Assessment of the Vanderhoof South Drinking Water Supply: Source Water Characteristics

James Jacklin, September 2005

Introduction

In British Columbia, drinking water quality is becoming a significant public issue. We all want to have confidence in the quality of the water we consume. Its protection is also important to local purveyors, who act as our water suppliers, and to provincial government ministries responsible for water management. Within the Omineca-Peace region of B.C., our most common potable source is ground water, although many communities do make use of rivers, streams or lakes. Our basic drinking water quality is determined by a number of factors including local geology, climate and hydrology. In addition to these, human land use activities such as urbanization, agriculture and forestry, and the pollution they may cause, are becoming increasingly important influences. Environmental managers have a responsibility to control land use development so as to minimise the effects of these activities on source water quality.

The province's Drinking Water Protection Act, enacted in October, 2002, places the responsibility for drinking water quality protection with the B.C. Ministry of Health and local water purveyors. However, through the B.C. Environmental Management Act, the British Columbia Ministry of Environment (MOE) is responsible for managing and regulating activities in watersheds that have a potential to affect water quality. Accordingly, the Ministry plans to take an active role in protecting drinking water quality at its source.

Plate 1. A view of the Vanderhoof South pump house where the raw water samples were collected.

MOE implemented a raw water quality and stream sediment monitoring program at selected communities in the Omineca-Peace region in 2002. Community sites were selected using a risk assessment process that considered:

- whether the source supply was surface water or ground water,
- the level of water treatment used,
- the population size served,
- the potential for upstream diffuse and point-source pollution,
- the availability of current, high-quality and representative data on each raw water source,
- whether past outbreaks of waterborne illness had been reported,
- the ability/willingness of local purveyors to assist with sampling.

Through this process and with available funding, a total of 18 community water supplies in the Omineca-Peace region were selected for monitoring during 2002/03, and two more were selected in 2004/05.

This brief report will summarise water quality data collected from the Vanderhoof South raw potable water source (ground water) (Plate 1). The data are compared to current provincial drinking water quality guidelines meant to protect finished water. This comparison should identify parameters with concentrations that represent a risk to human health. It is intended that this process will lead to the identification of human activities responsible for unacceptable source water quality, and that it will assist water managers to develop measures to improve raw water quality, where needed.

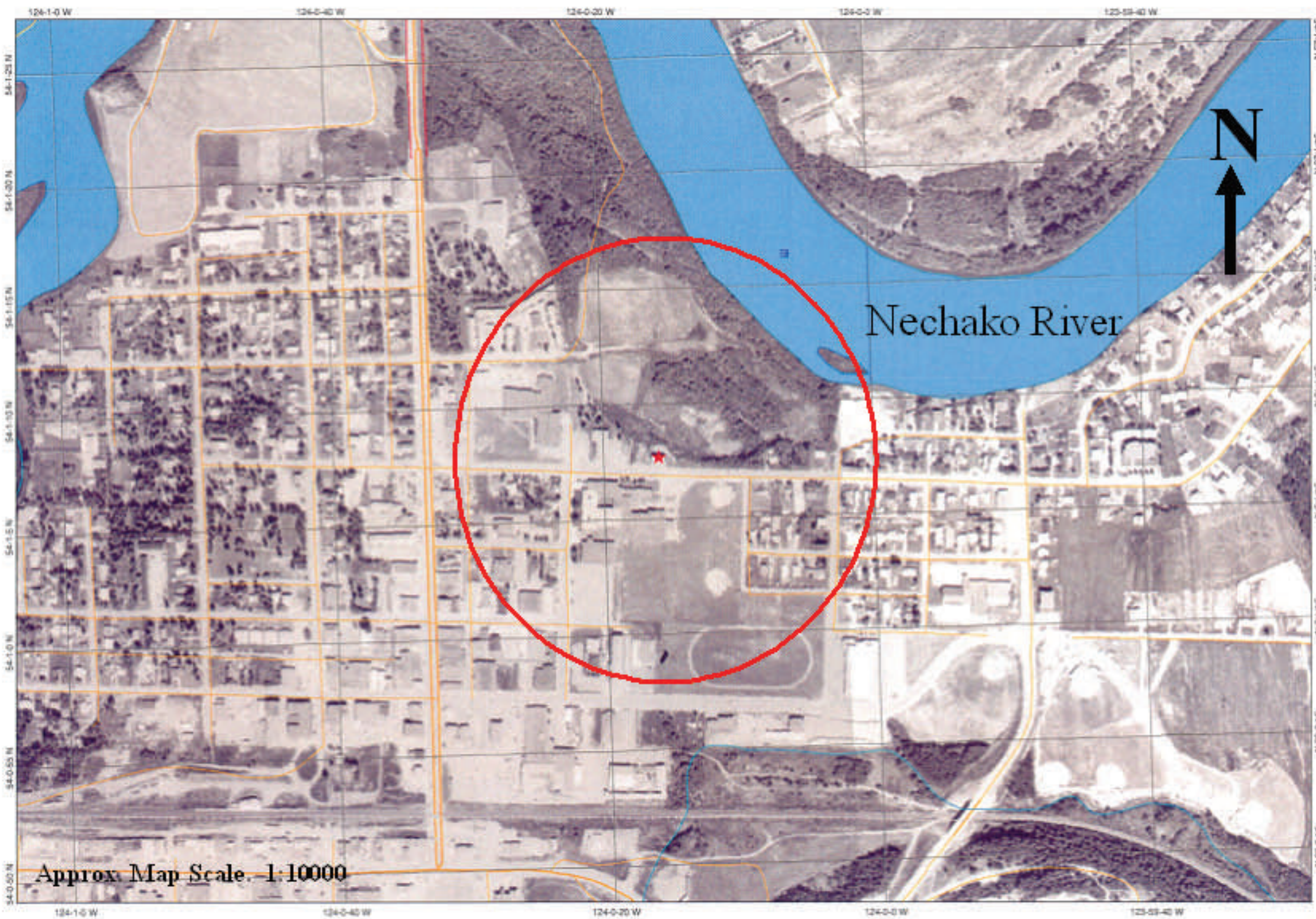

Figure 1. Air photo of Vanderhoof South water well and nearby land use practices. A 300 m radius surrounds the well indicating the zone from which contamination is most probable to occur.

Site Description

Watershed Overview

The community of Vanderhoof is located approximately 100km west of Prince George on Highway 16. This area lies within the Sub-Boreal Spruce biogeoclimatic zone, which is characterized by gently rolling terrain, dense coniferous forests and extremes in the annual temperature range of -40°C to 30°C (B.C. Ministry of Forests, 1998). However, a large proportion of the land surrounding the Vanderhoof water well has been developed for urban use (Figure 1).

According to Mr. Ian Lesly, a water purveyor for the community, the current withdrawal rate from the water well is approximately 3300 litres/minute. The well log data collected during drilling indicates the ground surrounding the well has an abundance of clay and other fine material (Table 1), with a depth of approximately 639 feet. Lithology profiles that are composed of clay, silts and hardpan layers generally have a low permeability, which should help retard the flow rate of contaminants to the ground water table. This is beneficial compared to an aquifer composed of dominantly sands and gravels, which allow materials to percolate at a much faster rate.

There are two waste disposal permits in the Vanderhoof area, including the community's sewage effluent discharge to the Nechako River (PE 00296) and the Municipal landfill (PR 3387). Both of these discharges are located over a kilometre from the drinking water well, and are not expected to impact the Vanderhoof drinking water supply.

Table 1. Lithology profile from the Vanderhoof South community well (well tag number 19912). Data from the aquifer database of B.C..

Depth (Ft)	Grain Size	Depth (Ft)	Grain Size
0-3	Sandy with a little clay	549-550	Brown clay very
3-90	Sandy clay blue	550-560	Silty sand
90-110	Sandy brown clay	560-562	Clay with gravel
110-146	Brown hard clay	562-568	Green till
146-283	Brown clay	568-569	Green till
283-369	Luvial clay soft brown	569-585	Green clay
369-435	Brown clay with silt	585-590	Hardpan
435-445	More sandy formation	590-593	Clay sticky
445-468	Fine sand, few feet silt	593-594	Sandy clay
468-488	Brown clay	594-598	Silt and gravel
488-495	Sand	598-608	Hard brown clay
495-503	Coarser gravel and clay	608-613	Sandy clay/coarse
503-515	Blue clay/fine gravel	613-624	Coarse sand
515-523	Hardpan with gravel/sand	624-633	Hardpan
523-538	Blue clay with gravel	633-639	Hardpan with fine
538-549	Green till		

Drinking Water Supply & Treatment

Vanderhoof draws its domestic water from a ground water supply, consisting of one well. The well is located beside the water treatment building, approximately 250m from the Nechako River. As measured with a hand held GPS unit, the geographic co-ordinates of the pump house are 54° 1' 7.7"N/124° 0' 15.9"W. From the pump station the water is piped into two holding reservoirs (which have a combined capacity of approximately 650,000 Imperial Gallons), and then distributed throughout the community to the 879 household connections. The community currently uses potassium permanganate filtration to treat their source water for high iron and manganese levels.

There are some concerns regarding the source water supply, as indicated by Mr. Lesly. These concerns include: the two water reservoirs have a holding time of only one day; the water has high manganese levels; there is a recently discovered hole in the well casing at approximately 43 feet, which is allowing silt to enter the raw water. This last concern is currently being addressed, as a new well (located beside the current well) should be in place by the fall of 2005.

Materials & Methods

Review of Previous Data

Historical data relevant to the Vanderhoof South raw water supply assessment have been included in this report. The data were copied from Northern Health Authority files and are from 2002 through 2005.

Sample Collection & Analyses for the 2004/05 Water Monitoring Program

Water Quality

An experienced B.C. Environment staff member collected water samples in laboratory certified polyethylene bottles for a variety of chemical and bacterial analyses. Representative grab samples were collected from the raw water tap (Plate 2) inside the pump house (EMS site E257074).

Bottles used for general ion analyses were rinsed three times with source water prior to sample collection. Metal and bacterial bottles were not rinsed and metal samples were lab preserved. Prior to sampling the raw water tap, the source was flushed for 5 minutes in order to minimize contamination by system piping. Water samples were shipped by overnight courier in coolers with ice packs to JR Laboratories Inc. for bacteria and Maxxam Analytical Services for chemistry. Bacterial samples were analysed using membrane filtration. Metals analysis made use of ICPMS technology.

Plate 2. The raw water tap inside the Vanderhoof pump house.

Quality Assessment (QA)

To ensure accuracy and precision of data, quality assurance and control (QA/QC) procedures were incorporated into the monitoring program. This included use of rigorous sampling protocols, proper training of field staff, setting of data quality objectives and the submission of QA samples to the lab. Field QA included duplicate and blind blank samples.

Blank samples detect contamination introduced in the field and/or in the lab. A comparison of duplicate results measures the effect of combined field error, laboratory error and real between-sample variability. The blind blank and duplicate program accounted for roughly 25% of the overall chemistry and bacterial sample numbers.

Results

Review of Previous Data

Bacteriology

The NHA sampled Vanderhoof South for both total and fecal coliforms at ten locations (P&H Extension, 2991 Riverview Drive, L&M Extension, Ministry of Forest Office, Omineca Laundry Tub, 4th Street, Public Works Shop, Vanderhoof Arena, Pumphouse-Victoria Street, Filter Run 2) throughout the water distribution system between 2002 and 2005.

Of the 274 total samples colleted, total coliforms were found above the level of detection on two dates. On August 11th, 2003 the total coliform concentration was 100 CFU/100mL, detected at 2991 Riverview Drive. On January 27th, 2005 the total coliform concentration was 1 CFU/100mL, detected at L&M Extension. These exceedances, especially the 100 CFU/100mL, suggest contamination in the distribution system. However, all subsequent samples collected at these locations found no bacteria. The exceedance of 1 CFU/100mL is just above the detection limit, and may be due to holding temperatures, holding times or QA error. Regardless, because Vanderhoof uses no form of disinfection, continued bacterial monitoring should occur.

Water Monitoring Program (2004/05)

Quality Assessment (QA)

The field blank and duplicate results indicate that no field or lab contamination of samples with bacteria occurred and that acceptable precision in bacterial sampling and analysis was observed.

The three water chemistry field blank samples that were prepared the same day of the Vanderhoof collections tested positive for some parameters. The concentration of most of these parameters was either very close to or less than 5-fold the minimum detectable concentration, an acceptable threshold as per the lab acceptance criteria. Copper exceeded these acceptance criteria significantly on two dates (Table 2).

Table 2. Blind blank samples that tested strongly positive (≥ 5-fold MDL) for chemical contamination.

Date	Parameter	Measured Concentration	MDL
Dec. 1/04	Copper-Total	0.53 µg/L	0.05 µg/L
Mar. 3/05	Copper-Total	0.35 µg/L	0.05 µg/L

The copper contamination that did occur may have resulted during the de-ionization process in the lab or during the transfer of the de-ionized water between bottles in the field. Copper data for these two dates was excluded from interpretation. All other water quality parameters met QA requirements and were used in this program.

The water chemistry duplicate samples that were prepared either the same day or within one day of the Vanderhoof collections did have one phosphorus value outside the lab acceptance criteria of 25% relative percent difference. This difference may be due to problems with collection and/or analytical precision. Because of this exceedance, the phosphorus data on that particular date was considered unreliable and excluded from interpretation.

Bacteriology

The 2004/05 bacterial data are summarised in Table 3. Drinking water quality guidelines for *E. coli, Enterococci* and fecal coliforms are 0 CFU/100mL for raw water supplies that undergo no treatment (although potassium permanganate is used to treat the high iron and manganese levels, no disinfection is used for bacteria).

Table 4. 2004/05 sample parameters, summaries of current results and associated B.C. drinking water guidelines.

Parameter	*n*	Min.	Max.	Mean	Median	Std. Dev.	MDL	Guideline	Guideline Type
General									
pH	5	8.2	8.4	8.3	8.3	0.08	0.1	6.5-8.5	aesthetic objective
Colour (TCU)	5	5.0	5.0	5.0	5.0	0.00	5	≤ 15	aesthetic objective
Specific Conductance (μS/cm)	5	690	702	698	700.5	4.90	1	≤ 700	maximum acceptable concentration
Turbidity (NTU)	5	0.31	30.4	6.39	0.4	13.42	0.1	≤ 1	maximum acceptable concentration
Hardness Total (mg/L)	5	306	335	315	310	13.5			maximum acceptable concentration
Hardness Total -Diss. (mg/L)	0							≤ 500 $CaCO_3$	aesthetic objective
Alkalinity (mg/L)	5	369	385	374	372	6.38	0.5		
Residue Non-Filterable (mg/L)	5	4.0	68.85	16.97	4.0	29.00	4		
Total Organic Carbon (mg/L)									
TOC	5	0.6	2.3	1.5	1.5	0.68	0.5	≤ 4	maximum, to control THM production
Anions (mg/L)									
Chloride Dissolved	5	1.1	1.6	1.27	1.2	0.199	0.5	≤ 250	aesthetic objective
Fluoride Dissolved	5	0.42	0.51	0.462	0.5	0.041	0.01		
Bromide Dissolved	5	0.1	0.1	0.10	0.1	0.00	0.1		
Nutrients (mg/L)									
Nitrate+Nitrite	5	0.004	0.009	0.007	0.0	0.003	0.002	≤ 45 (Nitrate)	maximum acceptable concentration
Phosphorus Total	4	0.116	0.164	0.135	0.1	0.022	0.002	≤ 1.5	maximum acceptable concentration
Sulphate (mg/L)									
Sulphate		29.8	30.2	29.93	29.9	0.17	0.5	≤ 500	aesthetic objective
Metals Total (μg/L)									
Aluminum-T	5	0.4	316.5	64.3	1.3	141.00	0.3		
Antimony-T	5	0.024	0.032	0.028	0.03	0.003	0.005	≤ 6	interim maximum acceptable concentration
Arsenic-T	5	6.8	7.65	7.25	7.2	0.335	0.1	≤ 25	interim maximum acceptable concentration
Barium-T	5	82.6	98.85	88.59	87.5	6.20	0.02	≤ 1000	maximum acceptable concentration
Beryllium-T	5	<0.02	0.05	0.03	0.02	0.013	0.02		
Bismuth-T	5	<0.02	<0.02	<0.02	<0.02	0.000	0.02		
Cadmium-T	5	<0.01	0.03	0.02	0.02	0.007	0.01	≤ 5	maximum acceptable concentration
Calcium-T (mg/L)	5	57	82.3	73.5	75.7	9.63	0.05		
Chromium-T	5	<0.2	<0.2	<0.2	<0.2	0.00	0.2	≤ 50	maximum acceptable concentration
Cobalt-T	5	0.026	0.371	0.104	0.030	0.150	0.005		
Copper-T	3	<0.05	0.86	0.22	0.06	0.358	0.05	≤ 1000	aesthetic objective
Iron-T (mg/L)	5	0.104	0.135	0.118	0.120	0.016	0.005	≤ 0.3	aesthetic objective
Lead-T	5	<0.01	0.46	0.11	0.01	0.201	0.01	≤ 10	maximum acceptable concentration
Lithium-T	5	5.11	6.46	5.88	5.9	0.511	0.05		
Magnesium-T (mg/L)	5	28.4	30.4	29.2	29.2	0.73	0.05		
Manganese-T	5	528	639	600	622	45.2	0.008	≤ 50	aesthetic objective
Molybdenum-T	5	11	12.7	11.8	12.0	0.72	0.05	≤ 250	maximum acceptable concentration
Nickel-T	5	<0.05	0.38	0.12	0.05	0.150	0.05		
Selenium-T	5	<0.2	0.3	0.2	0.2	0.06	0.2	≤ 10	maximum acceptable concentration
Silver-T	5	<0.02	<0.02	<0.02	<0.02	0.000	0.02		
Sodium-T (mg/L)	5	35.5	36.9	36.5	36.8	0.66	0.05	≤ 200	aesthetic objective
Strontium-T	5	598	708	662	675	45.1	0.005		
Thallium-T	5	<0.01	0.04	0.02	0.01	0.01	0.002	≤ 2	maximum acceptable concentration
Tin-T	5	<0.01	0.02	<0.01	0.01	0.005	0.01		
Uranium-T	5	7.53	8.52	7.873	7.68	0.400	0.002	≤ 100	maximum acceptable concentration
Vanadium-T	5	0.06	1.10	0.27	0.1	0.467	0.06	≤ 100	maximum acceptable concentration
Zinc-T	5	<0.1	1.3	0.3	<0.1	0.54	0.1	≤ 5000	aesthetic objective

As seen in Table 3, no bacteria were detected during this sampling program. However, continued bacterial sampling should take place on a regular basis to ensure no microbial contaminants are entering the well via any faults in the system.

Table 3. Results of bacterial analyses for the Vanderhoof South water supply. Units are CFU/100mL.

Date	Total Coliform	*E. coli*	*Enterococci*	Fecal Coliform
Provincial Guideline	No Provincial Guideline	0 CFU/100 mL	0 CFU/100 mL	0 CFU/100 mL
May 20/04	<1	<1	<1	<1
Aug. 23/04	<1	<1	<1	<1
Dec. 1/04	<1	<1	<1	<1
Mar. 3/05	<1	<1	<1	<1
Jun. 22/05	<1; <1	<1; <1	<1; <1	<1; <1

Water Chemistry

In 2004/05, ground water samples were collected on five dates. The water samples were analysed for 15 general parameters as well as for the ICPMS low level metals package that includes 27 metals in the total form (Table 4).

Of the chemical and physical parameters tested through the duration of this study, six are of note.

Specific Conductance (µS/cm) - The mean specific conductance was 698µS/cm, just below the recommended guideline of 700µS/cm. High specific conductivity values indicate a high ion concentration, which can be related to the dissolved solids content of the ground water.

Arsenic-Total (µg/L) - The mean total arsenic concentration was 7.25µg/L with a maximum of 7.65µg/L, well below the interim drinking water guideline of 25µg/L; however, approaching the new guideline of 10µg/L that has been adopted by the US EPA for 2006, and is currently being used by the World Health Organization. Arsenic is a documented human carcinogen, and is found naturally in many areas due to the local geology.

Manganese, Total (µg/L) - The mean manganese concentration was 600µg/L with a maximum of 640µg/L, both far exceeding the aesthetic objective of 50µg/L. Manganese can colour water (it forms a black precipitate) and form colloidal material that can be difficult to remove. Furthermore, this black precipitate can create an unpleasant taste in the water, as well as allowing an increased growth of unwanted manganese bacteria that can form slimy layers on system piping (British Columbia Ground Water Association, 2002). Manganese is found naturally in many water supplies originating from the weathering and dissolution of natural rocks and minerals, with anthropogenic sources including industrial effluents, fertilizers, gasoline (manganese is an additive), as well as many other sources.

Hardness, Total (mg/L $CaCO_3$) - Water hardness, which can often be an aesthetic problem in ground water supplies, had a mean concentration of 315mg/L $CaCO_3$. This is considered very hard (>180mg/L $CaCO_3$) and above the optimum range of 60-120mg/L $CaCO_3$ for a drinking water supply. This hardness is mainly due to the presence of calcium and magnesium in the water. Hard water can reduce the toxicity of some metals, but can also leave scale deposits on piping (RIC, 1998). Some anthropogenic sources that contribute to water hardness include mining and industrial effluents (not necessarily applicable to Vanderhoof). High hardness values also occur naturally due to the local geology, as is the case here.

Sodium, Total (mg/L) - The mean sodium concentration was 36mg/L, well below the recommended drinking water guideline of 200mg/L; however, just above the 20mg/L alert level for people on sodium restricted diets. Natural sources of sodium include the weathering of salt deposits and contact of water with igneous rock. Anthropogenic sources include road salts, sewage and industrial effluents and the use of sodium products in corrosion control and water softening products (Health Canada, 1992).

The data from 2004/05 indicates that most chemical and physical parameters in the Vanderhoof south water supply have a low concentration compared to drinking water guidelines. There do however appear to be potential issues regarding specific conductance, total manganese, water hardness and sodium (for those people on sodium restricted diets).

A complete list of the raw data from the 2004/05 program is available on request.

Conclusions & Recommendations

Review of the Vanderhoof ground water data indicates an overall good raw drinking water quality. Most water soluble contaminants were present at concentrations well below drinking water guidelines. Some parameters were detected at levels over recommended water quality guidelines, including specific conductance, total manganese and sodium. The current water treatment system (potassium permanganate) should help decrease most of these, specifically manganese, iron and arsenic. However, it may be of interest for the community to test the treated water supply for these three parameters to evaluate the effectiveness of their treatment system.

The June 22nd, 2005 data shows a large increase in many parameter concentrations. This is attributable to the defect in the well casing at approximately 43ft. This defect has decreased the water quality in the well, and has allowed the system to become more vulnerable to possible contamination. A new well will replace this well in the fall of 2005, and should produce similar water quality to the first four samples collected in this program. It is recommended that sufficient water quality sampling, including both chemical and biological parameters, is undertaken on the new water supply.

Based on a lack of hydrogeological information regarding the well, a 300m radius has been arbitrarily assigned as the source from which contamination is most likely (Mike Wei, Senior Hydrogeologist, B.C. Environment, p.c.). Since the well is over 600 ft deep and the lithology profile is dominated by silts, clays and hardpan layers, the aquifer probably has a low permeability and should be more buffered against land use activities compared to a ground composed of sands and gravels. However, as mentioned the current well is already vulnerable to contamination due to the defect in the well casing. A future site inspection may be beneficial so that possible contamination sources that are located nearby are known.

Because the Vanderhoof South water supply currently uses no form of microbial water treatment (i.e. disinfection), it is also recommended that periodic bacterial samples are collected to ensure that levels do not exceed recommended drinking water guidelines of 0 CFU/100mL.

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