Tab 2. A Summary of Water Quality Analysis from the Colville River and other high latitude Alaskan and Canadian Rivers

A SUMMARY OF WATER QUALITY ANALYSES FROM THE COLVILLE RIVER AND OTHER HIGH LATITUDE ALASKAN AND CANADIAN RIVERS

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INTRODUCTION

Between 2009 and 2014, ABR, Inc.—Environmental Research & Services (ABR) collected water samples for chemical analysis at up to 3 locations on the Niġliq Channel of the Colville River delta. Analytes included a suite of metals, nitrates/nitrites, and diesel and residual range organics. These collections were part of a larger effort funded by ConocoPhillips Alaska, Inc., (CPAI) aimed at monitoring and quantifying harvests of Arctic Cisco (*Coregonus autumnalis*) during the annual fall fishery of the village of Nuiqsut, Alaska. The primary purpose of collecting these water samples was to establish a baseline of water quality information for locations upstream and downstream of CPAI infrastructure in the Niġliq Channel where overwintering Arctic Cisco are common and where the bulk of local fishery activity occurs (Figure 1) (Seigle et al. 2015). However, an important constraint in interpreting water chemistry data in the Colville River delta is the current lack of context for evaluating these results, in large part because there is no known synthesis of existing water chemistry data in the Colville River or other similar arctic waterbodies.

Recently, some residents of Nuiqsut have expressed concern for Colville River water quality because of the sudden and noticeable appearance of a naturally occurring freshwater fish mold (*Saprolegnia* spp.). This mold has infected a portion of the harvest for another species, Broad Whitefish (*Coregonus nasus*), in waters upstream from the Colville River delta, starting in 2013 (See Fact Sheet, Appendix A) (Figure 1). The reasons for this sudden appearance of *Saprolegina* infected fish remain unknown at this time. With these factors in mind, the North Slope Borough Department of Wildlife Management has requested a review and synthesis of all known water quality data collected for the lower Colville River or similar arctic waterbodies.

The objectives of this effort are to 1) perform a review of historical literature and other data sources with the goal of locating additional water quality data for the Colville River and other high latitude Alaska and western arctic Canada waters, and 2) to compare water quality data from arctic rivers with Alaska Department of Environmental Conservation (ADEC) water quality standards.

METHODS

ABR performed a review of historical literature to summarize available water quality data from the lower Colville River and similar waterbodies into a single document. Most Colville River data were collected by ABR between 2009 and 2015. Additional data were pulled from the Study of Northern Alaska Coastal System (SNACS) river chemistry data set and the U.S. Geological Survey (USGS) (Schuster et al. 2003, 2006a, 2006b, 2006c, 2007, 2011; NCAR 2015; USGS 2015). An electronic file containing all available water quality data presented in this report accompanied the final report.

Water quality analysis results were compared to standards established by the United States Environmental Protection Agency (EPA) (USEPA 2013) and the Alaska Department of Environmental Conservation (ADEC) (ADEC 2008). Results were compared to 1) the EPA criterion continuous concentration (CCC), which is the EPA's aquatic life standard representing the highest instream concentration of certain analytes to which aquatic organisms can be exposed indefinitely without causing harm, and 2) the EPA drinking water standard, which sets a maximum contaminant level (MCL) on certain analytes. Typically, ADEC follows Alaska Water Quality (AWQ) standards which are the same as EPA CCC for most analytes. However, AWQ standards are more conservative for some analytes of greater concern, such as Mercury. Additionally, the AWQ standards for the analtyes cadmium, chromium, copper, lead, nickel, silver, and zinc depending on total water hardness. The State of Alaska has determined that for these analytes, the AWQ standards vary depending upon total water hardness levels of a given sample. Water hardness can either be provided directly by the testing laboratory or by the following a formula when calcium and magnesium concentrations are known: water hardness = (2.497 × calcium result in µg/L) + (4.118 × magnesium result in µg/L). ADEC will provide interested parties with an interactive spreadsheet where a sample's water hardness can be entered, yielding the AWQ standard for any of the analytes mentioned above (See Appendix B for an example).

RESULTS AND DISCUSSION

The Colville River travels 350 miles from its headwaters in the DeLong Mountains of the Brooks Range, and generally follows a west–east pattern of flow until reaching Umiat where it turns north and flows into Harrison Bay in the Beaufort Sea (Figure 1). The river is an important transportation and subsistence hunting corridor for residents of the Arctic Coastal Plain of Alaska. In the past 2 decades there has been increased industrial activity near the village of Nuiqsut as several oil industry satellite wells and associated infrastructure have been established in the region. As a result of this industry activity, several long-term field surveys of environmental and subsistence resources have been initiated in the area of Nuiqsut to satisfy agency permit requirements (Johnson et al. 2014, Lawhead et al. 2015). An example of this type of long-term monitoring is the 30-year subsistence harvest monitoring effort for Arctic Cisco (known locally as *Qaaktaq*) caught near the community of Nuiqsut, Alaska (Seigle et al. 2015). In 2007, ABR became responsible for harvest monitoring for the Arctic Cisco caught near Nuiqsut. In the years that followed, local residents of Nuiqsut began voicing concerns over the safety of their subsistence food sources because of the proximity of the river to CPAI wells. Some residents requested that water quality monitoring be established. In discussion with the North Slope Borough Department of Wildlife Management, it was determined that CPAI would support initial baseline collections of a subset of water chemistry analytes. ABR collected water quality data on behalf of CPAI during the Nuiqsut fall fishery each year from 2009 until 2014 for analysis by Arctic Fox Environmental, Inc., in Prudhoe Bay, Alaska (Table 1). No water sample analyses were available in 2012 due to a shipping error.

Analysis of fall water collection events from 4 sites on the Niġliq Channel and 1 site on the Main Channel of the Colville River between 2009 and 2014 resulted in no detectable diesel range or residual range organics either upstream or downstream of CPAI infrastructure activity (Table 1, Figure 1). Likewise, there were no detections of cadmium, chromium, or silver in any water samples. Lead was detected in 2 of 26 samples where that analyte was tested and was slightly elevated above the EPA aquatic life standard limit of 2.5 µg/L (3.2 µg/L on 24 October 2013) at the downstream sampling location (ABR Water Station 1, Table 1). Lead was not detected in 2 subsequent sampling events at the same location the following year.

As mentioned above in Methods, ADEC standards for cadmium, lead, and silver depend on water hardness calculations to determine individual water sample concentration limits. Unfortunately, water hardness was not calculated before 2014 in ABR water samples. This point is rendered mostly moot as no concentrations were detected for these analytes in ABR water samples aside from the 2 lead detections in 2013.

Arsenic was detected in only 6 of 26 samples tested for that analyte in ABR water samples. Arsenic concentrations ranged from 1.0 µg/L to 2.1 µg/L (mean = 1.6 µg/L). Nonetheless, these concentrations are well below the EPA aquatic life and drinking water standard limits and also meet ADEC AWQ standard limits for arsenic (Table 1).

Mercury was detected in 6 of 26 samples collected during ABR water collection efforts. Concentrations of mercury were below EPA drinking water standard limits for all samples but were elevated above EPA aquatic life standard limits on 30 October 2011 (1.7 µg/L) (ABR Water Station 3, Table 1). Mercury was not detected at the same location on 15 November 2011, nor in subsequent sampling in 2014. For mercury, ADEC takes a more stringent approach to maximum concentrations by applying the EPA's "Human Health Criteria for Non-Carcinogens, Water + Aquatic Organisms" standard limit of 0.05 µg/L (See Appendix B). Thus, all 6 instances where mercury was detected were higher than ADEC standards. However, mercury is commonly elevated in the high arctic due to atmospheric transport and distillation from Eurasian anthropogenic sources which is then deposited as precipitate (Douglas and Sturm 2004). Other potential sources of mercury include runoff from landfills or the natural weathering of inorganic substrates. The fact that mercury was not detected in most samples indicates that this is not a chronic issue of concern.

Barium was detected in all samples collected and ranged from a minimum of 58 µg/L to 222 µg/L (mean = 105.6 µg/L). These values are also below EPA drinking water and aquatic life standard limits as well as ADEC AWQ standard limits for barium concentrations. It is likely that the detection of dissolved barium can be attributed to the local geology of the Colville River drainage which has barium-rich lithology throughout (Crecelius et al. 1991, Rember and Trefry 2004).

The availability of water chemistry from the Colville River and other high latitude Alaskan rivers is extremely limited and the CPAI supported water collections represent a large proportion of the available data for the river. A search of available literature revealed sparse (n = 17) water chemistry sample events collected from various sections of the river between the 1950s and

2000s by the USGS and the National Center for Atmospheric Research (NCAR) (USGS 2015, NCAR 2015) (Figure 2). However, few analytes were tested and the only notable detections were for arsenic (n = 9) (Table 1). Arsenic detections ranged from 1.0 µg/L to 8.0 µg/L (mean = 3.3). These concentrations were well below the EPA's drinking water and aquatic life standard limits as well as ADEC AWQ standard limits for arsenic.

Water chemistry data have been reported for several other high latitude rivers in Alaska and northwest Canada (Appendix C) (Figure 2). These include samples from the Kuparuk River and Sagavanirktok River in Alaska as well as the Mackenzie River and Peel River in Canada. Unfortunately, few of the same analytes were tested in the Colville River and other locations. However, values for mercury were reported in the Mackenzie River and Peel River, and were below the EPA aquatic life and water quality standard limits as well as ADEC AWQ standard limits.

More data exist from the Yukon River in Alaska (Appendix C). Barium was found in 33 of 34 Yukon River samples collected between 2001 and 2005 at lower concentrations on average than in the Colville River (47.8 µg/L versus105.6 µg/L) (Shuster et al. 2003; Shuster et al. 2006a, b, c; Shuster et al. 2007). Concentrations of manganese in Yukon River samples exceeded stringent ADEC AWQ standards (50 µg/L) in 6 of 34 samples. These samples were all collected in April or May of their respective sample years, presumably during or after spring breakup. Values for manganese decreased below ADEC AWQ limits during summertime sampling events. These results underscore the potential impact of seasonal flow conditions on analyte concentrations and the importance of representative seasonal sampling in determining overall water quality in any given waterbody.

In general, water chemistry in large rivers of Alaska and northwest Canada appear to meet EPA and ADEC standards for most analytes tested in any given year and depending on the timing of sampling from year to year. Though ABR water chemistry sampling on the Colville River has only occurred in the fall and is not representative of overall year-round water quality in the delta, these samples appear to meet EPA and ADEC standards for drinking water and aquatic life in most instances.

ADEC typically applies maximum concentration thresholds for a given analyte using the most conservative of several EPA water quality standards (Appendix B). In some cases, a different EPA standard (e.g., drinking water versus aquatic life standards) is adopted as the ADEC standard, depending on the analyte tested. An example of this would be for mercury. The ADEC standard for mercury, as noted above, is far more conservative than for the EPA drinking water or aquatic life standard limits reported in Table 1 and Appendix C. Regardless of the water chemistry test being performed, factors like local geology, the impacts of atmospheric deposition, seasonal precipitation and flood events, the presence of communities, and the proximity of industrial activities must be taken into consideration when interpreting the presence of particular analytes in water.

Recent concerns by residents of Nuiqsut regarding the *Saprolegnia* mold appearance in Broad Whitefish (Appendix A) has drawn additional scrutiny of water chemistry in the Colville River. However, *Saprolegnia* is a commonly occurring freshwater fungus and, though harmful to fish, is not considered a direct threat to human health (Meyers et al. 2008). At this time there is no direct evidence that Colville River water chemistry is responsible for the mold outbreak in fish and the reason(s) for the outbreak of *Saprolegnia* remain unknown. Future surveys should consider additional factors including the timing and intensity of outbreaks, seasonal temperatures in the Colville River and nearshore Beaufort Sea waters, and fish reproductive status and overall body condition around the time of outbreaks.

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Table 1. Water chemistry results from 5 ABR sample stations and 1 station sampled by both the USGS and NCAR on the lower Colville River, Alaska, 1977–2014. All results are given in μg/L.

Location Source Date	Total water hardness	Calcium	Magnesium	Arsenic	Barium	Cadmium	Chromium	Iron	Lead	Manganese	Mercury	Selenium	Silver	Nitrate Nitrite as Total Nitrogen	Diesel Range Organics	Residual Range Organics
Station 1																
ABR																
3-Nov-09	–	–	–	–	–	–	–	209	–	51.5	–	–	–	–	ND	ND
21-Oct-10	–	–	–	ND	103.0	ND	ND	–	ND	–	ND	ND	ND	88.8	ND	ND
7-Nov-10	–	–	–	1.9	120.0	ND	ND	–	ND	–	ND	8.8	ND	75.2	ND	ND
18-Nov-10	–	–	–	ND	147.0	ND	ND	–	ND	–	ND	ND	ND	69.9	ND	ND
30-Oct-11	–	–	–	ND	79.2	ND	ND	–	ND	–	ND	ND	ND	ND	ND	ND
15-Nov-11	–	–	–	ND	90.5	ND	ND	–	ND	–	ND	ND	ND	77.9	ND	ND
24-Oct-13	–	–	–	ND	68.0	ND	ND	–	3.20	–	ND	ND	ND	ND	ND	ND
3-Nov-14	4,400,000	290,000	890,000	1.1	58.0	ND	ND	–	ND	–	0.26	2.7	ND	ND	ND	ND
18-Nov-14	4,300,000	290,000	880,000	2.1	81.0	ND	ND	–	ND	–	0.57	4.3	ND	ND	ND	ND
Station 2																
ABR																
24-Oct-13	–	–	–	ND	76.0	ND	ND		2.30	–	ND	ND	ND	ND	ND	ND
Station 3																
ABR																
21-Oct-10	–	–	–	ND	89.8	ND	ND		ND	–	ND	ND	ND	88.8	ND	ND
7-Nov-10	–	–	–	1.8	126.0	ND	ND		ND	–	ND	7.4	ND	66.1	ND	ND
18-Nov-10	–	–	–	ND	164.0	ND	ND		ND	–	ND	ND	ND	55.9	ND	ND
30-Oct-11	–	–	–	ND	90.2	ND	ND		ND	–	1.70	ND	ND	39.9	ND	ND
15-Nov-11	–	–	–	ND	90.5	ND	ND		ND	–	ND	ND	ND	77.9	ND	ND
3-Nov-14	2,800,000	200,000	560,000	ND	100.0	ND	ND		ND	–	ND	ND	ND	33.0	ND	ND
18-Nov-14	3,600,000	250,000	720,000	1.4	100.0	ND	ND		ND	–	ND	ND	ND	ND	ND	ND

Table 1. Continued.

Location Source Date	Total water hardness	Calcium	Magnesium	Arsenic	Barium	Cadmium	Chromium	Iron	Lead	Manganese	Mercury	Selenium	Silver	Nitrate Nitrite as Total Nitrogen	Diesel Range Organics	Residual Range Organics
Station 4																
ABR																
3-Nov-09	–	–	–	–	–	–	–	312	–	23.7	–	–	–	–	ND	ND
21-Oct-10	–	–	–	ND	86.7	ND	ND		ND	–	ND	ND	ND	87.0	ND	ND
7-Nov-10	–	–	–	ND	116.0	ND	ND		ND	–	ND	ND	ND	90.5	ND	ND
18-Nov-10	–	–	–	ND	222.0	ND	ND		ND	–	ND	ND	ND	104.0	ND	ND
30-Oct-11	–	–	–	ND	118.0	ND	ND		ND	–	0.35	ND	ND	81.2	ND	ND
15-Nov-11	–	–	–	ND	108.0	ND	ND		ND	–	0.67	ND	ND	139.0	ND	ND
17-Oct-13	–	–	–	ND	72.0	ND	ND		ND	–	ND	ND	ND	ND	ND	ND
24-Oct-13	–	–	–	ND	110.0	ND	ND		ND	–	0.33	ND	ND	ND	ND	ND
3-Nov-14	1,900,000	150,000	380,000	ND	120.0	ND	ND		ND	–	ND	ND	ND	24.0	ND	ND
18-Nov-14	2,400,000	180,000	480,000	1.0	130.0	ND	ND		ND	–	ND	ND	ND	ND	ND	ND
Station 5																
ABR																
21-Oct-13	–	–	–	ND	79.0	ND	ND	–	ND	ND	–	ND	ND	ND	ND	ND
Nuiqsut																
USGS																
10-Jun-77	23,000	–	–	6.0	–	ND	–	–	–	–	–	–	–	–	–	–
12-Jun-77	26,000	–	–	8.0	–	ND	–	–	–	–	–	–	–	–	–	–
8-Sep-77	87,000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
7-Jun-79	36,000	–	–	1.0	–	ND	–	–	–	–	–	–	–	30.0	–	–
20-Aug-79	76,000	–	–	1.0	–	ND	–	–	–	–	–	–	–	70.0	–	–
11-Sep-79	88,000	–	–	–	–	–	–	–	–	–	–	–	–	130.0	–	–

Table 1. Continued.

Location Source Date	Total water hardness	Calcium	Magnesium	Arsenic	Barium	Cadmium	Chromium	Iron	Lead	Manganese	Mercury	Selenium	Silver	Nitrate Nitrite as Total Nitrogen	Diesel Range Organics	Residual Range Organics
6-Jun-80	31,000	–	–	4.0	–	ND	–	–	–	–	–	–	–	140.0	–	–
10-Sep-80	82,000	–	–	1.0	–	ND	–	–	–	–	–	–	–	690.0	–	–
11-Aug-81	81,000	–	–	2.0	–	ND	–	–	–	–	–	–	–	30.0	–	–
Nuiqsut																
NCAR																
May–July 2006[a]	28,775	9,040	3,197	–	–	–	–	–	–	–	–	–	–	–	–	–
May–August 2007[b]	53,467	19,842	7,284	–	–	–	–	–	–	–	–	–	–	–	–	–
Water Standards																
EPA DWS[c]	NEL	NEL	NEL	10.0	2000.0	5.00	100.0	NEL	15.00	NEL	2.00	50.0	NEL	10,000	NEL	NEL
EPA ALS[d]	NEL	NEL	NEL	150.0	NEL	0.25	74.0	1,000	2.50	NEL	0.77	5.0	NEL	NEL	NEL	NEL
ADEC WQS[e]	NEL	NEL	NEL	10.0	2000.0	CALC[f]	100.0	1,000	CALC[f]	50.0	0.05	5.0	CALC[f]	10,000	NEL	NEL

[a] Mean of 12 sampling events at 1 station
[b] Mean of 9 sampling events at 1 station
[c] EPA Drinking Water Standard, Maximum Contaminant Level (MCL)
[d] EPA Aquatic Life Standard, Criterion Continuous Concentration (CCC)
[e] Alaska Department of Environmental Conservation, Water Quality Standards
[f] These standards are "total water hardness" dependent for individual samples. Refer to the "Methods" section for a description of how these standards are calculated.
CALC = Calculation Required
NEL= No Established Limit
ND = Not detected at the reporting limit
– = Not Tested

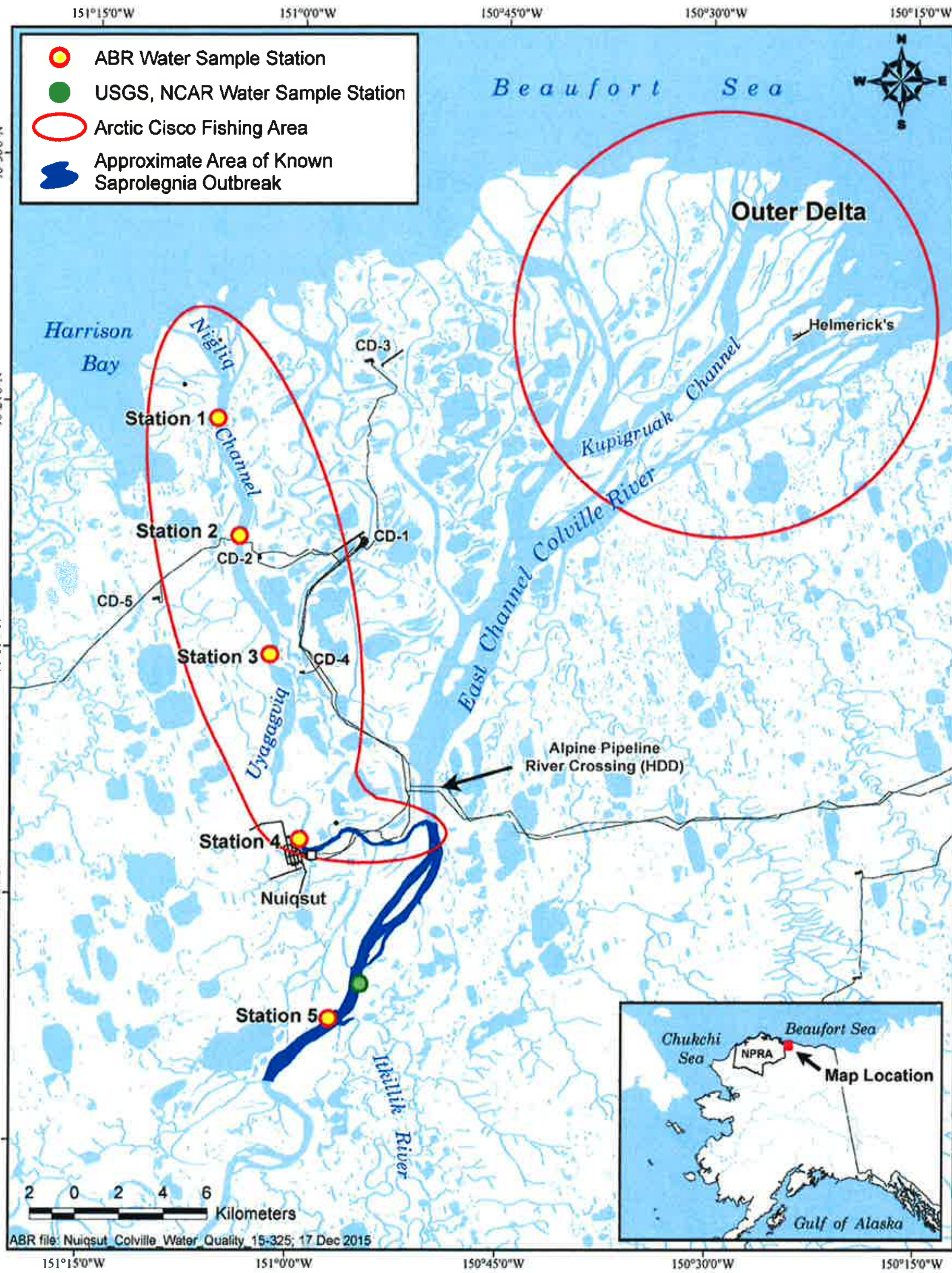


Figure 1. The location of water chemistry sample collections in the Colville River by ABR, USGS, and NCAR along with important Arctic Cisco fishing locations and *Saprolegnia* outbreaks, 2009–2015.

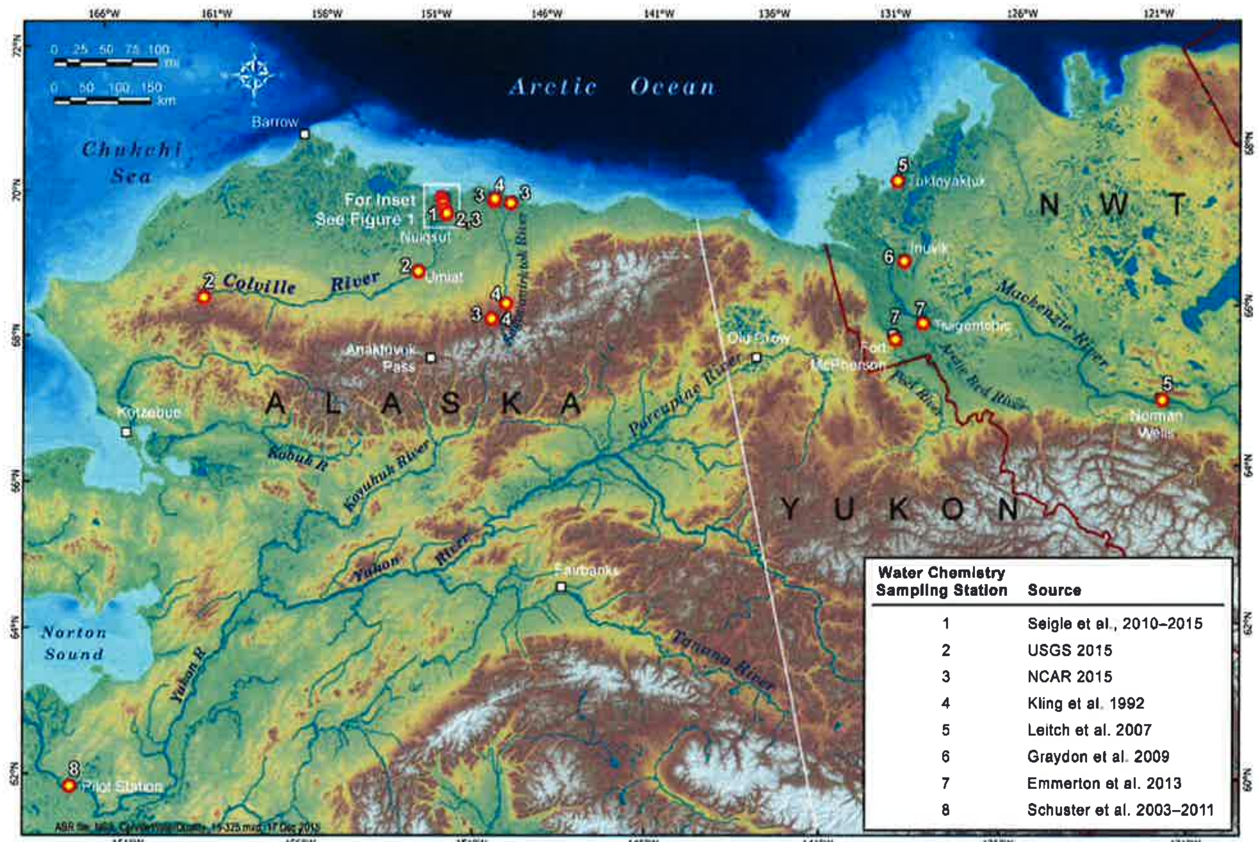


Figure 2. The location of water chemistry sample collections in large rivers of Alaska and Canada, 1953–2014.

Appendix A. North Slope Borough Department of Wildlife Management *Saprolegnia* spp. fact sheet, 2013.

NUIQSUT FISH CONCERN UPDATE - OCTOBER 2013

NSB Department of Wildlife Management
October 29, 2013

Background and Concerns:

In October 2013, Nuiqsut fishermen began seeing a mold/fungus on *Aanaaqliq* (broad whitefish) that they have not seen before. They were concerned about health to the fish and to people eating them. They are concerned that the disease was related to industrial pollution. Samples of affected fish were sent to NSB DWM for analysis.

Response/What is being done:

NSB DWM staff initial response:

- Examined fish received from Nuiqsut fishermen (October 14, 2013).
- Department staff Billy Adams and Todd Sformo traveled to Nuiqsut on October 17 to collect affected fish & water samples:
  - submitted fish/mold samples to Alaska Fish Pathology Lab in Anchorage
  - submitted water samples to Arctic Fox Environmental Lab
- Consulted with Nuiqsut community representatives (KSOP meeting) and ABR biologists
- Consultation and updates to NSB Mayor's office and NSB Planning Department

Laboratory Analysis Results:

Analysis fish mold:

- Initial ID of mold is *Saprolegnia* spp. made by the Alaska Fish Pathology Lab
- This type of mold occurs in freshwater bodies across the globe from Alaska to Antarctica. It is known to 'flare up' in response to injury to individual fish and/or environmental stress such as high water temperatures and decrease in river flow.
- Although the mold has probably been resident on the North Slope, we find no previous reports, and fishermen in Nuiqsut have never seen this before
- We do not know the reason this mold has recently affected fish in Nuiqsut

Water Analysis:

- Water samples collected by both NSB DWM & ABR staff
- Natural elements were at normal levels
- Further water analyses are in underway by ABR

Which species are affected to date?

- Aanaakliq (broad whitefish) appear to be the principle fish species affected
- No evidence of mold on *qaaktaq* (arctic cisco) to date
- Village very concerned about other species as well

Public Health Risk?

- According to a State of Alaska Fish Pathology Laboratory publication, there is no risk to human health[1]. The Department of Wildlife Management encourages fishermen to maintain their traditional and customary practices when dealing with unusual fish

Continued Monitoring Activities:

1. Continue to work with local residents who are providing fish samples and observations. We are also working with fish and mold experts to devise sampling/study plans.
2. Current monitoring in place:
   - Nuiqsut fisherman reporting on and monitoring their catch
   - Nuiqsut Fish Monitoring Program – ABR (harvest rates, locations, species, etc)
   - ABR is monitoring fish catch rates as part of a 25+ year study funded by Conoco Phillips (CP)
   - NSB DWM has made two visits (Billy Adams and Todd Sformo) and are working with local, State and Federal, and International entities

Main Groups Involved To Date:

- Nuiqsut fishermen
- North Slope Borough
- ABR Inc.
- Conoco Phillips
- Alaska Department of Environmental Conservation
- United States Army Corps of Engineers

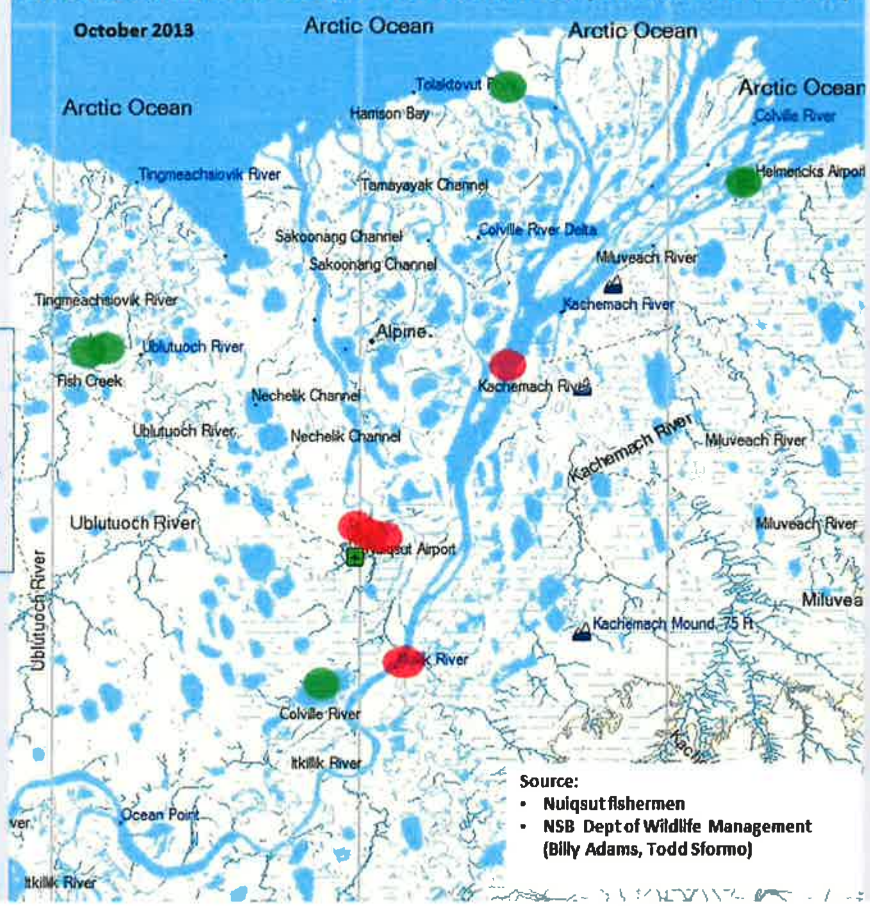
Laboratories include:

- ADFG Fish Pathology Lab
- Arctic Fox Environmental, Inc
- Others: Dr. Todd O'Hara/UAF, Dr. Larry Moulton, Dr. James Winton (Chief, Fish Health Section, USGS Western Fisheries Research Center, Seattle, WA) , and Dr. Javier Dieguez-Uribeondo, (Dept. of Mycology, Real Jardin Batanico, Madrid, Spain)

[1] Common Diseases of Wild and Cultured Fishes in Alaska. 2008. Theodore Meyers, et al. ADFG, Fish Pathology Laboratories.

DRAFT
Oct 29, 2013

NET LOCATIONS OF MOLD ON *AANAAKLIQ* (BROAD WHITEFISH)



Not affected

Affected
(About 50% affected)

Notes:
- Map covers October 2013
- No reports of mold July-Sept.
- Arctic cisco appear unaffected as of Oct 2013

Preliminary Findings: Water Mold on Fish in Nuiqsut

October 2013

Several *Aanaakliq*, or broad whitefish, caught near Nuiqsut had a white-to-brown 'water-mold' growth on their bodies. As of October 21st, the State of Alaska Fish Pathology Lab in Anchorage has initially identified it as *Saprolegnia*-like water mold. This water mold is commonly found in other areas of Alaska and can infect fish under a variety of conditions.

Todd Sformo, NSB-DWM, 18 Oct 2013, Nuiqsut

Although unsightly, the mold is not a threat to human health; however, NSB-DWM advises fishermen to follow customary practices regarding consumption of traditional foods. While we have an initial identification, we do not know the reason(s) for its occurrence. We are continuing to investigate and monitor the fishery.

If fishermen catch fish that have been affected, we encourage them to contact:

NSB Department of Wildlife Management at 907-852-0350

Provide the following information on your catch:

Number of fish affected, Number of normal-looking fish, Location and Date caught, and any photos taken

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Appendix B. Example of interactive worksheet for Alaska water quality standards as established by the Alaska Department of Environmental Conservation (ADEC), 2015.

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Enter the appropriate **Hardness** value for the water you are interested in: 84 mg/L as CaCO3 ****

color key: orange highlighting: the most stringent criterion
yellow highlighting: the criterion depends on the hardness

Calculation of Hardness
adapted from Standard Methods, Method 2340B — units in mg/L
input calcium and magnesium concentrations:
Calcium: 24.4
Magnesium: 5.71 — Resulting Hardness= 84.4

all units in micrograms per liter (ug/L)

all units in micrograms per liter (ug/L)

Parameter	Drinking Water	Stockwater	Irrigation Water	Aquatic Life-Fresh Water: Acute					Aquatic Life-Fresh Water: Chronic					Human Health Criteria for NonCarcinogens	
				the criterion is	as	*using the conversion factor*	the criterion is	as	the criterion is	as	*using the conversion factor*	the criterion is	as	Water + Aquatic Organisms	Aquatic Organisms Only
alkalinity									20,000 minimum						
aluminum			5,000	750	TR				87*	TR					
antimony	6													14	4,300
arsenic	10	50	100	340	TR	1	340	D	150	TR	1	150	D		
barium	2,000														
beryllium	4		100												
boron			750												
cadmium	5	10	10	1.79	TR	0.951	1.70	D	0.24	TR	0.916	0.22	D		
chloride				860,000					230,000						
chlorine (total residual)				19					11						
chromium	100														
chromium (total)			100												
chromium III				1563.12	TR	0.316	493.95	D	74.71	TR	0.86	64.25	D		
chromium VI		50		16	D				11	D					
cobalt			50												
copper			200	11.88	TR	0.960	11.40	D	8.04	TR	0.960	7.72	D	1,300	
cyanide (free)	200**			22 **					5.2 **					700	220,000
fluoride	2,000		1,000												
iron			5,000						1,000						
lead		50	5,000	65.39	TR	0.816	53.39	D	2.55	TR	0.816	2.08	D		
lithium			2,500												
manganese			200											50	100
mercury	2			2.4	TR				0.012	TR				0.05	0.051
molybdenum			10												
nickel	100		200	404.83	TR	0.998	404.02	D	45.01	TR	0.997	44.87	D	610	4,600
nitrate (as N)	10,000														
nitrite (as N)	1,000														
nitrate + nitrite	10,000														
selenium***	50	10	20	20	TR	0.922	--	D	5	TR	0.922	4.60	D	170	11,000
silver				2.80	TR	0.850	2.38	D							
thallium	2													1.7	6.3
vanadium			100												
zinc			2,000	103.36	TR	0.978	101.09	D	103.36	TR	0.986	101.91	D	9,100	69,000

all units in micrograms per liter (ug/L)

all units in micrograms per liter (ug/L)

* if pH ≥7.0 & hardness ≥50, then 750 ug/L
** measured as WAD CN
*** more information is needed to determine most stringent criteria
**** note that as far as the criteria go, any sample hardness above 400mg/L defaults to a maximum of 400mg/L as per the Toxics Manual although this spreadsheet will calculate to higher hardness values.

TR — total recoverable
D — dissolved
H — some of the criteria for this parameter are hardness dependant
FWA — Fresh Water Acute
FWC — Fresh Water Chronic

updated 3 July 2007

Appendix C. Water chemistry results from samples collected in high latitude rivers of Alaska and Canada, 1953–2014. All results are given in µg/L.

RIVER SYSTEM / Location / Source	Date	Total water hardness	Calcium	Magnesium	Arsenic	Barium	Cadmium	Chromium	Iron	Lead	Mercury	Manganese	Selenium	Silver	Nitrate Nitrite as Total Nitrogen	Residual Range Organics	Diesel Range Organics
COLVILLE RIVER																	
Headwaters (AK)																	
USGS 2015	26-Jun-77	41,000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Umiat (AK)																	
USGS 2015	28-Jul-53	52,000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	30-Apr-69	320,000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	1-May-69	140,000	–	–	–	–	–	–	230	–	–	–	–	–	–	–	–
	19-Apr-75	110,000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	25-Apr-78	140,000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KUPARUK RIVER																	
Lower river (AK)																	
Kling et al. 1992	19-Aug-88	–	20,480	2,115	–	–	–	–	–	–	–	4.9	–	–	–	–	–
Upper river (AK)																	
Kling et al. 1992	3-Jul-90	–	3,807	1,580	–	–	–	–	–	–	–	2.4	–	–	–	–	–
Spine Road (AK)																	
NCAR 2015	2006[a]	35,283	10,349	1,414	–	–	–	–	–	–	–	–	–	–	–	–	–
	2007[b]	30,315	10,662	1,402	–	–	–	–	–	–	–	–	–	–	–	–	–
Upper river (AK)																	
Kling et al. 1992	2006[c]	8,507	4,312	968	–	–	–	–	–	–	–	–	–	–	–	–	–
SAGAVANIRKTOK RIVER																	
Upper river (AK)																	
Kling et al. 1992	10-Jul-98	–	12,985	4,594	–	–	–	–	–	–	–	14.6	–	–	–	–	–

RIVER SYSTEM / Location / Source	Date	Total water hardness	Calcium	Magnesium	Arsenic	Barium	Cadmium	Chromium	Iron	Lead	Mercury	Manganese	Selenium	Silver	Nitrate Nitrite as Total Nitrogen	Residual Range Organics	Diesel Range Organics
Lower river (AK)																	
NCAR 2015	May–Jul 2006[d]	77,110	17,261	4,719	–	–	–	–	–	–	–	–	–	–	–	–	–
	May–Jul 2007[e]	119,383	31,217	10,006	–	–	–	–	–	–	–	–	–	–	–	–	–
MACKENZIE RIVER																	
Near Arctic Red River (CAN)																	
Emmerton et al. 2013	2007–2010[f]	–	–	–	–	–	–	–	–	–	0.015	–	–	–	–	–	–
Delta (CAN)																	
Leitch et al. 2007	2003–2005[g]	–	–	–	–	–	–	–	–	–	0.002–0.003	–	–	–	–	–	–
Inuvik (CAN)																	
Graydon et al. 2009	2004	–	–	–	–	–	–	–	–	–	0.01	–	–	–	–	–	–
Headwaters to mouth (CAN)																	
Leitch et al. 2007	2003–2005[h]	–	–	–	–	–	–	–	–	–	0.01	–	–	–	–	–	–
PEEL RIVER																	
Above Ft. McPherson (CAN)																	
Emmerton et al. 2013	2007–2010[i]	–	–	–	–	–	–	–	–	–	0.02	–	–	–	–	–	–
YUKON RIVER																	
Pilot Station (AK)																	
Schuster et al. 2011	2001–2005	–	–	–	–	–	–	–	–	–	0.02	–	–	–	–	–	–
Schuster et al. 2003	19-Apr-01	145,000	47,100	10,700	0.4	77.0	0.00	<0.8	80	<0.8	–	95.8	0.4	<1.0	206.0	–	–
	5-Jul-01	72,000	27,000	5,630	1.0	45.1	0.03	<0.8	170	0.29	–	12.6	0.4	<1.0	48.0	–	–
	25-Jul-01	78,000	27,300	6,700	0.9	43.4	0.02	<0.8	110	0.15	–	3.5	0.5	<1.0	68.0	–	–
	14-Aug-01	78,000	28,200	6,770	0.8	47.4	<0.04	<0.8	50	0.20	–	2.9	<0.3	<1.0	65.0	–	–

RIVER SYSTEM Location Source	Date	Total water hardness	Calcium	Magnesium	Arsenic	Barium	Cadmium	Chromium	Iron	Lead	Mercury	Manganese	Selenium	Silver	Nitrate Nitrite as Total Nitrogen	Residual Range Organics	Diesel Range Organics
	30-Aug-01	78,000	29,500	7,190	0.9	46.9	<0.04	<0.8	90	0.20	–	4.1	0.6	3.00	73.0	–	–
	21-Sep-01	84,000	31,000	8,010	0.9	43.8	<0.04	<0.8	150	0.06	–	9.9	0.5	<1.0	71.0	–	–
Schuster et al. 2006a	2-Apr-02	147,000	45,300	10,400	0.3	82.0	0.03	<0.8	51	<0.8	–	162.0	0.3	<1.0	163.0	–	–
	12-Jun-02	59,000	22,300	4,250	0.8	38.0	0.05	<0.8	279	0.29	–	15.1	<0.3	<1.0	46.0	–	–
	20-Jun-02	66,000	22,900	5,230	1.0	42.0	0.03	<0.8	320	0.31	–	9.9	0.3	<1.0	55.0	–	–
	1-Jul-02	70,000	27,000	6,210	0.9	39.0	0.02	<0.8	238	0.14	–	6.6	0.4	<1.0	56.0	–	–
	16-Jul-02	80,000	26,600	6,470	0.8	42.0	0.04	<0.8	115	0.32	–	4.9	0.4	<1.0	79.0	–	–
	8-Aug-02	84,000	30,100	7,410	0.9	52.0	0.02	<0.8	24	0.06	–	2.4	0.2	<1.0	79.0	–	–
	24-Sep-02	78,000	30,100	8,190	0.8	39.0	0.04	<0.8	125	0.09	–	6.9	0.4	<1.0	87.0	–	–
Schuster et al. 2006b																	
	25-Mar-03	141,000	44,000	10,500	0.5	86.0	0.02	<0.8	101	<0.8	–	96.8	0.6	<1.0	0.0	–	–
	28-May-03	60,000	23,700	5,120	0.7	35.0	0.02	<0.8	303	0.28	–	14.0	<0.5	<1.0	83.0	–	–
	17-Jun-03	66,000	24,200	5,090	0.8	38.0	0.03	<0.8	173	0.17	–	13.0	0.4	<1.0	57.0	–	–
	10-Jul-03	70,000	29,000	7,150	0.9	0.0	NA	<0.8	126	NA	–	0.0	<0.5	NA	82.0	–	–
	24-Jul-03	71,000	30,100	7,650	0.9	44.0	<0.04	<0.8	43	0.07	–	2.0	0.5	<1.0	0.0	–	–
	19-Aug-03	74,000	28,900	7,550	0.9	41.0	<0.04	<0.8	91	0.22	–	2.9	0.4	<1.0	79.0	–	–
	23-Sep-03	75,000	29,600	7,880	0.9	37.0	<0.04	<0.8	244	0.10	–	6.9	0.3	<1.0	94.0	–	–
Schuster et al. 2006c	7-Apr-04	143,000	48,700	11,500	0.4	80.0	0.04	<0.8	91	<0.8	–	143.0	0.3	<1.0	188.0	–	–
	26-May-04	58,000	22,800	4,430	0.8	37.0	<0.04	<0.8	306	0.20	–	16.4	0.2	<1.0	84.0	–	–
	15-Jun-04	68,000	26,900	4,890	1.0	41.0	<0.04	<0.8	123	0.11	–	14.3	0.3	<1.0	54.0	–	–
	29-Jun-04	73,000	28,000	5,690	0.9	42.0	<0.04	<0.8	141	0.09	–	5.4	0.4	<1.0	69.0	–	–
	20-Jul-04	83,000	32,800	7,340	0.9	49.0	<0.04	<0.8	14	<0.8	–	0.5	0.7	<1.0	82.0	–	–
	18-Aug-04	86,000	34,500	7,690	0.9	51.0	<0.04	<0.8	25	<0.8	–	1.9	0.4	<1.0	82.0	–	–
	22-Sep-04	98,000	38,200	9,720	0.8	54.0	<0.04	<0.8	64	<0.8	–	15.3	0.4	<1.0	108.0	–	–
Schuster et al. 2007	17-Mar-05	141,000	47,900	11,700	0.4	81.0	0.04	<0.8	94	0.20	–	139.0	0.3	<1.0	195.0	–	–
	17-May-05	60,000	22,400	4,200	1.1	39.0	<0.04	<0.8	332	0.23	–	72.4	<0.4	<1.0	12.1	–	–
	1-Jun-05	65,000	24,200	4,630	1.0	45.0	<0.04	<0.8	193	0.63	–	29.3	0.3	<1.0	79.0	–	–
	14-Jun-05	70,000	27,600	5,950	0.9	43.0	0.02	<0.8	150	0.17	–	16.8	0.3	<1.0	84.0	–	–

RIVER SYSTEM / Location	Source	Date	Total water hardness	Calcium	Magnesium	Arsenic	Barium	Cadmium	Chromium	Iron	Lead	Mercury	Manganese	Selenium	Silver	Nitrate Nitrite as Total Nitrogen	Residual Range Organics	Diesel Range Organics
		12-Jul-05	81,000	30,800	7,390	1.1	48.0	0.06	<0.8	207	0.20	–	2.7	0.5	<1.0	94.0	–	–
		16-Aug-05	89,000	35,200	8,610	0.9	50.0	<0.04	<0.8	50	0.07	–	3.7	0.5	<1.0	105.0	–	–
		27-Sep-05	78,000	30,800	7,860	0.9	46.0	0.03	0.21	178	0.14	–	10.0	0.4	<1.0	113.0	–	–
Water Standards																		
	EPA DWS[j]		NEL	NEL	NEL	10.0	2000.0	5.00	100.0	NEL	15.00	2.00	NEL	50.0	NEL	10,000	NEL	NEL
	EPA ALS[k]		NEL	NEL	NEL	150.0	NEL	0.25	74.0	1,000	2.50	0.77	NEL	5.0	NEL	NEL	NEL	NEL
	ADEC WQS[l]		NEL	NEL	NEL	10.0	2000.0	CALC[m]	100.0	1,000	CALC[m]	0.05	50.0	5.0	CALC[m]	10,000	NEL	NEL

[a] Mean of thirty sampling events at one station
[b] Mean of thirteen sampling events at one station
[c] Mean of eighty sampling events at one station
[d] Mean of twenty-nine sampling events at one station
[e] Mean of thirty sampling events at one station
[f] Mean of twelve sampling events at one station sampled three times per year
[g] Mean of five sampling events at seven stations over three years
[h] Mean of two hundred thirty-seven sampling events at seventy-nine stations sampled once per year
[i] Mean of twelve sampling events at one station sampled three times per year
[j] EPA Drinking Water Standard, Maximum Contaminant Level (MCL)
[k] EPA Aquatic Life Standard, Criterion Continuous Concentration (CCC)
[l] Alaska Department of Environmental Conservation, Water Quality Standards
[m] These standards are "total water hardness" dependent for individual samples. Refer to the "Methods" section for a description of how these standards are calculated.
CALC = Calculation Required
NEL= No Established Limit
ND = Not detected at the reporting limit
– = Not Tested