Aspen Mobile Estates Drinking Water Supply:
Source Water Characteristics

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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 per capita 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.

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, 18 community water supplies in the Omineca-Peace region were selected for monitoring during 2002/03, with four or more sites being selected each subsequent year.

This brief report will summarise water quality data collected from Aspen Mobile Estates raw potable water source (ground water) (Figure 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.

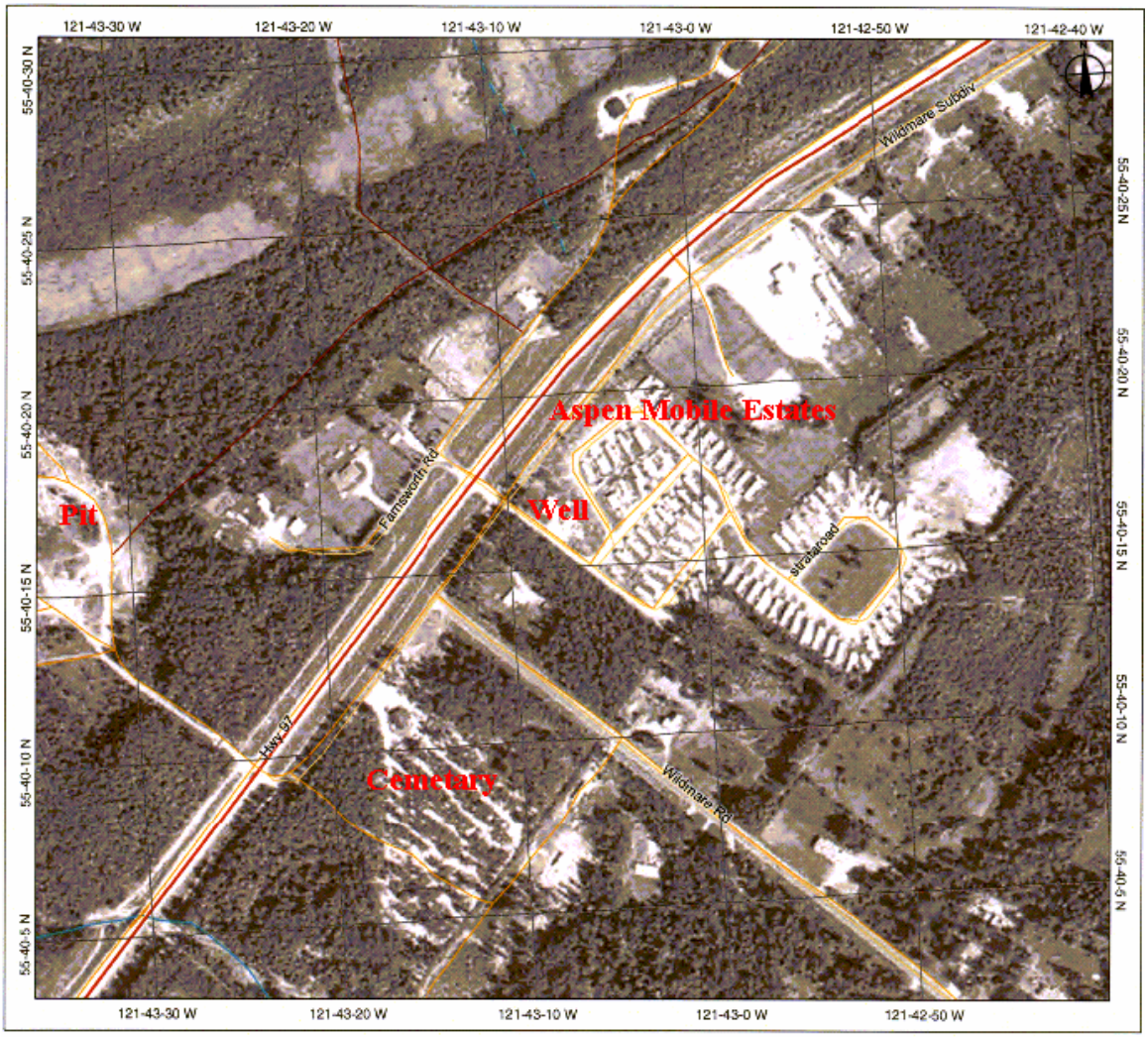

Figure 1. Aspen Mobile Estates overview map. Note the surrounding land use activities including urban development, a major highway, a large open pit and a cemetery. The map scale is 1:5000.

Site Description

Watershed Overview

Aspen Mobile Estates is located approximately 5km south of Chetwynd, B.C. The drinking water supply consists of one well, located near the parks main office. This area lies within the Boreal White and Black Spruce biogeoclimatic zone, which is characterized by rolling topography, long and cold winters and a landscape composed of black spruce bogs intermixed with stands of white spruce and trembling aspen at higher elevations (B.C. Ministry of Forests, 1998).

The predominant land use activity surrounding the trailer park includes urban and rural development, as well as a large pit and a cemetery. Most of these sources are located greater than 200m from the water well.

The Aspen Mobile Estates well is located in aquifer #627, which is approximately 6.45km^2 in size. Information on the aquifer suggest it to be a bedrock (shale) deposit confined by an overlying clay layer with some till deposits. It has been given a IIIB

rating according to the British Columbia Aquifer Classification System, which suggests a moderately vulnerable aquifer with a low demand.

According to the well log, the lithology includes a 25ft (7.6m) layer of sand and gravel, followed by 335ft (102m) of clay and another 20ft (6.1m) of shale. This thick clay layer suggests the ground to have a very low permeability, which should help retard the flow rate of contaminants to the aquifer the well is located in. However, according to the aquifer report, there are wells in the area that have a much thinner confining layer (0.61m or 2ft) where contamination is more likely to occur.

According to Mr. Ernest Rowe, the caretaker of the park, the current production of the water well is 12-15 gallons per minute (GPM). The well is approximately 380ft (166m) deep, with the casing set at 360ft (110m). The water table level is approximately 11ft (3.4m) down from the surface, with a draw down of 7ft (2.1m) at 10GPM.

There is a waste disposal permit at Aspen Mobile Estates, which allows for the discharge of sewage waste to the ground. However, according to the waste disposal permit, this discharge is located downstream of the ground water flow. Therefore, the discharge should not have an impact on the drinking water well.

Drinking Water Supply & Treatment

Aspen Mobile Estates draws its domestic water from a ground water supply consisting of one well. The well is located beside the parks office, at the approximate UTM co-ordinates 10U 580594, 6170233. The water comes up from the well into a small aerator and is subsequently pumped to approximately 300 people. Current water treatment includes disinfection with a 12% liquid chlorine. Furthermore, as the water enters the aerator, the dissolved iron precipitates out and is removed manually by a scoop (Figure 2).

The caretaker of Aspen Mobile Estates does not currently have any quantity concerns regarding the water supply; however, he does have some quality issues. More specifically, elevated levels of barium, sodium and specific conductance have been problematic in the past.

Materials & Methods

Sample Collection & Analyses for the 2005/06 Water Monitoring Program

An experienced MOE 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 well at the aerator.

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. Water samples were shipped by overnight courier in coolers with ice packs to Cantest Laboratories Inc. for bacteria and Maxxam Analytical Services for chemistry. Bacterial samples were analysed using membrane filtration. Metals analysis made use of ICPMS technology.

Figure 2. View of the Aspen Mobile Estates well aerator. The raw water is pumped up from the well and sprayed into this holding reservoir. A chlorine drip disinfects this water before it is distributed throughout the park. The red staining around the holding reservoir is from high iron levels in the water.

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 (DQO) 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 10% of the overall chemistry and bacterial sample numbers.

Results

Water Monitoring Program (2005/06)

Quality Assessment (QA)

The field blank and duplicate results indicate that minimal field or lab contamination of samples with bacteria occurred and that acceptable precision in bacterial sampling and analysis was observed.

The water chemistry field blank and replicate samples were all considered to be of good

quality. There were no blanks that exceeded the lab acceptance criteria of 5 times the minimum detectable limit (MDL) and no replicates exceeding our set objective of 25% relative percent difference.

Since there were no DQO exceedances during this sampling program, all data are considered to be of good quality and suitable for review.

Bacteriology

The 2005/06 bacterial data are summarised in Table 1.

Drinking water quality guidelines for *E. coli*, *Enterococci* and fecal coliforms are 0 CFU/100mL for source (raw) water supplies that undergo no treatment. When disinfection is used, as is the case with Aspen Mobile Estates, the recommended guideline for source (raw) is less than or equal to 10 CFU/100mL, 3 CFU/100mL and 10 CFU/100mL 90th percentile for *E.coli*, *Enterococci* and fecal coliforms, respectively. Treated water samples were not tested during this program.

As seen in Table 1, no bacteria were detected during this sampling program. This suggests that no fecal waste is entering the well supplying Aspen Mobile Estates, at least during this program.

Table 1. Results of bacterial analysis for Aspen Mobile Estates source water. Results are in CFU/100mL.

Date	Total Coliforms	*E.coli*	*Enterococci*	Fecal Coliforms
Provincial Guideline	0 CFU/100mL	10 CFU/100mL 90th Percentile	3 CFU/100mL 90th Percentile	10 CFU/100mL 90th Percentile
10/06/05	<1	<1	<1	<1
11/01/05	<1	<1	<1	<1
03/22/06	<1; <1	<1; <1	<1; <1	<1; <1
05/16/06	<1	N/A	<1	<1
08/02/06	<1	<1	<1	<1

Water Chemistry

In 2005/06, ground water samples were collected on five dates. The water samples were analysed for general parameters as well as for the ICPMS low level metals package that includes metals in the total and dissolved form (Table 2).

Of the chemical and physical parameters tested through the duration of this study, three consistently exceeded the provincial guidelines for raw drinking water and one was of note.

Barium, Total (µg/L) - The mean and maximum barium concentrations for the year were 3277 and 3585µg/L, respectively. The provincial drinking water guideline is 1000µg/L. Barium can cause short term gastrointestinal disturbances and muscular weakness, and long term high blood pressure problems (EPA, 2002). The main anthropogenic use of barium (the mineral barite) is during the drilling of oil and gas wells. It is used as a mud to aid in the support of drill rods, and to help prevent the blow out of gas (Klein and Hurlbut, Jr., 1999). Barite is also found naturally in many locations.

Sodium, Total (mg/L) - The mean sodium concentration was 288.3mg/L, above the current recommended aesthetic drinking water guideline of 200mg/L. Sodium is not toxic. The taste of water generally becomes unpleasant when concentrations exceed 200mg/L, resulting in the guideline level. However, to maintain a daily sodium intake of 500mg/day, which is generally the case for people on sodium restricted diets, the drinking water concentration needs to be less than 20mg/L. 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).

Specific Conductance (µS/cm) - The mean specific conductance was 1310µS/cm, exceeding 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 water. High concentrations can affect the palatability of water.

pH (pH units) – The pH drinking water guideline maximum of 8.5 was exceeded during two of the five sample rounds. Elevated pH levels tend to promote the incrustation and scaling of system piping. Furthermore, the effectiveness of chlorine disinfection can be reduced. The mean pH concentration during this program was 8.5.

The data from 2005/06 suggests that most chemical and physical parameters in the Aspen Mobile Estates water supply have a low concentration compared to drinking water guidelines. However, barium and sodium continually exceeded the recommended guidelines.

Table 2. Results of chemical analysis for Aspen Mobile Estates source water.

	Units	MDL	Sample Date 06/10/2005	Sample Date 11/01/2006, 13:15	Sample Date 03/22/2006, 10:30	Sample Date 03/22/2006, 10:31	03/22/2006 AVERAGE	Sample Date 05/16/2006	Sample Date 08/02/2006	DW Guideline	DW Guideline Type
Bacteria											
Total Coliforms	CFU/100mL	<1	<1	<1	<1	<1	<1	<1	< 1	<10	
Fecal Coliforms	CFU/100mL	<1	<1	<1	<1	<1	<1	<1	< 1	<1	
E.Coli	CFU/100mL	<1	<1	<1	<1	<1	<1		< 1	<1	
Enterococci	CFU/100mL	<1	<1	<1	<1	<1	<1	<1	< 1	<1	
Misc. Inorganics											
Bromide (Br)	mg/L	0.1	0.4	<0.1	0.4	0.4	0.4	0.3	<0.1		
Fluoride (F)	mg/L	0.01	0.7	0.79	0.87	0.85	0.86	0.74	0.62	1.5	Maxium
Preparation											
Filter and HNO3 Preservation	N/A	N/A	YES	YES	YES	YES		Yes	Yes		
Calculated Parameters											
Total Hardness (CaCO3)	mg/L	0.5	67	70	68	64	66	69	72		
Misc. Inorganics											
Dissolved Hardness (CaCO3)	mg/L	0.5	67	70	68	64	66	69	72	500	Unacceptable
Alkalinity (Total as CaCO3)	mg/L	0.5	516	680	521	523	522	522	521		
Total Organic Carbon (C)	mg/L	0.5	0.8	<0.5	0.8	0.7	0.75	<0.5	0.6	4	Max when chlorination
Anions											
Dissolved Sulphate (SO4)	mg/L	0.5	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	500	Aesthetic
Dissolved Chloride (Cl)	mg/L	0.5	35.7	387	41	41.8	41.4	35.6	38.9	250	
Dissolved Metals by ICPMS											
Dissolved Aluminum (Al)	ug/L	3	<3	15	<0.3	<0.3	<0.3	0.6	0.5	200	Maxium
Dissolved Antimony (Sb)	ug/L	0.05	<0.05	<0.05	0.01	0.012	0.011	<0.005	0.006		
Dissolved Arsenic (As)	ug/L	1	<1	<1	0.4	0.2	0.3	0.2	0.3		
Dissolved Barium (Ba)	ug/L	0.2	2970	3500	3350	2960	3155	2860	2740		
Dissolved Beryllium (Be)	ug/L	0.2	<0.2	<0.2	<0.02	<0.02	<0.02	<0.02	<0.02		
Dissolved Bismuth (Bi)	ug/L	0.2	<0.2	<0.2	<0.02	<0.02	<0.02	<0.02	<0.02		
Dissolved Cadmium (Cd)	ug/L	0.1	0.1	0.1	0.01	0.01	0.01	0.02	0.02		
Dissolved Chromium (Cr)	ug/L	2	<2	<2	<2 (1)	<2 (1)	<2	<2 (1)	<5 (1)		
Dissolved Cobalt (Co)	ug/L	0.05	<0.05	0.06	0.021	0.014	0.0175	0.015	0.007		
Dissolved Copper (Cu)	ug/L	0.5	<0.5	<0.5	<0.5 (1)	<0.5 (1)	<0.5	<0.5 (1)	<5 (1)		
Dissolved Lead (Pb)	ug/L	0.1	<0.1	0.8	<0.01	<0.01	<0.01	<0.01	<0.01		
Dissolved Lithium (Li)	ug/L	0.5	397	457	458	390	424	527	521		
Dissolved Manganese (Mn)	ug/L	0.08	4.35	1.41	3.87	3.47	3.67	4.71	4.29		
Dissolved Molybdenum (Mo)	ug/L	0.5	4	6.9	6.42	5.7	6.06	5.96	7.23		
Dissolved Nickel (Ni)	ug/L	0.5	<0.5	<0.5	<0.05	<0.05	<0.05	<0.05	<0.05		
Dissolved Selenium (Se)	ug/L	2	<2	<2	<0.2	<0.2	<0.2	<0.2	<0.2		
Dissolved Silver (Ag)	ug/L	0.2	<0.2	<0.2	<0.02	<0.02	<0.02	<0.02	0.02		
Dissolved Strontium (Sr)	ug/L	0.05	385	435	391	356	373.5	379	318		
Dissolved Thallium (Tl)	ug/L	0.02	0.03	0.10	0.009	0.01	0.0095	<0.002	<0.002		
Dissolved Tin (Sn)	ug/L	0.1	<0.1		0.01	0.02	0.015	<0.01	0.01		
Dissolved Uranium (U)	ug/L	0.02	<0.02	<0.02	<0.002	<0.002	<0.002	0.01	0.003		
Dissolved Vanadium (V)	ug/L	0.6	<0.6	<0.6	0.2	0.24	0.22	0.18	<0.06		
Dissolved Zinc (Zn)	ug/L	1	<1	<1	<1 (1)	<1 (1)	<1	<1 (1)	<50 (1)		
Leachable Metals											
Total Aluminum (Al)	ug/L	3	<3	16	3.7	2.2	2.95	7.6	1		
Total Antimony (Sb)	ug/L	0.05	<0.05	<0.05	0.017	0.014	0.0155	<0.005	<0.005	6	Interim Maxium
Total Arsenic (As)	ug/L	1	<1	<1	0.4	0.3	0.35	0.2	0.2	10	Interim Maxium
Total Barium (Ba)	ug/L	0.2	3430	3580	3610	3560	3585	3310	2480	1000	Maxium
Total Beryllium (Be)	ug/L	0.2	<0.2	<0.2	0.02	<0.02	0.02	<0.02	<0.02	4	EPA Guideline
Total Bismuth (Bi)	ug/L	0.2	<0.2	<0.2	<0.02	<0.02	<0.02	<0.02	<0.02		
Total Cadmium (Cd)	ug/L	0.1	0.1	0.2	0.01	0.01	0.01	0.02	0.01	5	Maxium
Total Chromium (Cr)	ug/L	2	<2	<2	<2 (1)	<2 (1)	<2	<2 (1)	<5 (1)	50	Maxium
Total Cobalt (Co)	ug/L	0.05	<0.05	0.08	0.022	0.018	0.02	0.016	0.005		
Total Copper (Cu)	ug/L	0.5	<0.5	<0.5	<0.5 (1)	<0.5 (1)	<0.5	<0.5 (1)	<5 (1)	1000	Maxium
Total Lead (Pb)	ug/L	0.1	<0.1	1.0	0.03	0.03	0.03	<0.01	0.01	10	Maxium
Total Lithium (Li)	ug/L	0.5	442	482	504	505	504.5	579	520		
Total Manganese (Mn)	ug/L	0.08	5.42	5.71	4.25	4.15	4.2	5.08	4.18	50	Aesthetic
Total Molybdenum (Mo)	ug/L	0.5	4.8	7.0	6.88	6.9	6.89	6.5	6.12	250	Maxium
Total Nickel (Ni)	ug/L	0.5	<0.5	1.0	<0.05	<0.05	<0.05	<0.05	<0.05		
Total Selenium (Se)	ug/L	2	<2	<2	<0.2	<0.2	<0.2	<0.2	<0.2	10	Maxium
Total Silver (Ag)	ug/L	0.2	<0.2	0.4	<0.02	<0.02	<0.02	<0.02	<0.02		
Total Strontium (Sr)	ug/L	0.05	444	442	436	431	433.5	429	307		
Total Thallium (Tl)	ug/L	0.02	0.04	0.10	0.01	0.009	0.0095	<0.002	<0.002	2	EPA Guideline
Total Tin (Sn)	ug/L	0.1	<0.1	0.2	0.03	0.03	0.03	0.02	0.01		
Total Uranium (U)	ug/L	0.02	<0.02	<0.02	<0.002	<0.002	<0.002	0.016	0.002	100	Maxium
Total Vanadium (V)	ug/L	0.6	<0.6	1.3	0.3	0.35	0.325	0.4	0.07		
Total Zinc (Zn)	ug/L	1	<1	<1	<1 (1)	<1 (1)	<1	<1 (1)	<50 (1)	5000	Aesthetic
MISCELLANEOUS											
True Colour	Col. Unit	5	5	<5	<5	<5	<5	<5	<5	15	Aesthetic
Nutrients											
Total Kjeldahl Nitrogen (Calc)	mg/L	0.02	0.8	0.04	0.65	0.71	0.68	0.77	0.77		
Total Organic Nitrogen (N)	mg/L	0.02	0.14	0.04	0.12	0.13	0.125	0.1	0.11		
Dissolved Phosphorus (P)	mg/L	0.002	0.111	0.112	0.081	0.084	0.0825	0.092	0.075		
Ammonia (N)	mg/L	0.05	0.67	<0.5	0.53	0.59	0.56	0.67	0.66	Refer to tables	
Total Inorganic Carbon					134	135	134.5	133	196		
Nitrate plus Nitrite (N)	mg/L	0.002	0.005	0.159	0.004	<0.002	0.004	0.004	<0.002	10	
Total Nitrogen (N)	mg/L	0.02	0.81	0.20	0.65	0.71	0.68	0.78	0.77		
Total Phosphorus (P)	mg/L	0.002	0.111	0.106	0.097	0.103	0.1	0.144	0.108		
Physical Properties											
Conductivity	uS/cm	1	1030	2430	1050	1050	1050	1010	1030	700	Maxium
pH	pH Units	0.1	8.6	8.7	8.5	8.4	8.45	8.5	8.4	6.5-8.5	Aesthetic
Physical Properties											
Total Suspended Solids	mg/L	4	<4	<4	<4	<4	<4	<4	<4	Refer to tables	
Turbidity	NTU	0.1	1.0	0.9	0.7	0.7	0.7	0.6	0.8	1	Maxium
Dissolved Metals by ICP											
Dissolved Boron (B)	mg/L	0.008		0.193							
Dissolved Calcium (Ca)	mg/L	0.05	15.6	16.2	15.7	16.1	15.9	15.9	16.7		
Dissolved Iron (Fe)	mg/L	0.005	0.029	0.006	0.022	0.027	0.0245	0.023	<0.005	0.3	Aesthetic
Dissolved Magnesium (Mg)	mg/L	0.05	6.73	0.006	6.95	5.88	6.415	7.15	7.31	100	Aesthetic
Dissolved Phosphorus (P)	mg/L	0.1		0.2							
Dissolved Potassium (K)	mg/L	1		2							
Dissolved Sodium (Na)	mg/L	0.05		509							
Dissolved Sulphur (S)	mg/L	0.1		0.2							
Dissolved Titanium (Ti)	mg/L	0.003		<0.003							
Dissolved Zirconium (Zr)	mg/L	0.005		<0.005							
Total Metals by ICP											
Total Boron (B)	mg/L	<0.008		0.208							
Total Calium (Ca)	mg/L	0.05	15.6	16.0	16.2	14.7	15.45	15.9	15.5		
Total Iron (Fe)	mg/L	0.005	0.257	0.203	0.097	0.079	0.088	0.211	0.133		
Total Magnesium (Mg)	mg/L	0.05	6.72	7.03	6.88	6.31	6.595	7.15	6.85		
Total Phosphorus (P)	mg/L	1		0.2							
Total Potassium (K)	mg/L	1		2							
Total Sodium (Na)	mg/L	0.05	221	547	221	206	213.5	237	223	200	Aesthetic
Total Sulphur (S)	mg/L	0.1		<0.1							
Total Titanium (Ti)	mg/L	0.003		<0.003							
Total Zirconium (Zr)	mg/L	0.005		<0.005							

(1) MDL raised due to sample matrix interference.

Conclusions & Recommendations

Review of the Aspen Mobile Estates ground water data suggests some problems with the source water. More specifically, there were continual drinking water guideline exceedances by total barium, total sodium and specific conductance, with infrequent exceedances by pH. The US EPA (2002) suggests that barium may cause gastrointestinal disturbances, muscular weakness and high blood pressure. Conversely, there is no evidence to suggest that barium is a carcinogenic (WHO, 2004). As previously mentioned, sodium is not toxic. However, the current level which continuously exceeded the recommended guideline suggests the palatability of the water may be poor and that people on a sodium restricted diet should further treat their water. The source of the detected barium and sodium is likely natural, with other water samples collected in the area showing similar results.

Without doing a more detailed assessment on the well and aquifer in question, a 300m radius can be arbitrarily assigned as the zone where contamination is most likely to happen (Mike Wei, Senior Ground Water Hydrologist, MOE, p.c.). Since the lithology profile of the well suggests a 335ft clay layer, the aquifer is probably well buffered against potentially harmful land use activities. However, according to the aquifer classification sheet, the thick confining layer varies substantially throughout the aquifer, suggesting areas with a thinner clay layer may be more susceptible to possible contamination. Because of this, poor land use activities in close vicinity of the well (approximately 300m), as well as in areas with a thin confining layer are discouraged. Regardless, a 300m radius site assessment may still be useful to pinpoint possible contamination sources.

As previously mentioned, elevated barium levels appear to be common in the Chetwynd area, suggesting a natural origin. However, because the levels greatly exceed recommended drinking water guidelines, further treatment options may be recommended. These potential options should be discussed with the Northern Health Authority.

This study is one part of a broader water quality management program being carried out by the Environmental Quality Section in MOE's Omineca-Peace Region. The overall objectives of this program are to monitor water quality to identify problems, to determine causes, and to work with local governments, landowners and other interested parties to improve or otherwise protect water quality and aquatic life. Information sharing between governments, specifically MOE, the Northern Health Authority and various Regional and Municipal governments, is an ongoing practice.

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Contact Information

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- Ministry of Environment (Prince George) - James Jacklin, 250-565-4403
- Northern Health Authority (Dawson Creek) - Jimmy Yee, 250-719-6500

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