Photo A-13). Approximately 0.2 km downstream from the confluence, there was a beaver dam in the main flow of the Farm Channel. This beaver dam had created a substantial backwater area, where the beaver lodge was located (APPENDIX A Photo A-14). Satellite imagery (Google Earth, 2006 and 2012) suggests that this dam has been intact since at least 2006, with the backwater area becoming larger in 2012. The beaver lodge appeared to be built on two culverts which were the inlet into a man-made rectangular pond (APPENDIX A Photo A-



5 A-16). After visually assessing the rectangular pond, it became evident that there were several juvenile fish residing in the pond, possibly trapped by the beaver dam/lodge. Water temperatures in the rectangular pond ranged from 15.3-17.3 °C (APPENDIX B).

The beaver dam adjacent to the rectangular pond appeared to present a barrier to juvenile fish for the majority of its length; however, there were small areas of spillover on downstream right bank. Approximately 0.1 km below the beaver dam was what appeared to be another side channel of the Klondike River. However, investigation suggested it is only flowing during high water, when the side channel to the Farm Channel floods or has high water (APPENDIX A Photo A-17). There were a few very small standing pools of water, likely surface water or remaining water from the spring freshet. There was a small isolated pool that contained five juvenile round whitefish (APPENDIX A Photo A-18).

2.2.2 FISH SAMPLING

The fish sampling results on the Farm Channel provided information on fish presence within the channel, the Klondike River side channel, and the rectangular pond. From the top of the Farm Channel downstream to the confluence with the side channel, only a single slimy sculpin was captured (Table 4; Figure 3); it is speculated that this is due to the relatively cold temperatures of the groundwater fed section of the Farm Channel at the time of the sampling. At the confluence with the side channel there were at least 20 juvenile Chinook observed at FC16, where a minnow trap was subsequently set. There were several other groups of juvenile Chinook observed swimming throughout the side channel (>50 individuals). A total of 32 juvenile Chinook salmon were captured using minnow traps in the side channel (FC16-FC19), with more observed outside the traps upon pulling (e.g., 12 Chinook counted outside of trap at FC16). The size of the juvenile Chinook indicated they were in the 0+ age class (mean FL = 71.8 ± 3.0 mm SE, range = 67-80 mm; Table 5; Photo 3). A juvenile burbot and three slimy sculpin were also captured in the side channel. Juvenile Chinook salmon CPUE was highest at the two sites closest to the Klondike River (FC19 and FC18) at 15.57 and 13.32 fish per 24 minnow trap hours, respectively (Table 4). The CPUE of juvenile Chinook salmon were lower at the sites closer to Farm Channel (FC16 and FC17) at 4.43 and 2.22 fish per 24 minnow trap hours, respectively (Table 4). It is not uncommon for groundwater fed channels to have relatively low numbers of juvenile Chinook during the summer due to lower water temperatures compared to areas dominated by surface flow. Five years of biological monitoring associated with a groundwater fed channel restoration project on the Mayo River found very low numbers of juvenile Chinook in a cold groundwater fed channel during July and August compared to surface flow dominated side channels (Tobler and Snow 2011).

The only other location juvenile Chinook were captured was in the rectangular pond (FC25; Table 4), where fish appeared to be isolated by the aforementioned beaver lodge and dam. The juvenile Chinook caught in the rectangular pond were exceptionally large and are thought to be in the 1+ age class (mean FL = 116.4 ± 2.1 mm SE, range = 109-123 mm; Table 5; Photo 4). There were seven juvenile Chinook caught in the rectangular pond, as well as seven juvenile burbot and one juvenile round whitefish (Table 4). When minnow traps were set, it was apparent that some of the juvenile Chinook salmon had infections of the skin and eyes; one of these fish was caught in a minnow trap (Photo 5).



There were three minnow traps set downstream from the rectangular pond and beaver dam (FC26, FC31, FC32; Table 4). There were two juvenile burbot captured (FC26) and three slimy sculpin (FC31); no fish were caught in the backwater area of the Klondike River (Table 4).

Table 4. Summary of minnow trapping effort and fish capture data from the Farm Channel study area, July 2017.

Location	Site Name	Number of Minnow Traps Set	Total Trap Hours	Number of fish captured				Chinook CPUE (fish/24 trap hours)
				Juvenile Chinook	Burbot	Slimy Sculpin	Round Whitefish	
Farm Channel	FC3	3	45.68	0	0	0	0	0.00
	FC4	2	30.37	0	0	0	0	0.00
	FC6	2	29.08	0	0	1	0	0.00
	FC7	1	14.25	0	0	0	0	0.00
	FC8	1	14.08	0	0	0	0	0.00
	FC9	1	13.98	0	0	0	0	0.00
	FC10	1	22.67	0	0	0	0	0.00
	FC11	2	44.98	0	0	0	0	0.00
	FC13	1	21.70	0	0	0	0	0.00
	FC14	1	21.67	0	0	0	0	0.00
	FC23	1	21.67	0	0	0	0	0.00
	FC26	1	20.48	0	2	0	0	0.00
	FC31	1	19.57	0	0	3	0	0.00
Side channel	FC16	1	21.67	4	0	2	0	4.43
	FC17	1	21.65	2	0	0	0	2.22
	FC18	1	21.62	12	1	0	0	13.32
	FC19	1	21.58	14	0	1	0	15.57
Rectangle Pond	FC25	3	62.38	7	7	0	1	2.69
Klondike River backwater	FC32	1	19.50	0	0	0	0	0.00

Table 5. Summary of juvenile Chinook lengths captured via minnow trapping in the Farm Channel study area, July 2017.

Location	Number Captured	Age	Fork lengths (mm)		
			Minimum	Maximum	Mean \pm SE
Side channel	32	0+	67	80	71.8 \pm 3.0
Rectangular Pond	7	1+	109	123	116.4 \pm 2.1



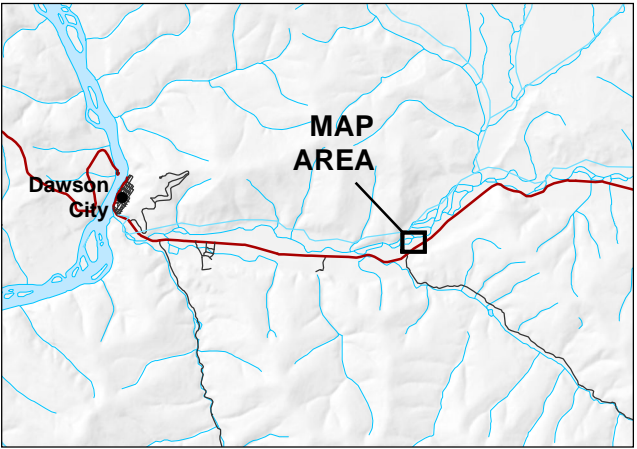
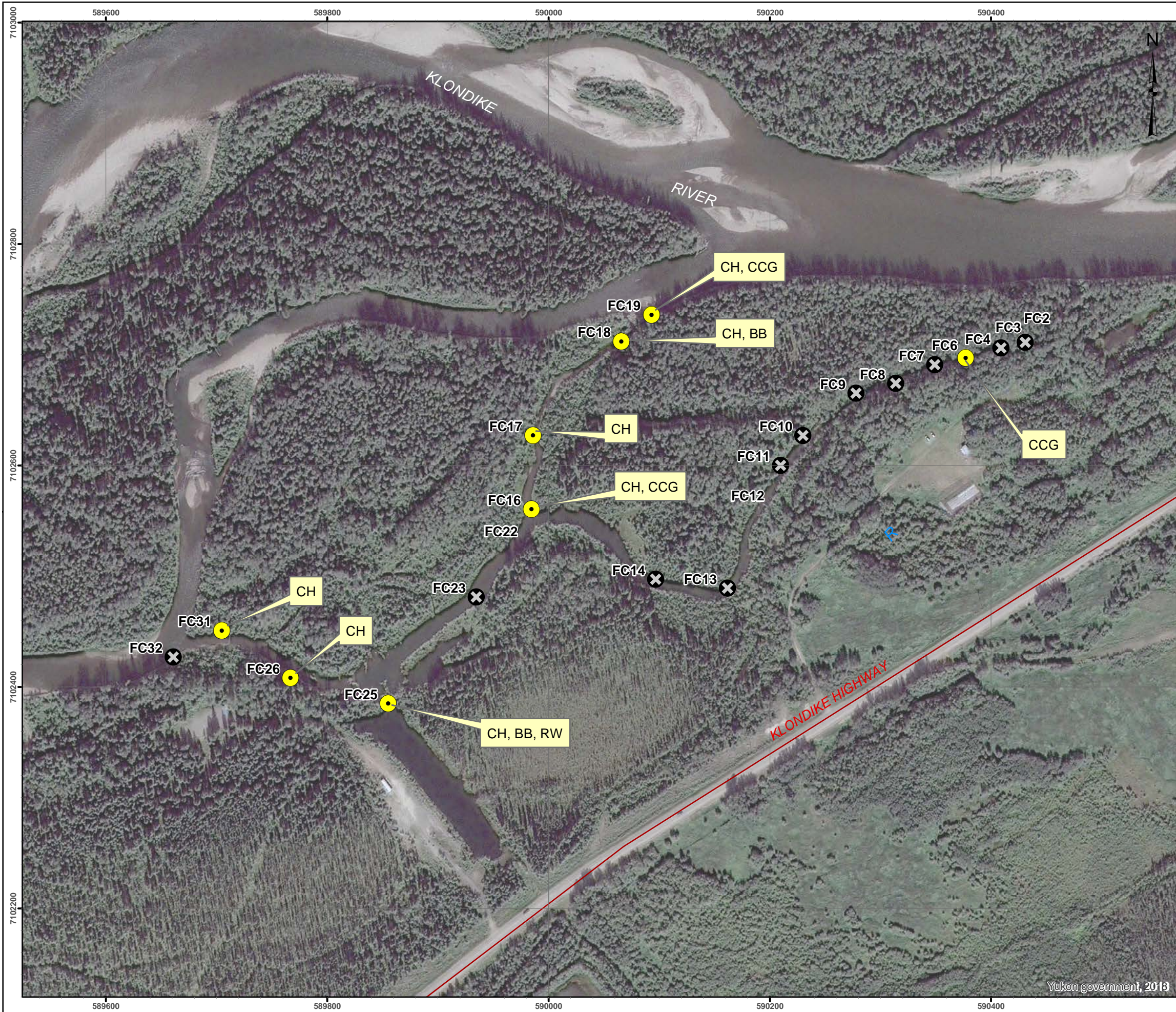
Photo 3. Juvenile 0+ Chinook salmon captured in the side channel to Farm Channel.



Photo 4. Juvenile 1+ Chinook salmon captured in the rectangular pond.







Photo 5. Juvenile 1+ Chinook salmon captured in the rectangular pond with evidence of an eye infection.



Legend

Fish Sampling Results

-  Fish Caught
-  No Fish Caught
-  Highway
-  Secondary Road

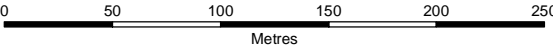
Farm Channel fish sampling results

Data Sources
1:50,000 and 1:1,000,000 Topographic Spatial Data courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Digital Elevation Model and 1:50,000 and 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. Data collected by EDI Environmental Dynamics Inc. (2017) was obtained using Garmin GPS technology.

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



Map Scale = 1:3,500 (printed on 11 x 17)
Map Projection: NAD 1983 UTM Zone 7N

Drawn: MP	Checked: PS/BSc	Date: 3/27/2018	FIGURE 3
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Yukon government, 2018



2.2.3 WATER QUALITY

None of the water quality sample parameters in the Farm Channel exceeded the Canadian Council of Ministers of the Environment (CCME) guidelines (CCME 2007). The pH levels at all sites were circumneutral (range = 7.11-7.23; Table 6) and had low specific conductivity (range = 335-388 $\mu\text{S}/\text{cm}$; Table 6). The water hardness range was hard-very hard (range = 154-184 mg/L; APPENDIX C; Fisheries and Environment Canada 1977). Water clarity was very high, with the total suspended solids (mg/L) being below the lab detection limit.

Table 6. In-situ results for the Farm Channel water quality sites in July and September 2017.

Site	Date	Temperature (°C)	DO (mg/L)	Specific conductivity ($\mu\text{S}/\text{cm}$)	pH
FC9	July 27, 2017	8.0	4.0	316	6.7
	September 5, 2017	9.9	n/a	335	7.2
FC13	July 28, 2017	5.9	6.9	335	6.9
	September 5, 2017	6.9	n/a	347	7.2
FC16	July 28, 2017	12.7	11.2	300	8.1
	September 5, 2017	5.8	n/a	376	7.2
FC23	July 28, 2017	8.0	6.0	346	7.0
	September 5, 2017	6.1	n/a	388	7.1

All nutrients present were below the CCME guidelines, and in general the Farm Channel and the side channel may be considered ultra oligotrophic which is not atypical for northern streams. Nitrate, nitrite, potassium, and ammonia levels were very low, and in most cases below the lab detection limit. Metals were also present in very low quantities, with none exceeding the CCME guidelines, and many being below the lab detectable limit (APPENDIX C).

2.2.4 WINTER ASSESSMENT

The February and March field assessments of the Farm Channel provided information on winter fish habitat conditions in the channel and the Klondike River side channel. The most upstream portion of the Farm Channel that was assessed during the summer investigations was frozen to the bed or dry and snow covered in February (APPENDIX A Photo A-19). Approximately 70 m downstream of the summer FC2 site there was flowing water with ice cover on top that was chipped through to allow for the collection of in-situ water quality measurements (Table 7); this ice cover continued for another 80 m downstream. The ice transitioned to approximately 100 m of fresh overflow on top of the ice (APPENDIX A Photo A-20), before being characterized by light ice cover and open leads (APPENDIX A Photo A-21). Open leads and light ice coverage persisted until the confluence with the side channel.

The March field assessment consisted of temperature and dissolved oxygen measurements at FC2, FC9, and FC12 (Table 8; Figure 2) and an opportunistic aerial visual assessment of the confluence of the Farm Channel and side channel to the Klondike River. Similar to the February assessment, there was groundwater seepage at FC2 covered by ice and snow. The most upstream location with open flowing water was FC9; there was



little ice surrounding the open lead, with water flowing under the ice upstream of FC9 (APPENDIX A Photo A-22). Between FC9 and FC12 there was substantial open flowing water, with some ice coverage along the banks. At FC12 was open flowing water, with thin ice coverage downstream (APPENDIX A Photo A-23).

There were two hypotheses from the summer investigation that were supported by the results of the winter investigation. Firstly, that groundwater is the main contributor for the Farm Channel during most of the year (with the exception of seasonal flooding from the Klondike River). This was evidenced by flowing water and open leads during the winter assessment. Secondly, the side channel was primarily fed by water from the Klondike River (not groundwater), and only during higher water when the Klondike River can spill into the side channel. The side channel was characterized by an ice layer, which when chipped through exposed the streambed with some water frozen in the rocks, suggesting flows decreased as late fall and early winter progressed (APPENDIX A Photo A-24). Groundwater fed channels are known to provide valuable overwintering habitat for juvenile Chinook salmon in the Yukon River watershed (Bradford et al. 2001) due to warmer water temperatures and less ice accumulation. The results of the Farm Channel investigations suggest that the channel likely provides this form of habitat for juvenile Chinook. The winter water temperatures were less than a degree above freezing; however, this is likely sufficient to maintain suitable overwintering conditions. On the Mayo River, it was found that groundwater fed channels provide valuable overwintering habitat with juvenile Chinook captures being considerably higher than surface water dominated channels despite temperatures being less than 1 °C warmer during the winter months (Tobler and Snow 2011).

Table 7. Summary of in-situ water quality measurements during the February winter assessment.

Location	Temperature (°C)	DO (mg/L)	Specific conductivity (µS/cm)	pH	Turbidity	Ice thickness (m)	Water depth (m)
FC2	0.1	10.8	348.3	6.6	3.3	0.12	0.24
FC12	0.2	11.4	344.9	6.5	0.0	0.02	0.07
FC20	0.6	7.4	394.9	6.4	4.4	0.40	0.65
FC16 ^a	n/a	n/a	n/a	n/a	n/a	0.12	0.00
FC22	0.5	9.5	405.3	6.0	0.0	0.05	> 0.3

^a Side channel frozen to bed, no in-situ water quality parameters taken.

Table 8. Summary of in-situ water quality measurements during the March winter assessment.

Location	Temperature (°C)	DO (mg/L)	Ice thickness (m)	Water depth (m)
FC2	0.3	9.2	0.15	0.1
FC9	0.3	10.3	0.00	0.1
FC12	0.7	10.6	0.00	0.15



3 ROCK CREEK CHANNEL INVESTIGATIONS

The Rock Creek groundwater channel was assessed, as previous reconnaissance indicated it was an ideal location for future hatchery interests. Information collected during the field assessment included stream and habitat investigations, in-situ water quality sampling (YSI Pro Plus; temperature, pH, dissolved oxygen, and specific conductivity; Oakton T100 for measuring turbidity), as well as fish sampling.

3.1 METHODS

3.1.1 STREAM INVESTIGATION

The Rock Creek channel was accessed from the Yukon River Campground and investigated to assess juvenile Chinook salmon habitat suitability and collect information on in-situ water quality parameters. Approximately 0.25 km of Rock Creek channel was assessed, in the same reach as previous investigations (EDI 2010; Figure 1).

3.1.2 FISH SAMPLING

Fish sampling was conducted on Rock Creek from July 29-30, 2017. Fish habitat was visually evaluated and gee-style minnow traps were set at accessible locations along the river left of Rock Creek channel. Five sites were sampled, and the number of traps per site varied from one to three (Table 9; Figure 4). The trapping techniques adhered to the Yukon River Panel protocols, with each trap containing chum roe in perforated plastic bags. Ideal minnow trap placement was specific to areas that appeared to be likely juvenile Chinook salmon habitat, with adequate cover (e.g., wood debris) and slow flowing water. Each site was assigned a unique identifier, a GPS coordinate, and photo documentation collected (Photo 6; APPENDIX B). In-situ water quality parameters were measured during minnow trap deployment, and physical characteristics of the area were noted. Juvenile Chinook salmon CPUE was calculated using the same techniques as in the Farm Channel to allow for comparisons between sites.

Table 9. Summary of fish sampling stations in the Rock Creek study area, July 2017.

Location	Site Name	UTM Co-ordinates (Zone 7)	
		Easting	Northing
Rock Creek	RC1	591908	7104111
	RC2	591856	7104075
	RC3	591783	7103990
	RC4	591739	7103979
	RC5	591726	7103987



Photo 6. Minnow trap set up on Rock Creek channel, July 2017.



3.2 RESULTS AND DISCUSSION

3.2.1 STREAM INVESTIGATION

Rock Creek appeared to have changed since the last reconnaissance, with significantly higher water levels and large amounts of detritus and silt on the substrate (APPENDIX A Photo A-25). The Rock Creek channel had a wide and deep channel, with good coverage and woody debris along the banks (Photo 7). There were several areas where the substrate entirely consisted of organic matter and fines near the banks; the middle of the channel appeared to have less detritus but was too deep to wade. Approximately 0.23 km downstream of where the assessment began, there was a large, fairly established beaver dam with approximately a two foot drop which was likely a barrier to fish passage (APPENDIX A Photo A-26, A-27). It is likely that this dam caused flooding and widening in the upstream portion of the channel (APPENDIX A Photo A-28, A-29), and may be partially responsible for the amount of silt and detritus observed. Downstream of the beaver dam there was less siltation and the channel narrowed, with wood debris and other natural features conducive to juvenile Chinook rearing (APPENDIX A Photo A-30). Beyond the area that was surveyed, there was another smaller beaver dam which was not investigated in detail.



Photo 7. Aerial photograph of Rock Creek, July 2017. Image was opportunistically taken during another project in the same area.



3.2.2 FISH SAMPLING

The results from the Rock Creek fish sampling indicated that fish are present in very low numbers. There were no fish captured upstream of the large beaver dam (RC1-RC4; Table 10); these results may support that the beaver dam is a barrier to juvenile fish. Juvenile Chinook were only caught downstream of the beaver dam in an area of dense woody debris (APPENDIX A Photo A-31), with a total of six juvenile Chinook salmon captured (RC5; Table 10).

Table 10. Summary of minnow trapping effort and fish capture data from the Rock Creek channel, July 2017.

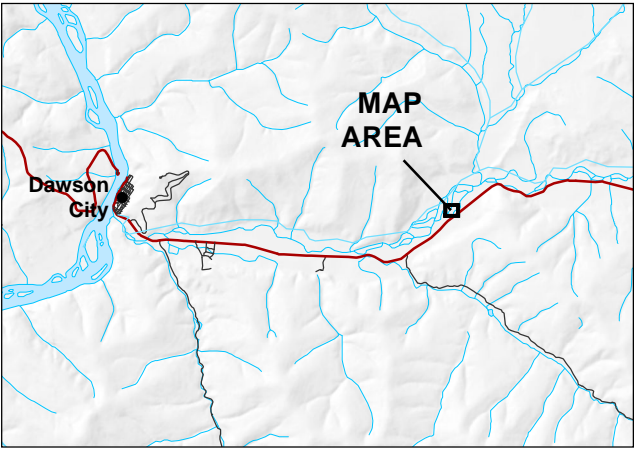
Location	Site Name	Number of Minnow Traps Set	Total Set Time (hours)	Number of fish captured		Chinook CPUE (fish/24 trap hours)
				Juvenile Chinook	Slimy Sculpin	
Rock Creek channel	RC1	2	28.07	0	0	0.00
	RC2	2	27.83	0	0	0.00
	RC3	2	26.58	0	0	0.00
	RC4	1	12.48	0	0	0.00
	RC5	3	38.50	6	0	3.74

3.2.3 WATER QUALITY

In-situ water quality measurements taken at all minnow trapping sites in the Rock Creek channel (Table 11). Water temperatures were fairly similar to those found in the Farm Channel, suggesting there are groundwater contributions. The dissolved oxygen levels are within optimal guidelines for healthy fish populations (CCME 1999) and both the specific conductivity and pH were within the expected ranges.





Table 11. In-situ results for the Rock Creek channel water quality sites in July 2017.

Site	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (µS/cm)	pH
RC1	8.3	9.5	300.1	6.4
RC2	6.7	9.5	300.3	7.0
RC3	9.3	9.1	296.9	7.1
RC4	7.4	8.2	296.8	7.1
RC5	10.6	8.9	294.3	7.2



Legend

Fish Sampling Results

-  Fish Caught
-  No Fish Caught
-  Highway
-  Secondary Road

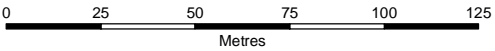
Rock Creek channel fish sampling results

Data Sources
1:50,000 and 1:1,000,000 Topographic Spatial Data courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Digital Elevation Model and 1:50,000 and 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. Data collected by EDI Environmental Dynamics Inc. (2017) was obtained using Garmin GPS technology.

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Map Scale = 1:2,000 (printed on 11 x 17)
Map Projection: NAD 1983 UTM Zone 7N

Drawn: MP	Checked: PS/BSc	Date: 3/27/2018	FIGURE 4
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4 CONCLUSIONS

The results of the Farm Channel investigations during the summer and winter months suggest that the channel is largely groundwater fed. This information suggests that the channel be may a suitable candidate location for some form of Chinook restoration project such as a habitat restoration/improvement project or as a water source for a streamside incubation facility. Additional information would be required to better determine the feasibility of these potential projects at the location and there are a few factors which would also need to be considered. Firstly, the Farm Channel shows evidence of flooding and the extent of which is unknown and could only be speculated. Another consideration is the previous beaver activity upstream of the confluence of the Farm Channel and the side channel, and the present beaver activity downstream of the confluence. Beavers are known to severely alter habitat and flow velocity, which may influence the practicality of future restoration projects in this location. The collection of additional information in the Farm Channel is recommended to further assess the feasibility of a restoration project at this location. Such information may include, but not be limited to: sampling for juvenile Chinook during the mid-winter and late winter, continued water temperature monitoring, and streamflow monitoring in the groundwater fed portion of the channel during all times of year.

The field investigations at the Rock Creek channel suggest the presence of groundwater inputs; however, conditions in the channel appear to have changed considerably since the previous investigations. These changes appear to be the result of beaver activity which has impounded a considerable amount of area and altered the bed material which is now dominated by fine materials. Although the fish habitat value of the Rock Creek channel may currently be less than it was previously due to these changes, the presence of groundwater in this location continues to provide a potential rationale for future restoration projects.



5 LITERATURE CITED

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APPENDIX A. SITE PHOTOGRAPHS



Photo A-1. Area of groundwater seepage at the upstream end of the Farm Channel.



Photo A-2. Evidence of flooding on the Klondike River, upstream from the Farm Channel.



Photo A-3. Large deposited logs near the groundwater seepage of the Farm Channel.



Photo A-4. Evidence of undercut banks in the Farm Channel from previous flooding events.



Photo A-5. Right side of bank shows evidence of a blown-out beaver dam.



Photo A-6. Algal growth on the substrate of the Farm Channel.



Photo A-7. View looking upstream from the mouth of the side channel.



Photo A-8. Side channel substrate.



Photo A-9. Side channel disturbed substrate.



Photo A-10. Natural features providing fish habitat on the side channel.



Photo A-11. Small debris jam where water entered the side channel from the Klondike River.



Photo A-12. Log jam at inlet of side channel, Klondike River main flow on the right.



Photo A-13. Algae covering the substrate below the confluence of the Farm Channel and the side channel.



Photo A-14. Active beaver lodge in backwater area of the Farm Channel.



Photo A-15. One of the culverts leading into the rectangular pond. The second culvert is out of the photo; it is located directly in the top left area of the photo.



Photo A-16. A view of the rectangular pond.



Photo A-17. Investigation along the unnamed side channel; evidence of a channel at high flows.



Photo A-18. Investigation along the unnamed side channel; standing water pool containing five juvenile round whitefish.



Photo A-19. Upstream portion of Farm Creek, overflow conditions with snow cover, February 2018.



Photo A-20. Extensive area of overflow, February 2018.



Photo A-21. Areas of thin ice and open leads, February 2018.



Photo A-22. Facing upstream of FC9, March 2017.



Photo A-23. Facing downstream of FC12, March 2018.



Photo A-24. Klondike River fed side channel, evidence of no flow during the winter, February 2018.



Photo A-25. Rock Creek channel cobble and boulder substrate, covered with silt and detritus.



Photo A-26. Beaver dam on Rock Creek channel.



Photo A-27. Below the beaver dam on the Rock Creek channel, facing upstream.



Photo A-28. Aerial view of the beaver dam on Rock Creek. Note the widening and flooding of the channel upstream of the beaver dam.



Photo A-29. Evidence of flooding in the Rock Creek channel.



Photo A-30. Fish habitat downstream of the beaver dam on the Rock Creek channel.



Photo A-31. Woody debris where all juvenile Chinook were captured in the Rock Creek channel.



APPENDIX B. SAMPLING AND SITE INVESTIGATION DATA

Table A-1. Farm Channel and Rock Creek channel sampling and site investigation data.

Date	Site Name	Trap	UTM Coordinates			In-situ Water Quality					Minnow Trap Set		Minnow Trap Pull		Depth (m)	Species	Fork Length (mm)
			Zone	Easting	Northing	Water Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Specific Conductance (µs)	Turbidity (ntu)	Date	Time	Date	Time			
27-Jul-17	KR1		7	590493	7102772												
27-Jul-17	KR2		7	590635	7102784												
27-Jul-17	KR3		7	590610	7102780												
27-Jul-17	FC1		7	590487	7102751												
27-Jul-17	FC2		7	590454	7102726												
27-Jul-17	FC3	FC3_T1	7	590431	7102711	7.2	3.07	6.91	302.5		27-Jul-17	19:09	28-Jul-17	10:30	0.39	NFC	
27-Jul-17	FC3	FC3_T2	7	590431	7102711	7.2	3.07	6.91	302.5		27-Jul-17	19:12	28-Jul-17	10:22	0.57	NFC	
27-Jul-17	FC3	FC3_T3	7	590431	7102711	7.1	2.75	6.92	303.2		27-Jul-17	19:15	28-Jul-17	10:25	0.46	NFC	
27-Jul-17	FC4	FC4_T1	7	590409	7102706	7.5	2.8	6.91	303.5		27-Jul-17	19:15	28-Jul-17	10:35	0.45	NFC	
27-Jul-17	FC4	FC4_T2	7	590409	7102706	7.5	2.8	6.91	303.5		27-Jul-17	19:20	28-Jul-17	10:22	0.55	NFC	
27-Jul-17	FC5			590393	7102701												
27-Jul-17	FC6	FC6_T1	7	590377	7102697	8.6	4.24	6.94	296.9		27-Jul-17	19:40	28-Jul-17	10:15	n/a	CCG	
27-Jul-17	FC6	FC6_T2	7	590377	7102697	8.6	4.41	6.98	289.5		27-Jul-17	19:40	28-Jul-17	10:10	0.40	NFC	
27-Jul-17	FC7	FC7_T1	7	590343	7102688	8.5	4.79	6.97	297.5	2.3	27-Jul-17	19:50	28-Jul-17	10:05	0.76	NFC	
27-Jul-17	FC8	FC8_T1	7	590314	7102674	8.1	5.71	6.97	277.2	0.81	27-Jul-17	19:55	28-Jul-17	10:00	0.44	NFC	
27-Jul-17	FC9	FC9_T1	7	590278	7102665	8	3.99	6.74	316.4	1.58	27-Jul-17	19:55	28-Jul-17	9:50	0.27	NFC	
28-Jul-17	FC10		7	590230	7102627												
28-Jul-17	FC10	FC10_T1	7	590230	7102627	6.9	6.18	7.13	300.5	2.36	28-Jul-17	11:10	29-Jul-17	9:50	0.30	NFC	
28-Jul-17	FC11	FC11_T1	7	590210	7102600	5.8	5.17	7.11	299.5	0.61	28-Jul-17	11:22	29-Jul-17	9:52	0.31	NFC	
28-Jul-17	FC11	FC11_T2	7	590210	7102600	5.6	4.18	7.08	296.3	0.61	28-Jul-17	11:26	29-Jul-17	9:55	0.40	NFC	
28-Jul-17	FC12		7	590198	7102567												
28-Jul-17	FC13	FC13_T1	7	590162	7102489	5.9	6.85	6.94	335.4	0.01	28-Jul-17	12:18	29-Jul-17	10:00	0.75	NFC	
28-Jul-17	FC14	FC14_T1	7	590097	7102497	5	5.72	6.9	403.4	0.56	28-Jul-17	12:30	29-Jul-17	10:10	0.61	NFC	
28-Jul-17	FC15		7	590057	7102542												
28-Jul-17	FC16		7	589985	7102560												
28-Jul-17	FC16	FC16_T1	7	589985	7102560	12.7	11.16	299.8	8.08		28-Jul-17	13:00	29-Jul-17	10:40	0.24	CH	67
28-Jul-17	FC16	FC16_T1	7	589985	7102560	12.7	11.16	299.8	8.08		28-Jul-17	13:00	29-Jul-17	10:40	0.24	CH	67
28-Jul-17	FC16	FC16_T1	7	589985	7102560	12.7	11.16	299.8	8.08		28-Jul-17	13:00	29-Jul-17	10:40	0.24	CH	65
28-Jul-17	FC16	FC16_T1	7	589985	7102560	12.7	11.16	299.8	8.08		28-Jul-17	13:00	29-Jul-17	10:40	0.24	CH	80
28-Jul-17	FC16	FC16_T1	7	589985	7102560	12.7	11.16	299.8	8.08		28-Jul-17	13:00	29-Jul-17	10:40	0.24	CCG	77
28-Jul-17	FC16	FC16_T1	7	589985	7102560	12.7	11.16	299.8	8.08		28-Jul-17	13:00	29-Jul-17	10:40	0.24	CCG	77
29-Jul-17	FC17		7	589986	7102627												
28-Jul-17	FC17																
28-Jul-17	FC17	FC17_T1	7	589986	7102627	12.4	11.52	8.04	299.7	5.84	28-Jul-17	13:15	29-Jul-17	10:54	0.63	CH	68
28-Jul-17	FC17	FC17_T1	7	589986	7102627	12.4	11.52	8.04	299.7	5.84	28-Jul-17	13:15	29-Jul-17	10:54	0.63	CH	74

Date	Site Name	Trap	UTM Coordinates			In-situ Water Quality					Minnow Trap Set		Minnow Trap Pull		Depth (m)	Species	Fork Length (mm)
			Zone	Easting	Northing	Water Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Specific Conductance (µs)	Turbidity (ntu)	Date	Time	Date	Time			
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	BB	170
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	CH	68
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	CH	68
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	CH	66
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	CH	68
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	CH	67
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	CH	70
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	CH	68
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	CH	65
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	CH	68
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	CH	74
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	CH	69
28-Jul-17	FC18	FC18_T1	7	590066	7102712	11.9	11.58	7.94	299.5	0.59	28-Jul-17	13:30	29-Jul-17	11:07	0.32	CH	65
28-Jul-17	FC19		7	590093	7102736												
28-Jul-17	u/s FC19					11.5	11.79	300.8	7.99								
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	70
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	74
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	71
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	67
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	69
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	60
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	65
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	68
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	67
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	72
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	67
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	68
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	64
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CH	71
28-Jul-17	FC19	FC19_T1	7	590093	7102736	11.5	11.34	7.97	300.9	2.04	28-Jul-17	13:45	29-Jul-17	11:20	0.39	CCG	80
29-Jul-17	FC20		7	589995	7102551	5.7	6.23	376.5	6.9								
28-Jul-17	FC21		7	589978	7102562	13.7	11.21	296.9	7.89								
29-Jul-17	FC22		7	589975	7102535	7.7	7.45	358.1	6.97								
28-Jul-17	FC23	FC23_T1	7	589935	7124810	8	6.01	6.99	346.2	0.88	28-Jul-17	15:00	29-Jul-17	12:40	0.61	NFC	
28-Jul-17	FC24		7	589862	7102408												
28-Jul-17	FC25	FC25_T1	7	589855	7102385	15.3	4.56	806	6.78		28-Jul-17	16:15	29-Jul-17	12:53		CH	120

Date	Site Name	Trap	UTM Coordinates			In-situ Water Quality					Minnow Trap Set		Minnow Trap Pull		Depth (m)	Species	Fork Length (mm)
			Zone	Easting	Northing	Water Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Specific Conductance (µs)	Turbidity (ntu)	Date	Time	Date	Time			
28-Jul-17	FC25	FC25_T1	7	589855	7102385	15.3	4.56	806	6.78		28-Jul-17	16:15	29-Jul-17	12:53		CH	121
28-Jul-17	FC25	FC25_T1	7	589855	7102385	15.3	4.56	806	6.78		28-Jul-17	16:15	29-Jul-17	12:53		CH	109
28-Jul-17	FC25	FC25_T1	7	589855	7102385	15.3	4.56	806	6.78		28-Jul-17	16:15	29-Jul-17	12:53		CH	110
28-Jul-17	FC25	FC25_T1	7	589855	7102385	15.3	4.56	806	6.78		28-Jul-17	16:15	29-Jul-17	12:53		CH	123
28-Jul-17	FC25	FC25_T1	7	589855	7102385	15.3	4.56	806	6.78		28-Jul-17	16:15	29-Jul-17	12:53		CH	113
28-Jul-17	FC25	FC25_T1	7	589855	7102385	15.3	4.56	806	6.78		28-Jul-17	16:15	29-Jul-17	12:53		CH	119
28-Jul-17	FC25	FC25_T1	7	589855	7102385	15.3	4.56	806	6.78		28-Jul-17	16:15	29-Jul-17	12:53		BB	140
28-Jul-17	FC25	FC25_T1	7	589855	7102385	15.3	4.56	806	6.78		28-Jul-17	16:15	29-Jul-17	12:53		BB	144
28-Jul-17	FC25	FC25_T1	7	589855	7102385	15.3	4.56	806	6.78		28-Jul-17	16:15	29-Jul-17	12:53		BB	155
28-Jul-17	FC25	FC25_T1	7	589855	7102385	15.3	4.56	806	6.78		28-Jul-17	16:15	29-Jul-17	12:53		BB	155
28-Jul-17	FC25	FC25_T2	7	589855	7102385	15.3	4.56	806	6.78		28-Jul-17	16:15	29-Jul-17	13:05		NFC	
28-Jul-17	FC25	FC25_T3	7	589855	7102385	17.3	5.35	808	6.77		28-Jul-17	16:15	29-Jul-17	13:10	1.31	BB	170+
28-Jul-17	FC25	FC25_T3	7	589855	7102385	17.3	5.35	808	6.77		28-Jul-17	16:15	29-Jul-17	13:10	1.31	BB	150+
28-Jul-17	FC25	FC25_T3	7	589855	7102385	17.3	5.35	808	6.77		28-Jul-17	16:15	29-Jul-17	13:10	1.31	BB	150+
28-Jul-17	FC25	FC25_T3	7	589855	7102385	17.3	5.35	808	6.77		28-Jul-17	16:15	29-Jul-17	13:10	1.31	RW	81
28-Jul-17	FC26	FC26_T1	7	589767	7102408	9.9	8.7	7.05	373.9	0.34	28-Jul-17	16:55	29-Jul-17	13:24	0.25	BB	150+
28-Jul-17	FC26	FC26_T1	7	589767	7102408	9.9	8.7	7.05	373.9	0.34	28-Jul-17	16:55	29-Jul-17	13:24	0.25	BB	120
28-Jul-17	FC27		7	589945	7102555												
28-Jul-17	FC28		7	589838	7102495	17.8	7.45	287.9	7.31								
28-Jul-17	FC29		7	589787	7102480	10.3	5.56	281.4	6.84								
28-Jul-17	FC30			589740	7102439												
28-Jul-17	FC31	FC31_T1	7	589705	7102451	9.8	9.57	7.02	359.8	0.01	28-Jul-17	18:00	29-Jul-17	13:34	1.10	CCG	72
28-Jul-17	FC31	FC31_T1	7	589705	7102451	9.8	9.57	7.02	359.8	0.01	28-Jul-17	18:00	29-Jul-17	13:34	1.10	CCG	83
28-Jul-17	FC31	FC31_T1	7	589705	7102451	9.8	9.57	7.02	359.8	0.01	28-Jul-17	18:00	29-Jul-17	13:34	1.10	CCG	70
28-Jul-17	F32					13.4	11.47	8.06	301.4								
28-Jul-17	FC32	FC32_T1	7	589661	7102427	12.3	9.01	7.35	331.4	0.85	28-Jul-17	18:15	29-Jul-17	13:45	0.30	NFC	
28-Jul-17	RC1	RC1_T1	7	591908	7104111	8.3	9.49	6.4	300.1	3.15	28-Jul-17	18:28	29-Jul-17	8:30	1.12	NFC	
28-Jul-17	RC1	RC1_T2	7	591908	7104111	8.3	9.49	6.4	300.1	3.15	28-Jul-17	18:28	29-Jul-17	8:30	0.88	NFC	
28-Jul-17	RC2	RC2_T1	7	591856	7104075	6.7	9.49	7.01	300.3	4.2	28-Jul-17	18:45	29-Jul-17	8:40	0.90	NFC	
28-Jul-17	RC2	RC2_T2	7	591856	7104075	6.7	9.49	7.01	300.3	4.2	28-Jul-17	18:45	29-Jul-17	8:40	0.64	NFC	
28-Jul-17	RC3	RC3_T1	7	591783	7103990	9.3	9.06	7.11	296.9	1.69	28-Jul-17	19:05	29-Jul-17	8:25	0.50	NFC	
28-Jul-17	RC3	RC3_T2	7	591783	7103990	9.3	9.06	7.11	296.9	1.69	28-Jul-17	19:10	29-Jul-17	8:25	0.99	NFC	
28-Jul-17	RC4	RC4_T1	7	591739	7103979	7.4	8.19	7.1	296.8	0.45	28-Jul-17	19:43	29-Jul-17	8:12	0.94	NFC	
28-Jul-17	RC5	RC5_T1	7	591726	7103987	7.4	8.19	7.1	296.8	0.45	28-Jul-17	19:40	29-Jul-17	8:10	0.39	NFC	
28-Jul-17	RC5	RC5_T2	7	591726	7103987	10.6	8.85	7.2	294.3		28-Jul-17	19:45	29-Jul-17	8:20	0.40	CH	75
28-Jul-17	RC5	RC5_T3	7	591726	7103987	10.6	8.85	7.2	294.3		28-Jul-17	19:50	29-Jul-17	9:15	0.38	CH	68

Date	Site Name	Trap	UTM Coordinates			In-situ Water Quality					Minnow Trap Set		Minnow Trap Pull		Depth (m)	Species	Fork Length (mm)
			Zone	Easting	Northing	Water Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Specific Conductance (µs)	Turbidity (ntu)	Date	Time	Date	Time			
28-Jul-17	RC5	RC5_T3	7	591726	7103987	10.6	8.85	7.2	294.3		28-Jul-17	19:50	29-Jul-17	9:15	0.38	CH	68
28-Jul-17	RC5	RC5_T3	7	591726	7103987	10.6	8.85	7.2	294.3		28-Jul-17	19:50	29-Jul-17	9:15	0.38	CH	68
28-Jul-17	RC5	RC5_T3	7	591726	7103987	10.6	8.85	7.2	294.3		28-Jul-17	19:50	29-Jul-17	9:15	0.38	CH	69
28-Jul-17	RC5	RC5_T3	7	591726	7103987	10.6	8.85	7.2	294.3		28-Jul-17	19:50	29-Jul-17	9:15	0.38	CH	65

Notes:

Fish species codes: BB- burbot, CCG – slimy sculpin, CH-Chinook salmon, RW – round whitefish



APPENDIX C. WATER QUALITY CERTIFICATE OF ANALYSIS



EDI ENVIRONMENTAL DYNAMICS INC.
ATTN: Lyndsay Doetzel
2195 2nd Avenue
Whitehorse YT Y1A 3T8

Date Received: 06-SEP-17
Report Date: 15-SEP-17 17:14 (MT)
Version: FINAL

Client Phone: 867-393-4882

Certificate of Analysis

Lab Work Order #: L1987015
Project P.O. #: NOT SUBMITTED
Job Reference: 17Y0179
C of C Numbers:
Legal Site Desc:

Shane Stack
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ADDRESS: 8081 Lougheed Hwy, Suite 100, Burnaby, BC V5A 1W9 Canada | Phone: +1 604 253 4188 | Fax: +1 604 253 6700
ALS CANADA LTD Part of the ALS Group An ALS Limited Company

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1987015-1 Water 05-SEP-17 13:21 FC9	L1987015-2 Water 05-SEP-17 13:05 FC13	L1987015-3 Water 05-SEP-17 12:36 FC16	L1987015-4 Water 05-SEP-17 12:22 FC23	
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (uS/cm)	326	338	365	383	
	Hardness (as CaCO3) (mg/L)	154	164	178	184	
	pH (pH)	8.06	8.01	7.96	7.88	
	Total Suspended Solids (mg/L)	<3.0	<3.0	<3.0	<3.0	
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	90.9	104	114	121	
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	0.0061	<0.0050	
	Nitrate (as N) (mg/L)	0.0982	0.131	0.126	0.0971	
	Nitrite (as N) (mg/L)	0.0013	<0.0010	<0.0010	<0.0010	
Total Metals	Aluminum (Al)-Total (mg/L)	<0.0030	0.0051	0.0031	0.0051	
	Antimony (Sb)-Total (mg/L)	0.00021	0.00019	0.00019	0.00018	
	Arsenic (As)-Total (mg/L)	0.00030	0.00023	0.00026	0.00036	
	Barium (Ba)-Total (mg/L)	0.0760	0.0679	0.0644	0.0644	
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Boron (B)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	
	Cadmium (Cd)-Total (mg/L)	0.0000268	0.0000223	0.0000324	0.0000467	
	Calcium (Ca)-Total (mg/L)	42.9	44.1	48.9	50.2	
	Cesium (Cs)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Chromium (Cr)-Total (mg/L)	0.00048	0.00015	<0.00010	0.00038	
	Cobalt (Co)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Copper (Cu)-Total (mg/L)	0.00075	0.00080	0.00110	0.00128	
	Iron (Fe)-Total (mg/L)	0.020	0.011	0.023	0.048	
	Lead (Pb)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Lithium (Li)-Total (mg/L)	0.0028	0.0026	0.0032	0.0031	
	Magnesium (Mg)-Total (mg/L)	12.9	13.4	15.2	16.6	
	Manganese (Mn)-Total (mg/L)	0.00325	0.00108	0.00794	0.0239	
	Molybdenum (Mo)-Total (mg/L)	0.000560	0.000430	0.000434	0.000418	
	Nickel (Ni)-Total (mg/L)	0.00053	<0.00050	0.00064	0.00091	
	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	
	Potassium (K)-Total (mg/L)	0.734	0.739	0.831	0.839	
	Rubidium (Rb)-Total (mg/L)	0.00038	0.00035	0.00035	0.00035	
	Selenium (Se)-Total (mg/L)	0.000676	0.000610	0.000602	0.000575	
	Silicon (Si)-Total (mg/L)	3.35	3.85	3.98	3.99	
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Sodium (Na)-Total (mg/L)	2.76	2.91	3.09	3.13	
	Strontium (Sr)-Total (mg/L)	0.255	0.258	0.289	0.294	
	Sulfur (S)-Total (mg/L)	25.5	25.4	26.4	28.2	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID Description Sampled Date Sampled Time Client ID	L1987015-1 Water 05-SEP-17 13:21 FC9	L1987015-2 Water 05-SEP-17 13:05 FC13	L1987015-3 Water 05-SEP-17 12:36 FC16	L1987015-4 Water 05-SEP-17 12:22 FC23	
Grouping	Analyte						
WATER							
Total Metals	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020		
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010		
	Thorium (Th)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010		
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010		
	Titanium (Ti)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030		
	Tungsten (W)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010		
	Uranium (U)-Total (mg/L)	0.000601	0.000735	0.000823	0.000932		
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050		
	Zinc (Zn)-Total (mg/L)	0.0037	<0.0030	<0.0030	<0.0030		
	Zirconium (Zr)-Total (mg/L)	<0.000060	<0.000060	<0.000060	<0.000060		
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD		
	Aluminum (Al)-Dissolved (mg/L)	<0.0010	0.0019	0.0014	0.0024		
	Antimony (Sb)-Dissolved (mg/L)	0.00017	0.00016	0.00016	0.00015		
	Arsenic (As)-Dissolved (mg/L)	0.00026	0.00022	0.00024	0.00030		
	Barium (Ba)-Dissolved (mg/L)	0.0752	0.0684	0.0667	0.0645		
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010		
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050		
	Boron (B)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010		
	Cadmium (Cd)-Dissolved (mg/L)	0.0000202	0.0000234	0.0000294	0.0000377		
	Calcium (Ca)-Dissolved (mg/L)	42.3	44.8	47.3	47.6		
	Cesium (Cs)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010		
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	0.00013	<0.00010		
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010		
	Copper (Cu)-Dissolved (mg/L)	0.00058	0.00071	0.00096	0.00117		
	Iron (Fe)-Dissolved (mg/L)	<0.010	<0.010	0.015	0.025		
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050		
	Lithium (Li)-Dissolved (mg/L)	0.0028	0.0028	0.0031	0.0034		
	Magnesium (Mg)-Dissolved (mg/L)	11.8	12.7	14.4	15.9		
	Manganese (Mn)-Dissolved (mg/L)	0.00247	0.00094	0.00757	0.0243		
	Molybdenum (Mo)-Dissolved (mg/L)	0.000496	0.000413	0.000369	0.000408		
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	0.00080		
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050		
	Potassium (K)-Dissolved (mg/L)	0.680	0.716	0.798	0.824		
	Rubidium (Rb)-Dissolved (mg/L)	0.00035	0.00031	0.00039	0.00033		
	Selenium (Se)-Dissolved (mg/L)	0.000663	0.000626	0.000557	0.000569		
	Silicon (Si)-Dissolved (mg/L)	3.11	3.65	3.76	3.74		
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1987015-1 Water 05-SEP-17 13:21 FC9	L1987015-2 Water 05-SEP-17 13:05 FC13	L1987015-3 Water 05-SEP-17 12:36 FC16	L1987015-4 Water 05-SEP-17 12:22 FC23	
Grouping	Analyte					
WATER						
Dissolved Metals	Sodium (Na)-Dissolved (mg/L)	2.39	2.61	2.81	2.86	
	Strontium (Sr)-Dissolved (mg/L)	0.246	0.255	0.273	0.280	
	Sulfur (S)-Dissolved (mg/L)	23.4	23.4	24.8	26.5	
	Tellurium (Te)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Thorium (Th)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Titanium (Ti)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	
	Tungsten (W)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Uranium (U)-Dissolved (mg/L)	0.000516	0.000661	0.000739	0.000896	
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Zinc (Zn)-Dissolved (mg/L)	<0.0010	0.0011	0.0011	0.0016	
	Zirconium (Zr)-Dissolved (mg/L)	<0.000060	<0.000060	<0.000060	<0.000060	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Barium (Ba)-Total	MS-B	L1987015-1, -2, -3, -4
Matrix Spike	Calcium (Ca)-Total	MS-B	L1987015-1, -2, -3, -4
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1987015-1, -2, -3, -4
Matrix Spike	Manganese (Mn)-Total	MS-B	L1987015-1, -2, -3, -4
Matrix Spike	Sodium (Na)-Total	MS-B	L1987015-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Total	MS-B	L1987015-1, -2, -3, -4

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.			
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.
This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.			
EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510
Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.			
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B
Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO ₃ equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.			
MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)
Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.			
Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.			
MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)
Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.			
Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.			
NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH ₃ -NITROGEN (AMMONIA)
This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.			
NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC
This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.			
NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode			
It is recommended that this analysis be conducted in the field.			
TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC
This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis			

Reference Information

methods are available for these types of samples.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

mg/kg - milligrams per kilogram based on dry weight of sample.

mg/kg ww - milligrams per kilogram based on wet weight of sample.

mg/kg lw - milligrams per kilogram based on lipid-adjusted weight of sample.

mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.



Report To			Report Format / Distribution			Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)															
Company: EDI			Select Report Format: <input checked="" type="checkbox"/> PDF <input checked="" type="checkbox"/> EXCEL <input type="checkbox"/> EDD (DIGITAL)			R <input checked="" type="checkbox"/> Regular (Standard TAT if received by 3 pm - business days)															
Contact: Lyndsay Doetzel			Quality Control (QC) Report with Report <input type="checkbox"/> Yes <input type="checkbox"/> No			P <input type="checkbox"/> Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT															
Address: 2195 - 2nd Avenue Whitehorse, YT Y1A 3T8			<input type="checkbox"/> Criteria on Report - provide details below if box checked			E <input type="checkbox"/> Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT															
Phone: 867-393-4882			Select Distribution: <input checked="" type="checkbox"/> EMAIL <input type="checkbox"/> MAIL <input type="checkbox"/> FAX			E2 <input type="checkbox"/> Same day or weekend emergency - contact ALS to confirm TAT and surcharge															
			Email 1 or Fax ldoetzel@edynamics.com			Specify Date Required for E2, E or P:															
			Email 2 bschonewille@edynamics.com																		
Invoice To Same as Report To <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No			Invoice Distribution			Analysis Request															
Copy of Invoice with Report <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			Select Invoice Distribution: <input checked="" type="checkbox"/> EMAIL <input type="checkbox"/> MAIL <input type="checkbox"/> FAX			Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below															
Company: EDI			Email 1 or Fax sljenner@edynamics.com																		
Contact: S Jenner			Email 2 ldoetzel@edynamics.com																		
Project Information			Oil and Gas Required Fields (client use)																		
ALS Quote #:			Approver ID:		Cost Center:																
Job #: 17Y0179			GL Account:		Routing Code:																
PO / AFE:			Activity Code:																		
LSD:			Location:																		
ALS Lab Work Order # (lab use only)			ALS Contact: B. Makelki		Sampler: J. Duncan																
ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)				Date (dd-mm-yy)	Time (hh:mm)	Sample Type	ALK-PCT-VA	NO2-L-IC-N-WR, NO3-L-IC-N-WR	EC-MAN-WR, PH-MAN-WR	TSS-MAN-WR	MET-T-CCMS-VA	MET-D-CCMS-VA	HARDNESS-CALC-VA	NH3-F-VA						Number of Containers
	FC9				05-Sep-17	13:21	Water	R	R	R	R	R	R	R	R						
	FC13				05-Sep-17	13:05	Water	R	R	R	R	R	R	R	R						
	FC16				05-Sep-17	12:36	Water	R	R	R	R	R	R	R	R						
	FC23				05-Sep-17	12:22	Water	R	R	R	R	R	R	R	R						
Drinking Water (DW) Samples¹ (client use)			Special Instructions / Specify Criteria to add on report (client Use)			SAMPLE CONDITION AS RECEIVED (lab use only)															
Are samples taken from a Regulated DW System? <input type="checkbox"/> Yes <input type="checkbox"/> No						Frozen <input type="checkbox"/> SIF Observations Yes <input type="checkbox"/> No <input type="checkbox"/>															
Are samples for human drinking water use? <input type="checkbox"/> Yes <input type="checkbox"/> No						Ice packs Yes <input type="checkbox"/> No <input type="checkbox"/> Custody seal intact Yes <input type="checkbox"/> No <input type="checkbox"/>															
						Cooling Initiated <input type="checkbox"/>															
						INITIAL COOLER TEMPERATURES °C: FINAL COOLER TEMPERATURES °C:															
						7.0 8.9 6.4															
SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)															
Released by: <i>Amelia Allister</i>	Date: Sept. 7/2017	Time: 15:10	Received by: <i>[Signature]</i>	Date: Sept 6/17	Time: 15:17	Received by: <i>Sharon</i>	Date: Sept 7	Time: 1600													

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY

YELLOW CLIENT COPY

NA-FM-D328b v09 Exord:04-January 2015

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.