LIARD FIRST NATION

UPDATED AQUIFER AND WELLHEAD PROTECTION PLAN
LIARD FIRST NATION COMMUNITY WELLS

2 MILE COMMUNITY
WATSON LAKE, YT

W23101082

December 2008

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PAGE

TABLES (ATTACHED)

TABLES (IN TEXT)

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APPENDICES

1.0 INTRODUCTION AND BACKGROUND

1.1 GENERAL

At the request of Mr. Robert Greenway, Capital Project Director of Liard First Nation (LFN), EBA Engineering Consultants Limited (EBA) has completed an Aquifer and Wellhead Protection Plan (AWHPP) for the LFN Community Wells in the study area ("2 Mile Community" includes 2, 2.4 and 2.5 Mile Communities) of Watson Lake, Yukon (Figure 1). Indian and Northern Affairs Canada's (INAC's) *First Nation Water Management Strategy* provided funding for the development of this AWHPP for the LFN Community Wells.

The risk-based approach to develop an Aquifer and Wellhead Protection Plan has been developed by EBA and is presented in a paper included in Appendix D.

This risk-based Aquifer and Wellhead Protection Plan is presented in three key stages: Stage 1 – Risk Framework, Stage 2 – Risk Assessment, Stage 3 – Risk Management. This report presents the findings, discussion, conclusions and recommendations resulting from this study.

1.2 PURPOSE AND SCOPE

The purpose of this project was to complete a risk-based AWHPP for the two future LFN Community Wells in the 2 Mile Community. The wells **TW05-02** and **TW05-03** (referred to as the Community Wells in this report) are currently being connected to a water treatment plant to serve LFN residents through bulk water truck delivery, and will be the main source of water for the Liard First Nation. Figures 2 and 3 show the location of the Community Wells.

This AWHPP is intended to be used to identify, forestall, manage, mitigate, monitor and communicate issues of water quality and quantity in groundwater supplies used by humans. Groundwater ultimately entering a well comes from an area that is defined as a capture zone or recharge area for that well. The basic objective of an AWHPP is to provide realistic protective measures to pragmatically manage activities in the capture zone or recharge area of a well or well field, to reduce risks to a water supply source. Establishing an AWHPP is an important step to protect the valuable resource, the health and safety of the community, and to protect the investment in water supply infrastructure.

The scope of work was completed in accordance with the EBA proposal dated October 2007, and included the following:

- Definition of capture zones and groundwater travel times for the two Community Wells (TW05-02 and TW05-03);
- Identification and mapping of groundwater contamination hazards;
- Assessment of risk and development of management strategies; and,
- Presenting and reporting results.

1.3 SURFICIAL GEOLOGY

Surficial geology mapping indicates that the study area is located within the limits of the McConnell glaciation, and the terrain is dominated by undulating morainic and colluvial deposits overlying bedrock. The mapping also indicates a continuous zone of shallower, surficial overburden deposits extending throughout the study area. These deposits are described as gravel, sand and silt, outwash plain deposits with occurrences of silty till sediments, typically less than 30 m in thickness.

1.4 HYDROGEOLOGY

EBA reviewed existing hydrogeological information in order to develop a conceptual hydrogeology model. The development of this conceptual model involved a detailed review of the following information:

- Well logs for domestic and community supply wells within the 2 Mile Community;
- A report entitled "Hydrogeological Study for Potable Groundwater Supply" (EBA 2006);
- A report entitled "Hydrogeological Evaluation for Groundwater Supply" (EBA 2005);
- A report entitled "Liard First Nation Groundwater Source Evaluation" (Pacific Hydrology 2003);
- Environment Canada climate data for the Watson Lake airport station; and,
- Air photos for the Watson Lake area.

Available lithological information recorded in well logs confirms the surficial geology interpretations mentioned previously. As indicated on Table 1, the majority of the existing wells have been completed to depths less than 30 m below grade (bg), and logs indicate a large degree of heterogeneity with respect to the grain size distribution (and by inference permeability) of the sediments encountered. Bedrock has been encountered within 10 m of ground surface at some locations within the study area, and is known to be at least 45 m in depth at the location of the Community Wells based on the drilling logs for these wells (Appendix A). EBA interprets that continuous zones of sediments with similar grain size distributions are not likely to extend over long distances, i.e. >10 m vertically or >100 m horizontally. The logs indicate that the coarse-grained deposits are intermixed with well graded deposits of lower permeability sediments.

The hydrogeological setting of the 2 Mile Community was assessed to determine the location of aquifer boundaries, aquitards, sources of recharge and discharge, static water levels within the aquifer and hydraulic properties. This information was then used to define the numerical model (see Section 3) extent and boundary conditions. Static water level information was collected by EBA on October 31 and November 1, 2007.

TW05-02 and TW05-03 are completed at depths of 37.5 and 43.4 m bg within a semi-confined sand and gravel aquifer (see well construction details in Appendix A). The well logs indicate that the aquifer is overlain by variable amounts of sand, silt, gravel and occasional clay/till. The safe sustainable yields for TW05-02 and TW05-03 are 10.8 L/sec (142 Igpm) each, which is significantly higher than the projected water demand of 3.16 L/sec (41.7 Igpm) for the LFN system.

Static water level elevations collected by EBA on October 31st and November 1st, as well as information presented on drillers logs (Table 1) indicate that the depth to static groundwater varies from 11 m bg to 14 m bg within the study area. The groundwater flow direction within the aquifer is primarily northwest towards Watson Lake. Based on the available well logs, the surficial and bedrock geology, and the topography, it appears that the wetland area located southwest of the Community Wells acts as a recharge area. Additional sources of recharge include regional groundwater flow from the topographic highs (located to the southeast of the study area) and infiltrating precipitation (rain and snowmelt).

1.5 AQUIFER VULNERABILITY

The level of vulnerability of an aquifer is a measure of its exposure likelihood should a contaminant be introduced into the subsurface (i.e. spills, leaks, at surface or from underground piping, tanks or septic fields). The vulnerability of the aquifer is later taken into account when defining a risk event.

EBA estimated the vulnerability of the aquifer where the LFN Community Wells are completed using the semi-quantitative Intrinsic Susceptibility Index (ISI) method presented by the Ontario Ministry of Environment (2001). This method was chosen because EBA believes it is a good semi-quantitative method and also because there is no comparable method established for the Yukon. ISI scores ranging from 0 to 30 indicate high vulnerability; scores ranging from 30 to 80 indicate medium vulnerability, and scores greater than 80 suggest low vulnerability. The ISI evaluation, based on lithology presented in logs for both TW05-02 and TW05-03, resulted in scores of 34 and 26 respectively, which indicates that this aquifer has a medium to high vulnerability to potential surface sources of contamination (See Appendix B – Tables B1 and B2).

2.0 STAGE ONE – RISK FRAMEWORK

2.1 RISK APPROACH

The initial step towards a risk-based AWHPP is to determine the appropriate risk approach for the project. Risk identification can be qualitative (a descriptive assessment of the risk elements; hazards, exposure likelihood and receptor) or quantitative, (based on numerical and probabilistic mathematical analysis of the risk elements). A qualitative risk approach was deemed sufficient for this project.

2.2 RESPONSIBLE PARTIES

The responsible parties in the context of this risk-based AWHPP are the community well owners, that is the LFN as represented by the Chief and Council. INAC also shares responsibility by having fiduciary responsibility and by providing funding for this project.

2.3 RISK MANAGEMENT TEAM

One of the initial steps to successful development and implementation of an AWHPP is to form a risk management team, comprising representatives from the owner, technical advisors and any key stakeholder groups such as well users in the area. The risk management team for this AWHPP currently consists of a selection of the LFN Chief and Council members (the Owner) and EBA (the technical advisor). For the remainder of this report, "LFN Chief and Council" is referred to as LFN.

2.4 RISK TOLERANCE

Risk tolerance is a measure of the acceptable level of risk by the responsible parties (owner). A risk-tolerant owner would be able to accept or transfer some level of risk, while a risk adverse owner would seek to eliminate or transfer all but the lowest levels of risk to the water supply. Based on discussions with LFN we consider them to be moderately risk adverse.

3.0 STAGE TWO – RISK ASSESSMENT

3.1 GROUNDWATER MODELING AND CAPTURE ZONE ANALYSIS

Capture zone analysis is a fundamental part of the well and aquifer protection process as capture zones provide the physical boundaries for the well and aquifer protection area. A numerical groundwater flow model was developed to facilitate capture zone analysis for the new LFN supply wells.

The groundwater flow model was built using the Visual MODFLOW modeling pre- and post-processor (Version 4.1.0.145) developed by Waterloo Hydrogeologic Inc. Visual MODFLOW uses the USGS MODFLOW code for simulating groundwater flow (McDonald & Harbough, 1988). The following sections describe the methodology used to build and calibrate the model.

3.1.1 Model Construction

A base plan of the 2 Mile Community detailing roads and well locations was imported into the model to assist with model construction.

A model grid comprising 59 columns and 50 rows was constructed to represent the 1500 by 2067 m model area (Figure B1; Appendix B). Cell dimensions within the grid range from 20 m in the vicinity of the pumping wells to 75 m near the model limits. This allows for increased resolution and greater accuracy in the vicinity of the water supply wells (and

where calibration points are located). The model has two flat layers: the lower layer (layer 2) represents the semi-confined aquifer, and the upper layer (layer 1) represents the overlying semi-confining layer. Layer thickness was defined based on cross-sections and well logs.

The overall extent of the groundwater flow model (domain and model grid) is shown on Figure B1 (Appendix B). As the areal extent of the aquifer is unknown, the model area was selected to incorporate known and interpreted constant head boundaries and groundwater flow divides.

Constant head cells were positioned within the model area to represent groundwater areas of groundwater recharge (Small Lake, wetlands) and discharge (Watson Lake). Constant head elevations were assigned based on topographical mapping and surveyed groundwater elevations.

The hydraulic conductivity (K) value for the top layer was set at 5.0 x 10^{-5} m/s, based on descriptions provided in surficial geology mapping and well logs. The value for the aquifer material (lower layer) was set at 1.0 x 10^{-4} m/s, based on the typical hydraulic conductivity values for sediment materials encountered in the new wells. A summary of well logs descriptions and typical hydraulic conductivity values are summarized in Table 2 below.

Table 2: Estimated Average Aquifer Hydraulic Conductivity for Model

TW-05-02				TW-05-03		
unit	saturated thickness	K (estimated book value)		unit	saturated thickness	K (estimated book value)
sand, trace silt	1.4	1E-04		Sand and Gravel, silty	3.9	1E-04
SAND, silty	6.09	1E-05		Sand and Silt	13.7	1E-06
Sand and Silt	3.96	1E-06		Sand, trace silt	1.5	1E-04
Sand, some silt	2.73	5E-05		SILT, some sand	3.7	1E-07
Sand, silty	8.52	1E-05		SAND, trace of silt	1.5	1E-04
SAND and GRAVEL	2.48	1E-03		SILT, some sand	2.8	1E-07
Total thickness:	25.18			SAND, trace of silt	0.5	1E-04
				SAND and GRAVEL	2.9	1E-03
				Total thickness:	30.5	
Average	**Kx =**	**1E-04**		**Average**	**Kx =**	**1E-04**

A recharge of 81 mm/year of recharge was assigned at the top layer in the model equivalent to approximately 20% of the average annual precipitation measured at the Watson Lake airport (Environment Canada). This recharge rate was based on the surficial deposits composition and the unpaved area.

3.1.2 Model Calibration

In order to compare actual and simulated groundwater flow, model calibration was performed. Seven observation well locations were imported into the model to allow for a

comparison of predicted versus observed groundwater elevations (or head) during model calibration. The groundwater flow models were calibrated under steady-state conditions.

The difference between the predicted and observed hydraulic heads was assessed using the root mean square error (RMS).

The calibration process was conducted in order to obtain a RMS error as close as possible to zero. Using only seven observation wells with known screen intervals and known static water levels, the RMS error was 7.7% or 0.569 m, this is well within the accuracy of the observation well data. A figure of the calibrated water levels is included as Figure B2 (Appendix B), and a plot of calculated versus observed heads is included as Figure B3.

3.1.3 Capture Zones and Travel Time Analysis

A predictive simulation was performed with the calibrated groundwater flow model using the backward tracking particle feature. With this feature, particles are "released" at the well, then tracked backward through time toward a source area assuming they are transported by the flow field generated by the computer model (MODFLOW). The results of this simulation are shown on Figure B4.

This simulation conservatively assumes that both of the pumping wells (TW05-02 and TW05-03) are pumped at the projected 2025 average day demand of 1.6 L/s (approx. 25 USgpm). Since these capture zones represent the projected average daily extraction rate (until 2025), the capture zones are a conservative representation of the well protection area. Actual groundwater extraction will likely be lower than the 2025 average daily extraction rates, resulting in slightly narrower capture zones with the same shape for each well.

3.1.4 Areas of Uncertainty and Model Limitations

Groundwater models inherently contain a degree of uncertainty, stemming from a number of simplifying assumptions that need to be made, in order to model a natural system. In this groundwater flow model, specific areas of uncertainty include:

- The rate of surface water infiltration into the aquifer as well as the rate of groundwater discharge to surface waterbodies remain uncertain as limited information is available;
- The hydraulic conductivity of the aquifer material has been estimated based on typical values for soils recorded on well logs throughout the area.
- The observation well water levels and lithologic profiles which have been approximated based on drillers well logs and topographic mapping; and,
- The geometry of the hydrostratigraphic units (flat and tabular), assumed for the two layers of the model

The groundwater flow model developed as described above is useful to define the capture zone geometry and travel times. However, the hydrogeology of this area is complex. There is insufficient information, or budget to complete a detailed model. This model is based on some simplifications and assumptions as presented above. For the purpose of this study (to

define capture zones and travel times, upon which to assess risk) the model is considered appropriate.

Due to the uncertainties identified above, a 20 m buffer zone has been added to the outside of the defined capture zones as a factor of safety. EBA considers this 20 m buffer zone appropriate because it accounts for some lateral dispersivity. This entire area should be considered and included in the well capture zones (See Figure 2 and 3).

3.2 POTENTIAL RECEPTORS

Potential human receptors are the users of the Community Wells, as previously noted in Section 2.1 of this plan, namely, the LFN residents who receive trucked water from the Community Wells.

3.3 IDENTIFICATION OF RISK SCENARIOS

Risk can be defined as a potential exposure of a receptor to a hazard. Risk assessment is the process of evaluating the consequences of hazard severity and likelihood of exposure, then evaluating, ranking and mapping the identified risk scenarios. The three key elements of risk (exposure, hazard and receptors) all must combine to generate risk. Risk can be effectively removed or reduced to acceptable levels if any of the three elements are eliminated or blocked. Exposure can be expressed in terms of the likelihood of a receptor, e.g. humans, animals and plants, coming into contact with a hazard. Hazards can be expressed in terms of severity (contaminant toxicity). To be practical and conservative, the evaluation of a hazard in this analysis assigns the highest potential concern that may be present at the wellhead for that hazard (i.e., no retardation or reduction in hazard severity along its travel path to the well).

In order to assess potential risks to the Community Wells, EBA identified existing and potential hazards and then plotted these hazards on a map in relation to the capture zones. EBA used several different methods to identify potential hazards near and within the capture zones, including:

- Meeting with LFN representatives to collect anecdotal information (completed on December 19, 2007);
- Site reconnaissance (completed on October 31, November 1 and December 19, 2007);
- Reviewing current and historical maps for the area;
- Completing a large area search (5 km radius of the site) for spills records within Environment Canada (EC) Environmental Protection Branch Spills Records that search for spills up to 2001;
- Completing a large area search (5 km radius of the Site) for contaminated sites and spills within the Government of Yukon (YG), Department of Environment, Environmental Programs Branch;

- Reviewing previous relevant reports; and,
- Soliciting review comments from LFN based on draft Table 3 and Figures 2 and 3, provided by EBA to LFN on January 28, 2008. Review comments were returned by email from LFN on April 2, 2008.

3.3.1 Contaminated Sites and Spills Search, Environment Canada

EC maintained spill records within the Yukon between 1972 and 2001. After 2001, the responsibility was transferred to the YG. A large search area (5 km radius of the Site) was requested from EC records. A total of 42 spills were identified within the search area; however only one spill was identified within the 2 Mile Community. No spills were identified within the capture zones of the Community Wells. The spill identified within the 2 Mile Community is listed in Table 3 as SR1 and shown on Figure 2. EC reports for all reported spills are included in Appendix C.

3.3.2 Contaminated Sites and Spills Search, Government of Yukon

YG Department of Environment (DE) has maintained the Yukon Spills Report Centre since 2001. A large area search (5 km radius of the Site) was requested from contaminated sites and spills. A total of seven Contaminated Sites records, eight spill reports, six land treatment facilities and a pipeline right-of-way (ROW) were identified within the search area; however only one spill and the pipeline ROW were identified within the 2 Mile Community. The spill identified within the 2.5 Mile Community is shown in Table 3 as SR1 (previously reported by EC) and shown on Figure 2. The correspondence between YG-DE and EBA is also presented in Appendix C.

3.3.3 Summary of Identified Potential Hazards

Table 3 presents a summary of existing hazards identified throughout the area and their distance to each Community Well. A total of twenty-eight (28) sites out of the fifty-six (56) APECs identified in Table 3 are located in or near the well capture zones. All sites that were identified as part of this study are listed in Table 3 to assist with future planning and development. The inventory should not be considered as a static "one-time" item; rather, it is a framework for on-going management and should be reviewed and revised over time as potential hazards or the associated risks change.

3.4 RISK EVALUATION AND MAPPING

The estimate of risk for each hazard takes into account several factors including:

- Size and magnitude of the hazard (point source or non-point source);
- Location (i.e., distance from well(s));
- Groundwater travel time to the well(s);
- Aquifer vulnerability;
- The likelihood of the contaminant of concern directly affecting water at the well, and;

- The severity of the hazard to the user from contaminants entering the well.

The above mentioned considerations were used to define the categories of exposure likelihood and hazard consequence. Table 4 also provides some rationale for assigning a "Low", "Medium" or "High" potential value to exposure likelihood and hazard consequence.

TABLE 4: EXPOSURE AND HAZARD CATEGORIES

Exposure Likelihood	
Biological Hazard	
None	Outside Capture Zone for Community Well
Low	Within 1 to 10 year travel time
Medium	Within 90 day to 1 year travel time
High	Within 90 day travel time
Chemical Hazard	
None	Outside Capture Zone for Community Well
Low	Within 5 to10 year travel time
Medium	Within 1 to 5 year travel time
High	Within 1 year travel time
Hazard Consequence	
Low	Exceeds aesthetic objectives in drinking water guidelines
Medium	Short-term health conditions (Lost time: days to months)
High	Chronic to Acute health hazard (Permanent Disabilities or fatalities)

Table 5 presents a summary of risk scenarios within the capture zones identified in Table 2. The risk rank results are a function of applying the hazard scenario to the risk matrix framework.

TABLE 5: AREAS OF POTENTIAL ENVIRONMENTAL CONCERN WITHIN CAPTURE ZONES				
I.D.	Hazard Description	Exposure Likelihood	Hazard Consequence	Risk Rank
	TW05-02 and TW05-03			
LS1	Livestock Corral	Medium	High	Medium
PL1	Former pipeline / pipeline ROW	Medium	High	Medium
PT1	Potential Heating Fuel Above Ground Storage Tank	High	High	High
PR1	Potential Spill on Robert Campbell Highway	Medium	High	Medium
S1	Lot 1 - Septic System	Low	High	Medium
S3	Lot 3 - Septic System	Low	High	Medium
S1B	Lot 1B - Septic System	Low	High	Medium
S5	Lot 5 - Septic System	Low	High	Medium
S7	Lot 7 - Septic System	Medium	High	Medium
S9	Lot 9 - Septic System	Medium	High	Medium
S13	Lot 13 - Septic System	Medium	High	Medium
S15	Lot 15 - Septic System	Medium	High	Medium
S17	Lot 17 - Septic System	Medium	High	Medium
S42	Lot 42 - Septic System	Low	High	Medium
T1	Lot 1 - Above Ground Fuel Storage Tank	Medium	High	Medium
T1B	Lot 1B - Above Ground Fuel Storage Tank	Medium	High	Medium
T2	Lot 2 - Above Ground Fuel Storage Tank	Medium	High	Medium
T3	Lot 3 - Above Ground Fuel Storage Tank	Medium	High	Medium
T5	Lot 5 - Above Ground Fuel Storage Tank	Medium	High	Medium
T42	Lot 42 - Above Ground Fuel Storage Tank	Medium	High	Medium
DH#1	Existing well	Medium	High	Medium
#1LJS	Existing well	Medium	High	Medium
W02-02	Existing well	Medium	High	Medium
DS1	Development of New Subdivision Septic (Lots 117,119, 121)	High	High	High
DS2	Development of New Subdivision Septic (Lot 122, 123, 124, 125, 126, 127)	Medium	High	Medium
DS3	Development of Subdivision Septic (Lots 128, 129, 130, 131)	Low	High	Medium
DF1	Development of New Subdivision Heating Fuel (Lots 117, 119, 121, 122, 123, 124, 125, 126 and 127)	High	High	High
DF2	Development of New Subdivision Heating Fuel (Lots 128, 129, 130 and 131)	Medium	High	Medium

Figure 4 provides the potential risk posed by each hazard located within the well capture zones for the LFN Community Wells. Based on the combined exposure likelihood and hazard consequence for each hazard, an overall risk of "low", "medium", or "high" has been assigned to each potential hazard identified.

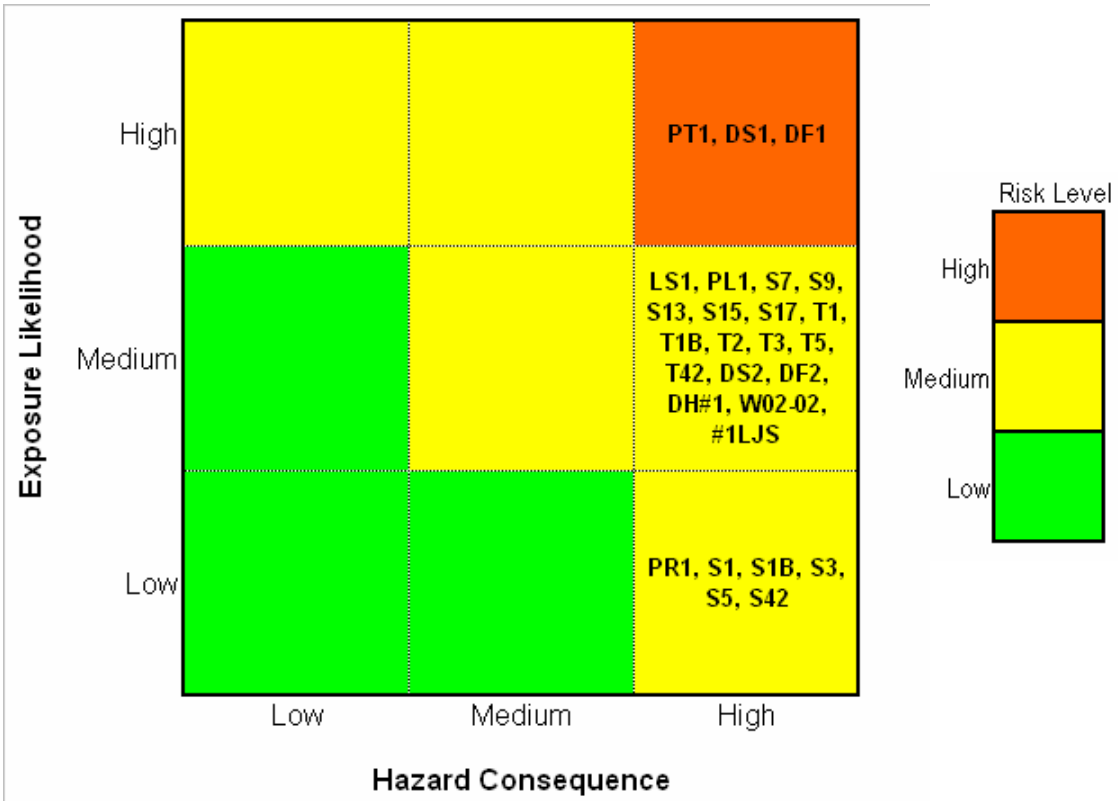

Figure 4: Risk matrix for the Community Wells.

Note: Figure 4 is originally produced in colour; non-color reproductions may not be representative of original.

The resulting risk ranks "high", "medium" and "low" are then plotted on the Risk Map (Figures 2 and 3).

Understanding, tracking, and managing identified risks are made simple and intuitive by using symbols to represent different risk categories. The Risk Maps included as Figures 2 and 3 show the estimated travel times associated with the Community Wells (90 day zone, 1 year capture zone, and 2.5 years capture zone). Risk scenarios were plotted on the Risk Map using different symbols to represent their individual risk.

The Risk Maps are the key deliverable and form the basis for the AWHPP. The Risk Maps are also presented in a Risk Information Poster for the LFN Community.

The Risk Database and Risk Maps represent the current conditions of the well and aquifer and should not be considered as a static "one-time" item. The Risk Database and Risk Maps should be updated as new risks are identified and as known risks are managed to low levels and taken off the database.

4.0 STAGE THREE – RISK MANAGEMENT

4.1 RISK MANAGEMENT STRATEGY

The risk management strategy integrates information collected during the capture zone delineation and hazard identification steps and provides workable strategies for preventing, detecting, and responding to wellhead protection risks. The following includes examples of such strategies:

- Endorsing and promoting recommended management practices;
- Providing public and landowner information sessions and training; and,
- Implementing action and management strategies provided in Table 6.

Many risk scenarios identified are *potential* rather than existing threats to the LFN Community Wells. Therefore, risk management strategies for this site should include a preventative action and contingency planning in the event that one of the potential hazard scenarios occurs.

In terms of risk communication, the Risk Maps and Risk Information Poster can form a concise and convenient basis for communicating information regarding the status of potential threats to all stakeholders including the risk management team, water system operators, community organizations, or municipal councils. Frequent reporting is important to document progress, improve public perception, reduce potential legal issues and possibly reduce insurance costs.

4.2 RISK REDUCTION PLAN

A Risk Reduction Plan involves pre-planning actions to respond to identified risks situated within the capture zones. For example, this would include emergency response actions and communication should a contaminant release (e.g., spill from a fuel truck) occur within a well capture zone. Table 6 on the following page summarizes potential strategies to be considered in order to reduce and/or eliminate the risk previously identified.

4.3 RISK MONITORING

A Risk Monitoring Plan involves periodic review, auditing and updating of the Risk Maps and Risk Database. Once an AWHPP is in place, continued implementation and at least annual monitoring of the program is essential to protect the wells and reduce risks to users.

TABLE 6: Risk Reduction/ Elimination Strategies to be Considered				
I.D.	Hazard Description	Current Risk Rank	Risk Reduction Option to Consider	Risk Elimination Option to Consider
LS1	Livestock Corral	Medium	Ensure that corral is used only periodically, and/or manure does not accumulate, and that surface drainage is routed away from the corral.	Relocate corral
PL1	Contaminant migration from Former pipeline / Leak from future pipeline ROW	Medium	Implement spill contingency plan	Do not allow/support pipeline development.
Ds1, Ds2, Ds3 DF1, DF2	Development of new residential lot: improperly operating septic systems and potential leaks/spills from heating fuel (Lots 117,119, 121,122, 123, 124,125,126,127,128, 129, 130, 131)	Medium to High	Allow residential development only. Develop residential lots with conditions such as: septic holding tank only (no field), tank monitoring program, fuel tank to be double walled, flex hose, inspect tanks bi-annually. Ensure that fuel delivery personnel exercise extreme caution when refilling of ASTs. An LFN representative should act as a spotter during filling. Or, heat with alternate source (propane, electricity, other). Note for lots 122, 124, 126, 128, and 130, risk can be greatly reduced or eliminated by installing septic systems and ASTs in back 1/2 of lot to remove from capture zone.	Designate lots as "Green space" or Park. Do not develop.
S1, S3, S1B, S42	Existing Septic Systems	Medium	Educate and train owners how to properly maintain these systems. Implement a monitoring program to ensure proper operation.	Remove systems and relocate.
PT1	Proposed Oil Tank for Water Treatment Building	High	Implement spill contingency plan. Ensure that fuel delivery personnel exercise extreme caution when refilling of ASTs. An LFN representative should act as a spotter during filling of all ASTs.	Replace with propane system.
T1, T1B, T2, T3, T5	Heating Oil Fuel Tank at House # 42	Medium	Replace fuel line with flex hose, and/or put in secondary containment. Implement spill contingency plan.	Replace heating oil tank and furnace with alternate system such as propane, electric etc..
DH#1, #1LSJ, W02-02	**Existing Wells**	Medium	Decommission abandoned wells, ensure that existing wells are above grade, and are secure (not accessible for tampering)	Decommission all wells.
PR1	Potential Chemical Spill on Highway	Medium	Implement spill contingency plan	N/A

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

EBA has developed this AWHPP for the Community Wells within the LFN community. Based on the findings of this study, EBA emphasizes the following conclusions:

- The vulnerability of the semi-confined aquifer in which the LFN Community Wells are completed, is rated as medium to high;
- Most existing risks identified were all ranked as medium and included: septic systems, heating oil tanks, livestock corral.
- There were two potential high risks identified related to planned future development on residential lots;
- There was one potential high risk associated with the former pipeline (in the event that there had been any historical releases);
- Any release of contaminants within the identified capture zones would represent a potential risk to the aquifer and water quality of the Community Wells;
- Table 5, Figure 2 and Figure 3 summarize the risk evaluation based on exposure likelihood and hazard consequence of the potential hazards identified through this process;
- Risk Management/Mitigation and Monitoring strategies should be used to reduce existing risks and the likelihood of potential risk scenarios.

5.2 RECOMMENDATIONS

EBA recommends that LFN complete the following:

- Endorse and promote hazardous waste minimization and collection programs;
- Review the risk reduction and elimination plans presented in Table 6, and implement these strategies to reduce or eliminate risk;
- Implement contingency planning including emergency response actions and communication. LFN council should create an emergency and spill response plan identifying key personnel responsible to respond in the event of an occurrence or spill;
- Complete regular annual tracking and monitoring of all well risks (either with internal staff resources or outsourced to EBA);
- Implement a septic system monitoring program for systems identified to be within the capture zone;
- Increase security at Community Wells by installing fences to enclose wells and treatment systems;

- Maintain the well Risk Maps and Poster created for this study in a public part of the community, and update the Risk Map and Poster as necessary;
- Educate the LFN community members regarding the importance of maintaining a clean environment of the land surrounding their Community Wells;
- Review and update the AWHPP annually; and,
- Incorporate this AWHPP into the LFN community development plan, and develop a Groundwater Protection Program for the area. This Groundwater Protection Program should consist of the following:
    - Formal recognition and protection status for identified well protection zones such as those identified in this report;
    - Enforcement of well protection measures;
    - Restrictions on some land use activities within sensitive areas and well protection zones; and,
    - Hydrogeological assessment as a requirement of development for land use activities considered as higher risk, and including groundwater monitoring on and adjacent to specified sites as a condition of development.

6.0 CLOSURE AND LIMITATIONS

This report has been prepared specifically for Liard First Nation for the purposes described in Section 1.2 of this report. The report has been prepared in accordance with generally accepted geo–environmental practices. Additional information regarding the use of this report is presented in the Geo-environmental Report - General Conditions (attached), which form a part of this report.

We trust this report is satisfactory. If you have any questions about this report, please contact the undersigned at your convenience.

Sincerely,

EBA Engineering Consultants Ltd.

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GEO-ENVIRONMENTAL REPORT – GENERAL CONDITIONS

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 EBA's client. 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 EBA's Client unless otherwise authorized in writing by 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 EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 ALTERNATE REPORT FORMAT

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

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

Electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. 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 EBA in its reasonably exercised discretion.

TABLES

TABLE 1: SUMMARY OF WELL INFORMATION FOR LIARD FIRST NATION AT 2.4 and 2.5 MILE [1]

	Well Serving	Elevation	Elevation	Well	Drilling	Date Drilled	Drilled	Completion	Groundwater	Groundwater	Groundwater	Groundwater	Screen Information			Surface Details
	New Address	surveyed (+/- 0.1m) m-asl	est. based on topo (+/- 1 m) m-asl	Log (Y/N)	Contractor		Depth (m)	Depth (m)	Depth (Log) (m)	Depth (measured) m-bc	Elevation (surveyed) (+/- 0.1m) m-asl	Elevation (est.) (+/- 1 m) m-asl	Length (m)	Slot Size (mm)	Tailpipe (m)	
2.4 Mile Community	#30 TCD	697.98	697	Y	Territorial	Oct-95	18.3	17.1	11.9	9.58	688.4	685.7	2.4	0.25	0.3	pitless
	#32 TCD	697.65	697	Y	Territorial	Sep-95	26.1	26.1	14.6	14.0	683.6	683.0	no screen			pitless
	#23 TCD	-	698	Y	Territorial	Oct-95	17.4	17.6	13.4			685.2	1.2	0.38	0.3	pitless
	#38 TCD	696.62	697	Y	Territorial	Sep-95	24.3	22.3	11.0	10.2	686.4	686.6	1.2	0.38	0.25	pitless
	#89,89a, 90, 91, 92	-	696	Y	Northwind	Sep-01	31.7	31.7	12.2	-	-	684.4	2.4	0.38/0.51	-	surface seal
	#93, #94	-	696	Y	Northwind	-	23.8	22.6	13.7	-	-	682.9	2.4	0.25/0.51	-	-
	#19 TCD	-	697	Y	Northwind	Sep-01	19.5	19.5	12.2	-	-	685.4	1.2	0.51	-	surface seal
	#34,#36 TCD	-	698	Y	Territorial	Sep-95	16.7	16.7	13.2	-	-	685.4	no screen			pitless
	#21 TCD	697.73	698	Y	Territorial	Oct-95	17.7	17.7	13.4	12.81	684.9	684.7	no screen			pitless
2.5 Mile Community	**TW05-2 (COMMUNITY)**	692.75	-	Y	Double D	Nov-05	41.15	37.5	13.3	9.85	682.9	-	1.5	1.5	0	pitless
	TW05-3 (COMMUNITY)	692.77	-	Y	Double D	Nov-05	43.4	43.4	12.9	9.92	682.8	-	1.5	1.5	0	pitless
	#1 LJS	695.59	-	N	Fredelana	Jun-05	15.5	-	-	9.215	686.4	-	screen installed			-
	W02-01	-	695	Y	Northwind	Aug-02	32.6	26.5	11.6	-	-	683.5	2.4	0.64/0.51	-	surface seal
	W02-02	-	696	Y	Northwind	Sep-02	22.6	20.7	13.1	-	-	683.5	2.4	0.64/0.51	-	surface seal
	W02-03	-	695	Y	Northwind	Oct-02	22.0	22.0	9.8	-	-	685.3	2.4	0.64/0.51	-	surface seal

Notes:
1) Some of this information has been compiled and interpreted from previous reports by EBA, Pacific Hydrology (2003), and Gartner Lee Ltd. (2002)

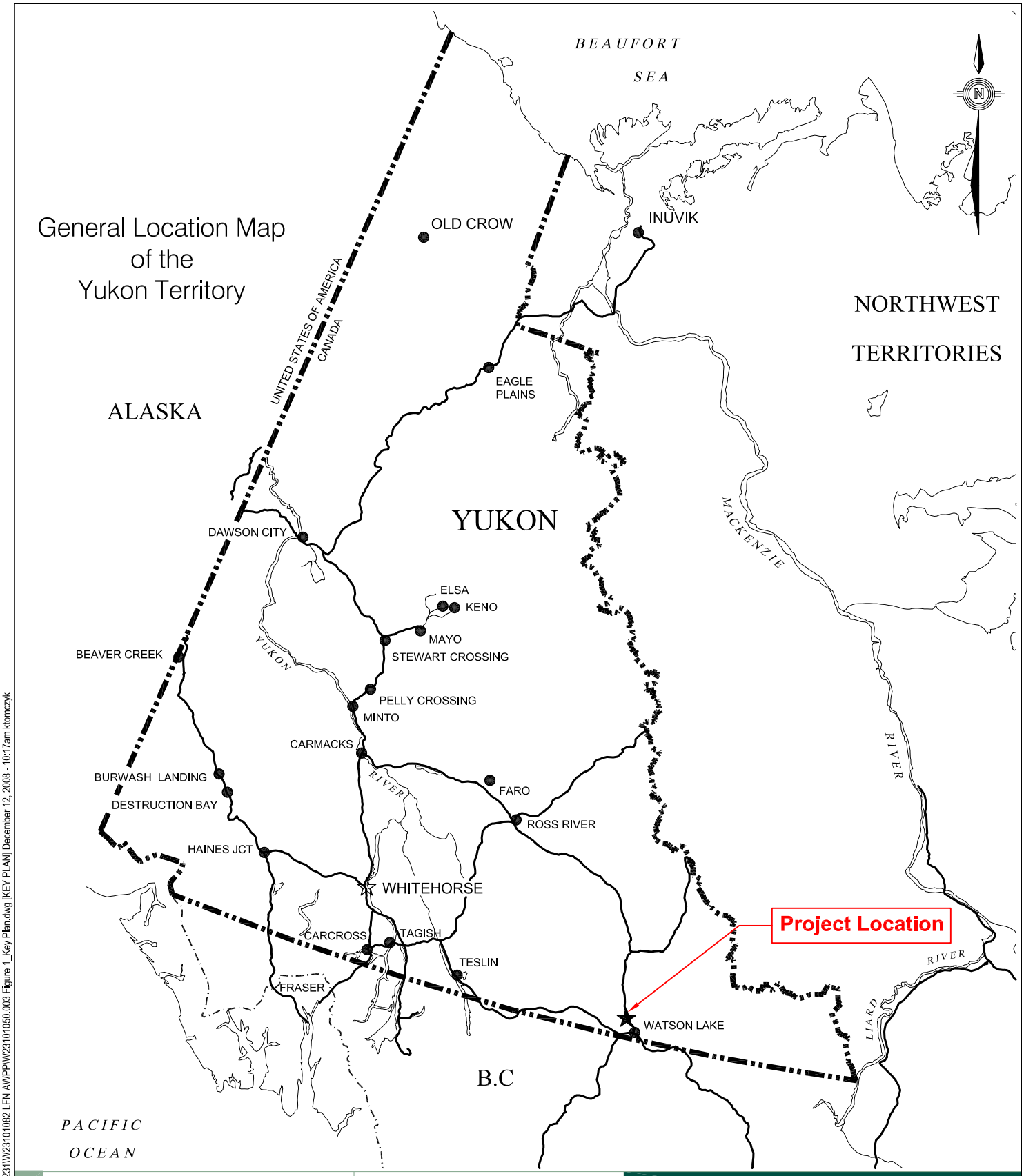
TABLE 3: POTENTIAL HAZARDS

I.D.	APECs	Approximate Distance (m)		Notes	Inside AWHPP zone (Yes/No)	Potential Contaminants of Concern	Source	Location
		TW05-03	TW05-02					
	Spill Reports							
SR1	13 Tucho Drive	760	703	Spill report 03-012	No	Hydrocarbons (fuels, oils)	Yukon Government Spill Reports	2.5 mile settlement
PR1	Potential Spill on Robert Campbell Highway			Potential Highway Spill	Yes	Hydrocarbons (fuels, oils)	-	Robert Campbell Hwy
	Septic Systems							
S1	Lot 1 septic	373	374	-	Yes	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S1B	Lot 1B septic	336	337	-	Yes	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S2	Lot 2 septic	405	415	-	No	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S3	Lot 3 septic	299	302	-	Yes	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S4	Lot 4 septic	359	372	-	No	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S5	Lot 5 septic	269	263	-	Yes	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S6	Lot 6 septic	291	313	-	No	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S7	Lot 7 septic	273	241	-	Yes	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S8	Lot 8 septic	264	287	-	No	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S9	Lot 9 septic	201	212	-	Yes	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S10	Lot 10 septic	232	260	-	No	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S11	Lot 11 septic	170	187	-	No	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S12	Lot 12 septic	40	240	-	No	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S13	Lot 13 Septic	141	160	-	Yes	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S14	Lot 14 Septic	184	221	-	No	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S15	Lot 15 septic	113	137	-	Yes	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S17	Lot 17 septic	89	120	-	Yes	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 mile settlement
S42	Lot 42 septic	450	449	-	Yes	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Communication with LFN	2.5 Mile settlement
	Dump Areas							
D1	Former Military Dump	83	141	Anecdotal Information - Community Planning Team (Dec 19, 2007)	No	Waste leachate, biological (bacteria, viruses, protozoa), hydrocarbons (fuels, oils, lubricants), chemicals (pesticides, herbicides, cleaning agents) and metals	Anecdotal Information - Community Planning Team (Dec 19, 2007)	2.5 mile settlement
D2	Old Army Dump	1670	1672	Based on Contaminated Site Inventory - Site ID WL003	No	Waste leachate, biological (bacteria, viruses, protozoa), hydrocarbons (fuels, oils, lubricants), chemicals (pesticides, herbicides, cleaning agents) and metals	Based on Contaminated Site Inventory - Site ID WL003	Robert Campbell Hwy
D3	Barrel Dump	>3000	>3000	Based on Contaminated Site Inventory - Site ID WL054	No	Waste leachate, biological (bacteria, viruses, protozoa), hydrocarbons (fuels, oils, lubricants), chemicals (pesticides, herbicides, cleaning agents) and metals	Based on Contaminated Site Inventory - Site ID WL054	Watson Lake
D4	Campbell Subdivision Abandoned Dumpsite	2322	2297	Former Military Dump	No	Waste leachate, biological (bacteria, viruses, protozoa), hydrocarbons (fuels, oils, lubricants), chemicals (pesticides, herbicides, cleaning agents) and metals	Yukon Government Contaminated Sites Files	Robert Campbell Hwy
D5	km 1.5 Campbell Hwy	2194	2164	Dump covered with gravel	No	Waste leachate, biological (bacteria, viruses, protozoa), hydrocarbons (fuels, oils, lubricants), chemicals (pesticides, herbicides, cleaning agents) and metals	Research of Former military Sites & Activities in the Yukon - K. Bisset & Associates. April 1995.	Robert Campbell Hwy
	Pipelines							
PL1	Former pipeline ROW	550	552	Running along Robert Campbell Hwy	Yes	Hydrocarbons (fuels, oils)	Air photo investigation, meeting Dec 19, 2007	Robert Campbell Hwy
	Rock pits							
RP1	Rock pit for water treatment wastestream disposal	68	50	Communication with Dayton & Knight	No	Manganese greensand	Communication with Dayton & Knight regarding potential sources within facility	2.5 mile settlement
	Livestock							
LS1	Corral	230	243	-	Yes	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit	2.5 Mile settlement

TABLE 3: POTENTIAL HAZARDS

I.D.	APECs	Approximate Distance (m)		Notes	Inside AWHPP zone (Yes/No)	Potential Contaminants of Concern	Source	Location
		TW05-03	TW05-02					
	Above ground Storage Tanks							
T1	Above ground Tank - heating fuel - lot 1	386	388	-	Yes	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T1B	Above ground Tank - heating fuel - lot 1B	331	335	-	Yes	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T2	Above ground Tank - heating fuel - lot 2	392	400	-	Yes	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T3	Above ground Tank - heating fuel - lot 3	299	318	-	Yes	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T4	Above ground Tank - heating fuel - lot 4	346	356	-	No	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T5	Above ground Tank - heating fuel - lot 5	278	286	-	Yes	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T6	Above ground Tank - heating fuel - lot 6	285	304	-	No	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T7	Above ground Tank - heating fuel - lot 7	244	255	-	No	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T8	Above ground Tank - heating fuel - lot 8	247	271	-	No	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T9	Above ground Tank - heating fuel - lot 9	212	226	-	No	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T10	Above ground Tank - heating fuel - lot 10	231	257	-	No	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T11	Above ground Tank - heating fuel - lot 11	179	198	-	No	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T12	Above ground Tank - heating fuel - lot 12	206	235	-	No	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T13	Above ground Tank - heating fuel - lot 13	156	172	-	No	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T14	Above ground Tank - heating fuel - lot 14	179	214	-	No	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T15	Above ground Tank - heating fuel - lot 15	127	137	-	No	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T17	Above ground Tank - heating fuel - lot 16	100	135	-	No	Hydrocarbons (fuels, oils)	Site Visit	2.5 mile settlement
T42	Above ground Tank - heating fuel - lot 42	462	461	-	Yes	Hydrocarbons (fuels, oils)	Communication with LFN	2.5 mile settlement
PT1	Potential Above ground Tank - Generator Fuel	41	22	-	Yes	Hydrocarbons (fuels, oils)	Communication with Dayton & Knight regarding potential sources within facility	2.5 mile settlement
	Existing Wells							
DH#1	Existing Well			-	Yes	Waste leachate, biological (bacteria, viruses, protozoa), hydrocarbons (fuels, oils, lubricants), chemicals (pesticides, herbicides, cleaning agents) and metals	Site Visit and Background Data Review	2.5 mile settlement
DH#2	Existing Well			-	No	Waste leachate, biological (bacteria, viruses, protozoa), hydrocarbons (fuels, oils, lubricants), chemicals (pesticides, herbicides, cleaning agents) and metals	Site Visit and Background Data Review	2.5 mile settlement
#1 LJS	Existing Well			-	Yes	Waste leachate, biological (bacteria, viruses, protozoa), hydrocarbons (fuels, oils, lubricants), chemicals (pesticides, herbicides, cleaning agents) and metals	Site Visit and Background Data Review	2.5 mile settlement
#38 TCD	Existing Well			-	No	Waste leachate, biological (bacteria, viruses, protozoa), hydrocarbons (fuels, oils, lubricants), chemicals (pesticides, herbicides, cleaning agents) and metals	Site Visit and Background Data Review	2.5 mile settlement
W02-01	Existing Well			-	No	Waste leachate, biological (bacteria, viruses, protozoa), hydrocarbons (fuels, oils, lubricants), chemicals (pesticides, herbicides, cleaning agents) and metals	Site Visit and Background Data Review	2.5 mile settlement
W02-02	Existing Well			-	Yes	Waste leachate, biological (bacteria, viruses, protozoa), hydrocarbons (fuels, oils, lubricants), chemicals (pesticides, herbicides, cleaning agents) and metals	Site Visit and Background Data Review	2.5 mile settlement
W02-03	Existing Well			-	No	Waste leachate, biological (bacteria, viruses, protozoa), hydrocarbons (fuels, oils, lubricants), chemicals (pesticides, herbicides, cleaning agents) and metals	Site Visit and Background Data Review	2.5 mile settlement
	Future Development							
DS*	Future Development of Septic on Surveyed Lots	-	-	-	Yes	Biological (bacteria, viruses, protozoa), Chemicals (nitrates, phosphates)	Site Visit and Communication with LFN	2.5 mile settlement
DF*	Future Development of Heating Fuel on Surveyed Lots	-	-	-	Yes	Hydrocarbons (fuels, oils)	Site Visit and Communication with LFN	2.5 mile settlement

FIGURES



Q:\Whitehorse\Data\0201drawings\Watson Lake\W231\W23101082 LFN AWPP\W23101050.003 Figure 1_Key Plan.dwg [KEY PLAN] December 12, 2008 - 10:17am ktomczyk

CLIENT
LIARD FIRST NATION
P.O. Box 328
On Campbell Highway
Watson Lake, YT

AQUIFER AND WELLHEAD PROTECTION PLAN

SITE LOCATION MAP

EBA Engineering Consultants Ltd.

PROJECT NO.	DWN	CKD	REV
W23101082	KJT	DSM	0

OFFICE: EBA-WHITEHORSE
DATE: December 2008

Figure 1

Q:\Whitehorse\Data\0201drawings\Watson Lake\W231\W23101082 LFN AWPP\W23101082_CURRENT.dwg [FIGURE 02] December 12, 2008 - 4:30pm ktomczyk

Watson Lake

Small Lake

Wetland

SEE FIGURE 3

90 DAYS

1 YEAR

2.5 YEARS

PIPELINE ROW

New Subdivision

Tu Cho Drive

Eskeyeh Tene Drive

Robert Campbell Highway

Watson Lake Town Centre

PLAYGROUND

TBM #9 TOP OF SEPTIC

TBM #11

TBM #12

TBM #13

TBM #14

TBM #7

PILES

D1 D2 D3

DF1 DF2 DS1 DS2 DS3

PP1 PR1 PT1 PL1

TW05-02 TW05-03

SR1

NOTES

1) CAPTURE ZONES FROM MODEL OUTPUT (See Appendix B)

2) SITE PLAN FROM DAYTON AND KNIGHT (2004)

3) RISK MAP: GEOGRAPHIC DISTRIBUTION OF IDENTIFIED HUMAN RISK SCENARIOS AND CAPTURE ZONES

RISK LEVEL

- NO RISK
- LOW RISK
- MEDIUM RISK
- HIGH RISK

LEGEND

- COMMUNITY SUPPLY WELL
- DOMESTIC SUPPLY WELL
- COMMUNITY WELLS PREDICTED CAPTURE ZONE
- COMMUNITY WELLS PREDICTED CAPTURE ZONE BUFFER

0 50 100 200 m

SCALE 1:5000

CLIENT

LIARD FIRST NATION

P.O. Box 328
On Campbell Highway
Watson Lake, YT

EBA Engineering Consultants Ltd.

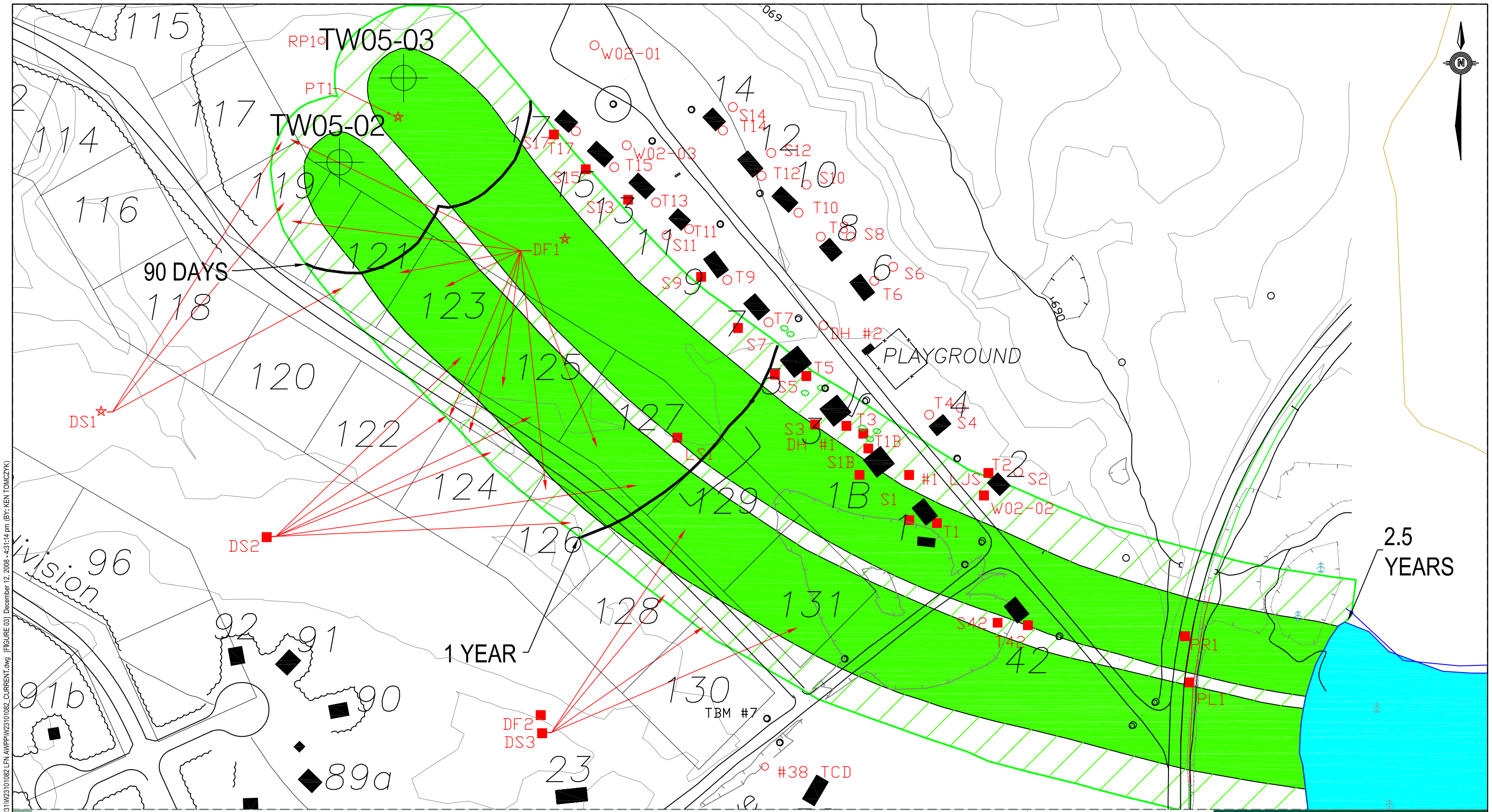
AQUIFER AND WELLHEAD PROTECTION PLAN

RISK MAP (LARGE SCALE)

PROJECT NO.	DWN	CKD	REV
W23101082	KJT	DSM	0

OFFICE	DATE
EBA-WHSE	December 2008

Figure 2



LEGEND

- COMMUNITY SUPPLY WELL
- DOMESTIC SUPPLY WELL
- COMMUNITY WELLS PREDICTED CAPTURE ZONE
- COMMUNITY WELLS PREDICTED CAPTURE ZONE BUFFER

RISK LEVEL

- NO RISK
- LOW RISK
- MEDIUM RISK
- HIGH RISK

NOTES

1) CAPTURE ZONES FROM MODEL OUTPUT (See Appendix B)

2) SITE PLAN FROM DAYTON AND KNIGHT (2004)

3) RISK MAP: GEOGRAPHIC DISTRIBUTION OF IDENTIFIED HUMAN RISK SCENARIOS AND CAPTURE ZONES

10 0 20 50 90m

SCALE: 1 : 2,000

CLIENT

LIARD FIRST NATION

P.O. Box 328
On Campbell Highway
Watson Lake, YT

AQUIFER AND WELLHEAD PROTECTION PLAN

RISK MAP (SMALL SCALE)

EBA Engineering Consultants Ltd.

PROJECT NO.	DWN	CKD	REV
W23101082	KJT	DSM	0

OFFICE: EBA-WHSE

DATE: December 2008

Figure 3

APPENDIX

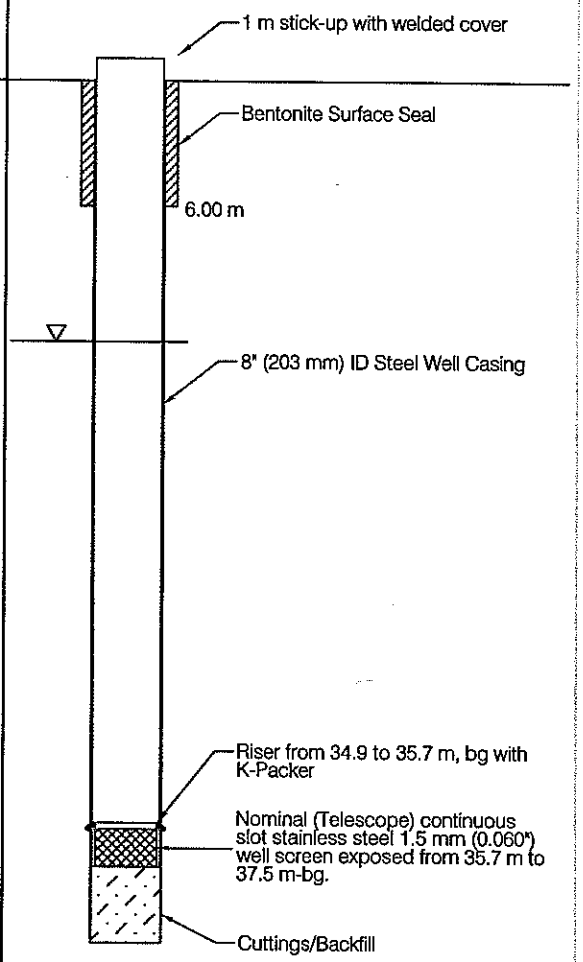
APPENDIX A LIARD FIRST NATION COMMUNITY WELL LOGS (TW05-02 & TW05-03)

HYDROGEOLOGIC LOG

PURPOSE OF HOLE: Water Supply Well
DRILLING METHOD: Dual Air Rotary
START DRILLING: November 3, 2005
SCREEN INSTALLED: November 7, 2005
CONTRACTOR: Double "D" Drilling Ltd.

BOREHOLE NO. TW05-02

GROUND ELEV. (m-geod): 693
TOP OF CASING (m-geod): 694
CASING STICK UP (m): 1.0
DEPTH TO STATIC (m): 12.30 m-bg.
DEPTH TO SCREEN TOP (m): 35.7 m-bg.
UTM coordinates from GPS: 6661822 N, 514043 E

Lithology (Depth (m))	Comments	Well Installation Summary
0m SAND - silty, some cobbles, brown 2.43 m SAND & GRAVEL - silty, fine-med. grained sand, med.-coarse gravel, some cobbles/boulders, brown 5m 5.79 m SAND - trace of silt, trace of gravel, med.-fine grained sand, well rounded gravel, moist, brown 10m 13.72 m 15m SAND - silty, trace of gravel, fine-med. grained sand with trace of coarse sand, fine-med. grained rounded gravel - becomes finer with depth, grey, brown 20m 19.81 m SAND & SILT - fine grained sand-trace of med. grained sand, wet, grey/brown 23.77 m 25m SAND - some silt, fine-med. grained sand 26.50 m SAND - silty, trace of gravel, fine grained sand-some med. grained sand, med. grained gravel becoming coarser with depth, brown 30m 35m 35.02 m SAND & GRAVEL - trace of silt, well graded sand, fine-med. grained rounded gravel, some wood, wet, grey 40m 41.15 m END OF BOREHOLE 45m	Water Level = 12.30 m-bg January 10, 2006	

EBA Engineering Consultants Ltd.

PROJECT: HYDROGEOLOGICAL STUDY FOR POTABLE GROUNDWATER SUPPLY - LIARD FIRST NATION WATER SUPPLY 2/2.4/2.5 MILE COMMUNITY - WATSON LAKE , YUKON

CLIENT: DAYTON & KNIGHT LTD. LIARD FIRST NATION

TITLE: WELL LOG TW05-02

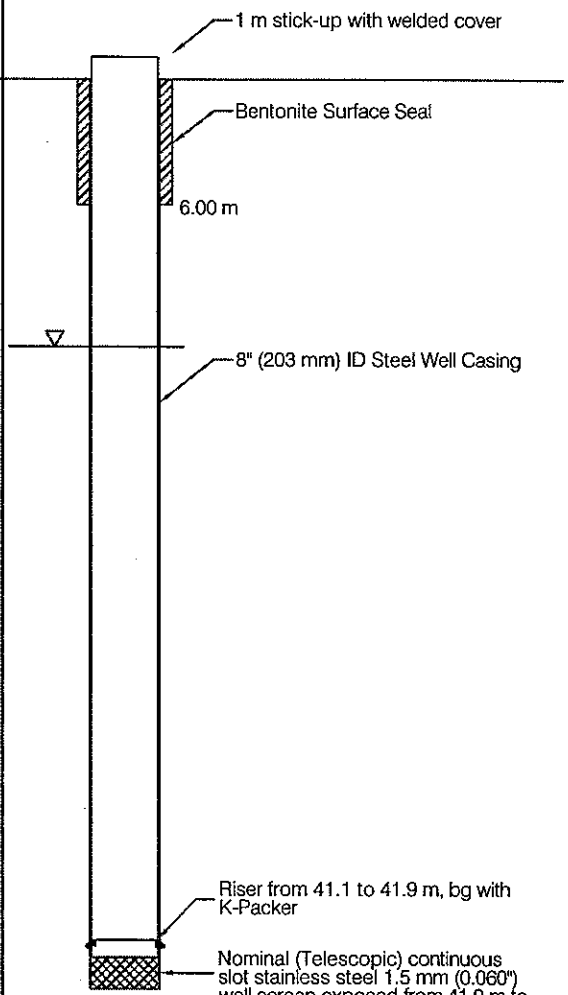
DATE	DWN.	CHKD.	FILE NO.	DRWG.
FEB. 2006	JSB	KSJ	0201-1260004	APPENDIX B1

HYDROGEOLOGIC LOG

BOREHOLE NO. TW05-03

PURPOSE OF HOLE: Water Supply Well
DRILLING METHOD: Dual Air Rotary
START DRILLING: November 13, 2005
SCREEN INSTALLED: November 16, 2005
CONTRACTOR: Double "D" Drilling Ltd.

GROUND ELEV. (m-geod): 694
TOP OF CASING (m-geod): 695
CASING STICK UP (m): 1.0 m-above grd.
DEPTH TO STATIC (m): 12.9 m-below grd.
DEPTH TO SCREEN TOP (m): 41.9 m-bg.
UTM Coordinates from GPS: 6661867 N, 514080 E

Lithology (Depth (m))	Comments	Well Installation Summary
0m SAND & GRAVEL - silty, fine-med. grained sand, med.-coarse gravel, inferred cobbles/boulders, dry, brown 5m 6.1 m SAND & GRAVEL - trace of silt, med.-fine sand, dry, brown 10m 15m 16.8 m SAND & SILT - trace of organics, fine-med. grained sand, wet, brown 20m 25m 30m 30.5 m SAND - trace of silt, fine-med. grained sand, wet, grey 32.0 m SILT - some sand, trace of organics, wet, brown 35m 35.7 m SAND - trace of silt, med.-coarse grained sand, wet, grey 37.2 m SILT - some sand, trace of organics, wet, brown 40m SAND - trace of silt, med.-coarse grained sand, wet, grey 40.5 m SAND & GRAVEL - trace of silt, med.-coarse sand, fine-med. grained sub-angular to 45m sub-rounded gravel, wet, grey 42.0 m GRAVEL & SAND - trace of silt, fine-med. grained sub-angular to sub-rounded gravel, wet, grey 43.4 m END OF BOREHOLE	Water Level = 12.90 m-bg January 12, 2006	

EBA Engineering Consultants Ltd.

PROJECT: HYDROGEOLOGICAL STUDY FOR POTABLE GROUNDWATER SUPPLY - LIARD FIRST NATION WATER SUPPLY 2/2.4/2.5 MILE COMMUNITY - WATSON LAKE , YUKON

CLIENT: DAYTON & KNIGHT LTD. LIARD FIRST NATION

TITLE: WELL LOG TW05-03

DATE	DWN.	CHKD.	FILE NO.	DRWG.
FEB. 2006	JSB	KSJ	0201-1260004	APPENDIX C1

APPENDIX

APPENDIX B GROUNDWATER MODEL CONFIGURATION AND CALIBRATION

Table B1 - Instrinsic Susceptibility Index for Semi-Confined Aquifer at LFN TW05-02

Interval		Effective Thickness (a)	Description	K factor (b)	(a*b)
from	to				
0.0	2.4	2.4	SAND (Silty)	3	7.3
2.4	5.8	3.4	SAND AND GRAVEL (Silty)	2	6.7
5.8	12.3	6.5	SAND (Silt)	3	19.5
					34

Table B2 - Instrinsic Susceptibility Index for Semi-Confined Aquifer at LFN TW05-03

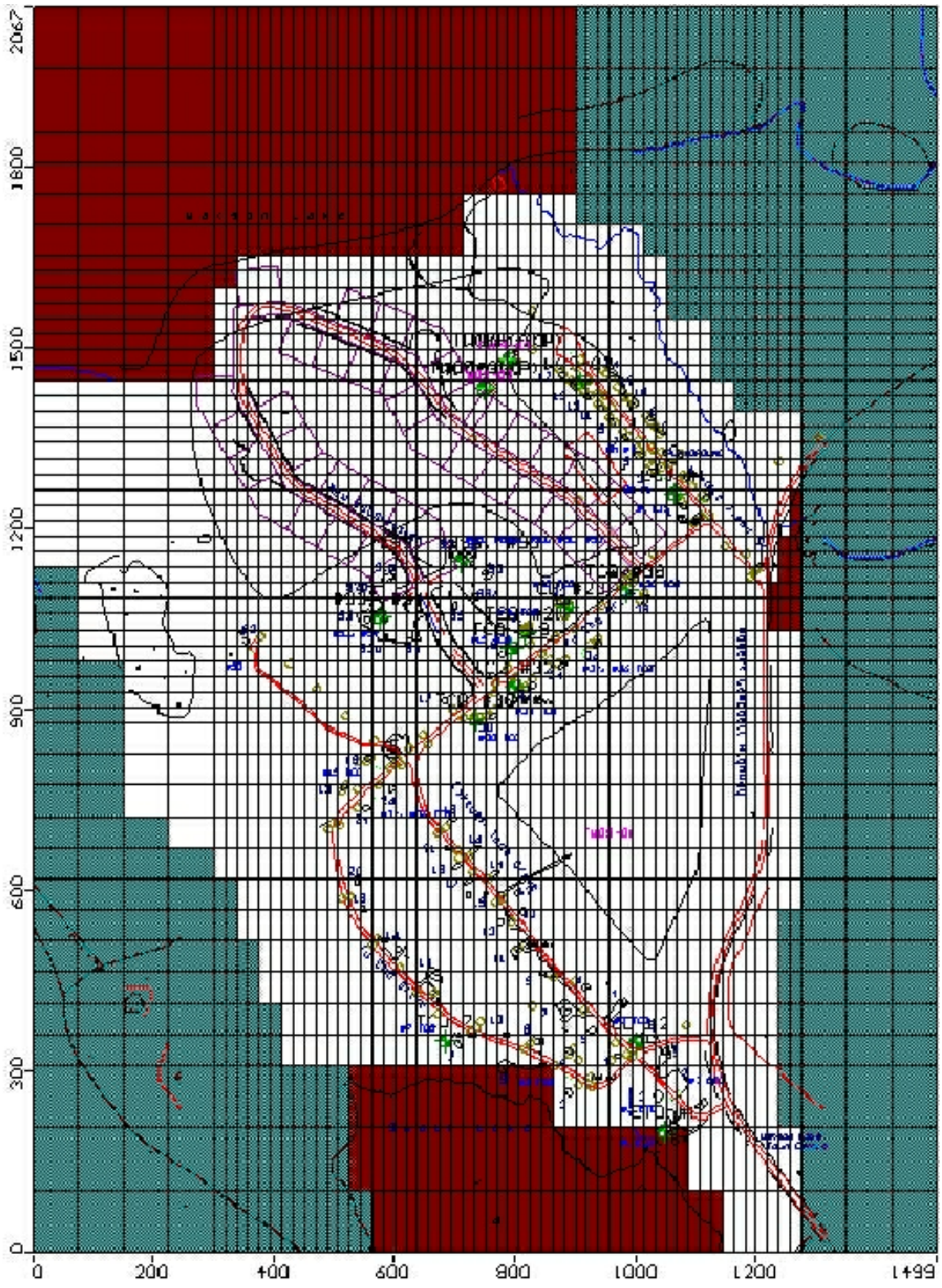
Interval		Effective Thickness (a)	Description	K factor (b)	(a*b)
from	to				
0.0	6.1	6.1	SAND AND GRAVEL (Silty)	2	12.2
6.1	12.9	6.8	SAND AND GRAVEL	2	13.6
					26

Notes:

Low (> 80), Medium(30 to 80), high (0 to 30)

LFN Aquifer Intrinsic Vulnerability is very low.

ISI Method from Ontario Minisrtry of Environment (November, 2001)



LEGEND/NOTES

SCALE: 1cm = 100m (1 : 10,000)

50 0 100 250 450m

CLIENT

LIARD FIRST NATION

P.O. Box 328
On Campbell Highway
Watson Lake, YT

EBA Engineering Consultants Ltd.

AQUIFER AND WELLHEAD PROTECTION PLAN

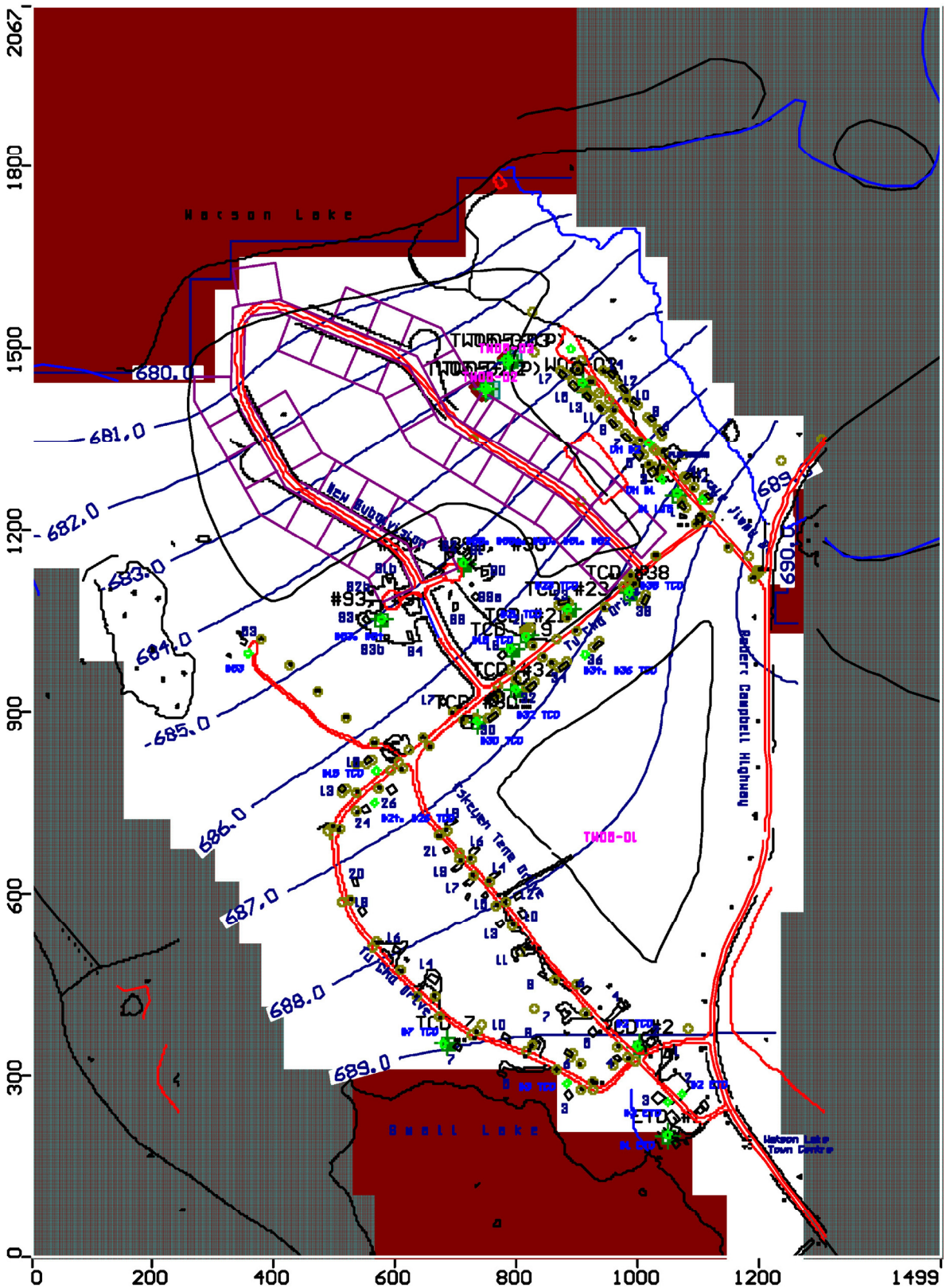
MODEL GRID AND BOUNDARIES
LIARD FIRSTNATION COMMUNITY WELLS
2/2.4/2.5 MILE, NEAR WATSON LAKE, YT

PROJECT NO.	DWN	CKD	REV
W23101082	MR	KJ	-

OFFICE: EBA-KELOWNA

DATE: December 12, 2008

APPENDIX B1



LEGEND/NOTES

SCALE: 1cm = 100m (1 : 10,000)

50 0 100 250 450m

CLIENT

LIARD FIRST NATION

P.O. Box 328
On Campbell Highway
Watson Lake, YT

EBA Engineering Consultants Ltd.

AQUIFER AND WELLHEAD PROTECTION PLAN

CALIBRATED HEADS
LIARD FIRSTNATION COMMUNITY WELLS
2/2.4/2.5 MILE, NEAR WATSON LAKE, YT

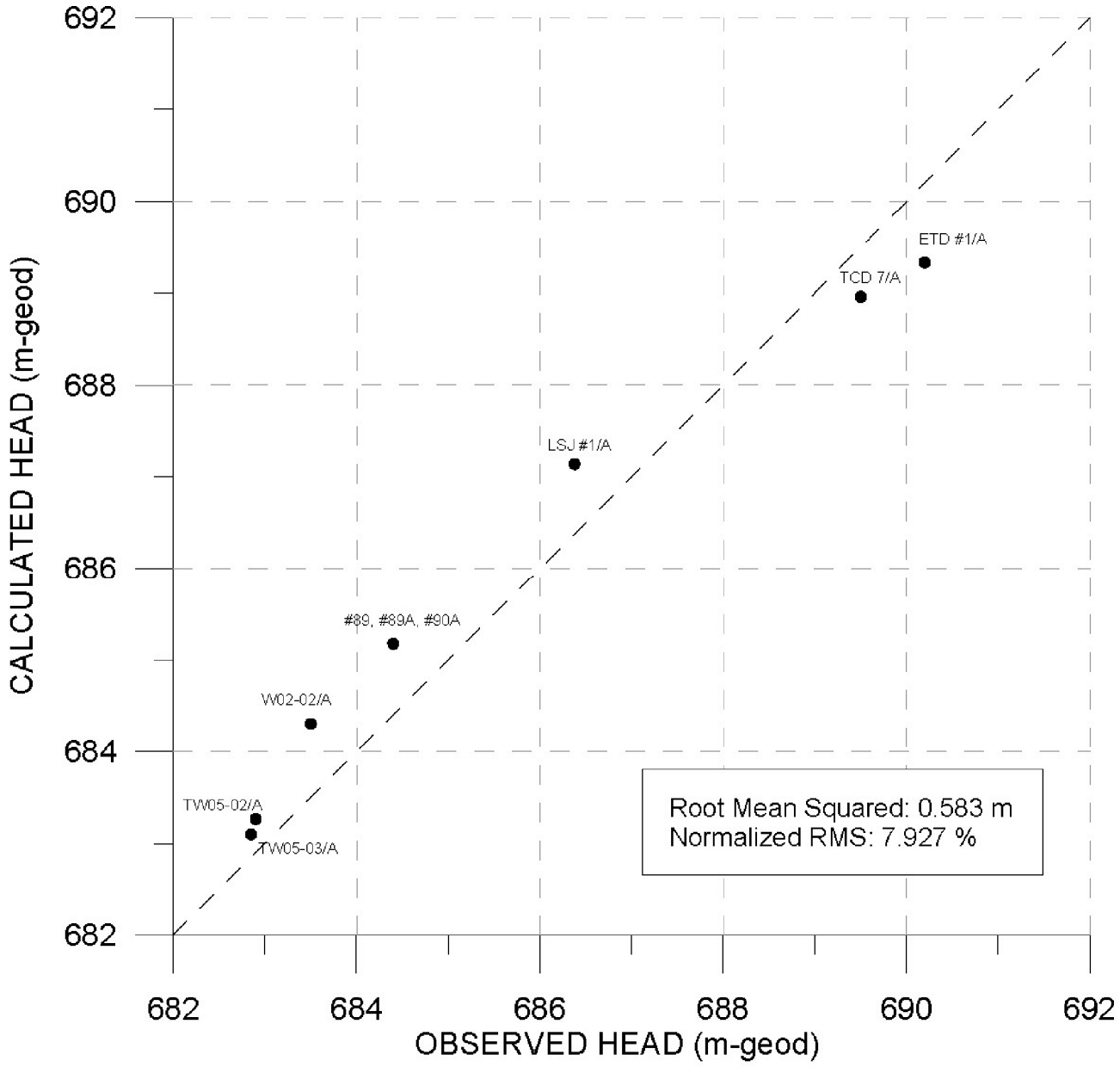
PROJECT NO.	DWN	CKD	REV
W23101082	MR	KJ	-

OFFICE: EBA-KELOWNA

DATE: December 12, 2008

APPENDIX B2

\\eba.local\coorp\Kelowna\Drafting\W231\W23101082\W23101082_R1.dwg [APPENDIX B2] December 12, 2008 - 2:41:41 pm (BY: LAURA MAJETICH)



CLIENT
LIARD FIRST NATION
P.O. Box 328
On Campbell Highway
Watson Lake, YT

AQUIFER AND WELLHEAD PROTECTION PLAN

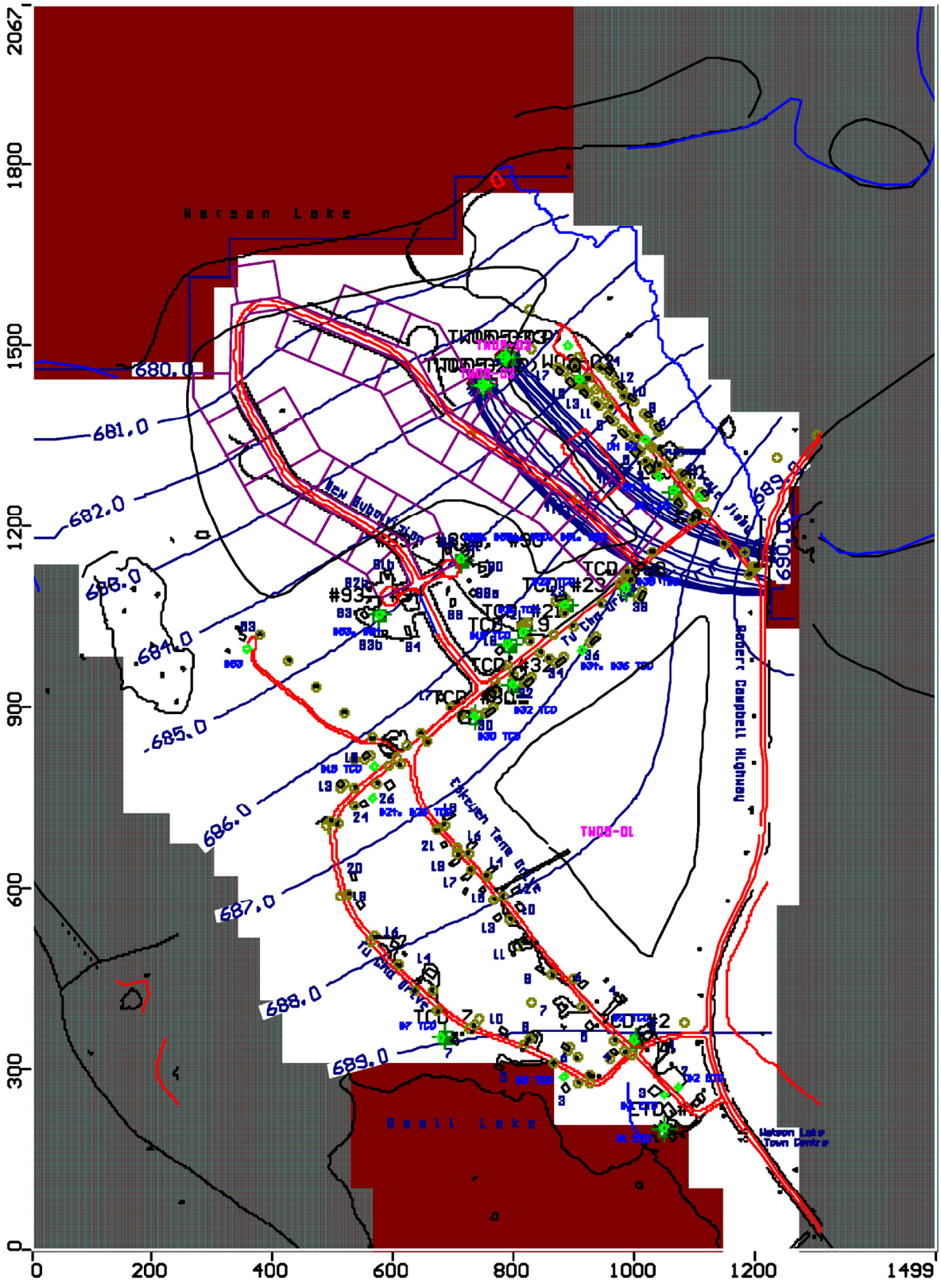
CALCULATED VERSUS OBSERVED HEAD
LIARD FIRSTNATION COMMUNITY WELLS
2/2.4/2.5 MILE, NEAR WATSON LAKE, YT

EBA Engineering Consultants Ltd.

PROJECT NO.	DWN	CKD	REV
W23101082	MR	KJ	-

OFFICE: EBA-KELOWNA
DATE: December 12, 2008

APPENDIX B3



LEGEND/NOTES

SCALE: 1cm = 50m (1 : 5,000)

25 0 50 125 225m

CLIENT
LIARD FIRST NATION
P.O. Box 328
On Campbell Highway
Watson Lake, YT

EBA Engineering Consultants Ltd.

AQUIFER AND WELLHEAD PROTECTION PLAN

MODEL OUTPUT
LIARD FIRSTNATION COMMUNITY WELLS
2/2.4/2.5 MILE, NEAR WATSON LAKE, YT

PROJECT NO.	DWN	CKD	REV
W23101082	MR	KJ	-

OFFICE	DATE
EBA-KELOWNA	December 12, 2008

APPENDIX B4

\\eba.local\corp\Kelowna\Drafting\W231\W23101082\W23101082_R1.dwg [APPENDIX B4] December 12, 2008 - 2:42:30 pm (BY: LAURA MAJETICH)

APPENDIX

APPENDIX C CONTAMINATED SITE AND SPILL SEARCH RESULTS

Search results from:

1) Marlene Sparks of Yukon Government for AST/UST search within Liard First Nation – 2 Mile Community, Watson Lake, YT.
2) Nathalie Lowry of Yukon Government for Spill Records search up to 2001 in Liard First Nation – 2 Mile Community, Watson Lake, YT.
3) Matthew Nefstead of Yukon Government for CSR and Devolution Search in Liard First Nation – 2 Mile Community, Watson Lake, YT.
4) Janice Mazerolle of Yukon Government for Sewage System Inspection Records, # 1 and # 3 Little Jimmy St.

David-Scott McQuinn

From: Marlene.Sparks [Marlene.Sparks@gov.yk.ca]
Sent: Tuesday, December 18, 2007 8:41 AM
To: David-Scott McQuinn
Subject: RE: AST/UST search - Liard First Nation Community, Watson Lake, YT

Hello Dave

I can not do a search using coordinates and I have checked I do not have any permits listed under the Liard First Nation, Watson Lake.

Marlene

-----Original Message-----
From: David-Scott McQuinn [mailto:dmcquinn@eba.ca]
Sent: Monday, December 17, 2007 2:31 PM
To: Marlene.Sparks
Cc: Ryan Martin
Subject: FW: AST/UST search - Liard First Nation Community, Watson Lake, YT

Hello Marlene,
Tammera is no longer with EBA Whitehorse. I have been given the responsibilities for the work outlined below. I have attached the email that was available to me. As such have not been able to find a response to the request for information that Tammera made. It is possible that she has not filed it properly, and this is the reason that I am unable to find it. Can you please forward me the email that you would have sent to Tammera. As I am headed to the field for consultation with the community on Wednesday I would like to have the email as early as possible. Thank you.

Dave

David-Scott McQuinn, RPF
Environmental Scientist
p. 867.668.3068x247
f. 867.668.4349
e. dmcquinn@eba.ca
EBA Engineering Consultants Ltd.
Calcite Business Center
Unit 6, 151 Industrial Road
Whitehorse YT, YIA 2V3
Canada

www.eba.ca

From: Tammera Kostya

Sent: Monday, October 29, 2007 11:22 AM
To: 'Marlene.Sparks'
Subject: AST/UST search - Liard First Nation Community, Watson Lake, YT

Hi Marlene,
I am conducting an Aquifer and Wellhead Protection Plan for the Liard First Nation Community Wells near Watson Lake, Yukon which requires an Environmental Assessment of the area surrounding the wellheads. Unfortunately the only legal description of the lots I can give you is the legal of the land the Liard First Nation community resides on (located north of the Town of Watson Lake and East of Watson Lake).

The legal is Lot 1018, Quad A/2.
However, is it possible for you to do a search based on an area given to you be UTM coordinates? The search area I would require is listed below:

North East Corner: E 517410 N 6665596
North West Corner: E 510957 N 6664942
South West Corner: E 511166 N 6657786
South East Corner: E 518520 N 6657564
This is a 5 km radius around the Liard First Nation Community.
This area incorporates the Town of Watson Lake to the southeast and just south of the Watson Lake Airport. I would also like you to focus on any incidences that may have occurred along the Robert Campbell Highway between the Town of Watson Lake and the Watson Lake Airport.
I've also provided the coordinates of the Community Wells which are located centrally within the community if that helps with your search?

TW05 - 2 (Community Well 1): E 514046 N 6661819
TW05 - 3 (Community Well 2): E 514077 N 6661867
I would appreciate if you could conduct an AST/UST search within the Liard First Nation Community just north of the Town of Watson Lake, as well as the surrounding land to the community. If you need any further information, please feel free to contact me at the number below. Please note that your response will be included with the final report, for record keeping.

Tammera Kostya, BSc
Junior Hydrogeologist
p. 867.668.2071 x237 • f. 867.668.4349 • c. 867.334.4595
e. tkostya@eba.ca

EBA Engineering Consultants Ltd.
Calcite Business Centre, Unit 6, 151 Industrial Road
Whitehorse, Yukon Y1A 2V3 • CANADA

David-Scott McQuinn

From: Lowry,Nathalie [PYR] [Nathalie.Lowry@ec.gc.ca]
Sent: Monday, December 17, 2007 2:33 PM
To: David-Scott McQuinn
Subject: RE: Spills search - Liard First Nation Community, Watson Lake, YT

Hi Dave,
I faxed the reports to Tammera on November 20, 2007. Let me know if you'd like them resent - there was 43 pages. Maybe there was a problem with the fax?

Nathalie

Nathalie Lowry, B.Sc., M.GIS
Environmental Emergencies Program - Yukon
Environment Canada - Environmental Protection Operations
91782 Alaska Hwy, Whitehorse, YT Y1A 5B7
Phone: 867.667.3405 Cell: 867.333.9917 Fax: 867.667.7962
Email: Nathalie.Lowry@ec.gc.ca

From: David-Scott McQuinn [mailto:dmcquinn@eba.ca]
Sent: Monday, December 17, 2007 2:19 PM
To: Lowry,Nathalie [PYR]
Cc: Ryan Martin
Subject: FW: Spills search - Liard First Nation Community, Watson Lake, YT

Hello Nathalie,

Tammera is no longer with EBA Whitehorse. I have been given the responsibilities for the work outlined below. I have attached the email string that was available to me. As such have not been able to find a response to the request of information that Tammera made. It is possible that she has not filed it properly, and this is the reason that I am unable to find it. Can you please forward me the email that you would have sent to Tammera. Thank you .

Dave

David-Scott McQuinn, RPF
Environmental Scientist
p. 867.668.3068x247
f. 867.668.4349
e. dmcquinn@eba.ca
EBA Engineering Consultants Ltd.
Calcite Business Center
Unit 6, 151 Industrial Road

Whitehorse YT, YIA 2V3
Canada

www.eba.ca

CREATING AND DELIVERING BETTER SOLUTIONS

From: Lowry,Nathalie [PYR] [mailto:Nathalie.Lowry@ec.gc.ca]
Sent: Friday, November 02, 2007 4:32 PM
To: Tammera Kostya
Subject: RE: Spills search - Liard First Nation Community, Watson Lake, YT

Hi Tammera,
I have not had time to process your request yet. I will be away for the next week - I will work on it when I return.

Thanks,
Nathalie

Nathalie Lowry, B.Sc., M.GIS
Environmental Emergencies Program
Environmental Protection - Environment Canada
91782 Alaska Highway, Whitehorse, YT Y1A 5B7
Work: 867.667.3405 Cell: 867.333.9917

From: Tammera Kostya [mailto:tkostya@eba.ca]
Sent: Monday, October 29, 2007 11:20 AM
To: Lowry,Nathalie [PYR]
Subject: Spills search - Liard First Nation Community, Watson Lake, YT

Hi Nathalie,
I am conducting an Aquifer and Wellhead Protection Plan for the Liard First Nation Community Wells near Watson Lake, Yukon which requires an Environmental Assessment of the area surrounding the wellheads. Unfortunately the only legal description of the lots I can give you is the legal of the land the Liard First Nation community resides on (located north of the Town of Watson Lake and East of Watson Lake).

The legal is Lot 1018, Quad A/2.
However, is it possible for you to do a search based on an area given to you be UTM coordinates? The search area I would require is listed below:

North East Corner: E 517410 N 6665596
North West Corner: E 510957 N 6664942
South West Corner: E 511166 N 6657786
South East Corner: E 518520 N 6657564
This is a 5 km radius around the Liard First Nation Community.
This area incorporates the Town of Watson Lake to the southeast and just south of the Watson Lake Airport. I would also like you to focus on any incidences that may have occurred along the Robert Campbell Highway between the Town of Watson Lake and the Watson Lake Airport. I've also provided the coordinates of the Community Wells which are located centrally within the community if that helps with your search?

TW05 - 2 (Community Well 1): E 514046 N 6661819
TW05 - 3 (Community Well 2): E 514077 N 6661867
I would appreciate a review of the spill records to determine if there have been any documented spills within the Liard First Nation Community just north of the Town of Watson Lake, as well as the surrounding land to the community and within the Town of Watson Lake. In addition, are there any spills incidences along the Alaska Highway near the Town of Watson Lake and within the Town of Watson Lake and along the Robert Campbell Highway up to the Watson Lake Airport with a 1 km buffer on either side (making a 2 km girth). Thank you for your assistance. If you need any further information, please feel free to contact me at the number below. Please note that your response will be included with the final report, for record keeping.

Tammera Kostya, BSc
Junior Hydrogeologist
p. 867.668.2071 x237 • f. 867.668.4349 • c. 867.334.4595
e. tkostya@eba.ca

EBA Engineering Consultants Ltd.
Calcite Business Centre, Unit 6, 151 Industrial Road
Whitehorse, Yukon Y1A 2V3 • CANADA

Environment Canada **Environnement Canada**
Pacific and Yukon Region Région du Pacifique et du Yukon

FAX

TO: Tammera Kostya	FROM: Nathalie Lowry
COMPANY: EBA Engineering	DATE: 11/20/2007
FAX NUMBER: 668.4349	TOTAL NO. OF PAGES INCLUDING COVER: 43
PHONE NUMBER: 668.2071	SENDER'S REFERENCE:
RE: Spill Report Search – Watson Lake, YT	

Hi Tammera,

Following are the spill reports for the Watson Lake area, as per your October 29, 2007 request. While there is one report included from 2003, please note that the database is only complete up to and including 2001. For reports after 2001 please contact Yukon Government Environmental Programs.

Nathalie

ENVIRONMENTAL PROTECTION OPERATIONS
EMERGENCIES PROGRAM – YUKON SECTION
91782 Alaksa Highway, Whitehorse, YT Y1A 5B7
phone: 867.667.3405 fax: 867.667.7962

Environment Canada | Environnement Canada

Emergencies Program - Yukon Section
91782 Alaska Highway, Whitehorse, YT Y1A 5B7
PH: 867.667.3400 FAX: 867.667.7962

Spill Report Information

Spill #	0043
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	YTG Highways Compound/Complex - transfomer brought down by accident - transformer oil spilled from damaged equipment
Incident Date	10/2/2000 2:05:00 PM
Lead Agency	Emergency Measures Organization
Other Agency	Yukon Government - Environmental Programs
Major Contaminant	Transformer Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	90
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	>50 ppm PCB
Phase	Liquid
Release	Spilled
Outcome	contaminated soil excavated and put in barrels - transformer repaired - oil tested - previous tests (late 80's) showed >50 ppm PCB - soil to be remediated - no further info

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Emergencies Program - Yukon Section
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PH: 867.667.3400 FAX: 867.667.7962

Spill Report Information

Spill #	0135
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	surface slick reported on Watson Lake
Incident Date	7/20/2001
Lead Agency	Yukon Government - Renewable Resources
Other Agency	
Major Contaminant	Unknown Substance
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	
Phase	
Release	
Outcome	part of "slick" green algae, other part a turquois cell - Ken observed but did not take samples or do further investigation - no other info on file

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Emergencies Program - Yukon Section
91782 Alaska Highway, Whitehorse, YT Y1A 5B7
PH: 867.667.3400 FAX: 867.667.7962

Spill Report Information

Spill #	0141
Jurisdiction	Yukon
Community	Watson Lake
Address	Frank Trail
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Petro Canada service station - auto-nozzles not shutting off properly on pumps
Incident Date	8/13/2001 3:30:00 PM
Lead Agency	Yukon Government - Fire Marshall
Other Agency	
Major Contaminant	Gasoline
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	5L each time
Phase	Liquid
Release	Chronic Discharge
Outcome	sorbent pads down to soak up gas but gas running off - employees would not close pumps - messages left for YTG Fire Marshall - YTG RR CO looking into - no other info

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Spill Report Information

Spill #	0311
Jurisdiction	Yukon
Community	Watson Lake
Address	13 Tucho Dr
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	21/2 Mile - Liard FN housing - above ground home fuel tank tipped over due to broken leg
Incident Date	5/6/2003 1:30:00 PM
Lead Agency	Municipality - identified in Community
Other Agency	
Major Contaminant	Diesel
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	300
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	Liard FN and North 60 staff investigating - no further information on file

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Spill Report Information

Spill #	7504
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	WPYR Watson Lake bulk plant - overfill of bulk storage tank
Incident Date	5/2/1975 4:20:00 AM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	Gasoline
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	3780
Units	Litres
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	gas was contained in the retaining dyke - all fuel was recovered

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Spill Report Information

Spill #	7824
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	White Pass agency - spill occurred during tanker truck unloading operation
Incident Date	11/13/1978 4:29:00 AM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	Department of Indian Affairs and Northern Development
Major Contaminant	Diesel
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	1134
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	no apparent damage - spill contained within berm at bulk tank - soaked into snow cover and ground within berm

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Spill Report Information

Spill #	8010
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Ace Asphalt property - storage tank rupture
Incident Date	6/20/1980 5:13:00 AM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	Tar
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	1890
Units	Litres
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	
Phase	Liquid
Release	Leaked
Outcome	due to heavy viscous nature of tar seal migration limited - little possibility of it reaching lake 400 ft away or ground water contamination

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Emergencies Program - Yukon Section
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Spill Report Information

Spill #	8023
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	WPYR Bulk Plant - tank overflow - transfer procedure error
Incident Date	11/12/1980 11:00:00 PM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	Yukon Government - other
Major Contaminant	Furnace Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	7560
Units	Litres
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	operator unaware of overfilling - spill detected during inventory on 11/21/80 - fuel soaked into ground in bermed area - no water near by - ground water?

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Spill Report Information

Spill #	8301
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Watson Lake within 100-200 m of site - overfill of home storage tank - coordinates in file wrong so best guess
Incident Date	1/10/1983 10:00:00 AM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	Federal Government - other
Major Contaminant	Furnace Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	0.22
Units	Tonnes (Metric)
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	drinking water well few feet from tank contaminated - if quanitiy correct little or no migration to lake expected - being cleaned-up by PetroCanada

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Spill Report Information

Spill #	8305
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Ace Asphalt yard - valve on storage tank found open and draining tank - vandalism indicated by operator
Incident Date	7/3/1983 11:30:00 PM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	Department of Indian Affairs and Northern Development
Major Contaminant	Asphalt Emulsion
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	11
Units	Tonnes (Metric)
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	limited ot about 200 ft from tank - contained in yard - small amount flowed over bank into forest - no further spreading expected - no dmg to water

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Emergencies Program - Yukon Section
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Spill Report Information

Spill #	8405
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Ace Asphalt yard - overflow of storage tank
Incident Date	6/25/1984 3:00:00 PM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	Asphalt Emulsion
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	2.75
Units	Tonnes (Metric)
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	product restricted to yard - no environmental damage expected - co directed to clean-up by mixing with gravel and removing to dump

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Emergencies Program - Yukon Section
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Spill Report Information

Spill #	8407
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Ace Asphalt yard - broken hose on pumping unit to tanker resulted in some loss to ground
Incident Date	7/18/1984 6:50:00 PM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	Asphalt
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	1.1
Units	Tonnes (Metric)
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	no dmg anticipated due to viscous nature of product - restricted to industrial site adjacent to plant - gravel spread over spill and removed to local landfill

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Emergencies Program - Yukon Section
91782 Alaska Highway, Whitehorse, YT Y1A 5B7
PH: 867.667.3400 FAX: 867.667.7962

Spill Report Information

Spill #	8408
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Ace Asphalt yard - broken hose due to mechanical failure
Incident Date	8/1/1984 5:00:00 PM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	Federal Government - other
Major Contaminant	Sodium Hydroxide
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	204
Units	Litres
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	solution with 50 kg sodium hyd
Phase	Liquid
Release	Spilled
Outcome	spill confined to yard - all solution soaked into ground - within 100 ft of drinking water well - excavation of soil and removeal to land fill carried out

Environment Canada Environnement Canada

Emergencies Program - Yukon Section
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PH: 867.667.3400 FAX: 867.667.7962

Spill Report Information

Spill #	8410
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Ace Asphalt yard - overfill of tanker truck
Incident Date	8/6/1984 9:00:00 PM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	Asphalt Emulsion
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	0.275
Units	Tonnes (Metric)
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	no dmg expected as area previously sealed with asphalt - impact area 10 ft sq - emulsion covered with gravel and removed

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Spill Report Information

Spill #	8412
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Ace Asphalt - dyke surrounding facility failed due to heavy rain and deliberate drainage of facility water tank
Incident Date	9/10/1984 7:30:00 PM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	RCMP
Major Contaminant	Contaminated Water
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	6.36
Units	Tonnes (Metric)
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	water with asphalt, diesel, NaO
Phase	Liquid
Release	Spilled
Outcome	contaminated water flowed into surrounding bush - deliberate drainage of water tank in prep for winter shutdown contributed - samples taken

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Spill Report Information

Spill #	8519
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Airport - hose burst at coupling while refueling
Incident Date	5/6/1985 3:27:00 PM
Lead Agency	
Other Agency	
Major Contaminant	Aviation Fuel (Jet A Or B)
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	15
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	happened on tarmac - absorbant laid down and later picked up

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Spill Report Information

Spill #	8709
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	WPYR bulk plant - bulk fuel storage tank overfilled
Incident Date	4/24/1987 10:30:00 AM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	Diesel
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	0.645
Units	Tonnes (Metric)
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	spill contained within dyked area - majority removed by pump - remainder to be removed with sorbents - no immediate threat to surface or well water

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Spill Report Information

Spill #	8720
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	weigh station - overfill of tank truck - tank leaked
Incident Date	10/20/1987 11:05:00 AM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	Diesel
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	9
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Leaked
Outcome	min hazard to health and env - no surface water affected - weigh stn well approx 50m away - advised to contain spill with absorbant and repair leak

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Spill Report Information

Spill #	8723
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	campground service station - mechanical repairs to equipment on a LPG car - explosion resulted
Incident Date	12/2/1987 9:20:00 AM
Lead Agency	Yukon Government - other
Other Agency	Environment Canada - Environmental Protection Service
Major Contaminant	Propane
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	50
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Gas
Release	Spilled
Outcome	2 injuries from explosion - emergency response for medical and fire - fire extinguished, no further release of propane - extensive dmg to building

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Spill Report Information

Spill #	8913
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Airport - Frontier's hangar - fill nozzle disconnected from unattended pressurized fuel supply line
Incident Date	7/10/1989 5:00:00 PM
Lead Agency	Municipality - identified in Community
Other Agency	Environment Canada - Environmental Protection Service
Major Contaminant	Aviation Fuel (Jet A Or B)
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	11
Units	Tonnes (Metric)
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	fuel migrated <50m soaked into ground - fire hazard controlled by foam - contaminated soil removed - drinking water wells tested and monitored HWC

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Spill Report Information

Spill #	9013
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Petro Canada Bulk Plant - overfill of bulk storage tank due to employee negligence
Incident Date	10/9/1990 2:00:00 PM
Lead Agency	Yukon Government - Fire Marshall
Other Agency	
Major Contaminant	Gasoline
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	900
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	contained in bermed area surrounding storage tank - fire hazard - minimal environmental hazard - pumped off and sold to be used in fire training

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Spill Report Information

Spill #	9024
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	BC Forest Service base - removing sunken barrels from Watson Lake - one ruptured
Incident Date	8/17/1990 1:30:00 PM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	Hydrocarbons
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	5
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	10-15 more drums to be removed - advised to have spill equipment on hand before proceeding due to environmental concerns

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Spill Report Information

Spill #	9107
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Airport - Fire Training Area - contents of storage tank leaked - valve not properly closed due to ice in fuel
Incident Date	4/1/1991 8:00:00 AM
Lead Agency	Transport Canada
Other Agency	Environment Canada - Environmental Protection Service
Major Contaminant	Gasoline
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	6800
Units	Litres
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	
Phase	Liquid
Release	Leaked
Outcome	test pits excavated - plume determined - contaminated water pumped out - evaporation and sorbents used to clean - monitoring well dug

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Spill Report Information

Spill #	9109
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Petro Canada bulk plant - leaking above ground storage tank
Incident Date	6/11/1991 8:00:00 AM
Lead Agency	Yukon Government - Public Safety
Other Agency	
Major Contaminant	Gasoline
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	12000
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Leaked
Outcome	contained within synthetic liner berm and treated through evaporation - tank repair and clean-up being monitored

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Spill Report Information

Spill #	9112
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	ACE Asphalt - spill from open top tank - escaped containment berm - improper container and no maintenance
Incident Date	6/14/1991
Lead Agency	Municipality - identified in Community
Other Agency	Environment Canada - Environmental Protection Service
Major Contaminant	Asphalt Emulsion
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	200
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Chronic Discharge
Outcome	plant not operational for a year - headquarters in Calgary authorized repairs to tank, berm and fence - advised that more needs to be done

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Spill Report Information

Spill #	9143
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	caller's home - no address given - coord for general area - spill on floor and into septic tank during filling of home fuel tank
Incident Date	1/11/1991
Lead Agency	
Other Agency	
Major Contaminant	Furnace Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	38
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	EP suggested she contact HWC-EHO for specifics on septic and well problems and see about having delivery co pay for repairs

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Spill Report Information

Spill #	9221
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	bank near Gateway Transport washbay - allegedly discharged sludge from sump over bank
Incident Date	10/19/1992
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	
Addl Quanitity Info	3 sump truck loads reported
Phase	
Release	
Outcome	site inspected by Watson Lake ARMO - no signs of discharge from settling pond - owner thinks fired employees harassing him

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Spill Report Information

Spill #	9327
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Petro Canada Bulk Plant - possible spill - variance in dipping tank reported
Incident Date	8/11/1993
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	None
Addl Quanitity Info	
Phase	
Release	
Outcome	tanks tested and found to be sound - no leaks detected - variance attributed to inaccurate readings by operator

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Spill Report Information

Spill #	9333
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Industrial area west of sewage lagoon and RMO Office - waste oil used for dust suppression
Incident Date	7/8/1993
Lead Agency	Department of Indian Affairs and Northern Development
Other Agency	
Major Contaminant	Waste Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	
Phase	Liquid
Release	Dumped
Outcome	DIAND advised us of observations - no action taken on EP's part

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Spill Report Information

Spill #	9411
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	ICG Yard - safety valve broke off 1000 ga tank during unloading operations - gas released to atmosphere
Incident Date	4/7/1994 1:00:00 PM
Lead Agency	Municipality - identified in Community
Other Agency	
Major Contaminant	Propane
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	5
Units	Percent (%)
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Gas
Release	Leaked
Outcome	Watson Lake Fire Dept responded (lead) - applied water fog to disperse leak - area evacuated, highway closed, power dropped - dissipated w/in 20 min

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Spill Report Information

Spill #	9417
Jurisdiction	Yukon
Community	Watson Lake
Address	3rd St N & Wye Dr
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	spring melt carrying oil from contaminated soil into ditches - behind KPI Northern
Incident Date	4/28/1994
Lead Agency	Municipality - identified in Community
Other Agency	
Major Contaminant	Waste Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	
Phase	Liquid
Release	Chronic Discharge
Outcome	oil sheen on water in ditches - ditches drain toward 2nd Wye Lake but dead end halfway - 100m from lake - no storm sewers nearby

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Spill Report Information

Spill #	9426
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	swimming pool facility - fuel oil forced out of vent pipe of above ground storage tank during servicing - accidental
Incident Date	5/31/1994
Lead Agency	Municipality - identified in Community
Other Agency	Environment Canada - Environmental Protection Service
Major Contaminant	Fuel Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	1800
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	soil contaminated under tank - no sewers or surface water nearby - well water 120m away - soil excavated and removed to dump

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Spill Report Information

Spill #	9437
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	NWTel Compound - overflow from waste oil storage facility - due to lack of attention
Incident Date	8/5/1994
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	Waste Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	200
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	sump & trench dug - oil removed to NWT holding tank - sorbent applied to trench & sump - sorbent & soil to be removed - site to be remediated

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Spill Report Information

Spill #	9627
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	200 ft W of Watson Lake Weight Station - product leaking from transport truck - truck carrying load of barrels
Incident Date	5/27/1996 12:20:00 PM
Lead Agency	Yukon Government - Dangerous Goods
Other Agency	Municipality - identified in Community
Major Contaminant	Methanol
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	115
Units	Litres
Concentration	7
Units	%
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	product from one barrel spilt - soaked up with absorbant and recovered - clean-up complete

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Spill Report Information

Spill #	9628
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	ACE Asphalt plant - inspection of site by DIAND resulted in discovery of several leaks / spills from storage tanks
Incident Date	5/22/1996 1:30:00 PM
Lead Agency	Department of Indian Affairs and Northern Development
Other Agency	
Major Contaminant	Asphalt Emulsion
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	
Phase	Liquid
Release	Chronic Discharge
Outcome	ACE hired contractors to clean up and secure the sight as directed by DIAND

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Spill Report Information

Spill #	9724
Jurisdiction	Yukon
Community	Watson Lake
Address	Adela Trail & 3rd St N
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	product in roadside ditch
Incident Date	4/7/1997
Lead Agency	Yukon Government - Environmental Programs
Other Agency	
Major Contaminant	Oil
2nd Contaminant	Diesel
3rd Contaminant	Ethylene Glycol
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	oil, diesel, antifreeze mixture
Phase	Liquid
Release	
Outcome	suspect KPI Northern may be responsible as the business operates in the area - being investigated by the Watson Lake CO - no further information on file

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Spill Report Information

Spill #	9729
Jurisdiction	Yukon
Community	Watson Lake
Address	Adela Trail
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Chevron and Car Wash - nozzle on fuel pump broken - person filling truck went inside for coffee and pump didn't shut off
Incident Date	5/17/1997 10:00:00 AM
Lead Agency	Yukon Government - Environmental Programs
Other Agency	
Major Contaminant	Diesel
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	157
Units	Litres
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	Watson Lake ARMO inspected spill site - pump handle broken off previous night (vandalism) - fuel stained area 3m x 10m - unrecoverable - no plans for excavation of soil

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Spill Report Information

Spill #	9731
Jurisdiction	Yukon
Community	Watson Lake
Address	3rd St N & Wye Drive
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	product in roadside ditch - ditch is 1/2 full
Incident Date	5/20/1997
Lead Agency	Yukon Government - Environmental Programs
Other Agency	
Major Contaminant	Unknown Substance
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	yellow, dark, turpentine smell
Phase	Liquid
Release	Unknown
Outcome	Bryan Levia inspected spill site - samples taken to see if it was a hazardous waste - no other informaiton on file

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Spill Report Information

Spill #	9816
Jurisdiction	Yukon
Community	Watson Lake
Address	3rd St N & Wye Drive
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	oil in ditch on corner - was reported last year - Spill No 9731
Incident Date	4/14/1998
Lead Agency	Yukon Government - Environmental Programs
Other Agency	
Major Contaminant	Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	
Phase	Liquid
Release	Unknown
Outcome	concern about waste getting into Second Wye Lake - CO in Watson Lake to investigate - no further information on file

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Spill Report Information

Spill #	9841
Jurisdiction	Yukon
Community	Watson Lake
Address	Adela Trail
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	new Town Hall construction site - old drums being excavated from site - no signs of contaminated soil
Incident Date	10/2/1998
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	None
Addl Quanitity Info	
Phase	
Release	
Outcome	2 drums dug up - suspect drums have been there at least 25 years - no signs of product from drums - both crushed and empty - YTG-EP not concerned - no further info

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Spill Report Information

Spill #	9905
Jurisdiction	Yukon
Community	Watson Lake
Address	
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	North 60 Bulk Plant - overfill of tank
Incident Date	2/22/1999
Lead Agency	Yukon Government - Public Safety
Other Agency	
Major Contaminant	Furnace Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	300
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	fuel ran down sides of tank into bermed area - contaminated snow to be cleaned up - will be monitored in spring - no further info on file

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Spill Report Information

Spill #	9943
Jurisdiction	Yukon
Community	Watson Lake
Address	Kilowatt Lane
Highway	
Milepost	
Feature	Watson Lake
Location / Cause	Power Plant - old buried waste pit discovered while excavating a trench
Incident Date	10/6/1999 2:45:00 PM
Lead Agency	Yukon Government - Environmental Programs
Other Agency	
Major Contaminant	Waste Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	
Phase	Liquid
Release	Dumped
Outcome	no surface waterbodies nearby - interviewing past employees and collecting samples - contamination extends down 10' to clay layer - area ~ 20m2 - excavating - no other info

David-Scott McQuinn

From: Matthew.Nefstead [Matthew.Nefstead@gov.yk.ca]
Sent: Tuesday, October 30, 2007 3:50 PM
To: Tammera Kostya
Subject: RE: CSR and Devolution Search_Liard First Nation Community, Watson Lake, YT

Hi Tammera,

Sorry for the omissions; please see my notes below. In addition, I've noticed that there's an easement running along the Campbell Highway – this easement is titled as "Canadian National Telegraph Line R/W", but in a report on the Campbell Subdivision Abandoned Dumpsite (see below), the easement is labeled as "Pipeline R.O.W." It's unclear whether a pipeline exists or existed along that easement, but I thought I should pass it along. The plan number for the easement is 57108 CLSR.

Cheers,

Matthew Nefstead
Contaminated Sites Analyst
Yukon Department of Environment (V-8)
(867) 667-5076

-----Original Message-----
From: Tammera Kostya [mailto:tkostya@eba.ca]
Sent: Tuesday, October 30, 2007 2:39 PM
To: Matthew.Nefstead
Subject: RE: CSR and Devolution Search_Liard First Nation Community, Watson Lake, YT

Just need specifics of locations - would prefer UTM or legal CLSR lot numbers if possible. See which ones require more specific locations. Thanks Matthew

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From: Matthew.Nefstead [mailto:Matthew.Nefstead@gov.yk.ca]
Sent: Tuesday, October 30, 2007 9:47 AM
To: Tammera Kostya
Subject: RE: CSR and Devolution Search_Liard First Nation Community, Watson Lake, YT

Hi Tammera,

Contaminated Sites Files:
There are no Designated Contaminated Sites in Watson Lake. The following properties for which we hold contaminated sites files appear to be within 5 km of the wellhead locations provided:
4202-20-080: Watson Lake Airport
4202-20-136: South Yukon Forest Corporation Lease (Lease # 105A02-131) - where is this (can you provide UTM coordinates or at least a legal lot #?) ***[MN]*** The lease # is the entire legal description (it's not a titled lot). Located at approx. 513465 E 6658758 N
4202-20-097: Shell Gas Station (Lot 1, Block 10, Plan 43475 CLSR)
4202-20-098: Campbell Subdivision Abandoned Dumpsite - Where? (see above question) ***[MN]*** Approx. 515047 E 6659745 N – on aerial photos it's clearly visible as a small cleared area adjacent to the pipeline ROW.
4202-20-022: Petro-Canada Gas Station (Frank Trail, between 5th St. and 8th St. S.)
4202-20-132: Watson Lake Motors (824 Adela Trail)
4202-20-076: Yukon Electrical Generating Station - Where? ***[MN]*** Lot 1032, 71431 CLSR

Additionally, the Watson Lake Landfill is located within 5 km of the wellhead locations, and may pose a risk of

contamination. The landfill is unlined and contains no groundwater monitoring wells or leachate collection system. - where? ***[MN]*** Approx. 514122 E 6659132 N

Spill Reports:
The following spills appear to have occurred within 5 km of the wellhead locations:
00-025: Oct 2, 2000, Watson Lake Highway Maintenance Camp, 90 L transformer oil spilled when a pole-mounted transformer fell and broke. - where?***[MN]*** Block 43, 63144 CLSR
01-035: Aug 13, 2001, Watson Lake Petro-Can, 5 L gasoline was leaking with each fill-up due to malfunctioning auto-shutoff nozzles.
03-012: May 6, 2003, 13 Tucho Drive, 300 L fuel leaked from a residential fuel tank. - where(not on map - is this in Watson lake?) ***[MN]*** Our file indicates this is a Liard FN residence – perhaps in the neighbourhood where the wells are located? Could also be in Upper Liard. I don't have a lot number or coordinates.
05-069: Oct 20, 2005, Watson Lake Motors, 500-1000 L diesel spilled from over-filling a tank.
05-102: Jun 5, 2005, 3 miles north of Watson Lake on the Robert Campbell Highway, 20 L hydraulic oil spilled when a pail fell out of a truck.
07-025: Jan 16, 2007, between Morley and Nahanni Drive, 4 L hydraulic oil spilled from blown hose.
07-045: Apr 12, 2007, Anglican Church (1103 Frank Trail), 800 L fuel lost from leaking tank.
07-059: Jul 3, 2007, Watson Lake Landfill access road, 23 L transmission oil spilled due to equipment malfunction.

Land Treatment Facilities:
The following land treatment facilities appear to be within 5 km of the wellhead locations:
4202-24-003: Petro-Canada Gas Station (no longer in use)
4202-24-008: Yukon Electrical Generating Station
4202-24-010: Transport Canada – Watson Lake Airport
4202-24-013: North 60 Petro Ltd. (Lot 37, Group 757, Plan 51684 CLSR) - is this to the west of the Town of Watson? ***[MN]*** Yes, on the south side of the Alaska Highway about 1.2 km west of the junction with the Campbell Highway.
4202-20-060: Watson Lake Landfill (an LTF was operated by Yukon Electrical; no longer in use)
4202-24-027: Watson Lake Landfill (proposed LTF to be operated by the Town of Watson Lake)

Yukon Contaminated Sites Inventory:
This inventory contains information on contaminated sites and waste sites in the Yukon, and was inherited from Indian and Northern Affairs Canada (INAC) as part of the Devolution Transfer Agreement. I cannot guarantee that the information contained in the inventory is complete, accurate, or up-to-date. I have attached information on 5 sites which may be of interest to you. I can also provide copies of any photos and reports noted in the attached database printouts, if desired. If you require additional information on these sites, please contact Rick Seaman at INAC's Waste Management office (seamanr@inac-ainc.gc.ca).

I hope this information is helpful. Please let me know if you have any questions, wish to view any of our files, or need further information in the future.

Matthew Nefstead
Contaminated Sites Analyst
Yukon Department of Environment (V-8)
(867) 667-5076

-----Original Message-----
From: Tammera Kostya [mailto:tkostya@eba.ca]
Sent: Monday, October 29, 2007 11:11 AM
To: Matthew.Nefstead
Subject: FW: CSR and Devolution Search_Liard First Nation Community, Watson Lake, YT

Correction

From: Tammera Kostya
Sent: Monday, October 29, 2007 11:09 AM
To: 'Matthew.Nefstead'
Subject: CSR and Devolution Search_Liard First Nation Community, Watson Lake, YT

Hi Matthew
I am conducting an Aquifer and Wellhead Protection Plan for the Liard First Nation Community Wells near Watson Lake, Yukon which requires an Environmental Assessment of the area surrounding the wellheads. Unfortunately the only legal description of the lots I can give you is the legal of the land the Liard First Nation community resides on (located north of the Town of Watson Lake and East of Watson Lake).

The legal is Lot 1018, Quad A/2.
However, is it possible for you to do a search based on an area given to you be UTM coordinates? The search area I would require is listed below:

North East Corner: E 517410 N 6665596
North West Corner: E 510957 N 6664942
South West Corner: E 511166 N 6657786
South East Corner: E 518520 N 6657564
This is a 5 km radius around the Liard First Nation Community.
This area incorporates the Town of Watson Lake to the southeast and just south of the Watson Lake Airport. I would also like you to focus on any incidences that may have occurred along the Robert Campbell Highway between the Town of Watson Lake and the Watson Lake Airport. I've also provided the coordinates of the Community Wells which are located centrally within the community if that helps with your search?

TW05 - 2 (Community Well 1): E 514046 N 6661819
TW05 - 3 (Community Well 2): E 514077 N 6661867
I would like to confirm if there are any contaminated sites and/or spills within 5 km of the Community Wells.
I would also appreciate a search of any devolution sites within the Liard First Nation Community area. Once again, my concern is more for any sites that are located within 5 km to the Liard First Nation Community along the Alaska Highway near the Town of Watson Lake and along the Robert Campbell Highway with a 1 km buffer on either side (making a 2 km girth).

Thank you for your assistance. If you need any further information, please feel free to contact me at the number below. Please note that your response will be included with the final report, for record keeping.

Tammera Kostya, BSc
Junior Hydrogeologist
p. 867.668.2071 x237 • f. 867.668.4349 • c. 867.334.4595
e. tkostya@eba.ca

EBA Engineering Consultants Ltd.
Calcite Business Centre, Unit 6, 151 Industrial Road
Whitehorse, Yukon Y1A 2V3 • CANADA

Yukon Contaminated Site

Report printed on 30 Oct 2007

Information last modified on 14 Feb 2005, 11:30:56

CSR File Number:
Site ID Number: WL001
Site Name: Watson Lake Dump Site
Public Registry:

Location and Access

Latitude: 60° 4' 0" N
Longitude: 128° 44' 0" W
UTM Zone 9V
Easting: 514844.0856
Northing: 6658865.6796
NTS sheet: 105 A/02
District: Watson Lake

Legal Description:

Civic Description:

Traditional Territory
Kaska Dena

Site Access: Road
Name of access route:
GENERAL ACCESS: WATSON LAKE TOWN DUMP SITE; VEHICLE

Contaminated Site Regulation (CSR) Status

Land Uses	Water Uses	CSR Status	Orders issued
		10 Feb 2005 Dump Site	☐

Federal Status

Devolution Site Status: Not Applicable

Date	Follow-up action plan details

Description

General Description

DOCUMENTED FOR RECORD PURPOSES. NO RESTORATION PLANNED FOR FORESEEABLE FUTURE. PREVIOUS OCCUPANT: MAINTAINED BY TOWN OF WATSON LAKE . ABANDONED . VEGETATION: PINE, POPLAR AND FIREWEED.

Distance to Residence:
actual distance (m):

Visual Impact:

Distance to Surface Water:
Depth to Ground Water (m):

Area of site (m²): 00,000

Land Tenure

Owner	End date
Territorial	

Site Occupants

Occupant	From date	To date	Activity 1	Activity 2	Activity 3
Government			Active Dump		

Potential Concerns

Solid waste landfill? Y

Contaminants	Hazards	Structures	Waste Material
			Debris/Refuse

Documentation

Yukon Contaminated Site

Report printed on 30 Oct 2007

Information last modified on 14 Feb 2005, 11:30:56

CSR File Number:
Site ID Number: WL001
Site Name: Watson Lake Dump Site
Public Registry:

Reports

Year	Author	Title	Location	Reference num

Maps and Photos

Type	Year	Description	File name

Monitoring and Inspections

Date	Inspected by	Observations	Next visit
31 Oct 1989	K.T.C. RISTAU		

Comments and Recommendations

DOCUMENTED FOR RECORD PURPOSES. NO RESTORATION PLANNED FOR FORESEEABLE FUTURE. MAINTAINED BY TOWN OF W. LAKE. YTG RESERVE 042

Feb. 10/05: Reviewed for CSR status. Is this the active dump site?

Yukon Contaminated Site

Report printed on 30 Oct 2007

Information last modified on 14 Feb 2005, 11:24:07

CSR File Number:
Site ID Number: WL002
Site Name:
Public Registry:

Location and Access

Latitude: 60° 3' 0" N
Longitude: 128° 44' 0" W
UTM Zone 9V
Easting: 514851.5715
Northing: 6657009.5444
NTS sheet: 105 A/02
District: Watson Lake

Legal Description:

Civic Description:

Traditional Territory
Kaska Dena

Site Access:
GENERAL ACCESS: PUBLIC WORKS CAMP, WATSON LAKE BLT; VEHICLE

Name of access route:

Contaminated Site Regulation (CSR) Status

Land Uses	Water Uses	CSR Status	Orders issued
		10 Feb 2005 Sources of potential contamination	☐

Federal Status

Devolution Site Status: Remediated Sites

Date	Follow-up action plan details
	CLEANED BY THE LIARD FIRST NATION IN THE FALL OF 1994.

Description

General Description
ONE VEHICLE BODY, BUILDING DEBRIS, VEHICLE TIRES

Distance to Residence:
actual distance (m):

Visual Impact:

Distance to Surface Water:

Area of site (m²): 00,000

Depth to Ground Water (m):

Land Tenure

Owner	End date
Federal	

Site Occupants

Occupant	From date	To date	Activity 1	Activity 2	Activity 3

Potential Concerns

Solid waste landfill? N

Contaminants	Hazards	Structures	Waste Material

Documentation

Yukon Contaminated Site

Report printed on 30 Oct 2007

Information last modified on 14 Feb 2005, 11:24:07

CSR File Number:
Site ID Number: WL002
Site Name:
Public Registry:

Reports

Year	Author	Title	Location	Reference num

Maps and Photos

Type	Year	Description	File name

Monitoring and Inspections

Date	Inspected by	Observations	Next visit

Comments and Recommendations

THIS AREA COULD BE CLEANED UP WITH A CAT WITHOUT TOO MUCH DISTURBANCE TO THE AREA. IN WATSON LAKE BLT.

Feb. 10/05: Reviewed for CSR status. "Info available" due to the presence of abandoned vehicle.

Yukon Contaminated Site

Report printed on 30 Oct 2007
Information last modified on 14 Feb 2005, 11:24:13

CSR File Number:
Site ID Number: WL003
Site Name: Old Army Dump
Public Registry:

Location and Access

Latitude: 60° 5' 0" N **UTM** **Easting:** 514836.5984 **NTS sheet:** 105 A/02
Longitude: 128° 44' 0" W Zone 9V **Northing:** 6660721.8194 **District:** Watson Lake

Legal Description:
Civic Description:

Traditional Territory
Kaska Dena

Site Access: Road **Name of access route:**
GENERAL ACCESS: OLD ARMY DUMP; VEHICLE
OLD ARMY DUMP

Contaminated Site Regulation (CSR) Status

Land Uses	Water Uses	CSR Status	Orders issued
		10 Feb 2005 Sources of potential contamination	☐

Federal Status

Devolution Site Status: Sites Not Requiring Remediation

Date	Follow-up action plan details
	HERITAGE REPORT: OLD ARMY DUMP CONSISTS OF DRUMS, REFUSE

Description

General Description
OLD ARMY DUMP. VEGETATION: PINE,POPLAR AND FIREWEED. ABANDONED

Distance to Residence:
actual distance (m):

Visual Impact:

Distance to Surface Water:
Depth to Ground Water (m):

Area of site (m²): 00,000

Land Tenure

Owner	End date
Federal	

Site Occupants

Occupant	From date	To date	Activity 1	Activity 2	Activity 3
			Inactive Dump		
Unknown			Inactive Dump		

Potential Concerns

Solid waste landfill? N

Yukon Contaminated Site

Report printed on 30 Oct 2007

Information last modified on 14 Feb 2005, 11:24:13

CSR File Number:
Site ID Number: WL003
Site Name: Old Army Dump
Public Registry:

Contaminants	Hazards	Structures	Waste Material
	OLD VEHICLES		Scrap Metal Drums Debris/Refuse

Documentation

Reports

Year	Author	Title	Location	Reference num

Maps and Photos

Type	Year	Description	File name
Photo	1989	Site overview	WL003a01

Monitoring and Inspections

Date	Inspected by	Observations	Next visit
	K.T.C. RISTAU		

Comments and Recommendations

AREA IS GROWN UP AND MOST OF THE DEBRIS IS HARD TO SPOT. OLD VEHICLES SHOULD BE TOWED AWAY- ONLY NOTICEABLE FEATURE FROM THE AIR & GROUND DISTURBANCE TO NEW GROWTH WOULD BE MINIMAL. IN TOWN OF W.L. BLT

Feb. 10/05: Reviewed for CSR status. "Info available" due to presence of abandoned vehicles.

Yukon Contaminated Site

Report printed on 30 Oct 2007
Information last modified on 26 Apr 2005, 11:44:01

CSR File Number: 4202-20-080
Site ID Number: WL054
Site Name: Watson Lake Barrels
Public Registry:

Location and Access

Latitude: 60° 7' 0" N
Longitude: 128° 48' 0" W
UTM Zone 9V
Easting: 511116.2240
Northing: 6664421.0295
NTS sheet: 105 A/02
District: Watson Lake

Legal Description:

Civic Description:

Traditional Territory
Kaska Dena

Site Access: Water
GENERAL ACCESS: WATSON LAKE; DIVING

Name of access route: Watson Lake

Contaminated Site Regulation (CSR) Status

Land Uses	Water Uses	CSR Status	Orders issued
		11 Feb 2005 Information available	☐

Federal Status

Devolution Site Status: Remediated Sites

Date	Follow-up action plan details

Description

General Description

APPROX. 150+ DRUMS IN WATSON LAKE. ARMY POSSIBLY DUMPED DRUMS IN LAKE PRIOR TO PULLING OUT. BELIEVED TO CONTAIN DIESEL FUEL, ROAD TAR, PESTICIDES. MAY BE STARTING TO LEAK SLOWLY. AT APPROX 30' WATER DEPTH. FRASER BURRARD DIVING LTD CONDUCTED A FIELD INVESTIGATION IN OCTOBER 1991 USING SIDE SCAN SONAR. THEY PREDICTED THERE WERE A TOTAL OF 220 DERELICT 45 GALLON DRUMS, 2 SUNKEN BOATS AND THE TAIL OF A LANCASTER AIRCRAFT IN THE BOTTOM OF WATSON LAKE. IN 1994, FORESHORE TECHNOLOGIES INC. RECOVERED 84 DRUMS AND B.C. FOREST SERVICES INITIAL ATTACK BASE RECOVERED 130 DRUMS. SOME OF THE DRUMS CONTAINED TAR-LIKE RESIDUES, MOST WERE FILLED WITH LAKE WATER. MOTOR OIL AND DIESEL RESIDUES WERE DETECTED IN 2 DRUMS. ONLY DRUMS IN CLOSE PROXIMITY TO THE SHORE HAVE BEEN INVENTORIED, IT IS PROBABLE THAT BARRELS WERE LEFT ON THE ICE AND WILL BE FOUND IN DEEPER SECTIONS OF THE LAKE.

Distance to Residence: 0 - 500 m
actual distance (m):
Visual Impact: Medium

Distance to Surface Water: 0 m - below high wa
Depth to Ground Water (m):
Area of site (m²): 00,000

Land Tenure

Owner	End date
Federal	

Site Occupants

Occupant	From date	To date	Activity 1	Activity 2	Activity 3
Military	23 Apr 1905	23 May 1905	Active Dump		

Potential Concerns

Solid waste landfill? N

Yukon Contaminated Site

Report printed on 30 Oct 2007

Information last modified on 26 Apr 2005, 11:44:01

CSR File Number: 4202-20-080
Site ID Number: WL054
Site Name: Watson Lake Barrels
Public Registry:

Contaminants	Hazards	Structures	Waste Material
Hydrocarbons			Drums Contaminants

Documentation

Reports

Year	Author	Title	Location	Reference num
1991	FBDiving ltd	Watson Lk Bottom Survey	Waste Mgt DIAND	BUR-065-1991
1994	Foreshore Technologies Inc.	Report on the Environmental Cleanup and Recovery of Derelict Barrels from Watson Lake, YT	AES, DIAND	c1994_07

Maps and Photos

Type	Year	Description	File name
Photo	1991	Barrels in the lake	WL054a01
Photo	1994	Recovered barrels	WL054a02
Photo	1994	Leaking barrel	WL054a03
Airphoto	1980	Watson Lake 1:50,000	WL054c01
Airphoto	1992	Watson Lake 1:40,000	WL054c02

Monitoring and Inspections

Date	Inspected by	Observations	Next visit
01 Oct 1997	GORD MITCHELL		

Comments and Recommendations

FORESHORE TECHNOLOGIES INC. 1997 RECOMMEND THAT FURTHER INVESTIGATION OF THE EXTENT OF THE DEBRIS IN WATSON LAKE, AND FUTURE CLEAN UP IS WARRENTED.

Feb. 11/05: Reviewed for CSR status. This site is included in EPB file 4202-20-080 as an APEC. FTI's 1994 report notes that 130 barrels were recovered offshore of BC Forest Services' Initial Attack Base and 84 more distributed around the lakeshore. ~142 additional barrels were identified that were not listed on the FB Diving survey completed in 1991. Report speculates that more barrels remain unidentified and recommends additional surveying, particularly at deeper depths.

Yukon Contaminated Site

Report printed on 30 Oct 2007

Information last modified on 11 Feb 2005, 08:50:49

CSR File Number: 4202-20-80
Site ID Number: WL060
Site Name: Transport Canada Site
Public Registry:

Location and Access

Latitude: 60° 7' 0" N
Longitude: 128° 49' 0" W
UTM Zone 9V
Easting: 510189.8737
Northing: 6664418.3427
NTS sheet: 105 A/02
District: Watson Lake

Legal Description:

Civic Description:

Traditional Territory
Kaska Dena

Site Access:
GENERAL ACCESS: TRANSPORT CANADA DUMP SITE; VEHICLE

Name of access route:

Contaminated Site Regulation (CSR) Status

Land Uses	Water Uses	CSR Status	Orders issued
		11 Feb 2005 Information available	☐

Federal Status

Devolution Site Status: Remediated Sites

Date	Follow-up action plan details

Description

General Description

DRUMS AND GENERAL REFUSE - ON MOT LAND (W.L. AIRPORT) PRESENT OCCUPANT: ON MOT LAND, WATSON LAKE AIRPORT MOT DUMP. VEGETATION: WILLOW. POSSIBLE CHEMICAL LEACHING PROBLEM.

Distance to Residence:
actual distance (m):

Visual Impact:

Distance to Surface Water:

Area of site (m²): 00,000

Depth to Ground Water (m):

Land Tenure

Owner	End date
Federal	

Site Occupants

Occupant	From date	To date	Activity 1	Activity 2	Activity 3
Government			Airport		

Potential Concerns

Solid waste landfill? N

Contaminants	Hazards	Structures	Waste Material
	Chemical		Drums Debris/Refuse

Yukon Contaminated Site

Report printed on 30 Oct 2007

Information last modified on 11 Feb 2005, 08:50:49

CSR File Number: 4202-20-80
Site ID Number: WL060
Site Name: Transport Canada Site
Public Registry:

Documentation

Reports

Year	Author	Title	Location	Reference num

Maps and Photos

Type	Year	Description	File name

Monitoring and Inspections

Date	Inspected by	Observations	Next visit
31 Oct 1989	K.T.C. RISTAU		

Comments and Recommendations

DOCUMENTED FOR RECORD PURPOSES
Feb. 11/05: Reviewed for CSR status. This site is (probably) part of the W.L. Airport group of APECs - see file 4202-20-80.

Health Canada / Santé Canada

Environmental Health Services
100 - 300 Main Street
Whitehorse, Yukon
Y1A 2B5

ph. 667-3939
fax. 668-5726

Your file / Votre référence

Our file / Notre référence

November 15, 1996

Liard First Nation
Box 328
Watson Lake, Yukon
Y0A 1C0

Now
#1 Little Jimmy Street
Ann Dickson

To whom it may concern:

Re: **PRIVATE SEWAGE SYSTEM**
Permit # 1291
Lot 44, 2.5 Mile Subdivision
1000 gal. (total capacity) Septic Tank, Siphon, and Absorption Bed (12' x 47') with 2 feet of Filter Sand

Your notification of installation form and photographs of the private sewage disposal system for your premises located on above-noted site, have been received by our office.

Your system appears to have been installed according to your application and permit (this observation is not a warranty as to performance). Please be advised that the permitting and notification requirements of the Regulations Governing Private Sewage Disposal Systems pursuant to the Public Health Act have been satisfied.

If you have any questions, please contact this office at 667-3939.

Yours truly,

Todd Pinkess, C.P.H.I.(C)
Environmental Health Officer

p.c. Building Inspection, YTG
Bill Johnston, DIAND

Canada

Legal description
Description légale Lot 4 @ 2.5 mile Stewart

Plan • *Plan*

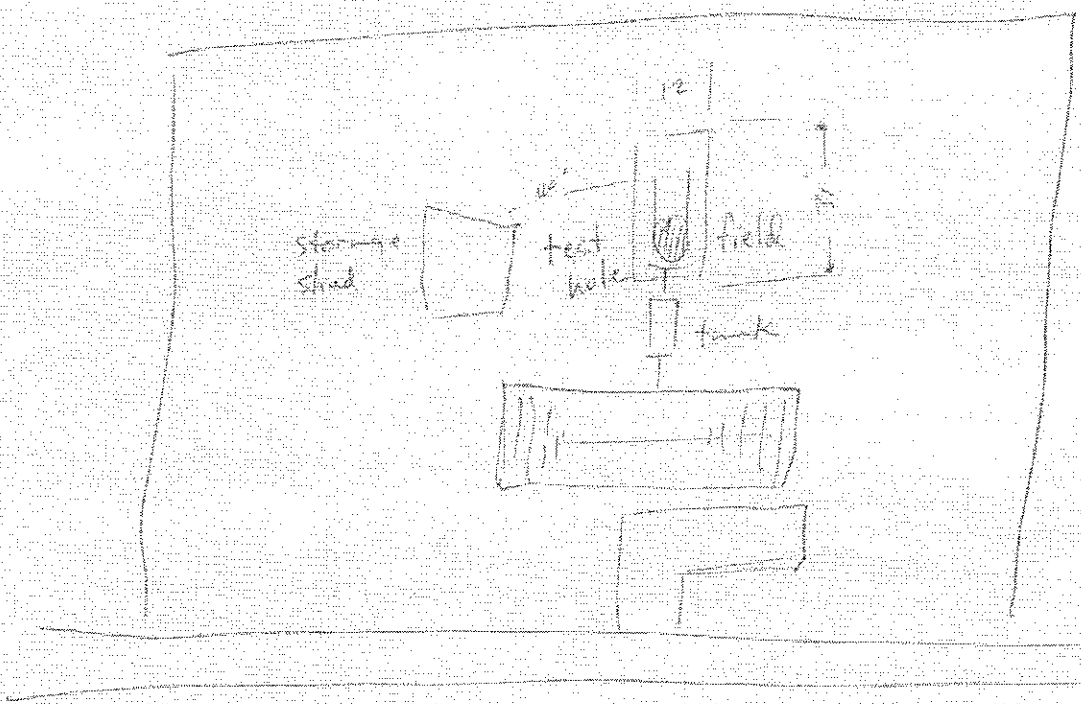
Lot size
Dimensions du terrain _____ hectares or *hectares ou* _____ acres

Line drawing is to include location of septic tank, siphon, stand pipes, absorption area and perforated pipes. Refer to "Standards for onsite domestic sewage treatment in the Yukon" for details on design specifications.

Le croquis doit inclure l'emplacement de la fosse septique, du siphon, des tuyaux de refoulement, de la zone d'absorption et l'emplacement des rampes perforées. Pour obtenir des détails sur les spécifications de conception, consultez «Standards for onsite domestic sewage treatment in the Yukon».

Show lot boundaries, wells and watercourses (include distances); location of hole(s) used to determine soil profile and percolation rate; and other features which might be affected by the proposed installation.

Indiquer les limites du terrain, les puits et les cours d'eau (inclure les distances), l'emplacement des forages d'essai ayant servi à déterminer le profil pédologique et le taux de percolation; inclure également tout autre élément qui pourrait être touché par l'installation proposée.



Septic tank meeting CSA standard
Fosse septique répondant aux normes de la CSA

Total rated liquid capacity
Capacité totale en liquide _____ litres *litres* 1000 gallons *gallons*

Working capacity (exclusive of siphon)
Capacité de travail (sans compter le siphon) _____ litres *litres* 750 gallons *gallons*

Siphon *Siphon* ☑ yes *oui* ☐ no *non*

Type of ground absorption system (check one)
Type de système d'absorption par la terre
☑ bed *lit* ☐ trench *tranchée* ☐ other *autre (préciser)* _____

Is sand filter proposed?
Prévoit-on recourir au filtrage à gravier?
☐ non *non* ☑ yes (reason) *oui (justifier)* test pending

Absorption area dimensions
Dimensions de la zone d'absorption
length *longueur* 44' X 12' width *largeur* = 528' total area *superficie totale*

Proposed depth of percolation pipe below grade
Profondeur proposée d'enfouissement des tuyaux de percolation sous le niveau du sol 4'

Depth of drainrock below percolation pipes
Épaisseur de caillou de drain sous les tuyaux de percolation 6"

Health Canada / Santé Canada

Environmental Health Services
100 - 300 Main Street
Whitehorse, Yukon
Y1A 2B5

ph. 667-3939
fax. 668-5726

Your file / Votre référence

Our file / Notre référence

November 15, 1996

Liard First Nation
Box 328
Watson Lake, Yukon
Y0A 1C0

New
#3 Little Jimmy Street
Ceclia Jimmy

To whom it may concern:

Re: **PRIVATE SEWAGE SYSTEM**
Permit # 1292
Lot 45, 2.5 Mile Subdivision
1000 gal. (total capacity) Septic Tank, Siphon, and Absorption Bed (12' x 47') with 2 feet of Filter Sand

Your notification of installation form and photographs of the private sewage disposal system for your premises located on above-noted site, have been received by our office.

Your system appears to have been installed according to your application and permit (this observation is not a warranty as to performance). Please be advised that the permitting and notification requirements of the Regulations Governing Private Sewage Disposal Systems pursuant to the Public Health Act have been satisfied.

If you have any questions, please contact this office at 667-3939.

Yours truly,

Todd Pinkess, C.P.H.I.(C)
Environmental Health Officer

p.c. Building Inspection, YTG
Bill Johnston, DIAND

Canada

Legal description
Description légale Lot 4 2.5 mile Shakwak

Plan • *Plan*

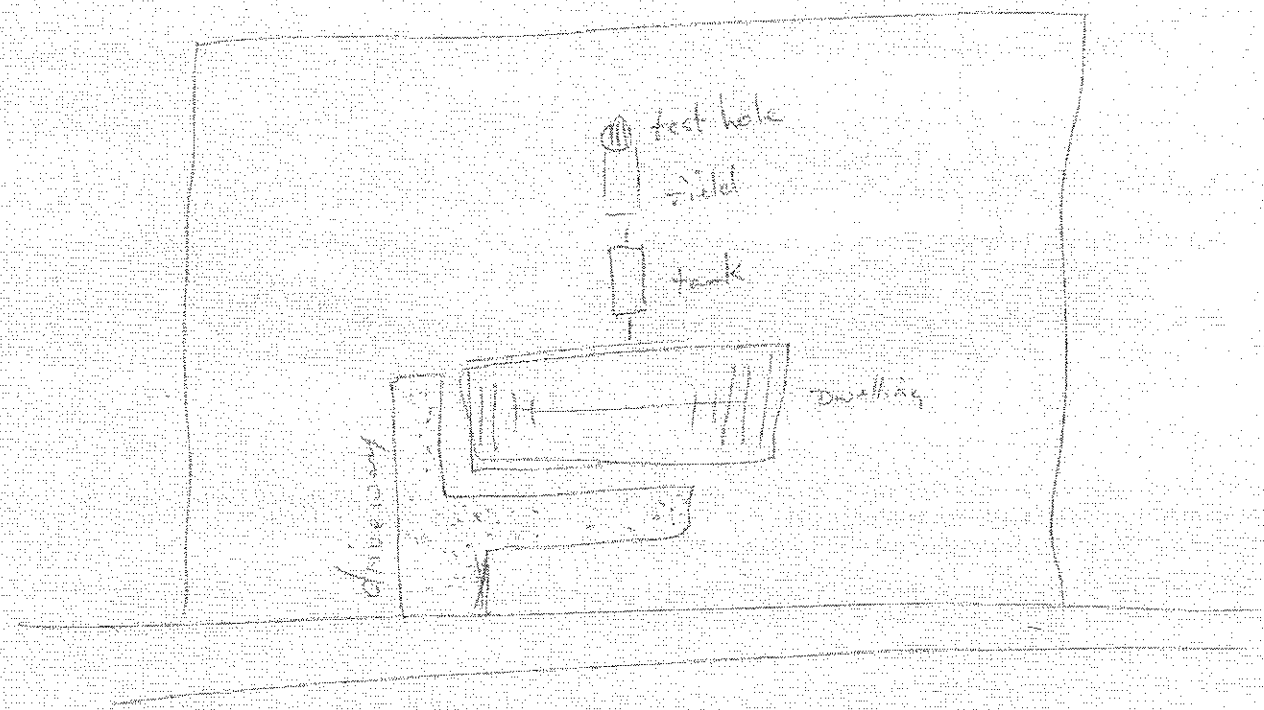
Lot size
Dimensions du terrain _____ hectares or *hectares ou* _____ acres

Line drawing is to include location of septic tank, siphon, stand pipes, absorption area and perforated pipes. Refer to "Standards for onsite domestic sewage treatment in the Yukon" for details on design specifications.

Le croquis doit inclure l'emplacement de la fosse septique, du siphon, des tuyaux de refoulement, de la zone d'absorption et l'emplacement des rampes perforées. Pour obtenir des détails sur les spécifications de conception, consultez «Standards for onsite domestic sewage treatment in the Yukon».

Show lot boundaries, wells and watercourses (include distances); location of hole(s) used to determine soil profile and percolation rate; and other features which might be affected by the proposed installation.

Indiquer les limites du terrain, les puits et les cours d'eau (inclure les distances), l'emplacement des forages d'essai ayant servi à déterminer le profil pédologique et le taux de percolation; inclure également tout autre élément qui pourrait être touché par l'installation proposée.



Septic tank meeting CSA standard
Fosse septique répondant aux normes de la CSA

Total rated liquid capacity
Capacité totale en liquide _____ litres *litres* 1000 gallons *gallons* 220

Working capacity (exclusive of siphon)
Capacité de travail (sans compter le siphon) _____ litres *litres* 750 gallons *gallons* 165

Siphon ☑ yes *oui* ☐ no *non*

Type of ground absorption system (check one)
Type de système d'absorption par la terre ☑ bed *lit* ☐ trench *tranchée* ☐ other *autre (préciser)* _____

Is sand filter proposed?
Prévoit-on recourir au filtrage à gravier? ☐ non *non* ☑ yes (reason) *oui (justifier)* _____

Absorption area dimensions
Dimensions de la zone d'absorption length *longueur* 47 X 12 width *largeur* = 564 total area *superficie totale* 564

Proposed depth of percolation pipe below grade
Profondeur proposée d'enfouissement des tuyaux de percolation sous le niveau du sol 4'

Depth of drainrock below percolation pipes
Épaisseur de caillou de drain sous les tuyaux de percolation 12"

APPENDIX

APPENDIX D RISK-BASED WELLHEAD PROTECTION PLANNING

Risk-Based Wellhead Protection Planning

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1.0 Introduction

1.1 Statement of Problem

Wellhead Protection Plans (WHPPs) are established to identify, manage, monitor and communicate issues of quality and quantity in water supplying wells used by humans, domestic animals, crops or for process uses. Water well owners need a pragmatic approach for managing wellhead risks that can be affordably developed and maintained. Standard WHPP approaches rely on groundwater travel times within a capture zone as a basis for management, planning and contingency action. However, a travel time based approach does not provide an intuitive framework for ranking risk priorities or determining correct levels of risk response or communication. Typical travel time increments (e.g., 1, 2, 5 years) are inferred to correspond with meaningful thresholds for response action or monitoring. However, actual response times to well threats form a *continuum* - from emergency response (in minutes) to long-term education, training programs and public education (months to years).

1.2 Alternative risk-based approach

Alternatively, WHPPs can be established within a *risk framework* using *risk assessment* (hazard and risk identification), *risk management* (mitigation, risk transfer, preventive action, monitoring and contingency planning) and *risk communication* (education and training). Specific well threats or *risk scenarios* can be identified, prioritized and reordered as they are addressed or as new risks appear. Importantly, a risk-based approach can be readily adapted to existing management frameworks, so there is no need for wholesale redevelopment of a useful existing system. The risk-based method here offers a rational, defensible framework for deciding appropriate action in response to a real or perceived threats to a well, the level and type of that response, and appropriate risk communication throughout the process. The approach includes simplifying conservative assumptions and is aimed at providing an internal management tool that, once set up by the owner's risk management team, is easily maintained, with minimized on-going requirements from outside technical experts.

1.3 Previous work on risk-based WHPPs

Previous studies have involved risk concepts for wellhead protection. The U.S. Environmental Protection Agency published several documents on the wellhead protection process incorporating qualitative and relative risks (e.g., US EPA, 1991; US EPA, 1993). The British Columbia provincial government adapted the US EPA approach in a six step approach (Wei et al., 2000). Quantitative, stochastic risk assessment has been applied to WHPP (Chin and Chittaluru, 1994), although this requires detailed site-specific information often unavailable or

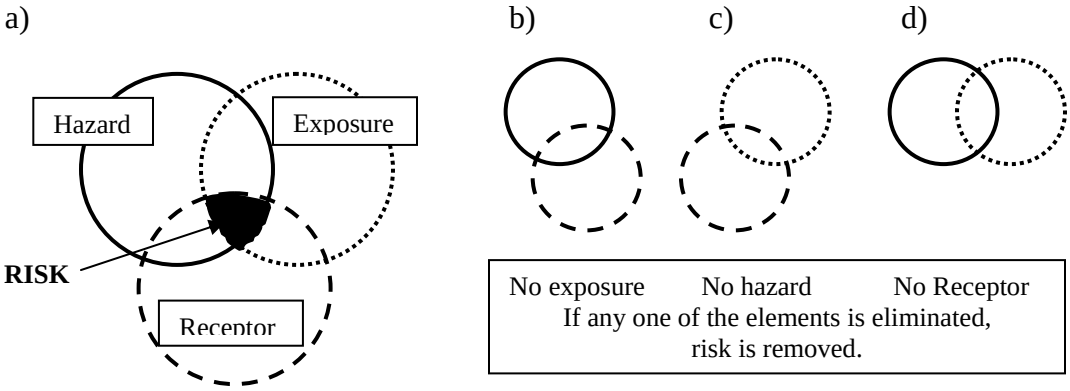
unaffordable for most well managers. EPRI (2000) presents a specialized tool (Health Standard Exceedance Index) for determining the severity of hazards in groundwater approaching wells. This type of tool may be useful as a refinement to the hazard evaluation in the examples presented here. In addition, the analysis and uncertainties of capture zones and travel times have been addressed by several authors (Bair et al., 1991; Evers and Lerner, 1998; Feyen et al., 2001; Guadagnini and Franzetti, 1999).

2.0 Risk Fundamentals

2.1 Essential Risk Elements

Risk can be defined as a measure of the likelihood for an adverse effect on a receptor due to exposure to a hazard. Here, receptors are taken to be any combination of human, animal, plant or process equipment users of well water. The three key elements of risk (receptor, hazard and exposure) must all combine to generate a risk (Figure 1a). In theory, risk can never be absolutely eliminated (i.e., "zero risk") since there always remains a possibility of combining the risk elements. However, in practical terms, risks can be effectively removed or reduced to acceptable levels if any of the three elements are eliminated or blocked (Figure 1b, 1c or 1d).

Figure 1 – Fundamental concepts of risk and risk management



Exposure can be expressed in terms of the frequency or likelihood of receptors coming in contact with a hazard, which in this case is water from a well. Hazards can be expressed in terms of severity (or contaminant toxicity). To be pragmatic and conservative, we evaluate risks for the highest concentration of a given hazard that would confront receptors at the wellhead. Therefore a surrogate measure of exposure likelihood is the speed of water migration along the pathway from a hazard source to the well. If the speed is rapid, there is limited time for intervention and a higher likelihood of exposure. Both exposure and hazard can be described in qualitative terms such as Low, Medium, High or Very High, with specific and meaningful definitions developed to suit the risk management group.

2.2 Relationships of Hazard, Exposure and Risk

A hazard is a *potential* threat to a receptor and only evolves into a risk if a receptor is exposed to it. A banana peel on its own is a hazard (Figure 2a) but poses a risk when a person (receptor) slips on it (exposure) and falls (Figure 2b). Likewise, a gasoline spill does not pose a wellhead risk when it occurs outside its capture zone (Figure 3a), but does within the zone (Figure 3b).

Figure 2 – Relationship of Hazard and Risk

a) Hazard b) Risk

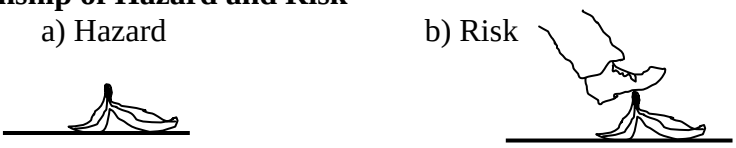
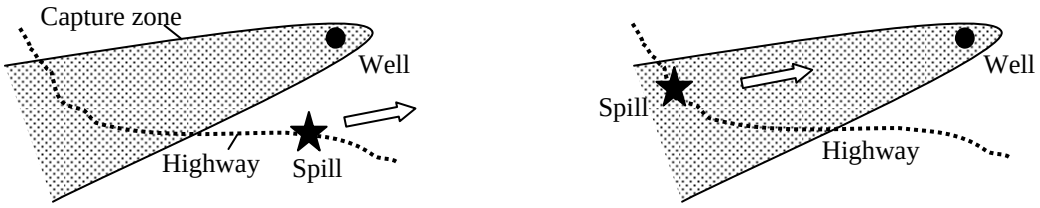


Figure 3 – Importance of Exposure in establishing Risk

a) Spill outside capture zone: no wellhead risk b) Spill in capture zone: wellhead risk



Aquifer vulnerability can be considered as the ease by which a contaminant could enter an aquifer. Typically an unconfined aquifer with shallow water table is considered more highly vulnerable than a deep confined aquifer. Similarly, groundwater *travel time zones* are a measure of speed of transport along a pathway between a point in the capture zone and a receptor (well user). However, in a risk sense, aquifer vulnerability and groundwater travel times are simply measures of the likelihood of exposure of a receptor to potential contaminants in well water. Importantly, neither a vulnerable aquifer nor a short groundwater travel time inherently signify higher *risk*, as the risk will appear only with a combination of exposure and hazard.

2.3 Risk Framework, Risk Assessment and Risk Management

A *Risk framework* as defined here is the approach and context a risk management team takes in addressing well risks. This includes defining their risk tolerance (risk-averse or risk-tolerant) and to what extent the responsible party wants to accept, reduce or transfer risk. Risk identification can be qualitative, as presented here, or quantitative, based on probabilistic mathematical analysis. Due to the limited site information and resources, most risk-based WHPPs are likely to be qualititative. *Risk assessment* is the process of evaluating the consequences of hazard severity and likelihood of exposure, then evaluating, ranking and mapping the identified risk scenarios. *Risk management* is the process of mitigation, risk transfer, preventive action (e.g., through land-use planning), monitoring and contingency actions in response to identified risks. *Risk communication* relates to the interpretation and flow of information between the risk management team and other parties (such as well users, media or the public) and is integral to the WHPP process.

3.0 Risk-Based Wellhead Protection Methodology

3.1 Overview of Methodology

The methodology presented here consists of three stages (Table 1). The internal steps shown could be grouped or further subdivided to suit the risk management team.

Table 1 – Summary of Risk-based Wellhead Protection Methodology

Risk Stage	Step	Content	
I Risk Framework	1	-	Decide risk approach (qualitative or quantitative)
		-	Identify Responsible Party
		-	Form Risk Management Team
		-	Rate risk perception (tolerance)
		-	Determine position to accept/reduce/transfer risk
II Risk Assessment	2	-	Define capture zone (professional judgement, analytical or numerical methods)
	3	-	Identify receptors
		-	Identify risk scenarios (hazards & exposure)
		-	Define exposure likelihood and hazard consequence categories
		-	Evaluate and rank risks in Risk Database
		-	Plot risks on Risk Matrix and Risk Map
III Risk Management	4	-	Establish roles and resources
		-	Establish responsibilities and liabilities
		-	Establish risk communication strategy
		-	Establish risk reduction strategy
	5	-	Develop risk reduction plan for each risk level
		-	Implement risk reduction plan for desired risk levels
		-	Undertake risk monitoring
		-	Undertake preventive actions
	6	-	Audit (check progress of risk reduction)
		-	Update/revise risk database
		-	Report (risk management team to Responsible Party using Risk Map)
		-	On-going risk communication and education

3.2 Illustrative Examples

To explain the proposed risk-based wellhead protection methodology, we present two hypothetical cases. Case 1 considers a privately-owned irrigation well. Case 2 considers a municipal well supplying drinking water for humans and livestock. These cases are used to present a range of receptors, contaminant types (point and non-point sources), and differing risk management teams, risk tolerance and risk management steps.

Five realistic hazard scenarios are imposed identically in both cases. These are 1) fertilizer applied in orchard 3 km upgradient of well, 2) road salt depot at 0.8 year travel time upgradient of well, 3) gasoline tanker spill 50 m from well, 4) gasoline tanker spill 500 m from well, and 5) sanitary sewer main break 200 m upgradient of well. These were chosen to represent a range of inorganic, synthetic organic and biological contaminant groups. As shown below, the risk posed by a given hazard depends on the receptors exposed to it. Recognizing that contaminant concentrations vary with time as a contaminant plume arrives at a well, for simplicity we considered only that consequences of maximum hazard severity for water arriving at a wellhead. As mentioned above, more sophisticated tools for evaluating well water health hazards are

available and could be applied. Analogously, the greatest likelihood for exposure (minimum travel time between source and well) is considered. All of the key elements of a risk-based WHPP are developed for both cases below, showing the utility and adaptability of risk approach.

3.2.1 Risk Framework (Stage I)

Table 2 shows the elements of a Risk Framework and plausible information for Cases 1 and 2. The risk framework ranges from simple (Case 1) to complex (Case 2). As a minimum, the risk management team should include the *responsible party* (or representative), a provincial health or environment representative and a technical expert (e.g., in-house or outsourced hydrogeologist). The method shown here can accommodate changes in risk tolerance over time. If the City Council became more risk-tolerant in Case 2, the methodology would allow risks to be readily re-evaluated and re-ranked to fit the revised risk tolerance, without recreating the entire WHPP.

Table 2 – Stage I - Risk Framework for Example Cases

Content	Case 1 – Private Irrigation Well	Case 2 – Municipal Multi-use Well
Risk approach	Qualitative	Qualitative
Responsible Party	Well Owner	City engineer
Risk Management Team	Well owner, provincial health official, consultant (3 total with funding from minor grant money through municipal green funding)	City engineer, City manager, Farmer's Co-op Chair, provincial health official, Citizens for Clean Groundwater (lobby group), Waste manager for Regional District, neighbor landowner, University professor, consultant (9 total, with town staff time, vehicles, media/PR staff available to assist; funding from municipal budget and federal funding)
Risk tolerance	Risk-tolerant	Risk-averse (current City Council)
Position to accept/ reduce/ transfer risk	Seek to accept or reduce at lowest cost	Seek to reduce with large emergency fund or transfer (insurance, contracts) to the maximum

3.2.2 Risk Assessment (Stage II)

Table 3 shows the key elements of a Risk Assessment and plausible results for Cases 1 and 2. The well capture zone is defined by judgement, analytical calculation or numerical modeling, depending on the risk tolerance of the risk management team, and requires technical expertise from a hydrogeologist. A risk-tolerant group might abide professional judgement, while a risk-averse group may require the rigor of a numerical model. We do not consider that fixed radius approaches (arbitrary or calculated) allow meaningful determination of exposure or risk level because they can include areas to manage which are outside of the actual capture zone contributing to a well.

Table 3 – Stage II - Risk Assessment for Example Cases

Content	Case 1 – Private Irrigation Well	Case 2 – Municipal Multi-use Well
Define capture zone	Calculated or defined by judgement (consultant)	Numerical modelling (consultant with input from City engineer & staff)
Base map for Risk Map	Figure 5a	Figure 5b
Identify receptors	Crops only (vineyard)	Humans; livestock

Identify risk scenarios	The same hazard scenarios are used for both cases (all within capture zone): 1. Fertilizer in orchard 3 km upgradient of well 2. Road salt depot at 0.8 year travel time upgradient of well 3. Gasoline tanker spill 50 m from well 4. Gasoline tanker spill 500 m from well 5. Sanitary sewer main break 200 m from well	
Exposure likelihood/ Hazard consequence categories	Table 4a	Table 4b
Evaluate & rank risks	Table 5a (Risk Database, Case 1)	Table 5b (Risk Database, Case 2)
Plot Risk Matrix & Risk Map	Figure 4a (Risk Matrix, Case 1) Figure 5a (Risk Map, Case 1)	Figure 4b (Risk Matrix, Case 2) Figure 5b (Risk Map, Case 2)

Receptors can be a single group (crop in Case 1) or combination (humans and livestock in Case 2). Risks are evaluated and can be shown for all receptors. The *Risk Database* is an organized archive to track the classifications, rankings and notes relating to hazard scenarios, exposure likelihood, hazard consequences and evaluated risks for each scenario by the risk management team. Each scenario can be updated, re-ranked and re-plotted as changes occur or new scenarios are recognized by the risk management team. An adaptable Risk Database is one of the key attributes of this risk-based methodology.

Table 4a and 4b show the exposure likelihood and hazard consequence categories defined by the hypothetical risk management teams for Case 1 and 2, respectively. The number of categories is at the discretion of the risk management team but, practically, three is a minimum and five is a maximum. Exposure likelihoods for the different categories are artifacts of the differing risk tolerance for Cases 1 and 2. For example, Case 1 shows a one year travel time as only a medium exposure likelihood, while for Case 2, the risk-averse team chooses 1 year as their cutoff for very high exposure likelihood. Different or more sophisticated health/toxicity criteria could be used for hazard consequences. Secondary effects of contaminated water, such as degradation of stream water quality from discharged well water, are beyond the scope considered here.

Table 4a – Categories of Exposure and Hazard for Case 1 – Private Irrigation Well

	Criteria
Exposure likelihood	
Low	Groundwater travel time over one year
Medium	Groundwater travel time 6 months to one year
High	Groundwater travel time less than 6 months
Hazard consequence	
Low	Crop yields marginally diminished, plants stressed but recoverable
Medium	Crop yields strongly diminished, plants stressed, some die
High	Crop failure likely, many plants die

Table 4b – Categories of Exposure and Hazard for Case 2 - Municipal Multi-use Well

	Criteria
Exposure likelihood	
Low	Groundwater travel time over 4 years
Medium	Groundwater travel time 2 to 4 years
High	Groundwater travel time greater than 1 but less than 2 years
Very High	Groundwater travel time 1 year or less

Hazard consequence	
Low	Human: Exceeds aesthetic objectives in Drinking Water guidelines (staining, taste) Livestock: Some aversion to water, animals distressed
Medium	Human: Short-term health condition, discomfort, illness (Lost time: days) Livestock: Illness or disease (full recovery probable); minor loss in commercial value
High	Human: Chronic health hazard, long-term disease or illness (Lost time: weeks-months) Livestock: Illness or disease (recovery in long term); major loss in commercial value
Very High	Human: Acute health hazard, disease or illness (permanent disability or fatalities) Livestock: Fatalities (major loss of herd)

A Risk Database could consist of a simple spreadsheet (Case 1) or be embedded (with the Risk Map) in an elaborate Graphical Information System (Case 2). An electronic (or web-based) format is favoured since it facilitates adding, removing and resorting risk scenarios. Tables 5a and 5b show risk evaluations for Case 1 and 2, respectively. Each table can be considered as an extract from a risk database.

Table 5a – Risk Evaluation for Case 1 – Private Irrigation Well

Scenario	Exposure likelihood	Hazard consequence	**Risk rank****
1 Fertilizer in orchard 3 km	Low	Low	**Low**
2 Salt depot 0.8 yr travel time	Medium	Medium	**Medium**
3 Gas tanker 50 m	High	High*	**High**
4 Gas tanker 500 m	Low	High*	**Medium**
5 Sanitary sewer break 200 m	Low	Low	**Low**

Note: *assumes no degradation in transit to well (conservative). Alternatively, retardation along a flow path could be calculated or modeled with sufficient resources, site information and necessity. ** Refer to Figure 4a

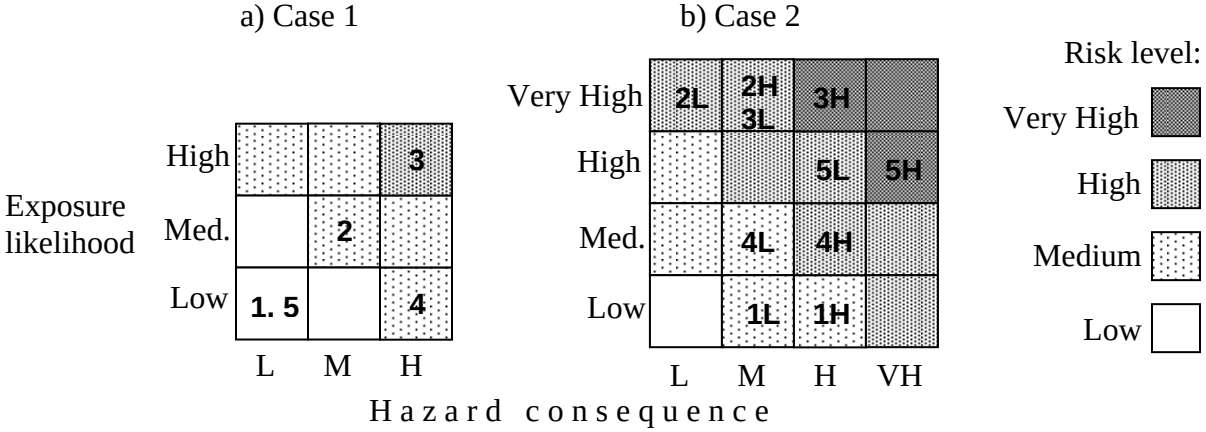
Table 5b – Risk Evaluation for Case 2 - Municipal Multi-use Well
(H = Human, L = Livestock)

Scenario	Exposure likelihood	Hazard (H) consequence	**Risk (H) Rank****	Hazard (L) consequence	**Risk (L) Rank****
1 Fertilizer in orchard 3 km	Low	High	**Medium**	Medium	**Medium**
2 Salt depot 0.8 yr travel time	Very High	Medium	**High**	Low	**High**
3 Gas tanker 50 m	Very High	High*	**Very High**	Medium	**High**
4 Gas tanker 500 m	Medium	High*	**High**	Medium	**Medium**
5 Sanitary sewer break 200 m	High	Very High	**Very High**	High	**High**

Note: *assumes no degradation in transit to well (conservative). Alternatively, retardation along a flow path could be calculated or modeled with sufficient resources, site information and necessity. ** Refer to Figure 4b.

Figure 4a shows a 3x3 Risk Matrix for Case 1 and Figure 4b shows a 4x4 Risk Matrix for Case 2. The five example risk scenarios are plotted on Figure 4a and 4b (according to their risk rank in Tables 5a and 5b, respectively). Note that Figure 4a conveys a risk-tolerant approach (emphasis on Low and Medium risk fields) which might reflect the entrepreneurial outlook of private farmer, while Figure 4b conveys a risk-averse approach (emphasis on Very High and High risk fields) which might reflect a conservative public health approach of a municipal water supply manager.

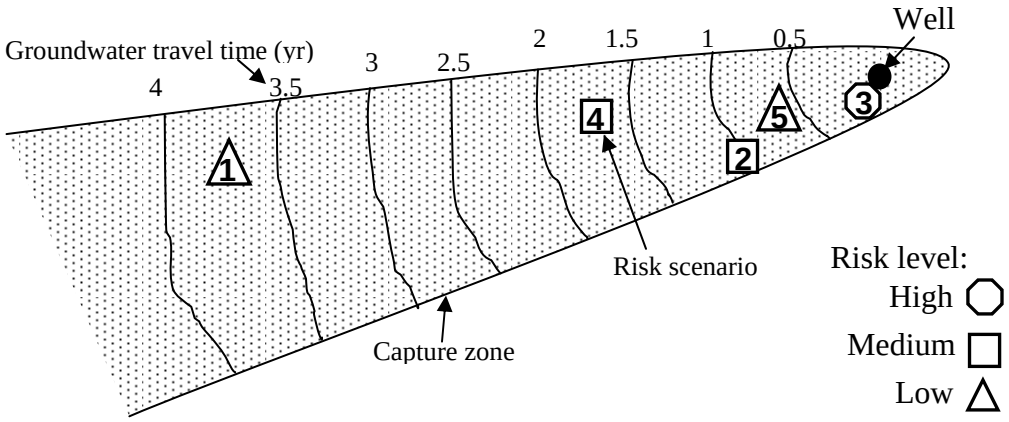
Figure 4 – Risk Matrices with Risk Scenarios for Cases 1 and 2



In Case 1 (Figure 4a), the five scenarios plotted (for crop receptors only) comprise one high, two medium and two low risks. In contrast for Case 2 (Figure 4b), the same scenarios (five for human and five for livestock receptors) constitute two very high, five high, three medium and no low risks. The risk results are different due to the differing receptor groups, risk-tolerance, and exposure likelihood and hazard consequence definitions for the two cases.

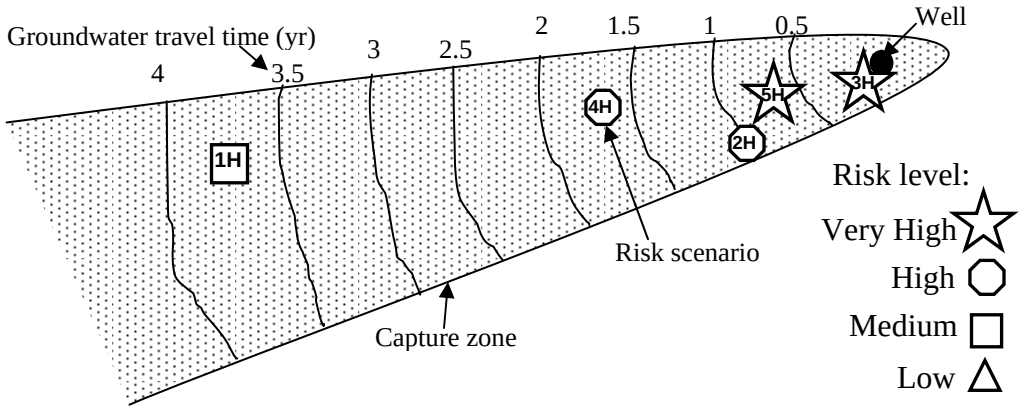
The risk results are on a *Risk Map* (Figures 5a and 5b) for Cases 1 and 2, respectively.

Figure 5a – Risk Map showing geographic distribution of risk scenarios for Case 1



The numbered risk scenarios (1-5) can be easily distinguished by symbol shape and number, making explanation to non-technical viewers and management tracking straightforward. Note that *risk is not necessarily directly indicated by travel time*, as shown for example by scenario 5 which is closer to the well than scenario 2 but with lower risk level. Scenarios with the same risk level (e.g., 2 and 4, at medium risk) can lie at different distances from the well.

Figure 5b – Risk Map showing geographic distribution of human risk scenarios for Case 2



For simplicity, only human risk scenarios (1H-5H) are plotted on Figure 5b. On Figure 5b, the very high risks (3H and 5H) are closest to the well, with lesser risks farther away. The differing risk assessment results are readily apparent by comparing Figure 5a and 5b, for the same five hazard scenarios. Any number of risk scenarios could be plotted on a Risk Map, with the symbols changing as risks are managed to lower levels, new ones added, or deleted as risks are managed below a threshold of concern set by the risk management team.

3.3 Risk Management (Stage III)

Risk Management begins with clarification of responsibilities, liabilities and resources in implementing risk management actions. Commitments to monitoring, auditing, risk reappraisal and stakeholder education are also considered. A risk reduction strategy entails devising a preplanned level of effort for various levels of risk. The approach might be to address only High or Very High risks due to resource constraints. The level of effort might range from immediate emergency response with mutual aid (fire dept, police, government authorities) for Very High risk, ranging down to simple long-term monitoring for Low risk.

Risk communication is essential throughout the entire WHPP process. A risk communication strategy entails the collection, selection and release of information tailored to the level of risk. The strategy identifies who speaks for the team (normally the chair) and the frequency of communication proportional to risk level (e.g., daily for Very High risk, or annually for Low risk). Involvement by a public relations firm may be elected for highly sensitive risk scenarios.

Preventive actions are taken to avoid repetitive problems. For example, this may entail changes in the storage, handling or distribution of chemicals, land use controls, legal/contractual agreements with land owners and public education.

The Risk Database should be reviewed and reappraised periodically by internal or external audit. From a management perspective, this could include regular review of the status of risk reduction and preventive actions for the top ten risks. The Risk Map forms a concise and convenient basis for the risk management team, Council or Board to view the status of risk management. Auditing frequency can also vary with risk level (e.g., weekly for Very High risk; annually for Low risk). Reporting is important to document progress, improve public perception, reduce

potential legal issues and possibly reduce insurance costs. Reports may take the form of a section in an annual report, an entry on a web site or a community newsletter.

Table 6 presents plausible risk management actions for Cases 1 and 2.

Table 6 – Summary of Risk Management (Stage 3) Elements for Cases 1 and 2

Risk Management Element	Case 1 – Irrigation Well	Case 2 – Municipal Multi-Use Well
Roles, Responsibilities & Resources	Team: well owner (responsible party), Ministry of Health rep & consultant; owner is legally responsible and speaks for Team; owner is volunteer with minor grant through municipal green funding	Team: Town manager, town engineer, delegates from farmer's co-op, Ministry of Health representative and local groundwater lobby group, Waste Manager for Regional District, landowner (neighbor to well), University professor, consultant; town staff time and vehicles, media staff, University laboratories funded by major municipal infrastructure grant
Risk Reduction Strategy	Respond only to medium or high risks; High risk: immediate notify/seek help from municipality, regional district, emergency services (Fire Dept); invoke emergency water supply (own or Farmer's Coop); seek funding assistance from Provincial or Federal gov. for remediation & monitoring; no outside PR; Medium risk: Seek advice from municipal or regional district engineer; hire consultant for mitigation/monitoring; Low Risk: no remedial action; minimal monitoring	Respond to all risk levels; Very High Risk: immediately invoke Emergency Response Plan with coordinated mutual aid from other municipalities, province and federal agencies; use emergency fund to pay for contingencies; hire consultant for rapid engineered response and initiate appropriate monitoring; initiate risk communication plan; High Risk: rapid engineered response with consultant hired within days to follow emergency services in cleanup and monitoring; municipal engineer dedicated as point of contact for consultant; initiate risk communication plan; Medium Risk: standard engineered response with consultant (through proposals) hired within weeks for characterization & monitoring along with in-house resources; issue one press release; Low Risk: monitor with in-house resources, no media release
Risk Communication Strategy	Owner is sole spokesman; no press releases	Town engineer is sole spokesperson; internal briefings: Very High Risk: daily; High risk: weekly; Medium-Low Risk: monthly. Press releases: Very High Risk: daily; High risk: weekly-monthly; Medium Risk: one time; Low Risk: none.
Preventive Action	Informal, in-house changes in procedures; education & training for staff at next low-cost opportunity	Land use (zoning) changes; environmental bond required for certain commercial/industrial uses; contractual liability for polluters; certification requirements enforced (lawsuits as required); public education; warning signage; changes in type and level of municipal insurance
Auditing	Informal,internal; owner monitors and briefs staff	Monthly review of top ten risks using Risk Map; Annual external audit by consultant; root cause analysis; lessons learned review
Reporting	Informal, internal; minutes at monthly staff meeting	Formal internal and external reports; monthly review by risk team of "top ten" risk scenarios, with Chair enabled to trigger an Emergency Response Plan; section in Annual Report; newspaper article by risk team chair

4.0 Costs

Costs for a WHPP vary widely depending on the user (receptor) group, location of the well in relation to the complexity of the surrounding hydrogeology and potential sources of well stressors, significance attached to well protection (i.e., risk tolerance) by the well owner, duration of preventive action, auditing and followup monitoring undertaken, and other factors. A simple WHPP may cost on the order of $10,000 to $30,000, while complex WHPPs may be several times this amount. However, in light of higher public scrutiny of the integrity of water supplies, changing regulatory environment and the potential legal implications faced by water supply managers, the cost of *not* implementing a WHPP would undoubtedly be much higher. Williams and Fenske (2004) show that the avoided cost to benefit ratio for WHPPs is on average 8:1.

5.0 Conclusions

WHPPs involve a complex interplay of technical hydrogeology, well management, municipal land-use planning and user education, requiring both stakeholder and professional input. In our opinion, realistic capture zones must be used, either developed from professional judgement, analytical calculations or numerical modeling. Fixed radius approaches are essentially cost-saving shortcuts which can mislead users and do not add value to a risk-based approach.

We suggest that WHPPs are best developed using a risk-based approach, which allows managers to focus on salient risks, are flexible and easily updated, and are adaptable to all levels of risk tolerance and management sophistication. Technical expertise is required, especially in the risk assessment stage.

WHPPs should be considered as a dynamic and on-going process to understand and protect groundwater resources, prioritize and manage responsibilities and liabilities, and guide decision-making strategies. WHPPs offer sound planning and economical benefits, with the cost of preparing and maintaining a plan being far less than the costs of remediating or replacing a contaminated groundwater supply.

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