LSCFN - Engineering

LITTLE SALMON CARMACKS FIRST NATION
COMMUNITY WELL PROTECTION PLAN

Prepared For

LITTLE SALMON CARMACKS FIRST NATION
Post Office Box 135
Carmacks, YT
Y0B 1C0

By

VISTA TEK LTD.
803 WOOD STREET
WHITEHORSE, YT, Y1A 2G6

MARCH 24, 2008
2007-900

VISTA TEK LTD

Our File: 2007-900

March 24, 2008

Little Salmon Carmacks First Nation
Post Office Box 135,
Carmacks, YT
Y0B 1C0

Attention: *Mr. Jordan Mullet*
Manager, Water and Sanitation

Re: LSCFN Well Head Protection Plan

Please find enclosed six copies of the above noted report as well as three copies of the wall protection plan wall chart.

We have enjoyed working with you on this project and would like to extend our appreciation to yourself and the entire community project team for the assistance provided in the completion of this work.

If you should have any questions or require additional information on the above, please contact the undersigned directly at 867 393-3458.

Yours truly,

Vista Tek Ltd.	J.C. Environmental	Golder Associates Ltd.
Victor Menkal, P.Eng. Water Resources Engineer	Jillian Chown Project Manager	Gary Hamilton, P.Geo. Review Engineer

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EXECUTIVE SUMMARY

Between November 2007 and March 2008, the Little Salmon Carmacks First Nation (LSCFN) developed a Well Head Protection Plan for their new community well, PW05-1. A Well Head Protection Plan involves the delineation a capture zone (the area of an aquifer from which groundwater will be derived in a predefined amount of time) for the community well and the use of protection measures to manage activities within the zone. LSCFN retained Vista Tek Ltd., along with sub-consultants JC Environmental Consulting and Golder and Associates Ltd. to prepare the plan.

Based on the well log for PW05-1, the well was drilled to a depth of 47.2 m below ground, and a screen was set from 40.1 to 43.1 m within a sand and gravel aquifer. A review of the well log for PW05-1 indicates the well is located in an unconfined aquifer.

The results of the capture zone analysis indicates a 120m wide capture path extending to the Yukon River. The majority of the capture zone is within the one year travel time boundary and the entire capture zone (including the Yukon River) should be considered as a high-risk area for management purposes.

Based on information collected during the development of the protection plan, the following Areas of Potential Environmental Concern (APEC's) were identified within the capture zone for PW05-1:

- Green House (GH)
    - There is a potential for nitrates/nitrites and pathogens to leach from manure stored at the site into aquifer
- UST (UST 1) at Old Laundromat
    - Although this underground storage tank is not currently in service, there is a potential for hydrocarbons from old spills or leaks to enter into aquifer

- Septic Field (SF)
  - There is a potential for heavy metals, solvents, household waste products, fecal coliforms, etc., to enter into aquifer
- Maintenance Shop (MS)
  - There is a potential for hydrocarbons and other maintenance chemicals (anti-freeze, glycols, etc.) to enter into aquifer
- UST (UST 2) at Heritage Hall
  - Although this underground fuel oil storage tank is located outside the estimated capture zone, there is still concern that a large spill may affect the aquifer

The Community Planning Team developed the following management strategies to help manage the risks associated with the APEC's:

1. Remove and replace existing UST at Heritage hall with approved AST and complete level II environmental assessment;
2. Remove existing UST at old community Laundromat and complete level II assessment;
3. Ensure that septic systems in the capture zone be inspected and upgraded or replaced as required;
4. Endorse and promote hazardous waste minimization and collection programs;
5. Implement contingency planning including emergency response actions and communication. LSCFN council should create an emergency and spill response plan identifying key personnel responsible to respond in the event of an occurrence or spill;
6. A groundwater monitoring program should be developed, where regular water quality monitoring is conducted on community well and individual wells;
7. Implement a septic tank monitoring program for tanks within Zone 1. This would consist of monitoring tank levels, taking extra care on pump outs to ensure that spills do not occur, and developing an awareness program for owners of tanks within zone 1;

8. Add security to new well by installing fencing and lockable gate;
9. Maintain the poster created for this study in a public part of the community, and update the poster as necessary;
10. Educate the LSCFN community members regarding the importance of maintaining a clean environment of the land surrounding their community and residential wells.

Additional management strategies are located in section 8.0 Conclusions.

1.0 INTRODUCTION

This report summarizes the results of the initial phases in the development of a Well Head Protection Plan (WHPP) for the new Salmon Carmacks First Nation (LSCFN) community well, identified as PW05-01, located in Carmacks, Yukon (Figure 1).

The well was drilled by Double D Drilling in June 2005 and hydrogeolical testing and logging completed by EBA Engineering Consultants Ltd. (EBA). The well was drilled to a depth of 47.2 m below ground, and a screen was set from 40.1 to 43.1 m below ground within an unconfined sand and gravel aquifer. According to EBA, the safe sustainable yield for PW05-1 is 9.7 litres per second (L/s) (128 Imperial gallons per minute (Igpm)). This is greater than the LSCFN's required well yield of 1.9 L/s (25 Igpm) (EBA, 2006) if the well is used to supply a piped water system for the entire LSCFN community.

It is understood that the LSCFN plans to use the well to supply its new bulk water delivery facility, scheduled to be built in the summer of 2008, and to supply its future small diameter piped water system for the main village area. With financial support from Indian and Northern Affairs First Nation Water Management Strategy, LSCFN requested that Vista Tek Ltd. complete a Well Head Protection Plan for PW05-1.

A Well Head Protection Plan involves the delineation of time of travel zones (the area of an aquifer from which groundwater will be derived in a predefined amount of time) for the community well and the use of protection measures to manage activities within those zones. The well head protection plan is considered essential for the protection of the water quality in the area of the new community well.

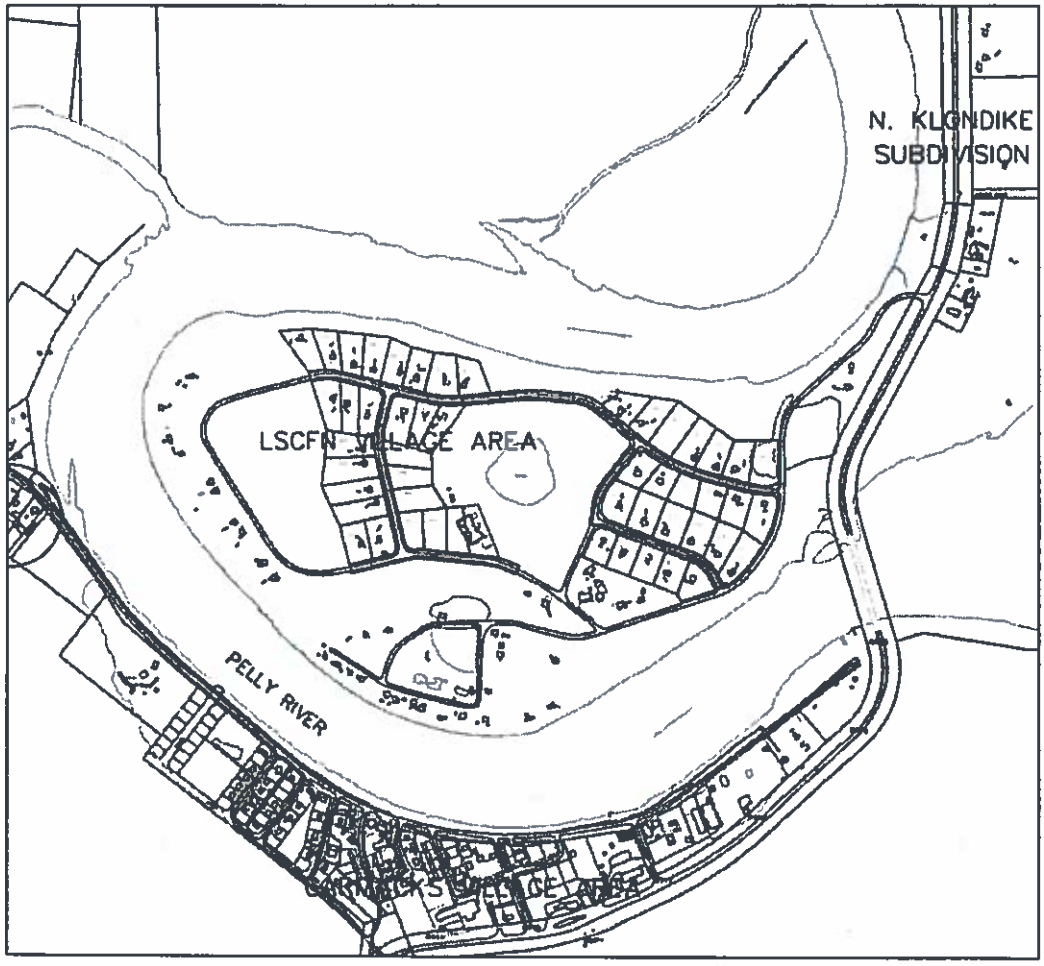


Figure 1 Site Map

2.0 SCOPE OF WORK

In order to prepare the Well Head Protection Plan, Vista Tek Ltd. followed guidelines found in the British Columbia Ministry of Environment (BC MoE) Well Protection Tool Kit (BC MoE, 2000) and the Government of Ontario Groundwater Studies 2001/02 Technical Terms of Reference (Ontario Ministry of the Environment, November 2001).

The BC MoE Well Protection Toolkit consists of a six-step process to assist communities that utilize groundwater to better manage and protect their drinking water sources. The six steps outlined in the Well Protection Toolkit are defined as follows:

1. Form a Community Planning Team
2. Define the Well Protection Area
3. Identify Potential Contaminants
4. Develop Management Strategies
5. Develop Contingency Plans
6. Monitor Results and On-Going Evaluation of the Plan

Vista Tek Ltd. was retained to complete Steps 1 through 4 of the Well Protection Toolkit, with the scope of work consisting of the following:

- Gather and review available information on PW05-1 and the underlying aquifer in which the well is completed, such that aquifer recharge and discharge areas can be determined.
- Estimate the extent of short-duration time-of-travel capture zones for PW05-1 at the proposed pumping rate for the well.
- Collect background information to conduct a contaminant inventory.
- Conduct a field reconnaissance to provide information regarding the contaminant inventory within the capture zones.

- Prepare a large scale wall map depicting the capture zone and potential contaminants
- Develop management strategies and assist the LSCFN with community education
- Prepare a report summarizing Steps 1 through 4 with preliminary recommendations for additional work

3.0 BACKGROUND

3.1 Physical Setting

Carmacks has served many functions over the years, including campsite, trading post, coal mining community, and steam-boat-refueling stop. Today it is a highway service centre and the home of the Little Salmon Carmacks First Nation. Carmacks is located at the confluence of the Yukon and Nordenskiold Rivers. It lies approximately 180 kilometers north of Whitehorse on the Klondike Highway, at its junction with the Robert Campbell Highway (Figure 1).

The LSCFN has approximately 295 of its citizens residing in the Carmacks area. Members reside in five different subdivisions:

- The LSCFN Village area (north of the Yukon River),
- The Ptarmigan Subdivision (west side of Klondike highway, south of Village of Carmacks),
- Nordenskiold Subdivision,
- Pocket Park (also referred to as "Johnsonville"), located in the Village of Carmacks and
- Residences and commercial lots bordering the Klondike highway to the north east of Carmacks.

With the exception of one home, all residences are supplied by private water wells with approximately 72 wells supplying water to 96 homes. The single home not currently being supplied by a water well is located within the Village area and is supplied by trucked water.

A number of the residential wells have reported Fecal Coliform contamination. As well, some residents have experienced sickness, inferred to be related to the quality of their well water. It is understood that the LSCFN plans to install a small diameter piped water system, using the new community well (PW05-1) as the water supply source, in order to remove residents from the high risk wells.

The new community well (drilled by Double D Drilling in 2005) is located in the main village area of the Little Salmon Carmacks First Nation (Figure 2). The current truck fill station is also located in the main village area, next to the Heritage Hall. It is understood that the LSCFN has applied for funding to build a new truck fill station at the location of the new community well.

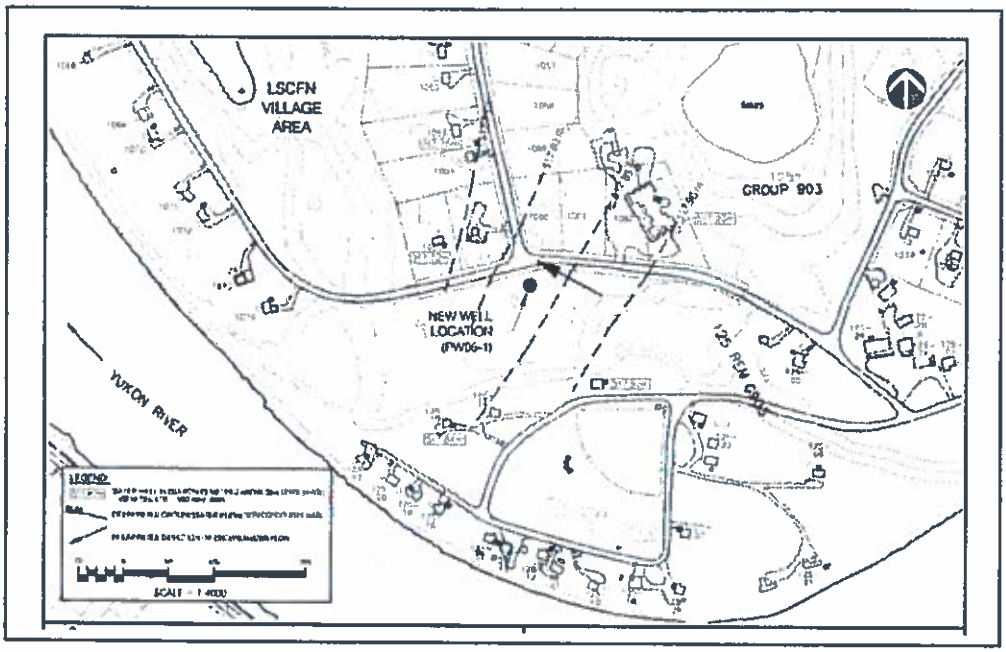


Figure 2 – Location of new community well

Source: EBA report " Preliminary Hydrogeological Assessment and Well Completion Report- Carmacks Yukon". 2006

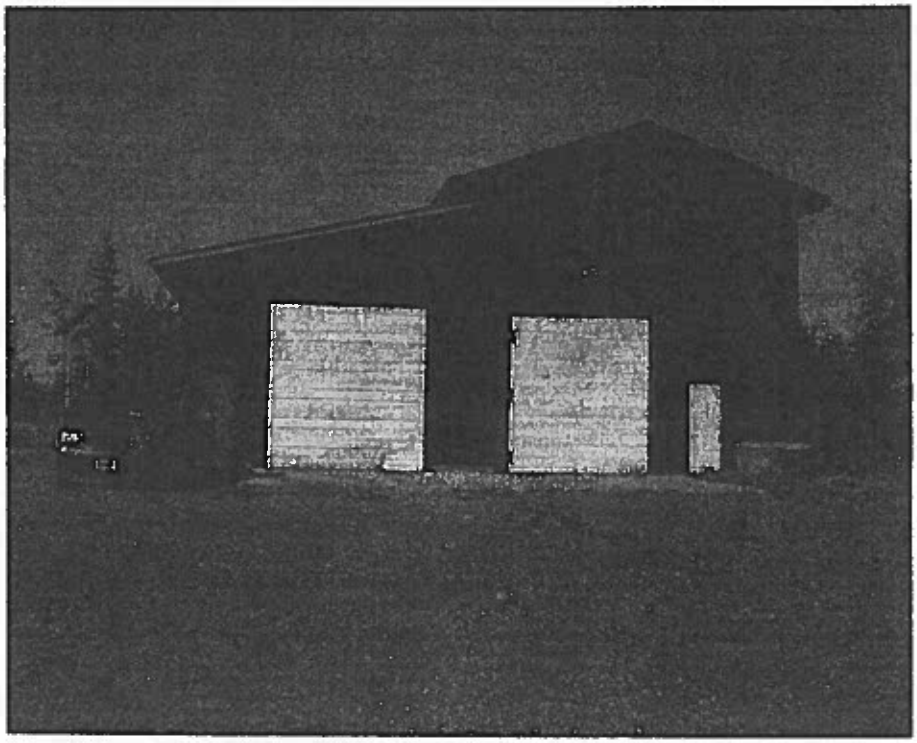


Figure 3 – LSCFN Truckfill Station

3.2 Geology and Hydrogeology

The LSCFN Main Village Area is situated upon a complex terraced formation of ice-contact and glaciofluvial deposits. In general, the surficial materials are sand and gravel with minor quantities of silt and clay deposited during de-glaciation.

The hummocky terrain and depressions present in the LSCFN Village area were created during stagnation of the ice mass as glaciofluvial materials in-filled voids within the ice mass. Subsequently, when the remainder of the ice mass melted, the depressions were created. The materials in the area have also been reworked by the nearby river systems and overlain by younger fluvial deposits.

The majority of wells in the area intercept a shallow unconfined sand and gravel aquifer that is hydraulically connected to the Yukon River, i.e. groundwater levels fluctuate in

response to changes in the river level. Some of the deeper wells in the area reportedly intercept a gravel aquifer at depth (in excess of 70 m below ground surface) that is overlain by a thick deposit of silt and clay. Water levels measured within the shallow and deep aquifer were similar in elevation to each other, which infers that the deep aquifer may be hydraulically connected to the shallow aquifer and the Yukon River.

Water levels indicate that the direction of groundwater flow in the area of the Village is towards the northwest, at a gradient of approximately 0.0008, as depicted in Figure 4.

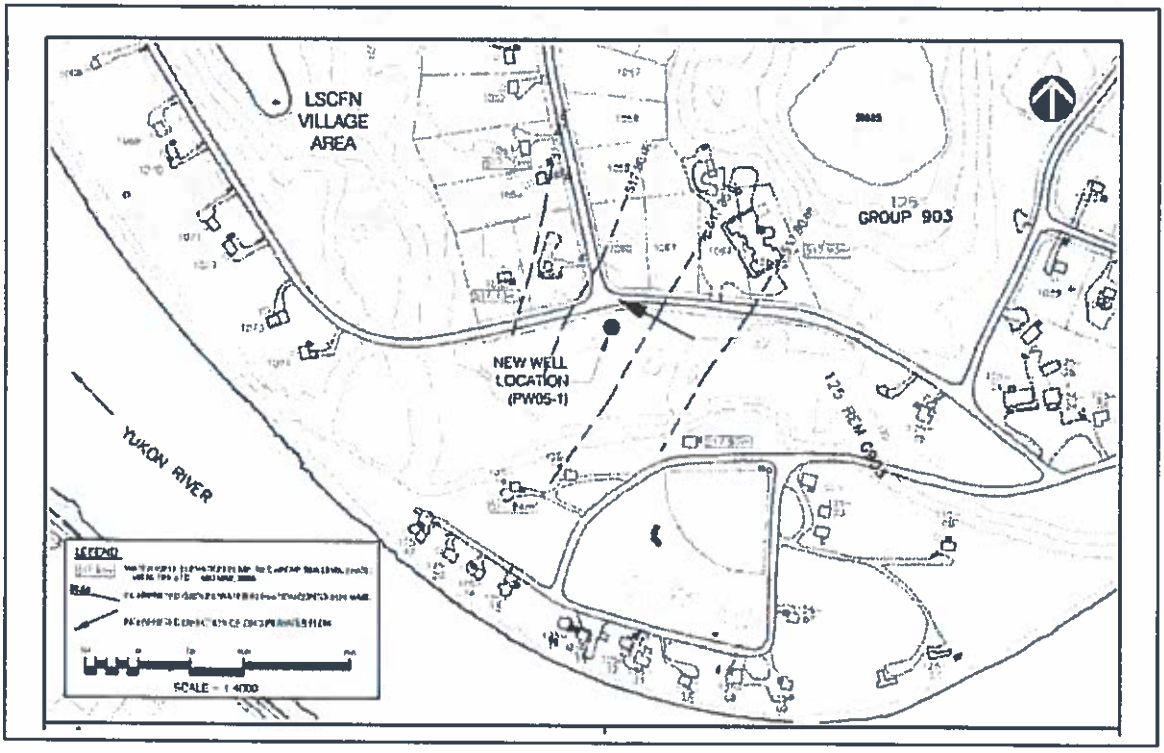


Figure 4 – Predicted Ground Water Flow Direction

Source: EBA report " Preliminary Hydrogeological Assessment and Well Completion Report- Carmacks Yukon". 2006

The local groundwater flow regime in the area of the Village is likely influenced by water levels within the Yukon River (EBA 2006). As such, the direction of groundwater flow and hydraulic gradient may fluctuate seasonally.

4.0 LSCFN NEW COMMUNITY WELL

4.1 Well Details

In June 2005, a new 200 mm (8 inch) diameter drinking water well (PW05-1) was drilled for the LSCFN in Carmacks. EBA Engineering Consultants (EBA) was retained in order to provide hydrogeological services for the well drilling, the results of which were summarized in their 2006 report entitled, *"Preliminary Hydrogeoligical Assessment and Well Completion Report, Little Salmon Carmacks First Nation, Carmacks, Yukon"*. Below is the borehole log and summary of well completion details for the new community well, taken from the EBA Well Completion Report (2006).

TABLE 2: SUMMARY OF BOREHOLE LITHOLOGY

Depth (m-bg)	Soil Description
0.0 m to 1.5 m	SAND – fine.
1.5 m to 9.1 m	SAND AND GRAVEL – well graded sand, coarse gravel.
9.1 m to 9.4 m	BOULDER
9.4 m to 12.2 m	SAND AND GRAVEL – trace cobbles.
12.2 m to 25.0 m	SAND – fine to medium, brown
25.0 m to 34.1 m	SAND – silty
34.1 m to 40.2 m	SAND AND GRAVEL – silty, fine to medium, grey.
40.2 m to 44.2 m	SAND AND GRAVEL – sand is well graded, gravel is medium to coarse.
44.2 m to 47.2 m	SAND AND SILT – fine sand, trace gravel.

TABLE 3: SUMMARY OF WELL CONSTRUCTION DETAILS	
REQUIRED DETAILS	**DETAILS OR REPORT REFERENCE**
Date of construction:	Well was completed between June 24th and June30th 2005.
Type of work conducted:	Well drilling, construction, and development and testing.
Name and address of the owner of the well:	Carmacks First Nation Box 135, Carmacks, Yukon,
Legal description of the property:	LSCFN Village across road from Lot 1060, Carmacks, Yukon
Location of the well on the property:	See Figure 3.
Method of construction:	Dual Air Rotary.
Description, depth and thickness of geologic materials encountered during construction:	See Well log PW05-1 in Appendix B. Double D Drilling log for this well is also included in Appendix B.
Depth and diameter of the well:	The well construction details are provided on Well log in Appendix B.
Type of casing materials and thickness:	Steel Casing – 0.250 inches (6.35 mm) thick.
Static water level:	21.36 m below top of casing, or approximately 20.36 m bg.
Type, size, length and location of screen:	Stainless steel V-wire 200 (0.200") slot Johnson screen. Total screen length is 3.0 m. Screen set between 40.1 m and 43.1 m bg.
Location of major water-bearing zones:	Major water bearing sand and gravel zone from 40 to 44 m bg. Minor water bearing zone in silty sands and gravels from 21 to 40 m bg.
Presence of any poor quality water or gas encountered:	None encountered.
Results of any hydrofracturing undertaken:	No hydrofracturing completed.
Location, type and thickness of grout sealant placed around the well:	Concrete grout was placed between annulus of conductor pipe and native sand and gravel. Seal is completed from grade to 6.0 m bg.
Name, address and signature of person completing the work:	The well was constructed by Double D Drilling Ltd. Address: 5275 Arthur Rd, Terrace, BC, V8G 4R1. Primary Driller was Doug Stanvick. Well drilling was supervised by Ryan Martin, EBA Engineering Consultants Ltd.

In summary, the well was drilled to a depth of 47.2 m below ground, and a screen was set from 40.1 to 43.1 m within a sand and gravel aquifer. A review of the well log for PW05-1 indicates the well is located in an unconfined aquifer.

A review of the pumping test results indicate an aquifer transmissivity ranging from 7150 m2/day to 9070 m2/day. The safe sustainable yield for PW05-1 was identified to be 9.7 L/s (128 Igpm), which is slightly greater than the rate the pumping test was run 6.8 L/s (91 Igpm). PW05-1 is able to meet the LSCFN's required water demand of 1.85 L/s (24 Igpm) for a complete piped water system for the community.

Water from PW05-1 meets all Canadian Drinking Water Quality Guidelines (CDWQG) health based standards. The concentration of manganese (0.126 mg/L) was in excess of the CDWQG aesthetic objective of 0.05 mg/L (EBA, 2006).

4.2 Preliminary GUDI Assessment

A preliminary GUDI (Groundwater Under the Direct Influence of surface water) assessment was conducted for PW05-1 by EBA at the time of well construction, using the Ontario Ministry of Environment guidelines. The results of the GUDI assessment are summarized as follows (EBA 2006):

- PW05-1 is located approximately 250 m from the Yukon River at its closest point, which is greater than the minimum required distance of 100 m.
- Based on available information regarding the hydraulic gradient and direction of groundwater flow, the estimated travel time for surface water to reach PW05-1 is approximately 105 days, which is greater than the 50 day horizontal saturated travel time from surface water.

It was noted that although information regarding the hydraulic gradient and direction of groundwater flow are limited, based on the distance of the well to a surface water body (250 m), the risk that surface water organisms could enter the well screen was considered to be low due to the natural filtration that would occur. In addition, it is understood that the LSCFN will chlorinate the water in PW05-1 prior to distribution.

5.0 THE COMMUNITY PLANNING TEAM

The Community Planning Team was developed during the first community meeting held in Carmacks to discuss the Well Head Protection Plan, and consists of Jordan Mullett (LSCFN Capital), James Baker (LSCFN Executive Director), George Skookum (LSCFN Counsellor), and Robert Kashin (LSCFN Lands). In later meetings, Kevin Rumsey (Indian and Northern Affairs), Pat Paslawski (Government of Yukon Department of Environment), and Greg Tone (Government of Yukon, Department of Environmental Health) were also invited to participate on the planning team.

Table 1 provides a summary of the dates and outcomes of each community meeting held in Carmacks for the development of the Well Head Protection Plan.

Table 1 – Community Meetings Summary

November 6, 2007	Created community planning team consisting of Jordan Mullett (LSCFN Capital), James Baker (LSCFN Ex. Director), George Skookum (LSCFN Counsellor), Robert Kashin (LSCFN Lands), Jillian Chown (JC Environmental), Victor Menkal, P.Eng. (Vista Tek Ltd.).
December 12, 2007	Second community meeting held to present draft protection map. Areas of potential environmental concern were identified through site reconnaissance survey and meeting with LSCFN staff.
February 13, 2008	Third community meeting. Posted large scale draft protection zone map on wall. Began developing management strategies for areas of potential environmental concern (APEC's). Greg Tone (Government of Yukon Environmental Health Services), and Pat Paslawski (Government of Yukon Department of Environment) attended meeting as well.
March 25, 2008	Final community meeting to present final source protection plan map to community.

6.0 THE WELL PROTECTION AREA

6.1 Chosen Delineation Method

There are a number of methods which can be used to delineate a capture zone for a well. The capture zone is the surface area which recharges groundwater entering a well or is the area in which a spill on the surface may eventually affect the water being pumped from a well.

The methods recommended by BCMOE, et al, in their "Well Protection Toolkit" were applied for this evaluation. The methods include:

- Arbitrary fixed radius (AFR)
- Calculated fixed radius (CFR)
- Analytical Equations
- Hydrogeological Mapping
- Numerical Modeling

Each method is described briefly in the following sections.

6.1.1 Arbitrary Fixed Radius (AFR)

The AFR is based on drawing an arbitrary circle of fixed radius around the well. BCMOE guidelines recommend a radius of 300m. YG EHS regulations require a minimum protection zone of 60m around any community well.

The advantages of this method are that it does not require any technical analysis and the area identified is small enough so that capture zone management does not become unduly difficult.

The primary disadvantage is that the radius is purely arbitrary and does not take into account subsurface or hydrogeologic conditions for a particular well. This method is normally only used if no well or hydrogeologic information is available.

As there is considerable data available for the new community well, the project team eliminated this method from further consideration.

6.1.2 Calculated Fixed Radius

This method is similar to the AFR in that a fixed radius boundary is established to delineate the capture zone around the well. The difference from AFR is the hydrogeologic data from the well development are used to define the radius that reflects existing conditions at the well site.

The circular area is calculated based on the volume of water pumped from the well over 1, 5 and 10 year periods. The method assumes a sand and gravel aquifer that is applicable for this well.

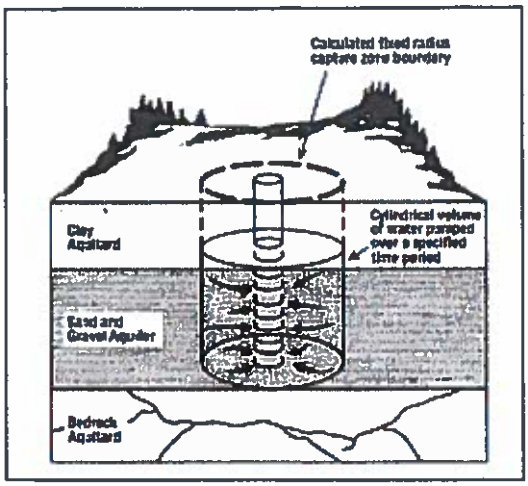


Figure 5 – CFR Model *from BCMOE Well Protection Toolkit*

Based on data from the new well, the CFR is calculated as follows

$R = (10038\ Q\ t/(n\ b))^{.5}$

Q = flow, t = travel time n= porosity 0.3 (assumed sand and gravel aquifer)

B = aquifer thickness

$R_1 = (10038 * 2 * 1/(.25 * 14))^{.5}$

$R_1 =$ 76 m for a 1 year travel time

$R_5 = 380$ m

$R_{10} = 800$ m

It is interesting to note that the one year travel time CFR of 76m compares well with the AFR set by YG EHS of 60 m.

6.1.3 Analytical Methods

Analytical methods provide a more refined method of defining the capture zone as they take into account the affect of the movement of ground water. The capture zone developed by this method reflects this movement by identifying that contaminants considerably up stream of the well may enter the ground water supply and that down stream contaminants will have less of an impact on the well.

In order to use this method, more detailed hydrogeologic information is required including pumping rates, aquifer transmissivity and water table slope. As well, the method is generally limited to sand and gravel aquifers.

As the data required for this method is available for the LSCFN community well and the aquifer is composed of sand and gravel, the project team selected this method for estimating the community well capture zone.

The full analysis is presented in the following section.

6.1.4 Hyrdogeologic Mapping

This method is applicable if sufficient data is available on aquifers, aquitards and groundwater levels which are used to generate ground water contours which are used to map ground water flow.

Considerable additional data would need to be collected in order to implement this method for the LSCFN well and the project team identified that the additional fieldwork was not warranted at this time.

6.1.5 Numerical Modeling

Numerical modeling uses computer models of ground water flow system to determine capture zones and requires considerable amounts of data, technical analysis and interpretation to develop.

The project team determined that the level of effort was not warranted at this time for the LSCFN community well due to the relatively small capture zone and consistent geologic conditions at the well site.

6.2 Analytical Model Development Results and Discussion

After review of the various options available the project team determined that there is sufficient data to use analytical equations for developing a model for the capture zone for the new community well.

It must be noted that hydrogeological analysis provides an estimate only of the capture zone as many factors can affect ground water movement. For this reason any models which are developed must be viewed as general indicators only of the subsurface water movement.

The analytical method is applicable for a sloping water table. Figure 6 provides a schematic of the mathematical model that is used to determine the capture zone based on water table slope and other hyrdogeological data.

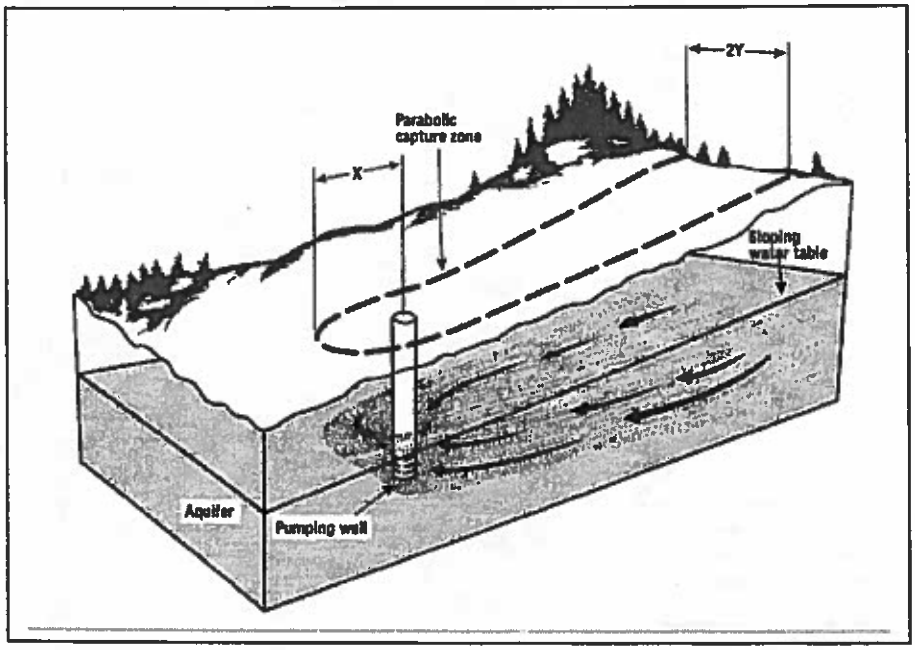


Figure 6 – Analytical Equation Capture Zone Model *from BCMOE Well Protection Toolkit*

The slope of the water table was determined previously by measuring water levels in a number of residential wells surrounding the new community well as is depicted in figure 7.

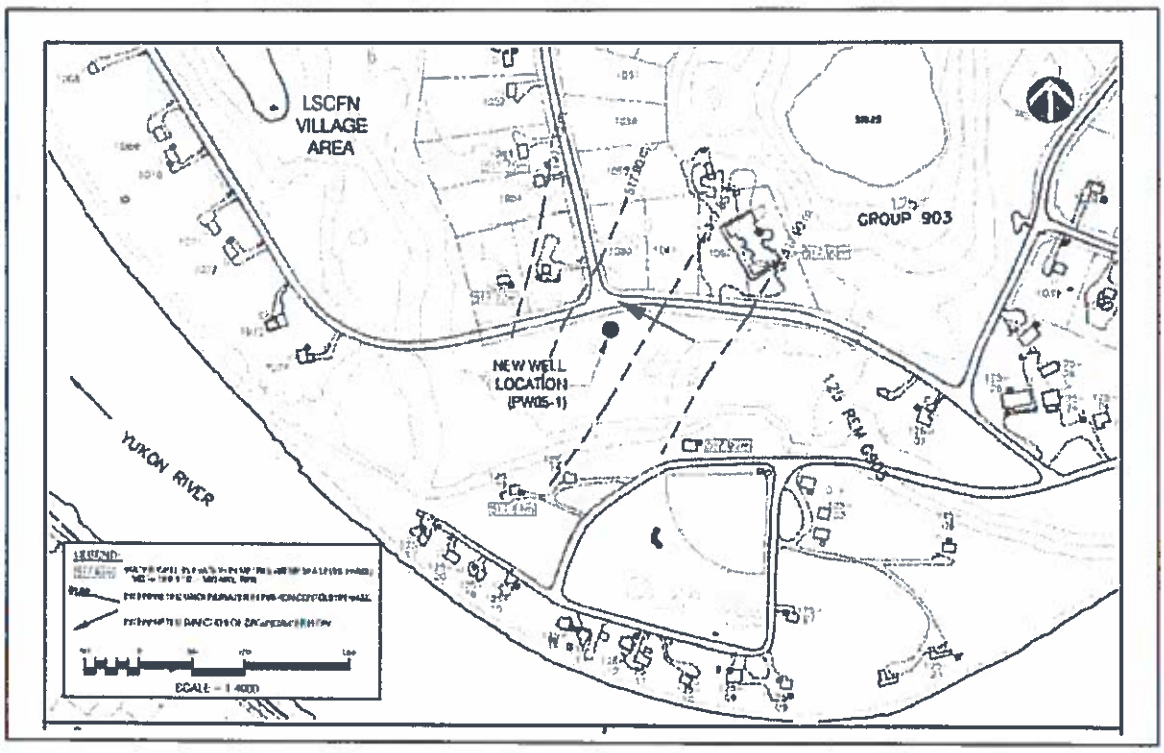
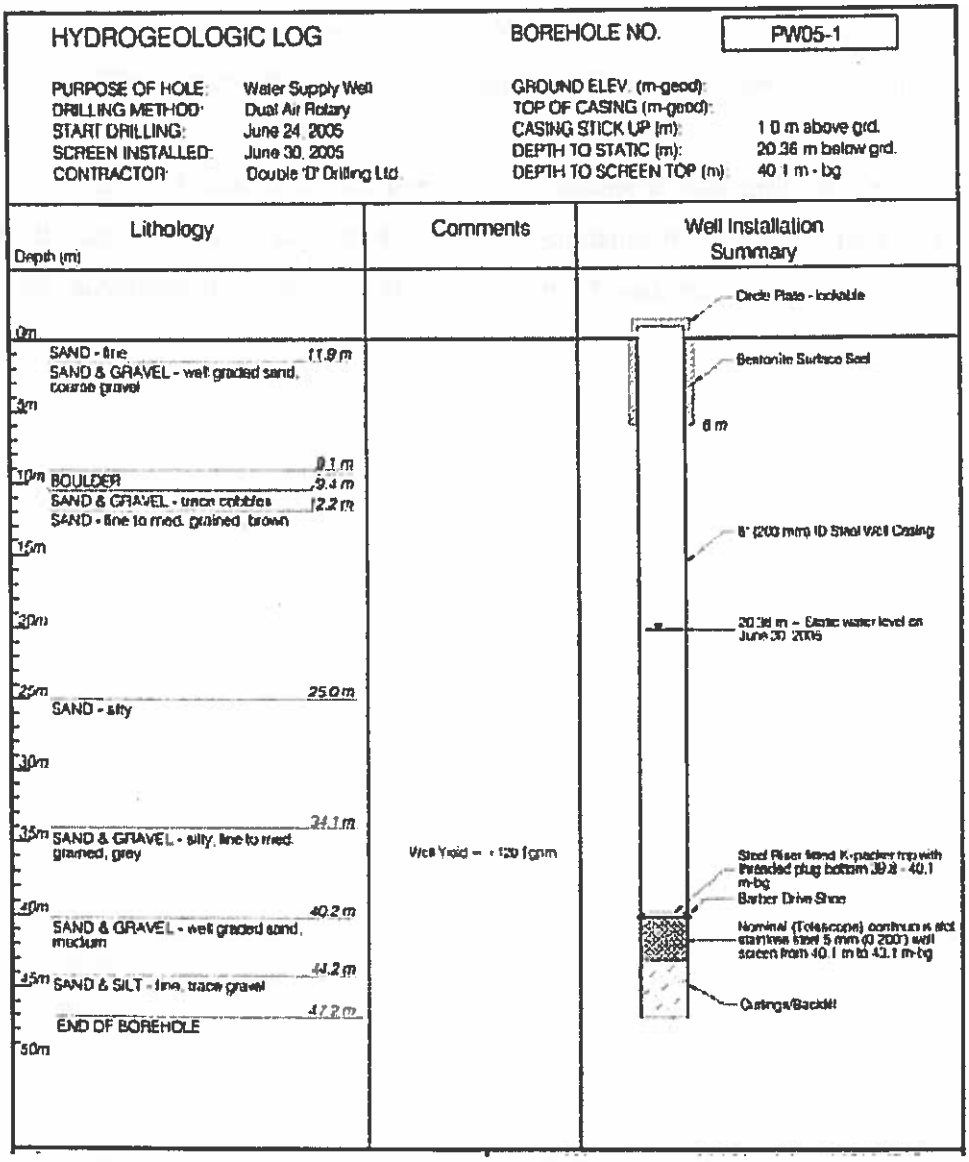


Figure 7 – Predicted Ground Water Flow Direction

Source: EBA report " Preliminary Hydrogeological Assessment and Well Completion Report- Carmacks Yukon". 2006

As can be seen from figure 7, the predicted ground water flow direction is generally from the south east with the primary energy source being the difference in elevation of the Yukon River above and below the well.

Detailed information on subsurface conditions was collected during the development of the community well and is summarized in figure 8.



20 m gw-tl

Figure 8 – Summary of Hydrogeologic Data

Source: EBA report " Preliminary Hydrogeological Assessment and Well Completion Report- Carmacks Yukon". 2006

The borehole data indicates that soils are predominantly sand and gravel to depth with a water table approximately 20.4m below the surface at the well. The sand and gravel aquifer provides for rapid transmission of water that provides relatively high well yields.

As there is no impermeable boundary between the surface and the ground water table, these conditions are of concern as they will also rapidly transmit any surface contaminants to the ground water table and hence the community water supply.

Hydrogeologic data from tests completed on the community well were used in conjunction from the analytical equations in the Well Protection Toolkit to determine the extent of the predicted capture zone for the community well and are presented in table 2.

Table 2 – Capture Zone Data

LSCFN COMMUNITY WELL
CAPTURE ZONE ANALYSIS

I =	0.0008 m/m	hydraulic gradient
Q =	2 L/s	pumping rate @ 40 years
n =	0.25	porosity sand and gravel
Aquifer thick	23 m	
T =	aquifer transmitivity (m2/s)	
K =	hyd conductivity (T/ aquifer thickness) (m/year)	

$Y = Q/2000TI$ 1/2 width of upstream capture zone (m)

$X = Y/n$ down gradient capture zone boundry (m)

$d_{TOT} = tKI/n$ distance to 1, 5 & 10 travel boundry (m)
t = time in years

Capture Zone Calculations

Location	*PW-05-1*	*PW-05-1*	*Geo Mean Yukon EHS*	
T (m2/day)	7150	9070	8053.0	
T (m2/sec)	0.0828	0.1050	0.0932	
Q (l/s)	2	2	2	
I (m/m)	0.0008	0.0008	0.0008	
Y (m)	**15.1**	**11.9**	**13.4**	**60**
X (m)	**4.8**	**3.8**	**4.3**	**60**

Travel Boundry Calculations

Location	*PW-05-1*	*PW-05-1*	*Geo Mean*
K (m/s)	0.021	0.026	0.023
K (m/year)	662256	819936	736890
d_{TOT} 1 year(m	**2119**	**2624**	**2358**
d_{TOT} 5 year(m	**10596**	**13119**	**11790**
d_{TOT} 10 year(n	**21192**	**26238**	**23580**

PW-05-1 Travel Distance Aquifer = 23 m thick

Location	*PW-05-1*	*PW-05-1*	*Geo Mean*
K (m/s)	0.003598	0.004564	0.004052
K (m/year)	113467	143937	127797
d_{TOT} 1 year(m	**363**	**461**	**409**
d_{TOT} 5 year(m	**1815**	**2303**	**2045**
d_{TOT} 10 year(n	**3631**	**4606**	**4090**

The first step in the analysis was to determine the extents of the capture zone. Using data from well testing and equations provided by the Well Protection Tool Kit, it was determined that the capture zone would be approximately 13m wide and extend approximately 4m down gradient of the well. The resulting capture zone is a relatively

narrow "finger" that extends well upstream of the well which reflects the high transmissivity of the sand and gravel aquifer.

In reviewing these data, the project team identified that the management zone would also be impacted by regulatory requirements, in particular the YG EHS exclusion zone radius of 60m for a community well. The project team decided to use the 60m radius for establishing the capture zone to reflect regulatory requirements, the inherent variability in ground water modeling and the lack of detailed geotechnical data for wells upstream of the community well.

The next step in the analysis was to determine the time that it would take for a contaminant spilled in the capture zone to travel to the well. Test data from the new community well was used to estimate the distance upstream of the well it would take contaminants to reach the well in one, five and ten years.

Using the data from the hydrogeologic report on the well resulted in extremely long travel distances. Review of the data with EBA (per. Com. R. Martin, EBA Engineering Ltd.) identified that INAC reporting requirements resulted in a lower aquifer thickness. Travel distances were recalculated using the full aquifer thickness resulting in a travel distance of approximately 400m per year that is consistent with previous work in the community.

The results of the capture zone analysis are summarized graphically in figure 9 that indicates a 120m wide capture path extending to the Yukon River. The majority of the capture zone is within the one year travel time boundary and the entire capture zone (including the Yukon River) should be considered as a high-risk area for management purposes.

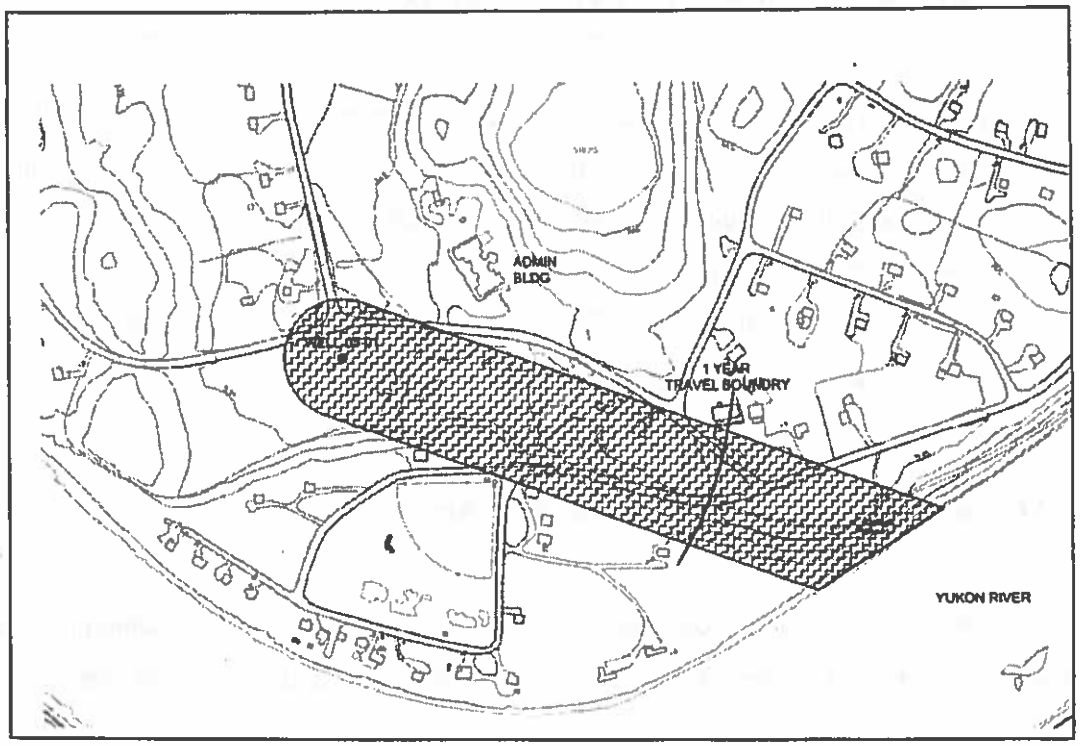


Figure 9 – Estimated Capture Zone and Travel Boundaries

7.0 PRELIMINARY CONTAMINANT INVENTORY

In order to identify Areas of Potential Environmental Concern (APEC's) within the Well Head Protection Area, a preliminary contaminant inventory was conducted, during which time meetings and site reconnaissance visits were carried out with LSCFN team members for the main LSCFN village area. In addition, the Government of Yukon and Environment Canada Spills Report Databases were researched. The results of the preliminary contaminant inventory are presented below.

7.1 Contaminated Sites and Spills Search, Government of Yukon

Since 2001, the Government of Yukon Department of Environment has maintained the Yukon Spills Report Centre. Below is a list of reported spills in the Carmacks area.

a. Lot 75, Carmacks: A leaking fuel tank was discovered under a housing unit on Sept 08, 2006. 1.45 cubic meters of petroleum hydrocarbon-contaminated soil were removed.

b. LSCFN Health & Social Services Building, Carmacks: 60 cubic meters of petroleum hydrocarbon-contaminated soil were relocated from this site in 2003 after 3500 L of heating fuel leaked from an incorrectly installed fuel spout. Approximately 60 cubic meters of hydrocarbon impacted soil was removed from the area.

c. Wildland Fire Management Carmacks Tanker Base: 1400 – 3000 L of fire retardant concentrate were spilled on the ground. Reportedly pumped into a lined evaporation pit.

d. Lot 1031, within Lot 125, Carmacks: On March 29, 2004, a valve was broken causing the release of approx. 6 L of some substance. The nature of the substance and of any follow-up actions are not available.

e. On July 23, 2003, approx. 80 L of diesel were spilled while filling a "Tidy Tank" on the Campbell Highway "outside of Carmacks". The exact location is not listed. Approx. 8 cubic meters of petroleum hydrocarbon-contaminated soil were recovered and removed.

Only the heating fuel spill at the LSCFN Health and Social Building occurred near PW05-1.

7.2 Contaminated Sites and Spills Search, Environment Canada

Environment Canada maintained spill records within the Yukon between 1972 and 2001. Only one spill was recorded within the Main Village area of Carmacks, but outside of the well time-of-travel zones, and that was the 2003 fuel oil spill at the LSCFN Health and Social Services Building, where 3500 liters of heating fuel leaked from a fuel spout. Approximately 60 cubic meters of hydrocarbon contaminated soils were removed. There were several other spills and leaks reported in Carmacks, as identified on the Environment Canada database, and these spill reports are appended to this report.

7.3 Site Reconnaissance Survey and Meetings with LSCFN Team Members

Based on information collected during site visits and meetings with LSCFN team members, the following list of APEC's were identified within the one year or less travel time zone for PW05-1:

- Green House (GH)
    - There is a potential for nitrates/nitrites and pathogens to leach from manure stored at the site into aquifer
- UST (UST 1) at Old Laundromat
    - Although this underground storage tank is not currently in service, there is a potential for hydrocarbons from old spills or leaks to enter into aquifer
- Septic Field (SF)
    - There is a potential for heavy metals, solvents, household waste products, fecal coliforms, etc., to enter into aquifer
- Maintenance Shop (MS)
    - There is a potential for hydrocarbons and other maintenance chemicals (anti-freeze, glycols, etc.) to enter into aquifer
- UST (UST 2) at Heritage Hall
    - Although this underground fuel oil storage tank is located outside the estimated capture zone, there is still concern that a large spill may affect the aquifer

An APEC located outside the capture zone, but which still may pose a concern to the quality of the community well water, is the heating fuel spill at the LSCFN Health and Social Building that occurred in 2003.

7.4 Risks associated with each APEC

Based on the contaminant inventory results, a preliminary risk assessment was completed to assist in the relative ranking of each potential threat identified. The risk assessment can be useful for prioritization of action items.

The results of the risk assessment were based on the following criteria:

CONSEQUENCE x PROBABILITY = RISK

In the matrix, two criteria are used to define risk; Exposure Likelihood and Hazard Consequence. The Probability Likelihood defines how likely it is that the hazard will occur within the time-of-travel zone identified and how likely it is that a consumer will be exposed to an APEC (i.e. the potential risk that contaminants will travel through the ground and into the well water). Below is a list of the Probability of Occurrence or Exposure Likelihood Criteria used in the risk matrix:

Probability of Occurrence or Exposure Likelihood Criteria

Low- Groundwater travel time over 5 years

Medium- Groundwater travel time 1 to 5 years

High- Groundwater travel time 1 year or less

The Hazard Consequence Criteria is based on the likelihood of the APEC causing harm to human health. Below is a list of Hazard Consequence Criteria used in the Risk Matrix:

Hazard Consequence Criteria

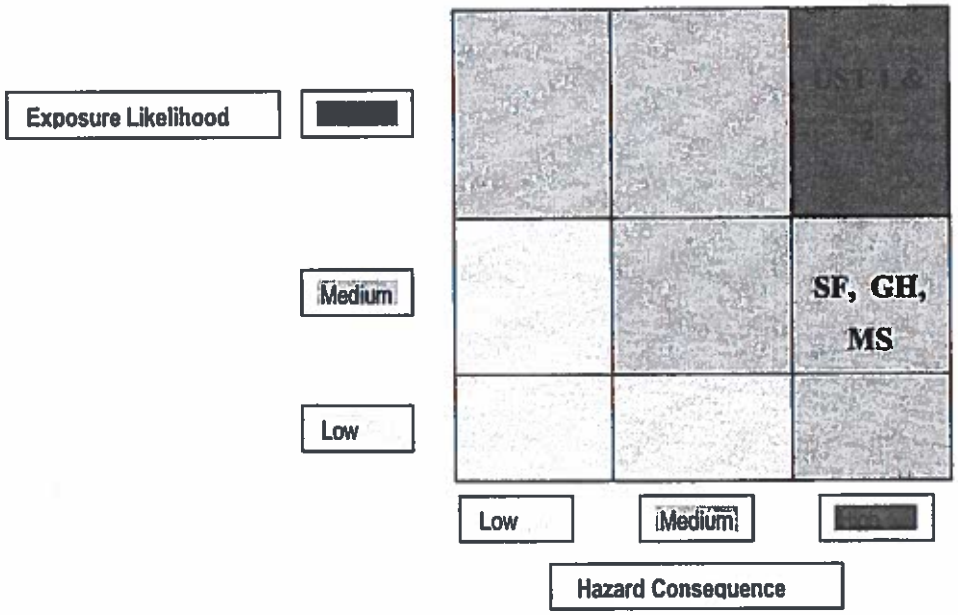
Low- Small change in water quality; exceeding aesthetic water quality guidelines

Medium- Moderate change in water quality requiring mitigation (treatment of water supply)

High- Significant change in water quality that cannot be mitigated by treatment or potentially causing acute health concerns

Each APEC is placed in the appropriate risk category. Table 3 below shows where each APEC falls within the risk matrix.

Table 3 - Risk Matrix for LSCFN New Community Well



As the underground storage tank at the old Laundromat (UST 1) is located within the capture zone, its exposure likelihood is high. It also ranks high in the hazard consequence criteria, as any discharge from old spills or leaks could potentially affect ground water quality and have serious health effects on humans. This tank should be removed and the area remediated to reduce this risk.

The underground storage tank at Heritage Hall (UST 2) is located just outside the capture zone and is currently in use. Due to the large volume stored and the age of the tank, its exposure likelihood is still considered high. It also ranks high in the hazard consequence criteria, as any discharge from old spills or leaks could potentially affect ground water quality and have serious health effects on humans. This tank should be removed and replaced with an approved double walled above ground tank.

The green house (GH), septic field (SF) and maintenance shop (MS) are all considered Medium Risk. All received a high risk in Exposure Likelihood Criteria because they are so close to the community well.

The septic field and green house received a medium Hazard Consequence Criteria value as only moderate changes in water quality requiring mitigation (treatment of water supply) would likely result of being exposed to these APEC's.

The maintenance shop received a medium Hazard Consequence Criteria due to relatively low volume of petrochemical products stored on site.

7.5 Risk Management

In the community planning team meeting held on February 13th, 2008, the APEC's and associated risks were discussed and several management strategies were developed for consideration. Table 4 describes the management strategies developed for the APEC's.

Table 4 – APEC's and Potential Management Options.

Green House	Off site storage of manure
UST	UST removal & replacement
Maintenance Shop	Complete inventory of potential contaminants on site; determination if special waste permit is required
Septic tanks/fields	Inspect tanks once per year to make sure they are working properly; regular pump-outs; education for home owners regarding proper maintenance of fields
Fuel oil spill at Health and Social Services Building	Continue follow-up sampling on water wells within vicinity of spill to ensure no hydrocarbon contamination is present; conduct follow-up soil sampling
Signage- signs delineating water source protection zone will be made and posted around zone to make public aware of the area, especially roads in the management area. *Education*- pamphlets and community discussions will help spread awareness of the well head protection plan and the APEC's within the protection zone. Education on what activities are permitted within the protection area will be a focus for LSCFN staff.	

7.6 Risk Monitoring

During the community meeting held on February 13th, 2008, LSCFN staff expressed an interest in developing an on-going water quality monitoring program for the new community well, and selected wells within the main village area. As well, an on-going inventory of potential contaminants and wastes at the Maintenance Shop was

recommended as a means to mitigate any potential risks to the aquifer. LSCFN sees the need for continued monitoring of activities within the time-of-travel zone boundaries. As well, they see the need to re-visit the plan on a yearly basis to update information and APEC's.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

Based on the capture zone analysis for the new community well, a 120m wide protection zone extending from the new well to the Yukon River to the south east and 60m to the north west was established.

The sand and gravel soils in this area result in rapid transmission of surface contaminants and this area should be protected against uses that may result in spills of surface materials.

Existing contaminant sources within and in close proximity to this management zone should be eliminated as soon as possible and management of the area should include public education as well as an ongoing management program.

8.2 Recommendations

The following recommendations are provided with regards to continuing the groundwater protection planning process for the LSCFN.

1. In order to confirm the direction of groundwater flow and hydraulic gradient in the area of PW05-1, it is recommended that static water levels within all wells upstream of the community well be confirmed. As there are several wells completed within the deeper aquifer, consideration could be given to installing water level transducers in some of these wells to reconcile groundwater elevations and flow directions, thereby recording seasonal fluctuations in groundwater levels. Once the groundwater levels and hydraulic gradient have been confirmed, capture zones should be refined;

2. The groundwater protection area for PW05-1 be identified to consist of both the 1-year time-of-travel zone for the well based on the FR methodology and the analytical methodology. This would incorporate the required YG EHS exclusion zone radius of 60 m surrounding the well;
3. Remove and replace existing UST at Heritage hall with approved AST and complete level II environmental assessment;
4. Remove existing UST at old community Laundromat and complete level II assessment;
5. Ensure that improperly constructed septic systems be replaced with properly constructed septic tanks; (or holding tanks).
6. Endorse and promote hazardous waste minimization and collection programs;
7. Implement contingency planning including emergency response actions and communication. LSCFN council should create an emergency and spill response plan identifying key personnel responsible to respond in the event of an occurrence or spill;
8. It has been previously identified that most of the individual residential wells in the Main Village area have been improperly constructed which may allow surface contaminants to enter the aquifer. It is recommended that all wells be inspected and upgraded to prevent surface water and potential contaminants from migrating to the aquifer;
9. A groundwater monitoring program should be developed, where regular water quality monitoring is conducted on community well and individual wells;
10. Implement a septic tank monitoring program for tanks within Zone 1. This would consist of monitoring tank levels, taking extra care on pump outs to ensure that spills do not occur, and developing an awareness program for owners of tanks within zone 1;
11. LSCFN may want to consider assessing the interaction of septic tanks with the aquifer to make sure that septic tanks do not adversely impact the well;

12. Add security to new well by installing fencing and lockable gate;

13. Maintain the poster created for this study in a public part of the community, and update the poster as necessary;

14. Educate the LSCFN community members regarding the importance of maintaining a clean environment of the land surrounding their Community Well;

15. Routine well inspection (monitoring) and maintenance are mandatory in order to prolong the life of a well. Any changes in the water chemistry and operating characteristics of the well should be closely monitored and dealt with promptly, as both the well and pump can deteriorate beyond repair if problems are left unattended. For non-domestic (municipal) wells completed in alluvial aquifers, the typical frequency for major well maintenance is usually every 5 to 10 years. Down-hole video camera inspection should be completed every 3 to 5 years, or at the same time when down-hole pumping equipment is removed for scheduled inspection;

16. In order to continue to monitor well performance, it is recommended that static and pumping water levels, pumping rates and duration be recorded on a regular basis for PW05-1. Water levels can be collected either manually or using a permanently installed data logger within the well. The purpose of the data logger is to collect water levels within the well at predetermined intervals. Water levels can then be downloaded monthly for review and analyses. The purpose of the monitoring program is to continue to assess the well efficiency, and determine when well rehabilitation is required.

9.0 REFERENCES

BC Ministry of Environment Website:
http://www.env.gov.bc.ca/wat/gws/well_protection/wellprotect.html Well Protection Toolkit.

EBA Engineering Consultants. Preliminary Hydrogeological Assessment and Well Completion Report Little Salmon Carmacks First Nation, Carmacks, Yukon . 2006

Ontario Ministry of Environment, Groundwater Studies - Technical Terms of Reference, November 2001.

Federal–Provincial–Territorial Committee on Drinking Water of the Federal–Provincial–Territorial Committee on Health and the Environment, (April 2004), "Summary of Canadian Drinking Water Quality Guidelines".

Government of Yukon. Drinking Water Regulation. Public Health and Safety Act, Section 24. August, 2007.

APPENDIX A

Spill Report from Environment Canada

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 #	0011
Jurisdiction	Yukon
Community	Carmacks
Address	
Highway	
Milepost	
Feature	Carmacks
Location / Cause	Carmacks Dump - uncontrolled burn in metals/tires dump - fire jumped from scheduled burn in wood dump
Incident Date	3/29/2000
Lead Agency	Municipality - identified in Community
Other Agency	
Major Contaminant	
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	
Phase	
Release	Burned
Outcome	possible air / water quality issues from burning metal and tires - EC advised any drainage from fire area to Nordenskold be controlled and to call back if any further concerns

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 #	0302
Jurisdiction	Yukon
Community	Carmacks
Address	
Highway	
Milepost	
Feature	Carmacks
Location / Cause	LSCFN Health & Social Services Building - fuel pumped into casing surrounding UST fill pipe - fuel spout incorrectly inserted
Incident Date	3/4/2003 3:21:00 PM
Lead Agency	Yukon Government - Environmental Programs
Other Agency	
Major Contaminant	Furnace Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	3500
Units	Litres
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	responsible party hired Jacques Whitford Consuting to assess site on coming weekend - YG-EP working with responsible party - no further info on outcome provided

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 #	7607
Jurisdiction	Yukon
Community	Carmacks
Address	
Highway	Klondike Highway
Milepost	
Feature	Carmacks
Location / Cause	Carmacks Chevron Station - overfill of storage tank
Incident Date	6/18/1976 9:00:00 AM
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	Diesel
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	227
Units	Litres
Concentration	
Units	
Quantity	Actual
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	no environmental damage - contaminated soil removed

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 #	9023
Jurisdiction	Yukon
Community	Carmacks
Address	
Highway	
Milepost	
Feature	Carmacks
Location / Cause	sewage sludge pit 5 KM N of Carmacks - waste oil dumped by unknown party
Incident Date	9/10/1990 11:50:00 AM
Lead Agency	Department of Indian Affairs and Northern Development
Other Agency	
Major Contaminant	Waste Oil
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	38
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Dumped
Outcome	will attempt to burn and use sorbents for final clean-up

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 #	9403
Jurisdiction	Yukon
Community	Carmacks
Address	
Highway	Klondike Highway
Milepost	KM 362.9
Feature	Carmacks
Location / Cause	2 KM N Carmacks at access to sewage pit - sewage truck rolled and spilled load
Incident Date	1/28/1994 2:30:00 PM
Lead Agency	Yukon Government - Highways
Other Agency	Department of Indian Affairs and Northern Development
Major Contaminant	Raw Sewage
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	2700
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	contaminated snow from edge of hwy to be removed to sewage pit - contaminated snow from steep ditch slopes will not be removed - truck removed

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 #	9418
Jurisdiction	Yukon
Community	Carmacks
Address	
Highway	
Milepost	
Feature	Carmacks
Location / Cause	Copper Pilot Plant - event pond flooding
Incident Date	3/31/1994
Lead Agency	Department of Indian Affairs and Northern Development
Other Agency	
Major Contaminant	
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	
Phase	
Release	Flooded
Outcome	inspected by EP and DIAND - no evidence of spill - all soaked into soil - no evidence of runoff

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 #	9451
Jurisdiction	Yukon
Community	Carmacks
Address	
Highway	
Milepost	
Feature	Carmacks
Location / Cause	Sunrise Service Station - overfill of storage tanks - human error
Incident Date	10/17/1994
Lead Agency	Yukon Government - Fire Marshall
Other Agency	
Major Contaminant	Gasoline
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	150
Units	Litres
Concentration	
Units	
Quantity	Estimate
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	Fire Marshall's office supervising clean-up

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 #	9520
Jurisdiction	Yukon
Community	Carmacks
Address	
Highway	
Milepost	
Feature	Carmacks
Location / Cause	diesel smell - suspected leaking UST's or old pumps behind Carmacks Hotel
Incident Date	5/19/1995
Lead Agency	Environment Canada - Environmental Protection Service
Other Agency	
Major Contaminant	Hydrocarbons
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	
Phase	Liquid
Release	
Outcome	EP staff possibly able to stop by following week to take a look - no further info on file

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 #	9774
Jurisdiction	Yukon
Community	Carmacks
Address	River Dr
Highway	
Milepost	
Feature	Carmacks
Location / Cause	100m past the park towards Nordenskiold Bridge - truck roll-over
Incident Date	9/17/1997
Lead Agency	Municipality - identified in Community
Other Agency	
Major Contaminant	Ethylene Glycol
2nd Contaminant	Engine Oil
3rd Contaminant	Sulfuric Acid
4th Contaminant	
Amount	5
Units	Litres
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	minimal amounts of fluids leaking - EC advised caller to have Village of Carmacks remove contaminated soil when vehicle removed - soil will contain spill - no further info

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 #	9813
Jurisdiction	Yukon
Community	Carmacks
Address	
Highway	Klondike Highway
Milepost	
Feature	Carmacks
Location / Cause	Sunrise Services and along Klondike Highway - leaking tanks on tractor trailer
Incident Date	3/29/1998
Lead Agency	Yukon Government - Highways
Other Agency	Yukon Government - Renewable Resources
Major Contaminant	Diesel
2nd Contaminant	
3rd Contaminant	
4th Contaminant	
Amount	
Units	
Concentration	
Units	
Quantity	Unknown
Addl Quanitity Info	
Phase	Liquid
Release	Spilled
Outcome	caller noticed two separate pools in yard - didn't know carrier company but knew they were on refueling run - EC advised him on burning and remediation - passed to YG

APPENDIX B

Photos

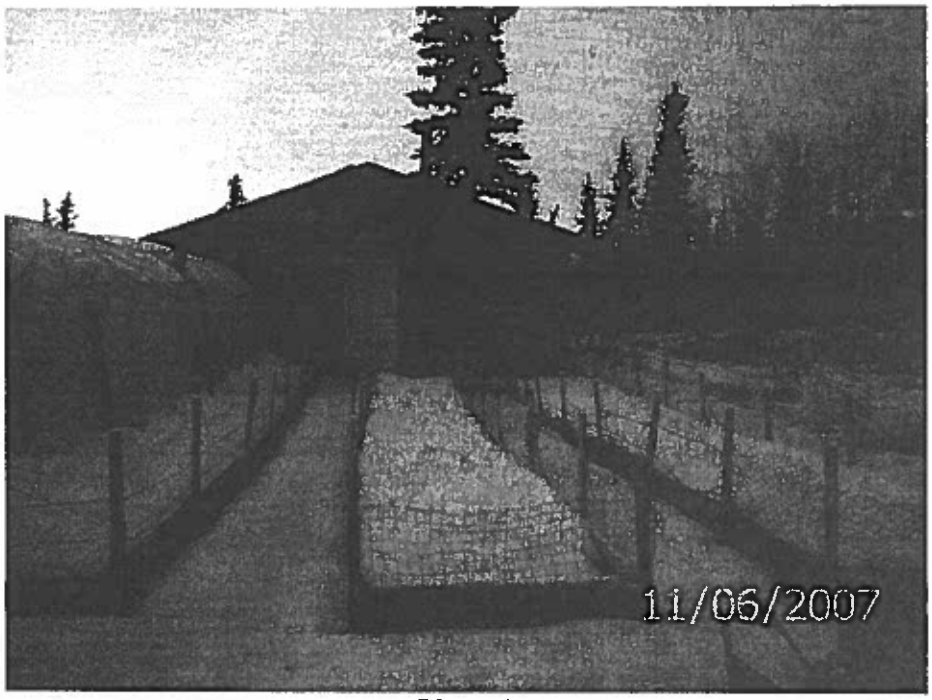


Photo 1
LSCFN Green House

Photo 2 Maintenance Shop

Photo 3
LSCFN Maintenance Garage

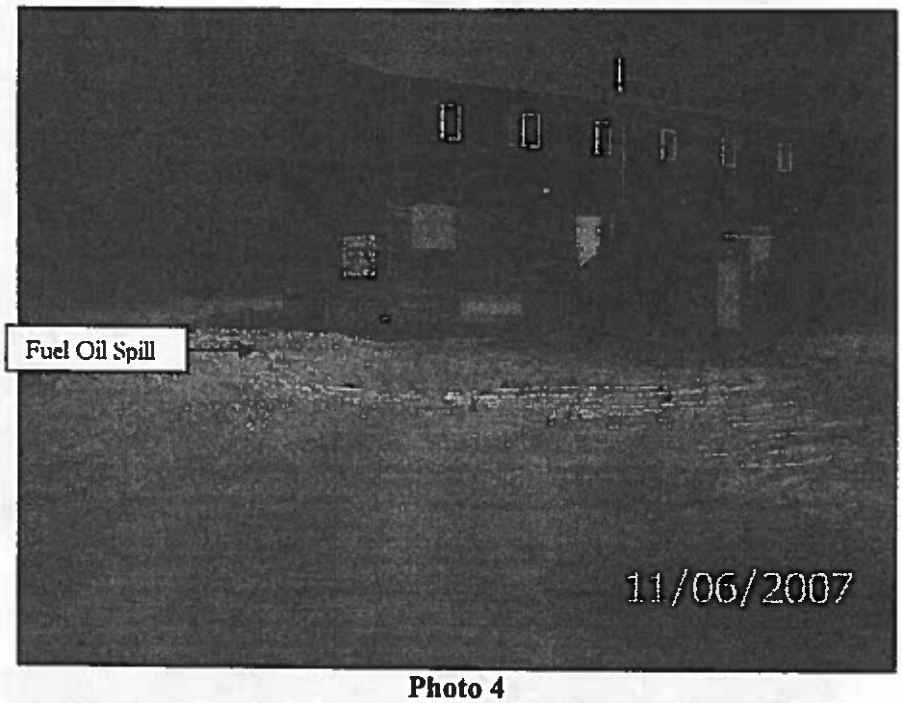


Photo 4
LSCFN Health and Social Services Building

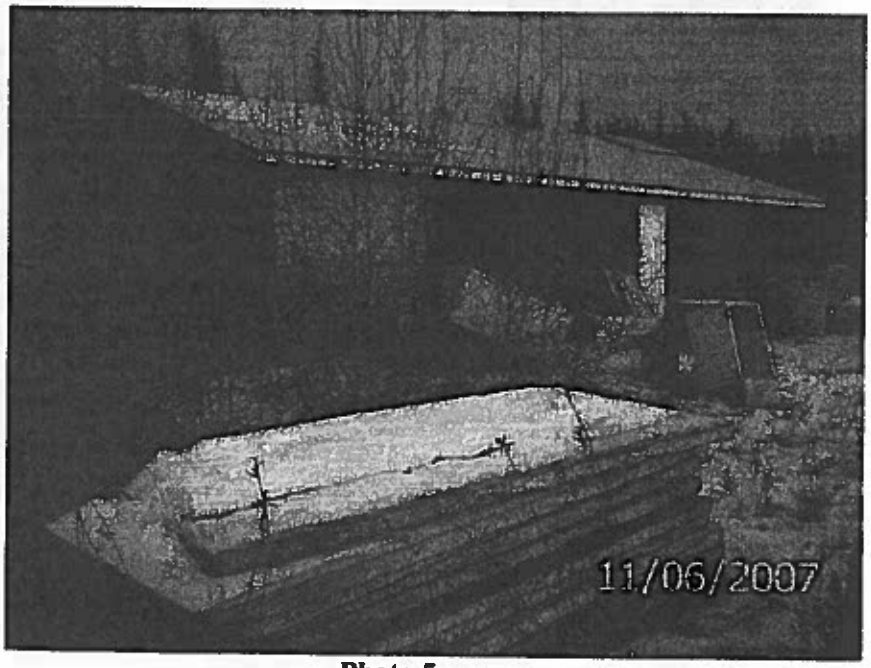


Photo 5
LSCFN Old Laundry Mat

Photo 6
View from green house looking towards Yukon River and Carmacks

Photo 7
Fuel drums located on Maintenance Shop

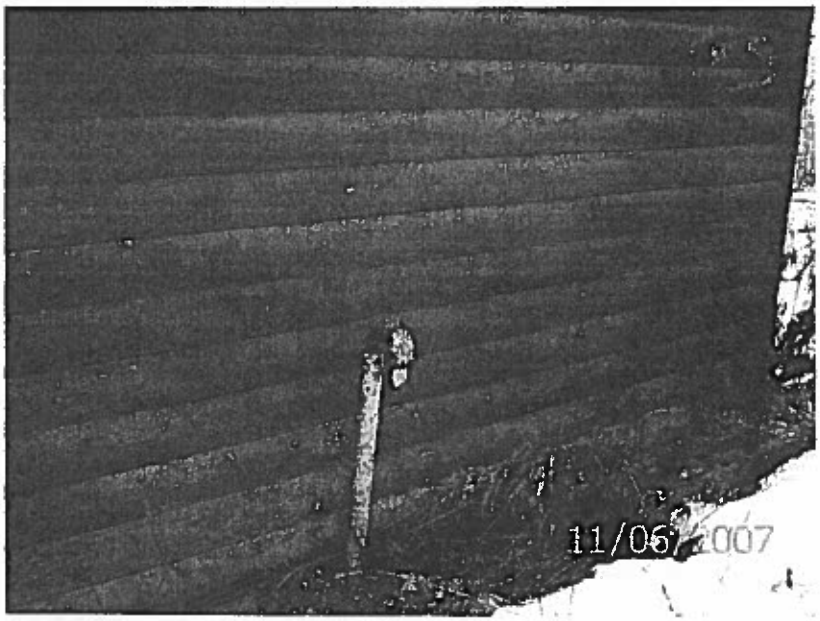


Photo 8
UST at Old Laundry Mat

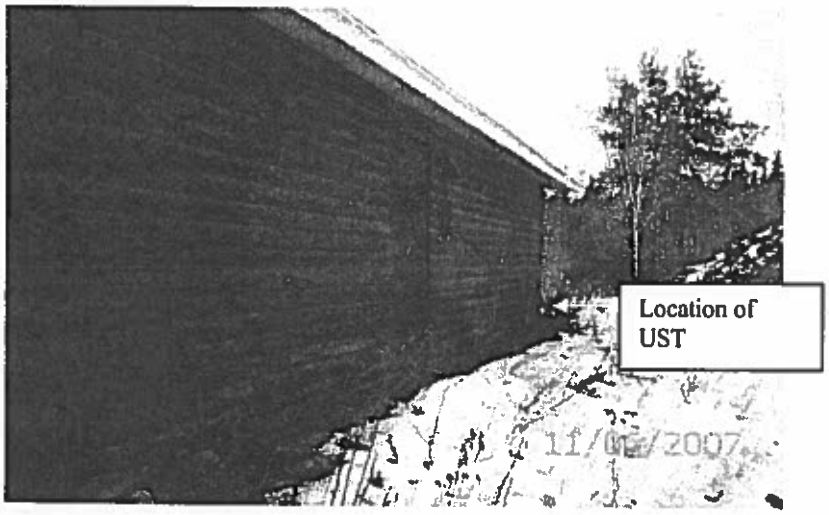
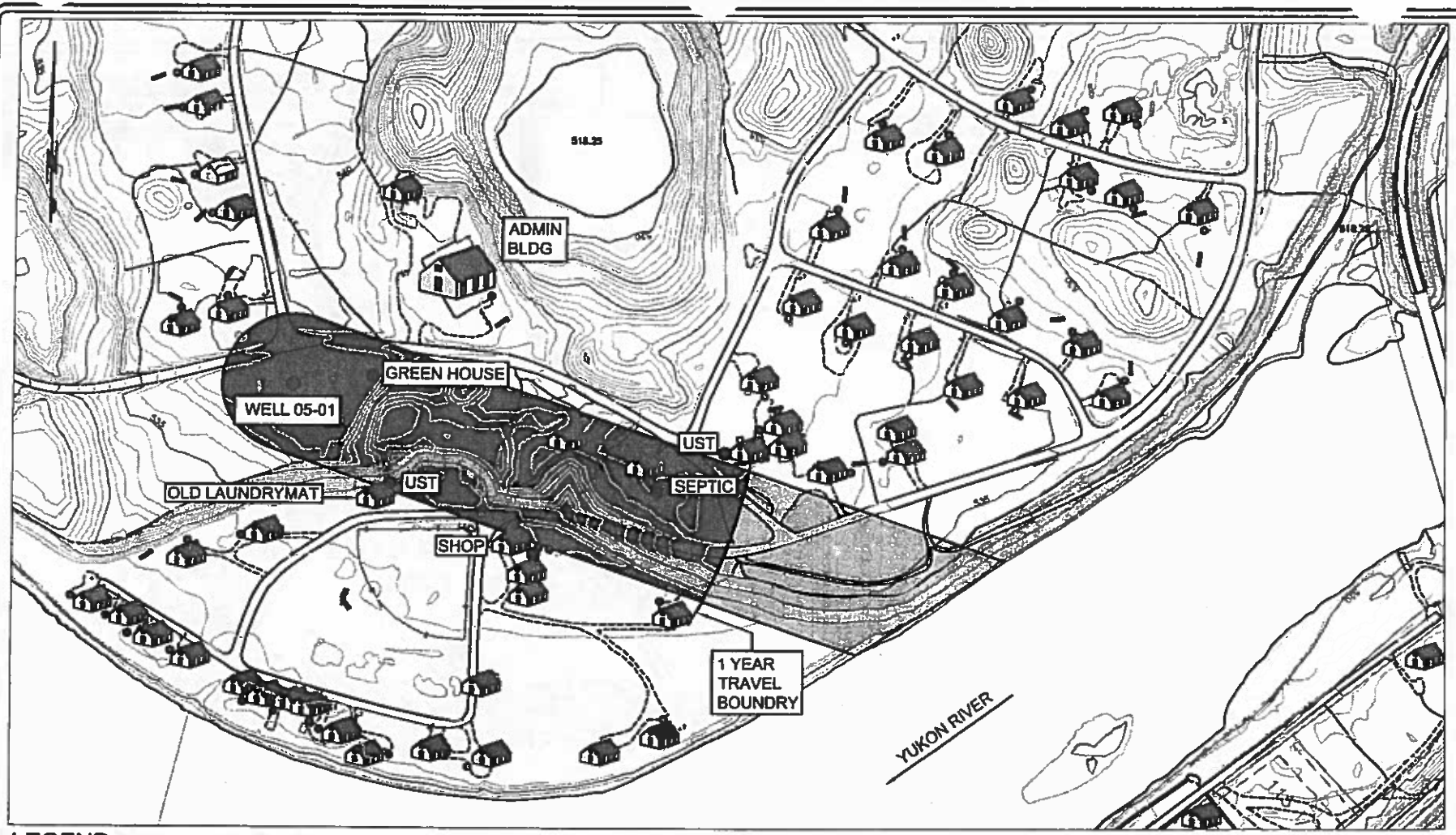


Photo 9 same as above

APPENDIX C

Final Map of Capture Zone



LEGEND:

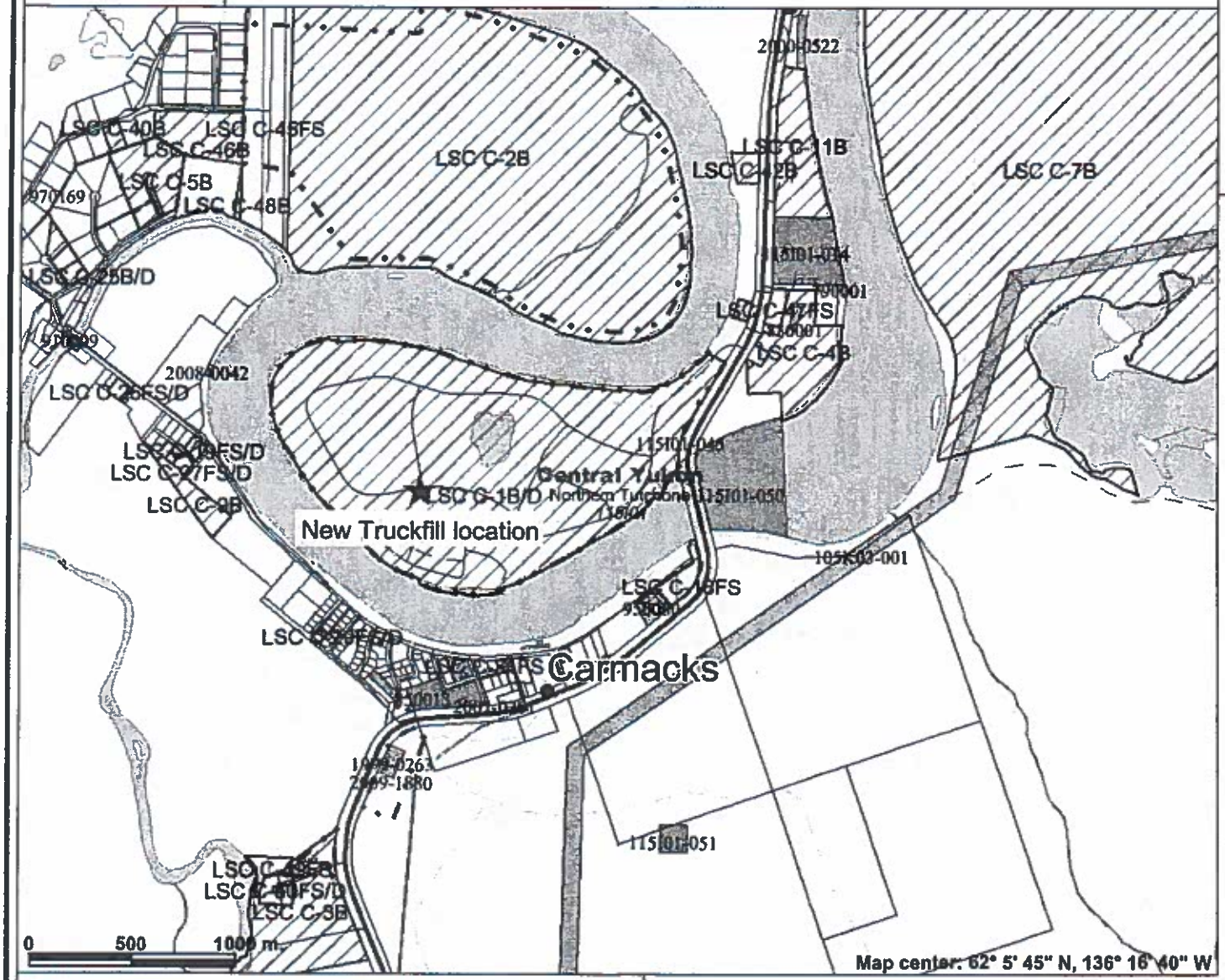
- PAVED ROAD
- GRAVEL ROAD
- BUILDING
- SEPTIC FIELD
- SEPTIC TANK
- CONTAMINANT LOCATION
- WELL LOCATION
- INDEX CONTOUR
- INTERMEDIATE CONTOUR
- OUTSIDE OF 1 YR TRAVEL BOUNDARY
- WITHIN 1 YR TRAVEL BOUNDARY

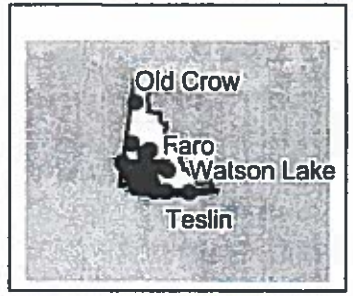
WELL PROTECTION PLAN
CAPTURE ZONE
CARMACKS, YUKON

VISTA TEK LTD

DRAWN	LINDERMAN
SCALE	1:4000
DATE	MARCH 17, 2008
PROJECT NO.	0330
DRAWING	0330-002_01
TITLE	LAYOUT
SHEET	1 OF 1

LSCFN New Truckfill Location





Legend

National Road Network - All Roads

- Expressway / Highway
- Arterial
- Collector
- Ramp
- Resource / Recreation
- Local / Street
- Local / Strata
- Local / Unknown
- Alley or Service Lane
- Service Lane
- Winter

YESAA Mapped Communities (50K)

Planning Regions

First Nations Traditional Territory (250K)

YESAA Assessment Districts (250K)

Unsurveyed First Nation Interim Protected Lands

Unsurveyed First Nation Settlement Land

- A
- A/D
- B
- B/D
- FS
- FS/D

Surveyed Settlement Lands

Scale: 1:29,137

This map is a user generated static output from an Internet mapping site and is for general reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. THIS MAP IS NOT TO BE USED FOR NAVIGATION.