Drinking Water Quality (July 2013)
Preliminary Results
Pangnirtung, NU.

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Summary

This report describes the preliminary results obtained from the environmental assessment of the drinking water supply in Pangnirtung, which was conducted from July 24 to 28, 2013. In close collaboration with community members, inhabitants were interviewed regarding their views on the drinking water supply and habits of water usage. The interviews were held in both public buildings (5) and private homes (6). Samples of raw untreated water from the water reservoir, the adjacent river, and treated drinking water samples from water trucks and taps were also obtained to undergo chemical and microbiological testing for a panel of parameters, including chlorine and the content fecal indicator bacteria (i.e., total coliforms and *Escherichia coli*). Not included in this report are results from the on-going metal and in-depth microbiological testing and the findings from the interviews.

The main finding presented in this preliminary was that the levels of chlorine residuals in the freshly treated drinking water were in the lower spectrum of the recommended range (0.2-2.0 mg/L) in the drinking water. However, once the drinking water reached the building water tanks the residual chlorine disappeared, meaning that the chlorine demand of the water tanks was high. This may indicate that the water tanks contained organic material and/or biofilms (surface attached microbial communities) which "used" up the chlorine.

Coliform bacteria and *E. coli* were absent from all drinking water samples. Only two raw water samples contained coliform bacteria and none contained *E. coli*. This would indicate that during the study period there were no sources of fecal contamination affecting the water quality in the river and water catchment area supplying the water reservoir.

In conclusion, it is recommended that the treated drinking water leaving the WTP contains free chlorine levels of at least 0.2 mg/L to improve the protection of the drinking water during transportation and delivery (including during the resident time in the water tanks) to the community. Also, it is recommended that the water tanks are cleaned on a regular basis to ensure that a resident microbial biofilm population does not develop. Although very low levels of coliform bacteria and no *E. coli* were detected in the source water during the study period, it is still prudent to advise against the consumption of untreated water from the river.

1.0 Introduction

The typical model of potable water delivery in most Northern communities is fundamentally different than in Southern communities. In the North, water is extracted from lakes, rivers or glacier streams and either piped or trucked to water reservoirs within the town, from where it is trucked to community households and public buildings and stored in tanks. Depending on the community, chlorination for microbial control is performed either on discharge from the water reservoir, or directly within the water delivery truck. There are several points along the delivery train where water may become contaminated. Contaminants may be either microbial (bacteria, viruses, protozoa) or chemical (heavy metals, organics, disinfection by-products) in nature. The

management and maintenance of municipal as well as in-home infrastructures will presumably play a large role in the potential for water contamination.

The overall objective of this project is to monitor and better understand drinking water quality and potential sources of contamination from the original source (e.g., lake, river, glacier) to the tap (the point of human use) within Nunavut communities, including Pangnirtung.

This project was initiated in response to the interest in drinking water quality research voiced by Nunavut communities while team members from the Centre for Water Resource Studies (CWRS) at Dalhousie University and Nunavut Research Institute in Iqaluit were originally in the communities working on wastewater related research projects. It is important to note this is an exploratory research project designed to assess the drinking water quality and water delivery methods rather than to address known water quality issues.

2.0 Material and Methods

Water samples from the source-to-tap continuum in the drinking water supply in Pangnirtung, which is located on Baffin Island, NU, were collected over five days from July 24 to 28, 2013.

The source water in Pangnirtung comes from a man-made water reservoir located on the eastern edge of the hamlet (Figure 1). The water reservoir is mainly filled with water that is pumped from the adjacent river although snow/ice melt water may also contribute. The water level in the water reservoir must be stocked to an adequate level before freeze-up to ensure there being enough water for the winter season. As is indicated in Figure 1, raw water samples were obtained from the water reservoir at the intake to the water treatment plant (WTP) and across from the intake. The river was similarly sampled in two locations, one (River 1) close to where the water would be pumped to the water reservoir while the other upstream River 2 sampling site was found close to a point of easy road access. A sample of raw water was also obtained from a culvert located on a small stream feeding into the main river just upstream of the River 1 sampling site. Our interviews conducted with members of the community revealed that some locals occasionally drink the untreated river water. Also, young people were observed to swim in the river close to the sampling sites.

Treated (chlorinated) drinking water samples were obtained from the WTP, three water trucks and taps in five public buildings and six private homes. In the case of one of the public buildings, the same tap was sampled immediately before and after refilling of the water tank. The six private homes represented both private and public housing units of different ages and locations in the community.

At the time of sampling, household inhabitants and public building managers were interviewed about their views on the drinking water supply and habits of water usage to aid in contextualizing the water quality data. Also, the Municipal Water Foreman and several Water Truck Drivers were consulted regarding their typical work routines, the chlorination injection process that occurs at

the WTP, and their chlorine monitoring and record keeping protocol. The results of these interviews are not included in this preliminary report.

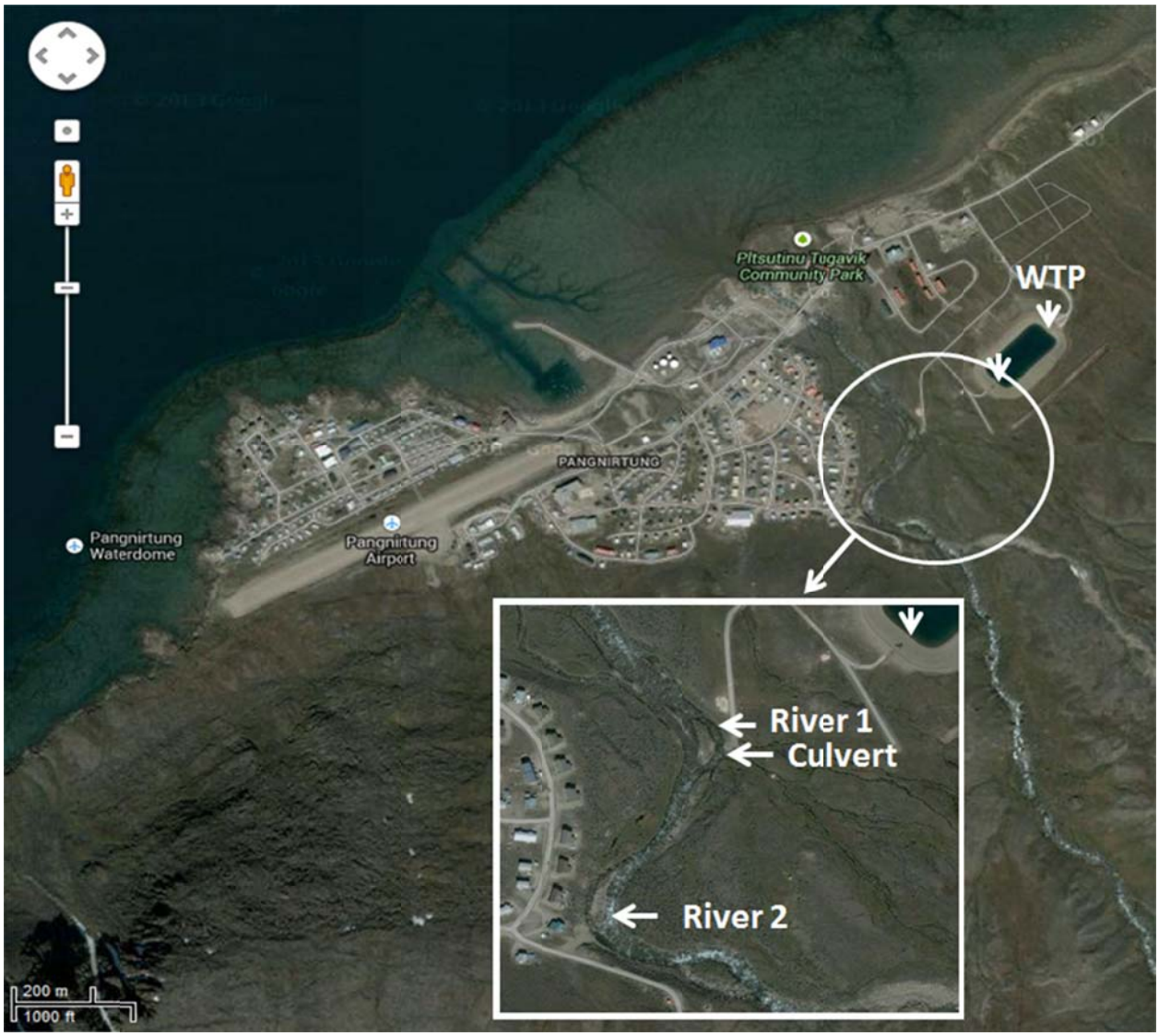

Figure 1. Aerial photo of Pangnirtung showing the location of the water reservoir, water treatment plant (WTP) and the source water river. The sampling sites located on the water reservoir by the intake to the WTP and across from the intake as well as on three different locations on the river are indicated by white arrows (source: Google Map).

2.1 Sample collection and analysis of water temperature, pH, conductivity and contents of chlorine (free and total)

Water samples were collected in 4 L plastic containers following rinsing of the container three times with the water sample.

Water reservoir and stream samples were obtained using a sampling pole with a sampling bottle strapped to the pole. Care was taken to obtain samples below the water surface in the case of the water reservoir and in "runs" of the river and culvert.

Before sampling the drinking water taps, the aerators were first removed followed by disinfection of the taps with a sanitizing napkin (Antibacterial Wipes, Life brand, Shoppers Drug Mart, Canada). The tap was then run for approximately one minute before sampling the drinking water.

On site measurements of the water temperature and pH were done using a handheld YSI sonde (Yellow Springs, OH, USA). All water samples were brought back to the field laboratory in Pangnirtung. Here, the contents of chlorine (free and total) were measured using a HACH Pocket Colorimeter II for Chlorine (HACH, Ames, IA, USA) and DPD pillows according to the manufacturer's instructions. The conductivity was measured using a calibrated Thermo Orion 5-Star apparatus (Fisher Scientific, Nepean, ON, Canada) equipped with a conductivity electrode.

Microbial cells from one litre of the water sample was concentrated onto a filter with a pore size of 0.45 µm to be subjected to DNA extraction in Iqaluit in our laboratory located at the Nunavut Research Institute. Sample volumes of approximately 40-50 mL were preserved with nitric acid for future metal analysis.

Following processing all samples were stored at 5°C and shipped to Iqaluit the same or next day for storage or analyses. The metal samples (5°C) and DNA extracts (-20°C) were finally transferred to our laboratory at Dalhousie University in Halifax, Nova Scotia for the final analyses which are still on-going at the time of writing this preliminary report.

2.2 Enumeration of coliforms and Escherichia coli

For determination of the total coliform and *E. coli* contents, a sub-set of each sample was aseptically transferred to two sterile bottles (*ca*. 100 mL in each) with thiosulfate to inactivate any chlorine residues. The samples were stored at 5°C and shipped to Iqaluit where they were analyzed within 24 hours of being sampled.

One hundred mL of the water samples were added directly to the Idexx Colilert Quanti-Trays (Westbrook, ME, USA), sealed and incubated for 18 hours at 37°C. Following incubation, yellow wells were enumerated for the determination of coliforms while presumptive *E. coli* were counted as light blue fluorescing wells. Using the manufacturer's conversion table, the number of positive wells was converted into the most probable number (MPN) per 100 ml of water. Each water sample was done in duplicate.

3.0 Results

3.1 Water Quality in Public Buildings

The temperature of the drinking water varied widely in the five public buildings with temperatures from 15.3 to 23.5°C (Table 1). The pH levels were consistently close to neutral (pH=7), while conductivity values were stable and averaging ~15 µS/cm. The level of chlorine (free

and total) was very low with concentrations of 0-0.07 mg/L. However, when a tap water sample was obtained in building 2 immediately after the water tank had been refilled it contained free and total chlorine levels of 0.08 and 0.13 mg/L, respectively.

None of the tap water samples contained any coliforms or *E. coli* in the duplicate 100 ml sample volumes (Table 1).

Table 1. Water Quality in Public Buildings in Pangnirtung.

Building		Temperature (°C)	pH	Conductivity (µS/cm)	Chlorine (mg/L)		Total coliform (MPN/100 mL)	*E. coli* (MPN/100 mL)
					Free	Total		
1		15.3	7.29	14.93	0.05	0.07	<1	<1
2	Before refill	22.0	6.88	15.03	0	0.03	<1	<1
	After refill	nt	nt	15.13	0.08	0.13	<1	<1
3		15.7	7.06	14.86	0.04	0.06	<1	<1
4		17.6	7.10	15.12	0.02	0.04	<1	<1
5		23.5	6.89	15.00	0.01	0.01	<1	<1

3.2 Water Quality in Private Homes

The water quality in the private homes showed similar trends to those presented above for the public buildings.

It is worth noting that the chlorine levels in the tap water were consistently low with free chlorine concentrations between 0.01 to 0.04 mg/L (Table 2).

The average temperature and conductivity of the drinking water coming directly from the domestic drinking water taps were 23.1°C and 15.77 µS/cm, respectively. Coliform bacteria and *E. coli* were absent in both of the 100 ml samples analyzed from each home (Table 2).

Table 2. Water Quality in Private Homes in Pangnirtung.

Home	Temperature (°C)	pH	Conductivity (µS/cm)	Chlorine (mg/L)		Total coliform (MPN/100 mL)	*E. coli* (MPN/100 mL)
				Free	Total		
1	21.9	7.40	15.96	0.01	0.01	<1	<1
2	23.6	7.36	14.83	0.02	0.03	<1	<1
3	24.6	7.34	16.78	0.01	0.01	<1	<1
4	19.8	7.05	15.46	0.03	0.03	<1	<1
5	24.2	7.35	16.13	0.04	0.05	<1	<1
6	24.5	6.92	15.44	0.02	0.03	<1	<1

3.3 Raw Source Water Quality in Pangnirtung

The temperature in the untreated source water samples ranged from 11.9 to 12.2°C in the water reservoir to 14.4 to 15.5°C in the different parts of the river (Table 3, Figure 1). The untreated water had close to neutral pH values (pH 6.96-7.32). The water reservoir and culvert samples exhibited higher conductivities (13.06-16.48 µS/cm) than the water samples from the adjacent river, where the conductivity averaged 6.84 µS/cm. This difference probably reflects different origins of the water, as in groundwater/melt water vs. surface water. The higher conductivity in the culvert sample could also be related to a turbulent flow with more suspension of particles. This may explain why only the culvert sample contained coliforms (1 MPN/100 mL) while these bacteria and *E. coli* were absent from the other river samples (Table 3). Only one of the water reservoir samples contained coliform bacteria (1 MPN/100 mL), and none contained *E. coli*. The finding of very low levels of fecal indicator bacteria in the raw source water samples from Pangnirtung indicate that these mostly fecally derived bacteria were not ubiquitous in the catchment draining into the river and water reservoir.

Table 3. Quality of Raw Source Water in Pangnirtung.

Water Source	Tempera-ture (°C)	pH	Conductivity (µS/cm)	Total coliform (MPN/100 mL)	*E. coli* (MPN/100 mL)
WR Intake	12.2	7.20	16.48	<1	<1
WR Across from Intake	11.9	7.12	13.92	1	<1
River Site 1	15.5	7.32	6.23	<1	<1
River Site 2	14.4	6.96	7.44	<1	<1
River Culvert	14.7	6.98	13.06	5.5	<1

WR – Water Reservoir, nt – not tested (see also Figure 1 for specification of sampling locations)

3.4 Treated Drinking Water Quality in Pangnirtung

Freshly treated water samples were obtained directly from the WTP and three water trucks that had just been filled at the WTP (Table 4). The truck samples were obtained on two different days. The water quality parameter values (pH, temperature, and conductivity) resembled those obtained in the raw water from the water reservoir (see Table 3).

The freshly treated water from the WTP contained 0.13 and 0.16 mg/L of free and total chlorine, respectively. Similar levels of chlorine were detected in the truck water. This meant that the chlorine levels in the freshly treated water were in the lower range of the recommended chlorination levels for drinking water. It is normally recommended that drinking water leaving the WTP should contain between 0.2-2.0 mg/L to provide the drinking water with a chlorine residual for downstream protection against microbial contamination and regrowth.

Total coliform bacteria and *E. coli* were absent in duplicate 100 ml samples of the fresh drinking water.

Table 4. Water Quality in Freshly Treated Drinking Water Samples in Pangnirtung.

Water Source	Temperature (°C)	pH	Conductivity (µS/cm)	Chlorine (mg/L)		Total coliform (MPN/100 mL)	*E. coli* (MPN/100 mL)
				Free	Total		
WTP	12.5	7.40	15.13	0.13	0.16	<1	<1
Truck 1	13.7	8.07	15.34	0.13	0.17	<1	<1
Truck 2	14.6	7.00	14.55	0.17	0.19	<1	<1
Truck 3	18.5	7.33	14.86	0.13	0.17	<1	<1

4.0 Summary of Results

A total of 16 drinking water samples obtained from the WTP, water delivery trucks, public buildings and homes in Pangnirtung were analyzed for basic water quality parameters (temperature, pH and conductivity), levels of free and total chlorine and the presence of coliform bacteria and *E. coli*. The temperature of the drinking water obtained from taps in homes and most public buildings tended to be above 20°C which can potentially cause issues around biofilm regrowth in premise plumbing structures and water tanks. It should be noted that the warm drinking water temperatures can likely be attributed to the water tanks commonly being located beside the furnace.

The levels of chlorine residuals in the freshly treated drinking water were in the lower spectrum of the recommended range (0.2-2.0 mg/L) in the drinking water. However, once the drinking water reached the building water tanks the residual chlorine disappeared, meaning that the chlorine demand of the water tanks was high. This may indicate that the water tanks contained organic material and/or biofilms (surface attached microbial communities) which "used" up the chlorine.

Coliform bacteria and *E. coli* were absent from all drinking water samples. Only two raw water samples contained low counts of coliform bacteria and none contained *E. coli*. This would indicate that during the study period there were no sources of fecal contamination affecting the water quality in the river and fresh water catchment area supplying the water reservoir. Although no *E. coli* bacteria were found in the river water at this time, it is not recommended that this water be consumed without prior treatment.

In conclusion, it is recommended that the treated drinking water leaving the WTP contains free chlorine levels of at least 0.2 mg/L to provide the water with some residual protection during transportation and delivery to the community. Also, it is recommended that the water tanks are cleaned on a regular basis to ensure that a resident microbial biofilm population does not develop. Although very low levels of coliform bacteria and no *E. coli* were detected in the raw source water during the study period, it is still prudent to advice against the intake of untreated water from the water reservoir and adjacent river.

5.0 Acknowledgements

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