GEOEXCHANGE FEASIBILITY ASSESSMENT, BURWASH LANDING, YUKON

PRESENTED TO

Kluane First Nation

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Tetra Tech EBA Inc.
61 Wasson Place
Whitehorse, YT Y1A 0H7 CANADA
Tel 867.668.3068 Fax 867.668.4349

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LIMITATIONS OF REPORT

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1.0 INTRODUCTION

Tetra Tech EBA Inc. (Tetra Tech EBA) has been retained by the Kluane First Nation (KFN) to complete a feasibility assessment to evaluate geoexchange and heat use options for utilizing the warm water well KFN-L in the community of Burwash Landing, Yukon. The objective of this study is to move forward from the earlier *Guidance Document for Development of Cold and Warm Water Well System, Burwash Landing, Yukon* (EBA, 2013) completed by Tetra Tech EBA in 2013 and evaluate the feasibility of KFN's currently preferred geoexchange and heat use options.

In addition, Tetra Tech EBA's scope of work here also included the preparation of general specifications and lifecycle costs for a new water delivery truck, as well as estimates of capital and lifecycle costs for a piped water distribution system.

Tetra Tech EBA understands that the water supply and treatment system in Burwash Landing is planned to include a new water treatment plant (WTP) which will be connected to recently completed water wells denoted as KFN-K and KFN-L. Table 1 provides a summary of key characteristics for these wells (based on completion reports for these wells; EBA (2012)).

Table 1: Summary of Key Information for Wells KFN-K and KFN-L

	KFN-K (new cold water well)	KFN-L (new warm water well)
Well Depth	73.5 m (241 ft.)	387.4 m (1,271 ft.)
Estimated Safe Well Yield	9.5 L/s (150 USgpm)	6.3 L/s (100 USgpm)
Water Level/ Artesian Pressure at Wellhead	3 psi (SWL ~2.1 m (6.9 ft) ags)	1 psi (SWL ~0.7 m (2.3 ft) ags)
Water Temperature	1.9ºC	15.9ºC
Water Quality Summary	As (0.012 mg/L) slightly exceeds GCDWQ MAC (0.01 mg/L); hard (150 mg/L CaCO3); pH (up to 8.8) exceeds MAC (6.5-8.5)	As (0.075 mg/L) exceeds GCDWQ MAC (0.01 mg/L); exceeds AO for TDS, Fe, colour; very hard (406 mg/L CaCO3)

Notes: GCDWQ – Guidelines for Canadian Drinking Water Quality; USgpm = US gallon per minute; SWL = static water level; bgs = below ground surface; ags = above ground surface; AO = aesthetic objective; MAC = maximum allowable concentration

Based on a review of previous sampling results, KFN-K shows a more favourable water quality with respect to potable water supply than KFN-L, and has sufficient yield for use as the primary water supply well under currently projected water use demand. Due to the less desirable water quality encountered at KFN-L, KFN has decided that KFN-K would be developed as the primary water well to supply the proposed new WTP. As part of on-going work at Burwash Landing, the Government of Yukon issued a public tender on April 22, 2015 for the design of a new WTP which includes considerations for potential future addition of a geoexchange heating system.

1.1 Purpose and Scope of Work

Tetra Tech EBA understands that KFN intends to develop a geoexchange system to utilize the warm water from KFN-L as part of an overall water improvement program. The purpose of this assessment is to further evaluate and update the feasibility of selected heat extraction and heat use options which were identified in the guidance document (EBA 2013). The scope of work completed as part of this assessment is described below.

Based on recent communications and discussions with KFN, the following options were evaluated for the extraction of heat energy from the geothermal resource (Well KFN-L).

- Option 1 – Basic Closed Loop System
- Option 2a – Modified Closed Loop System with Flow
- Option 2b – Semi-open Loop System
- Option 3 – Open Loop System

Based on Tetra Tech EBA's understanding of current KFN priorities, the following heat use options were evaluated:

A. Heating of the Proposed New Water Treatment Plant

B. Heating of a Proposed Greenhouse Facility

C. Freeze Protection for a Proposed Piped Water Distribution System – Tetra Tech EBA understands that the piped water distribution system would serve the core area of Burwash Landing, with service to approximately 25 buildings.

The potential heat extraction options were evaluated in combination with potential heat uses. The two most desirable scenarios, as selected by KFN, were used to calculate Class C (+/- 25 to 35%) capital costs.

In addition to the assessment of geoexchange options, Tetra Tech EBA assessed the feasibility of installing a piped water distribution system to serve the core area of Burwash Landing. Class C capital and operation and maintenance cost estimates were prepared for both piped and trucked water service to the core area of Burwash Landing.

In addition to the scope of services outlined above, Tetra Tech EBA has prepared:

- A summary of expected permits and approvals required for the scenarios considered as part of this study;
- A summary of potential funding programs in consideration of the scenarios assessed as part of this study; and,
- Requirements for a new water delivery truck. The water truck requirements are presented in a technical memorandum appended to this report in Appendix E.

2.0 GEOEXCHANGE OPTIONS ASSESSMENT

2.1 Heat Extraction Options

Tetra Tech EBA have discussed available options with KFN and agreed to consider four heat extraction options which could potentially be integrated with the water supply and treatment system. KFN leaders have directed the Tetra Tech EBA team toward these options considering a wide range of factors affecting current and future development in Burwash Landing, including their Community Land Use Plan. Details of the three extraction options are described below.

It is important to note that the heat extraction methods and estimated heat output are based on information collected from KFN-L in 2012 including the well water temperature of 15.9°C and a safe well yield of up to 6.3 L/s (100 USgpm). KFN-L has since been frozen due to the presence of permafrost in the area. Prior to the next steps in developing the geothermal resource including the conceptual design of a geoexchange system, it will be critically important to verify the information collected in 2012 which should include a thermal profile of the well column and a comprehensive water quality assessment, which will particularly important for any options that use the groundwater as the heat transfer fluid.

2.1.1 Option 1 – Basic Closed Loop System

Heat Extraction:

- For this option, we considered a simple closed-loop geoexchange concept.
- Heat exchange would be accomplished using a closed-loop durable plastic pipe heat exchanger placed in well KFN-L, with the wellhead sealed to prevent artesian overflow.
- Heat transfer fluid in the closed loop would be an environmentally safe antifreeze-water solution.
- An open-ended passive convection promoter pipe is necessary to keep water circulating vertically in the well and to prevent freezing due to the presence of permafrost.
- The WTP would need to be constructed near the KFN-L wellhead and designed to house heat exchange/recovery equipment and controls.

Water Disposal:

- This extraction option has the least complexity and water disposal would not be required.

The general configuration of Option 1 is shown in Figure 1 below.

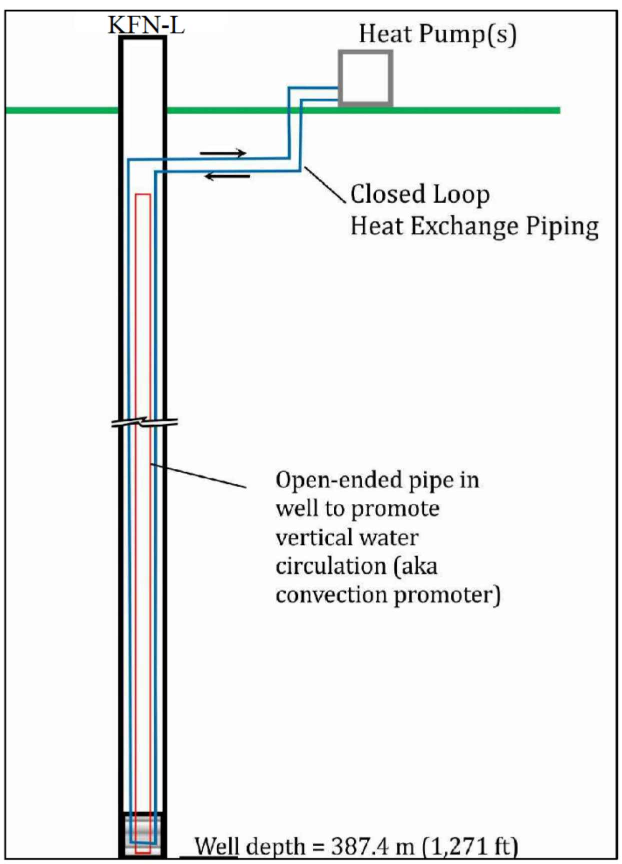

**Figure 1 – Heat Extraction Option 1 –
Basic Closed Loop System**

2.1.2 Option 2a – Modified Closed Loop System with Flow

Heat Extraction:

- Option 2 would include the same heat exchange plumbing in the well as for Option 1, as well as discharge from the wellhead (either under natural artesian flow, with a suction pump, or submersible pump) at a rate of between 0.63 and 3.8 L/s (10 and 60 USgpm). The well discharge removes cold water from the system, thereby moderating the well temperature.
- The WTP or an addition to the WTP would need to be constructed near KFN-L wellhead and designed to house heat exchange/recovery equipment and controls.

Water Disposal:

- With this option, the heat output is directly correlated with the well discharge (or "bleed") rate. This option is therefore limited by the amount of water that can be safely discharged to the environment.
- The water disposal rate (bleed rate) would depend on the desired heat output from the system, and on possible regulatory limitations. Over time, the existing artesian pressure may subside, and a suction pump may be required to achieve the desired flow. Bleed rate controls may be set manually or may be automated using a thermostat control loop system. Such bleed rates are usually controlled with an aquastat (a thermostat for water). When the well water reaches a low set point temperature, the aquastat energizes the pump to remove water from the well.
- Water disposal options are discussed in Section 3.0.

The general configuration of Option 2a is shown in Figure 2 below.

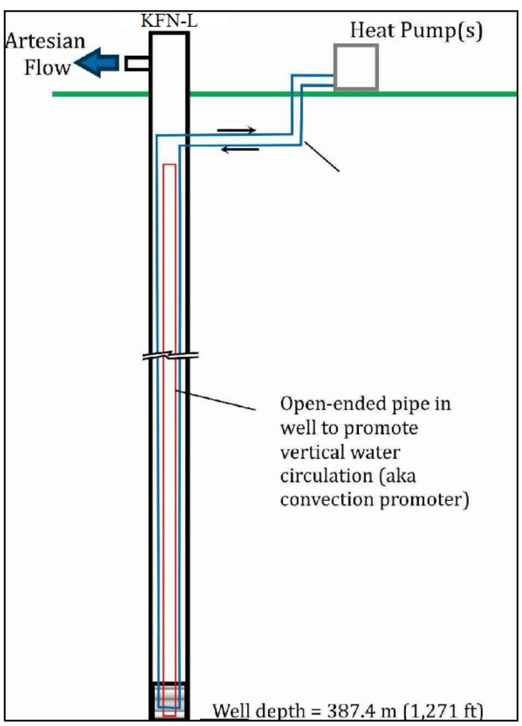

Figure 2 – Heat Extraction Option 2a – Modified Closed Loop System with Flow

2.1.3 Option 2b – Semi-open Loop System

Heat Extraction:

- Option 2b would include a semi-open loop (a.k.a. standing column well) configuration. The heat transfer fluid is the well water itself, circulated through a heat exchanger above ground and discharged back to the top of KFN-L. For this option, it will be necessary to bleed some well water out of the system at a rate of approximately 0.63 L/s (10 USgpm) to moderate well water temperature and prevent freezing. The well water would be isolated from the heat pump equipment to prevent scaling and fouling. Higher bleed rates of up to 6.3 L/s (100 USgpm) were also considered to increase heat output.
- The WTP or an addition to the WTP would need to be constructed near KFN-L wellhead and designed to house heat exchange/recovery equipment and controls.

Water Disposal:

- With the standing column well concept (Option 2b), water disposal will be required (from 0.63 to 6.3 L/s, or 10 to 100 USgpm). Heat output is directly correlated with discharge bleed rate. Heat extraction with this option is therefore governed by the amount of water that can be safely discharged to the environment.
- Water disposal options are discussed in Section 3.0.

The general configuration of Option 2b is shown in Figure 3 below.

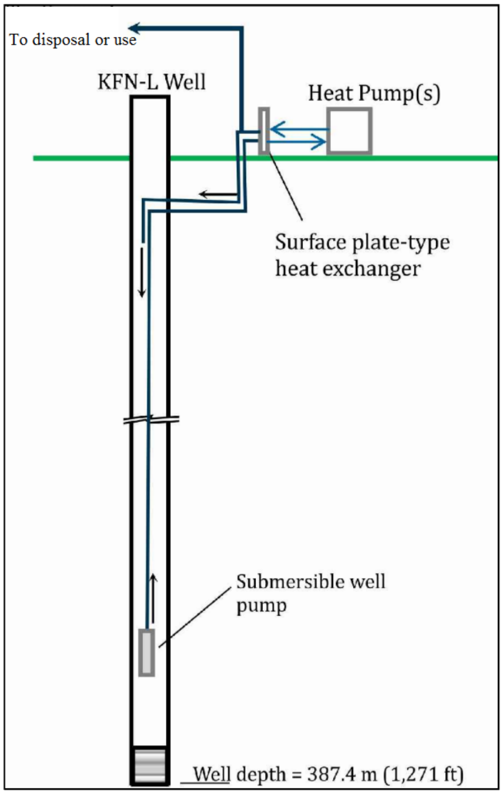

Figure 3 – Heat Extraction Option 2b – Semi-open Loop System

2.1.4 Option 3 – Open Loop System

Heat Extraction:

- An open loop approach for heat extraction is considered in this option. This will require a surface plate-type heat exchanger, heat pump(s) and controls at the new WTP near the KFN-L wellhead.
- The heat transfer fluid would be the well water itself, circulated through an above ground heat exchanger and disposed of. The well water would be isolated from the heat pump equipment to prevent scaling and fouling. The heat output would be directly proportional to the flow rate from the well. Short term (hours to days) maximum flow rates of up to 100 USgpm would be possible based on the estimated long-term sustainable yield presented in Table 1 above.

Water Disposal:

- All of the water extracted from KFN-L would require disposal. Heat output is directly correlated with pumping rate therefore this option is governed by the amount of water that can be safely discharged to the environment.
- Water disposal options are discussed in Section 3.0.

The general configuration of Option 3 is shown in Figure 4 below.

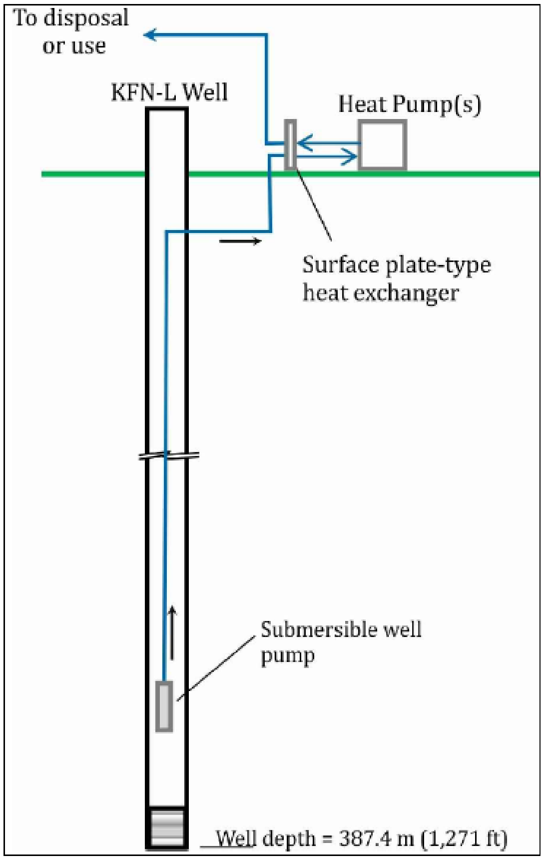

**Figure 4 – Heat Extraction Option 3 –
Open Loop System**

2.1.5 Heat Extraction Options Evaluation

Table 2 summarizes the heat extraction options assessed along with the estimated heat output and assumptions used for calculating the anticipated heat output.

Table 2: Summary of Geoexchange Cases for Heat Extraction from KFN-L

Heat Extraction Option	Estimated Heat Output (kW)	Groundwater Disposal Quantity	Key Assumptions
Option 1 – Basic Closed Loop System	15 kW	None	▪ Heat exchange accomplished with closed-loop, durable plastic pipe heat exchanger placed in well KFN-L. ▪ Heat carrier fluid is an environmentally-safe antifreeze-water solution. ▪ An open-ended “convection promoter” pipe is necessary to keep water passively circulating vertically in the well. ▪ Well water will be mixed only by convection, therefore the system may only capture the average water temperature over the entire water column. ▪ Average undisturbed Earth temperature from surface to ~400 m depth = 6.6°C. ▪ Thermal conductivity = 2.0 W m^{-1} K^{-1}. ▪ Thermal diffusivity = 0.076 m^2 day^{-1}.
Option 2a – Modified Closed Loop System with Flow	53-111 kW	10-60 USgpm	▪ Heat exchanger system same as for Option 1. ▪ **Additional feature:** Well is allowed to flow artesian or is bled using a suction pump or submersible pump. This pumping discharge promotes inflow of warm groundwater entering at the well bottom. ▪ Artesian flow or active pumping would promote an increase of warm groundwater from the targeted aquifer mixing into the water column, raising the average water temperature inside the well. ▪ The use of a suction pump would limit the practical drawdown in the well to about 6.1 m (20 ft) of lift. This translates to a bleed rate limit with a suction pump to about 15 USgpm. A submersible pump installed below the heat exchanger could be used for higher bleed rates but would increase the overall complexity of the system and maintenance requirements.
Option 2b – Semi-open Loop System	73-298 kW	10-100 USgpm	▪ “Semi-open” loop (standing column well). ▪ The heat transfer fluid is the well water itself, circulated through surface heat exchanger and disposed of back into the top of well KFN-L. ▪ It is necessary to bleed some well water out of the system to moderate well water temperature and prevent freezing. ▪ Well water is isolated from heat pump equipment to prevent possible scale, fouling of the heat pump(s).

Heat Extraction Option	Estimated Heat Output (kW)	Groundwater Disposal Quantity	Key Assumptions
Option 3 – Open Loop System	41-410 kW	10-100 USgpm	▪ Open loop geoexchange system. ▪ The heat transfer fluid is groundwater which would be extracted from the well using a submersible pump installed above the screened interval. ▪ All water must be used or disposed of. ▪ Well water is isolated from heat pump equipment to prevent possible scale, fouling of the heat pump(s).

As stated in Sections 2.1.2, 2.1.3 and 2.1.4, the heat output for Options 2a, 2b and 3 is correlated with the rate of water disposal (bleed rate) from KFN-L. The heat output was therefore estimated for a range of potential bleed or flow rates for Options 2a, 2b and 3. A graph of heat output versus bleed rate is presented as Figure 5.

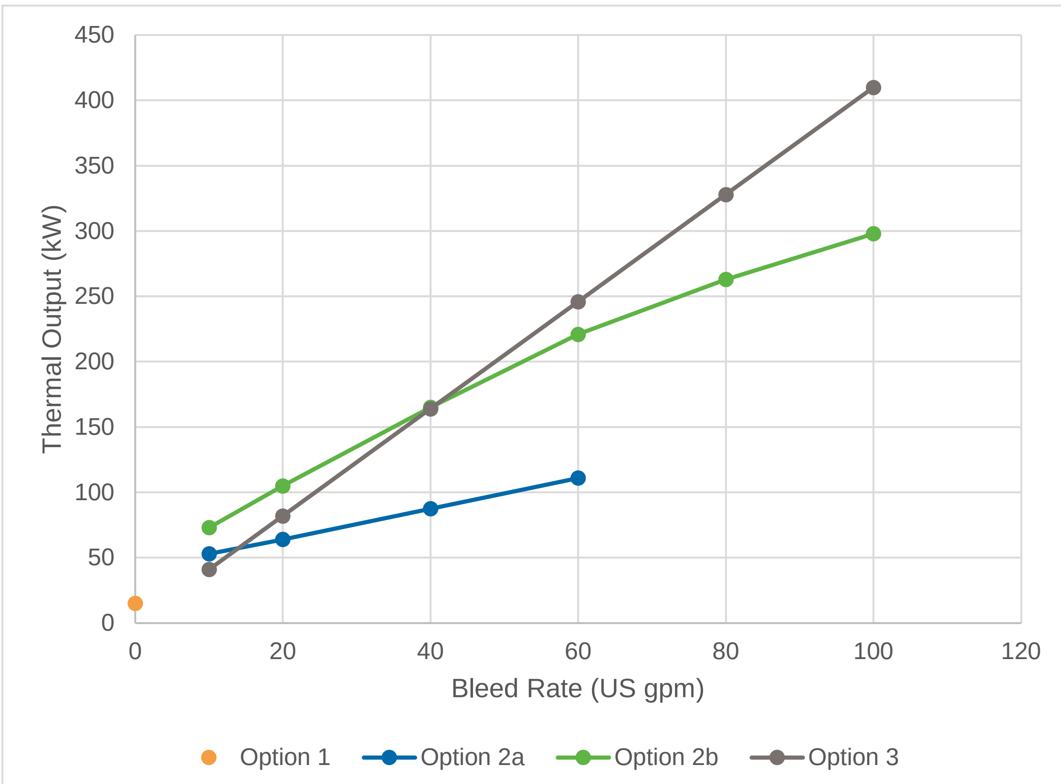

Figure 5 – Graph Showing Estimated Heat Output for Options 2a, 2b, and 3 at Various Bleed Rates

The estimated heat output results presented in Figure 5 indicate that Option 2b will provide the highest heat output for bleed rates of up to approximately 40 USgpm. Option 3 will provide the highest heat output for bleed rates greater than approximately 40 USgpm.

2.1.6 KFN-L Safe Well Yield and Bleed Rate Considerations

A recommended safe sustainable yield at KFN-L of 6.32 L/s (100 USgpm) was determined based on the 100 day projected specific capacity of KFN-L derived from the 72 hour constant rate pumping test conducted in 2012 (EBA, 2012). This safe sustainable well yield is governed by the transmission capacity of the well screen (rather than aquifer yield). (EBA 2012)

From first principles, we expect that KFN-L may experience a drop in artesian pressure and well yield over an extended period of continuous pumping due to aquifer depressurization. Based on the safe sustainable yield, the bleed rate for any of the proposed geoexchange options is not recommended to exceed 100 USgpm. It should also be noted that for bleed rates approaching the safe sustainable yield, artesian pressure and well yield may more rapidly over time.

Option 2a may either include a suction pump or submersible pump that would draw water from the well for discharge. Suction pumps are generally able to lift water from a well up to about 6 m (20 ft). Based on the specific capacity of KFN-L, the maximum bleed rate that can be achieved with a suction pump is about 15 USgpm which would result in a drawdown of approximately 4.5 m (14.8 ft). To allow for a factor of safety, and for potential future drop in artesian pressure and well yield over an extended time period, we recommend that suction pump bleed rates be limited to about 0.63 L/s (10 USgpm) for Option 2a.

A submersible pump would be able to provide larger bleed rates with an associated increased heat output. However, a submersible pump would likely have to be installed below the in-well heat exchanger due to space restrictions within the 6-inch diameter well casing. This would increase the overall complexity and maintenance requirements of the system. In addition, the heat exchanger would have to be removed from the well for submersible pump maintenance or replacement. For these reasons, a submersible pump configuration with higher discharge flows for Option 2a was not considered.

2.1.7 Existing Wood Chip Boiler

If a surplus of heat energy is not available from the geoexchange system, it may be feasible to further incorporate the existing wood chip boiler to provide heat to community buildings such as the KFN Administrative Building, Jacquot Hall, Sedata Centre, a proposed future RCMP detachment or future micro housing developments.

Tetra Tech EBA reviewed the Central Wood Heating System Report prepared by Northern Climate Engineering Ltd. for KFN in March 2001 to determine the amount of available boiler heat. Based on a review of this report, there are approximately 550,000 BTU per hour available on the east loop of the boiler system (Northern Climate, 2001).

Buildings that may be heated using this available heat include several small houses located to the east of the boiler system. Northern Climate estimated that the houses, which were relatively small, would have a heat demand of approximately 60,000 BTU per hour and a total of 9 houses could therefore be added within the existing wood chip boiler capacity (Northern Climate, 2001).

2.2 Heat Use Options

KFN and Tetra Tech EBA have discussed and agreed to consider three main heat use options which are intended to be integrated with the water supply and treatment system. If surplus heat energy is available after satisfying the demands of heat use options A, B or C, then heating of additional community buildings may be considered. The components of the heat use options are shown on Figure 6.

2.2.1 Option A – Heating of the Proposed New Water Treatment Plant

The location of the WTP is expected to be adjacent to wells KFN-K and KFN-L. Heat recovered from KFN-L would be conveyed into the WTP building to provide a base temperature greater than the outdoor air temperature. A companion heat source such as propane, wood or oil furnace would likely be required as redundant backup in case of power failure.

2.2.2 Option B – Heating of a Proposed Greenhouse Facility

The option will be evaluated for providing building conditioning heat to an (aquaponic) greenhouse facility which is proposed to be located to the north and adjacent to the WTP. Heat recovered from KFN-L would be conveyed into the greenhouse building to provide a base indoor air temperature greater than the outdoor air temperature to extend the greenhouse growing season. The geoexchange system as evaluated here would heat building air space only.

2.2.3 Option C – Freeze Protection for a Proposed Piped Water Distribution System

The proposed water distribution would consist of a single loop which would be installed adjacent to the road way along Sedata Street from the proposed WTP location to Jaquot Hall, returning along the parallel street to the north. Tetra Tech EBA understands that the piped water distribution system would serve the core area of Burwash Landing and would provide service to approximately 25 buildings. The geoexchange system would be used to pre-heat or temper the water supply in the WTP before it is circulated through the piped water distribution loop to prevent freezing.

2.2.4 Heat Use Options Evaluation

Table 3 summarizes the heat use options and estimated heat demand for each option.

Table 3: Estimated Heating Demands for Heat Use Options

Heat Use Options	Estimated Heat Demand (kW)	Key Assumptions
Option A – Heating of the Proposed New Water Treatment Plant	28	▪ The heat load per floor area was estimated to be 63 W/m^2 as estimated in the EBA (2013). ▪ The floor area of the proposed WTP was estimated to be 450 m^2 (~4,850 ft^2) based on the average floor area of the existing Burwash Landing WTP and similar WTPs in other Yukon communities.
Option B – Heating of the Proposed Greenhouse Facility	53	▪ The heat load per floor area was estimated to be 190 W/m^2 as estimated in EBA (2013). ▪ The floor area of the proposed greenhouse was estimated to be a maximum of 280 m^2 (~3000 ft^2 or 75 ft x 40 ft). ▪ Assumes heating the indoor air space only. ▪ The geoexchange would only provide half of the peak demand. ▪ It is assumed that a growing season may start in February.
Option C – Freeze Protection for a Proposed Piped Water Distribution System	7	▪ The geoexchange system would be used to pre-heat or temper the water supply before it is circulated through the piped water distribution loop to prevent freezing. ▪ Individual service connections will be equipped with electric heat trace for freeze protection between the building and municipal supply line. ▪ Estimated assuming the system will include a 50 mm diameter, 1,750 m long insulated water main and 550 m of 75 mm diameter carrier pipe (for service connections). ▪ Regional winter temperature conditions were applied to estimate the maximum freeze protection load. ▪ Steady State Thermal Equations were referenced from Cold Regions Utilities Monograph (Smith et al., 1996).

2.3 Piped Water Distribution System Feasibility Assessment

2.3.1 General Description

Based on communications with KFN representatives, Tetra Tech EBA has prepared a conceptual layout for a proposed piped water distribution system. The conceptual layout is presented on Figure 6. It should be noted that the locations of the proposed infrastructure (WTP, greenhouse, piped water distribution system) presented on Figure 6 are for illustration purposes only. The proposed system would include a recirculating water distribution loop to service the core area of Burwash Landing and is estimated to deliver water to approximately 25 buildings. Based on previous construction projects in the core area of Burwash Landing, shallow permafrost is expected to be present near the ground surface. Due to the expected presence of permafrost in this area, it is proposed that the water distribution loop and the individual service connections be buried nominally 1.0 to 1.5 m deep to remain above the permafrost layer. The piped water distribution loop would also require freeze protection.

Tetra Tech prepared Class C capital and operating and maintenance cost estimates to be compared to the current operating costs for trucked water delivery to the 25 buildings having proposed piped connections.

The following key assumptions have been made in preparation of the Class C Cost Estimates:

- The water distribution loop will extend from the proposed water treatment plant site and follow the roadway as shown on Figure 6;
- Minimal clearing, stripping and grubbing will be required along the water main alignment; The water main will consist of 1,750 m of a 50 mm diameter insulated pipe and thaw points and access vaults will be placed at 100 m intervals for thawing and draining in the event of water main freezing;
- At the main water supply loop (water main), freeze protection will include tempering of the water supply using the proposed geoexchange system (KFN-L);
- The service connections to all 25 buildings will consist of 25 mm diameter supply and return pipes housed within an insulated 75 mm diameter carrier pipe and will have a total length of 550 m.
- Each service connection will include heat trace cable for freeze protection powered by the building power supply;
- Annual operating and maintenance tasks included in the cost estimate were limited to: electrical utility cost for pumping and for heat trace freeze protection, and assumed incidental repairs and maintenance costs;
- The system will include a total of 25 service connections with 25 mm diameter supply and return lines housed within a 75 mm insulated carrier pipe;
- Trenches for water main and service connections will be approximately 1.5 m in depth;
- Each service connection will include a recirculation pump and electrical panel installation along with all typical fittings and valves;
- The costs associated with connecting the water main into the new WTP are not included in this estimate;
- The piped distribution system would be flushed, tested and disinfected prior to commissioning;
- KFN's internal labour costs associated with operations and maintenance would be constant since the water treatment and water truck operator is salaried;

- KFN's trucked water delivery cost records provided per residence or building can be averaged and applied to the 25 buildings having proposed piped connections for the purposes of this cost comparison; and
- Net present value (NPV) is calculated using a 2% inflation rate reported by the Bank of Canada, 2014.

2.3.2 Cost Comparison

The Class C capital and operating and maintenance costs estimated for the proposed piped water distribution loop, and the estimated cost to provide continued trucked water distribution are presented in Table 4. A detailed summary of the Class C capital and operating cost estimates is presented in Appendix D.

Table 4: Piped Distribution Class C Cost Estimates

Scenario	Capital Cost	Annual Operation and Maintenance Cost
Piped Water Distribution System	$1,291,000	$7,000
Trucked Water Delivery	None – (It is assumed that truck purchase, truck fill infrastructure and other capital costs would not change)	$13,000

The capital cost estimates indicate that continued trucked water delivery would be more cost effective in the short term. Piped water distribution would have lower annual operation and maintenance costs.

To evaluate the capital and operation and maintenance costs, the net present value (NPV) was calculated for piped water distribution and trucked water delivery, respectively, over 25 years, 50 years and 100 years. The estimated NPV results are summarized in Table 5.

Table 5: Net Present Value Estimates

Scenario	25 Years	50 Years	100 Years
Piped Water Distribution System	$1,510,000	$1,865,000	$3,376,000
Trucked Water Delivery	$428,000	$1,135,000	$4,252,000

Based on the NPV results, the piped water distribution system would be more expensive for an operating life of up to approximately 75 years. If the system is to be operated for longer than 75 years, trucked water delivery would be more expensive. A graph of NPV results for piped vs. trucked water distribution over a 25 to 100 year time period is shown in Figure 7.

It is important to note that the NPV analysis presented above assumes that the piped distribution system will have a lifespan of at least 100 years which is likely unrealistic. Considering that the actual lifespan of the piped water distribution system will likely be much smaller than 75 years, the NPV analysis indicates that the trucked water delivery is substantially cheaper than a piped water distribution system over the likely lifespan of the system.

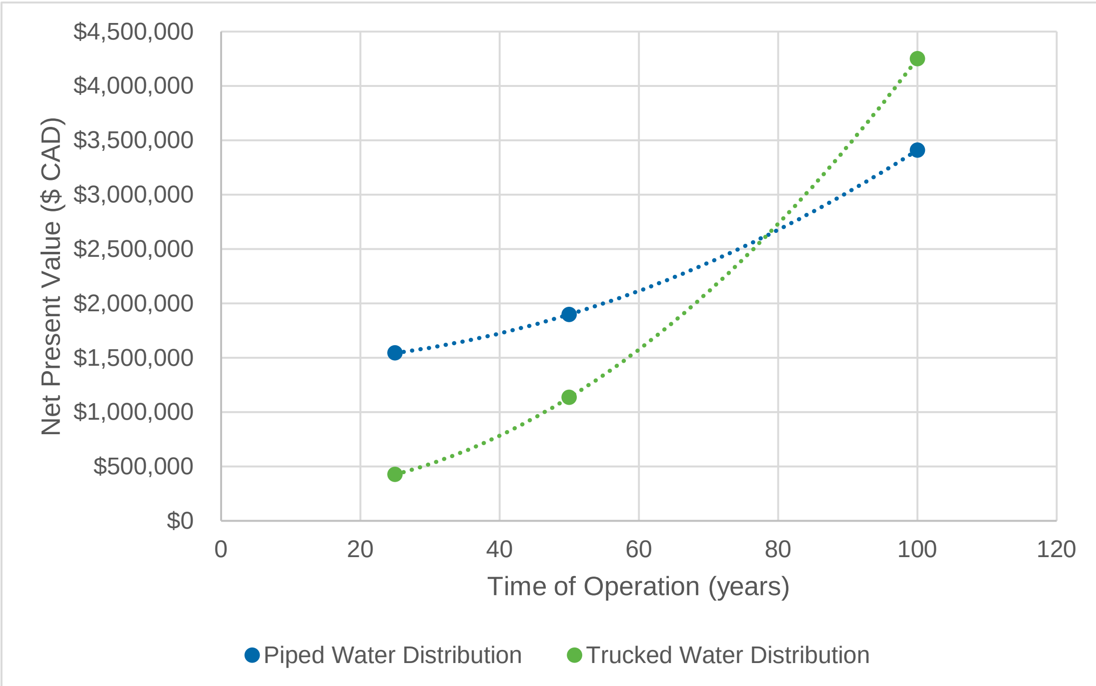

Figure 7 – NPV Comparison – Piped Vs. Trucked Water Distribution Systems

3.0 GEOEXCHANGE WATER DISPOSAL ASSESSMENT

3.1 Source Water Quality (KFN-L)

A groundwater sample from the warm water well KFN-L was collected on August 23, 2012 following a 72-hour constant rate pumping test. The sample was analyzed for typical drinking water parameters including major ions and total metals. The analytical results are summarized in Table 6.

The water from KFN-L is very hard and can be characterized as magnesium-sodium-calcium-bicarbonate (Mg-Na-Ca-HCO3) type water. The water is moderately mineralized with a total dissolved solids (TDS) concentration of 725 mg/L. The pH is near neutral at 7.50. The source water temperature was measured at 15.9°C during the 72-hour constant rate pumping test.

For the purpose of this study and consideration of potential water disposal options, the water chemistry of the source water was compared to both the Guidelines for Canadian Drinking Water Quality (GCDWQ) and the Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of Aquatic Life (AL). Exceedances of these water quality guidelines are highlighted in Table 7 and discussed in more detail below.

Analytical results show that water from the well exceeded the GCDWQ Maximum Allowable Concentration (MAC) for arsenic and the aesthetic objectives (AO) for temperature, colour, TDS, and iron. All other parameters tested met the GCDWQ at the date of sample collection.

The source water from KFN-L also exceeds several CCME-AL guidelines, including arsenic, iron, and zinc. Arsenic exceeds the CCME-AL guideline value by a factor of 15, whereas the other exceedances are less than significant with a factor between 2 and 10.

Table 7: Exceedances of Water Quality Guidelines

Parameter	Unit	KFN-L	GCDWQ	CCME-AL
Colour	TCU	29.0	15 (AO)	–
TDS	mg/L	725	500 (AO)	–
Arsenic	mg/L	0.075	0.01 (MAC)	0.005
Iron	mg/L	0.557	0.3 (AO)	0.3
Zinc	mg/L	0.393	5 (AO)	0.03

Notes:
GCDWQ – Guidelines for Canadian Drinking Water Quality
CCME-AL – Council of the Ministers of the Environment water quality guidelines for the protection of freshwater aquatic life
TDS – Total Dissolved Solids
AO – Aesthetic objective (affects taste or odour of water but no associated health risk)
MAC – Maximum Acceptable Concentration (health-based guideline for drinking water)

3.2 Water Disposal Options

Using water from KFN-L for heat extraction, except for a closed-loop geoexchange system, would require water disposal after the heat was extracted.

The following disposal options were considered as part of this study:

- Injection into shallow cold aquifer
- Discharge to surface water (Pond or Kluane Lake)

The following disposal options were not further considered due to the reasons stated below:

- Injection into deep aquifer
  - This option was not further considered based on the high capital cost to install another deep well into the warm-water aquifer that would be used as an injection well. Based on this, KFN decided that this option should not be further considered.
- Discharge to rock pit or shallow dry well
  - This option was not further considered due to the presence of extensive permafrost throughout the area and the associated limited infiltration capacity.
- Discharge to surface/wetland
  - Simple discharge to surface in an area to the north of KFN-L that is naturally wet does not appear to be a feasible disposal option due to the extensive permafrost in the area and the associated limited infiltration capacity. Water discharge to surface within this area would like result in surface runoff towards Kluane Lake with potential erosion issues. Also, uncontrolled wetland discharge and surface runoff into Kluane Lake (or the Pond) would be unacceptable from an environmental point of view.
  - Any direct discharge to surface or a wetland should include a constructed wetland or engineered bioreactor. A more detailed assessment of the feasibility of such a disposal option was beyond the scope of this project.

– Based on our preliminary findings disposal to surface water, which is discussed in more detail below, appears to be the most feasible option. However, depending on the constraints of disposal to surface water that need further assessment, the constructed wetland or engineered bioreactor option may warrant some further consideration. For example, a constructed wetland or engineered bioreactor could potentially be used for passive water treatment prior to discharge to surface water if treatment is required to meet effluent quality criteria.

3.2.1 Shallow Well Disposal

Injection of the used water from KFN-L into a shallow aquifer (e.g., the aquifer in which KFN-K is completed) would be the most cost efficient subsurface disposal option. However, subsurface disposal into a different aquifer than the supply aquifer poses the risk of depleting (depressurizing or dewatering) the deep warm water aquifer over time, and/or jeopardizing the water quality in the shallower aquifer. Given the relatively high safe well yield from KFN-L 6.3 L/s (100 USgpm) we do not expect a significant loss in KFN-L well yield at a low or moderate extraction rate in the order of 10 to 15 USgpm. However, a long-term decrease in well yield or artesian pressure is expected from first principles due to gradual depressurization of a confined aquifer due to groundwater extraction.

Water disposal to the shallow aquifer would require the drilling of a new shallow injection well which could be completed within the same aquifer as KFN-K. Waste water pumped into such an injection well would cause a rise in local static groundwater elevation (i.e., groundwater mounding would occur near the injection well). A suitable injection well would need to be located cross- or down-gradient from KFN-K to minimize well interference and to protect the water quality of KFN-K. To meet these objectives, the injection well would need to be placed outside of the capture zone of KFN-K. Well siting and capture zone analysis would be part of engineering feasibility studies if this disposal option was pursued.

Any discharge of waste water into an injection well needs to take into account the water quality of the waste water and the in situ groundwater quality. The mixing of two different water types may considerably alter the chemical conditions in the vicinity of the injection well and cause issues including scaling and incrustation of the well screen and surrounding aquifer matrix. A comprehensive assessment of the chemical composition of both the waste water and the groundwater in the receiving aquifer ought to be conducted along with water quality modelling to assess potential issues due to mixing of the different water types. Water quality issues can be substantial and lead to complete failure of the injection well if they are not addressed properly. Water treatment prior to reinjection may be required to mitigate potential water quality issues.

Another aspect of injecting the waste water to the shallow cold water aquifer is the fact that the aquifer is artesian (with a pressure of about 3 psi observed in 2012 at the KFN-K wellhead). Waste water would therefore need to be pumped into the injection well to overcome the artesian head of the shallow aquifer. Costs associated with such a pumping system would offset some of the benefits of a geoexchange system relying on reinjection.

Finally, for good practice, an alternative disposal option needs to be available for situations when the injection well is off-line (e.g., pump failure or injection well maintenance or rehabilitation). Temporary disposal to surface water (most likely the Pond) should be considered as a practical backup option.

In summary, disadvantages and potential issues of injecting the waste water from the geoexchange system to a shallow aquifer along with the requirement for a practical backup option (likely disposal to surface water) make this option unfavourable compared to the surface disposal option discussed below.

3.2.2 Surface Disposal

Possible surface water disposal locations include the Pond to the north of the location of KFN-L or Kluane Lake. Disposal to shallow ground (i.e. rock pit or disposal field) was not considered because of the presence of extensive permafrost in the area.

The direct disposal into Kluane Lake is less desirable due to potential fish habitat effects and public concern. However, depending on the suitability of Pond, the option of direct disposal into Kluane Lake should also be further assessed if disposal to surface water is considered.

The water quality of the discharge is a key factor in the permitting of the water disposal, especially if the water is to be discharged into a surface water body with potential adverse effects on fish and fish habitat. Water quality objectives are often based on Canadian Council of Ministers of Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life. However, baseline water quality should be taken into account when developing site specific water quality objectives and effluent quality criteria.

For a preliminary assessment of baseline water quality of the Pond and Kluane, KFN collected two water samples from the Pond and two water samples from Kluane Lake on March 16, 2015 at locations selected by Tetra Tech EBA. The sampling locations are shown on Figure 8. The water samples were analyzed for routine parameters, major ions, and total metals. The analytical results are summarized in Table 6 along with the water quality results for KFN-K and KFN-L.

The Piper diagram in Figure 9 illustrates the major ion composition of the samples collected from the deep warm water well (KFN-L) the shallow cold water well (KFN-K), the Pond, and Kluane Lake. The samples collected from the deep and shallow wells KFN-L and KFN-K show a similar major ion composition that is different from the composition of the samples collected from the Pond and Kluane Lake. The main difference in the major ion composition between the groundwater and surface water samples are the higher sodium concentrations observed in the groundwater.

The Pond and Kluane Lake also show distinct chemical compositions. The samples from Kluane Lake contain higher relative concentrations of calcium and sulphate, whereas the Pond water is more dominated by calcium/magnesium and bicarbonate.

The Pond water is generally more mineralized than Kluane Lake with TDS of more than 400 mg/L and an alkalinity (as $CaCO_3$) of also more than 400 mg/L. Kluane Lake, however, only exhibits a TDS of about 175 mg/L and an alkalinity (as $CaCO_3$) of about 150 mg/L. Total metals concentrations are also generally higher in the Pond than in Kluane Lake (see Table 6).

The fluoride concentration in both samples collected from the Pond exceeded the CCME-AL guideline value by a factor of about 2 (see Table 6). The iron and manganese concentrations in the Pond also appear elevated compared to Kluane Lake, with the iron concentration only slightly below the CCME-AL guideline.

The Pond has no clear surface inflow except for some surface runoff from the area to the south of the Pond. As a result, the potential water sources for the Pond include Kluane Lake or groundwater. Based on the distinct differences in water quality between the Pond and Kluane Lake it appears unlikely that Kluane Lake is the main source of the Pond water at least at the time of sample collection. The Pond water quality is also considerably different from the groundwater quality observed in KFN-K and KFN-L. However, groundwater remains the most likely source of the Pond water given its high mineralization and elevated metals concentrations. Groundwater from a shallow aquifer other than the one that KFN-K is completed in may be the main water source for the Pond.

It should be noted that there is currently a lack of seasonal data for the water quality of the Pond (and Kluane Lake). Based on changes in the water levels in the Pond and Kluane Lake as well as the hydraulic head of the shallow groundwater adjacent to the Pond, it is possible that the hydraulic gradient may change seasonally with an associated change in Pond water quality.

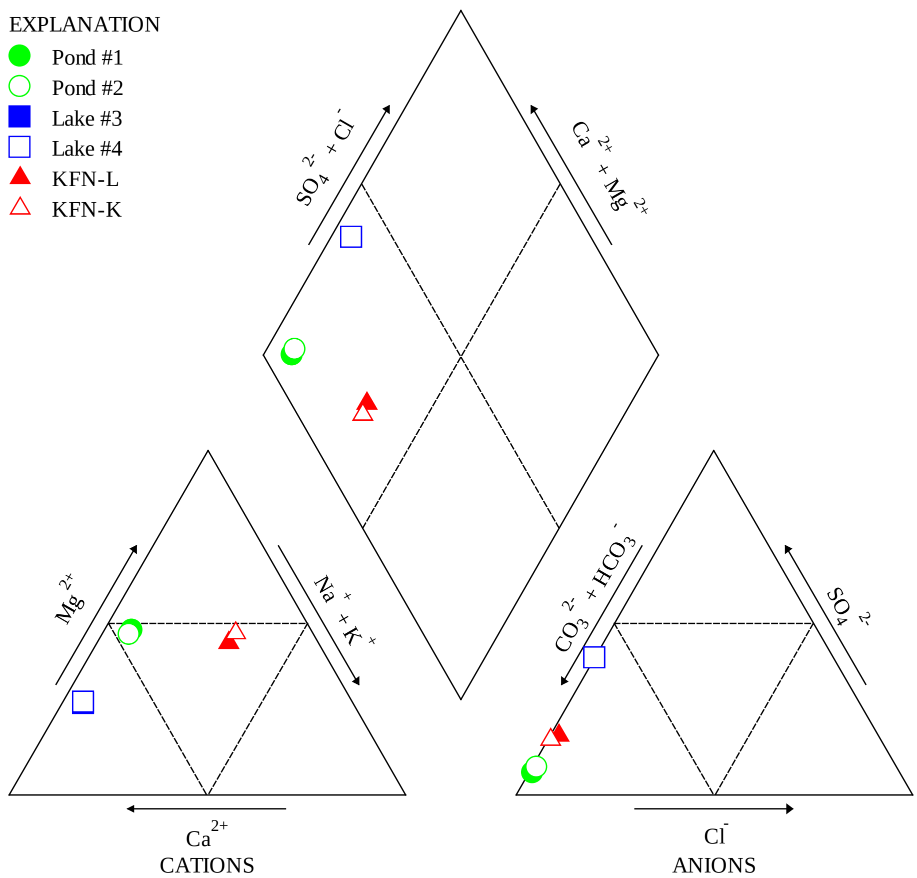

Figure 9 – Piper diagram illustrating the relative major ion composition of samples collected from KFN-K, KFN-L, the Pond, and Kluane Lake.

3.3 Regulatory Approval and Data Gaps

Based on the information presented to this point, disposal of the waste water from the geoexchange system into the Pond appears to be the most feasible disposal option based on currently available data. However, regulatory approval will be required for the discharge of waste water into the Pond, including an assessment under the Yukon Environmental and Socioeconomic Assessment Act (YESAA) and a Type A or B water licence issued by the Yukon Water Board. The applications under YESAA and for the water licence have to be based on an assessment of baseline environmental conditions and an assessment of potential effects on the receiving environment.

The following data gaps currently exist and would need to be filled prior to a submission under YESAA and to the Water Board:

- Collection of additional baseline data from KFN-L and the receiving environment (Pond and Kluane Lake) including physical and chemistry data:
  - Volume capacity of the Pond.
  - Seasonal changes of the lake level and associated changes in storage capacity.
  - Depth of freezing in the winter.
  - Baseline water quality.
  - Fish habitat assessment.
- An assessment of the connectivity of the Pond to Kluane Lake with identification of (preferential) discharge zones and depth.
- Based on the baseline conditions and project details, an effects assessment to identify potential adverse effects on the Pond and Kluane Lake due to the proposed discharge of waste water from the geoexchange system.
- Development of mitigations to minimize or eliminate adverse effects on the receiving environment (may include water treatment to meet discharge criteria).

The severity of potential effects of water disposal will largely depend on whether the Pond is fish-bearing or not. Tetra Tech EBA understands from anecdotal information that the Pond is not fish-bearing. However, a proper fish survey will be required to confirm this information. The fish survey should also include the adjacent near-shore area of Kluane Lake where Pond water potentially discharges into Kluane Lake.

The next step would include liaison with regulatory agencies to determine course of action for KFN to apply for the required regulatory approvals for water disposal.

4.0 OPTIONS EVALUATION AND CLASS C COST ESTIMATES

Tetra Tech EBA presented the preliminary findings of this study to KFN representatives on April 23, 2015. Based on the options assessed for geothermal heat extraction and heat use, KFN selected the cases described below for further cost evaluation. Heat use Option C for freeze protection of a proposed piped water distribution system was not considered as a preferred option because KFN has indicated (during the course of this project) that a piped water distribution system would not be further considered at this time.

- **Case 1:** Modified closed loop system (Option 2a) supplying heat to the proposed Water Treatment Plant of 450 m^2 (~4,850 ft^2) and a greenhouse of approximately 130 m^2 (1400 ft^2) (Options A and modified Option B). In this case, the available heat would be limited to approximately 53 kW (based on use of suction pump for bleed rate) which would meet the combined heat demand of approximately 53 kW.
- **Case 2:** Semi-open loop system (Option 2b) supplying heat to the proposed Water Treatment Plant of 450 m^2 (~4,850 ft^2) and a greenhouse of approximately 280 m^2 (3000 ft^2) (Options A and B). In this case, the available heat ranges from 73-298 kW (based on bleed rate) which would be adjusted to meet the combined heat demand of Options A and B of approximately 81 kW.

To evaluate the feasibility of the cases described above, Tetra Tech EBA has prepared Class C (+/- 25 to 35%) capital cost estimates as summarized in Table 8. The items considered in the capital cost estimates include earth coupling works, distribution and piping works, heat pumps and mechanical works. For the purposes of this cost estimate, it was assumed that no water treatment would be required for water disposal. The items considered in the additional investigation costs include a designated office level assessment under YESAA and an environmental effects assessment including baseline water quality and aquatic wildlife data collection. It should be noted that the completion of the additional investigations would support but not necessarily secure approval for permitting of the proposed geoexchange system. Depending on the results, regulators may require further assessment beyond the scope included in the Class C cost estimates here.

A detailed summary of the Class C capital cost estimates is presented in Appendix D.

Table 8: Class C Capital Cost Estimates

Case	Assumptions	Capital Cost	Additional Investigation Cost
1	▪ Modified closed loop system (Option 2a) ▪ Use of an above-ground suction pump for well discharge for reduced system complexity ▪ Operating with a bleed discharge rate of 10 USgpm would provide heat to the proposed WTP and a greenhouse of approximately 130 m^2 (1400 ft^2) ▪ Greenhouse size was reduced from full Option B due to available heat output	$290,000	$95,000
2	▪ Semi-open loop system (Option 2b) ▪ Operating with a discharge rate of 15 USgpm would provide heat to the proposed WTP and a greenhouse of approximately 280 m^2 (3000 ft^2) ▪ Heat output depends on bleed rate (assumed to be 15 USgpm here). Higher heat outputs are possible with increased bleed rate ▪ Greenhouse size is as originally scoped within heat use option B	$440,000	$95,000

There are advantages to the use of a closed loop configuration (Case 1) for the proposed geoexchange system. One advantage is that a closed loop system uses a fluid that is intended for use within heat exchangers and associated infrastructure. Fluid quality is therefore of little concern for closed loop system. Conversely, an open loop or semi-open loop geoexchange system uses groundwater where water quality issues may arise. Highly mineralized groundwater such as the water found at KFN-L has elevated hardness which can cause scaling, fouling or blockages in heat exchangers, piping and other system components on the well side of the heat extraction system.

Some key operation and maintenance considerations associated with each Case are presented in Table 9.

Table 9: Operation and Maintenance Considerations

Case	Operation and Maintenance Tasks and Considerations
1	▪ One passive element in KFN-L (closed loop/promoter tube assembly) ▪ A surface pump system (controls and maintenance) to enhance natural artesian discharge ▪ Heat pump circuit and controls (minimal maintenance after commissioning) ▪ Well bleed off discharge monitoring and controls ▪ Lower level of training and availability required of operators (could get by with one trained operator; a sudden 100% system stoppage is unlikely)
2	▪ Multiple active elements in KFN-L (pump and well water level monitoring/shut off controls) ▪ Submersible pump and controls (periodic pump maintenance and replacement; down time) ▪ Above ground heat exchanger (regular maintenance, antifouling, possible groundwater treatment prior to heat extraction or disposal) ▪ Recirculation of spent water back to top of KFN-L (level controls, antifouling) ▪ Heat pump circuit and controls (minimal maintenance after commissioning) ▪ Well bleed off discharge monitoring and controls ▪ Higher level of training and availability required of operators (at least two trained operators recommended for 24/7 coverage; a sudden 100% system stoppage is possible)

The operation and maintenance tasks and system complexity should be considered as an important factor in the evaluation of the potential geoexchange cases. Case 2 would be substantially more complex to run and maintain than Case 1 as a result of the additional controls, operation and maintenance tasks, and training required.

In addition to operational considerations, comparison of the Class C cost estimates indicates that Case 1 would be less costly. One aspect associated with Case 1 is that it produces less energy for a given water discharge rate. Case 1 allows for a discharge rate of 10 USgpm; therefore; the greenhouse size would be limited to approximately 130 m^2 (1400 ft^2) based on the estimated heating demand (cf. Section 2.2.4). If KFN considered supplementing the geothermal heating system with a secondary heat source such as wood, a larger greenhouse may be feasible.

5.0 FUTURE PROJECT FUNDING & SUPPORT

Tetra Tech EBA has identified the following potential funding and support opportunities applicable to the development of the proposed geoexchange system in Burwash Landing.

Table 10: Summary of Funding and Support Opportunities

Organization	Program / Fund	Contact	Notes
Infrastructure			
Building Canada	Economic Action Plan, First Nations Infrastructure	Martin Guilbreault 867.667.3240 Martin.guilbeault@aandc-aadnc.gc.ca http://actionplan.gc.ca/en/initiative/support-first-nations-infrastructure	This Fund focuses on five priority areas: improving First Nations energy systems (linking to power grids, sustainable energy systems), broadband connectivity, garbage disposal (including landfills and recycling), road and bridge projects, and improving community capacity for infrastructure planning.
Infrastructure Canada	Federal Gas Tax Fund	Martin Guilbreault 867.667.3240 Martin.guilbeault@aandc-aadnc.gc.ca http://www.infrastructure.gc.ca/plan/gtf-fte-eng.html	As part of the New Building Canada Plan, the renewed federal Gas Tax Fund (GTF) provides predictable, long-term, stable funding for Canadian municipalities to help them build and revitalize their local public infrastructure while creating jobs and long term prosperity. Communities are able to use the GTF towards a wide range of projects that include community energy systems, wastewater infrastructure, drinking water and capacity building.
PPP Canada	P3 Canada Fund	info@p3canada.ca http://www.p3canada.ca/en/about-p3s/	P3 Canada Fund was created to improve the delivery of public infrastructure and provide better value, timeliness and accountability by increasing the effective use of P3s. It is a merit-based program, designed to incent innovation.

Table 10: Summary of Funding and Support Opportunities

Organization	Program / Fund	Contact	Notes
AANDC	EcoENERGY for Aboriginal and Northern Communities Program 2011 – 2016	ecoENERGIE-ecoENERGY@aadnc-aandc.gc.ca http://www.aadnc-aandc.gc.ca/eng/1100100034258/1100100034259	Program is focused exclusively on providing funding support to Aboriginal and northern communities for renewable energy projects. It is delivered by AANDC and is part of a suite of clean energy programs funded by the Government of Canada that address action on climate change. Priority for funding consideration will be given to projects with the following characteristics: ▪ Projects in northern communities (in the territories). ▪ Projects in off-grid communities (those not connected to a provincial or regional electrical grid). ▪ Communities/proponents that have not received funding from EANCP in the past (i.e. since 2007).
Natural Resources Canada	ecoENERGY Innovation Initiative. http://actionplan.gc.ca/en/initiative/ecoenergy-innovation-initiative	info@actionplan.gc.ca	Funding areas: energy efficiency, clean electricity and renewables, bioenergy, electrification of transportation and unconventional oil and gas. Two streams of funding: one for research and development and one for demonstration projects.
Canadian Northern Economic Development Agency (CanNor)	Community Infrastructure Improvement Fund	ytinfo@cannor.gc.ca http://www.cannor.gc.ca/eng/1385559254357/1385559335415	The fund supports, on a cost-shared basis, repairs and improvements to existing community infrastructure that is accessible to the public.
Environment Canada	EcoAction Community Funding Program	http://ec.gc.ca/ecoaction/default.asp?lang=En&n=FA475FEB-1	Funding Program has provided financial support to community-based, non-profit organizations for projects that have measurable, positive impacts on the environment. The Program encourages action focused projects that will protect, rehabilitate or enhance the natural environment, and build the capacity of communities to sustain these activities into the future. Four themes: clean air, clean water, climate change and nature.
Canada	Clean Energy Portal	http://www2.nrcan.gc.ca/cleanenergy/index.cfm?action=init.summary&etid=8	Information portal.

Table 10: Summary of Funding and Support Opportunities

Organization	Program / Fund	Contact	Notes
Agriculture and Business			
Agriculture Canada	AgriInnovation Program Growing Forward 2	http://www.agr.gc.ca/eng/?id=1354301302625 Tony Hill, Director tony.hill@gov.yk.ca 867-667-5838 http://www.agr.gc.ca/eng/about-us/key-departmental-initiatives/growing-forward-2/?id=1294780620963	Industry-led Research and Development stream provides non-repayable support for Agri-science cluster: Support aims to mobilize and coordinate a critical mass of scientific expertise in industry, academia and government. The agri-science cluster would be national in scope, industry-led, and address components of the sector's applied science plan under a single application. Hence, it would address several themes that are priorities to the industry and would request support toward several research activities across the country. Programs focus on innovation, competitiveness and market development to ensure Canadian producers and processors have the tools and resources they need to continue to innovate and capitalize on emerging market opportunities.
Canadian Northern Economic Development Agency (CanNor)	Strategic Investments in Northern Economic Development	ytinfo@cannor.gc.ca http://www.cannor.gc.ca/eng/1385477070180/1385477215760	Program is made up of four streams: ▪ Targeted Investment Program ▪ Innovation & Knowledge Fund ▪ Partnership and Advisory Forums ▪ Pan-Territorial Fund
Canadian Northern Economic Development Agency (CanNor)	Northern Aboriginal Economic Opportunities Program	ytinfo@cannor.gc.ca http://www.cannor.gc.ca/eng/1385486556734/1385486648146	Program intended to increase the participation of northern Aboriginal communities and businesses in economic opportunities. Two funding streams: ▪ Community Readiness and Opportunities ▪ Entrepreneurship and Business Development

Table 10: Summary of Funding and Support Opportunities

Organization	Program / Fund	Contact	Notes
Yukon College	Cold Climate Innovation Yukon Research Centre	Stephen Mooney 867-456-8670 smooney@yukoncollege.yk.ca Clint Sawicki 867-668-8772 csawicki@yukoncollege.yk.ca	Funding areas: research and development particularly cold hardy preparation; demonstrating new technologies; funding levels vary $50-100k, with partnerships favoured. Access to research and development funding and partnership support.
Yukon Economic Development	Community Development Fund Strategic industries Development Fund	cdf@gov.yk.ca http://www.cdf.gov.yk.ca/ http://www.economicdevelopment.gov.yk.ca/general/si.html etf@gov.yk.ca	CDF gives Yukon community, industry and professional associations; non-profit and charitable organizations; and municipal and First Nations governments money for projects and events that: ▪ Support community well-being. ▪ Create jobs. ▪ Generate spending on Yukon goods and services. ▪ Have measurable social, cultural and economic benefits for Yukon residents and communities. Fund helps identify and assist the development of industries and strategic projects in the Yukon with the potential for broad-based economic benefits.
Agriculture Canada	Greenhouse and Processing Crops Research Centre http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1180624240102	mailto:della.johnston@agr.gc.ca http://www.agr.gc.ca/eng/science-and-innovation/research-centres/ontario/greenhouse-and-processing-crops-research-centre/?id=1180624240102	Mission is to develop and transfer new technologies for the production and protection of greenhouse vegetables and ornamentals. The centre leads research in several areas including greenhouse systems and environmentally sustainable agro-ecosystems for full-season crops.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Heat Extraction

The most feasible options for heat extraction are:

- Option 2a – Modified Closed Loop System with Flow, and
- Option 2b – Semi-open Loop System

Option 2a is a simpler concept than Option 2b in that it has no external heat exchanger, and does not use raw well water in the heat extraction process which avoids scaling and fouling issues. Option 2a also had lower estimated capital cost.

Option 2b is more complex, using raw well water in an external heat exchanger with possible scaling and fouling issues, and requires control of re-injected water to the top of the well. Option 2b also uses a submersible pump which will require periodic servicing or replacement during the life of the well. While Option 2b has higher capital cost than 2a, there is more overall geoexchange heat available with Option 2b than 2a.

Heat Use

The most feasible options for heat extraction were determined to be:

- Option A – Heating of the Proposed New Water Treatment Plant
- Option B – Heating of the Proposed Greenhouse Facility

KFN decided that Option C (freeze protection for a new piped water distribution system) is not of interest at this time and was therefore not further considered as part of the cost evaluation of the geoexchange options.

Water Distribution

The Class C capital cost for the new piped distribution system was estimated to be approximately $1,291,000. A piped water distribution system would have a high capital cost and would have a relatively long period return on the initial investment, compared with the trucked water option. Depending on the pay-back period requirements of KFN, it would be more cost effective to continue trucked water distribution to service the core area of Burwash Landing.

Water Disposal

Both heat extraction Options 2a and 2b require disposal of excess water from well KFN-L. Disposal of the waste water from the geoexchange system into the Pond appears to be the most feasible disposal option based on currently available information. However, additional assessment of the baseline conditions in the receiving environment and an environmental effects assessment would be required to satisfy necessary regulatory approval requirements.

6.2 Recommendations

Tetra Tech EBA recommends the following:

- KFN should select their preferred heat extraction and heat use options, and proceed to a conceptual design stage for the preferred option. This stage should include an updated thermal profile of KFN-L and groundwater samples and laboratory testing to confirm current characteristics and groundwater quality for water treatment design purposes.
- Concurrently with the conceptual design stage, an environmental baseline and effects assessment should be completed to determine the feasibility and acceptability of disposal of KFN-L water to the Pond. The assessment would include consultation with relevant permitting authorities to ensure adequate assessment scope and duration. As a minimum, the assessment should he verify the following:
  - Volume capacity of the Pond
  - Seasonal changes of the Pond level and Kluane Lake levels.
  - Depth of freezing in the Pond in winter.
  - Baseline water quality in the Pond and proposed discharge water from the geoexchange system.
  - Fish habitat assessment in the Pond and adjacent near-shore areas of Kluane Lake

7.0 ACKNOWLEDGEMENTS

Tetra Tech EBA would like to acknowledge the primary contributors for their role in this study:

- Kluane First Nation – Colum McCready, Director, Public Works and Municipal Services, and Herb Danroth, Manager, Public Works and Municipal Services; provided background data and input to the study.
- Marlene Jennings, B.Sc.; Project Manager; completed the research and authored the sections related to funding opportunities and regulatory considerations.
- Rob Dickson, E.I.T.; was the primary report author
- Stephan Klump, Ph.D.; completed the water quality and water disposal components of the study.
- Andrew Chiasson, Ph.D., P.Eng.; led the technical components of the geoexchange part of this study.
- Scott Schillereff, Ph.D., P.Geo.; senior technical support and review.

8.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech EBA Inc.

Prepared by:
Rob Dickson, E.I.T.
Environmental Engineer – Water Resources
Direct Line: 867.668.9243
Rob.Dickson@tetratech.com

Prepared by:
Stephan Klump, Ph.D.
Acting Director – Water Resources
Direct Line: 867.668.9220
Stephan.Klump@tetratech.com

Reviewed by:
H. Scott Schillereff, Ph.D., P.Geo.(BC)
Principal Specialist – Water Resources
Direct Line: 867.668.3068
Scott.Schillereff@tetratech.com

/cgc

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TABLES

Table 6: Water Quality Results

Parameter		Unit	Sample Location	POND#1	POND#2	LAKE#3	LAKE#4
				Pond	Pond	Kluane Lake	Kluane Lake
			Sampling Date	16-Mar-15	16-Mar-15	16-Mar-15	16-Mar-15
			Source	Kluane First Nation	Kluane First Nation	Kluane First Nation	Kluane First Nation
			Year	2015	2015	2015	2015
Physical Parameters							
Colour	Colour	TCU		9.5	11.6	<5.0	<5.0
Electrical Conductivity	EC	uS/cm		707	742	297	288
Turbidity	TURB	NTU		34.7	47.7	0.22	0.16
pH (Lab)	pH	pH_Units		7.91	7.85	8.04	8.05
Total Dissolved Solids (Lab)	TDS	mg/L		423	461	178	173
Non-metals/Anions							
Hardness	$CaCO_3$			406	440	156	151
Alkalinity (total)	$CaCO_3$			403	429	94.8	92.1
Nitrate	N			<0.0050	<0.0050	0.0058	<0.0050
Nitrite	N	mg/L		0.0018	<0.0010	<0.0010	<0.0010
Sulfate	SO_4			26.9	35.7	60.1	58.7
Chloride	Cl			3.01	3.81	<0.50	<0.50
Fluoride	Fl			**0.228**	**0.235**	0.110	0.109
Metals - Extractable/Total							
Aluminum	Al			0.0077	0.0540	0.0081	0.0088
Antimony	Sb			<0.00050	<0.00050	<0.00050	<0.00050
Arsenic	As			0.00214	0.00255	<0.00050	<0.00050
Barium	Ba			0.250	0.281	0.026	0.026
Beryllium	Be			<0.0010	<0.0010	<0.0010	<0.0010
Boron	B			0.10	0.11	<0.10	<0.10
Cadmium	Cd			<0.000010	<0.000010	<0.000010	<0.000010
Calcium	Ca			78.5	87.4	44.8	43.5
Chromium	Cr			<0.0010	<0.0010	<0.0010	<0.0010
Cobalt	Co			<0.00030	<0.00030	<0.00030	<0.00030
Copper	Cu			<0.0010	0.0012	<0.0010	<0.0010
Iron	Fe			0.101	0.266	<0.030	<0.030
Lead	Pb			<0.00050	<0.00050	<0.00050	<0.00050
Lithium	Li			0.0053	0.0055	<0.0050	<0.0050
Magnesium	Mg	mg/L		50.9	53.8	10.6	10.4
Manganese	Mn			*0.955*	*1.01*	0.00153	0.00128
Mercury	Hg			<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum	Mo			<0.0010	<0.0010	0.0017	0.0017
Nickel	Ni			<0.0010	0.0014	<0.0010	<0.0010
Potassium	K			9.3	10.4	2.8	2.8
Selenium	Se			0.00019	0.00030	0.00064	0.00062
Silver	Ag			<0.000020	<0.000020	<0.000020	<0.000020
Sodium	Na			8.9	9.6	2.5	2.4
Thallium	Tl			<0.00020	<0.00020	<0.00020	<0.00020
Tin	Sn			<0.00050	<0.00050	<0.00050	<0.00050
Titanium	Ti			0.011	0.013	<0.010	<0.010
Uranium	U			0.00033	0.00031	0.00099	0.00096
Vanadium	V			<0.0010	<0.0010	<0.0010	<0.0010
Zinc	Zn			<0.0050	<0.0050	<0.0050	<0.0050

[1] Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines for the Protection of Fresh Water Aquatic Life

[2] Guidelines for Canadian Drinking Water Quality (GCDWQ) criteria are referenced from Health Canada's *Guidelines for Canadian Drinking Water Quality Summary Table* (October 2014)

[3] The guideline applied for copper is the most stringent based on water hardness values measured across all samples. The following rule is applied: at hardness less than or equal to 180 mg/L, CW at hardness >180 mg/L, the CWQG is 4 µg/L, if the hardness is unknown, the CWQG is 2 µg/L.

[4] The CCME guideline applied for lead is the most stringent based on water hardness values measured across all samples. The following rule is applied: at hardness less than or equal to 180 mg/L at hardness >180 mg/L, the CWQG is 7 µg/L, if the hardness is unknown, the CWQG is 1 µg/L.

[5] The CCME guideline applied for nickel is the most stringent based on water hardness values measured across all samples. The following rule is applied: at hardness less than or equal to 180 mg/ at hardness >180 mg/L, the CWQG is 150 µg/L, if the hardness is unknown, the CWQG is 25 µg/L.

[6] Turbidity is not regulated for untreated water

AO refers to the Aesthetic Objective according to the GCDWQ criteria.

OG refers to an Operational Guideline according to the GCDWQ criteria. OG values are related to plant operations and can be compared based on a running annual average of monthly samples.

MAC refers to the Maximum Acceptable Concentration according to the GCDWQ criteria.

Bold indicates parameter exceeds CCME Canadian Environmental Quality Guidelines for the Protection of Fresh Water Aquatic Life

Underline indicates parameter exceeds Guidelines for Canadian Drinking Water Quality MAC

Italics indicates parameter exceeds Guidelines for Canadian Drinking Water Quality OG or AO

FIGURES

LEGEND:

- CONCEPTUAL PIPED WATER DISTRIBUTION SYSTEM
- CONCEPTUAL GEOTHERMAL HEAT DISTRIBUTION SYSTEM

0 100

Scale: 1: 2 500 (metres)

ISSUED FOR USE

CLIENT

TETRA TECH EBA

WATER DISTRIBUTION AND GEOEXCHANGE FEASIBILITY STUDY
BURWASH LANDING, YUKON

CONCEPTUAL SITE PLAN

PROJECT NO.	DWN	CKD	REV
ENVH2O03086-01	CB	RD	0

OFFICE	DATE
EBA-WHSE	March 6, 2015

Figure 6

LEGEND:

● - APPROXIMATE SAMPLING LOCATIONS

0 100m

Scale: 1:2,000 @ 8.5"x11"

CLIENT

KLUANE FIRST NATION BURWASH LANDING

TETRA TECH EBA

WATER DISTRIBUTION AND GEOEXCHANGE FEASIBILITY STUDY
BURWASH LANDING, YUKON

APPROXIMATE WATER SAMPLING LOCATIONS

PROJECT NO.	DWN	CKD	REV	
ENVH2O03086-01	CB	SK	0	**Figure 8**
OFFICE	DATE			
EBA-WHSE	April 22, 2015			

APPENDIX A
TETRA TECH'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOENVIRONMENTAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 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 EBA’s client. Tetra Tech EBA 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 EBA’s Client unless otherwise authorized in writing by Tetra Tech EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of Tetra Tech EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA’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 EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. The Client warrants that Tetra Tech EBA’s instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 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 EBA in its reasonably exercised discretion.

4.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

APPENDIX B

GEOEXCHANGE AND HEAT USE OPTIONS MEMO

KLUANE FIRST NATION
ATTN: Herb Danroth
Box 20
Burwash Landing YT Y1A 1V0

Date Received: 17-MAR-15
Report Date: 24-MAR-15 15:01 (MT)
Version: FINAL

Client Phone: 867-841-4200

Certificate of Analysis

Lab Work Order #: L1588522

Project P.O. #: 54504
Job Reference:
C of C Numbers: 10-152976
Legal Site Desc:

Can Dang
Senior Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1588522-1	L1588522-2	L1588522-3	L1588522-4
	Description	Water	Water	Water	Water
	Sampled Date	16-MAR-15	16-MAR-15	16-MAR-15	16-MAR-15
	Sampled Time	17:00	17:00	17:00	17:00
	Client ID	POND#1	POND#2	LAKE#3	LAKE#4
WATER					
Physical Tests	Colour, True (CU)	9.5	11.6	<5.0	<5.0
	Conductivity (uS/cm)	707	742	297	288
	Hardness (as CaCO3) (mg/L)	406	440	156	151
	pH (pH)	7.91	7.85	8.04	8.05
	Total Suspended Solids (mg/L)	3.4	12.2	<1.0	<1.0
	Total Dissolved Solids (mg/L)	423	461	178	173
	Turbidity (NTU)	34.7	47.7	0.22	0.16
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	403	429	94.8	92.1
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	403	429	94.8	92.1
	Ammonia, Total (as N) (mg/L)	1.45	1.08	<0.0050	0.0052
	Chloride (Cl) (mg/L)	3.01	3.81	<0.50	<0.50
	Fluoride (F) (mg/L)	0.228	0.235	0.110	0.109
	Nitrate (as N) (mg/L)	<0.0050	<0.0050	0.0058	<0.0050
	Nitrite (as N) (mg/L)	0.0018	<0.0010	<0.0010	<0.0010
	Sulfate (SO4) (mg/L)	26.9	35.7	60.1	58.7
	Anion Sum (meq/L)	8.72	9.43	3.15	3.07
	Cation Sum (meq/L)	8.88	9.60	3.29	3.20
	Cation - Anion Balance (%)	0.9	0.9	2.1	2.1
Total Metals	Aluminum (Al)-Total (mg/L)	0.0077	0.0540	0.0081	0.0088
	Antimony (Sb)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050
	Arsenic (As)-Total (mg/L)	0.00214	0.00255	<0.00050	<0.00050
	Barium (Ba)-Total (mg/L)	0.250	0.281	0.026	0.026
	Beryllium (Be)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010
	Boron (B)-Total (mg/L)	0.10	0.11	<0.10	<0.10
	Cadmium (Cd)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010
	Calcium (Ca)-Total (mg/L)	78.5	87.4	44.8	43.5
	Chromium (Cr)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010
	Cobalt (Co)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030
	Copper (Cu)-Total (mg/L)	<0.0010	0.0012	<0.0010	<0.0010
	Iron (Fe)-Total (mg/L)	0.101	0.266	<0.030	<0.030
	Lead (Pb)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050
	Lithium (Li)-Total (mg/L)	0.0053	0.0055	<0.0050	<0.0050
	Magnesium (Mg)-Total (mg/L)	50.9	53.8	10.6	10.4
	Manganese (Mn)-Total (mg/L)	0.955	1.01	0.00153	0.00128
	Mercury (Hg)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1588522-1	L1588522-2	L1588522-3	L1588522-4	
	Description	Water	Water	Water	Water	
	Sampled Date	16-MAR-15	16-MAR-15	16-MAR-15	16-MAR-15	
	Sampled Time	17:00	17:00	17:00	17:00	
	Client ID	POND#1	POND#2	LAKE#3	LAKE#4	
Grouping	**Analyte**					
WATER						
Total Metals	Molybdenum (Mo)-Total (mg/L)	<0.0010	<0.0010	0.0017	0.0017	
	Nickel (Ni)-Total (mg/L)	<0.0010	0.0014	<0.0010	<0.0010	
	Potassium (K)-Total (mg/L)	9.3	10.4	2.8	2.8	
	Selenium (Se)-Total (mg/L)	0.00019	0.00030	0.00064	0.00062	
	Silver (Ag)-Total (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	
	Sodium (Na)-Total (mg/L)	8.9	9.6	2.5	2.4	
	Thallium (Tl)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	
	Tin (Sn)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Titanium (Ti)-Total (mg/L)	0.011	0.013	<0.010	<0.010	
	Uranium (U)-Total (mg/L)	0.00033	0.00031	0.00099	0.00096	
	Vanadium (V)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Zinc (Zn)-Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	
Aggregate Organics	BOD (mg/L)	7.9	11.4	<2.0	<2.0	

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

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Barium (Ba)-Total	MS-B	L1588522-1, -2, -3, -4
Matrix Spike	Iron (Fe)-Total	MS-B	L1588522-1, -2, -3, -4
Matrix Spike	Titanium (Ti)-Total	MS-B	L1588522-1, -2, -3, -4

Qualifiers for Individual Parameters Listed:

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

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 "Alkalinity"

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BOD5-VA	Water	Biochemical Oxygen Demand- 5 day	APHA 5210 B- "BIOCHEMICAL OXYGEN DEMAND"

This analysis is carried out using procedures adapted from APHA Method 5210 B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

BOD5-VA	Water	Biochemical Oxygen Demand- 5 day	APHA 5210 B- BIOCHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5210 B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

CL-IC-N-WR	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method.
Colour measurements can be highly pH dependent, and apply to the pH of the sample as received (at time of testing), without pH adjustment. Concurrent measurement of sample pH is recommended.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

F-IC-N-WR	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

IONBALANCE-VA	Water	Ion Balance Calculation	APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

Reference Information

MET-T-CCMS-VA Water Total Metals in Water by CRC ICPMS APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-TOT-ICP-VA Water Total Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-WR Water Nitrite in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-WR Water Nitrate in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

SO4-IC-N-WR Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-CALC-VA Water TDS (Calculated) APHA 1030E (20TH EDITION)

This analysis is carried out using procedures adapted from APHA 1030E "Checking Correctness of Analyses".

TSS-LOW-WR Water Total Suspended Solids by Grav. (1 mg/L) APHA 2540 D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids are determined by filtering a sample through a glass fibre filter and drying the filter at 104 degrees celsius.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

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

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

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

Chain of Custody Numbers:

10-152976

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-152976

L1588522-COFC

Chain of Custody / Analytical Re[quest Form]
Canada Toll Free: 1 800 668[...]
www.alsglobal.com

ALS Environmental

Page ____ of ____

Report To	KLUANE FIRST NATION
Company:	" " "
Contact:	HUGR DANROTH
Address:	BOX 20
Phone:	1-867-841-4274 Fax: 1-867-841-5900
Invoice To	Same as Report ? (circle) (Yes) or No (if No, provide details)
	Copy of Invoice with Report? (circle) (Yes) or No
Company:	
Contact:	
Address:	
Phone:	Fax:
Lab Work Order # (lab use only)	

Report Format / Distribution

Standard: Other (specify):

Select: PDF Excel Digital Fax

Email 1: maintenance@kfn.ca

Email 2: pwmsdirector@kfn.ca

stephan.klump@tetratech.com

Client / Project Information

Job #:

PO / AFE: 54504

LSD:

Quote #:

ALS Contact: Sampler:

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)

- Regular (Standard Turnaround Times - Business Days)
- Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
- ✓ Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
- Same Day or Weekend Emergency - Contact ALS to confirm TAT

Analysis Request
(Indicate Filtered or Preserved, F/P)

Number of Containers

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type / Analysis
1	125 ML Pone	MAR16/15	5pm	Routine Chemistry Major Ions
2	125 ML Pone	" "	5pm	" "
3	125 ML LAKE	" "	5pm	" "
4	125 ML LAKE	" "	5pm	" "
1	Brown Bottel Pone	" "	5.10 pm	" "
2	Brown Bottel Pone	" "	5.10 pm	" "
3	Brown Bottel Lake	" "	5.10 pm	" "
4	Brown Bottel Lake	" "	5.10 pm	" "
1	500 mL Pone	MAR16/15	5.15 pm	Same has above Routine Chemistry Major Ions
2	500 mL Pone	" "	5.15 pm	
3	500 mL Lake	" "	5.15 pm	
4	500 mL Lake	" "	5.15 pm	

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by: [signature]	Date: 17-MAR-15	Time: 1:45	Temperature: 2.6 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

APPENDIX C
ANALYTICAL RESULTS

TETRA TECH EBA

TECHNICAL MEMO

ISSUED FOR REVIEW

To:	Chief Math'ieya Alatini – Kluane First Nation	**Date:**	February 23, 2015
c:	Colum McCready, Director of Public Works & Housing, Kluane First Nation	**Memo No.:**	01
From:	Marlene Jennings, PM	**File:**	704-ENVH2O03086-01
Subject:	Geoexchange and Heat Use Options to be Considered as part of the Feasibility Study		

1.0 INTRODUCTION

Tetra Tech EBA Inc. (Tetra Tech EBA) has been retained by the Kluane First Nation (KFN) to complete a feasibility study to evaluate geoexchange and heat use options for utilizing the warm water well KFN-L in the community of Burwash, Yukon. The objective of this study is to move forward from the Guidance Document completed by Tetra Tech EBA in 2013[1] to evaluate the feasibility of KFN's preferred options. Based on recent communications with KFN, Tetra Tech EBA has prepared the following proposed geoexchange and heat use options to be evaluated as part of the current study. The purpose of this memo is to describe the proposed options and solicit confirmation from KFN that these options are acceptable for this study.

To ensure that the project remains on schedule, please confirm whether the options described herein are agreeable by Wednesday, February 25, 2015.

2.0 OPTIONS TO EXTRACT HEAT ENERGY

The following options will be evaluated for the extracting heat energy from the geothermal resource (well KFN-L) in light of current study constraints and priorities from KFN:

1. **Basic Closed Loop System:** A closed loop, durable plastic pipe with an environmentally-safe heat conducting circulating fluid (antifreeze-water solution) would be inserted into KFN-L to extract heat energy from the geothermal resource. The well would be shut in and no water disposal would be necessary.

2. **Modified Closed Loop System with Flow** A closed loop, durable plastic pipe with an environmentally-safe heat conducting circulating fluid (antifreeze-water solution) would be inserted into KFN-L to extract heat energy from the geothermal resource. The well would be allowed to flow under controlled Artesian conditions or would be pumped at a low flow rate to increase the average water column temperature within the well outside of the closed loop. This option would require low volume water disposal.

3. **Semi-open Loop System:** The heat transfer fluid is the well water itself, collected near the bottom of the well, circulated through a surface heat exchanger and disposed of back into the top of KFN-L. It would be necessary to 'bleed' some water out of the system to moderate well water temperature. This option would therefore require low volume water disposal.

[1] Tetra Tech EBA (2013) Guidance Document for Development of Cold and Warm Water Well System, Burwash Landing, Yukon. Prepared for Government of Yukon (Tetra Tech EBA File: W23103077-01).

Tetra Tech EBA Inc.
61 Wasson Place
Whitehorse, YT Y1A 0H7 CANADA
Tel 867.668.3068 Fax 867.668.4349

As part of the evaluation of these options, Tetra Tech EBA will discuss the energy output and water disposal requirements related to extraction options 1, 2 and 3. Based on previous analyses, we would not consider a fully open loop system option as that would require the drilling of a deep injection well (similar to KFN-L) with prohibitively high costs.

Since the wood-fired boiler is not located close to the proposed water treatment plant (WTP) or greenhouse facilities, heat losses are expected to be substantial to convey boiler heat to these points of use. As a result, the boiler would not be considered a potential heat source for these facilities. However, it may be a feasible supplementary heat source for freeze protection for part of the proposed water distribution system. We would therefore evaluate the potential excess heat available from the existing the boiler system.

3.0 OPTIONS FOR USING HEAT ENERGY

Based on our understanding of current KFN priorities, the following geoexchange heat use options would be evaluated:

A. **Heating of the Proposed New Water Treatment Plant (WTP):** The option will be evaluated for providing heat to the new WTP building.

B. **Freeze Protection for a Proposed New Water Distribution System:** The option for freeze protection for the proposed new piped water distribution system will be evaluated. Our current understanding of the approximate configuration of the water distribution system is depicted on Figure 1.

C. **Heating of the Proposed Greenhouse Facility:** The option will be evaluated for providing heat to the proposed aquaponic greenhouse facility.

For each use option, we will determine any geothermal heat surplus (or deficit). Where there is a heat surplus, there may be other uses for this heat. In consultation with KFN, we would prepare an inventory of existing and potential buildings with estimated heating demands that may be considered for future use of excess heat energy from either a geoexchange system or the existing wood-fired boiler. Such buildings could include the KFN administrative building, Jacquot Hall, Sedata Centre, new school, new RCMP detachment building, or new micro housing project.

4.0 OPTIONS EVALUATION AND CLASS C COST ESTIMATES

Potential heat extraction options (Section 2.0) will be evaluated in combination with potential heat uses (Section 3.0). The two most desirable scenarios of heat extraction and heat use, as selected by KFN, will be used by Tetra Tech EBA to calculate Class C capital and operating and maintenance costs. Our cost analysis would not include constructing or operating the new WTP.

The feasibility assessment of a piped water distribution system will also include a capital estimate and a cost comparison for the operational costs for the water supply of the core area of Burwash Landing with proposed piped distribution versus the current trucked water delivery system.

General requirements, and capital and life-cycle costs will be presented for a new water delivery truck in conjunction with any updated WTP design information from the upcoming Yukon Government RFP for the WTP.

5.0 REGULATORY ISSUES AND FUTURE PROJECT FUNDING

In addition to the scope of services outlined above, we will also complete the following scope items as per our proposal:

- Summary of expected permits, approvals and timelines required for the scenarios considered as part of this study.
- Summary of potential funding programs in consideration of the scenarios assessed as part of this study.

LEGEND

- PROPOSED WATER DISTRIBUTION LINE

0 250

Scale: 1: 5 000 (metres)

STATUS
ISSUED FOR USE

CLIENT

Yukon Government
Department of Community Services

eba
A TETRA TECH COMPANY

GUIDANCE DOCUMENT FOR DEVELOPMENT
OF COLD AND WARM WATER WELL SYSTEM

SITE PLAN SHOWING EXISTING CONDITIONS
AND RELEVANT SITE FEATURES

PROJECT NO.	DWN	CKD	REV
W23103077-01	CB	RMM	0
OFFICE	DATE		
EBA-WHSE	April 18, 2013		

Figure 1

Q:\Whitehorse\Data\0201drawings\Burwash\W23103077-01 Guidance Document for Cold & Warm Water Well System\Report #2\W23103077-01 Fig 1_R0.dwg [FIGURE 1] February 19, 2015 - 4:01:25 pm (BY: BUCHAN, CAMERON)

APPENDIX D

SUMMARY OF CLASS C COST ESTIMATES

Geoexchange Case1 - Class C Capital Cost Estimate

Item Number	Item	Unit	Quantity	Unit Cost	Total
1.0	*Earth Coupling Works*				
1.1	Downhole heat exchange piping	m	400	$ 16.80	$ 7,000.00
1.2	Antifreeze fluid	m3	0.6	$ 630.00	$ 1,000.00
2.0	*Distribution System and Piping Works*				
2.1	Pre-insulated main (supply + return)	m	40	$ 130.00	$ 6,000.00
2.2	Discharge Line	m	180	$ 130.00	$ 24,000.00
2.2	Trenching and backfilling	m	220	$ 60.00	$ 14,000.00
3.0	*Heat Pumps and Mechanical Works*	kW	54	$ 3,080.00	$ 167,000.00
	Sub-Total				**$ 219,000.00**
	Engineering (20 %), (rounded up to nearest thousand)				$ 33,000.00
	Contingency (15 %), (rounded up to nearest thousand)				$ 33,000.00
	Total (rounded up to nearest thousand)				**$ 290,000.00**

(1) This estimate is based on recent U.S. cost surveys (Kavanaugh et al. (2012) and Battocletti and Glassley (2012)) and includes heat pumps plus all associated mechanical equipment and installation costs

Case 1 Additional Investigations and Consulting Services Class C Capital Cost Estimate

Item Number	Item	Unit	Quantity	Unit Cost	Total
1	Designated office level assessment under YESAA	Lump Sum	1	$ 15,000.00	$ 15,000.00
2	Baseline Water Quality Assessment	Lump Sum	1	$ 30,000.00	$ 30,000.00
3	Aquatic Baseline Assessment	Lump Sum	1	$ 22,000.00	$ 22,000.00
4	Type B water license application	Lump Sum	1	$ 15,000.00	$ 15,000.00
	Sub-Total				**$ 82,000.00**
	Contingency (15 %), (rounded up to nearest thousand)				$ 13,000.00
	Total (rounded up to nearest thousand)				**$ 95,000.00**

Geoexchange Case 2 - Class C Capital Cost Estimate

Item Number	Item	Unit	Quantity	Unit Cost	Total
1.0	*Earth Coupling Works*				
1.3	Submersible well pump	kW	0.4	$ 2,800.00	$ 2,000.00
1.4	Well pump house	lump	1	$ 21,000.00	$ 21,000.00
1.5	Surface plate-type heat exchanger(s)	kW	81	$ 21.00	$ 2,000.00
2.0	*Distribution System and Piping Works*				
2.1	Pre-insulated main (supply + return)	m	40	$ 130.00	$ 6,000.00
2.2	Discharge Line	m	180	$ 130.00	$ 24,000.00
2.3	Trenching and backfilling	m	220	$ 60.00	$ 14,000.00
3.0	*Heat Pumps and Mechanical Works*	kW	81	$ 3,080.00	$ 250,000.00
	Sub-Total				**$ 319,000.00**
	Engineering (20 %), (rounded up to nearest thousand)				$ 64,000.00
	Contingency (15 %), (rounded up to nearest thousand)				$ 48,000.00
	Total (rounded up to nearest thousand)				**$ 440,000.00**

Table X: Case 1 Additional Investigations and Consulting Services Class C Capital Cost Estimate

Case 2 Additional Investigations and Consulting Services Class C Capital Cost Estimate

Item Number	Item	Unit	Quantity	Unit Cost	Total
1	Designated office level assessment under YESAA	Lump Sum	1	$ 15,000.00	$ 15,000.00
2	Baseline Water Quality Assessment	Lump Sum	1	$ 30,000.00	$ 30,000.00
3	Aquatic Baseline Assessment	Lump Sum	1	$ 22,000.00	$ 22,000.00
4	Type B water license application	Lump Sum	1	$ 15,000.00	$ 15,000.00
	Sub-Total				**$ 82,000.00**
	Contingency (15 %), (rounded up to nearest thousand)				$ 13,000.00
	Total (rounded up to nearest thousand)				**$ 95,000.00**

Class C Capital Cost Estimate - Piped Water Distribution System

Item Number	Item	Unit	Quantity	Unit Cost	Total
1.0	*Distribution System and Piping Works*				
1.1	Clearing	m^2	4600	$ 1.40	$ 7,000.00
1.2	Grubbing and disposal	m^2	4600	$ 0.75	$ 4,000.00
1.3	Stripping and Salvage for F	m^2	4600	$ 0.30	$ 2,000.00
1.4	Trenching and backfilling	L.m.	2300	$ 90.00	$ 207,000.00
1.5	Supply and install pre-insul	L.m.	1750	$ 180.00	$ 315,000.00
1.6	Supply and install pre-insul	L.m.	550	$ 226.25	$ 125,000.00
1.7	Tie services to house plum	Each	25	$ 6,000.00	$ 150,000.00
1.8	Supply and Install Double Wy	Each	18	$ 2,900.00	$ 53,000.00
1.9	Supply and Install Valves, c/w	Each	36	$ 600.00	$ 22,000.00
1.10	Supply and Install Watermair	Each	25	$ 125.00	$ 4,000.00
1.11	Tie Services to Main, c/w sad	Each	25	$ 700.00	$ 18,000.00
1.12	Flush, Test, Disinfect Waterm	Lump	1	$ 6,400.00	$ 7,000.00
2.0	*Permafrost investigation drilling*				
2.1	Drilling company	Lump Sum	1	$ 24,000.00	$ 24,000.00
2.2	EBA field review	Lump Sum	1	$ 17,000.00	$ 17,000.00
2.3	EBA reporting	Lump Sum	1	$ 8,000.00	$ 8,000.00
Sub-Total					**$ 963,000.00**
Engineering (20 %), (rounded up to nearest thousand)					$ 183,000.00
Contingency (15 %), (rounded up to nearest thousand)					$ 145,000.00
Total (rounded up to nearest thousand)					**$ 1,291,000.00**

Class C Annual Operation and Maintenance Cost Estimate - Piped Water Distribution System

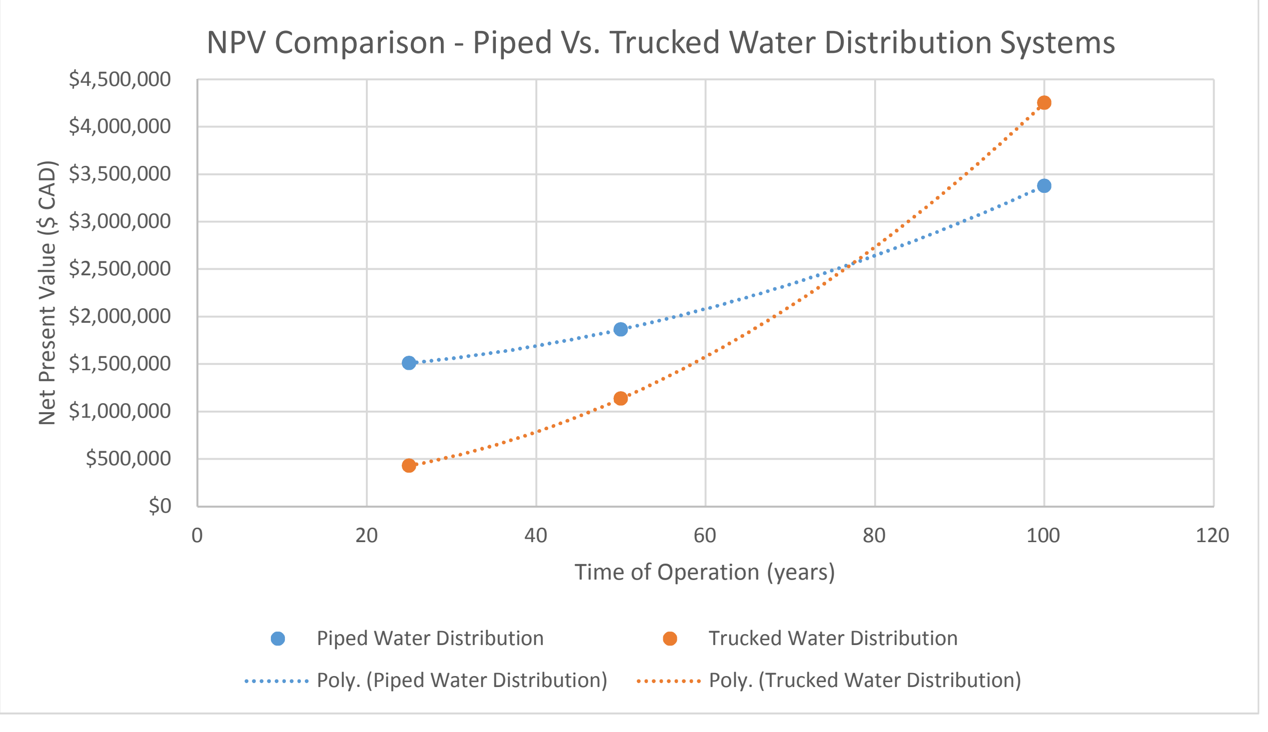
Item Number	Item	Unit	Quantity	Unit Cost	Total
1.0	*Distribution System and Piping Works*				
1.1	Electrical Utilities (Heat Trace	kWh	23927	$ 0.1645	$ 4,000.00
1.2	Electrical Utilities (Pumping)	kWh	1971	$ 0.1547	$ 1,000.00
1.3	Incidental Repairs and Maint	Lump Sum	1	$ 1,000	$ 1,000.00
	Sub-Total				**$ 6,000.00**
	Contingency (15%)				$ 900.00
	Total (rounded up to nearest thousand)				**$ 7,000.00**

Trucked Water Distribution Class C Annual Operation and Maintenance Cost Estimate

Item Number	Item	Unit	Quantity	Unit Cost	Total
1.1	Vehicle Fuel	Cost Per Residence	25	$ 300	$ 8,000.00
1.2	Vehicle Repairs and Mainten	Cost Per Residence	25	$ 108	$ 3,000.00
	Sub-Total				**$ 11,000.00**
	Contingency (15%)				$ 1,650.00
	Total (rounded up to nearest thousand)				**$ 13,000.00**

Net Present Value Calculated Using 2% Inflation [Bank of Canada, 2014] ($)

Years of Operation	25 Years	50 Years	100 Years
Piped Water Distribution	$1,510,000	$1,865,000	$3,376,000
Trucked Water Distribution	$428,000	$1,135,000	$4,252,000
	25	50	100



APPENDIX E
WATER TRUCK REQUIREMENTS

TETRA TECH EBA

TECHNICAL MEMO

ISSUED FOR USE

To:	Chief Math'ieya Alatini – Kluane First Nation	**Date:**	April 30, 2015
c:	Colum McCready, Director of Public Works & Housing, Kluane First Nation Nick Rodger, Senior Program Manager, Infrastructure Development, Government of Yukon	**Memo No.:**	01
From:	Rob Dickson, E.I.T. and Dharshan Kesavanathan, P.Eng.	**File:**	704-ENVH2O03086-01
Subject:	Water Truck Requirements for Water Supply and Treatment System Upgrades, Burwash, Yukon		

1.0 INTRODUCTION

Tetra Tech EBA Inc. (Tetra Tech EBA) was retained by Kluane First Nation (KFN) to assess options and requirements for the supply of a new water truck to be used as a primary trucked water service vehicle as part of the proposed water supply and treatment system upgrades in Burwash, Yukon. The requirements have been prepared in general accordance with the *Yukon Drinking Water Regulation* (O.I.C. 2007/139) and the *Design Guidelines for First Nations Water Works* published by Indian and Northern Affairs Canada, now Aboriginal Affairs and Northern Development Canada (AANDC) (March 2006). Tetra Tech EBA has also worked with KFN public works personnel to incorporate any specific requests related to truck function into the water truck requirements.

2.0 GENERAL REQUIREMENTS

2.1 General Description

Supply and deliver one (1) water truck unit fitted with a 2000 imperial gallon (9092 litre) potable water tank and other appurtenances as specified. The truck shall be new and unused.

The water truck unit is to have a standard road package that meets all legal requirements for operating on public roadways including, but not limited to, the Yukon *Motor Vehicles Act*, the federal *Motor Vehicle Safety Act*, Yukon Occupational Health and Safety Regulations, and shall be built in accordance with the Society of Automotive Engineers' (SAE) international automotive standards.

Prospective bidders must complete in full and submit the attached supplier price table (Table 1) and summary of proposed materials and equipment (Table 2).

2.2 Equivalent Products

Bids will be accepted for consideration on any make and model that is equal or superior to the truck chassis, fittings, and other appurtenances specified. The equivalency of bids will be interpreted and decided at KFN's sole discretion.

Tetra Tech EBA Inc.
61 Wasson Place
Whitehorse, YT Y1A 0H7 CANADA
Tel 867.668.3068 Fax 867.668.4349

2.3 Delivery

The water truck unit shall be delivered to KFN's public works manager, located at an agreed upon location in Burwash Landing, Yukon, Canada, Y0B 1V0. Cost of freight shall be included in the bid price.

Contractor shall state delivery time after receipt of order.

2.4 Title, Risk of Loss, Freight

Title of goods received under a Government of Yukon contract or purchase order agreement shall remain with the supplier until they are delivered in full to KFN's public works manager.

The supplier will bear all risks of loss, theft, injury, or destruction or damage of goods and materials ordered herein, which occur prior to delivery and acceptance. Such loss, theft, injury, or destruction or damage shall not release the supplier from any obligations under the contract or purchase order agreement.

3.0 TECHNICAL REQUIREMENTS

All items listed below representKFN's minimum water truck requirements. All bid submissions must satisfy all requirements listed below. Unauthorized conditions, limitations, or provisions shall be cause for rejection. KFN reserves the right to reject any and all bids, at their sole discretion. Water truck units proposed by prospective bidders must be in accordance with all applicable legislation including, but not limited to, Yukon transportation, occupational health and safety, SAE international automotive standards and environmental health standards and guidelines.

The water truck must be supplied in accordance with the following.

1.0 Truck

1.1 Diesel Transmission 5 Tonne Truck (400 horsepower gasoline engine).

1.2 The truck's chassis must be single axel [four (4) wheels].

1.3 The total truck length should not exceed 7.6 m.

1.4 The total truck width should not exceed 2.6 m.

1.5 The total truck height should not exceed 3.6 m.

1.6 Side mirrors should be collapsible and should be less than 0.5 m in length.

1.7 The truck must be fitted with mud flaps, a rear bumper, and tow plate.

1.8 Brakes shall be hydraulically operated.

1.9 A spare tire on a rim shall be provided.

1.10 Rims of wheels shall be powder coated.

1.11 Driver seat shall be bucket type, passenger seats and rear seats (if applicable) shall be bench type.

1.12 The truck must be fully capable of being fitted with the water tank described below, and must be fully capable of operating with a full water tank in accordance with all applicable standards and guidelines.

Note: It is essential that the dimensions not exceed those specified above to allow the truck to fit within the water treatment building.

2.0 Water Tank

2.1 2000 imperial gallon (9092 litre) carbon steel potable water tank.

2.2 Exterior stainless steel ladder and landing with side railings for fall protection for accessing the top of the tank.

2.3 The tank shall have compatibility for gravity top filling.

2.4 The water tank must be mounted and installed in accordance with all applicable transportation and safety regulations and SAE international automotive standards.

3.0 Pump

3.1 75 mm (3 in.) diameter Gardner Denver Drum FP 2000 (stainless steel) or an approved equivalent.

3.2 An in line flow meter and totalizer for accurate measurement and display of dispensed water volumes in litres (L) and metres cubed (m^3).

4.0 Fittings and Hose Cabinet

4.1 An electric hose reel (stainless steel).

4.2 Piping and valves within cabinet to be stainless steel to reduce chlorine induced corrosion.

4.3 Two 75 mm (3 in.) diameter stainless steel vents.

4.4 The hose reel and components located in the valve compartment should be made of stainless steel to reduce chlorine-induced corrosion.

4.5 The hose must be 22 m long, 37.5 mm (1.5 in.) inner diameter, arctic-grade potable water hose.

4.6 The hose fittings must be compatible with a 37.5 mm (1.5 in.) diameter hose bib connection or approved equivalent.

5.0 Controls

5.1 System should provide manual flow rate pump control and emergency shutoff capabilities.

5.2 A metering and totalizing system should be included to allow for measurement of water volumes dispensed during day-to-day operations.

5.3 The flow meter and totalizer should be readily visible to the operator when operating the pump controls.

6.0 Other Appurtenances

6.1 The supplied water truck must be run and all functions must be tested prior to delivery.

6.2 The system must be disinfected in accordance with the applicable guidelines.

6.3 The water truck must be washed to KFN's approval upon delivery.

4.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Kluane First Nation and their agents. Tetra Tech EBA Inc. 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 Kluane First Nation, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are attached to this memo.

Attachments: Tetra Tech EBA's General Conditions – Design Report
Table 1 – Supplier Price Table
Table 2 – Summary of Proposed Materials and Equipment

GENERAL CONDITIONS

DESIGN REPORT

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT AND OWNERSHIP

This Design Report pertains to a specific site, a specific development, and a specific scope of work. The Design Report may include plans, drawings, profiles and other support documents that collectively constitute the Design Report. The Report and all supporting documents are intended for the sole use of Tetra Tech EBA's Client. Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, analyses or other contents of the Design Report when it is used or relied upon by any party other than Tetra Tech EBA's Client, unless authorized in writing by Tetra Tech EBA. Any unauthorized use of the Design Report is at the sole risk of the user.

All reports, plans, and data generated by Tetra Tech EBA during the performance of the work and other documents prepared by Tetra Tech EBA are considered its professional work product and shall remain the copyright property of Tetra Tech EBA.

2.0 ALTERNATIVE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA'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 EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. Tetra Tech EBA's instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless so stipulated in the Design Report, Tetra Tech EBA was not retained to investigate, address or consider, and has not investigated, addressed or considered any environmental or regulatory issues associated with the project specific design.

4.0 CALCULATIONS AND DESIGNS

Tetra Tech EBA has undertaken design calculations and has prepared project specific designs in accordance with terms of reference that were previously set out in consultation with, and agreement of, Tetra Tech EBA's client. These designs have been prepared to a standard that is consistent with industry practice. Notwithstanding, if any error or omission is detected by Tetra Tech EBA's Client or any party that is authorized to use the Design Report, the error or omission should be immediately drawn to the attention of Tetra Tech EBA.

5.0 GEOTECHNICAL CONDITIONS

A Geotechnical Report is commonly the basis upon which the specific project design has been completed. It is incumbent upon Tetra Tech EBA's Client, and any other authorized party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the geotechnical information that was reasonably acquired to facilitate completion of the design.

If a Geotechnical Report was prepared for the project by Tetra Tech EBA, it will be included in the Design Report. The Geotechnical Report contains General Conditions that should be read in conjunction with these General Conditions for the Design Report.

6.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

Table 1 - Supplier Price Table

Item	Unit	Unit Price ($CAD)	Number of Units	Total Price ($CAD)
Truck Unit	Lump Sum		1	
Water Tank, Pump, Controls and Appertenences Supply	Lump Sum		1	
Water Tank, Pump, Controls and Appertenences Installation/Assembly	Lump Sum		1	
Testing and Disinfection	Lump Sum		1	
Freight	Lump Sum		1	
Total Price ($CAD)	Lump Sum		1	

Table 2 - Summary of Proposed Materials and Equipment

Specified Performance-Based Requirements		Included?		Manufacturer's Specifications of Equipment Proposed (Suppliers must complete all spaces in this column.)
		Yes	No	
1.0	**Truck**			
1.1	Automatic Transmission 5 Tonne Truck (300 – 400 horsepower gasoline engine).			
1.2	The truck's chassis must be single axel [four (4) wheels].			
1.3	The total truck length should not exceed 7.6 m.			
1.4	The total truck width should not exceed 2.6 m.			
1.5	The total truck height should not exceed 3.6 m.			
1.6	Side mirrors should be collapsible and should be less than 0.5 m in length.			
1.7	The truck must be fitted with mud flaps, a rear bumper, and tow plate.			
1.8	Brakes shall be hydraulically operated.			
1.9	A spare tire on a rim shall be provided.			
1.10	Rims of wheels shall be powder coated.			
1.11	Driver seat shall be bucket type, passenger seats and rear seats (if applicable) shall be bench type.			
1.12	The truck must be fully capable of being fitted with the water tank described below, and must be fully capable of operating with a full water tank in accordance with all applicable standards and guidelines.			
	Note: It is essential that the dimensions not exceed those specified above to allow the truck to fit within the water treatment building.			
2.0	**Water Tank**			
2.1	2000 imperial gallon (9092 litre) steel potable water tank.			
2.2	Exterior stainless steel ladder and landing with side railings for fall protection for accessing the top of the tank.			
2.3	The water tank must be mounted and installed in accordance with all applicable transportation and safety regulations and SAE international automotive standards.			
3.0	**Pump**			
3.1	75 mm (3 in.) diameter Gardner Denver Drum FP 2000 (stainless steel) or an approved equivalent.			
3.2	An in line flow meter and totalizer for accurate measurement and display of dispensed water volumes in litres (L) and metres cubed (m^3).			
4.0	**Fittings and Hose Cabinet**			
4.1	An electric hose reel (stainless steel).			
4.2	Piping and valves within cabinet to be stainless steel to reduce chlorine induced corrosion.			
4.3	Two 75 mm (3 in.) diameter stainless steel vents.			
4.4	The hose reel and components located in the valve compartment should be made of stainless steel to reduce chlorine-induced corrosion.			
4.5	The hose must be 22 m long, 37.5 mm (1.5 in.) inner diameter, arctic-grade potable water hose.			
4.6	The hose fittings must be compatible with a 37.5 mm (1.5 in.) diameter hose bib connection or approved equivalent.			
5.0	**Controls**			
5.1	System should provide manual flow rate pump control and emergency shutoff capabilities.			
5.2	A metering and totalizing system should be included to allow for measurement of water volumes dispensed during day to day operations.			
5.3	The flow meter and totalizer should be readily visible to the operator when operating the pump controls.			
6.0	**Other Appurtenances**			
6.1	The supplied water truck must be run and all functions must be tested prior to delivery.			
6.2	The system must be disinfected in accordance with the applicable guidelines.			
6.3	The water truck must be washed to KFNs approval upon delivery.			