Overarching Yukon Source Water Supply and Protection Study – Summary Report

PRESENTED TO

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
AO	Aesthetic Objectives
AST	Above-Ground Storage Tank
ATB	Airport Terminal Building
BC MoE	British Columbia Ministry of Environment
BMPs	Best Management Practices
BTEXS	Benzene, Toluene, Ethylbenzene, Xylenes and Styrene
CAFN	Champagne and Aishihik First Nation
CBSA	Canada Border Services Agency
CGWA	Canadian Ground Water Association
CoD	City of Dawson
CTFN	Carcross Tagish First Nation
CU	Colour Units
CS	Community Services
DCA	Dawson City Aquifer
EC	Environment Canada
EDI	Environmental Dynamics Inc.
EHS	Environmental Health Services
EMR	Energy Mines and Resources
EPH	Extractable Petroleum Hydrocarbons
FCQ	Forestry Crew Quarters
FDO	Forestry District Office
FNWMS	First Nation Water Management Strategy
GCDWQ	Guidelines for Canadian Drinking Water Quality
GIS	Geographic Information System
GLL	Gartner Lee Limited
GUDI	Groundwater Under the Direct Influence of surface water
HAA	Haloacetic Acids
HDPE	High Density Polyethylene
HEPH	Heavy Extractable Petroleum Hydrocarbons

Acronyms/Abbreviations	Definition
IGPM	Imperial Gallons Per Minute
INAC	Indigenous and Northern Affairs Canada
ISI	Intrinsic Susceptibility Index
KFN	Kluane First Nation
LEPH	Light Extractable Petroleum Hydrocarbons
LFN	Liard First Nation
LPDWS	Large Public Drinking Water System
LSCFN	Little Salmon Carmacks First Nation
m ags	Metres Above Ground Surface
m bgs	Metres Below Ground Surface
MAC	Maximum Acceptable Concentration
MH	Morrison Hershfield
NBJ	Nelnah Bessie John
NTU	Nephelometric Turbidity Units
OCP	Organochlorine Pesticides
OD	Outside Diameter
PAH	Polycyclic Aromatic Hydrocarbons
Y-DWR	Yukon Drinking Water Regulation
PMA	Property Management Agency
PMD	Property Management Division
SPDWSA	Small Public Drinking Water System Assessment
SWAPP	Source Water Assessment and Protection Plan
SWPP	Source Water Protection Plan
TDS	Total Dissolved Solids
Tetra Tech	Tetra Tech Canada Inc. (formerly EBA Engineering Consultants Ltd.)
THM	Trihalomethane
TOC	Total Organic Carbon
TRS	Takhini River Subdivision
US gpm	US gallons per minute
USGS	United States Geological Survey
UST	Underground Storage Tank

Acronyms/Abbreviations	Definition
UV	Ultra Violet
VGFN	Vuntut Gwitchin First Nation
VHJ	Village of Haines Junction
VOC	Volatile Organic Compounds
VoM	Village of Mayo
VFD	Variable Frequency Drive
VPH	Volatile Petroleum Hydrocarbons
WHPP	Well Head Protection Plan
WRFN	White River First Nation
WTP	Water Treatment Plant
YG	Government of Yukon
YWP	Yukon Wildlife Preserve

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by Yukon Government - Department of Community Services (YG CS) to complete an overarching Yukon source water supply and protection study. The study involved collaborating with other Yukon stakeholders to compile, review and collate information with respect to public water supplies and community source water protection planning in Yukon. The project captured data held by the owners and operators of public water systems throughout Yukon, as well as Government bodies such as YG Property Management Division (YG PMD), Environmental Health Services (YG EHS), Community Services (YG CS our client for this project), Yukon Housing, Government of Canada Border Services, and various First Nation governments to create this overarching report and a database of existing water supplies and source water protection measures for public water supply in Yukon.

The objectives of this study were to:

- Create a platform for source water and source water protection data collection and sharing;
- Interact with communities and other governments fostering information and knowledge sharing and partnership, and promotion of source water protection planning;
- Provide useful information for YG CS, governments, planners, engineers and scientists for future planning (and potentially for public in future on web linkable tool);
- Identify and compile source water protection plans that have already been completed, are in progress, or are planned to be completed within the near future, and identify gaps where source water protection is currently lacking;
- Identify relevant Yukon legislation, and legislation and Best Management Practices (BMPs) from other neighbouring provinces with respect to community water supply source water protection; and
- Identify data gaps and provide recommendations on how best to move forward with source water protection planning in Yukon.

The two primary project deliverables include this report, which summarizes available existing information on public water systems throughout the Yukon with an emphasis on community drinking water sources and source water protection, and a database captured on a Geographical Information System (GIS) platform. The GIS database is intended to create a visual georeferenced record of existing data related to public water systems and source water protection in Yukon and contains:

- Spatial data including well and source water locations, well capture zones; and
- Georeferenced metadata including aquifer and hydrogeology information, well logs, well completion details, water quality information, source water protection planning information, and water treatment and distribution information from this report.

Issued for Review versions of the water system sections of this report (Section 5.1 o 5.59) were provided to system owners/operators on behalf of YG CS in order to fill data gaps and ensure that accurate, up to date information was being referenced. Where comments and information were received, they have been incorporated into this report.

2.0 BACKGROUND

2.1 Yukon Source Water

Public drinking water sources in Yukon include both groundwater and surface water sources; with a large majority of the public drinking water systems sourced from groundwater. Both surface and groundwater resource can be safe, reliable sources of drinking water provided systems are designed with appropriate and adequate treatment and are properly: monitored, operated, managed and protected. Groundwater is inherently a more secure source of public drinking water as the geologic formation itself can offer some protection from chemical and microbiological contaminants. Groundwater resources; however, can also be vulnerable to anthropogenic sources of contamination, have varying degrees of vulnerability depending on the hydrogeological conditions, and like surface water sources must be protected to ensure the long-term security and sustainability of the resource.

Yukon has complex geology including regions with very little overburden; regions with extensive overburden deposits of glacial till, glaciofluvial, fluvial, alluvial and colluvial deposits; regions of discontinuous and continuous permafrost; regions such as Crow Flats with little topographical relief; and, regions such as the Shakwak Valley with very mountainous terrain.

Groundwater in Yukon occurs in both overburden and bedrock aquifers; shallow to very deep aquifers; and unconfined, semi-confined and confined (including artesian) aquifers. The many different types of aquifers offer differing protection from surface sources of contamination with varying degrees of vulnerability to surface sources of contamination depending on the specific geological and hydrogeological conditions.

Water chemistry encountered in Yukon's aquifers has a great deal of natural variation with hardness ranging from soft to very hard; pH ranging from the lower limit of the Guidelines for Canadian Drinking Water Quality (GCDWQ) Aesthetic Objective (AO) of 6.5 to above the upper limit of 8.5; water types including nearly all possible combinations of calcium, magnesium, sodium, bicarbonate and sulphate; variable concentrations of iron and manganese including several locations where these metals exceed the GCDWQ AO; and areas with naturally occurring concentrations of uranium and arsenic which in some cases exceed the health based GCDWQ Maximum Acceptable Concentration (MAC).

2.2 Yukon Public Water Systems

There are two main types of "Community" water supplies that are considered in this study. There are the large community systems that fall under the Yukon Drinking Water Regulation (YOIC 2007/139) and are governed under Part I – Large Public Drinking Water Systems (these systems have 15 or more service connections to a piped distribution system or, five or more delivery sites on a trucked distribution system). These systems typically serve communities through piped distribution or bulk delivery and include the 22 larger systems throughout Yukon. There are also other smaller public water systems that provide water to the public that are not currently governed by the *Public Drinking Water Regulation* referred to as "Small Drinking Water Systems" by Yukon Environmental Health Services. These can include restaurants, roadhouse motels, service stations, grader stations, ambulance stations, libraries, health centres, schools, airports etc.

This study was intended to focus on those systems that are regulated as Large Public Systems under the Drinking Water Regulation and any small public systems that are maintained by the Yukon Government, First Nations and Municipalities that provide water to the public. Systems serving highway maintenance camps (i.e. grader stations) were excluded from the scope of this study.

2.3 Yukon Drinking Water Protection Regulations, Standards and Practices

Public drinking water systems in Yukon are regulated under various acts and regulations. Large Public Drinking Water Systems are regulated under the Public Health and Safety Act – Drinking Water Regulation O.I.C. 2007/139. The Yukon *Drinking Water Regulation* (Y-DWR) has two parts: Part I – Large Public Drinking Water Systems and Part II – Bulk Delivery of Drinking Water.

Guidelines for water systems that provide drinking water for public consumption, but are not classified as Large Public Drinking Water Systems are provided by Environmental Health Services. These drinking water systems are governed under the *Public Health and Safety Act*, General Regulations, Section 18 which requires that systems supplying water for human consumption be subject to inspection and testing by a medical officer of health or Health Officer (*Public Health Act,* C.O. 1958/079) . The Yukon Government Health and Social Services provides a guidance document "Small Drinking Water Systems in Yukon - Information for Owners and Operators – June 2013". The guidance document references the treatment objectives for these types of systems – the Guidelines for Canadian Drinking Water Quality (GCDWQ); and provides Treatment Standard for 2 different water types (Type 1: Surface water or Groundwater under the Direct Influence of Surface Water (GUDI), Type 2: Secure Groundwater (non-GUDI).

In Yukon there are currently a number of laws in place that assist in protection of groundwater and surface waters including Solid Waste Regulations, Contaminated Sites Regulations, Yukon Waters Act and Regulations, and the Public Health and Safety Act (which include the Drinking Water Regulation and Sewage Disposal Systems Regulation). However, there are currently no overarching well construction guidelines/specifications (although these are currently under development and planned for release in 2017), and there are no legislated requirements for communities to develop source water protection plans.

The Drinking Water Regulation (Y-DWR) O.I.C. 2007/139 currently references the most recent version of the Canadian Groundwater Association's Well Construction Guidelines and requires that wells serving Large Public Drinking Water Systems meet this guideline as a minimum. Because the Canadian Groundwater Association itself is now defunct and the guidelines are relatively dated, and because they do not pertain some system types (small public, domestic) and are not specific to Yukon, the Yukon Government is in the process of developing potable water well construction guidelines that will be referenced in future legislation. We understand that the guidelines will pertain to both public and domestic potable water wells and will provide valuable information to guide drillers, well owners and other stakeholders on the construction of safe potable water wells. The Guidelines are intended to provide well construction information to well drillers and the public regarding current best practices for potable water well construction in Yukon. The guidelines will likely contain information on well planning, siting, construction, development, disinfection, testing, wellhead completion, decommissioning and reporting. It is intended that these guidelines will provide standards that protect health, the environment, and future users of Yukon's groundwater through the application of best practices.

The Yukon's Domestic Water Well Program is intended to provide financial assistance in the form of a loan for residential property owners to construct a domestic potable water system. All groundwater wells under this program also have to be drilled by registered water well drillers and the well construction must meet the minimum specifications of the Canadian Groundwater Association's - Well Construction Guidelines. Currently there is no overarching well construction regulation or specification for water wells other than those serving Large Public Drinking Water Systems, unlike most other jurisdictions in Canada. As such, Small Public Water Systems, and domestic systems that are not completed under the Domestic Water Well Program do not currently have a minimum legislated standard for construction.

As mentioned previously, Yukon Government does have some authority over Small Public Water Systems because they can ensure that these systems do not pose a threat to public health and safety and can therefore complete

inspections and issue orders for enforcement. Without a standard well construction guideline; however, this authority may be difficult to enforce and regulate.

The *Public Drinking Water Regulation* provides medical health officers the power to "require an owner to prepare an assessment and response plan for the source water, in relation to Large Public Drinking Water System, that will identify, inventory and assess risk to the drinking water source, including land use and other activities or conditions that may adversely affect or threaten the water source; identify measures for example, public education, changes to land use, increase in monitoring, or selection of a new water source that can be taken to address risk; *and* outline an implementation plan to manage risks to the drinking water source with respect to those measures that will be taken by the owner". This clause in essence describes a Source Water Protection Plan, and source water protection plans in Yukon thus are not mandated for all Large Public Drinking Water Systems but could be required if a medical health officer thought it was warranted.

Indigenous and Northern Affairs Canada (INAC) has published a document titled "Protocol for Drinking Water in First Nation Communities (Standards for Design, Construction, Operation, Maintenance, and Monitoring of Drinking Water Systems). Section 3.1 of the Protocol related to source water protection requirements states that "Source protection, the prevention of contaminants from entering into water sources, is the first layer of defense in a multi-barrier approach to water protection. First Nation authorities responsible for drinking water systems covered by the protocol shall participate with other stakeholders in the development and implementation of a watershed and aquifer protection plan." It also states that First Nations communities shall also develop and implement community-specific source water protection plans to prevent, minimize, or control potential sources of contaminants in or near the community's raw water sources. INAC provides a guidance for source protection plan development as Appendix B of the Protocol. Excerpts from Appendix B of the Protocol include:

- A primary element of the First Nations Water Management Strategy (FNWMS) is to encourage First Nation communities to develop source water protection plans (SWPPs) for their drinking water systems. Persons responsible *(i.e.,* First Nations operating authorities) for drinking water systems covered by the protocol, must participate with stakeholders (e.g., province, territory, conservation authorities, local municipalities, etc.) in the development and implementation of an SWPP.
- The goal of a Source Water Protection Plan is to maintain healthy watersheds and aquifers that benefit all who have a stake in them. The plan is intended to be a flexible, evolving strategy providing an initial template of goals and actions based on current conditions, potential risks and hazards, and desired water quality objectives. The plan and its objectives can be expanded and adapted as its implementation progresses.
- Source protection involves all steps required to prevent contaminants from entering raw drinking water sources.

3.0 SOURCE WATER PROTECTION PLANNING OVERVIEW

A "multi-barrier" approach to ensuring the security of drinking water has become a Canada wide approach following from the Walkerton, Ontario tragedies related to poor water source protection and management. A source water protection plan is the first element in the multi-barrier approach to water protection, which prevents contaminants from entering drinking water by providing a layered defence based on four main elements:

- ***Barrier 1: Source water protection*;**
- Barrier 2: Effective drinking water treatment;
- Barrier 3: Maintenance of a clean distribution system; and
- Barrier 4: Regular testing.

Source water protection planning, as the first barrier of the multi barrier approach to safe drinking water, is comprised of several key sub-barriers:

- Legislation, regulation, land use planning and emergency response planning provide administrative protection for water resources;
- Physical well construction such as ensuring proper well siting with respect to hazards such as sources of contamination or traffic that could damage the well, installation of proper surface seals, ensuring appropriate materials are used in the construction of water wells, ensuring water wells are properly designed, proper wellhead completion with adequate stickup and freeze protection;
- Development of a source water protection plan with risk assessment, implementation of risk mitigation measures and regular monitoring and review of the status of risks to the source water provide focused management tools to protect the water resource.

The source water protection planning process is intended to provide practical protective measures for groundwater and surface water resources by identifying and managing activities within the watershed that contributes to a water resource. Source water protection planning identifies hazards that may threaten the safety, security and sustainability of a water supply and provide practical measures for managing these risks. Source water protection planning may come in the form of a 'Source Water Protection Plan' (SWPP) or an 'Aquifer and Wellhead Protection Plan' (AWPP). Both plans are intended to protect water resources; AWPPs are specifically related to groundwater resources while SWPPs may apply to surface water resources. Development of a Plan typically follows the following steps:

- Step 1 – Identify team members
- Step 2 – Delineate a source water protection area boundary
- Step 3 – Identify potential contaminants and assess risk
- Step 4 – Develop the source water protection plan
- Step 5 – Develop a monitoring program

3.1 Source Water Protection Planning in Yukon

Source Water Protection Planning is a key piece of water security that many Yukon water supply systems are currently in the process of developing. Source water Protection planning has been in progress in Yukon over the past 10 years, and today source water protection plans exist for 12 Yukon Water Systems and are in progress for three more. In 2013, Ecojustice, a Canadian Environmental Law Charity, in its 3rd national report card for water in Canada (Waterproof 3), gave the Yukon a 'D+'. They state that "While it has improved its water treatment standards, the territory does not have specific source water protection planning in place. The Yukon's low-grade is a drop from the 'C-' it received in 2006" (http://www.ecojustice.ca/pressrelease/yukon-gets-d-for-drinking-water-protection/#sthash.s4zl1zru.dpuf). It is unlikely that Ecojustice had access to all of the SWPPs that were in place at the time of their assessment as there was no overarching report or database for Yukon source protection planning.

Four approaches to source water protection planning have been used for Yukon systems to date:

- The BC Ministry of Healthy Living and Sport Comprehensive Drinking Water Source to *Tap Assessment Guideline* (2010) was developed to provide a structured and consistent approach to evaluating risks to drinking water. This Guideline consists of eight modules, of which Modules 1, 2, 5 and 8 are covered in the Source Water Protection Plans developed in Yukon based on this approach.

- The British Columbia Ministry of Environment Well Protection Toolkit was developed in 2000 and updated in 2006. The Toolkit is a set of guidelines for the six-step approach on how a community can develop and put into place a well protection plan to prevent contamination of their well water supply. The toolkit contains seven booklets which discuss these six steps and includes an example of how each step is implemented. The BC Well Protection Toolkit is intended to be a component of the multi-barrier approach to source water protection.

- The Tetra Tech's 'Risk Based Approach' was developed based on the BC Well Protection Toolkit and is intended to create a framework for AWPP where risks can be identified and ranked according to urgency in order to guide the approach to elimination, mitigation and management of risk to a water resource.

- Ontario source protection guidelines: the Clean Water Act (2006) and the Technical Rules Assessment (2008, Amended 2013).

4.0 DATA SOURCES AND METHODOLOGY

The intent of this overarching study was to capture existing source water protection information for the Yukon by collating information related to community water sources and source water protection measures. In the course of compiling this information, we have also collected some basic information related to Steps 2 and 3 of the multi-barrier approach such as the types of treatment systems and distribution systems in place in Community Systems in Yukon. The primary focus of this study; however, was to be on water sources and source protection and, while raw water quality is related to the water source characterization, and provides good information for planning and information purposes, the scope of this project did not include a review of treated water quality for these systems. Presumably, where water treatment systems are in place, the treatment system is designed and operated to provide water that is disinfected as necessary for the type of source and system, and meets the applicable GCDWQ. The scope of this project was not to assess the adequacy or performance of water treatment systems.

Relevant background documents and prior studies that are pertinent to this study include:

- Well logs and water quality results provided by water system owners.

- Technical reports such as well completion reports, source water protection plans, aquifer and wellhead protection plans, groundwater under the direct influence of surface water studies, and record drawings prepared by various engineering consultants for various water system owners and agencies.

- The Small Public Water System Assessments (SPDWSA) for 98 water systems under the purview of YG Property Management Agency (YG PMA) completed in 2005 by Tetra Tech (Tetra Tech 2005). This study was completed for YG PMA and included assessment of the source water and potential contaminants of concern in the vicinity of the drinking water supply. This provided the basis of data for much of the water source, construction, hydrogeological conditions, and source water chemistry captured for small public water supply systems included in this study. Note: It is recognized that YG PMA has since become a YG Division and is no longer involved with many of these systems and many of the systems may have been upgraded, changed, or even taken out of use since the time of this study. The information however related to hydrogeology, raw water quality, aquifer vulnerability captured in these studies is valuable to this study; and it is intended that this information such any water source or water treatment changes can be updated once new information is available and compiled as part of the review process.

- Large Public Drinking Water Systems Assessments (LPDWSA) for a total of 16 Large Public Drinking Water Systems in Yukon completed in 2012 by Yukon Engineering Services (YES) and Tetra Tech (YES 2012). This study was completed for YG EHS and included assessment of the source water and potential contaminants of concern in the vicinity of the drinking water supply. This study provide the basis of data for several of the Large Public Drinking Water Systems water source, construction, hydrogeological conditions, and source water chemistry captured in this study. Where available new information was also included from System owners/operators to update these systems.

Tetra Tech approached water system stakeholders including water system owners, operators and regulators to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Following compilation of the information, draft sections of each water system overview were provided to water system owners/operators to request their review comments and feedback. Almost all of the stakeholder groups contacted were able to provide data, provided review feedback, and received the project positively. Through the process of compiling the data, Tetra Tech has had communication with the following 30 water system owners, operators and agents:

- YG Community Services – YG CS provided data for Army Beach, Carcross Community, Klondike Valley Firehall, Deep Creek, Faro, Amy Beach, Mayo, Mendenhall, Old Crow, Ross River, Tagish Community, and Teslin Community.
- YG Environmental Health – YG EHS was contacted and assisted with the provision of data for several systems including SFN Pelly Crossing, LFN 2 Mile Community, Mayo and Teslin.
- YG Property Management Division – YG PMD was consulted and provided review comments and data for small water systems where they are involved in the operations and/or management of the system.
- YG Environment Yukon – Environment Parks Division was contacted and provided review comments regarding the Tombstone Interpretive Centre water supply system.
- YG Yukon Housing – Yukon Housing provided review comments and information regarding the nursing residence water supply in Destruction Bay.
- YG Water Resources – YG Water Resources was brought in as an informative step in the early stages of the project and the overall project intent and scope was discussed.
- Indigenous and Northern Affairs Canada – Provided some direction on contacts and data locations.
- Canadian Border Service Agency – Provided information for the CBSA water system in Beaver Creek, and reviewed the system summary.
- Village of Teslin – Was contacted and provided information regarding wells and water treatment as well as review comments.
- City of Dawson – Provided data for new wells and the planned new water treatment plant as well as review comments.
- Town of Faro – Was contacted and provided information regarding wells and water treatment as well as review comments.
- Village of Mayo – Was contacted and provided information regarding wells and water treatment as well as review comments.
- Town of Watson Lake – Was contacted and provided information regarding wells and water treatment as well as review comments.
- Village of Haines Junction – Confirmed that the most up to date information had been captured in the 2012 LPDWSA and subsequent work which Tetra Tech was involved in and therefore additional data was not needed and gave approval for use of Tetra Tech data for the project.
- City of Whitehorse – Provided their SWAPP, gave approval for use of Tetra Tech data for the project, and provided information regarding wells and water treatment as well as review comments.

- White River First Nation – Confirmed that the most up to date information had been captured in the 2012 LPDWSA, and subsequent work which Tetra Tech was involved in and therefore additional data was not needed and gave approval for use of Tetra Tech data for the project
- Kluane First Nation - Confirmed that Tetra Tech had the most up to date data including projects that are currently underway, provided well details and gave approval for use of Tetra Tech data for the project.
- Selkirk First Nation – Confirmed that the most up to date information had been captured in the 2012 LPDWSA, and gave approval for use of Tetra Tech data for the project.
- Little Salmon Carmacks First Nation – Was not able to provide additional data (AWPP) at the time of the project. Tetra Tech contacted LSCFN to request review comments, but did not receive any.
- Carcross Tagish First Nation – Confirmed that the most up to date information had been captured in the 2012 LPDWSA, and gave approval for use of Tetra Tech data for the project.
- Liard First Nation - Confirmed that Tetra Tech had the most up to date well data as of 2016, gave information for water deliver and water connections to new subdivision and gave approval for use of Tetra Tech data for the project. Tetra Tech was unsuccessful in contacting the water system operator or manager at LFN to request review comments in 2017.
- Champagne Aishihik First Nation - Confirmed that Tetra Tech had the most up to date data based on recent work completed in the community including the drilling of a new supply PW Well 2 and completion of a preliminary AWPP, and gave approval for use of Tetra Tech data for the project.
- Nacho Nyak Dun First Nation - Provided well rehabilitation report, confirmed the well configuration and use, and gave approval for use of Tetra Tech data for the project. Reviewed the data summary and confirmed that the information is complete and up to date.
- Vuntut Gwitchin First Nation – Was not able to provide data at the time of the project and requested Tetra Tech contact YG CS regarding the Old Crow Community water supply.
- Chena Corporation - Lobird Park water system owner and operator provided review comments regarding the Lobird Park water supply system.
- Other consulting engineering firms (Opus International, Morrison Hershfield, Golder Associates, and Associated (formerly Summit) Environmental) were contacted to determine whether they were aware of any additional SWPPs or AWPPs that were missing from our summary.
- Some water system information was provided by consulting engineering firms - Opus and Stantec on behalf of, and with permission from water system owners for Liard 2 Mile, Rock Creek Fire Hall and City of Dawson.

The ArcGIS database was created by importing AutoCAD and GIS data into the mapping program to create a map layer showing the location of water infrastructure and well protection areas or capture zones. Metadata (well logs, the system overview reports, source water protection plans) were added to the database using an attachment and attributes tool.

5.0 WATER SYSTEM SUMMARIES

5.1 Beaver Creek – White River First Nation Water Supply Systems

Beaver Creek is the home of the White River First Nation and is located on the Alaska Highway at km 1870.6. Beaver Creek has a population of approximately 93 residents (Yukon Bureau of Statistics 2016). White River First Nation (WRFN) owns and operates two public drinking water systems, referred to as System 1 and System 2, in Beaver Creek, Yukon. The systems each have redundant groundwater wells supplying water to the treatment plants that following treatment (filtration, chlorination) and storage is distributed to users via piped distribution networks. Wells 1a and 1b serve System 1, and Wells 2a and 2b serve System 2. System 1 provides water to a total of 20 service connections, and is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007). Though System 2 only provides water to 7 connections, it is classified by YG-EHS as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007).

5.1.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following parties regarding the WRFN Water Systems:

- White River First Nation – Confirmed that the most up to date information had been captured in the 2012 LPDWSA and other Tetra Tech projects, and gave approval for use of Tetra Tech reports and data for the project.

5.1.2 Hydrogeology

Beaver Creek is located on a broad glaciofluvial plain with the nearest bedrock outcrops occurring approximately 4 km northeast and northwest of the community (Gordey and Markpeace 2003). The subsurface soils in Beaver creek consist of sand and gravel units with veneers of organic soils (Gordey and Markpeace 2003). Regional groundwater flow in the Beaver Creek area is driven by infiltration in the upland areas to the west and southwest of Beaver Creek and discharge to the Beaver Creek drainage (Tetra Tech 2013). The groundwater flow direction has been found to be in a north to northeast direction with a hydraulic-gradient of about 0.001 m/m and a flow-velocity of about 6.5 m/day (Tetra Tech 2004, Tetra Tech 2013).

The WRFN systems are used to supply domestic water to WRFN residents of Beaver Creek as well as to the WRFN administration and government buildings. The four wells serving the two WRFN public water supply systems are completed in glaciofluvial sands and gravels.

The WRFN wells are completed in the Beaver Creek aquifer, which is considered to be an unconfined and in some places semi-confined aquifer (Tetra Tech 2013). The Beaver Creek aquifer is utilized by both the community water system and by private domestic water users with their own water wells. Tetra Tech completed an analysis of the vulnerability of the Beaver Creek aquifer in 2012 based on the semi-quantitative ISI (Ontario Ministry of Environment 2001). The ISI value for the Beaver Creek Aquifer was found to be 35, which suggests medium vulnerability to surface sources of contamination.

The nearest surface water body to the WRFN wells is Beaver Creek, which is about 1,100 m up-gradient of the closest wells (1a/1b) (Tetra Tech 2012a). The four wells serving the WRFN system have been screened for GUDI status and all have been determined to be not under the direct influence of surface water (i.e. Non-GUDI) (Tetra

Tech 2007, Tetra Tech 2008, Tetra Tech 2012a). Well 2a required a retrofitted surface seal, completed in 2007, to achieve the non-GUDI status (Tetra Tech 2007).

5.1.3 Summary of Wells

Logs for the four WRFN public wells serving System 1 and System 2 are included in the GIS map produced for this study. The following tables summarize the completion characteristics of the WRFN wells.

Table 5-1: WRFN, Well No. 1a Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Double D Drilling Ltd. in September 2006.	Well log
Total well depth	34.7 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	31.7 m bgs	
Well screen	3 m 20 slot (0.51 mm) stainless steel well screen from 31.7 m bgs to 34.7 m bgs	Tetra Tech 2008
Static water level	15.0 m bgs (September 18, 2006)	Well log
Sanitary seal	Bentonite surface seal to 6 m bgs.	
Wellhead completion	Pitless unit	Tetra Tech 2013
Wellhead stickup	0.6 m ags	Tetra Tech 2008
Well rated capacity	4.6 L/s (60 IGPM)	
Well GUDI status	Non-GUDI	Tetra Tech 2012a
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-2: WRFN, Well No. 1b Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Double D Drilling Ltd. in August 2007	Well Log
Total well depth	35.0 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	33.8 m bgs	

Table 5-2: WRFN, Well No. 1b Summary

Well Construction Parameters	Details	Source
Well screen	1.2 m 100 slot (2.54 mm) stainless steel well screen from 33.8 m bgs to 35.0 m bgs.	
Static water level	14.6 m bgs (September 14, 2007)	
Sanitary seal	Bentonite surface seal to 6 m bgs.	
Wellhead completion	Pitless unit	Tetra Tech 2013
Wellhead stickup	0.6 m ags	Tetra Tech 2008
Well rated capacity	8.3 L/s (110 IGPM)	
Well GUDI status	Non-GUDI	Tetra Tech 2012a
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-3: WRFN, Well No. 2a Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Midnight Sun Drilling Co. Ltd. in November 1983	Well Log
Total well depth	35 m bgs	
Casing	178 mm	
Casing depth	33.8 m bgs	
Well screen	1.2 m 20 slot (0.5 mm) stainless steel well screen from 33.8 m bgs to 35 m bgs	
Static water level	14.6 m bgs (September 14, 2007)	
Sanitary seal	6 m bgs	Tetra Tech 2013
Wellhead completion	Pitless unit	
Wellhead stickup	>0.5 m ags	Tetra Tech site visit 2016
Well rated capacity	4.2 L/s (55 IGPM)	Tetra Tech 2006
Well GUDI status	Non-GUDI	Tetra Tech 2007
Well Construction Comments:	Well was upgraded in 2007 with sanitary seal, pitless unit and casing extension to meet Canadian Groundwater Association Well Construction Guidelines (Tetra Tech 2008).	

Table 5-4: WRFN, Well No. 2b Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Double D Drilling in August 2007.	Well log
Total well depth	34.4 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	33.2 m bgs	
Well screen	1.2 m 100 slot (2.54 mm) stainless steel well screen from 33.2 m bgs to 34.4 m bgs.	
Static water level	13.75 m bgs (September 10, 2007)	
Sanitary seal	Bentonite surface seal to 6 m bgs	Tetra Tech 2013
Wellhead completion	Pitless unit	
Wellhead stickup	0.6 m ags	Tetra Tech 2008
Well rated capacity	8.3 L/s (110 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.1.4 Source Water Quality

The water supplied from the four WRFN public water supply wells comes from the Beaver Creek Aquifer; very similar chemistry is observed in all of the Community wells which are completed at similar depths within the same aquifer. The water from the four wells can be classified as calcium-bicarbonate type and is moderately hard (Tetra Tech 2008).

Tetra Tech collected samples from the WRFN water systems on five different dates between 2006 and 2010. In addition to this monitoring, samples were collected from the systems in 2011 and 2012 as part of GUDI assessment work and AWPP updates. In the samples reviewed, all parameters have been within the GCDWQ MAC and AO with the exception of a raw water sample retrieved in March 2007 from Well 1a which had an iron concentration in excess of the GCDWQ AO of 0.3 mg/L and a turbidity measurement greater than 1 NTU (Tetra Tech 2011). Test results for all treated water yielded results have been within the GCDWQ (Tetra Tech 2011, Tetra Tech 2012b, and Tetra Tech 2013).

Laboratory water quality results from 2012 can be found in the AWPP in the attached GIS database.

5.1.5 Water Treatment and Distribution

Table 5-5: WRFN System 1 Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	White River First Nation	Tetra Tech 2008
Water source	Groundwater	
Wells serving the system	Wells No. 1a and No. 1b	
Treatment type	Filtration (10 and 1 micron steps) and chlorination	Tetra Tech 2015
Number of connections	20 connections	
Delivery method	Shallow bury low flow recirculating piped water distribution system	
Age of system/last known update	System upgrades ongoing. Most recent upgrades completed in 2011. The design work and permitting are completed, and work is planned to expand System 1 to serve an additional 15 service connections in a proposed new WRFN subdivision	Tetra Tech 2015 Current projects with Tetra Tech

Table 5-6: WRFN System 2 Water Treatment and Distribution Details

	Details	Source
Owner/Operator	White River First Nation	Tetra Tech 2008
Water source	Groundwater	
Number of wells serving the system	Wells No. 2a and No. 2b	
Treatment type	Filtration (10 and 1 micron steps) and chlorination	Tetra Tech 2015
Number of connections	7 connections	
Delivery method	Shallow bury low flow recirculating piped water distribution system	
Age of system/last known major work	System modifications are planned. Most recent upgrades completed in 2011.	Current projects with Tetra Tech

5.1.6 Source Water Protection Planning

Source water protection planning in the form of an AWPP was completed in 2007 and updated in 2012 (Tetra Tech 2012b). The updated 2012 AWPP is included in the GIS mapping portion of this project.

Beaver Creek was established as a community in the 1950s shortly after the completion of the Alaska Highway. There is very little industrial activity in Beaver Creek and potential sources of contamination in the area of the WRFN water supply system are primarily related to domestic septic fields, ASTs, livestock holding pens and historical fuel spills.

The Beaver Creek WRFN AWPP was developed and updated by White River First Nation representatives with technical input and consulting services provided by Tetra Tech. A risk based approach was used to create the AWPP. Tetra Tech identified the well capture zones using a combination of analytical method based on the Theim Equation and groundwater flow modelling using the Waterloo Hydrogeologic Inc. Visual MODFLOW modelling code (Version 3.1.0.86). Visual MODFLOW is based on the USGS MODFLOW code and simulates groundwater flow in three-dimensions using the finite-difference method in either steady state or transient mode. The modelling showed long narrow capture zones which Tetra Tech modified for the AWPP to add a safety factor by using a 'buffer zone' around the AWPP area.

The AWPP was updated in 2012 to capture changes and updates to potential risks to the groundwater resource. Tetra Tech emphasized the following key conclusions:

- There had been no identified contamination in groundwater sampled from the Community Wells; however, any release of contaminants within the identified capture zones would represent a potential risk to the aquifer and water quality of the Community Wells;
- A total of 11 wells had been decommissioned in accordance with the Canadian Groundwater Association - Guidelines for Water Well Construction;
- Water quality results from the Community Wells did not suggest that up-gradient septic fields and manure pile storage are currently impacting the water quality of the wells; however, septic fields and manure pile storage had the potential to impact the Beaver Creek Aquifer and community wells;
- The identified risks to the Community Wells were from livestock manure storage; leachate from septic fields; potential releases and spills from Aboveground Storage Tanks (ASTs); and other potential spills; and
- ASTs located outside of the well capture zones were identified as potential sources of contamination, for which environmental concerns should be addressed.

From the 2012 update, Tetra Tech made several recommendations which are included in the attached AWPP, included in the GIS map and database portion of this summary.

5.1.7 Water Supply Information Data Gaps

There are no known gaps with respect to source water protection in the White River First Nation community at Beaver Creek and Tetra Tech was able to obtain all known reports and data for the purposes of this summary. There are some remaining recommendations for risk reduction/mitigation that WRFN have been working towards.

5.2 Beaver Creek - Nelnah Bessie John School Water Supply System

Nelnah Bessie John (NBJ) School is located in the community of Beaver Creek in northwestern Yukon. NBJ School is served by a potable water supply system served by a groundwater well, Well 3100-C, located near the school building. The well was drilled in 2006 to replace wells 3100-A and 3100-B drilled in the 1950s and 1960s. The NBJ School water system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.2.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.2.2 Hydrogeology

Beaver Creek is located on a broad glaciofluvial plain with the nearest bedrock outcrops occurring approximately 4 km northeast and northwest of the community (Gordey and Markpeace 2003). The subsurface soils in Beaver Creek consist of sand and gravel units with veneers of organic soils (Gordey and Markpeace 2013).

The Beaver Creek aquifer is used for both community and domestic water supply. Most of the wells in the Beaver Creek area indicate coarse sand and gravel with cobbles and small boulders to depths of at least 30 m (Tetra Tech 2006). The well logs also indicate that discontinuous lenses of finer-grained sediments persist throughout the area, the sediments are generally dominated by coarse alluvium. Some discontinuous permafrost is also interpreted to persist throughout the Beaver Creek area. Due to the variability of sediments in the Beaver Creek area, some areas may have significantly higher vulnerability to surface source of contamination than others. Regional groundwater flow in the Beaver Creek area is driven by infiltration in the upland areas to the west and southwest of Beaver Creek coupled with discharge to the Beaver Creek drainage (Tetra Tech 2013). The direction of groundwater flow is determined to be north to northeasterly (Tetra Tech 2006).

The NBJ School water supply system provides potable water to the school. The water well was completed in an unconfined sand and gravel aquifer. Sand and gravel extends from about 3.7 m bgs to the final depth of well completion (28.9 m bgs) and consists of water bearing sands and gravels with intermittent silty sand units. Due to the variability of sediments in the Beaver Creek area, some areas may have significantly higher vulnerability to surface source of contamination than others.

5.2.3 Well Summary

A copy of the well log for this well is included in the GIS map and database portion of this project. The following table summarizes available data for the water well.

Table 5-7: Nelnah Bessie John School, Well 3100-C Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Double D Drilling Ltd. in October 2006	Tetra Tech 2007
Total well depth	28.9 m bgs	

Table 5-7: Nelnah Bessie John School, Well 3100-C Summary		
Well Construction Parameters	**Details**	**Source**
Casing	6” (152 mm) ID Steel Well Casing	
Casing depth	27.7 m bgs	
Well screen	1.2 m 60 slot (1.52 mm) stainless steel well screen from 27.7 m bgs to 28.9 m bgs	
Static water level	12.1 m bgs (October 2006)	
Sanitary seal	Bentonite surface seal to 6 m bgs	
Wellhead completion	We understand that the well was connected in general accordance with the Well Connection Standards for Typical YG Small Public Drinking Water Systems (FSC, Tetra Tech, 2008); except rather than a pitless unit it has a pitless adapter.	Anecdotal Information from YG PMA circa 2008.
Wellhead stickup	Unknown	Tetra Tech 2007
Well rated capacity	6.9 L/s (90 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.2.4 Source Water Quality

As part of the well completion, Tetra Tech collected a water sample in October 2006 and reviewed the water chemistry results. Following are the key observations noted by Tetra Tech:

- Water quality met the GCDWQ for all the health-based and aesthetic parameters analyzed on the date sampled; and
- The water was characterized as calcium-bicarbonate type and considered hard with a measured hardness of 163 mg/L (as $CaCO_3$).

5.2.5 Water Treatment and Distribution

Table 5-8: Nelnah Bessie John School, Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2007 p.c. Nick Barnett 2017 p.c. Martin Eckervogt 2017
Water source	Groundwater	
Wells serving the system (s)	Well 3100-C	
Treatment type	Charcoal filtration and water softening	
Water users	Nelnah Bessie John School	
Delivery method	Directly connected to school	
Age of system/last known update	New well was completed in 2006.	

5.2.6 Source Water Protection Planning

There is no source water protection planning in place for the NBJ School Well 3100-C in Beaver Creek. The interbedded nature of the fine sediments which persist in the area, and the thick unsaturated zone provides some limited aquifer protection from surficial sources of contamination (moderate vulnerability as indicated previously). The vulnerability of the overburden aquifer underlying the community of Beaver Creek is variable due to variation in the sedimentary sequence. Implementing a source water protection plan for the community of Beaver Creek would provide a comprehensive approach to protecting this groundwater resource.

Potential sources of contamination to the NBJ School well have not been identified since completion of the well in 2006. Potential sources of contamination that were identified previously in the vicinity of the old wells 3100-A and 3100-B during the site review in 2005, included: an UST, a septic field and an abandoned uncapped well. The new well was located to ensure adequate distance from these potential sources of contamination.

5.2.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system summary includes all available data and is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- There is no source water protection planning for this groundwater resource. The SWPP for the new school well could be tied in with the planning completed for the WRFN source water wells to increase the security of the entire Beaver Creek Aquifer; and
- Tetra Tech has not received documentation or confirmation of the decommissioning of wells 3100-A and 3100.

5.3 Beaver Creek - Health and Visitor Centre Water Supply System

The Beaver Creek Health Centre and Visitor Centre are supplied by a piped water system served by one groundwater well. Water from this system is used to provide potable domestic water to the two buildings and the system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.3.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.3.2 Hydrogeology

Beaver Creek is located on a broad glaciofluvial plain with the nearest bedrock outcrops occurring approximately 4 km northeast and northwest of the community (Gordey and Markpeace 2003). The subsurface soils in Beaver Creek consist of sand and gravel units with veneers of organic soils (Gordey and Markpeace 2013).

The Beaver Creek aquifer is used for both community and domestic water supply. Most of the wells in the Beaver Creek area indicate coarse sand and gravel with cobbles and small boulders to depths of at least 30 m (Tetra Tech 2006). The well logs also indicate that discontinuous lenses of finer-grained sediments persist throughout the area, the sediments are generally dominated by coarse alluvium. Some discontinuous permafrost is also interpreted to persist throughout the Beaver Creek area. Due to the variability of sediments in the Beaver Creek area, some areas may have significantly higher vulnerability to surface source of contamination than others. Regional groundwater flow in the Beaver Creek area is driven by infiltration in the upland areas to the west and southwest of Beaver Creek coupled with discharge to the Beaver Creek drainage (Tetra Tech 2013). The direction of groundwater flow is determined to be north to northeasterly (Tetra Tech 2006).

Materials encountered during drilling consisted of sand and gravel to a depth of 23 m bgs underlain by a silt, sand and gravel unit to a depth of 27 m bgs. A sand and gravel unit was encountered from 27 m bgs to the maximum extent of drilling (59.5 m bgs). The materials encountered and the well completion depth in the aquifer, suggest the well is completed in the same unconfined to semiconfined Beaver Creek aquifer as wells completed elsewhere in the community.

5.3.3 Well Summary

A copy of the well log for this well is included in the associated GIS map and database. The following table summarizes available data for the water well.

Table 5-9: Beaver Creek Health/Visitor Centre, Well 3964/3121-B Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Double D Drilling Ltd. in September 2007	Tetra Tech 2008
Total well depth	59.5 m bgs	

Table 5-9: Beaver Creek Health/Visitor Centre, Well 3964/3121-B Summary		
Well Construction Parameters	**Details**	**Source**
Casing	6” (152 mm) ID steel casing	
Casing depth	58.3 m bgs	
Well screen	1.2 m 80 slot (2.03 mm) stainless steel well screen from 58.3 m bgs to 59.5 m bgs	
Static water level	14.7 m bgs (September 24, 2007)	
Sanitary seal	Bentonite surface seal to 6 m bgs	
Wellhead completion	We understand that the well was connected in general accordance with the Well Connection Standards for Typical YG Small Public Drinking Water Systems (FSC, Tetra Tech, 2008); however it was connected by pitless adapter rather than pitless unit.	Anecdotal Information from YG PMA circa 2008.
Wellhead stickup	Unknown	Tetra Tech 2008
Well rated capacity	7.6 L/s (100 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.3.4 Source Water Quality

As part of the well completion in September 2007, the drilling contractor collected a water sample and Tetra Tech reviewed the water chemistry result and noted the following:

- Water from Well 3964/3121-B was calcium-bicarbonate type with a pH of 8.3 and was considered to be hard with hardness measured at 150 mg/L (as $CaCO_3$) during the initial sampling event; and
- Water collected during the initial sampling event from Well 3964/3121-B met the GCDWQ for all the health-based and aesthetic parameters analyzed.

5.3.5 Water Treatment and Distribution

Table 5-10: Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2008

Table 5-10: Water Treatment and Distribution Details		
Item	**Details**	**Source**
Water source	Groundwater	p.c. Nick Barnett 2017 p.c. Martin Eckervogt 2017
Wells serving the system	Well 3964/3121-B	
Treatment type	Sediment filtration and GE membrane treatment	
Water users	YG employees, patients and tourists	
Delivery method	Connected directly to buildings	
Age of system/last known update	New well was drilled in 2007 and connected in 2008.	

5.3.6 Source Water Protection Planning

There is no source water protection planning in place for the Beaver Creek Health and Visitor Centre's Well 3964/3121-B in Beaver Creek. The vulnerability of the overburden aquifer underlying the community of Beaver Creek is variable due to variation in the sedimentary sequence. Implementing a source water protection plan for the community of Beaver Creek would provide a comprehensive approach to protecting this groundwater resource.

Potential sources of contamination to for Well 3964/3121-B have not been identified. Potential sources of contamination that were identified in the vicinities of the previously used supply wells during the site review in 2005 included:

- An effluent discharge field 18 m from the old Health Centre well;
- An indoor fuel storage tank located 20 m from the old Health Centre well;
- Various fuel, oil and paint drums on the Grader Station property located approximately 20 m from the old Health Centre well;
- As asphalt mix pile located on the nearby Grader Station property;
- An AST located at 19 m from the old Visitor Centre well ASTs;
- An active parking lot and the active highway (Alaska Highway) with potential for fuel and sewage spills from automobiles and recreational vehicles near the old Visitor Centre well; and
- Septic fields within 30 m of the well.

The new Well 3964/3121-B was drilled in a location selected to ensure the above-mentioned potential sources of contamination were adequately distanced from the wellhead to achieve at least 30 m setback, and to avoid being downgradient of PCOCs.

5.3.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system summary includes all available data and is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- There is no source water protection planning for this groundwater resource. SWPP could be tied in with the planning completed for the WRFN source water supply and integrated with planning in other areas of Beaver Creek to create a comprehensive source water protection plan for the Beaver Creek Aquifer;
- Tetra Tech had recommended that the wells that previously supplied water to the Health Centre and the Visitor Centre be decommissioned in accordance with CGWA guidelines for well decommissioning; however, YG PMD did not confirm the completion of this work.

5.4 Beaver Creek - Canada Border Services Water Supply System

The Canada Border Services Agency (CBSA) Beaver Creek water system supplies water to three CBSA duplexes in Beaver Creek, Yukon. The system is supplied by one groundwater well, CBSA-Beaver Creek-YT-WDS-000025, completed in July 2011 and serves potable water to the Beaver Creek CBS duplexes. The system is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.4.1 Data Compilation Methodology

Tetra Tech approached all the stakeholders including government departments, water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech the following parties regarding data for the Beaver Creek CBS supply system:

- Government of Canada – Canada Border Services Agency was consulted regarding the current status of this system. CBS owns and operates the water system and provided review comments as well as recent water quality testing results.
- YG Property Management Division – YG PMD has been consulted and provided permission to use available data for the first iteration of data compilation.

For the Beaver Creek CBS Water Supply system, data from the SPDWS review with updates from more recent work were used and the summary was reviewed by the current water system operator.

5.4.2 Hydrogeology

Based on previous hydrogeological investigations in the Beaver Creek area, the groundwater flow direction in the area was assumed to be towards the northeast or north-northeast (Tetra Tech 2011a).

The aquifer is a semi-confined sand and gravel aquifer, with a low permeability silt layer about 14 m thick located above the aquifer which offers some protection from potential infiltration from surface sources of contamination (Tetra Tech 2011). Due to the variability of sediments in the Beaver Creek area, some areas may have significantly higher vulnerability to surface source of contamination than others.

Pumping test results from the well indicate an aquifer transmissivity in the order of 1×10-3 m^2/s (86 m^2/day) (Tetra Tech 2011).

5.4.3 Well Summary

The log for the well serving the CBS housing in Beaver Creek is included in the GIS map and database portion of this project. The following table summarizes the completion characteristics of the well.

Table 5-11: Canada Border Services Beaver Creek Well Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Impact Drilling Ltd. in July 2011	Tetra Tech 2011

Table 5-11: Canada Border Services Beaver Creek Well Summary		
Well Construction Parameters	**Details**	**Source**
Total well depth	41.3 m bgs	
Casing	6" (152 mm) OD Steel Well Casing	
Casing depth	40.1 m bgs	
Well screen	1.2 m 50 slot (1.27 mm) stainless steel well screen from 40.1 m bgs to 41.3 m bgs	
Static water level	10.6 m bgs (July 24, 2011)	
Sanitary seal	Bentonite sanitary seal to 5.6 m bgs	
Wellhead completion	Unknown	
Wellhead stickup	Unknown	
Well rated capacity	3 L/s (40 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.4.4 Source Water Quality

Tetra Tech reviewed available water quality information for the Beaver Creek CBS well including water quality testing completed at the time of well construction and water quality testing for 2016. In general, the water from the CBS Beaver Creek well meets Health Canada's Guidelines for Canadian Drinking Water Quality (GCDWQ) for the parameters analyzed with the exception of the aesthetic objective (AO) for manganese and iron (2016 results and Tetra Tech 2011). The key water quality observations include:

- The groundwater source was is very hard and can be characterized as a calcium-bicarbonate type water;
- The total iron concentration measured at one water use point in 2016 exceeded the GCDWQ AO of 0.3 mg/L with a concentration of 2.67 mg/L; and
- The total manganese concentration (0.0642 to 0.193 mg/L in the raw water) exceeded GCDWQ AO value of 0.05 mg/L with concentrations measured at the point of use as high as 0.334 mg/L.

5.4.5 Water Treatment and Distribution

Table 5-12: Canada Border Services Beaver Creek *Water Treatment and Distribution Details*		
Item	**Details**	**Source**
Owner/Operator	Canadian Border Services Agency	Tetra Tech 2011

Table 5-12: Canada Border Services Beaver Creek *Water Treatment and Distribution Details*		
Item	**Details**	**Source**
Water source	Groundwater	
Well serving the system	CBS Beaver Creek well	
Delivery Method	3 duplex service connections	Tetra Tech 2012
Treatment type	Water softening and UV	
Age of system/last known update	Water Treatment system installed in 2012	

5.4.6 Source Water Protection Planning

No records were found indicating that any source water protection planning which includes the CBS Well in Beaver Creek. Although the aquifer is semi-confined and is protected from surface-based contamination by silts encountered during drilling, the aerial extent of this impermeable layer is unknown. The vulnerability of the overburden aquifer underlying the community of Beaver Creek is variable due to variation in the sedimentary sequence. Implementing a source water protection plan for the community of Beaver Creek would provide a comprehensive approach to protecting this groundwater resource.

5.4.7 Water Supply Information Data Gaps

Tetra Tech has compiled this summary from the most recent reports available and has obtained review comments from the system operator. For the purpose of this study, Tetra Tech identified the following data gaps:

- Wellhead completion details have not been provided; and
- No SWPP is in place for this system.

5.5 Beaver Creek - Pool Centre Water Supply System

The Beaver Creek Pool Centre and the nearby the Community Club Building have their water supplied from a 40.5 m well (Well 3122-B), which was drilled in 2007 as part of the system upgrade work completed at the site. These facilities were previously supplied by a 19.2 m deep well (Well 3122-A), which, during the SPDWSA work completed by Tetra Tech in 2005, was found to have several deficiencies, including no surface sanitary seal, and poor surface completion of the wellhead (located in a pit below ground) (Tetra Tech 2006 and 2008). Well 3122 B was subsequently drilled to replace 3122 A. The system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.5.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.5.2 Hydrogeology

Beaver Creek is located on a broad glaciofluvial plain with the nearest bedrock outcrops occurring approximately 4 km northeast and northwest of the community (Gordey and Markpeace 2003). The subsurface soils in Beaver Creek consist of sand and gravel units with veneers of organic soils (Gordey and Markpeace 2013).

The Beaver Creek aquifer is used for both community and domestic water supply. Most of the wells in the Beaver Creek area indicate coarse sand and gravel with cobbles and small boulders to depths of at least 30 m (Tetra Tech 2006). The well logs also indicate that discontinuous lenses of finer-grained sediments persist throughout the area, the sediments are generally dominated by coarse alluvium. Some discontinuous permafrost is also interpreted to persist throughout the Beaver Creek area. Due to the variability of sediments in the Beaver Creek area, some areas may have significantly higher vulnerability to surface source of contamination than others. Regional groundwater flow in the Beaver Creek area is driven by infiltration in the upland areas to the west and southwest of Beaver Creek coupled with discharge to the Beaver Creek drainage (Tetra Tech 2013). The direction of groundwater flow is determined to be north to northeasterly (Tetra Tech 2006).

The lithology encountered at Well 3122-B indicates that the near surface soils consisted of sand and gravel to a depth of 18 m bgs, a silt and sand unit from 18 m to 25 m bgs, and a water-bearing sand and gravel unit from 25 to 45 m bgs (the maximum extent of the borehole). This is generally consistent with the lithology for the old Well 3122-A; however, the limited presence of fine-grained materials encountered at both Well 3122-A and 3122-B indicates that these two wells are most likely completed within a unconfined or semi-confined aquifer with limited protection from surficial sources of contamination (Tetra Tech 2006 and 2008). Results of the 24-hour constant rate pumping test conducted on Well 3122-B in September 2007 indicate an aquifer transmissivity of 6.2×10^{3} m^2/day and a hydraulic conductivity of 3×10^{-3} m/s, respectively (Tetra Tech 2008).

The nearest up-gradient surface waterbody is approximately 1,100 m from Well 3122-B (Tetra Tech 2008).

5.5.3 Well Summary

The well log for the new well (Well 3122-B) serving the Beaver Creek Pool Centre Building (Building #3122) and the Community Club Building, Beaver Creek is provided in the GIS map and database portion of this project. The following table summarizes the completion characteristics of the well.

Table 5-13: Beaver Creek Pool Centre, Well 3122-B Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Double D Drilling Ltd. in August 2007	Well log
Total well depth	40.5 m bgs	
Casing	6” (152 mm) OD Steel Well Casing	
Casing depth	39.3 m bgs	
Well screen	1.2 m 120 slot (3.05 mm) stainless steel well screen from 39.3 m to 40.5 m bgs	
Static water level	12.2 m bgs (September 18, 2007)	
Sanitary seal	Bentonite sanitary seal to 6 m bgs	Tetra Tech 2008
Wellhead completion	We understand that the well was connected in general accordance with the Well Connection Standards for Typical YG Small Public Drinking Water Systems (FSC & Tetra Tech, 2008); except rather than a pitless unit it has a pitless adapter.	Anecdotal Information from YG PMD circa 2008.
Wellhead stickup	Unknown	Tetra Tech 2008
Well rated capacity	8.5 L/s (113 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.5.4 Source Water Quality

The key observations regarding the groundwater analysis of Well 3122-B on September 18, 2007 are summarized as follows (Tetra Tech 2008):

- Water from Well 3122-B was a calcium-bicarbonate type with a pH of 8.1;
- Water from this well was hard, with a hardness of 171 mg/L (as $CaCO_3$);
- Water from Well 3122-B met all GCDWQ for health-based and aesthetic parameters on the date sampled and for the parameters tested; and
- The total copper concentration (<0.005 mg/L) was much less than the concentration (0.432 mg/L, sampled on June 15, 2005) from Well 3122-A. Both reported copper concentrations were below the GCDWQ AO of 1 mg/L.

5.5.5 Water Treatment and Distribution

Table 5-14: Beaver Creek Pool Centre Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017 p.c. Martin Eckervogt 2017
Water source	Groundwater	
Well serving the system	Beaver Creek Pool Centre well (Well 3122-B)	
Treatment type	None	
Water users	YG employees and users of the swimming pool	
Delivery method	Piped (to the Pool Centre Building and the Community Club Building)	
Age of system/last known update	Unknown	

5.5.6 Source Water Protection Planning

There is no source water protection planning in place for the Pool Centre Well 3122-B in Beaver Creek. The limited presence of fine-grained materials indicates that Well 3122-B is most likely completed within an unconfined or semi-confined aquifer with some protection from surficial sources of contamination. The vulnerability of the overburden aquifer underlying the community of Beaver Creek is variable due to variation in the sedimentary sequence. Implementing a source water protection plan for the community of Beaver Creek would provide a comprehensive approach to protecting this groundwater resource.

5.5.7 Water Supply Information Data Gaps

Tetra Tech was involved in the system upgrade work at the Beaver Creek Pool Centre 2007 and 2008. YG PMD has reviewed this summary and provided comments. To our knowledge, this system summary includes all available data and is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- No SWPP is in place for this groundwater resource, Source water protection planning here could be incorporated into a greater Beaver Creek SWPP and provide comprehensive planning to protect the moderately vulnerable groundwater resource.
- Several upgrades on the water system including installation of a disinfection system, were recommended by Tetra Tech in 2006; however, it is our understanding that no updates have been completed to the system since 2006.

5.6 Beaver Creek - Airport Terminal Building Water Supply System

The Beaver Creek Airport Terminal Building (ATB) has water supplied from a groundwater supply well (Well 3125-B), which was drilled in 2006 to replace the old well (Well 3125-A). Well 3125-A, which was located in a pit, had several deficiencies, including several contaminant sources within 30 m of the wellhead and poor water quality (Tetra Tech 2006 and 2014).

The system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.6.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.6.2 Hydrogeology

Beaver Creek is located on a broad glaciofluvial plain with the nearest bedrock outcrops occurring approximately 4 km northeast and northwest of the community (Gordey and Markpeace 2003). The subsurface soils in Beaver Creek consist of sand and gravel units with veneers of organic soils (Gordey and Markpeace 2013).

The Beaver Creek aquifer is used for both community and domestic water supply. Most of the wells in the Beaver Creek area indicate coarse sand and gravel with cobbles and small boulders to depths of at least 30 m (Tetra Tech 2006). The well logs also indicate that discontinuous lenses of finer-grained sediments persist throughout the area, the sediments are generally dominated by coarse alluvium. Some discontinuous permafrost is also interpreted to persist throughout the Beaver Creek area. Due to the variability of sediments in the Beaver Creek area, some areas may have significantly higher vulnerability to surface source of contamination than others. Regional groundwater flow in the Beaver Creek area is driven by infiltration in the upland areas to the west and southwest of Beaver Creek coupled with discharge to the Beaver Creek drainage (Tetra Tech 2013). The direction of groundwater flow is determined to be north to northeasterly (Tetra Tech 2006).

The aquifer where Well 3125-B was completed is a semi-confined sand and gravel aquifer which is overlain by about 14 m of low permeability silt. The thick low permeability silt layer offers some protection from potential infiltration of contaminants originating from ground surface, however, the sediments in the Beaver Creek area are variable and the aerial extent of the silt layer is unknown (Tetra Tech 2007). Grain size analysis of the aquifer bearing unit indicates a hydraulic conductivity of approximately 6 x 10^{-3} m/s (Tetra Tech 2007).

5.6.3 Well Summary

The well log for the new well (Well 3125-B) serving the ATB in Beaver Creek is included in the GIS map and database portion of this project. The following table summarizes the completion characteristics of the well.

Table 5-15: Beaver Creek ATB Well 3125-B Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Double D Drilling Ltd. in October 2006	Well log
Total well depth	28.9 m bgs	
Casing	6” (152 mm) OD Steel Well Casing	
Casing depth	27.7 m bgs	
Well screen	1.2 m 40 slot (1.02 mm) stainless steel well screen from 27.7 m to 28.9 m bgs	
Static water level	9.8 m bgs (October 20, 2006)	
Sanitary seal	Bentonite sanitary seal to 6 m bgs	Tetra Tech 2007
Wellhead completion	Pitless unit and heat trace cable for the well for freeze protection	Tetra Tech 2014
Wellhead stickup	Approx. 0.65 m ags	Tetra Tech 2007
Well rated capacity	5.5 L/s (72.6 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.6.4 Source Water Quality

Key observations (Tetra Tech 2006) regarding the groundwater analysis conducted on Well 3125-B when sampled in 2006 are:

- All parameters tested met current Health Canada’s Guidelines for Canadian Drinking Water Quality (GCDWQ) for health-based and aesthetic parameters on the date sampled; and
- Water from Well 3125-B was calcium-bicarbonate type with a pH of approximately 8, and was considered very hard with a measured hardness of 194 mg/L.

5.6.5 Water Treatment and Distribution

Table 5-16: Beaver Creek ATB Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2014 p.c. Nick Barnett 2017
Water source	Groundwater	
Well serving the system	Beaver Creek ATB well (Well 3125-B)	
Treatment type	None	
Water users	ATB workers	
Delivery method	Directly connected to the Air Terminal Building	
Age of system/last known update	Well 3125-B was connected to the system in 2014. No known major upgrades/expansions on the system since 2014	

5.6.6 Source Water Protection Planning

There is no source water protection planning in place for ATB Well 3125-B in Beaver Creek. Although the aquifer is semi-confined and is protected from surface-based contamination by the silts encountered during drilling, the aerial extent of this impermeable layer is unknown. The vulnerability of the overburden aquifer underlying the community of Beaver Creek is variable due to variation in the sedimentary sequence. Implementing a source water protection plan for the community of Beaver Creek would provide a comprehensive approach to protecting this groundwater resource.

5.6.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system summary includes all available data and is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- There is no source water protection planning for this groundwater resource. SWPP could be tied in with the planning completed for the WRFN source water supply and integrated with planning in other areas of Beaver Creek to create a comprehensive source water protection plan for the Beaver Creek Aquifer.
- Several upgrades on the water system including installation of a disinfection system, were recommended by Tetra Tech in 2006; however, it is our understanding that no updates have been completed to the system since 2006 other than the connection of the new water well in 2014.

5.7 Beaver Creek - Firehall Water Supply System

The Beaver Creek Firehall has water supplied from a 34.0 m deep well (Well 3102-A). The system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption. A new well was drilled and tested at the site in 2007, however we understand that the well was not ever commissioned due to permafrost/freezing issues.

5.7.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.7.2 Hydrogeology

There was no driller's log for Well 3102-A available for review. Most of the wells in the Beaver Creek area indicate coarse sand and gravel with cobbles and small boulders to depths of at least 30 m. The well logs also indicate that discontinuous lenses of finer-grained sediments persist throughout the area; however, the sediments are generally dominated by coarse alluvium. Some discontinuous permafrost is also interpreted to persist throughout the Beaver Creek area. Due to the variability of sediments in the Beaver Creek area, some areas may have significantly higher vulnerability to surface source of contamination than others. A study previously completed in the Beaver Creek area by Tetra Tech determined that the direction of groundwater flow in the vicinity of the site is north to northeasterly (Tetra Tech 2006).

Pumping test results from Well 3102-B indicate an aquifer transmissivity in the order of 3×10^{-3} m^2/s (259.5 m^2/day) (Tetra Tech 2008).

5.7.3 Well Summary

The log for the Beaver Creek Firehall Well (Well 3102-A) serving the system is not available for review. The following table summarizes the completion characteristics of the well.

Table 5-17: Beaver Creek Firehall, Well 3102-A Summary

Well Construction Parameters	Details	Source
Date of construction	Unknown	Tetra Tech 2006
Total well depth	34.0 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	Unknown	
Well screen	Unknown	
Static water level	13.1 m bgs (July 2005)	
Sanitary seal	No record that a bentonite sanitary seal has been installed	

Table 5-17: Beaver Creek Firehall, Well 3102-A Summary		
Well Construction Parameters	**Details**	**Source**
Wellhead completion	The well is completed with a pitless adapter in the yard of the new Firehall. The well was not equipped with bollards to protect it from vehicle traffic at the time of inspection.	Tetra Tech 2015 site visit
Wellhead stickup	Approximately 0.4 m ags	Tetra Tech 2015 site visit
Well rated capacity	Unknown	Tetra Tech 2006
Well GUDI status	Potentially GUDI	Based on well construction
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-18: Beaver Creek Firehall (Unused), Well 3102-B Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Double D Drilling in September 2007.	Tetra Tech 2008
Total well depth	41 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	38.9 m bgs	
Well screen	1.2 m of 80-slot (2.03 mm) stainless steel well screen from 39.8 m bgs to 41 m bgs	
Static water level	12.3 m bgs (September 26, 2007)	
Sanitary seal	Bentonite surface seal to 6 m depth	
Wellhead completion	Unknown – well was equipped with a lockable circle plate at the time of completion	
Wellhead stickup	1.0 m ags at the time of well completion	
Well rated capacity	4.5 L/s (60 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines. Tetra Tech understands this well was never commissioned due to permafrost and freezing issues.	

5.7.4 Source Water Quality

Tetra Tech reviewed water quality results from the original water well 3102-A from 2004 and 2005 as well as those collected from the new water well upon completion in 2007. In general, the water from the Firehall well 3102 A met the GCDWQ in the 2004 and 2005 results for the parameters analyzed and the key observations and comments noted in the 2006 SPDWSA assessment and the 2007 Well 3102-B well completion report are (Tetra Tech 2006 and 2007):

- Water from both Well 3102-A and Well 3102-B was a very hard calcium-bicarbonate type with hardness ranging from about 170 mg/L to 214 mg/L and pH of 7.79 to 8.4;
- Although the copper concentration measured in the 2004 and 2005 results was not in exceedance of the GCDWQ maximum allowance concentration (MAC), copper was elevated with respect to regional groundwater quality for the Beaver Creek area;
- The new well 3102-B had copper concentrations below detection limit at the time of completion in September 2007;
- The new well 3102-B had lead concentration more than an order of magnitude lower than those observed in well 3102-A;
- Although the lead concentration was not in exceedance of the GCDWQ MAC in either well, lead was elevated with respect to regional groundwater quality for the Beaver Creek area;
- The screening for Extractable Petroleum Hydrocarbons (EPH) in 2005 did not indicate any parameter above detection limits;
- Turbidity of the water sample ranged from 2.3 NTU to 2.69 NTU when sampled between September 2004 and July 2005. Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration was expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU;
- Turbidity measurements from well 3102-B were significantly lower upon completion in 2007 than those observed in well 3102-A.

5.7.5 Water Treatment and Distribution

Table 5-19: Beaver Creek Firehall Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2006
Water source	Groundwater	
Well serving the system	Well 3102	
Treatment type	Sediment filtration, reverse osmosis, chlorination	M. Eckervogt 2017
Water users	Public fill station and Firehall	Tetra Tech 2006

Table 5-19: Beaver Creek Firehall Water Treatment and Distribution Details		
Item	**Details**	**Source**
Delivery method	Directly connected to the Firehall and a water fill station outside the Firehall for public use	Tetra Tech 2006
Age of system/last known update	A new Firehall was completed in 2015.	

5.7.6 Source Water Protection Planning

At the time of the 2006 assessment, the well was located within 30 m of potential contaminant sources, including an above-ground storage tank at 3.5 m, a leach pit located at approximately 16 m, and garage activities immediately adjacent to the wellhead (Tetra Tech 2006).

There is no source water protection planning in place for the Beaver Creek Firehall Well 3102-A in Beaver Creek. The interbedded nature of the fine sediments which persist in the area, and the thick unsaturated zone provides some limited aquifer protection from surficial sources of contamination (moderate vulnerability as indicated previously). The vulnerability of the overburden aquifer underlying the community of Beaver Creek is variable due to variation in the sedimentary sequence. Implementing a source water protection plan for the community of Beaver Creek would provide a comprehensive approach to protecting this groundwater resource.

5.7.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system summary includes all available data and is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- No SWPP is in place for this groundwater resource; Source water protection planning here could be incorporated into a greater Beaver Creek SWPP and provide comprehensive planning to protect the moderately vulnerable groundwater resource.

5.8 Burwash Landing - Kluane First Nation Public Water Supply System

The community of Burwash Landing is located on the Alaska Highway at km 1700, approximately 285 km northwest of Whitehorse, in an area known as the Shakwak trench between Kluane Lake and the steep slopes of the Kluane Range mountains. The community bulk water delivery system, with water sourced from a deep sub-permafrost groundwater well, is owned and operated by the Kluane First Nation (KFN). The system serves a population of approximately 72 people (Yukon Bureau of Statistics 2016), and is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007) and is also regulated under the Yukon Drinking Water Regulations - Guidelines for Part II - Bulk Delivery of Drinking Water (YG 2007).

New sub-permafrost water wells were drilled in 2015, and a new water treatment plant (with greensand filtration for manganese removal, and chlorination) is scheduled for construction in 2017.

5.8.1 Hydrogeology

Burwash Landing is underlain by glaciofluvial sediments with a thin, overlying veneer of silt (Rampton 1977). Water wells are typically completed at depths ranging from 45 m bgs to 60 m bgs in a sub-permafrost aquifer. Well KFN-F, the groundwater well currently serving the KFN's Burwash Landing distribution system, is completed in a confined sand and gravel overburden aquifer below a permanently frozen (permafrost) silt and clay unit. Two wells (KFN-M and KFN-N) drilled and constructed in 2015 were completed at a similar depth in a confined sand and gravel aquifer overlain by frozen silt and clay till with materials similar to those encountered by KFN-F. A similar aquifer has been encountered at approximately the same depth by well KFN-J suggesting that there is an aerially extensive aquifer in which the wells are completed.

None of the wells in Burwash Landing encountered bedrock; thus, depth to bedrock in the area is unknown. It is anticipated that the depth to bedrock may be up to several hundreds of metres based on the completion depth of KFN-L, a deep geothermal exploration well, in a sand aquifer approximately 385 m bgs.

The regional groundwater flow direction is north-easterly from the topographic highs of the Kluane Range to the topographic low of Kluane Lake (Tetra Tech 2006).

As part of the 2012 LPDWSA, Tetra Tech completed a semi-quantitative analysis of the aquifer vulnerability based on the methodology presented in the Technical Terms of Reference for Groundwater Studies (Ontario Ministry of Environment 2001). The ISI method resulted in a score of 226 for the deep sub-permafrost aquifer at KFN-F and 219 for KFN-G. Aquifers with ISI values greater than 80 are considered to have low intrinsic susceptibility to surface sources of contamination (Ontario Ministry of Environment 2001), and the high ISI scores calculated at the two wells are an indication that the aquifer underlying the site has a low to very low vulnerability to potential surface-based contamination due to a highly impermeable layer of frozen, fine-grained materials overlying a deep confined aquifer.

As KFN-J, KFN-L, KFN-M, KFN-N appear to be completed in one aerially extensive groundwater aquifer in the area, the vulnerability is expected to be similarly low throughout the aquifer.

5.8.2 Summary of Wells

The well logs for the KFN's Burwash Landing current and proposed public water supply system are included in the GIS map and database portion of this project. The following tables summarize the completion characteristics of the Burwash public water supply wells.

Table 5-20: KFN Burwash Landing Public Water Supply, Well KFN-F Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	The well was completed by Midnight Sun Drilling Co. Ltd. in August 1981	Tetra Tech 2012a
Total well depth	61 m bgs	
Casing	6" (152 mm) OD Steel Well Casing	
Casing depth	59.7 m bgs	Well Log
Well screen	20 slot (0.51 mm) well screen (length and interval unknown)	Tetra Tech 2012a
Static water level	12.0 m bgs (February 2005)	
Sanitary seal	Bentonite gout seal installed in 2012	
Wellhead completion	Pitless Unit	
Wellhead stickup	~0.7 m ags	Stantec &Tetra Tech 2012
Well rated capacity	0.23 L/s (3 IGPM) long term safe sustainable yield, or 0.75 L/s (10 IGPM) short term	Tetra Tech 2005
Well GUDI status	Very likely non-GUDI	Tetra Tech 2012a
Well Construction Comments:	Well was upgraded to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-21: KFN Burwash Landing Public Water Supply, Well KFN-M Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Midnight Sun Drilling Inc. in October 2015	Tetra Tech 2015
Total well depth	57.3 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	54.3 m bgs	
Well screen	0.4 m 25 slot (0.64 mm) exposed from 54.3 m bgs to 54.7 m bgs 1.3 m 18 slot (0.46 mm) exposed from 54.7 m bgs to 56.0 m bgs 1.3 m 20 slot (0.51 mm) exposed from 56.0 m bgs to 57.3 m bgs The total exposed screen length is 3.05 m	
Static water level	~1.5 m bgs (October, 2015)	

Table 5-21: KFN Burwash Landing Public Water Supply, Well KFN-M Summary		
Well Construction Parameters	**Details**	**Source**
Sanitary seal	Portland cement seal to 6.0 m bgs	
Wellhead completion	Not yet connected – intended to be completed with Pitless Unit connection	
Wellhead stickup	0.9 m ags	Tetra Tech 2015
Well rated capacity	0.83 L/s (11 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-22: KFN Burwash Landing Public Water Supply, Well KFN-N Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Midnight Sun Drilling Inc. in October 2015	Tetra Tech 2015
Total well depth	57.8 m bgs	
Casing	6 1/8” (156 mm) ID Steel Well Casing	
Casing depth	54.7 m bgs	
Well screen	0.4 m 18 slot (0.46 mm) exposed from 53.8m bgs to 55.1 m bgs; 1.3 m 20 slot (0.51 mm) exposed from 55.1 m bgs to 56.4 m bgs 1.4 m 25 slot (0.64 mm) exposed from 56.4 m bgs to 57.8 m bgs The total exposed well screen length is 3.05 m	
Static water level	~1.5 m bgs (October 18, 2015)	
Sanitary seal	Portland cement seal to 6 m bgs	
Wellhead completion	Not yet connected – intended to be completed with Pitless Unit connection	
Wellhead stickup	0.9 m ags	
Well rated capacity	0.83 L/s (11 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.8.3 Source Water Quality

Tetra Tech completed a review of the water quality from Well KFN-F during the 2012 LPDWSA; comments from are summarized below:

- The water from KFN-F was calcium-sodium-magnesium-bicarbonate type with a pH of approximately 8.3 and was considered hard with a measured hardness of approximately 130 mg/L (as CaCO3);
- Manganese concentrations were above the GCDWQ AO in raw water samples from KFN-F for all sampling events. Manganese concentrations have remained consistent over time; and
- The turbidity from the raw water sample from the well was considered typical of a groundwater source. The turbidity of treated water samples, however, was relatively high at all treated water sampling points. As the turbidity of the treated water was higher than the raw water source, it was postulated that the turbidity may be related to precipitates of manganese and /or iron forming post chlorination.

Upon completion of water supply wells KFN-M and KFN-N in 2015, water samples were collected from the wells to characterize the water quality and potability. From the water quality results provided in the 2015 well completion report:

- To evaluate the quality of the analysis Tetra Tech calculated the ion balance (i.e. the balance between sum of anion and cation equivalent charges) of each water sample. Typically, an ion balance of within ± 10% is considered satisfactory. The calculated ion balances of KFN-M and KFN-N were both within ± 5%, suggesting that analytical errors are within acceptable limits and all major cations and anions present in the sample water were analyzed;
- The water from both KFN-M and KFN-N was classified as being hard and characterized as magnesium-sodium-calcium-bicarbonate-sulphate type water; and
- Analytical results were compared against the GCDWQ MAC and AO values, and the concentration of manganese exceeded the GCDWQ AO of 0.05 mg/L at both wells.

5.8.4 Water Treatment and Distribution

Table 5-23: KFN Burwash Landing Public Water Supply, Water Treatment and Distribution Details for Existing System

Item	Details	Source
Owner/Operator	Kluane First Nation	YES, 2012
Water source	Groundwater	
Wells serving the system	KFN-F	
Treatment type	Chlorination for primary and secondary disinfection	
Population served	72	Yukon Bureau of Statistics 2016
Delivery method	Trucked	YES 2012
Age of system/last known update	New wells in 2015. New water treatment plant scheduled to be completed in 2017	Stantec & Tetra Tech 2017

As mentioned previously, a new water treatment plant with greensand filtration for manganese removal and chlorination is scheduled for construction in 2017.

5.8.5 Source Water Protection Planning

Tetra Tech completed an Aquifer and Wellhead Protection Plan (AWPP) for KFN in July 2007 which addressed risk to community water supply well KFN-F. Water supply wells KFN-J, KFN K, KFN-M, KFN-N, and warm water well KFN-L were not included in the 2007 plan as they did not exist at the time.

The KFN AWPP was based on Tetra Tech's risk based approach which is adapted from British Columbia's Environment (BC MoE) Tool Kit. The well capture zones in the community were predicted using numerical modelling. Tetra Tech used Visual MODFLOW developed by Waterloo Hydrogeological Inc. based on the USGS MODFLOW code to create three dimensional models of the well capture zones for the Burwash KFN community water wells. The model was used to simulate 1, 5 and 10 year capture zones for each well. Conservative assumptions were built into the groundwater flow model to create reasonable and realistic areas for wellhead protection planning.

Potential sources of contamination to the Burwash Landing public supply wells and aquifer were identified as part of the 2012 LPDWSA. These potential sources of contamination included ASTs for domestic heating fuel, septic truck holding bay, sewage holding tank and former location of septic leach pit and an unused well (KFN-G). Key conclusions and recommendations can be reviewed in the attached AWPP, included in the GIS map and database portion of this project.

A new AWHPP is currently being prepared for the two new community water supply wells (KFN-M and KFN-N) that are intended to replace KFN-F in 2018. As part of this AWHPP, well capture zones have been determined in consideration of the hydrogeological regime and planned pumping rates. The capture zone delineates an area around the wells that contributes water to the wells and with be the basis for development of the protection plan to reduce risks to water quality from these wells servicing the community system. Defined well captures zones are provided in the GIS database. The final AWHPP will address potential risk and risk management strategies related specifically to these wells in recognitions of the delineated capture zone.

5.8.6 Water Supply Information Data Gaps

Tetra Tech has reviewed available data from KFN and YG Community Services as well as our internal database to complete this summary for KFN water systems. Work is currently underway to prepare a new AWPP to include the new water supply wells KFN-M and KFN-N and upon completion, the new AWPP should be included in the database when completed.

5.9 Burwash Landing - KFN Administration and Jacquot Hall Water Supply System

The community of Burwash Landing is located on the Alaska Highway at km 1700, approximately 285 km northwest of Whitehorse, in an area known as the Shakwak trench between Kluane Lake and the steep slopes of the Kluane Range mountains. The area is gently but irregularly sloping to the northeast down towards Kluane Lake.

The KFN Administration Building and Jacquot Hall in Burwash are served by a groundwater well (KFN-J) located near the buildings. The water system is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.9.1 Hydrogeology

Burwash Landing is underlain by glaciofluvial sediments with a thin overlying veneer of silt (Rampton 1977). Water wells in the area are typically completed at depths ranging from 45 m bgs to 60 m bgs in a sub-permafrost aquifer.

The groundwater well currently serving the Burwash KFN administration building, Well KFN-J, is completed in a confined sand and gravel overburden aquifer below a permanently frozen (permafrost) silt and clay unit. Groundwater flow direction in the area is north-northeast toward Kluane Lake.

None of the wells in Burwash Landing encountered bedrock; thus, depth to bedrock in the area is unknown. It is anticipated that the depth to bedrock may be up to several hundreds of metres based on the completion depth of KFN-L, a deep geothermal exploration well completed in a sand aquifer approximately 385 m bgs.

The groundwater flow direction is northeast from the topographic highs of the Kluane Range to the topographic low of Kluane Lake (Tetra Tech 2006).

Tetra Tech completed a semi-quantitative analysis of the aquifer vulnerability at KFN-J based on the methodology presented in the Technical Terms of Reference for Groundwater Studies (Ontario Ministry of Environment 2001). The ISI value for the aquifer at well KFN-J was 257 for the deep sub-permafrost aquifer. Aquifers with ISI values greater than 80 are considered to have low intrinsic susceptibility to surface sources of contamination (Ontario Ministry of Environment 2001), and the value of 257 calculated here indicates that the aquifer underlying the site has a low to very low vulnerability to potential surface-based contamination due to a highly impermeable layer of frozen, fine-grained materials overlying a deep confined aquifer.

5.9.2 Well Summary

The log for KFN-J well is included in the GIS map and database portion of this project. The following table summarizes available data for the water well.

Table 5-24: KFN Burwash Landing Administration Building and Jacquot Hall, Well KFN-J Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Impact Drilling Ltd. in November 2009	Tetra Tech 2010
Total well depth	51.6 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	

Table 5-24: KFN Burwash Landing Administration Building and Jacquot Hall, Well KFN-J Summary		
Well Construction Parameters	**Details**	**Source**
Casing depth	49.0 m bgs	
Well screen	2.6 m 80 slot (2.03 mm) well screen from 49.0 m bgs to 51.6 m bgs	
Static water level	9.3 m bgs (November 5, 2009)	
Sanitary seal	Bentonite grout surface seal to 6 m bgs	
Wellhead completion	Pitless Adapter	p.c. Keith Dickson 2017
Wellhead stickup	0.76 m ags	p.c. Keith Dickson 2017
Well rated capacity	2.82 L/s (37.2 IGPM)	Tetra Tech 2010
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.9.3 Source Water Quality

Upon completion of KFN-J in 2009, Tetra Tech collected a sample of the water to test for general water chemistry and potability. From the 2009 initial sampling results, the following key observations were noted:

- Groundwater from KFN-J was characterized as sodium-bicarbonate-sulphate type, with a pH of approximately 8.24 and was considered to be hard with a measured hardness of 132 mg/L (as CaCO3);
- The manganese concentration, measured at 0.057 mg/L, slightly exceeded the GCDWQ AO of 0.05 mg/L; and,
- The water met all other GCDWQ health-based criteria and aesthetic objectives for all parameters measured.

5.9.4 Water Treatment and Distribution

Table 5-25: KFN Burwash Landing Administration Building and Jacquot Hall Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Kluane First Nation	p.c. Keith Dickson 2017
Water source	Groundwater	
Wells serving the system	KFN-J	
Treatment type	Filtration and UV disinfection	
Water users	Users of the Administration Building and Jacquot Hall	
Delivery method	Well is connected directly to the building	
Age of system/last known update	Well was completed in 2009	

5.9.5 Source Water Protection Planning

KFN-J was drilled after the completion of the KFN Burwash Aquifer and Wellhead Protection Plan. The well is not included in the existing plan, but is located in the vicinity of KFN-C, which was replaced by KFN-J. KFN-J is likely completed in the same aerially extensive confined aquifer as other KNF wells, KFN-F, KFN-K, KFN M and KFN-N. The aquifer is highly confined and artesian pressure is observed in some of the wells. The well protection area would be very similar in shape and size to KFN-C as it replaces this well and is in the similar geological setting with similar demand. When the Aquifer and wellhead protection plan for the community is updated, this should be considered and included.

5.9.6 Water Supply Information Data Gaps

Tetra Tech has reviewed available data from YG Community Services and Kluane First Nation and noted the following data gaps or areas where the protection of the water source could be improved:

- KFN-J was drilled after the completion of the KFN Burwash Aquifer and Wellhead Protection Plan. The 2007 AWHPP should be updated to include this well.
- Tetra Tech recommended decommissioning of KFN-C and KFN-I in the vicinity of Jacquot Hall to protect the deep groundwater resource from surface sources of contamination. Tetra Tech has is not aware if this work has been completed or not.

5.10 Burwash Landing - KFN Daycare and Teacher's Residence Water Supply System

The community of Burwash Landing is located on the Alaska Highway at km 1700, approximately 285 km northwest of Whitehorse, in an area known as the Shakwak trench between Kluane Lake and the steep slopes of the Kluane Range mountains. The area is gently but irregularly sloping to the northeast down towards Kluane Lake.

The KFN Daycare and Teacher's residence in Burwash is served by a groundwater well (KFN G) located near the building. The water system is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.10.1 Hydrogeology

Burwash Landing is underlain by glaciofluvial sediments with a thin overlying veneer of silt (Rampton 1977). Water wells in the area are typically completed at depths ranging from 45 m bgs to 60 m bgs in a sub-permafrost aquifer.

The groundwater well currently serving the Burwash Daycare and Teacher's Residence, Well KFN-G, is completed in a confined sand and gravel overburden aquifer below approximately 40 m of permanently frozen (permafrost) clay till. Groundwater flow direction in the area is north-northeast toward Kluane Lake (Tetra Tech 2007).

None of the wells in Burwash Landing encountered bedrock; thus, depth to bedrock in the area is unknown. It is anticipated that the depth to bedrock may be up to several hundreds of metres based on the completion depth of KFN-L, a deep geothermal exploration well completed in a sand aquifer approximately 385 m bgs.

Tetra Tech completed a semi-quantitative analysis of the aquifer vulnerability at KFN-G based on the methodology presented in the Technical Terms of Reference for Groundwater Studies (Ontario Ministry of Environment 2001). Aquifers with ISI values greater than 80 are considered to have low intrinsic susceptibility to surface sources of contamination (Ontario Ministry of Environment 2001). The ISI value for the aquifer at well KFN-G was 219 for the deep sub-permafrost aquifer, indicating that the aquifer underlying the site has a low vulnerability to potential surface-based contamination due to a highly impermeable layer of frozen, fine-grained materials overlying a deep confined aquifer.

5.10.2 Well Summary

The log for KFN-G well is included in the GIS map and database portion of this project. The following table summarizes available data for the water well.

Table 5-26: KFN Daycare and Teacher's Residence Supply Well KFN-G Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed in 1976 by Midnight Sun Drilling Co.	Tetra Tech 2007
Total well depth	49.3 m bgs (total drilled depth)	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	46.5 m bgs	Well Log

Table 5-26: KFN Daycare and Teacher's Residence Supply Well KFN-G Summary		
Well Construction Parameters	**Details**	**Source**
Well screen	40-slot (1.0 mm) stainless steel well screen welded to the bottom of the casing. Interval is unknown	
Static water level	3.874 m bgs (March 21, 2007)	Tetra Tech 2007
Sanitary seal	None installed at time of drilling	Well Log
Wellhead completion	Well house	p.c. Keith Dickson 2017
Wellhead stickup	~0.5 m ags	
Well rated capacity	0.16 L/s (2.1 IGPM)	Well Log –estimate by driller
Well GUDI status	Not assessed	
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines as the well has no surface seal.	

5.10.3 Source Water Quality

Tetra Tech reviewed water quality information for KFN-G in 2004 (Tetra Tech 2004).

- Groundwater from KFN-G was characterized as calcium-magnesium-bicarbonate type, with a pH of approximately 8.3 and was considered to be hard with a measured hardness of 155 mg/L (as CaCO3); and
- The water met all GCDWQ health-based criteria and aesthetic objectives for the parameters measured.

5.10.4 Water Treatment and Distribution

Table 5-27: KFN Daycare and Teacher's Residence Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Kluane First Nation	Tetra Tech 2007
Water source	Groundwater	
Wells serving the system	KFN-G	
Treatment type	Filtration and UV disinfection	KFN-G O&M Manual 2005 p.c. Keith Dickson 2017
Water users	Daycare workers, teacher and children	Tetra Tech 2007
Delivery method	Well is connected directly to daycare and teacher's residence	KFN-G O&M Manual 2005**

Table 5-27: KFN Daycare and Teacher's Residence Water Treatment and Distribution Details		
Item	**Details**	**Source**
Age of system/last known update	Well was incorporated in AWPP in 2007 and will be included in the updated 2016 AWPP	Current projects with Tetra Tech

5.10.5 Source Water Protection Planning

KFN-G is likely completed in the same aerially extensive confined aquifer as other KNF wells, KFN-F, KFN-J, KFN-K, KFN-M and KFN-N. The aquifer is highly confined and artesian pressure is observed in some of the wells. KFN-G is included in the KFN AWPP from 2007. The KFN AWPP was based on Tetra Tech's risk-based approach which is adapted from British Columbia's Environment (BC MoE) Tool Kit. The well capture zones in the community were predicted using numerical modelling. Tetra Tech used Visual MODFLOW developed by Waterloo Hydrogeological Inc. based on the USGS MODFLOW code to create three dimensional models of the well capture zones for the Burwash KFN community water wells. The model was used to simulate 1-, 5- and 10-year capture zones for each well. Conservative assumptions were built into the groundwater flow model to create reasonable and realistic areas for wellhead protection planning.

Key conclusions and recommendations can be reviewed in the attached AWPP, included in the map and database portion of this project. The AWPP is currently under revision by Tetra Tech as several new community wells have been installed including two new community water supply wells intended to replace KFN-F.

5.10.6 Water Supply Information Data Gaps

Tetra Tech has reviewed available data from YG Community Services and Kluane First Nation and noted the following data gaps or areas where the protection of the water source could be improved:

- Tetra Tech has not completed work on the KFN-G well since the review for the AWPP in 2007. We are not aware of any work that has been completed on this well since 2007, but it is possible that water treatment has been added or wellhead improvements have been completed. If the well or treatment system has been amended since 2007, the database should be updated to reflect these changes.

5.11 Burwash Landing - Firehall Water Supply System

The community of Burwash Landing is located on the Alaska Highway at km 1700, approximately 285 km northwest of Whitehorse, in an area known as the Shakwak trench between Kluane Lake and the steep slopes of the Kluane Range mountains. The Burwash Landing Firehall is currently served by a water supply system that delivers water from a 39.2 m deep well. The water system serves both the Firehall domestic water system and the fire truck fill and is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide water for human consumption.

5.11.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.11.2 Hydrogeology

There was no log available for review for this well. Burwash Landing is underlain mostly by glaciofluvial sediments with a thin overlying veneer of silt (Rampton 1977). Water wells in the area are typically completed at depths ranging from 39 m bgs to 60 m bgs in sub permafrost aquifers.

Well logs for the nearby community wells (approx.. 500 m away) indicate that the wells are drawing water from a deep confined aquifer overlain by 42 m to 47 m of frozen clay and silt. Recharge to this aquifer is likely melting snow and glaciers, and precipitation on the eastern flank of the Kluane Range. At a depth of 39 m, the Firehall well is most likely completed within the same aquifer. The inferred presence of a significant confining layer provides protection of the aquifer from surface sources of contamination.

Groundwater flow direction in this area is inferred from topography and the proximity to surface water to be north to northeast towards Kluane Lake.

5.11.3 Well Summary

There is no well log available for Well 3204. The following table summarizes the known details of the well.

Table 5-28: Burwash Landing Firehall, Well 3204 Summary

Well Construction Parameters	Details	Source
Date of construction	Unknown	Tetra Tech 2006 p.c. Martin Eckervogt 2017 p.c. Nick Barnett 2017
Total well depth	39.2 m bgs (may be depth to the pump)	
Casing	Unknown	
Casing depth	Unknown	
Well screen	Unknown	
Static water level	Approximately 6.1 m bgs (measured on July 28, 2005)	

Table 5-28: Burwash Landing Firehall, Well 3204 Summary		
Well Construction Parameters	**Details**	**Source**
Sanitary seal	No record of sanitary seal installation	
Wellhead completion	The well is located in an enclosure off from the Firehall building	
Wellhead stickup	Below grade	
Well rated capacity	Unknown	
Well GUDI status	Potentially GUDI	Based on well construction
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.11.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern (Tetra Tech 2006):

- The water quality results indicated that the water from Well 3204 was a sodium-bicarbonate type water with a pH of approximately 8.3 on the dates sampled;
- The water had a hardness of about 115 mg/L;
- The turbidity of the water from Well 3204 was high and ranged from 4.01 NTU to 11.1 NTU on the dates sampled. Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration is expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU;
- On September 21, 2004, total iron concentration (0.45 mg/L) exceeded the GCDWQ AO of 0.3 mg/L, but from the subsequent sample collected on June 15, 2005 the total iron concentration decreased to 0.154 mg/L;
- On September 21, 2004, total manganese concentration (0.059 mg/L) exceeded the GCDWQ AO of 0.05 mg/L; but from the subsequent sample collected on June 15, 2005 the total manganese concentration decreased to 0.0467 mg/L;
- The water quality results indicated that the water from Well 3204 met all other GCDWQ health-based criteria and aesthetic objectives for the parameters analyzed;
- Chloride concentrations were reported to be low and are considered to be within the normal background ranges for groundwater in the area, suggesting that the aquifer from which the groundwater is obtained for the Burwash Landing Firehall is not under the influence of surface water sources or septic wastes; and
- At the time of the SPDWSA in 2005, the water was very turbid and a strong odour was noticed due to sulphide off-gassing.

5.11.5 Water Treatment and Distribution

Table 5-29: Burwash Landing Firehall Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017 p.c. Martin Eckervogt 2017
Water source	Groundwater	
Number of wells serving the system	Burwash Landing Firehall well (Well 3204)	
Treatment type	None	
Water users	Firehall	
Delivery method	Direct connection to Firehall	
Age of system/last known update	Unknown	

5.11.6 Source Water Protection Planning

There is no source water protection planning in place for the Burwash Landing Firehall water system. There is no record of GUDI assessment for the well.

During the 2005 SPDWSA, Tetra Tech identified one AST and one sewage eduction tank located within 30 m of the wellhead (Tetra Tech 2006). In addition, it was reported that a spill occurred on November 10, 1998 at a gas station in Burwash Landing near this site (Tetra Tech 2006). Approximately 3,800 L of diesel fuel spilled from Burwash Fuels when a valve was left on and the fuel ran down approximately 400 m towards Kluane Lake, which was likely within 100 m of the Firehall well (Tetra Tech 2006). Due to the proximity of the spill to the site, and the inferred confined and protected nature of the aquifer (based on an understanding of the lithology from other well logs for the area), it was not anticipated that the spill was a cause of concern to the water quality delivered from this well (Tetra Tech 2006).

Although the vulnerability of the aquifer in which this well is completed is considered to be low, a SWPP would provide a valuable tool for identifying, monitoring and managing risks to the wells and aquifer.

5.11.7 Water Supply Information Data Gaps

Tetra Tech has reviewed available data from YG Community Services and Kluane First Nation YG PMD has reviewed this summary and provided comments. To our knowledge, this system summary includes all available data and is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- Several upgrades on the water system including installation of a disinfection system were recommended by Tetra Tech in 2006; however, it is our understanding that no updates have been completed to the system since 2006; and
- No SWPP or GUDI assessment has been completed for Well 3204. Source water protection planning here could be incorporated with planning completed by KFN to create a comprehensive Burwash SWPP.

5.12 Burwash Landing Air Terminal Building Water Supply System

The community of Burwash Landing is located on the Alaska Highway at km 1700, approximately 285 km northwest of Whitehorse, in an area known as the Shakwak trench between Kluane Lake and the steep slopes of the Kluane Range mountains. Burwash Landing Air Terminal Building (ATB) is served by a water supply well, Well 3201-C, located about 30 m from the building. The well was completed in November 2006. Water from the Burwash Landing ATB water supply well is used for potable water for the building and is regulated under the *Public Health Act,* General Regulations Sections 18 and 19 (YG *Public Health Act,* 1958/079), which requires safety measures and inspection for water and water sources for systems that provide for human consumption.

5.12.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.12.2 Hydrogeology

Burwash Landing is underlain mostly by glaciofluvial sediments with a thin overlying veneer of silt (Rampton 1977). Water wells in the area are typically completed at depths ranging from 45 m bgs to 60 m bgs in a deep sand and gravel aquifer below the permafrost unit.

Based on a review of the well log and well drilling observations, it appears that Well 3201-C is completed in a confined sand a gravel aquifer. Subsurface materials encountered above the aquifer included silt and sand till with trace to some gravel.

5.12.3 Well Summary

A copy of the well log for this well is included in the attached GIS map and database portion of this project and the well completion details are summarized in the following table.

Table 5-30: Burwash Landing Air Terminal Building, Well 3201-C Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Double D Drilling Ltd. in November 2005	Tetra Tech 2006b
Total well depth	34.9 m bgs	
Casing	6” (152 mm) ID Steel Well Casing	
Casing depth	33.7 m bgs	
Well screen	1.2 m 60 slot (1.52 mm) stainless steel well screen from 33.7 m bgs to 34.9 m bgs	
Static water level	Flowing artesian (3 IGPM upon completion)	
Sanitary seal	Bentonite surface seal to 6 m bgs	

Table 5-30: Burwash Landing Air Terminal Building, Well 3201-C Summary		
Well Construction Parameters	**Details**	**Source**
Wellhead completion	Well was likely connected in general accordance with the Well Connection Standards for Typical YG Small Public Drinking Water Systems (FSC & Tetra Tech, 2008) except rather than a pitless unit it has a pitless adapter.	
Wellhead stickup	Well was completed with a stick-up of 0.65 m ags, but subsequent well connection work likely resulted in changes to this.	Tetra Tech 2006b
Well rated capacity	1.6 L/s (21 IGPM)	
Well GUDI status	Not assessed	
Well Construction Comments:	Well was constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.12.4 Source Water Quality

As part of the well completion, Tetra Tech collected a water sample near the end of the pumping test and reviewed the water chemistry results and noted the following:

- Water quality met the GCDWQ MAC for health-based parameters analyzed on the date sampled;
- Total manganese was measured at 0.149 mg/L, which exceeded the GCDWQ AO of 0.05 mg/L; and
- From the 2005 water quality results, the water was calcium-bicarbonate type and was considered to be hard to very hard with a measured hardness of 179 mg/L (as $CaCO_3$).

5.12.5 Water Treatment and Distribution

Table 5-31: Burwash Landing Air Terminal Building Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2006a p.c. Nick Barnett 2017 p.c. Martin Eckervogt 2017
Water source	Groundwater	
Wells serving the system (s)	Well 3201-C	
Treatment type	Sediment filtration on potable water supply	
Water users	Airport workers, flight crews and passengers	
Delivery method	Direct connection to building	Tetra Tech 2006b

Table 5-31: Burwash Landing Air Terminal Building Water Treatment and Distribution Details		
Item	**Details**	**Source**
Age of system/last known update	New well was completed in 2006. Well connection completion planning and decommissioning of well 3201-B was completed in spring 2006.	

5.12.6 Source Water Protection Planning

No SWPP is in place for the Burwash Landing ATB well. Potential sources of contamination to the Burwash Landing ATB Well 3201-C have not been identified. Potential sources of contamination were identified in the vicinity of Well 3201-A during the site review in 2005 and the new well was located to minimize potential for contamination from these sources.

5.12.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system summary includes all available data and is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- There is no source water protection planning for this groundwater resource; and
- YG PMD did not provide a record or confirmation of the decommissioning of Well 3201-A, and Tetra Tech understands as of March 2016 this well had not yet been decommissioned.

5.13 Carcross - Community Water Supply System

Government of Yukon, Department of Community Services owns and operates the community water supply system in the Village of Carcross, Yukon. The Carcross water system obtains surface water from a surface water intake in Bennett Lake. The surface water intake consists of a 150 mm pipe extending about 380 m from the shoreline (EDI 2010) and about 417 m from the wet well to a screened intake installed in Bennett Lake. The water is pumped about 140 m from the wet well to a treatment plant facility located at the corner of 4th Street and Tagish Avenue. After treatment (filtration, UV and chlorination), the water is pumped into an overhead water storage tank inside the facility and is then distributed to the residents of Carcross through bulk water delivery with a piped connection to the Carcross School. The Carcross Community Water Supply System is classified as a Large Public Drinking Water Supply System (LPDWS) under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007).

5.13.1 Data Compilation Methodology

Tetra Tech approached stakeholders including YG departments, water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech obtained data regarding the Carcross Community Water Supply system from the following proponents:

- YG Community Services (the client) – YG CS provided data for the Carcross Community Water Supply as this system is owned and operated by YG CS. The YG CS operator provided review comments and edits for the final summary to ensure completeness and accuracy.

5.13.2 Hydrology and Hydrogeology

5.13.2.1 Hydrology

The Bennett Lake catchment area covers 3,525 km^2 extending from Yukon into the northwest corner of British Columbia and a small area in Southeast Alaska. This catchment area receives water from the Yukon Stikine Highlands which encompasses the Boundary Range Mountains. Drainage from this area into Bennett Lake displays typical glacial system flows with large snowmelt discharges in May and peak discharge in July and August due to glacial melting (EDI 2010).

The vulnerability of the surface water supply to contamination was assessed by EDI in 2010 (EDI 2010). EDI detailed the level of risk posed by sources of contamination to Bennett Lake as follows:

- Recreational use of Bennett Lake and Watershed: Low
- Land use in Community of Carcross: Low
- Industrial Site Contamination: Low
- Historic Mine Sites: Low
- Mining Exploration and Production: Low (as it is controlled by regulation)
- Railroad: Low (as regulated by safety standards and maintenance)
- Sedimentation: Moderate
- Climate Change and Extreme Weather Events: Moderate

- Vandalism: High
- Severe Earthquake: High

5.13.2.2 Hydrogeology

The groundwater flow direction is inferred to range from southwesterly to southeasterly in the vicinity of the Carcross Firehall, towards Bennett Lake and/or the Nares River (Tetra Tech 2006). From the log for the abandoned well "Carcross Firehall," the well is 105.8 m (347 feet) deep completed in a confined aquifer underlying sand clay, and till (Tetra Tech 2006). The well was abandoned due to high arsenic concentrations.

5.13.3 Bennett Lake Intake Details

The following table summarizes the surface water intake details on the Carcross LPDWS.

Table 5-32: Carcross Large Public Drinking Water System Surface Water Intake Summary

Well Construction Parameters	Details	Source
Date of construction	The intake, the wet well and the transfer line were constructed in 1990	Tetra Tech 2012
Intake	150 mm dia. Polyethylene (PE) Series 160. End of intake is 560 mm dia., screened, on concrete base in deep water close to south shore of lake.	
Pumps	Submersible pumps in wet well were installed in May 2010. Pumps are 5 hp, 230 V, 3 phase Grundfos 75550-8.	

5.13.4 Source Water Quality

The Carcross LPDWS is supplied by water from a surface water source (Bennett Lake). Records provided to Tetra Tech for review during the 2012 LPDWSA indicates that the wet well was previously sampled in June 2005, July 2009, and April 2010 (Tetra Tech 2012). The key observations and comments noted by Tetra Tech during the 2012 chemical water quality review are summarized as follows (Tetra Tech 2006):

- Over the testing period, there were no exceedances of GCDWQ for the parameters analyzed; and,
- When tested in the field during the 2012 LPDWSA, turbidity of the raw water sample (1.06 NTU) was considered typical of a surface water source. The water treatment plant was designed to provide cartridge filtration to 1 NTU or less using stepped filtration with a 10-micron screen, 5-micron cartridge filters and 1-micron absolute filter;
- Tetra Tech did not review recent water quality data but understands water chemistry analysis is completed at this system annually and bacteriological monitoring is completed on a regular basis with results sent to YG EHS for review.

5.13.5 Water Treatment and Distribution

Table 5-33: Carcross Large Public Drinking Water System Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon – Community Services	Tetra Tech 2012
Water source	Surface Water	
Treatment type	Cartridge filtration, UV disinfection, chlorination	ODK 2013
Population served	Approximately 336 people	Yukon Bureau of Statistics 2016
Delivery method	Gravity feed to bulk water delivery truck Gravity fed piping to school Piped delivery to ambulance bay Self-serve fill point	ODK 2013 p.c. Steve Perrin 2017
Age of system/last known update	New water treatment plant completed in 2013.Tetra Tech understands maintenance on the intake structure was completed in 2016.	ODK 2013 p.c. Chris Evans, YG-CS

5.13.6 Source Water Protection Planning

EDI completed a SWPP for the Carcross LPDWS in 2010. EDI identified historical, existing and future potential sources of contamination to the Carcross water supply; possible sources identified by EDI are summarized below (Tetra Tech 2012):

- Historical, current and future contamination due to mining activity, industrial land use, and residential land use;
- Existing and future recreational use of Bennett Lake and watershed; and
- Future potential events including vandalism, sedimentation, earthquake, flooding and other natural events, climate change and changes in railroad activity.

Recommendations from this plan are summarized below:

- Increase security at the water intake by installing a cage around the structure in the water;
- Institute regular maintenance for the water intake (bi-annual at minimum);
- Continue regular monitoring of the raw water quality; and
- Institute water quality and hydrology monitoring for Bennett Lake watershed including monitoring mining inputs, fecal coliform and hydrocarbon monitoring in the vicinity of the intake, monitoring of precipitation and hydrology.

During the 2012 LPDWSA, several potential contaminant sources were identified in the vicinity of the system, including sewage holding tanks, fuel tanks, abandoned wells and other groundwater wells. Potential contaminant sources nearest the intake would have a higher potential for impacting the source water quality for this system;

however, as Bennett Lake is continuously mixed through wind and wave action, and generally is slowly flowing to the southeast towards the Nares River, potential sources of contamination could be derived from anywhere in the Bennett Lake watershed.

Tetra Tech understands that YG has begun implementing recommendations from the SWPP including cleaning of the water intake structure, ongoing monitoring of water quality and implementing increased filtration to address high turbidity during freshet.

5.13.7 Water Supply Information Data Gaps

A new water treatment plant was built in Carcross in 2013 and Tetra Tech understands that maintenance was completed on the intake structure in 2016 include verifying the location and cleaning of the intake structure (ODK 2013; p.c. Chris Evans, YG-CS March 2016, p.c. Steve Perrin, YG-CS 2017).

- The status of the abandoned well at the Firehall is unknown, the well should be properly secured or decommissioned based on future planning for the site.

5.14 Carmacks – LSCFN Truck Fill Water Supply System

The Village of Carmacks is located at km 354 on the North Klondike Highway. Carmacks is the home of the Little Salmon Carmacks First Nation (LSCFN). The LSCFN community is located in a meander of the Yukon River. The LSCFN trucked water supply facility is served by one water supply well, PW05-01, and serves approximately 25 people at a total of 16 delivery points (from the LPDWS water licence application). The LSCFN trucked water supply system is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007).

5.14.1 Methodology and Data Sources

Tetra Tech approached stakeholders including the water system owner and operator, LSCFN, and the Government of Yukon to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following parties regarding the LSCFN Carmacks Water Supply:

- Little Salmon Carmacks First Nation – Did not respond to requests to provide review comments for this 2017 summary.
- Indigenous and Northern Affairs Canada – Directed Tetra Tech to contact YG EHS or LSCFN for data regarding the system.
- Yukon Government Environmental Health Services – YG EHS provided the AWPP for inclusion in the project summary.

We have made an effort to present the most up-to-date information available to us at the time of this project and included the source and year for all information presented in this report and the GIS database. Data gaps, including obtaining buy-in and review comments from LSCFN, should be addressed in the next iteration of the project.

5.14.2 Hydrogeology

The LSCFN Village is located on a glaciofluvial plain adjacent to the Yukon River. The surficial geology in the area is mapped as moderately-well to well drained veneer of fine sand and silt fluvial material overlying thick glaciofluvial and fluvial deposits of loose sandy gravel and/or gravelly sand (Jackson 2000). Wells drilled in the area range in depth from 11 m bgs to 55 m bgs and the average well depth is 16 m bgs (Tetra Tech 2001). Bedrock exposed on higher-relief and resistant bluffs to the southeast of Carmacks are mapped as conglomerate, sandstone and shale with coal seams (Klassen 1978).

There is some suggestion that both a shallow, unconfined aquifer and a deeper, confined aquifer exist in the LSCFN Village area; however, seasonal fluctuation of groundwater elevation in concert with changes in the Yukon River suggests both are hydraulically connected to the Yukon River.

The groundwater flow direction, interpreted from groundwater elevation measurement, was inferred to be northwest with a horizontal gradient of 0.001 m/m. However, the presence of the confluence of the Nordenskiold and Yukon Rivers directly northwest and down-gradient of the area may complicate the groundwater flow regime and the groundwater flow direction and gradient may vary.

Lithology encountered during the drilling of PW05-01 included varying amounts of sand and gravel and the material becomes silty from 25.0 m bgs to 40.2 m bgs. The presence of 15 m of silty material will provide some protection from surface sources of contamination.

5.14.3 Well Summary

The log for the LSCFN truck fill supply well PW05-01 is included in the GIS mapping portion of this project. The following tables summarize the completion characteristics of the well.

Table 5-34: LSCFN Truck Fill Supply, Well PW05-01 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Double D Drilling Ltd. in June 2005	Tetra Tech 2006
Total well depth	43.1 m bgs	
Casing	8” (203 mm) ID Steel Well Casing	
Casing depth	40.1 m bgs	
Well screen	3.01 m 200 slot (5.08 mm) v-wire well screen from 40.1m bgs to 43.1 m bgs.	
Static water level	20.4 m bgs (June 30, 2005)	
Sanitary seal	Cement bentonite grout seal to 6.0 m bgs	
Wellhead completion	Pitless unit	
Wellhead stickup	1 m ags	
Well rated capacity	9.7 L/s (128 IGPM)	
Well GUDI status	Potentially GUDI	Tetra Tech 2010
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.14.4 Source Water Quality

Upon completion of PW05-01 in 2005, Tetra Tech collected a water sample to characterize the water quality and potability. From the water quality results and summaries provided in the well completion report:

- The water provided from PW05-01 was calcium-bicarbonate type with a pH of approximately 7.8 and was considered hard with a measured hardness of 154 mg/L (as CaCO3);
- The Langelier Saturation Index of groundwater from PW05-1 was -0.2, indicating the water would dissolve calcium carbonate;
- The Ryznar Stability Index for the water was 8.1, indicating the water is slightly corrosive;
- The total manganese concentration measured in the well was 0.126 mg/L, which exceeds the GCDWQ AO of 0.05 mg/L; and
- The water quality from the well met the GCDWQ MAC and AO for all other parameters tested.

Tetra Tech has not completed a review of more recent water quality data, but understands this data is collected on a regular basis and is on file with YG-EHS.

5.14.5 Water Treatment and Distribution

The Little Salmon Carmacks First Nation owns and operates the LSCFN trucked water distribution system. Water is distributed to residential and commercial properties in the community via truck. In 2012, a new WTP was built in the community.

Table 5-35: LSCFN Truck Fill Supply *Water Treatment and Distribution Details – System 1*

Item	Details	Source
Owner/Operator	Little Salmon Carmacks First Nation	Tetra Tech 2010
Water source	Groundwater	
Wells serving the system	PW05-1	
Treatment type	Filtration (10 micron to 1 micron), and chlorine disinfection**	LPDWS water license application
Population served	25 people	LPDWS water license application
Delivery method	Trucked	LPDWS water license application
Age of system/last known update	New WTP was completed in 2012.	

**Note: Water treatment may have changed since 2012. This should be verified and updated.

5.14.6 Source Water Protection Planning

Carmacks is a hub for transport of goods and services from southern Yukon to communities in northern Yukon including City of Dawson, Ross River, Faro, Mayo and Keno. Industrial activities in the area are primarily related to transport and residential needs. Goods transported through the community include mineral ore, fuel, and chemicals for mining and road maintenance purposes.

An AWPP was completed for the LSCFN Community Water Supply by Vista Tek in March 2008. The LSCFN AWPP was based on British Columbia's Environment (BC MoE) Well Protection Tool Kit (BC MoE 2000). The well capture zone was estimated using the analytical model presented in BC MoE's Well Protection Toolkit. The well capture zone resulting from this analysis is long and narrow and truncated at one end by the Yukon River indicating water from the well is primarily recharged from the river. Vista Tek applied a conservative assumption to account for variation in groundwater flow direction by assuming the width and downgradient extent of the capture zone is 60 m (approximately 4 to 7 times greater than predicted by the analytical model).

Key conclusions and recommendations are summarized below and the AWPP is included, included in the GIS map and database.

- A 120 m wide protection zone extending from the new well southeast to the Yukon River and northwest 60 m from the well was established.
- Due to the sand and gravel soil and the lack of any fine grained materials between the ground surface and the aquifer that supplies the community well, the aquifer is considered to be vulnerable to surface sources of contamination;

- Vista Tek recommended existing potential contaminant sources in the vicinity of the well protection area including two underground fuel storage tanks be removed and/or upgraded to reduce the risk of contamination to the aquifer.
- Vista Tek recommended ongoing monitoring of groundwater levels in the community to determine the groundwater flow direction more exactly;
- Remove UST at Heritage Hall and at the old laundromat and complete level II environmental assessment;
- Ensure properly constructed septic systems or holding tanks are in place and implement septic monitoring program;
- Endorse and promote hazardous waste minimization and collection programs and educate LSCFN community members on the importance of maintaining a clean environment on the land surrounding their community well;
- Implement contingency planning including emergency response planning for the water supply system in the event of a spill in the well capture zone;
- Upgrade residential wells as needed to ensure they are properly constructed and do not provide a pathway for surface contaminants to enter the aquifer;
- Install security measures around the community well including fencing and a lockable gate and conduct routine inspection of the well to ensure the longevity of the well;
- Include residential well monitoring in regular water quality monitoring and monitor the water level in the community well to monitor the well performance and determine if rehabilitation is needed.

Tetra Tech understands LSCFN has undertaken some of the measures including the removal of the Heritage Hall UST and environmental assessment of the area.

5.14.7 Water Supply Information Data Gaps

Tetra Tech has reviewed available data from YG Community Services, but was not able to obtain data from LSCFN, YG Property Management Division or Environmental Health Services at the time of completion of this reporting. Significant data gaps include:

- Tetra Tech understands that a new well has been completed for backup supply to this water system, but was not provided with a copy of the well log and well completion report;
- The new water well completed for this system has not been included in the AWPP, this should be updated when the AWPP is updated; and,
- The wellhead completion details have not been confirmed. The wells should be properly completed with adequate stick up (at least 0.5 m above the highest flood level) and proper piping connections to the system.

5.15 Carmacks – Tantalus School Water Supply System

Tantalus School is located in Carmacks, Yukon on the North Klondike Highway. In 2008, a new school was built, and the water system connected to a new water well completed in April 2005. The former well is included here only for information and the new well should be incorporated into this summary when data is obtained. The former water system was served by a 16.5 m deep well. The new water system supplies potable water to the school and is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.15.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following water system owners, operators and proponents regarding the water systems operated and/or managed by YG PMD:

- YG Property Management Division – YG PMD has been consulted and has provided review comments and data for the compilation.
- YG Community Services (the client) – YG CS provided data for systems where proponents contacted were not able to find the documents and/or YG CS had the data readily available.
- YG Environmental Health – YG EHS was not able to provide details on the new water well or water treatment system and directed Tetra Tech to contact YG PMD.

5.15.2 Hydrogeology

The aquifer underlying the Central Carmacks Village area is a permeable, unconfined sand and gravel aquifer comprised of glaciofluvial and recent alluvial deposits. The regional groundwater flow direction in the vicinity of the Village core is inferred from topography to be northeast towards the Yukon River. From nearby well data, the static water level is estimated to be about 6 m bgs. The new school is located near the central Village and the well is likely completed in the same aquifer as the old well.

5.15.3 Well Summary

No well log was available for the old Tantalus school Well 6511-A or for Well 6511-B. The following tables summarize available data for the old water well 6511-A and the available completion characteristics of 6511-B.

Table 5-36: Tantalus School, Well 6511-A Summary

Well Construction Parameters	Details	Source
Date of construction	Unknown	Tetra Tech 2006
Total well depth	16.5 m bgs	
Casing	7” (178 mm) Steel Well Casing	
Casing depth	Unknown	
Well screen	Unknown	

Table 5-36: Tantalus School, Well 6511-A Summary		
Well Construction Parameters	**Details**	**Source**
Static water level	Unknown	
Sanitary seal	Likely no surface seal	
Wellhead completion	Split gasket cap	
Wellhead stickup	1.6 m bgs	
Well rated capacity	Unknown	
Well GUDI status	Unknown	Unknown
Well Construction Comments:	Based on the wellhead completion and the lack of a surface seal, the well was not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

Table 5-37: Tantalus School, Well 6511-B Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	April 2005	p.c. Nick Barnett 2017
Total well depth	Unknown	
Casing	Unknown	
Casing depth	Unknown	
Well screen	Unknown	
Static water level	Unknown	
Sanitary seal	Sanitary seal installed	
Wellhead completion	Pitless adaptor	
Wellhead stickup	Unknown	
Well rated capacity	Unknown	
Well GUDI status	Unknown	Unknown
Well Construction Comments:	Unknown	

5.15.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The new well is completed relatively near the existing well, and the wells likely obtain water from the same aquifer. The observations made in 2005 are summarized below:

- The groundwater source was calcium-magnesium-sulphate type water and was considered very hard with a measured hardness of 208 mg/L (as $CaCO_3$);
- The water met all GCDWQ health-based and aesthetic objectives for the parameters tested;
- EPH and PAH were below the laboratory detection limits, indicating that the well had not been impacted by hydrocarbons; and
- Review of chloride, nitrate and nitrite showed all three to be low and within the normal background ranges, suggesting that the aquifer was not under the influence of anthropogenic surface sources of nutrients or anions such as septic wastes at the time of sampling.

5.15.5 Water Treatment and Distribution

Table 5-38: Tantalus School Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Wells serving the system	Tantalus School well	
Treatment type	Sediment filtration and chlorine injection disinfection**	
Water users	Tantalus School	
Delivery method	Piped from well to School	
Age of system/last known update	New school in 2008	

**Note: Tetra Tech understands this system may be equipped with UV disinfection in the near future.

5.15.6 Source Water Protection Planning

There is no SWPP in place for Tantalus School Well 6511-A or 6511-B, and Tetra Tech was not able to obtain any record of GUDI assessment completed for Well 6511-A or 6511-B. Given the unconfined, vulnerable nature of the aquifer, a SWPP would provide a valuable tool for identifying, monitoring and managing risks to the wells and aquifer. The planning for this site should be incorporated into with planning for the Carmacks Village centre to create a comprehensive SWPP.

Potential sources of contamination in the vicinity of well 6511-A that were identified as part of the 2005 SPDWSA site review included:

- Sewer lines from the Carmacks community sewer system are likely within 30 m of the well;
- An AST located 1 m from the wellhead; and
- Well 6511-B should be located with respect to potential sources of contamination, but Tetra Tech was not able to confirm this.

5.15.7 Water Supply Information Data Gaps

Tetra Tech has obtained review comments from YG PMD regarding the current status of this system; however, they were not able to provide details on the water system or the new water well. The following data gaps have been identified:

- There is no source water protection planning for this groundwater resource. Source water protection planning here could be incorporated with planning for other locations in the central Carmacks Village to create a comprehensive Carmacks SWPP; and
- The new school built in 2008 and is connected to a new water well completed in 2005, but well details were not provided.

5.16 Carmacks - Health Centre Water Supply System

The Village of Carmacks is located on the North Klondike Highway approximately 180 km north of Whitehorse, Yukon. The Carmacks Health Centre water system is served by a 17.7 m deep well located in a well house approximately 3 m from the Health Centre building. The water system supplies potable water to the Health Centre and the adjacent Nursing Residence and is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.16.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.16.2 Hydrogeology

The aquifer underlying the central Carmacks Village area is a permeable, unconfined sand and gravel aquifer comprised of glaciofluvial and recent alluvial deposits. The well log for this well shows coarse grained lithology from surface consisting of sands and gravels. The well is completed in an unconfined aquifer, and, from other wells in the area, the static water level is likely relatively shallow resulting in high vulnerability of the aquifer to surface sources of contamination. The regional groundwater flow direction in the vicinity of the Village core is inferred from topography to be northeast towards the Yukon River.

5.16.3 Well Summary

A partially complete well log for the Carmacks Health Centre well is included in the GIS map and database portion of this project. The following table summarizes available data for the water well.

Table 5-39: Carmacks Health Centre Well Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed in 1982	Well log
Total well depth	17.7 m bgs	
Casing	6” (152 mm) Steel Well Casing	Tetra Tech 2006 p.c. Nick Barnett 2017
Casing depth	Unknown	
Well screen	Unknown	
Static water level	Unknown	
Sanitary seal	Likely no surface seal	
Wellhead completion	Well cap, well is located in a generator room	
Wellhead stickup	0.06 m ags	

Table 5-39: Carmacks Health Centre Well Summary		
Well Construction Parameters	**Details**	**Source**
Well rated capacity	Unknown	
Well GUDI status	Potentially GUDI	Based on well construction
Well Construction Comments:	Based on the wellhead completion and the lack of a surface seal, the well was not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.16.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The observations made in 2005 are summarized below:

- The source water was likely calcium-magnesium-sulphate type as seen from nearby wells, but the treated water was potassium-sulphate type, due to the water softening;
- All GCDWQ health-based criteria and aesthetic objectives were met for the parameters analyzed;
- Additional testing included EPH and PAH and the reported concentrations of these parameters were below the laboratory detection limits, indicating that the well had not been impacted by hydrocarbons from the previously recorded spill at the time of sampling; and
- Review of chloride, nitrate and nitrite showed all three to be low and within the normal background ranges, suggesting that the aquifer was not under the influence of anthropogenic surface sources of nutrients or anions such as septic wastes at the time of sampling.

5.16.5 Water Treatment and Distribution

Table 5-40: Carmacks Health Centre Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Wells serving the system	Carmacks Health Centre well	
Treatment type	Filtration and water softening on the Health Centre side of the system	
Water users	YG employees and patients	
Delivery method	Piped to Health Centre building and to nursing residences	
Age of system/last known update	Well completed in 1982	

5.16.6 Source Water Protection Planning

There is no SWPP in place for Carmacks Health Centre Well 6975, and Tetra Tech was not able to obtain any record of GUDI assessment completed for Well 6975. Given the unconfined, vulnerable nature of the aquifer, a SWPP would provide a valuable tool for identifying, monitoring and managing risks to the wells and aquifer. Source water protection planning here could be incorporated with planning for the Central Carmacks Village area to create a comprehensive SWPP.

Potential sources of contamination in the vicinity of the wellhead that were identified as part of the 2005 SPDWSA site review, included:

- An electric generator is located 2 m from the well;
- An AST is located 11 m from the wellhead; and
- A soil relocation permit was issued in 2003 for this site. It is understood that a heating oil fuel leak occurred between the AST and the Health Centre sometime between 2001 and 2002; however, the 2005 groundwater quality analysis shows no evidence of hydrocarbon contamination from this leak.

5.16.7 Water Supply Information Data Gaps

Tetra Tech has obtained review comments from YG PMD regarding the current status of this system and to our knowledge this summary is complete and accurate to March 2017. The following data gaps have been identified:

- There is no source water protection planning for this groundwater resource. Source water protection planning here could be incorporated with planning for other locations in the central Carmacks Village to create a comprehensive Carmacks SWPP;
- Additional filtration (to 1 micron) and disinfection was recommended for this system, and Tetra Tech understands this has not yet been completed.
- Upgrades to the fuel storage were recommended; however, Tetra Tech understands this work has not yet been completed; and
- Upgrades to the wellhead were recommended in 2006; however Tetra Tech understands this has not yet been completed.

5.17 Carmacks - Airport Terminal Building Water Supply System

The Village of Carmacks is located on the North Klondike Highway approximately 180 km north of Whitehorse, in Yukon. The Carmacks Airport is located off the Robert Campbell Highway about 5 km east of the Village. Carmacks Airport Terminal Building (ATB) water supply system, which is served by a groundwater well located about 17 m south of the ATB, supplies water to workers at the site as well as passengers traveling through the terminal.

This system is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.17.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.17.2 Hydrogeology

No well log was available for the Carmacks ATB Well 6522, and no other hydrogeology data is available for this area. From the topography and proximity to surface waterbodies, the groundwater flow direction is inferred to be south or southwest towards the Yukon River.

5.17.3 Well Summary

The log for the Carmacks ATB well was not available; however, the following table summarizes available data for the water well.

Table 5-41: Carmacks Airport Terminal Building, Well 6522 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	The well was completed in 1992	Tetra Tech 2006
Total well depth	23.4 m bgs (may be pump depth)	
Casing	6” (152 mm) Steel Well Casing	
Casing depth	Unknown	
Well screen	Unknown	
Static water level	14.9 m bgs (May 13, 2005)	
Sanitary seal	Likely no surface seal	
Wellhead completion	Split gasket cap, well pit	
Wellhead stickup	0.6 m bgs	
Well rated capacity	Unknown	
Well GUDI status	Potentially GUDI	Based on well construction (likely no surface seal)
Well Construction Comments:	Based on the wellhead completion and the lack of a surface seal, the well was not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.17.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The observations made in 2005 are summarized below:

- The water was calcium-bicarbonate type, has a pH of approximately 8.1, and was considered very hard with a measured hardness of 331 mg/L to 336 mg/L (as $CaCO_3$);
- Turbidity measurements of 2.9 NTU and 17.6 NTU present some concern. Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration is expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU;
- Total iron concentration in the sample results reviewed were measured at 0.497 mg/L to 1.44 mg/L and exceeded the GCDWQ AO of 0.3 mg/L. Dissolved iron concentration (<0.03 mg/L) in the sample that Tetra Tech collected was significantly lower than the total iron concentration, indicating that the high total iron concentration can be attributed to the elevated turbidity;
- Total manganese was measured at 0.25 mg/L to 0.255 mg/L and exceeded the GCDWQ AO of 0.05 mg/L. Dissolved manganese concentration in the sample that Tetra Tech collected was 0.296 mg/L, indicating that the manganese is dissolved and filtration to reduce turbidity will not reduce the manganese concentration;
- Water quality met the GCDWQ health-based criteria and aesthetic objectives for all the other parameters analyzed; and

- Review of chloride, nitrate and nitrite showed all three to be low and within the normal background ranges suggesting that the aquifer was not under the influence of surface sources of contamination or septic wastes at the time of sampling.

5.17.5 Water Treatment and Distribution

Table 5-42: Carmacks Airport Terminal Building Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Wells serving the system	Carmacks ATB well	
Treatment type	Filtration	
Water users	Airport workers, flight crews and passengers	
Delivery method	Direct piped connection to Carmacks ATB	
Age of system/last known update	Unknown	

5.17.6 Source Water Protection Planning

There is no SWPP in place for the Carmacks ATB Well 6522. Given the lack of data on well completion depth and aquifer characteristics, a SWPP may provide a valuable tool for identifying, monitoring and managing risks to the wells and aquifer; however, as the water use is relatively limited, a SWPP may not be warranted for this system.

Potential sources of contamination in the vicinity of the wellhead that were identified during the 2005 SPDWSA site review, included:

- A septic field located approximately 25 m from the well;
- Aviation fuel drums located at 30 m from the well; and
- A fuel storage trailer was located 20 m from the well (at time of the 2005 assessment).

5.17.7 Water Supply Information Data Gaps

Tetra Tech has obtained review comments from YG PMD regarding the current status of this system and to our knowledge this summary is complete and accurate to March 2017. The following data gaps have been identified:

- There is no source water protection planning for this groundwater resource; however, SWPP may not be warranted due to the limited use of the water;
- In 2006, Tetra Tech recommended a new water well be drilled and a treatment system added, if necessary, to provide potable water to meet the GCDWQ; we understand this work has not been completed; and,
- The well completion details and aquifer vulnerability and hydrogeology are not known.

5.18 Carmacks - Forest District Office Water Supply System

The Village of Carmacks is located on the North Klondike Highway approximately 180 km north of Whitehorse, in Yukon. The Carmacks Forest District Office (FDO) is located in central Carmacks Village on the shores of the Yukon River. Carmacks FDO water supply system, which is served by a groundwater well located in the building basement, supplies water to workers in the office and members of the public who visit the office.

The system is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.18.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.18.2 Hydrogeology

The aquifer underlying the central Carmacks Village area is a permeable, unconfined sand and gravel aquifer comprised of glaciofluvial and recent alluvial deposits. The regional groundwater flow direction in the vicinity of the Village core is inferred from topography to be northeast towards the Yukon River.

5.18.3 Well Summary

The lithology and well completion log for the Carmacks FDO well is included in the GIS map and database portion of this project. The following table summarizes available data for the well.

Table 5-43: Carmacks Forest District Office Well Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed in August 1973	Well Log
Total well depth	12.2 m bgs	
Casing	6” (152 mm) Steel Well Casing	Tetra Tech 2006
Casing depth	Approximately 7.6 m bgs	Well Log
Well screen	1.5 m well screen from 7.6 m bgs to 9.1 m bgs; the slot size is unknown	
Static water level	1.5 m bgs (August 1973)	
Sanitary seal	Likely no surface seal	Tetra Tech 2006 p.c. Nick Barnett 2017
Wellhead completion	Split gasket cap, wellhead located in basement of district office	
Wellhead stickup	1.2 m bgs	
Well rated capacity	3.2 L/s (42 IGPM) (estimated by the driller)	Well Log

Table 5-43: Carmacks Forest District Office Well Summary		
Well Construction Parameters	**Details**	**Source**
Well GUDI status	Potentially GUDI	Based on well construction
Well Construction Comments:	Based on the wellhead completion and the lack of a surface seal, the well was not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.18.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The observations made in 2005 are summarized below:

- The water was calcium-bicarbonate type, had a pH of approximately 8.1, and was considered very hard with a measured hardness of approximately 198 mg/L (as $CaCO_3$);
- Turbidity was measured at 1.2 NTU. Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration is expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU;
- Water quality met all other GCDWQ health-based criteria and aesthetic objectives for the parameters analyzed; and
- Review of chloride, nitrate and nitrite showed all three to be low and within the normal background ranges, suggesting that the aquifer was not under the influence of anthropogenic surface sources of nutrients or anions such as septic wastes at the time of sampling.

5.18.5 Water Treatment and Distribution

Table 5-44: Carmacks Forest District Office Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Wells serving the system	Carmacks FDO well	
Treatment type	Well is equipped with a sediment filter	
Water users	YG employees	
Delivery method	Directly connected to the Forest District Office via a buried piped connection	
Age of system/last known update	Unknown	

5.18.6 Source Water Protection Planning

There is no SWPP in place for the Carmacks FDO Well 6542. Given the shallow depth of the well and the likely unconfined nature of the aquifer, a SWPP would provide a valuable tool for identifying, monitoring and managing risks to the wells and aquifer. Source water protection planning here could be incorporated with planning for the Carmacks Village centre to create a comprehensive SWPP.

Potential sources of contamination in the vicinity of the wellhead that were identified as part of the 2005 SPDWSA site review, included:

- Two ASTs located at 5 m and 24 m from the well; and
- An improperly constructed sewer manhole located 24 m from the well.

5.18.7 Water Supply Information Data Gaps

Tetra Tech has obtained review comments from YG PMD regarding the current status of this system and to our knowledge this summary is complete and accurate to March 2017. The following data gaps have been identified:

- There is no source water protection planning for this groundwater resource. Source water protection planning here could be incorporated with planning for other locations in the central Carmacks Village to create a comprehensive Carmacks SWPP; and,
- It was recommended at the time of the system review in 2005 that the FDO be either connected to the new school well or to a new Carmacks municipal water distribution system. Tetra Tech understands the building has not been connected to the new school well, and there is no municipal piped distributions system at this time (p.c. Nick Barnett 2017).

5.19 Dawson City - Water Supply System

The City of Dawson (CoD) was established in the late 1800s at the confluence of the Yukon and Klondike Rivers during the Yukon Gold Rush. Industrial activity in the area has included riverboat transport, placer gold mining in the Klondike River Valley and industrial services to the community and ongoing placer operations including repair shops and heavy equipment operation in the surrounding watershed.

CoD owns and operates a public water supply system providing domestic water to the residents of Dawson City. The system has water sourced from four water supply wells, PW-1N, PW-2N, PW-3N and PW-4N that provide water in a common raw water main to a water treatment plant where it is chlorinated and stored prior to distribution via a piped distribution network or by bulk truck delivery. The system, which serves approximately 2,075 residents of Dawson City (Yukon Bureau of Statistics September 2015), is considered a LPDWS under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007).

5.19.1 Data Compilation Methodology

Tetra Tech approached CoD water supply stakeholders including the CoD water system operators and owners, YG Community Services and YG Environmental Health Services to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following parties regarding the City of Dawson Water Supply System:

- City of Dawson – Provided the majority of data for this summary including data for wells PW-1N through PW-4N and the planned new water treatment plant.
- YG Community Services (the client) – YG CS provided data for recent upgrades to the City of Dawson Water Supply System.
- YG Environmental Health – YG EHS was contacted and assisted with confirming the data compiled for the COD water supply system.

5.19.2 Hydrogeology

Dawson City is located on a low-lying alluvial terrace at the confluence of the Klondike and Yukon Rivers. The sedimentary deposits comprise of discontinuous permafrost, with unfrozen sand and gravel sediments found near the mouth of the Klondike River in the southern end of the City and ice rich, organic sediments found in the northern portion (MH 2014).

A shallow water table aquifer (the Dawson City Aquifer (DCA)) exists under parts of the town where sand and gravel deposits are unfrozen in close proximity to the Yukon and Klondike Rivers. The DCA is inferred to be hydraulically connected to the Klondike and Yukon Rivers and the majority of recharge to the DCA is interpreted to be via horizontal infiltration of surface water from these water bodies. To a lesser extent, recharge is expected through vertical infiltration of surface water throughout the city area and on the slopes of the Midnight Dome, and there may be some upwards discharge from the underlying bedrock to the DCA. Little to no horizontal groundwater flow into the DCA is expected from the frozen zones to the north and east. Discharge from the DCA is ultimately to the Yukon River. General groundwater flow direction is inferred to be in a west to northwesterly direction from the Klondike River, through the course sedimentary deposits towards the Yukon River and is bounded to the west and north by the effectively impermeable permafrost boundary.

The four CoD production wells are located in the area between Front Street and the Yukon River, in the general vicinity of the Commissioner's residence. The wells were completed in the shallow unconfined aquifer consisting of native sands and gravels. Under pumping conditions, the DCA flow regime is much the same, however in the vicinity

of the four wells, the hydraulic gradient towards the Yukon River is reversed and flow is induced from the river towards the pumping wells.

While, geographically, the four wells are inferred to draw a significant proportion of their water directly from the Yukon River, review of aerial images indicates that under high water levels, water from the Klondike River flows almost mid-way across the Yukon River and water from the two rivers does not appear to be mixing until several hundred metres past the wells. Under low river level conditions, a gravel bar at the confluence of the two rivers is exposed to approximately mid-way across the Yukon River. The bar diverts Yukon River flow to the west and away from the wells, while the Klondike River flows along several channels, one aligned directly past the wells. Given these observations, it is inferred that the majority of water pumped by the wells from the Yukon River is likely sourced from the Klondike River and is representative of Klondike River water quality. Based on this reasoning, there is considered to be little to no contribution from Yukon River water (i.e. water sourced form upstream of the confluence) to any of the four water supply wells. Based on the modelled capture zone, approximately 90% of water pumped by the wells is drawn from the Yukon River while approximately 5% of water is drawn from the capture zone extending to the east and south and ultimately from the Klondike River (Tetra Tech 2017); however, due to lack of mixing at the confluence of the two rivers, the 90% drawn from the Yukon River is expected to essentially have the same water quality as the Klondike River. The remaining 5% is sourced from recharge to the DCA from surface water, lateral flow of perched groundwater from the adjacent permafrost zone and discharge from underlying bedrock.

As part of the well completion reporting for the Dawson community wells, Morrison Hershfield completed an analysis of the vulnerability of the wells and aquifer based on the semi-quantitative ISI (Ontario Ministry of Environment 2001). The ISI score for the shallow, unconfined aquifer was found to be between 5.6 and 6.0. The OME 2001 ISI method defines aquifers with scores of less than 30 as having high intrinsic susceptibility to surface sources of contamination. The calculated ISI scores therefore suggest that the DCA at the location of the water supply wells has a high vulnerability to surface-based contamination. A high ISI is to be expected given the permeable nature of the sand and gravel that overly the aquifer.

5.19.3 Summary of Wells

There are four wells (PW-1N through PW-4N) supplying the COD LPDWS that have been in service since October 2015. Logs for these four wells are included in the GIS map and database attached. The three former CoD water supply wells (PW-1, PW-2 and PW 3) located in the vicinity of the current water supply wells were decommissioned in 2016 and another former CoD water supply well PW-4 (YEC-Well), a dug well adjacent to the Klondike River and close to the end of Fifth Ave, was decommissioned in 2015 (p.c. Geoff Quinsey 2017). All four old water supply wells are believed to have been decommissioned in conformance with the Canadian Ground Water Association Guidelines for Water Well Construction (p.c. Geoff Quinsey 2017). The following tables summarize the completion characteristics of the current water supply wells.

Table 5-45: City of Dawson, Well PW-1N Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Midnight Sun Drilling Ltd. in July 2014	MH 2014
Total well depth	20.1 m bgs	
Casing	15 3/16" (386 mm) ID Steel Well Casing	
Casing depth	16.4 m bgs	

Table 5-45: City of Dawson, Well PW-1N Summary		
Well Construction Parameters	**Details**	**Source**
Well screen	3.3 m 120 slot (3.05 mm) stainless steel well screen exposed from approximately 16.87 m bgs to 20.1 m bgs	
Static water level	6.3 m bgs (314.151 m asl) (July 28, 2014)	
Sanitary seal	Bentonite surface seal to 5 m bgs	
Wellhead completion [1]	Pitless unit with vented well cap. Wellhead in locked, heated enclosure.	
Slab Elevation (m asl)[2]	320.740	
Top of Casing Elevation (m asl)[2]	321.291	
Wellhead stickup	0.551 m ag[3]	MH 2014 Stantec 2013
Well rated capacity	37 L/s (488 IGPM)	
Inferred well GUDI status	GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

[1] Observations by Tetra Tech during February 2017 inspection. [2] Elevations surveyed by Underhill Geomatics in February 2017.

Table 5-46: City of Dawson, Well PW-2N Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	The well was completed by Midnight Sun Drilling Ltd. in July 2014	MH 2014
Total well depth	18.8 m bgs	
Casing	15 3/16" (386 mm) ID Steel Well Casing	
Casing depth	15.1 m bgs	
Well screen	3.4 m 120 slot (3.05 mm) stainless steel well screen exposed from 15.4 m bgs to 18.8 m bgs	
Static water level	6.0 m bgs (July 22, 2014)	
Sanitary seal	Bentonite surface seal to 5 m bgs	
Wellhead completion[1]	Pitless unit with vented well cap. Wellhead in locked, heated enclosure.	Tetra Tech 2017
Slab Elevation (m asl)[2]	320.628	
Top of Casing Elevation (m asl)[2]	321.139	
Wellhead stickup	0.511 m ag	MH 2014 Stantec 2013
Well rated capacity	41 L/s (541 IGPM)	

Table 5-46: City of Dawson, Well PW-2N Summary		
Well Construction Parameters	**Details**	**Source**
Inferred well GUDI status	GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

[1] Observations by Tetra Tech during February 2017 inspection. [2] Elevations surveyed by Underhill Geomatics in February 2017.

Table 5-47: City of Dawson, Well PW-3N Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	The well was completed by Midnight Sun Drilling Ltd. in July 2014	MH 2014
Total well depth	18.2 m bgs	
Casing	15 3/16" (386 mm) ID Steel Well Casing	
Casing depth	14.5 m bgs	
Well screen	3.4 m 120 slot (3.05 mm) stainless steel v-wire screen exposed from approximately 14.8 m bgs to 18.2 m bgs	
Static water level	5.09 m bgs (314.41 m asl) (July 26, 2014)	
Sanitary seal	Bentonite surface seal to 5 m bgs	
Wellhead completion[1]	Pitless unit with vented well cap. Wellhead in locked, heated enclosure.	
Slab Elevation (m asl)[2]	320.566	
Top of Casing Elevation (m asl)[2]	321.116	
Wellhead stickup	0.55 m ag	MH 2014 Stantec 2013
Well rated capacity	42 L/s (554.5 IGPM)	
Inferred well GUDI status	GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

[1] Observations by Tetra Tech during February 2017 inspection. [2] Elevations surveyed by Underhill Geomatics in February 2017.

Table 5-48: City of Dawson, Well PW-4N Summary		
Well Construction Parameters	**Details**	**Source[1]**
Date of construction	The well was completed by Midnight Sun Drilling Ltd. in July 2014	MH 2014
Total well depth	19.0 m bgs	
Casing	15 3/16" (386 mm) ID Steel Well Casing	
Casing depth	15.3 m bgs	
Well screen	3.4 m 120 slot (3.05 mm) stainless steel v-wire screen exposed from 15.6 m bgs to 19.0 m bgs	
Static water level	5.7 m bgs (314.51 m asl) (July 27, 2014)	
Sanitary seal	Bentonite surface seal to 5 m bgs	
Wellhead completion[1]	Pitless unit with vented well cap. Wellhead in locked, heated enclosure.	
Slab Elevation (m asl)[2]	320.639	
Top of Casing Elevation (m asl)[2]	321.154	
Wellhead stickup	0.515 m ag	MH 2014 Stantec 2013
Well rated capacity	45 L/s (591 IGPM)	
Inferred well GUDI status	GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

[1] Observations by Tetra Tech during February 2017 inspection. [2] Elevations surveyed by Underhill Geomatics in February 2017.

5.19.4 Source Water Quality

Source water quality was tested upon completion of the four CoD water supply wells in 2014 and the analytical results met the GCDWQ for the aesthetic and health related parameters analyzed (MH 2014). Based on these water quality results the following observations can be made:

- The water from the four wells is of similar quality and derived from the same aquifer.
- Water from the City of Dawson production wells can be classified as calcium-sulphate type and considered hard, with hardness in the initial samples ranging from 149 mg/L to 168 mg/L (MH 2014).
- This water chemistry is similar to that observed in the previous production wells and suggests that the Dawson City Aquifer water quality is relatively consistent.
- As the City of Dawson wells are classified as GUDI, Health Canada requires that water from GUDI sources have appropriate filtration and disinfection. Filtration is expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU. We understand that a new water treatment plant is currently being designed and is scheduled for construction in 2019.

5.19.5 Water Treatment and Distribution

Table 5-49: City of Dawson Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	City of Dawson	
Water source	Groundwater under the influence of Surface Water	MH 2014
Wells serving the system	Wells PW-1N, PW-2N, PW-3N, and PW-4N	MH 2014
Treatment type	Water is disinfected through a gas chlorination feed system. The chlorine gas dosage is manually controlled and adjusted and residual free chlorine is monitored manually by the operator once a day. After chlorine application, the treated water is stored in two reservoirs (storage capacity of 961 m^3 and 1,352 m^3 respectively), where an uncontrolled contact time is provided before water is pumped into the distribution system. Increasing chlorine concentration in water supply from 0.4 mg/L to 0.6 mg/L following detection of biological contaminant in raw water supply.	Stantec 2013
Number of connections	700 (and approximately 1375 people)	Stantec 2013; Yukon Bureau of Statistics 2016
Bleeding	Water is bled through the system during cold months to prevent freezing.	p.c. Louis Gerberding 2017
Delivery method	Piped and Trucked	Stantec 2013
Age of system/last known update	New wells in 2014	p.c. Louis Gerberding 2017
Planned Upgrades	New Water Treatment Plant in the planning stages, which will be equipped with filtration as well as UV and chlorine disinfection	p.c. Louis Gerberding 2017

5.19.6 Source Water Protection Planning

City of Dawson is currently in the process of completing an AWPP with support from Tetra Tech and project management from YG Community Services. The AWPP is due to be completed in summer 2017.

A key first step of an AWHPP is to define the well capture zones. Tetra Tech (2017) used a finite difference numerical model of the Dawson City hydrogeological regime to assist in the delineation of the capture zone of the four CoD water supply wells. A copy of the modeling technical with appended figures showing the modelled capture zones is included in the GIS database.

Preliminary findings from the AWHPP work to date are:

- The primary water source for the four water supply wells is the Yukon River (approximately 90%) with approximately 5% sourced from the Klondike River; however, the water quality in the portion drawn from the Yukon River is expected to be essentially the same as the Klondike River water. Approximately 5% is sourced

from recharge to the DCA from surface water, lateral flow of perched groundwater from the adjacent permafrost zone and discharge from underlying bedrock.

- The well capture zones are presented in Tetra Tech (2017) and extend from the four wells west to the Yukon River, north and east to the defined permafrost boundary and south to the Klondike River.
- The majority of water pumped form the four water supply wells is considered to be sourced from the Klondike River. Given the potential for rapid migration of contamination along the Klondike River and tributaries, the well capture zone has been extended to include the Klondike River Valley (up to Rock Creek) and tributary valleys to the south to include current and historical placer mining operations.
- A preliminary list of potential sources of contamination and primary contaminants identified in the community within the well capture zones are:
  - Above-ground fuel storage tanks (Petroleum Hydrocarbons)
  - Underground fuel storage tanks (Petroleum Hydrocarbons)
  - CoD sanitary sewer system (Biological, Nutrients)
  - Wastewater treatment plant: (Biological, Nutrients)
  - Yukon River and Klondike River (Biological)
  - In ground septic disposal systems in the Klondike River valley (Biological, Nutrients)
  - Placer mining activities (Turbidity, Metals, Hydrocarbons)

The four new supply wells are expected to meet the water demand in City of Dawson, and will provide redundancy in the system to prevent loss of water supply should one (or more) well(s) fail or be temporarily shut off for maintenance or repair.

5.19.7 Water Supply Information Data Gaps

Tetra Tech has been in contact with the City of Dawson and requested all recent data. To the best of our knowledge, this summary is up to date and complete. Tetra Tech notes the following could be addressed by future work:

- The City of Dawson source water protection planning is in progress and the resulting AWPP should be included in the database once completed.

5.20 Dawson City Area – Klondike Valley Firehall Water Supply System

The Klondike Valley Firehall (Building 2592) is located at Rock Creek at about km 696 on the North Klondike Highway, 20 km south of Dawson City, Yukon. The serve-serve water system sources water from a shallow drilled well (Well 2592B). Improvements to the Klondike Valley Fire Hall water system in 2012 included water treatment upgrades to ensure adequate treatment for a groundwater under the direct influence of surface water source. The small system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which provide measures for inspection and oversight by an officer of medical health for systems that provide water for human consumption.

5.20.1 Data Compilation Methodology

Tetra Tech approached stakeholders including YG departments, water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech obtained data regarding the Klondike Valley Firehall Water Supply system from the following proponents:

- YG Community Services (the client) – YG CS provided data for the Klondike Valley Firehall Water Supply as this system is owned and operated by YG CS. The YG CS operator provided review comments and edits for the final summary to ensure completeness and accuracy.

5.20.2 Hydrogeology

The well completion log for Well 2592-B indicates that the well is completed at a depth of 14.9 m within a shallow unconfined gravel aquifer, i.e., within the same aquifer as the original Well 2592-A. The static water level in Well 2592-B was 3.4 m below ground at the time of drilling and significant fine-grained sediments were encountered. The aquifer materials are primarily gravel with some sand and trace silt (Tetra Tech 2013).

Both Well 2592-B and Well 2592-A are located southeast of the Klondike River, and are most likely completed within alluvial floodplain sediments deposited by the river. Discontinuous lenses of permafrost are also known to exist in the area. Water levels in the aquifer are likely strongly connected to water levels in the Klondike River. The shallow depth of this aquifer, presence of various ephemeral surface water features in the area, combined with the absence of fine-grained material leaves this aquifer vulnerable to surficial sources of contamination (Tetra Tech 2006 and 2013).

The expected direction of groundwater flow is westerly to northwesterly along the Klondike River valley with a component of flow towards the Klondike River (Tetra Tech 2006).

5.20.3 Well Summary

The lithology and well completion log for the Klondike Valley Firehall Well (Well 2592-B) serving the system is included in the GIS map and database. The original Well 2592-A is located near the firehall building, and YG CS is considering decommissioning it in the near future (p.c. Steve Perrin 2017). The following table summarizes the completion characteristics Well 2592-B.

Table 5-50: Klondike Valley Firehall, Well 2592-B Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Cathway Water Resources Ltd. in October 2012	Well log
Total well depth	14.9 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	13.8 m bgs	
Well screen	1.1 m 100 slot (2.54 mm) stainless steel well screen from 13.8 m bgs to 14.9 m bgs	
Static water level	3.4 m bgs (October 19, 2012)	
Sanitary seal	Bentonite surface seal to 6 m bgs	Tetra Tech 2013
Wellhead completion	Pitless Unit	Government of Yukon Record Drawings 2013
Wellhead stickup	1.0 m	Government of Yukon Record Drawings 2013
Well rated capacity	Approximately 3.1 L/s (41 IGPM)	Tetra Tech 2013
Well GUDI status	GUDI	Tetra Tech 2013
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines with the exception of the well completion depth.	

5.20.4 Source Water Quality

In general, the water from the new Klondike Valley Firehall well (Well 2592-B) meets Health Canada's Guidelines for Canadian Drinking Water Quality (GCDWQ) for the parameters analyzed and the key observations and comments noted in 2006 are (Tetra Tech 2013):

- The water was hard, has a pH of approximately 7.5 and can be characterized as calcium-magnesium-bicarbonate-sulphate type water;
- Turbidity was measured at 2.3 NTU during well development. Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration is expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU; and,
- A lab detectable concentration of extractable petroleum hydrocarbon (127 parts per billion) was detected during initial sampling. However, the results of the re-sampling showed that extractable petroleum hydrocarbon concentrations were non-detect and this result was likely from the drilling process.

Tetra Tech did not review recent water quality data but understands water chemistry analysis is completed at this system annually and bacteriological monitoring is completed on a regular basis with results sent to YG EHS for review.

5.20.5 Water Treatment and Distribution

Table 5-51: Klondike Valley Firehall Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2013
Water source	Groundwater	
Well serving the system	Klondike Valley Firehall Well 2592-B	
Treatment type	UV Disinfection and chlorine disinfection	Government of Yukon Record Drawings 2013
Number of connections	Approximately 20 to 30 people	Tetra Tech 2013
Delivery method	Directly connected to the Firehall and the water storage tanks with a self-serve fill station outside the Firehall for public use consisting of a 3” overhead fill and a blue jug fill point	
Age of system/last known update	Water treatment upgraded in 2012 to account for GUDI source	

5.20.6 Source Water Protection Planning

Well 2592-B was installed about 5 m north of the northwest corner of the Firehall building and about 17 m from, and cross-gradient to, the sewage holding tank serving the facility (Tetra Tech 2013). Industrial activity in the Dawson area has included riverboat transport, placer gold mining in the Klondike River Valley and industrial services to the community and ongoing placer operations including repair shops and heavy equipment operation in the surrounding watershed.

There is no source water protection planning in place for the Klondike Valley Firehall wells. As the aquifer is shallow and unconfined, it is vulnerable to surface-based contamination, source water protection planning is considered important to ensure safe drinking water. The well is located near the Klondike Highway and the Klondike River and is vulnerable to sources of contamination from these features.

5.20.7 Water Supply Information Data Gaps

Tetra Tech has identified the following data gaps:

- There is no source water protection planning in place to protect this shallow groundwater resource.
- Tetra Tech understands that the original water well has not been connected as a backup water supply, and that YG CS is considering decommissioning it in the near future.

5.21 Dawson City - Airport Terminal Building Public Water Supply System

Dawson City Airport is located on the North Klondike Highway approximately 15 km east of Dawson City. The Airport Terminal Building is approximately 400 m from the Klondike River at its closest point. The Dawson Airport Terminal Building (ATB) is served by a groundwater well, Well W-2544, located approximately 4 m east of the ATB. The water system supplies potable water to the airport workers, flight crews and members of the public who utilize the building and is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.21.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.21.2 Hydrogeology

The Dawson City ATB well is situated southeast of the Klondike River and is completed within alluvial floodplain deposits from the river. Water levels and groundwater flow direction in the aquifer are likely closely connected to water levels in Klondike River. The groundwater flow direction in the vicinity of the well is inferred from topography and the proximity to surface water to be northwest toward the Klondike river.

The Dawson City ATB well is completed at a depth of 12.2 m bgs in a coarse gravel, cobble and boulder aquifer. The well log does not indicate the presence of any fine-grained material in the sequence overlying the aquifer, and the static water level is quite shallow at 4.7 m bgs. The aquifer is very vulnerable to surface sources of contamination due to the shallow static water level and the well construction because it lacks a surface seal. An abandoned well is also located on the property in the crawl space under the terminal building approximately 9 m from the well that is in use.

5.21.3 Well Summary

A partially complete well log for the Dawson City ATB Well is included in the GIS map and database portion of this project. The following table summarizes available data for the water well.

Table 5-52: Dawson City Airport Terminal Building, Well W-2544 Summary

Well Construction Parameters	Details	Source
Date of construction	Completed by Midnight Sun Drilling Co. Ltd. in September 1988	Well Log
Total well depth	12.2 m bgs	
Casing	6” (155 mm) ID steel casing	
Casing depth	11.4 m bgs	
Well screen	0.8 m 18 slot (0.46 mm) steel well screen installed from 11.4 m bgs to 12.2 m bgs	

Table 5-52: Dawson City Airport Terminal Building, Well W-2544 Summary		
Well Construction Parameters	**Details**	**Source**
Static water level	4.7 m bgs	
Sanitary seal	No surface seal	
Wellhead completion	Split gasket cap, well pit	Tetra Tech 2006
Wellhead stickup	0.45 m bgs	
Well rated capacity	1.26 L/s (16.6 IGPM) (estimated by the driller)	Well Log
Well GUDI status	Potentially GUDI	Based on shallow depth and well construction – there is no surface seal in place
Well Construction Comments:	Well likely does not have a surface seal and is not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.21.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The observations made in 2005 are summarized below:

- The water was calcium-bicarbonate type with a pH of approximately 7.4 and was considered moderately hard with a measured hardness of 170 mg/L (as $CaCO_3$);
- All GCDWQ health-based criteria and aesthetic objectives were met for the parameters analyzed; and
- Review of chloride, nitrate and nitrite showed all three to be low and within the normal background ranges, suggesting that the aquifer was not under the influence of anthropogenic surface sources of nutrients or anions such as septic wastes at the time of sampling.

5.21.5 Water Treatment and Distribution

Table 5-53: Dawson City Airport Terminal Building Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017 p.c. Michael Fraser 2107
Water source	Groundwater	
Wells serving the system	Dawson ATB well	
Treatment type	None	
Water users	Airport workers, flight crews and passengers	
Delivery method	Piped connect directly to ATB	

Table 5-53: Dawson City Airport Terminal Building Water Treatment and Distribution Details		
Item	**Details**	**Source**
Age of system/last known update	Unknown	

5.21.6 Source Water Protection Planning

There is no Source Water Protection Planning in place for the Dawson City ATB Well 2544. Given the unconfined, vulnerable nature of the aquifer and the industrial nature of work at the site (including significant fuel storage), a SWPP would provide a valuable tool for identifying, monitoring and managing risks to the wells and aquifer.

Potential sources of contamination in the vicinity of the wellhead that were identified as part of the 2005 SPDWSA site review, included:

- A septic holding tank located 28 m from the well;
- An AST located 30 m from the well;
- An abandoned well 9 m from the well; and
- Several spills have occurred at the airport over the history of operation.

5.21.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- There is no source water protection planning for this groundwater resource, source water protection planning here could be incorporated into a greater City of Dawson SWPP and provide comprehensive planning to protect the shallow water resources in the area that are closely tied to the Klondike and Yukon rivers;
- An adequate water treatment system consisting of filtration (to 1 micron absolute) and UV disinfection was recommended for this system; however, it is our understanding that no updates have been completed to the system since 2006;
- Ongoing monitoring of the water quality for impacts from petroleum products, drilling of a new well or conversion of the water system to trucked deliver was recommended for this system, and YG PMD was not able to confirm if these changes have been implemented.

5.22 Dawson City Area - Tombstone Interpretive Centre Water Supply System

The Tombstone Interpretive Centre located at the Tombstone Territorial Park at km 71 on the Dempster Highway, Yukon water system has water supplied from one groundwater well (Well 2607). The system serves the visitors at the Interpretive Centre and is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide water for human consumption.

5.22.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system owners and operators to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Many of the stakeholder groups contacted were able to provide data and received the project positively. For the Tombstone Interpretive Centre water supply system, Tetra Tech contacted the following proponents:

- YG Property Management Division – YG PMD has been consulted and has reviewed the data set for the Tombstone Interpretive Centre.
- Yukon Department of Environment – YG Parks Branch has been consulted and has reviewed the data set for the Tombstone Interpretive Centre.

5.22.2 Hydrogeology

Tombstone Interpretive Centre is located in an area with significant topographic relief in the immediate surrounds. Groundwater recharge likely occurs at higher elevations in the mountains surrounding the Centre with discharge to streams and creeks in the valley bottom. Well 2607 is completed in an overburden aquifer. The saturated sand and gravel sequence encountered from 8 to 29.2 m bgs is interpreted as one unconfined aquifer consisting of sand and angular to sub-angular tabular gravel clasts (Tetra Tech 2009). The grain size results indicate that the aquifer material is primarily gravel with some sand (Tetra Tech 2009).

Hydraulic testing results from the pumping test conducted at the time of well construction show that the well is completed within a highly productive aquifer. An aquifer transmissivity was calculated from pumping test results and is on the order of 3 x 10^{-2} m^2/s with hydraulic conductivity on the order of 2 x 10^{-3} m/s (Tetra Tech 2009).

5.22.3 Well Summary

A lithology and well construction log for Well 2607, serving Tombstone Visitor Reception Centre, is included in the GIS mapping and database. The well is located upgradient of fuel handling and vehicle traffic on the site. The following table summarizes the completion characteristics of the well.

Table 5-54: Tombstone Interpretive Centre Well 2607 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Double D Drilling Ltd. In September 2008	Tetra Tech 2009 M. Eckervogt 2017
Total well depth	29.1 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	27.8 m bgs	

Table 5-54: Tombstone Interpretive Centre Well 2607 Summary		
Well Construction Parameters	**Details**	**Source**
Well screen	1.3 m 150 slot (3.8 mm) well screen from approximately 27.8 m to 29.1 m bgs.	
Static water level	8.2 m bgs (October 2008)	
Sanitary seal	Bentonite surface seal to 6 m bgs	
Wellhead completion	Well is equipped with an above grade pitless adapter and protected by a fenced enclosure around the wellhead.	
Wellhead stickup	1.2 m ags (after well completion)	
Well rated capacity	10 L/s (132 IGPM)	
Well GUDI status	Potentially GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.22.4 Source Water Quality

Key observations and comments noted in 2009 (Tetra Tech 2009) and from communication with YG PMD are:

- The water from the well is hard and can be characterized as a calcium-magnesium-sulphate-bicarbonate type water;
- The raw water from the well met the GCDWQ for health-based parameters and aesthetic objectives at time of sampling, with the exception of the presence of total coliform bacteria. Tetra Tech understands subsequent tests have been negative for total coliform bacteria (p.c. M. Fraser 2017).
- Tetra Tech understands bacteriological testing is completed at start up and quarterly during seasonal system operation and bacteriological testing has shown satisfactory water quality results, but no further chemistry testing has been completed since well construction.

5.22.5 Water Treatment and Distribution

Table 5-55: Tombstone Interpretive Centre Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2009 M. Eckervogt 2017
Water source	Groundwater	
Well serving the system	Well 2607	
Treatment type	5 micron filtration, UV disinfection**	
Water users	Visitors and YG employees	

Table 5-55: Tombstone Interpretive Centre Water Treatment and Distribution Details		
Item	**Details**	**Source**
Delivery method	Directly connected to buildings	
Age of system/last known update	Plans are in place to upgrade filtration and UV systems in 2017	

**Tetra Tech understands that YG plans to upgrade filtration and UV systems for this water system in summer 2017.

5.22.6 Source Water Protection Planning

No records were found indicating that a source water protection plan has been completed for the Tombstone Interpretive Centre well. The aquifer is unconfined and the aquifer materials are relatively permeable (gravel with some sand); therefore, a SWPP would provide a valuable tool for identifying, monitoring and managing risks to the wells and aquifer.

5.22.7 Water Supply Information Data Gaps

Tetra Tech has reviewed available information for this system and has obtained review comments from both YG PMD and from YG Department of Environment. For the purpose of this project, the following data gaps were identified:

- No GUDI assessment has been conducted for Well 2607;
- No Source Water Protection Plan is in place; and,
- Details of the water system upgrades planned for summer 2017 should be included in this summary once complete.

5.23 Destruction Bay - Kluane Lake School Public Water Supply System

Kluane Lake School, located in Destruction Bay, Yukon, has water supplied by a water well drilled adjacent to the school. The well is piped into the school for domestic water supply. This system is regulated under the *Public Health Act,* General Regulations Sections 18 and 19 (YG *Public Health Act,* 1958/079), which requires safety measures and inspection for water and water sources for systems that provide for human consumption.

5.23.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.23.2 Hydrogeology

Tetra Tech oversaw the drilling and completion of a new water well at the Kluane Lake School in 2006. During the drilling of the well, Tetra Tech noted lithology and recorded well completion details. Subsurface soils consist primarily of till deposits with lenses of sand and gravel. Wells in this area are frequently confined and under artesian pressure. The well was installed in a confined sand and gravel aquifer. Other wells installed in the vicinity supply domestic water to residences, the community centre, the health centre and the Talbot Arm Lodge.

5.23.3 Well Summary

The well log for the Kluane Lake School supply well is included in the GIS map and database portion of this project. The following table summarizes the completion characteristics of the Kluane Lake School well.

Table 5-56: Kluane Lake School, Well 3171-B Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Double D Drilling Ltd. in October 2006	Tetra Tech 2007
Total well depth	24.4 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	23.2 m bgs	
Well screen	1.2 m 30 slot (0.76 mm)) stainless steel v-wire screen from 23.2 m bgs to 24.4 m bgs	
Static water level	6.4 m bgs (October 26, 2006)	
Sanitary seal	Bentonite surface seal to 6 m bgs	
Wellhead completion	Enclosed in a locked insulated wood box with locked fence	Onsite observation, Tetra Tech
Wellhead stickup	Approximately 1 m ags	
Well rated capacity	1.0 L/s (13 IGPM)	Tetra Tech 2007

Table 5-56: Kluane Lake School, Well 3171-B Summary		
Well Construction Parameters	**Details**	**Source**
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.23.4 Source Water Quality

Tetra Tech reviewed the original well quality testing results. From the water sample collected on October 27, 2006, the water quality met the GCDWQ AO and MAC for all the parameters analyzed. The water can be described as calcium-magnesium-sulphate type and was considered very hard with a hardness of 367 mg/L (as $CaCO_3$) on the date sampled.

5.23.5 Water Treatment and Distribution

Table 5-57: Kluane Lake School Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2007 p.c. Nick Barnett 2017 p.c. Martin Eckervogt 2017
Water source	Groundwater	
Wells serving the system	Kluane Lake School	
Treatment type	Charcoal filtration, water softening	
Water users	Kluane Lake School	
Delivery method	Direct connection to building	
Age of system/last known update	New water well was completed in 2006	

5.23.6 Source Water Protection Planning

There is no source water protection planning in place for the Kluane Lake School Well 3171-B. Source water protection planning here should be incorporated with source water protection planning throughout the community to create a comprehensive Destruction Bay SWPP.

Destruction Bay was established as an US army camp during the construction of the Alaska Highway in the 1940s. Historical industrial activity here included army activities relating to highway construction and maintenance. Destruction Bay is the modern location of the YG Department of Highways and Engineering Grader Station and other services stations, including Talbot Arm fuel storage and a private mechanic shop, are also located in the area up-gradient of the Kluane Lake School well.

Potential sources of contamination in the area of the well that were identified during the 2006 site review, included a small drainage less than 30 m from the well; the Alaska Highway to the north of the well; UST and AST fuel

storage tanks on the site; scrap cars and septic lines in the vicinity of the wellhead; *and* septic and fuel spills in the surrounding area.

5.23.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system summary includes all available data and is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- No source water protection is in place for the system. Source water protection planning is an effective tool for maintaining the integrity of water supply systems and aquifers and is considered an essential part of best management practices for water supply systems; and,
- Several upgrades on the water system including installation of a disinfection system were recommended by Tetra Tech in 2006; however, it is our understanding that no updates have been completed to the system since 2006.

5.24 Destruction Bay - Health Centre Water Supply System

Destruction Bay is located about 270 km north of Whitehorse, Yukon on the Alaska Highway. The Destruction Bay Health Centre water system has water supplied from a 69 m deep artesian well, Well 3957. The well also provides water for two adjacent nursing residences. This system is regulated under the *Public Health Act,* General Regulations Sections 18 and 19 (YG *Public Health Act,* 1958/079), which requires safety measures and inspection for water and water sources for systems that provide for human consumption.

5.24.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.24.2 Hydrogeology

The log for Well 3957 indicates that the well was originally drilled to a depth of 25.2 m bgs and completed in a gravel aquifer. The well was subsequently deepened to 68.9 m bgs and completed in a confined flowing artesian aquifer. The well log indicates that the subsurface lithology is comprised of variable gravel, silt, clay and till with fine-grained sediments from 46.9 m bgs to 60.3 m bgs comprising a significant confining layer. The depth of the well, presence of the confining layer and the artesian pressure indicate that there is protection from surface sources of contamination.

The groundwater flow direction in the vicinity of the well is inferred from topography to be east towards Kluane Lake.

5.24.3 Well Summary

The log for the Destruction Bay Health Centre well is included in the associated GIS map and database portion of this project. The following table summarizes available data for the water well.

Table 5-58: Destruction Bay Health Centre, Well 3957 Summary

Well Construction Parameters	Details	Source
Date of construction	The well was originally drilled by Midnight Sun Drilling Co. Ltd. in October 1989. The well was subsequently deepened by the same contractor in September/October 1993	Well Log
Total well depth	68.9 m bgs	
Casing	6” (152 mm) ID Steel Casing	
Casing depth	Unknown	
Well screen	Unknown	
Static water level	Artesian Flowing	Well log
Sanitary seal	No surface seal	

Table 5-58: Destruction Bay Health Centre, Well 3957 Summary		
Well Construction Parameters	**Details**	**Source**
Wellhead completion	Split gasket cap modified for artesian pressure	Tetra Tech 2006
Wellhead stickup	0.35 m bgs	
Well rated capacity	Unknown	
Well GUDI status	Potentially GUDI	Based on well construction
Well Construction Comments:	Well was not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.24.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The observations made in 2005 are summarized below:

- The total arsenic concentration, which ranged from 0.114 mg/L to 0.0148 mg/L on the dates sampled, exceeds the current GCDWQ MAC of 0.01 mg/L.
- The pH in the water samples collected from the first two sampling events, ranged from 8.68 to 8.79, and was in exceedance of the GCDWQ AO upper threshold value of 8.5 for pH;
- The water quality met all other health-based and aesthetic objectives for the parameters analyzed; and
- A review of indicators of potential contamination including chloride, nitrate and nitrite found that nitrate and nitrite concentrations were low and within the natural background ranges but chloride was slightly elevated above the natural background concentration. The slightly elevated chloride was likely due to the water softening system, and the analytical results of the indicator parameter suggest that the deep groundwater aquifer has not been affected by surface sources of contamination.

5.24.5 Water Treatment and Distribution

Table 5-59: Destruction Bay Health Centre Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon**	Tetra Tech 2006 p.c. Nick Barnett 2017 p.c. Martin Eckervogt 2017 p.c. Lester Balsillie 2017
Water source	Groundwater	
Wells serving the system	Destruction Bay Health Centre Well 3957	
Treatment type	Treatment for the Health Centre connection consists of water softener, pH neutralizer, and colour removal.	

Table 5-59: Destruction Bay Health Centre Water Treatment and Distribution Details		
Item	**Details**	**Source**
	For the nursing residences, in addition to the above treatment, there is an reverse osmosis unit at the point of use in Residence #1 kitchen	
Water users	YG employees and patients	
Delivery method	Piped to Health Centre and nursing residences	
Age of system/last known update	Unknown	

**Note: The care of this system is split between YG PMD and Yukon Housing. Tetra Tech understands the Health Centre water treatment system and the well are maintained by YG PMD and the nursing residences are maintained by Yukon Housing.

5.24.6 Source Water Protection Planning

There is no source water protection planning in place for the Destruction Bay Health Centre Well 3957. Source water protection planning here should be incorporated with source water protection planning throughout the community to create a comprehensive Destruction Bay SWPP.

Potential sources of contamination in the vicinity of the wellhead that were identified as part of the 2005 SPDWSA site review, included:

- An indoor fuel storage tank located 20 m from the well;
- An AST located 26 m from the well;
- A septic field located 65 m from the well;
- An abandoned well on the property; and,
- There had been a number of spill events of diesel fuel and raw sewage in the nearby area.

5.24.7 Water Supply Information Data Gaps

YG PMD and Yukon Housing have each reviewed this summary and provided comments. To our knowledge, this system summary includes all available data and is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- There is no source water protection planning for this groundwater resource. Source water protection planning here could be incorporated into a greater Destruction Bay SWPP and provide comprehensive planning to protect the groundwater resource; and,
- The construction details of the well are missing (well screen, screen size, casing depth, etc.).

5.25 Destruction Bay - Firehall Water Supply System

The Destruction Bay Firehall has water supplied from an approximately 31.4 m deep well (Well 3172). The well is located in a pit approximately 5 m from the Firehall. The water system is split to serve both the domestic and firefighting water needs for the Firehall. The system used for firefighting is equipped with an elevated 22,500 L water storage tank. This system provides domestic water to the Firehall and is regulated under the *Public Health Act,* General Regulations Sections 18 and 19 (YG *Public Health Act,* 1958/079), which requires safety measures and inspection for water and water sources for systems that provide for human consumption.

5.25.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.25.2 Hydrogeology

The log for Well 3172 indicates that the well is completed at a depth of 31.4 m within a sand aquifer. Overlying the aquifer is approximately 29.9 m of interbedded clay and till, and this is consistent with most well logs in the Destruction Bay area, which typically indicate 25 m to 50 m of fine-grained material overlying a confined sand and gravel aquifer. The presence of a fine-grained confining layer provides some aquifer protection from surficial sources of contamination. The static water level at the time of drilling was 7.6 m bgs and the expected direction of groundwater flow in the vicinity of the site from topography and proximity to surface water is inferred to be east to northeast towards Kluane Lake.

5.25.3 Well Summary

The log for Well 3172 is included in the GIS map and database portion of this project. The following table summarizes the completion characteristics of the well.

Table 5-60: Destruction Bay Firehall, Well 3172 Summary

Well Construction Parameters	Details	Source
Date of construction	The well was constructed by Midnight Sun Drilling Co. Ltd. in September/October 1987	
Total well depth	31.4 m bgs	
Casing	6” (152 mm) OD Steel Well Casing	
Casing depth	30.3 m bgs	
Well screen	1.1 m 30 slot (0.76 mm) well screen from 30.3 m bgs to 31.4 m bgs	
Static water level	Approximately 7.6 m bgs (September 1987)	
Sanitary seal	No record of sanitary seal installation	Well log and Tetra Tech 2006

Table 5-60: Destruction Bay Firehall, Well 3172 Summary		
Well Construction Parameters	**Details**	**Source**
Wellhead completion	The wellhead is located in a pit approximately 5 m from the Firehall building. The pipes are insulated and likely are equipped with heat trace for freeze protection	Tetra Tech 2006
Wellhead stickup	0.7 m bgs (measured on July 28, 2005)	Tetra Tech 2006
Well rated capacity	1.9 L/s (25 IGPM) (estimated by the driller)	Well log
Well GUDI status	Potentially GUDI	Based on well construction
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.25.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern (Tetra Tech 2006):

- The water quality results indicated that the water from Well 3172 was a magnesium-bicarbonate type water;
- The water was considered very hard, with a hardness ranging from 308 mg/L to 312 mg/L on the dates sampled; and
- The water quality results indicated that the water from Well 3172 meets the GCDWQ for all the parameters analyzed with the exception of colour. The colour of the sample when sampled on October 19, 2004 was greater than 60 CU, which exceeds the GCDWQ AO of 15 CU; however, the colour of the two subsequent samples was less than the laboratory detection limit of 5 CU and meets the GCDWQ AO.

5.25.5 Water Treatment and Distribution

Table 5-61: Destruction Bay Firehall Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017 p.c. Martin Eckervogt 2017
Water source	Groundwater	
Number of wells serving the system	Destruction Bay Firehall well (Well 3172)	
Treatment type	None	
Water users	Users of the Firehall	
Delivery method	Directly connected to the Firehall	

Table 5-61: Destruction Bay Firehall Water Treatment and Distribution Details		
Item	**Details**	**Source**
Age of system/last known update	Unknown	

5.25.6 Source Water Protection Planning

There is no source water protection planning in place for the Destruction Bay Firehall Well 3172, and there is no record of a GUDI assessment for the well. Source water protection planning here should be incorporated with source water protection planning throughout the community to create a comprehensive Destruction Bay SWPP.

During the 2005 SPDWSA, one underground and one above ground fuel storage tank and a number of scrap cars were found to be located within 30 m of the well; the fuel storage tanks and scrap cars are considered to be potential contamination sources (Tetra Tech 2006).

There had been multiple spill events of raw sewage due to failures of the community sewage system in Destruction Bay (Tetra Tech 2006). On two occasions in 1993, a mechanical failure caused approximately 37,800 L and 11,340 L of raw sewage to spill (Tetra Tech 2006). The sewage had in both cases reportedly flowed over the ground surface and ponded near Kluane Lake (Tetra Tech 2006). Additionally, four recorded spill events occurred in 1995 and 1996 caused by leaking or broken sewer mains, spilling raw sewage in the Destruction Bay area (Tetra Tech 2006). Two events recorded spills of approximately 200 L each, but the other two events spilled an unknown amount (Tetra Tech 2006).

Although the vulnerability of the aquifer in which this well is completed is considered to be low, a SWPP would provide a valuable tool for identifying, monitoring and managing risks to the wells and aquifer.

5.25.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system summary includes all available data and is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- There is no source water protection planning for this groundwater resource, source water protection planning here could be incorporated into a greater Destruction Bay SWPP and provide comprehensive planning to protect the groundwater resource;
- Tetra Tech recommended in 2006 that the well supplying the Firehall be decommissioned and that the Firehall be connected to the Kluane Lake School Well. Tetra Tech understands this connection has not been completed.

5.26 Faro -Community Water Supply

The Town of Faro was established as a mining town in 1968 during the early operation of the Faro Mine. Today, Faro is home to about 348 residents though the mine is closed down and reclamation is in progress (Yukon Bureau of Statistics 2016). The water source for the Town of Faro Large Public Drinking Water System (LPDWS) consists of three groundwater wells (Wells 1, 2 and 3) located in an undeveloped area near the confluence of the Pelly River and Vangorda Creek approximately 700 m southwest of the Faro Town site. Two additional wells, Well 4 and Well 5, were completed in 2016 and will be incorporated into the system in 2017. The system serves more than 20 connections and is classified as a Large Public Drinking Water Supply System under the Yukon Public Drinking Water Regulation – Part I Large Public Drinking Water Systems.

5.26.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech contacted the following proponents to request data regarding the Faro Water supply system:

- Town of Faro – The Town of Faro manager of operations was able to provide historical documents for the Town of Faro water system and provided contact information for accessing additional data.
- YG Community Services (the client) – YG CS provided data for Faro including well completion reports and information regarding the water treatment system.
- YG Environmental Health – YG EHS was contacted and assisted with the provision of data for the Faro Water Treatment System.

5.26.2 Hydrogeology

The public drinking wells in Faro are completed in an unconfined sand and gravel aquifer in close proximity to each other. The sand and gravel aquifer is an alluvial fan deposited by Vangorda Creek as it discharges to the Pelly River flood plain. Wells are relatively shallow and are reportedly completed at total depths of about 12 m bgs. The driller's well log for Well 3 indicates that there is up to 3.6 m of silt overlying the sand and gravel aquifer in this location. There are no well logs available for Well 1 and Well 2 (Tetra Tech 2012).

A comprehensive study of the town of Faro water wells was completed by Gartner Lee Limited (GLL) for Deloitte and Touche Inc. (GLL 2006). Some key findings with respect to the hydrogeology and source water are summarized below:

- Water is being recharged to the Town of Faro water supply aquifer by Vangorda Creek and the Pelly River, with the relative proportion of recharge varying seasonally;
- Given the response of water levels in observation wells between the pumping well and Vangorda Creek, GLL has interpreted that the cone of depression from the wells does extend to Vangorda Creek; and
- Calculated groundwater velocities under pumping conditions in the Town of Faro water supply aquifer are fast (may be less than 7 days travel time from Vangorda Creek).

Tetra Tech assessed the vulnerability of the aquifer encountered by Well 3 in 2012 using the semi quantitative Intrinsic Susceptibility Index (ISI) method suggested by the Ontario Ministry of Environment. The ISI method resulted in a value of 12, which indicates that the aquifer underlying the site has a high vulnerability to potential

surface sources of contamination and the aquifer water quality may be subject to influence from changes in water quality at the Pelly River and Vangorda Creek (Tetra Tech 2012).

5.26.3 Summary of Wells

The Town of Faro water supply system is served by three groundwater wells, Well 1, Well 2 and Well 3. Two additional wells, Well 4 and Well 5, completed in 2016, will be incorporated into the system in 2017, and Well 1 and Well 2 will be decommissioned.

The logs for the Well 3 serving the Town of Faro, and the newly completed wells Well 4 and Well 5 are included in the GIS map and database portion of this project. There are no well logs available for Well 1 and Well 2. The following tables summarize the completion characteristics of the Faro wells.

Table 5-62: Town of Faro, Well 1 Summary**

Well Construction Parameters	Details	Source
Date of construction	The well was completed in 1968	Jacobsen 2003 Tetra Tech 2012 GLL 2006 GLL 2008
Total well depth	Approximately 12.8 m bgs	
Casing	8" (203 mm) ID Steel Well Casing	
Casing depth	8.2 m bgs	
Well screen	3.8 m long well screen from approximately 8.2 m bgs to 12 m bgs; slot size is unknown.	
Static water level	Unknown	
Sanitary seal	Likely no bentonite surface seal. In addition, no records of well upgrades indicated a subsequent installation of a bentonite seal	
Wellhead completion	Wellhead is located within Pumphouse 2 which is heated and locked. Wellhouse is equipped with 12 in. thick cement block poured around the well casing to provide some protection form surface sources of contamination.	
Wellhead stickup	0.56 m ags	
Well rated capacity	Unknown; however, it was reported that there have been no historical problem with well yield.	
Well GUDI status	Likely GUDI based on the short travel time (GLL 2006, GLL 2008)	
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

**Tetra Tech understands this well will be decommissioned in 2017 and replaced with Well 4 or Well 5.

Table 5-63: Town of Faro, Well 2** Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	The well was completed in 1968	Jacobsen 2003 Tetra Tech 2012 GLL 2008
Total well depth	Approximately 12.5 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	9.4 m bgs	
Well screen	2.6 m long well screen from approximately 9.4 m to 12 m bgs; slot size is unknown.	
Static water level	Unknown	
Sanitary seal	Likely no bentonite surface seal. In addition, no records of well upgrades indicated a subsequent installation of a bentonite seal	
Wellhead completion	Wellhead is located within Pumphouse 2 which is heated and locked. Wellhouse is equipped with 12 in. thick cement block poured around the well casing to provide some protection form surface sources of contamination. Well 2 is located 4.5 m from Well 1	
Wellhead stickup	0.57 m ags	
Well rated capacity	Unknown; however, it was reported that there have been no historical problem with well yield.	
Well GUDI status	Likely GUDI based on the short travel time (GLL 2006, GLL 2008)	
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

**Tetra Tech understands this well will be decommissioned in 2017 and replaced with Well 4 or Well 5.

Table 5-64: Town of Faro, Well 3 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Midnight Sun Drilling Co. Ltd. in May 1980	Well log
Total well depth	11.9 m bgs	
Casing	12.75" (324 mm) OD Steel Well Casing	
Casing depth	7.3 m bgs	
Well screen	4.6 m 100 slot (2.54 mm) stainless steel well screen from approximately 7.3 m to 11.9 m bgs	
Static water level	2.9 m bgs (May 1980)	
Sanitary seal	Likely no bentonite surface seal. In addition, no records of well upgrades indicated a subsequent installation of a bentonite seal	Tetra Tech 2012 GLL 2008
Wellhead completion	Wellhead is located within Pumphouse 1 which is heated and locked. Wellhouse is equipped with 12 in. thick cement block poured around the well casing to provide some protection form surface sources of contamination.	
Wellhead stickup	0.62 m ags	
Well rated capacity	Unknown; however, it was reported that there have been no historical problem with well yield.	
Well GUDI status	Likely GUDI based on the short travel time (GLL 2006, GLL 2008)	
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-65:Town of Faro, Well 4 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	The well was completed in July 2016 by Midnight Sun Drilling Inc. under direction by Morison Hershfield	MH 2016
Total well depth	Approximately 9.3 m bgs	
Casing	12" (305 mm) ID Steel Well Casing	
Casing depth	6.4 m bgs	
Well screen	2.9 m Variperm 100 slot (2.5 mm) well screen from approximately 6.4 m bgs to 9.3 m bgs	
Static water level	2.75 m bgs (July 15, 2017)	
Sanitary seal	Bentonite surface seal to 4.9 m bgs	
Wellhead completion	Not yet completed, will most likely be finished with a pitless unit when the well is connected.	
Wellhead stickup	1.2 m ags	
Well rated capacity	34.4 L/s (546 US gpm)	
Well GUDI status	Potentially GUDI based on the shallow well completion and proximity to Vangorda Creek	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines with the exception of the total well depth.	

Table 5-66:Town of Faro, Well 5 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	The well was completed in July 2016 by Midnight Sun Drilling Inc. under direction by Morison Hershfield	MH 2016
Total well depth	Approximately 10.2 m bgs	
Casing	12" (305 mm) ID Steel Well Casing	
Casing depth	7.8 m bgs	
Well screen	2.4 m Variperm 100 slot (2.5 mm) well screen from approximately 7.8 m bgs to 10.2 m bgs	
Static water level	4.14 m bgs (July 17, 2017)	
Sanitary seal	Bentonite surface seal to 4.9 m bgs	
Wellhead completion	Not yet completed, will most likely be finished with a pitless unit when the well is connected.	
Wellhead stickup	1.2 m ags	
Well rated capacity	28.6 L/s (453 US gpm)	
Well GUDI status	Potentially GUDI based on the shallow well completion and proximity to Vangorda Creek	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines with the exception of the total well depth.	

5.26.4 Source Water Quality

In general, the raw water from the three public water supply wells meets Health Canada's Guidelines for Canadian Drinking Water Quality (GCDWQ) with the exception of the maximum allowable concentration (MAC) for total dissolved solids (Tetra Tech 2012, J. Gibson Env. Consulting 2017). Key observations and comments on water quality are:

- The water from the Faro groundwater wells can be classified as calcium-sulphate type and has a pH of approximately 7.5 to 7.7;
- Total dissolved solids concentrations were nearing the GCDWQ for majority of the results reported over the period of record, and on one occasion (March 2010) the concentration was found to exceed the GCDWQ MAC; and
- The groundwater source is very hard ranging from 266 mg/L to 630 mg/L on the dates sampled.

Groundwater samples were collected from Well 4 and Well 5 during pumping testing in 2016. Based on the results from these samples, Tetra Tech makes the following observations:

- Water quality from the wells met all GCDWQ health based and aesthetic objectives for the parameters tested;
- The water from the two new wells is very similar, can be classified as calcium-bicarbonate type and the measured pH ranged from 7.67 to 8.03;
- The groundwater is very hard with measured hardness of 275 to 300 mg/L on the dates sampled.

5.26.5 Water Treatment and Distribution

Table 5-67: Town of Faro Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Town of Faro	Tetra Tech 2012
Water source	Groundwater	Tetra Tech 2012
Wells serving the system	Wells 1, 2 and 3	Tetra Tech 2012, Confirmed by operator and YG CS
Treatment type	UV and chlorine disinfection	p.c. Trevor Peircey 2017 p.c. Mike O'Connor 2017
Population served	Approximately 348	Yukon Bureau of Statistics 2016
Delivery method	Piped	
Age of system/last known update	New water treatment plant completed in 2014. New Pumphouse #3 in 2014. New water wells completed in 2016 to be commissioned in 2017.	p.c. Trevor Peircey 2017 J.Gibson Env. Consulting 2017

5.26.6 Source Water Protection Planning

Tetra Tech understands that new water wells are planned for 2017, and Tetra Tech understands the Town of Faro plans to complete source water protection planning once these wells are in place (p.c. Trevor Peircey 2017). As the current wells will soon be replaced, source water protection planning for the existing wells would not be warranted. As the system is classed as a LPDWS and provides water to the community of Faro, a SWPP which includes the new wells would provide a valuable tool for identifying, monitoring and managing risks to the wells and aquifer.

5.26.7 Water Supply Information Data Gaps

Tetra Tech was not able to obtain all known reports and data for the purposes of this summary. For the purpose of this project, the following data gaps were identified:

- There are no well logs available for Well 1 or Well 2 so well completion details and aquifer characteristics in these locations are unknown;
- No Source Water Protection Planning is in place, and ,as new wells have been completed to serve the system, a SWPP should be considered to increase the protection of this shallow groundwater resource
- Tetra Tech understands upgrades to the water system will be completed in 2017 including the decommissioning of Well 1 and 2, commissioning of Well 4 and Well 5, a new above ground pressure reducing valve (PRV) chamber, new water reservoir, new pumphouse and upgrades to the SCADA system.

5.27 Haines Junction - Water Supply System

The Village of Haines Junction (VHJ) was established as a community in the 1940s and today is home to approximately 613 people (Yukon Bureau of Statistics 2016). The VHJ system supplies domestic water to the residents and to commercial and government buildings in the community. VHJ is served by a water supply system with two deep groundwater wells (Wells No.3 and No. 5) completed in confined artesian aquifers. One additional well, known as Well No.4, is not currently in use, and, Tetra Tech understands it will be decommissioned in summer 2017. The VHJ water supply system is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007).

5.27.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the parties regarding the VHJ Water Supply System:

- Village of Haines Junction – Confirmed that the most up to date information had been captured in the 2012 LPDWSA and subsequent work such as the 2017 AWPP which Tetra Tech was involved in and therefore additional data was not needed and gave approval for use of Tetra Tech data for the project.
- YG Community Services (the client) – YG CS provided data and approval for Tetra Tech to use information from reports where YG CS provided project management and funding.

  YG Environmental Health – YG EHS provided review and general comments for the summary.

5.27.2 Hydrogeology

Haines Junction is located in the Dezadeash Valley, east of the Auriol Range. Based on regional geology maps and soil stratigraphy reported on well logs from past drilling investigations, Haines Junction is underlain primarily by glaciolacustrine silt and clay deposits and occasional sand lenses. Groundwater recharge is thought to occur at higher elevations in the Auriol Range.

Both Wells No.3 and No.5 are completed in deep, confined sand and gravel aquifers at different depths and are artesian under static conditions. The VHJ aquifers are used for both community and domestic water supplies. In 2012, Tetra Tech completed an analysis of the vulnerability of the aquifers serving the two wells based on the semi-quantitative ISI (Ontario Ministry of Environment, 2001). The ISI score for the deep artesian aquifer at Well No.3 was calculated to be 381 and the score for the deep artesian aquifer at Well No.5 was found to be 1316 (EBA 2012b). The high ISI scores suggest that the aquifers underlying the two well sites have very low to extremely low vulnerability to surface-based contamination.

The nearest surface waterbody to the VHJ wells is the Dezadeash River which is approximately 40 m from Well No.3. In 2014, Tetra Tech completed GUDI screening for Well No.3, which found that the well is very unlikely to be GUDI (Tetra Tech 2014).

5.27.3 Summary of Wells

Logs for the two VHJ public wells currently serving the community are included in the GIS map produced for this study. The following tables summarize the completion characteristics of the VHJ Wells 3 and 5.

Table 5-68: Village of Haines Junction, Well No.3 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Midnight Sun Drilling Co. Ltd. in May 1980.	Well Log
Total well depth	82.3 m bgs	
Casing	8" (203 mm) ID Steel Well Casing	
Casing depth	79.3 m bgs	
Well screen	3 m 50 slot (1.27 mm) stainless steel well screen from 79.3 m bgs to 82.3 m bgs.	Well Log, Tetra Tech 2012b
Static water level	Artesian (~3.6 m ags)	Tetra Tech 2014, Tetra Tech 2017
Sanitary seal	None	
Wellhead completion	Pitless unit	Tetra Tech 2013
Wellhead stickup	1.5 m ags	
Well rated capacity	8.4 L/s (111 IGPM)	Tetra Tech 2012b
Well GUDI status	Non-GUDI	Tetra Tech 2014
Well Construction Comments:	The well is constructed without a sanitary seal; however, Tetra Tech concluded that natural silts and clays have formed an adequate seal around the well casing (Tetra Tech 2014). The well has a pressure vent valve to allow for flow during artesian conditions positioned 330 mm ags.	

Table 5-69: Village of Haines Junction, Well No.5 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Midnight Sun Drilling Co. Ltd. in September 2002 under the supervision of Gartner Lee Limited	GLL 2002, Tetra Tech 2012a
Total well depth	369.2 m bgs	
Casing	366 mm steel surface casing to 15 m bgs, 244 mm steel casing to 303 m bgs, and 7” (178 mm) steel liner from 144 m bgs to 361.9 m bgs. 99 mm (3.9”) bridging casing from 139.08 m bgs to 145.30 m bgs.	
Casing depth	361.9 m bgs	

Table 5-69: Village of Haines Junction, Well No.5 Summary		
Well Construction Parameters	**Details**	**Source**
Well screen	7.3 m 60 slot (1.52 mm) stainless steel well screen from 361.9 m bgs to 369.2 m bgs.	GLL 2002 Tetra Tech 2012a
Static water level	Artesian, 76.4 psi shut in pressure after 15 minutes (August 2011)	
Sanitary seal	Portland cement seal to 154 m bgs	
Wellhead completion	Welded casing cap and sealed piping.	Tetra Tech 2012b
Wellhead stickup	0.95 m ags	
Well rated capacity	25.8 L/s (340 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Guidelines.	

5.27.4 Source Water Quality

As part of the AWHPP process in 2016, Tetra Tech reviewed water quality results for the VHJ wells from 2004 to 2016. The following summary is based on the water quality review from that report. Samples collected from the wells have been analyzed for general chemical and physical parameters as well as total metals as required for yearly reporting under the Yukon Public Health and Safety Act. In addition to the water chemistry results, Tetra Tech reviewed bacteriological sampling results as part of the Large Public Drinking Water Systems review in 2012, and the results of this review are included herein.

- The water supplied from Wells 3 and 5 comes from aquifers at different depths. Water from Well No.3 was classified as calcium-bicarbonate type and soft, with hardness measured between 41 mg/L and 47 mg/L (as CaCO3). Water from Well No.5 was sodium-bicarbonate type and soft with hardness measurements from 9 mg/L to 33.4 mg/L (as CaCO3). Health Canada's GCDWQ defines water with hardness from 0 mg/L to 60 mg/L to be soft;
- Over the period of April 4, 2005 to April 19, 2011 there were three positive Total Coliform results from raw water samples and no positive *E. coli* results reported. Raw water samples were taken from Well No.3 and Well No.5 as well as a mixed water line at Pump House 1, and positive total coliform results included one sample at Well No.5 and two samples from the mixed water line (0.7% of all tests). Positive Total Coliform results were observed in August and April 2005 and October 2008;
- Arsenic in raw water has been consistently elevated at both Well No.3 and Well No.5 above the Guidelines for Canadian Drinking Water Quality (GCDWQ) maximum acceptable concentration (MAC) of 0.01 mg/L;
- In 2009, the cadmium concentration in a raw water sample taken from Well No.5 was more than 20 times higher than the GCDWQ MAC of 0.005 mg/L. Results prior and subsequent to 2009 were below the GCDWQ MAC; and,
- In 2006, the copper concentration in a sample taken from Well No.5 exceeded the GCDWQ AO of 1 mg/L. Subsequent samples taken from this well had copper concentrations below the GCDWQ AO value.

5.27.5 Water Treatment and Distribution

Table 5-70: Village of Haines Junction Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Village of Haines Junction	YES 2012
Water source	Groundwater	
Wells serving the system	Well No.3 and Well No.5	Tetra Tech 2012b, Tetra Tech 2017
Treatment type	Chlorine injection, pH adjustment (CO_2 injection), oxide arsenic filtration	p.c. Dave Hatherley 2016
Number of connections	Approximately 613 people	Yukon Bureau of Statistics 2016
Delivery method	Piped	YES 2012
Age of system/last known update	Installation of new pump and drop pipe in Well No.3 in 2013. AWPP in 2016.	Tetra Tech 2013 Tetra Tech 2017

5.27.6 Source Water Protection Planning

VHJ has an AWHPP completed in February 2017. The VHJ AWHPP was developed following the guidelines provided in the BC Ministry of Environment Well Protection Toolkit with the addition of risk-based consideration of potential threats to the security of the water source.

To calculate the well capture zones, Tetra Tech conservatively assumed the gradient of the groundwater flow is similar to topography from surrounding mountain range to the wellhead location for both wells, resulting in an inferred groundwater gradient of 0.05 m/m, which is within the general range of typical groundwater gradients. Based on this assumption, and the aquifer characteristics, Tetra Tech calculated the distance to the edge of the horizontal well capture zone for 90 days, one year, five years and ten years using the analytical method as presented in the BC Well Toolkit. Both wells are protected by significant thicknesses of fine grained overburden materials, and, to evaluate the potential for surficial sources of contamination to migrate to the depth of the aquifers targeted by Well No.3 and Well No.5 through the overlying fine-grained sediments, Tetra Tech made a very conservative estimate of vertical travel time at each well. Based on the results of these calculations, Tetra Tech broke down the well capture zones for the two wells into reasonable well protection areas as shown in the GIS map.

Key conclusions and recommendations From the VHJ AWHPP are summarized below:

- Well No.3 and Well No.5 are completed in highly protected, artesian aquifers with likely recharge zones in the Auriol Range within Kluane National Park. The chance of anthropogenically sourced contaminants to enter either aquifer is considered extremely low.
- The risks presented to the source water quality in VHJ are related to potential contaminant sources in the vicinity of Well No.3. These risks have been identified as:
  - Ground squirrels living under the Well No.3 well house cement slab (Medium Risk);
  - Potential former waste oil dump site approximately 200 m north of Well No.3 (Medium Risk); and
  - Potential military waste burial in the area surrounding Well No.3 (Medium Risk).

- Risks from each of the identified APECs can be mitigated through eliminating rodent access under the Well No.3 slab and through assessment and assessment and remediation (if required) of the potential waste oil dump site and military waste.
- The nearest surface waterbody to the VHJ water supply wells is the Dezadeash River which is not thought to be hydraulically connected to either well (Tetra Tech 2012b, Tetra Tech 2014).
- The VHJ water supply system is supported by two wells resulting in some redundancy in the system and preventing total loss of water supply should one well fail or be temporarily shut off for maintenance or repair.
- Tetra Tech recommended decommissioning Well No.4 and completing upgrades to Well No.3, testing for hydrocarbons in the water and completing a Phase II Environmental Site Assessment in the vicinity of Well No.3. Government of Yukon is currently in the planning process to complete these works in summer 2017.
- Tetra Tech recommended long term risk management measures including forming a risk management team, conducting public education program, implementing an emergency response plan for the water supply system, implementing tracking and monitoring programs in the vicinity of the wellheads, review and update AWHPP on a regular basis and ensure AWHPP recommendations are considered in community planning.

5.27.7 Water Supply Information Data Gaps

Tetra Tech has not identified any data gaps with respect to the VHJ water supply system. Tetra Tech understands Village of Haines Junction and Government of Yukon are currently in the planning stages to complete the work recommended in the AWHPP with several of the recommendations to be addressed in summer 2017.

5.28 Marsh Lake - Army Beach Water Supply System

Army Beach is located at km 1379 on the Alaska Highway on the shores of Marsh Lake. Government of Yukon Department of Community Services owns and operates the small public self-serve system. This system obtains surface water from a directionally drilled high density polyethylene (HDPE) intake structure that extends about 600 m southeast into Marsh Lake. The system is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems.

5.28.1 Data Compilation Methodology

Tetra Tech approached stakeholders including YG departments, water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech obtained data regarding the Army Beach Water Supply system from the following proponents:

- YG Community Services (the client) – YG CS provided data for the Army Beach Water Supply as this system is owned and operated by YG CS. The YG CS operator provided review comments and edits for the final summary to ensure completeness and accuracy.

5.28.2 Hydrology

Marsh Lake is one of the Southern Lakes, which are the long and narrow glacier fed lakes that form the headwaters of the Yukon River. Marsh Lake is drained by the Yukon River to the North, and although it is a lake, water here flows slowly northward. The Southern Lake Watershed upstream of Marsh Lake includes Atlin, Teslin, Tagish, Tutshi, Bennett and Nares Lakes to the south. Several small sediment laden rivers and creeks also flow into Marsh Lake near Army Beach.

The lake level fluctuates up to 3.5 m annually and the level is partially controlled by Yukon Energy Corporation's Lewes River control structure.

The Army Beach public drinking water system obtains water from a surface water source, thus, is inherently vulnerable to potential contamination including anthropogenic sources, viruses and naturally occurring bacteria ubiquitous in surface water sources.

5.28.3 Intake Details

The following tables summarize the intake details of the system.

Table 5-71:Marsh Lake/Army Beach Water Intake

Construction Parameters	Details	Source
Date of construction	2009 (directional drilling), Pumping systems in 2010.	Tetra Tech 2010
Intake	600 m long x 200 mm diameter high density polyethylene (HDPE), directionally drilled, with screened intake installed on welded baseplate with concrete anchor blocks. Screen is approximately 2.6 m above bottom or lake, approximately 4 m below low water level. (Dayton and Knight Phase 1 Drawings, 2009)	
Pump	Submersible 5 HP 208 V, 3 phase Series 12 Model No. WSOPT12-6 SurePump installed June 2010 by Norcope.	

5.28.4 Source Water Quality

The system was brought on line in June of 2010, the following are the key observations and comments noted on the water quality:

- The raw water sample collected from the Marsh Lake intake in November 2010 met GCDWQ for the parameters analyzed (Tetra Tech 2010); and,
- The turbidity of treated water (0.04 NTU) at the water treatment plant was within the GCDWQ requirement of 0.1 NTU (Tetra Tech 2010).

Tetra Tech did not review recent water quality data but understands water chemistry analysis is completed at this system annually and bacteriological monitoring is completed on a regular basis with results sent to YG EHS for review.

5.28.5 Water Treatment and Distribution

The Army Beach water treatment system was completed in 2010 and is equipped with a membrane filtration and chlorination system (YES 2012).

Table 5-72: Marsh Lake/Army Beach Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon Department of Community Services	YES 2012 p.c. Steve Perrin 2017
Water source	Surface Water (Marsh Lake)	
Treatment type	Filtration (0.02 micron) and chlorination	
Number of connections	~150 residents	
Delivery method	Self-serve fill station including blue jug fill, 2” pickup trick fill and 4” overhead fill for bulk water	
Age of system/last known update	The system was completed in 2010	

5.28.6 Source Water Protection Planning

There is no SWPP in place for the Army Beach public drinking water system. Given that this water system provides potable water for public consumption, a SWPP would provide a valuable tool for identifying, monitoring and managing risks to the water supply. However, as the water supply is comprised of the entirety of the Yukon Southern Lakes, a comprehensive SWPP covering this surface water resource might be the best and most complete approach.

5.28.7 Water Supply Information Data Gaps

Tetra Tech has reviewed available data from the 2012 LPDWSA and the summary has been reviewed by YG CS water system operators. To our knowledge this summary is complete and accurate to March 2017. The following data gaps have been identified:

- There is no source water protection planning in place for this water system. As source water protection planning for this surface water system would involve the entire Southern Lakes watershed and headwaters of the Yukon River, an integrated approach to water resource management with multiple proponents and stakeholders would likely be required to create a SWPP here.

5.29 Marsh Lake - Firehall Water Supply System

The Marsh Lake Firehall is currently serviced by a water supply system that delivers water from a 28 m deep well. The water from the well flows from a holding tank by gravity to an overhead truck fill for water delivery to local residents and also feeds into a pressurized domestic system servicing the Firehall (Tetra Tech 2006). There is also an exterior public water station where local residents retrieve water. In addition, water is fed to two water-holding tanks used to fill the fire truck (Tetra Tech 2006). Tetra Tech understands that a new water treatment system is in the planning stages to be installed in 2017. The Marsh Lake Firehall water supply system is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide water for human consumption.

5.29.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following water system owners, operators and proponents regarding the water systems operated and/or managed by YG PMD:

- YG Property Management Division – YG PMD has been consulted and has provided review comments and data for the compilation.
- YG Community Services – YG CS (the client) has been consulted and provided review comments for the data compilation.

5.29.2 Hydrogeology

The groundwater flow direction in the vicinity of the Marsh Lake Firehall is inferred to be southwesterly towards Marsh Lake (Tetra Tech 2006). The driller's log indicates that well-graded granular sediments were the predominant materials encountered during the drilling of the Firehall well, and the well appears to have been terminated within a reasonably productive overburden aquifer. The well log indicates that the well is likely to be completed within an unconfined sand and gravel aquifer. Due to the absence of finer-grained sediments overlying the aquifer, the vulnerability of the aquifer to surficial contamination is considered to be high.

5.29.3 Well Summary

The log for Well 1334 is included in the GIS map and database portion of this report. The following table summarizes the completion characteristics of the well.

Table 5-73: Marsh Lake Firehall, Well 1334 Summary

Well Construction Parameters	Details	Source
Date of construction	The well was constructed by Fredalena Enterprises in June 1992	Well log
Total well depth	28.0 m bgs	
Casing	6" (152 mm) OD Steel Well Casing	
Casing depth	26.8 m bgs	

Table 5-73: Marsh Lake Firehall, Well 1334 Summary		
Well Construction Parameters	**Details**	**Source**
Well screen	1.2 m 25 slot (0.64 mm) well screen from 26.8 m bgs to 28.0 m bgs	
Static water level	Approximately 19.5 m bgs (June 1992)	
Sanitary seal	No record of sanitary seal installation	Well log and Tetra Tech 2006
Wellhead completion	The wellhead is located approximately 1.7 m below grade inside a 1.2 m diameter steel culvert with a wooden box enclosure at surface. The well is equipped with heat trace for freeze protection	Tetra Tech 2006
Wellhead stickup	1.8 m bgs (measured on May 9, 2005)	
Well rated capacity	3.2 L/s (42 IGPM) (estimated by the driller)	Well log
Well GUDI status	Potentially GUDI	Based on well construction
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.29.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The key observations and comments noted during Tetra Tech's 2005/2006 chemical water quality review and groundwater sampling on the well are summarized as follows (Tetra Tech 2006):

- The water quality results indicated that the water from the well was a calcium-bicarbonate type water with a pH of approximately 8.22 on the date sampled;
- The water was considered very hard, with a hardness of 163 mg/L on the date sampled;
- The water quality results indicated that the water from the well meets the GCDWQ for all the parameters analyzed;
- The reported concentrations of THM and HAA were below the laboratory detection limits; and
- Review of chloride, nitrate and nitrite showed all three to be low and within the normal background ranges, suggesting that the aquifer was not under the influence of anthropogenic surface sources of nutrients or anions such as septic wastes at the time of sampling.

5.29.5 Water Treatment and Distribution

Table 5-74: Marsh Lake Firehall Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	
Water source	Groundwater	Tetra Tech 2006
Number of wells serving the system	Marsh Lake Firehall well (Well 1334)	
Treatment type	Chlorination	
Water Users	Firefighting and domestic water fill point	
Delivery method	Piped (to the building)	
Age of system/last known update	A new water treatment plant is planned for 2017	

5.29.6 Source Water Protection Planning

There is no source water protection planning in place for the Marsh Lake Firehall water system. The vulnerability of the aquifer in which this well is completed is considered to be high, and a SWPP would provide a valuable tool for identifying, monitoring and managing risks to the wells and aquifer. Source water protection planning here could be incorporated with planning for the Marsh Lake Community Centre and private water supplies where applicable to create a comprehensive Marsh Lake Community SWPP.

Tetra Tech was not able to find and records indicating that a GUDI assessment has been completed for the system.

During the 2005 SPDWSA, Tetra Tech identified an above ground fuel storage tank located approximately 27 m from the well (Tetra Tech 2006). In addition, there had been a spill reported on November 22, 1987 (Tetra Tech 2006). The spill has been recorded in the EC Spill Report Information Database as Spill # 8717. There had reportedly been a transport truck that had lost control and crashed approximately 500 m south of the Lakeview Marina turnoff on the Alaska Highway. Due to frozen condition and lack of surface drainage area, environmental damage was reportedly minimal (Tetra Tech 2006). Since the reported spill location is at least 1 km away from Marsh Lake Firehall, this spill was not considered to be a potential concern to the water quality at the Firehall (Tetra Tech 2006).

5.29.7 Water Supply Information Data Gaps

This summary has been reviewed by YG PMD and Tetra Tech is awaiting review comments from YG CS, Tetra Tech identified the following data gaps:

- Tetra Tech recommended that a GUDI assessment be completed for the system, the well be retrofitted with a sanitary surface seal and that a water softening system be installed should manganese staining prove problematic;
- There is no source water protection planning in place to protect this groundwater resource. As the aquifer is unconfined and considered vulnerable to surface sources of contamination, the implementation of a SWPP would be valuable to reduce the risk of contamination of the aquifer. A SWPP developed here could be incorporated with the Marsh Lake Community Centre well SWPP to create an integrated plan.

5.30 Marsh Lake - Community Centre Water Supply System

Government of Yukon owns and operates the Marsh Lake Community Centre public drinking water system at Marsh Lake, Yukon. The water supply at the Marsh Lake Community Centre is sourced from a moderately deep drilled well that supplies water to the facility (Tetra Tech 2006). The system serves potable water to the users of the community centre and is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide water for human consumption.

5.30.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.30.2 Hydrogeology

The groundwater flow direction in the vicinity of the Marsh Lake Community Centre is likely westerly towards Marsh Lake; however, there is inadequate hydrogeological information to confirm the estimate at this time (Tetra Tech 2006). Predominantly well-graded granular sediments were encountered during the well drilling, and the Marsh Lake Community Centre well appears to have been terminated within a reasonably productive unconfined overburden aquifer (Tetra Tech 2006). The well log reports a low permeability till layer from 3 m to 5 m below grade. This till unit, if continuous across the site would offer some protection to the aquifer by hindering the vertical migration of potential surface contaminants (Tetra Tech 2006).

5.30.3 Well Summary

The well log for the well serving the Marsh Lake Community Centre water system is included in the GIS map and database portion of this project. The following table summarizes the completion characteristics of the well.

Table 5-75: Marsh Lake Community Centre Well Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Hollow Point Exploration in June 2006	Well log
Total well depth	33.1 m bgs	
Casing	6.6" (168 mm) ID Steel Well Casing	
Casing depth	30.8 m bgs	
Well screen	2.3 m 30 slot (0.76 mm) stainless steel well screen from 30.8 m to 33.1 m bgs	
Static water level	12.2 m bgs (May 2006); 7.1 m bgs (July 18, 2006)	Well log and Tetra Tech 2006
Sanitary seal	No record that a bentonite sanitary seal has been installed	Tetra Tech 2006

Table 5-75: Marsh Lake Community Centre Well Summary		
Well Construction Parameters	**Details**	**Source**
Wellhead completion	The wellhead is equipped with a pitless unit and also heat trace for freeze protection. The wellhead is located in an insulated wooden enclosure.	
Wellhead stickup	Approximately 0.55 m ags	
Well rated capacity	Approximately 1.9 L/s (25 IGPM) (estimated by the driller)	Well log
Well GUDI status	Potentially GUDI	Tetra Tech 2013
Well Construction Comments:	Based on the lack of a surface seal, the well was not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.30.4 Source Water Quality

In 2006, 2007 and 2012, Tetra Tech sampled the raw water from the Marsh Lake Community Centre water system. In addition to the results of the groundwater samples collected by Tetra Tech, Tetra Tech also reviewed the water quality results of the samples collected between November 2007 and October 2011 as part of the field review of the system in 2013 (Tetra Tech 2013). Following summarizes Tetra Tech's observations and comments on the groundwater quality of the Marsh Lake Community Centre well (Tetra Tech 2006 and 2013):

- The water quality indicated that the raw groundwater source was calcium-bicarbonate type with a pH of 7.8 to 8.2 and was classified as very hard water with a measured hardness of 346 mg/L to 371 mg/L as CaCO3;
- Four raw samples were collected between July 2006 and October 2012 and the total manganese concentrations of the raw water samples collected between this period ranged between 0.053 mg/L and 0.161 mg/L and all exceeded the GCDWQG AO of 0.05 mg/L;
- The water quality results of the raw samples indicated that all other health-based and aesthetic objectives were met for the parameters analyzed when sampled in 2006, 2007; however, the total iron concentration (1.93 mg/L) from the raw water sample collected on October 16, 2012 exceeded the CDWQG AO of 0.3 mg/L;
- No septic indicator parameters were found to be elevated above inferred background levels, indicating that the well water supply was not likely being impacted by anthropogenic sources of contamination on the dates sampled;
- Laboratory analytical results for the treated sample collected from the kitchen sink on October 16, 2012 indicated that the filtration system was effective in reducing iron and manganese concentrations associated with suspended solids. The total iron and manganese concentrations in the treated sample were 0.033 mg/L and <0.001 mg/L, respectively; and
- The treated water sample had a hardness of 2 mg/L when sampled in October 2012.

5.30.5 Water Treatment and Distribution

Table 5-76: Marsh Lake Community Centre Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	
Water source	Groundwater	
Treatment type	Filtration (20 micron and 5 micron stages) and water softener (Model ECR 3500R30, rated for 11 gallons per minute). UV System. A RO system was installed on one of the kitchen sinks for drinking water use	Tetra Tech 2013
Number of connections	Typically 5 to 30 people, but can be up to 150 people during part of the day when meals are served, and up to 300 people for full day events	
Delivery method	Piped directly from the well to the Community Centre building	
Age of system/last known update	Tetra Tech recommended upgrades to the water treatment system including installation of a UV disinfection system with a redundant unit, installation of a second filter system, replacement of the filtration with 10 micron and 1 micron absolute cartridge	

5.30.6 Source Water Protection Planning

No SWPP has been completed for the Marsh Lake Community Centre public drinking water system. Although the near-surface low permeability till layer encountered at the Community Centre well will provide some protection to the aquifer, and the well is considered to be non-GUDI, several potential contaminant sources were observed to be located within 30 m of the wellhead during the 2005 SPDWSA work (Tetra Tech 2006). Given the water is used for consumption by the users of the community centre, implementation of a source water protection plan is still considered important to ensure safe drinking water. Source water protection planning here could be incorporated with planning for the Marsh Lake Firehall and private water supplies where applicable to create a comprehensive Marsh Lake Community SWPP.

5.30.7 Water Supply Information Data Gaps

Tetra Tech has obtained review comments from YG PMD regarding the current status of this system and to our knowledge this summary is complete and accurate to March 2017. The following data gaps have been identified:

- There is no source water protection planning in place for this water supply system.

5.31 Mayo - Village of Mayo Water Supply System

The Village of Mayo (VoM) is located at the confluence of the Mayo and Stewart Rivers and is accessed via the Silver Trail (Highway 11). Mayo has a population of approximately 200 residents (Yukon Bureau of Statistics 2016). The Village of Mayo community water supply is, under normal circumstances, owned and managed by the Village of Mayo, but is currently under partial management of YG-CS while upgrades are completed on the system. Water is delivered by a combination of piped and trucked distribution. Upgrades including the isolation of the former CWW1 from the water supply system, addition of CWW1a, and CWW2 to the water supply system, additional water treatment and upgrade of the chlorination system, were completed in 2015. Further upgrades that are planned include decommissioning of CWW1 and commissioning of CWW4.

The Mayo community water supply system is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007) and is also regulated under the Yukon Drinking Water Regulations - Guidelines for Part II - Bulk Delivery of Drinking Water (YG 2007).

5.31.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators, owners and regulators to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following parties regarding the Mayo Water Supply System:

- Village of Mayo – Provided EHS water quality reports, reviewed the data summary and provided review comments.
- YG Community Services (the client) – YG CS provided data for water treatment, well completion details and Source Water Protection Plan.
- YG Environmental Health – YG EHS provided data and review comments for the Mayo Water Treatment system.

5.31.2 Hydrogeology

Mayo is located on a low alluvial plain consisting of fluvial sand and gravel over glaciolacustrine silt and clay till. Bedrock mapped in the area includes argillaceous sandstone, bedded shale, fine to course grained quartz-rich sandstone and quartz-pebble conglomerate.

VoM cold water wells CWW1a, CWW2, CWW3 and CWW4, which supply potable water to the VoM community water supply system, are completed at depths of 7.5 to 8.8 m bgs. The old community water supply well, CWW1 is a dug well that was completed at 7.6 m bgs in a shallow aquifer consisting of alluvial sands and gravels. CWW1 was taken out of service as it is not currently in compliance with current best practice well construction guidelines. The four current water supply wells are completed in the same area as CWW1 and are completed at similar depths in the same aquifer.

From the well logs of the four current village water supply wells, the shallow VoM aquifer consists of primarily sand and gravel and extends to 8.5 m bgs in all four well locations. There is some evidence of fine grained soils overlying CWW2; however the lack of a confirmed confining layer in the three other well logs confirms that the aquifer is unconfined. Lacustrine fine-grained silt, unsuitable for targeting as a water supply underlie the VoM Aquifer and extend from approximately 8.5 m bgs to 165 m bgs. The natural groundwater flow direction in the vicinity of the VoM

wellfield is inferred to be south-southwest towards the Stewart River (EBA 2000). The shallow unconfined aquifer is hydraulically connected to the Mayo and Stewart River.

A deep, confined aquifer is also present beneath the Village of Mayo. The two warm water wells used for tempering the temperature of the community water supply are completed in a confined artesian aquifer overlain by 165 m of lacustrine fine grained silt (EBA 2000). The water from the deep warm water wells is of poor quality and would require treatment if to be considered for potable use. The recharge source for this deep confined aquifer is not known.

5.31.3 Summary of Wells

There are five cold water supply wells and two warm water supply wells connected to the VoM community water supply system. Currently CWW1a, CWW2, CWW3 and CWW4 are in use. CWW1 is not in service, but pipework is still in place connecting it directly to the water reservoir, bypassing the water treatment plant. The two warm water wells produce non-potable water which is used in a heat exchange system with the cold water wells to prevent freezing. CWW1A and CWW4 both have variable frequency drive (VFD) control which allows automatic modulation the water output based on water drawdown, allowing wells to be pumped as efficiently as possible in recognition of demands. CWW2 and CWW3 pump at their maximum outputs until the water level draws down to a level sensor, at which time the pump is shut off.

The four active wells are grouped to deliver water to the VoM water system as follows:

- Group 1: CWW1A and CWW2;
- Group 2: CWW3;
- Group 3: CWW1A and CWW4; and,
- Group 4: CWW2 and CWW4 (This group is never used)

Review of SCADA data (logged water elevations and pumping rates) indicates that since March 2016, Group 1 and Group 2 are typically used and duty is generally cycled between these two groups. VoM consider that if CWW3 was to go out of service, the remaining three wells would be insufficient to meet the VoM water demand (Scott Hamilton pers. Com); and further engineering investigations are currently being completed to provide recommendations to address this.

Logs for the six VoM community water system well are included in the GIS mapping portion of this project. The following tables summarize the completion characteristics of the VoM wells.

Table 5-77:VoM CWW1a Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Midnight Sun Drilling Inc. in July 2013	Summit Environmental 2013
Total well depth	8.69 m bgs	
Casing	12" (305 mm) ID Steel Well Casing	
Casing depth	5.79 m bgs	

Table 5-77:VoM CWW1a Summary

Well Construction Parameters	Details	Source
Well screen	2.9 m of 100 slot (2.54 mm) telescopic Variperm well screen exposed from 5.79 m bgs to 8.69 m bgs	
Static water level	2.64 m bgs (July 6, 2013)	
Sanitary seal	Bentonite surface seal to 4.57 m bgs	
Wellhead completion[1]	Pitless unit with vented, watertight well cap. The wellhead is located within the fenced WTP enclosure and also within a heated, lockable wellhouse. The well cap has provision to be locked using padlocks.	Tetra Tech 2017
Wellhead stickup	0.73 m ags (at well completion)	Summit Environmental 2013
Well rated capacity	13 L/s (172 IGPM)	
Well GUDI status	Not assessed (Likely GUDI based on the status of the other wells in the field)	
Well Construction Comments:	The well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-78: VoM CWW2 Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Impact Drilling Ltd. in October 2010	Tetra Tech 2010
Total well depth	7.85 m bgs	
Casing	10" (254 mm) ID Steel Well Casing	
Casing depth	6.33 m bgs	
Well screen	0.61 m 40 slot (1.02 mm) stainless steel well screen from 6.33 m bgs to 6.94 m bgs 0.91 m 80 slot (2.03 mm) stainless steel well screen from 6.94 m bgs to 7.85 m bgs	
Static water level	2.75 m bgs (October 19, 2010)	
Sanitary seal	Bentonite surface seal to 5.5 m bgs	

Table 5-78: VoM CWW2 Summary

Well Construction Parameters	Details	Source
Wellhead completion	Pitless unit with vented, watertight well cap. The wellhead is located within the fenced WTP enclosure and also within a heated, lockable wellhouse. The well cap has provision to be locked using padlocks.	Tetra Tech 2017
Wellhead stickup	Unknown	
Well rated capacity	5.1 L/s (67 IGPM)	Tetra Tech 2010
Well GUDI status	Likely GUDI	Tetra Tech 2010 (based on results of AECOM 2010 GUDI study)
Well Construction Comments:	The well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-79: VoM CWW3 Summary

Well Construction Parameters	Details	Source
Date of construction	Ensign Coring and Drilling September 2011	AECOM 2011
Total well depth*	7.43 m bgs	
Casing	15" (381 mm) ID Steel Well Casing	
Casing depth*	5.91 m bgs	
Well screen	1.52 m of 100 slot (2.54 mm) telescopic Variperm well screen exposed from 5.91 m bgs to 7.43 m bgs	
Static water level	2.38 m bgs (September 2011)	
Sanitary seal	Bentonite grout surface seal to 3.0 m bgs	
Wellhead completion	Pitless unit with vented, watertight well cap. The wellhead is located within the fenced WTP enclosure and also within a heated, lockable wellhouse. The well cap has provision to be locked using padlocks.	Tetra Tech 2017
Wellhead stickup	0.7 m (approx.)	Summit 2013a (from photograph)

Table 5-79: VoM CWW3 Summary

Well Construction Parameters	Details	Source
Well rated capacity	18.2 L/s (240 IGPM)	AECOM 2011
Well GUDI status	GUDI	
Well Construction Comments:	The well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.*Note that these depths appear different on the log. The well completion details were taken from the AECOM summary table including in the well completion report (AECOM 2011).	

Table 5-80: VoM CWW4 Summary

Well Construction Parameters	Details	Source
Date of construction	Ensign Coring and Drilling September 2011	AECOM 2011
Total well depth*	8.83 m bgs	
Casing	15" (381 mm) ID Steel Well Casing	
Casing depth*	7.31 m bgs	
Well screen	1.52 m of 100 slot (2.54 mm) telescopic Variperm well screen exposed from 7.31 m bgs to 8.83 m bgs	
Static water level	3.03 m bgs (September 2011)	
Sanitary seal*	Bentonite grout surface seal to 3.0 m bgs	
Wellhead completion	Pitless unit with vented, watertight well cap. The wellhead is located within the fenced WTP enclosure and also within a heated, lockable wellhouse. The well cap has provision to be locked using padlocks.	Tetra Tech 2017
Wellhead stickup	Unknown	
Well rated capacity	6.2 L/s (82 IGPM)	
Well GUDI status	GUDI	
Well Construction Comments:	The well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.*Note that these depths appear different on the log. The well completion details were taken from the AECOM summary table including in the well completion report (AECOM 2011).	

Table 5-80: VoM CWW4 Summary		
Well Construction Parameters	Details	Source

Table 5-81: VoM WWW1 Summary (no longer in use)

Well Construction Parameters	Details	Source
Date of construction	The well was completed in 1975 with upgrades in 1986	Tetra Tech 2010
Total well depth	255 m bgs	
Casing	10" (254 mm) ID Steel Well Casing	
Casing depth	~252 m bgs	
Well screen	3 m total of well screen from 252 m bgs to 255 m bgs ▪ 4 slot (0.10 mm) stainless steel well screen ▪ 20-slot (0.51 mm) stainless steel well screen	
Static water level	~20 psi artesian pressure (July 21, 2009)	
Sanitary seal	Unknown	
Wellhead completion	Sealed well cap to account for artesian pressure, wellhead located well shack	Tetra Tech 2010
Wellhead stickup	Unknown	
Well rated capacity	56.7 L/s (760 IGPM)	Tetra Tech 2010
Well GUDI status	Not assessed	
Well Construction Comments:	It is not known if the well is completed with a sanitary surface seal, thus the well may not be completed in accordance with the Canadian Groundwater Association Well Construction Guidelines.	

Table 5-82: : VoM WWW2 Summary		
Well Construction Parameters	Details	Source
Date of construction	The well was completed by Impact Drilling Ltd. in October 2010	Tetra Tech 2010
Total well depth	250.6 m bgs	
Casing	12" (305 mm) ID Steel Well Casing	
Casing depth	245.5 m bgs	
Well screen	5.1 m of 40-slot (0.51 mm) stainless steel well screen from 245.5 m bgs to 250.55 m bgs	
Static water level	~24 psi artesian pressure (July 21, 2009)	
Sanitary seal	Bentonite surface seal to 5.5 m bgs	
Wellhead completion	Sealed well cap to account for artesian pressure, wellhead located well shack	Tetra Tech 2010
Wellhead stickup	Unknown	
Well rated capacity	16.4 L/s (216 IGPM)	Tetra Tech 2010
Well GUDI status	Not assessed	
Well Construction Comments:	It is not known if the well is completed with a sanitary surface seal, thus the well may not be completed in accordance with the Canadian Groundwater Association Well Construction Guidelines.	

5.31.4 Source Water Quality

Water quality results were collected from all four wells as part of the well completion process, and water from all wells was found to meet the Guidelines for Canadian Drinking Water Quality (GCDWQ) for health based MACs and aesthetic objectives for the parameters tested on the dates sampled. All four water supply wells are considered to all be completed within the same aquifer, which is generally reflected in water quality results.

- The water from the four wells is calcium-bicarbonate type;
- The laboratory measured pH from the four wells ranges from 7.17 to 7.81; and,
- The water from all four wells is considered medium with a measured hardness of approximately 102 to 114 mg/L (as CaCO3).

5.31.5 Water Treatment and Distribution

Table 5-83:Village of Mayo Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Village of Mayo	p.c. V. Sarrazin (Associated Eng.) June 2016
Water source	Groundwater under the influence of surface water	
Wells serving the system	CWW1a, CWW2, CWW3, CWW4	
Treatment type	Cartridge filtration (5 micron and 1 micron), UV disinfection and chlorination	
Population served	~200	Yukon Bureau of Statistics 2016
Delivery method	Piped and trucked	p.c. V. Sarrazin (Associated Eng.) June 2016
Age of system/last known update	System upgrades ongoing. Most recent upgrades completed in 2015	p.c. V. Sarrazin (Associated Eng.) June 2016

5.31.6 Source Water Protection Planning

The Village of Mayo is located within the traditional territory of the Na-Cho Nyak Dun First Nation, and the townsite of Mayo was established in 1903 as a river community and a service centre for mining activities in the area. The all-weather road linking Mayo to Whitehorse was completed in 1950. Today the Silver Trail (Highway 11) begins in Stewart Crossing on the Klondike Highway, passes through Mayo and leads to the Elsa mining camp and the small community of Keno. Today industrial activity in Mayo is still primarily related to transportation and services for mining projects and other activities in the area with other services in place to serve Mayo residents and tourism in the area.

Source Water Protection Planning for the Village of Mayo community water supply wells in the form of a Well Head Protection Plan (WHPP) was completed in 2013 (Summit 2013a and 2013b). The WHPP is included in the GIS map and database portion of this project.

Summit completed the WHPP in consultation with VoM. The WHPP is based on the 2010 British Columbia Comprehensive Source-to-Tap Assessment Guideline (BC-CSTTA). Summit identified the well capture zones using a combination of the Calculated Fixed Radius method and the Hydrogeological Mapping method outlined in the BC-CSTTA. The mapped capture zones, shown in the GIS map, are bounded by the Mayo and Stewart rivers as they were found to have enough volume relative to predicted pumping rates to create flow boundaries.

Potential sources of contamination identified during the WHPP process included petroleum storage, special waste permits, historical petroleum spills and potentially degraded septic system components. Summit assessed the risk associated with the potential contaminant sources, and recommended that VoM develop the following:

- A risk management plan with specific recommendations addressing water monitoring, fuel storage, wellhead protection, community education, underground infrastructure, and herbicide and pesticide use;

- A raw water monitoring program that details the frequency of sampling events and the parameters to be tested with the frequency of sampling events based on the severity of risk each contaminant source was assigned; and,
- An organizational framework and additional emergency actions to be included in the VoM Emergency Response Plan in the event of an emergency involving contamination of the drinking water aquifer.

The wellhead stickup completion details are not included in the current WHPP, these details are pertinent in regards to potential for flooding, traffic or other surface hazards to create impacts to the wells. These details should be recorded during the next update to the WHPP.

5.31.7 Water Supply Information Data Gaps

Tetra Tech was able to consult with all identified stakeholders regarding this system and obtained review comments from the system operator. This summary is completed to our knowledge to March 2017. In the course of this data compilation, we have identified the following data gaps:

- The new water well CWW1a should be incorporated into the Source Water Protection Plan upon completion of the water system upgrades.
- Wellhead stickup height at all four water supply wells should be confirmed.

5.32 Mayo - NNDFN Water Supply System

The Na-cho Nyak Dun First Nation (NNDFN) owns and operates the potable water and the open loop Ground Source Heat Pump (GSHP) systems that service the NNDFN Government House and NNDFN's bulk water supply facility, located in Mayo, Yukon. The system is classified as a Large Public Drinking Water Supply System under the Yukon Public Drinking Water Regulation. The system was commissioned in 2013 (MH 2016) and is regulated under the Public Health Act, General Regulations Sections 18 and 19 (YG Public Health Act, 1958/079), which requires safety measures and inspection for water and water sources for systems that provided for human consumption.

The potable water system is supplied with groundwater from two deep supply wells, Extraction Well 1A (NNDFN-SW2) and Extraction Well 1B (NNDFN-SW1R). Extraction Well 1B (NNDFN-SW1R) is a replacement well to the decommissioned supply well NND-SW1, which was damaged during pump installation (Tetra Tech 2013). NNDFN-SW1 was decommissioned in September 2012 in accordance with Y-DWR requirements as detailed in CGWA Guidelines for Water Well Construction (Tetra Tech 2013). The groundwater is treated for hardness (including iron and manganese removal) and is chlorinated prior to delivery and consumption (MH 2016).

The supply wells also provide a source of groundwater to the NNDFN's GSHP system (MH 2016). Once the groundwater passes through the GSHP system, the water is re-injected into the aquifer using a single injection well, NNDFN-IW1.

According to the water license for the NNDFN potable water and the GSHP systems, NNDFN can extract a maximum of 10.4 L/s (137 IGPM) from the two supply wells, and 92% of this water can be used for heating / geoexchange with the remaining 8% used for municipal consumption (Tetra Tech 2006).

The two supply wells and the injection well were cleaned and rehabilitated in September 2015 (MH 2016).

For the purpose of this project, well completion details and the chemical water quality data for the injection well (NNDFN-IW1) for the GSHP system will not be discussed further.

5.32.1 Data Compilation Methodology

Tetra Tech approached stakeholders including the water system owner/operator and regulatory bodies to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following parties regarding the NNDFN water supply system:

- Nacho Nyak Dun First Nation - Provided well rehabilitation report, confirmed the well configuration and use, and gave approval for use of Tetra Tech data for the project and reviewed the water system summary.

5.32.2 Hydrogeology

The "NNDFN Aquifer" is a well-protected, confined, deep aquifer. Results of the hydraulic testing conducted on the NNDFN wells indicate that there is a high degree of hydraulic connectivity between the wells and the transmissivity, storativity, and conductivity results for all the hydraulic testing were similar (Tetra Tech 2011). The aquifer has high transmissibility and is characterized as a highly conductive, confined sand and gravel aquifer (Tetra Tech 2011). Confined conditions typically present a higher degree of drawdown for similar aquifer materials (Driscoll, 1986). Confined aquifers as well as aquifers with high transmissivity typically have a very large radius of influence though the drawdown in surrounding wells is typically quite shallow (Driscoll, 1986). However, rapid hydraulic pressure response between the NNDFN wells does not mean the actual water flow or heat transfer would be unacceptably rapid between the wells (Tetra Tech 2011).

Results of the pumping tests on the NNDFN wells indicate that a hydraulic conductivity of about 2.3×10^{-4} m/s for the “NNDFN Aquifer” and a calculated transmissivity of about 1.3×10-2 m2/s and storativity of about 3.3×10^{-4}), respectively (Tetra Tech 2011). The calculated hydraulic conductivity is typical for conductive sand and gravel deposits and the calculated transmissivity and storativity are typical for a confined sand and gravel aquifer (Driscoll, 1986).

5.32.3 Summary of Wells

Well logs for the two water supply wells currently serving the NNDFN potable system are included in the GIS map and database portion of this project. The following tables summarize the completion characteristics of these two wells.

Table 5-84: NNDFN Mayo, Extraction Well 1 (NNDFN-SW2) Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Impact Well Drilling in September 2010	Well log
Total well depth	104.8 m bgs	
Casing	8" (203 mm) OD Steel Well Casing	
Casing depth	99.4 m bgs	
Well screen	1.6 m 40 slot (1.02 mm) stainless steel well screen from 100 m bgs to 101.6 m bgs and 3.2 m 80 slot (2.03 mm) stainless steel well screen from 101.6 m bgs to 104.8 m bgs. The total well screen length is 4.8 m.	
Static water level	42.6 m bgs (October 6, 2010)	
Sanitary seal	Bentonite surface seal to 5.8 m bgs	
Wellhead completion	Locking well cap	Tetra Tech 2011
Wellhead stickup	0.63 m ags (September 2010)	
Well rated capacity	6.3 L/s (83 IGPM)	
Well GUDI status	Not assessed	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-85: NNDFN Mayo, Extraction Well 2 (NNDFN-SW1R) Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Cathway Water Resources, in August 2012	Well log

Table 5-85: NNDFN Mayo, Extraction Well 2 (NNDFN-SW1R) Summary		
Well Construction Parameters	**Details**	**Source**
Total well depth	95.9 m bgs	
Casing	8" (203 mm) ID Stainless Steel Well Casing	
Casing depth	92.9 m bgs	
Well screen	3 m 80 slot (2mm) stainless steel well screen from 92.9 m to 95.9 m bgs	
Static water level	42.8 m bgs (August 30, 2012)	Tetra Tech 2013
Sanitary seal	Bentonite surface seal to 4.6 m bgs	
Wellhead completion	Pitless unit	
Wellhead stickup	0.74 m ags	
Well rated capacity	9.5 L/s (125 IGPM)	
Well GUDI status	Not assessed	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.32.4 Source Water Quality

Historical chemical water quality data available for review includes groundwater samples collected from the supply wells, including the decommissioned well NNDFN-SW1, between October 17, 2005 and September 1, 2012. Some of the samples were submitted to ALS Environmental and some were submitted to WSEI for laboratory analysis (Tetra Tech 2013). The results are summarized as follows:

- The groundwater chemistry observed in all three supply wells are similar;
- The water quality from all the wells was very hard, containing calcium-bicarbonate with significant amounts of magnesium (35.8 mg/L to 57.6 mg/L) and sulphate (86 mg/L to 97.4 mg/L);
- The pH in the water from the supply wells ranged from 6.95 to 8.16 on the dates sampled;
- Groundwater quality of the water from the three supply wells meets the GCDWQ for all parameters analyzed with the exception of TDS, total arsenic, total iron and total manganese;
- The TDS concentration in the water from the wells ranged 380 mg/L to 426 mg/L. Water from the three supply wells had the TDS concentrations exceeding the GCDDWQ AO of 500 mg/L at least once over the testing period;
- The total arsenic concentrations in water from all three supply wells exceed the GCDWQ MAC of 0.01 mg/L on the dates sampled. The reported total arsenic concentration ranged from 0.0355 mg/L to 0.0465 mg/L;
- The total iron concentrations in water from all three supply wells exceed the GCDWQ AO of 0.3 mg/L on the dates sampled. The reported total iron concentration ranged from 0.88 mg/L to 1.47 mg/L; and,

- The total manganese concentrations in water from all three supply wells exceed the GCDWQ AO of 0.05 mg/L on the dates sampled. The reported total manganese concentration ranged from <0.1 mg/L to 0.259 mg/L.

5.32.5 Water Treatment and Distribution

Table 5-86: NNDFN Mayo Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Na-Cho Nyak Dun First Nation	Tetra Tech 2012
Water source	Groundwater	
Wells serving the system	Extraction Wells 1 and 2 (for the potable system)	
Treatment type	RO and electro dialysis (to remove hardness and TDS), iron and manganese removal, and chlorination	MH 2016
Water users	NNDFN employees and residents	Tetra Tech 2012
Delivery method	Bulk delivery to NND residents, piped connection to the Government House	Tetra Tech 2013, NovaTec 2007
Age of system/last known update	Replacement water well SW1R drilled in 2013	Tetra Tech 2013

5.32.6 Source Water Protection Planning

There is no SWPP or AWPP in place for the NNDFN water supply system. Although the vulnerability of the aquifer is low, a SWPP would provide a valuable tool for identifying, monitoring and managing risks to the wells and aquifer and for protecting the groundwater resources in the Mayo area.

5.32.7 Water Supply Information Data Gaps

Tetra Tech has been involved in the development of the potable water system and the GSHP system for the NNDFN, in Mayo, Yukon. For the purpose of this project, the following data gaps were identified:

- There is no record of source water protection planning or GUDI assessment completed for this groundwater resource. Source water protection planning completed for this system could be incorporated into a greater SWPP for groundwater resources in the Village of Mayo.

5.33 Mayo Air Terminal Building Water Supply System

The Mayo Airport Terminal Building (ATB) has water supplied from a 38 m deep well (Well 5653) located in a pit below grade. The system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.33.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.33.2 Hydrogeology

No well log was available for review for Well 5653. Examination of well logs in the Mayo area show that well completion depths and lithology in the area is highly variable (Tetra Tech 2006). Wells are completed at various depths, ranging from shallow dug wells to drilled wells greater than 150 m deep.

The Mayo area has been affected by one or more glaciations, sediments in the Village of Mayo area tend to consist of recent alluvium overlying fine-grained silts with varying interbedded sand and gravel (Tetra Tech 2006). Sediment deposits are generally underlain by metamorphic bedrock, which is exposed in much of the upland areas. Widespread discontinuous permafrost is known to exist in the Mayo area and has been noted in several of the well logs examined (Tetra Tech 2006).

Based on topography and proximity to surface water sources, the groundwater flow direction is inferred to be in the range of south to west towards the Mayo and/or Stewart River. Given the depth of the well and based on the surficial geology of the area, it is likely that the well is completed in a confined aquifer and may have thick sequences of fine-grained soils overlying the aquifer (Tetra Tech 2006).

5.33.3 Well Summary

Tetra Tech was not able to obtain a well log for Well 5653. The following table summarizes the completion details for the well.

Table 5-87:Mayo ATB, Well 5653 Summary

Well Construction Parameters	Details	Source
Date of construction	1968	Tetra Tech 2006 p.c. Nick Barnett 2017
Total well depth	38 m bgs (reported)	
Casing	6” (152 mm) OD Steel Well Casing	
Casing depth	Unknown (> 10 m)	
Well screen	Unknown	
Static water level	Approximately 9 m bgs (measured on August 17, 2005)	

Table 5-87:Mayo ATB, Well 5653 Summary		
Well Construction Parameters	**Details**	**Source**
Sanitary seal	No records of sanitary seal installation. It was noted that a steel plate is welded over the annulus between the 8" (200 mm) surface casing and the 6" (152 mm) steel casing, but there was no mention if a grout seal was installed between the two casings.	
Wellhead completion	The wellhead is located in a pit that is approximately 3 m away from the ATB	
Wellhead stickup	1.2 m bgs (measured on August 17, 2005)	
Well rated capacity	Unknown	
Well GUDI status	Potentially GUDI	Based on well construction
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.33.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The key observations and comments noted by Tetra Tech during the 2005/2006 chemical water quality review are summarized as follows (Tetra Tech 2006):

- The water hardness was measured at 349 mg/L (as $CaCO_3$) and the water was considered very hard;
- The turbidity on the dates sampled, ranged from 23.5 NTU to 65.4 NTU. Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration was expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU;
- The water quality results indicated that the water from the well meets the GCDWQ for all the parameters analyzed with the exceptions of turbidity, colour, arsenic, iron and manganese:
  - The colour of the September 2004 sample was greater than 60 CU which exceeds the GCDWQ AO of 15 CU; however, the colour of the August 17, 2005 sample (<5.0 CU) meets the GCDWQ AO;
  - The reported total arsenic concentrations on the dates sampled ranged from 0.0575 mg/L to 0.0756 mg/L and exceed the GCDWQ MAC of 0.01 mg/L. The reported dissolved arsenic concentration was slightly lower, at 0.02 mg/L, but still exceeds the GCDWQ MAC;
  - The reported total iron concentrations on the dates sampled ranged from 2.62 mg/L to 3.77 mg/L and exceed the GCDWQ AO of 0.3 mg/L. The reported dissolved iron concentration was less than the laboratory

detection limit of 0.030 mg/L which was much less than the GCDWQ and also the reported total iron concentrations, indicating that elevated iron was most likely related to elevated turbidity;

- The reported total manganese concentrations on the dates sampled ranged from 0.272 mg/L to 0.289 mg/L and exceed the GCDWQ AO of 0.05 mg/L. The reported dissolved manganese concentration (0.273 mg/L) was similar to the total manganese concentrations and also exceeds GCDWQ; and

- Review of chloride, nitrate and nitrite showed all three to be low and within the normal background ranges, suggesting that the aquifer was not under the influence of anthropogenic surface sources of nutrients or anions such as septic wastes at the time of sampling.

5.33.5 Water Treatment and Distribution

Table 5-88: Mayo ATB Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Number of wells serving the system	Mayo ATB well (Well 5653)	
Treatment type	Filtration (5 micron)	
Water users	Airport workers, flight crews and passengers	
Delivery method	Piped connection to the Mayo ATB building	
Age of system/last known update	Unknown	

5.33.6 Source Water Protection Planning

There is no source water protection planning in place for the Mayo ATB Well 5653 and Tetra Tech was not able to find any record of a GUDI assessment for this well. Given the unknown aquifer characteristics, source water protection planning for this groundwater source may provide a valuable tool for identifying, monitoring and managing risks to the well and aquifer

During the 2005 SPDWSA, Tetra Tech identified an AST located approximately 18 m from the well. In addition, there is a cemetery located 63 m south of the well, which does not meet the required setback distance (120 m) for potential contaminant sources in the vicinity of a water supply well (Tetra Tech 2006).

It was reported by EC that four spills occurred between the 1970s and 1991 at the White Pass and Yukon Route tank farm which is approximately 200 m south of the site, and two spills occurred at the North 60 Petroleum Tank Farm in 1997 and 1997 (Tetra Tech 2006). The well serving the Mayo ATB is approximately 200 m from the spill site locations in a direction inferred to up-gradient. It is considered very unlikely that these reported spills or other activities at the bulk fuel sites would impact the deep groundwater in the vicinity of the Mayo ATB well due to both the well depth and the fact that the well is likely up-gradient of these spill sites (Tetra Tech 2006).

5.33.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- Several upgrades on the water system including installation of a disinfection system, were recommended by Tetra Tech in 2006; however, it is our understanding that no updates have been completed to the system since 2006;
- There is no record of source water protection planning or GUDI assessment completed for this groundwater resource.

5.34 Mayo - Wildlife Workshop Water Supply System

The Mayo Wildlife Workshop has water supplied from a drilled well (Well 5653) located in a pit below grade approximately 4 m east of the building (Tetra Tech 2006). The system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.34.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.34.2 Hydrogeology

No well log was available for review for this well. Examination of well logs in the Mayo area show that well completion depths and lithology in the area is highly variable (Tetra Tech 2006). Wells are completed at various depths, ranging from shallow dug wells to drilled wells greater than 150 m deep. The Mayo area has been affected by one or more glaciations, sediments in the Village of Mayo area tend to consist of recent alluvium overlying fine-grained silts with varying interbedded sand and gravel (Tetra Tech 2006). Sediment deposits are generally underlain by metamorphic bedrock, which is exposed in much of the upland areas. Widespread discontinuous permafrost is known to exist in the Mayo area and has been noted in several of the well logs examined.

Shallow groundwater flow generally occurs in the overlying alluvial deposits in the Village of Mayo area. Based on topography and proximity to surface water sources, the groundwater flow direction is inferred to be in the range of south to west towards the Mayo and/or Stewart River.

5.34.3 Well Summary

The well log for the well is not available for review. In addition, the construction of the wellhead enclosure made the wellhead inaccessible to measurements for depth during the 2005 SPDWSA and no information pertaining to the completion of the well is available.

Table 5-89: Mayo Wildlife Workshop, Well 5650 Summary

Well Construction Parameters	Details	Source
Date of construction	1981	Tetra Tech 2006 p.c. Nick Barnett 2017
Total well depth	Unknown	
Casing	6” (152 mm) OD Steel Well Casing	
Casing depth	Unknown	
Well screen	Unknown	
Static water level	Unknown	
Sanitary seal	No records of sanitary seal installation.	

Table 5-89: Mayo Wildlife Workshop, Well 5650 Summary		
Well Construction Parameters	**Details**	**Source**
Wellhead completion	The wellhead is located in a pit that is approximately 4 m away from the building	
Wellhead stickup	Approximately 1.0 m bgs (measured on August 17, 2005)	
Well rated capacity	Unknown	
Well GUDI status	Potentially GUDI	Based on well construction
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.34.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The key observations and comments noted by Tetra Tech during the 2005/2006 chemical water quality review and groundwater sampling on the well are summarized as follows (Tetra Tech 2006):

- The groundwater source from the well was likely a calcium-magnesium-bicarbonate-sulphate-chloride type water;
- The water hardness (as CaCO3), which ranged from 273 mg/L to 280 mg/L on the dates sampled, was considered very hard;
- The turbidity on the dates sampled, was high and ranged from 92.7 NTU to 96.1 NTU. Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration was expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU;
- The water quality results indicated that the water from the well meets the GCDWQ for all the parameters analyzed with the exceptions of turbidity, colour, arsenic, barium, iron and manganese:
  - The colour of the September 2004 sample was greater than 60 CU which exceeds the GCDWQ AO of 15 CU; however, the colour of the subsequent sample collected on June 8, 2005 (<5.0 CU) meets the GCDWQ AO;
  - The reported total arsenic concentrations on the dates sampled, which ranged from 0.00828 mg/L to 0.0142 mg/L, either are marginally below or exceed the GCDWQ MAC of 0.01 mg/L. The reported dissolved arsenic concentration, at 0.00177 mg/L, was much less than the GCDWQ and the total arsenic concentrations;
  - The reported total barium concentrations on the dates sampled ranged from 1.38 mg/L to 1.53 mg/L and exceed the GCDWQ MAC of 1 mg/L. The reported dissolved barium concentration, at 1.31 mg/L, which was similar to the total barium concentrations, also exceeds the GCDWQ MAC;

  - The reported total iron concentrations on the dates sampled ranged from 4.3 mg/L to 6.53 mg/L and exceed the GCDWQ AO of 0.3 mg/L. The reported dissolved iron concentration was less than the laboratory detection limit of 0.030 mg/L which is much less than the GCDWQ and also the reported total iron concentrations, indicating that elevated iron was most likely related to elevated turbidity;
  - The reported total manganese concentrations on the dates sampled ranged from 0.626 mg/L to 0.683 mg/L and exceed the GCDWQ AO of 0.05 mg/L. The reported dissolved manganese concentration, at 0.657 mg/L, was similar to the total manganese concentrations and also exceeds GCDWQ; and
  - Chloride concentrations in water samples collected from this system were slightly higher than expected background concentrations for the Mayo area. It should be noted that the water from the Mayo Grader Station well, which was inferred to be up-gradient of the site, also had higher chloride concentration in the shallow aquifer. Bulk salt storage on the Grader Station site may be the cause of the higher chloride observed in the shallow aquifer in the area; and

- Concentrations of nitrate and nitrite are low and within the normal background ranges for groundwater in the Mayo area. Although impact by septic discharge cannot be definitely ruled out, it does not appear that septic wastes were impacting on water quality in this well at the time of sampling.

5.34.5 Water Treatment and Distribution

Table 5-90: Mayo Wildlife Workshop Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Number of wells serving the system	Mayo Wildlife Workshop well (Well 5650)	
Treatment type	Filtration	
Water Users	YG employees	
Delivery method	Piped to the workshop building	
Age of system/last known update	Unknown	

5.34.6 Source Water Protection Planning

There is no source water protection planning in place for the Mayo Wildlife Workshop Well 5650 and Tetra Tech was not able to find any record of a GUDI assessment for this well. Given the unknown aquifer characteristics, source water protection planning for this groundwater source may provide a valuable tool for identifying, monitoring and managing risks to the well and aquifer.

During the 2005 SPDWSA, Tetra Tech identified a number of potential contaminant sources located within 30 m of the wellhead (Tetra Tech 2006):

- A septic tank located at 16 m; the septic field was between 16 m and 28 m from the field;
- An AST located at 7 m; and
- Vehicle parking located at 2m.

It was reported by EC that four spills occurred between the 1970s and 1991 at the White Pass and Yukon Route tank farm which was approximately 200 m south of the site, and two spills occurred at the North 60 Petroleum Tank Farm in 1997 and 1997.

5.34.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- Several upgrades on the water system including installation of a disinfection system, were recommended by Tetra Tech in 2006; however, it is our understanding that no updates have been completed to the system since 2006; and
- There is no record of source water protection planning or GUDI assessment completed for this groundwater resource.

5.35 Mendenhall Water Supply System

Mendenhall is located about 50 km west of Whitehorse, Yukon along the Alaska Highway. Mendenhall Subdivision has a self-serve water system with water sourced from a 67 m deep bedrock well (TW1-2013). Treatment for the self-serve system includes uranium removal and chlorination. This small public system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which provide measures for inspection and oversight by an officer of medical health for systems that provide water for human consumption.

5.35.1 Data Compilation Methodology

Tetra Tech approached stakeholders including YG departments, water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech obtained data regarding the Mendenhall Water Supply system from the following proponents:

- YG Community Services (the client) – YG CS provided data for the Mendenhall Water Supply as this system is owned and operated by YG CS. The YG CS operator provided review comments and edits for the final summary to ensure completeness and accuracy.

5.35.2 Hydrogeology

The lithology of the Mendenhall area generally consists of sand silt, gravel and cobbles overlying bedrock (Tetra Tech 2006). The depth to bedrock varies from 3 m bgs to 30 m bgs. All wells drilled past 30 m in depth in the Mendenhall area are completed in bedrock. There is insufficient information to establish a definite groundwater flow direction in the area; however, based on topography and proximity to surface waterbodies, it is inferred that the groundwater flow direction is likely south or east. The depth of the wells in this area, and the deep sequences of overburden deposits over the bedrock decrease the vulnerability of bedrock aquifer to surface sources of contamination (Tetra Tech 2006).

Previous studies indicate that uranium at concentrations above the GCDWQ MAC value of 20 µg/L are naturally occurring in groundwater in the Mendenhall area. However, there are some domestic wells in the area that have uranium concentrations below the GCDWQ MAC value (Tetra Tech 2006 and 2014).

Residents of Mendenhall and other users of the water fill station have been notified of the presence of uranium in the groundwater source (Tetra Tech 2006 and 2014).

5.35.3 Summary of Wells

The well log for Well TW1-2013, which serves the Mendenhall Subdivision drinking water system is included in the GIS map and database. The following table summarizes the completion characteristics of TW1-2013.

Table 5-91: Mendenhall Subdivision Public Drinking Water Supply, TW1-2013 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Midnight Sun Drilling Inc. in October 2013	MH 2013 p.c. Steve Perrin 2017
Total well depth	67.0 m bgs	

Table 5-91: Mendenhall Subdivision Public Drinking Water Supply, TW1-2013 Summary		
Well Construction Parameters	**Details**	**Source**
Casing	6" (152 mm) OD Steel Well Casing	
Casing depth	9.45 m bgs (approximately 0.7 m into bedrock)	
Well screen	Well is completed open hole in a bedrock aquifer.	
Static water level	19.3 m bgs (October 8, 2013)	
Sanitary seal	Sanitary seal extends to approximately 5.6 m bgs	
Wellhead completion	Pitless adaptor within chain-link fenced enclosure	
Wellhead stickup	0.79 m ags	
Well rated capacity (estimated by the driller)	0.75 L/s (10 IGPM)	
Well GUDI status	Not Assessed	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.35.4 Source Water Quality

MH collected a groundwater sample from TW1-2013 during the October 2013 constant-rate pumping test, just prior to pump shut down, and the following are the key observations and comments noted by MH (2013):

- The water quality results indicate that the samples collected meet all of the tested health and aesthetic related parameters of the GCDWQ with the exception of the total uranium concentration. The total uranium concentration from TW1-2013 was found to be higher (0.0742mg/L) than the MAC of 0.02 mg/L;
- The TDS concentration from TW1-2013 was lower (352 mg/L) than the aesthetic objective of ≤ 500 mg/L;
- Water from TW1-2013 was considered very hard, with a measured hardness of 272 mg/L as CaCO3. According to Health Canada, “hard water causes incrustation in distribution systems and excessive soap consumption. Public acceptability of the degree of hardness may vary considerably from community to community depending on local conditions. Therefore, a maximum acceptable level for hardness is not specified by Health Canada. Waters with hardness levels in excess of 200 mg/L are considered poor but have been tolerated by consumers;”
- A comparison of results between the total and dissolved metals indicate similar concentrations, suggesting that adequate development has occurred, particulate matter was not contributing to the total metal concentrations, and that the clarity/turbidity of the water was very good;
- Groundwater samples collected from TW1-2013 were analyzed and found to have gross alpha and gross beta detections of 1.13 Bq/L and 0.46 Bq/L respectively. Since the gross alpha threshold value of 0.5 Bq/L was exceeded, individual alpha emitters identified under the GCDWQ were then analyzed. There is only one

individual naturally occurring alpha admitter regulated under the GCDWQ (Radium 226) and it has a maximum allowable concentration of 0.5 Bq/L. The re-test of individual alpha emitters found the Radium 226 level to be 0.0047 +/- 0.0059 Bq/L, which was considerably less than the applicable MAC. In summary, the tested radiological parameters were found to meet the GCDWQ;

- Samples were also collected and submitted for a suite of common hydrocarbons. All tested parameters were well below the relevant GCDWQ, and furthermore these compounds were found to be less than their analytical detection limits, suggesting that impacts from hydrocarbons are currently not detectable in the aquifer; and
- The THM Formation Potential results from TW1-2013 indicate a concentration of 0.091 mg/L, which was marginally less than the drinking water quality guideline of 0.100 mg/L. This result suggests a low but modest potential for THM to be formed if a chlorinated treatment system is to be utilized. It was recommended by MH that further testing be conducted in conjunction with the other water treatment requirements (i.e., uranium removal) to ensure that potential THM health issues are addressed and that THM concentrations at the point of consumption do not exceed the GCDWQ (MH 2013).

Tetra Tech did not review recent water quality data but understands water chemistry analysis is completed at this system annually and bacteriological monitoring is completed on a regular basis with results sent to YG EHS for review.

5.35.5 Water Treatment and Distribution

Table 5-92: Mendenhall Subdivision Public Drinking Water Supply Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon, Community Services	Tetra Tech 2013
Water source	Groundwater	MH 2013
Number of wells serving the system	One (TW1-2013)	
Treatment type	Uranium removal and chlorination	Tetra Tech 2013 p.c. Steve Perrin 2017
Number of connections	Approximately 165 people	
Delivery method	Blue jug fill and 2” pickup truck fill point serving	
Age of system/last known major work	Water Treatment Plant was installed in 2015	

5.35.6 Source Water Protection Planning

There is no SWPP in place for the Mendenhall Subdivision Large Public Drinking Water System. Due to the significant thickness of overburden overlying the bedrock aquifer at the well location, the aquifer likely has low vulnerability to surface sources of contamination; however, as the system provides drinking water to residents in the area, Source Water Protection Planning may be merited to provide additional tools to protect the groundwater resource.

5.35.7 Water Supply Information Data Gaps

Based on communication with YG CS (Elise Bingeman) and on Tetra Tech’s involvement in the water treatment feasibility study in 2013, Tetra Tech considers that the water supply information presented here is complete and up to date, with the exceptions of the following data gaps:

- The GUDI status of the well has not been evaluated; and,
- There is no SWPP in place for this system.

5.36 Old Crow - Water Supply System

Old Crow, the northernmost community in Yukon, is home to the Vuntut Gwitchin First Nation (VGFN) and has a population of about 221 people (Yukon Bureau of Statistics 2016). The community is served by a public drinking water system operated by Government of Yukon, Community Services Department. Water is supplied from two deep sub-permafrost groundwater wells completed in bedrock. The water wells were constructed in the 1980s with upgrades completed in 2012 prior to the construction of a new water treatment plant in 2013. Following iron and manganese removal, and disinfection treatment, water is delivered by bulk truck delivery to consumers. The system is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007).

5.36.1 Data Compilation Methodology

Tetra Tech approached stakeholders including YG departments, water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech obtained data regarding the Old Crow Water Supply system from the following proponents:

- YG Community Services (the client) – YG CS provided data for the Old Crow Water Supply as this system is owned and operated by YG CS. The YG CS operator provided review comments and edits for the final summary to ensure completeness and accuracy.

5.36.2 Hydrogeology

Old Crow is located in a region of continuous permafrost. The Old Crow system is supported by two wells (WW 1 and WW 2) which allows for redundancy in the system to prevent loss of water supply should one well fail or be temporarily shut off for maintenance or repair. Both production wells are completed in a sub permafrost limestone bedrock aquifer. Permafrost in the Old Crow area was interpreted, during well drilling, to extend from near surface to approximately 63.5 m bgs.

Upon completion of drilling, the aquifer was found to be artesian and WW-1 flowed at approximately 6.1 L/s (80 IGPM) (Tetra Tech 1982). During inspection by Tetra Tech in March 2010, WW-1 was found to have about 5 psi of artesian pressure and to flow at about 2.2 L/s (29 IGPM) under artesian conditions. The artesian head at the well is similar to that observed when drilled, indicating that the aquifer is not being “mined” or depleted with time based on the current demand. The reduction in observed flow is attributed to the fact that the flow of 6.1 L/s (80 IGPM) was observed from top of casing, while when observed during the site visit in March 2010, the flow was from the overhead fill; thus, the water was overcoming a greater head which would result in reduced flow. The well adequately met the needs for water supply by trucked water delivery to the Old Crow community between 1982 and 2012.

Upon completion of WW-2 in 1982, artesian flows of approximately 2.3 L/s (30 IGPM) were observed. After completing well thawing on WW-2, Tetra Tech completed a pumping test in May 2012. Pumping test results clearly indicate a hydraulic connection between WW-1 and WW-2.

The Old Crow aquifer is considered to be highly confined, and both community wells are artesian. The nearest surface waterbody to the Old Crow wells is the Porcupine River, which, as the wells are highly artesian, cannot be hydraulically connected to the aquifer. Tetra Tech completed an analysis of the vulnerability of the Old Crow aquifer from the WW-1 well log in 2012 based on the semi-quantitative Intrinsic Susceptibility Index (ISI) (Ontario Ministry of Environment, 2001). The ISI value for the Old Crow aquifer was found to be 325, which suggests very low vulnerability to surface sources of contamination (Tetra Tech 2011a).

5.36.3 Summary of Wells

The Old Crow system is supported by two wells, WW-1 and WW 2 which creates redundancy in the system and prevents loss of water supply should one well fail or be temporarily shut off for maintenance or repair. Well logs for WW-1 and WW-2 are included in the associated GIS map and database.

Table 5-93: Old Crow Public Drinking Water Supply System, Well WW-1 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed in March 1982	Tetra Tech 1982
Total well depth	79 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	78 m bgs	
Well screen	No well screen present	
Static water level	approx. 8.0 m ags (March 2010)	Tetra Tech 2010
Sanitary seal	No sanitary seal is present	Tetra Tech 1982
Wellhead completion	Pitless Unit	Tetra Tech 2010
Wellhead stickup	1 m ags	
Well rated capacity	8.0 L/s (105.6 IGPM)	Tetra Tech 2010, 2011
Well GUDI status	Not assessed	
Well Construction Comments:	No sanitary seal is in place; however, artesian conditions with no flow around the wellhead during well shut in indicate a natural seal is present around the casing.	

Table 5-94: Old Crow Public Drinking Water Supply System, Well WW-2 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed in March 1982	Tetra Tech 1982
Total well depth	121.9 m bgs	
Casing	6" (155 mm) ID Steel Well Casing	
Casing depth	97 m bgs	
Well screen	Open borehole	
Static water level	Artesian	
Sanitary seal	No sanitary seal	
Wellhead completion	Split gasket cap	Tetra Tech 2012b
Wellhead stickup	1 m ags	
Well rated capacity	15.2 L/s (201 IGPM)	

Table 5-94: Old Crow Public Drinking Water Supply System, Well WW-2 Summary		
Well Construction Parameters	**Details**	**Source**
Well GUDI status	Not assessed	
Well Construction Comments:	No sanitary seal is in place, however artesian conditions with no flow around the wellhead during well shut in indicate a natural seal is present around the casing. Well is partially blocked by rock and well seal plate approximately 105.5 m bgs (Tetra Tech 2012)	

5.36.4 Source Water Quality

The water supplied from the two Old Crow wells has been shown to be sourced from the same artesian, confined aquifer. As part of the Old Crow LPDWSA in 2012, Tetra Tech completed a review of available water quality data. From this review of groundwater chemistry from WW-1, Tetra Tech made the following observations:

- The source water from the well is hard to very hard ranging from 167 mg/L to 214 mg/L (as CaCO3) on the dates sampled. According to Health Canada, “hard water causes incrustation in distribution systems and excessive soap consumption. Public acceptability of the degree of hardness may vary considerably from community to community depending on local conditions. Therefore, a maximum acceptable level for hardness is not specified by Health Canada. Waters with hardness levels in excess of 200 mg/L are considered poor but have been tolerated by consumers;”
- Manganese concentrations were above the GCDWQ AO for all sample results. Manganese concentrations were highest (0.589 mg/L) in July 2009; all other results fluctuated between 0.14 mg/L to 0.16 mg/L; and,
- The water from both wells can be classified as calcium-bicarbonate type water.

Tetra Tech did not review recent water quality data but understands water chemistry analysis is completed at this system annually and bacteriological monitoring is completed on a regular basis with results sent to YG EHS for review.

5.36.5 Water Treatment and Distribution

Table 5-95: Old Crow Public Drinking Water Supply System Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Yukon Government Community Services	Tetra Tech 2012
Water source	Groundwater	
Wells serving the system	WW-1 and WW-2	
Treatment type	Manganese-iron removal filtration, disinfection	Stantec 2013
Number of people served	221	Yukon Bureau of Statistics 2016
Delivery method	Trucked bulk delivery	YES 2012

Table 5-95: Old Crow Public Drinking Water Supply System Treatment and Distribution Details		
Item	**Details**	**Source**
Age of system/last known update	Well WW-2 was brought online in 2012. New water treatment plant was completed in 2013.	Tetra Tech 2012 Stantec 2013

5.36.6 Source Water Protection Planning

Tetra Tech was not able to find any record of a SWPP/AWPP or GUDI assessment for the Old Crow community water supply wells or aquifer. An aquifer vulnerability assessment was completed in 2011 and found that the aquifer is well protected from surface sources of contamination (Tetra Tech 2011a). Given this water source is the key water supply for the remote community, source water protection planning for this groundwater source may provide a valuable tool for identifying, monitoring and managing risks to the well and aquifer.

Potential sources of contamination in the vicinity of the wells that were identified include the following:

- Industrial activity, which in Old Crow is limited to community services including operation of a diesel generator and public services for septic and solid waste disposal.
- The nearest surface waterbody to the Old Crow wells is the Porcupine River, which as the wells are highly artesian, cannot be directly hydraulically connected to the aquifer.

5.36.7 Water Supply Information Data Gaps

Tetra Tech has contacted YG CS water system operator as well as the VGFN public services manager, and to our knowledge, the data compiled here is complete with the exceptions of the following data gaps:

- Tetra Tech notes that Source Water Protection Planning has not been completed for the Old Crow community water supply system.

5.37 Pelly Crossing – Selkirk First Nation Water Supply System

The Selkirk First Nation (SFN) owns and operates a public drinking water system in Pelly Crossing, Yukon. The SFN public water supply system sources water from two groundwater wells: Well 1 (called PW05-1 in previous reports) and Well 2 (called BW06-1 in previous reports), both of which are located in an undeveloped area in the Willow Creek Subdivision on the North side of the Pelly River in Pelly Crossing. The system is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007) and is also regulated under the Yukon Drinking Water Regulations - Guidelines for Part II - Bulk Delivery of Drinking Water (YG 2007).

5.37.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. For the SFN system, the following proponents were contacted to request information:

- Selkirk First Nation – Confirmed that the most up to date information had been captured in the 2012 LPDWSA, and gave approval for use of Tetra Tech data for the project.
- YG Community Services (the client) – YG CS provided data for several systems that they have been involved with the construction of when the other proponents contacted were not able to find the documents.
- YG Environmental Health – YG EHS was contacted and assisted with the provision of data for systems where a full dataset was not available from other sources.

5.37.2 Hydrogeology

Well 1 and Well 2 are both completed in the same unconfined gravel aquifer (Tetra Tech 2007). Depth to groundwater is approximately 15 m bgs to 18 m bgs. The groundwater flow direction is reported to be southwesterly (Vista Tek 2008).

The vulnerability of the aquifer encountered by Well 1 and Well 2 was assessed using the semi quantitative Intrinsic Susceptibility Index (ISI) method suggested by the Ontario Ministry of Environment. The ISI method defines aquifers with an ISI score of less than 30 as having high intrinsic susceptibility to surface sources of contamination. The ISI method calculated for Well 1 and Well 2 resulted in a value of 22 to 23, which indicates that the aquifer underlying the site has a high vulnerability to potential surface sources of contamination (Tetra Tech 2012).

5.37.3 Summary of Wells

Well logs for the two SFN public wells serving the system are included in the GIS map and database portion of this project. The following tables summarize the completion characteristics of the SFN wells.

Table 5-96: SFN Public Drinking Water System, Well 1 (PW05-1) Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Double D Drilling in July 2005	Well log
Total well depth	28.9 m bgs	
Casing	8" (203 mm) ID Steel Well Casing	
Casing depth	25.9 m bgs	
Well screen	3 m x 200 slot (5 mm) stainless steel well screen from 25.9 m to 28.9 m bgs	Tetra Tech 2012
Static water level	6.45 m bgs (May 26, 2009)	Well log
Sanitary seal	Bentonite surface seal to 6 m bgs	
Wellhead completion	Pitless adaptor and enclosed within a fence. Freeze protection consists of an insulated cover and heat trace extending into the well	Tetra Tech 2012
Wellhead stickup	0.85 m ags	
Well rated capacity	4.9 L/s (65 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-97: SFN Public Drinking Water System, Well 2 (BW06-1) Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Double D Drilling in September/October 2006	Well Log
Total well depth	32.0 m bgs	
Casing	8" (203 mm) ID Steel Well Casing	
Casing depth	29.0 m bgs	
Well screen	3 m 150 slot (3.8 mm) stainless steel well screen from 29.0 m bgs to 32.0 m bgs	
Static water level	6.45 m bgs (May 26, 2009)	
Sanitary seal	Bentonite surface seal to 6 m bgs	
Wellhead completion	Pitless adaptor and enclosed within a fence. Freeze protection consists of an	Tetra Tech 2012

Table 5-97: SFN Public Drinking Water System, Well 2 (BW06-1) Summary		
Well Construction Parameters	**Details**	**Source**
	insulated cover and heat trace extending into the well	
Wellhead stickup	0.8 m ags	
Well rated capacity	4.1 L/s (54 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.37.4 Source Water Quality

Records provided to Tetra Tech for review during the 2012 LPDWSA indicate that Well 1 was sampled for water chemistry twice in 2009 and Well 2 was sampled twice in 2009 and once in 2010. The key observations and comments noted during Tetra Tech's 2012 review on the water quality are summarized as follows:

- The water from the SFN wells meets GCDWQ with the exception of the aesthetic objectives for total iron and total manganese;
- There have been no exceedances of GCDWQ maximum acceptable concentrations for parameters listed in Y DWR Schedule B; and
- A "spike" in both iron and manganese concentrations was observed on November 2, 2009 in Well 2 but have since returned to acceptable concentrations This could have been a result of analytical error, elevated turbidity (from biol. sloughing), etc.

5.37.5 Water Treatment and Distribution

Table 5-98: SFN Public Drinking Water System Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Selkirk First Nation	Tetra Tech 2012
Water source	Groundwater	
Wells serving the system	Well 1 and Well 2	
Treatment type	Filtration (10 and 1 micron steps) and chlorination	YES 2012
Number of connections	Population of approximately 200 (100 service connections, 48 delivery sites)	
Delivery method	Piped distribution and bulk water delivery	
Age of system/last known update	Water Treatment system completed in 2009	Tetra Tech 2012

5.37.6 Source Water Protection Planning

A Well Head Protection Plan (WHPP) was completed by Vista Tek in March 2008 and presents the following:

- Well capture zone is approximately 154 m wide and extends from the wells in a northeast direction;
- Groundwater flow is estimated to be 271 m/year and there are no known surface waterbody within the 1 year travel time boundary, but the Klondike Highway may be within the 10 year travel boundary; and
- The permeable sand and gravel soils in this area will contribute to the rapid transmission of surface contamination and the management area should be protected against the possibility of spills of hazardous materials;
- There were no potential contaminants of concern identified within the well capture zones.

Based on the results of the WHPP, Vista Tek recommended the following:

- Community education to communicate well protection areas and the importance of protecting the community groundwater resource.
- Signage on the Klondike Highway notifying the area where it passes through the well capture zone;
- Regular inspection of residential septic fields and the immediate vicinity of the wellheads and monitoring of water levels in Well 1 and Well 2; and,
- Creation of a contingency plan for the water supply system and utilization of the WHPP in community planning to ensure the well protection areas are maintained.

Although the aquifer is considered vulnerable to surface sources of contamination as indicated above, the following reduce the risk of aquifer contamination significantly:

- There have been no residential, industrial or agricultural developments previously within the well capture zones;
- Source Water Protection Planning is in place for this system; and,
- There were no potential contaminants of concern identified within the well capture zones by Tetra Tech's 2012 LPDWSA.

5.37.7 Water Supply Information Data Gaps

Tetra Tech has not identified any major system upgrade or expansion since 2012. For the purpose of this project, the following data gaps were identified:

- As the WHPP was created in 2008, it should be updated to include any changes that have occurred in the well capture zones and surrounding area since 2008.

5.38 Pelly Crossing - Eliza van Bibber School Water Supply System

Eliza van Bibber School is located in Pelly Crossing, Yukon on the North Klondike Highway. Pelly Crossing is where the North Klondike Highway crosses the Pelly River and is located about midway between Dawson and Whitehorse. The school water system has water supplied the SFN water system and the summary included here is for information purposes only.

5.38.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.38.2 Hydrogeology

The Pelly Crossing area is situated inside the bend of the Pelly River, and most wells in the Village area obtain water from an unconfined aquifer consisting of floodplain alluvial sand and gravel deposits. The relatively shallow depth of the aquifer combined with the absence of a confining material leaves this aquifer vulnerable to surface sources of contamination. The Eliza van Bibber School well is completed at a depth of about 15.2 m bgs in a sand and gravel aquifer and this is consistent with other well logs in the area that no fine-grained soils were observed overlying the aquifer. The static water level in the well was approximately 6.7 m bgs at the time of well completion in 1982. The expected groundwater flow direction in the vicinity of the well is north to northwest (Tetra Tech 2004).

5.38.3 Well Summary

The log for Eliza van Bibber School well is included in the GIS map and database portion of this project. The following table summarizes available data for the water well.

Table 5-99: Eliza van Bibber School, Well 5676 Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Midnight Sun Drilling Co. Ltd. in August 1982	Well Log
Total well depth	15.2 m bgs	
Casing	6” (152 mm) ID Steel Casing	
Casing depth	14.0 m bgs	
Well screen	1.2 m 15 slot (0.38 mm) well screen from 14.0 m to 15.2 m bgs	
Static water level	6.7 m bgs (August 1982)	
Sanitary seal	Likely no surface seal	Tetra Tech 2006
Wellhead completion	Split gasket cap, located in school mechanical room	
Wellhead stickup	Unknown	

Table 5-99: Eliza van Bibber School, Well 5676 Summary		
Well Construction Parameters	**Details**	**Source**
Well rated capacity	2.2 L/s (29 IGPM) (estimated by the driller)	Well Log
Well GUDI status	Potentially GUDI	Based on well construction
Well Construction Comments:	Well was not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.38.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The observations made in 2005 are summarized below:

- The groundwater source is calcium-bicarbonate type water, has a pH of approximately 8.1 and is considered very hard with a measured hardness of 177 mg/L to 191 mg/L (as $CaCO_3$);
- Turbidity in the samples reviewed was as high as 1.0 NTU. Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration is expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU;
- The total iron concentration in the samples reviewed ranged from 0.198 mg/L to 0.35 mg/L, which is below or slightly above the GCDWQ AO of 0.3 mg/L;
- The manganese concentration measured ranged from 0.535 mg/L to 0.611 mg/L and is significantly in exceedance of the GCDWQ AO of 0.05 mg/L;
- The water met all other GCDWQ health-based and aesthetic objectives for the parameters tested;
- EPH and PAH were below the laboratory detection limits indicating that the well has not been impacted by hydrocarbons; and
- Review of chloride, nitrate and nitrite showed all three concentrations to be low and within the normal background ranges, suggesting that the aquifer was not under the influence of anthropogenic surface sources of nutrients or anions such as septic wastes at the time of sampling.

5.38.5 Water Treatment and Distribution

Table 5-100: Eliza van Bibber School Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	

Table 5-100: Eliza van Bibber School Water Treatment and Distribution Details		
Item	**Details**	**Source**
Wells serving the system	Eliza van Bibber school well	
Treatment type	N/A	
Water users	Not in use**	
Delivery method	Not in use**	
Age of system/last known update	Unknown	

**Note: The school now has a connection to the SFN water treatment system, and the water well has been decommissioned. (p.c. Michael Fraser 2017).

5.38.6 Source Water Protection Planning

There is no source water protection planning in place for the Eliza van Bibber School Well 5676 and Tetra Tech was not able to obtain any record of a GUDI assessment for this well; however, as this system is no longer in use, SWPP or GUDI assessment here would not be warranted.

5.38.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps Tetra Tech has not identified any data gaps.

5.39 Pelly Crossing - Health Centre Water Supply System

Pelly Crossing, Yukon is where the North Klondike Highway crosses the Pelly River and is located about midway between Dawson and Whitehorse. The Pelly Crossing Health Centre is now connected to the SFN water system and the summary included here is for information purposes only.

5.39.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.39.2 Hydrogeology

The Pelly Crossing Health Centre Well is completed at a depth of 12.7 m bgs in a sand and gravel aquifer. The static water level at the time of drilling was 6.7 m bgs. Most wells in Pelly Crossing obtain water from an unconfined aquifer consisting of floodplain alluvial sand and gravel deposits. Lithology recorded during drilling of the Pelly Crossing Health Centre well indicated alternating sand and gravel units overlying the aquifer with very little fine-grained material documented. The lithology encountered during drilling is consistent with other wells drilled in the area, and this well is likely completed in the same unconfined aquifer. The shallow well completion, high water table and absence of fine-grained material to act as a confining layer, leave this aquifer vulnerable to surface sources of contamination. The groundwater flow direction in the vicinity of the Pelly Crossing Health Centre Well is north to northwesterly (Tetra Tech 2004).

5.39.3 Well Summary

The log for the Pelly Crossing Health Centre Well 5987 is included in the GIS map and database portion of this project. The following table summarizes available data for the water well.

Table 5-101: Pelly Crossing Health Centre Well 5987Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Midnight Sun Drilling Co. Ltd. in June 1977	Well Log
Total well depth	12.7 m bgs	
Casing	6” (152 mm) ID Steel Casing	
Casing depth	11.3 m bgs	
Well screen	1.4 m 15 slot (0.38 mm) well screen from 11.3 m to 12.7 m bgs	
Static water level	7.8 m bgs (November 20, 1999)	Tetra Tech 2006
Sanitary seal	No surface seal	
Wellhead completion	Split gasket cap, well pit	
Wellhead stickup	0.66 m bgs	

Table 5-101: Pelly Crossing Health Centre Well 5987Summary		
Well Construction Parameters	**Details**	**Source**
Well rated capacity	0.32 L/s (4.2 IGPM) (estimated by the driller)	Well Log
Well GUDI status	Potentially GUDI	Based on well construction
Well Construction Comments:	Well was likely not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.39.4 Source Water Quality

As part of the SPDWSA assessment conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The observations made in 2005 are summarized below:

- The groundwater source is calcium-bicarbonate type water with a pH of about 8.1;
- The water is considered very hard with a measured hardness of about 195 mg/L (as $CaCO_3$);
- The water quality met all GCDWQ health-based and aesthetic objectives for the parameters tested;
- Additional testing for BTEX, VPH, EPH and PAH was conducted due to records of a fuel spill in the vicinity of the wellhead. Review of these results did not indicate any evidence of impacts from fuel spills on groundwater quality for the parameters analysed; and
- Review of chloride, nitrate and nitrite results showed concentrations of all three parameters to be low and within the normal background ranges, suggesting that the aquifer was not under the influence of anthropogenic surface sources of nutrients or anions such as septic wastes at the time of sampling.

5.39.5 Water Treatment and Distribution

Table 5-102: Pelly Crossing Health Centre Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Wells serving the system	Pelly Crossing Health Centre Well	
Treatment type	None	
Water users	Not in use**	
Delivery method	Not in use**	
Age of system/last known update	Unknown	

**Note: The health centre now has a connection to the SFN water treatment system, and the water well has been decommissioned (p.c. Michael Fraser 2017)

5.39.6 Source Water Protection Planning

There is no source water protection planning in place for the Pelly Crossing Health Centre Well 5987 and Tetra Tech was not able to obtain any record of a GUDI assessment for this well however, as this system is no longer in use, SWPP or GUDI assessment here would not be warranted.

5.39.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system is accurate and up to date as of March 2017. Tetra Tech has not identified any data gaps.

5.40 Pelly Crossing - Swimming Pool Water Supply System

Pelly Crossing, Yukon is where the North Klondike Highway crosses the Pelly River and is located about midway between Dawson and Whitehorse. The Pelly Crossing Swimming Pool has water supplied from the SFN water system and the summary included here is for information purposes only.

5.40.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.40.2 Hydrogeology

Most wells in the Pelly Crossing Main Village area are completed at depths of 10 m to 17 m below ground within an unconfined sand and gravel aquifer consisting of floodplain alluvial sand and gravel deposits. The relatively shallow depth of the aquifer combined with the absence of confining material leaves this aquifer vulnerable to surficial sources of contamination (Tetra Tech 2006). A driller's well log was not available for review for this well to confirm the sub-surface conditions at the swimming pool location.

The expected direction of groundwater flow is north to northwesterly (Tetra Tech 2004).

5.40.3 Well Summary

No well log for Well 5672 was available for review. The well construction and completion details are summarized below.

Table 5-103: Pelly Crossing Swimming Pool, Well 5672 Summary

Well Construction Parameters	Details	Source
Date of construction	1984	Tetra Tech 2006 p.c. Nick Barnett 2017
Total well depth	Unknown	
Casing	6" (152 mm) ID Steel Casing	
Casing depth	Unknown	
Well screen	Unknown	
Static water level	Unknown	
Sanitary seal	No surface seal	
Wellhead completion	Split gasket cap, wooden enclosure, below ground well pit	
Wellhead stickup	Unknown	
Well rated capacity	Unknown	Well Log
Well GUDI status	Potentially GUDI	Based on well construction

Table 5-103: Pelly Crossing Swimming Pool, Well 5672 Summary		
Well Construction Parameters	**Details**	**Source**
Well Construction Comments:	Well was likely not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.40.4 Source Water Quality

Water quality results from June 2005 and August 2005 were reviewed by Tetra Tech as part of the SPDWSA. More recent results were not available for review. The key observations and comments noted by Tetra Tech are summarized as follows:

- The water quality results indicated that the water from Well 5672 is a calcium-bicarbonate type water with a pH of approximately 8.2;
- The hardness (as CaCO3) was 181 mg/L and is considered very hard;
- The turbidity of the water from Well 5672 ranged from 1.29 NTU to 4.07 NTU. Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration is expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU;
- The water quality results indicated that the water from Well 5672 meets the GCDWQ for all the parameters analyzed with the exception of turbidity, total and dissolved iron, and total and dissolved manganese:
  - The reported total iron concentrations, at 0.748 mg/L and 0.945 mg/L, exceed the GCDWQ AO of 0.3 mg/L. The reported dissolved iron concentration (0.104 mg/L), which is below the GCDWQ AO, indicates that most of the iron can be attributed to suspended solids;
  - The reported total manganese concentrations, at 0.452 mg/L and 0.5 mg/L, and the reported dissolved manganese concentration, at 0.437 mg/L, exceed the GCDWQ AO of 0.05 mg/L; and
- Review of chloride, nitrate and nitrite showed all three to be low and within the normal background ranges, suggesting that the aquifer was not under the influence of anthropogenic surface sources of nutrients or anions such as septic wastes at the time of sampling.

5.40.5 Water Treatment and Distribution

Table 5-104: Pelly Crossing Swimming Pool Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Operated by Selkirk First Nation	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Number of wells serving the system	One (Well 5672)	
Treatment type	None	

Table 5-104: Pelly Crossing Swimming Pool Water Treatment and Distribution Details		
Item	**Details**	**Source**
Water users	Not in use**	
Delivery method	Not in use**	
Age of system/last known update	Unknown	

**Note: The swimming pool now has a connection to the SFN water treatment system, and the water well has been decommissioned. (p.c. Michael Fraser 2017).

5.40.6 Source Water Protection Planning

There is no source water protection planning in place for the Pelly Swimming Pool Well 5672, and Tetra Tech was not able to find any record of a GUDI assessment for this well however, as this system is no longer in use, SWPP or GUDI assessment here would not be warranted.

5.40.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system is accurate and up to date as of March 2017. Tetra Tech has not identified any data gaps.

5.41 Pelly Crossing - Firehall Water Supply System

Pelly Crossing is where the North Klondike Highway crosses the Pelly River and is located about midway between Dawson and Whitehorse. The Pelly Crossing Firehall has water supplied the SFN community water system and the summary included here is for information purposes only.

5.41.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.41.2 Hydrogeology

Most wells in the Pelly Crossing Village area obtain their water from an unconfined aquifer consisting of floodplain alluvial sand and gravel deposits (Tetra Tech 2006). The log for the Firehall Well 5678 indicates that the well is completed at a depth of 13.7 m within an unconfined sand and gravel aquifer. A thin silt horizon is shown to exist from ground surface to 2.1 m below grade. The well log shows the static water level to be 10.4 m below ground.

The relatively shallow depth of the aquifer combined with the limited presence of fine-grained material leaves this aquifer vulnerable to surficial sources of contamination (Tetra Tech 2006).

The expected direction of groundwater flow is northerly parallel to the Pelly River (Tetra Tech 2006).

5.41.3 Well Summary

The well log for Well 5678 included in the GIS map and database portion of this project. The following table summarizes the completion characteristics of the well.

Table 5-105: Pelly Crossing Firehall, Well 5678 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	The well was constructed by Midnight Sun Drilling Co. Ltd. in September 1988	Well log
Total well depth	13.7 m bgs	
Casing	6” (152 mm) OD Steel Well Casing	
Casing depth	12.5 m bgs	
Well screen	1.2 m 15 slot (0.38 mm) well screen from 12.5 m bgs to 13.7 m bgs	
Static water level	Approximately 10.4 m bgs (September 1988)	
Sanitary seal	No record of sanitary seal installation	Well log and Tetra Tech 2006
Wellhead completion	The wellhead is located in a pit below grade approximately 2.5 m east of the Firehall building	Tetra Tech 2006
Wellhead stickup	0.92 m bgs (measured on August 23, 2005)	
Well rated capacity	0.32 L/s (4.2 IGPM) (estimated by the driller	Well log
Well GUDI status	Potentially GUDI	Based on well construction and shallow completion
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.41.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The observations made in 2005 are summarized below:

- The water quality results indicated that the water from Well 5678 is a calcium-bicarbonate type water with a pH of approximately 8.2;
- The water is considered very hard, with a hardness ranging from 189 mg/L to 209 mg/L;
- The turbidity of the water from Well 5678 ranges from 1.39 NTU to 4.94 NTU. Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration is expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU; and
- The water quality results indicated that the water from Well 5678 meets the GCDWQ for all the parameters analyzed with the exception of total iron and turbidity. The reported total iron concentrations, ranged from

0.3 mg/L to 1.51 mg/L, which are either at or above the GCDWQ AO of 0.3 mg/L. However, the reported dissolved iron concentration was below the laboratory detection limit of 0.030 mg/L, indicating that elevated iron can be attributed to elevated turbidity.

5.41.5 Water Treatment and Distribution

Table 5-106: Pelly Crossing Firehall Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Number of wells serving the system	One (Well 5678)	
Treatment type	None	
Water users	Not in use**	
Delivery method	Not in use**	
Age of system/last known update	Unknown	

**Note: The Firehall now has a connection to the SFN water treatment system, and the water well has been decommissioned (p.c. Michael Fraser 2017).

5.41.6 Source Water Protection Planning

There is no source water protection planning in place for the Pelly Crossing Firehall well 5678 and Tetra Tech was not able to obtain any record of a GUDI assessment for this well however, as this system is no longer in use, SWPP or GUDI assessment here would not be warranted.

5.41.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system is accurate and up to date as of March 2017. Tetra Tech has not identified any data gaps.

5.42 Ross River - Village of Ross River Water Supply System

The Ross River community water supply has water sourced from a deep, sub-permafrost groundwater well. A new water treatment plant was constructed in 2013. Water treatment includes iron and manganese removal, arsenic removal and chlorination. Water is distributed to residential and commercial properties in the community via trucked bulk delivery. The system is owned and operated by Government of Yukon and serves a population of approximately 293 people (Yukon Bureau of Statistics 2016). The system is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007) and is also regulated under the Yukon Drinking Water Regulations - Guidelines for Part II - Bulk Delivery of Drinking Water (YG 2007).

5.42.1 Data Compilation Methodology

Tetra Tech approached stakeholders including YG departments, water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech obtained data regarding the Ross River Water Supply system from the following proponents:

- YG Community Services (the client) – YG CS provided data for the Ross River Water Supply as this system is owned and operated by YG CS. The YG CS operator provided review comments and edits for the final summary to ensure completeness and accuracy.

5.42.2 Hydrogeology

Tetra Tech completed a hydrogeological study in 2009 to determine the vulnerability of the Ross River Firehall well to surface sources of contamination. From this study, Tetra Tech found that the well is completed in a confined sand and gravel aquifer overlain by 100 m of clay and silt which were inferred to be lacustrine lake bed sediments. Permafrost was encountered from 8.2 m to 18.6 m below grade (Tetra Tech 2009). Perched groundwater also exists within the active zone (seasonal zone of freezing and thawing) above permafrost. Tetra Tech confirmed through testing completed in 2009 that the perched aquifer is not hydraulically connected to the deep artesian aquifer.

The Ross River water supply system is supplied by one groundwater well. The well is located about 500 m to the southwest of Pelly River. The groundwater flow direction in this area is likely northeast towards the river (Tetra Tech 2006). Other water supply wells exist in Ross River and are used for domestic water supply.

Tetra Tech completed an analysis of the vulnerability of the Ross River community water supply well in 2012 based on the semi-quantitative ISI (Ontario Ministry of Environment, 2001). Based on the Tetra Tech 2009 lithology logging, the ISI score for the deep confined aquifer was calculated to be 393. The ISI method defines aquifers with ISI scores greater than 80 as having low susceptibility to surface sources of contamination, and the score here of 339 suggests that the aquifer underlying the well site has very low to extremely low vulnerability to surface-based contamination.

5.42.3 Well Summary

The well log for the Ross River public supply well is included in the GIS map and database portion of this project. The following table summarizes the completion characteristics of the Ross River well.

Table 5-107: Ross River Community Water Supply Well Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed in 1986 by Midnight Sun Drilling Co. Ltd.	Well Log
Total well depth	110 m bgs	
Casing	8" (203 mm) ID Steel Well Casing	
Casing depth	105.1 m bgs	
Well screen	3.7 m of 25 slot (0.64 mm slot) stainless steel well screen from 105.1 m bgs to 108.8 m bgs; *and* 1.2 m of 30 slot (0.76 mm) stainless steel well screen from 108.8 m bgs to 110.0 m bgs. The total screen length is 4.9 m.	Tetra Tech 2012a
Static water level	3.8 m bgs	Tetra Tech 2010
Sanitary seal	Bentonite surface seal to 4.7 m bgs	Tetra Tech 2012b
Wellhead completion	Pitless unit	
Wellhead stickup	Approximately 1 m ags	
Well rated capacity	18.9 L/s (249 IGPM)	Jacobsen 2003
Well GUDI status	Very unlikely that the well is GUDI	Tetra Tech 2012a
Well Construction Comments:	Well was upgraded to meet Canadian Groundwater Association Well Construction Guidelines.	

5.42.4 Source Water Quality

In 2012, Tetra Tech reviewed water quality result from the Ross River supply system between 2003 and 2009. Tetra Tech made the following observations based on available water quality results:

- Ross River water can be characterized as calcium-sulphate type and is considered to be very hard with hardness ranging from 266 mg/L to 301 mg/L in the sample results reviewed;
- The manganese concentration in water samples obtained from the Ross River Firehall well has been consistently above the GCDWQ AO of 0.05 mg/L over the sampling period;
- The arsenic concentration in water samples obtained from the Ross River Firehall well has exceeded the GCDWQ MAC on each occasion tested; and

Tetra Tech did not review recent water quality data but understands water chemistry analysis is completed at this system annually and bacteriological monitoring is completed on a regular basis with results sent to YG EHS for review.

5.42.5 Water Treatment and Distribution

Table 5-108: Ross River Community Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2012a
Water source	Groundwater	
Wells serving the system	Ross River Firehall Well	
Treatment type	Pre-chlorination, iron and manganese removal by pressure filtration, arsenic removal, filtration, post chlorination	p.c. Rob Anderson March 2017 p.c. Steve Perrin March 2017
Population served	Approximately 293 people	Yukon Bureau of Statistics 2016
Delivery method	Trucked	Tetra Tech 2012a
Age of system/last known update	New Water Treatment Plant completed in 2013.	Tetra Tech 2012b

5.42.6 Source Water Protection Planning

Tetra Tech understands that a Source Water Protection Plan (SWPP) was commissioned by YG – SARU, and is in progress and should be completed and delivered in 2017.

Potential sources of contamination in the vicinity of the Ross River community water supply well that were identified as part of the 2012 LPDWSA included:

- Potential sources of contamination to the Ross River supply well and aquifer were identified as part of the 2012 LPDWSA and are mainly related to the storage of heating fuel, historic storage of gasoline and diesel at nearby abandoned service stations, historical fuel spills and septic tanks and fields in the community.
- The Ross River area was traditionally used by the Dena people as a seasonal camp and gathering place. Modern development began in the early 1900s. In the 1940s, the US Army built the Canol pipeline and Canol Road from Norman Wells to Whitehorse.
- Current industrial activity in Ross River is limited to activities related to residential needs with some trucking of equipment for mining activity travelling through the community on the Canol Road.
- The nearest surface waterbody to the Ross River water supply well is the Pelly River which is about 400 m down-gradient of the Firehall well.

In addition to the potential contamination sources that could impact the community water supply well, Tetra Tech notes that water supply system is served by just one well, which means the system will not operate should the well fail, be temporarily shut off for maintenance or repair or impacted by contaminants.

5.42.7 Water Supply Information Data Gaps

Tetra Tech has reviewed available information and has been provided review comments from the YG CS water system operator. To our knowledge, this summary is complete and accurate to March 2017. For the purpose of this study, Tetra Tech identified the following data gaps:

- The system is supplied by only one water well (Firehall well). Drilling and connecting a backup water supply well will result in redundancy in the system and reduce the change of the water supply system being shut down for well repair or maintenance.
- The SWPP for this community is currently in progress, and a final completed plan should be included the database once it is published.

5.43 Tagish - Carcross Tagish First Nation Tagish Water Supply System

Carcross Tagish First Nation (CTFN) owns and operates a bulk delivery water system at Tagish, Yukon. The system is supplied by two groundwater wells (CTFN Wells No. 2 and No. 3), and the water treatment and storage system consists of a chlorination injection system, and a manganese removal unit, with three 1,500-Igal tanks for chlorine contact and storage (Tetra Tech 2012). The system serves more than 20 residences and is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007) and is also regulated under the Yukon Drinking Water Regulations - Guidelines for Part II - Bulk Delivery of Drinking Water (YG 2007).

5.43.1 Data Compilation Methodology

Tetra Tech approached stakeholders including the water system owner/operator and regulatory bodies to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following parties regarding the CTFN Tagish Water Supply System:

- Carcross Tagish First Nation - CTFN confirmed that the most up to date information had been captured in the 2012 LPDWSA, and gave approval for use of Tetra Tech EBA data for the project.
- YG Environmental Health – YG EHS was contacted and assisted with the provision of data and contact information for water system operators.

5.43.2 Hydrogeology

CTFN Wells No. 2 and 3 are both completed within a deep confined aquifer at approximately 50 m bgs. The aquifer is overlain by a thick clay and/or silty to sandy till unit that is at least 18 m in thickness. From the Well No. 2 log, the apparent aquifer thickness is 9.2 m. However, due to the limited number of wells in the study area, it is not possible to delineate the extent of this deep confined aquifer (Tetra Tech 2012).

Bedrock underlying the overburden sediments is mapped as the Lower and Middle Jurassic Laberge Group which consists of poorly sorted, medium bedded to massive arkosic sandstone and minor shale with interbeds of thick resistant pebble and boulder conglomerate. Bedrock was not encountered at any of the CTFN public drinking wells; thus, depth to bedrock is unknown (Tetra Tech 2012).

According to available surficial mapping (Morison & Klassen 1991), the Laberge Group formation is overlain by any or all of the following:

- Alluvial valley bottom deposits of gravel, sand and silt with a thickness of 5 m to 20 m;
- Glaciolacustrine deposits of clay, silt, and sand with a thickness of 5 m to 10 m; and/or
- Silty to sandy till (lodgement to ablation till) deposits of 1 m to 30 m thick.

The groundwater flow direction within the aquifer is inferred to be northwesterly towards Marsh Lake, under a hydraulic gradient of 0.02 m/m; however, available groundwater elevation data suggested that the groundwater flow direction could change seasonally and even reverse temporarily. The actual magnitude of seasonal fluctuation and potential changes of the hydraulic gradient and groundwater flow direction cannot be determined due to limited available data (Tetra Tech 2012).

The main source of aquifer recharge is inferred to be from infiltration in topographically higher areas surrounding the valley. Local recharge to the aquifer from precipitation and snowmelt is probably very limited due to the confined

aquifer conditions and the relatively thick fine grained sediment cover present in the valley bottom. Given an inferred groundwater flow direction toward northwest, the main aquifer recharge area is likely to be from higher elevations approximately 4 km southeast of the well site.

The vulnerability of the aquifer encountered by Wells No. 2 and 3 was assessed using the semi quantitative ISI method suggested by the Ontario Ministry of Environment. The ISI method resulted in a calculated value of 269 to 285 for the two wells. The ISI method defines aquifers with ISI values greater than 80 as having a low intrinsic susceptibility to surface sources of contamination. The high values calculated for Well No. 2 and Well No. 3 indicate that the aquifer underlying the site has a low to very low vulnerability to potential surface-based contamination because of thick overlying poorly permeable lacustrine and till sediments above the aquifer and the depth of the aquifer zones (Tetra Tech 2012).

5.43.3 Summary of Wells

Logs for the two CTFN Tagish public wells serving the area of Tagish are included in the GIS map and database portion of this project. The following tables summarize the completion characteristics of the CTFN Tagish wells.

Table 5-109: CTFN Public Drinking Water System, Well No. 2 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Midnight Sun Drilling Co. Ltd. in September 2003	Well log
Total well depth	63 m bgs (tail pipe from 60.4 m to 63 m bgs)	
Casing	8.6" (220 mm) OD Steel Well Casing	
Casing depth	57.9 m bgs	
Well screen	2.5 m 10 slot (0.254 mm) stainless steel well screen from 57.9 m to 60.4 m bgs	
Static water level	1.4 m bgs (2003)	
Sanitary seal	Bentonite surface seal to 5.6 m bgs	
Wellhead completion	The wellhead is completed with a split gasket cap, and is located in a 1.9 m x 1.9 m building with a removable roof to allow future access for well rehabilitation or redevelopment.	Tetra Tech 2012
Wellhead stickup	0.93 m ags	
Well rated capacity	0.88 L/s (11.6 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-110: CTFN Public Drinking Water System, Well No. 3 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Cathway Resources in September 2004	Well Log
Total well depth	51.2 m bgs	
Casing	8" (203 mm) ID Steel Well Casing	
Casing depth	49.7 m bgs	
Well screen	1.5 m 200 slot (5.1 mm) stainless steel well screen from 49.7 to 51.2 m bgs	
Static water level	3.99 m bgs (2004)	
Sanitary seal	Bentonite surface seal to 6 m bgs	
Wellhead completion	Pitless adapter. The wellhead is located in 0.65 m x 0.65 m lockable metal clad plywood framed enclosure	Tetra Tech 2012
Wellhead stickup	0.6 m ags	
Well rated capacity	1.28 L/s (16.9 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.43.4 Source Water Quality

Tetra Tech reviewed water quality data for the CTFN Tagish public water supply system as part of the LPDWSA in 2012. In general, the raw water from the two CFTN Tagish public water supply wells meets the GCDWQ for all the parameters analyzed with the exceptions of total iron, total manganese and total arsenic (Tetra Tech 2012). The key observations and comments noted in 2012 are:

- The water is similar between the two wells and is considered soft with a measured hardness of 41.0 mg/L to 47.3 mg/L as CaCO3, is classified as sodium-sulphate type, and has a pH of 8.1 to 8.4;
- Arsenic concentrations were consistently approaching or in exceedance of the GCDWQ MAC in raw water samples obtained from Wells No. 2 and No. 3 over the period of record with measured concentrations ranging from 0.096 mg/L to 0.0152 mg/L. Arsenic concentrations have been slightly higher at Well No. 2 than Well No. 3 over this period. There is no notable trend with respect to changes in arsenic concentrations in raw water over time;
- Arsenic concentration exceeded the MAC in the two treated water samples considered with measured concentrations of 0.0119 mg/L and 0.0105 mg/L;
- Total iron concentration exceeded the AO of 0.3 mg/L with measured values between 0.034 mg/L to 0.487 mg/L in raw water over the period of monitoring. Iron concentrations were variable and likely related to suspended solids within samples. Treated water samples had total iron concentrations below the AO;

- Total manganese concentration in the raw water exceeded the AO of 0.05 mg/L with measured values between 0.19 mg/L and 0.211 mg/L in the results reviewed. Treated water samples had total manganese concentrations below the AO; and,
- The water met all other GCDWQ health-based criteria and aesthetic objectives for the parameters in the results reviewed.

5.43.5 Water Treatment and Distribution

Table 5-111: CTFN Public Drinking Water System Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Carcross Tagish First Nation	Tetra Tech 2012
Water source	Groundwater	
Wells serving the system	Well No. 2 and Well No.3	
Treatment type	Chlorination and manganese removal	Tetra Tech 2010
Population Served	Residents in the CTFN Tagish community and other communities in the Tagish and Squanga Lake areas obtain their drinking water from this water treatment system through bulk water delivery.	
Delivery method	Bulk truck delivery	Tetra Tech 2012
Age of system/last known major work	New water wells in 2003	

5.43.6 Source Water Protection Planning

Source Water Protection Planning in the form of Source Water Protection Plan (SWPP) was completed in 2010 for Wells No. 2 and No. 3, and can be found in the GIS map and database portion of this project. The key findings of the 2010 SWPP are (Tetra Tech 2010):

- Risks identified within the 1-year, 5-year and 10-year travel time zones for the CTFN public water supply wells can be eliminated or reduced if preventative action and contingency planning can be developed. Identified risks included:
  - Abandoned Well No. 1 (which was subsequently decommissioned in accordance to the Canadian Groundwater Association Guidelines for well decommissioning);
  - Miscellaneous household wastes including car, hulks and batteries; and
  - Above-ground and Underground Storage Tanks, septic systems, outhouses, the cemetery area, and potential spills that may occur.
- There had been no identified contamination in groundwater sampled from CTFN Wells No. 2 and No. 3 for water quality results available for review up to 2010; however, any release of contaminants within the travel time zones would represent a potential risk to the groundwater quality of the aquifer supplying these public water supply wells.

Tetra Tech understands CTFN has taken steps to address the recommendations made in the 2010 SWPP including decommissioning of Well No. 1.

5.43.7 Water Supply Information Data Gaps

To our knowledge we have captured the current status of the CTFN community water supply with the exception of the water system upgrades that were planned for 2016. The following data gaps were identified in the preparation of this report and where possible, this data should be obtained and included in future updates to this summary:

- The SWPP was completed in 2010, and, as Tetra Tech recommends updating SWPPs on a regular basis and as changes occur within the well capture zones, it is likely this SWPP is due to be updated.
- CTFN did not provide additional information system regarding upgrades that are thought to have been completed in 2016.

5.44 Tagish - Community Water Fill Station

The Tagish Community Fill Station is located in the Taku Subdivision at km 2 on the east side of Reid Road near the Tagish Firehall (Building #1953). The Tagish Community Fill Station sources water from a groundwater well (Well TFHW 02), which was drilled in 2013 to replace the old Firehall well (THFW-01 called Well 1953 in previous studies). Treatment includes iron and manganese removal, and chlorine disinfection. The system is a self-serve water supply for local residents to obtain potable water. The system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.44.1 Data Compilation Methodology

Tetra Tech approached stakeholders including YG departments, water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech obtained data regarding the Tagish Community Water Fill Station from the following proponents:

- YG Community Services (the client) – YG CS provided data for the Tagish Community Water Fill Station as this system is owned and operated by YG CS. The YG CS operator provided review comments and edits for the final summary to ensure completeness and accuracy.

5.44.2 Hydrogeology

From existing well logs, the Tagish glaciolacustrine overburden in the vicinity of the site is relatively deep with a silt/clay layer beginning at about 7.5 m bgs and extending to about 29 m bgs (Tetra Tech 2013a).

No permafrost was encountered during the drilling of any of the wells on the site. Overburden sediments encountered varied from silt with some sand and clay with some silt, to sand and gravel. Sediment material became saturated at about 29 m bgs, and a sand and gravel aquifer was encountered at 44.5 m bgs. No bedrock was encountered. Groundwater elevations in TFHW-02 were observed to be influenced by the pumping at Well TFHW-01 indicating that the new well, TFHW-02, is completed in the same sand and gravel confined overburden aquifer as the original Tagish Community Firehall well, TFHW-01 (Tetra Tech 2013a).

Another new well (TFHW-03) intended to provide water for fire protection only to the Tagish Fire Hall was drilled in 2016 and there are plans to connect it to the Fire hall in 2017.

Pumping test results from the wells indicate an aquifer transmissivity in the order of $6.5x10^{-5}$ to $6×10^{-3}$ m^2/s (5.6 to 518.4 m^2/day) (Tetra Tech 2013a, Tetra Tech 2017).

The groundwater flow direction in the vicinity of the Tagish Firehall is inferred to be in an east to north-easterly direction, towards 6 Mile River and Marsh Lake.

5.44.3 Well Summary

The well logs for Well TFHW-02 and THFW-03 are included in the GIS map and database portion of this project. The following tables summarize the completion characteristics of the wells.

Table 5-112: Tagish Firehall, Well TFHW-02 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Impact Well Drilling Ltd. in August 2013	Well log
Total well depth	46.8 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	45.5 m bgs	
Well screen	1.3 m 30 slot (0.76 mm) stainless steel well screen from 45.5 m to 46.8 m bgs	
Static water level	11.3 m bgs (September 4, 2013)	Tetra Tech 2013a
Sanitary seal	Bentonite sanitary seal to 6 m bgs	Well log and Tetra Tech 2013a
Wellhead completion	Pitless unit with >1 m stickup	Tetra Tech onsite observation, 2016
Wellhead stickup	0.7 m ags	Tetra Tech 2013a
Well rated capacity	3.8 L/s (50 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-113: Tagish Firehall, Well TFHW-03 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Cathway Water Resources in September 2016	Well log
Total well depth	54.7 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	53.5 m bgs	
Well screen	1.2 m 20 slot (0.508 mm) stainless steel well screen from 53.5 m to 54.7 m bgs	
Static water level	13.2 m bgs (October 7, 2016)	Tetra Tech 2017
Sanitary seal	Bentonite sanitary seal to 4.5 m bgs	Well log and Tetra Tech 2017
Wellhead completion	Not yet complete	Tetra Tech 2017
Wellhead stickup	0.7 m ags (at well completion)	
Well rated capacity	3.8 L/s (50 IGPM)	
Well GUDI status	Non-GUDI	

Table 5-113: Tagish Firehall, Well TFHW-03 Summary		
Well Construction Parameters	**Details**	**Source**
Well Construction Comments:	Well was constructed in general accordance with Canadian Groundwater Association Well Construction Guidelines.	

5.44.4 Source Water Quality

The chemical water quality data of Well TFHW-02 and TFHW-03 are very similar and can be summarized as follows (Tetra Tech 2013a, Tetra Tech 2017):

- The groundwater source is hard (274 mg/L as CaCO3) and can be characterized as calcium-magnesium-bicarbonate type water which is the same as water analyzed from TFHW-01 (228 mg/L to 263 mg/L as CaCO3 on the dates sampled). The elevated hardness is considered to be generally poor for aesthetic purposes;
- The analytical results for the water samples collected on September 11, 2013 indicate that the water from the well meets the GCDWQ for all parameters analyzed with the exceptions of colour, iron and manganese:
- The colour of the water sample (26 CU) exceeds the GCDWQ AO of 5 CU;
- The reported iron concentration, at 0.669 mg/L, exceeds the GCDWQ AO of 0.3 mg/L; and,
- The reported manganese concentration, 0.069 mg/L, exceeds the GCDWQ AO of 0.05 mg/L.

5.44.5 Water Treatment and Distribution

A new water treatment plant was commissioned at this site in 2015. From preliminary design records, Tetra Tech has summarized the characteristics of the water treatment and distribution.

Table 5-114: Tagish Community Fill Station Water System Treatment and Distribution Details		
	Details	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2013a
Water source	Groundwater	
Wells serving the system	Tagish Firehall Well TFHW-02	
Treatment type	Iron and manganese removal by press filtration, chlorination	p.c. Nick Barnett 2017
Delivery method	Self-serve fill station	Tetra Tech 2013a p.c. Nick Barnett 2017
Age of system/last known major work	New water treatment plant commissioned in 2015, new water well completed in 2013	Tetra Tech 2017

5.44.6 Source Water Protection Planning

Tetra Tech did not find any records indicating that a SWPP has been completed for the Tagish Firehall Well TFHW-02. Though the well is completed in a confined aquifer, the well serves as a public water fill for the residents of Tagish and a SWPP would provide a valuable tool for identifying, monitoring and managing risks to the well and aquifer.

Tetra Tech completed a Phase 1 GUDI screening for the well and based on the screening results, well TFHW 02 is considered to be a groundwater source, and not under the direct influence of surface water (i.e., non-GUDI) for the following reasons (Tetra Tech 201b):

- The well was drilled and completed in the same aquifer as the existing well; a deep confined aquifer with a very low vulnerability to surface sources of contamination;
- The new well is not a vulnerable type or in a vulnerable location and is constructed in accordance with the Y DPWR and CGWA's Well Construction Guidelines; in particular it has a sanitary seal and adequate stick-up;
- The nearest waterbodies are greater than 600 m from the new well; and
- The groundwater quality is substantially different than nearby surface water quality, and water samples from the existing well (completed in the same aquifer) had only 1 in 60 bacteriological test results positive for total coliform; and re-test results were negative.

5.44.7 Water Supply Information Data Gaps

For the purpose of this study, Tetra Tech identified the following data gaps:

- There is no source water protection planning in place for this system. As the system supplies potable water to the public, a SWPP would provide a valuable additional protection for the groundwater resource.

5.45 Takhini Subdivision – Champagne and Aishihik First Nation Water Supply System

Champagne Aishihik First Nation (CAFN) owns and operates a public drinking water system in the Tahkini River Subdivision (TRS), located at km 1470.2 on the Alaska Highway in Yukon. The system consists of two deep drilled groundwater wells, Potable Water Well 1 (PW Well 1, called Well 1 in previous reports) and Potable Water Well 2 (PW Well 2, called Well 3 in previous reports). One other groundwater well, Geoexchange Well 1 (GE Well 1, called Well 2 in previous reports) was drilled in 2005 but, due to low flow was not used as a production well and was instead incorporated into a geoexchange heating system. Both drinking water wells are located next to the water treatment building. The system is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007).

5.45.1 Data Compilation Methodology

Tetra Tech approached all the stakeholders, water system operators and owners that we could contact to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Many of the stakeholder groups contacted were able to provide data and received the project positively. Through the process of compiling the data, Tetra Tech has had communication with the following parties regarding the CAFN Takhini River Subdivision Water System:

- Champagne Aishihik First Nation – CAFN provided approval to use Tetra Tech data and review comments for this system summary.
- Indigenous and Northern Affairs Canada – Was contacted at the project outset and provided some direction on available information and contacts.

5.45.2 Hydrogeology

According to the driller's well log, PW Well 1 is completed in a confined sand and gravel overburden aquifer which is separated from the surface by a thick layer of low permeability silt and clay sediments. Surficial geology mapping in the area of the TRS and inferred well capture zone indicates that the overburden in the area is comprise primarily of glaciolacustrine deposits likely deposited in the historical Glacial Lake Champagne. Deposits are composed of silt and clay with some sand and gravel lenses based on the lithology encountered at PW Well 1 and GE Well 1 and information in Morison and Klassen (1991). Bedrock geology mapping in the development area indicates that the quaternary overburden deposits are underlain early Jurassic aged granite and granodiorite from the Long Lake Plutonic Suite (Gordey 2008).

PW Well 1 is located approximately 660 m from the Takhini River and the nearest surface water is greater than 300 m from the well completion location (Tetra Tech 2012).

Results of a pumping test conducted on PW Well 1 in 2008 indicated that the aquifer behaved differently in early and late pumping stages (EBA 2008). The late pumping test transmissivity was higher than the early transmissivity, which suggests that the well is completed in a 'leaky, confined aquifer' as reported by Gartner Lee Limited (2001) and Summit Environmental (2010). Using the 2008 results which gave an aquifer transmissivity of $6x10^{-5}$ m2/s and an aquifer thickness of 1.2 m, the hydraulic conductivity of this aquifer is estimated to be $5x10^{-5}$ m/s.

The vulnerability of the aquifer encountered by PW Well 1 was assessed using the semi-quantitative ISI method suggested by the Ontario Ministry of Environment. The ISI method result of 764 indicated that the aquifer underlying the site has a low vulnerability to potential surface-based contamination due to the thick low permeability silt and clay over a deep confined aquifer (Tetra Tech 2012).

5.45.3 Summary of Wells

Well logs for CAFN PW Well 1 and PW Well 2 serving the Takhini River Subdivision Public Water Supply System are included in the GIS map and database portion of this project. The well log for CAFN GE Well 1 was not available for review. The following tables summarize the completion characteristics of CAFN PW Well 1, PW Well 2, and GE Well 1.

Table 5-115:CAFN TRS Public Drinking Water System, Potable Water Well 1 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Fredelana Enterprises Ltd. in May 1995	Well log
Total well depth	130.5 m bgs	
Casing	6" (152 mm) OD Steel Well Casing	
Casing depth	129.3 m bgs	
Well screen	1.2 m 10 slot (0.254 mm) stainless steel well screen from 129.3 m bgs to 130.5 m bgs (by Cathway Water Resources in 2008)	Tetra Tech 2008
Static water level	20.0 m bgs (May 2005); 21.7 m bgs (November 2010)	Well log and Tetra Tech 2012
Sanitary seal	No record of sanitary seal installation. Based on the depth of the well and the thickness of low permeability sediment between the surface and the screened depth, the lack of surface seal does not pose risk to the groundwater source (Summit 2010).	Summit 2010
Wellhead completion	The wellhead is completed in an insulated metal clad enclosure with heat trace extending into the well to prevent freezing.	Tetra Tech 2012
Wellhead stickup	1.14 m ags (measured July 2011)	
Well rated capacity	0.94 L/s (12.4 IGPM)	
Well GUDI status	Non-GUDI	Summit 2010
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-116: CAFN TRS Public Drinking Water System, Potable Water Well 2 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed in November 2014	Tetra Tech 2014
Total well depth	129.4 m bgs	
Casing	6” (150 mm) ID steel well casing	
Casing depth	128.2 m bgs	
Well screen	1.2 m of 10-slot (0.25 mm) v-wire stainless steel well screen from 128.2 m bgs to 129.4 m bgs	
Static water level	20.5 m bgs (November 18, 2014)	
Sanitary seal	Bentonite seal to 6 m bgs	
Wellhead completion	Pitless Unit	
Wellhead stickup	1.0 m ags	
Well rated capacity	1.3 L/s (17 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-117: CAFN TRS Public Drinking Water System, GeoExchange Well 1 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed in 2003	Tetra Tech 2012
Total well depth	157 m bgs	
Casing	Unknown	
Casing depth	155 m bgs	
Well screen	2 m 30 slot (0.76 mm) stainless steel well screen from 155 m bgs to 157 m bgs	
Static water level	Unknown	
Sanitary seal	Unknown	
Wellhead completion	Unknown	
Wellhead stickup	Unknown	
Well rated capacity	very low yield (<1.1 IGPM), and not considered to be suitable for a back-up well	

Table 5-117: CAFN TRS Public Drinking Water System, GeoExchange Well 1 Summary		
Well Construction Parameters	**Details**	**Source**
Well GUDI status	Non-GUDI	Summit 2010
Well Construction Comments:	Well was likely not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

**Tetra Tech understands this well is currently used as a heat source well in a geoexchange heating system.

5.45.4 Source Water Quality

In 2012, Tetra Tech reviewed water quality result from the Takhini River Subdivision PW Well 1 with results from 2008 and 2010. In addition to the 2012 water quality results from PW Well 1, Tetra Tech completed sampling and analysis as part of the well completion reporting for PW Well 2 in 2014. In general, the raw water from the CAFN TRS public water supply well meets the GCDWQ with the exception of total arsenic (Tetra Tech 2012). The key observations and comments noted in 2012 are:

- The groundwater source from PW Well 1 and PW Well 2 is a calcium-magnesium-bicarbonate type, with relatively low mineralization; and has a measured pH of 8.1 to 8.3;
- The water is considered medium hard with measured hardness ranging from 110 mg/L to 118 mg/L as CaCO3;
- The arsenic concentration in raw and treated samples from the Takhini River Subdivision well has been consistently higher than the GCDWQ MAC of 0.01 mg/L with measured concentrations ranging from 0.0142 mg/L to 0.0160 mg/L in the results reviewed; and
- The water met all other GCDWQ health-based criteria and aesthetic objectives for the parameters measured.

5.45.5 Water Treatment and Distribution

Table 5-118: CAFN TRS Public Drinking Water System Treatment and Distribution Details		
	Details	**Source**
Owner/Operator	Champagne Aishihik First Nation	Tetra Tech 2012
Water source	Groundwater	
Wells serving the system	PW Well 1 and PW Well 2	
Treatment type	Sand filter, filtration (10 microns and 1 micron stages), chlorination, arsenic removal	YES 2012 AdEdge 2012
Number of people served	30 delivery points (approximately 90 people)	
Delivery method	Bulk truck delivery	
Age of system/last known major work	New water well PW Well 2 completed in 2014 and connected in 2015	

5.45.6 Source Water Protection Planning

An AWPP was prepared by CAFN for the Takhini River Subdivision Water Supply System with technical input from Tetra Tech in 2014. The AWPP was prepared prior to the completion of PW Well 2. The Takhini River Subdivision Preliminary AWPP was developed based on Tetra Tech's risk based approach, which is adapted from British Columbia's Environment (BC MoE) Tool Kit.

Due to the uncertainty in the groundwater flow direction and to ensure that capture zones were conservatively estimated, Calculated Fixed Radius method was used for the inferred downgradient area of the capture zone (i.e.,, to the north and east), whereas the Theim Method was used for the inferred upgradient area of the capture zone (i.e.,, the west and south). The irregular capture zone shape is therefore a conservative hybrid of these two evaluation methods.

Key conclusions from the AWPP include:

- Though a contaminant release within the identified well capture zone will present a potential risk to the aquifer and the water quality from PW Well 1. The thick glaciolacustrine silt and clay unit overlying the aquifer provides significant protection against potential contaminants originating from surface sources.
- The highest risks to the community PW Well 1 are from potential releases and spills from above ground storage tanks (ASTs), leachate from septic fields, and a waste transfer station site to the west of the well.
- Old vehicles and other debris that were dumped in an area to the west of the well may also pose a potential risk. Most of the old vehicles have been removed from the site; however, no further assessment has been carried out to identify potential soil contamination in this area.

Tetra Tech recommended the following:

- Mitigation measures including replacement of some ASTs; public education and awareness initiatives; a hazardous waste minimization and collection; implementing an emergency response plan; and implementing regular tracking and monitoring of risks to the community wells.
- PW Well 2 is not included in the current AWPP, and Tetra Tech recommended updating the AWPP to include this well.

Tetra Tech understands that CAFN is in the process of implementing some of the recommendations from the AWPP and are planning to update the AWPP to include PW Well 2 in 2017.

5.45.7 Water Supply Information Data Gaps

Tetra Tech has reviewed available data in our database and communicated with CAFN and YG CS. From these reviews, we are not aware of any upgrades to the system outside of those captured in this summary. Tetra Tech has noted the following data gaps or areas where the protection of the water source could be improved:

- The AWPP currently does not include protection considerations for PW Well 2, and Tetra Tech understands this will be updated in the near future. The updated version of the AWPP should be included when it is available.

5.46 Teslin - Village of Teslin Water Supply System

The Village of Teslin (VoT) is located at km 1244 on the Alaska Highway and is situated on the shores of Teslin Lake where Nisutlin Bay meets the main body of the lake. Teslin has a population of approximately 263 residents (Yukon Bureau of Statistics 2016). Water is sourced from a groundwater supply well, and is treated for iron, manganese and arsenic, and is disinfected through chlorination and then delivered by trucked distribution. A new water treatment plant was completed in 2013, and the treatment plant and water well TW10-02 were put into use in summer 2013. The VoT community water supply is owned and managed by VoT, but Tetra Tech understands that Yukon Government Community Services (YG-CS) is currently involved in the management of the system as upgrades are under way. The VoT community water supply system is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007) and is also regulated under the Yukon Drinking Water Regulations - Guidelines for Part II - Bulk Delivery of Drinking Water (YG 2007).

5.46.1 Data Compilation Methodology

Tetra Tech approached stakeholders including governing and regulatory bodies as well as water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete and accurate data set possible. Many of the stakeholder groups contacted were able to provide data and received the project positively. Through the process of compiling the data, Tetra Tech has had communication with the following entities in regard to the Teslin Community Water Supply System:

- Village of Teslin – VoT was contacted and directed for the original data compilation and has provided review comments on this data summary.
- YG Community Services (the client) – YG CS provided for systems where the operator and other proponents contacted were not able to find the documents.
- YG Environmental Health Services – YG EHS was contacted and assisted with the provision of data for Teslin.

We have made an effort to present the most up-to-date information available to us at the time of this project and included the source and year for all information presented in this report and the GIS database.

The data summary was compiled as data was received. The ArcGIS database was created by importing CAD and GIS data into the mapping program to create a map layer showing the location of water infrastructure and capture or buffer zones. Metadata was added to the database using an attachment and attributes tool.

5.46.2 Hydrogeology

The Village of Teslin (VoT) is located on the shores of Teslin Lake. Surficial geology mapped in the vicinity of VoT is mapped as lodgment and ablation till with a silty to sandy matrix. The thickness of the till is likely controlled by the bedrock contact and the depth to bedrock somewhat irregular. Three test wells have been completed in the vicinity of the new community water supply well. Bedrock was encountered in only one of these wells at a depth of 130 m bgs.

Bedrock mapped in the vicinity of VoT consists of a combination of metamorphosed sedimentary and intrusive rocks from the Cache Creek Terrane, Teslin Suite plutonic intrusives and Yukon-Tanana group sedimentary rocks. In the vicinity of the VoT water wells, the bedrock is mapped as altered volcanic rocks. A dry well (TW10-01) drilled to a depth of 182.2 m bgs in the vicinity of Teslin community water supply well TW10-02 encountered bedrock at approximately 130 m bgs. Bedrock encountered in test well TW10-01 consisted of chlorite schist. This confirms the mapping of altered volcanic rocks in this area.

Aquifers underlying VoT are thought to consist of isolated sand and gravel lenses within the till complex. The source aquifer for the new community water supply well, TW10-02, appears to have some limited aerial extent as indicated as follows:

- Test well (TW10-01), 400 m away, did not encounter significant water to a depth of 182.2 m.
- The old community water supply well, about 550 m to the west from the new well TW10-02, encountered water at a depth of 38.4 m. No drawdown was observed in this well during pump testing at TW10-02.
- Two nearby wells, the library well about 120 m to the south and the VoT Maintenance Compound well about 100 m to the south of TW10-02, appear to be completed in the same aquifer. During the pumping test completed for TW10-02, drawdown was observed in the library well and pumping from the Maintenance Compound well was observed to cause additional drawdown in TW10-02.

5.46.3 Summary of Well Completion Details

The VoT community water system is supplied from one groundwater well located in the Village of Teslin Recreation Park. The well log for this well is included in the GIS mapping and database and the well completion details are summarized below.

Table 5-119: VoT TW10-02 Community Water Supply Well

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Impact Drilling in June 2010	Tetra Tech 2010 p.c. C. Hunking 2017
Total well depth	21.79 m bgs	
Casing	8" (203 mm) ID Steel Well Casing	
Casing depth	19 m bgs	
Well screen	▪ 1.1 m of 80-slot (2.03 mm) telescopic Variperm well screen exposed from 19.0 m bgs to 20.1 m bgs ▪ 1.7 m of 20-slot (0.51 mm) stainless steel well screen from 20.1 m bgs to 21.8 m bgs	
Static water level	5.28 m bgs (May 2010)	
Sanitary seal	Bentonite surface seal to 5.8 m bgs	
Wellhead completion	Pitless adapter	
Wellhead stickup	0.61 m ags	
Well rated capacity	3.47 L/s (45.8 IGPM)	
Well GUDI status	Non-GUDI (based on Phase 1 Initial GUDI Screening)	
Well Construction Comments:	The well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.46.4 Source Water Quality

Tetra Tech collected one water sample during the completion of the well in June 2010 and reviewed water quality results from January 2017, and the following were noted:

- Other than manganese, arsenic and TDS the water met all GCDWQ heath based requirements and aesthetic objectives for the parameters analyzed;
- The concentration of arsenic in the water was 0.0142 mg/L in 2010 and 0.0107 mg/L in 2017, both of which exceed the GCDWQ MAC of 0.01 mg/L;
- The manganese concentration was 0.199 mg/L in 2010 and 0.346 mg/L in 2017, both of which exceed the GCDWQ AO of 0.05 mg/L.
- In 2017 the total dissolved solids (TDS) concentration was 565 mg/l which exceeds the GCDWQ AO of 500 mg/L;
- The water from the well is very hard and can be characterized as magnesium-calcium-bicarbonate type; and,
- The laboratory measured pH of the water was 8.10 in 2010 and 8.22 in 2017.

5.46.5 Water Treatment and Distribution

Table 5-120: VoT Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Village of Teslin	Tracey Kinsella, YG-EHS June 2016
Water source	Groundwater	Permit to Operate Application 2013
Wells serving the system	TW10-02	Permit to Operate Application 2013
Treatment type	Chlorination, greensand filtration to remove iron and manganese, granular ferric hydroxide filters to remove arsenic from water, reverse osmosis, chlorination for disinfection	Teslin Control Narrative 2013
Population served	263	Yukon Bureau of Statistics 2016
Delivery method	Trucked bulk delivery	Tracey Kinsella, YG-EHS June 2016
Age of system/last known update	New water treatment system in 2013. New water well constructed in 2010.	Permit to Operate Application 2013, Tetra Tech 2010.

5.46.6 Source Water Protection Planning

We are not aware of any source water protection planning completed for the Teslin community water supply system. Implementing a source water protection plan for the community of Teslin would provide a comprehensive approach to protecting the VoT drinking water supply.

5.47 Teslin - School Water Supply System

Village of Teslin is located at km 1244 on the Alaska Highway in Yukon. The Teslin School water system is served by an approximately 45 m deep water well located in a pit enclosure approximately 4 m from the school. The water system supplies potable water to the school and is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.47.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.47.2 Hydrogeology

Two primary aquifers have been identified by Tetra Tech through studies in the Teslin area: a shallow unconfined aquifer and a deep confined aquifer. Based on topography and proximity to surface water, the groundwater flow direction in the vicinity of the Teslin School well is inferred to be west to south towards Teslin Lake.

5.47.3 Well Summary

A well log for the Teslin School well is included in the attached GIS map and database portion of this project. The following table summarizes available data for the water well.

Table 5-121: Teslin School, Well 4762 Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Midnight Sun Drilling Co. Ltd. in March 1973	Well Log
Total well depth	45.4 m bgs	
Casing	5” (127 mm) ID Steel Casing	
Casing depth	43.7 m bgs	
Well screen	1.7 m 7 slot (0.18 mm) well screen from 43.7 m bgs to 45.4 m bgs.	
Static water level	14.4 m (June 16, 2005)	Tetra Tech 2006
Sanitary seal	No surface seal	Well Log
Wellhead completion	Well pit	Tetra Tech 2006
Wellhead stickup	1.4 m bgs	
Well rated capacity	0.95 L/s (12.5 IGPM) (estimated by the driller)	Well Log
Well GUDI status	Potentially GUDI	Based on well construction

Table 5-121: Teslin School, Well 4762 Summary		
Well Construction Parameters	**Details**	**Source**
Well Construction Comments:	Based on the wellhead completion and the lack of a surface seal, the well was not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.47.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for the identified parameters of concern. The observations made in 2005 are summarized below:

- The TDS concentration measured at the time of sampling was 550 mg/L, which is in excess of the GCDWQ AO of 500 mg/L;
- The total and dissolved arsenic concentrations, ranged from 0.00696 mg/L to 0.0074 mg/L on the dates sampled, are below the current GCDWQ MAC of 0.01 mg/L;
- All other parameters measured were below the applicable GCDWQ health-based and aesthetic objectives; and
- No elevated concentrations of indicator parameters were observed in the two sets of sample results.

5.47.5 Water Treatment and Distribution

Government of Yukon owns and operates the Teslin School water supply system. Water entering the school is treated through several processes prior to entering the distribution piping.

Table 5-122: Teslin School Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Wells serving the system	Teslin School well	
Treatment type	Chlorine injection, cartridge filtration, activated carbon vessels, and water softener	
Water users	Teslin School	
Delivery method	Piped to the school	
Age of system/last known update	Unknown	

5.47.6 Source Water Protection Planning

There is no source water protection planning in place for the Teslin School Well 4762. Given the fact that the water supplies the Teslin School, source water protection planning here may be merited. An integrated SWPP that includes the Teslin Health Centre and Village of Teslin water supply wells would provide a comprehensive approach to protecting the groundwater resource in Teslin.

Potential sources of contamination in the vicinity of the wellhead were identified as part of the 2005 SPDWSA site review; these potential contaminant sources included the following:

- The Teslin community sewage system and service lines are possibly less than 30 m from the well;
- Several septic spills have been recorded in the community, and the proximity of the sewage system and lines presents a concern for potential from contamination by septic waste; and
- The well pit has been subject to flooding as evidenced by observed staining.

5.47.7 Water Supply Information Data Gaps

Tetra Tech has obtained review comments from YG PMD regarding the current status of this system and to our knowledge this summary is complete and accurate to March 2017. The following data gaps have been identified:

- There is no source water protection planning for this groundwater resource. Source water protection planning here could be incorporated into a greater Village of Teslin SWPP and provide comprehensive planning to protect the identified shallow and deep Teslin groundwater aquifers.

5.48 Teslin - Health Centre Water Supply System

Village of Teslin is located at km 1244 on the Alaska Highway in Yukon. The Teslin Health Centre water system is served by a groundwater well located in a pit approximately 4 m from the Health Centre. The Teslin Health Centre water supply system supplies potable water to the Health Centre and is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.48.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.48.2 Hydrogeology

The Teslin Health Centre site is located near the southeast corner of a small peninsula extending into Teslin Lake. In general, two primary aquifers, a shallow unconfined and a deep confined aquifer, have been identified by Tetra Tech through studies in the Teslin area. Based on topography and proximity to surface water, the groundwater flow direction in the vicinity of the Teslin Health Centre well is inferred to be east to south.

5.48.3 Well Summary

No well log was available for the Teslin Health Centre well. The following table summarizes available data for the water well.

Table 5-123: Teslin Health Centre, Well 4951 Summary

Well Construction Parameters	Details	Source
Date of construction	1999	Tetra Tech 2006 p.c. Nick Barnett 2017
Total well depth	32 m bgs	
Casing	6” (152 mm) ID Steel Casing	
Casing depth	Unknown	
Well screen	Unknown	
Static water level	Unknown	
Sanitary seal	Likely no surface seal	
Wellhead completion	Locked pit, split gasket cap	
Wellhead stickup	0.75 m bgs	
Well rated capacity	Unknown	
Well GUDI status	Potentially GUDI	Based on well construction

Table 5-123: Teslin Health Centre, Well 4951 Summary		
Well Construction Parameters	**Details**	**Source**
Well Construction Comments:	Based on the wellhead completion and the lack of a surface seal, the well was not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.48.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The observations made in 2005 are summarized below:

- The TDS concentration in the sample collected by YG was measured at 865 mg/L which exceeds the GCDWQ AO of 500 mg/L;
- The total arsenic concentration in the two sample results was 0.0083 mg/L and 0.007 mg/L, which are slightly below the current GCDWQ MAC of 0.01 mg/L;
- The pH, measured between 8.51 in sample results and 8.57 in the field, is above the GCDWQ AO upper threshold value of 8.5 for pH;
- All other parameters measured were below applicable GCDWQ health-based criteria and aesthetic objectives at the time of sampling; and
- A review of indicators for potential contamination shows no elevated concentrations of any of the parameters analyzed.

5.48.5 Water Treatment and Distribution

Table 5-124: Teslin Health Centre Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Wells serving the system	Teslin Health Centre well	
Treatment type	Sand filter and water softener	
Water Users	YG employees and patients	
Delivery method	Connected directly to Health Centre	
Age of system/last known update	Unknown	

5.48.6 Source Water Protection Planning

There is no SWPP in place for the Teslin Health Centre Well 4951. Given the unknown aquifer and well characteristics and the fact that the water supplies the Health Centre, source water protection planning here may be warranted. An integrated SWPP that includes the Teslin School and Village of Teslin water supply wells would provide a comprehensive approach to protecting the groundwater resource in Teslin.

Potential sources of contamination in the vicinity of the wellhead were identified as part of the 2005 SPDWSA site review. The potential contaminant sources included:

- The community sewer main located approximately 30 m from the well;
- Two ASTs located approximately 5 m and 9 m from the well; and
- Four raw sewage spills had occurred at the lift station 2 on Jackson Avenue, which is located approximately 200 m from the well. However, it is unlikely these spills impacted the well.

5.48.7 Water Supply Information Data Gaps

Tetra Tech has obtained review comments from YG PMD regarding the current status of this system and to our knowledge this summary is complete and accurate to March 2017. The following data gaps have been identified:

- Several upgrades on the water system including installation of a disinfection system, were recommended by Tetra Tech in 2006; however, it is our understanding that no updates have been completed to the system since 2006; and
- There is no source water protection planning for this groundwater resource. Source water protection planning here could be incorporated into a Village of Teslin SWPP and provide comprehensive planning to protect the shallow and deep groundwater aquifers identified at this well location. The well depth, lithology, GUDI status and other details are unknown, effort spent to track down the well log would be merited.

5.49 Watson Lake - Town of Watson Lake Water Supply System

The Town of Watson Lake is located at km 1,022 on the Alaska Highway and is served by a community water system. Water for the community water system is sourced from groundwater supply wells (Well 4 and Well 5), is treated at a water treatment plant (constructed in 2013), and delivered via a piped water distribution system. The water system is owned and operated by the municipality. The Watson Lake water supply system serves a population of approximately 790 people (Yukon Bureau of Statistics 2016) and is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007).

5.49.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners, governing bodies and regulators to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. The following stakeholders were contacted to provide information regarding the Town of Watson Lake water supply system:

- Town of Watson Lake – Town of Watson Lake water system operator provided review comments and information regarding the new water treatment system and the local hydrology.
- YG Community Services (the client) – YG CS provided data for Watson Lake regarding the water system upgrades when the other proponents contacted were not able to find the documents.
- YG Environmental Health – YG EHS was contacted and assisted with the provision of data for Watson Lake water treatment.

5.49.2 Hydrogeology

The Town of Watson Lake is underlain by glaciofluvial deposits consisting of sands and gravels. The thickness of the overburden underlying Watson Lake is unknown, but wells drilled in the well field area as deep as 32 m have not encountered bedrock. The glaciofluvial deposits are heterogeneous with varying composition, including cobbles, gravels, sands and silts. Wells in the Watson Lake municipal well field are completed in these glaciofluvial deposits.

The nearest surface water body to the Watson Lake wells is Wye Lake. Wye Lake has limited surface water inflow and discharge and is thought to primarily recharge and discharge through shallow groundwater flow.

Wells 4 and 5 both encountered similar lithology during drilling. Materials encountered were coarse and permeable from surface to the well completion depths with sands and gravels encountered above the target aquifer. The target aquifer is comprised of sand and gravel and was encountered at 23.0 m bgs in Well 4 and at 20.8 m bgs in Well 5. At both well locations, the aquifer consists of sand and gravel to the drilling completion depth of about 29.5 m bgs. The lack of a fine-grained confining layer means this aquifer is vulnerable to surface sources of contamination.

As part of the completion of Well 4, MH completed a semi-quantitative analysis of the aquifer vulnerability based on the methodology presented in the Technical Terms of Reference for Groundwater Studies (Ontario Ministry of Environment 2001). The intrinsic susceptibility of the aquifer at Well 4 was calculated to be 5.56. The ISI method defines aquifers with ISI scores of less than 30 to have high susceptibility to surface sources of contamination, and the score here indicates the Watson Lake aquifer is highly vulnerable to surface sources of contamination. The ISI value for Well 4 is similar to the value of 5 calculated for Well 1 (which is completed in the same area and is no longer in use) in 2012 (Tetra Tech 2012). This suggests that the ISI value for the aquifer is likely similar throughout the area.

5.49.3 Summary of Wells

The well logs for the Town of Watson public supply wells are included in the GIS map and database portion of this project. The following tables summarize the completion characteristics of the Watson Lake wells.

Table 5-125: Watson Lake Public Water Supply System, Well 4 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Midnight Sun Drilling Inc. in April 2012	MH 2012
Total well depth	28.3 m bgs	
Casing	12" (305 mm) ID Steel Well Casing	
Casing depth	25.2 m bgs	
Well screen	3.1 m 60 slot (1.52 mm) v-wire well screen from 25.2 m bgs to 28.3 m bgs.	
Static water level	5.6 m bgs (measured on April 25, 2012)	
Sanitary seal	Bentonite gout seal to 4.9 m bgs	
Wellhead completion	Pitless Unit	
Wellhead stickup	0.69 m ags	
Well rated capacity	30 L/s (396 IGPM)	
Well GUDI status	Non-GUDI	Golder Associates Ltd.2015
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-126: Watson Lake Public Water Supply System, Well 5 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Midnight Sun Drilling Inc. in May 2015	MH 2015
Total well depth	26.8 m bgs	
Casing	12" (305 mm) ID Steel Well Casing	
Casing depth	23.1 m bgs	
Well screen	3.05 m of 60 slot (1.52 mm) exposed from 23.8 m bgs to 26.8 m bgs	
Static water level	5.6 m bgs (measured on May 14, 2015)	
Sanitary seal	Bentonite grout surface seal to 4.9 m bgs	
Wellhead completion	Pitless Unit	
Wellhead stickup	0.7 m ags	
Well rated capacity	11.5 L/s (152 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.49.4 Source Water Quality

Upon completion of the two water supply wells in 2012 and 2015, water samples were collected to characterize the water quality and potability. From the water quality results and summaries provided in the well completion reports (MH 2012, MH 2015):

- The water provided from both the wells is calcium-bicarbonate type with a pH of approximately 8.1 and is considered hard to very hard with a measured hardness of 156 mg/L in Well 4 and 209 mg/L in Well 5;
- Measureable nitrite and ammonia concentrations were detected in the water, but are likely attributable to the organic sediments found in the aquifer soils rather than anthropogenic effects;
- The total iron concentration measured in the two wells was between 0.408 mg/L and 0.697 mg/L, which exceeded the GCDWQ AO of 0.3 mg/L;
- The total manganese concentration measured in the wells was between 0.139 mg/L and 0.148 mg/L, which exceeded the GCDWQ AO of 0.05 mg/L;
- The wells were tested for petroleum hydrocarbons including VOC and PAH. All hydrocarbon parameters analyzed were below the detection limits;
- Testing for potential formation of THM and HAA through chlorination treatment found that the results were below the GCDWQ and that THM and HAA formation associated with chlorination treatment process is not likely to occur from Wells 4 and 5; and

- The water quality from both wells met the GCDWQ MACs for all parameters tested (including radiological parameters from Well 4).

5.49.5 Water Treatment and Distribution

Table 5-127: Watson Lake Public Water Supply System Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Town of Watson Lake	Tetra Tech 2012
Water source	Groundwater	p.c. Alan Puckett 2016
Wells serving the system	Well 4 and Well 5	
Treatment type	Pre-chlorination, greensand filtration to remove iron and manganese, secondary chlorine disinfection with baffled tanks for chlorine contact time	Opus DaytonKnight 2014 p.c. Alan Puckett 2017
Population served	Approximately 790	Yukon Bureau of Statistics 2016
Delivery method	Piped	p.c. Alan Puckett 2016
Age of system/last known update	New Water Treatment Plant completed in 2013.	

5.49.6 Source Water Protection Planning

Tetra Tech was not able to find any record that a SWPP/AWPP has been developed for the Town of Watson Lake community water supply system and both YG CS and the system operator were not aware of any such plans. Given that the system supplies the residents of Watson Lake with potable drinking water and is classed as a LPDWS, source water protection planning here is merited.

Watson Lake was established as an air base in 1941 and became an important stop on the military supply route to Alaska with the completion of the Alaska Highway in 1942 and later as an industrial supply route to mines accessed by the Robert Campbell Highway. Today, Watson Lake is a hub for transportation for goods transported from the south into the Yukon.

Potential sources of contamination to the Town of Watson Lake wells and aquifer were identified as part of the 2012 LPDWSA. Wells 4 and 5 were drilled in the same area as Wells 1 and 1a, therefore are in close proximity to the same identified potential sources of contamination. Potential sources of contamination in the vicinity of the Watson Lake supply wells that were identified in 2012 included:

- Above-ground storage tanks, all located >60 m from the wells;
- Wye Lake located approximately 100 m from the wells; and
- Sewer main located approximately 45 m from Well 5.

The nearest surface waterbody to the Watson Lake water supply wells is Wye Lake, which is about 100 m down-gradient of the nearest water well (Well 4).

5.49.7 Water Supply Information Data Gaps

Tetra Tech was not able to obtain all records for the updates to the water supply system since 2012, as a result some data gaps have been identified:

- No source water protection is in place for the system. Source water protection planning is an effective tool for maintaining the integrity of water supply systems and aquifers and is considered an essential part of best management practices for water supply systems. Source water protection for the Watson Lake well field would allow for increased protection of the unconfined, vulnerable groundwater aquifer; and.
- Wells 1, 1a, 2 and 3 have not been decommissioned. These wells should either be securely maintained in anticipation of future use, or, if they are no longer needed, should be decommissioned in accordance with best management practices to protect the groundwater supply.

5.50 Watson Lake Area - 2/2.4/2.5 Mile Liard First Nation Water Supply System

The 2/2.4/2.5 Mile Community (2 Mile Community) is located on the Alaska Highway just north of Watson Lake and is home to residents of the Liard First Nation (LFN). The community is home to about 397 people (Neegan Burnside, 2010). Residents in the LFN communities of Upper Liard, 2 Mile Village, and Albert Creek as well as other locations are supplied with domestic water by a trucked water distribution from the LFN bulk water delivery system. The system consists of two groundwater wells (TW05-02 and TW05-03), a treatment plant, a piped distribution system and a trucked distribution system. Both the water supply system and water treatment plant are owned and operated by LFN. The LFN bulk water delivery system is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007).

5.50.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following proponents regarding the Liard First Nation 2 Mile Community water supply system:

- Liard First Nation – Confirmed in 2016 that Tetra Tech had the most up to date well data, gave information for water delivery and water connections to new subdivision and gave approval for use of Tetra Tech data for the project.
- YG Environmental Health – YG EHS was contacted and project review comments and data for systems where the information available was not complete.

Tetra Tech was not able to contact LFN water system operators or public works managers to obtain review comments for this 2017 system summary.

5.50.2 Hydrogeology

The LFN 2 Mile Community is located on undulating moraine and colluvium deposits overlying bedrock. Surficial geology mapping indicates a continuous zone of similar overburden sediments extending throughout and in between the Town of Watson Lake community wells and the 2 Mile Community on the west side of the Robert Campbell Highway. These sediments are described as gravel, sand and silt, outwash plain deposits with occurrences of silty till sediments, typically less than 30 m in thickness (Tetra Tech 2006).

Available lithological information recorded in well logs confirm the above surficial geology interpretations. The majority of existing wells in the area have been completed a depths less than 30 m, and have generally indicated a large degree of heterogeneity with respect to the grain size distribution and permeability of the sediments encountered. Continuous zones of sediments with similar grain size distributions are not likely to extend for large distances vertically or horizontally; therefore, the groundwater potential at specific locations is difficult to predict. Nonetheless, the potential for development of a groundwater supply to meet the water demand of small communities, is typically quite high for these types of deposits (Tetra Tech 2006).

Groundwater flow directions in the 2 Mile Community area are interpreted to be south to southwesterly in the immediate vicinity of Small Lake. A groundwater flow divide is inferred along the topographic high between Tu Cho Drive and Eskeyeh Tene Drive. The groundwater flow direction to the north of this divide is interpreted to range from west to north, generally towards Watson Lake (Tetra Tech 2006).

The two wells serving the LFN public water supply system, TW05-02 and TW05-03, are both completed within a semi-confined to unconfined sand and gravel aquifer overlain by varying degrees of silt, sand and till (Tetra Tech 2008).

As part of aquifer and wellhead protection planning, Tetra Tech completed an analysis of the vulnerability of the aquifer in 2008 based on the semi-quantitative ISI (Ontario Ministry of Environment, 2001). The ISI values for the aquifer were found to be 34 and 26 at TW05-02 and TW05-03 respectively. The ISI method defines aquifers that score between 30 and 80 as having moderate susceptibility to surface source of contamination and those scoring less than 30 as having high susceptibility to surface source of contamination. The score of 26-34 suggests that the aquifer here has medium to high vulnerability to surface sources of contamination.

5.50.3 Summary of Wells

Logs for the two public wells serving the LFN public water supply system are included as attachments in the map and database portion of this project. The following tables summarize the completion characteristics of the LFN wells.

Table 5-128: Liard First Nation Public Water Supply, Well TW05-02 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Double D Drilling Ltd. in November 2005	Tetra Tech 2006
Total well depth	37.5 m bgs	
Casing	8" (203 mm) ID Steel Well Casing	
Casing depth	35.7 m bgs	
Well screen	1.8 m 60 slot (1.52 mm) stainless steel well screen from 35.7 m bgs to 37.5 m bgs	
Static water level	13.3 m bgs (January 10, 2006)	
Sanitary seal	Bentonite surface seal to 5.8 m bgs	
Wellhead completion	Pitless unit	Tetra Tech 2012 site visit
Wellhead stickup	1.0 m	
Well rated capacity	10.8 L/s (142 IGPM)	Tetra Tech 2006
Well GUDI status	Not assessed	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-129: Liard First Nation Public Water Supply, Well TW05-03 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Double D Drilling Ltd. in November 2005	Tetra Tech 2006
Total well depth	43.4 m bgs	
Casing	8" (203 mm) ID Steel Well Casing	
Casing depth	41.9 m bgs	
Well screen	1.5 m 60 slot (1.52 mm) stainless steel well screen from 41.9 m bgs to 43.4 m bgs	
Static water level	12.9m bgs (January 12, 2006)	
Sanitary seal	Bentonite surface seal to 6.1 m bgs	
Wellhead completion	Pitless unit	Tetra Tech 2012 site visit
Wellhead stickup	1.0 m	
Well rated capacity	10.8 L/s (142 IGPM)	Tetra Tech 2006
Well GUDI status	Not assessed	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.50.4 Source Water Quality

Water supplied from wells TW05-02 and TW05-03 at the 2 Mile Community system is sourced from the same aquifer based on well completion depth, hydraulic testing results and water chemistry results. In 2012, Tetra Tech conducted a review of groundwater chemistry results for this site as part of the LPDWSA. At the time of the 2012 LPDWSA, only three water samples were available for review. The following observations are from the 2012 review:

- The water from the aquifer can be classified as calcium-bicarbonate type;
- The source water was hard to very hard ranging from 167 mg/L to 214 mg/L (as CaCO3) on the dates sampled;
- Iron has been found in all samples collected from both wells to be in exceedance of GCDWQ AO of 0.3 mg/L. The iron concentration was found to increase in well TW05-02 and reached a maximum concentration of 2 mg/L on January 12, 2006; the measured iron concentration was approximately 6.7 times the GCDWQ AO value;
- Manganese has consistently been found to have a concentration of approximately 0.1 mg/L in all the samples taken, which were above the GCDWQ AO of 0.05 mg/L; and
- Turbidity was found to be high in all samples taken, ranging from 13.1 NTU to 26.2 NTU. Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration is expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU.

5.50.5 Water Treatment and Distribution

Table 5-130: Liard First Nation Public Water Supply, Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Liard First Nation	Tetra Tech 2006
Water source	Groundwater	
Wells serving the system	TW05-02 and TW05-03	
Treatment type	Pre-chlorination, greensand filtration, chlorine disinfection	Annual inspection report 2016/2017
Number of connections	10 piped and approximately 90 truck delivery locations	p.c. Robert Greenway, March 2016
Delivery method	Trucked/Piped	
Age of system/last known update	The water treatment system was constructed in 2010	

5.50.6 Source Water Protection Planning

Source Water Protection Planning in the form of an AWPP for the LFN public water supply wells was completed in 2008 by Tetra Tech. The AWPP can be found as an attachment to the GIS map and database.

Tetra Tech developed the AWPP for these wells based on the Risk Based Approach. Capture zones for the wells were developed using numerical modelling based on the Visual MODFLOW modelling code (Version 4.1.0.145) developed by Waterloo Hydrogeological Inc., and based on the USGS MODFLOW code for simulating groundwater flow. To account for uncertainty in the model, Tetra Tech added a 20 m buffer zone to the outside of the modelled capture zones.

The key recommendations and conclusions from the AWPP included:

- The vulnerability of the semi-confined aquifer in which the LFN Community Wells are completed is rated as medium to high;
- Most existing risks were medium including septic systems, heating oil tanks, and livestock corrals, however the existence of the former oil pipeline represented a high risk if historical spills had occurred;
- The proposed (at the time, now built) development on residential lots could present risk to the aquifer;
- Any release of contaminants within the identified capture zones would represent a potential risk to the aquifer and water quality for the community wells;
- Risk management/mitigation and monitoring strategies including contingency planning, regular annual tracking, septic system monitoring, increased well security and hazardous waste minimization and collection programs should be used to reduce the existing risks and the likelihood of potential risk scenarios;
- Potential contaminants of concern in the vicinity of the public supply wells are related to residential use including heating fuel supply, septic systems and livestock corals. Additional potential contamination sources include possible spills on the Robert Campbell Highway and a former pipeline right of way; and

- The LFN water supply system is supported by two wells serving as the primary and backup supply wells to create redundancy and prevent loss of water supply should one well fail or be temporarily shut off for maintenance or repair.

5.50.7 Water Supply Information Data Gaps

Tetra Tech conducted reviews of available data, and after communication with YG CS, INAC and the water system operator, we are not aware of any other upgrades to the system. Tetra Tech was not able to contact the LSCFN water system operator to obtain review comments for this 2017 system summary. For the purposes of this study, Tetra Tech has identified the following data gaps:

- The AWPP was last updated in 2008, and Tetra Tech recommends updating the AWPP on a 5-year basis to capture any changes in the well capture zones. Potential risks posed from the new residential area that has been developed in the vicinity of TW05-02 and TW05-03 should be assessed and incorporated in the AWPP.

5.51 Watson Lake Area - Upper Liard Firehall Water Supply System

The Upper Liard Firehall is supplied water from a well (Well 4962) located inside the Firehall washroom. The well supplies water to the domestic water supply for the Firehall as well as a 4,300 L steel water storage tank for firefighting use (Tetra Tech 2006). The system is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide for human consumption.

5.51.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following water system owners, operators and proponents regarding the Upper Liard Firehall Water Supply System:

- YG Property Management Division – YG PMD has been consulted and has provided review comments and data for the compilation.
- YG Community Services (the client) – YG CS provided data for systems where proponents contacted were not able to find the documents and/or YG CS had the data readily available.

5.51.2 Hydrogeology

There is no log available for Well 4962. Examination of other well logs in the Upper Liard area indicate alternating sand and gravel sediments with occasional silt and peat (Tetra Tech 2006). Most wells in the area are completed at depths of 10 m to 16.5 m within a sand and gravel aquifer, and no significant fine-grained material or confining layer is noted (Tetra Tech 2006); thus the vulnerability of the aquifer is considered to be high.

Well 4962 is located approximately 500 m west of the Liard River and 200 m south of Albert Creek. The direction of groundwater flow is likely east to north towards the Liard River and Albert Creek (Tetra Tech 2006).

5.51.3 Well Summary

The following table summarizes the known details for Well 4962.

Table 5-131: Upper Liard Firehall, Well 4962 Summary

Well Construction Parameters	Details	Source
Date of construction	Likely in 1987	p.c. Nick Barnett 2017
Total well depth	Unknown	
Casing	6” (152 mm) OD Steel Well Casing	Well log
Casing depth	Unknown	Tetra Tech 2006
Well screen	Unknown	
Static water level	Unknown	
Sanitary seal	No record of sanitary seal installation	

Table 5-131: Upper Liard Firehall, Well 4962 Summary		
Well Construction Parameters	**Details**	**Source**
Wellhead completion	The well is located inside the Firehall washroom	
Wellhead stickup	At grade (measured on June 22, 2005)	
Well rated capacity	Unknown	
Well GUDI status	Potentially GUDI	Based on well construction
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines as there is likely no sanitary seal and the well stick-up does not extend 600 mm above grade.	

5.51.4 Source Water Quality

The most recent available water quality results from the system for this study were from September 13, 2004 and June 22, 2005. Water quality results include typical drinking water package as well as laboratory analysis of UV absorbance, tannins and lignin, turbidity, total and dissolved manganese, and TOC. The key observations and comments noted in the chemical water quality review for Well 3172 are summarized as follows (Tetra Tech 2006):

- The water was considered very hard (approximately 220 mg/L as $CaCO_3$) on the date sampled and the high hardness is considered poor for aesthetic purposes;
- The turbidity of the water ranges from 3.0 NTU to 49.9 NTU on the dates sampled. The severe increase in turbidity between the September 2004 and June 2005 samples, however, does indicate that the aquifer from which the Liard Firehall receives its water supply may be subject to seasonal fluctuations in water quality and as such may be under the direct influence of surface water (GUDI). Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration is expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU;
- The water quality results indicated that the water from Well 4962 meets the GCDWQ for all the parameters analyzed with the exceptions of total iron *and* total and dissolved manganese:
  - The total iron concentration was reported to be 0.16 mg/L for the sample collected on September 13, 2004; however, the sample collected subsequently on June 22, 2005 had a total iron concentration of 1.4 mg/L, which exceeded the GCDWQ AO of 0.3 mg/L; and
  - The total manganese concentrations were reported to range from 0.0537 mg/L to 0.118 mg/L and the dissolved manganese concentration was reported to be 0.0573 mg/L on the dates sampled, signifying that the manganese content can be almost entirely attributed to dissolved particles. The total and dissolved manganese concentrations all exceed the GCDWQ AO of 0.05 mg/L.
- Review of chloride, nitrate and nitrite showed all three to be low and within the normal background ranges, suggesting that the aquifer was not under the influence of anthropogenic surface sources of nutrients or anions such as septic wastes at the time of sampling.

5.51.5 Water Treatment and Distribution

Table 5-132: Upper Liard Firehall Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Number of wells serving the system	Upper Liard Firehall well (Well 4962)	
Treatment type	None	
Water users	Users of the Firehall	
Delivery method	Direct piped connection to the Firehall	
Age of system/last known update	Unknown	

5.51.6 Source Water Protection Planning

There is no SWPP or AWPP in place for the Upper Liard Firehall water system. Tetra Tech was not able to obtain any record of a GUDI assessment for the system. During the 2005 SPDWSA, the following potential contaminant sources were identified within 30 m of the well (Tetra Tech 2006):

- A septic tank located approximately 8 m from the well;
- A septic field (if present) is less than 30 m from the well; and
- The well is located in the Firehall washroom.

During the SPDWSA conducted in 2005, it appeared that the septic system was not constructed in accordance with regulation. It is likely that the tank discharges effluent to a field located east of the tank and less than 30 m from the well; however, this should be confirmed (Tetra Tech 2006).

In addition, on May 9, 1996, it was reported that a fuel tank near the Upper Liard Wash House tipped over, spilling approximately 113 L of fuel oil (Tetra Tech 2006). The spill occurred a significant distance from the Firehall and there is no risk associated with this water system (Tetra Tech 2006).

It is unknown whether some of these PCOC have been relocated. The vulnerability of the aquifer in which this well is completed is considered to be high and a SWPP would provide a valuable tool for identifying, monitoring and managing risks to the wells and aquifer.

5.51.7 Water Supply Information Data Gaps

YG PMD has reviewed this summary and provided comments. To our knowledge, this system is accurate and up to date as of March 2017. Tetra Tech identified the following data gaps:

- Several upgrades including water treatment and disinfection were recommended by Tetra Tech in 2006; however, Tetra Tech understands there have not been major upgrades to the system since 2006; and
- No SWPP or GUDI assessment is in place for this groundwater resource.

5.52 Watson Lake - Airport Pumphouse Water Supply System

The Watson Lake Airport is located about 8 km northwest of the Town of Watson Lake, Yukon. The Watson Lake Airport pumphouse water supply system provides potable water to the Watson Lake Air Terminal Building, Maintenance Garage and Camping Area. The water system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water sources for human consumption.

5.52.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with YG PMD regarding all water systems they operate and/or maintain. YG PMD has provided review comments review comments and data for the compilation.

5.52.2 Hydrogeology

This Watson Lake Airport well was drilled to a depth of 33.2 m bgs and completed at a depth of 32.6 m bgs. From the well log, lithology encountered during drilling included a silt and sandy silt layer from 17.8 m bgs to 21.1 m bgs, and this 3.3 m thick fine-grained layer provides some degree of protection from surface contamination sources. The static water level in this well at the time of drilling was 5.3 m bgs. The groundwater flow direction inferred from topography is south towards Watson Lake.

5.52.3 Well Summary

The well log from the Watson Lake Airport Pumphouse well is included in the GIS map and database portion of this project. The following table summarizes available data for the water well.

5.52.4 Source Water Quality

The most recent water quality data available for this current study was from 2005 when Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified potential parameters of concern. The observations made in 2005 are summarized below:

- The groundwater source is calcium-bicarbonate type with a pH of approximately 7.4 and is considered medium-hard with a measured hardness of 112 mg/L to 114 mg/L (as $CaCO_3$) on the dates sampled;
- Turbidity measured ranged from 23.4 NTU to 142 NTU. Health Canada recommends that groundwater sources provide water with turbidity less than 1.0 NTU and that water from GUDI sources have appropriate filtration and disinfection. Filtration is expected to achieve a turbidity level of 1.0 NTU for slow sand or diatomaceous earth filtration, 0.3 NTU for conventional direct filtration and 0.1 NTU for membrane filtration in 95% of samples between filter changes or per month with no measurements exceeding 3.0 NTU;
- The colour in the initial sample was measured at 60 CU which exceeds the GCDWQ AO of 15 CU, but the water colour in the subsequent sample was measured at <5 CU;
- Total iron concentration measured ranged from 1.28 mg/L to 3.14 mg/L, and exceeded the GCDWQ AO of 0.3 mg/L. The dissolved iron concentration was measured at 1.25 mg/L, which was similar to the total iron concentrations, indicating that the iron content can be attributed to both suspended solids an dissolved particles;
- Total manages concentration measured ranged from 1.84 mg/L and 2.69 mg/L, and exceeded the GCDWQ AO of 0.05 mg/L. The dissolved manganese concentration, measured at 2.65 mg/L, also exceeded the GCDWQ

AO, and indicates that the manganese occurs as dissolved ions and cannot be entirely attributed to elevated turbidity;

- The water met all other GCDWQ health-based and aesthetic objectives for the parameters tested;
- EPH and PAH were below the detection limits; and
- Review of chloride, nitrate and nitrite showed all three to be low and within the normal background ranges, suggesting that the aquifer was not under the influence of anthropogenic surface sources of nutrients or anions such as septic wastes at the time of sampling.

5.52.5 Water Treatment and Distribution

Table 5-133: Watson Lake Airport Pumphouse Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017 p.c. Barry Drury 2017
Water source	Groundwater	
Wells serving the system	Watson Lake Airport Pumphouse Well	
Treatment type	None	
Water users	Wash water for airport workers, flight crews and passengers. Drinking water is supplied by water delivery	
Delivery method	Piped service connection to Airport building	
Age of system/last known update	Unknown	

5.52.6 Source Water Protection Planning

There is no SWPP/AWPP in place for the Watson Lake Airport Pumphouse Well 4851. Given the industrial nature of work on the adjacent Tanker Storage site and fuel storage at the airport, source water protection planning here would be warranted. An integrated SWPP that includes the Tanker Base supply well would provide a comprehensive approach to protecting the groundwater resource at the Watson Lake Airport.

Potential sources of contamination in the vicinity of the wellhead that were identified as part of the 2005 SPDWSA site review, included:

- Sewer service lines at approximately 20 m from the well; and
- Reported hydrocarbon contaminants in soil and groundwater as close as 5 m to the well.

5.52.7 Water Supply Information Data Gaps

Tetra Tech understands there have not been significant upgrades to the water system since the SPDWS review in 2005. Data gaps identified in the course of this summary are:

- There is no source water protection planning for this groundwater resource; and
- As an outcome of the 2005 SPDWSA, Tetra Tech recommended installation of potassium permanganate green sand filtration system and an activated carbon filtration to reduce the high concentrations of iron, manganese and turbidity and to remove any potential hydrocarbon contamination. Tetra Tech understands this work has not been completed. Tetra Tech also recommended routine quarterly sampling for hydrocarbon contamination indicators. Tetra Tech understands this monitoring has not been implemented (p.c. B. Drury 2017).

5.53 Whitehorse – City of Whitehorse Water Supply System

The City of Whitehorse is home to approximately 25,100 people (Yukon Bureau of Statistics 2016). The Whitehorse public water supply system serves water to the majority of Whitehorse residents by piped water distribution. The public water system is supplied from groundwater wells completed in the Riverdale Aquifer (formerly referred to as the Selkirk and Riverdale Aquifers). The City of Whitehorse water supply system is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007).

5.53.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Tetra Tech contacted the following proponents regarding data for the City of Whitehorse public water supply system:

- City of Whitehorse – Provided SWAPP (Summit Environmental 2013), gave approval for use of Tetra Tech data for the project, provided review comments for the final draft.
- YG Environmental Health – YG EHS was contacted for use of the 2012 LPDWS review report, verification of water treatment and to provide review comments and feedback throughout the project.

5.53.2 Hydrogeology

The Whitehorse public water supply wells are completed in overburden sand and gravel deposits of glaciofluvial origin. Wells in use include WW4, WW4N, WW5N, WW6, WW8, WW9 and WW10. The wells are completed in the Riverdale Aquifer with well clusters in two distinct areas:

- Wells WW8, WW9 and WW10 are completed in the southern area of Riverdale near the Chadburn Lake road. Tetra Tech understands that the majority of water supplied to the system is preferentially sourced from these three wells (p.c. Wayne Tuck 2017).
- Wells WW5N, WW4, WW4N and WW6 are completed along the Yukon River near the Selkirk Elementary School and F.H. Collins High school.

Lithology logs for the area indicate that there are some discontinuous fine-grained sediments overlying the aquifer in both wellfields; however, Tetra Tech considers the aquifer to be unconfined and vulnerable to surface sources of contamination.

As part of the 2012 LPDWSA of the Whitehorse water supply system, Tetra Tech assessed the vulnerability of the Riverdale Aquifer in the vicinity of the two well fields using the semi quantitative ISI method suggested by the Ontario Ministry of Environment (2001). The ISI method defines aquifers with ISI scores of less than 30 as having high intrinsic susceptibility to surface sources of contamination. The ISI method resulted in values in the high 20's at WW4 and WW6, an indication that the aquifer underlying the site has a relatively high vulnerability to potential surface sources of contamination. WW8 and WW9 had ISI values of 11 and 13, which also suggest high vulnerability to surface sources of contamination.

Tetra Tech understands that in 2016 wells WW1, WW2, and WW3 were decommissioned in accordance to the Canadian Groundwater Association Well Construction Guidelines for water well decommissioning to ensure they would not be a potential contaminant pathway in future. We also understand that the City plans to decommission well WW5 in 2017, and that WW4 will, in future, be replaced entirely by WW4N (p.c. L. Shipman 2017, p.c. Wayne Tuck 2017).

5.53.3 Summary of Wells

The well logs for the City of Whitehorse public supply wells are included in the GIS map and database produced for this project. The following tables summarize the completion characteristics of the City of Whitehorse wells.

Table 5-134: City of Whitehorse Public Drinking Water Supply, Well WW4 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by International Water Supply Limited in March 1972	Tetra Tech 2012
Total well depth	21.3 m bgs	Summit 2013
Casing	12” ID (305 mm) Steel Well Casing with welded joints	Well Log
Casing depth	16.8 m bgs	
Well screen	3 m 77-slot (0.18 mm) and 1.5 m 6-slot (0.15 mm) v-wire well screen from 16.8 m bgs to 21.3 m bgs.	Summit 2013
Static water level	1.7 m bgs	Well Log
Sanitary seal	A sanitary seal was not installed at the time of well construction, and there are no records indicating that a seal has ever been installed.	Tetra Tech 2012
Wellhead completion	Housed in a heated pump house with a removable roof hatch which is located within a locked fence enclosure.	
Wellhead stickup	0.70 m ags	
Well rated capacity	30.2 L/s (398 IGPM)	GLL 2000
Well GUDI status	Non-GUDI	AECOM 2010a
Well Construction Comments:	As the well is not completed with a sanitary seal, the well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-135: City of Whitehorse Public Drinking Water Supply, Well WW4N Summary

Well Construction Parameters	Details	Source
Date of construction	Encore Coring & Drilling Inc. 2010	AECOM 2011a
Total well depth	36.7 m bgs	Well Log
Casing	16” OD (406 mm) steel well casing with welded joints	
Casing depth	27.1 m bgs	

Table 5-135: City of Whitehorse Public Drinking Water Supply, Well WW4N Summary		
Well Construction Parameters	**Details**	**Source**
Well screen	9.57 m 200-slot (5.08 mm) -wire well screen from 27.1 m bgs to 36.7 m bgs.	
Static water level	9.15 m bgs	AECOM 2011b
Sanitary seal	5.5 m bgs	AECOM 2011a
Wellhead completion	Well completed in a concrete vault with Bilco hatch, floor at ground level, walls 1.2 m ags, ground built up and sloped away at 2% grade. The wellhouse is located within a locked and fenced enclosure	p.c. L. Shipman 2017
Wellhead stickup	0.84 m ags	p.c. L. Shipman 2017
Well rated capacity	77 L/s (1,016 IGPM)	AECOM 2011b
Well GUDI status	Not assessed	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-136: City of Whitehorse Public Drinking Water Supply, Well WW5N Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Midnight Sun Drilling Co. Ltd. In September 2005	Well Log
Total well depth	45.2 m bgs	
Casing	16” (406 mm) Steel Well Casing with welded joints	
Casing depth	36.1 m bgs	
Well screen	9.1 m 200 slot (5.08 mm) v-wire well screen from 36.1 m bgs to 45.2 m bgs.	
Static water level	3.99 m bgs (October 27, 2005)	
Sanitary seal	Surface seal to 3.35 m bgs	Summit 2013
Wellhead completion	Housed in a heated pump house with a removable roof hatch which is located within a locked fence enclosure	Tetra Tech 2012
Wellhead stickup	0.9 m ags	Tetra Tech 2012
Well rated capacity	168 L/s (2,200 IGPM)	GLL 2006

Table 5-136: City of Whitehorse Public Drinking Water Supply, Well WW5N Summary		
Well Construction Parameters	**Details**	**Source**
Well GUDI status	Non-GUDI	AECOM 2010a
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines as the surface seal was not completed to the recommended depth of 5.0 m bgs.	

Table 5-137: City of Whitehorse Public Drinking Water Supply, Well WW6 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	1974	Summit 2013
Total well depth	26.2 m bgs	
Casing	16” (406 mm) OD steel well casing with welded joints (15 ¼” / 378 mm ID)	Well Log
Casing depth	19.2 m bgs	
Well screen	6.2 m 200 slot (5.08 mm) v-wire well screen from 20.4 m bgs to 26.6 m bgs	
Static water level	8.9 m bgs (August 2009)	Tetra Tech 2012
Sanitary seal	A sanitary seal was not installed at the time of well construction. A silty, sandy barrier was installed around the perimeter of the wellhouse.	Tetra Tech 2012 City of Whitehorse 2016
Wellhead completion	Housed in a heated pump house located within a locked fence enclosure. Site grading was completed in 2016 to prevent water ponding around well building.	Tetra Tech 2012
Wellhead stickup	0.60 m ags	
Well rated capacity	90.9 L/s (1,200 IGPM)	GLL 2005
Well GUDI status	Non-GUDI; however it was recommended that ongoing monitoring related to GUDI status be completed.	AECOM 2010a, Summit 2013, Tetra Tech 2013
Well Construction Comments:	As the well is not completed with a sanitary seal, the well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-138: City of Whitehorse Public Drinking Water Supply, Well WW8 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Completed by Encore Coring & Drilling Inc. in October 2008.	Tetra Tech 2009
Total well depth	27.4 m bgs	
Casing	16” (406 mm) Steel Well Casing	
Casing depth	21.6 m	
Well screen	1.5 m 60 slot (1.52 mm) from 22.7 m bgs to 24.2 m bgs, 3.2 m 200 slot (5.08 mm) v-wire well screen from 24.2 m bgs to 27.4 m bgs. The total screen length is 4.7 m.	
Static water level	6.1 m bgs (November 3, 2008)	
Sanitary seal	Surface seal to 5.8 m bgs	
Wellhead completion	Housed in a heated pump house with a removable roof hatch which is located within a locked fence enclosure	Tetra Tech 2012
Wellhead stickup	0.80 m ags	
Well rated capacity	72.9 L/s (962 IGPM)	Tetra Tech 2009
Well GUDI status	Non-GUDI	AECOM 2010b
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-139: City of Whitehorse Public Drinking Water Supply, Well WW9 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Completed by Encore Coring & Drilling Inc. in October 2008	Tetra Tech 2009
Total well depth	29.0 m bgs	
Casing	16” (406 mm) Steel Well Casing	
Casing depth	20.6 m bgs	
Well screen	2.4 m 60 slot (1.52 mm) from 21.7 m bgs to 24.2 m bgs, 1.5 m 120 slot (3.05 mm) from 24.2 m bgs to 25.8 m bgs, 1.5 m 150 slot (3.81 mm) v-wire well screen from 25.8 m bgs to 27.4 m bgs; 1.5 m 20 slot (0.51 mm) screen from 27.4 m bgs to 29 m bgs. The total screen length is 7.3 m.	

Table 5-139: City of Whitehorse Public Drinking Water Supply, Well WW9 Summary		
Well Construction Parameters	**Details**	**Source**
Static water level	5.7 m bgs (November 7, 2008)	
Sanitary seal	12.1 m bgs	
Wellhead completion	Housed in a heated pump house with a removable roof hatch which is located within a locked fence enclosure.	Tetra Tech 2012
Wellhead stickup	0.75 m ags	
Well rated capacity	78.7 L/s (1,039 IGPM)	Tetra Tech 2009
Well GUDI status	Non-GUDI	AECOM 2010b
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-140: City of Whitehorse Public Drinking Water Supply, Well WW10 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Completed by Midnight Sun Drilling Ltd. in 2014	Morrison Hershfield 2015
Total well depth	62.2 m bgs	
Casing	16” (406 mm) OD Steel Well Casing with welded joints	Well Log
Casing depth	52.93 m bgs	
Well screen	9.14 m 150 slot (3.81 mm) v-wire well screen from 53.9 m bgs to 63.04 m bgs	
Static water level	7.32 m bgs (September 7, 2014)	Morrison Hershfield 2015
Sanitary seal	5 m bgs	
Wellhead completion	Housed in a heated pump house with a removable roof hatch which is located within a locked fence enclosure	p.c. L. Shipman 2017
Wellhead stickup	0.80 m ags	Morrison Hershfield 2015
Well rated capacity	163 L/s (2,151 IGPM)	
Well GUDI status	Not assessed	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.53.4 Source Water Quality

Tetra Tech reviewed the water quality summary from the Summit Environmental SWAPP as well as the most recent water quality results from City of Whitehorse 2016 monitoring. City of Whitehorse conducts ongoing monitoring for a number of water quality parameters, and Tetra Tech has not completed a comprehensive review of these results.

Based on a review of the water quality data from 2008 and 2010 included in the SWAPP, as well as the 2016 water quality results, Tetra Tech makes the following observations:

- The samples met the GCDWQ for all parameters tested.
- The water chemistry differs between the two wellfield areas of Riverdale. Water from Wells WW8 and WW9, in the south Riverdale area, is calcium-bicarbonate type is considered medium hard with measured hardness between 68 mg/L and 77 mg/L (as CaCO3), while water from wells WW4, WW5N, and WW6, located near the Selkirk Elementary School, is calcium-sulphate to calcium-bicarbonate type and is considered hard to very hard with a measured hardness of 143 mg/L to 220 mg/L (as CaCO3). Water samples from wells in the Selkirk Well Field (WW4, WW5N, and WW6) have higher chloride concentrations than wells in the South Riverdale Well Field (WW8 and WW9).
- Chloride concentrations in all of the results observed were far below the GCDWQ AO of 250 mg/L with concentrations varying from <0.05 to 3.0 mg/L in 2016; and,
- Nitrate concentrations in the wells varied between testing events with a range of about 0.03 mg/L to 0.13 mg/L. All the nitrate concentrations measured in the results reviewed were well below the GCDWQ guideline value of 10 mg/L.

5.53.5 Water Treatment and Distribution

The table below summarizes the characteristics of the City of Whitehorse Public Drinking Water Supply System.

Table 5-141: City of Whitehorse Public Drinking Water Supply Treatment and Distribution Details

Item	Details	Source
Owner/Operator	City of Whitehorse	Tetra Tech 2012
Water source	Groundwater	Summit 2013
Wells serving the system	WW4, WW4N, WW5N, WW6, WW8, WW9 and WW10	
Treatment type	Chlorination	YES 2012
Population served by System	Approximately 23,500 people	City of Whitehorse (Population of 26,608 minus residents in country residential)
Delivery method	Piped Distribution	YES 2012
Age of system/last known update	New water wells completed in 2010 and 2014	AECOM 2010, Morrison Hershfield 2014

5.53.6 Source Water Protection Planning

A source water protection plan (SWAPP) for the Riverdale Aquifer was developed by Summit Environmental on behalf of the City of Whitehorse in 2013. Summit Environmental followed the methodology laid out by the British

Columbia Ministry of Healthy Living and Sport Comprehensive Source-To-Tap Assessment Guideline (STTAG) to prepare the Source Water Assessment and Protection Plan for the City of Whitehorse water supply. Modules 3, 4, 5 and 6 of the BC STTAG, which apply to the engineering and governance of the water supply, were not addressed by the plan.

The capture zones for the Whitehorse water supply wells were characterized using the Numerical Flow Modelling Technique in 2011 by AECOM, and are indicated on the associated GIS map. Summit used the capture zones delineated by the numerical modelling to define aquifer protection areas. As part of the source water protection planning, Summit Environmental identified potential sources of contamination in the vicinity of the City of Whitehorse water supply wells. From the 2013 SWAPP, the following are noted:

- The air photos indicate that potential contamination sources associated with residential and business land use date back to about the 1950s;
- Records review search identified eight contaminated sites, two spills and three permitted fuel storage tanks within the primary and secondary Aquifer Protection Areas (APAs);
- Biological insecticides have been used around the City of Whitehorse. The most commonly used brands are Aquabac and Vectobac. These use a subspecies of the bacteria Bacillus thuringiensis (Bt) to limit the mosquito populations. There is low potential for these bacteria to infiltrate into the groundwater, so their risk is not discussed further;
- The area within the primary and secondary APAs is zoned by the City as residential (single detached and multiple housing), neighbourhood commercial, environmental protection, greenbelt, parks and recreation and public utilities. These zones typically pose low to moderate environmental concerns; and
- One significant conclusion from this work was the identification of 58 wells and/or boreholes in the study area. These provide preferential pathways to the groundwater aquifer and rarely have basic security (i.e., locked well caps and surface seals).

Key conclusions and recommendations from the SWAPP for Whitehorse include:

- Reduce the risk of fuel spills through the implementation of the Fuel Smart Plan;
- Improve emergency preparedness through the implementation of the Emergency Response Plan;
- Educate the public and key City staff about source water contamination;
- Address the management and upgrades of infrastructure in ways that reduce the risk of source water contamination; and
- Implement security and detection systems that protect and monitor the source wells.

Tetra Tech notes that the following recommendations from the SWAPP have been implemented:

- The City of Whitehorse has placed signage indicating the location of the Riverdale Source Water Area;
- City of Whitehorse has a public awareness campaign addressing source water protection underway.

In addition to the current additional source water protection measures, City of Whitehorse is considering the best way to address fuel storage in the source water protection area and is in the process of compiling water quality data to allow for analysis of changes and trends in water quality (p.c. Wayne Tuck 2017).

5.53.7 Water Supply Information Data Gaps

Tetra Tech has reviewed available data from YG Community Services, and data provided by the City of Whitehorse, as well as records kept by YG Environmental Health Services. At this time, Tetra Tech has not identified any significant data gaps related to the scope of this study. Tetra Tech understands that City of Whitehorse are working towards addressing the recommendations in the SWAPP to improve protection of the drinking water resource.

5.54 Whitehorse – Lobird Park Water Supply System

40023 Yukon Inc. (leased to Chena Corporation) owns and operates one public drinking water system at Lobird Park (trailer park), located approximately 1 km west of the Alaska Highway and about 3 km south of the Hillcrest Subdivision, in Whitehorse, Yukon. The system obtains water from five deep drilled groundwater wells (Wells 1, 2, 4, 6 and 8) and is supplemented by water delivery provided by Yukon Water Services due to low groundwater well yields (Tetra Tech 2012). Well 6 is used only seasonally due to freezing issues (Tetra Tech 2012). Wells 1, 2 and 4 are located next to Ice Lake. Wells 6 and 8 are located next to the Radar Apartments and at the north end of Lobird Park, respectively. Three additional wells, Wells 3, 5 and 7, have not been in use since about 2003 (Jacobsen 2003). The system is classified as a Large Public Drinking Water Supply System under the Yukon Drinking Water Regulations – Guidelines for Part I – Large Public Drinking Water Systems (YG 2007).

5.54.1 Data Compilation Methodology

Tetra Tech approached the water system stakeholders including the water system owner/operator and regulators to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Data regarding the Lobird Park water supply system was requested from the following proponents:

- Lobird Water System Owner/Operator Blake Battersby was contacted and provided review comments for the system summary.
- YG Environmental Health – YG EHS was contacted for use of the 2012 LPDWS review report, verification of source water protection planning and to provide review comments and feedback throughout the project.

5.54.2 Hydrogeology

Wells 1, 2 and 4 are completed in bedrock at depths ranging from 103.6 m to 216.4 m bgs near Ice Lake. According to the well logs for these wells, the depth to bedrock is relatively shallow, ranging from 2.1 m to 6.7 m bgs. Wells 6 and 8 are located in the Lobird Park area and completed in bedrock to 74.7 m bgs and 93 m bgs, respectively, overlain with approximately 7 m of overburden. The bedrock type is not indicated on the driller's well records; however, based on surficial geology maps for the area, it is anticipated to be granodiorite. Approximate well yields indicated on the well logs suggest that the bedrock aquifer (fractures) that the wells intersect have low yields, typical of a granodiorite (Tetra Tech 2012).

Bedrock aquifers can be subject to rapid transport of potential contaminants of concern, particularly when there is little overburden cover over the bedrock, or when there are bedrock outcrops nearby. The vulnerability of the bedrock aquifer was not assessed as the well logs had insufficient information regarding well fractures and discontinuities to identify aquifer zones and to semi-quantitatively evaluate the vulnerability (Tetra Tech 2012).

Wells 1, 2, 3, 4 and 5 are located within 60 m of the nearest surface body of water, Ice Lake. The nearest water body to Wells 6, 7 and 8 are the Lobird sewage treatment lagoons located about 400 m south of Well 8 and Icy Lake about 900 m northeast of Well 7.

5.54.3 Summary of Wells

The well logs for the five wells serving the Lobird Park drinking water system are included in the GIS map and database portion of this project. The following tables summarize the completion characteristics of the public drinking water wells at Lobird Park.

Table 5-142: Lobird Public Drinking Water System, Well 1 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Midnight Sun Drilling Co. Ltd. in August 1986	Well log
Total well depth	216.4 m bgs	
Casing	6" (152 mm) OD Steel Well Casing	
Casing depth	Approximately 13 m bgs (approximately 2 m into bedrock)	
Well screen	No well screen installed	
Static water level	Approximately 1.7 m bgs (August 1988)	
Sanitary seal	No record of sanitary seal installation. Wellhouse has a concrete floor.	Tetra Tech 2012
Wellhead completion	The wellhead is equipped with an improvised plastic well cap. Housed in a locked wooden enclosure, freeze protected with heat trace extending into the well.	
Wellhead stickup	Approximately 0.5 m ags	
Well rated capacity (estimated by the driller)	0.27 to 0.3 L/s (3.5 to 4.0 IGPM)	Well log
Well GUDI status	Potentially GUDI	Tetra Tech 2012
Well Construction Comments:	Well was not constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-143: Lobird Public Drinking Water System Well 2 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Midnight Sun Drilling Co. Ltd. in July 1985	Well log
Total well depth	103.6 m bgs	
Casing	6” (152 mm) OD Steel Well Casing	
Casing depth	3.5 m bgs	
Well screen	No well screen installed	
Static water level	2.2 m bgs (July 1985)	
Sanitary seal	No record of sanitary seal installation. Wellhouse has a concrete floor.	Tetra Tech 2012

Table 5-143: Lobird Public Drinking Water System Well 2 Summary		
Well Construction Parameters	**Details**	**Source**
Wellhead completion	The wellhead is equipped with an improvised plastic well cap. Housed in a locked metal enclosure, freeze protection consists of heat trace extending into the well.	Well log
Wellhead stickup	Approximately 0.5 m ags	
Well rated capacity (estimated by the driller)	0.38 L/s (5 IGPM)	
Well GUDI status	Potentially GUDI	Tetra Tech 2012
Well Construction Comments:	Well was not likely constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-144: Lobird Public Drinking Water System, Well 4 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Midnight Sun Drilling Co. Ltd. in October 1990	Well log
Total well depth	112.8 m bgs	
Casing	6" (152 mm) OD Steel Well Casing	
Casing depth	6.5 m bgs (4 m into bedrock)	
Well screen	No well screen installed	
Static water level	3.4 m bgs (October 1990)	
Sanitary seal	No record of sanitary seal installation.	Tetra Tech 2012
Wellhead completion	The wellhead is equipped with an improvised plastic well cap. Housed in a locked wooden enclosure, freeze protected with heat trace extending into the well.	Tetra Tech 2012
Wellhead stickup	0.75 m ags	Tetra Tech 2012
Well rated capacity (estimated by the driller)	0.04 L/s (0.5 IGPM)	Well Log
Well GUDI status	Potentially GUDI	Tetra Tech 2012
Well Construction Comments:	Well was not likely constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-145: Lobird Public Drinking Water System, Well 6 (Seasonal Use Only) Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Midnight Sun Drilling Co. Ltd. in June 1990	Well log
Total well depth	74.7 m bgs	
Casing	6" (152 mm) OD Steel Well Casing	
Casing depth	12 m bgs (5 m into bedrock)	
Well screen	No well screen installed	
Static water level	8.5 m (June 1990)	
Sanitary seal	No record of sanitary seal installation.	Tetra Tech 2012
Wellhead completion	The wellhead is equipped with an improvised plastic well cap. Housed in a locked wooden enclosure and equipped with freeze protection.	p.c. Blake Battersby 2017
Wellhead stickup	0.5 m ags	Tetra Tech 2012
Well rated capacity (estimated by the driller)	0.27 L/s (3.5 IGPM)	Well log
Well GUDI status	Potentially GUDI	Tetra Tech 2012
Well Construction Comments:	Well was not likely constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

Table 5-146: Lobird Public Drinking Water System, Well 8 Summary		
Well Construction Parameters	**Details**	**Source**
Date of construction	Well was completed by Midnight Sun Drilling Co. Ltd. in October 1997	Well log
Total well depth	93 m bgs	
Casing	6 $^{5}/_{8}$" (168 mm) OD Steel Well Casing	
Casing depth	7.5 m bgs (1 m into bedrock)	
Well screen	No well screen installed	
Static water level	25.1 m bgs (October 1997)	
Sanitary seal	No record of sanitary seal installation.	Tetra Tech 2012
Wellhead completion	The wellhead is equipped with an improvised plastic well cap. Housed in a locked wooden enclosure and freeze protection consists of heat trace.	

Table 5-146: Lobird Public Drinking Water System, Well 8 Summary		
Well Construction Parameters	**Details**	**Source**
Wellhead stickup	0.55 m ags	
Well rated capacity	0.38 L/s (5 IGPM)	Well log
Well GUDI status	Potentially GUDI	Tetra Tech 2012
Well Construction Comments:	Well was not likely constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.54.4 Source Water Quality

In 2012, as part of the LPDWSA, Tetra Tech reviewed water quality results for the Lobird Park wells from 2005 to 2010. The following summary is based on the water quality review from that report:

- Water from the wells serving the Lobird system is mixed and treated for uranium before the sampling point, the water quality, after uranium removal, is characterized as calcium-bicarbonate type with a pH of 7.2 to 7.5 and is considered very hard with a measured hardness of 363 mg/L;
- The combined treated water source from the Lobird Park public drinking water system meets the GCDWQ with the exceptions of the AO for total manganese and the MAC for total uranium;
- Manganese in treated water sample is in exceedance of the GCDWQ AO value in 2008, but is found to be below the GCDWQ AO value in 2009 and 2010; and
- In June 2010, the uranium concentration in the treated water sample exceeded the GCDWQ MAC. Environmental Health and the system operator investigated the issue and found that the resin in the uranium treatment system was not working properly. We understand that the water well use was discontinued until a new larger pre-filter was installed and the system was shown to be working properly.

5.54.5 Water Treatment and Distribution

Table 5-147: Lobird Public Drinking Water System Water Treatment and Distribution Details		
	Details	**Source**
Owner/Operator	40023 Yukon Inc. (leased to Chena Corporation)	Tetra Tech 2012
Water source	Blended groundwater supplemented with trucked water delivery from City supply	
Number of wells serving the system	Wells 1, 2, 4 and 8 (year round). Well 6 used in summer	
Treatment type	Chlorination, aeration and uranium removal	Jacobsen 2003 and Tetra Tech 2012
Number of connections	Approximately 250 people	

Table 5-147: Lobird Public Drinking Water System Water Treatment and Distribution Details		
	Details	**Source**
Delivery method	Piped	
Age of system/last known major work	Installation of a new larger capacity pre-filter after 2012 to allow the uranium removal system to operate correctly	

5.54.6 Source Water Protection Planning

Some preliminary source water protection planning has been completed for this system in the form of a review of risk assessment tools for small community water supplies completed by Health Canada in 2009. The Lobird Park System was used as an example system for assessing the performance of the Australian Community Water Planner and the Ontario Risk Categorization Tool.

The pilot study identified potential risk scenarios but lacks key source water protection plan components including:

- Report does not identify well capture zones or wellhead protection areas;
- Report does not provide a thorough summary of risks to the groundwater resource;
- Report does not provide a summary of potential contaminant sources;
- Report does not provide any graphics or maps showing potential contaminant sources;
- Report does not evaluate the level of risk posed to the water system users; and,
- No recommendations for improving source water security or managing potential risks to the system are provided.

5.54.7 Water Supply Information Data Gaps

Tetra Tech has completed the LPDWSA work for the Lobird Park in 2012, review comments have been provided by the water system owner and operator and YG EHS has provided data where available. We have identified the following data gaps:

- While some preliminary assessment of risk to the system has been completed, no SWPP is in place for this system. As the wells are completed in two areas, with Wells 1 through 5 completed in close proximity to a surface water body and Wells 6, 7 and 8 located in close proximity to anthropogenic sources of contamination, Tetra Tech recommends developing a formal SWPP for this system.
- Tetra Tech had recommended the decommissioning of Wells 3, 5 and 7 and possibly Well 8 in 2012; however, we understand that Wells 3, 5, and 7 are not in use, but will be maintained for potential future use and that use of Well 8 will be continued; and
- Tetra Tech was not able to find any record that a GUDI assessment has been completed on the wells.

5.55 Whitehorse Area - Deep Creek Water Supply System

The Deep Creek water system is located approximately 45 km north of Whitehorse, Yukon and provides a self-serve potable water source to residents in the area, including Deep Creek and Grizzly Valley subdivisions, residents of the Ta'an Kwach'an First Nation (TKFN) and Horse Creek (Service Area). Water for the self-serve system is sourced from a bedrock well and the water treatment includes filtration and chlorine disinfection. The small self-serve system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide water for human consumption.

5.55.1 Data Compilation Methodology

Tetra Tech approached stakeholders including YG departments, water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech obtained data regarding the Deep Creek Water Supply system from the following proponents:

- YG Community Services (the client) – YG CS provided data for the Deep Creek Water Supply as this system is owned and operated by YG CS. The YG CS operator provided review comments and edits for the final summary to ensure completeness and accuracy.

5.55.2 Hydrogeology

The Deep Creek area has undergone several episodes of glaciation, the most recent being the Quaternary McConnell glaciation. The topography and surficial geology of the Deep Creek area have been heavily influenced by glacial erosion and deposition (Tetra Tech 2014a).

The surficial geology in the Deep Creek area is characterized by both outcropping bedrock and glacial deposits. Glacial deposits are varied, including till, valley bottom complexes composed of alluvial, colluvial and glacial deposits, meltwater channels and glaciofluvial complexes (Tetra Tech 2014a). The bedrock is comprised of sedimentary members of the lower to middle Jurassic Laberge Group (around 160 to 200 myo) and Lower Jurassic Nordenskjold Group (around 175 to 200 myo). Laberge Group rock types in the study area are mapped as sedimentary rock, with interbedded mudstones, siltstones and sandstones and a conglomerate member. Nordenskjold Group rock types occurring in this area are mapped as sedimentary rocks with volcanic beds, dacite, tuff, sandstone, and conglomerate. Rock types encountered during drilling were members of the Laberge group (Tetra Tech 2014a).

Available logs of wells in the Deep Creek region show bedrock at depths typically between 4.5 m and 17 m, although bedrock outcropped at two well locations (Tetra Tech 2014a). In the Deep Creek region, bedrock was typically overlain by gravelly clay/silt (inferred to be till) with gravel or sand logged at surface in several logs (Tetra Tech 2014a).

The regional groundwater flow regime is interpreted to consist of groundwater recharging via infiltration in the upland areas to the west of DC-2 and groundwater discharging into Deep Creek and Lake Laberge (Tetra Tech 2014a). The regional groundwater flow direction was interpreted to be in an east, northeast direction, which generally corresponds to topography (Tetra Tech 2014a).

The water supply well, DC-2, is completed in the deep confined or semi confined bedrock aquifer (Tetra Tech 2014a). Water-bearing fractures were encountered at DC-2 location between 54.3 m and 121.0 m bgs (Tetra Tech 2014a). Some protection of the aquifer from surface sources of contamination is provided by overburden sediments to 10.5 m below grade, and a thick layer of competent bedrock extending from 17.1 m bgs to the first water bearing

fracture at 54.3 m bgs (Tetra Tech 2014a). The thick competent bedrock layer and properly constructed well completed with a sanitary seal and a bedrock seal decreases the potential for surface water and surface sources of contamination to infiltrate though and impact the water supply at DC-2 (Tetra Tech 2014a).

Well yields from fractured bedrock aquifers can be highly variable and are dependent upon the degree of fracturing and fracture connectivity. Pumping test results from DC-2 indicate a bulk aquifer transmissivity in the order of 7.5×10-5 m^2/s (6.5 m^2/day) (Tetra Tech 2014a).

5.55.3 Well Summary

Well log for DC-2 serving the new Deep Creek Water Supply Facility is included in the GIS map and database. The following tables summarize the completion characteristics of the well.

Table 5-148: Deep Creek Water Supply System, Well DC-2 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Midnight Sun Drilling Inc. in January 2014	Well log
Total well depth	122.5 m bgs	
Casing	6" (152 mm) ID Steel Well Casing	
Casing depth	17.1 m bgs (approximately 3.4 m into bedrock)	
Well screen	No well screen installed. However, 5” (127 mm) nominal diameter PVC liner was installed to 121.0 m bgs, with slotted section (20 slots; 0.51 mm) from 67.7 m bgs to 122.5 m bgs.	Tetra Tech 2014a
Static water level	6.70 m bgs (January 18, 2014)	
Sanitary seal	Bentonite surface seal to 6.1 m bgs	Tetra Tech 2014b
Wellhead completion	Pitless unit installed c/w heat trace strapped to the top of the well. Spray foam insulation on pitless unit	Tetra Tech 2014b
Wellhead stickup	0.89 m ags	Tetra Tech 2014a
Well rated capacity	1.6 L/s (621 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.55.4 Source Water Quality

Tetra Tech collected a groundwater sample from DC-2 at the end of the 48-hour constant-rate pumping test conducted in January 2014 and the following are the key observations and comments noted on the water quality (Tetra Tech 2014a):

- Based on analytical results from the sample collected at DC-2 on January 21, 2014, the water quality results meet the GCDWQ for all parameters tested, except for TDS, iron and hardness, which exceeded AO. When compared to the water quality encountered at test well DC-1, the key water quality design parameters are very similar;
- The total dissolved concentrations of iron, manganese, calcium and magnesium (hardness) contribute to the high TDS;
- Water from DC 2 is hard, with a harness of 433 mg/L (as CaCO3). Residents using water with high hardness face issues with scaling of plumbing features and more soap/detergent is required for washing;
- Sample results for radiological parameters were above the GCDWQ for gross alpha (0.74 Bq/L), but below the GCDWQ for gross beta. Further analysis was recommended to determine the concentration of radium-226 radionuclides, as radium has the most stringent MAC of radiological parameters contributing to the gross alpha concentration. The resulting concentration in DC-2 was below the detection limit (<0.05 Bq/L). Because this result is below the guideline for radium-226 (0.2 Bq/L), the source of the gross alpha remains unknown. However, all other species that contribute to the gross alpha have much higher MACs (greater than 5 Bq/L). As the concentration of the radium-226 was below the detection limit and the total gross alpha concentration does not exceed any MAC for individual species potentially contributing to the concentration of gross alpha, these results confirm that there are no exceedances of any radiological parameters in the samples collected from DC 2;
- The concentration of total THM was 0.023 mg/L, which is below the MAC of 0.1 mg/L; and,
- All hydrocarbons analysed were below detection limit and in consideration with the other water quality data (metals, nutrients) there was no indication of impact of the former landfill on the water quality from the test well (as expected given the distance and the Creek flow divide between the well and the dump site);

Tetra Tech did not review recent water quality data but understands water chemistry analysis is completed at this system annually and bacteriological monitoring is completed on a regular basis with results sent to YG EHS for review.

5.55.5 Water Treatment and Distribution

Table 5-149: Deep Creek Water Supply System Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2014a
Water source	Groundwater	
Wells serving the system	Well DC-2	
Treatment type	Pressure filtration, greensand filtration and chlorination	Urban Systems 2014 p.c. Steve Perrin 2017
Number of connections	Deep Creek and Grizzly Valley subdivisions, and residents of the Ta'an Kwach'an First Nation (TKFN) and Horse Creek	Tetra Tech 2014b p.c. Steve Perrin 2017

Table 5-149: Deep Creek Water Supply System Treatment and Distribution Details		
Item	**Details**	**Source**
Delivery method	Self-serve fill station including blue jug fill, 2" pickup truck fill and 4" fire suppression fill point	
Age of system/last known update	The new Facility was recently completed in 2014	Tetra Tech 2014c p.c. Steve Perrin 2017

5.55.6 Source Water Protection Planning

A risk-based Aquifer and Wellhead Protection Plan (AWPP) has been completed for DC-2. The AWPP includes capture zones of varying vulnerability for DC-2 which consists of three zones (Zones 1, 2 and 3). The capture zones were determined based on several assumptions including Deep Creek being considered a natural groundwater flow boundary, topography being considered to estimate a logical maximum width of the watershed and capture zone and two scenarios of groundwater transport in the bedrock aquifer (Tetra Tech 2014a). Zone 1 is the sanitary zone immediately around the wellhead with a capture zone within a 90 day travel time. Zone 2 is the capture zone within 90 day to one year travel time and Zone 3 is the capture zone within one year to seven year travel time (Tetra Tech 2014a). Based on the findings of the 2014 AWPP, Tetra Tech made the following conclusions:

- There has been no identified contamination in groundwater sampled from DC-2 at the time of the study;
- There are no known sources of contamination in the well capture zones at the time of the study;
- Any release of contaminants within the identified capture zone would represent a potential risk to the aquifer and water quality of the Deep Creek Water Supply Facility;
- The highest risks to DC-2 are from potential spills or releases within the capture zone areas up-gradient of DC 2;
- Risk reduction strategies to be considered include the following:
  - Prevent future development (with the exception of the water treatment plant) within Zones 1 and 2;
  - Ensure proper grading away from the wellhead;
  - Prohibit higher risk (commercial and industrial) development in the capture zones (Zone 1 to 3);
  - Do not have on-site sewage disposal or fuel storage at the water treatment plant;
  - Develop and implement an Emergency Response Plan; and
  - Community engagement and education regarding Best Management Practices for fuel storage and septic disposal in Zone 3;
- Risk monitoring, which includes periodic inspections of the DC-2 wellhead and the capture zones for new AWPP hazards, working together with the community of Deep Creek to identify and create zoning by-laws and updating the status of risks, is recommended and should be implemented as part of the Risk Monitoring Plan for the AWPP.

The AWPP is a living document which should be updated based on activities around the community wells that might result in additional risks, or when risks have been addressed. Tetra Tech understands that YG CS is in the process of implementing the recommendations from the AWPP including the development of an ERP which is currently underway.

5.55.7 Water Supply Information Data Gaps

Tetra Tech has received review comments regarding this system from YG CS and we believe the summary to be complete and accurate to March 2017.

5.56 Whitehorse Area - Ibex Valley Firehall Water Supply System

Ibex Valley Firehall is located at km 1442 Alaska Highway, in Yukon. Ibex Valley Firehall (Building 1950) water system supplies water to the Firehall building and also to an outside tap located at the front of the Firehall that can be used by the public for water pick-up (Tetra Tech 2006). The system consists of a shallow drilled well (Well 1950-A) which Tetra Tech understands is used to supply the fire protection system and a deep Well 1950-B which Tetra Tech understands is used to supply the potable water supply system. This system is governed under the Sections 12.1 (a) and (b) and 17 of the Public Health and Safety Act and Section 5 of the Public Health Regulations (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide water for human consumption.

Well 1950-B was drilled in November 2005 into the underlying bedrock for better water quality; however, the yield of the replacement well was inadequate for the system demand and the well was subsequently deepened in November 2006 to increase the well yield.

5.56.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following water system owners, operators and proponents regarding the Ibex Valley Firehall Water Supply System:

- YG Property Management Division – YG PMD has been consulted and has provided review comments and data for the compilation.
- YG Community Services (the client) – YG CS provided data for systems where proponents contacted were not able to find the documents and/or YG CS had the data readily available.

5.56.2 Hydrogeology

There is no well log for Well 1950-A; however, the well is shallow and is likely completed in an unconfined aquifer. Groundwater quality suggests that the shallow aquifer may be under the direct influence of surface water. There was not enough information to determine the groundwater flow direction at the time of the SPDWSA in 2005, and is difficult to infer based on the available information (Tetra Tech 2006a).

Well 1950-B is completed in a bedrock aquifer. The bedrock is overlain by sand with some gravel to a depth of 8.8 m bgs. The bedrock encountered during the well deepening consisted of a fine-grained sedimentary rock with alterations from light brown to light green colour (Tetra Tech 2007). Bedrock geology mapping (YGS 2003) confirms that the primary bedrock unit in the area is the Aksala assemblage, which is described as a mixed clastic-carbonate assemblage divisible into three dominant facies including calcareous greywacke, locally thick carbonate and red-coloured clastics (Tetra Tech 2007). Clastic components consist of igneous or limestone-clast pebbles and rare feldspar-augite (Tetra Tech 2007). Potential fracture zones at Well 1950-B were previously identified at 43.3 and 63.1 m-bgs, and additional fracture zones were observed during the deepening of the well, at 67.1 m, 70.1 m and 85.4 m bgs (Tetra Tech 2007).

Pumping test results of test Well 1950-B indicate that a low aquifer transmissivity on the order of 1 x 10^{-2} m^2/day and an equivalent hydraulic conductivity of 2 x 10^{-9} m/sec, using an equivalent aquifer thickness of 55.5 m (Tetra Tech 2006b).

5.56.3 Summary of Wells

There is no well log for the original Ibex Valley Firehall Well 1950-A. The well log for the new Well 1950-B is included in the GIS map and database portion of this project. The following tables summarize the completion characteristics of the wells.

Table 5-150: Ibex Valley Firehall, Well 1950-A Summary

Well Construction Parameters	Details	Source
Date of construction	Unknown	Tetra Tech 2006a
Total well depth	11.8 m bgs	
Casing	6" (152 mm) ID PVC Well Casing	
Casing depth	11.5 m bgs	
Well screen	0.38 m well screen from 11.5 m bgs to 11.8 m bgs; slot size is unknown	
Static water level	10.4 m bgs (measured May 2005)	
Sanitary seal	No record that a bentonite sanitary seal has been installed	
Wellhead completion	The wellhead is located in an insulated pit	
Wellhead stickup	1.75 m bgs	
Well rated capacity	Unknown	
Well GUDI status	Potentially GUDI	Based on well construction and depth
Well Construction Comments:	Based on the wellhead completion and the lack of a surface seal, the well was not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

Table 5-151: Ibex Valley Firehall, Well 1950-B Summary		
Well Construction Parameters	**Details**	
Date of construction	The well was originally constructed by Double D Drilling Ltd. in November 2005. Due to the very low well yield, the well was deepened by Double D Drilling Ltd. in November 2006.	Tetra Tech 2007
Total well depth	123.5 m bgs (deepened from 65.5 m bgs)	
Casing	6" (152 mm) steel casing	
Casing depth	12.5 m bgs	
Well screen	No well screen – open hole from 12.5 m to 123.5 m bgs	
Static water level	8.6 m bgs (measured November 21, 2006)	
Sanitary seal	Bentonite sanitary seal to 6.1 m bgs	
Wellhead completion	The wellhead is equipped with a lockable plate	Tetra Tech 2006b
Wellhead stickup	1.4 m ags	
Well rated capacity	0.05 L/s (0.7 IGPM)	Tetra Tech 2007
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.56.4 Source Water Quality

Well 1950-A

In general, the raw water from the Ibex Valley Firehall well (Well 1950-A) meets Health Canada's Guidelines for Canadian Drinking Water Quality (GCDWQ) for the parameters analyzed (Tetra Tech 2006a). The key observations and comments noted in 2006 are (Tetra Tech 2006a):

- The groundwater source was calcium-bicarbonate type water with very high hardness and a pH of approximately 8;
- The hardness (as CaCO3) was reported to be 265 mg/L, was generally poor for aesthetic purpose;
- Although the nitrate concentration of 1.5 mg/L did not exceed the GCDWQ maximum acceptable concentration (MAC) of 10 mg/L, the results were generally higher than normal; and
- At 52 mg/L, chloride concentrations for the sample result provided were also in excess of background concentrations expected for the area; and

- The total iron concentration in the sample collected on May 19, 2005 was 0.852 mg/L, which was elevated compared to the previous sample collected in October 2005 (0.064 mg/L), and greater than the current GCDWQ aesthetic objectives (AO) of 0.3 mg/L.

Well 1950-B

The key observations and comments noted after well deepening in 2006 are (Tetra Tech 2007):

- Water from well 1950-B was calcium-bicarbonate type;
- Water from Well 1950-B met all current GCDWQ for health and aesthetics based parameters;
- Total iron and manganese concentrations were above GCDWQ AO. Elevated iron concentrations are likely due to interaction with stagnant water within the cased portion of the well;
- Laboratory results for water from 1950-B do not indicate any evidence of impacts from septic effluent;
- From an aesthetic perspective, water from 1950-B was of much better quality than water from 1950-A, with a lower hardness and total dissolved solids; *and*
- Radiological screening results indicate a gross alpha concentration of 0.13 ±0.05 Bq/L, which was slightly above the MAC of 0.1 Bq/L at the time, however current GCDWQ regulations indicate that gross-alpha measurements above 0.5 Bq/L should be a trigger for further analysis, and the lowest GCDWQ MAC for is 0.2 Bq/L for radiation from Lead-210. The result of the changes in regulations is that the gross alpha measurement from the Ibex Firehall screening was below all GCDWQ MACs.

5.56.5 Water Treatment and Distribution

Table 5-152: Ibex Valley Firehall Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2007 p.c. Nick Barnett 2017
Water source	Groundwater	
Well serving the system	Well 1950-A and Well 1950-B	
Treatment type	None	
Number of connections	Approximately 20 to 30 people	
Delivery method	Piped (to the Firehall and the water storage tank) and a water fill station outside the Firehall for public use	
Age of system/last known update	Well 1950-B was deepened in 2006.	

5.56.6 Source Water Protection Planning

No records were found indicating that a source water protection plan has been completed for the Ibex Valley Firehall well and the test well. Given that the water supply system is used to supply a public water fill point, implementation of a source water protection plan is considered important to increase security of the Firehall firefighting water supply and the drinking water supply.

5.56.7 Water Supply Information Data Gaps

Tetra Tech has obtained review comments from YG PMD regarding the current status of this system and to our knowledge this summary is complete and accurate to March 2017. The following data gaps have been identified:

- There is no SWPP in place to protect the groundwater aquifer here; and
- No information regarding the connection of 1950-B and installation of a potable water system separate from the firewater system was provided.

5.57 Whitehorse Area - Golden Horn Firehall Water Supply System

The Golden Horn Firehall is located south of Whitehorse, Yukon at the intersection of Alaska Highway and Klondike Highway. Water for firefighting is supplied by an onsite water well and domestic water is supplied to the Firehall by bulk truck delivery. The firefighting water supply system consists of an approximately 38 m deep well (Well 1439) with a direct piped connection to the Firehall. As the system does not provide domestic water from the onsite water well, it is not governed under any present regulation intended to ensure safety measures and inspection for water and water sources for systems that provide water for human consumption.

5.57.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following water system owners, operators and proponents regarding the Golden Horn Firehall Water Supply System:

- YG Property Management Division – YG PMD has been consulted and has provided review comments and data for the compilation.
- YG Community Services (the client) – YG CS provided data for systems where proponents contacted were not able to find the documents and/or YG CS had the data readily available.

5.57.2 Hydrogeology

During drilling of the new Well 1439, a water-bearing zone consisting of silty gravel and sand was encountered at a depth of about 33.5 m bgs to 40 m bgs; the bedrock surface was encountered at a depth of about 40.2 m bgs (Tetra Tech 2009).

The well log does not indicate a thick sequence of finer-grained silt and clay overlying the aquifer (Tetra Tech 2009); thus, the vulnerability of the aquifer to surface sources of contamination is considered to be moderate to high. Results of the pumping test conducted on Well 1439 in October 2009 indicate an aquifer transmissivity on the order of 10^{-6} to 10^{-5} m^2/s (0.1 to 1 m^2/day) (Tetra Tech 2009).

The inferred groundwater flow direction based on topography and proximity to surface water sources is northeast or easterly direction towards the Yukon River (Tetra Tech 2006).

5.57.3 Well Summary

A well log for the new Golden Horn Firehall well (Well 1439) serving the new Firehall building is included in the GIS map and database portion of this project. The following table summarizes the completion characteristics of the well.

Table 5-153: Golden Horn Firehall, Well 1439 Summary

Well Construction Parameters	Details	Source
Date of construction	Well was completed by Double D Drilling Ltd. in October 2008	Well log
Total well depth	37.7 m bgs	
Casing	6" (152 mm) OD Steel Well Casing	

Table 5-153: Golden Horn Firehall, Well 1439 Summary		
Well Construction Parameters	**Details**	**Source**
Casing depth	36.4 m bgs	
Well screen	1.3 m 15 slot (0.38 mm) stainless steel well screen from 35.1 m to 36.4 m bgs over 1.3 m 20 slot (0.51 mm) well screen from 36.4 m to 37.7 m bgs. Total exposed screen length is 2.6 m.	
Static water level	10.9 m bgs (October 2008)	Tetra Tech 2009
Sanitary seal	Bentonite sanitary seal to 6 m bgs	Well log and Tetra Tech 2009
Wellhead completion	Pitless Adaptor	
Wellhead stickup	1.0 m ags	Tetra Tech 2009
Well rated capacity	0.08 L/s (1.1 IGPM)	
Well GUDI status	Non-GUDI	
Well Construction Comments:	Well was constructed to meet Canadian Groundwater Association Well Construction Guidelines.	

5.57.4 Source Water Quality

The chemical water quality data of Well 1439 can be summarized as follows (Tetra Tech 2009):

- The water sample from Well 1439 was very hard (280 mg/L as CaCO3) and can be characterized as a magnesium-calcium-bicarbonate-sulphate type water. The elevated hardness was considered to be generally poor for aesthetic purposes;
- Water from the well meets the GCDWQ for all the parameters analyzed on the date sampled, with the exception of the manganese concentration (0.06 mg/L) which slightly exceeded the GCDWQ AO of 0.05 mg/L; and
- Water from Well 1439 was similar to that from the existing Well 1924, with respect to water chemistry and type of water. An important distinction is that the arsenic concentration in the existing Well 1924, at 0.029 mg/L, exceeded the GCDWQ MAC of 0.01 mg/L for arsenic. The reported arsenic concentration in the new Well 1439, at 0.0036 mg/L, was below the GCDWQ MAC on the date sampled.

5.57.5 Water Treatment and Distribution

Domestic water for the Firehall users is supplied by trucked delivery to a 250-gallon water storage tank.

Table 5-154: Golden Horn Firehall Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2009
Water source	Groundwater	

Table 5-154: Golden Horn Firehall Water Treatment and Distribution Details		
Item	**Details**	**Source**
Well serving the system	Golden Horn Firehall well (Well 1439)	
Treatment type	None	
Water users	Firewater supply only	p.c. Nick Barnett 2017
Delivery method	Direct connection to Firehall holding tanks	
Age of system/last known update	The new Firehall was completed in 2009	

5.57.6 Source Water Protection Planning

No records were found indicating that a source water protection plan has been completed for the new Golden Horn Firehall Well 1439. Given the limited nature of water distribution here (water is used only for firefighting and domestic water supply in the Firehall), source water protection planning may not be warranted for this water supply.

Tetra Tech completed a Phase 1 GUDI screening for the well in 2009 and based on the screening results, Well 1439 is considered to be a groundwater source, and not under the direct influence of surface water based on the Phase 1 screening assessment (Tetra Tech 2009).

5.57.7 Water Supply Information Data Gaps

Tetra Tech has obtained review comments from YG PMD regarding the current status of this system and to our knowledge this summary is complete and accurate to March 2017. The following data gaps have been identified:

- There is no source water protection planning in place to protect this groundwater resource; however, considering that the water supply system provides only fire protection water, it is not likely warranted at this site

5.58 Whitehorse Area - Hootalinqua Firehall Water Supply System

The Hootalinqua Firehall is serviced by a water supply system that delivers water from a 156 m deep well (Well 1391) with static water level of approximately 30 m bgs. From the wellhead, the water system splits to service the two water storage tanks for firefighting use, and to service the domestic water supply for the Firehall (Tetra Tech 2005). This system is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide water for human consumption.

5.58.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following water system owners, operators and proponents regarding the Hootalinqua Firehall Water Supply System:

- YG Property Management Division – YG PMD has been consulted and has provided review comments and data for the compilation.
- YG Community Services (the client) – YG CS provided data for systems where proponents contacted were not able to find the documents and/or YG CS had the data readily available.

5.58.2 Hydrogeology

The aquifer in which Well 1391 is completed, is deep and confined under several sequences of silt and till. The aquifer is therefore considered to be well protected from surface sources of contamination so long as the well itself does not provide a pathway (Tetra Tech 2006). Based on topography and proximity to surface water features, the groundwater flow direction is inferred to be in a northeasterly direction towards the Yukon River (Tetra Tech 2006). The well at Hootalinqua Firehall is well protected from potential sources of contamination (Tetra Tech 2006).

PHCL completed a 24-hour pump test of the well in September 2003 and reported an aquifer transmissivity of 4 to 8 m^2/day (PHCL 2003).

5.58.3 Well Summary

A log for the well is included in the GIS map and database portion of this project. The following table summarizes the completion characteristics of the well.

Table 5-155: Hootalinqua Firehall, Well 1391 Summary

Well Construction Parameters	Details	Source
Date of construction	The well was constructed by Cathway Water Resources in 2002	Well log
Total well depth	157 m bgs	
Casing	6” (152 mm) OD Steel Well Casing	
Casing depth	152.3 m bgs	

Table 5-155: Hootalinqua Firehall, Well 1391 Summary		
Well Construction Parameters	**Details**	**Source**
Well screen	3.7 m 240 slot (1.02 mm) well screen from approximately 152.3 m bgs to 156 m bgs	
Static water level	Approximately 31.8 m bgs	PHCL 2003
Sanitary seal	No records of sanitary seal installation. It was noted that a steel plate is welded over the annulus between the 8” (200 mm) surface casing and the 6” (152) steel casing, but there was no mention if a grout seal was installed between the two casings	Well log
Wellhead completion	The wellhead is located in a pit that is approximately 14 m away from the Firehall building	Tetra Tech 2005
Wellhead stickup	1.5 m bgs (May 19, 2005)	
Well rated capacity	1.44 L/s (19 IGPM)	PHCL 2003
Well GUDI status	Not assessed	
Well Construction Comments:	Based on the wellhead completion and the lack of a surface seal, the well was not constructed to meet the Canadian Groundwater Association Well Construction Guidelines.	

5.58.4 Source Water Quality

As part of the SPDWSA review conducted in 2005, Tetra Tech reviewed available groundwater chemistry data and collected an additional sample to test for identified parameters of concern. The key observations and comments noted during Tetra Tech’s 2005/2006 chemical water quality review and groundwater sampling on the well are summarized as follows (Tetra Tech 2006):

- The water quality results indicated that the water from the well was a sodium-sulphate type water with moderate hardness (ranging from 90.2 mg/L to 131 mg/L as CaCO3) and a pH of approximately 8 to 8.23 on the date sampled;
- The turbidity of the water on the date sampled ranges from 1.5 NTU to 2.6 NTU;
- The water quality results indicated that the water from the well meets the GCDWQ for all the parameters analyzed with the exception of total iron. The reported total iron concentrations on the dates sampled ranges from 0.531 mg/L to 0.556 mg/L. The reported dissolved iron concentration was less than the laboratory detection limit of 0.030 mg/L which is less than the GCDWQ and also the reported total iron concentrations, suggesting that the elevated iron can likely be attributed to suspended iron particles in the water;
- Review of chloride, nitrate and nitrite showed all three to be low and within the normal background ranges, suggesting that the aquifer was not under the influence of anthropogenic surface sources of nutrients or anions such as septic wastes at the time of sampling; and

- Concentrations of EPH and PAH were below the laboratory detection limits on the date sampled.

5.58.5 Water Treatment and Distribution

Table 5-156: Hootalinqua Firehall Water Treatment and Distribution Details

Item	Details	Source
Owner/Operator	Government of Yukon	Tetra Tech 2006 p.c. Nick Barnett 2017
Water source	Groundwater	
Number of wells serving the system	Hootalinqua Firehall well (Well 1391)	
Treatment type	Chlorination (for the water storage tanks); Filtration (sand trap and 5 micron), but no chlorination for the domestic system Iron/manganese filtration added	
Water users	Users of the Firehall	
Delivery method	Piped (to the building)	
Age of system/last known update	Iron and manganese filtration added since 2005	

5.58.6 Source Water Protection Planning

There is no SWPP in place for the Hootalinqua Firehall water system. Given the limited nature of water distribution here (water is used only for firefighting and domestic water supply in the Firehall), source water protection planning may not be warranted for this water supply. Tetra Tech was not able to locate any record of a GUDI assessment for the well.

During the 2005 SPDWSA, Tetra Tech identified an AST located approximately 24 m from the well; other than the AST, there were no other potential contaminant sources identified within 30 m of the wellhead (Tetra Tech 2005). However, it was noted that the AST at the Hootalinqua Firehall has had the concrete supports oriented with respect to the supports on the tank that would make it susceptible to being knocked off the concrete supports in the event of contact with a vehicle, or an earthquake (Tetra Tech 2005). This could potentially result in a piping to break or leak and cause a significant hydrocarbon spill (Tetra Tech 2005).

There was no recorded spill events or contaminated sites reported on or near the property (Tetra Tech 2005). However, during the 2005 SPDWSA site review, it was noted, by two different sources, that there had previously been a hydrocarbon spill resulting from a leak at the union for the transfer pipe in 2005 during the winter months (Tetra Tech 2005). The UST was approximately 27 m from the well (Tetra Tech 2005). The volume of fuel spilled was unknown, and it was unclear if the spill had not been properly cleaned up (Tetra Tech 2005). A noticeable diesel odour in the vicinity of the AST was obvious at the time of the SPDWSA in 2005 (Tetra Tech 2006). Given the depth of the well, and the horizontal separation distance, it was considered unlikely that hydrocarbons from this spill would have impacted on deep groundwater quality and the concentrations of EPH and PAH in the groundwater sample collected from Well 1391 were non-detect (Tetra Tech 2006).

5.58.7 Water Supply Information Data Gaps

Tetra Tech has obtained review comments from YG PMD regarding the current status of this system and to our knowledge this summary is complete and accurate to March 2017. The following data gaps have been identified:

- There is no source water protection planning in place for this water supply system.

5.59 Whitehorse Area - Mount Lorne Firehall Water Supply System

The Mount Lorne Firehall is serviced by a well, Well 1955, located approximately 4.5 m from the Firehall. The water is delivered from the well to a pressure tank and is separated into domestic water supply and two water storage tanks for firefighting purposes. The water system supplies domestic water to the Firehall and the water supply is governed under the Sections 12.1 (a) and (b) and 17 of the *Public Health and Safety Act* and Section 5 of the *Public Health Regulations* (C.O. 1958/079, O.I.C. 2009/194), which require safety measures and inspection for water and water sources for systems that provide water for human consumption.

5.59.1 Data Compilation Methodology

Tetra Tech approached stakeholders including water system operators and owners to let them know the project was in progress and to request their assistance in compiling the most complete data set possible. Through the process of compiling the data, Tetra Tech has had communication with the following water system owners, operators and proponents regarding the Mount Lorne Firehall Water Supply System:

- YG Property Management Division – YG PMD has been consulted and has provided review comments and data for the compilation.
- YG Community Services (the client) – YG CS provided data for systems where proponents contacted were not able to find the documents and/or YG CS had the data readily available.

5.59.2 Hydrogeology

According to the driller's well log, the well is completed through approximately 2 m of silt, which is underlain by sand with varying degrees of silt to approximately 35 m bgs. The static water level as recorded on the driller's well log at the time of well completion was 18.3 m bgs. Based on the lithology and water level, the aquifer in which the well is completed is inferred to be unconfined. Although unconfined aquifers are more vulnerable to contamination than confined aquifers, the thickness of the unsaturated zone and the presence of the silt layer at surface offers some protection of the aquifer from surface sources of contamination. The local groundwater flow direction is unknown at this time.

5.59.3 Well Summary

No well log was available for this well. The following table summarizes available data for the water well.

Table 5-157: Mount Lorne Firehall, Well 1955 Summary

Well Construction Parameters	Details	Source
Date of construction	The well was completed by Midnight Sun Drilling Co. Ltd. in November 1994.	Well log
Total well depth	34.7 m bgs	
Casing	6" (152 mm) Steel Casing	
Casing depth	33.5 m bgs	
Well screen	1.2 m 20 slot (0.51 mm) from 33.5 m bgs to 34.7 m bgs	
Static water level	18.3 m bgs (November 1994)	

Table 5-157: Mount Lorne Firehall, Well 1955 Summary		
Well Construction Parameters	**Details**	**Source**
Sanitary seal	3.0 m bgs to 4.5 m bgs	Tetra Tech 2006b
Wellhead completion	Pitless adapter	
Wellhead stickup	0.55 m ags	
Well rated capacity	Unknown	Tetra Tech 2006a
Well GUDI status	Not assessed	
Well Construction Comments:	Well upgraded to meet Canadian Groundwater Association Well Construction Guidelines.	

5.59.4 Source Water Quality

As part of the SPDWSA (Tetra Tech 2006a), Tetra Tech reviewed water quality results from samples collected in October 2004 and noted the following:

- The raw water quality for the sample obtained on October 4, 2004 indicated that the groundwater source was calcium-magnesium-sulphate type water with very high hardness. The hardness (as $CaCO_3$) was reported to be 206 mg/L and was generally poor for aesthetic purposes; and
- The water quality results indicated that all other health-based and aesthetic objectives were met for the parameters analyzed.

5.59.5 Water Treatment and Distribution

Government of Yukon owns and operates the Mount Lorne Firehall water supply system. Water is distributed to the Firehall via a piped connection.

Table 5-158: Mount Lorne Firehall Water Treatment and Distribution Details		
Item	**Details**	**Source**
Owner/Operator	Government of Yukon	Tetra Tech 2006a p.c. Nick Barnett 2017
Water source	Groundwater	
Wells serving the system	Well 1955	
Treatment type	None	
Water Users	Water users	
Delivery method	Piped to the Firehall	
Age of system/last known update	Wellhead was upgraded in 2006	Tetra Tech 2006b

5.59.6 Source Water Protection Planning

There is no SWPP in place for the Mount Lorne Firehall water system. Given the limited nature of water distribution here – water is used only for firefighting and domestic water supply in the Firehall, source water protection planning may not be warranted for this water supply. Tetra Tech was not able to locate any record of a GUDI assessment for the well.

Potential sources of contamination to the Mount Lorne Firehall well were identified during the system review in 2005. The report identified the following potential sources of contamination in the vicinity of the wellhead (Tetra Tech 2006a):

- There is a sewer line leading to an onsite septic tank located approximately 26 m from the well; and
- There is a waste transfer station and former burn pit located approximately 180 m north (or up-gradient) of the well.

5.59.7 Water Supply Information Data Gaps

Tetra Tech has obtained review comments from YG PMD regarding the current status of this system and to our knowledge this summary is complete and accurate to March 2017. The following data gaps have been identified:

- There is very little known about the hydrogeology in the vicinity of the Mount Lorne Firehall and the lack of data regarding lithology means that the vulnerability of the well/aquifer to surface sources of contamination is not known.

6.0 SOURCE WATER PROTECTION AND DATA COMPILATION PRACTICES IN ALBERTA AND BRITISH COLUMBIA

6.1 Centralized Water Well Information

In both BC and Alberta, water well information is available to the public online.

In BC, water well information can be obtained from two online resources through the BC Ministry of Environment (MOE) website: the BC Water Resources Atlas (BCWRA) database and the WELLS database.

The WELLS database currently contains more than 100,000 well records; however, it was estimated that approximately 2,000 well records that had been submitted to MOE for data processing may be officially un-locatable and not possible to assign geographic coordinates (BCGWA 2015). Previously, paper copies of the well records were submitted to the MOE for data processing and publication. The value of such a database depends on the number of wells entered in it, and the MOE has invested substantial time and effort to enter paper records on file into this database. Over the last decade, water well drilling contractors registered in BC have also been encouraged to submit their well records electronically (using the eWELLS online system), although the MOE still accepts paper copies from the drillers (BCGWA 2015). The MOE also provides training on how to use the eWELLS system and the importance of identifying well location accurately. Users of eWELLS are encouraged to use GPS-based locations for new wells, and to provide information on well location in relation to local landmarks.

Wells can be searched using the WELLS database if a well tag number, well ID plate number, well location (legal property description), and/or lithology for a particular well is known. The well tag number is a unique database number the BC MOE assigns to a particular well at the time of data entry.

The BCWRA is a map-based GIS tool. Wells can be located by narrowing into a particular search area and adding map layers (e.g., aquifer boundary, water wells and points of diversion, etc.) to view well records and other features within the search area. This is particularly useful for identifying existing wells within a given search radius of a point or site of interest.

In Alberta, water well information and baseline water well test information can be obtained from the online Alberta Water Well Information Database. This database, which is also a map-based GIS tool, is similar to the BCWRA database and contains approximately 500,000 records (AEP 2016). Key information such as well depth, geochemistry and well location (approximate) are available for review. Alberta Environment and Parks (AEP) administers and updates this database. Approximately 5,000 new drilling reports are added to the database annually (AEP 2016). Registered users can report water well-related activities through a secure website (AEP 2016).

The value of well databases and GIS-based searching systems depends on the number of wells in the system. Systems that have a large proportion of existing wells entered in the database and have mandatory reporting for all new wells will be more useful and reliable than databases that are only partially populated. A key step is getting all existing paper records on file entered into the database, with suitable checking of the completeness and accuracy of the information on each record.

6.2 Aquifer Mapping

In BC, an aquifer classification system, which consists of the following two components, was developed by the BC MOE specifically for Aquifer Mapping in BC (BC MOE 2016):

1. A classification component to categorize aquifers based on the level of development and vulnerability to contamination at the time of the assessment. Typically the highly vulnerable aquifers are the unconfined sand and gravel aquifers associated with river valley deposits.

2. A ranking component to indicate the relative importance of an aquifer. The ranking component is based on hydrogeologic and water use criteria such as productivity, aquifer size, vulnerability, demand, type of use, quality concerns and quantity concerns. The ranking scores range from 5 to 21; the higher the score the greater the aquifer's priority. Only aquifers with sufficient groundwater development *and* typically greater than 1 km^2, are delineated, classified and mapped. Where aquifers cannot be fully delineated, boundaries are defined by the area of groundwater development.

This classification system was developed primarily for in-house use to assist with groundwater management (BC MOE 2016), but information on the locations of these mapped aquifers and their classification and ranking component results are available to the public through the BCWRA database. As of January 2016, over 1,100 aquifers in BC have been mapped.

In addition to the aquifer mapping exercises that have been conducted by the BC MOE, Natural Resources Canada (NRC) has also been conducting a groundwater study to map groundwater in Canada. The study began in 2002 with completion date planned in 2025. So far, the aquifers in the Fraser Valley, Gulf Islands and Okanagan Valley of BC have been mapped and the information can be found on NRC's online Groundwater Information Network database.

Information on mapped aquifers in Alberta can be obtained from various online sources in the forms of reports or maps; however, to the best of our knowledge, the information is not yet available on the Alberta Water Well Information Database. Most of the aquifers in Alberta have been mapped by Alberta Geological Survey (AGS) and AEP and the results are presented in various published maps.

The Alberta Research Council - Groundwater Division has compiled the Hydrogeological Map Series of Alberta, which provide 1:250,000-scale hydrogeological maps over much of Alberta. These hydrogeological maps with accompanying cross-sections, contain information on bedrock geology, meteorology, water well locations, groundwater depths, hydrochemistry and groundwater probability. However, these maps do not contain information on groundwater contamination or groundwater resource vulnerability. These Hydrogeological Maps can be found on the AGS' website.

In 2008, AGS and AESRD (now AEP) have assembled over 20,000 chemical analyses of groundwater within the Edmonton-Calgary Corridor (ECC) area, showing the reginal groundwater chemistry of major bedrock aquifers (Paskapoo, Horseshoe Canyon, Bell River and Bearpaw aquifers) and the overlying surficial sediments aquifers. Within the mapped area, sediments with a thickness is >10 m were considered to be an aquifer. Chemical analyses were assembled based on geochemical, sampling interval and temporal data. The results were presented in series of maps (Maps of Fresh Groundwater Chemistry, Edmonton-Calgary Corridor, Alberta; AGS 2013a to AGS 2013e) available on AGS's website for review

Aquifers in other regions of Alberta are shown in Alberta Energy Resources Conservation Board (ERCB)/AGS Open File Report 2009-02, Compilation of Alberta Groundwater Information from Existing Maps and Data Sources. Various figures included in the Open File Report 2009-02 show aquifer types, groundwater use by domestic wells, irrigation, municipal wells in each region of Alberta (ERCB/AGS 2009).

In Alberta, the Paskapoo Aquifer, Buried Valley Aquifer System, and Milk River Aquifer have been mapped by the NRC. In addition to the mapped aquifers, the Upper Cretaceous Aquifer System, the Judith River Aquifer, and the Inter-till aquifer system will be mapped by 2025. Information on the NRC-mapped aquifers can be on the NRC website using the search engine or the online Groundwater Information Network database.

The main buried valley aquifers in Alberta (such as the Calgary Buried Valley Aquifer, Beverly Channel Aquifer, Whisky Valley Aquifer, Gregoire Channel Aquifer, and the largest, the Hatfield Valley Aquifer of the Empress Group) have been mapped, but only parts (such as the Cold Lake area) have been mapped in detail (Alberta Water Portal 2016).

Two other important sources of groundwater information in Alberta are:

- Regional Groundwater Assessment Reports completed by Hydrogeological Consultants Ltd. (HCL 2016). These regional groundwater assessment reports contain information on well locations, well depths, well yields, surficial and bedrock geology and cross-sections, etc. for different regions of Alberta; and
- Base of Groundwater Protection (BGWP) as managed by the Alberta Energy Regulator (AER). BGWP Protection is an online query tool which provides information on BGWP elevation and the deepest protected geological unit for an area of interest (AER 2016).

6.3 Aquifer Vulnerability Mapping

In BC, the vulnerability of an aquifer is typically assessed based on type, thickness and extent of the overlying confining layer, depth to groundwater, and type of aquifer materials. Some of the recent aquifer mapping exercises in BC (Liggett, J. et al. 2011) used the DRASTIC (Depth to groundwater, Recharge, Aquifer media, Soil media, Topography, Impact of the vadose zone, and hydraulic Conductivity of the aquifer) method to evaluate the level of vulnerability. Where the aquifer has been classified and mapped by the BC MOE, information on aquifer vulnerability as well as productivity and demand can be obtained from the BCWRA database. Information on aquifer quantity and quality is also available on the BCWRA database.

To the best of our knowledge, aquifer vulnerability in Alberta has only been assessed on the aquifers within the ECC Region, Northern and Southern Saskatchewan Regions, and Red Deer Region of Alberta. The results are presented in the maps on various online sources.

- Aquifer vulnerability for the ECC area was assessed based on the aquifer properties, water levels and climatic conditions (modified DRASTIC method). The results are presented in a map based on the DRASTIC index values (ERCB/AGS 2011).
- Aquifer vulnerability for the three southern regional planning areas is presented in the Northern and Southern Saskatchewan Regions and Red Deer Region Vulnerability maps available on the AEP website (AEP 2016).

6.4 Source Water Protection Planning

In BC, the level of detail required for a Source Water Protection Plan (SWPP) depends on the size of the water system. Completion of a SWPP assessment is required under the Drinking Water Protection Act. A Drinking Water Quality Improvement Program began in 1990s with some large water suppliers in BC. Municipal and community systems serving more than 1000 people (or over 300 connections) are already participating in the program. The SWPP is now being introduced to water systems serving more than 500 people (or over 150 connections).

In the Interior BC, a SWPP is currently required for large water supply systems and is included as a condition on each operating permit (IHA 2009). Water systems in the Interior BC serving more than 500 people are expected to complete an assessment equivalent to Modules 1, 2 and 7 specified in the Comprehensive Drinking Water Source-

to-Tap Assessment (CS2TA) document (BC MOHLS 2010; IHA 2009). CS2TA is an eight-module process for conducting source-to-tap assessments, and Modules 1, 2 and 7 of the CS2TA provides guidance on delineation and characterization of drinking water sources, contaminant source inventory and risk characterization (MOHLS 2010). Typically, the SWPP assessment report will also include a section on Module 8, *Recommendations*.

For small water systems (<500 people) in Interior BC, at a minimum, an assessment equivalent to BC Drinking Water Source-to-Tap Screening Tool, is required (IHA 2009). However, if a Drinking Water Officer (DWO) identifies significant risks through the review process, the DWO can request a Comprehensive Drinking Water Source-to-Tap Assessment to be completed on the system (IHA 2009).

To our knowledge, there are no specific SWPP requirements for water systems in the other regions of BC, but the assessment is typically completed using the *Source to Tap Screening Tool (BC MOE 2004)*, Small *Water System Guidebook (MOH 2013)*, *Comprehensive Drinking Water Source to Tap Assessment* (BC MOHLS 2010) and/or BC *Well Protection Tool Kit (BC MOE 2000)*, as the guidance documents. In addition, specific requirements for a SWPP may vary between health authorities in BC and consultation with the local DWO is recommended prior to completing a SWPP.

Most of Alberta's drinking water systems are regulated by Alberta Environment and Parks (AEP) or Alberta Health and Wellness (AHW). AEP regulates approved waterworks systems for a city, town, village, or settlement area, and AHW regulates unapproved public water systems such as for schools, mobile home parks, campgrounds, or resorts.

Under AEP's Codes of Practice, the registration holder for a waterworks system is required to complete a drinking water safety plan (DWSP) (AEP 2012a and AEP 2012b).

There is a DWSP Excel Template available on the AEP website for registration holders to use (AEP 2016). A training document has been prepared by the AEP (formerly known as Alberta Environment and Sustainable Resource Development [AESRD]) to assist the registration holder to prepare a DWSP and identify, categorize and manage risks. Each identified risk is measured in terms of likelihood and consequence, and risks with a score of 32 or more are considered high risks and will require action to reduce the risks (AEP 2016).

In addition to the DWSP (local scale), the AEP has recently issued a guidance document to source water protection planning in the South Saskatchewan (SS) Region (AEP 2015). The guide was developed for the SS Region, but the main concepts can be applied to other regions of Alberta (AEP 2015). Unlike DWSP which applies to a rather local area, SWPP applies to a sub-watershed/sub-regional area. The Alberta SS WSPP follows the CCME's guidance document on source water protection planning using a multi-barrier approach which is similar to the CS2TA guidance document and delineates and characterizes drinking water sources, identifies contaminant source in the vicinity of the wellhead(s) and assess the vulnerability of the aquifer (CCME 2004; AEP 2015).

7.0 DISCUSSION

This Yukon Government funded study resulted in the compilation of data for a total of 60 public water supply systems in Yukon. By compiling this information into one location in a consistent format, the database can form a starting point to allow improve information access, data sharing and communication as well as creating a platform to improve the state of knowledge on Yukon's water resources. The hope is that this GIS database will become a living document from which to improve access to water information and support the community education goal inherent and key to source water protection and planning in Yukon. This compilation pulls much of the relevant information related to source water protection planning such as: water sources, well construction, and hydrogeology into one location.

Through the process of contacting as many stakeholders as possible for each water system, going through several iterations of review and providing system summaries to water system operators and owners for review, we have made a concerted effort to obtain the most up to date information possible for each system; however, there may be aspects of some systems such as up to date treatment system information that has been completed that is not captured in this report and database.

This study included all regulated community water treatment systems (LPDWS), and all Yukon Government, First Nation and municipality maintained facilities that serve potable water to the public.

From the review of BC and Alberta's approaches to source water protection planning, it is clear that the Yukon could implement some legislative requirements that would achieve better information collection, sharing and ultimately provide much better tools for source water protection development. These improvements could include:

1. Well Guidelines/ Specifications – There is currently no regulatory requirement for well construction or any minimum specification for wells in Yukon with the exception of Large Public Drinking Water Systems as captured in the Drinking Water Regulation and water wells drilled under the YG Domestic Water Well Program. Implementing an overarching regulatory requirement for well construction, testing, and decommissioning for all wells including domestic, small public and large public would achieve a consistent first barrier in the source water protection multi barrier approach. Note: ***As indicated previously, development of potable water well guidelines for Yukon is in progress.***

2. Mandatory Reporting/ Well Database – Currently the only water well records that are captured for the Yukon water well database are those that are drilled with funding by YG, or financed through the YG Domestic Water Well Program. Following from other jurisdictions like BC and Alberta to require mandatory submission of water well records would significantly improve the robustness of the data set for water wells in Yukon and better enable aquifer mapping and vulnerability mapping, and ultimately development of source water protection plans. Ultimately an online tool available to the public with information such as well logs, chemistry, yield data similar to that which exists in Alberta and BC is recommended. The Government of Yukon should contact representatives of ministries administering the well databases in both BC and Alberta to determine the level of effort and key success strategies to build a similar new system for Yukon.

3. Aquifer and Vulnerability Mapping – The Yukon should consider aquifer and vulnerability mapping throughout developed areas of Yukon. This would provide valuable information for development of source water protection plans.

4. Source Water Protection Legislation – Regulation or Guidelines regarding the requirement of Source Water Protection Plans with clear direction depending on the type of system or population served. In the case of small systems, to be pragmatic, there could be a requirement to complete a preliminary assessment of

potential risks to the water system and based on the outcome, a full SWPP/AWPP would have to be prepared for higher risk systems.

8.0 DATA GAPS

Through this study, Tetra Tech identified several systems that are in an unknown state of operation and may or may not have an associated water source that could be included here:

- The community of Champagne, Yukon has had some previous groundwater quality concerns and groundwater has not been used from the area in the recent past. The wells and data here may, however, be relevant to source water protection in Yukon, and the groundwater source may be used in the future.
- Aishihik Village may have a public water supply well. The relevant information including well location, well log and lithology, as well as the well water use are unknown, but this water source may be worth including in the database.
- Eagle Plains Lodge and Eagle Plains Grader station are thought to take their water from a wet well source located on the Eagle River. Tetra Tech was involved in some testing work for this water source in 2001, but were not able to confirm that this surface water supply wet well is in use for public water supply.
- Tetra Tech is aware of potable and non-potable water supply wells located in several YG campgrounds throughout Yukon. Data from these wells would be valuable to help complete the database of groundwater in Yukon. Tetra Tech considered these wells outside the scope of the current project.
- Tetra Tech was made aware from anecdotal information that there is a blue jug water fill station located at Judas Creek on the day of finalization of this report. We do not have any information on this system, and therefore it is not included in this summary report or the database. As the system apparently provides drinking water to public users, addition of this system to the database should be considered.
- Grader stations were excluded from the scope of this study; however, Tetra Tech understands the Stewart Crossing Grader Station supplies a blue jug fill station. This system should be included in future when the database is updated.
- The Carcross School well was excluded from this study, as the school is now supplied by the municipal water supply system, but Tetra Tech understands that this well supplies water to the Carcross swimming pool and this system should be included in future when the database is updated.
- The Keno Water Supply System has not been included in this summary as the system is currently not in service and the future of the water supply system is uncertain.
- Water systems at Grader Stations throughout the Yukon have been excluded from this study as the majority of these systems do not provide potable water to the public. The water well information from these systems could be valuable for future aquifer mapping and source water protection planning.
- Private water systems including water systems owned and operated by businesses that provide potable water to the public have not been included here. Water system information from these sources could provide a valuable resource for future aquifer mapping and source water protection planning.
- Water quality data held by YG EHS has been only briefly reviewed with small summaries included here. Additional water quality data held by YG EHS could potentially be incorporated into the database developed for this study as a valuable resource for water supply source selection.

- Some water system owners and operators did not respond to requests for review during this iteration of the database compilation. Obtaining buy in and review comments from these owners and operators should be addressed in the next iteration of the project.

9.0 CONCLUSIONS

The following conclusions are presented from this study with respect to source water protection planning in Yukon:

- Information from a total of 60 public water supply systems was captured, compiled and considered in this study, summary report and GIS database. Of the 60 public systems, information on all 22 of the Large Public Drinking Water Systems was available. The other 39 systems that are captured in this study are “Small Public Drinking Water Systems” that are owned and operated by Yukon Government, Municipalities or First Nations.

- Source water protection plans for the Yukon systems that we are aware of include:

  - City of Whitehorse SWPP – The City of Whitehorse with consulting support from Summit Environmental Consultants Ltd. developed a Source Water Assessment and Protection Plan for the City of Whitehorse in 2013 based on the Comprehensive Drinking Water Source to Tap Assessment Guideline (2010) published by the BC Ministry of Healthy Living and Sport. The plan covers the active wells Well 4, Well 4N, Well 5N, Well 6, Well 8 and Well 9.

  - City of Dawson AWPP is currently in progress and will be completed in summer 2017. The AWPP will be based on the BC Ministry of Environment Well Protection Toolkit with modifications based on Tetra Tech’s ‘Risk Based Approach’. The wellhead protection zones have been completed for this study and are included in the database along with the technical memo supporting the well capture zone analyses. When finalized, the full AWPP plan should be added to the database created for this study.

  - Village of Haines Junction AWPP was developed by VHJ in 2016 with technical support from Tetra Tech. The plan was developed following guidance from the BC Ministry of Environment Well Protection toolkit with modifications based on Tetra Tech’s ‘Risk Based Approach’.

  - Kluane First Nation AWPP – This plan was developed in 2007 and includes all of the water wells in Burwash used for KFN government and citizen use. Yukon Government has also recently contracted Tetra Tech to prepare an AWPP for the new community wells KFN-M and KFN-N that are planned to serve a new Community Water Treatment Plant. This plan is currently developed based on Tetra Tech’s ‘Risk Based Approach’. The wellhead protection zones have been completed for this study and are included in the database. When finalized, the full plan should be added to the database created for this study.

  - White River First Nation AWPP – This plan for WRFN lands in Beaver Creek was developed by WRFN with technical support from Tetra Tech in 2007 and updated in 2013 to capture changes to the water supply system. The AWPP includes community supply wells Well 1a, Well 1b, Well 2a and Well 2b. This plan was developed based on Tetra Tech’s ‘Risk Based Approach’.

  - Carcross Community Water Supply SWPP – The SWPP for the Carcross Drinking Water Supply system was developed in 2010 by Yukon Government with technical support from Environmental Dynamics Inc. (EDI). This plan was developed based on the Comprehensive Drinking Water Source to Tap Assessment Guideline (2010) published by the BC Ministry of Healthy Living and Sport.

  - Little Salmon Carmacks First Nation AWPP – A source water protection plan in the form of a Community Well Protection Plan was developed by LSCFN with support from Vista Tek Ltd in 2008. This plan was developed based on the BC Ministry of Environment Well Protection Toolkit.

  - Some preliminary source water protection planning in the form of a risk assessment tool review has been completed for the Lobird Park Large Public Drinking Water System; however, the report is missing key

components of source water protection planning including risk analysis and recommended mitigation measures.

- Deep Creek AWPP – The AWPP for the Deep Creek Water Supply Facility was developed as part of the completion reporting for well DC-2 in 2014 by Yukon Government and Tetra Tech. The plan was developed for Well DC-2, as this is the only well that supplies the Deep Creek Water Supply Facility. This AWPP was based on Tetra Tech's 'Risk Based Approach'.
- Liard First Nation AWPP – Liard First Nation (LFN) and Tetra Tech developed an AWPP for the LFN community water supply facility in the 2 Mile Community in 2008. The AWPP applies to the two community water supply wells TW05-02 and TW05-03 and used the 'Risk Based Approach'.
- Selkirk First Nation WHPP – Vista Tek and Selkirk First Nation developed a Wellhead Protection Plan for Selkirk First Nation wells PW05-1 and BW06-1. This plan was developed based on the BC Ministry of Environment Well Protection Toolkit method.
- Carcross Tagish First Nation AWPP – Carcross Tagish First Nation (CTFN), with consulting support from Tetra Tech developed the aquifer and wellhead protection plan for CTFN in 2010. The plan addresses aquifer and wellhead protection planning for CTFN Well No. 1, CTFN Well No. 2 and CTFN Well No. 3. Wells No. 2 and No. 3 are in use. This plan was developed based on Tetra Tech's 'Risk Based Approach'.
- Takhini River Subdivision AWPP – Champagne and Aishihik First Nation and Tetra Tech developed a Preliminary AWPP for the Takhini River Subdivision water supply Well 1 serving the community water system. A backup well has subsequently been completed, which should be included in the next iteration of AWPP. The AWPP was developed using Tetra Tech's 'Risk Based Approach'.
- Ross River Community Well SWPP – A source water protection plan is being completed for the Ross River Community Well that serves the Ross River LPDWS. The plan is being completed by Blumetric for the Yukon Government – Site Assessment and Remediation Unit. We understand that the capture zone analysis is complete, and the plan is in its final development stages. The plan was developed using Ontario source water protection tools and based on the Ontario regulation. Once completed, the plan should be included in the database completed for this study.

- Although not legislated, source water protection plans have been developed for about half of the larger community systems (LPDWS) in Yukon. Because of this, and the fact that Whitehorse is one of the LPDWS with a source water protection plan in place, from a population perspective it is estimated that more than 90% of the Yukon population served by community water systems have SWPPs in place.
- Eight of the nine First Nation systems that are LPDWS have SWPPs in place. This suggests that a much higher proportion of the First Nation systems have SWPPs; likely influenced by the Protocol for Safe Drinking Water, and FNWMS, and available funding.
- Half of the Large Public Drinking Water Systems identified do not have SWPP/AWPP in place; and most of the small public water systems are lacking source water protection. Source water protection planning is lacking and sparse for the small systems serving drinking water to public facilities such as schools and health centres. This compilation demonstrates that, in many Yukon communities, source water protection planning strategies would be best approached with an integrated team to create community-wide plans for comprehensive planning to protect both capture zones for individual water supply systems and to protect aquifers which are used by multiple systems. In addition to comprehensive plans, community based planning for aquifer protection has the benefit of engaging stakeholders at the outset and providing a basis for planning of future developments throughout communities.

10.0 RECOMMENDATIONS

Tetra Tech makes the following recommendations to Government of Yukon based on this study:

- Tetra Tech understands that water systems included in this summary undergo frequent changes and upgrades where the data may or may not be captured in completion reporting and/or previous engineering inspections. Tetra Tech recommends updating this database frequently to capture relevant changes to maintain the utility of the information; a suggested frequency of update would be 5 years or on an as needed basis when major changes are made or engineering inspections are completed.
- Use the comparison of Yukon Regulations and Best Management Practices, and discussion herein to guide Yukon's approach to source water protection and management – such as minimum well construction standards, mandatory well record reporting, a public-accessible well database system on line, and using the data compiled here as well as any additional data available to generate aquifer mapping and vulnerability assessments for the groundwater resources that serve Yukon communities.
- Consider the development of consistent guidelines and regulation regarding the requirement of Source Water Protection Plans with clear direction depending on the type of systems or population served. In the case of small systems, to be pragmatic, there could be a requirement to complete a preliminary assessment of potential risks to the water system and based on the outcome, a full SWPP/AWPP would have to be prepared for higher risk systems.

11.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

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APPENDIX A
TETRA TECH'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOENVIRONMENTAL REPORT – GOVERNMENT OF YUKON

This report incorporates and is subject to these "General Conditions".

1.1 USE OF REPORT AND OWNERSHIP

This report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment.

This report and the assessments and recommendations contained in it are intended for the sole use of TETRA TECH's client. TETRA TECH does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than TETRA TECH's Client unless otherwise authorized in writing by TETRA TECH. Any unauthorized use of the report is at the sole risk of the user.

1.2 ALTERNATE REPORT FORMAT

Where TETRA TECH submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed TETRA TECH's instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by TETRA TECH shall be deemed to be the original for the Project.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 NOTIFICATION OF AUTHORITIES

In certain instances, the discovery of hazardous substances or conditions and materials may require that regulatory agencies and other persons be informed and the client agrees that notification to such bodies or persons as required may be done by TETRA TECH in its reasonably exercised discretion.

1.4 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of the report, TETRA TECH may rely on information provided by persons other than the Client. While TETRA TECH endeavours to verify the accuracy of such information when instructed to do so by the Client, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information which may affect the report.