NWTPAS

Lue Túé Sulái Candidate Area

Phase II Ecological Assessment

Aquatic Survey Summary

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2013

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Executive Summary

This document summarizes information collected during the both years of the Phase II ecological assessment of the Lue Túé Sulái area of interest. Phase II was initiated to help fill information gaps on the basic limnology, hydrology, water quality and fish species inventories. The results will be used by the Candidate Area Working Group in the drafting of a working group report and in the future to make suggestions for management of the area.

The Jean Marie River First Nations community supported the work and provided community monitors who were pivotal to the success of the surveys. The Dehcho First Nations (DFN) Aboriginal Aquatic Resources and Ocean Management (AAROM) program also provided critical support that included water quality measurements & collection, fisheries management & mercury accumulation surveys and workshops, bathymetric profiles, Canadian Aquatic Biomonitoring Network (CABiN) assessments and youth science camps.

Inflow, centre and outflow sites were established for all five lakes and GPS waypoints were recorded for all fifteen of these locations. Thereafter temperature, and dissolved oxygen readings were taken initially at the surface and then every meter thereafter until the bottom was reached. Secchi depths were also recorded at each site.

Water samples were also collected at the surface of each site and shipped within 24 hours to the Taiga Environmental Laboratory in Yellowknife. The samples were analyzed using standard analytical methods established by the US Environmental Protection Agency for the Examination of Water and Waste Water. Results were compared to Canadian Water Quality Guidelines for Drinking Water (CCME 2010), the Protection of Aquatic Life (CCME 2011) and values reported in similar surveys conducted in the region.

General hydrological, stream inflow locations and shoreline habitat were recorded and documented using a GPS equipped camera. Depth measurements were taken using a handheld sonar unit, along 22 transects in Deep Lake and at evenly spaced locations down the center line of McGill Lake. Seine netting was also attempted at one shore station in Ekali Lake. Monitors/Elders provided traditional knowledge on original names as well as fishing and spawning information for each lake.

Results

The water quality within all lakes was generally good. However one reading (195 ug/L of Nickel recorded at the Deep Lake inflow station) fell outside the drinking water and protection of aquatic life guidelines. Surface water temperatures were warm. Dissolved oxygen values were uniformly high at the surface and down the water column of both McGill and Deep Lake but values were reduced at depths below 5 meters in Ekali and Sanguez. During the 2011 survey 50% saturation values were recorded for all depths within Lake Gargan but when the lake was re-sampled in 2012 values were uniformily high.

Major ion concentrations and nutrient levels were moderate, chlorophyll a concentrations low and pH readings were slightly basic in all lakes. Metal levels for all five lakes were most often near or below detection limits. Concentrations were within the range recorded during the Mackenzie Gas Project baseline survey for a site on the Jean Marie River upstream of Deep Lake (MGP, 2004) and the DFO bioassessment survey downstream of McGill Lake. (Remple & Gill, 2011).

However the total concentrations of Aluminum, Chromium, Iron, Lithium, Nickel and Zinc recorded for both McGill and Deep Lake during the 2012 survey were generally higher than those recorded during the 2011 survey on Ekali,

Sanguez and Gargan. The specific metals listed above seem to be associated with particulate material and the higher concentrations noted at the Deep and McGill inflow stations suggest that this material settles when it enters the basin.

Hydrocarbons and solvents values were not detectable in any of the lakes.

Vegetation around all lakes was similar and ranged from Black Spruce, Tamarack, Birch, Aspen, Willow, Alders, Dogwoods and Rosehips. Emergent vegetation was more common in the shallow (epilimnetic) areas of McGill Lake because Deep Lake basin contours were very steep. The maximum depth reading recorded was 6 meters for Ekali, 8 meters for Sanguez, 4 meters for Gargan, 9 meters for McGill, and 37 meters for Deep.

Sediment ranged from organic and woody debris to sandy and small rocks in both lakes and limestone cobble was very common along the Deep Lake shoreline especially on the north-east side. Rock outcrops occasionally occurred along the shoreline of Ekali Lake and according to the accompanying Elders these areas are good fishing locations but this varies with season. Three small inflows occurred on the west side of McGill Lake, two forming sandy beaches, the other discharging black organic mud from a low lying bog area. Elders indicated that Walleye spawn near the sandy shorelines and the anoxic nature of bog inflow warrants further investigation as a possible methyl mercury point source.

Deep Lake also has a stream inflow that enters on the west shore but it was much smaller than those that occur on McGill Lake. However the west shoreline has small slump areas that contain Black Spruce and their close proximity to the lake suggest that these erosion sites could also be a methyl mercury point source. More research is needed.

A natural boulder dam in the creek between Ekali and Sanguez lakes was identified as an important spawning site. Elders expressed concern that increased beaver dam construction along the watershed would adversely affect fall spawning migration of local white fish populations, however these stocks have co-existed with beaver populations that may benefit the watershed by maintaining lake levels.

No minnows were seen during the 2011 habitat surveys and several attempts to seine net the near-shore of Ekali Lake yielded only small Northern Pike. In addition no forage fish were found in any of the Northern Pike or Walleye stomachs during the 2011 stock assessment survey of Ekali Lake. A spot-tailed shinner was captured by hand at the McGill Lake shore station 1 during the 2012 survey.

The report also contains unpublished DFN-AAROM mercury survey data that is included here to support the recommendation that additional research is needed to help determine why mercury levels in fish are changing and whether increasing fish harvest could be used to reverse the trend.

Recommendations

- Continue to support the partnership between the Łue Túé Sųlái management authorities and the DFN-AAROM program.
- Support DFN-AAROM mercury biomagnification proposals and the ENR-GNWT water quality and contaminants monitoring initiatives.
- Ensure both traditional knowledge and modern science methods are integrated into all the experimental design of future research/surveys.
- Develop better ways to explain health advisories, how they are determined and what they mean.

- Promote the importance of traditional foods in the diet of First Nations culture and health: focus on youth and get them out on the water and land.
- Test fish organs that are traditionally eaten by community members, such as fish guts, for mercury.
- Include a watershed component within the working group report and resolve transboundary issues with other Dehcho communities in particular Sambaa K'e. Cooperation will be essential for an ecosystem-level management approach to be effective.
- Develop community based science education and environmental quality monitoring programs to support cultural and ecological values and management recommendations for Łue Túé Sųlái, once established.
- As part of the visioning process for Łue Túé Sųlái, develop education outreach materials for local use as well as for visitors. This could include signage to promote the cultural and ecological significance of the area as well as to profile area monitoring initiatives.
- Deep and McGill Lake sediments should be analyzed or passive water samplers deployed to measure metals, organics and hydrocarbons to better establish background levels.
- A detailed bathymetric chart should be drawn for each of the Five Lakes.
- In-situ water quality measurements should be routinely taken at established lake stations whenever other monitoring and fishing surveys are conducted in the area.
- The marsh area and the creek between McGill and Deep Lake and the "Selero Watershed Area" upstream of Deep Lake should be surveyed if additional ecological studies are planned.

Acknowledgements

- The survey would not have been possible without the enthusiastic support of the working group and community monitors.
- The superior administrative and technical talents of Claudia Haas, GNWT-ENR, are also recognized.
- The unwavering support of George & Mike Low as well as the entire DFN-AAROM team is very much appreciated.
- Dr. Marlene Evans and her Environment Canada analytical team provided the fish mercury data.
- Dr. John Rudd and Mr. Mike Stainton provided technical advice on mercury cycling and the water chemistry results.

Figure 1
The Working Group has provided strong leadership and advice.
Left-right, front row- Ernest Hardisty, Florence Hardisty, Stanley Sanguez
Second row - Yvonne Norwegian, Margaret Ireland, Laura Sanguez
Back row - Michael Blyth, Kris Johnson, Angus Sanguez, Michael Mageean

Introduction

This document summarizes information collected during the 2011/12 surveys for the Phase II ecological assessment of the Lue Túé Sulái Candidate Area. The two year assessment was designed to help fill the information gaps on the basic limnology and fish species of the five "finger" lakes identified within the 2010 Phase I Ecological Assessment report prepared by SENES Consultants Ltd. Ekali, Sanguez & Gargan were sampled in August 2011 and the remaining two lakes, Deep & McGill, were surveyed in September 2012.

The Jean Marie River First Nations put forward the area through the NWT Protected Areas Strategy (PAS) process and the GNWT agreed to sponsor it as Cultural Conservation Area under the Territorial Parks Act. A Working Group was formed to oversee the documentation and assessment of the area's cultural, ecological, and economic values, Step 5 in the PAS process.

> *"The lands around these five lakes: Kelly Lake, Sanguez Lake, Gargan Lake, Deep Lake and McGill Lake has sustained us as the Tthets'ehk'e Deli Got'ie Got'ie from the past. According to our stories and cultural beliefs it is a very important area to us. It is for this reason that we respect the area and feel that it must be protected for our further generations."*
>
> \- *(Lue Túé Sulái Vision Statement)*

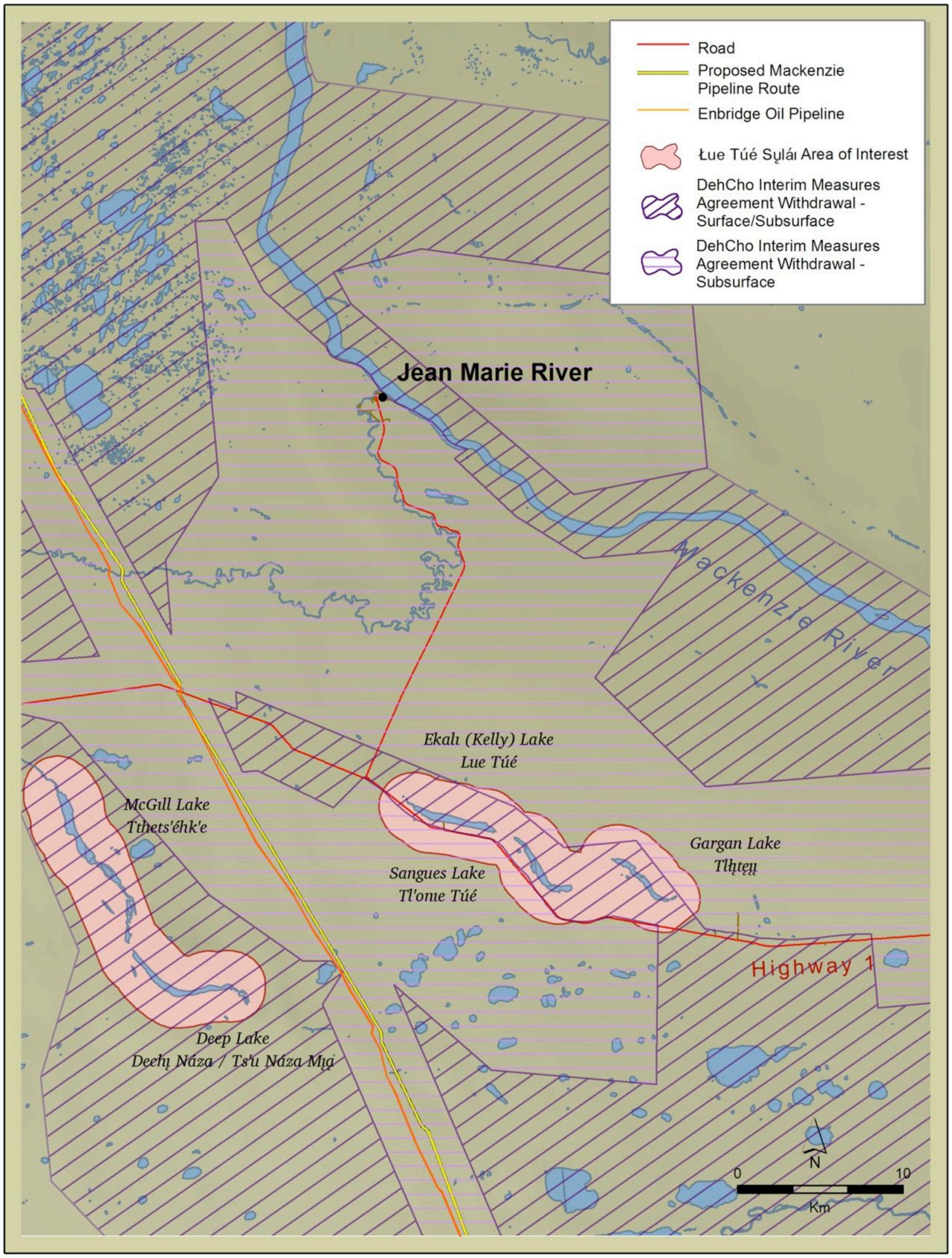

Figure 2
Map Showing Area of Interest

The Norman Wells or Enbridge Oil Pipeline and the right-of-way for the proposed Mackenzie Valley Gas Pipeline extend through the western subarea of the Lue Túé Sulái Candidate Area. The corridor crosses the Jean Marie Creek upstream of Deep Lake and the Jean Marie River downstream of McGill Lake. Baseline studies were conducted on the Jean Marie River during 1971-73 as part of the Mackenzie Valley Gas pipeline assessment, in 1981 for the Inter-provincial Pipeline study, and in 1986 during water crossing evaluations for the Norman Wells Pipeline. (Dryden et al., 1973; McCart & McCart, 1982; Fernet, 1986). More recently the Jean Marie River has been sampled both upstream of Deep Lake (MGP, 2004) and downstream of McGill Lake (Remple & Gill, 2011) and fish surveys were conducted in the area too (Stewart et al. 2003; Evans et al. 2005). A combined phase 1 ecological assessment was also completed for the area (Senes, 2010).

The Jean Marie River First Nations community supported this year's initiative and provided community monitors/elders who were pivotal to the success of the survey. The Dehcho First Nations (DFN) Aboriginal Aquatic Resources and Ocean Management (AAROM) program also provided critical support that included water quality measurements, fisheries management assessments, mercury accumulation surveys, bathymetric profiles, stream health (CABiN) initiatives and youth science camps.

Figure 3
Community monitors were pivotal to the success of the survey.

Methods

In keeping with the 2011 Phase 2 survey design both shore and lake stations (labelled as inflow, centre and outflow) were also established in 2012 for McGill and Deep Lake and GPS waypoints were recorded for all of the fifteen locations(Tables 1-5).

Table 1
Shore Station Locations 2011

Description	WAY	POINTS	Comments
EKALI	N	W	Garmin GPS-Map 62st
Shore Station A	61 16 59.3	120 33 05.6	Sandy Gravel Bottom
Shore Station B	61 17 09.4	120 33 00.0	Sandy Woody Debris
Shore Station C	61 17 21.5	120 34 13.9	Sandy Bottom
SANGUEZ	N	W	Garmin GPS-Map 62st
Shore Station A	61 16 12.7	120 30 18.4	Organic Sediments with Bubbles
Shore Station B	61 15 30.5	120 29 33.0	Sandy Pebble Sediments Steep Grade
Shore Station C	61 15 21.6	120 29 56.0	Sand Organic Mix - Mussels Present
GARGAN	N	W	Panasonic DMC-TS3 Camera
Shore Station A	61 15 37.5	120 24 28.6	Observations/Pictures
Shore Station B	61 15 7.9	120 23 22.6	Were Taken From
Shore Station C	61 14 11.9	120 21 35.6	The Float Plane

Table 2
Shore Station Locations 2012

Description	WAY	POINTS	Comments
DEEP	N	W	Garmin GPS-Map 62st
Upstream River Site	61 12 31.5	120 50 41.8	Secchi 2.9M, Depth 3M, DO 9.4 mg/L
Shore Station 1	61 12 41.1	120 51 00.4	Escarpment Exposed - North Side
Shore Station 2	61 12 31.8	120 52 59.6	South Side – Lower/Wetter than North?
Stream In - Dry	61 12 28.8	120 54 46.8	But with Signs of Seasonal Freshet
Shore Slump	61 12 52.7	120 55 50.2	Possible Methyl Hg Point Source?
Shore Station 3	61 13 59.5	120 57 09.3	North East Side Limestone Cobble
INTERLAKE	N	W	
Creek Begins Again	61 14 3.0	120 57 15.7	Exposed Stream Bed
Creek Channel	61 14 7.9	120 57 25.6	Benthic Insects - Mayfly Nymphs
Creek Channel Widens	61 14 21.4	120 57 39.2	Narrow Channel Ends
Expanded Channel	61 14 35.0	120 57 37.9	Low Flow – Shallow Bays
Expanded Channel	61 15 24.3	120 57 20.9	Low Flow - Shallow Bays
Marsh Area Begins	61 15 26.3	120 57 8.0	Very Shallow Less Water than 2011
Marsh Area Ends	61 16 58.4	120 59 9.9	Very Shallow Less Water than 2011
McGILL			
Bog Inlet - West Side	61 17 07.9	120 59 50.4	Methyl Hg Point Source?
Station 2 – West Side	61 17 54.3	121 00 35.8	Low - Marshy – Beaver Activity
Station 3 – East Side	61 17 30.7	120 59 45.7	Cabin - Area Floods in Spring
Stream In – West Side	61 18 05.0	121 01 02.6	Sandy Delta - Moose Sign
Stream In – West Side	61 18 18.3	121 01 11.6	Sandy Beach - Walleye Spawn Here
Station 1 - East Side	61 19 25.8	121 01 17.7	Rat Root, Lily Pads, Mussels Present.

Table 3
Lake Station Locations 2011

Lake	Date	Inflow	Middle	Outflow
Ekali	Aug 09/11	N61 17.059 W120 33.065	N 61 17.287 W120 34.364	N 61 17.787 W120 37.125
Sanguez	Aug 11/11	N61 16.311 W120 30.481	N61 15.463 W 120 29.697	N 61 14.892 W120 27.876
Gargan	Aug 16/11	N 61 15 37.51 120 24 28.55W	N 61 15 36.44 W120 24 26.08	N 61 15 7.90 W120 23 22.56

Ekali/Sanguez taken with Garmin, Gargan taken with Panasonic

Table 4
Lake Station Locations
McGill Lake 2012

N	W	Comments
61 19 38.0	121 01 35.8	Jean Marie River Begins
61 19 24.1	121 01 28.5	Outflow Station - 6.5 M
61 18 55.7	121 01 03.1	Depth Check - 9.1 Meters
61 18 27.4	121 00 54.7	Depth Check - 6.4 Meters
61 17 55.0	121 00 30.7	Center Station
61 17 30.1	121 00 00.4	Depth Check - 3.5 Meters
61 17 13.1	120 59 45.5	Inflow Station

Table 5
Lake Station Locations
Deep Lake 2012

N	W	Comments
61 12 31.5	120 50 41.8	Upstream Deep
61 12 36.0	120 50 57.2	Lake Begins
61 12 37.0	120 50 58.7	Inflow Station
61 12 34.9	120 53 00.8	Center Station
61 13 58.2	120 57 15.9	Outflow Station

In situ water quality measurements (temperature, dissolved oxygen, conductivity, pH) were taken at each site initially at the surface and then every meter thereafter until the bottom was reached. Secchi depths were also recorded at each location.

Water samples were collected at the surface of each site and shipped within 24 hours to the Taiga Environmental Laboratory in Yellowknife. They were analyzed using standard analytical methods established by the US Environmental Protection Agency for the Examination of Water and Waste Water. Recorded values were compared to Canadian Water Quality Guidelines for Drinking Water (CCME 2010), the Protection of Aquatic Life (CCME 2011) and values reported in simular surveys conducted in the region.

During both years, general hydrological, stream inflow locations, and shoreline habitat observations were described and documented using a GPS equipped camera. In 2011 an unexpected helicopter ride along the Jean Marie River as far as Deep Lake provided an opportunity to collect aerial photos. In 2012 depth measurements were taken using a hand-held sonar unit along 22 transects in Deep Lake and at evenly spaced locations down the center line of McGill Lake. Monitors/Elders provided traditional knowledge on original names as well as fishing & spawning information.

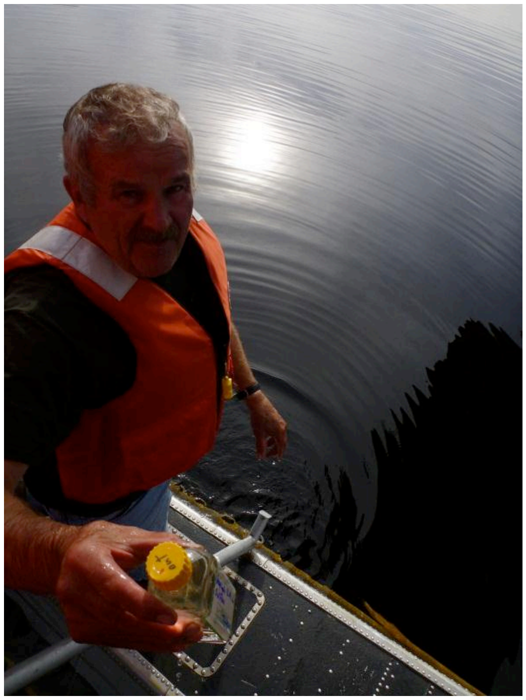

Figure 4
Water samples were shipped within 24 hours of collection.

Results

Geology

The five lakes are located in the western part of the Great Slave Plain near the community of Jean Marie River. The two small northwest-southeast oriented subareas, established using a buffer zone drawn around each lake chain, contain approximately 90 km2 of low relief lake valley that lies at about 250 meters average elevation along the marshy drainage of the Jean Marie River. The area is underlain by Devonian carbonates (limestone) and siliciclastics (sandstone) that overlie Precambrian strata. The petroleum potential of the area is not considered high(Morrow, 2007).

Deep and McGill are separated from Gargan, Sanguez and Ekali by a large plain of morainal (glacial) deposits. McGill Lake lies in a lacustrine (lake) deposit of gravel and sand some 3-10 m deep but Deep Lake lies in a shallower alluvial (river) one. During the Norman Wells Pipeline survey a borehole was drilled approximately 100 m north of Deep Lake on Nov 23, 1969, and it showed till from the surface to 3.3 m and then limestone below. (Rutter et al. 1973). After exiting the north end of McGill Lake, the Jean Marie River flows through an alluvial floodplain and empties into the MacKenzie River(Senes Consultants, 2010).

The landscape surrounding Deep and to a lesser extent McGill is dominated by limestone ridges that run in a northwest direction. The ridges extend along the northeast side of both lakes but appear to be less steep on the southwest side where it quickly recedes at the southwest corner of McGill Lake. Limestone cobble was very common along the shoreline of Deep Lake.

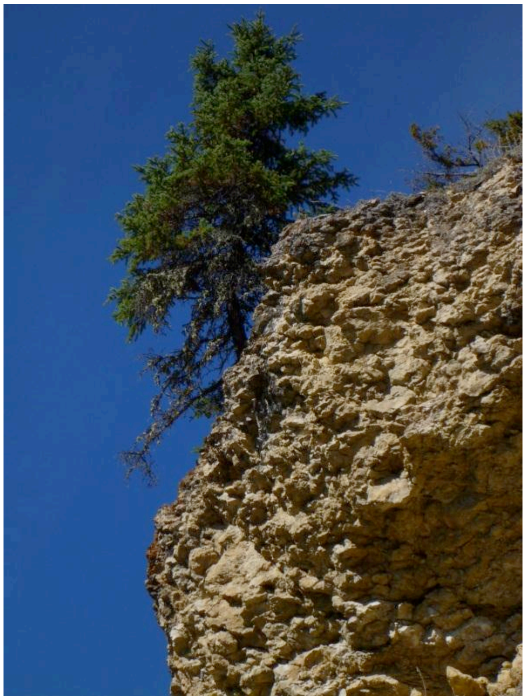

Figure 5
Limestone ridges dominate the Deep Lake landscape.

Hydrology

Margaret Ireland, Jean Marie River First Nations, provided the information on traditional names.

Ekali/Sanguez/Gargan

In the spring water levels downstream of Ekali Lake can be significant as shown by an elder in the picture below.

Figure 6.
Elder Showing Water Levels in the Spring

Beaver damns constrain water flow between Sanguez and Ekali Lakes and there is also a very large damn at the outflow of Ekali Lake.

Figure 7.
Showing a small section of an approximately 500M long beaver damn downstream of Ekali Lake.

A rock pile (N61 16 32.17 W 120 30 54.38) in the creek between Ekali and Sanguez Lakes was identified as an important spawning site. Elders expressed concern that increased beaver dam construction along the watershed would adversely affect fall spawning migration of local white fish populations.

Figure 8
Rock Pile Site Between Ekali and Sanguez

JMR/Deep/McGill

The area southeast and upstream of Deep Lake is known as Selero Area and there is also a lake there called Selero which is close to a lake called Miro (Robinson Lake). There is no English name for this beautiful rich habitat area that was a central encampment for the JMR people. Selero means a big patch of popular. The creek that flows from this area into Deep Lake is known traditionally as Selero/Selecho Deha (creek).

The literal translation of the original name of Deep Lake is "Wood/tree Standing" and the land surrounding the lake was called Tthembaa which means "Canyon Like with Steep Embankments". The traditional story is that big trees grow in the area and when landslides happened the people could see just the tip of them in the water. The Jean Marie Creek enters the south east end of the lake, flows through its steep deep basin and exits at the northwest end through a shallow, and during the survey, a predominately dry channel that runs for approximately 500m downstream of the lake. Traditionally this section of the creek is called "Rock/stone spark path/place between flowing".

The channel then widens, deepens and runs for approximately another 2 kilometers where it enters a very shallow marsh area. The marsh drains north into the long shallow basin of McGill Lake and at the northwest outflow of the lake the creek becomes the Jean Marie River. The traditional name for McGill Lake is "Rock/stone spark path place" and the river that flows from it "Rock/stone spark path/place flowing from". After it crosses the MacKenzie Highway the river swings to the northeast and enters the McKenzie River adjacent to the community of Jean Marie River. The traditional name of the Jean Marie River People is "Rock/stone spark path/place flowing from/People of".

The Water Survey of Canada monitoring station for the Jean Marie River is located just east of the Mackenzie Highway but the values recorded here do not include the inflow from Ekali/Sanguez/Gargan because the outflow from this lake chain enters the river downstream of the monitoring site. The average 2012 daily discharge data from the monitoring station is not yet available but the flow values shown in figure 9 for 2011 valves reflect seasonal trends that are similar to the 40 year average values reported in Senes 2010.

Water levels were very low during the 2012 survey and this made travel between the two lakes difficult. Elders indicated however that the shore areas along both lake basins regularly flood in the spring and the channel between the two lakes was seen to be full during the 2011 aerial survey .

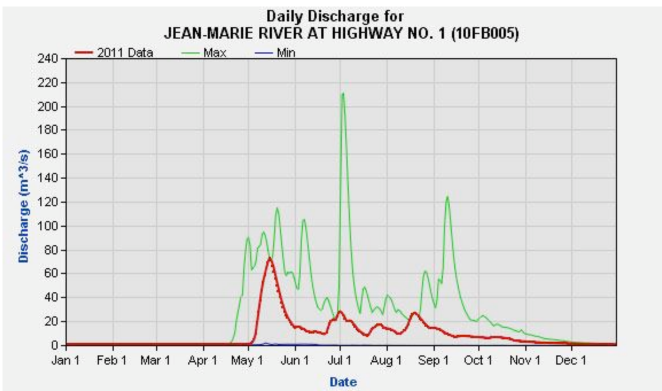

Figure 9
JMR daily discharge volumes for 2011.
(Water Survey of Canada 2011)

Remple and Gill (2011) established a catchment area estimate, landscape attributes, and soil/drainage characteristics for the portion of the Jean Marie River upstream of their sample site located at N61 27 10.30; W 121 0 28.19. Their sample location is upstream of the Ekali/Sanguez/Gargan lake chain confluence so the area surrounding these three lakes is not included. They estimated the JMR/Deep/McGill basin perimeter length as 319 km, a basin area of 1500 km2 , and a stream length of 460km. The local morainal deposits of this area are known to have low permeability and combined with the lack of relief results in relatively poor drainage of surface waters and the presence of peat and muskeg deposits(MGP 2004).

Figure 10
The water levels in the channel downstream from Deep were low in 2012.

Average annual precipitation ranges from 400 to 600 mm with most of it coming in the summer in the form of rain. However the warming climate is expected to cause significant changes to precipitation patterns and permafrost distribution and this will likely affect flow patterns of surface water into as well as movement between the lakes. (Senes, 2010).

Figure 11
The water level in the marsh area was very low during the 2012 survey.

Streams Inputs

McGill Lake

Three small streams entered on the west side of McGill Lake; two formed small sand beaches and the other discharged black organic mud from a low lying bog area. Elders indicated that Walleye spawn near the sandy shorelines. The black anoxic appearance of bog inflow warrants further investigation as a possible methyl mercury point source.

Figure 12
Stream 1 Inflow McGill (2012)

Figure 13
Stream 2 Inflow McGill (2012)

Figure 14
Bog Inflow McGill (2012)

Deep Lake

There is also a small inflow that enters Deep Lake on the South West corner where the basin swings northward. Although it was almost dry during the survey, the adjacent shoreline suggests that higher flows do occur during the year.

Figure 15
Stream Inflow Deep (2012)

Shore Stations: (Tables 1-5)

The NWT Ecosystem Group classification system (2007) can be used to develop a better understanding of soil and vegetation distribution within the area. Lue Túé Sulái lies within the Mackenzie and Slave Mid-Boreal Level III ecoregion that has a mild climate and large number of fens and bogs due to poor drainage and discontinuous permafrost.

Vegetation around all lakes was similar and ranged from Black Spruce (Picea), Tamarack (Larix), Birch (Betula), Aspen (Populus), Willow (Salix), Alders (Alnus), Dogwoods (Cornus) and Rosehips (Rosa).

Ekali/Sanguez/Gargan

Emergent vegetation most always occurred in the shallows and near shore sediment ranged from organic woody debris to sandy and small rocks. Organic sediments were dark black in colour possibly anaerobic (no oxygen present), and combined with high ambient temperatures represent suitable habitat for methylating bacteria. Mussels were common in many of the shallow water areas of Ekali and Sanguez Lakes.

Ekali Lake gets itS name from Henry Ekali who lived to be 107 and with his wife had a cabin on the lake. Original names also give clues of the local habitat and the literal translation of Ekali was “Reed/grass/weed blade path/place”. The literal translation of Sanguez is “Reed/grass/weed” for the large grass island located on it. The literal translation for Gargan is “Dog carry/in land to shore”. The story surrounding this name is that one spring the people were making their way back from Selero area, there was no food and all but one of the dogs died. Everyone helped carry the last dog and when they got to Gargan they caught fish and slowly the people and the dog regained their strength. The stream that connects Sanguez and Gargan is called Tthedhuh which means “*a creek that flows over an outcrop of rock*”.

Large rock outcrops occasionally occurred along the shoreline for example at Ekali Lake (N61 17.294 W 120 33.898) and Sanguez Lake (N 61 16.330 W 120 30.596) and according to the accompanying Elders these areas are good fishing locations but this varies with season.

Figure 16
Rock Outcrops Often Indicate Good Fishing Sites on Ekali & Gargan (2011)

McGill/Deep

Emergent vegetation was common in the shallow (epilimnetic) areas of McGill Lake but less so in Deep Lake because its basin contours were much steeper. Near shore sediment ranged from organic and woody debris to sandy and small rocks in both lakes. Limestone cobble beaches were a very common feature of the Deep Lake shoreline particularly on the northeast side of the basin. The west shoreline of Deep Lake also has small slump areas that contain Black Spruce and their close proximity to the lake suggest that these erosion sites could be a methyl mercury point source.

Figure 17
Shoreline Slump Deep Lake (2012)

Freshwater mussels were very plentiful and it is worth considering if they could be used for bio-monitoring purposes such as establishing mercury uptake rates in the different lake basins (Malley et. al.1995). A spot-tailed shinner/minnow (Notropis hudsonius) was captured by hand at the McGill Lake shore station 1.

Figure 18
Spot-tail Shiner McGill Lake (2012)

Lake Stations:

In keeping with the 2011 Phase 2 survey design, inflow, centre and outflow sites were established for McGill and Deep Lake and GPS waypoints were recorded for all six of these locations. Thereafter temperature, and dissolved oxygen readings were taken initially at the surface and then every meter thereafter until the bottom was reached. Secchi depths were also recorded at each site.

In Situ Water Quality Measurements (Tables 6-13)

Temperature affects the solubility of many compounds in water and therefore influences their impact on aquatic life. For example warmer water holds less oxygen but it also increases metabolic demand and this combination can stress many species. Temperature also influences water density, vertical stratification patterns and the distribution of dissolved and suspended compounds(see ILMB, British Columbia).

Dissolved Oxygen (DO) is a measure of the amount of oxygen dissolved in water and its concentration is subject to daily and seasonal fluctuations due in part to variations in temperature and photosynthetic activity.

The water quality in McGill and Deep Lake was generally good and dissolved oxygen (DO) values were uniformly high even in the deeper (hypolimion) waters of Deep Lake. Surface water temperatures were uniformly warm but the depths of Deep were Cold! However in 2011 the entire water column of Ekali and Sanguez was very warm and the DO values were very much reduced near the bottom.

Table 6
In Situ Water Quality Measurements
Ekali Lake 2011

Ekali Lake	10-Aug-11	Inflow	N 61.17.059	W 120.33.065	Secchi: 2.5M	
Depth (M)	Temperature (*C)	DO (mg/L)	DO %	Conductivity (uS/cm)	TDS (mg/L)	pH
0	20.3	7.57	83.6	171.1	122.2	7.9
1	20.3	7.45	82.9	171.3	122.2	
2	20.2	7.33	80.2	171.1	122.2	
2.5	20	6.83	75.3	167.8	122.6	
3.0 Bottom	19.7	0.09	1.1	194.6	140.4	

Ekali Lake	10-Aug-11	Middle	N 61.17.287	W 120.33.364	Secchi: 2.1M	
Depth (M)	Temperature (*C)	DO (mg/L)	DO %	Conductivity (uS/cm)	TDS (mg/L)	pH
0	20.8	7.4	82	174.3	123.5	7.85
1	20.7	7.48	84.2	174.1	123.5	
2	20.7	7.5	85.5	173.6	123.9	
3	20.6	7.64	85.7	173.4	122.9	
4	20.6	7.66	85.2	173.5	123.5	
5	19.9	3.88	42.4	171	124.8	
6	17	0.43	4.6	158.4	122.2	
6.5 bottom	15.4	0.08	0.7	153.3	122.2	

Ekali Lake	10-Aug-11	Outflow	N 61.17.787	W 120.37.125	Secchi: 2.1M	
Depth (M)	Temperature (*C)	DO (mg/L)	DO %	Conductivity (uS/cm)	TDS (mg/L)	pH
0	19.8	6.49	69.8	173.6	125.5	7.37
1	19.7	6.23	69.5	173.7	125.5	
2	19.8	6.32	69.7	171.6	124.2	
2.5	19.5	4.82	52.4	172.8	125.5	

Table 7
In Situ Water Quality Measurements
Sanguez Lake 2011

Sanguez Lake	11-Aug-11	Outflow	N 61.16.311	W 120.30.481	Secchi: 2.5M	
Depth (M)	Temperature (*C)	DO (mg/L)	DO %	Conductivity (uS/cm)	TDS (mg/L)	pH
0	19.4	7.54	82.4	169.1		7.89

Sanguez Lake	11-Aug-11	Middle	N 61.15.463	W 120.29.697	Secchi: 3.2M	
Depth (M)	Temperature (*C)	DO (mg/L)	DO %	Conductivity (uS/cm)	TDS (mg/L)	pH
0	20.5	8.02	90.4	173.8	123.5	8.01
1	20.3	7.82	89	174	124.2	
2	20.4	7.77	85.5	173.7	124.2	
3	20	7.44	83.9	172.2	124.2	
4	18.6	5.8	63.5	174	129	
5	14.4	2.2	22	153.2	125.5	
6	10.7	1.55	14.2	141.7	126.8	
7	9.3	1.39	12.1	138.6	128.7	
8	8.8	1.39	11.9	137.1	129.4	

Sanguez Lake	11-Aug-11	Inflow	N 61.14.892	W 120.27.876	Secchi: 2.9M	
Depth (M)	Temperature (*C)	DO (mg/L)	DO %	Conductivity (uS/cm)	TDS (mg/L)	pH
0	21	8.14	90.4	175.6	124.1	7.86
1	20.9	8.12	89.4	176.9	124.8	
2	20.6	7.93	84.5	176	126	
3	19.6	7.8	85.4	187	135	

Table 8
In Situ Water Quality Measurements
Gargan Lake 2011

Gargan Lake	16-Aug-11	Outflow	N 61.15.37.51	W 120.24.28.55		
Depth (M)	Temperature (*C)	DO (mg/L)	DO %	Conductivity (uS/cm)	TDS (mg/L)	pH
0	18.2	3.4	38.4	131	98.8	7.93
1	18.2	3.06	38.6	131.6	98.2	

Gargan Lake	16-Aug-11	Middle	N 61.15.36.44	W 120.24.26.08		
Depth (M)	Temperature (*C)	DO (mg/L)	DO %	Conductivity (uS/cm)	TDS (mg/L)	pH
0	18.9	3.02	32.5	138	104	7.54
1	18.9	2.95	32	138	101.4	
2	18.9	3.58	38	138	101.4	
3	18.8	3.66	40.6	137.3	101.4	
4	18.7	3.84	40.6	136.7	100.8	

Gargan Lake	16-Aug-11	Inflow	N 61.15.7.90	W 120.23.22.56		
Depth (M)	Temperature (*C)	DO (mg/L)	DO %	Conductivity (uS/cm)	TDS (mg/L)	pH
0	18.7	3.17	33.5	139.5	102.7	7.15
1	18.8	3.74	40.3	139.6	102.7	
2	18.7	3.9	42.3	140.1	103.4	
2.5	18.6	3.91	42.5	140	104	

Note: GPS waypoints taken with Panasonic DMC-TS3 Camera

Table 9
In Situ Water Quality Measurements
Gargan Lake 2012 (resampled)

Gargan Lake	13-Sept-12	Middle	N 61.15.36.44	W 120.24.26.08		
Depth (M)	Temperature (*C)	DO (mg/L)	DO %	Conductivity (uS/cm)	TDS (mg/L)	pH
0	12.9	9.67	91.9	Not Taken	No	No
1	12.5	9.66	90.7	-	-	-
2	12.4	9.40	89.0	-	-	-
3	12.2	9.39	87.4	-	-	-
4	12.1	9.29	86.7	-	-	-
5	12.1	9.32	88.4	-	-	-

Table 10
In Situ Water Quality Measurements
McGill Lake 2012

Outflow Station	Sept 11/12	11:11 hrs	McGill
N 61 19 24.1 Depth (M)	W121 01 28.5 Temp C	Overcast DO	Secchi 2.3 M % Sat
Air	6.4	n/a	n/a
Surface	14.3	8.05	79
1	14.5	8.15	80.2
2	14.5	8.13	80.1
3	14.5	8.23	81
4	14.5	8.2	81
5	14.5	8.19	80.3
6	14.5	8.04	79.3
6.5	Bottom		

Center Station	Sept 11/12	12:30	McGill
N 61 17 55.0 Depth (M)	W 121 00 30.7 Temp C	Light Wind NW DO	Secchi 2.5 M % Sat
Air	9	n/a	n/a
Surface	14.1	8.4	82
1	14	8.56	83.8
2	14.4	8.59	83.9
3	14.4	8.56	84
4	14.4	8.59	84.4
4.5	14.4	8.51	83.3
5	Bottom		

Inflow Station	Sept 11/12	13:00	McGill
N 61 17 13.1 Depth (M)	W 120 59 45.5 Temp C	Overcast DO	Secchi 1.5 M % Sat
Air	10.6	n/a	n/a
Surface	12	9.06	84.6
1	12.2	9.09	84.6

Table 11
In Situ Water Quality Measurements
Deep Lake 2012

Outflow	Sept 12/12	16:50	Deep
N 61 13 56.9 Depth	W 120 57 14.0 Temp C	Calm/Clear DO	Secchi 3 M %Sat
Air	12.5	n/a	n/a
Surface	13.9	8.08	79.9
1	13.6	8.26	79.6
2	13.3	8.32	79.6
3	13.2	8.14	79
4	13.1	8.31	78.3
5	13.1	8.27	78.6
6	13.1	8.18	76.9
7	13	8.1	77.1
8	13	8.14	76.9
9	11.5	6.87	64.7
10	8.9	6.57	56.7
11	7.3	6.49	54
12	6.4	6.53	53
13	6.3	6.5	52.9
14	6	6.42	52
15	5.9	6.4	51.6
16	5.7	6.41	51.3
17	5.7	6.25	50.1
18	Bottom		

Figure 19
Secchii Readings Were Taken at Each Site

Table 12
In Situ Water Quality Measurements
Deep Lake 2012

Center	Sept 12/12	14:40	Deep
N 61 12 34.9	W 120 53 00.8	Clear	Secchi 2.9 M
Depth (M)	Temp C	DO	% Sat
Air	10.4	n/a	n/a
Surface	14.3	8.41	82
1	14.4	8.37	83.7
2	14.2	8.35	81.9
3	14.2	8.5	82.9
4	14.2	8.52	83.3
5	14.2	8.51	83
6	14.2	8.5	82.9
7	14.1	8.57	83.6
8	14.1	8.55	83.2
9	14.1	8.54	83.1
10	10.1	6.41	57.7
11	6.6	6.82	56.3
12	6.1	6.92	55.6
13	5.9	6.86	55
14	5.7	6.9	54.9
15	5.3	6.93	54.7
16	5.2	6.93	53.8
17	5.1	6.84	53.7
18	5	6.81	53.3
19	4.9	6.81	53.2
20	4.8	6.87	53.7
21	4.8	6.8	53
22	4.7	6.9	53.7
23	4.6	6.92	53.7
24	4.6	6.92	53.6
25	4.6	6.87	52.8
26	4.6	6.84	52.8
27	4.5	6.79	52.4
28	4.5	6.85	53
29	4.5	6.8	52.4
30	4.4	6.85	52.8
31	4.4	6.81	52.8
32	4.4	6.73	52
33	4.4	6.74	51.4
34	4.3	6.71	51.8
35	4.3	6.43	50
36	4.2	6.33	48.7
Bottom	4.1	0.3	2.4

Table 13
In Situ Water Quality Measurements
Deep Lake 2012

Inflow	Sept 12/12	13:30	Deep
N 61 12 37.0	W 120 59 58.7	Sunny/Clear	Secchi 2.1 M
Depth (M)	Temp C	DO	% Sat
Surface	14.1	8.95	87.3
1	14.1	8.99	87.9
2	14	9	87.7
3	14	9	89
4	14	8.88	86.6
5	14	9.02	88
6	Bottom		

Figure 20
Mussels were common in the shallows of all lakes

Deep Lake Basin Morphology

A preliminary bathymetric survey of Deep Lake shows a steep walled basin that appears to contain numerous slump points within it. Twenty-one transects were established along the basin and Table 14 records the waypoint numbers at the beginning and end of each and five depth readings between them. Appendix A provides a GPS coordinate for each of the waypoints listed.

Table 14
Depth Transects Deep Lake 2012

Way Point			Depth (Meters)			Way Point
57 N	1.2	5.3	10.8	9.9	6.3	58 S
60 N	5.7	8.9	12.5	11.4	6.0	59 S
61 N	3.4	4.3	8.0	12.7	6.2	62 S
64 S	16.2	23.5	23	15.7	8.7	63 S
65 N	13.6	26.7	32.4	35.9	12.2	66 S
68 N	12.2	41.1	39.2	34.2	11.2	67 S
69 N	11.6	34.3	30.4	38.5	15.2	70 S
74 N	16.0	27.1	24.6	42.3	8.1	73 S
75 N	10.9	24.4	34.4	30.8	9.4	76 S
78 N	15.2	34.8	38.9	31.7	16.1	77 S
79 N	16.0	34.0	35.7	35.1	11.6	80 S
82 NE	8.8	25.2	26.6	26.3	10.4	81 SW
83 NE	13.8	23.0	24.8	27.7	12.2	84 SW
86 NE	8.8	15.4	18.0	14.2	11.3	85 SW
87 NE	11.2	17.5	19.8	21.3	5.9	88 SW
90 NE	8.6	16.0	16.9	7.3	5.9	89 SW
91 NE	11.2	22.8	23.4	22.9	6.9	92 SW
94 NE	10.8	14.4	11.0	8.7	7.4	93 SW
95 NE	15.3	15.2	23.1	17.2	6.4	96 SW
98 NE	9.0	16.5	16.2	11.2	6.0	97 SW
99 NE	11.6	22.9	19.9	10.2	4.8	100 SW

Water Chemistry

The physical, geological, chemical and biological processes that occur within the Jean Marie River watershed influence the water chemistry of the five lakes area. The physical movement of water is controlled by local topography, the shape of the lake basin and the streams that flow into it. Geology determines what is dissolved and the resulting water chemistry controls growth within local food webs. The four processes work together and the biogeochemical cycles that occur in lakes and river support the plants and animals that live there.

The water chemistry within all lakes was generally good and only one reading (195 ug/L of Nickel recorded at the Deep Lake inflow station 2012) fell outside the drinking water and protection of aquatic life guidelines. Values were within the range recorded during the Mackenzie Gas Project baseline survey (MGP, 2004) for a site on the Jean Marie River upstream of Deep Lake and the DFO bioassessment survey downstream of McGill Lake(Remple & Gill, 2011).

Inorganics/Physicals (Tables 15 & 16)

Alkalinity is a general indicator of the capacity of water to neutralize acids and it usually means that carbonate and bicarbonates are present. Results are expressed in terms of calcium carbonate (CaCO3) equivalents that indicate the sensitivity of lakes to acidic inputs. With readings above 20 mg/L all lakes have low sensitivity.

Specific conductivity is the measurement of the ability of water to conduct electrical current. All readings show moderately low values.

pH is the measurement of hydrogen-ion concentration in water and higher values can affect the solubility of ammonia, heavy metals and salts. All lakes are slightly basic but well within drinking water standards.

Total dissolved solids (TDS) measures dissolved material in the water column and dissolved salts such as sodium, chloride, magnesium and sulphate can elevate filterable residue values.

Turbidity is a measure of the suspended particular matter in the water body and it can influence transparency and light penetration, that in turn can affect plant growth. Particles entering a lake can also affect water chemistry. Using the Secchi disc to measure light extinction depth in lakes is another way to express turbidity. Although turbidity was low in all lakes the secchi readings at both the Deep and McGill inflow sites suggest that transparency was slightly reduced here.

Table 15
Inorganics/Physicals
Taiga Lab Analysis 2011

Parameter (mg/L)	Ekali Lake			Sanguez Lake			Gargan Lake			Detection Limit
	Inflow	Mid	Outflow	Inflow	Mid	Outflow	Inflow	Mid	Outflow	
Total Alkalinity ($CaCO_3$)	95.9	96.6	96.9	96.2	94.9	94.6	78.8	78.2	75.9	0.4
Conductivity, Specific	204	203	204	208	208	208	161	158	153	0.4
pH	8.1	8.1	8	8.2	8.1	8	8	8	8	
Total Dissolved Solids	136	136	132	126	138	144	112	116	112	10
Total Suspended Solids	*	6	4	4	*	*	8	*	6	3
Turbidity (NTU)	0.56	0.62	0.6	0.58	0.61	0.62	0.92	1.04	0.81	0.05

*Indicates a reading below the detection limit

Table 16
Inorganics/Physicals
Taiga Lab Analysis
2012

Parameter (mg/L)+	McGill Lake			Deep Lake			Detection Limit
	Inflow	Mid	Outflow	Inflow	Mid	Outflow	
Total Alkalinity ($CaCO_3$) +	115	110	110	112	108	106	0.4
Conductivity, Specific (uS/cm)	244	233	232	245	239	234	0.4
pH	8.2	8.15	8.16	8.2	8.18	8.16	
Total Dissolved Solids +	158	148	142	146	148	152	10
Total Suspended Solids +	4	*	*	*	*	*	3
Turbidity (NTU)	1.3	1.21	0.98	0.88	0.75	0.68	0.05

*Indicates a reading below the detection limit

Major Ions (Tables 17 & 18)

Atoms are the building blocks of matter and they are very, very small. Atoms have a neutral charge because the positively charged nucleus is surrounded by negatively charged particles called electrons and the two parts balance each other. However atoms can loose or gain electrons and when this happens the charge changes. When an atom has extra electrons it has a negative charge (anion) and when it loses them it has a positive one (cation). The electrical charge determines how an atom behaves and how it affects animals and other chemicals in solution.

Freshwater contains varying amounts of negatively and positively charged ions and a group called the "Major Ions" make up most of the dissolved solids present in freshwater. The major ions enter the water cycle through weathering of bedrock or on airborne particles that fall in rain. The total ionic salinity, composed almost entirely of the eight major ions, is important for osmotic regulation of metabolism and in the distribution of regional biota. (Wetzel, 2001) All values were well within water quality guidelines.

Cations

Calcium (Ca^{2+}) is a common cation and it easily dissolves in water.

Magnesium (Mg^{2+}) is common and is found in both igneous & sedimentary rock.

Sodium (Na+) and **Potassium (K^+)** are much less common but are essential for growth.

Anions

Chloride (Cl^-) uncommon but important for metabolism & water balance in plants and animals.

Fluoride (Fl^-) comes from the natural decomposition of rocks but it was not detected.

Nitrite (NO_2^-) is an unstable intermediate form of nitrogen that is either rapidly oxidized to nitrate (nitrification) or reduced to nitrogen gas (de-nitrification). It is normally present in surface water in only minute quantities where it can be a nutrient source for plants but it is toxic to animal life even at low concentrations. Anthropogenic sources include sewage treatment plant effluents and blasting residues. Non was detected.

Nitrate (NO_3^-) is the most oxidized and stable form of nitrogen in water and is used by plants as a nutrient to stimulate growth. Animals can only get it from the plants or animals that they eat and without human inputs most surface waters have less that 0.3 mg/L. Reported values are much lower and well below drinking & aquatic life standards.

Table 17
Major Ions
Taiga Lab Analysis 2011

Parameter (mg/L)	Ekali Lake Inflow	Ekali Lake Mid	Ekali Lake Outflow	Sanguez Lake Inflow	Sanguez Lake Mid	Sanguez Lake Outflow	Gargan Lake Inflow	Gargan Lake Mid	Gargan Lake Outflow	Detection Limit
Calcium	32	33.6	34.4	32.1	32	31.9	27.5	28.4	27.6	0.1
Chloride	1.6	1.7	1.8	1.9	2	1.9	0.7	0.8	0.7	0.7
Fluoride	*	*	*	*	*	*	*	*	*	0.1
Magnesium	6.2	6.5	6.7	6.2	6.2	6.2	5.2	5.4	5.2	0.1
Nitrate	*	*	*	0.06	0.12	0.09	0.08	0.08	0.08	0.01
Nitrite	*	*	*	*	*	*	*	*	*	0.01
Potassium	0.6	0.6	0.7	0.6	0.6	0.6	0.3	0.3	0.3	0.1
Sodium	2.7	2.8	2.9	2.7	2.7	2.7	1.8	1.9	1.8	0.1
Sulphate	7	7	7	9	9	9	8	8	8	1

*Indicates a reading below the detection limit.

Table 18
Major Ions
Taiga Lab Analysis 2012

Parameter (mg/L)	McGill Lake Inflow	McGill Lake Mid	McGill Lake Outflow	Deep Lake Inflow	Deep Lake Mid	Deep Lake Outflow	Detection Limit
Calcium	40.4	39	38.1	40.4	40.2	38.7	0.1
Chloride	1.4	1.2	1.1	1.5	1.5	1.3	0.7
Fluoride	*	*	*	*	*	*	0.1
Magnesium	8.4	8	6.7	8.2	8.1	7.8	0.1
Nitrate	*	0.02	0.02	0.02	0.02	0.03	0.01
Nitrite	*	*	*	*	*	*	0.01
Potassium	0.4	0.4	0.4	0.4	0.4	0.4	0.1
Sodium	4.1	3.8	3.7	4.3	4.2	3.9	0.1
Sulphate	11	12	11	16	16	15	1

*Indicates a reading below the detection limit.

Nutrients & Chlorophyll a (Tables 19 & 20)

Aquatic nutrients include nitrogen, carbon and phosphorus and each one of them is essential for aquatic life.

Nitrogen is most commonly found as nitrogen gas molecule N2 and it makes up about 78% of our atmosphere. However only a very small amount of N2 is available to organisms and before it can make its way up the food chain it must be transformed through a biochemical process called nitrogen fixation. In aquatic environments this is done by Cyanobacteria. Sources of nitrogen include: precipitation directly on the lake surface; nitrogen fixation both in the water and sediments; and inputs from surface and groundwater drainage(Wetzel, 2001).

However humans also transform nitrogen into fertilizers, doubling annual production and allowing biologically available forms to enter freshwater ecosystems far downstream from agricultural sources. Total nitrogen is the measure of all forms of nitrogen (organic and inorganic) and in the Five Lakes Area concentrations were low.

Total Organic Carbon is a combination of both the dissolved and particular forms and it is composed of humic substances and partly degraded plant and animal material. It is generally low in most Northern river systems and the values for the Five Lakes Area are in the middle of the range commonly reported in natural waters.

Phosphorous is considered the "limiting nutrient" because it is in limited supply and thus controls the growth of aquatic vegetation. Total phosphorous is a measure of both inorganic and organic forms and it can be present as either dissolved or particulate forms. The total phosphorous concentrations are generally less that 0.01 mg/L and these are around the values recorded for all lakes. Orthophosphate is a measure of the inorganic oxidized form of soluble phosphorus and it was below detection limits in all lakes.

Table 19
Nutrients & Chlorophyll a
Taiga Lab Analysis 2011

Parameter (mg/L)	**Ekali Lake**			**Sanguez Lake**			**Gargan Lake**			**Detection Limit**
	Inflow	**Mid**	**Outflow**	**Inflow**	**Mid**	**Outflow**	**Inflow**	**Mid**	**Outflow**	
Ammonia as Nitrogen	0.01	*	*	*	*	*	*	*	*	0.01
Dissolved Nitrogen	0.54	0.6	0.55	0.5	0.53	0.48	0.55	0.58	0.62	0.06
Total Nitrogen	0.57	0.64	0.57	0.51	0.6	0.53	0.6	0.6	0.7	0.06
Dissolved Organic Carbon	15.9	16	15.8	15.4	15	15.3	17.1	16.9	16.9	0.5
Total Organic Carbon	16.8	16.9	17.1	16.4	16.4	16.3	17.2	17	17.2	0.5
Ortho-Phosphate	*	*	*	*	*	*	*	*	*	0.002
Dissolved Phosphorous	0.02	*	*	0.01	*	0.02	*	*	*	0.01
Total Phosphorous	0.01	0.02	0.01	0.01	*	*	*	0.02	0.02	0.01
Chlorophyll a	0.002	.003	0.002	0.001	0.002	0.002	0.003	.004	0.005	0.001

*Indicates a reading below the detection limit.

Chlorophyll a concentrations can be used to measure a lake's productive state. Chlorophyll is the green pigment in plants that allows them to capture sunlight and the amount of algae found in a lake greatly affects it's physical, chemical, and biological makeup. Chlorophyll a is a measure of the pigment that is actively working and is therefore an indirect measurement of the levels of algae/phytoplankton involved.. The presence of algae in the water column is the main factor affecting Secchi disk readings. Recorded values indicate that productivity in all five lakes is very low.

Table 20
Nutrients & Chlorophyll
Taiga Lab Analysis 2012

Parameter (mg/L)	McGill Lake Inflow	McGill Lake Mid	McGill Lake Outflow	Deep Lake Inflow	Deep Lake Mid	Deep Lake Outflow	Detection Limit
Ammonia as Nitrogen	0.016	0.02	0.014	0.014	0.02	0.013	0.005
Dissolved Nitrogen	0.42	0.41	0.41	0.38	0.4	0.4	0.06
Total Nitrogen	0.46	0.46	0.45	0.45	0.45	0.44	0.06
Dissolved Organic Carbon	18.2	17.8	17.7	17.7	18	18.4	0.5
Total Organic Carbon	20.8	20.7	20.7	20	20.5	20	0.5
Ortho-Phosphate	*	*	*	*	*	*	0.002
Dissolved Phosphorous	*	*	*	*	*	*	0.01
Total Phosphorous	*	*	*	*	*	*	0.01
Chlorophyll – a	0.001	0.002	*	0.002	0.002	0.002	0.001

*Indicates a reading below the detection limit.

Hydrocarbons (Tables 21 & 22) are organic compounds made from carbon and hydrogen and they naturally occur in crude oil. Although all values were below detection limits, the information is valuable because it establishes a baseline reference point, should contamination occur in the future.

Table 21
Organics
Taiga Lab Analysis 2011

Parameter (mg/L)	Ekali Lake Inflow	Ekali Lake Mid	Ekali Lake Outflow	Sanguez Lake Inflow	Sanguez Lake Mid	Sanguez Lake Outflow	Gargan Lake Inflow	Gargan Lake Mid	Gargan Lake Outflow	Detection Limit
Benzene	*	*	*	*	*	*	*	*	*	0.01
Ethylbenzene	*	*	*	*	*	*	*	*	*	0.06
Hydrocarbons (a)	*	*	*	*	*	*	*	*	*	0.06
Hydrocarbons (b)	*	*	*	*	*	*	*	*	*	0.5
m/p-xylene	*	*	*	*	*	*	*	*	*	0.5
o-p-xylene	*	*	*	*	*	*	*	*	*	0.002
Toluene	*	*	*	*	*	*	*	*	*	0.01
(a) extractable										
(b) purgeable										

*Indicates a reading below the detection limit.

Table 22

Organics
Taiga Lab Analysis 2012

Parameter (mg/L)	McGill Lake Inflow	McGill Lake Mid	McGill Lake Outflow	Deep Lake Inflow	Deep Lake Mid	Deep Lake Outflow	Detection Limit
Benzene	*	*	*	*	*	*	0.01
Ethylbenzene	*	*	*	*	*	*	0.06
Hydrocarbons (a)	*	*	*	*	*	*	0.06
Hydrocarbons (b)	*	*	*	*	*	*	0.5
m/p-xylene	*	*	*	*	*	*	0.5
o-p-xylene	*	*	*	*	*	*	0.002
Toluene	*	*	*	*	*	*	0.01
(a) extractable			(b) purgeable				

*Indicates a reading below the detection limit.

Metals (Tables 23-26)

Cadmium concentrations in Ekali Lake during the 2011 survey were higher than total values suggesting that contamination may have occurred during sampling. Readers are further advised that the accuracy and precision for concentrations reported at less than twice the detection limit are often poor.

During the 2012 survey only one metal reading, for Nickel at 195 ug/L, (that occurred at the inflow station of Deep Lake), fell outside the drinking water and protection of aquatic life guidelines. It is uncertain if this was a result of cross contamination or if it is a reflection of a local point source. Most other metal readings were near or below detection limits, and all were similar to the values recorded during the Mackenzie Gas Project baseline survey (MGP, 2004) for a site on the Jean Marie River upstream of Deep Lake and the DFO bioassessment survey downstream of McGill Lake. (Remple & Gill, 2011).

However the total concentration of Aluminum, Chromium, Iron, Lithium, Nickel and Zinc were generally higher than those recorded during the 2011 survey on Ekali, Sanguez and Gargan and appeared to be associated with suspended solids. Concentrations were also higher at inflow sites and this suggests a source outside the lake basin.

Table 23
Dissolved Metal Concentrations
Taiga Lab Analysis 2011

Element	Ekali Lake			Sanguez Lake			Gargan Lake			Detection
ug/L	Inflow	Mid	Outflow	Inflow	Mid	Outflow	Inflow	Mid	Outflow	Limit
Aluminum	*	1.4	1.1	1	*	0.8	2.5	2.2	2.8	0.6
Antimony	*	*	*	*	*	*	*	*	*	0.1
Arsenic	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.2
Barium	39.6	39.1	39.2	37	36.8	37.1	28	27.3	28.1	0.1
Beryllium	*	*	*	*	*	*	*	*	*	0.1
Cadmium	0.06(?)	0.08(?)	0.06(?)	*	*	*	*	*	*	0.05
Cesium	*	*	*	*	*	*	*	*	*	0.1
Chromium	*	0.1	*	*	*	*	*	*	*	0.1
Cobalt	*	*	*	*	*	*	*	*	*	0.1
Copper	0.4	0.7	0.5	0.3	0.3	0.4	0.4	0.4	0.3	0.2
Iron	24	24	26	21	21	22	23	20	12	5
Lead	0.2	0.3	0.2	*	*	*	*	*	*	0.1
Lithium	1.6	1.6	1.6	2.1	1.9	1.9	1.8	1.8	1.7	0.2
Manganese	0.3	0.3	0.4	0.1	*	0.8	0.4	0.4	0.3	0.1
Mercury	*	*	*	*	*	*	*	*	*	0.01
Molybdenum	0.1	0.1	0.1	*	*	*	*	*	*	0.1
Nickel	0.5	0.5	0.5	0.3	0.3	0.3	0.4	0.4	0.4	0.1
Rubidium	0.6	0.6	0.6	0.5	0.5	0.5	0.3	0.3	0.4	0.1
Selenium	*	*	*	*	*	*	*	*	*	0.3
Silver	*	*	*	*	*	*	*	*	*	0.1
Strontium	89.2	89.1	88.5	90.6	90.2	90.6	77.3	76.3	72.7	0.1
Thallium	*	*	*	*	*	*	*	*	*	0.1
Titanium	*	*	*	*	*	*	*	*	*	0.1
Uranium	0.1	0.1	0.1	0.1	0.1	0.1	*	*	*	0.1
Vanadium	0.1	0.1	0.1	*	*	*	0.2	0.2	0.1	0.1
Zinc	0.5	1.1	0.6	0.4	*	1	0.9	1	1.6	0.4

*Indicates a reading below the detection limit.
?Dissolved values higher than totals - sample contaminated?

Table 24
Dissolved Metal Concentrations
Taiga Lab Analysis 2012

Element ug/L	McGill Lake Inflow	McGill Lake Mid	McGill Lake Outflow	Deep Lake Inflow	Deep Lake Mid	Deep Lake Outflow	Detection Limit
Aluminum	3.6	3.9	4.5	4	4.6	4.6	0.6
Antimony	*	*	*	*	*	*	0.1
Arsenic	0.3	0.2	0.3	0.3	0.2	0.2	0.2
Barium	50.1	47.4	47.2	42.7	41.9	40.3	0.1
Beryllium	*	*	*	*	*	*	0.1
Cadmium	*	*	*	*	*	*	0.05
Cesium	*	*	*	*	*	*	0.1
Chromium	*	*	*	*	*	*	0.1
Cobalt	*	*	*	0.1	*	*	0.1
Copper	0.2	0.2	0.2	0.3	*	*	0.2
Iron	37	36	38	56	51	52	5
Lead	*	*	*	*	*	*	0.1
Lithium	3.3	3	2.9	3.8	3.5	3.8	0.2
Manganese	0.7	0.3	1.2	2.6	0.6	0.8	0.1
Mercury	*	*	*	*	*	*	0.01
Molybdenum	*	*	*	0.1	*	*	0.1
Nickel	0.5	0.4	0.5	0.5	0.5	0.5	0.1
Rubidium	0.4	0.4	0.4	0.4	0.4	0.4	0.1
Selenium	*	*	*	*	*	*	0.3
Silver	*	*	*	*	*	*	0.1
Strontium	114	104	104	116	113	108	0.1
Thallium	*	*	*	*	*	*	0.1
Titanium	0.2	0.1	0.1	0.1	*	0.1	0.1
Uranium	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Vanadium	0.1	0.1	0.1	*	0.1	*	0.1
Zinc	*	*	0.6	*	*	*	0.4

*Indicates a reading below the detection limit.

Table 25
Total Metal Concentrations
Taiga Lab Analysis 2011

Element	Ekali Lake			Sanguez Lake			Gargan Lake			Detection
ug/L	Inflow	Mid	Outflow	Inflow	Mid	Outflow	Inflow	Mid	Outflow	Limit
Aluminum	*	*	*	*	*	*	10	10	7	5
Antimony	*	*	*	*	*	*	*	*	*	0.1
Arsenic	0.3	0.3	0.3	*	*	*	0.3	0.3	0.3	0.2
Barium	40.3	38.6	38.1	39.5	36.8	38.2	27.5	27.1	30.4	0.1
Beryllium	*	*	*	*	*	*	*	*	*	0.1
Cadmium	*	*	*	*	*	*	*	*	*	0.1
Cesium	*	*	*	*	*	*	*	*	*	0.1
Chromium	*	*	0.1	*	*	*	0.1	0.1	*	0.1
Cobalt	*	*	*	*	*	*	*	*	*	0.1
Copper	0.8	0.8	0.7	1	0.9	0.9	0.8	0.8	0.9	0.2
Iron	41	40	40	39	37	38	48	50	23	5
Lead	*	*	*	*	*	*	0.4	0.2	*	0.1
Lithium	1.6	1.6	1.5	2.3	2.1	2.2	1.9	2	2	0.2
Manganese	7	6.6	7.8	6.6	5.7	13.5	18	14.7	10.4	0.1
Mercury	*	*	*	*	*	*	*	*	*	0.01
Molybdenum	0.1	0.1	*	0.1	*	*	*	0.1	*	0.1
Nickel	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.1
Rubidium	0.6	0.6	0.6	0.6	0.6	0.5	0.4	0.3	0.4	0.1
Selenium	*	*	*	*	*	*	*	*	*	0.5
Silver	0.1	*	*	*	*	*	*	*	*	0.1
Strontium	89.8	86	85.6	95.4	89.4	90	74.4	75.3	75.1	0.1
Thallium	*	*	*	*	*	*	*	*	*	0.1
Titanium	*	*	*	*	*	*	*	0.2	*	0.1
Uranium	0.1	0.1	0.1	0.2	0.2	*	*	*	*	0.1
Vanadium	0.2	0.2	*	0.2	0.2	*	0.2	0.3	0.2	0.1
Zinc	*	*	*	*	*	*	*	*	*	5

*Indicates a reading below the detection limit.

Table 26
Total Metal Concentrations
Taiga Lab Analysis 2012

Element ug/L	McGill Lake Inflow	McGill Lake Mid	McGill Lake Outflow	Deep Lake Inflow	Deep Lake Mid	Deep Lake Outflow	Detection Limit
Aluminum	21	19	16	17	11	14	5
Antimony	*	0.2	0.1	0.1	0.1	*	0.1
Arsenic	0.4	0.4	0.3	0.4	0.3	0.3	0.2
Barium	58.8	55.6	53.3	49.6	44.8	45.2	0.1
Beryllium	*	*	*	*	*	*	0.1
Cadmium	*	*	*	*	*	*	0.1
Cesium	*	*	*	*	*	*	0.1
Chromium	0.7	0.5	0.4	5.9	0.3	0.3	0.1
Cobalt	*	*	*	*	*	*	0.1
Copper	0.9	0.7	0.7	0.8	0.6	0.6	0.2
Iron	114	108	101	111	85	92	5
Lead	*	*	*	*	*	*	0.1
Lithium	3.9	3.6	3.6	4.7	4.4	4.1	0.2
Manganese	6.7	11.2	10.4	10.4	4.7	4.6	0.1
Mercury	0.01	0.03	*	0.03	*	*	0.01
Molybdenum	0.1	0.4	0.1	0.4	*	*	0.1
Nickel	12.6	11	6.2	195	6.5	6.9	0.1
Rubidium	0.5	0.5	0.5	0.5	0.4	0.5	0.1
Selenium	*	*	*	*	*	*	0.5
Silver	*	0.4	0.1	0.4	0.2	*	0.1
Strontium	128	118	113	131	118	118	0.1
Thallium	*	*	*	*	*	*	0.1
Titanium	0.4	0.4	0.4	0.4	0.2	0.3	0.1
Uranium	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Vanadium	0.5	0.4	0.4	0.5	0.4	0.4	0.1
Zinc	16	16	15	18	16	16	5

Mercury Survey:

Table 27 summarizes mercury levels in fish from both lake chains in the Lue Túé Sulái area. This information was presented at the "Return to Country Food" meeting and workshop held at Jean Marie River August, 2012. During the two day workshop participants reviewed the available data on contaminants in water and fish with focus on mercury. The meeting also provided an opportunity to identify community concerns and to guide future research. A report was prepared by Caroline Lafontaine, Environmental Consultant(Lafontaine, 2012).

During the workshop, Mike Low, DFN ARROM technical advisor, summarized Table 27 information as follows:

- Predatory fish had more mercury than species that are lower in the food chain.
- Lake Whitefish in all lakes tested are healthy and excellent for consumption.
- Larger predatory fish are still safe to eat but in lower amounts and less often.
- Smaller predatory fish have less mercury than larger ones.

Early work by DFO (see Stewart et al 2003b) established baseline values and more recent surveys by Environment Canada and others (see Evans et al. 2005) noted further increases. In response to this upward trend the DFN-AAROM "Country Food" survey was initiated to update the mercury levels database. Concurrently and as part of AAROM's community-based monitoring program, water quality measurements were routinely recorded.

Table 27
Mercury Data

Summary of mercury levels in fish from Lue Túé Sulái area.

McGill Lake	Year	N	Fork Length mm	Weight (g)	Age (years)	[Hg] (ug/g)
Lake Whitefish	2000	3	392.2 ± 57.0	1153.3 ± 582.8	7.7 ± 2.7	0.16 ± 0.05
Lake Whitefish	2010	3	419.7 ± 58.2	1168.3 ± 518.1	9.0 ± 4.0	0.10 ± 0.04
White Sucker	2000	17	471.4 ± 33.3	1740.6 ± 441.7		0.21 ± 0.08
White Sucker	2010	12	447.3 ± 39.6	1497.9 ± 403.4	11.6 ± 2.3	0.16 ± 0.06
Northern Pike	2000	28	577.2 ± 171.3	1905.8 ± 2127.8	8.5 ± 5.6	0.71 ± 0.37*
Northern Pike	2010	19	664.6 ± 180.8	2870.0 ± 2556.8	10.0 ± 4.1	0.83 ± 0.38*
Yellow Walleye	2000	22	480.4 ± 67.4	1428.6 ± 733.2	12.8 ± 5.4	1.13 ± 0.38*
Yellow Walleye	2010	20	464.4 ± 29.9	1162.8 ± 252.8	12.1 ± 3.0	1.25 ± 0.39*
Deep Lake	Year	N	Fork Length mm	Weight (g)	Age (years)	[Hg] (ug/g)
Lake Whitefish	2000	28	443.5 ± 40.9	1253.1 ± 345.0	11.4 ± 2.9	0.25 ± 0.12
Lake Whitefish	2010	1	474.0	1140.0		0.22
Burbot	2010	3	414.3 ± 123.1	550.0 ± 525.7	13.7 ± 3.1	0.91 ± 0.24*
Northern Pike	2000	6	583.7 ± 54.8	1420.0 ± 386.3	10.3 ± 4.3	0.67 ± 0.20*
Northern Pike	2010	4	574.3 ± 117.5	1387.5 ± 809.2	9.7 ± 4.5	1.15 ± 0.30*
Yellow Walleye	2000	4	448.0 ± 40.2	1040.0 ± 238.5	15.3 ± 3.5	1.11± 0.35*
Yellow Walleye	2010	5	401.0 ± 63.6	766.0 ± 395.3	11.6 ± 5.0	1.21 ± 0.46*
Ekali Lake	Year	N	Fork Length mm	Weight (g)	Age (years)	[Hg] (ug/g)
Lake Whitefish	1996	26	477.5 ± 70.4	1850.4 ± 807.3	7.9 ± 3.8	0.08 ± 0.04
Lake Whitefish	2011	20	473.1 ± 70.2	1782.3 ± 743.8	7.6 ± 2.4	0.12 ± 0.04
Northern Pike	1996	7	577.6 ± 90.8	1534,3 ± 960.7	7.6 ± 2.2	0.30 ± 0.11
Northern Pike	2011	16	622.1 ± 95.5	1910.6 ± 1085.8	8.3 ± 2.1	0.62 ± 0.17*
Yellow Walleye	1996	16	411.8 ± 28.9	842.5 ± 175.8	8.3 ± 1.6	0.26 ± 0.06
Yellow Walleye	2011	18	410.3 ± 42.0	738.3 ± 246.7	9.9 ± 3.3	0.54 ± 0.20*
Sanguez Lake	Year	N	Fork Length mm	Weight (g)	Age (years)	[Hg] (ug/g)
Northern Pike	1996	20	682.8 ± 84.8	2562.0 ± 985.3	9.7 ± 2.3	0.70 ± 0.18*
Northern Pike	2011	20	638.3 ± 50.7	1950.0 ± 471.6	9.4 ± 2.2	0.96 ± 0.22*
Yellow Walleye	1996	20	439.9 ± 40.4	1070.5 ± 368.9	9.4 ± 1.7	0.54 ± 0.12*
Yellow Walleye	2011	20	523.5 ± 44.5	1875.0 ± 507.2	8.9 ± 2.0	0.78 ± 0.25*

The 2010/11 values from DFN-AAROM Program Survey data of Low, G., M. Low, M. Evans.
Remainder from Evans et al. 2005., and Stewart et al 2003b.

* indicates values above guidelines for human consumptions

The objective of the survey was to:

- update data on current mercury levels
- identify which lakes and fish species are used for subsistence
- help determine why levels are rising

In addition to mercury levels, data was also collected on length, weight, age, sex and maturity and this provided valuable stock information.

Figure 21
Sampling Fish - Mercury Survey

During the workshop Dr. Marlene Evans from Environment Canada also discussed the results of the recent studies. Inorganic mercury is transformed by microbes into organic forms and this occurs more efficiently in warm productive shallow lakes and acidic wetland (Lafountaine, 2012). Recent ecosystem scale experiments have shown that although wetlands can be important sites for mercury methylation, water flow can greatly affect how wetland sources enter lakes (Harris et al., 2007). However the warming climate is expected to alter rainfall patterns and permafrost distribution (Senes, 2010) and this could affect water flow patterns into as well as between lakes.

Dr. Evans also recommended that future surveys should consider:

- Periodic re-assessment of mercury levels in fish
- Studies on mercury sources, reservoirs and long range transport
- More detailed analysis of lake parameters, productivity cycles and seasonal variability.
- Studies of lake sediments – the very top organic bacteria rich layer.

Discussion

The results listed above provide an important source of baseline data that will be used to advise the Candidate Area Working Group and help in the writing and implementing of a management plan for the Lue Túé Sulái Area. A well designed management plan will increase the ability to better understand the present and will allow a more timely and effective response to potential and actual environmental changes within the Five Lakes Area.

2011 Survey (Ekali, Sanguez, and Gargan Lakes)

During the 2011survey dissolved oxygen (DO) concentrations were very low in the bottom waters of Ekali and Sanguez Lakes. Gargan Lake values were also low with 50% saturation values recorded at the surface but when the profile was repeated in 2012 the values were close to saturation levels. It should be noted that lack of oxygen combined with the very warm water provides ideal growing conditions for mercury methylating bacteria.

From a limnology perspective however Gargan, Sanguez and Ekali lakes are isolated from the Jean Marie River and from Deep and McGill and this will need to be considered during management planning for this Candidate Area. Ekali Lake is easily accessible from the highway so it can be more easily impacted by increased use of outboard motors, fishing pressure, park infrastructure and invasive species. The hydrology of the three-lake chain is definitely influenced by beaver dam construction but a more carefully designed survey would be needed to quantify this impact. Melting permafrost could change groundwater movement as well.

The shore survey along Ekali Lake was worthwhile both for what we did not find and what we did. Forage fish, i.e. minnows, were absent in near shore areas and more work is needed to investigate this missing link in the food chain. Freshwater mussels were very plentiful and it is worth considering if they could be used for bio-monitoring purposes such as establishing mercury uptake rates in the different lake basins (Malley et. al.1995).

2012 Survey (McGill and Deep Lake)

The quality of the water collected during the 2012 survey was generally good and other than one high nickel concentration, chemistry values fell within the drinking water and protection of aquatic life guidelines. In situ water quality measurements were also good and the dissolved oxygen levels were high over all depths. Water temperatures were warm in the epilimion (upper) layers of both lakes but the depths of Deep Lake were cold!

However water levels were much lower than those noted during the 2011 aerial survey and if current warming trends continue, water quantity could become an issue. The timing of rainfall events could also be affected and forest fires could impact the watershed thereby altering water chemistry. Melting permafrost could change groundwater movement as well.

Management Issues

The two most extreme management issues that should be considered a priority would be a pipeline spill event and the elevated mercury levels in the predatory fish stocks.

Hydrocarbon Impact

The Norman Wells or Enbridge Oil Pipeline and the right-of-way for the proposed Mackenzie Valley Gas Pipeline cross the Jean Marie Creek upstream of Deep Lake and the Jean Marie River downstream of McGill Lake. A spill could greatly impact the entire watershed. The background hydrocarbon levels recorded during the survey provide valuable background data but sediment samples or better still polar organic chemical integrative samplers (POCIS) would provide better information.

It is uncertain if fracking exploration is planned to the south of Deep Lake but the headwaters of the Jean Marie watershed begin near Trout Lake and surface run-off should be considered before drilling occurs. Cooperation with other Dehcho communities, in particular Sambaa K'e, is essential for an ecosystem-level management approach to be developed. Resolving transboundary issues and including a watershed component within the working group report will help ensure water quality is protected in the future.

Mercury Levels

The increase of mercury concentrations in the predatory fish species in the Dehcho has caused wide spread concern in the region. In the coming years, mercury studies in the region will monitor ongoing trends and will try to determine if they are driven by temperature increases, permafrost melt, increased bacterial activity, increased Asian emissions, or more likely a combination of all these factors. Research efforts will continue to explore lake size and depth, watershed size and composition, water, nutrient and trace metal chemistry, food chain interactions and fish stock dynamics including whether increasing fish harvest could be used to lower mercury levels. It will be critical that both traditional and western ways of knowing are included, from the onset, in the experimental design.

Recommendations

The lands around the five lakes have sustained the Tthets'ehk'e Deli Got'ie Got'ie from the past and according to their stories and cultural beliefs it is a very important area. It is for this reason that they respect the area and feel that it must be protected for further generations. It is therefore recommended that the following be considered:

- Continue to support the partnership between the Łue Túé Sųlái management authorities and the DFN-AAROM program.
- Support DFN-AAROM mercury biomagnification proposals and the ENR-GNWT water quality and contaminants monitoring initiatives.
- Ensure both traditional knowledge and modern science methods are integrated into all the experimental design of future research/surveys.
- Develop better ways to explain health advisories, how they are determined and what they mean.
- Promote the importance of traditional foods in the diet of First Nations culture and health: focus on youth and get them out on the water and land.
- Test fish organs that are traditionally eaten by community members, such as fish guts, for mercury.
- Include a watershed component within the working group report and resolve transboundary issues with other Dehcho communities in particular Sambaa K'e. Cooperation will be essential for an ecosystem-level management approach to be effective.
- Develop community based science education and environmental quality monitoring programs to support cultural and ecological values and management recommendations for Łue Túé Sųlái, once established.
- As part of the visioning process for Łue Túé Sųlái, develop education outreach materials for local use as well as for visitors. This could include signage to promote the cultural and ecological significance of the area as well as to profile area monitoring initiatives.
- Deep and McGill Lake sediments should be analyzed or passive water samplers deployed to measure metals, organics and hydrocarbons to better establish background levels.
- A detailed bathymetric chart should be drawn for each of the Five Lakes.
- In-situ water quality measurements should be routinely taken at established lake stations whenever other monitoring and fishing surveys are conducted in the area.
- The marsh area and the creek between McGill and Deep Lake and the "Selero Watershed Area" upstream of Deep Lake should be included if additional ecological surveys are planned.

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Appendix

I: Summary table of pictures taken during the surveys

II: Way Point Summary Table for Deep Lake

III: Copies of Taiga water sample reports