Real Time Water Quality Report

Tata Steel Minerals Canada:
Elross Lake Network

Annual Deployment Report 2023

2023-06-20 to 2023-10-27

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment & Climate Change
Water Resources Management Division

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ACKNOWLEDGEMENTS

The comprehensive Real-Time Water Quality/Quantity Monitoring Network near the Elross Lake Iron Ore Mine in western Labrador is fully funded by Tata Steel Minerals Canada Limited (TSMC). Its effectiveness hinges on a collaborative partnership among TSMC, Environment and Climate Change Canada (ECCC), and the Newfoundland & Labrador Department of Environment and Climate Change (ECC). Managers and program leaders from each entity are dedicated to the network's operation, ensuring it delivers meaningful and precise water quality/quantity data.

In 2023, TSMC provided assistance to ECC staff during fieldwork operations following the initial deployment. This aid was crucial in overcoming significant equipment and instrumentation challenges and reducing travel times to the site, thereby minimizing delays in repairs or interruptions in water quality data collection and monitoring.

ECCC assumes a critical role in managing the data logging/communication aspect of the network. Specifically, staff from the Water Survey of Canada (WSC), under ECCC, regularly visit network stations to verify the functionality of data logging and transmission equipment. ECC holds responsibility for recording and overseeing water quality data. While WSC oversees the hydrometric component of these stations, due to differences in protocols, quality control for WSC hydrometric data occurs less frequently than for water quality data. The hydrometric data presented in this report is provisional and has not undergone quality control checks. Accurate hydrometric data can be accessed at https://wateroffice.ec.gc.ca/ or by request to Water Survey Canada.

INTRODUCTION

On April 18, 2011, a formal agreement was established between the Newfoundland & Labrador Department of Environment and Climate Change (ECC) and Tata Steel Minerals Canada Limited (TSMC) to deploy two real-time water quality/quantity stations near the Elross Lake Iron Ore Mine in western Labrador, adjacent to Schefferville, QC.

Subsequently, an amendment to the original agreement was enacted on February 10, 2015, to introduce an additional station at Joan Brook, situated below the outlet of Joan Lake. This additional station aimed to monitor the effects of mining activities on surface water downstream of the five pits (Kivivic 1, 2, 3N, 4, and 5) within the DSO4 Project 2B mining operation, located approximately 24 km northwest of the primary mine complex. Goodream Creek – Sept 12, 2011

The agreement has been extended in accordance with the terms and conditions outlined in the original agreement, subsequent amendments (February 2015, March 2018, December 2021), and extension letters (April 2016, March 2018, August 2020).

Each station is officially designated as follows: ELROSS CREEK BELOW PINETTE LAKE INFLOW, GOODREAM CREEK 2KM NORTHWEST OF TIMMINS 6 (now GOODREAM CREEK ABOVE TRIANGLE LAKE), and JOAN BROOK BELOW OUTLET OF JOAN LAKE, hereafter referred to as the Elross Creek Station, the Goodream Creek Station, and the Joan Brook Station, respectively (refer to Figure 1).

The real-time network at these stations serves the purpose of monitoring, processing, and disseminating water quality and quantity data to TSMC, ECC and ECCC, for the evaluation and management of water resources. It also functions to provide early warnings of any potential or emerging water issues, enabling timely implementation of mitigative measures.

Throughout the ice-free months, each station diligently measures six parameters, encompassing five water quality parameters (temperature, pH, specific conductivity, dissolved oxygen, and turbidity) and one water quantity parameter (stage). ECC undertakes the responsibility of collecting and managing the hourly recorded water quality data, typically spanning from early June to early October when streams are devoid of ice, while ECCC oversees the year-round collection and management of stage data recorded on an hourly basis.

Additionally, ECCC is tasked with logging and transmitting all water quality and quantity data to a centralized repository via satellite communications. This real-time network's primary objective is to monitor, process, and distribute water quality and quantity data to TSMC, ECC, and ECCC for the evaluation and management of water resources, ensuring the timely implementation of mitigative measures in response to potential or emerging water issues. ECC remains responsible for communicating significant water quality events to TSMC through email notifications, while monthly and annual deployment reports are compiled to document the parameters measured at these stations.

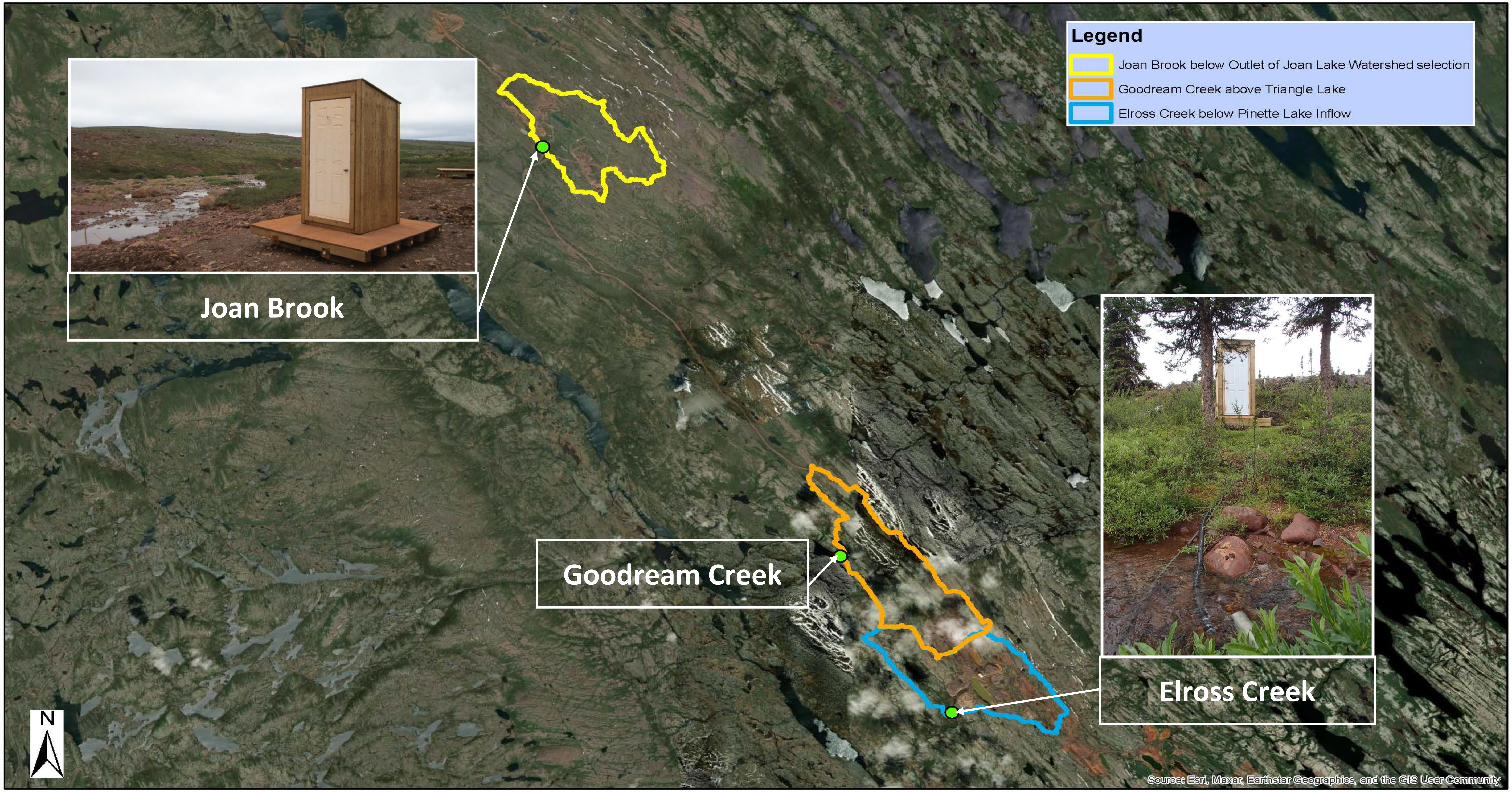


Figure 1: Map and images of TSMC Schefferville, RTWQ station watersheds located alongside Elross Creek, Goodream Creek & Joan Brook.

JOAN BROOK STATION

The Joan Brook station is within a watershed that covers an area of 10.12km^2 and is responsible for monitoring surface water downstream of five pits (Kivivic 1, 2, 3N, 4, and 5) within the DSO4 Project 2B mining operation. Operational since June 2016, it assesses stage values and water quality. Originating from Joan Lake and fed by various tributaries, Joan Brook is a small stream flowing southwest into Howells River. The distance from its headwaters to the sampling site (NF03OB0042) is approximately 1.2 km, with a distance to the outlet at Howells River of around 7.4 km.

ELROSS CREEK STATION

The Elross Creek station site was strategically chosen to oversee all surface water outflows from both the Elross Lake mining site and the DSO4 Project 2B mining sites, as depicted in Figure 2. This station focuses on monitoring surface water within the 11.91 km^2 watershed, downstream of the Timmins 1 pit and downstream of Pinette Lake. Commencing operations on October 17-18, 2011, the station initially recorded only stage values for seven months until June 5, 2012, when water quality instruments were deployed for the first time.

This station sits about 1.2 km southwest of the Timmins 1 pit within the Elross Basin, and 60 m downstream from the confluence of water inflows from Pinette Lake into Elross Creek. Originating from Pinette Lake and the Timmins 1 pit of the Elross Lake Iron Ore Mine in western Labrador, Elross Creek flows primarily southwest into Elross Lake, part of the Churchill River drainage basin. The distance from its headwaters to the sampling site (NF03OB0039) is approximately 3 km, while the distance from the sampling site to the mouth of the Churchill River at Lake Melville spans around 1000 km.

GOODREAM CREEK STATION

Operation of the original Goodream Creek Station, 2KM Northwest of Timmins 6, was temporarily halted in 2017 to facilitate its relocation to a new site further downstream, close to Triangle Lake. We anticipate TSMC completing this relocation early in the 2024 field season, with the objective of having the station fully operational at its new location before the conclusion of the same field season.

The Goodream Creek Station at Triangle Lake is situated within the 12.76 km^2 watershed is northwest of the Timmins 6 pit within the Goodream Basin and was established to monitor potential impacts stemming from groundwater flow from the Timmins 6 pit into the surface water of Goodream Creek. Additionally, this station will extend monitoring to assess impacts from the Howse deposit.

Monitored since October 17-18, 2011, the Goodream Creek stations initially collected stage values exclusively for seven months until June 5, 2012, when water quality instruments were introduced. Goodream Creek, originating from wetlands near the Timmins 6 pit of the Elross Lake Iron Ore Mine in western Labrador, flows northwest into Triangle Pond, forming part of the Churchill River drainage basin. The distance from its headwaters to the sampling site (NF03OB0040) is approximately 2 km, with a further approximate distance of 1000 km to the mouth of the Churchill River at Lake Melville.

During the 2023 season, a Hydrolab DS5X instrument was deployed at the Goodream Creek above Triangle Lake station, with data being logged internally for subsequent statistical analysis and interpretation.

Table 1. Geographic coordinates of Elross Creek, Goodream Creek (old location) and Joan Brook Stations

	Elross Creek Station		**Goodream Creek Station** **(New location highlighted yellow)**		**Joan Brook Station**	
	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
Instrument	54.877757	-67.099728	*54.92794 (54.927898)	*-67.15597 (-67.153892)	*55.03334	*-67.17597
Gauge house	54.877698	-67.099848	*54.92794	*67.15597	*55.03334	*-67.17597
Helicopter pad	54.877604	-67.100014	*54.92794	*67.15597	*55.03334	*-67.17597

*General Site Location

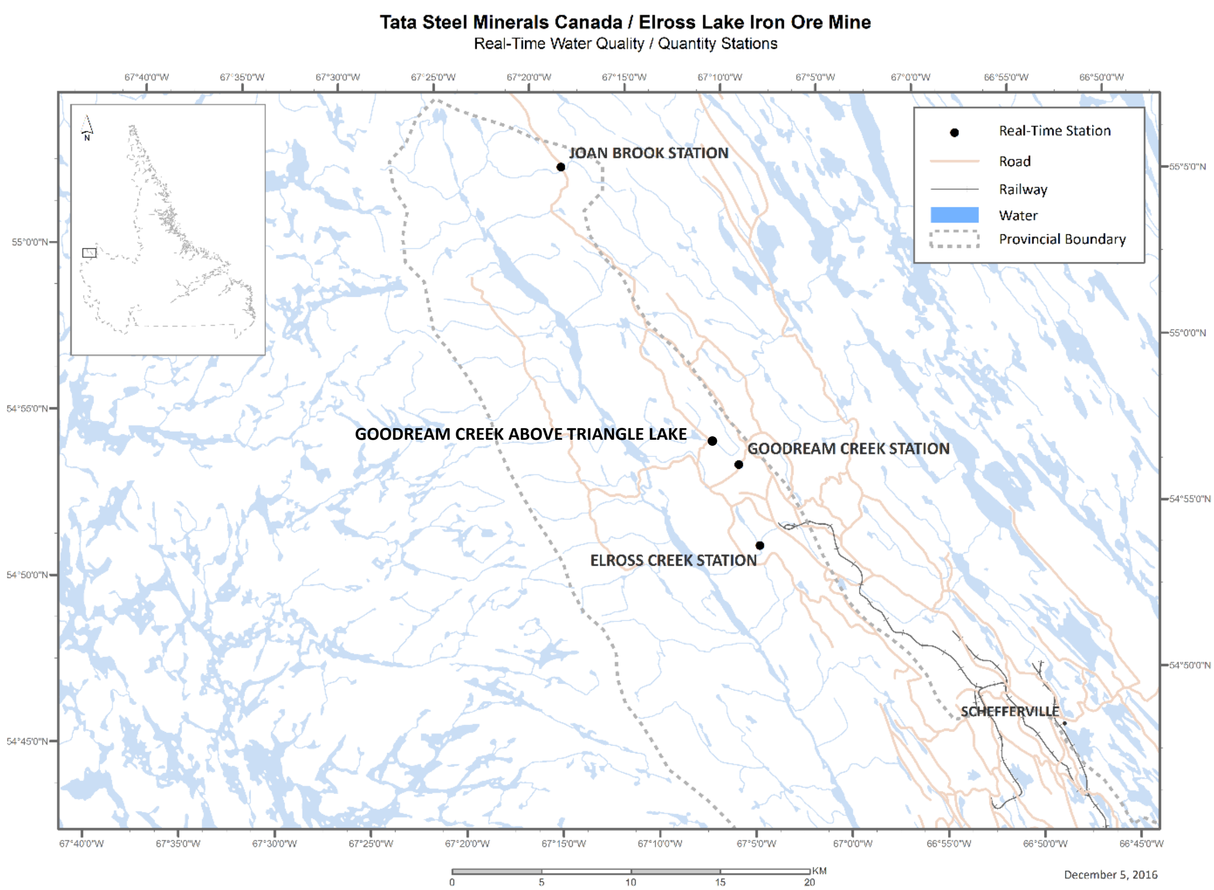


Figure 2. Map of real-time water quality/quantity stations in the vicinity of Elross Lake Iron Ore Mine in Western Labrador.

QUALITY ASSURANCE & QUALITY CONTROL

The Department of Environment and Climate Change implement quality control and quality assessment procedures in order to ensure accurate data collection.

For more information on the ECC's QA/QC procedures please see Appendix A or the Government of NL webpage https://www.gov.nl.ca/ecc/waterres/watermonitoring/rtwq/qa/

Model DS5X © 2005 Hach Company

Figure 3. Hydrolab DS 5X DataSonde used for monitoring five water quality parameters.

The six (6) water quality parameters mentioned previously in this report were measured at each station utilizing a Hydrolab DS5X DataSonde instrument (refer to Figure 3). Quality assurance procedures are carefully implemented, encompassing thorough instrument cleaning to mitigate errors induced by biofouling and/or sensor drift, replacement of damaged or unsuitable sensor parts, and calibration of four key instrument sensors (i.e., pH, specific conductivity, dissolved oxygen, and turbidity sensors). These procedures are typically conducted both at the commencement and conclusion of each new deployment period, as detailed in Table 2.

Additionally, as part of quality control measures, instrument performance undergoes testing at the initiation and conclusion of each deployment period, with the process delineated in Appendix A. Instruments are evaluated and assigned a performance rating (ranging from poor, marginal, fair, good to excellent) for each water quality parameter measured, ensuring robust data collection and maintenance of data integrity.

Table 2. Water quality instrument deployment start and end dates for 2023 at Elross Creek, Goodream Creek and Joan Brook.

Station	Start date	End date	Duration (days)
Elross Creek	2023-06-21	2023-09-18	90
	2023-09-18	2023-10-27	40
Joan Brook	2023-06-20	2023-07-23	34

	2023-07-27	2023-10-01	67
	2023-10-01	2023-10-23	22
Goodream Creek	2023-06-20	2023-10-27	130

The rankings of field instrument sensors to QAQC instrument sensors could not be provided at the time of deployment and removal, as adjacent QAQC readings were limited. Where possible, grab samples were collected during some point of deployment and compared to field values near collection time to provide another way to QAQC three of the sensors. Table 3 below indicates the comparison rankings of the instrument to the corresponding grab sample, when available.

During the implementation of annual Performance Testing and Evaluation (PTE) for Hydrolab sondes in the winter of 2023, preceding the commencement of the field season, it was observed that all sensors exhibited satisfactory performance across all instruments.

Table 3. Field instrument sensor performance (data from ADRS & log file) compared to QAQC grab sample during deployment for the Elross Creek, Joan Brook and Goodream Creek RTWQ stations.

Station	Date of Comparison Data (yyyy-mm-dd)	pH	Specific conductivity (µS/cm)	Turbidity (NTU)
Joan Brook	2023-06-21	Marginal	Good	Excellent
	2023-08-03	Excellent	Excellent	Excellent
	2023-09-19	Good	Excellent	Excellent
	2023-10-17	Excellent	Excellent	Excellent
Elross Creek	2023-06-21	Fair	Excellent	Excellent
	2023-08-03	Good	Excellent	NA - Failure
	2023-09-19	Good	Excellent	Excellent
	2023-10-17	Good	Excellent	Excellent
Goodream Creek	2023-06-20	Good	Good	Excellent
	2023-08-03	Excellent	Fair	Excellent
	2023-10-17	Excellent	Good	Excellent

For less than desirable rankings observed in Table 3, acknowledgement of the inherent challenges posed by transportation delays in sample submission to the analytical laboratory for testing must be considered.

Specifically, the method of transportation via charter plane from the collection site to St. John's introduces potential temperature fluctuations, impacting the pH, conductivity, and turbidity of grab samples. Furthermore, environmental factors such as exposure to air, biological activity, chemical reactions, and physical disturbances further complicate the preservation of sample integrity.

In effort to mitigate these challenges, we implement rigorous protocols, including the use of insulated containers with ice packs to stabilize temperatures during transportation, streamlining logistics to reduce time delays between sample collection and analysis, and comprehensive quality assurance measures encompassing personnel training and robust monitoring and control mechanisms. Through these concerted efforts, WRMD and TSMC strive to ensure the accuracy and consistency of our analytical results, upholding our commitment to excellence in water quality assessment.

DEPLOYMENT NOTES

Mining Operations - 2023

Mining operations at TSMC's DSO project in 2023 consisted of mining from 1 deposit: Goodwood Pit (Quebec) located in Area 4. Low grade ore was hauled to the Concentrator where the ore is beneficiated before sending to Sept-Iles via rail. Direct Ship Ore (DSO) ROM material was hauled to Plant 1 and Plant 2 where it was crushed and screened then sent to Sept-Iles via rail. A portion of the DSO crushed at Plant 1 was dried on site before being sent to Sept-Iles. The product from Dryer and Plant 1 was hauled to rail loops where it could be loaded onto the trains. Equipment Nordique was awarded the contract for rock crushing in 2023 and crusher was setup in KM20 quarry for crushing rock into various sizes for construction purposes.

Major environmental improvement projects were taken up in 2023 regarding the Goodwood haul road which included the construction of water management infrastructure at Morley Lake and Km22 stream sectors. TSMC will continue the improvement works along the other haul road locations in phases until all major water bodies and water crossings have permanent infrastructure to manage the runoff and mitigate any potential impacts.

In Quebec for the Goodwood project, construction of the contact water ditch below the waste dump continued to allow for its expansion. In 2023, TSMC finished all major repair works in Goodwood and will do the testing startup of the mine water treatment unit in Spring 2024. Due to the Covid-19 pandemic and associated issues with travel across borders, TSMC staff on site deployed and removed the equipment for the 2023 field season.

The Goodream Creek Station 2km Northwest of Timmons 6 was not active for the 2023 season pending its move to a new location further downstream near Triangle Lake. A Hydrolab DS5X was deployed, and data was collected via internal logging at the proposed new station location for continued water quality monitoring. It is hoped that this move would be completed by September 30, 2024, as requested by the WRMD.

Deployment – Instrumentation & Data Transmission

Multiple issues arose during the 2023 deployment season due to various instrumentation and transmission malfunctions.

ELROSS CREEK

Automatic Data Retrieval System (ADRS) – Data Transmission

2023-07-04 (12:00): Hydrolab sonde cable chewed and broke by animal – transmission lost until 2023-08-02 (19:00)
2023-07-07 (8:00): Transmission loss of stage data until 2023-07-23 (17:00)
2023-08-15 (17:00): ADRS timing issue - transmission lost until 2023-08-20 (20:00)
2023-09-17 (6:00): Transmission lost until 2023-09-18 (10:00)
2023-10-07 (8:00): Transmission lost until 2023-10-10 (10:00)
2023-10-27: Transmission very sporadic

LOGFILE

2023-07-02 (19:00): Turbidity sensor malfunction until 2023-09-18 (10:00)

2023-07-19 (5:00): power loss to sonde until 2023-08-02 (19:00)

2023-08-15 (17:00): Power loss to sonde until 2023-08-20 (20:00)

2023-09-10 (20:00): DO Sensor Failure

2023-09-17 (5:00): Power failure to sonde until 2023-09-18 (12:00)

2023-09-18 (17:00) – Power loss

2023-09-18: Replacement of sonde

JOAN BROOK

ADRS

2023-06-20: Datalogger SDI-12 set-up parameters were out of order for the entirety of the 2023 deployment season for the parameters of Dissolved Oxygen (mg) (%Sat), Turbidity and Total Dissolved solids. Logfile data used to make corrections.

2023-07-27 (13:00): Power loss to sonde until 2023-07-27 (18:00)

2023-09-01: Turbidity data removed for the remainder of 2023 deployment due to erroneous data. This was the result of sensor malfunction.

GOODREAM CREEK

2023-06-21 to 2023-10-27: No logfile issues observed during deployment.

DATA INTERPRETATION

Performance issues and data records were interpreted for each station during the deployment period for the following six parameters. A description of each parameter is provided in Appendix B.

(i.) Stage (m)

(ii.) Temperature (^{o}C)

(iii.) pH

(iv.) Specific conductivity (µs/cm)

(v.) Dissolved oxygen (mg/l)

(vi.) Turbidity (NTU)

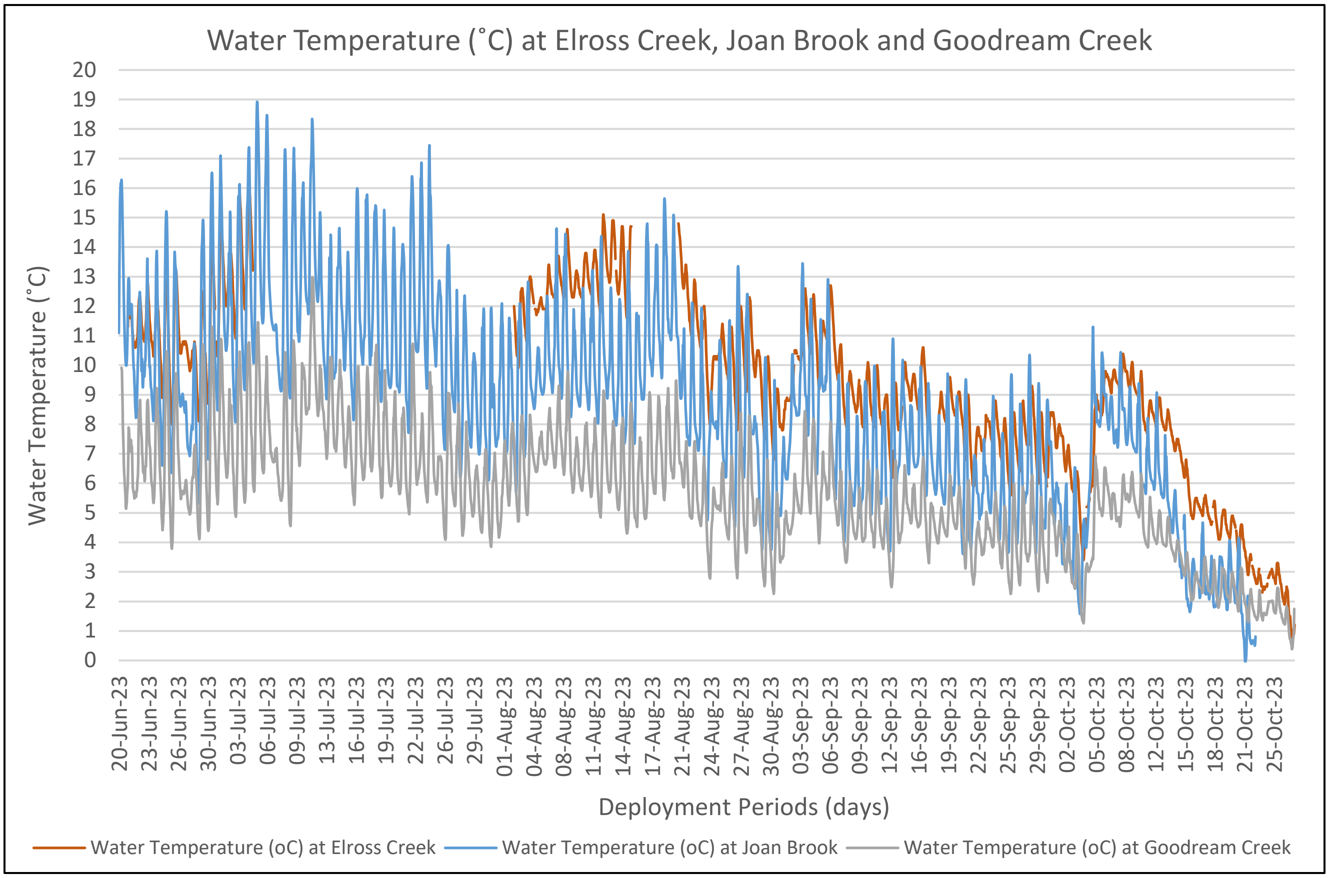
Water Temperature

Water temperature is a crucial determinant of water quality due to its profound impact on biological activity, oxygen solubility, chemical reactions, stratification, habitat suitability, and pollution transport. It affects the metabolic rates of aquatic organisms, with warmer water generally increasing oxygen demand and decreasing dissolved oxygen levels. Cold water holds more dissolved oxygen, essential for supporting aquatic life. Temperature influences chemical reactions and nutrient cycling, while stratification can create hypoxic conditions in deeper layers of lakes and reservoirs. Additionally, temperature fluctuations can disrupt habitat suitability and stress sensitive species, ultimately affecting the ecological balance of aquatic ecosystems and the transport and behavior of pollutants. Thus, managing and monitoring water temperature is vital for maintaining healthy aquatic environments.

The provided data in Figure 4 showcases the average, minimum, and maximum water temperatures for Elross Creek, Joan Brook, and Goodream Creek from June to October.

At the TSMC mine site, Elross Creek, Joan Brook, and Goodream Creek exhibit distinct and typical seasonal variations in daily average water temperature from June to October. Elross Creek experienced a loss of data from July 4 to August 2, 2024, due to cable damage by animals and as such, the statistical analysis for this station is considered skewed. Based on available data, Elross Creek generally experiences warmer temperatures, with an hourly average of 9.15°C over the period, peaking at 15.92°C in July and gradually decreasing to 0.76°C in October. Joan Brook follows a similar trend, with temperatures averaging 8.67°C, peaking at 18.92°C in July and declining to -0.07°C in October. Goodream Creek, comparatively cooler, maintains an average temperature of 5.62°C, reaching its highest point at 12.98°C in July and declining to 0.38°C in October. These variations suggest a consistent seasonal pattern across all three rivers.

The significant diurnal fluctuations in water temperatures observed at all stations are characteristic of shallow water streams and ponds, where the water responds swiftly to changes in ambient air temperatures. However, Joan Brook displays a notably wider daily temperature range, consistently reaching lower temperatures compared to Elross Creek. This disparity likely stems from various factors including differences in water depth, flow dynamics, and surrounding vegetation cover, all of which can impact the rate of temperature change within the water body. The heightened temperature variability in Joan Brook suggests that it may be more susceptible to rapid environmental shifts, potentially influencing the ecological dynamics and species composition within its ecosystem.



Station	JOAN BROOK		ELROSS CREEK		GOODREAM CREEK	
	Hourly	Daily Average	Hourly	Daily Average	Hourly	Daily Average
MAX	18.92	14.72	15.92	14.6	12.98	10.44
MIN	-0.07	0.61	0.76	0.97	0.38	0.73
MEDIAN	8.68	8.89	9.2	9.31	5.56	5.68
MEAN	8.67	8.63	9.15	9.22	5.62	5.61

Figure 4: Hourly and Daily Average Water Temperature (°C) at Joan Brook, Elross Creek and Goodream Creek.

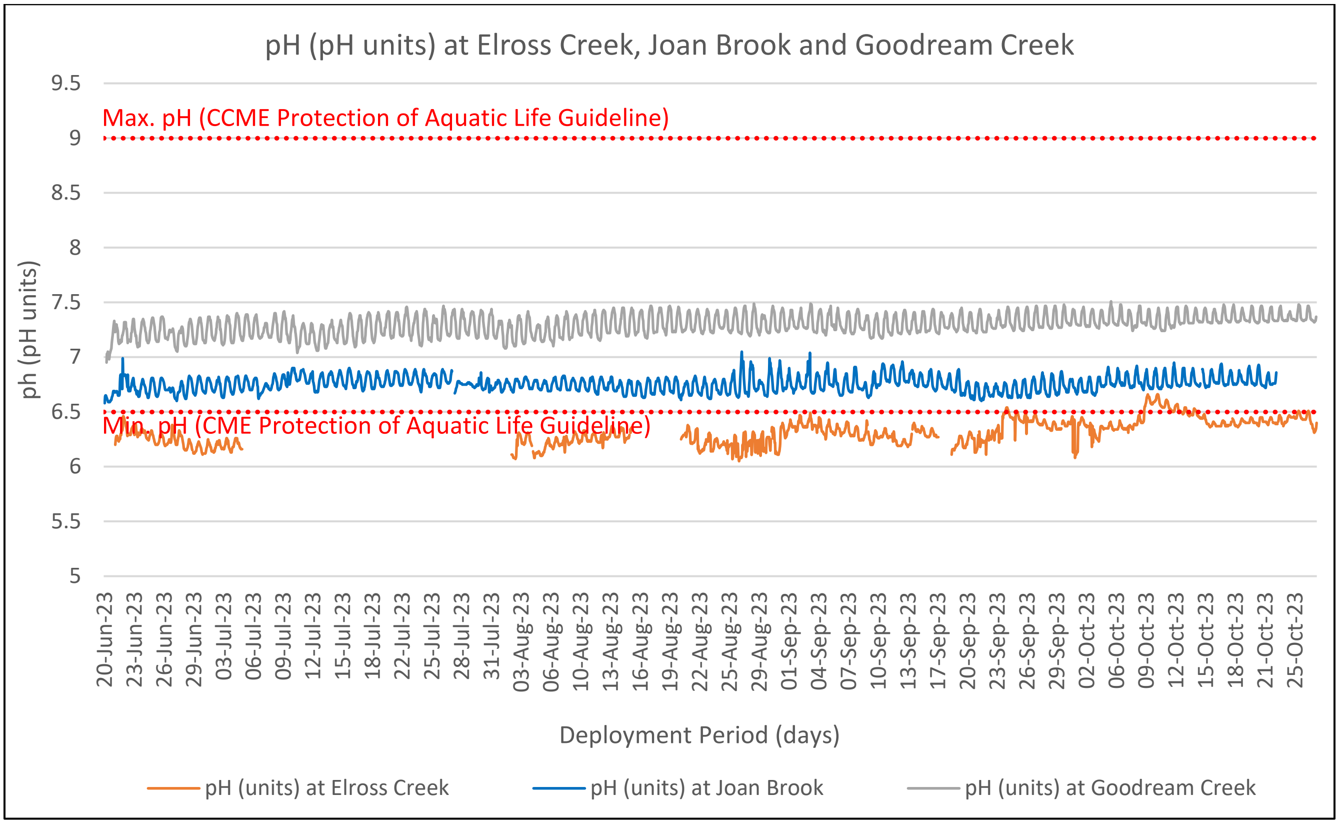
pH

pH is used to give an indication of the acidity or basicity of a solution. A pH of 7 denotes a neutral solution while lower values are acidic and higher values are basic. Technically, the pH of a solution indicates the availability of protons to react with molecules dissolved in water. Such reactions can affect how molecules function chemically and metabolically.

Over the deployment period from June to October, the pH data for Joan Brook, Elross Creek, and Goodream Creek within the TSMC mine area reveal notable distinctions in the water quality characteristics of each river. Joan Brook consistently maintains a relatively narrow pH range from 6.58 to 7.05 pH units, with minor fluctuations between its maximum and minimum pH values. The mean (6.75) and median (6.75) pH values suggest stable conditions around neutral to slightly acidic levels throughout the monitoring period.

In contrast, Elross Creek exhibits a slightly narrower pH range (6.05 to 6.49 pH units) compared to Joan Brook, with lower pH values overall (6.26). Despite this, the pH data indicates relatively stable conditions, albeit with a tendency towards slightly more acidic levels. Goodream Creek stands out with consistently higher pH values compared to the other two rivers, indicating a wider range of values (6.96 to 7.51 pH units) and neutral to slightly alkaline conditions. Both the mean (7.30) and median (7.29) pH values for Goodream Creek suggest a stable pH regime, similar to Joan Brook.

At Joan Brook and Goodream Creek, pH remained within the CCME guidelines for the protection of aquatic life (6.5 to 9.0 pH units) throughout the deployment year. Elross Creek consistently displays pH values below the recommended minimum guideline of 6.5 for freshwater ecosystems. Despite the minor fluctuations observed in pH levels over the monitoring period, the data indicates that Elross Creek tends to have slightly lower pH values. Potential influences such as geological characteristics, land use practices, and proximity to mining activities within the TSMC mine area may be contributing to the observed pH levels, in addition to the potential of calibration errors or sensor malfunction.



pH	JOAN BROOK	ELROSS CREEK	GOODREAM CREEK
	Hourly	Hourly	Hourly
MAX	7.05	6.49	7.51
MIN	6.58	6.05	6.96
MEAN	6.75	6.26	7.30
MEDIAN	6.75	6.26	7.29

Figure 5: Hourly and Daily Average pH (pH units) data at Joan Brook, Elross Creek and Goodream Creek.

Specific Conductivity and TDS

Conductivity relates to the ease of passing an electric charge – or resistance – through a solution. Conductivity is highly influenced by the concentration of dissolved ions in solution: distilled water has zero conductivity (infinite resistance) while salty solutions have high conductivity (low resistance). Specific Conductivity is corrected to 25^{o}C to allow comparison across variable temperatures. Monitoring specific conductivity is crucial for assessing water quality, identifying potential sources of contamination, and ensuring the health of aquatic ecosystems. Deviations from expected conductivity levels may signal the need for further investigation and management actions to maintain water quality and ecosystem integrity.

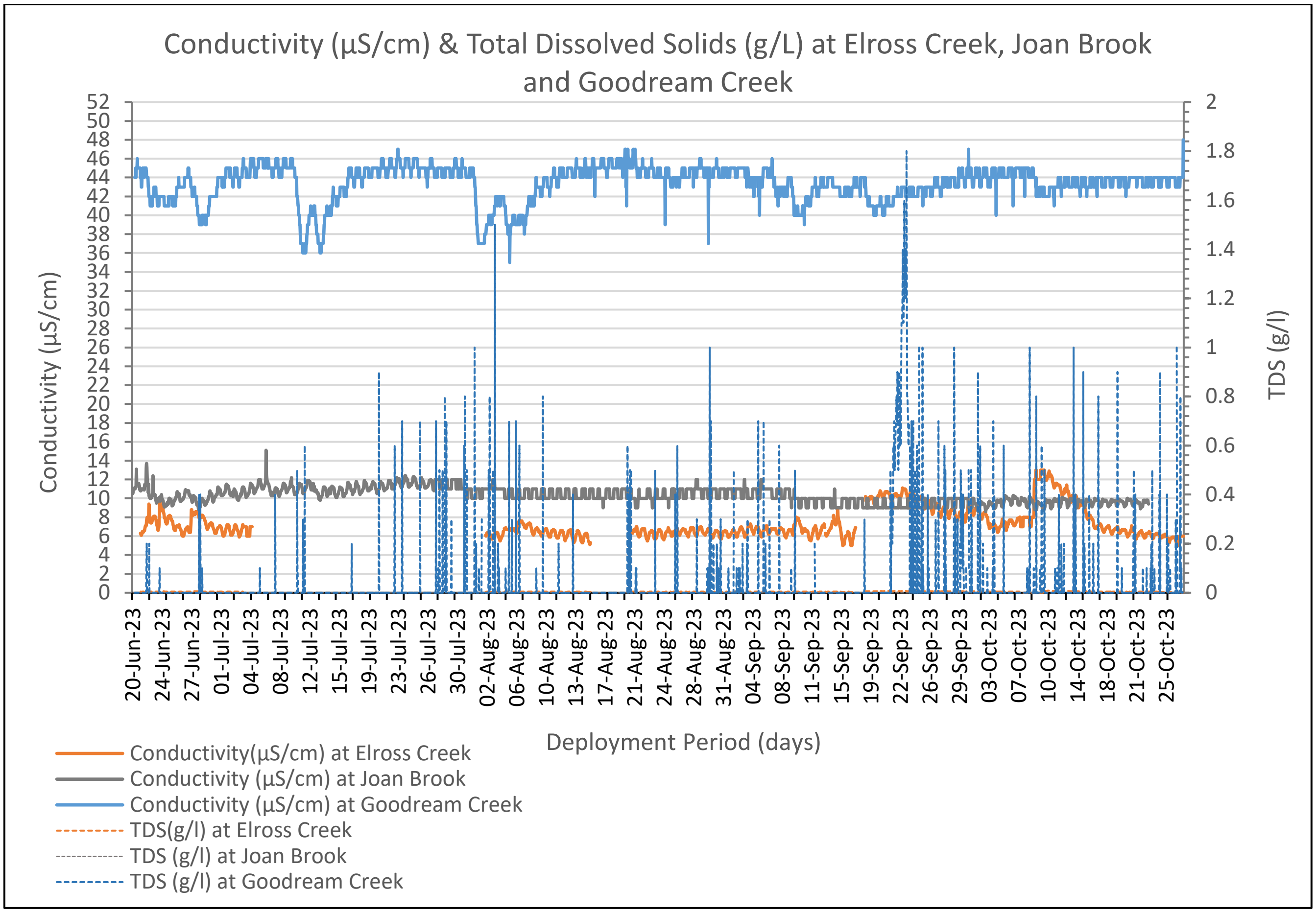
The provided data in Figure 6 outlines conductivity measurements from June to October. For Joan Brook, the data reveals a minimum specific conductance of 8.6 µS/cm and maximum of 15.1 µS/cm and no detectable total dissolved solids throughout the monitoring period. In analyzing freshwater conductivity, a calculated total dissolved solids (TDS) value of zero (0) seems unusual and likely indicates a discrepancy in the estimation/calculation process. This discrepancy may arise from an inappropriate conversion factor, measurement error, or unusual water chemistry.

Elross Creek exhibits lower specific conductance and TDS values compared to Joan Brook, with a range in specific conductance of 5.0 to 13.0 µS/cm and maximum TDS of 0.0083 g/L. These values indicate slightly higher levels of dissolved ions and minerals compared to Joan Brook, possibly influenced by local geological conditions.

Lastly, Goodream Creek displays the highest specific conductance and TDS values among the three rivers, with a specific conductance range of 35.0 to 48.0 µS/cm and maximum TDS of 1.800 g/L. These elevated values suggest a higher concentration of dissolved ions and minerals in the water, potentially influenced by factors such as runoff or activities in the watershed. Sudden decreases in conductivity are likely the result of precipitation events and the addition of freshwater.

Significant diurnal fluctuations observed at all stations are characteristic of shallow water streams and ponds, where the water responds swiftly to changes in ambient air temperatures. This disparity likely stems from various factors including differences in water depth, flow dynamics, and surrounding vegetation cover, all of which can impact the rate of temperature change within the water body.

Conductivity levels fluctuate throughout the months within each river. While there isn't a consistent trend of increasing or decreasing conductivity over the months, fluctuations are observed, likely influenced by factors such as precipitation, temperature, and human activities. Low water specific conductivity and Total Dissolved Solids (TDS), as observed in the three waterbodies, indicate high water purity and minimal contamination.



Variable	JOAN BROOK		ELROSS CREEK		GOODREAM CREEK	
	SP. COND	**TDS**	**SP. COND**	**TDS**	**SP. COND**	**TDS**
MAX	15.1	0.000	13.00	0.0083	48.0	1.800
MIN	8.6	0.000	5.00	0	35.0	0.000
MEDIAN	10.0	0.000	6.80	0.0043	44	0.0000
MEAN	10.3	0.000	7.41	0.00451	43.4	0.0391

Figure 6: Hourly Specific Conductivity (µS/cm) and Total Dissolved Solids – TDS (g/L) data at Joan Brook, Elross Creek & Goodream Creek.

Dissolved Oxygen

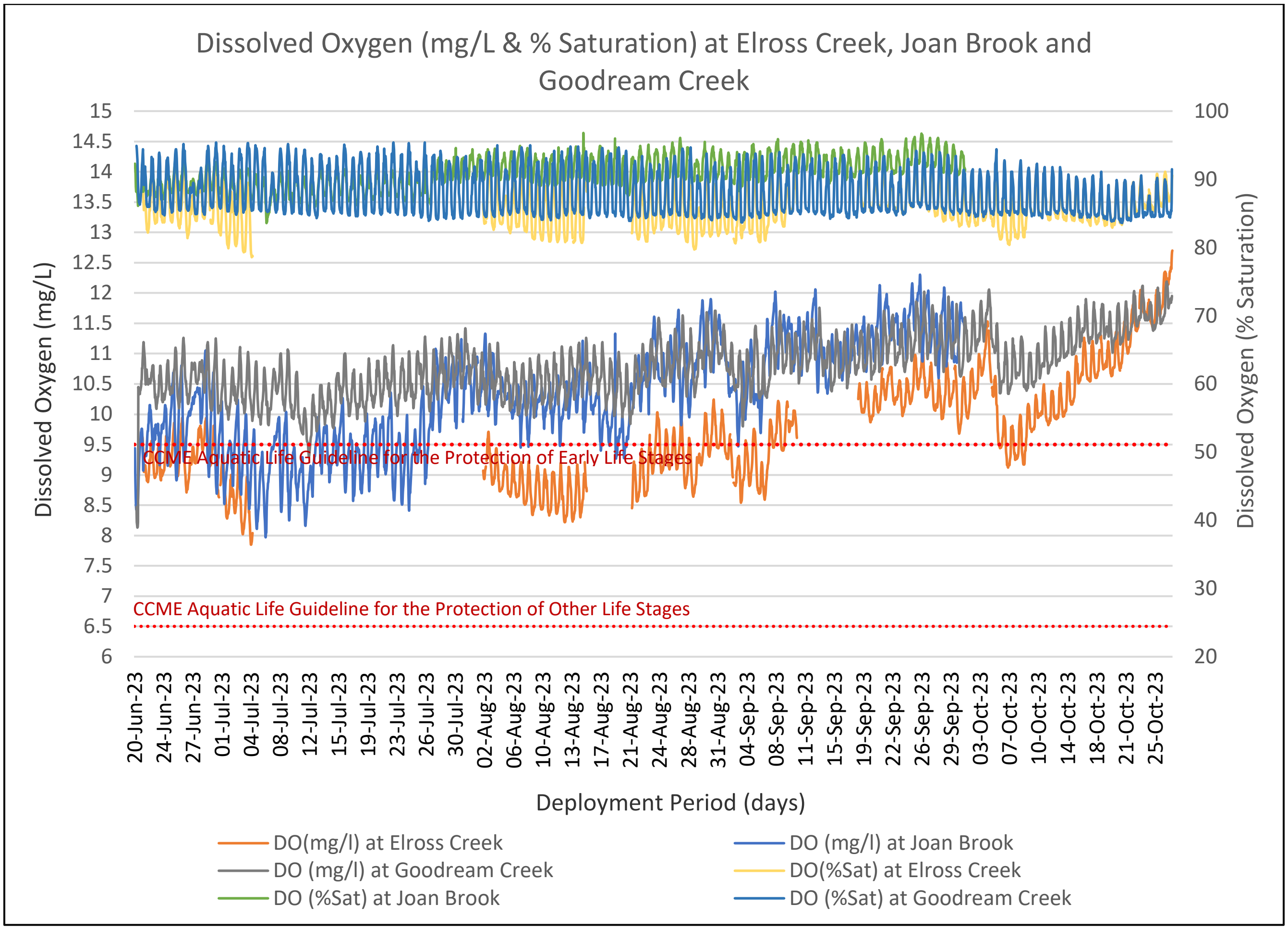
Dissolved oxygen is a metabolic requirement of aquatic plants and animals. The concentration of oxygen in water depends on many factors, principally temperature – the saturation of oxygen in water is inversely proportional to water temperature. Oxygen concentrations also tend to be higher in flowing water compared to still, lake environments. Low oxygen concentrations can give an indication of excessive decomposition of organic matter or the presence of oxidizing materials.

The statistical data for dissolved oxygen (DO) concentrations (mg/L) and percent saturation (% Sat) offers valuable insights into the water quality dynamics of each freshwater river within the monitoring period. Due to DO sensor failure at Joan Brook Station on September 10, 2023, until the end of the deployment period, data could not be collected and included in data analysis for this time frame. Data collected from June to September reveals a wide range of DO concentrations, with a maximum of 12.30 mg/L (96.8%) and a minimum of 7.97 mg/L (83.6%), indicating significant variability in oxygen levels. Despite this variability, the median and mean DO concentrations of 10.31 mg/L (90.7%) and 10.29 mg/L (90.9%), respectively, suggest relatively stable oxygen levels on average.

Conversely, Elross Creek exhibits slightly lower DO concentrations compared to Joan Brook, with a maximum of 12.7 mg/L (93.0%) and a minimum of 7.85 mg/L (78.6%). The median and mean DO concentrations of 9.66 mg/L (85.7%) and 9.76 mg/L (85.9%) respectively, indicate consistent oxygen levels overall. Meanwhile, Goodream Creek demonstrates favorable oxygen levels similar to Joan Brook, with a maximum DO concentration of 12.19 mg/L (95.4%) and a minimum of 8.13 mg/L (83.6%). The median and mean DO concentrations of 10.77 mg/L (87.0%) and 10.79 mg/L (88.1%) further confirm stable oxygen levels, reflecting the health of this freshwater ecosystem.

The observed increase in dissolved oxygen (DO) levels from June to October corresponds to decreasing water temperatures throughout deployment. As temperatures dropped due to the natural transition from summer to fall, the solubility of oxygen in water increased due to the colder water's ability to hold more dissolved gases. Dissolved oxygen level remained consistently above the Canadian Council of Ministers of the Environment (CCME) Guideline for the Protection of the Other Life (6.5 mg/L), and at or above the CCME guideline of 9.5 mg/l for the protection of early life stage cold water biota for most of the deployment period.

A diurnal variation pattern was evident. The extent of this variation is linked to the daily range of water temperature, duration of daylight, and fluctuations in rates of photosynthesis and respiration. Consequently, the observed attenuation of the diurnal pattern is expected, given the decrease in aquatic biotic activity, and narrowing daily temperature ranges during the summer-fall season.



Variable	JOAN BROOK		ELROSS CREEK		GOODREAM CREEK	
	mg/L	**%Sat**	**mg/L**	**% Sat**	**mg/L**	**% Sat**
MAX	12.30	96.8	12.7	93.0	12.19	95.4
MIN	7.97	83.6	7.85	78.6	8.13	83.6
MEDIAN	10.31	90.7	9.66	85.7	10.77	87.0
MEAN	10.29	90.9	9.76	85.9	10.79	88.1

Figure 7: Hourly Dissolved Oxygen (mg/L & % Saturation) at Joan Brook, Elross Creek & Goodream Creek.

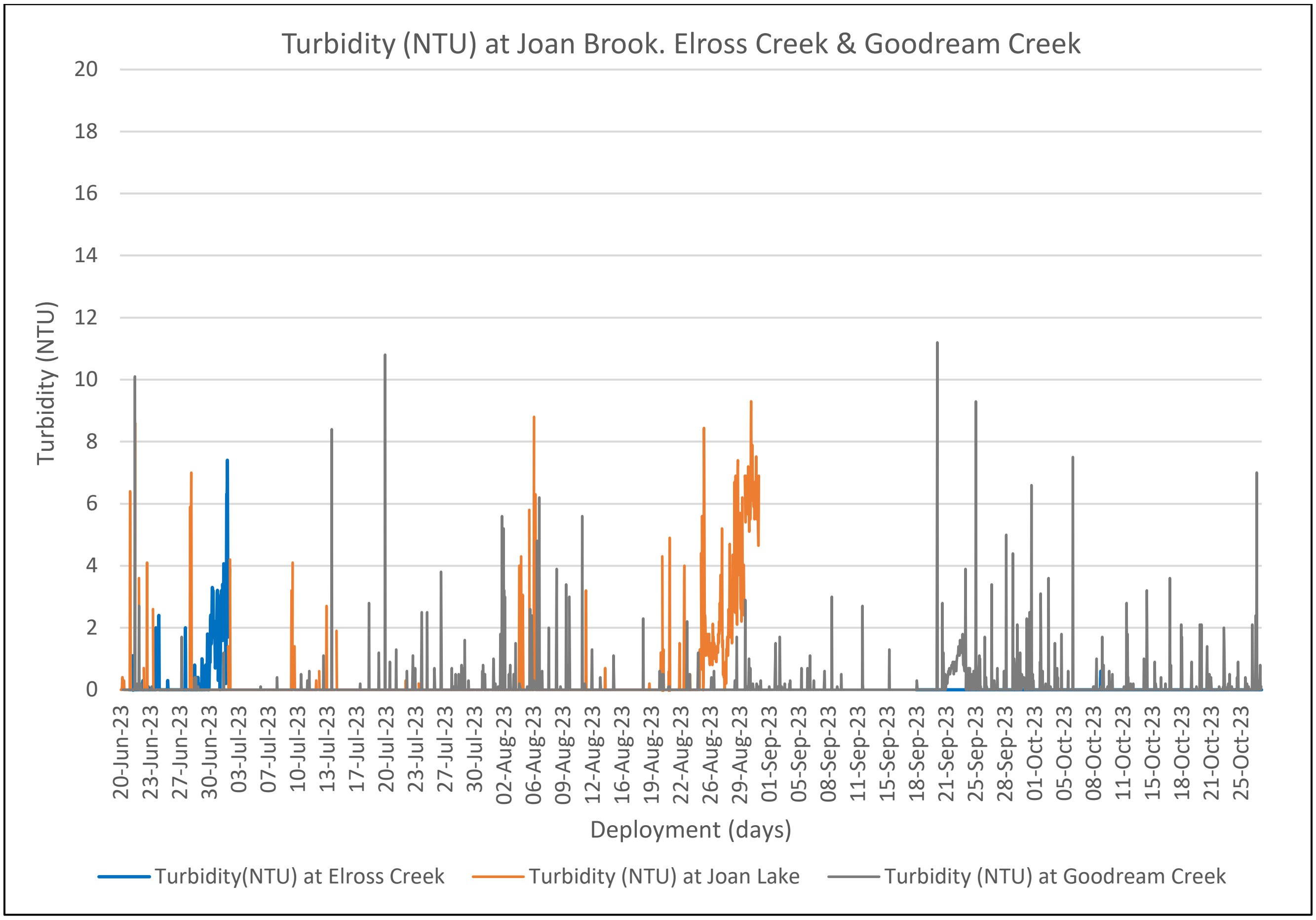
Turbidity

Water turbidity is characterized by the cloudiness or haziness caused by suspended particles and can significantly impact water quality. High turbidity reduces light penetration, hindering photosynthesis and affecting aquatic vegetation growth and habitat suitability. It can lead to temperature fluctuations, oxygen depletion from microbial decomposition of organic matter, and sedimentation, smothering benthic habitats and compromising biodiversity. Turbidity can also transport nutrients and pollutants, contributing to eutrophication, algal blooms, and contamination of drinking water sources. Furthermore, it highlights the significance of monitoring and managing turbidity levels to uphold the health and functionality of aquatic ecosystems.

The provided turbidity data in Figure 8, for Elross Creek, Joan Lake, and Goodream Creek across the months of June to October, illustrates varying levels of water clarity in these freshwater bodies. Please note that turbidity data for Joan Brook was omitted from statistical analysis after August 31, 2023 (16:00hrs) due to the collection of erroneous data. This was determined to be the result of sensor failure upon return of the instrument to the St. John 's laboratory. Due to power loss to the water quality instrument, turbidity data at Elross Creek was not collected July 2, 2023 (19:00hrs) to September 18, 2023 (10:00hrs).

Throughout the observation period, all three locations consistently registered minimal turbidity, with some sporadic instances of elevated readings, particularly in July and September. Goodream Creek generally exhibited slightly higher turbidity levels compared to Joan Lake and Elross Creek, with maximum readings reaching 11.2 NTU. Joan Lake recorded the highest maximum turbidity value of 9.3 NTU in August, indicating a temporary increase in suspended particles, possibly due to external factors such as rainfall. erosion or runoff events. Elross Creek showed lower turbidity levels, with maximum readings of 7.3 NTU. Despite variations in maximum turbidity levels, all three waterbodies consistently record minimum and median turbidity readings of 0.00 NTU, suggesting periods of relatively clear water. The mean turbidity values, however, show slight differences, with Joan Brook having the highest mean turbidity of 0.402 NTU, followed by Elross Creek at 0.122 NTU, and Goodream Creek at 0.117 NTU. These variations may be indicative of differences in sedimentation rates, flow dynamics, or land use practices within each waterbody.

Overall, despite occasional fluctuations, the turbidity levels remained relatively low across all locations, suggesting good water quality conditions in these freshwater ecosystems during the observation period. Ongoing monitoring and further investigation into the factors influencing turbidity spikes are essential to ensure the continued health and sustainability of these water bodies.



Variable	JOAN BROOK	ELROSS CREEK	GOODREAM CREEK
MAX	9.3	7.3	11.2
MIN	0.00	0.0	0.0
MEDIAN	0.00	0.0	0.0
MEAN	0.402	0.122	0.117

Figure 8: Hourly Turbidity (NTU) at Joan Brook, Elross Creek and Goodream Creek.

Stage

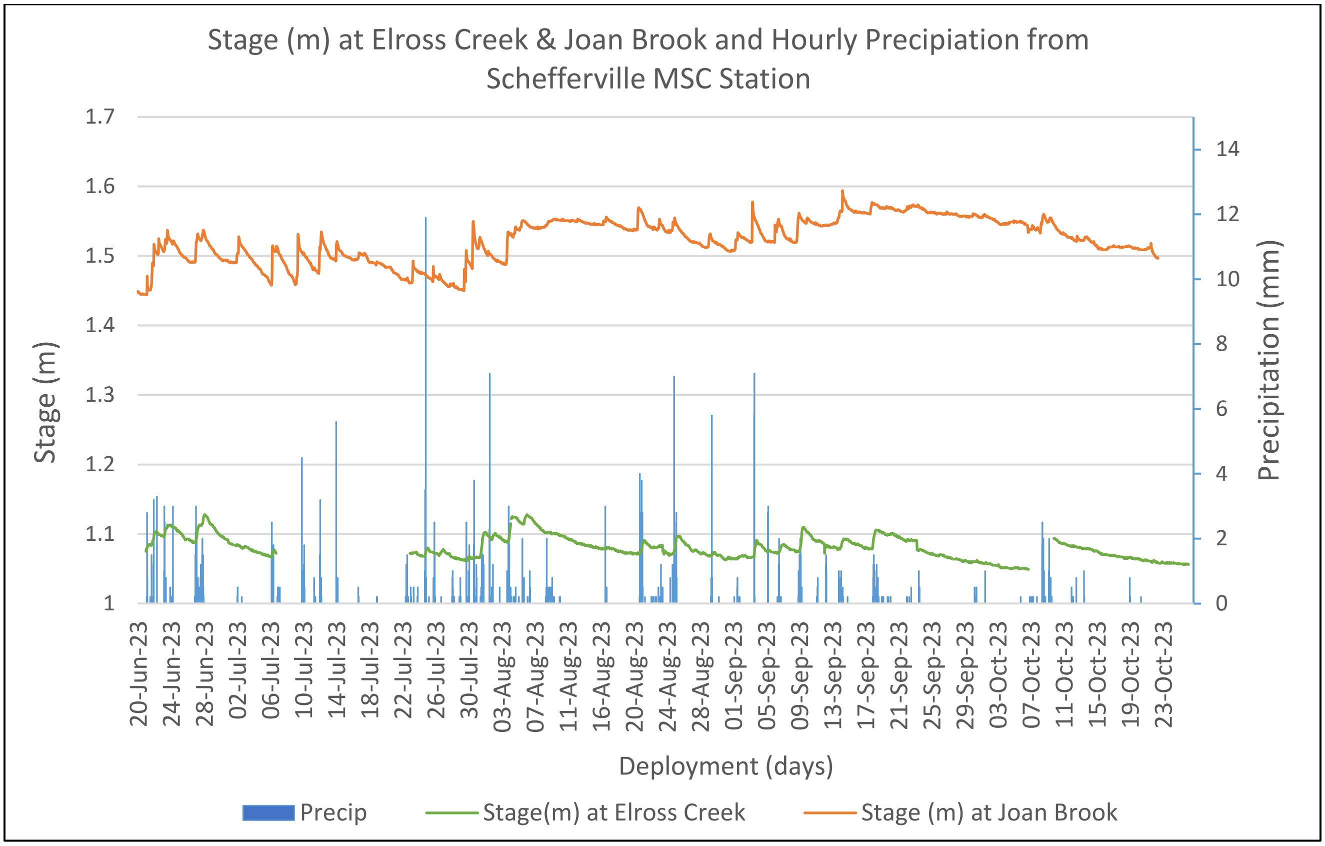
Stage values are determined by a vertical reference specific to each station, rendering absolute stage values incomparable between stations. However, relative change in stage can be meaningfully compared across stations.

The provided data in Figure 9, offers insights into the stage measurements of two of the three freshwater rivers, Joan Brook and Elross Creek, within the TATA mine site. Goodream Creek stage data was not collected due to the decommissioning of the station in 2018. Joan Brook appears to maintain relatively consistent measurements, as indicated by its maximum (1.59m), mean (1.53m), and median (1.52m) values being closely clustered together. This suggests minimal variability or outliers within the data set.

Similarly, Elross Creek exhibits a slight increase in disparity between its maximum value (1.128m) and the mean (1.08m) and median (1.20m) values. Consequently, while the available data sheds light on the characteristics of Joan Brook and Elross Creek, the absence of information for Goodream Creek limits comprehensive comparisons across all three sites.

Fluctuations in stage corresponded well with rainfall events (climate data located in Appendix C). During periods of increased rainfall, water levels in both Joan Brook and Elross Creek rose, leading to higher stage measurements. Conversely, during drier periods with minimal rainfall, the water levels may decrease, resulting in lower stage measurements.

As mentioned previously, while WSC oversees the hydrometric component of these stations, due to differences in protocols, quality control for WSC hydrometric data occurs less frequently than for water quality data. The hydrometric data presented in this report is provisional and has not undergone quality control checks. Accurate hydrometric data can be accessed at https://wateroffice.ec.gc.ca/ or by request to Water Survey Canada.



Variable	JOAN BROOK	ELROSS CREEK	GOODREAM CREEK
MAX	1.59	1.128	N/A
MIN	1.44	1.05	
MEAN	1.53	1.08	
MEDIAN	1.52	1.20	

Figure 9: Hourly Stage Level (m) and precipitation at Joan Brook and Elross Creek.

CONCLUSIONS

Deployment

- Water quality monitoring instruments were deployed at two established stations near the Elross Lake and DSO4 Project 2B, Iron Ore Mine, between June 20th and October 27th, 2022. The stations are located on Elross Creek and Joan Brook.
- Goodream Creek Station 2km Northwest of Timmons 6 has been temporarily suspended to allow for its relocation downstream, near Triangle Lake. We expect TSMC to complete this relocation early in the 2024 field season, aiming for full operational readiness at the new site before the season concludes. Additionally, during the 2023 season, a Hydrolab DS5X instrument was deployed at the proposed new station location downstream nearer to Triangle Lake, utilizing internal data logging for subsequent statistical analysis and interpretation. These actions represent significant steps towards enhancing our monitoring capabilities and ensuring the reliability of our data for informed decision-making in water resource management.
- The water quality monitoring instruments were deployed once at Goodream Creek Station for the entirety of the ice-free season, twice at Elross Creek Station and three (3) times at Joan Brook Station during 2023. There were some issues with timing of deployments and grab sample collection, however, the overall QAQC result comparisons indicated the instruments functioned well during the season.
- Both Joan Brook and Elross Creek stations suffered data loss due to transmission and power issues. Elross Creek suffered substantial losses due to vandalism by wildlife. Where possible, internally logged data from the sondes were used to limit the data loss for water quality parameters.
- The instruments at Elross Creek and Goodream Creek were deployed for a total of 130 and days, while Joan Brook was deployed for 123 days.

Data Interpretation

The comprehensive analysis of water temperature data from Elross Creek, Joan Brook, and Goodream Creek underscores the critical role of temperature in shaping aquatic ecosystems. The distinct seasonal patterns observed across all three rivers highlight their unique thermal characteristics, with Elross Creek consistently warmer, Joan Brook exhibiting intermediate temperatures, and Goodream Creek maintaining cooler conditions. Further examination of minimum and maximum temperatures reveals variations in thermal extremes, indicating differential heating and cooling dynamics among the water bodies. Additionally, the significant diurnal fluctuations, particularly pronounced in Joan Brook, emphasize the influence of local factors such as water depth and vegetation cover on temperature variability.

pH data analysis reveals distinct water quality profiles for each river. Joan Brook consistently maintains a stable pH range around neutral to slightly acidic levels throughout the monitoring period, indicative of relatively stable conditions for aquatic life. Conversely, Elross Creek exhibits slightly lower pH values, consistently falling below the recommended guidelines for freshwater ecosystems, suggesting potential concerns for aquatic organisms. Goodream Creek stands out with consistently higher pH values, indicating a wider range of values and neutral to slightly alkaline conditions, also within the acceptable range for aquatic life protection. The observed variations in pH levels among the rivers may be influenced by a combination of factors including geological characteristics, land use practices, and proximity to mining activities within the TSMC mine area. Monitoring and addressing pH fluctuations in Elross Creek are essential to ensure the long-term health and sustainability of the aquatic ecosystem in the region.

Specific conductivity data analysis highlights distinct water quality characteristics within the monitoring period. Joan Brook consistently demonstrates low specific conductance and total dissolved solids (TDS) values, indicating good water quality with minimal contamination. Elross Creek exhibits slightly lower average specific conductance and TDS values compared to Joan Brook, potentially influenced by local geological conditions. Conversely, Goodream Creek shows the highest specific conductance and TDS values, suggesting a higher concentration of dissolved ions and minerals, possibly influenced by runoff or watershed activities. Diurnal fluctuations in conductivity levels are evident across all stations, reflecting the dynamic nature of shallow water bodies. While no consistent trend in conductivity changes over the months is observed, fluctuations likely result from environmental factors such as temperature, precipitation, and human activities. Overall, the low specific conductivity and TDS levels across the three water bodies indicate high water purity and minimal contamination.

Dissolved oxygen (DO) data analysis reveals significant variability in oxygen levels within Joan Brook, Elross Creek, and Goodream Creek, with relatively stable median and mean concentrations. Despite a DO sensor failure at Joan Brook Station from September onwards, the available data suggests favorable oxygen levels across the monitored period. Elross Creek exhibits slightly lower DO concentrations compared to Joan Brook, while Goodream Creek demonstrates similar levels, reflecting overall ecosystem health. The increase in DO levels from June to October corresponds to decreasing water temperatures, aligning with the natural solubility of oxygen in colder water. Importantly, DO levels remained consistently above Canadian Council of Ministers of the Environment (CCME) guidelines for aquatic life protection throughout most of the deployment period. Diurnal variations in DO levels are evident, influenced by factors such as temperature ranges and rates of photosynthesis and respiration, with a decrease in variability during the summer-fall season. This highlights the importance of continued monitoring and management to sustain the health and integrity of these freshwater ecosystems.

The analysis of turbidity data for Elross Creek, Joan Lake, and Goodream Creek indicates generally minimal turbidity levels with sporadic instances of elevated readings, particularly in July and September. Despite some fluctuations, all three locations consistently maintained relatively low turbidity levels throughout the observation period, suggesting good water quality conditions in these freshwater ecosystems as historically observed. The occasional spikes in turbidity, such as the temporary increase recorded in Joan Lake in August, may be attributed to external factors like rainfall, erosion, or runoff events. Ongoing monitoring and investigation into the factors influencing these fluctuations are crucial for ensuring the continued health and sustainability of these water bodies.

Stage measurements for Joan Brook and Elross Creek indicate relatively consistent patterns, with minimal variability observed in Joan Brook and a slight increase in disparity for Elross Creek. The absence of stage data for Goodream Creek limits comprehensive comparisons across all three sites, highlighting potential shifts in monitoring priorities or operational changes within the mine site. Fluctuations in stage correspond well with rainfall events, suggesting a direct influence of precipitation on water levels in these freshwater rivers.

PATH FORWARD

- Considering the age-related concerns and maintenance issues linked with the Hydrolab DS5 instrumentation, four (4) YSI EXO3 sondes were procured, configured, and calibrated for deployment at Elross Creek and Joan Brook in 2024. The additional sondes will be used for Qa/Qc and Goodream Creek above Triangle Lake.
- In 2023, WRMD installed a Tipping Bucket Rain Gauge at the Joan Brook Station as a component of the federal National Disaster Mitigation Program. WSC has connected it to the new *Sutron SatLink 3 Datalogger*. WRMD is responsible for ensuring the proper functioning of the tipping bucket and obtaining accurate data upon 2024 site visit. Integrating a precipitation tipping bucket at a real-time water quality station provides a multifaceted approach to environmental monitoring and analysis. By combining precipitation data with water quality parameters, such as turbidity, dissolved oxygen, and nutrient levels, at the same location, a comprehensive understanding of hydrological processes and their impact on water quality is achieved. This integrated approach enables hydrological analysis, flood monitoring, and resource management, as precipitation data aids in assessing rainfall patterns, predicting flood events, and managing water resources effectively.
- ECC staff will redeploy RTWQ instruments at Elross Creek, Joan Brook and Goodream Creek (Hydrolab DS5X) in the spring of 2024, when ice conditions allow. The field season, typically June to October will consist of one (1) deployment contingent on instrument and sensor functionality, and ECC staff with the assistance of TSMC staff will perform regular maintenance of the instruments to ensure continuous accurate data collection and transmission.
- ECC staff will continue to work co-operatively with TSMC staff to co-ordinate the relocation of the Goodream Creek Station to a new monitoring location further downstream on Goodream Creek above Triangle Lake. An instrument will be redeployed with near real-time data transmission at the new Goodream Creek location as soon as possible in the 2024 field season once the new station hut is installed.
- ECC staff will continue to rely on input and assistance from TSMC staff in the operation and maintenance of all three TSMC Real Time Water Quality stations at Elross Creek, Goodream Creek and Joan Brook. Every effort will be made to coordinate in advance with TSMC staff for site visits during the 2024 field season. ECC staff are very appreciative of the field assistance provided by TSMC staff during the 2023 field season and are hoping to carry on with this arrangement again next year if necessary to maintain network operations.
- If necessary, deployment techniques will be evaluated and adapted to each site, ensuring secure and suitable conditions for RTWQ monitoring.
- ECC staff will update TSMC staff on any changes to processes and procedures with handling, maintaining, and calibrating the real-time instruments.
- ECCC staff will perform regular site visits to ensure water quantity instrumentation is correctly calibrated and providing accurate measurements.
- TSMC will continue to be informed of data trends and any significant water quality events in the form of email and/or monthly deployment reports, when the deployment season begins. TSMC will also receive an annual report, summarizing the events of the deployment season.

- ECC has begun development of models using water quality monitoring data and grab sample data to estimate a variety of additional water quality parameters (e.g., TSS and major ions). This work will continue with a goal in implementing these models for RTWQ data collected.
- ECC will continue to work on its Automatic Data Retrieval System, to incorporate new capabilities in data management and data display.
- ECC will be active in creating new value-added products using the RTWQ data and water quality indices.
- Open communication will continue to be maintained between ECC, ECCC and TSMC employees involved with the agreement, in order to respond to emerging issues on a proactive basis.

REFERENCES

Allan, D. (2010). Advanced Water Quality Instrumentation Training Manual. Edmonton, AB: Allan Environmental Services Inc. (pp. 160).

AMEC, 2009, Fish and Fish Habitat Investigation for the Direct-Shipping Ore Project. Report No. TF 8165902. Submitted to Groupe Hémisphères for New Millennium Capital Corp.

Canadian Council of Ministers of the Environment. 2007. Canadian water quality guidelines for the protection of aquatic life: Summary table. Updated December, 2007. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg. (Website: http://ceqg-rcqe.ccme.ca/download/en/222/)

Hach (2006) Important water quality factors - H2O University. Hach Company. Online: http://www.h2ou.com/index.htm (accessed August 24, 2010).

NML, 2009, Elross Lake Area Iron Ore Mine, Environmental Impact Statement, submitted to Government of Newfoundland and Labrador, December 2009. Online: http://www.env.gov.nl.ca/env/env_assessment/projects/Y2010/1380/nml_pfwa_eis_for_gnl_december_2009.pdf (accessed October 12, 2012).

Swanson, H.A., and Baldwin, H.L., 1965. A Primer on Water Quality, U.S. Geological Survey. Online: http://ga.water.usgs.gov/edu/characteristics.html (accessed August 24, 2010)

APPENDIX A - Quality Assurance / Quality Control Procedures

As part of the Quality Assurance / Quality Control (QA/QC) protocol, the performance of a station's water quality instrument (i.e., Field Sonde) is rated at the start and end of its deployment period. The procedure is based on the approach used by the United States Geological Survey (Wagner *et al.* 2006)[1].

At the start of the deployment period, a fully cleaned and calibrated QA/QC water quality instrument (i.e., QA/QC Sonde) is placed *in-situ* with the fully cleaned and calibrated Field Sonde. After Sonde readings have stabilized, which may take up to five minutes in some cases, water quality parameters, as measured by both sondes, are recorded to a field sheet. Field Sonde performance for all parameters is rated based on differences recorded by the Field Sonde and QA/QC Sonde. If the readings from both sondes are in close agreement, the QA/QC Sonde can be removed from the water. If the readings are not in close agreement, there will be attempts to reconcile the problem on site (e.g., removing air bubbles from sensors, etc.). If no fix is made, the Field Sonde may be removed for recalibration.

At the end of the deployment period, a fully cleaned and calibrated QA/QC Sonde is once again deployed *in-situ* with the Field Sonde, which has already been deployment for 30-40 days. After Sonde readings have stabilized, water quality parameters, as measured by both sondes, are recorded to a field sheet. Field Sonde performance for all parameters is rated based on differences recorded by the Field Sonde and QA/QC Sonde.

Performance ratings are based on differences listed in the table below.

	Rating				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (°C)	≤ ±0.2	> ±0.2 to 0.5	> ±0.5 to 0.8	> ±0.8 to 1	> ±1
pH (unit)	≤ ±0.2	> ±0.2 to 0.5	> ±0.5 to 0.8	> ±0.8 to 1	> ±1
Sp. Conductance ≤ 35 (µS/cm)	≤ ±3	> ±3 to 10	> ±10 to 15	> ±15 to 20	> ±20
Sp. Conductance > 35 (µS/cm)	≤ ±3	> ±3 to 10	> ±10 to 15	> ±15 to 20	> ±20
Dissolved Oxygen (mg/l)	≤ ±0.3	> ±0.3 to 0.5	> ±0.5 to 0.8	> ±0.8 to 1	> ±1
Turbidity ≤ 40 NTU (NTU)	≤ ±2	> ±2 to 5	> ±5 to 8	> ±8 to 10	> ±10
Turbidity > 40 NTU (NTU)	≤ ±5	> ±5 to 10	> ±10 to 15	> ±15 to 20	> ±20

[1] Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; accessed April 10, 2006, at http://pubs.water.usgs.gov/tm1d3

APPENDIX B - Water Parameter Description

Dissolved Oxygen - The amount of Dissolved Oxygen (DO) (mg/l) in the water is vital to aquatic organisms for their survival. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (Allan 2010).

pH - pH is the measure of hydrogen ion activity and affects: (i) the availability of nutrients to aquatic life; (ii) the concentration of biochemical substances dissolved in water; (iii) the efficiency of hemoglobin in the blood of vertebrates; and (iv) the toxicity of pollutants. Changes in pH can be attributed to industrial effluence, saline inflows or aquatic organisms involved in the photosynthetic cycling of CO_2 (Allan 2010).

Specific conductivity - Specific conductivity (µS/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25ºC. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Stage – Stage (m) is the elevation of the water surface and is often used as a surrogate for the more difficult to measure flow.

Temperature - Essential to the measurement of most water quality parameters, temperature (°C) controls most processes and dynamics of limnology. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth (Allan 2010; Hach 2006).

Total Dissolved Solids - Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Turbidity - Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Allan 2010; Hach 2006; Swanson and Baldwin 1965.

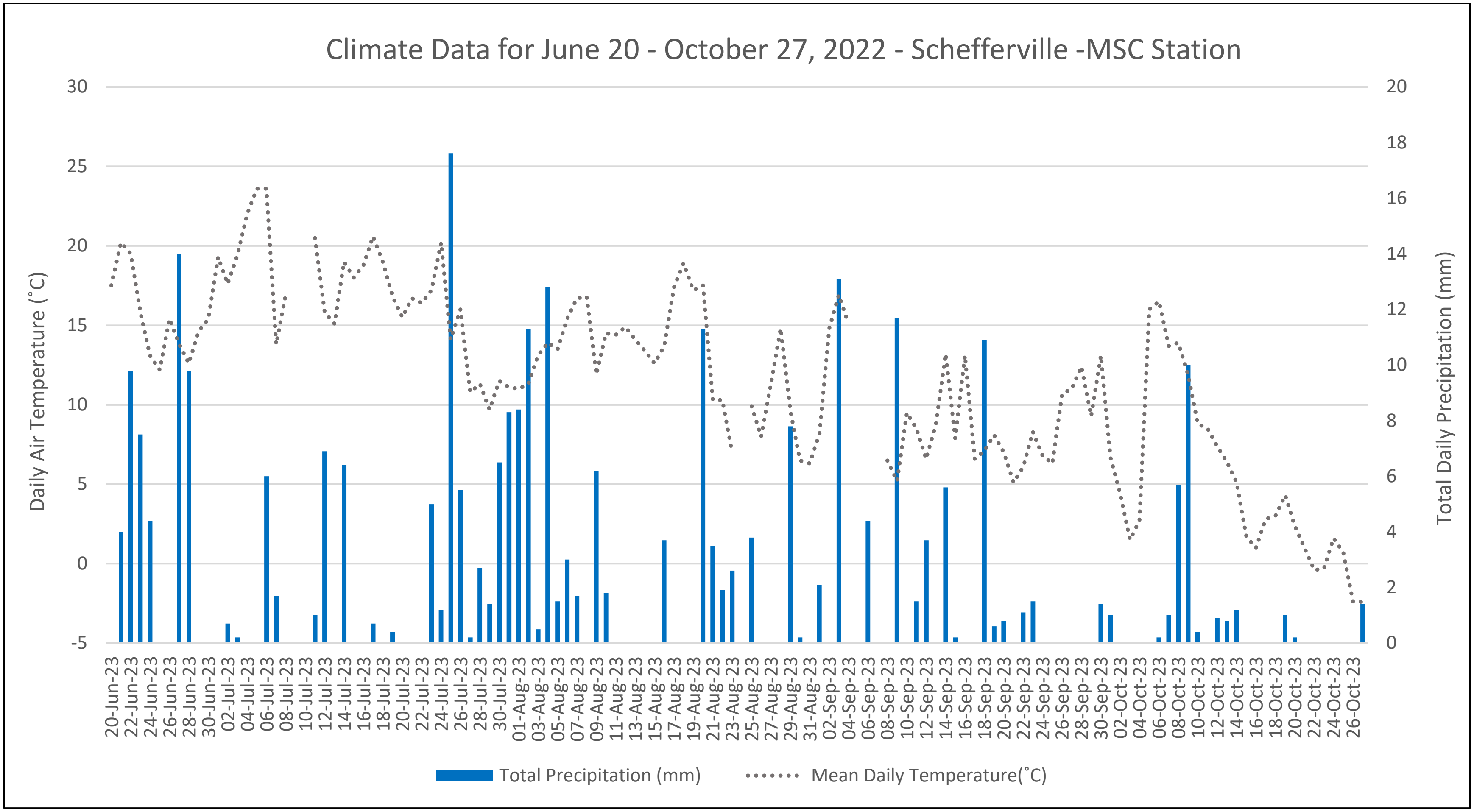
Important Terminology

ADRS – Automated Data Retrieval System: A database management system designed to collect data from a variety of telemetry sources such as GOES, Iridium, and cell network in order to populate a database of all water quality, hydrometric, and climate systems in the province. The system is also responsible for generating graphs for public consumption amongst other duties.

Field Sonde: The multi-parameter water quality monitoring device (typically a Hydrolab DS5X, in the Newfoundland and Labrador monitoring network) deployed on a 30 day schedule.

QAQC Sonde: The multi-parameter water quality monitoring device (typically a Hydrolab DS5X, in the Newfoundland and Labrador monitoring network) cleaned and recalibrated before each field visit, to be used as an unfouled data source for comparison to the Field Sonde.

APPENDIX C – Daily Air Temperature & Total Precipitation from Nav Canada Station: Schefferville - 7117823



APPENDIX D - QA/QC Grab Sample Results