

prepared for:

Ross Burnett Habitat Coordinator City of Whitehorse 2121-2nd Avenue Whitehorse, YT Y1A 1C2

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April 19, 2004

Ross Burnett
Habitat Coordinator
City of Whitehorse
2121 – 2nd Avenue
Whitehorse, Yukon
Y1A 1C2

Re: City of Whitehorse Detailed Salmon Habitat Management Plan – Final Deliverables

Dear Ross:

Please find enclosed the final deliverables associated with Project # CRE-71N-03: Detailed Salmon Habitat Management Plan for the City of Whitehorse, Yukon. Seven hard copies of the final report will be delivered to your office with the following digital deliverables:

CD One: City of Whitehorse Detailed Salmon Habitat Management Plan – Final Deliverables

- Digital copy of the final project report in pdf format:
 - o 23644_cow_final_report_April2004.

CD Two: City of Whitehorse Fish Survey Questionnaire

- Digital copies of all documents associated with the Fish Survey Questionnaire in pdf format:
 - gll_cow_fish_survey_appendix_20Nov2003;
 - o gll_cow_fish_survey_guidelines_20Nov2003;
 - o gll_cow_fish_survey_questionnaire_20Nov2003.
- Digital copies of all maps associated with the Fish Survey Questionnaire in pdf format (please note all maps must be plotted out on 36" by 24" paper):
 - $\verb| o | gll_cow_fish_survey_map1of3_20Nov2003; \\$
 - o *gll_cow_fish_survey_map2of3_20Nov2003*;
 - o gll_cow_fish_survey_map3of3_20Nov2003.

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Thank you Ross for allowing Gartner Lee Ltd. to assist you in this important work. We very much look forward to having the opportunity to work with you again and continue efforts to improve fish habitat and aquatic health within the City.

Yours very truly, GARTNER LEE LIMITED

Kirk Cameron, Manager, Whitehorse Office

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- A. City of Whitehorse Fish Survey Questionnaire
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1. Introduction

Fish and fish habitat data have been inventoried on some watercourses within the City of Whitehorse and are available in a variety of formats from a variety of sources. These data were collated, synthesized and integrated by AEM in a previous project (CRE-71-02) to create a digital Geographic Information System (GIS) database of chinook salmon (*Oncorhynchus tshawytscha*) values within the City of Whitehorse, e.g., occurrence of chinook migration or presence of spawning chinook. An accompanying report interpreted the results of this work and documented areas where chinook values and potential or recognized impacts on chinook values were identified, e.g., the presence of culverts that may impede fish passage. The current report (CRE-71N-03) builds upon the findings of the previous work and provides more detailed, operational-level recommendations that can be used by the City of Whitehorse to direct restoration and enhancement activities. This report documents, on a stream-by-stream basis, specific management actions that can be taken to maintain, restore or enhance fish habitat. Emphasis is placed on recommending actions that are relatively simple and cost effective, and that will, whenever possible, encourage community habitat stewardship.

1.1 Objectives

The objective of this report is to provide detailed, operational-level recommendations that can be used to guide restoration and enhancement activities within the City. Particular emphasis is placed on identifying activities that can be conducted by community stewardship groups, e.g., site clean-up, water sampling, fish distribution surveys. However, there are also potential restoration activities that are beyond the scope of community stewardship groups, e.g., contaminated site clean-up, culvert restoration. These situations are also identified and suggestions provided with the aim of facilitating restoration activities that can be conducted on the site by the responsible authority.

2. Methods

2.1 Field Methods

Detailed culvert assessments were conducted on culverts identified during the previous study (AEM 2003) to be potential barriers to the upstream passage of chinook. Culvert assessment procedures followed those outlined in Parker (2000). The following culvert parameters were recorded: length, diameter, material, shape, water velocity in the culvert, wetted width, high water mark, water depth, slope, outfall drop, pool depth at outfall and fill slope depth. The measured parameters were then compared against threshold values to determine whether any characteristics of the culvert would result in

an impedance to fish passage, e.g., water velocities exceeding 1.2 m/sec in a culvert 25m long would be an impedance to the passage of adult chinook (Parker 2000). Characteristics of the stream channel upstream and downstream of the culvert were also recorded: wetted width, bankfull width, water depth, bankfull depth, water velocity and stream gradient. These measurements provided information on the suitability of the culvert to the stream channel and also supplemented habitat data collected during the previous study (AEM 2003). The characteristics of the channel upstream or downstream of culverts were not recorded when there were additional culverts <25m from the inlet or outlet of the assessed culverts (Parker 2000). The reason being that the stream channel is usually modified on either side of a culvert and is not representative of the true nature of the stream, e.g., width, depth and pattern. Sites identified during fieldwork to require clean up were described and photographed.

3. Results

3.1 General Guidelines

3.1.1 Regulatory Framework

All restoration activities must be placed within the appropriate regulatory framework. The responsibility for the administration of the Fisheries Act rests with the Federal Minister of Fisheries and Oceans (Canadian Department of Justice 1985) and Environment Canada (DFO 1986). The following prohibitions in the Fisheries Act are relevant to activities on fish bearing streams:

- Harmful alteration, disruption or destruction of fish habitat, unless authorized (Section 35 (1) of Fisheries Act);
- Depositing of substances deleterious to fish in waters frequented by fish (Section 36 (3) of Fisheries Act);
- Destruction of fish (Section 32 of Fisheries Act);
- Obstruction of fish migration (Section 22 and 26 of Fisheries Act).

Fish habitat is defined in the Fisheries Act as: "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes" (Section 34 (1) of Fisheries Act). Notification and request for review from the Department of Fisheries and Oceans (DFO) for any restoration project is advised to ensure fisheries agencies support the rehabilitative measures of the project and also accept measures to minimize and mitigate temporary effects.

The Navigable Waters Protection Act regulates any activity in, around, under and over navigable waters and is administered by the Canadian Coast Guard of DFO. Navigable waters are defined as any waters capable of being used by commerce, transportation or recreation (FPC 2002).

The Yukon Waters Act provides territorial legislation to regulate the use of water (including the deposition of waste) in Yukon waters and is administered by YTG Water Resources. In the Act, the following definitions are provided:

"use, in relation to waters, means a direct or indirect use of any kind, including,

- a) any diversion or obstruction of waters,
- b) any alteration of the flow of waters, and
- c) any alteration of the bed or banks of a river, stream, lake or other body of water, whether or not the body of water is seasonal,"

"Waste means:

- a) any substance that, if added to water, would degrade or alter, or form part of a process of degradation or alteration of, the quality of the water to an extent that is detrimental to its use by people or by any animal, fish or plant, or
- b) water that contains a substance in such a quantity or concentration, or that has been so treated, processed, or changed, by heat or other means, that it would, if added to any other water, degrade or alter, or form part of a process of degradation or alteration of, the quality of that water to the extent described in paragraph (a),"

"Waters means any inland water, whether in a liquid or frozen state, on or below the surface of the land."

In addition, there are also municipal bylaws in place that regulate activities near streams. The policy outlined in the City of Whitehorse 2002 Official Community Plan with regards to riparian areas states that:

"A 30-metre riparian setback along both sides of all rivers, streams, lakes and wetlands, year-round or seasonal, shall be protected from development, except for access and non-motorized viewing trails or as otherwise noted. Where steep banks contain the riparian area, the setback shall be applied from the top of the bank. These riparian areas shall be retained in a natural condition."

3.1.2 Restoration of Sites Impeding Fish Passage

Sites impeding fish passage are often related to road construction activities requiring stream crossings, e.g., culverts. Improperly installed culverts can also be a source of sediment transfer into the stream. The following presents a summary of guidelines relating to best management practices for the construction and rehabilitation of culverts on fish bearing streams.

Open Bottom Structures: General Guidelines for Installation / Replacement

Open bottom structures (e.g., bridges and open arch culverts) are preferred over closed bottom structures (e.g., round or oval culverts) in areas of critical fish habitat (FPC 2002). Closed bottom structures are an option in marginal habitats where stream channel width is <2.5m; stream gradient is <6%, the culvert is partially embedded, culvert substrate replicates the stream bed and timing windows are adhered to (FPC 2002). The following notes provide guidance for the consideration of fish and fish habitat during the installation of open bottom structures in fish bearing areas and are adapted from the British Columbia Forest Practices Code Stream Crossing Guidebook (FPC 2002):

- When designed and constructed with abutments that do not constrict the stream channel, bridges have the least impact on fish passage and fish habitat.
- When practical, instream piers should be avoided; piers can result in hydrological changes such as bed load scour or deposition that may adversely affect fish habitat.
- When constructing footings ensure excavation and back filling does not encroach on the stream channel width.
- Practices such as pile driving and blasting that result in vibrations are potentially harmful to fish or fish eggs and should be carried out during instream timing windows. In addition, fish salvage may be required to remove fish from potential harm. Instream timing windows are periods of time when work in and about a stream can be conducted with reduced risk to fish and fish habitat. These periods are specific to fish species and geographic area and are determined by such factors as the time when there are no known fish eggs or alevin present in the stream; when stream flow is low and soil conditions are dry. These are periods of least risk and are not to be confused with periods of no risk.
- To avoid unnecessary sediment release where feasible all equipment should be operated from above the top of the stream bank, the work area should be isolated from water sources and sediments should be contained within the work site. Sediment-laden water can be pumped out to a settling site during construction and installation.
- To avoid unnecessary sediment and contaminant release do not allow road ditches to drain directly into the stream.
- Activities should not result in the constriction of the stream channel width. This includes the placement of rip-rap.

- Precautionary measures should be used to prevent deleterious substances from entering streams, e.g., new concrete, grout, paint, ditch sediment, fuel, lubricants, fertilizers and preservatives. Workers should comply with all regulations governing the storage, handling and application of hazardous materials that could be deleterious to fish. Precautionary measures could include the development of a contingency plan for the use of all hazardous materials that provides protocols on activities such as spill containment, clean up and notification of the appropriate regulatory agencies in the event of a spill.
- If installing an arch culvert, consider the use of geotextiles to prevent the loss of fines and gravels through seepage along walls of the arch.
- Turnouts and pullouts should be constructed at sufficient distance from the stream to prevent road materials from entering the stream and to minimize potential impacts on riparian vegetation.

Closed Bottom Structures: General Guidelines for Restoration

In situations where culverts have been improperly installed and it is either not possible or not desirable to replace culverts, restoration activities may be effective. The following provides some general background on potential restoration activities for the restoration of closed bottom structures primarily based on guidance from the Forest Practices Code of British Columbia Fish Stream Crossing Guidebook (FPC 2002) and technical input from DFO personnel. The objective of restoration of a closed bottom structure is to ensure fish passage. Where closed bottom culverts are perched or not sufficiently embedded (i.e., if >40% of the culvert or 0.6m is not embedded), potential mitigation may include:

- Streambed recontouring can be employed in an attempt to eliminate the outfall drop or increase the proportion of the culvert that is embedded.
- An instream weir may be established downstream of culverts in low gradient streams (i.e., <1%) to raise the water surface approximately 20cm above the culvert outlet to eliminate the outfall drop and increase the proportion of the culvert that is embedded (A. von Finster, pers. comm., March 2004).
- An instream weir may be established between 1.5 and 2 channel widths downstream of the culvert outlet to help retain substrate within the culvert and prevent the formation of a perched outlet into a plunge pool. Residual pool depth formed by the weir should be < 0.3m (residual pool depth is the difference between the maximum pool depth and the outlet pool depth (RIC 1999). This method is most effective in higher gradient streams (i.e., >1%); in low gradient streams (<1%) plunge pools may be preferred to assist fish passage (A. von Finster, pers. comm., March 2004).
- Baffles may be installed to slow water velocity and increase water depth within the culvert.
 However, baffles can easily clog with debris and sediment that can result in damage to the culvert or failure.

It should be noted that any mitigation / restoration activities conducted should be regularly inspected to ensure they are functioning and specific consideration be given to potential risks, e.g., clogging of culverts with debris and sediment due to baffle or weir installations.

Where closed bottom structures do not emulate the natural streambed in terms of substrate characteristics, if possible:

- Natural substrate materials can be placed in the culvert to assist fish passage.
- The size of materials placed in the culvert should be similar in size to materials in adjacent natural stream channel but should be supplemented with substrate that is equal to or greater than the stream channel D90 particle size (i.e., diameter of the bed material particle that is larger than 90% of the materials in the stream channel) to reduce the likelihood of materials being washed out of the culvert. This is particularly important where stream gradients are 3 6%. A sufficient amount of fines are also required to seal the streambed in the culvert to ensure subsurface flow does not occur and create a barrier to fish passage through low water volumes.
- A thalweg should be established through the culvert to enable fish passage at low flows. A thalweg is
 the longitudinal line connecting the lowest point of a series of cross sections in a stream or valley and
 corresponds to the path of maximum depth.
- An instream weir may be established between 1.5 and 2 channel widths downstream of the culvert outlet to help retain substrate within the culvert.
- Natural deposition characteristics of the stream should be maintained by ensuring: substrate flows
 through the culvert naturally and there is no build up of sediment upstream or downstream of the
 culvert and that the natural meandering pattern of the stream is maintained.

The effectiveness of these mitigation measures will depend upon site-specific limitations, e.g., culvert slope and position, available streambed materials, culvert width and site suitability (e.g., accommodation to the 100-year flood event).

Where side slope and backfill materials are depositing into the culvert or channel, if possible:

• Rip-rap or other geotextiles may be placed on the slope to retain the materials.

Fords can result in habitat degradation through sedimentation, channel compaction and the creation of barriers to fish passage. Fords are not considered compatible with fish and fish habitat protection and can be deactivated (e.g., through road closure and / or deactivation) or replaced with a bridge.

Assumptions

The following assumptions were adhered to, unless the cost/risk of restoration activities outweighed the benefits of restoration:

- Where there is a culvert that presents an obstruction to fish passage and where there are documented
 or anticipated upstream values to chinook, culvert rehabilitation is suggested. These activities are
 classed as a high priority;
- Where there is a culvert that presents an obstruction to fish passage and where there are no documented or anticipated upstream values to chinook, but there are documented upstream values to freshwater fish, culvert rehabilitation is suggested. These activities are classed as a low priority;
- Where there is a culvert that presents an obstruction to fish passage and there are no documented or anticipated upstream values to chinook, no documented but anticipated upstream values to freshwater fish, culvert rehabilitation is not suggested at present. Suggestions are made to prioritize freshwater fish sampling and / or fish survey in these areas;
- Where there is a culvert that presents an obstruction to fish passage and there are no documented or anticipated upstream values to chinook or freshwater fish, culvert rehabilitation is not suggested;
- Where there is beaver dam activity that presents an obstruction to fish passage and there are
 documented upstream values to chinook, stream management practices will be suggested, e.g., dam
 removal or dam rehabilitation as described in the Telkwa Project (Finnigan and Marshall 1997);
- Where there is beaver dam activity that presents an obstruction to fish passage where there are no
 documented upstream values to chinook, but anticipated upstream values to chinook or freshwater
 fish, dam removal or rehabilitation is not suggested.

The Telkwa Project (Finnigan and Marshall 1997) provides a means by which fish passage can be maintained without removing beavers or breaching beaver dams. This methodology allows fish passage through beaver pond(s) by means of a low gradient (<2%) diversion channel into the sidewall of a beaver pond. Damming in the diversion channel is discouraged through the placement of wire-mesh fencing along the banks and by the presence of floating debris in the upper portion of the diversion channel. A large log is buried into the banks across the diversion channel near the pool outlet to retain this debris near the pool outlet. Deep holes are also constructed in the beaver pond to enhance over-wintering habitat and debris and boulders are added to the diversion channel and in the pond to provide cover for juveniles. This methodology requires the use of a large track excavator for the construction of the diversion channel, deep holes and the movement of woody debris and boulders. This project has operated successfully since 1996 on a small tributary of the Telkwa River in northwestern British Columbia and could be investigated for use on some streams in the City of Whitehorse. Where stream conditions are not appropriate for use of the methods of the Telkwa Project, other non-invasive restoration methods may be considered, e.g., capture and transfer of juvenile chinook salmon to habitat upstream of the beaver dam(s) and the building of fish ladders to maintain fish passage through the dams (Yukon River Panel 2004). Other non-lethal restoration methods may also be considered, e.g., live beaver trapping / translocation and dam breaching (DFO 1999).

It should be noted that the removal or rehabilitation of beaver dams or culverts requires review by DFO and adherence to the Fisheries Act, review by YTG Water Resources and adherence to the Yukon Waters Act and approval by the responsible authority for the land, e.g., YTG or City of Whitehorse. If beaver translocation or removal is a necessary measure, YTG Conservation Officer Service is the responsible authority and should be contacted.

3.1.3 Best Management Practices for Road Maintenance Activities

Many of the concerns to fish habitat previously identified in the 2003 report are related to stream crossings and the proximity of roads to streams and the potential for these roads to effect stream water quality, water quantity and fish passage (AEM 2003). The Forest Practices Code of British Columbia Fish Stream Crossing Guidebook (FPC 2002) provides some guidance for best management practices relating to fish and fish habitat in regards to road maintenance.

- Snow dumps should be located with sufficient distance from the stream to prevent road materials
 and potential contaminants (e.g., road salt) from entering the stream and to minimize potential
 impacts on riparian vegetation.
- To avoid unnecessary sediment and contaminant release do not allow road ditches or super elevated surfaces such as bridges to drain directly into the stream.
- Precautionary measures should be used to prevent deleterious substances from entering streams, e.g., road salt from snow dumps, new concrete, grout, paint, ditch sediment, fuel, lubricants, fertilizers and preservatives. Workers should comply with all regulations governing the storage, handling and application of hazardous materials that could be deleterious to fish. Precautionary measures could include the development of a contingency plan for the use of all hazardous materials that provides protocols on activities such as spill containment, clean up and notification of the appropriate regulatory agencies in the event of a spill.
- Turnouts and pullouts should be constructed with sufficient distance from the stream to prevent road materials from entering the stream and to minimize potential impacts on riparian vegetation.
- Ensure culverts are of sufficient length to provide adequate extension from the road subgrade.
 This will prevent the deposition of road surface and subgrade material in to streams during maintenance grading, snow plowing and heavy rainfall events.
- Ensure damaged culvert inlets and outlets are repaired.
- Armoring around inlets and outlets should be maintained to reduce sediment transfer.
- Remove debris blocking or obstructing culvert inlets and outlets.
- Install beaver protection devices in areas where beaver activity creates a high risk of crossing failure.
- Replace culverts where the bottoms are rusted out and when subject to damage from water seepage.
- Repair major culvert headwalls and spillways when necessary to protect the integrity of the structure and maintain adequate interception of road surface material.

- Inspect and repair weirs that are installed in streams to maintain water levels for fish passage.
- Asphalt paving of the road surface approaching bridges is a commonly used preventative measure
 to reduce sediment transfer from gravel roads to streams in the Smithers area. Approximately
 10m on either side of the bridge is paved and installed with curbs and drainage pipes.

3.1.4 Areas of High Site Sensitivity

Sites of high site sensitivity can be identified for a number of reasons, e.g., where improperly installed culverts have washed out the stream can continue to erode the road and deposit road materials into the creek. These sites have been identified on specific streams within the City. Sites can also be intrinsically sensitive due to natural site conditions, e.g., steep, eroding slopes or unstable slopes resulting from the presence of permafrost or naturally fluctuating water levels (AEM 2003). Where these sites occur in close proximity to streams, special considerations are made to the management of adjacent lands (City of Whitehorse 2002). The City of Whitehorse Official Community Plan addresses the concern of steep slopes in the following paragraph (City of Whitehorse 2002):

"New development near escarpments that have a slope in excess of 30% shall be set back at a site-specific distance. In no case shall new development be less than 15 metres from the top or the toe of the slope in order to reduce the impact of erosion and slumping. The only exception is for trails and view points."

It is recognized, however, that land practices beyond the 15m setback can impact the stability of a slope and natural site conditions other than steep slopes can cause areas to be sensitive, e.g., presence of permafrost. The determination of the location of these sites as well as the extent of the potential zone of influence around these sites requires a detailed terrain survey using primarily aerial photograph interpretation (historical and recent imagery) and interpretation of existing data, e.g., soil and terrain maps of the City (Mougeot et al. 1998) and ecosystem mapping conducted within the City (AEM 2000).

3.1.5 Determination of Fish Distribution

It became apparent during previous work (AEM 2003) that there are many areas within the city where fish occurrence and distribution is unknown. In an attempt to fill these information gaps and supplement fish and habitat sampling activities ongoing within government agencies, the questionnaire contained in Appendix A was designed. It is intended that this questionnaire be used by interested parties, e.g., stream stewardship groups, educational institutions or first nation, federal, territorial or municipal governments, to interview local experts with knowledge of fish occurrence and distribution in the creeks and lakes of the city. Local experts could be long-term resident fishers, first nation elders, biologists, field workers, fishing guides or commercial fishers. Data collected as part of these surveys could then be incorporated into the original GIS database (AEM 2003).

Priority sites for future fish sampling and / or fish questionnaire surveys were identified as follows:

- Where there are no fish distribution data available and the potential for fish to occur in the creek
 appears high as determined from habitat suitability, water flow levels, stream size and connectivity
 with known fish bearing waters;
- Where there are no fish distribution data available and there is potential risk to any fish that may occur within the creek:
- Where there are no fish distribution data available and the presence of culverts on the creek could impede fish passage if fish were to occur on the creek.

3.1.6 Water Sampling

Existing water quality and quantity data collected within the City's watersheds was collated and briefly reviewed. Provision of these data aims to provide a background resource to future water sampling efforts within the City. This information can be used in conjunction with the City of Whitehorse Adopt-a-Stream Program Resource Kit. This resource kit provides basic information on potential water quality issues and testing protocols. Appendix B provides a summary of the characteristics of available in stream and groundwater water sampling data collected within the City following the proceeding classification:

Water Quality Parameters

- Standard sampling parameters generally include: temperature; pH; dissolved oxygen; specific conductivity; turbidity; total suspended solids; total dissolved solids and can also include alkalinity; hardness; total organic carbon; total inorganic carbon; true colour and cyanide.
- **Nutrient** sampling parameters include total ammonia; nitrite; nitrate; total organic nitrogen; Kjeldahl nitrogen; total nitrogen; total phosphorus and orthophosphate.
- **Halide** sampling parameters include: chloride and fluoride.
- Metal sampling parameters include: aluminum; cadmium; copper; lead; manganese; mercury; molybdenum; silver and zinc.
- **Organic** sampling parameters include: polychlorinated biphenyls (PCBs); chlorophenols; polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDDs and PCDFs) and polycyclic aromatic hydrocarbons (PAHs).
- **Sediment** variables include: sediment particle size; metals (including arsenic; cadmium; chromium; copper; iron; lead; mercury; selenium and zinc) and organics (organochlorine compounds; polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs).
- **Biological** variables include: bacteria / coliform; quantification of macroinvertebrate communities; quantification of periphyton and phytoplankton communities; macrophyte taxonomy and fish taxonomy (for the purposes of indicating water quality).

Water Quantity Parameters

• Water quantity parameters include: discharge rates; peak flows; stream velocity; wetted width; bankful width; water depth and bankfull depth.

Priority focal sites for future water sampling surveys were identified where there is a potential risk from potential pollution sources to instream or downstream fish or fish habitat.

3.1.7 Site Clean-Up

Sites containing domestic and / or industrial waste adjacent to watercourses within the city were identified during fieldwork conducted in 2002 and 2003 and through consultation with representatives from the YTG departments responsible for the management of these sites. These sites have been identified on specific streams within the City. It is also recommended that stewardship groups continually monitor watercourses and waterbodies within the City and where sites requiring potential restoration are identified, they should be brought to the attention of DFO and YTG Water Resources and whenever possible coordinated restoration activities be conducted. It should be noted that any activities in and around streams require adherence to the Fisheries Act and the Yukon Waters Act.

3.2 Site Specific Guidelines

3.2.1 Yukon River Mainstem

Chinook (Oncorhynchus tshawytscha) are known to occur throughout the Yukon River mainstem within the City of Whitehorse. Due to the presence of upstream spawning sites chinook are known to migrate and rear within every reach of the Yukon River within the City and are documented to spawn between the confluence of McIntyre Creek and Schwatka Lake (A. von Finster, pers. comm., March 2003). Many freshwater fish species occur in the Yukon River mainstem within the City including: Burbot (Lota lota), least cisco (Coregonus said), arctic grayling (Thymallus arcticus), inconnu (Stendons leucichthys), lake chub (Couesins plumbeus), long nose suckers (Catostomus catostomus), lake trout (Salvelinus namaycusu), lake whitefish (Coregonus clupeaformis), humpback whitefish (Coregonus oidschian), broad whitefish (Coregonus nasus), round whitefish (Prosopium cylindraceum), northern pike (Esox lucius), rainbow trout (Oncorhynchus mykiss) and slimy sculpin (Cottus cognatus).

Chinook migrating upstream of Schwatka Lake as adults and downstream as juveniles must negotiate the Whitehorse hydroelectric dam. The dam allows the upstream migration of fish through a fish ladder and the downstream passage either over the spillway or through the turbines. The available data suggest that 2-5% of fry and 16% of smolts experience mortality in the turbines of the dam (A. von Finster, pers. comm., October 27, 2002). There are two bridges within the City across the Yukon River; a road bridge

with pilings and a suspension footbridge. Neither of these structures presents an obstruction to fish passage.

Fish Questionnaire / Sampling Priority

Stewardship groups could assist the activities of DFO and YTG personnel by assisting in redd counts on the Yukon River within the City. This would assist in the determination of the extent of spawning areas within the City and also provide stewardship and educational opportunities.

Sites of High Site Sensitivity

Almost every reach of the Yukon River has been identified as an area of high site sensitivity due to the presence of extensive steep, eroding slopes adjacent to the stream channel. The observed high level of land use and development adjacent to the channel (AEM 2003) combined with the sensitivity of these areas suggests that the slopes above the Yukon River within the City should be selected as a focal site for more detailed terrain analysis.

3.2.2 Takhini River

Chinook are known to occur throughout the mainstem of Takhini River adjacent to the City limits (A. von Finster, DFP memorandum dated June 27 1999). The southern boundary of the Takhini River forms a portion of the City of Whitehorse municipal boundary, i.e., from the confluence of the Yukon and Takhini rivers to approximately eleven kilometers upstream (5km straight line distance). Neither chinook spawning nor migration occur within any of the tributaries of Takhini River within the City and it is not known whether rearing occurs in these areas (A. von Finster, pers. comm., March 2003). Many freshwater fish are documented to occur in the mainstem of Takhini River including: arctic grayling, long nose suckers, lake whitefish, broad whitefish, round whitefish, inconnu, northern pike, least cisco, lake chub and slimy sculpin. However, it is not known whether these species occur within any of the tributaries of Takhini River within the City.

There are no stream crossings on Takhini River or any of its tributaries within the City.

Sites of High Site Sensitivity

The mainstem of Takhini River and tributary 2 that lie within the City are identified as areas of high site sensitivity due to the presence of extensive steep, eroding slopes adjacent to the stream channel (AEM 2003). The observed high level of land use and development adjacent to the channel (AEM 2003) combined with the sensitivity of these areas suggests that the southern slopes above the Takhini River should be selected as a focal site for more detailed terrain analysis. In this situation the influence of land use practices outside the jurisdiction of the City also has contributed to the highlighting of this area, however, there remains land use within City limits that may contribute to slope instability of the south banks of Takhini River, i.e., Hidden Valley and MacPherson residential subdivisions.

3.2.3 Unnamed Creek (Little Takhini Creek)

Little Takhini Creek is an example of a non-natal stream within the City. Juvenile chinook salmon are documented to rear in the mainstem of Little Takhini from the mouth of the creek to the North Klondike Highway (FISS report, ID 958) but the creek is considered too small to sustain spawning chinook (A. von Finster, pers. comm., March 2003). Freshwater fish (grayling and northern pike) are known to use reach 1 of Little Takhini Creek (A. von Finster, pers. comm., March 2003) but no data are available on the distribution of freshwater fish upstream of reach 1.

There are a total of three stream crossings on Little Takhini Creek. The first crossing contains two embedded, oval, corrugated metal culverts approximately 40m long across the North Klondike Highway (Plate 1) on reach 5 of Little Takhini Creek. This set of culverts was considered a potential barrier to the upstream passage of juvenile chinook (AEM 2003). In an attempt to determine the status of these culverts as barriers to fish passage, fieldwork was conducted during the summer of 2003 to provide more detailed information following the culvert inspection procedures outlined in Parker (2000). Culvert measurements for this culvert were taken on August 29, 2003 and are outlined in Table 1. Based on the results of this more detailed assessment, the culverts across the North Klondike Highway on Little Takhini Creek do in fact present a barrier to the upstream passage of all fish species and age-classes due to their length and water velocity, i.e., 40m length culverts and minimum water velocity of 0.94 m/sec exceeds the swimming abilities of adult chinook (Parker 2000). Since adult chinook are the strongest swimmers, juvenile chinook and individuals of other fish species, if they were to occur at this point in the stream, would not be able to pass through these culverts (Parker 2000). Plate 1 also shows that the fill slope above these culverts is a source of sediment into Little Takhini Creek.

Characteristics of the channel downstream of the culverts taken on August 29, 2003 are outlined in Table 2. Approximately 35m downstream of the culverts across the North Klondike Highway on reach 5 of Little Takhini Creek is an obstruction to fish passage (UTM Zone 8 NAD83: 0488873E 6741737N). Old culvert materials lie in pieces within the creek and create a step of approximately 47cm outfall height (Plate 2). Juvenile chinook documented to occur on this reach would not be able to pass this obstruction.

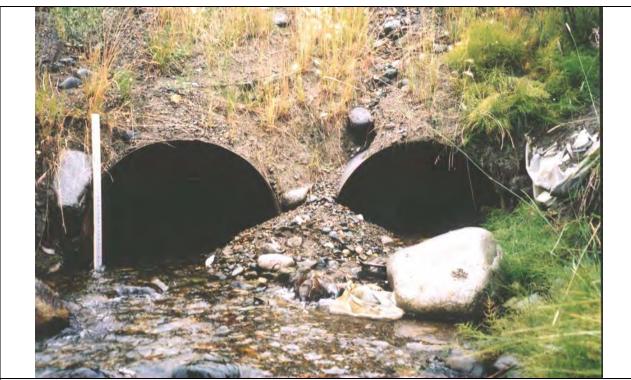


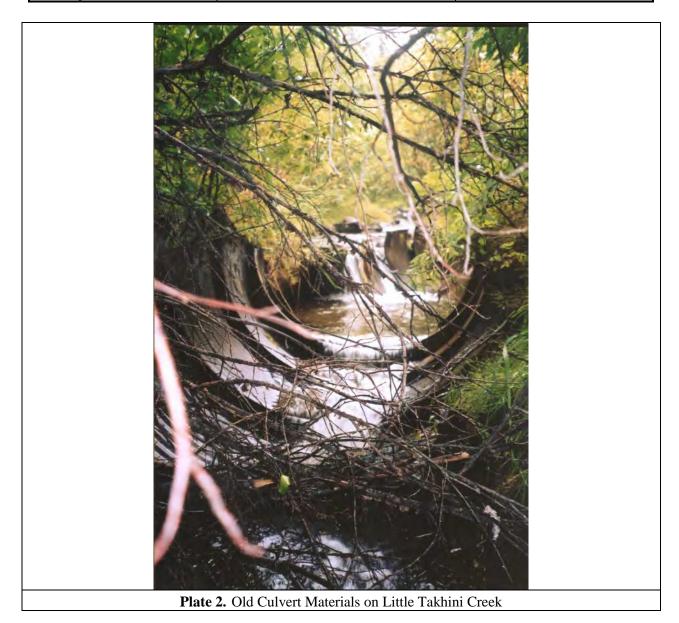
Plate 1. Culverts on Little Takhini Creek across the North Klondike Highway

Table 1. Characteristics of Culverts on Little Takhini Creek across the North Klondike Highway

Parameter	Culvert (Upstream Left)	Culvert (Upstream Right)
Culvert diameter (mm)	1100	1200
Culvert length (m)	40	40
Culvert material	Corrugated steel	Corrugated steel
Culvert water velocity (m/sec)	0.94	1.26
Culvert shape	Oval	Oval
Culvert wetted width (cm)	122	122
Culvert slope (%)	9	8
High water mark (cm)	47	45
Culvert water depth (cm)	6	13
Culvert outfall drop (cm)	0	0
Fill slope depth (m)	9.50	9.50
Pool depth at outfall (cm)	No pool	No pool

Table 2. Stream Characteristics Downstream of Culverts on Little Takhini Creek across the North Klondike Highway

Parameter	Below Culvert (Site 1)	Below Culvert (Site 2)
Wetted width (m)	2.05	2.70
Bankfull width (m)	1.53	2.56
Water depth (cm)	12.3	10
Bankfull depth (cm)	50	74
Stream water velocity (m/sec)	0.84	0.80
Stream gradient (%)	7	7



The second set of culverts on Little Takhini Creek are two perched, round, corrugated metal culverts approximately 70m long across the Alaska Highway (Plate 3) on reach 5. Culvert measurements for these structures were taken on August 29, 2003 following culvert inspection procedures outlined in Parker (2000) and are outlined in Table 3. The results of this more detailed assessment confirms that these culverts present a barrier to the upstream passage of fish on reach 5 of Little Takhini Creek due to the large outfall drop as well as the culvert length (70m) and water velocity (4.20m/sec).



Plate 3. Culverts on Little Takhini Creek across the Alaska Highway

Table 3. Characteristics of Culverts on Little Takhini Creek across the Alaska Highway

Parameter	Culvert (Upstream Left)	Culvert (Upstream Right)
Culvert diameter (mm)	1220	1220
Culvert length (m)	70	70
Culvert material	Corrugated steel	Corrugated steel
Culvert water velocity (m/sec)	NA ¹	4.20
Culvert shape	Round	Round
Culvert wetted width (cm)	20	62
Culvert slope (%)	4	4
High water mark (cm)	8	17
Culvert water depth (cm)	0.5	9
Culvert outfall drop (cm)	81	90
Fill slope depth (m)	9	9
Pool depth at outfall (cm)	22	25

¹ Insufficient water depth to measure water velocity in this culvert

Characteristics of the channel upstream of the culverts taken on August 29, 2003 are outlined in Table 4. Tables 2 and 4 provide information about the habitat quality of Little Takhini Creek that supplements the findings of habitat assessments conducted as part of previous work (AEM 2003). During summer 2002, a site was investigated on reach 7 of Little Takhini Creek (AEM site V7). Stream characteristics of this site are documented in Table 5.

Table 4. Stream Characteristics Upstream of Culverts on Little Takhini Creek across the Alaska Highway

Parameter	Above Culvert (Site 1)	Above Culvert (Site 2)
Wetted width (m)	1.16	1.34
Bankfull width (m)	2.02	2.52
Water depth (cm)	16	16
Bankfull depth (cm)	29.5	35
Stream water velocity (m/sec)	0.75	0.84
Stream gradient (%)	2	2

Table 5. Stream Characteristics of Site on Reach 7 of Little Takhini Creek

Characteristic	Description
Channel	
Dominant bed materials	Fines and gravels
Subdominant bed materials	Cobbles
Stream morphology	Step-pool
Riparian	
Crown closure (%)	20
Left bank shape	Undercut
Left bank texture	Fines and gravels
Left bank vegetation	Grasses and shrubs
Stage	Shrub
Right bank shape	Undercut
Right bank texture	Fines and gravels
Right bank vegetation	Grasses and shrubs
Stage	Shrub
Instream cover	
Small woody debris	Trace
Large woody debris	Subdominant
Boulders	None
Undercut banks	Dominant
Deep pools	Subdominant
Overstream vegetation	Subdominant
Instream vegetation	None
Total cover	Abundant
Functional LWD	Few
LWD distribution	Clumped

Due to the presence of abundant cover (large functional woody debris, undercut banks, overhanging vegetation and some deep pools) and low stream gradients, it would appear that the distribution of juvenile chinook in Little Takhini Creek is not limited by habitat quality but rather by the presence of the culverts across the North Klondike and Alaska Highways as well as the presence of old culvert materials within the creek on reach 5. Within 2.5 km upstream of the Alaska Highway, there is a natural obstruction to fish passage; a natural step of approximately 1.5m (Plate 4). This step likely represents the natural limit to juvenile chinook distribution in Little Takhini Creek.

The third stream crossing on Little Takhini Creek lies above the natural obstruction on reach 7; it is not known whether this crossing presents an obstruction to fish passage, the site was not field investigated.



Plate 4. Natural Step on Reach 7 of Little Takhini Creek

Restoration Activities

The distribution of juvenile chinook on Little Takhini Creek is limited by the presence of old culvert materials approximately 35m downstream of the North Klondike Highway, the presence of culverts across the North Klondike Highway and the presence of culverts across the Alaska Highway. Due to the close proximity of these obstructions, the effectiveness of the restoration of any one of these obstructions is related to the restoration of all three. While the removal of the old culverts materials approximately 35m downstream of the North Klondike Highway may be relatively inexpensive, the restoration of the culverts across the Klondike Highway and the removal and replacement of the culverts across the Alaska Highway would be very costly and disruptive to traffic on two major highways. However, these structures still result in a "net loss" of habitat and as such are not in accordance with current administration of the Fisheries Act (DFO 1986). The 2.5 km of stream length plus the distance between the three obstructions equates to a significant amount of productive habitat that is currently unusable. It is therefore recommended that when these structures are replaced, fish passage is ensured.

In the absence of any information regarding the presence of freshwater fish upstream of reach 1 on Little Takhini Creek, any potential restoration plans for the third crossing on reach 7 of this creek is considered premature.

Fish Questionnaire / Sampling Priority

Given the presence of obstructions on Little Takhini Creek, the potential suitability of fish habitat within this creek and the lack of information on the presence of freshwater fish, this creek should be considered of high priority for sampling in any freshwater fish surveys or fish survey questionnaires conducted in the future.

Water Sampling Priority

In the absence of culvert restoration, it is suggested that the culverts on Little Takhini Creek across the North Klondike Highway be selected as a focal site for water quality testing (especially sediment testing) due to the presence of the eroding fill slopes above the culverts. Given the presence of downstream chinook rearing habitat, this should be considered of high priority.

3.2.4 Unnamed Creek (Nine Mile Creek)

Nine Mile Creek is a small creek (approximately 3.5km mainstem length) that is subject to moderate to low stream flows. It is not known whether chinook or freshwater fish occur within Nine Mile Creek; no fish sampling has been conducted to date.

There are a total of three stream crossings on Nine Mile Creek. The first is approximately 40% embedded, round, corrugated metal culvert approximately 20m long, installed across a slip road of the Alaska Highway. Summer 2003 fieldwork provides more detailed sampling of this culvert following

culvert inspection procedures outlined in Parker (2000). Culvert measurements for this culvert were taken on August 29, 2003 and are outlined in Table 6. Characteristics of the channel downstream of the culvert taken on August 29, 2003 are outlined in Table 7. These results suggest that this culvert is a barrier to the upstream passage of fish; the culvert is approximately 20m long and water velocity within the culvert is 1.21 m/sec. These measurements exceed the threshold swimming abilities of juvenile chinook and other fish species and lie on the boundary of the swimming abilities of adult chinook.

Table 6. Characteristics of Culvert on Nine Mile Creek across Slip Road of the Alaska Highway

Parameter	Culvert
Culvert diameter (mm)	650
Culvert length (m)	20
Culvert material	Corrugated steel
Culvert water velocity (m/sec)	1.21
Culvert shape	Round
Culvert wetted width (cm)	60
Culvert slope (%)	NA ¹
High water mark (cm)	24.5
Culvert water depth (cm)	10
Culvert outfall drop (cm)	0
Fill slope depth (m)	7.10
Pool depth at outfall (cm)	No pool

¹ Culvert contained slight drop of ~10cm on upstream end, therefore an accurate culvert slope could not be determined.

Table 7. Stream Characteristics Downstream of Culvert on Nine Mile Creek across Slip Road of the Alaska Highway

Parameter	Below Culvert (Site 1)	Below Culvert (Site 2)
Wetted width (m)	0.79	0.75
Bankfull width (m)	0.80	0.72
Water depth (cm)	22	17
Bankfull depth (cm)	29	25.5
Stream water velocity (m/sec)	0.77	0.77
Stream gradient (%)	5	5

The second culvert is approximately 50% embedded, round, corrugated metal culvert of approximately 40m long installed across the Alaska Highway. Summer 2003 fieldwork provides more detailed sampling of this following culvert inspection procedures outlined in Parker (2000). Culvert measurements for this culvert were taken on August 29, 2003 and are outlined in Table 8. Characteristics of the channel upstream of the culvert taken on August 29, 2003 are outlined in Table 9. These results suggest that this culvert is a barrier to the upstream passage of fish; the culvert is approximately 40m long, and water velocity within the culvert is 1.19 m/sec the gradient of the stream is 3%. These measurements exceed the threshold swimming abilities of adult chinook and other fish species, i.e., water velocity in a culvert

greater than 24.4m long cannot exceed 0.9m/sec and remain passable to adult chinook and therefore any fish species (Parker 2000).

Table 8. Characteristics of Culvert on Nine Mile Creek across the Alaska Highway

Parameter	Culvert
Culvert diameter (mm)	900
Culvert length (m)	40
Culvert material	Corrugated steel
Culvert water velocity (m/sec)	1.19
Culvert shape	Round
Culvert wetted width (cm)	89
Culvert slope (%)	3^1
High water mark (cm)	39
Culvert water depth (cm)	13
Culvert outfall drop (cm)	0
Fill slope depth (m)	24.5
Pool depth at outfall (cm)	No pool

¹ Culvert slope based on stream gradient

Table 9. Stream Characteristics Upstream of Culvert on Nine Mile Creek across the Alaska Highway

Parameter	Above Culvert (Site 1)	Above Culvert (Site 2)
Wetted width (m)	1.04	0.92
Bankfull width (m)	1.96	0.97
Water depth (cm)	18	17
Bankfull depth (cm)	28	28.8
Stream water velocity (m/sec)	0.35	0.61
Stream gradient (%)	4	4

The third culvert on Nine Mile Creek is a perched, round, corrugated metal culvert approximately 5m long that has been laid across a trail upstream of the Alaska Highway. This last culvert is not properly installed; it is not embedded in the stream channel but rather lies on the surface of the streambed (Plate 5) thereby disrupting fish passage.

Restoration Activities

All culverts on Nine Mile Creek are barriers to upstream fish passage. Given the close proximity of these culverts, the effectiveness of the restoration of one culvert is dependant upon the restoration of all three. Given the lack of information on the presence of fish, the benefits of any restoration activities could not at present be measured. Until this information is available, any potential culvert restoration activities may be premature.

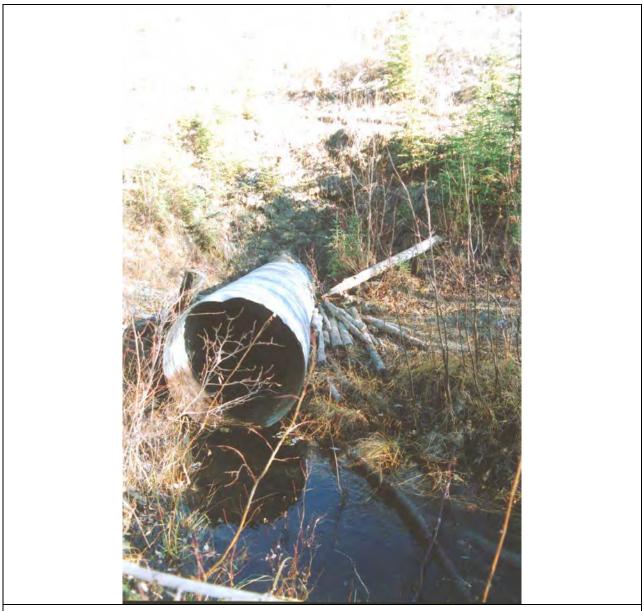


Plate 5. Culvert on Nine Mile Creek across Trail beside the Alaska Highway

The third culvert on reach 2 of Nine Mile is a source of sedimentation into the creek (Plate 5). The culvert lies across a trail used for motorized and non-motorized recreation. It is suggested that either the culvert be replaced with a small bridge or a boardwalk following guidelines outlined in Forest Practices Code, Fish Stream Crossing Guidebook (2002) or the trail be deactivated. Restoration activities should adhere to Fisheries Act and Yukon Waters Act regulations and be conducted under the auspices of the appropriate regulatory authorities, i.e., DFO and YTG.

Fish Questionnaire / Sampling Priority

Given the presence of obstructions on Nine Mile Creek, the lack of information on the presence of fish and moderate to low stream flows in Nine Mile Creek, this creek should be considered of moderate priority for sampling in any freshwater fish surveys or fish survey questionnaires that are to be conducted in the future.

Water Sampling Priority

In the absence of culvert restoration, it is suggested that the culvert on Nine Mile Creek across the trail beside the Alaska Highway be selected as a focal site for water quality testing (especially sediment testing) due to the presence of the improperly installed culvert. However due to the absence of chinook in this stream and the lack of information on the presence of freshwater fish, this should be considered of moderate priority.

3.2.5 MacAuley Creek

MacAuley Creek is a small stream (approximately 5.5km mainstem length) that is subject to moderate to low stream flows. It is not known whether chinook or freshwater fish occur within MacAuley Creek; no fish sampling has been conducted to date. A field investigation conducted on October 8, 2002 provides an overview of the stream characteristics downstream of the culverts on reach 3 (Table 10).

There are a total of twelve stream crossings within MacAuley Creek; at least two of which are barriers to the upstream passage of fish; two perched (>0.5m outfall drop), round, corrugated metal culverts approximately 20m long on reach 3 across the northern access route to the Crestview Sewage Lagoon (Plate 6) and one, perched, round, corrugated metal culvert approximately 40m long on reach 4 across the Alaska Highway. Field sampling conducted on January 11, 2004, showed that both sets of culverts on reach 3 of MacAuley Creek across the access routes to the Crestview Sewage Lagoon were full of ice and no water was able to pass through either set of culverts.

Restoration Activities

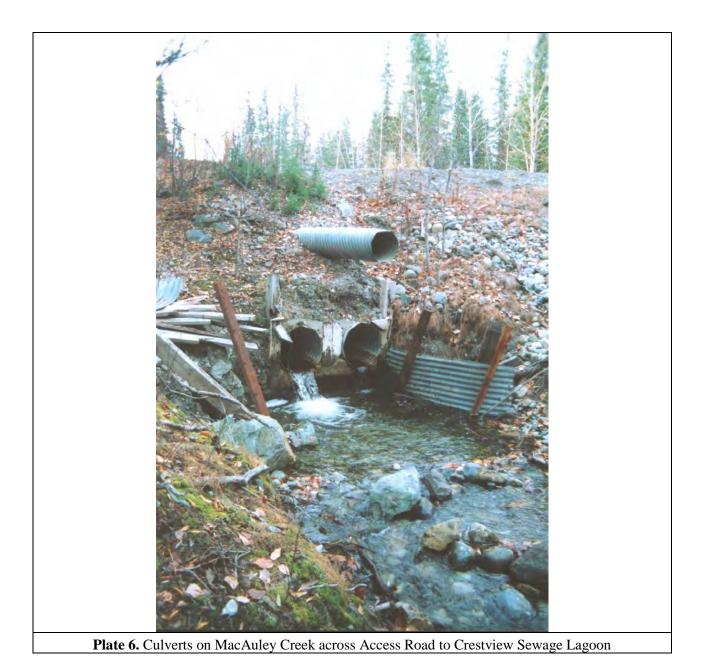
In the absence of information on the occurrence of fish species on MacAuley Creek, the potential effects of these culverts on fish distribution in MacAuley Creek is unknown and any potential restoration plans for culverts would be premature until this fish distribution information is obtained.

Fish Questionnaire / Sampling Priority

Given the presence of obstructions to fish passage, the absence of information on the occurrence of fish species on MacAuley Creek, the moderate to low stream flows, this creek should be considered a moderate priority for sampling in any chinook or freshwater fish surveys or fish survey questionnaires that are to be conducted in the future.

Table 10. Stream Characteristics Downstream of Culverts on Reach 3 on MacAuley Creek

Parameter	Below Culverts	
	0.00	
Wetted width (m)	0.90	
Bankfull width (m)	1.25	
Water depth (cm)	17	
Bankfull depth (cm)	26	
Stream gradient (%)	12	
Channel		
Dominant bed materials	Cobbles	
Subdominant bed materials	Gravels and fines	
Stream morphology	Step-pool	
Riparian		
Crown closure (%)	20	
Left bank shape	Sloping	
Left bank texture	Fines and gravels	
Left bank vegetation	Mixed forest	
Stage	Young forest	
Right bank shape	Sloping	
Right bank texture	Fines and gravels	
Right bank vegetation	Mixed forest	
Stage	Young forest	
Instream cover		
Small woody debris	Subdominant	
Large woody debris	Subdominant	
Boulders	None	
Undercut banks	Trace	
Deep pools	Trace	
Overstream vegetation	Dominant	
Instream vegetation	None	
Total cover	Moderate	
Functional LWD	Few	
LWD distribution	Clumped	



Water Sampling Priority

It is suggested that the reach 8 of MacAuley Creek mainstem and tributary 4 of MacAuley Creek be selected as a focal site for water quality testing due to the presence of a snow dump. However due to the lack of information on the presence of fish, this should be considered of moderate priority.

3.2.6 Croucher Creek

Croucher Creek is a non-natal stream, i.e., adult chinook do not spawn within the creek but juveniles migrate into the creek from the Yukon River to rear (Bradford et al. 2001). Chinook are known to rear as far upstream as reach 2 on both the north and south fork of Croucher Creek. There is no indication from the literature that the distribution of juvenile chinook is limited by the presence of culverts on either the north or south forks of Croucher Creek. However, there is some indication that distribution is limited on the north fork downstream of the Livingstone Trail (A. von Finster, field studies conducted July – August 1985).

There are three stream crossings on Croucher Creek. The first is a bridge on the Sewage Lagoon Road across the mainstem of Croucher Creek and the second is a culvert on reach 1 of the south fork across Livingstone Trail. Neither of these structures presents a barrier to fish passage (AEM 2003). The third stream crossing is an improperly installed culvert on reach 2 on the north fork of Croucher Creek (AEM 2003). This culvert is currently washed out and has the potential to release sediment into areas used by rearing chinook, affect downstream morphology and present an obstruction to fish passage. Plate 7 shows the status of this culvert in the summer of 2002 and Plate 8 (summer 2003) shows how much road materials have been washed into the creek since 2002. Summer 2003 fieldwork provides more detailed sampling of this site following culvert inspection procedures outlined in Parker (2000). Culvert measurements for both culverts taken on August 30, 2003 are outlined in Table 11.

Table 11. Characteristics of Culverts on North Fork of Croucher Creek across Livingstone Trail

Parameter Culvert	
Culvert diameter (mm)	1200
Culvert length (m)	8
Culvert material	Corrugated steel
Culvert water velocity (m/sec)	0.0^{1}
Culvert shape	Round
Culvert wetted width (cm)	109
Culvert slope (%)	NA^2
High water mark (cm)	24
Culvert water depth (cm)	24
Culvert outfall drop (cm)	0
Fill slope depth (m)	NA ³
Pool depth at outfall (cm)	No pool

¹ Water backed up in culvert; water velocity immediately adjacent to culvert where fill slope was washed away was 1.87m/sec

² Culvert collapsed and depressed in the middle, therefore an accurate culvert slope could not be determined

³ Fill slope washed away

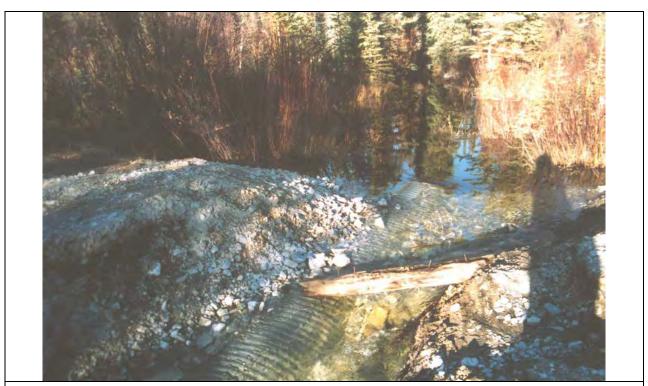


Plate 7. Culvert on Croucher Creek across Livingstone Trail October 2002



Plate 8. Culvert on Croucher Creek across Livingstone Trail August 2003

Table 12. Stream Characteristics Downstream and Upstream of Culverts on North Fork of Croucher Creek across Livingstone Trail

Parameter	Below Culvert	Above Culvert
Wetted width (m)	2.5	4
Bankfull width (m)	3.0	4
Water depth (cm)	50	1.6
Bankfull depth (cm)	80	1.6
Stream water velocity (m/sec)	0.91	0.0
Stream gradient (%)	0.5	0

The stream channel upstream of the culvert is backed up by the presence of the washed out culvert and a blockage at the upstream end of the culvert. The channel downstream of the culvert is characterized by frequent beaver damming activity. Characteristics of the channel downstream and upstream of the culvert taken on August 30, 2003 are outlined in Table 12.

Freshwater fish are known to occur throughout Croucher Creek. Slimy sculpin and northern pike are documented on reach 2 of both the north and south forks of Croucher Creek. The culvert on the north fork of Croucher Creek across the Livingstone Trail therefore has the potential to impede the movements of freshwater fish within the north fork. Lake chub, long nose suckers, rainbow trout and arctic grayling are known to occur on reach 3 of the south fork of Croucher Creek in Beaver / Livingstone Pond (P. Roach, field survey July 8, 1998).

Restoration Activities

The main concern regarding the presence of the culvert on the north fork of Croucher Creek across the Livingstone Trail remains to be the continual release of sediment downstream where chinook are known to rear and the potential this increased sedimentation has to impact the integrity of rearing (including over-wintering) habitat in these areas. It is recognized that Livingstone Trail is an unmaintained road, however, recreationalists use this trail regardless; at present a makeshift stream crossing is in place. In the absence of a complete road closure / deactivation, it is suggested that the culvert is replaced by a bridge following guidelines outlined in Forest Practices Code, Fish Stream Crossing Guidebook (2002). If the road is to be deactivated, it is suggested that the site be restored, i.e., culvert removed, the slope stabilized and the streambed reclaimed. Particular care should be taken to contain any sediment release during any restoration activities and these activities should adhere to the relevant regulations, i.e., Fisheries Act and Yukon Waters Act. Restoration activities should be conducted under the auspices of the appropriate regulatory authorities, i.e., DFO and YTG.

Sites of High Site Sensitivity

Site sensitivity is considered high on reach 2 of the north fork of Croucher Creek due to the presence of seepage slopes adjacent to the stream (AEM 2003). Slope movement and erosion are likely exacerbated at this site by frequent, long-term fluctuations in water level related to beaver activity on this reach.

3.2.7 McIntyre Creek

Chinook are documented to spawn as far upstream as reach 5 below the Alaska Highway on McIntyre Creek. The distribution of spawning chinook is thought to be naturally limited by beaver activity and wetland habitat on reach 6 and not impeded by the presence of the culverts across Range Road or Mountain View Drive. The upstream migration of juvenile chinook is, however, thought to be limited by the presence of the culverts across Range Road (A. von Finster, DFO memorandum dated April 18, 1994); two perched, round, corrugated metal culverts approximately 20m long, and would also likely be limited by two perched, round, corrugated culverts approximately 100m long across Mountain View Drive. Natal chinook are documented to rear as far upstream as reach 4 on McIntyre Creek (A. von Finster, DFO memorandum dated April 18, 1994; A. von Finster field survey July 20, 1999) and are thought not to be impeded in their downstream passage by these culverts. Freshwater fish (arctic grayling, round whitefish, lake trout, long nose suckers, slimy sculpin, burbot and rainbow trout) occur throughout McIntyre Creek watershed. It is possible that the culverts across Range Road and Mountain View Drive may impede the upstream passage of freshwater fish.

Beyond the region of chinook distribution in McIntyre Creek there are two embedded, round, corrugated metal culverts approximately 40m long across the Alaska Highway on reach 6 of McIntyre Creek (AEM 2003). These culverts do not appear to be an obstruction to fish passage (AEM 2003). There is a natural obstruction to the upstream passage of fish on reach 7; a rock fall (A. von Finster, pers. comm., March 2003).

Upstream of the confluence of McIntyre Creek and the locally known Reservoir Creek on reach 8, water levels decline significantly; much of the water in McIntyre Creek downstream of the confluence is fed by Reservoir Creek and controlled by the Yukon Electric Company Ltd. hydroelectric facilities. There are seven additional stream crossings on McIntyre Creek above the confluence of Reservoir Creek, one of which is a culvert that appears to not present a barrier to fish passage; an embedded, round corrugated culvert of approximately 30m long. The potential for any effect of these crossings on freshwater fish distribution in McIntyre Creek in this section is unknown; no fish sampling has been conducted to date in this section of the creek (AEM 2003).

Freshwater fish do occur in Reservoir Creek. There are two hydroelectric dams on Reservoir Creek that are complete obstructions to the passage of fish and a number of additional stream crossings, one of which is likely a barrier to the upstream passage of fish; two perched, round, corrugated culverts approximately 20m long across Copper Haul Road (AEM 2003).

Range Road Dump

The old Range Road Dumpsite is situated on the slopes above the confluence of McIntyre Creek and the Yukon River. This dump was first used by the U.S. army during WWII between 1942 and 1945 and then

operated as a municipal dump for the City of Whitehorse between approximately 1950 and 1975 (Axbey and Slonski 1986). While the amount and type of waste disposed of during WWII is unknown, it is known that the site was the primary disposal site for the City for more than twenty years and during that time received large volumes of waste (Stanley Associates Engineering Ltd., 1992). At that time, refuse material included household waste, automobiles (estimated 2000 vehicles), demolition debris, septic tank contents and waste oils (Stanley Associates Engineering Ltd., 1992). The site was operated as an open dump and wastes were often burned and regularly pushed over the edge of the slope. Some waste would then deposit directly into McIntyre Creek and the Yukon River (Stanley Associates Engineering Ltd., 1992). In 1968 a mass movement of earth and refuse entered the creek (Axbey and Slonski 1986). In an attempt to minimize the deposition of these materials into McIntyre Creek, the creek was diverted away from the toe of the slope and separated from the original channel by a berm and in 1975 the Range Road Dump was officially closed. In 1991, a restoration program was conducted that resulted in the removal of several hundred tires from the Yukon River shoreline (Stanley Associates Engineering Ltd., 1992).

Results of water sampling conducted between 1983 and 1985 at the Range Road Dump site showed "elevated levels of metals, plus other parameters such as ammonia, phosphates, sulphates and chemical oxygen demand (COD)....There were no elevated levels of PCBs or pesticides" (Axbey and Slonski 1986). PCBs were recorded in one of the two ponds at the foot of the slope in McIntyre Creek (Axbey and Slonski 1986). Sediment sampling conducted in 1990 reported low levels of PCBs in both ponds and the mouth of McIntyre Creek (Environment Canada 1991).

In 1992, Stanley Associates Engineering Ltd. completed a detailed subsurface investigation of the Range Road Dump. The objectives of the project were to establish whether the site was contaminated with PCB's, toxaphene or other organic chemicals that may have been disposed of at the dump and if so, determine the source and location of any contamination and potentials risks to McIntyre Creek and the Yukon River (Stanley Associates Engineering Ltd., 1992). As part of this study, Stanley Associates Engineering Ltd. analyzed groundwater samples taken from 10 newly installed groundwater wells. Analysis investigated levels of PCB's, persistent pesticides, petroleum hydrocarbons, chlorinated organics, trace metals and routine potability. Toxicity tests were also conducted using *Daphnia magna*. The results of this study show that although the deposition of wastes at the dump has had a measurable impact on groundwater quality, the impacts were considered to be minor (Stanley Associates Engineering Specifically, pesticides, PCB's, chlorinated organics, heavy metals and petroleum Ltd., 1992). hydrocarbons were below detection limits and the results of toxicity tests show that all groundwater samples (diluted and undiluted) were non-toxic to Daphnia magna. Groundwater samples down gradient of the dump did show some enrichment of sulphates, chlorides, nitrates, total organic carbon, iron and manganese, chemical oxygen demand (COD) and electrical conductivity however these increases were considered minor (Stanley Associates Engineering Ltd., 1992). It was also considered unlikely that groundwater from the dump would result in measurable changes to downstream surface water (Stanley Associates Engineering Ltd., 1992).

Restoration Activities

The culverts on McIntyre Creek across Range Road and Mountain View Drive do impede the passage of juvenile fish and potentially freshwater fish. However given adult chinook are able to navigate these culverts and juvenile chinook are not impeded in their downstream passage through these culverts, any suggested mitigation would be classed as a low priority. In the absence of any information regarding the presence of freshwater fish upstream of the confluence between McIntyre Creek and Reservoir Creek, any potential restoration plans for these crossings would be premature. Given the existing disruption of passage of freshwater fish on Reservoir Creek, i.e., two hydroelectric dams, any mitigation activities suggested for the culverts across Copper Haul Road on Reservoir Creek would be classed as a low priority.

The results of any groundwater, surface water and sediment sampling conducted on the Range Road Dump site (see below) would provide guidance to the utility and nature of any future restoration activities. However, future restoration activities on this site could include:

- The recovery and recycling of the scrap steel and tires still visible on the slopes and within the valley bottoms of McIntyre Creek and Yukon River (Stanley Associates Engineering Ltd., 1992). There have been a number of restoration programs conducted at this site over the years by local stewardship groups and government bodies that have resulted in the removal of tires and other waste materials by hand (DFO Memorandum from J. Jang dated August 2, 1999; A. Strutkowski, pers. comm., January 8, 2004). The waste materials that remain on site require removal by heavy equipment and therefore these activities will present many logistical considerations. For example, upgrading of the access route into the site in order to support heavy equipment, access to waste materials on the slope and above the ponds and the financial considerations of contracting heavy equipment to move the large volume of waste on site. Any restoration activities conducted on site should adhere to the relevant regulations, i.e., Fisheries Act and Yukon Waters Act, and be conducted under the auspices of the appropriate regulatory authorities, i.e., DFO and YTG.
- Following the removal of waste materials from the surface of the Range Road Dump site, revegetation is suggested (Stanley Associates Engineering Ltd., 1992). Efforts have been made over the years to revegetate the site (A. von Finster, email to G. Kent June 13, 2000) but have not as yet resulted in a notable level of revegetation. Recommendations outlined in Stanley Associates Engineering Ltd. (1992) include topsoil placement and / or active replanting and vegetation monitoring. Any restoration activities conducted on site should adhere to the relevant regulations, i.e., Fisheries Act and Yukon Waters Act, and be conducted under the auspices of the appropriate regulatory authorities, i.e., DFO and YTG.
- Another recommendation of the study by Stanley Associates Engineering Ltd. (1992) was the
 removal of the two large ponds at the toe of the slope above McIntyre Creek with the understanding
 that the presence of these ponds currently saturates a larger portion of the basal wastes in the dump.
 By recontouring the slope and allowing surface water to shed directly into McIntyre Creek, the local

water table would be reduced and the saturation zone diminished (Stanley Associates Engineering Ltd., 1992). The results of the monitoring program would be instrumental in determining whether this is a viable recommendation or if it would be more advisable to remove surface water for treatment off site. If it were determined that the diversion channel be maintained, it has been recommended that the upstream berm be stabilized to ensure McIntyre Creek does not flow through the ponds (A. von Finster, pers. comm., March 2004). Any restoration activities conducted on site should adhere to the relevant regulations, i.e., Fisheries Act and Yukon Waters Act, and be conducted under the auspices of the appropriate regulatory authorities, i.e., DFO and YTG.

Water Quality Sampling Priority

To the understanding of the authors, there has been no monitoring conducted at the Range Road Dumpsite since 1992 (R. Hall pers. comm., January 20, 2004). It is recommended that a monitoring program be designed and initiated at the Range Road Dump site with the aim to provide a more current picture of the status of groundwater, surface water and sediments on site. The sampling design should consider previous data collected in order to build upon the baseline work that has been conducted on site (Axbey and Slonski 1986; Environment Canada 1991; Stanley Associates Engineering Ltd., 1992). Sampling could be conducted in the same locations as in the previous work; it may be possible to collect groundwater samples using the original wells if these sites are still intact and collect surface water and sediment samples at the original locations in McIntyre Creek, Yukon River as well as in the ponds that lie at the foot of the slope in McIntyre Creek. This water sampling program could be combined with a sediment sampling program in the creek near Mountain View Drive on McIntyre Creek (see below) and water sampling on reaches 4 and 5 of McIntyre Creek. Levels of recreational activity on reaches 4 and 5 are considered high (R. Burnett pers. comm., March 2004) and include an informal creek crossing used by ATVs that may be a source of sedimentation and / or pollution into the creek. Given the presence of spawning and rearing chinook as far as reach 6 on McIntyre Creek water sampling at this site would be considered a priority.

Sites of High Site Sensitivity

The slopes above Mountain View Drive on McIntyre Creek have been identified as being sensitive to slumping and increased risk of sedimentation into McIntyre Creek (AEM 2003). The observed high level of land use and development adjacent to the channel (AEM 2003) combined with the sensitivity of these areas suggests that this area should be selected as a focal site for more detailed terrain analysis.

3.2.8 Unnamed Creek (Marwell Creek)

Marwell Creek is a small stream (approximately 3km mainstem length) that is subject to low stream flows. It is not known whether chinook or freshwater fish occur in Marwell Creek; no fish sampling has been conducted to date. Although juvenile chinook and juvenile freshwater fish of unknown species are

known to rear at the mouth of Marwell Creek (A. von Finster, pers. comm., November 1, 2002), passage into Marwell Creek is thought to be impeded by the presence of beaver dams at the mouth. (A. von Finster, pers. comm., November 1, 2002). However, these dams and wetlands may not be permanent barriers to fish passage if water levels in the wetlands fluctuate and although it is considered unlikely that chinook or freshwater fish species could occur above Marwell Wetlands (A. von Finster, pers. comm., March 2003), this has not been confirmed. In the absence of this information, the presence of three obstructions to fish passage on Marwell Creek is not currently considered a priority for culvert restoration activities relating to fish passage.

Marwell Tar Pit

A petroleum refinery was operated within the Marwell Creek drainage between 1944 and 1945 by Standard Oil of California under a contract from the US government (R. Hall, pers. comm., March 2004). During the dismantling of refinery, the site (locally known as the Marwell Tar Pit) was created within the old berm of one of the refinery storage tanks. The tar pit site was transferred to the Government of Yukon by the federal government as part of a block land transfer in 1979 (R. Hall, pers. comm., March 2004).

In 1989, Environment Canada investigated the influence of the Marwell tar pit on the surface water and soil quality of Marwell Creek drainage. Water samples were taken upstream and downstream of the influence of the tar pit site and from standing water within the tar pit. Chemical analyses were also conducted on soil samples and tar samples taken from the tar pit site (Environment Canada memorandum from J. Eamer to File 4186-3-19, 21st September 1989). Water samples taken from the creek were analyzed for metals, total organic and inorganic carbon, pH, chemical oxygen demand (COD) and oil and grease content. Results of these tests showed that there was no contamination in the surface water of Marwell Creek from the tar pit; no parameters analyzed in the downstream sample differed significantly from the upstream sample. However, water samples taken from the tar pit showed elevated levels of manganese. Manganese was also released from the soil samples from the tar pit. Oil and grease were extracted during analysis from the soil samples from the tar pit. Analyses of samples of tar from the pit detected PCBs and hydrocarbons (Environment Canada memorandum from J. Eamer to File 4186-3-19, 21st September 1989).

In 1990 and 1991, Piteau Engineering conducted a Phase I Site Assessment of the Tar Pit site (Piteau Engineering Ltd. 1990; Piteau Engineering Ltd. 1991). The results from 16 boreholes and 4 piezometers installed at the site indicated soils with high levels of petroleum contamination; oil and grease levels were high, heavy hydrocarbon fractions predominated and elevated concentrations of BTEX compounds were also detected. The presence of BTEX compounds raised particular concerns given their mobility and toxicity. Polycyclic aromatic hydrocarbons (PAHs) were also found in the soil samples that also raised concerns given their toxicity as human carcinogens. The results of groundwater analyses indicated high levels of oil and grease, trace levels of BTEX, elevated total petroleum hydrocarbons and dissolved organic carbon.

In 1992, Piteau Engineering conducted a Phase II Site Assessment of the Tar Pit site in an attempt to delineate more precisely the distribution and nature of petroleum contaminated soils and describe detailed guidelines for site remediation, if necessary (Piteau Engineering Ltd. 1992). Soil samples taken from 19 newly installed boreholes were sampled for total petroleum hydrocarbons, BTEX compounds (i.e., benzene, toluene, ethylbenzene, and xylene), polycyclic aromatic hydrocarbons (PAHs) and chlorinated volatile and semi-volatile organic compounds. Groundwater samples taken from 5 newly installed and 1 previously installed piezometers were sampled for standard, halide and organic parameters including dissolved organic carbon, total petroleum hydrocarbons, BTEX compounds, polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds, including chlorinated solvents. Results were compared to Quebec contaminated sites cleanup guidelines to possible remedial actions assuming commercial and industrial land use of this area (Ministere de l'Environment, Quebec 1988). Significant results include:

- Results of the analysis of soil samples taken from 19 boreholes showed that the Tar Pit site contained an estimated 26,096m³ of soil with over 1000ppm total petroleum hydrocarbons (TPH), 14,664m³ of soil with over 5000ppm TPH and 7,525m³ of soil over 10,000ppm TPH.
- Results of the laboratory analysis of soil samples showed that the concentration of BTEX compounds (specifically benzene, ethlybenzene and xylene) in the soil exceeded Quebec guidelines for commercially zoned areas.
- It was also discovered that BTEX concentrations may have been underestimated based on the results of a comparison between laboratory and field based estimates of BTEX concentration. Field estimates of the vapour phase analysis of BTEX compounds were conducted using a portable gas chromatograph. Field data suggested that significant levels of vapour phase BTEX continue to be generated from the Tar Pit site and therefore remain available for volatilization in air as well as solution in groundwater (Piteau Engineering Ltd. 1992).
- Results of soil analysis showed that the concentration of PAH (i.e., total PAH, naphthalene, phenanthrene and pyrene) exceeded Quebec guidelines for commercially and industrially zoned areas at sites within the Tar Pit.
- Results of soil analysis showed that no sites exceeded Quebec guidelines for chlorinated solvents, common pesticides and PCBs on commercially zoned areas. One sample exceeded Quebec guidelines for lead concentrations on industrially zoned areas.
- Results of groundwater analysis showed that significant levels of BTEX contamination were detected
 in groundwater within the Tar Pit site, i.e., benzene, toluene, ethlybenzene and xylene exceeded
 Quebec guidelines for commercially and / or industrially zoned areas at sites within the Tar Pit.

Results of groundwater analysis showed that PAHs were detected in groundwater at sites within the
Tar Pit, i.e., naphthalene and 2-methlynaphthaleneconcentrations exceeded Quebec guidelines for
industrially zoned areas.

Following the recommendations outlined in the report provided by Piteau Engineering Ltd. (1992), Komex International Ltd. (1992) conducted a small supplementary drilling and sampling program to delineate the southern edge of the soil contamination and complete an expanded groundwater monitoring network that would allow for regular monitoring of the potential impacts of the Tar Pit on local groundwater quality (Komex International Ltd. 1992). No further water, soil or groundwater sampling has been conducted on Marwell Creek or on the site of the Tar Pit since this study.

Restoration Activities

In 1992, Piteau Engineering Ltd. recommended a remediation option for the Marwell Tar Pit based on a review of eleven alternatives (Piteau Engineering Ltd. 1992). The suggested option involved the excavation and disposal of highly contaminated material by asphalt mixing and the on-site incineration and disposal of less contaminated soil. In 1992, this option was thought to cost approximately \$5.5 million. The remediation option provided by Piteau Engineering Ltd. (1992) was not adopted and to date no full scale remediation activities have been conducted. A number of additional remediation options have been investigated through pilot demonstration programs (Pelly Construction Ltd. and Keystone Environmental Ltd. 1994; TriWaste Reduction Services Inc. 1994) but to date none have been adopted. The responsibility of the Marwell Tar Pit is currently under dispute (R. Hall, pers. comm., January 20, 2004).

It is suggested that YTG efforts to manage the Tar Pit be facilitated by supporting a ground and surface water quality and soil quality monitoring program (see below). Establishing a monitoring program would ensure that any changes in the ground and surface water of Marwell Creek do not go unnoticed. If sampling shows significant changes, the program would support YTG's efforts to obtain funding to rehabilitate this contaminated site.

Marwell Creek was identified in previous work as a site requiring clean up due to the presence of industrial / domestic garbage within Marwell Creek and in the adjacent riparian areas (AEM 2003). It is suggested that this restoration be conducted by qualified personnel trained in working in potentially contaminated environments rather than by stewardship groups. Any activities should be endorsed by the landowner, i.e., YTG and reviewed by YTG Water Resources for compliance with the Yukon Waters Act.

Water Sampling Priority

Concerns remain that the presence of BTEX compounds and PAHs in the soil and groundwater within Marwell Creek drainage could present a potential hazard to downstream fish and fish habitat if these compounds were to make their way into the surface water. It is therefore suggested that Marwell Creek

be selected as a high priority for ground and surface water quality and soil quality monitoring. Groundwater quality testing was also a recommendation of the Piteau Engineering Ltd. 1992 report in which it was suggested that existing piezometers as well as the expanded network of piezometers (Komex International Ltd. 1992) be monitored twice annually for concentrations of the parameters of concern, especially BTEX compounds and PAHs. This program should be conducted by qualified personnel trained in working in potentially contaminated environments, reviewed by the YTG Water Resources for compliance with the Yukon Waters Act and endorsed by the landowner, i.e., YTG.

Fish Questionnaire / Sampling Priority

Given concerns over the water quality of Marwell Creek and the occurrence of chinook and freshwater fish species at the mouth of this creek in the Yukon River and the absence of information on the occurrence of fish species on Marwell Creek, Marwell Marshlands should be considered a high priority for sampling in any chinook or freshwater fish surveys or fish survey questionnaires that are to be conducted in the future.

3.2.9 Unnamed Creek (Spook Creek)

Spook Creek is a small stream (approximately 1.5km mainstem length) subject to very low stream flows that has been significantly impacted by industrial and urban development such that much of the original stream morphology is no longer visible. It is considered unlikely that Spook Creek could provide valuable habitat to either chinook or freshwater fish species (A. von Finster, pers. comm., March 2003). Therefore despite the presence of eight potential obstructions to fish passage on Spook Creek, it is not currently considered a priority area for culvert restoration activities relating to fish passage.

Restoration Activities

Although restoration efforts in terms of fish passage enhancement are not recommended, it is suggested that the seven culverts on reach 1 of Spook Creek across Quartz Road be rehabilitated in order to maintain functional stream flow through Spook Creek. These culverts have the potential to be blocked by the deposition of large slope fill materials (mostly cobbles) from the slope above. In an attempt to mitigate the potential for culvert blockage, it is suggested that concrete headwalls and sidewalls be constructed above these culverts. Alternatively, the length of the culverts could be extended by attaching extensions to both the intake and outflows.

Water Sampling Priority

It is suggested that Spook Creek be selected as a focal site for water quality testing due to the proximity and extent of commercial / industrial areas and roads. Given the presence chinook rearing habitat and the presence of many freshwater fish species at the mouth of Spook Creek (A. von Finster, pers. comm., March 2003; DFO memorandum File No. 5830 C.O.W.), this should be considered of high priority.

3.2.10 Unnamed Creek (Basalt Creek)

Basalt Creek is a small creek (approximately 5km mainstem length) that is subject to low stream flows. It is considered unlikely that chinook spawn or rear in Basalt Creek (A. von Finster, pers. comm., March 2003). There is an obstruction to fish passage on Basalt Creek across the Alaska Highway; one perched, round, corrugated metal culvert approximately 40m long (AEM 2003). The potential for an effect of this culvert on freshwater fish distribution in Basalt Creek is unknown; no fish sampling has been conducted to date in this creek (AEM 2003).

Restoration Activities

In the absence of any information regarding the presence of freshwater fish on Basalt Creek, any potential restoration plans for the Alaska Highway culvert would be premature.

Fish Questionnaire / Sampling Priority

Given the presence of an obstruction, the lack of information on the presence of freshwater fish and low stream flows in Basalt Creek, this creek should be considered of moderate priority for sampling in any freshwater fish surveys or fish survey questionnaires that are to be conducted in the future.

Water Sampling Priority

It is suggested that Basalt Creek be selected as a focal site for water quality testing due to the proximity and extent of industrial areas and the Alaska Highway. Given the presence chinook at the mouth of Basalt Creek (A. von Finster, pers. comm., March 2003), this should be considered of high priority.

3.2.11 Unnamed Creek (MacRae Creek)

Chinook and freshwater fish species (arctic grayling, round whitefish, lake chub, northern pike, slimy sculpin and long nose suckers) occur on the lower two reaches of MacRae Creek below the boundary of the Meadow Lakes golf course (Letter from A. von Finster to N. Heap, October 5, 1997). It is thought that juvenile and adult chinook are unable to access MacRae Creek above the Meadow Lakes golf course due to low flows and locally high gradients downstream on reach 2 (A. von Finster, pers. comm., March 2003) and as a result these areas are also likely barriers to freshwater fish species passage.

There is also a complete barrier to fish passage on reach 5 of MacRae Creek across the Alaska Highway; one perched, round, corrugated culvert approximately 40m long (AEM 2003). There are an additional two stream crossings above the Alaska Highway culvert on the mainstem of MacRae Creek that are of unknown effect on fish passage (these crossings were not field investigated). The potential for an effect of these stream crossings on freshwater species in MacRae Creek is unknown; freshwater fish have not

been documented above reach 1 of MacRae Creek although potential freshwater fish habitat does occur throughout MacRae, Sowdon and Sima Creeks (AEM 2003).

Restoration Activities

In the absence of more information regarding the presence of freshwater fish upstream of reach 1, any potential restoration plans for the stream crossings across the Alaska Highway and above the highway would be premature. If it were determined that freshwater fish species do occur throughout MacRae Creek upstream of reach 1, the potential effect on freshwater fish movements of the three stream crossings on MacRae Creek mainstem should be investigated in more detail as well as the potential effect of the three stream crossings on tributary two of MacRae Creek (one of which is a complete barrier to fish passage), the potential effect of the six stream crossings on Sowdon Creek and the one complete barrier on Sima Creek (AEM 2003).

Fish Questionnaire / Sampling Priority

Given the presence of obstructions to fish passage and the potential for upstream freshwater fish habitat in MacRae, Sima and Sowdon Creeks, these creeks should be considered high priorities for sampling in any freshwater fish surveys or fish survey questionnaires that are to be conducted in the future.

3.2.12 Wolf Creek

Chinook are known to have spawned and reared as far upstream as reach 5 on Wolf Creek near Whitehorse Copper Mine (A. von Finster, pers. comm., March 2003). Beaver dams on reach 3 of Wolf Creek below the Alaska Highway intermittently impede the upstream migration of spawning chinook (A. von Finster, pers. comm. March 2003). Fisheries personnel, non-governmental organizations, individuals and high flood events have regularly breached these dams over the years but as of summer 2002 the dams were again in place (AEM 2003). As a result approximately 10 km of previously inhabited spawning grounds were not accessible due to presence of obstructing beaver dams.

There is one pipe arch culvert across the Alaska Highway on Wolf Creek that presents no barrier to the passage of chinook and a second stream crossing on reach 4 that also does not appear to present a barrier (AEM 2003).

There is a complete barrier to fish passage at the outlet of Mary Lake Creek; a beaver dam is in place that has created a dry channel downstream to the confluence with Wolf Creek. This obstruction has blocked any potential passage of chinook into Mary Lake Creek and the passage of freshwater fish between Mary Lake watershed and Wolf Creek.

Restoration Activities

The procedures outlined in the Telkwa Project (Finnigan and Marshall 1997) were investigated for application on Wolf Creek and were found to be inappropriate for use in this stream due to seasonally high flows (A. von Finster, pers. comm., April 2004). Other non-invasive or non-lethal methods are available for application in this creek (Yukon River Panel 2004; DFO 1999) if considered necessary. Any restoration activities conducted on site should adhere to the relevant regulations, i.e., Fisheries Act and Yukon Waters Act, and be conducted under the auspices of the appropriate regulatory authorities, i.e., DFO and YTG.

Although the beaver dam at the outlet of Mary Lake block passage of freshwater fish, given the absence of documented use of Mary Lake watershed by chinook and despite anticipated upstream values to freshwater fish species, no mitigation measures are recommended for the beaver dams at the outlet of Mary Lake.

Land use activity on reach 4 of Wolf Creek is considered high due to the proximity of Wolf Creek Campground, Alaska Highway, Cadet Camp, Pine Ridge and Wolf Creek country residential subdivisions, the railway tracks and various access routes (AEM 2003). Given the presence of spawning and rearing chinook on this reach, water sampling at this site would be considered a priority.

Fish Questionnaire / Sampling Priority

It is suggested that Mary Lake be considered a moderate priority for sampling in any freshwater fish surveys or fish survey questionnaires that may be conducted in the future.

3.2.13 Cowley Creek

Historically, chinook were thought to have spawned throughout Cowley Creek (A. von Finster, DFO memorandum July 27, 1997). Their current distribution is unknown but thought to be limited at present to below sites of beaver activity on reach 1 (A. von Finster, DFO memorandum July 27, 1997). Chinook have been documented to rear in the lower two reaches of Cowley Creek, however their distribution is also considered limited by these beaver dams (A. von Finster, DFO memorandum July 27, 1997) although in some years the dams may act as partial barriers, allowing the migration of juveniles but not adults (AEM 2003).

There is a documented (A. von Finster, DFO memorandum December 1, 1996) obstruction to fish passage on reach 2 of Cowley Creek across the Alaska Highway; two perched, round, corrugated metal culverts approximately 40m long.

Summer 2003 fieldwork provided more detailed sampling of the culverts across the Alaska Highway following culvert inspection procedures outlined in Parker (2000). Culvert measurements for both

culverts taken on August 30, 2003 are outlined in Table 13. Plate 9 shows the upstream left culvert across the Alaska Highway. Characteristics of the channel downstream of the culvert on the same reach taken on August 30, 2003 are outlined in Table 14. Stream measurements were not taken upstream of the culvert since the upstream channel lies on a new reach. These results confirm that the culverts on Cowley Creek across the Alaska Highway present a barrier to the upstream passage of adult chinook due to their length and the water velocity within the culverts (Parker 2000); 40m length culverts and a minimum water velocity of 3.33m/sec. These measurements exceed the threshold swimming abilities of adult chinook and therefore other fish species that may occur within the creek (Parker 2000). Therefore the freshwater fish species (arctic grayling, lake chub and slimy sculpin) that are known to occur in Cowley Creek on either side of the Alaska Highway culverts, are likely not able to pass through these culverts. These culverts therefore likely block passage of chinook and freshwater fish species from Yukon River into Cowley Creek and within Cowley Creek.

There is a second culvert on Cowley Creek approximately 1300m from the Alaska Highways culverts. This culvert is an open bottomed arched, corrugated culvert of approximately 20m long that presents no barrier to fish passage (AEM 2003). There is an additional stream crossing on reach 3 of Cowley Creek; a ford. This structure does not appear to present an obstruction to fish passage (AEM 2003).

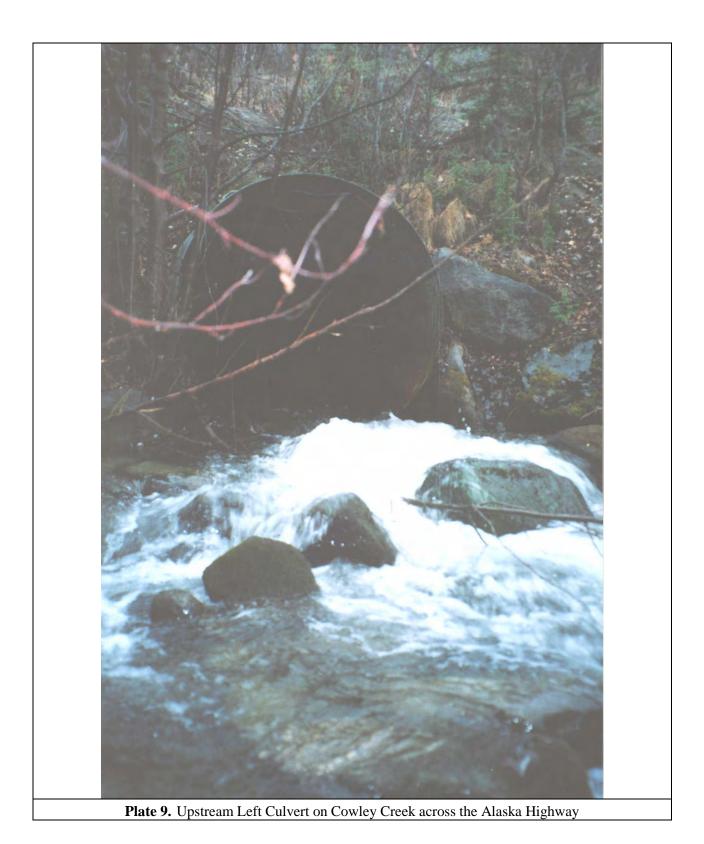
Table 13. Characteristics of Culverts on Cowley Creek across Alaska Highway

Parameter	Culvert (Upstream Left)	Culvert (Upstream Right)		
Culvert diameter (mm)	1875	1875		
Culvert length (m)	40	40		
Culvert material	Corrugated steel	Corrugated steel		
Culvert water velocity (m/sec)	5.26	3.33		
Culvert shape	Round	Round		
Culvert wetted width (cm)	104	77		
Culvert slope (%)	4	4		
High water mark (cm)	37	38		
Culvert water depth (cm)	15	7		
Culvert outfall drop (cm)	5	5		
Fill slope depth (m)	22	22		
Pool depth at outfall (cm)	38	21		

¹ Culvert slope based on stream gradient

Table 14. Stream Characteristics Downstream of Culverts on Cowley Creek across Alaska Highway

Parameter	Below Culvert
Wetted width (m)	3.88
Bankfull width (m)	4.46
Water depth (cm)	49
Bankfull depth (cm)	66
Stream water velocity (m/sec)	0.63
Stream gradient (%)	5



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Restoration Activities

Given the documented potential for chinook spawning and rearing upstream of the Alaska Highway culverts (A. von Finster, DFO memorandum July 27, 1997), the restoration of these culverts is considered a high priority. Restoration measures could include streambed recontouring at the outlets of the Alaska Highway culverts and the construction of step-pools to provide access to the pipes. Any restoration activities conducted on site should adhere to the relevant regulations, i.e., Fisheries Act and Yukon Waters Act, and be conducted under the auspices of the appropriate regulatory authorities, i.e., DFO and YTG.

Given that the beaver dams on reach 1 of Cowley Creek reduce the ability of chinook, particularly adults, to migrate upstream (A. von Finster, DFO memorandum July 27, 1997), any restoration of the Alaska Highway culverts would be less effective in the absence of the removal or rehabilitation of these dams. It is suggested that the procedures outlined in the Telkwa Project (Finnigan and Marshall 1997) be investigated for application on reach 1 of Cowley Creek to attempt rehabilitation of the beaver dams in this area. If these methods are found to be inappropriate for use in this stream, other non-invasive or non-lethal methods are suggested (Yukon River Panel 2004; DFO 1999). Any restoration activities conducted on site should adhere to the relevant regulations, i.e., Fisheries Act and Yukon Waters Act, and be conducted under the auspices of the appropriate regulatory authorities, i.e., DFO and YTG.

Project Team:

Marie Gallagher, M.Sc., R.P.Bio., Senior Biologist / Project Manager Chad Croft, B.Sc., R.P.F., R.P.Bio., Senior Biologist

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5. Personal Communication

Ross Burnett, Habitat Coordinator, City of Whitehorse, Whitehorse, Yukon.

- Al von Finster, Resource Restoration Biologist, Department of Fisheries and Oceans Canada, Habitat and Enhancement Branch, Whitehorse, Yukon.
- Lorne Gay, Senior Advisor, Sustainable Resources YTG Energy, Mines and Resources, Whitehorse, Yukon.
- Ruth Hall, Contaminated Sites Coordinator, Environmental Programs Branch YTG Department of Environment, Whitehorse, Yukon.
- Richard Janowicz, Manager Hydrology, Water Resources, Environmental Programs Branch. YTG Department of Environment, Whitehorse, Yukon.
- Adam Strutkowski, A/Supervisor, Administration & Finance Fire Management, YTG Community Services, Whitehorse, Yukon.

Appendices

Appendix A

City of Whitehorse Fish Survey Questionnaire

- > Guidelines
- > Questionnaire
- > Fish Species List
- > Maps

City of Whitehorse Fish Survey Questionnaire Guidelines for Interviewers

BACKGROUND

As part of the 2002 Yukon River Panel Restoration and Enhancement Initiative, the City of Whitehorse and Applied Ecosystem Management Ltd. worked collaboratively to produce a geographic information system (GIS) database and companion report that summarizes available documented information on the occurrence and distribution of freshwater fish and anadromous salmon within the City of Whitehorse (AEM 2003). It became apparent during this study that there are many areas within the city where fish occurrence and distribution is unknown. In an attempt to fill these information gaps, the following questionnaire was designed and prepared by the City of Whitehorse and Gartner Lee Ltd. (formally Applied Ecosystem Management Ltd.) as part of the 2003 Yukon River Panel Restoration and Enhancement Initiative.

This questionnaire is intended to be used by interested parties, e.g., stream stewardship groups, educational institutions or first nation, federal, territorial or municipal governments, to interview local experts with knowledge of fish occurrence and distribution in the creeks and lakes of the city. Local experts could be long term resident fishers, first nation elders, biologists, field workers, fishing guides or commercial fishers. Data collected as part of this survey will increase our understanding of the occurrence, distribution, biology and threats to fish and fish habitat within the City of Whitehorse. Data collected will also be in a format that can be easily incorporated as updates to the original GIS database. This information will allow the City to make more informed land use planning decisions and identify areas that may require special management consideration to protect fish and fish habitat.

This questionnaire package is available in digital format from the City of Whitehorse and completed questionnaires (and maps) can be dropped off by hand to the City of Whitehorse Habitat Coordinator's office located in the Municipal Services Building 4210 - 4th Ave, Whitehorse or sent to the Habitat Coordinator at the following address: $2121 - 2^{nd}$ Avenue, Whitehorse, YT, Y1A 1C2 (contact phone number: 668 8347).

TRADITIONAL KNOWLEDGE COLLECTION

The data collected in this questionnaire may come from a variety of sources, e.g., an observation made by the local expert (i.e., interviewee) or information recounted by the interviewee based on general local knowledge of an area. Data may also be in the form of traditional knowledge recounted by the interviewee based on first nations oral history. The collection of first nations traditional knowledge requires an understanding of the requirements of ethical and responsible data collection, retention and use. It is strongly advised that any research group intending to gather fish and fish habitat data from First Nations work collaboratively with the First Nation and follow the Traditional Knowledge Research Guidelines: A Guide for Researchers in the Yukon established by the Council of Yukon First Nations in August 2000. The traditional territories of both the Ta'an Kwa'chan and the Kwanlin Dun First Nations include the area that is now the City of Whitehorse.

GUIDELINES FOR QUESTIONNAIRE COMPLETION

The interviewer should introduce him / herself to the interviewee and provide a general background to the overall study and how the information gathered as part of this questionnaire may be used as follows:

As part of the 2002 Yukon River Panel Restoration and Enhancement Initiative, the City of Whitehorse and Applied Ecosystem Management Ltd. worked collaboratively to produce a geographic information system (GIS) database and companion report that summarizes available documented information on the occurrence and distribution of freshwater fish and anadromous salmon within the City of Whitehorse (AEM 2003). It became apparent during this study that there are many areas within the city where fish occurrence and distribution is unknown.

In an attempt to fill these information gaps, the following questionnaire was designed and prepared by the City of Whitehorse and Gartner Lee Ltd. (formally Applied Ecosystem Management Ltd.) as part of the 2003 Yukon River Panel Restoration and Enhancement Initiative. This questionnaire is intended to be used to interview local experts with knowledge of fish occurrence and distribution in the creeks and lakes of the city. These data will increase our understanding of the occurrence, distribution, biology and threats to fish and fish habitat within the City of Whitehorse and will allow the City to make more informed land use planning decisions and identify areas that may require special management consideration to protect fish and fish habitat.

Any information you would like to contribute with regards to the following would be greatly appreciated: the occurrence and distribution of freshwater fish and anadromous (sea-run) salmon within the City of Whitehorse; the location and timing of spawning fish; and any changes in fish habitat you may have observed or are aware of. Please do not feel that you must provide information on all lakes and creeks within the city but rather only in the areas where you have particular knowledge or experience. Many thanks for your time and contribution to this study.

More detailed information with regards to current available information on fish and fish habitat distribution within the City of Whitehorse is available in: Development of a Fish and Fish Habitat GIS Database and Restoration Plan for the City of Whitehorse, Yukon (AEM 2003).

CONTACT AND DATA TRACKING INFORMATION

The interviewer should complete the **name and contact information** for him / herself and for the interviewee (if appropriate). The interviewer should explain to the interviewee that the recording of his / her name is optional but would allow the information provided to be properly acknowledged and referenced. It also provides a means by which the interviewee may be contacted in the future, e.g., to clarify data provided or receive copies of materials produced.

An **interview code number** should be assigned to each interview conducted as well as the **date** the interview was conducted. The interview code number should be recorded on both the questionnaire and the overview map incase the datasheets are separated. It is suggested that an interview code number be generated based on the initials of the interviewer and then sequentially numbered for each interview conducted. For example, interviewer John Smolt's first interview

would be JS1. This code provides a unique number for each interview conducted and also provides a means to identify each record as a unique data point in the database (see below).

FISH OCCURRENCE AND DISTRIBUTION DATA

Question 1 relates to the background of the interviewee and allows opportunity to introduce him / herself.

- 1) How would you best describe your activities on the streams, rivers and lakes within the City of Whitehorse? N.B. you may circle more than one description.
 - a) Angler
 - b) Fishing guide
 - c) Subsistence fisher
 - d) Commercial fisher
 - e) Naturalist
 - f) Biologist
 - g) Other (please specify)

Question 2 relates to the occurrence and distribution of freshwater fish and anadromous (sea-run) salmon within the City of Whitehorse; the location and timing of spawning fish and any changes in fish habitat the interviewee may have observed or is aware of. Be aware that the interviewee should not feel that s/he should provide information on every watercourse and waterbody within the city but rather only in areas where s/he has particular knowledge or experience. Furthermore, interviewees should provide information only to the level of detail they are able, e.g., should not feel forced to provide information on reproductive / age class when this information is not known.

2) Please record any observations you or others have made on fish within the City of Whitehorse in the following table and on the overview maps provided.

The interviewer should explain to the interviewee that the information provided may be:

- Observations made by the interviewee or knowledge that has been passed on from other people or through oral history.
- Historical or current, e.g., the local expert may know that fish occurred in a certain location in the 1960's but has not observed or heard of fish occurring in that location since then.

The interviewer should present the fish species list (Appendix One) to the interviewee and ensure that all common and alternate species names are recognizable. The species list should be updated when:

- Interviewee knows a species by an alternate name that is not listed in the appendix. If necessary the interviewer should use the fish identification field guides listed in the reference section to ensure alternate name refers to the correct common and Latin name.
- Interviewee knows of a fish species that s/he knows to occur in the city that is not listed in the appendix.

The interviewer should present the overview maps of the city and assist the interviewee in map interpretation by pointing out:

- Scale of map (i.e., at 1:25,000 scale, 1cm equals 250m);
- Direction of the north arrow:
- Location of local landmarks such as roads and subdivisions.

The interviewer should then allow the interviewee to direct the focus of data collection to the particular areas the interviewee has specific knowledge. The interviewer may use the following checklist to ensure all potential information is gathered e.g., by asking the interviewee whether s/he knows anything about each of the creeks and lakes listed:

Takhini River Tavern Creek
Little Takhini Creek Porter Creek
Nine Mile Creek Harmon Lakes
MacAuley Creek Long Lake

Croucher Creek Hidden Lakes (south Whitehorse)

McIntyre Creek Chadden Lake Marwell Creek Chadburn Lake Spook Creek McLean Creek Basalt Creek McLean Lake MacRae Creek Mary Lake Wolf Creek Ear Lake Cowley Creek Canyon Creek Yukon River mainstem Copper Creek

Other (e.g., Ice Lake, Stinky Lake)

The interviewer should assist the interviewee in the completion of Table 1 by leading him / her through the table and documenting information s/he provides.

Record Number: assign each record number sequentially, i.e., 1, 2, 3.....beginning at record number 1 at the onset of each interview. This number can be used in conjunction with the interview code number to generate a code unique to each data point. For example, JS1-1; JS1-2; JS1-3 would refer to record numbers 1 to 3 of John Smolt's first interview and JS3-1, JS3-2, JS3-3 would refer to record numbers 1 to 3 of John Smolt's third interview.

Creek Name: refer to each creek, river or lake name as it is labeled on the overview map. These names are either gazetted names consistent with the Yukon Territory Watershed Code Dictionary (DeMarco & Associates, 1991) or where the gazetted name is recorded as unknown, consistent with the Whitehorse Surface Water Inventory (GLL 2001). If the interviewee knows creek by an alternate name, make note of this name in the comments section.

Fish Species: record fish species using DFO recognized FISS codes listed in appendix one. In some cases, juvenile fish of unknown species may have been observed. In these situations, enter species as unknown (code SP).

Location: use overview maps to pinpoint the location of observation or site knowledge. Record information directly on map using the record number to relate location back to information recorded in Table 1. Be as precise as possible, i.e., make every effort to accurately assign information to a particular reach (or set of reaches) but if this is not possible circle a general area, e.g., above Alaska Highway near Wolf Creek subdivision. Provide information on the general location of observation or site knowledge in Table 1.

Reproductive / Age Class: assign the appropriate code to distinguish between reproductive status and age of fish using the table below. If interviewee is not sure of fish reproductive class or age class, enter most accurate information, i.e., AU, JU or FU.

- AU Adult fish, unknown reproductive class;
- AN Adult fish, non-spawning;
- AS Adult fish, spawning;
- JU Juvenile, unknown age class;
- JF Juvenile, fry;
- JG Juvenile, fingerlings;
- JS Juvenile smolts;
- FU Fish of unknown age and unknown reproductive class.

Data Code: assign the appropriate code for the type of information provided using the following codes:

- O a direct observation made by the interviewee;
- LK information recounted by the interviewee based on observations made by other individuals:
- TK information recounted by the interviewee based on first nations oral history.

Month: record the time of year observation was made or season knowledge data refers to. Be as precise as possible, e.g., if possible provide the date (e.g., 6^{th} May) but in order of preference provide week (e.g., first week in May) or biweekly period (e.g., early May), month (e.g., May) or season (e.g., spring).

Year: record the year observation was made. Be as precise as possible, e.g., if possible provide exact year (1942) but if not provide estimate of period (early 1940's) or before or after a significant construction event (e.g., before Alaska Highway construction).

Comments: allow the interviewee to elaborate on observations and note any pertinent information in the comments section. Any information available on fish occurrence and distribution outside the city limits can be recorded in the comments section as well as any information on potential threats to fish or fish habitat, e.g., garbage, contaminated sites, contamination sources, washed out roads or culverts.

REFERENCES

SUGGESTED FIELD GUIDES

McPhail J.D. and Lindsey C.C. 1970. Freshwater Fishes of Northwestern Canada and Alaska. Fisheries Research Board of Canada. Bulletin 173.

McPhail J.D. and Carveth R. 1993. Field Guide to the Freshwater Fishes of British Columbia. Fish Museum, Department of Zoology, University of British Columbia.

BACKGROUND DOCUMENTS

Applied Ecosystem Management Ltd. 2003. Development of a Fish and Fish Habitat GIS Database and Restoration Plan for the City of Whitehorse, Yukon. CRE-71-02.

Council of Yukon First Nations 2000. Traditional Knowledge Research Guidelines: A Guide for Researchers in the Yukon.

Gartner Lee Ltd. 2001. Whitehorse Surface Water Inventory Users' Guide. Prepared for the City of Whitehorse and DIAND Water Resources.

DeMarco, R. & Associates 1991. Yukon Territory Watershed Code Dictionary. Prepared for Department of Renewable Resources, Whitehorse, Yukon and Department of Fisheries and Oceans, Vancouver, B.C..

City of Whitehorse Fish Survey Questionnaire

INTRODUCTION AND BACKGROUND

As part of the 2002 Yukon River Panel Restoration and Enhancement Initiative, the City of Whitehorse and Applied Ecosystem Management Ltd. worked collaboratively to produce a geographic information system (GIS) database and companion report that summarizes available documented information on the occurrence and distribution of freshwater fish and anadromous salmon within the City of Whitehorse (AEM 2003). It became apparent during this study that there are many areas within the city where fish occurrence and distribution is unknown. In an attempt to fill these information gaps, the following questionnaire was designed and prepared by the City of Whitehorse and Gartner Lee Ltd. (formally Applied Ecosystem Management Ltd.) as part of the 2003 Yukon River Panel Restoration and Enhancement Initiative. This questionnaire is intended to be used to interview local experts with knowledge of fish occurrence and distribution in the creeks and lakes of the city. These data will increase our understanding of the occurrence, distribution, biology and threats to fish and fish habitat within the City of Whitehorse and will allow the City to make more informed land use planning decisions and identify areas that may require special management consideration to protect fish and fish habitat.

Any information you would like to contribute with regards to the following would be greatly appreciated: the occurrence and distribution of freshwater fish and anadromous (sea-run) salmon within the City of Whitehorse; the location and timing of spawning fish; and any changes in fish habitat you may have observed or are aware of. Please do not feel that you must provide information on all lakes and creeks within the city but rather only in the areas where you have particular knowledge or experience. Many thanks for your time and contribution to this study.

CONTACT AND DATA TRACKING INFORMATION

Name & contact information of interviewer	
Name & contact information of local expert (optional)	
Date of interview	
Interview code number	

FISH OCCURRENCE AND DISTRIBUTION DATA

1) How would you	ı best describe yo	our activities	on the streams	, rivers	and lakes	within	the C	City o
Whitehorse? N.B.	you may circle m	ore than one	description.					

- a) Angler
- b) Fishing guide
- c) Subsistence fisher
- d) Commercial fisher
- e) Naturalist
- f) Biologist
- g) Other (please specify)
- 2) Please record any observations you or others have made on fish within the City of Whitehorse in the following table and on the overview maps provided.

Table 1. Fish Occurrence and Distribution within the City of Whitehorse

Record Number	Creek Name	Fish Species	Location	Reproductive Age Class	Data Code	Month	Year	Comments
		•						

Table 1 (cont.). Fish Occurrence and Distribution within the City of Whitehorse

Record Number	Creek Name	Fish Species	Location	Reproductive Age Class	Data Code	Month	Year	Comments
		•						

Fish Species List

Table 1. List of Fish Species Documented or Potentially Occurring within the City of Whitehorse

Code ¹	Common Name ²	Other Names	Latin Name ²
	Family Salmonidae		
	Subfamily Salmoninae		
СН	Chinook salmon	King salmon; spring salmon	Oncorhynchus tshawytscha
CM	Chum salmon	Dog salmon	Oncorhynchus keta
LT	Lake trout		Salvelinus namaycush
RB	Rainbow trout		Oncorhynchus mykiss
DV	Dolly varden trout		Salvelinus malma
BT	Bull trout		Salvelinus confluentus
AC	Arctic char		Salvelinus alpinus
	Subfamily Coregoninae		
IN	Inconnu	Coney	Stenodus leucichthys
CS	Least cisco	Freshwater herring	Coregonus sardinella
BW	Whitefish, broad		Coregonus nasus
LW	Whitefish, humpback	Lake whitefish; Crooked Back	Coregonus clupeaformis
PW	Whitefish, pygmy		Prosopium coulteri
RW	Whitefish, round		Prosopium cylindraceum
	Subfamily Thymallinae		
GR	Arctic grayling		Thymallus arcticus
	Family Gadidae		
BB	Burbot	Ling cod; Loche	Lota lota
	Family Cottidae		
CCG	Slimy sculpin		Cottus cognatus
	Family Cyprinidae		
LKC	Lake chub		Couesins plumbeus
	E 2 C 4 4 13		<u> </u>
I CII	Family Catostomidae		
LSU	Long nose suckers		Catostomus catostomus
	D		
ND	Family Esocidae		F I:
NP	Northern Pike		Esox lucius
	Unknown Species		
SP	Unknown species Unknown species		_
Sr.	Officiowii species	1	ļ -

¹ All species codes follow DFO FISS coding methods
² All species common and Latin names follow McPhail and Lindsey, 1970.

Appendix B

Name	Standard	Nutrients		ater Qua Metals		Sediment	Biological	Water Quantity All	References
Yukon River	Y	Y		Y	Y	Y			Axbey and Slonski 1986
Yukon River				Y		Y	Y		Baker 1979
Yukon River	Y	Y	Y	Y			Y		Bethel and Burns 1981
									Brown, Elson and Steigenberger
Yukon River	Y							Y	1976
									DFO memo dated July 21, 1999
Yukon River	Y								written by K. Maddigan
Yukon River	Y	Y	Y	Y					Environment Canada 1975
Yukon River						Y			Environment Canada 1991
									Environment Canada, Water Survey
									of Canada for Station No. 09AB001
Yukon River	Y							Y	(1902 - 2002)
									Garrett, MacLeod and Sneddon
Yukon River				Y		Y	Y		1980
Yukon River						Y	Y		Godin and Davidge 2002
									Government of Canada memo dated
Yukon River	Y								March, 24 1983
Yukon River	Y	Y	Y	Y					Jack, Osler and Burns 1983
Yukon River	Y	Y	Y	Y					McNaughton 1979
Yukon River	Y	Y	Y	Y			Y		Roach and Mitchell 1998
									Whitfield, McNaughton and
Yukon River	Y	Y							Whitley 1982
Yukon River	Y	Y	Y	Y					Whitfield and Whitley 1986
									Brown, Elson and Steigenberger
Takhini River	Y							Y	1976
Takhini River	Y	Y	Y	Y					Environment Canada 1975
									Environment Canada, Water Survey
									of Canada for Station No. 09AC001
Takhini River	Y							Y	(1948 - 2002)
Takhini River						Y	Y		Godin and Davidge 2002.
Takhini River	Y	Y	Y	Y					Jack, Osler and Burns 1983
Takhini River	Y							Y	Whitfield and McNaughton 1984
Takhini River	Y	Y	Y	Y					Whitfield and Whitley 1986.
Croucher Creek	Y	Y						Y	Bradford et al. 2001
									DFO Stream files sampling dated
Croucher Creek	Y								July – August 1985
									DIAND memo dated August 7,
Croucher Creek	Y	Y	Y	Y					1998 written by Pat Roach
Croucher Creek						Y	Y		Godin and Davidge 2002

			Water Quantity	zy					
Name	Standard	Nutrients		ater Qua Metals	Organics	Sediment	Biological	All	References
McIntyre Creek	Y	Y		Y	Y	Y			Axbey and Slonski 1986
McIntyre Creek								Y	Beniston and Lister 1991
									DFO Stream files sampling
									conducted by B. Godin,
McIntyre Creek							Y		Environment Canada
									DFO memo dated May 21, 1999
McIntyre Creek	Y							Y	written by K. Maddigan
McIntyre Creek	Y	Y							DFO memo dated July 27, 1997
									DFO Stream Files ground water
McIntyre Creek	Y	Y		Y					sampling dated March 16, 1989
									DFO memo dated July 21, 1999
McIntyre Creek	Y								written by K. Maddigan
McIntyre Creek						Y			Environment Canada 1991
McIntyre Creek						Y	Y		Godin and Davidge 2002
McIntyre Creek	Y	Y	Y	Y	Y		Y	Y	Stanley Associates Ltd. 1982
McIntyre Creek	Y	Y	Y	Y	Y		Y		Stanley Associates Ltd. 1992
									Environment Canada memo from J.
									Eamer to File 4186-3-19, 21st
Marwell Creek	Y	Y		Y	Y	Y			September 1989
									Piteau Engineering Ltd. 1990
Marwell Creek					Y	Y			(groundwater quality sampling)
									Piteau Engineering Ltd. 1991
Marwell Creek					Y				(groundwater quality sampling)
									Piteau Engineering Ltd. 1992
Marwell Creek	Y		Y		Y	Y			(groundwater quality sampling)
									Komex International Ltd. 1992
Marwell Creek	Y	Y	Y	Y	Y	Y			(groundwater quality sampling)
									DFO Stream files sampling
									conducted by B. Godin,
MacRae Creek							Y		Environment Canada
MacRae Creek						Y	Y		Godin and Davidge 2002
									Brown, Elson and Steigenberger
Wolf Creek	Y							Y	1976 (sampling on Coal Lake)
Wolf Creek						Y	Y		Godin and Davidge 2002
Wolf Creek	Y	Y	Y	Y				Y	Johnstone 1997
Wolf Creek	Y							Y	Matthews 1997
Wolf Creek								Y	Orecklin and McLachan 1981
Wolf Creek	Y	Y	Y	Y			Y		Roach and Mitchell 1998

	Water Quality Water Quantity								
Name	Standard	Nutrients	Halides	Metals	Organics	Sediment	Biological	All	References
									R. Janowicz, pers. comm., January
Wolf Creek								Y	15, 2004
Mary Lake	Y	Y	Y	Y			Y		Campbell and Davidge 1987
									DFO memo dated May 1, 1997
Cowley Creek	Y								written by A. von Finster
Cowley Creek						Y	Y		Godin and Davidge 2002
									DFO Stream Files sampling
									conducted February 6, 1992
Porter Creek	Y	Y	Y						(sampling on Hidden Lake)
Porter Creek	Y	Y	Y	Y			Y		Axbey and Slonski 1986
									Brown, Elson and Steigenberger
Porter Creek	Y							Y	1976 (sampling on Fish Lake)
Long Lake						Y	Y		Godin and Davidge 2002
Hidden Lakes						Y	Y		Godin and Davidge 2002
McLean Lake	Y	Y	Y	Y			Y		Campbell and Davidge 1987
									DFO Stream Files sampling
McLean Lake	Y								conducted July 2, 1963
McLean Lake	Y	Y	Y	Y			Y		Access Consulting Group 2003
McLean Creek	Y	Y	Y	Y			Y	Y	Access Consulting Group 2003

