ALBERTA-NWT TRANSBOUNDARY WATER QUALITY TECHNICAL REPORT

FOR SLAVE AND HAY TRANSBOUNDARY RIVERS

2020 | 2021

Government of
Northwest Territories

a technical companion report to the

Alberta-Northwest Territories Bilateral Management Committee Annual Report to Ministers, 2020-21

Surface water quality results for 2020

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December 2022

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English

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French

Kīspin ki nitawihtīn ē nīhīyawihk ōma ācimōwin, tipwāsinān.
Cree

Tłı̨chǫ yatı k'ę̀ę̀. Dı wegodı newǫ dè, gots'o gonede.
Tłı̨chǫ

ʔerıhtł'ís Dëne Sų́łiné yatı t'a huts'elkër xa beyáyatı theɂą ɂat'e, nuwe ts'ën yółtı.
Chipewyan

Edı gondı dehgáh got'ı̨e zhatıé k'ę́ę́ edatł'éh enahddhę nıde naxets'é edahłí.
South Slavey

K'áhshó got'ı̨ne xədə k'é hederı ɂedı̨htl'é yerınıwę nídé dúle.
North Slavey

Jii gwandak izhii ginjìk vat'atr'ijąhch'uu zhit yinohthan jì', diits'àt ginohkhìi.
Gwich'in

Uvanittuaq ilitchurisukupku Inuvialuktun, ququaqluta.
Inuvialuktun

ᑖᒃᑯᐊ ᑎᑎᕐᒃᑲᐃᑦ ᐱᔪᒪᒍᕕᒋᑦ ᐃᓄᒃᑎᑐᓕᕐᒃᓯᒪᓗᑎᒃ, ᐅᕙᑦᑎᓐᓄᑦ ᐅᖃᓚᔪᓐᓇᖅᑐᑎᑦ.
Inuktitut

Hapkua titiqqat pijumagupkit Inuinnaqtun, uvaptinnut hivajarlutit.
Inuinnaqtun

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Executive Summary

The Bilateral Management Committee (BMC) releases an annual water quality report as a component of the reporting requirements of the Alberta-Northwest Territories (NWT) Bilateral Water Management Agreement (BWMA). This is the fifth water quality report since the signing of the Agreement in 2015. It includes an assessment of the Environment and Climate Change Canada (ECCC) water quality data from the water samples collected from the Slave and Hay rivers in 2020 and the cooperative efforts of Alberta-NWT water quality staff between April 2020 and March 2021. Each year, water quality samples are collected from the Slave and Hay rivers. As part of this report, conventional parameters including major ions, nutrients and metals are reviewed. Site-specific interim water quality triggers, calculated from historical Slave and Hay River data, are used to assess the data. Typically, ECCC collects nine samples from the Slave River and four samples from the Hay Rivers; however, fewer samples were collected in 2020 due to the COVID-19 pandemic and subsequent temporary suspensions to ECCC's water quality field programs. GNWT and GoA made great efforts, within their capacity, to cover off any transboundary and oil sands monitoring that would have been undertaken by ECCC normally.

For the Slave River, 23 of the 69 parameters were flagged during the Trigger 1 assessment. Of these, levels of calcium, magnesium, sulphate, nitrate/nitrite, dissolved nitrogen, and dissolved uranium were significantly higher in present years (2015-2020) compared to the past. The Trigger 2 assessment flagged 10 of the 69 parameters for further assessment. Of these and on one occasion, dissolved magnesium was above its historical seasonal maximum but below its overall maximum value, whereas total mercury was above its historical overall maximum value. For the Hay River, 17 of the 42 parameters were flagged during the Trigger 1 assessment. Of these, the assessment indicated that levels of nitrate/nitrite were significantly statistically higher in recent years compared to the past. The Trigger 2 assessment flagged 10 of the 42 parameters for further assessment. Of these, dissolved sodium was above its historical seasonal maximum but below its overall maximum value, whereas total mercury was above its overall maximum value.

Assessment of the 2020 conventional water quality data highlighted a few trending parameters including magnesium, sulphate, nitrate/nitrite and dissolved nitrogen in the Slave River and nitrate/nitrite in the Hay River. Work is underway to examine and understand these trends further. The high mercury values measured in July for both the Slave and Hay rivers were attributable to the record high precipitation and associated river sediments that occurred over the year and throughout the region.

The BWMA commits the BMC to report on the detection (presence or absence) of toxic, bioaccumulative and persistent substances that are primarily of human origin. During the summer of 2020, three water samples from both the Slave and Hay rivers were analyzed for 14 of these kinds of substances. Some substances were detected in each river, but at very low concentrations. Comparisons with the available corresponding aquatic life guidelines/criteria show that the levels detected pose no risk to aquatic life.

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1. Background

In 1997, Canada, British Columbia, Alberta, Saskatchewan, the Northwest Territories and the Yukon signed the *Mackenzie River Basin Transboundary Waters Master Agreement* (herein, Master Agreement). The Master Agreement provided guidance for the negotiation of the Alberta-NWT Bilateral Water Management Agreement (BWMA) which was signed in 2015. The BWMA facilitates improved learning and reporting and includes provisions to develop site-specific triggers and objectives to maintain the ecological integrity of transboundary water ecosystems.

Each year, AB and NWT collaborate to release this report that describes the water quality-related activities undertaken during the previous fiscal year and the water quality data for the Slave and Hay rivers from the previous calendar year. The timing of reporting on the data is contingent on data availability and the analysis required.

The purpose of this report is to:

- Describe the Slave and Hay River transboundary water quality monitoring programs used for this assessment (Section 2);
- Describe the approach of the water quality assessment (Section 3);
- Present and discuss the results of the water quality assessment (Sections 4, 5 & 6); and,
- Describe the activities of the Alberta-NWT water quality technical team for the 2020-2021 fiscal year and any upcoming transboundary water quality-related tasks (Section 7).

2. Transboundary Water Quality Monitoring Programs

2.1 Slave River

Data from two long-term water quality monitoring sites (and two different programs) are used for the Slave River assessment. These include:

1) Long-term Monitoring Network, Slave River at Fitzgerald (1960 to present), led by Environment and Climate Change Canada (ECCC).

2) Transboundary Rivers Monitoring Program, Slave River at Fort Smith (1990-present), led by the Government of the Northwest Territories (GNWT).

Since 1960, ECCC has operated the Slave River at Fitzgerald monitoring site (AL07NB0001). The site is located near the community of Fort Fitzgerald in Alberta, approximately 20 km upstream from Fort Smith in the Northwest Territories. Since 1960, water samples have been collected two to thirteen times annually. In 2020, due to the COVID-19 pandemic, samples were only collected on 5 occasions, in January, February, August, September and October. The historical routine data generated from this sampling location were used to derive the water quality triggers for assessing the data from this site.

Since 1990, Crown-Indigenous Relations and Northern Affairs Canada (up to April 1, 2014) and the GNWT (after April 1, 2014) have operated the Slave River at Fort Smith monitoring site (NWT07QA0004). The site is located below the Rapids of the Drowned near the Town of Fort Smith. During the 1990s, when the Fort Smith baseline was being established, samples were collected anywhere from one to twelve times a year. In more recent years, as part of the ongoing monitoring in the Slave River at Fort Smith, samples are collected on 3[1] occasions in June, July and August. The organic substances data generated for this site are used to assess the substances that are subject to virtual elimination.

Table 1 presents a list of the water quality parameters reviewed to fulfill the water quality reporting requirements of the AB-NWT BWMA. The Slave River at Fitzgerald and Slave River at Fort Smith monitoring sites are shown in Figure 1.

Table 1: Water quality parameters for the Slave River, NWT reviewed for the 2020 water quality assessment

Parameter Grouping	**Parameters**
Physical Parameters (Slave River at Fitzgerald; ECCC data)	alkalinity, dissolved oxygen, pH, specific conductance, total dissolved solids, total suspended solids, turbidity
Major Ions (Slave River at Fitzgerald; ECCC data)	dissolved calcium, dissolved chloride, dissolved magnesium, dissolved sodium, dissolved potassium, dissolved sulphate
Nutrients (Slave River at Fitzgerald; ECCC data)	ammonia, dissolved nitrogen, nitrate/nitrite, dissolved organic carbon, particulate organic carbon, dissolved phosphorus, total phosphorus
Metals (dissolved and total) (Slave River at Fitzgerald; ECCC data)	aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, molybdenum, nickel, selenium, silver, strontium, thallium, uranium, vanadium, zinc
Substances Subject to Virtual Elimination (Slave River at Fort Smith; GNWT data)	aldrin, chlordane, dieldrin, endosulfan, endrin, heptachlor, hexachlorobenzene, hexachlorobutadiene, hexachlorocyclohexane (HCH; alpha, beta, gamma), mirex, DDD, DDE, DDT, toxaphene, PCBs, pentachlorobenzene

[1] Additional samples are collected from this site as part of the Community Based Monitoring (CBM) Program. The samples are also analyzed for routine substances including physical parameters, major ions, nutrients and metals. At this time, the CBM data are not part of these annual assessments as the site-specific triggers were specifically derived for the Slave River at Fitzgerald.

2.2 Hay River

Data from one long-term transboundary water quality monitoring site (but from two different programs) are used for the Hay River assessment:

1) Long-term Monitoring Network, Hay River near the Alberta/NWT Border (1988 to present), led by ECCC.

2) Transboundary Rivers Monitoring Program, Hay River near the Alberta/NWT Border (1995-present), led by GNWT.

Since 1988, ECCC has operated the Hay River near the Alberta/NWT Border monitoring site (NW07OB0002). The site is located at the border off the Alberta/NWT 60th Parallel Territorial Park approximately 100 km south from the Town of Hay River. Since 1988, samples have normally been collected three to six times a year. In 2020, samples were collected on three occasions in August, September and October.

Since 1995, Crown-Indigenous Relations and Northern Affairs Canada (up to April 1, 2014) and the GNWT (after April 1, 2014) have operated the Hay River near the Alberta/NWT Border monitoring site as part of their Transboundary Rivers Monitoring Program. In 2020, samples were collected three times in June, July and August.

Table 2 presents a list of the water quality parameters reviewed to fulfill the water quality reporting requirements of the AB-NWT BWMA. The Hay River near the Alberta/NWT Border monitoring site is shown in Figure 1.

Table 2: Water quality parameters for the Hay River, NWT reviewed for the 2020 water quality assessment

Parameter Grouping	**Parameters**
Physical Parameters (ECCC data)	alkalinity, dissolved oxygen, pH, specific conductance, total dissolved solids, total suspended solids, turbidity
Major Ions (ECCC data)	dissolved calcium, dissolved chloride, dissolved magnesium, dissolved sodium, dissolved potassium, dissolved sulphate
Nutrients (ECCC data)	ammonia, dissolved nitrogen, nitrate/nitrite, dissolved organic carbon, particulate organic carbon, dissolved phosphorus, total phosphorus
Metals (total) (ECCC data)	aluminum, antimony, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, molybdenum, nickel, selenium, silver, strontium, thallium, uranium, vanadium, zinc

Parameter Grouping	Parameters
Substances Subject to Virtual Elimination (GNWT data)	aldrin, chlordane, dieldrin, endosulfan, endrin, heptachlor, hexachlorobenzene, hexachlorobutadiene, hexachlorocyclohexane (HCH; alpha, beta, gamma), mirex, DDD, DDE, DDT, toxaphene, PCBs, pentachlorobenzene

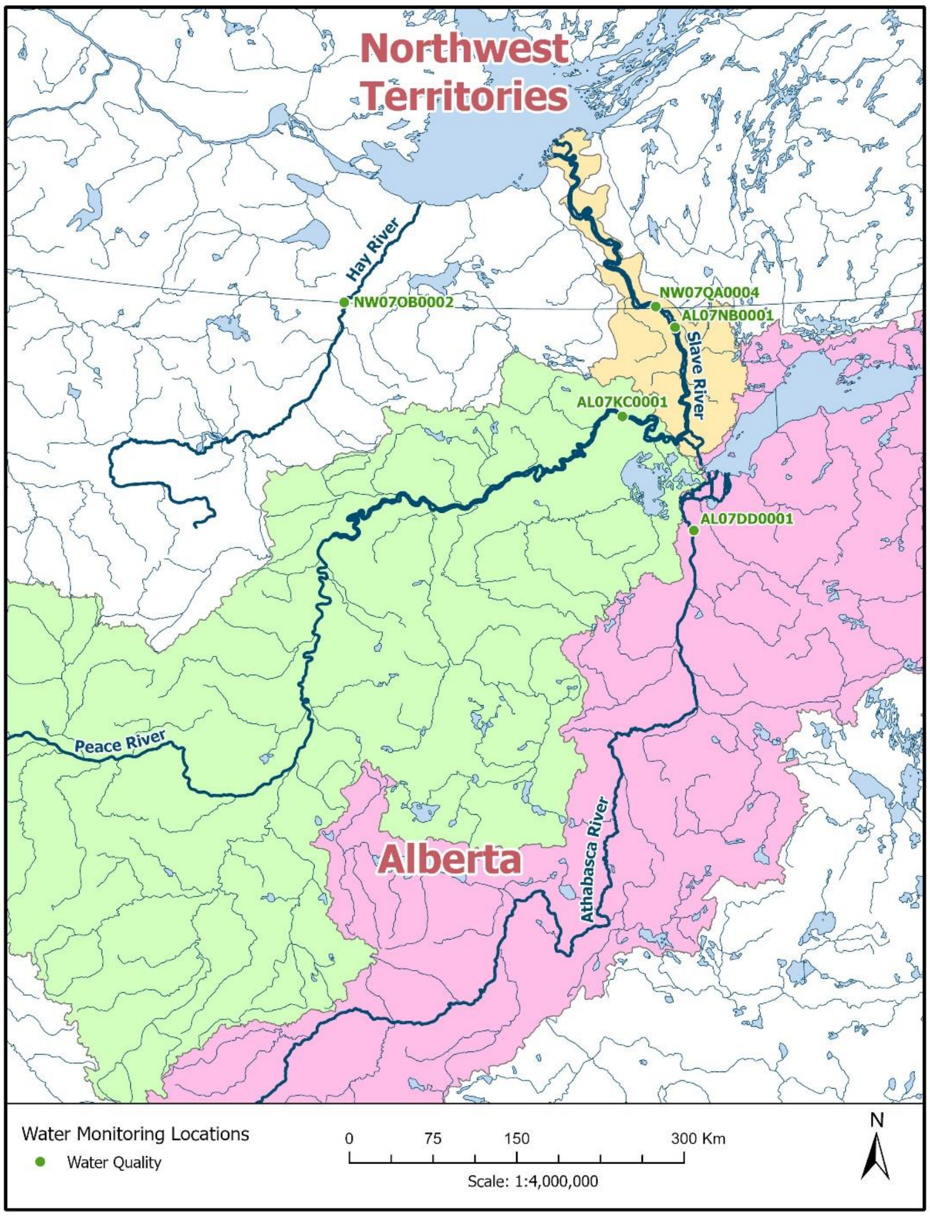

Figure 1: AB-NWT Slave and Hay River Transboundary Water Quality Sites. Also shown are two water quality sites: the Athabasca River at Baseline 27 and Peace River at Peace Point located in Northern Alberta.

3. Approach to Annual Water Quality Assessment

3.1 Introduction

According to the BWMA Risk Informed Management (RIM) approach, the Hay and Slave rivers are classified as Class 3 rivers. An important task associated with a Class 3 river designation is the development of site-specific water quality triggers and objectives to assess water quality. Site-specific water quality triggers and objectives are relevant benchmarks against which future water quality data can be compared and evaluated.

The BWMA defines a water quality trigger as a pre-defined early warning of potential changes in typical and/or extreme conditions which results in Jurisdictional and/or Bilateral Water Management to confirm that change. Triggers are an aid to manage water quality within the range of natural variability. Interim water quality triggers have been calculated based on the ambient background concentrations of a parameter at the water quality site under consideration. Seasonal water quality triggers were calculated for those parameters exhibiting seasonal differences. Triggers are set to identify changing water quality conditions.

The BWMA defines a water quality objective as a conservative value that is protective of all uses of the water body, including the most sensitive use. At the time of signing in 2015, water quality objectives had not been determined. The approach to developing water quality objectives is being discussed. Steps towards the development of objectives are discussed multilaterally through the Mackenzie River Basin Board's Water Quality Task Team. The task team meets regularly to discuss water quality themes common to each jurisdictions, including approaches to assess water quality.

While transboundary water quality objectives are being discussed, the water quality of the Slave and Hay rivers are assessed using interim water quality triggers.

3.2 Interim Water Quality Triggers Assessment

Interim water quality triggers are based on values that have been observed in the past and are useful to help identify potential changes in water quality. Triggers are set conservatively and therefore values above a trigger do not necessarily signal a concern, but rather highlight parameters that should be examined further to confirm whether a change is occurring.

3.2.1 Interim Trigger 1

Interim Trigger 1 (herein, Trigger 1) is intended to be an early warning signal of a potential change in typical water quality conditions. Here, the annual median (50^{th} percentile calculated using multiple years of historical data) is used as Interim Trigger 1. Trigger 1 was calculated from the historical water quality data for each conventional parameter listed in Tables 1 and 2.

To assess typical water quality conditions (what is expected), the data are compared to Trigger 1. By definition, values above the median are expected and therefore, a parameter is only flagged when the number of values above Trigger 1 occur more often than expected (50% of the time). For example:

Slave River

With five samples collected from the Slave River in 2020, a parameter will:

- not be flagged if two or less of the values are above Trigger 1
- be flagged if three or more of the values are above Trigger 1

Hay River

With three samples collected from the Hay River in 2020, a parameter will:

- not be flagged if one value is greater than Trigger 1
- be flagged if two or more values are greater than Trigger 1

3.2.2 Interim Trigger 2

Trigger 2 (herein, Trigger 2) is intended to be an early warning signal of changes in extreme water quality conditions. Here, the seasonal 90th percentile is used as the Interim Trigger 2 (herein, Trigger 2). Trigger 2 was calculated from the historical water quality data for each conventional parameter listed in Tables 1 and 2.

To assess extreme water quality conditions the data are compared to Trigger 2. The Trigger 2 assessment helps to answer questions such as: *are the data becoming more variable? Are there more extreme values today than in the past?* All flagged parameters are reviewed further.

3.3 Evaluation of Flagged Parameters

Any parameter flagged during the Trigger 1 or 2 assessments is further evaluated through a series of steps. These steps are described below and are necessary to help target parameters that may warrant further attention.

3.3.1 Trigger 1

Trigger 1 flagged parameters are evaluated further as follows:

- For a flagged parameter, the recent monitoring data (2015-2020) are statistically compared to the historical data[2]. A statistically significant difference between the two time periods suggests

[2] Periods of record for each parameter vary. This is common for many long-term datasets as new parameters are added to the monitoring list as the program evolves to measure new substances.

that water quality is changing. Using XLSTAT2021.1.1 software, the Wilcoxon-Mann-Whitney test is used to identify statistically significant[3] differences between two time periods.

- Any parameters that are highlighted by the Wilcoxon-Mann-Whitney test are examined for statistically significant[2] long-term trends. The Mann-Kendall monotonic trend test is used. The test is a non-parametric test which does not rely on assumptions of the dataset distribution. ProUCL V.5.1 software is used to explore trends.

- Lastly, trends revealed by the Mann-Kendall monotonic trend test are examined further. One drawback of any linear regression approach is that it does not account for the existence of structural breaks in a parameter's time series of observations. It attempts to fit an "average" trend based on the patterns in the observations. A structural break may occur when the trend changes its magnitude, direction, or significance over time. As is the case with samples of water quality data, the patterns, even after adjusting for the impacts of seasonality, can still be highly erratic and generally don't follow strictly linear trends over time. A statistically significant upwards or downwards trend in itself does not identify when water quality conditions changed. To augment the results of the trend analysis, the technical team used the piece-wise polynomial regression (PWPR) approach.

    - In circumstances when changes in trend may occur with a parameter's time series, the PWPR has proven useful. This approach attempts to find an appropriate mathematical model that looks at the relationship between values and sample dates by using piece-wise regressions. The linear-linear-linear (L-L-L) model was used to study the trends. The L-L-L model attempts to identify two structural breaks to separate the data into three different linear trends. NCSS v.11 statistical software was used to explore the variation of trends over time which provides very interesting and important insight into the data.

3.3.2 Trigger 2

Values above Trigger 2 are compared to their respective historical seasonal and maximum values to provide context. Any parameter above its historical seasonal (if available) and/or historical maximum value is evaluated further by:

- Examining the flow condition and associated sediment load at the time of sample to determine whether the values above Trigger 2 are attributable to any unusual flow events at the time of sampling; and,

- Comparing values to national and/or provincial water quality guidelines, where guidelines exist.

[3,2] An alpha value of 0.05 is used to determine statistical significance.

3.4 Further Evaluation

Any unexplained Trigger 1 and 2 flagged parameters undergo further review. The review may include, but not be limited to, the following steps:

- Examine water quality data from upstream sampling sites such as Athabasca River at Baseline 27 and Peace River at Peace Point to see if similar patterns are emerging upstream.
- Explore anthropogenic sources that could be responsible.
- Evaluate whether the existing monitoring program is adequate.

3.5 Toxic, Bioaccumulative and Persistent Substances Assessment

Alberta and the NWT, through the BWMA, have agreed to the goal of virtual elimination (VE) of substances that are human-made, toxic, bioaccumulative and persistent. The BWMA commits both jurisdictions to pollution prevention and sustainable development. Substances subject to VE that are monitored as part of this AB-NWT BWMA are listed in Tables 1 and 2. As part of this assessment, the data for substances subject to VE are reviewed, and the presence of any substance subject to VE is reported and discussed.

4. Slave River Water Quality 2020 Results

For 2020, 69 parameters[4] (345 individual conventional water quality results) were assessed against Trigger 1 and Trigger 2. Other than the mercury data, all data included in this assessment are from samples collected by Environment and Climate Change Canada from the Slave River at Fitzgerald on five occasions (January, February, August, September and October). The mercury data are from samples collected by the GNWT from the Slave River at Fort Smith on five different occasions between July and October.

4.1 Slave River Trigger 1 Assessment and Discussion

The 2020 water quality data were screened to determine the number of values higher than Trigger 1 (all-season median). If more than half of the results were higher than Trigger 1, the parameter was flagged. In 2020, 23 of 69 parameters were flagged (Table 3).

Table 3: Slave River 2020 Trigger 1 Assessment Summary

Parameter	Trigger 1	Trigger 1 Flagged Counts
Dissolved Aluminum (µg/L)	25.3	3/5
Total Arsenic (µg/L)	1.09	3/5
Dissolved Boron (µg/L)	13.8	3/5
Total Boron (µg/L)	14.1	3/5
Dissolved Calcium (mg/L)	28.3	3/5
Dissolved Organic Carbon (mg/L)	5.58	3/5
Dissolved Chromium (µg/L)	0.124	3/5
Dissolved Cobalt (µg/L)	0.055	5/5
Dissolved Iron (µg/L)	90.8	4/5
Dissolved Lithium (µg/L)	3.98	3/5
Magnesium (mg/L)	6.58	4/5
Dissolved Manganese (µg/L)	2.53	5/5
Dissolved Mercury (ng/L)	Discussed in Section 6	
Total Mercury (ng/L)		
Total Nickel (µg/L)	3.38	3/5

[4] 69 of 70 parameters listed in Table 8 (AB-NWT BWMA, Appendix E4) underwent the Trigger 1 assessment; total bismuth data are not available for 2020.

Parameter	Trigger 1	Trigger 1 Flagged Counts
Nitrate/Nitrite (mg/L)	0.08	3/5
Dissolved Nitrogen (mg/L)	0.22	4/5
Potassium (mg/L)	0.91	3/5
Sodium (mg/L)	6.19	3/5
Dissolved Strontium (µg/L)	134	3/5
Sulphate (mg/L)	18.0	3/5
Dissolved Uranium (µg/L)	0.41	3/5
Total Uranium (µg/L)	0.49	3/5

As outlined in Section 3.3.1, recent monitoring data (2015-2020) were compared to historical data for all parameters flagged by Trigger 1. Six of the 23 triggered parameters, including calcium, magnesium, nitrate/nitrite, dissolved nitrogen, sulphate and dissolved uranium, revealed statistically significant higher concentrations during the monitoring period compared to the historical period. Accordingly, these parameters were examined for trends. Trends were examined over the full period of record (which varies depending on the parameter; Table 4).

Table 4: Long-term trend results for the Slave River at Fitzgerald (full period of record for each parameter up to 2020). The bold text represents a statistically significant trend.

Slave River Full Period of Record	
Parameter	**p-value**
Calcium (1972-2020)	0.1
Magnesium (1978-2020)	**1.43E-05**
Nitrate/Nitrite (2005-2020)	**4.93E-10**
Nitrogen Dissolved (1978-2020)	**1.20E-04**
Sulphate (1972-2020)	**7.17E-06**
Uranium Dissolved (2006-2020)	0.055

Statistically significant increasing trends were observed for magnesium, sulphate, nitrate/nitrite and dissolved nitrogen but not for calcium and dissolved uranium.

To further explore the data, trends were also examined over a more recent period of record and compared to trends in the Peace and Athabasca rivers – two rivers that converge to form the Slave River (Figure 1). To facilitate trend comparisons, the 1989-2020 data record was used as this period of data record is available for each of the six parameters for the three rivers (Table 5).

Table 5: Long-term trend results for the Slave River (at Fitzgerald), Peace River (at Peace Point) and Athabasca River (at Baseline 27) 1989-2020. Bold text represents a statistically significant trend.

Parameter	**Slave River**	**Peace River**	**Athabasca River**
	p-value	*p*-value	*p*-value
Calcium (1989-2020)	**1.95E-04**	**0.0334**	0.333
Magnesium (1989-2020)	**2.59E-06**	**0.00325**	0.321
Nitrate/Nitrite (2005-2020)	**4.93E-10**	0.112	0.259
Nitrogen Dissolved (1989-2020)	**1.72E-05**	0.0979	**9.12E-07**
Sulphate (1989-2020)	**3.73E-06**	**4.28E-04**	0.138
Uranium Dissolved (2006-2020)	0.055	**1.01E-07**	**3.90E-08**

Similar to the Slave River (using the 1989-2020 data record), increasing trends were found in the Peace River for calcium, magnesium and sulphate. The increasing trend for nitrate/nitrite in the Slave River was not found in either the Peace or Athabasca rivers. The increasing trend for dissolved nitrogen in the Slave River was also seen in the Athabasca River but not in the Peace River. And finally, no significant trend was found in the Slave River for dissolved uranium; however increasing trends were found in both the Peace and Athabasca rivers. Discussions for these six parameters follow.

4.1.1 Calcium, Magnesium and Sulphate

Statistically significant increasing concentrations of calcium, magnesium and sulphate were found for the Slave and Peace Rivers but not the Athabasca River (Table 5). Figures 2, 3 and 4 present the 1989-2020 data and associated trend results for these parameters for each river. It is likely that the slowly increasing trends of calcium, magnesium and sulphate in the Slave River are driven by similar changes in the Peace River. On average, the Peace River contributes about 2.5 times more water to the Slave River than the Athabasca River. Given the higher flows in the Peace River compared to the Athabasca River, the water quality in the Slave River is highly influenced by the water quality of the Peace River.

The magnitude of the trend is given by the Sen's slope estimator. The Sen's slope estimates for the Slave and Peace Rivers range from 0.0023 to 0.0196 mg/L/yr. These magnitudes of change are low and within the range of natural variability.

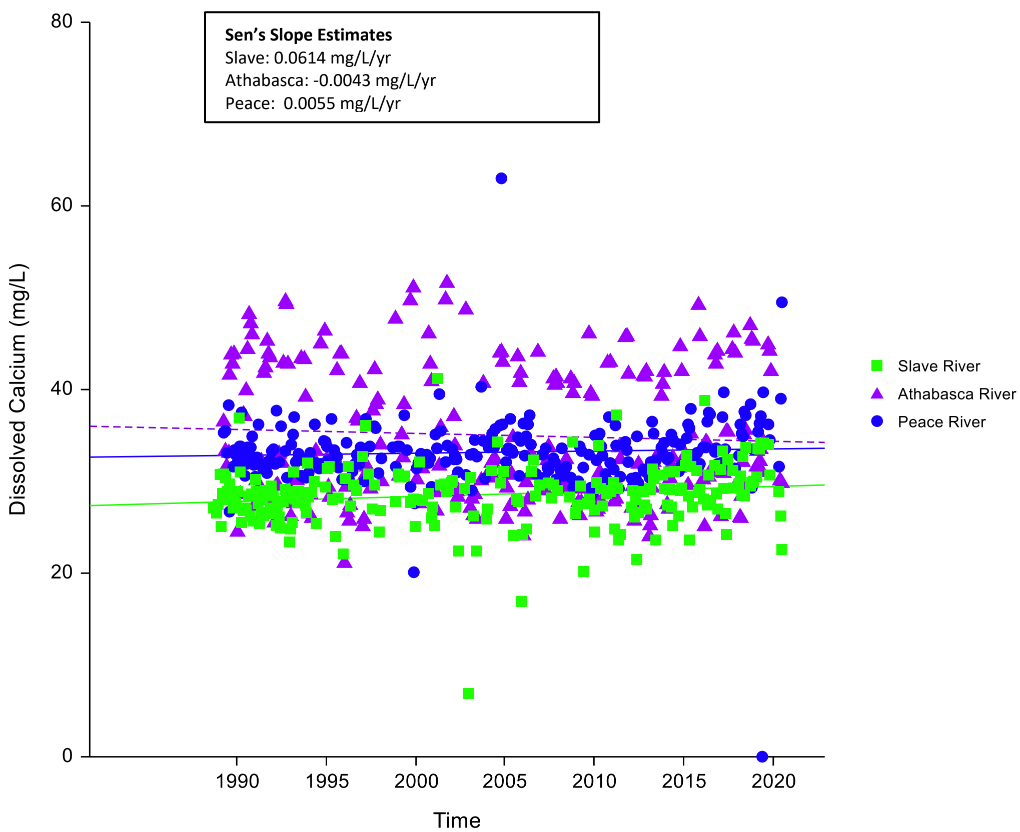

Figure 2. Long-term Temporal Trends for Calcium for the Slave River (at Fitzgerald), Athabasca River (at Baseline 27) and Peace River (at Peace Point) (1989-2020). A solid line represents a statistically significant trend.

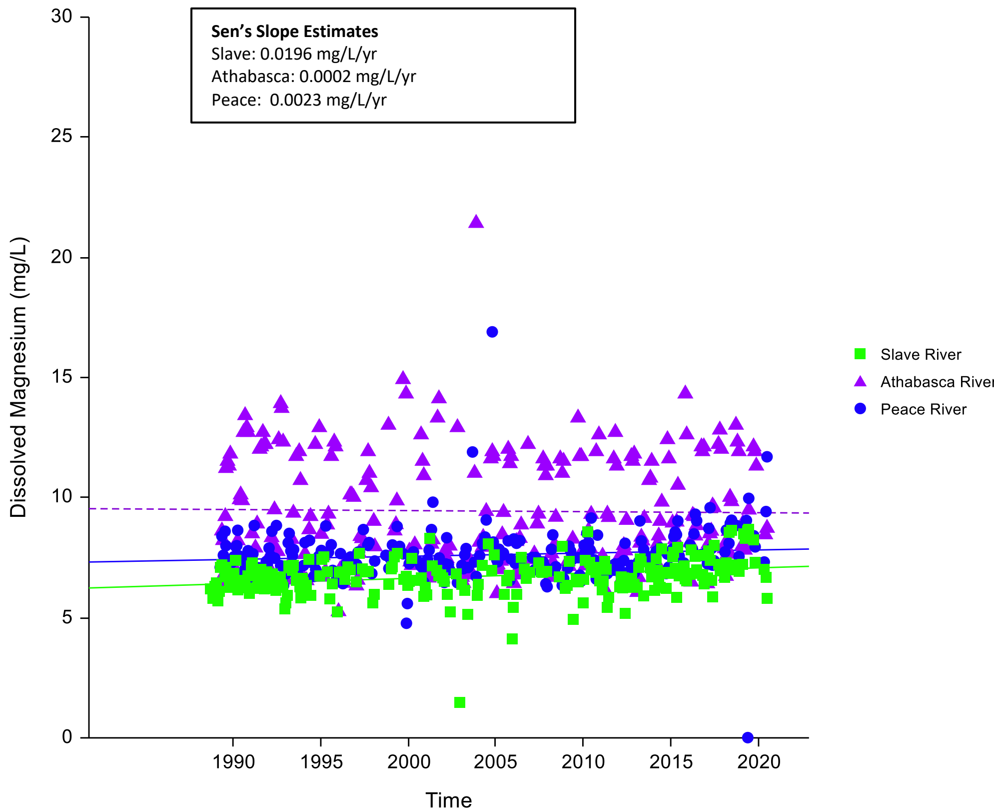

Figure 3. Long-term Temporal Trends for Magnesium for the Slave River (at Fitzgerald), Athabasca River (at Baseline 27) and Peace River (at Peace Point) (1989-2020). A solid line represents a statistically significant trend.

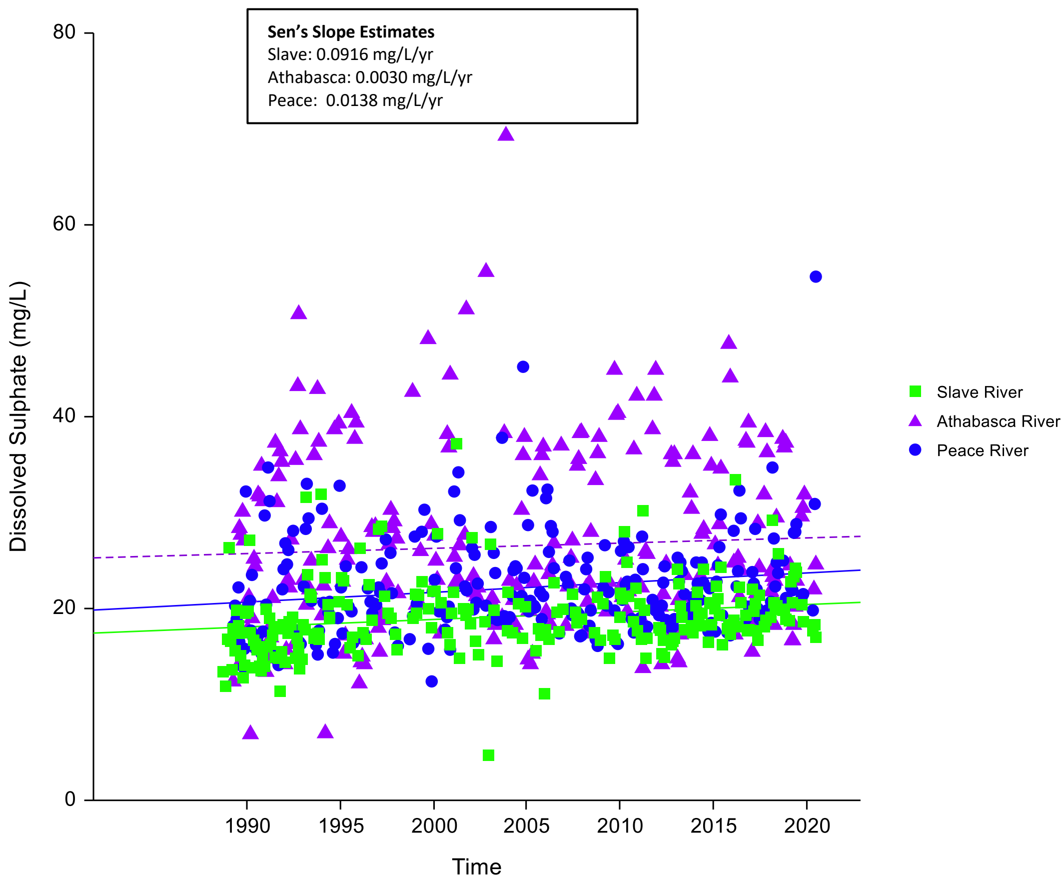

Figure 4. Long-term Temporal Trends for Sulphate for the Slave River (at Fitzgerald), Athabasca River (at Baseline 27) and Peace River (at Peace Point) (1989-2020). A solid line represents a statistically significant trend.

Typically, water quality does not trend in the same direction, magnitude and significance over time. Naturally, water quality tends to trend in one direction for a few years, then trend in another direction for a few years while sometimes water quality remains unchanged (is stable) for a few years in between trends. To examine patterns in water quality over time the piece-wise regression is useful. This approach attempts to find an appropriate mathematical model that looks at the relationship between values and sample dates by using piece-wise regressions. To better understand the patterns in calcium, magnesium and sulphate, the piece-wise regression was applied to the whole period of record for each parameter.

The piece-wise regression analysis for calcium and magnesium for the Slave River suggests that concentrations were stable or decreasing until 2012 when an increasing trend started to develop (Figure 5 and 6). The BMC will examine the calcium and magnesium data for the Peace River with an emphasis on trends to determine whether there are correlations in the development of trends between the two rivers. The BMC will report back on these findings in the next annual report.

The piece-wise regression analysis for sulphate shows two gradually decreasing trends interjected by a sharp increasing trend that occurred around 1993 (Figure 7). It appears that the statistically significant increasing monotonic trend (1972-2020) is driven by the step increase. Usually, this type of step increase is associated with changes in analytical methods at the laboratory. Having reviewed the analytical methods associated with the analysis of sulphate, and after discussions with staff from ECCC, no analytical method changes for sulphate occurred during that time (~1988-1994). Further exploration is required. The BMC will report back with any new information in the next annual report.

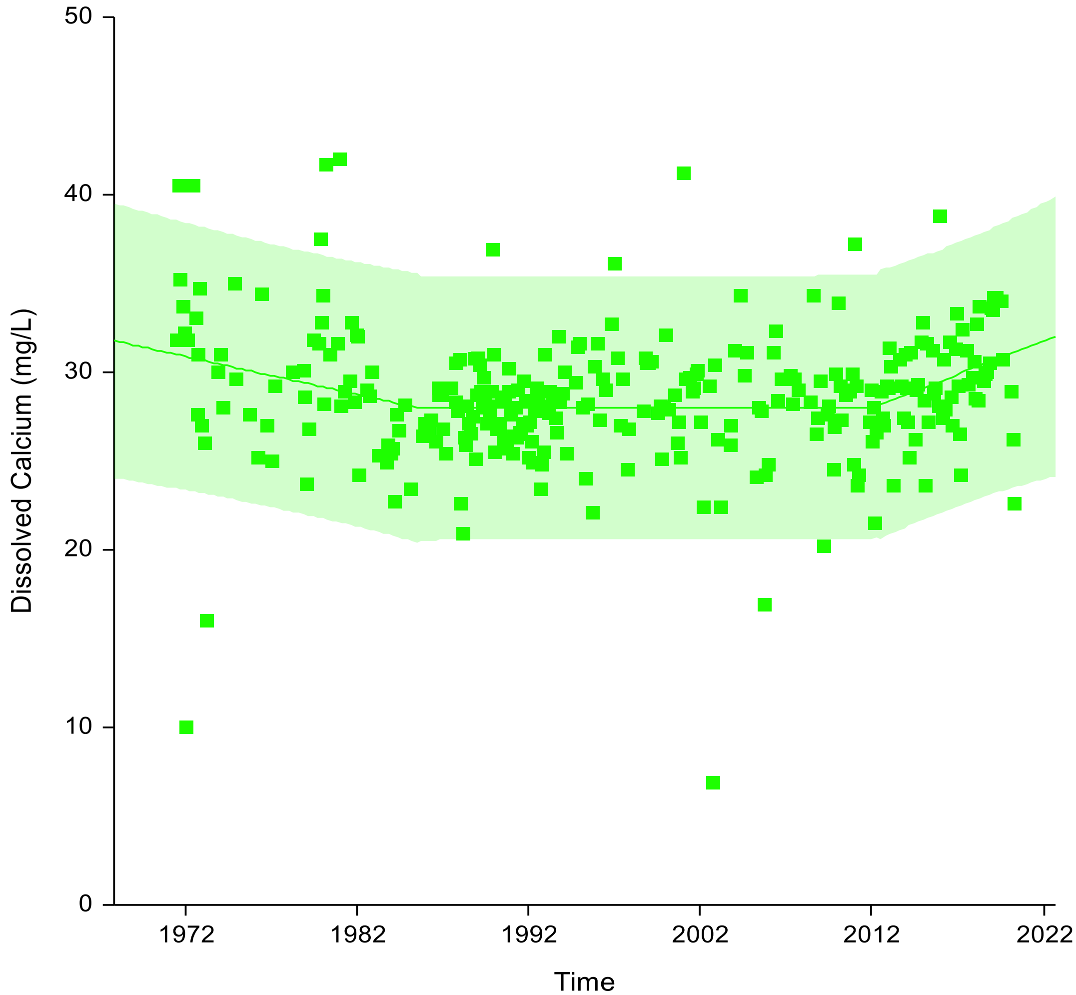

Figure 5. Linear-Linear-Linear Piece-wise Polynomial Regression Assessment for Calcium (1972-2020) in the Slave River (at Fitzgerald).

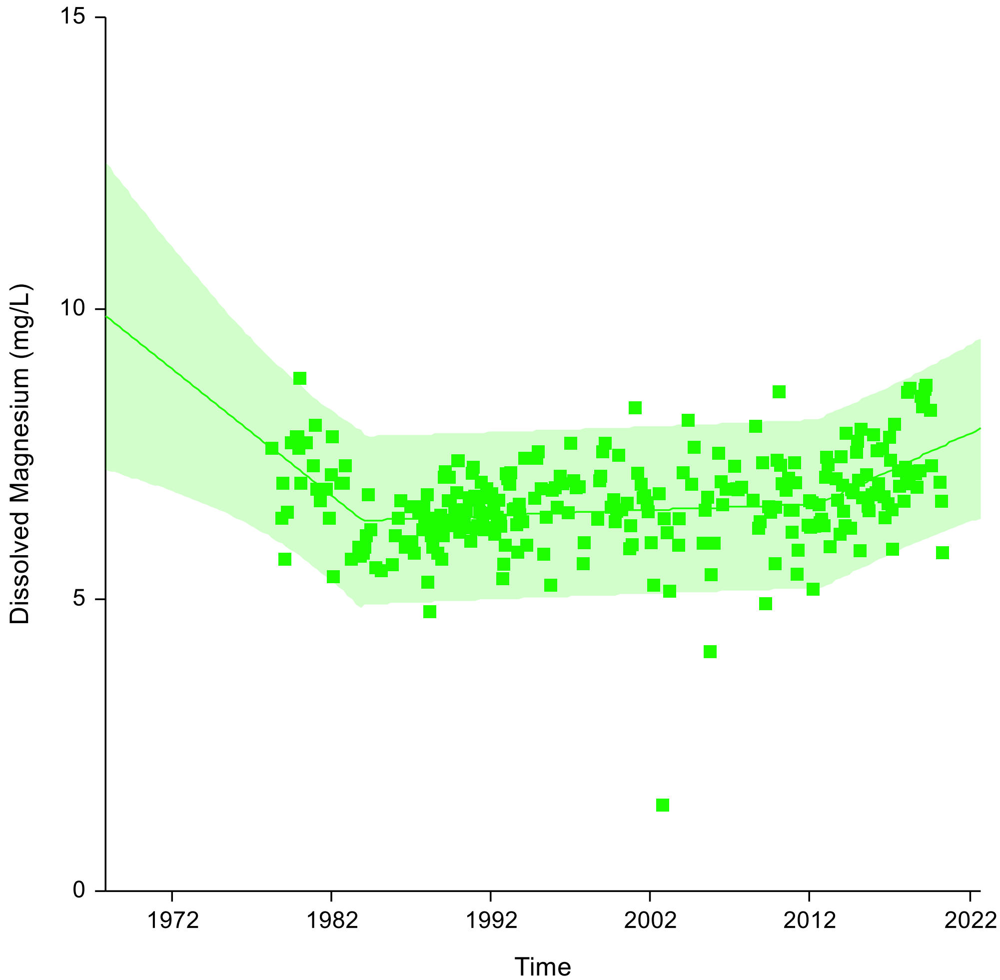

Figure 6. Linear-Linear-Linear Piece-wise Polynomial Regression Assessment for Magnesium (1978-2020) in the Slave River (at Fitzgerald).

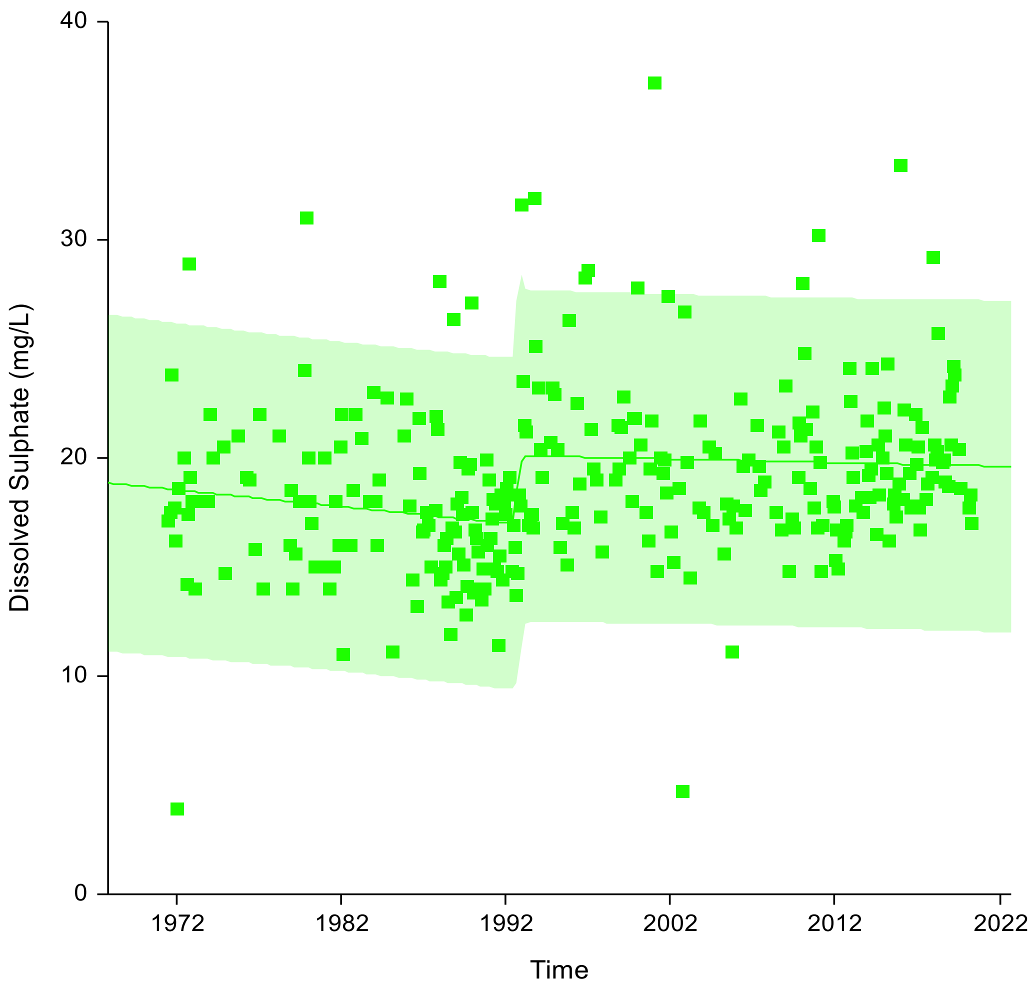

Figure 7. Linear-Linear-Linear Piece-wise Polynomial Regression Assessment for Sulphate (1972-2020) in the Slave River (at Fitzgerald).

4.1.2 Nitrogen (Nitrate/Nitrite and Dissolved Nitrogen)

Nitrogen is an essential nutrient which plants and animals use to structure proteins and other molecules. Many forms of nitrogen are very soluble and move easily through soils into groundwater and surface water. Many different forms of nitrogen are monitored in the Slave River. Two of which are reviewed each year (nitrate/nitrite and dissolved nitrogen) as requirement of the AB-NWT BWMA. Nitrate/nitrite (and ammonia and organic nitrogen) makes up a large proportion of the dissolved nitrogen concentration.

The nitrate/nitrite data and associated trend results for the Slave, Peace and Athabasca rivers between 2005[5] and 2020 are shown in Figure 8. Over this period, a significant increasing trend was found in the Slave River but not in the Peace or Athabasca rivers.

To explore this, the 2005-2020 dissolved nitrogen data were examined for trends in all three rivers. Nitrate/nitrite makes up a considerable fraction of the dissolved nitrogen data, and so we would expect to see similar patterns between nitrate/nitrite and dissolved nitrogen, but this was true only for the Athabasca and Peace Rivers (Figure 9). While the Slave River revealed an increasing trend in nitrate/nitrite, no trend was found for dissolved nitrogen over the same period of time (Figure 9).

To try to understand this better, the nitrogen data from another monitoring site located about 20 km downstream from the Slave River at Fitzgerald site (Slave River at Fort Smith[6]) was examined. As expected, and similarly to the Athabasca and Peace Rivers, the patterns of nitrate/nitrite and dissolved nitrogen were closely related at the Slave River at Fort Smith site (Figure 10).

While the nitrogen data and trend results for the Fort Smith monitoring site suggest that nitrate/nitrite is not likely a concern from a transboundary perspective, the differences in trend results between the two monitoring sites suggest that the data for these two particular nitrogen compounds at both Slave River monitoring sites (Slave River at Fitzgerald and Slave River at Fort Smith) should be reviewed with staff from ECCC. The BMC will report back on their findings in the next annual water quality report to the Ministers.

Of note is that the Canadian Council of Ministers of the Environment (CCME) guideline for the protection of aquatic life for nitrate is 13 mg/L. Levels in all three rivers are well below the recommended guideline.

[5] The reliable record for nitrate/nitrite in the Slave River started in 2005. This is a much shorter record than many of the other parameters that are monitored as part of this Agreement.
[6] The Slave River at Fort Smith monitoring site is located approximately 20 km downstream from the Slave River at Fitzgerald monitoring site just below the Rapids of the Drowned off the community boat launch.

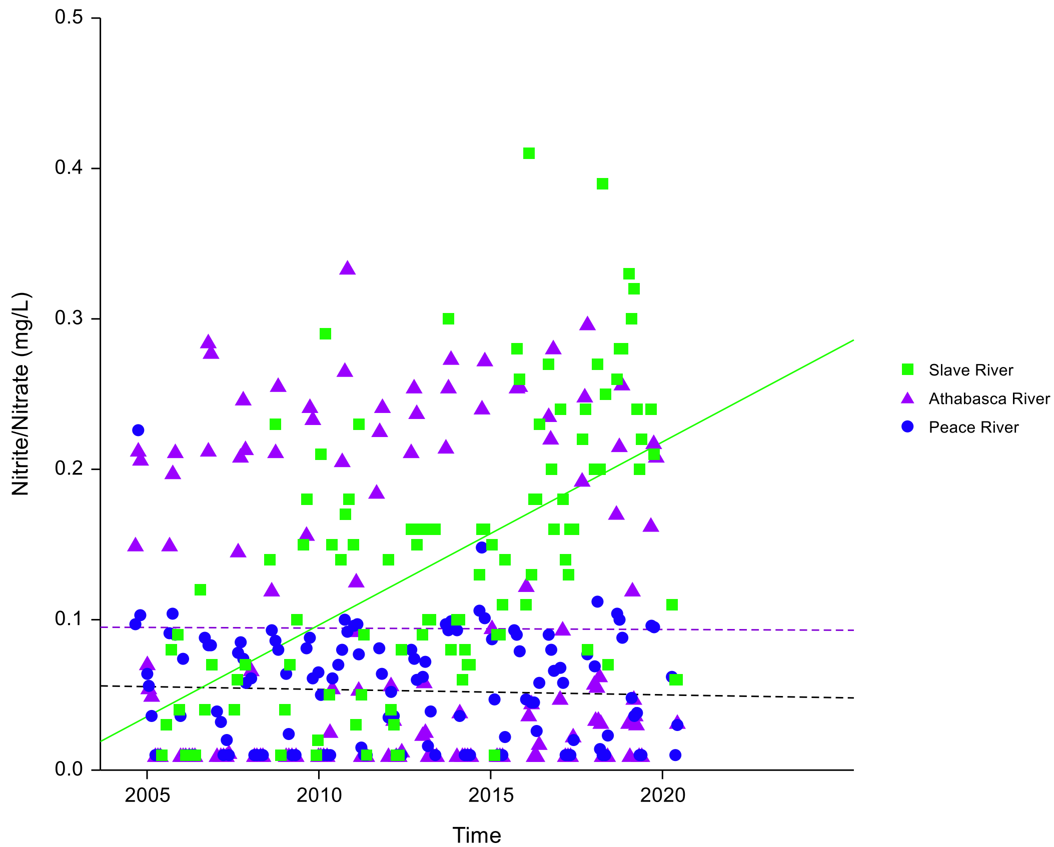

Figure 8. Long-term Temporal Trends for Nitrate/Nitrite for the Slave River (at Fitzgerald), Athabasca River (at Baseline 27) and Peace River (at Peace Point) (2005-2020). A solid line represents a statistically significant trend.

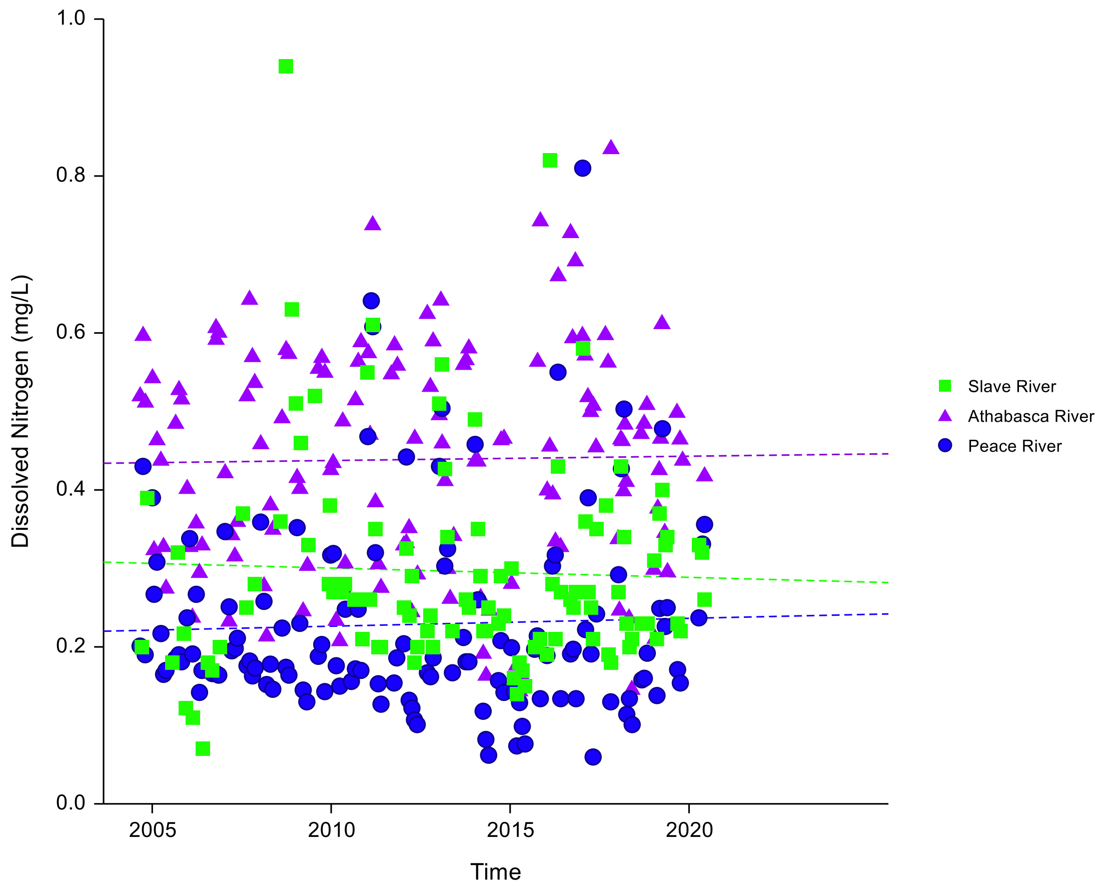

Figure 9. Long-term Temporal Trends for Total Dissolved Nitrogen for the Slave River (at Fitzgerald), Athabasca River (at Baseline 27) and Peace River (at Peace Point) (2005-2020). A solid line represents a statistically significant trend.

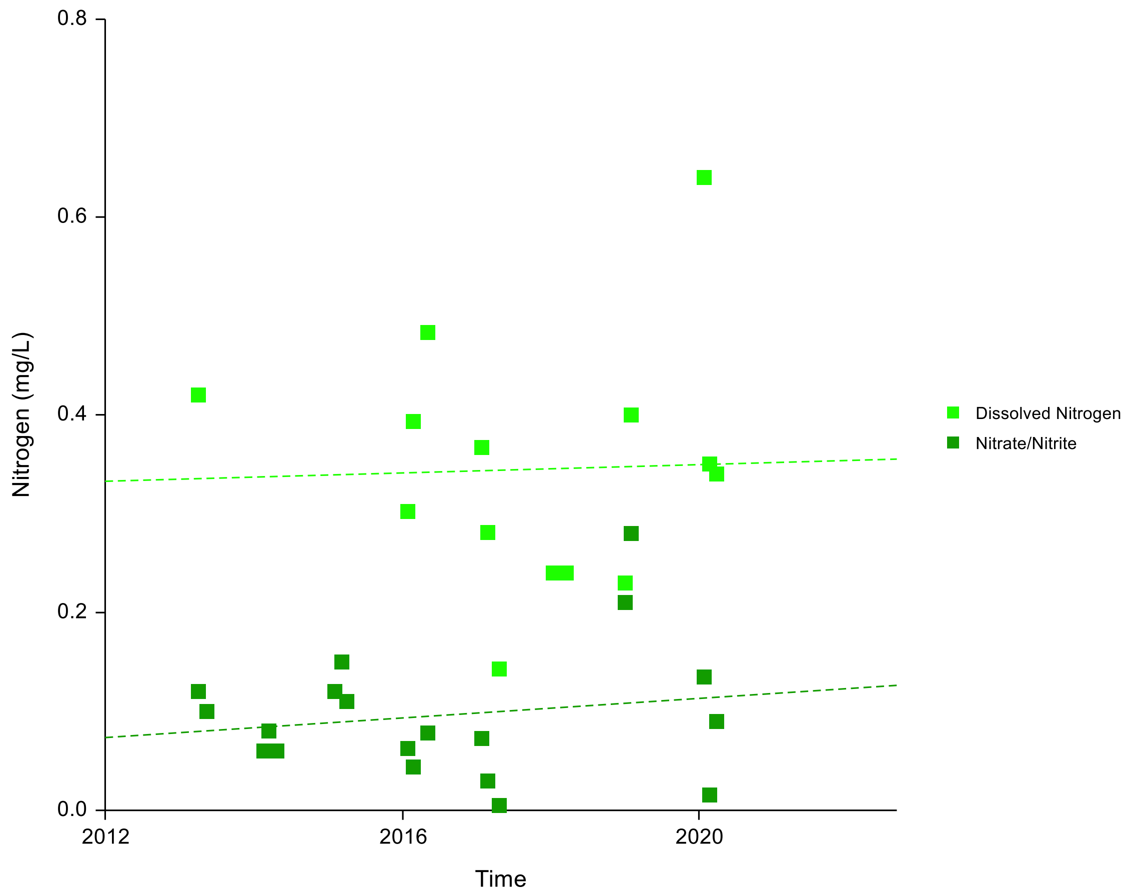

Figure 10. Data and associated trend patterns for Dissolved Nitrogen and Nitrate/Nitrite for the Slave River (at Fort Smith) (2012-2020).

4.1.3 Uranium

Dissolved uranium has been monitored in the Slave River since 2006. The Wilcoxon-Mann-Whitney test indicated that dissolved uranium concentrations are higher today than in the past; however, the difference between the two time periods (2003-2014 and 2015-2020) was not enough to drive a statistically significant trend (Table 4). The piece-wise regression analysis for dissolved uranium shows a very slight increasing trend up to 2011 when concentrations seem to stabilize (Figure 12).

Presently, a CCME aquatic life guideline for dissolved uranium does not exist but the guideline for total uranium is 15 µg/L; 2020 levels of total uranium in the Slave River are well below the recommended guideline[7].

[7] In 2020, levels of total uranium ranged from 0.38 to 0.60 µg/L in the Slave River (at Fitzgerald).

At this time, dissolved uranium is not a concern in the Slave River but considering increasing trends in the Athabasca and Peace rivers have been observed, dissolved uranium levels will continue to be monitored (Table 5; Figure 11).

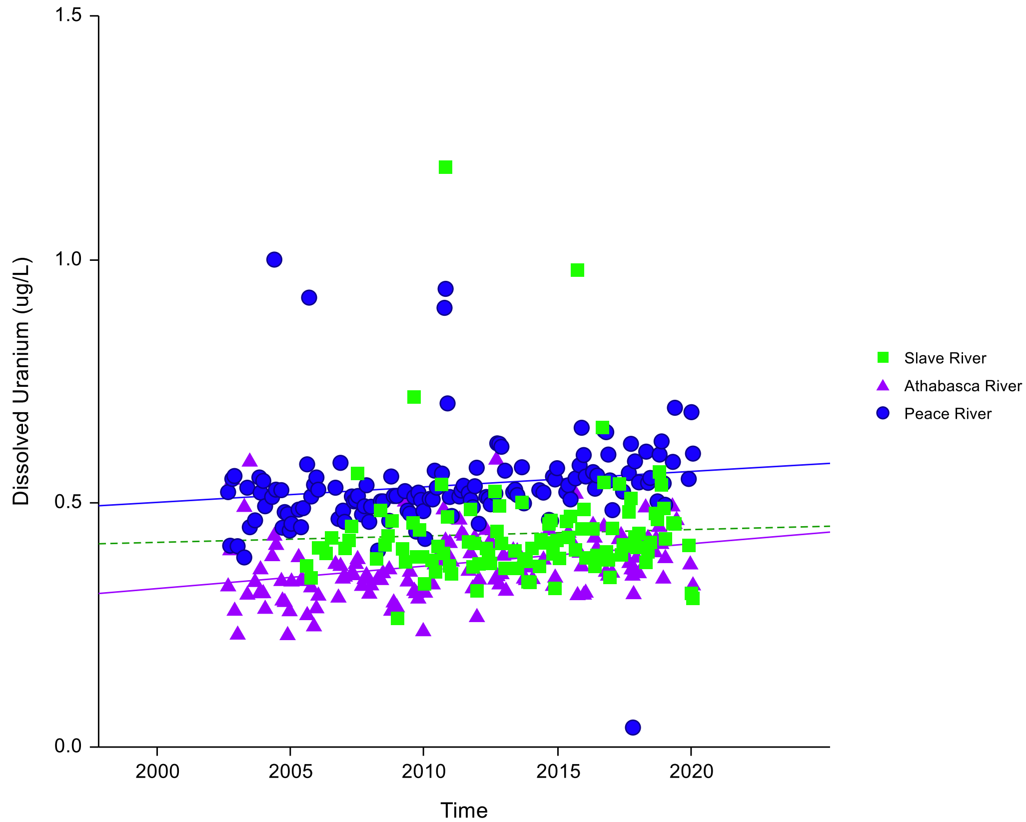

Figure 11. Long-term Temporal Trends for Dissolved Uranium for the Slave River (at Fitzgerald), Athabasca River (at Baseline 27) and Peace River (at Peace Point) (2003-2020). A solid line represents a statistically significant trend.

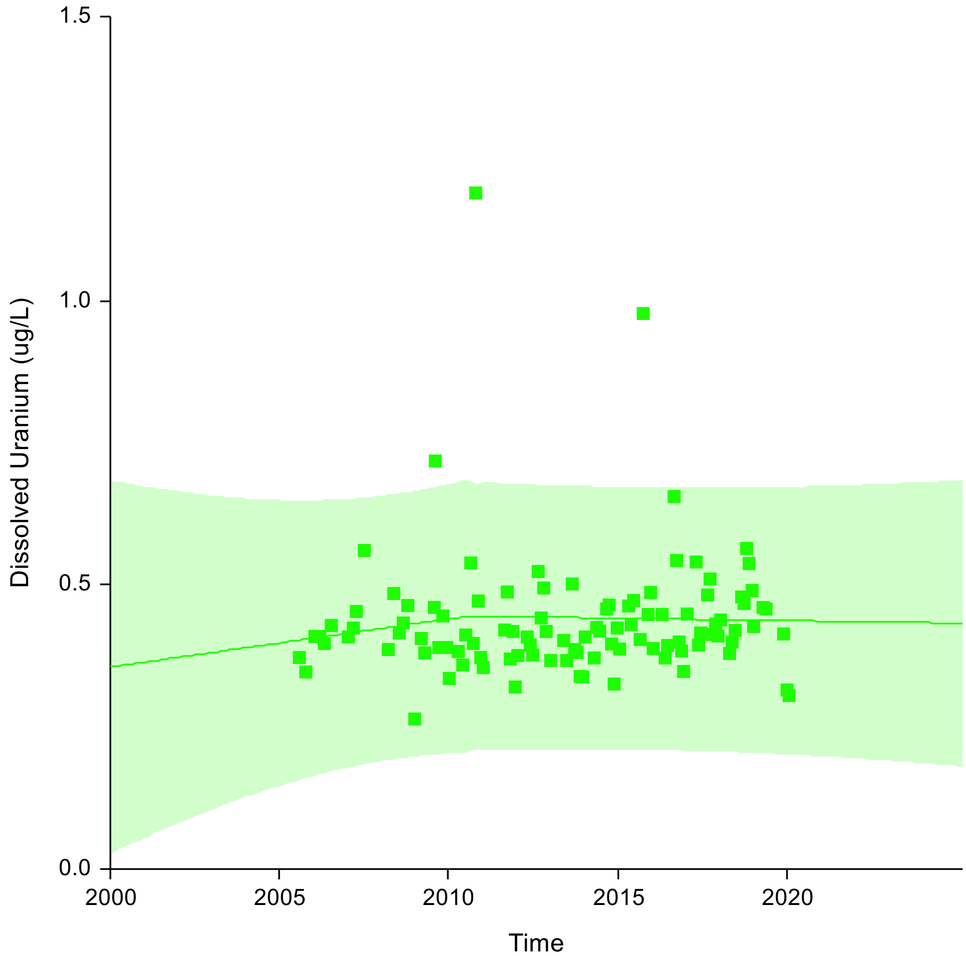

Figure 12. Linear-Linear Piece-wise Polynomial Regression Assessment for Dissolved Uranium (2006-2020) in the Slave River (at Fitzgerald).

4.2 Slave River Trigger 2 Assessment and Discussion

The 2020 water quality results were screened to determine how many values were higher than Trigger 2 (seasonal 90th percentile). In 2020, a total of 10 of the 69 parameters had concentrations above Trigger 2 (14 of 345 individual water quality results; Table 6). Of these 10 parameters, dissolved magnesium was above its historical seasonal maximum value but not its historical overall maximum value; whereas total mercury was above both its historical seasonal and overall maximum values. Concentrations of the remaining eight parameters did not exceed their historical seasonal values. A summary discussion for magnesium follows; mercury is discussed in Section 6.

Table 6: Slave River 2020 Trigger 2 Assessment Summary

Parameter	Trigger 2 (90th %ile)	2020 Value above Trigger 2	Historical OW or UI Seasonal Maximum Value	Historical Annual Maximum Value	National or Provincial Guideline
Dissolved Arsenic (µg/L)					
Annual (August)	0.58	0.62	0.65 (OW)	0.65	--
Total Boron (µg/L)					
Annual (September)	20.1	20.2	28.3 (OW)	28.3	1500[1,2]
Dissolved Calcium (mg/L)					
Winter (January)	31.8	34	40.5 (UI)	42	--
Dissolved Organic Carbon (mg/L)					
Fall (September)	8.7	10.3	22.1 (OW)	40.4	--
Dissolved Lithium (µg/L)					
Annual (September)	5.34	5.37		6.09	--
Magnesium (mg/L)					
Winter (January)	7.08	8.25	8.08 (UI)	8.80	--
Winter (February)	7.08	7.3	8.08 (UI)		--
Dissolved Manganese (µg/L)					
Annual (January)	6.63	8.26		13.6	200[1,2]
Total Mercury (ng/L)	Discussed in Section 6				
Nitrate/Nitrite (mg/L)					
Annual (January)	0.183	0.24		0.300	--

Parameter	Trigger 2 (90th %ile)	2020 Value above Trigger 2	Historical OW or UI Seasonal Maximum Value	Historical Annual Maximum Value	National or Provincial Guideline
Annual (February)	0.183	0.21			--
Potassium (mg/L)					
Fall (September)	1.02	1.18	2.58 (OW)	3.63	--
Fall (October)	1.02	1.10	2.58 (OW)		--

[1]CCME Water Quality Guidelines for the Protection of Aquatic Life
[2] Environmental Quality Guidelines for Alberta Surface Waters
OW: Open Water; UI: Under Ice; Season (Annual, Open Water, Under Ice, Spring, Summer, Fall or Winter) represents the season from which the trigger was derived; month (in parentheses) represents the month in which the sample was collected.

4.2.1 Magnesium

In January 2020, magnesium was above the Trigger 2 value of 7.08 mg/L. The January magnesium value (8.25 mg/L) was also over its winter seasonal maximum value of 8.08 mg/L. Repeatedly, magnesium values have been above Trigger 2 (2 of 9 samples in 2015; 3 of 8 in 2016, 3 of 9 in 2017, 3 of 9 in 2018 and 7 of 9 in 2019). The BMC has prioritized this particular parameter for further evaluation to confirm the changes. Initial analysis on upstream sites at Athabasca and Peace rivers reveal an increasing trend in the Peace River but not the Athabasca River. The BMC will continue to follow up on the parameter in the following years.

5. Hay River Water Quality 2020 Results

For this assessment, 42 parameters[8] (86 individual conventional water quality results) were assessed against the site-specific Trigger 1 and Trigger 2 values for the Hay River. Other than mercury, all results are from water samples collected during 2020 by ECCC from the Hay River near the Alberta/NWT Border on three occasions in August, September and October. The mercury data are from samples collected by the GNWT from the same site on five different occasions between July and October.

5.1 Hay River 2020 Trigger 1 Assessment and Discussion

The 2020 water quality results were screened to determine the number of water quality results higher than Trigger 1 (all-season median). If more than half of the values were higher than Trigger 1, the parameter was flagged. In 2020, seventeen of 42 parameters were flagged (Figure 7).

Table 7: Hay River 2020 Trigger 1 Assessment Summary

Parameter	Trigger 1	Trigger 1 Flagged Counts
Total Aluminum (µg/L)	196	2/2
Dissolved Calcium (mg/L)	45.9	2/3
Dissolved Organic Carbon (mg/L)	26.2	2/2
Total Chromium (µg/L)	0.5	2/2
Magnesium (mg/L)	13.3	2/3
Total Mercury (ng/L)	Discussed in Section 6	
Nitrate/Nitrite (mg/L)	0.095	2/2
Dissolved Nitrogen (mg/L)	0.72	2/2
Total Phosphorous (mg/L)	0.08	2/2
Total Dissolved Solids (mg/L)	269	2/2
Total Suspended Solids (mg/L)	12	2/2
Sodium (mg/L)	14.8	2/3
Specific Conductance (USIE/CM)	369	2/2
Total Strontium (µg/L)	138	2/2
Sulphate (mg/L)	73.45	2/3

[8] Although there are 70 parameters listed in Table 8 (AB/NWT BWMA, Appendix E), interim water quality triggers are only available for 42 parameters (total and dissolved mercury added) due to limited historical data. As more data are collected, triggers will be developed for all parameters. Due to breakage, the August sampling event resulted in only 6 individual results.

Parameter	Trigger 1	Trigger 1 Flagged Counts
Turbidity (NTU)	17.95	2/2
Total Vanadium (µg/L)	0.952	2/2

All 2020 flagged parameters were further assessed by combining the 2015-2020 water quality data for each parameter and comparing it to the historical record. Of these, nitrate/nitrite was found to have statistically higher concentrations in the monitoring period compared to the historical record which suggests that trends may be forming. Like the Slave River, a significant increasing trend was found in the Hay River for nitrate/nitrite (2005-2020; *p*=00697). A discussion for nitrate/nitrite follows.

5.1.1 Nitrogen (Nitrate/Nitrite and Dissolved Nitrogen)

Similar to the Slave River, a statistically significant increasing nitrate/nitrite trend was found in the Hay River (Figure 13). To fully understand nitrogen concentrations and trends, additional analyses of all the available nitrogen data are needed for this site and the Slave River site. The BMC will work with staff from ECCC to review the nitrogen data and report back on their findings in the next report to the Minsters.

The CCME aquatic life guideline for nitrate is 13 mg/L. Levels in the Hay River are well below the recommended guideline.

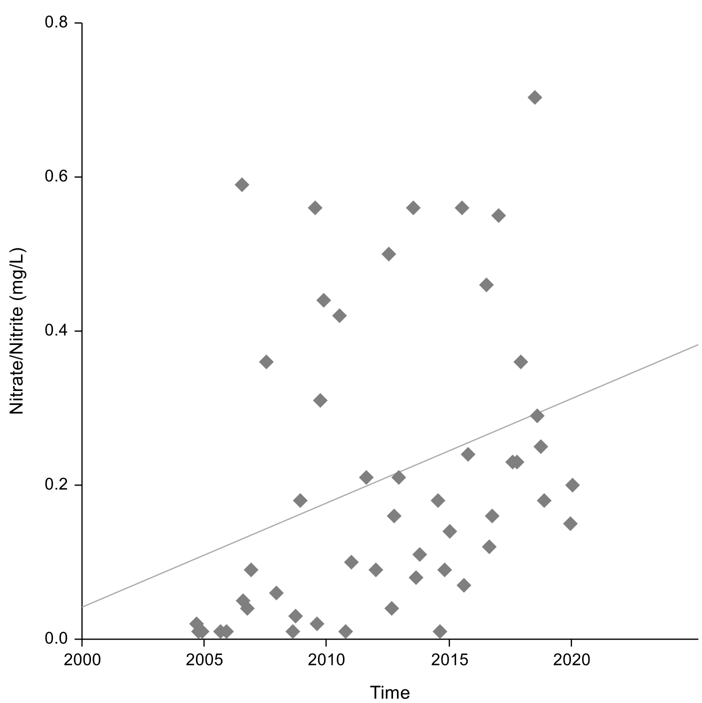

Figure 13. Nitrate/Nitrite Trend Results for the Hay River (near the Alberta/NWT Border) (2005-2020). A solid line represents a statistically significant trend.

5.2 Hay River 2020 Trigger 2 Assessment

The 2020 water quality results were screened to determine how many values were higher than Trigger 2 (seasonal 90th percentile). In 2020, ten of the 42 parameters had concentrations above Trigger 2 (13 of 96 individual water quality results; Table 8). Other than sodium, none of the flagged parameters were above their respective historical seasonal maximum values and therefore are not discussed further.

Table 8: Hay River 2020 Trigger 2 Assessment Summary

Parameter	Trigger 2	2020 Value above Trigger 2	Historical OW or UI Seasonal Maximum	Historical Annual Maximum Value	National or Provincial Guideline
Dissolved Calcium (mg/L)					
Open Water (October)	49.21	53.5	66.4 (OW)	115	--
Specific Conductance (µS/cm)					
Open Water (October)	405	453	513 (OW)	860	--
Total Dissolved Solids (mg/L)					
Open Water (October)	309.5	315	708 (OW)	2700	--
Dissolved Organic Carbon					
Open Water (September)	36.2	32.6	40.4 (OW)	72.6	--
Open Water (October)	36.4	32.6	40.4 (OW)	72.6	--
Total Mercury (ng/L)	Discussed in Section 6				
Dissolved Nitrogen (mg/L)					
Open Water (September)	1.01	1.09	1.26 (OW)	3.47	--
Open Water (October)	1.01	1.15	1.26 (OW)	3.47	--
Magnesium (mg/L)					
Open Water (October)	14.54	17	19 (OW)	32.6	--
Sodium (mg/L)					
Open Water (September)	15.97	16.7	18.6 (OW)	35.1	--
Open Water (October)	15.97	20.1	18.6 (OW)		--
Total Strontium (µg/L)					
Open Water (October)	156	161	190 (OW)	346	--
Sulphate (mg/L)					
Open Water (October)	88.4	95.9	104 (OW)	151	429[2]

[1]CCME Water Quality Guidelines for the Protection of Aquatic Life (chronic)
[2] Environmental Quality Guidelines for Alberta Surface Waters (for the Protection of Aquatic Life- chronic)
OW: Open Water; UI: Under Ice
Season (Annual, Open Water, Under Ice, Spring, Summer, Fall or Winter) represents the season from which the trigger was derived for the assessment; month (in parentheses) represents the month in which the sample was collected.

5.2.1 Sodium

On one occasion in 2020, sodium exceeded its open water seasonal maximum level, but was considerably lower than its historical maximum value (35.1 mg/L; Figure 16). The Wilcoxon-Mann-Whitney test did not reveal a significant difference between the historical and monitoring time periods and therefore sodium is not discussed further.

Figure 16. Sodium concentrations in the Hay River (near the Alberta/NWT Border) (1988-2020)

6. Mercury

Mercury occurs naturally and from anthropogenic sources. It is a contaminant of concern because of its potential toxicity to humans and elevated bioaccumulation in some fish populations (CCME, 2016). There are various forms of mercury (Hg) in the aquatic environment. As it changes form, it becomes more or less biologically available. Methylmercury (MeHg) is the most toxic form of mercury because it accumulates and magnifies in the food web (ECCC, 2016). Water samples collected from the Slave and Hay rivers are analyzed for dissolved mercury (DHg, includes MeHg) and total mercury (THg, includes all forms of mercury).

Mercury is released into the environment from natural processes such as the weathering of rocks, land erosions and forest fires. Primary human sources of mercury in Canada include metal smelting, coal-fired power stations, municipal waste incineration, cement manufacturing and mercury waste landfills (CCME, 2003).

6.1 Open-water Triggers for Mercury

When the AB-NWT BWMA was signed in 2015, there were insufficient ECCC data for the Slave and Hay rivers to develop interim site-specific water quality triggers for mercury. Therefore, in 2016, the collection of water samples for the analysis of mercury in the Slave (at Fort Smith) and Hay (at the Alberta/NWT Border) rivers became a priority for the GNWT.

With sufficient[9] data now available for both rivers, site-specific interim open-water mercury triggers have been calculated (Table 9) and, for the first time, applied to both rivers.

Table 9. Interim Open-Water Mercury Triggers 1 and 2 for the Hay and Slave Rivers

River	n	POR	DHg			THg		
			Trigger 1	Trigger 2	max value	Trigger 1	Trigger 2	max value
Hay River	31	2016-19	1.9	2.2	2.5	3.9	10.6	19.4
Slave River	38	2013-17	0.7	2.2	5.3	7.5	20.8	48.1

*n: number of samples; POR: period of record used to calculate Triggers 1 and 2; DHg: dissolved mercury; THg: total mercury

6.2 Total and Dissolved Mercury Assessment in the Slave and Hay Rivers (2020)

During 2020, five water samples were collected from the Slave and Hay rivers for the analysis of mercury. In the Slave River, four of five results were above Trigger 1 for THg, and three of five results are above Trigger 1 for DHg; whereas, for Trigger 2, there were two results above the threshold for THg and

[9] When the Agreement was signed in 2015, the BMC decided that a minimum of 30 samples per season were required prior to trigger development.

none exceeded Trigger 2 for DHg. While in the Hay River, four of the five results were above Trigger 1 for THg, and one of five was above Trigger 1 for DHg. Only one value of THg was above Trigger 2 in July 2020. The 2020 values above Trigger 2 in the Slave and Hay Rivers were higher than their respective overall historical maximum values.

6.3 Discussion

Average concentrations of mercury in the Hay and Slave Rivers are within the expected range of mercury for natural surface waters: 1 and 20 ng/L (THg) and less than 1 ng/L (DHg mercury) (CCME, 2003). To put these values into context, a comparison of THg and DHg concentrations from other large NWT rivers is presented in Table 10. Among these rivers, the Peel River has the highest average THg concentrations. However, the maximum THg concentration measured to date was in the Slave River in July 2020. Average DHg concentrations are highest in the Hay River (Table 10).

Table 10. Water concentrations of Hg in select large NWT rivers between 2014 and 2020 (GNWT Lodestar, 2020)

River	Period of Record	N	Total Mercury (ng/L)		Dissolved Mercury (ng/L)	
			Average	Maximum	Average	Maximum
Hay River (near Alberta/NWT Border)	2014-2020	36	6.1 ± 5.7	31.3	1.8 ± 0.5	3.6
Liard River (above Fort Liard)	2014-2020	27	10.2 ± 8.8	32.6	1.0 ± 0.7	3.0
Mackenzie River (upstream of Arctic Red River)	2014-2020	18	10.1 ± 9.1	40.0	0.6 ± 0.3	1.3
Peel River (above Fort McPherson)	2014-2020	31	16.7 ± 12.3	59.8	0.7 ± 0.3	1.1
Slave River (at Fort Smith)	2014-2020	50	12.0 ± 14.9	100.0	0.9 ± 0.6	2.9

In July of 2020 the levels of sediment in the Slave River were extremely high due to the sustained high flows associated with record high levels of precipitation throughout the Slave River watershed. Water levels were also very high in the Hay River watershed. Given the strong association between sediment load and mercury, it was not unexpected to have high levels of THg in 2020. DHg concentrations are highest in the Hay River likely due its warmer water temperatures and higher concentrations of organic carbon, both of which enhance Hg methylation (Chételat, et al, 2015).

Most data are below the CCME mercury guidelines for the protection of aquatic life (THg: 26 ng/L and DHg: 4 ng/L). All data are well below Health Canada’s drinking water quality guideline (1,000 ng/L). GNWT will continue monitoring and reporting on mercury in the Transboundary Rivers. For subsequent technical water quality reports, the mercury assessments will be included in Sections 4 and 5.

7. Toxic, Bioaccumulative, Persistent Substances

To help meet Canada's commitment for the virtual elimination (VE) of substances that are known to cause adverse effects on humans and the ecosystem, the BMC regularly reports on the monitoring results associated with these types of compounds. The substances are typically human made, persistent, bioaccumulative and toxic. When the Agreement was signed in 2015, 14 substances subject to VE were part of the GNWT's Transboundary Rivers Monitoring Program. These substances generally fall into three categories: pesticides, industrial chemicals and chemical degradation by-products (Table 11).

7.1 VE Substances 2020 Assessment and Evaluation

In 2020, three water samples from each river were collected and analyzed for the substances listed in Table 11. In both rivers, total PCBs were the highest measured substance subject to VE (Slave River: 0.17 ng/L; Hay River: 0.15 ng/L) but well below the United States Environmental Protection Agency's (USEPA) freshwater aquatic life chronic criteria of 14 ng/L. The highest value measured in 2020 for each substance from each river are included and compared to available water guidelines (Table 11). The results are below known thresholds for risks to aquatic life.

Table 11. Highest measured 2020 value for each substance from the Slave and Hay rivers. Values are reported in ng/L.

Substance	Slave River maximum value	Hay River maximum value	USEPA* Guideline	CCME** Guideline
Aldrin	0.394	0.072	3000	
Chlordane	0.204	0.067	4.3	
Dieldrin	Not detected	0.028	56	
Endosulphan	1.12	0.56	56	3
Endrin	0.053	0.179	36	
Heptachlor	0.22	0.064	3.8	
Hexachlorobenzene	0.11	0.03		
Hexachlorobutadiene	0.093	0.073		1300
Hexachlorcyclohexane	0.069	0.063	950	
Mirex	0.023	0.012	1	
DDD, DDE, DDT	Not detected	Not detected	1	
Total PCBs	0.169	0.148	14	
Pentachlorobenzene	0.019	0.023		6000
Toxaphene	Not detected	Not detected	0.2	

*USEPA: United States Environmental Protection Agency Chronic Criteria for the Protection of Aquatic Life. Accessed July 2020 https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table

**CCME: Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Aquatic Life. Accessed July 2020 https://ccme.ca/en/resources#

8. Conclusion

Interim transboundary water quality triggers established for the Slave and Hay rivers were designed to provide an early warning of potential changes in water quality. Trigger 1 is to identify changes under typical conditions and Trigger 2 under extreme conditions.

For the 2020 Slave River results, 23 of the 69 parameters were initially flagged during the Trigger 1 assessment. Wilcoxon-Mann-Whitney test revealed that calcium, magnesium, sulphate, nitrate/nitrite, dissolved nitrogen and dissolved uranium were statistically significantly higher in the monitoring period (2015-2020) compared to the historical period of record for each parameter. Further analysis on these six parameters revealed statistically significant increasing trends over the record for magnesium, sulphate, nitrate/nitrite, dissolved nitrogen and dissolved uranium. Under Trigger 2, 10 of the 69 parameters were flagged for further assessment. Of these, only dissolved magnesium was above its historical seasonal maximum value, whereas total mercury was above both its historical seasonal and overall maximum values.

For the Hay River 2020 results, 17 of the 42 parameters were initially flagged during the Trigger 1 assessment. Of these, the Wilcoxon-Mann-Whitney test revealed that nitrate/nitrite was statistically higher in the monitoring period (2015-2020) compared to the historical record. Further analysis revealed statistically significant increasing trends for nitrate/nitrite. Ten of the 42 parameters were flagged during the Trigger 2 assessment. Among these exceedances, sodium slightly exceeded its open water seasonal maximum level, but was considerably below its historical maximum value, while only one value of total mercury in July exceeded the overall historical maximum value.

During the summer of 2020, three samples from each river were analyzed for 14 toxic, bioaccumulative and persistent substances in water. Some of these substances were detected on each sampling occasion in each river, but at very low concentrations. Comparisons with the available corresponding CCME and USEPA chronic aquatic life guidelines/criteria show that the levels detected pose no risk to aquatic life.

Assessment of the 2020 water quality data for the Slave and Hay rivers did flag a few trends in the past twenty years (increasing magnesium, sulphate, nitrate/nitrite, dissolved nitrogen and dissolved uranium in the Slave River, increasing nitrate/nitrite in the Hay River), most of which are in low magnitudes and are not concerning at present. The new maximum total mercury levels in the two rivers in July were attributable to the high runoff and associated sediments this year.

9. References

2003. Canadian Council of Ministers of the Environment. Canadian water quality guidelines for the protection of aquatic life: Inorganic mercury and methylmercury. In: Canadian environmental quality guidelines, 1999. Canadian Council of Ministers of the Environment, Winnipeg

2015. John Chételat, Marc Amyot, Paul Arp, Jules M.Blais, David Depew, Craig A. Emmerton, Marlene Evans, Mary Gamberg, Nikolaus Gantner, Catherine Girard, Jennifer Graydon, Jane Kirk, David Lean, Igor Lehnherr, Derek Muir, Mina Nasr, Alexandre J. Poulain, Michael Power, Pat Roach, Gary Stern, Heidi Swanson, and Shannon van der Velden. *Mercury in Freshwater Ecosystems of the Canadian Arctic: Recent Advances on its Cycling and Fate*. Science of The Total Environment, Vol 509–510, 41-66,

2016. Environment and Climate Change Canada. Canadian Mercury Science Assessment Summary of Key Results. 46 pp. (Accessed at: https://publications.gc.ca/collections/collection_2016/eccc/En84-130-2-2016-eng.pdf)

2020. Government of the Northwest Territories (GNWT), Environment and Natural Resources (ENR), Water Management and Monitoring Division (WMMD). Lodestar Database.