



Meliadine Lake 3-D Hydrodynamic Modelling

Final Report Rev 0.0

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Prepared for Agnico Eagle Mines Limited






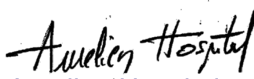

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Prepared for: Agnico Eagle Mines Limited
Represented by Lisa Ramilo, Permitting Lead Water & Waste

Prepared by:	
 Renan Ribeiro	 Aurelien Hospital
Approved by:	
 Danker Kolijn, M.Sc., P.Eng. Director of Projects, Americas-Pacific Marine & Coast	

Contact person: Lisa Ramilo, Permitting Lead Water & Waste, lisa.ramilo@agnicoeagle.com
Project Manager: Aurelien Hospital
Quality Supervisor: Danker Kolijn
Author: Renan Ribeiro, Aurelien Hospital
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Plain Language Summary

This report looks at how effluent from the Meliadine Mine is released into Meliadine Lake near Rankin Inlet, Nunavut. The study uses computer models to understand how the mine's effluent moves, mixes, and spreads in the lake over time. The main goal is to ensure the water meets environmental guidelines now and for future water discharges.

The study checks how the discharged water affects lake quality, especially focusing on substances dissolved in the water (called TDS) and how well the effluent mixes and dilutes as it moves away from the discharge point.

The study found that the computer model accurately predicts water levels, temperature, and the amount of dissolved substances by comparing results to real-world measurements between 2018 and 2024. The computer model was then used to simulate future effluent discharge in the lake, up to 2036. Adequate dilutions are obtained to meet water quality guidelines. Even during the least-favorable mixing conditions over the 12-year long simulation (2025-2036), water quality continues to meet the applicable standards. Water in the lake presents consistently low levels of dissolved substances, with total dissolved solids typically well below 360 mg/L, associated with adequate mixing of the mine's effluent.

Technical Executive Summary

This document presents a comprehensive hydrodynamic, transport and mixing modelling study of Meliadine Lake, focusing on the evaluation of effluent discharge from the Meliadine Mine diffuser system operated by Agnico Eagle Mines Limited (Agnico Eagle) near Rankin Inlet, Nunavut. The study aims to quantify the transport, mixing, and accumulation of mine effluent discharged into the southeastern sub-basin of Meliadine Lake, evaluating water quality impacts and compliance with regulatory standards at the edge of the 100-m mixing zone over both historical (2018–2024) and forecast (2025–2036) periods.

The Meliadine Mine, located near Rankin Inlet, began commercial production in May 2019, with mining activities including underground and open pit operations. The mine's processing involves a conventional gold circuit with cyanide leaching and tailings filtration. The proposed mine extension is expected to extend operations to 2036, increasing waste rock and water management needs. DHI Water & Environment, Inc. (DHI) was retained to develop a 3D hydrodynamic model to simulate physical lake processes and assess effluent impacts, focusing on total dissolved solids (TDS) concentrations and effluent dilution at the mixing zone boundary (MZB).

Key objectives of this study include:

- Validation of the 3D lake model against in-situ measurements.
- Assessment of effluent transport, mixing, and potential accumulation.
- Evaluation of long-term environmental effects of mine discharge on TDS concentrations.
- Quantification of effluent dilutions at the edge of the mixing zone.

The study employed a three-dimensional hydrodynamic numerical model using DHI MIKE 3 Flow Model Flexible Mesh (FM), combining hydrodynamic (HD) and transport (Advection–Dispersion, AD) modules. Near-field effluent mixing was simulated with MIKE JET, which models initial jet behavior and dilution from the diffuser ports, while lake-scale transport and mixing were resolved using MIKE 3 FM. The model domain covers the entire Meliadine Lake for an area of approximately 110 km².

First, the model was run from June 2018 through 2024. Validation focused on water levels, temperature, and TDS near the diffuser. Overall, the model was able to satisfactorily reproduce observed data:

- **Water levels:** The model accurately reproduced seasonal fluctuations and matched observations with negligible bias (mean bias 0.00 m, MAE and RMSE 0.01 m, correlation coefficient 0.99), indicative of excellent validation.
- **Water temperature:** Simulated temperatures closely followed observed seasonal patterns at the various monitoring stations, capturing summer warming and fall cooling during open-water seasons.
- **Total Dissolved Solids (TDS):** The model reproduced observed TDS magnitudes and variability near the diffuser, with modeled concentrations generally within the same order of magnitude as field measurements. TDS concentrations were typically less than 100 mg/L, consistent with natural background TDS concentrations in Meliadine Lake prior to effluent discharge ranged from 21 to 91 mg/L, with a median of 35 mg/L.

The second phase of the work focused on the continuation of mining, with a simulation covering 2025 to 2036.

Target Dilutions at the edge of the mixing zone were defined, based on water quality guidelines. Several effluent constituents have been identified as below guideline levels prior to discharge and, therefore, require no dilution. However, some constituents requiring dilution include ammonia, nitrate, chloride,

sulfate, arsenic, and others. Ammonia requires the highest dilution, with a target of 13:1. **This 13:1 dilution target has been adopted as the applicable target for assessment of compliance at the MZB.** Effluent dilutions will need to be at or above 13:1 at the edge of the mixing zone to comply with water quality guidelines.

Forecast simulations were then conducted over a 12-year duration (2025-2036), assessing effluent transport, mixing, and accumulation, using hydrological and meteorological forcings consistent with watershed modelling and climate-change scenarios. The following key outcomes were obtained:

- **TDS: Maximum TDS concentrations over the forecast period remain well below the regulatory compliance threshold of 1,000 mg/L at the mixing zone boundary, with values typically remaining below 361 mg/L.** For comparison, natural background TDS ranges from 21 to 91 mg/L. At the water withdrawal intake site in the lake narrows, TDS levels remain low and stable (approximately 44–62 mg/L), indicating minimal effluent impact at this location.
- Effluent dilutions characterizing effluent mixing in the lake: Minimum dilution ratios, representing worst-case mixing, stay in compliance with the target dilution levels of 13:1 at the mixing zone boundary. **No exceedance of applicable water-quality guidelines is predicted at the MZB.** Average dilution ratios consistently remain above 20:1, indicating robust mixing, by the time the effluent reaches the edge of the mixing zone. At the water withdrawal intake, dilution ratios range from approximately 52:1 to 480:1, confirming substantial mixing and attenuation of effluent before reaching the intake.

1 Introduction

Located near the western shore of Hudson Bay in the Kivalliq District of Nunavut, the Meliadine Mine is owned by Agnico Eagle Mines Limited (Agnico Eagle) and began commercial production in May 2019. Mining is carried out through several underground mining operations and open pits. The mill employs a conventional gold circuit comprised of crushing, grinding, gravity separation and cyanide leaching with a carbon-in-leach circuit, followed by cyanide destruction and filtration of the tailings for dry stacking.

Agnico Eagle has evaluated the potential to continue mining at Meliadine for an additional five years to 2036, which would include minor optimizations to the mine plan. The update also includes a minor increase to on-site fuel storage, and a minor increase to water use from approved waterbodies.

Agnico Eagle has retained DHI Water & Environment, Inc. (DHI) to support the Operational Update Application through hydrodynamic modelling. This modelling aims at quantifying the transport, mixing and accumulation of the mine's effluent released into Meliadine Lake. This report presents the domain of study, environmental data supporting the study, methodology, model validation (2018 to 2024) and model forecast for 2025 to 2036, characterizing effluent mixing. Key parameters such as TDS (Total Dissolved Solids) and effluent dilutions have been assessed.



Figure 1.1 Meliadine at Sunrise
Photo from Agnico Eagle

1.1 Study Objectives and Scenarios

The Meliadine Mine has been operating a 10-port diffuser since 2018. The system is located in the southeast (SE) basin of Meliadine Lake, as shown in Figure 1.2. With the potential to continue mining at Meliadine for an additional five years to 2036, this project is designed to simulate the physical processes of Meliadine Lake in order to evaluate the mixing of effluent discharge from the mine’s operational diffuser.

Utilizing a comprehensive 3D hydrodynamic model, the study simulates both natural environmental changes (such as variations in water level and temperature) and operational changes in the mine’s effluent (including discharge flow rates and total dissolved solids). Building on a successful validation of the 3D Meliadine Lake model against in-situ lake measurements, this integrated approach enables the quantification of effluent transport and mixing, and it also characterizes the concentrations at the edge of the mixing zone.

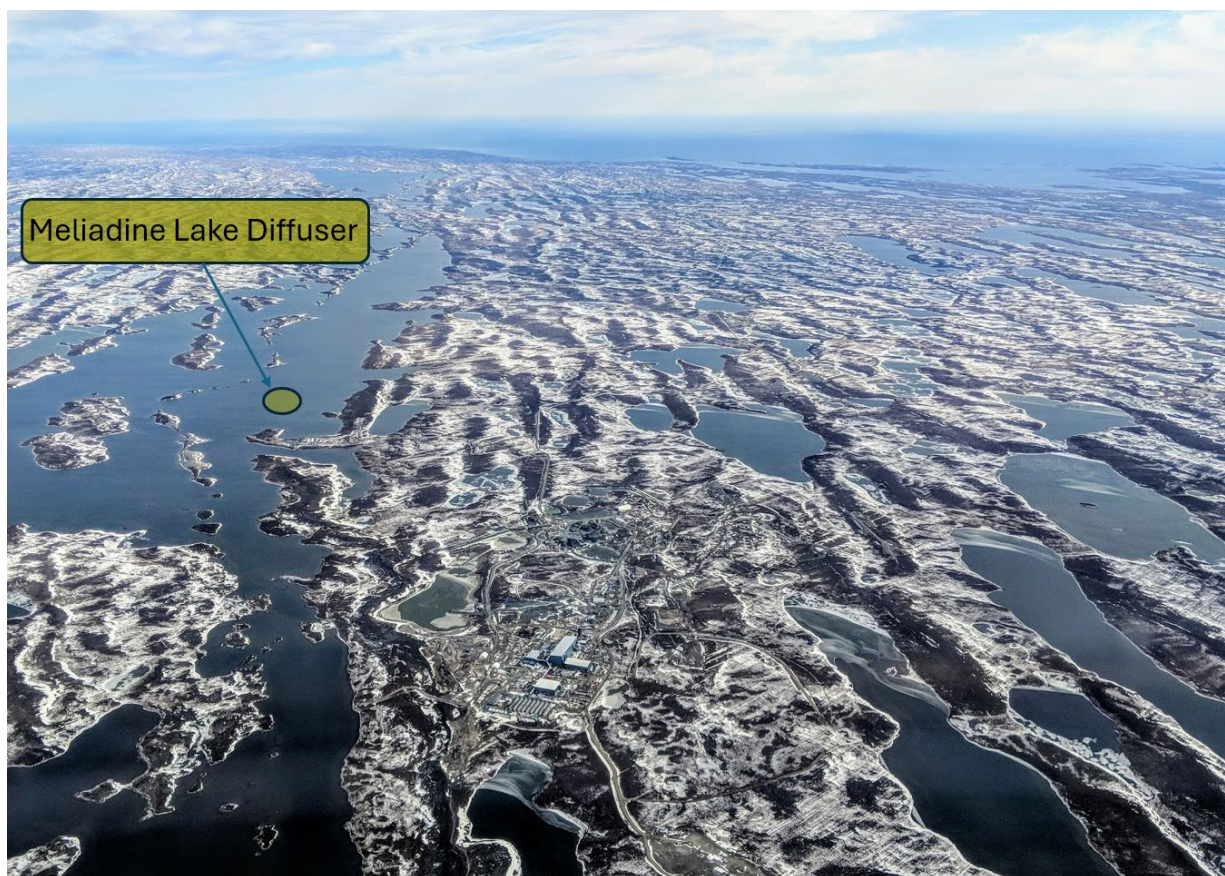


Figure 1.2 SE Basin of Meliadine Lake and Diffuser Location
 Photo from Bruce Giesbrecht – Google Earth (for illustration only)

In summary, this report provides the following key outputs:

- **Evaluate the long-term environmental effects of mine water discharge on Total Dissolved Solids concentrations in the lake** (Section 5.3)
- **Assess the long-term transport and mixing of discharged effluent in Meliadine Lake** (Section 5.3, Section 5.4, Appendix C)
- **Provide quantification of effluent mixing through dilutions at the edge of the mixing zone** (Section 5.4, Appendix C)

1.2 Study Approach

To conduct this assessment, DHI followed a four-step process outlined below in Table 1.1. The table illustrates the data and information required in each step, the analytical process, and resulting outputs.

Table 1.1 Study Tasks, Inputs, Processes, and Outputs for the Meliadine Lake Effluent Modelling Project

Step	Task Description	Key Input Requirements	Analysis & Processes	Outputs
1.0	Develop a 3D hydrodynamic model of Meliadine Lake	<ul style="list-style-type: none"> • Lake bathymetry • Inflows and outflows • Climate data 	<ul style="list-style-type: none"> • Develop a model grid • Develop all limnological inputs • Reproduce the seasonal heating/cooling of the lake 	An operational 3D hydrodynamic model of Meliadine Lake See Section 4 – Modelling Framework
2.0	Validate the model against in-situ observations	<ul style="list-style-type: none"> • Water temperature measurements • TDS measurements • Effluent discharge rate between 2018 and 2024 	<ul style="list-style-type: none"> • Simulate the 2018 to 2024 period • Compare modelled water temperature and TDS against observations 	A fully validated 3D hydrodynamic model of Meliadine Lake See Section 4.5 – Historical Discharge Modelling Scenario
3.0	Identify target dilutions	<ul style="list-style-type: none"> • Effluent constituent concentrations • Water quality guidelines 	<ul style="list-style-type: none"> • Identify maximum constituent concentration • Compute required dilution for each constituent 	Target dilution at edge of mixing zone See Section 5.2 – Target TDS Concentration and Effluent Dilution
4.0	Assess effluent concentrations and dilutions at edge of mixing zone	<ul style="list-style-type: none"> • Effluent flow rate and TDS for 2025 - 2036 	<ul style="list-style-type: none"> • Multi-year year-round simulation to assess transport, mixing and accumulation of effluent in the lake • Compute effluent concentrations at edge of mixing zone 	Water quality compliance assessment See Sections 5.2 and 5.3 – Meliadine Lake Forecast Discharge Modelling

2 Environmental Inputs

2.1 Lake Bathymetry

At the time of model development, bathymetric survey data were available for portions of Meliadine Lake, including the eastern, southeastern, and western basins. Bathymetric data for the northern basin were not available. To complete the model bathymetry, additional depth information for non-surveyed areas was derived from satellite imagery.

The final bathymetry dataset used in the model is shown in Figure 2.1.

2.2 Water Levels

Hydrometric stations were established and operated at Meliadine Lake in the late 1990s to monitor key hydrological characteristics of the lake, including water levels and outflows, as part of baseline studies. These observations provide the primary basis for understanding the natural seasonal variability of lake levels and for defining representative conditions for numerical modelling.

Figure 2.2 presents the measured lake-level hydrograph for the period 1997 to 2000. The annual maximum water levels typically occur during spring snowmelt, which generally takes place throughout June. From October to May, when the lake is often partially to fully ice-covered, water levels show a steady decline due to the limited freshwater inflow, although outflow from the lake continues throughout the year. Observations indicate that the annual range in lake levels can vary between years, with peak-to-trough differences of up to approximately 0.5 m.

To support the hydrodynamic modelling framework, the available measured water-level time series were used to derive a representative (climatological) lake-level signal. This was achieved by averaging the observed seasonal water-level variations over the measurement period, producing a smoothly varying time series that represents typical long-term lake-level behavior rather than conditions specific to any individual year. The resulting representative water-level cycle provides a consistent reference for model initialization and validation, while preserving the magnitude and timing of natural seasonal fluctuations observed in Meliadine Lake.

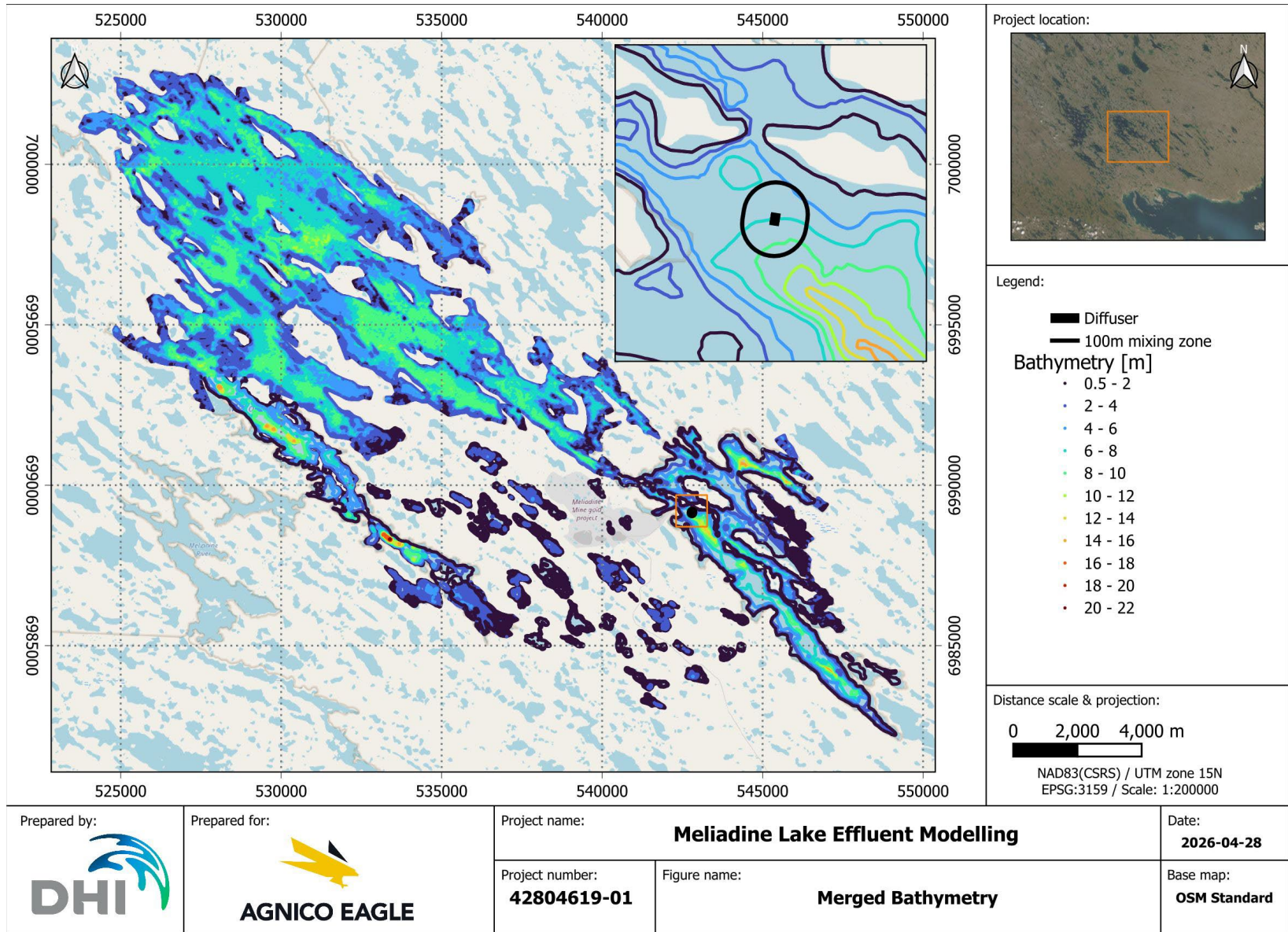


Figure 2.1 Bathymetry Dataset Used in the Model

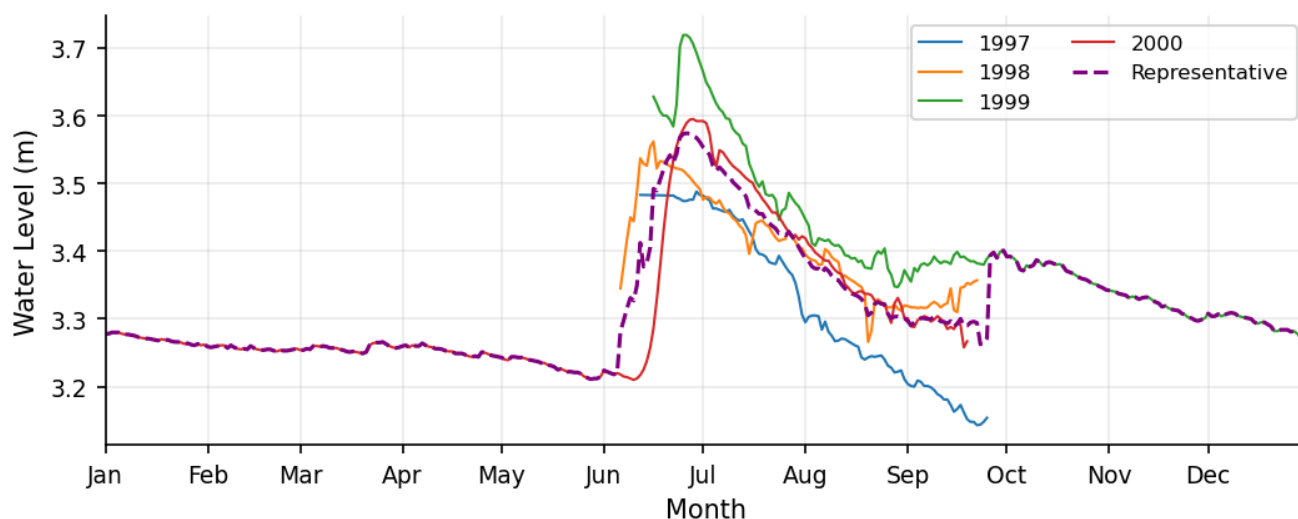


Figure 2.2 Measured Water Levels at Meliadine Lake for the Period 1997–2000, Together with the Derived Representative (climatological) Lake-level Time Series Used for Model Setup

2.3 Inflows and Outflows

Hydrological inflows to and outflows from Meliadine Lake were monitored during historical field programs conducted in the late 1990s (1997–2000) and, for selected inflows, again in 2008. These datasets provide the basis for characterizing seasonal water exchanges and for defining representative boundary fluxes used in the hydrodynamic model setup.

2.3.1 Outflows

Meliadine Lake has two surface-water outflows, both located on the western side of the lake: the Main Outflow and the West Outflow, which together represent the main natural drainage pathways from the lake.

Measured discharge time series for the Main Outflow are shown in Figure 2.3. The data indicate strong seasonal variability, with discharge initiating rapidly during the spring snowmelt in early to mid-June, followed by peak flows typically occurring in late June to early July. Across the monitored years, peak Main Outflow discharges ranged from approximately 5 m³/s in lower-flow years to nearly 15 m³/s in higher-flow years (e.g., 1999). Following the freshet, flows gradually decrease through the summer, reaching values of approximately 1–2 m³/s by late September.

Discharge at the West Outflow (Figure 2.4) exhibits a similar seasonal pattern but with lower overall magnitudes. Peak flows are typically around 5 m³/s, with an exceptional peak higher than 15 m³/s observed during 1999. Summer recession is rapid, and by late summer and early fall, West Outflow discharges are generally below 1 m³/s, although low but persistent discharge continues later into the year.

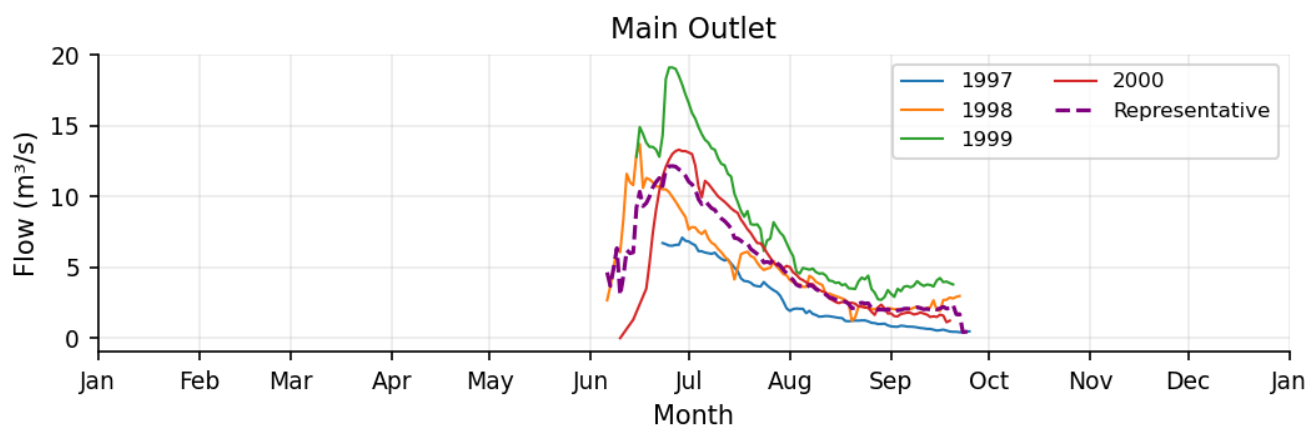


Figure 2.3 Measured Discharge at the Main Outflow of Meliadine Lake for the Period 1997–2000, Together with the Derived Representative Outflow Time Series used in the Model.

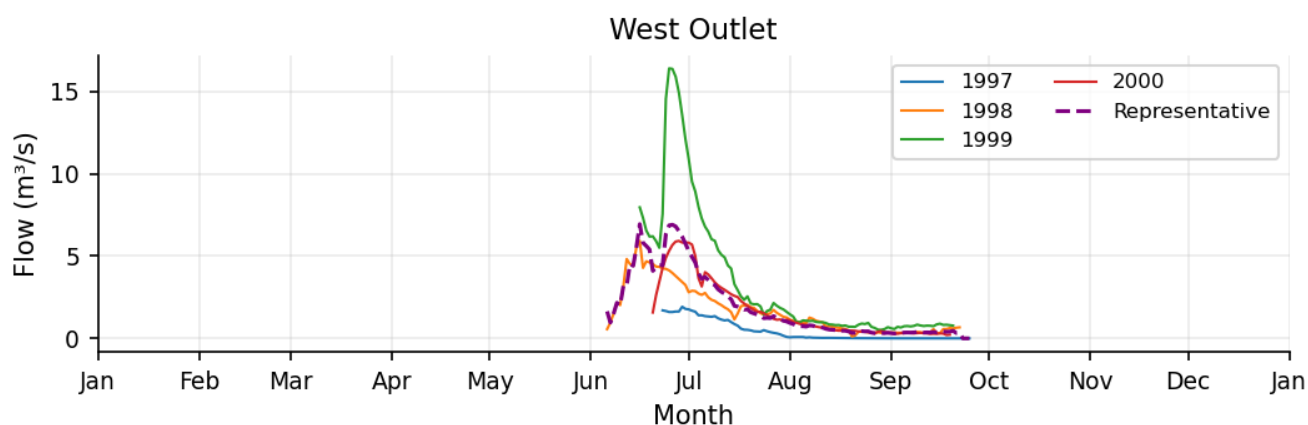


Figure 2.4 Measured Discharge at the West Outflow of Meliadine Lake for the Period 1997–2000, Together with the Derived Representative Outflow Time Series used in the Model.

Based on these observations, representative (climatological) outflow time series were derived for both the Main and West Outflows by averaging the seasonal patterns across the monitored years. These representative signals preserve the timing and magnitude of the spring freshet and subsequent summer recession, while smoothing inter-annual variability not critical for long-term circulation and transport simulations.

2.3.2 Inflows

Historical monitoring identified five primary inflow watersheds contributing freshwater to Meliadine Lake. Among these, B2 represents the largest and best-documented inflow and is shown in Figure 2.5.

Measured discharge at the B2 inflow demonstrates a highly event-driven and short-duration snowmelt response. Peak inflows occur shortly after the onset of spring melt in early June, with maximum discharges ranging between approximately 3 and 4.5 m³/s, depending on the year. Flows decrease rapidly following the freshet, typically falling below 1 m³/s within a few weeks, and approaching near-zero values by mid- to late summer, with only occasional minor rainfall-driven responses observed thereafter.

For the remaining inflow watersheds, continuous discharge measurements are limited in duration and temporal resolution. To address this limitation, a lake-wide water-balance approach was applied. Using observed lake-level variations (Section 2.2) in combination with measured Main and West Outflows, the

residual inflow required to close the lake water balance was calculated. This residual inflow was interpreted as the combined contribution of the remaining ungauged watersheds.

The residual inflow was subsequently apportioned among the non-monitored inflow areas based on relative drainage area and surface-water connectivity, and applied to the model at multiple locations distributed along mapped drainage lines and inflow zones. This spatial distribution ensures that freshwater inputs are introduced in a manner consistent with observed watershed geometry and expected flow pathways.

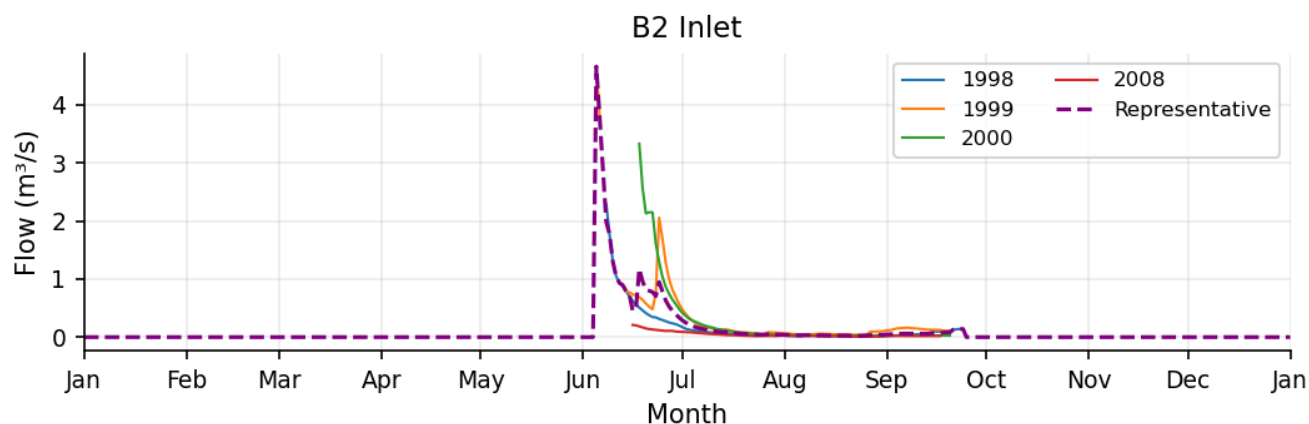


Figure 2.5 Measured Discharge at the B2 Inflow Watershed to Meliadine Lake for Selected Years (1998–2000 and 2008), Together with the Derived Representative Inflow Time Series.

2.3.3 Forecast Inflows and Outflows for Discharge Modelling (2025–2036)

For the Forecast Discharge Modelling scenario (2025–2036), lake inflows and outflows were derived directly from the DHI Meliadine Lake Watershed Hydrological Modelling completed as part of another project for Agnico Eagle (DHI, 2026). The hydrological model was developed using HEC-HMS, calibrated and validated against historical lake-level observations, and subsequently applied to generate future inflow time series under climate-change conditions.

The scenario adopted for the lake hydrodynamic and effluent transport modelling corresponds to Scenario ID 5, which is based on the RCP 6.0 climate-change pathway and represents the proposed maximum freshwater withdrawal conditions. The watershed model provides inflow time series at 33 distinct inflow points, corresponding to the delineated sub-basins draining to Meliadine Lake (Figure 2.6). Outflows from the lake continue to be represented by the two natural outlets, namely the Main Outflow and the West Outflow, consistent with both historical conditions and the watershed-model configuration. These inflow and outflow time series were used directly as boundary conditions or sources in the forecast hydrodynamic simulations for the 2025–2036 period.

This integrated modelling framework allows a solid and flawless connection between watershed models characterizing Meliadine Lake’s inflows and outflows for future conditions and the 3D Meliadine Lake model characterizing lake currents, dynamics and effluent mixing.

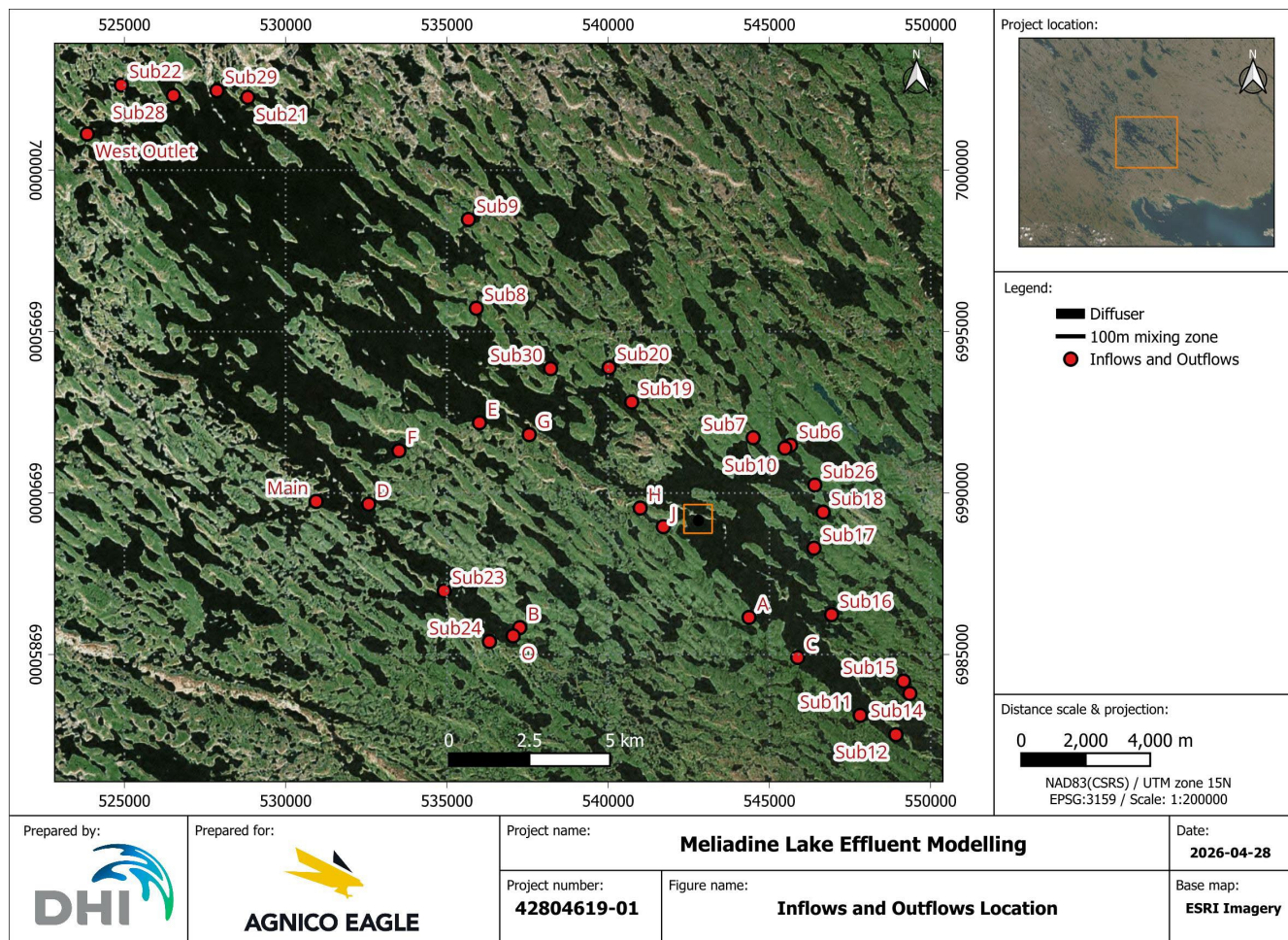


Figure 2.6 Spatial Distribution of Inflow and Outflow Applied in the 3D Meliadine Lake Forecast Discharge Modelling Scenario (2025–2036), with the Diffuser Location Indicated by an Orange Square.
 Horizontal Datum: NAD83 UTM Zone 15.

2.4 Atmospheric Forcing

Atmospheric forcing applied to hydrodynamic and transport models including wind speed and direction, air temperature, relative humidity, and cloud cover (clearness). These parameters are required to represent wind-driven circulation, air–water heat exchange, and surface energy fluxes influencing lake stratification and mixing processes.

Measured meteorological data were obtained from the Rankin Inlet Airport climate station (Lat: 62°48'38"N; Lon.: 92°06'53"W), operated by Environment and Climate Change Canada and accessed through the Canadian Climate Data portal¹. Two station identifiers were used to provide a continuous long-term dataset:

- Station ID 1721, covering the period 1981–2013
- Station ID 51277, covering the period 2013–2025

Long-term atmospheric conditions for Meliadine Lake were characterized using meteorological observations from the Rankin Inlet Airport climate station for the period 1981–2025. Key parameters

¹ <https://climate.weather.gc.ca/>

considered include air temperature, relative humidity, and wind speed, which are critical drivers of surface heat fluxes, evaporation, wind stress, and mixing processes in large lakes.

Figure 2.7 presents representative time series of wind speed and direction, air temperature, and relative humidity over a selected multi-year period, illustrating the strong seasonal variability typical of the region. Complementary long-term monthly statistics derived from the full 1981–2025 dataset are summarized in Table 2.1.

Table 2.1 Long-term Monthly Mean Atmospheric Conditions at Rankin Inlet Airport (1981–2025), Used to Characterize Atmospheric Forcing for Meliadine Lake

Monthly means of air temperature, relative humidity, and wind speed were computed from continuous meteorological observations spanning 1981–2025. Values represent climatological averages and are intended to describe typical long-term atmospheric conditions rather than conditions for any specific simulation year.

Month	Air Temperature (°C)	Relative Humidity (%)	Wind Speed (m/s)
January	-29.8	68.5	5.8
February	-30.1	68.3	5.7
March	-24.7	71.4	5.6
April	-15.4	78.8	5.4
May	-5.1	84.9	5.3
June	4.3	79.5	4.8
July	10.7	76.7	4.7
August	9.8	80.7	5.0
September	4.2	84.1	5.7
October	-3.7	86.6	6.3
November	-16.2	79.5	6.0
December	-25.0	72.3	5.7

The regional climate is characterized by very cold winters and cool summers. Monthly mean air temperatures range from approximately $-30\text{ }^{\circ}\text{C}$ during mid-winter (January–February) to about $10\text{--}11\text{ }^{\circ}\text{C}$ during the warmest summer month (July). Transitional seasons are relatively short, with rapid warming during late spring and cooling in early autumn. These pronounced seasonal temperature contrasts play a dominant role in controlling lake ice cover, water temperature, and seasonal mixing dynamics.

Mean monthly relative humidity varies between approximately 68 % in winter months and 85–86 % in autumn, with generally higher humidity conditions occurring from late spring through fall. As shown in Figure 2.7, relative humidity exhibits notable short-term variability superimposed on the seasonal cycle, reflecting changing synoptic conditions. Relative humidity influences latent heat fluxes and is therefore an important component of the surface energy balance represented in the hydrodynamic model.

Monthly mean wind speeds range from approximately 4.6 m/s during summer to over 6 m/s in autumn, indicating generally persistent windy conditions throughout the year. However, from November to May, Meliadine Lake is typically ice-covered, and direct wind forcing on the water surface is therefore largely suppressed during this period. As a result, wind-induced surface stress and mixing are primarily effective during the ice-free season, when wind forcing can directly influence circulation and dispersion processes.

The wind time series shown in Figure 2.7 also highlights episodic high-wind events exceeding 10 m/s, which, when occurring during ice-free conditions, are expected to contribute to short-term circulation variability and enhanced transport and dispersion within the lake.

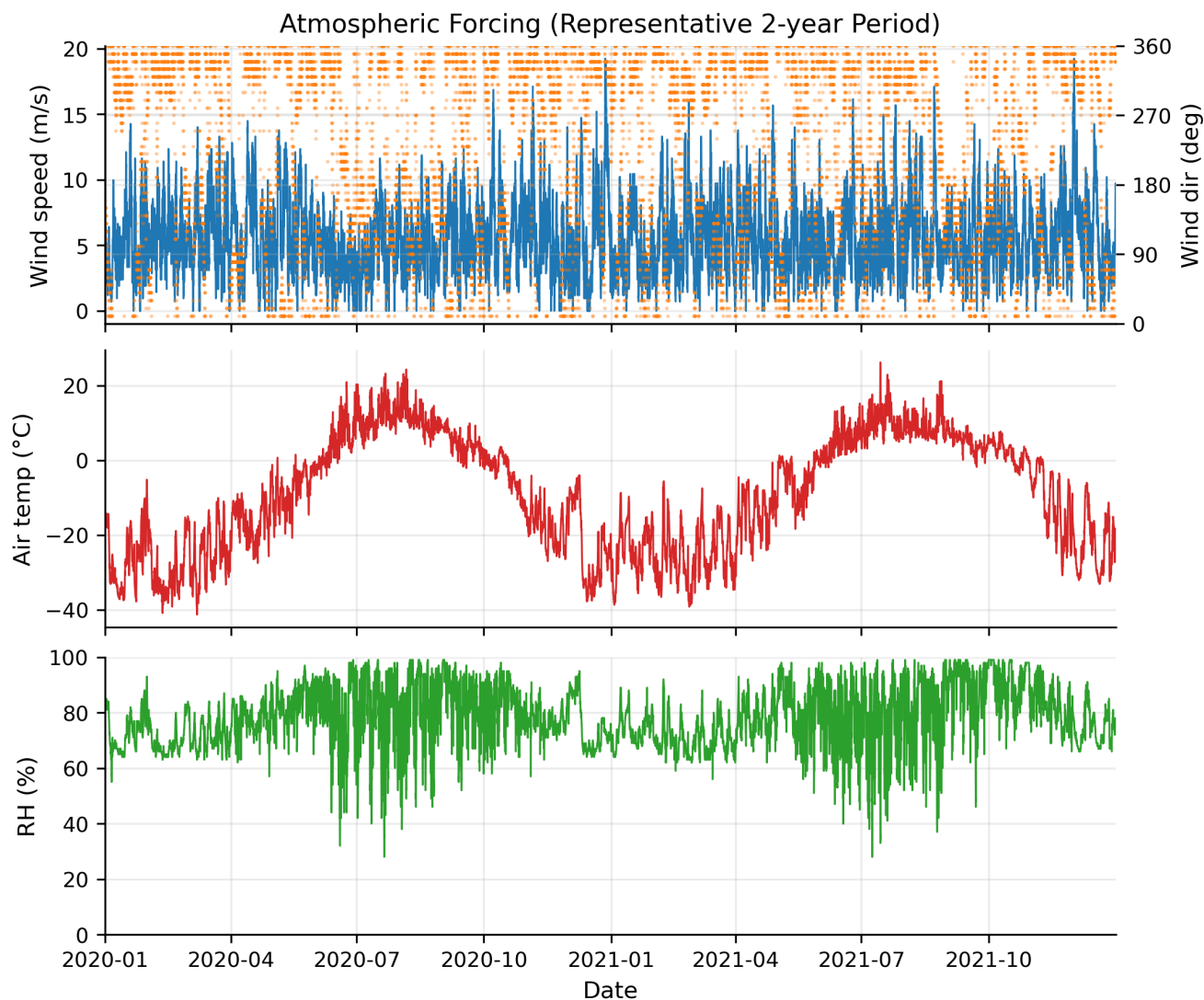


Figure 2.7 Representative time series of atmospheric forcing used in the hydrodynamic and transport modelling of Meliadine Lake, including wind speed and direction (top panel), air temperature (middle panel), and relative humidity (bottom panel).

The plots illustrate the strong seasonal variability characteristic of the study region.

Direct measurements of cloud cover were not available from the Rankin Inlet climate station. To address this limitation, cloud cover data were obtained from the Climate Forecast System Reanalysis (CFSR) and Climate Forecast System Version 2 (CFSv2) datasets (Saha et al., 2010; 2014), using a single grid-cell time series representative of the Meliadine Lake / Rankin Inlet area. The cloud cover input was applied as temporally varying but spatially uniform, consistent with the approach adopted for other large-scale atmospheric forcing parameters.

Given the Arctic setting of the study area, the discussion of cloud cover is focused on the summer period (June–August), when incoming shortwave radiation is relevant to lake heat fluxes. Climatological statistics for 1981–2025 indicate a marked seasonal minimum in cloud cover during summer, with mean values

decreasing from approximately 66 % in June to a minimum of about 58 % in July, before increasing again to around 64 % in August. These relatively lower cloud-cover conditions coincide with the warmest period of the year and enhanced solar input to the lake surface.

The representative time series shown in Figure 2.8 highlights substantial short-term variability in cloud cover, with frequent transitions between clear and overcast conditions. Nevertheless, the climatological means indicate that even during summer, cloud cover remains moderate, and thus continues to play an important role in modulating incoming shortwave radiation and surface heat-fluxes in the hydrodynamic model.

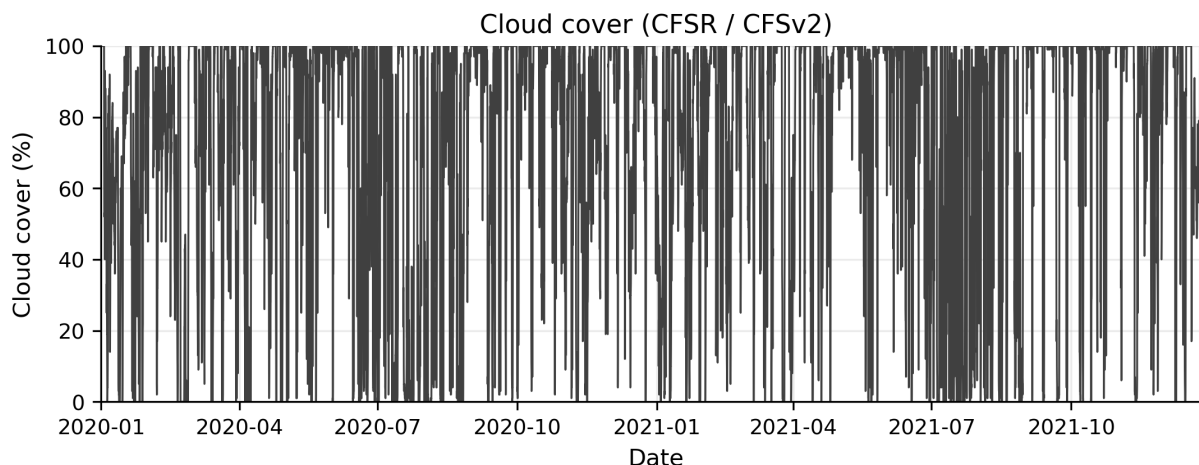


Figure 2.8 Time series of cloud cover used in the hydrodynamic and transport simulations, derived from CFSR/CFSv2 reanalysis data.

Cloud cover is expressed as percentage of sky cover.

2.5 Ice Thickness

Ice cover and ice thickness are key seasonal controls on circulation, mixing, and effluent dispersion in Meliadine Lake. The open-water season, with higher inflows/outflows and wind impact, is associated with more effluent mixing, while the ice season – with much more limited water movement – results in a latent effluent diffusion.

A time-varying ice-thickness forcing was defined, based on the following parameters:

- Regional experience with lake-ice conditions in the region,
- Operational records and mine reports indicating the typical start of open-water conditions in early June, and
- Requirement for realistic representation of the discharge window and mixing processes at the diffuser,

These considerations led to ice-free conditions from early June onward, consistent with observed lake operation periods and regional lake-ice behavior, while retaining realistic seasonal ice growth prior to breakup and melting.

The resulting ice-thickness in Meliadine Lake consists of a single, seasonally varying climatological time series, representative of typical annual evolutions of ice thickness, applied uniformly over the lake and repeated for each simulation year. Figure 2.9 presents the final ice-thickness time series applied in the model.

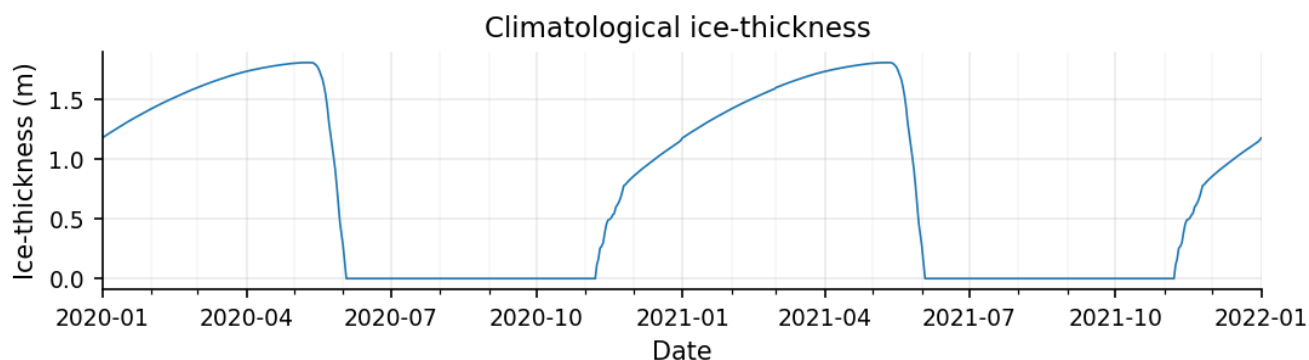


Figure 2.9 Seasonally Varying Climatological Ice Thickness Time Series in the Hydrodynamic Model

2.6 Background TDS (Pre-2018)

Measurement of TDS took place during the baseline study, as presented in the Volume 7 Freshwater Environment document. Displaying a non-trivial natural variability, TDS concentrations in Meliadine Lake ranged between 21 and 91 mg/L, with a median value of 35 mg/L. These values are pre-effluent discharge, reflective of natural lake conditions.

2.7 Water Temperature and TDS Measurements at MZB (Post 2018)

Measurements of water temperature and total dissolved solids (TDS) in the vicinity of the diffuser were provided by the client and collected between 2019 and 2024, representing approximately five years of monitoring data. These measurements were obtained at multiple stations located around the outfall area, as shown in Figure 2.10.

The primary purpose of this dataset was to support model validation, by providing observed temperature and TDS conditions against which simulated results could be compared. In particular, the data were used to evaluate the model's ability to reproduce near-field and short-range transport conditions associated with the effluent discharge.

The measurements themselves are not interpreted in this section. A comparison between observed and simulated water temperature and TDS concentrations is presented in Appendix A (Model Validation Results), where model performance is assessed quantitatively and qualitatively.

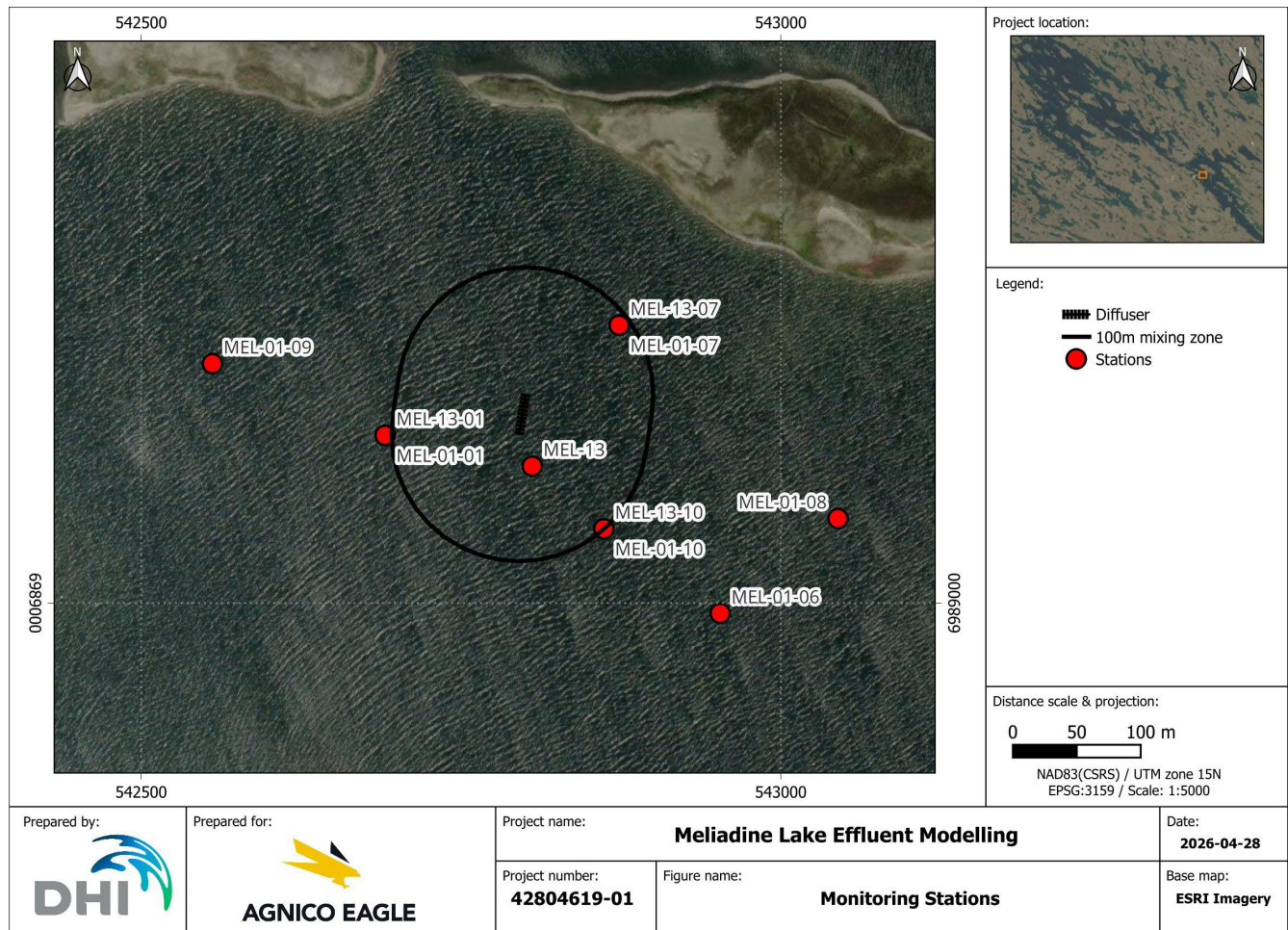


Figure 2.10 Location of Monitoring Stations Used for Model Validation. The Diffuser Location and the Associated 100 m Mixing Zone are shown in Black, while Monitoring Stations are highlighted in Red.
Horizontal Datum: NAD83 UTM Zone 15.

3 Mining Inputs

3.1 Effluent Characterization

For the 2018 to 2024 period, effluent flow discharge to Meliadine Lake was obtained from the yearly reports of the Aquatic Effects Monitoring Program (AEMP) reports. While Table 3.1 presents the effluent discharge data as monthly values, the model was implemented using daily discharge inputs, derived directly from the reported datasets. Two set of information can be found in Table 3.1: for each year and each month, the table indicates the total monthly volume of effluent discharge in the lake and, in brackets, the number of days within the month during which the discharge took place.

The AEMP reports also provided information on the total dissolved solids (TDS) concentration of the effluent, which was used to define the effluent water-quality characteristics applied in the transport simulations.

Table 3.1 Monthly Effluent Discharge (m³) to Meliadine Lake, 2018-2024.

Monthly and annual discharge rounded to the nearest 5 m³. Values within parenthesis indicate the number of days in which discharge was occurring.

Source: Aquatic Effects Monitoring Program 2024 Annual Report (Azimuth, 2025).

Year	Jun	Jul	Aug	Sep	Oct	Annual Totals
2018	134,270 (10)	352,550 (na*)	153,065 (26)	2,630 (3)	0 (0)	642,520 (70)
2019	0 (0)	30,615 (24)	107,540 (31)	157,910 (30)	10,710 (5)	306,775 (89)
2020	352,955 (26)	366,095 (31)	83,455 (31)	214,845 (30)	13,830 (3)	1,031,180 (121)
2021	0 (0)	133,440 (19)	397,400 (29)	221,210 (30)	99,080 (16)	851,130 (94)
2022	0 (0)	214,710 (31)	33,585 (11)	188,335 (25)	0 (0)	436,630 (67)
2023	209,025 (21)	81,120 (18)	54,895 (8)	184,510 (22)	0 (0)	529,550 (67)
2024	171,940 (14)	72,725 (14)	0 (0)	370,145 (29)	246,675 (15)	861,485 (72)

* No daily discharge date for July 2018 because of a malfunction with the flow meter. As a result, it was assumed that the discharge occurred over 31 days.

For the 2025 to 2036 period, effluent TDS and discharge flows were provided by Agnico Eagle. Figure 3.1 displays these values: the top panel shows the effluent flow rate in m³/day, typically varying from month to month. The discharge only takes place during the open-water season. Depending on operation needs, some years end up discharging from June to October, while others only during a couple of months in August and September. Similarly, the bottom panel shows the TDS concentration.

These same values are summarized in Table 3.1 and Table 3.2.

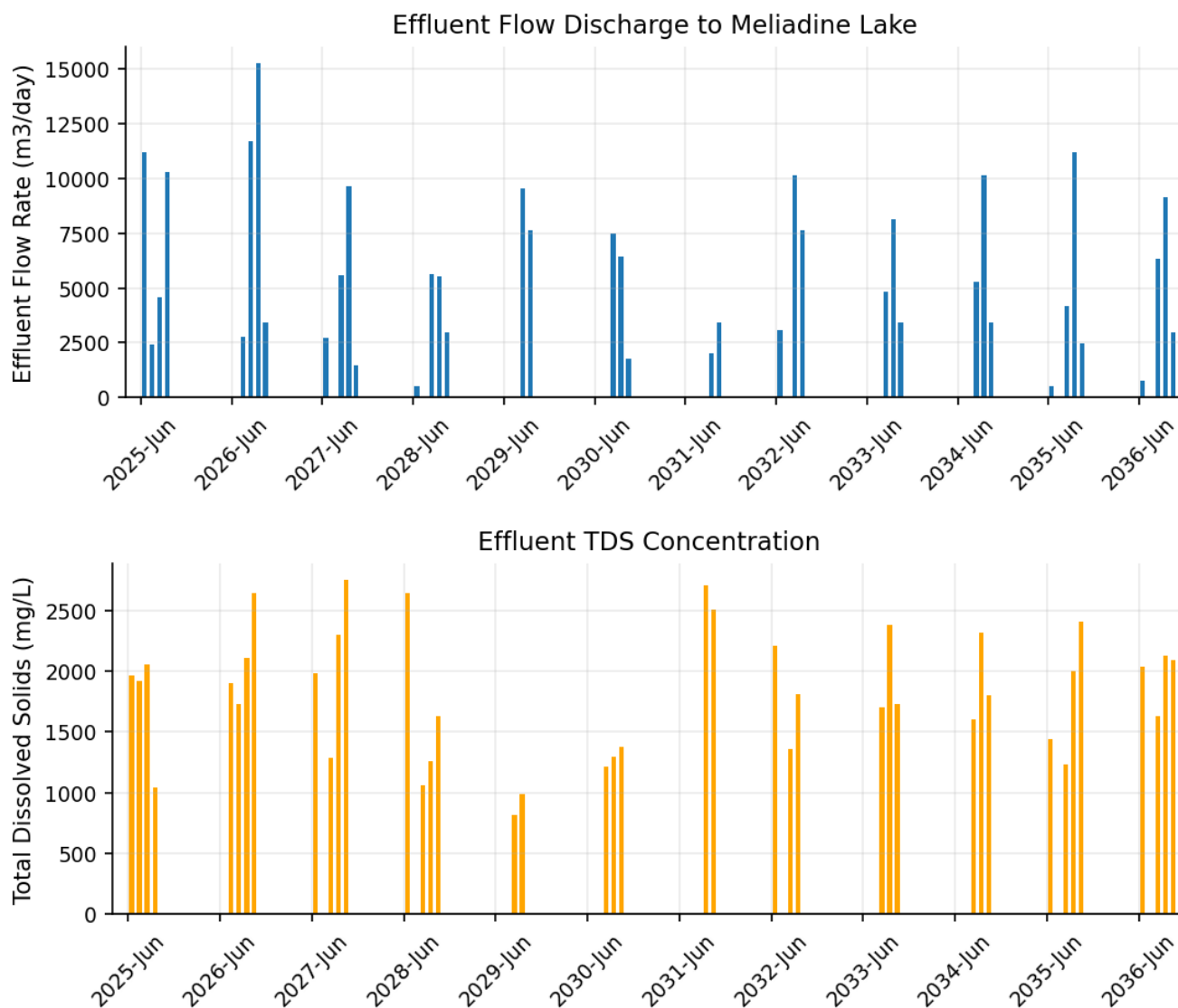


Figure 3.1 Bar Diagram of Effluent Discharge Rate and Associated TDS

Table 3.2 Effluent Discharge Rate (2025-2036)

Year	Effluent Discharge (m ³ /day)				
	June	July	August	September	October
2025	11,183	2,434	4,592	10,312	-
2026	-	2,774	11,689	15,250	3,444
2027	2,725	-	5,590	9,658	1,476
2028	508	-	5,612	5,526	2,952
2029	-	-	9,542	7,625	-
2030	-	-	7,477	6,419	1,748
2031	-	-	-	2,039	3,444
2032	3,050	-	10,121	7,625	-

Year	Effluent Discharge (m ³ /day)				
	June	July	August	September	October
2033	-	-	4,827	8,133	3,444
2034	-	-	5,299	10,167	3,444
2035	512	-	4,176	11,183	2,460
2036	764	-	6,326	9,150	2,925

Table 3.3 Effluent TDS Concentration (2025-2036)

Year	Effluent TDS Concentration (mg/L)				
	June	July	August	September	October
2025	1,966	1,915	2,052	1,040	-
2026	-	1,900	1,731	2,112	2,641
2027	1,984	-	1,284	2,294	2,748
2028	2,640	-	1,059	1,262	1,633
2029	-	-	818	992	-
2030	-	-	1,216	1,299	1,374
2031	-	-	-	2,705	2,505
2032	2,205	-	1,361	1,808	-
2033	-	-	1,702	2,381	1,727
2034	-	-	1,602	2,313	1,801
2035	1,438	-	1,232	2,003	2,409
2036	2,033	-	1,628	2,125	2,090

3.2 Water Withdrawal

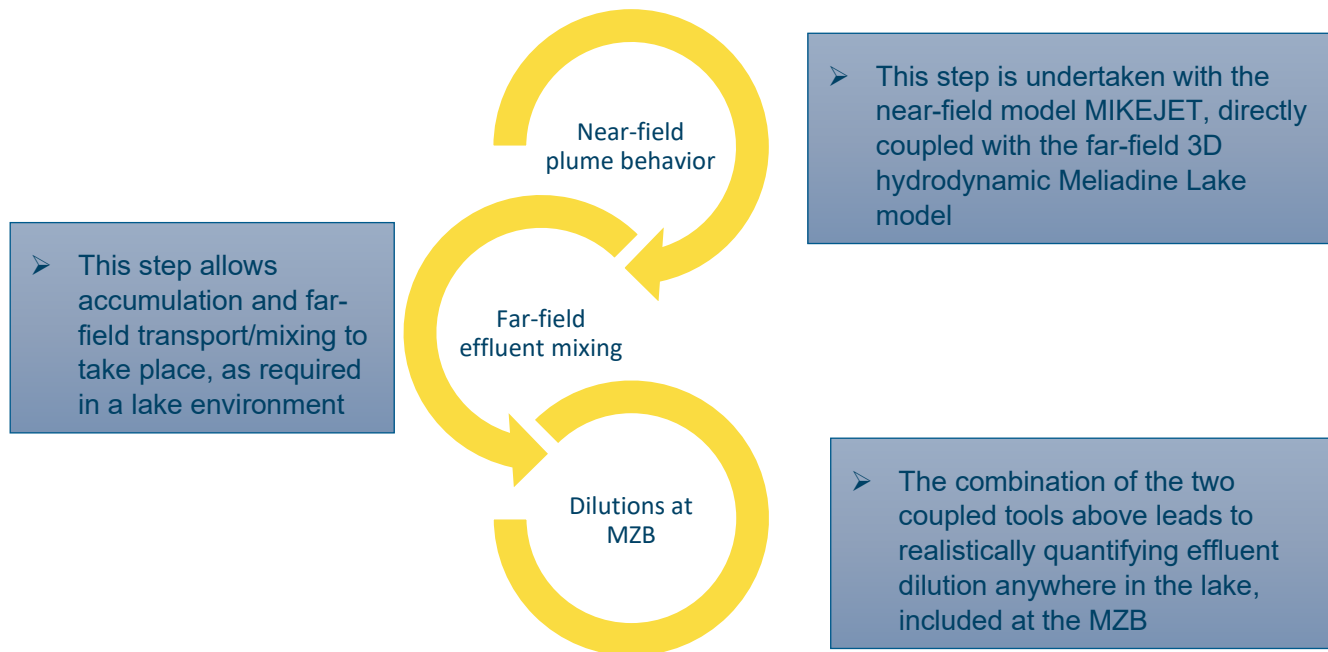
For the simulations, water withdrawal from Meliadine Lake, located at the lake's narrows, was represented as a fixed and continuous outflow applied uniformly throughout the year. The total annual withdrawal volume was set to 1,110,296 m³/year, corresponding to a constant monthly withdrawal of 92,525 m³/month, and an equivalent average withdrawal rate of approximately 0.035 m³/s.

4 Modelling Framework

4.1 Overview

A three-dimensional numerical model of the study area was developed using the 2026 version of the DHI MIKE 3 Flow Model Flexible Mesh (FM), applying the Hydrodynamic (HD) and Transport (Advection–Dispersion, AD) modules. This model is an industry-standard, used by both academia and industry, in support of limnologic and oceanographic projects. **This model and its modules allow the reproduction of the lake’s physical behavior with water transport, temperature changes and mixing of effluent.**

Through an integrated framework, near-field plume behavior and instantaneous dilutions were calculated through the near-field model, MIKEJET, and transferred to the far-field model, MIKE 3 (i.e., the 3D Meliadine Lake hydrodynamic model), where far-field transport, effluent mixing and accumulation occur.



Near-field model overview

MIKE JET is DHI’s near-field jet and plume model used to simulate the initial mixing and dilution of discharges released from outfalls and diffusers. Similar to CORMIX and the US EPA Visual Plumes, **the model resolves the buoyancy-driven and momentum-driven jet behavior immediately downstream of the diffuser, accounting for ambient current velocity, stratification, discharge flow rate, and discharge geometry.** The near-field model computes near-field trajectories, dilutions, and plume rise or descent until the plume reaches dynamic equilibrium with the surrounding water body. The resulting near-field dilution characteristics are then used to inform the far-field hydrodynamic and transport models, ensuring a physically consistent transition between small-scale discharge processes and lake-scale transport and mixing processes represented by the hydrodynamic simulations.

Far-field 3D model overview

The MIKE 3 hydrodynamic model is an industry-standard, used by both academia and industry, in support of limnologic and oceanographic projects. The model was configured using the 3D shallow water equations, which invoke the hydrostatic pressure assumption, and represent a reduced form of the incompressible Reynolds-averaged Navier–Stokes equations under the Boussinesq approximation. The governing hydrodynamic equation system includes conservation of mass (continuity) and momentum, together with transport equations for temperature and salinity, from which density variations and associated baroclinic forcing are derived. Turbulence effects are represented through an appropriate turbulence closure scheme, enabling simulation of vertical mixing processes under both stratified and unstratified flow conditions.

The MIKE 3 FM Transport (AD) module was used to simulate the transport and spreading of scalar quantities within the three-dimensional flow field. The transport model solves the advection–dispersion equation in conservative form, using the velocity field, turbulence parameters, and water depths provided by the HD module. This allows for simulation of the combined effects of advection by currents, turbulent diffusion, and vertical mixing on dissolved or suspended tracers such as salinity, temperature, or passive constituents.

Both hydrodynamic and transport simulations support Cartesian or spherical coordinate systems, and the free surface is resolved using a sigma-coordinate (terrain-following) vertical discretization, ensuring consistent representation of free-surface variations and bathymetric influences throughout the model domain. Spatial discretization of the governing equations, formulated in conservative form, is performed using a cell-centered finite volume method. The horizontal computational domain is represented by an unstructured flexible mesh, providing enhanced resolution in areas of complex bathymetry and strong gradients, while the vertical domain is discretized using a structured layered approach, enabling full three-dimensional resolution of both the flow and transported constituents.

4.2 Mesh and Model Domain

The model domain covers the entire Meliadine Lake, encompassing an area of approximately 110 km² and extending about 32 km in the horizontal direction from the southeastern to the northwestern regions of the lake. The horizontal resolution of the computational mesh varies spatially, ranging from approximately 20 m in the vicinity of the diffuser to about 200 m in the remaining parts of the domain, allowing enhanced resolution in areas of anticipated strong gradients while maintaining computational efficiency elsewhere.

As described in section 2.1, high-resolution bathymetric data provided by the client were used where available, primarily covering the southeastern and southwestern sub-basins of the lake. In areas not covered by bathymetric surveys, additional bathymetric information was derived from a Sentinel-2 satellite image acquired on 2022-07-12, using the Satellite-Derived Bathymetry (SDB) GUI tool (Harrys, 2025).

All available bathymetric datasets were quality-checked and interpolated onto the flexible mesh used by the hydrodynamic and transport models. The resulting bathymetric representation of the model domain is shown in Figure 4.1.

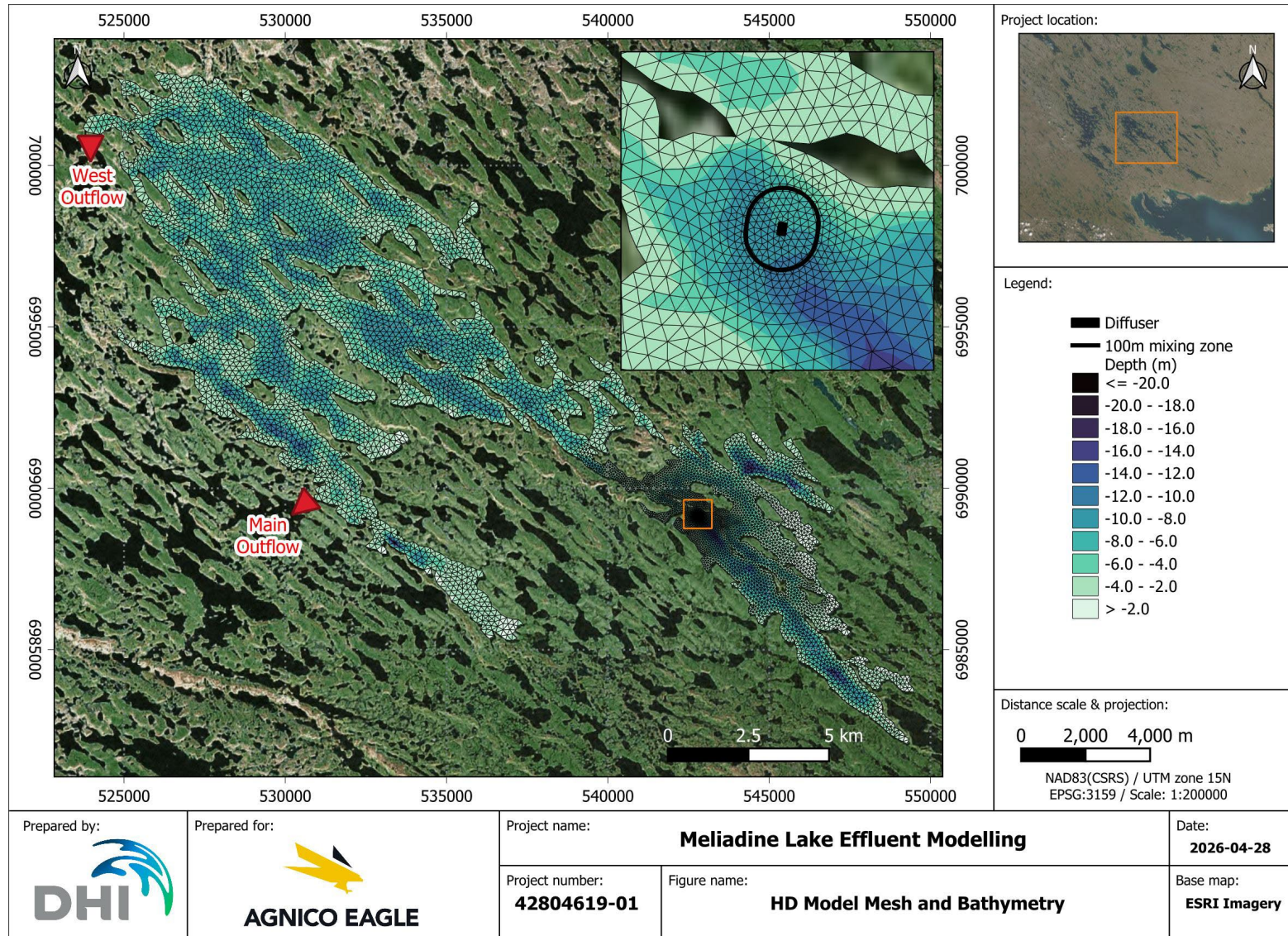


Figure 4.1 Meliadine Lake MIKE3 Flow Model Domain and Bathymetry. The Diffuser Location and the Associated 100 m Mixing Zone are shown in Black, while Model Outlets are highlighted in Red.
Horizontal Datum: NAD83 UTM Zone 15.

The horizontal reference system used for this project is the NAD83 UTM Zone 10. The vertical datum of the bathymetric data used in the model setup is not explicitly documented. Consequently, the bathymetry was used as provided by the client, without transformation to an external vertical geodetic datum. For modelling purposes, a local vertical reference system was adopted.

The assumed reference water level corresponds to a climatological mean lake level (data period 1997–2000; see Section 2.2), derived to represent typical long-term water level conditions in Meliadine Lake. Within the model framework, this mean lake level is defined as zero elevation, with water levels varying positively and negatively around this reference value according to simulated hydrodynamic conditions.

It is noted that portions of the bathymetric data were acquired during the wet season, when lake levels are generally higher than average. However, by referencing the model to a climatological mean lake level, the adopted vertical datum provides a relative and internally consistent reference suitable for hydrodynamic and transport simulations. All elevations and water levels reported herein are therefore expressed relative to this climatological mean lake-level datum, unless stated otherwise.

4.3 Forcings for Effluent Discharge Scenarios

The forcing datasets applied in the numerical simulations are described in Section 2 (Environmental Inputs) and Section 3 (Mining Inputs). These forcings were combined consistently to support two main modelling scenarios:

- **Historical discharge modelling, covering 2018 to 2024:** this period was used to validate the modeling framework and is described below in Sections 4.4 and 4.5.
- **Forecast discharge modelling, covering 2025 to 2036:** this period characterizes effluent mixing associated with future effluent discharges and is described in Section 6.

4.4 Near-Field Modelling Inputs

Near-field mixing of the mine effluent was simulated using the near-field module MIKE JET, which requires detailed information on the outfall diffuser location and configuration to accurately represent initial discharge momentum, buoyancy, and jet behavior. The diffuser geometry and installation details used in the model were taken directly from as-built drawings and technical documentation provided by Agnico Eagle, ensuring consistency with the constructed system.

The diffuser is approximately 30 m in length, the pipe has an external diameter of 400 mm and an internal diameter of 355 mm and is equipped with 10 discharge ports spaced at approximately 3 m intervals (with minor variability) and are aligned, discharging in a horizontal direction of approximately 100°, measured clockwise from north. Each port has a diameter of 51 mm and is fitted with a Tideflex® valve mounted on the top of the diffuser pipe to prevent fish access. The valves discharge at a vertical angle of 45°, with port outlets located approximately 1 m above the lakebed. These parameters fully define the discharge geometry applied in MIKE JET and provide the basis for computing near-field plume rise, dilution, and initial mixing prior to transition to the far-field hydrodynamic model.

4.5 Historical Discharge Modelling Scenario (2018-2024): Model Validation

The historical discharge modelling scenario covers the period from June 2018 to December 2024. The last six months of 2018 were used as a model warm-up period, allowing hydrodynamic and transport conditions within Meliadine Lake to adjust from initial conditions before evaluation against observations.

The 2019-2024 simulation period was used for model validation, focusing on:

- Water level variability, assessed using a climatological reference approach based on the data described in Section 2.2; and
- Temperature and total dissolved solids (TDS) concentrations in the vicinity of the diffuser, compared against available field measurements, as described in Section 2.6.

This scenario's goal is to confirm the adequacy of the modelling framework in-place and provide confidence in the model's ability to represent lake-wide circulation, thermal structure, and conservative tracer transport under observed discharge conditions.

Model Validation Results

The hydrodynamic, transport and mixing modelling framework was validated against in-situ observations collected between 2019 and 2024, focusing on water levels, water temperature, and total dissolved solids (TDS) in the vicinity of the diffuser. Overall, **the model demonstrates a strong capability in the reproduction of key physical and transport processes in Meliadine Lake, providing confidence for its application in the forecast discharge scenarios.** Detailed model–data comparisons, including time series, scatter plots, and year-by-year validation figures for water levels, temperature, and TDS, are provided in Appendix A.

A brief summary is as follows:

- **Water levels:** The model accurately reproduces the seasonal variability and magnitude of observed lake levels, with negligible bias and very low error metrics (MAE and RMSE of approximately 0.01 m) and a high correlation coefficient (0.99). This indicates an excellent representation of lake-wide hydrodynamic behavior.
- **Water temperature:** Simulated temperatures closely follow observed seasonal patterns, capturing summer warming, peak conditions, and fall cooling during the open-water period. Minor discrepancies are limited to short-term variability, with no systematic bias observed, indicating a reliable representation of thermal processes.
- **Total dissolved solids (TDS):** The model reproduces the magnitude, variability, and timing of observed TDS concentrations near the diffuser. Simulated concentrations are generally consistent with observations and remain within expected ranges relative to background conditions, demonstrating a realistic representation of effluent transport and mixing processes.

5 Meliadine Lake Forecast Discharge Modelling (2025-2036)

5.1 Overview

Using a representative model of Meliadine Lake that accurately simulates its physical properties and effluent effects, a long-term simulation was conducted for the Meliadine Operational Update. The forecast discharge modelling scenario covers the period from January 2025 to December 2036. **The objective of this scenario is to assess the transport, mixing, and longer-term accumulation of mine effluent discharged through the diffuser and to evaluate how the effluent propagates, disperses and mixes throughout the entire lake under forecast operational conditions.**

Simulations were performed on a year-by-year basis, starting on January 1st and ending on December 31st, where the hydrodynamic and transport conditions at the end of each year were used as the initial conditions for the subsequent year. This chain approach allows taking into account effluent accumulation in the lake over time, reflecting realistic transport conditions and concentrations of the effluent over a multi-year simulation.

5.2 Target TDS Concentration and Effluent Dilution

This section defines target dilutions at the edge of the mixing zone, i.e. the degree of required mixing for the effluent to be in compliance with water quality guidelines.

For each effluent constituent, the water quality guidelines were first identified. Based on monthly varying concentrations for each constituent of the effluent covering the 2025 to 2036 future discharge period, the maximum weighted long-term concentration (as the concentration at the MZB depends on both recent and historical discharges, due to accumulation) was then determined, allowing to derive the required dilution level to comply with water quality guidelines.

While a lot of constituents were already in compliance with water quality guidelines prior to the discharge, some constituents were identified needing dilutions between 1:1 and 13:1 in the most stringent case, as detailed in Appendix B. Ammonia is the constituent requiring the highest dilution, with a target dilution of 13:1. In other words, **dilutions will need to be at or above 13:1 at the edge of the mixing zone to achieve water quality guidelines for all constituents.**

Furthermore, TDS concentrations at the edge of the mixing zone (and beyond) will need to stay below 1,000 mg/L for compliance with water quality guidelines.

5.3 TDS concentrations

To characterize the maximum potential extent of the effluent signal in the lake, maximum TDS concentrations were computed at each model grid cell by taking the maximum TDS concentration over all simulated time steps and over the full water column (all vertical layers) for the period 2025-01-01 to 2036-12-31.

For regulatory and operational interpretation, the forecast results were summarized as a time series at the edge of the mixing zone (100-m radius). Figure 5.1 presents the maximum TDS concentration at the edge of the mixing zone as a function of time, including the background TDS concentration (taken as 35 mg/L as per Section 2.6) and the 1,000 mg/L not-to-exceed criterion. As anticipated given the discharge schedule

occurring during open-water season, the time series shows a recurring seasonal signal during the operational discharge window, with episodic peaks associated with periods of higher discharge and/or reduced mixing. For comparison purpose, as described in Section 2.6, natural background TDS in Meliadine Lake were measured ranging between 21 and 91 mg/L.

Across the full 2025-2036 forecast period, maximum concentrations remain substantially below the compliance threshold of 1,000 mg/L, with peak TDS concentrations remaining below 361 mg/L in the forecast results. This result is consistent with prior Meliadine Lake discharge-assessment reporting, where exceedance of the 1,000 mg/L threshold at the 100-m edge of the mixing zone was not observed for comparable assessments.

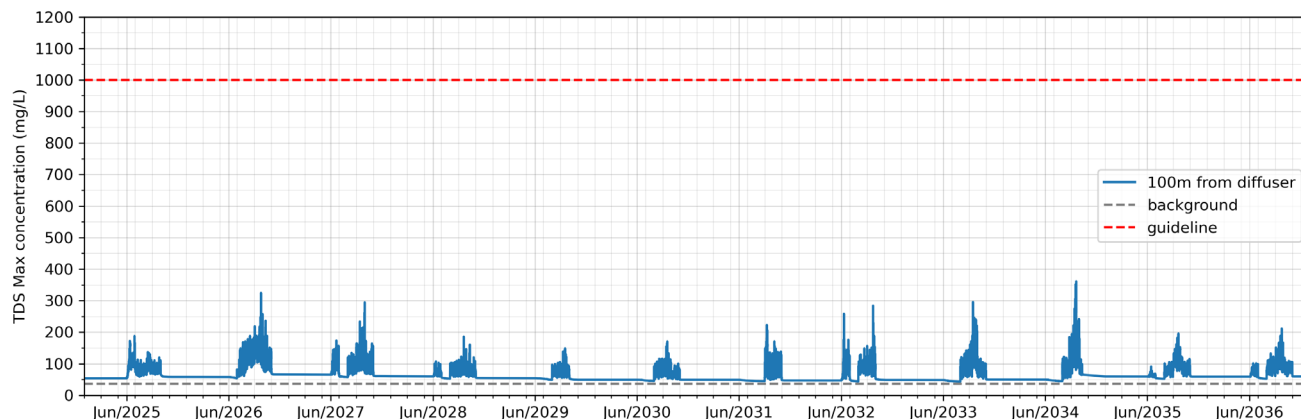


Figure 5.1 Time Series of Maximum TDS Concentration at Edge of Mixing Zone for the Period 2025–2036
The Background TDS Level and the 1,000 mg/L Guideline are shown for Reference.

To complement the maximum-value reporting, an average TDS concentration at the edge of the mixing zone was computed by taking the mean concentration across the selected elements surrounding the 100-m mixing zone at each time step (and across the water column). This average time series, shown in Figure 5.2, provides a more representative indicator of typical conditions at the mixing-zone boundary, and (as expected) remains significantly lower than the maximum-value envelope (Figure 5.1).

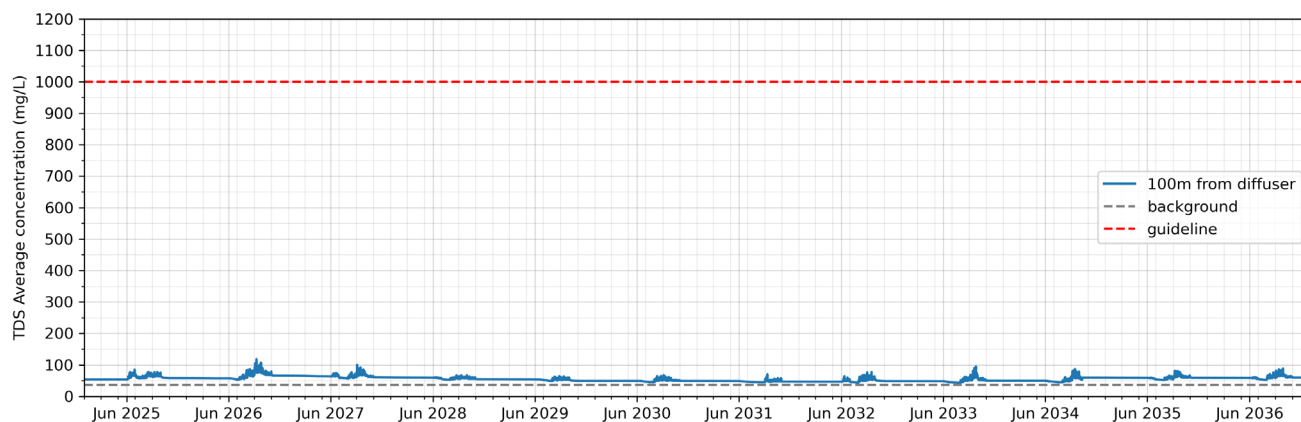


Figure 5.2 Time Series of Average TDS Concentration at Edge of Mixing Zone for the Period 2025–2036
The Background TDS Level and the 1,000 mg/L Guideline are shown for Reference.

Table 5.1 provides a summary of both maximum and average TDS concentrations. During the entire forecast discharge period from 2025 to 2036, the highest anticipated TDS concentration at the edge of the mixing zone occurs in 2034, reaching 361 mg/L. However, as shown in the previous time series graphs, this peak is not sustained and rapidly drops below 100 mg/L. On average, TDS concentrations range between 48 and 64 mg/L at the MZB.

Table 5.1 Annual Maximum and Average TDS Concentrations at MZB
Background Concentration of 35 mg/L is Included

Year	Maximum TDS Concentration at Edge of MZB (2025-2036)	Average TDS Concentration at Edge of MZB (2025-2036)
2025	188	58
2026	324	63
2027	294	64
2028	186	58
2029	148	53
2030	170	49
2031	223	48
2032	284	49
2033	296	50
2034	361	53
2035	196	59
2036	211	60

Figure 5.3 summarizes the distribution of maximum TDS concentrations at the edge of the MZB for each forecast year from 2025 to 2036, presented as box-and-whisker plots. The figure was built, identifying maximum TDS concentration along the MZB and throughout the water column. Similarly, Figure 5.4 summarizes the distribution of TDS concentrations along the MZB. For each year, the figures illustrate the statistical variability of maximum TDS values, including the median, mean, interquartile range (25th–75th percentile), and the minimum – maximum range, providing an overview of both typical conditions and less-frequent higher-concentration events.

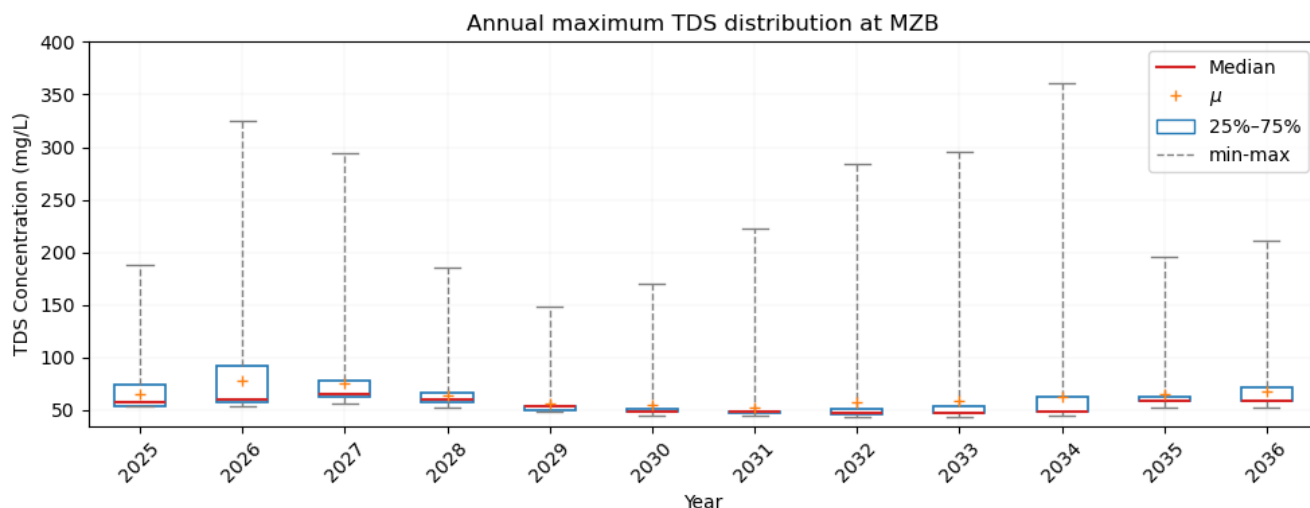


Figure 5.3 Box-and-whisker Plot Showing Year-by-Year Distribution of Maximum TDS Concentrations at Edge of MZB for the Forecast Period 2025–2036

The plots display the median, mean, interquartile range (25th–75th percentile), and min–max range of maximum TDS concentrations for each year. Guideline concentration is 1.000 mg/L.

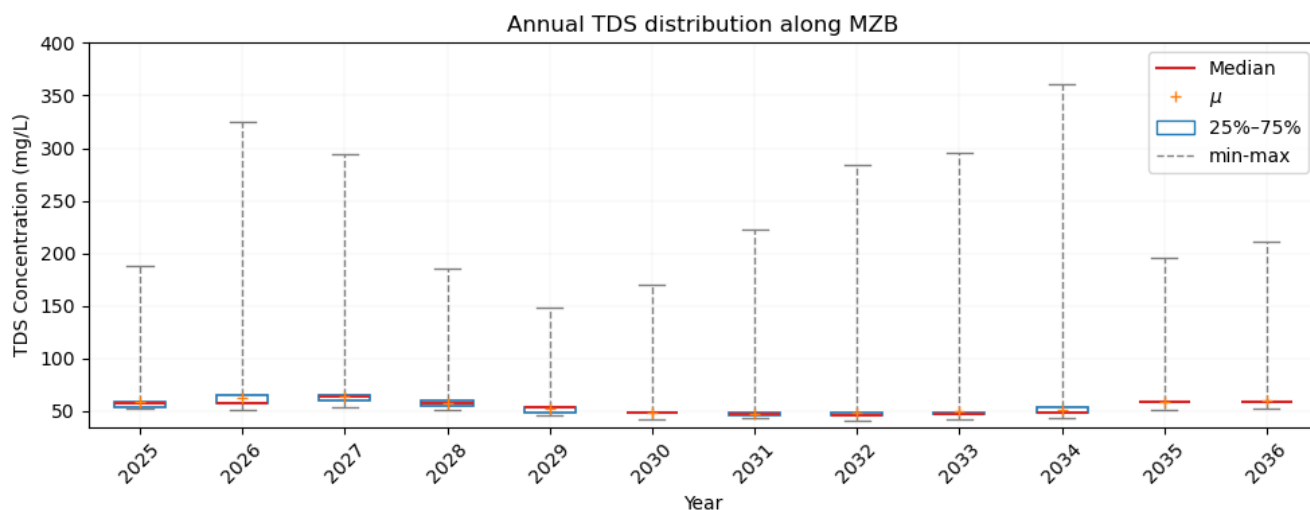


Figure 5.4 Box-and-whisker Plot Showing Year-by-Year Distribution of TDS Concentrations Along the MZB for the Forecast Period 2025–2036

The plots display the median, mean, interquartile range (25th–75th percentile), and min–max range of maximum TDS concentrations for each year. Guideline concentration is 1.000 mg/L.

In addition to results presented at the edge of the mixing zone, TDS concentrations were also evaluated at the mine’s water withdrawal intake location situated in the lake’s narrows region, to assess the potential for elevated concentrations at the intake under forecast discharge conditions. The analysis focused on the model layer near the lakebed, representing the most conservative intake depth. Figure 5.5 presents the time series of TDS concentration at this location for the period 2025–2036.

As shown in the figure, TDS concentrations at the intake location remain low and stable throughout the simulation period, ranging approximately between 39 and 63 mg/L, with an average concentration of about 50 mg/L. For comparison, the background concentration is 35 mg/L (with pre-discharge natural variation reaching over 90 mg/L). The increase in TDS concentration still maintains the values within natural range.

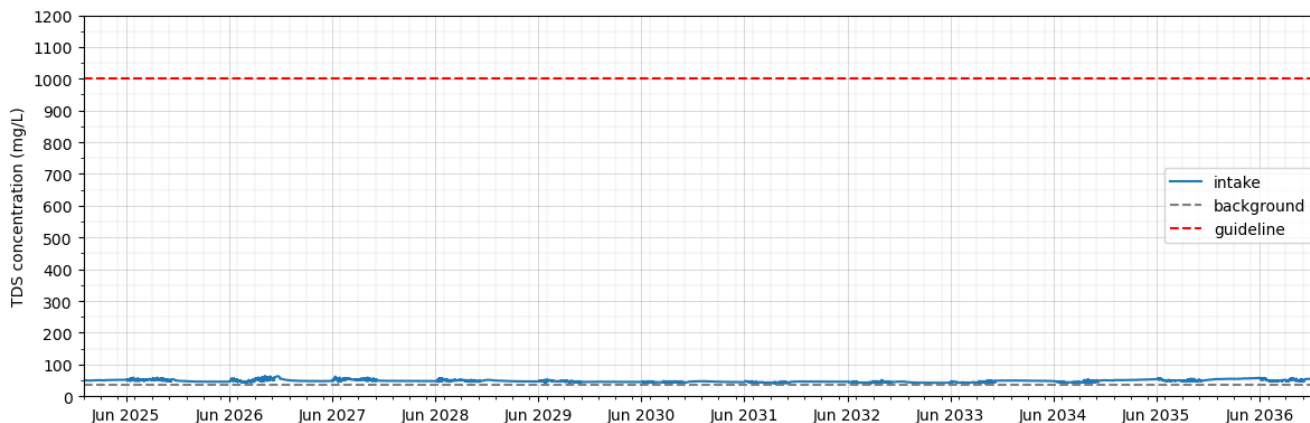


Figure 5.5 Time Series of Average TDS Concentration at the Water Intake Location for the Period 2025–2036

The Background TDS Concentration and the 1,000 mg/L Guideline are shown for Reference.

5.4 Effluent Dilutions

Dilution evaluation was assessed using the passive-tracer framework and summarized as the minimum dilution over the full simulation period. A minimum dilution represents a maximum concentration. In other words, the lower the dilution, the higher the effluent concentration. Minimum dilutions were computed at each grid cell by taking the minimum over all time steps and minimum over the full water column (all vertical layers), providing a conservative “worst-case” spatial envelope for the period 2025–2036.

The resulting plan-view map (Figure 5.6) indicates that the lowest dilutions are confined to the immediate vicinity of the diffuser and within/near the mixing-zone footprint, with the lake rapidly transitioning to higher dilution classes away from the outfall region. This spatial pattern is consistent with the adequate near-field mixing expected from diffuser operation and the broader lake circulation regime.

With effluent accumulation occurring in the southeast basin of Meliadine Lake (where the discharge takes place), dilutions are anticipated to stay above the target dilution of 13:1 (see Appendix B), indicating full compliance with water quality guidelines at the edge of the mixing zone and beyond.

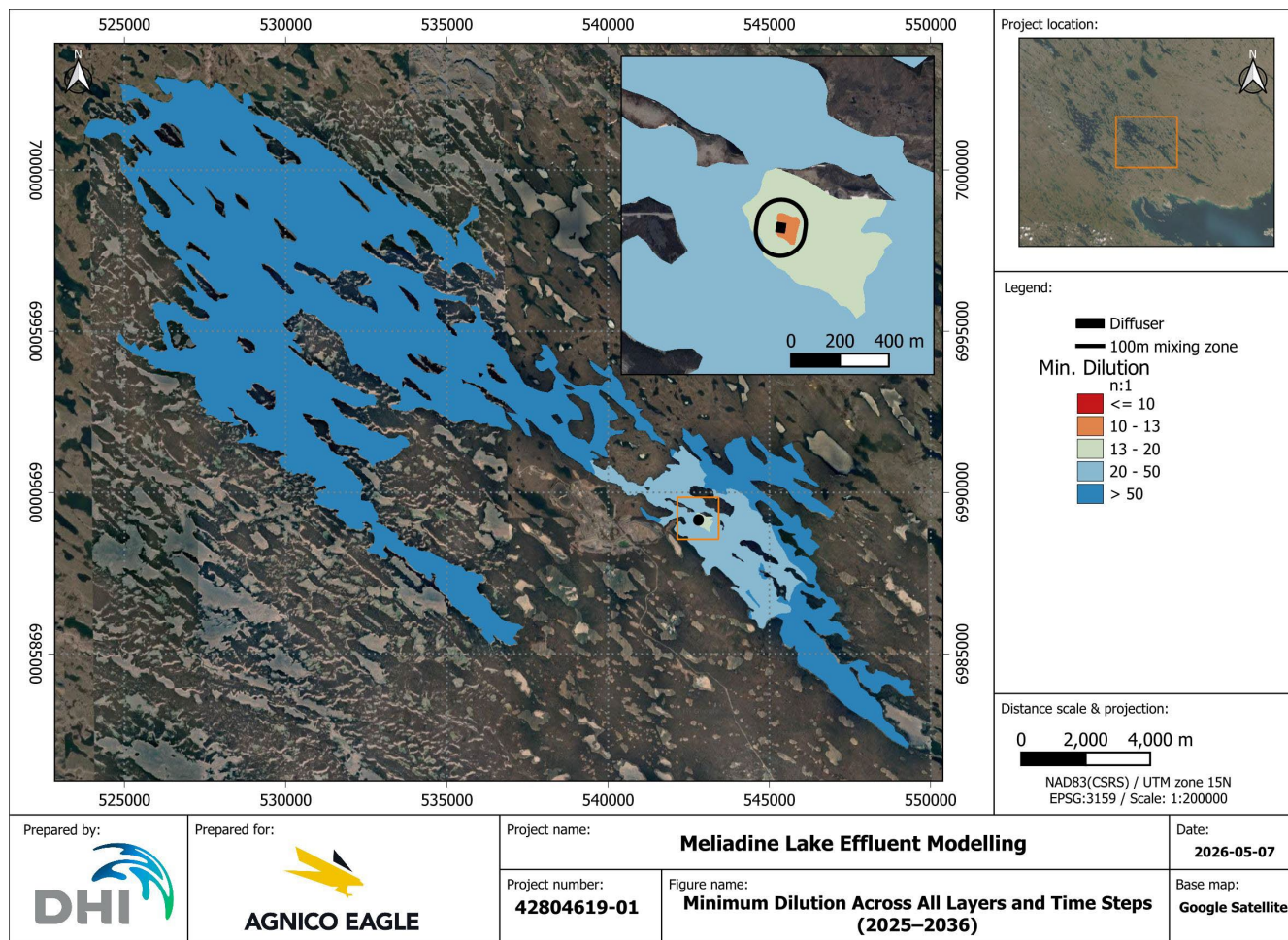


Figure 5.6 Minimum Dilution Computed Across Entire Simulation (2025–2036) and Throughout the Water Column, Displayed in Plan View

The Diffuser and the 100-m Mixing Zone are indicated for Reference.

Detailed dilution analyses, including full time series results, statistical distributions, spatial representations, and supporting figures, are provided in Appendix C.

Following the assessment of minimum dilution time series at the edge of the mixing zone, minimum dilution ratios are consistently above the applicable target threshold across the simulation period. On average, dilution ratios remain well above target levels, indicating effective dispersion and mixing of the effluent under typical operating conditions.

Figure 5.7 summarizes the distribution of minimum dilution at the edge of the mixing zone boundary (MZB) for each forecast year from 2025 to 2036, presented as box-and-whisker plot. For each year, the figure illustrates the statistical variability of dilution ratios, including the median, mean, interquartile range (25th–75th percentile), and the min–max range, providing an overview of both typical conditions and variability in dilution. A dilution above 13:1 indicates compliance with water quality guidelines.

The dilution results indicate that adequate mixing at the edge of the mixing zone is maintained over the long term, supporting the assessment of compliance with applicable water quality objectives.

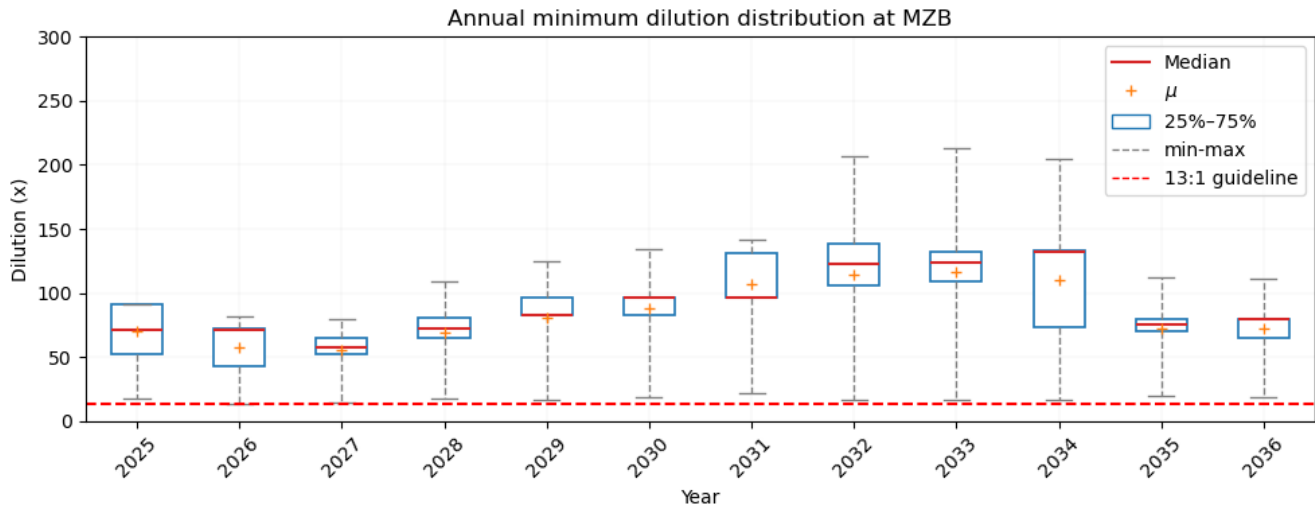


Figure 5.7 Box-and-Whisker Plot Showing the Year-by-Year Distribution of Minimum Dilution Ratios at the Edge of the MZB for the Forecast Period 2025–2036: Dilutions above 13:1 Guideline are in Compliance.

The plots display the median, mean, interquartile range (25th–75th percentile), and min–max range of minimum dilution for each year.

6 Conclusions

This document summarizes a hydrodynamic, transport, and mixing modeling study of Meliadine Lake to assess the environmental impacts of effluent discharge from the Meliadine Mine diffuser near Rankin Inlet, Nunavut. The goals are to evaluate water quality, quantify effluent dispersion, and ensure regulatory compliance at the 100-m mixing zone, covering both past (2018–2024) and future (2025–2036) discharge periods.

DHI developed a 3D hydrodynamic model (MIKE 3 Flow Model FM) to simulate lake hydrodynamics and effluent dilution, focusing on total dissolved solids (TDS) and mixing zone boundary (MZB) results.

Key objectives were the following:

- Validate the model with in-situ data.
- Assess effluent transport, mixing and potential accumulation.
- Evaluate long-term TDS behavior under forecast discharge conditions.
- Quantify effluent dilutions at the mixing zone boundary.

Model validation (2018–2024) showed strong alignment with observed seasonal water levels, temperatures, and TDS concentrations. Background TDS ranged from 21–91 mg/L, while post-discharge TDS typically stayed under 100 mg/L.

For the Meliadine Operational Update (2025–2036), forecast simulations determined target dilution ratios based on water quality guidelines. Most effluent constituents were already below guideline limits. Some constituents needed dilutions, with ammonia requiring the highest dilution (13:1) at the edge of the mixing zone. Simulations showed maximum TDS remained below regulatory thresholds (typically <361 mg/L for a threshold at 1,000 mg/L), and dilution ratios at the edge of the mixing zone were in compliance. Dilution at the mine water intake site ranged from 52:1 to 480:1, indicating substantial mixing and minimal impact.

7 References

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Appendix A Model Validation

This appendix presents the detailed results of the model validation undertaken for the Meliadine Lake hydrodynamic and transport model over the 2019–2024 period. The validation focuses on comparisons between simulated and observed water levels, water temperature, and total dissolved solids (TDS), using monitoring data collected in the vicinity of the diffuser and across the lake.

Appendix A.1 Water Level

Model performance was first evaluated through comparison of simulated and observed water levels in Meliadine Lake for the period from January 2019 to December 2023. Water levels are expressed relative to the climatological reference level adopted in the model setup (Section 2.2), i.e. representative of typical water level fluctuations in Meliadine Lake.

Figure A.1 presents the time-series comparison between modeled and observed water levels. Blue dots show modelled water level, while red dots present in-situ observations. **The model reproduces the seasonal pattern of lake water levels well, capturing both the timing and magnitude of observed fluctuations.** The simulated water levels closely follow the observations throughout the validation period, including periods of rising and falling lake levels.

A quantitative assessment of model performance is shown in Figure A.2, which presents a scatter-plot comparison between modeled and observed water levels. A perfect agreement will see all dots along the 1:1 central orange line. The further away the dots are from this 1:1 orange line, the more deviation there is between modelled and observed. The cloud of points is tightly distributed around the 1:1 line, indicating a high level of agreement between simulations and measurements across the full range of observed water levels.

Summary statistics derived from the comparison confirm the strong model performance. Over the validation period ($N = 1,827$ daily values), the modeled and observed mean water levels are identical (-0.03 m), resulting in a negligible mean bias of 0.00 m. Error metrics are low, with both the mean absolute error (MAE) and root mean square error (RMSE) equal to 0.01 m, indicating small absolute deviations between modeled and observed values. The correlation coefficient (CC) of 0.99 demonstrates an excellent linear relationship, while the explained variance (EV) of 0.98 indicates that nearly all of the observed variability is captured by the model.

Overall, the close agreement observed in both time-series and statistical comparisons demonstrates that the model provides a robust representation of lake-wide water-level dynamics under historical forcing conditions. **This level of performance provides confidence in the hydrodynamic framework used for subsequent transport and mixing analyses presented in later sections of the report.**

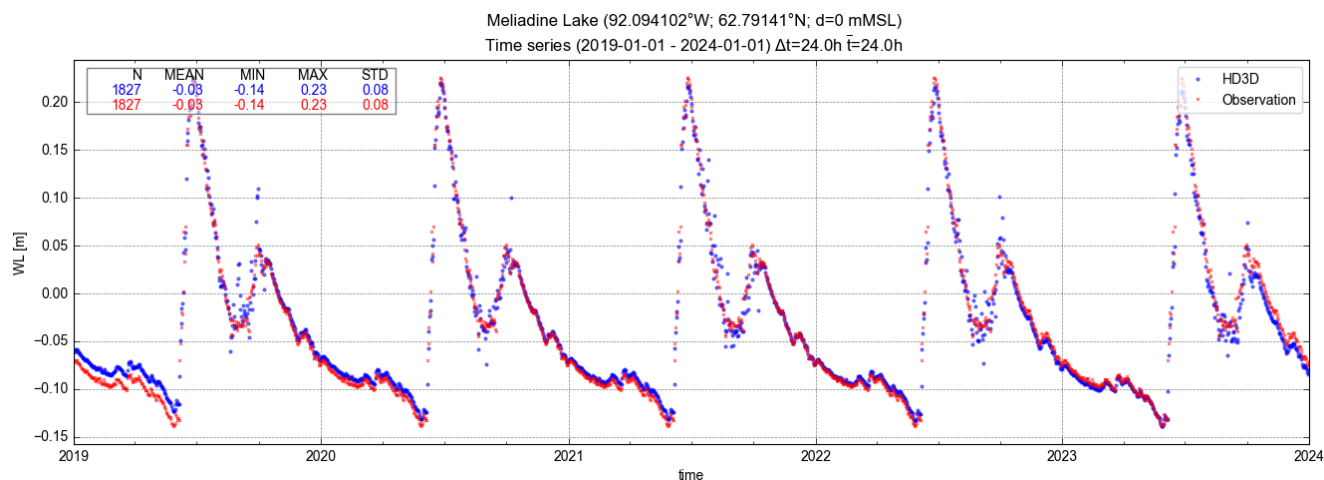


Figure A.1 Time-series Comparison of Modeled (in blue) and Observed (in red) Water Levels at Meliadine Lake for the Period January 2019 to December 2023
Water Levels are shown Relative to the Adopted Climatological Reference Level.

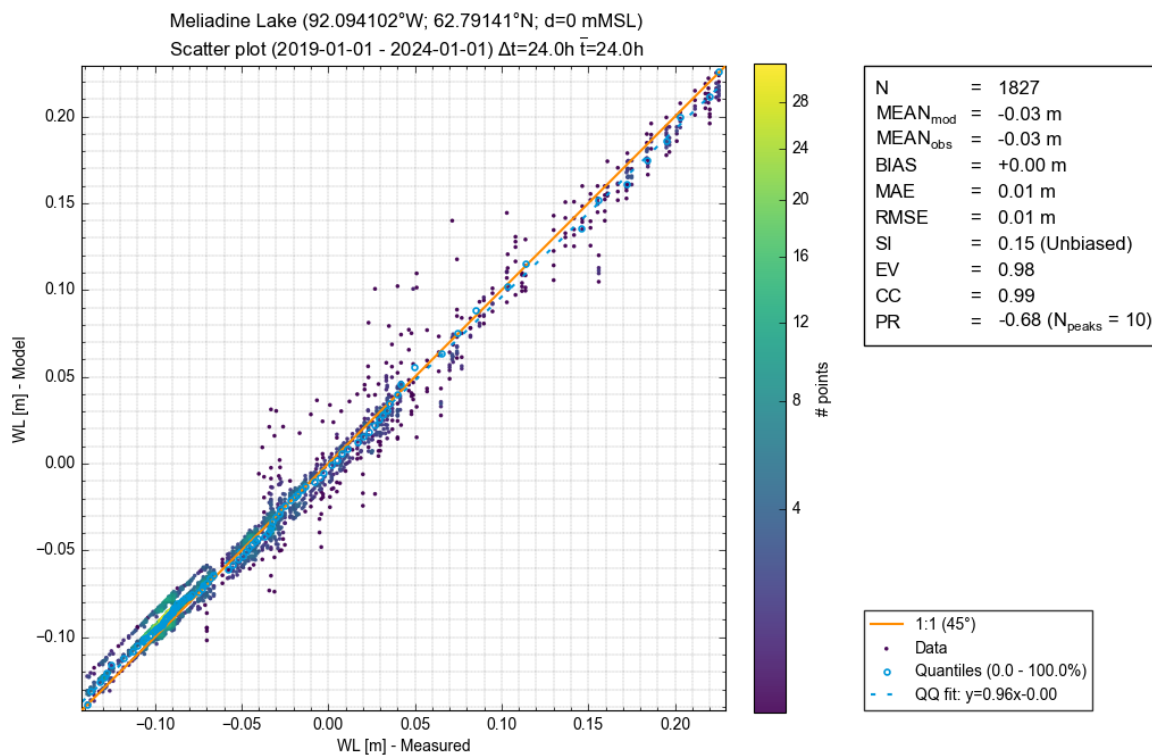


Figure A.2 Scatter-plot comparison between modeled and observed water levels at Meliadine Lake for the period January 2019 to December 2023, including the 1:1 line and associated statistical performance metrics.

Appendix A.2 Water Temperature

Model performance for water temperature was evaluated by comparison with observations collected at multiple stations in the vicinity of the diffuser for the period 2019 to 2024, focusing on the open-water season (July–October), associated with the effluent discharge. Due to the close proximity of the monitoring locations and the similarity of observed lake thermal conditions, results from the individual stations are presented together for each year (Figure A.3 and Figure A 4).

Across all five years, the model reproduces the seasonal evolution of water temperature well, capturing the timing and magnitude of summer warming, peak temperatures during mid-summer, and subsequent cooling during the fall. Simulated temperatures closely follow observed values at all stations, indicating consistent satisfactory model performance in the area surrounding the outfall.

Short-term variability observed in the temperature records is generally reflected in the simulations, suggesting that the applied atmospheric forcing and surface heat-flux formulation provide a realistic representation of thermal processes. Minor discrepancies occur intermittently, particularly during periods of rapid temperature change; however, no consistent bias is evident across stations or years. These slight deviations are also expected, given natural variations at site and within samples: up to 2°C (mid-July 2020 for example) were seen within samples around the diffuser site.

Given the objectives of the study, i.e. ability of the modelling framework to realistically reproduce the lake's physics, temperature validation is focused on seasonal patterns rather than point-specific agreement. **The results demonstrate that the model provides a credible representation of thermal conditions in the lake, supporting its application for transport and mixing analyses.**



Figure A.3 Comparison of modeled and observed water temperature at monitoring stations near the diffuser for the 2019 to 2022 open-water season.
 Modeled results are shown as continuous lines, while observations at individual stations are shown as circles.

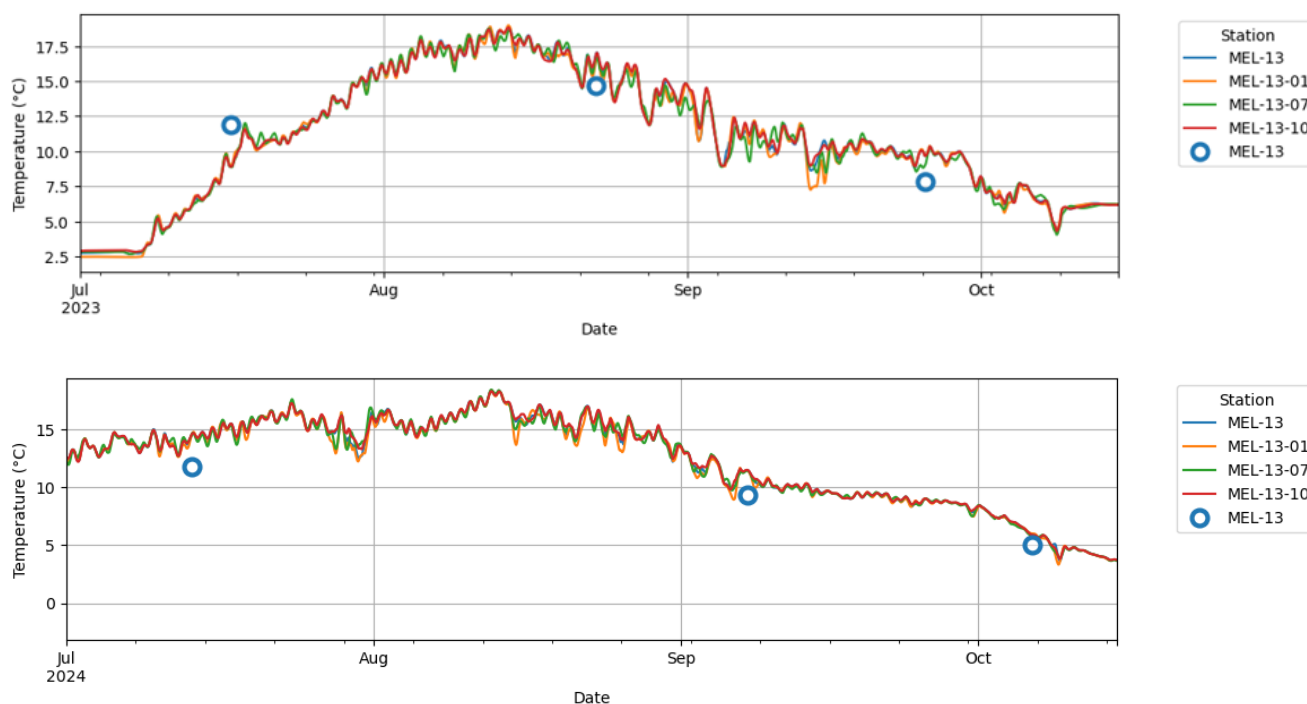


Figure A 4 Comparison of modeled and observed water temperature at monitoring stations near the diffuser for the 2023 to 2024 open-water season.

Modeled results are shown as continuous lines, while observations at individual stations are shown as circles.

Appendix A.3 Total Dissolved Solids

Model performance for total dissolved solids (TDS) was evaluated through comparison with observations collected at multiple monitoring stations in the vicinity of the diffuser for the period 2019 to 2024, as shown in Figure A.5 and in Figure A.6. As with temperature validation, results from individual stations are presented together for each year, since the observations indicate similar temporal patterns and concentration ranges across stations near the outfall.

Across the validation period, the model reproduces the overall magnitude, and variability of observed TDS concentrations during the open-water season. Simulated TDS concentrations are generally within the same order of magnitude as the observations and follow comparable temporal trends. Year-specific comparisons between modeled and observed TDS concentrations are summarized below:

- **2019:** Observed TDS concentrations near the diffuser are typically within the range of approximately 30 to 75 mg/L, with relatively limited variability. Modelled concentrations remain close to the observations, generally fluctuating between 40 and 75 mg/L, and capture the modest increases observed during the late-summer period.
- **2020:** A larger number of observations are available and indicate substantially greater variability, with measured TDS concentrations ranging from approximately 50 mg/L to over 100 mg/L, and short-duration peaks exceeding 150 mg/L at some stations. The model reproduces the timing and general magnitude of these elevated periods, with simulated concentrations typically between 60 and 125 mg/L, and occasional higher simulated peaks of up to approximately 200–250 mg/L.
- **2021:** Modeled TDS concentrations are generally within the range of 50 to 100 mg/L, while observed values are more narrowly distributed, typically between 50 and 75 mg/L, with a single

higher observed concentration exceeding 150 mg/L. The model tracks the mid- to late-summer increase reasonably well and maintains realistic background concentrations outside peak periods.

- **2022:** Observed TDS concentrations are comparatively stable, typically ranging between 50 and 100 mg/L, with one isolated high observation of approximately 150 mg/L. Modeled concentrations predominantly fall within the same 50 to 100 mg/L range, showing close agreement with observed baseline levels and seasonal behavior.
- **2023:** Observed TDS concentrations generally fall within the range of 50 to 100 mg/L, with moderate variability across monitoring stations. Modeled concentrations exhibit similar variability, typically ranging from 65 to 90 mg/L, and reproduce the timing and magnitude of late-summer increases.
- **2024:** Observed TDS concentrations generally fall within the range of 48 to 105 mg/L similar to last year, with moderate variability across monitoring stations. Modeled concentrations exhibit similar variability, typically ranging from 55 to 85 mg/L, and reproduce the timing and magnitude of late-summer increases.

Overall, **the model captures the timing of elevated TDS periods, the background concentration levels, and the inter-annual variability in the observations.** Differences between modelled and observed peak concentrations occur in some years, particularly during short-duration spikes, which is expected given the localized nature of the measurements, potential short-term discharge variability, and unresolved small-scale mixing processes in the near-field.

Given the objectives of the study, TDS validation is assessed with an emphasis on reproducing realistic concentration ranges, seasonal patterns, and responses to discharge conditions. Overall, **the validation demonstrates that the model provides a credible representation of TDS transport and mixing in the vicinity of the diffuser,** supporting its use for subsequent scenario analyses.

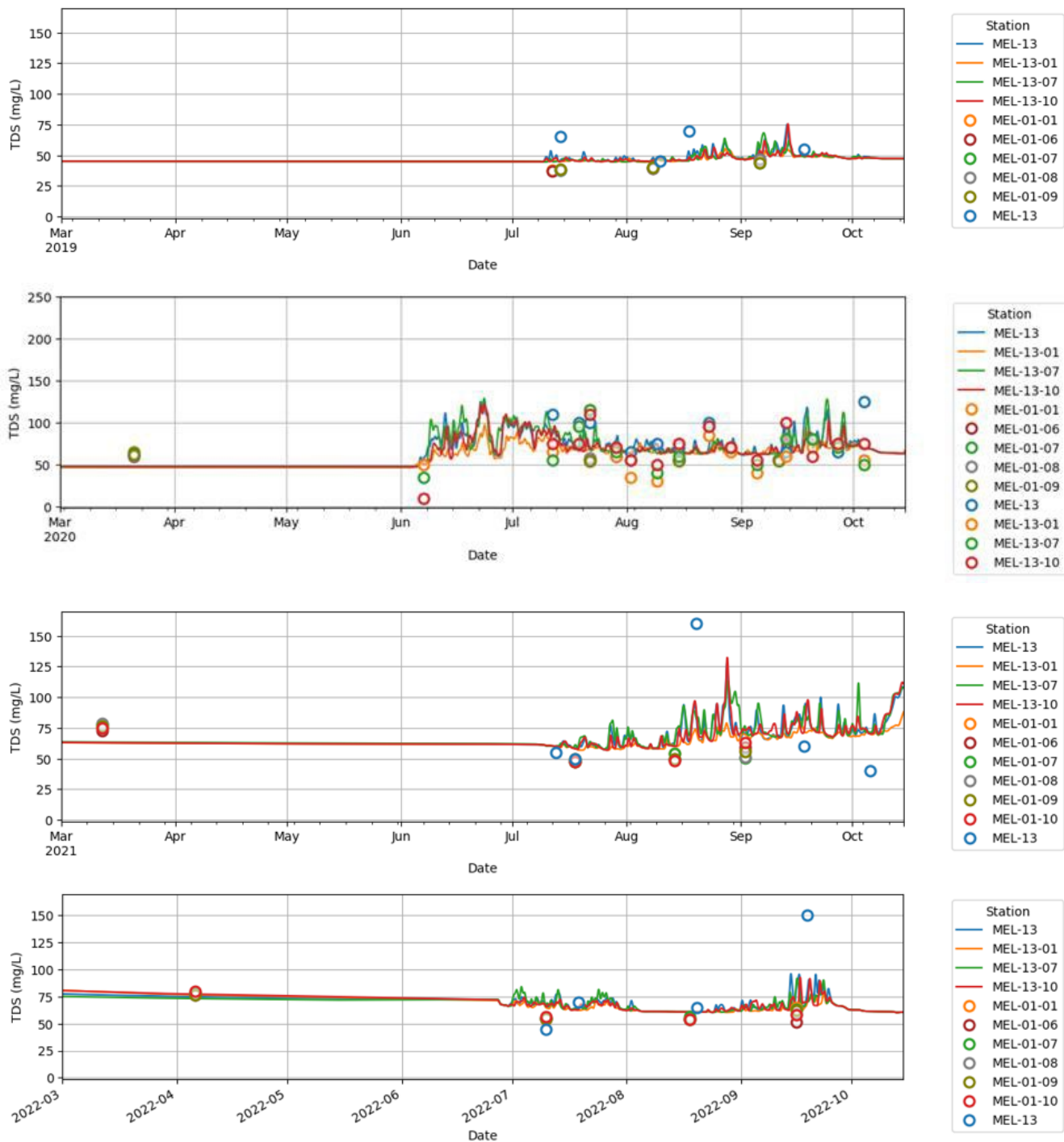


Figure A.5 Comparison of modeled and observed total dissolved solids (TDS) concentrations at monitoring stations near the diffuser for the 2019 to 2022 open-water season. Modeled results are shown as continuous lines, while observations at individual stations are shown as circles.

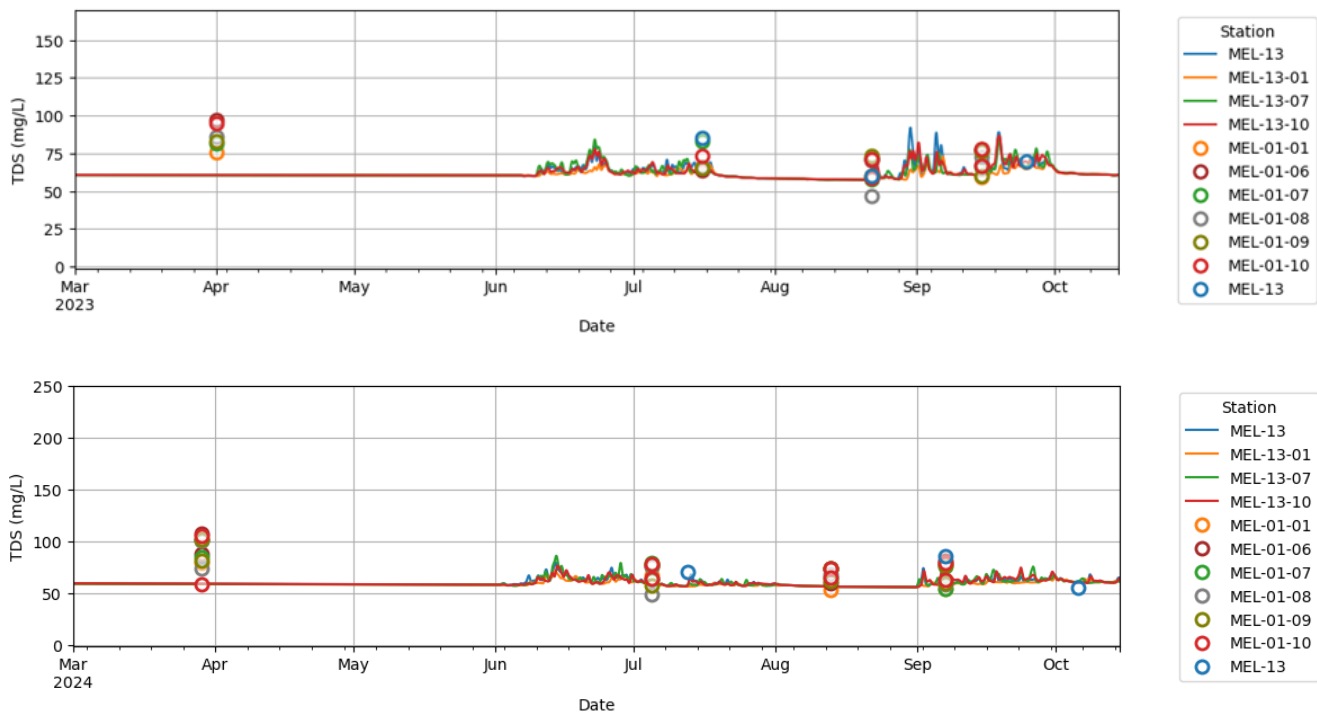


Figure A.6 Comparison of modeled and observed total dissolved solids (TDS) concentrations at monitoring stations near the diffuser for the 2023 to 2024 open-water season. Modeled results are shown as continuous lines, while observations at individual stations are shown as circles.

Appendix B Target Dilutions

This appendix defines target dilutions at the edge of the mixing zone. The target dilution represents the degree of required mixing for the effluent to be in compliance with water quality guidelines.

Table B.1 presents the various constituents present in the effluent. A time-series with monthly varying concentrations for each constituent was provided by Agnico Eagle, covering the 2025 to 2036 future discharge period. For each constituent, the maximum weighted long-term concentration was identified: this concentration reflects how effluent accumulation in the lake changes over time. The concentration at the MZB depends on both recent and historical discharges, due to accumulation. Therefore, this weighted value incorporates past (i.e. previous years) effluent flow rates and concentrations (50% weight) as well as current (i.e., current year) flow rates and concentrations (50% weight).

For each constituent, the water quality guideline was then identified and used to compute the corresponding target dilution requirement. Constituents with concentrations below guideline values prior to discharge do not require dilution and are therefore not included in the summary table, which focuses only on constituents requiring dilution.

Required dilution factors range from 1:1 to 13:1. Ammonia represents the limiting constituent, requiring the highest level of dilution. A target dilution of 13:1 is needed for ammonia to comply with water quality guidelines at the edge of the mixing zone. In other words, dilutions will need to be at or above 13:1 at the edge of the mixing zone to achieve water quality guidelines for all constituents.

Accordingly, this 13:1 dilution ratio has been adopted as the applicable target for assessment of compliance at the MZB.

Table B.1 Effluent Constituent Concentrations, Water Quality Guidelines and Required Dilutions

Constituent	Symbol	Maximum Weighted Long-term Concentration (mg/L)	Guidelines (mg/L)	Target dilution
ammonia	NH3	4.88	0.41	13:1
nitrate	NO3	20.21	2.9	10:1
nitrite	NO2	0.21	0.06	5:1
chloride	Cl	922	120	10:1
sulphate	SO4	322	128	3:1
total cyanide	T_CN	0.0043	0.005	1:1
arsenic	As	0.040	0.025	3:1
cadmium	Cd	0.000071	0.00004	2:1
copper	Cu	0.0033	0.00161	3:1
mercury	Hg	0.000023	0.000026	1:1
manganese	Mn	0.45	0.12	6:1
nickel	Ni	0.026	0.025	1:1
selenium	Se	0.0009	0.001	1:1
strontium	Sr	2.30	2.5	1:1

Appendix C Model Results – Dilution

This appendix presents the detailed results of the dilution assessment conducted for the Meliadine Lake effluent discharge scenarios over the 2025–2036 simulation period. The analysis focuses on dilution conditions at the edge of the 100-m mixing zone, using a conservative framework based on minimum dilution ratios.

These detailed results provide supporting evidence for the high-level conclusions presented in Section 5.4 and demonstrate the robustness of mixing and dilution processes under a range of hydrodynamic and operational conditions.

Figure C.1 presents the minimum dilution time series at the edge of the mixing zone (100-m radius), together with the applicable performance targets. The target dilution adopted for the assessment is 13:1, as presented in Appendix B, consistent with the project framework used to evaluate compliance at the mixing zone boundary. Dilutions at or above 13:1 at the MZB indicate compliance with water quality guidelines.

The time series indicates that minimum dilution at the mixing zone edge remains above the 13:1 target dilution throughout the simulation period. Lower dilution values are observed during periods of higher discharge and/or reduced ambient mixing; however, dilution ratios consistently remain above the target threshold. The lowest simulated dilution occurs in 2026 and is equal to 14:1, **confirming that dilution criteria are met under all simulated conditions**. In other words, **compliance at the MZB is met with all constituents throughout the forecast period**.

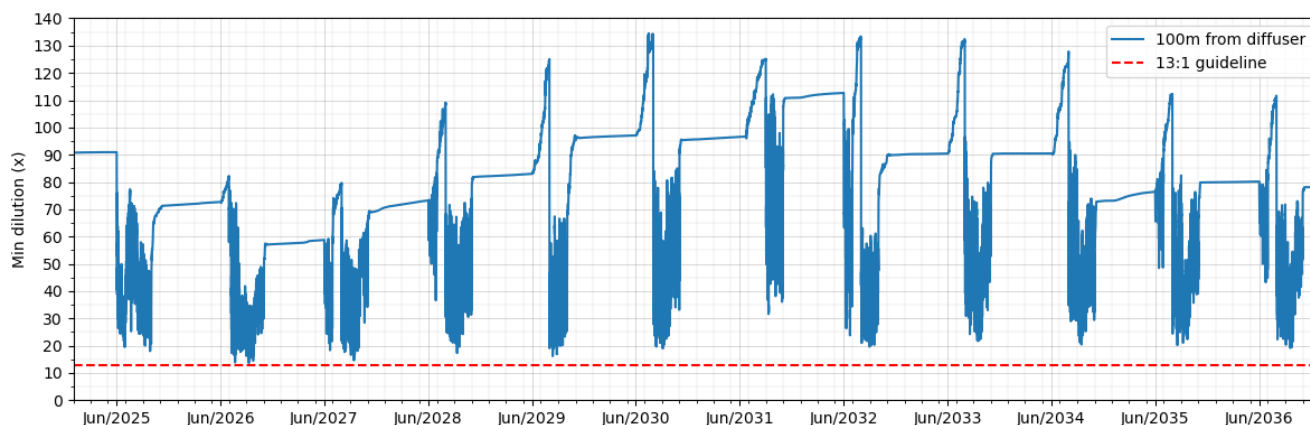


Figure C.1 Time Series of Minimum Dilution at Edge of Mixing Zone for the Period 2025–2036. The 13:1 Target Dilution is shown for Reference. Dilutions above 13:1 are in Compliance.

Average dilution provides a complementary measure of typical mixing conditions at the mixing-zone boundary. Figure C.2 presents the average dilution time series at the edge of the mixing zone, computed as the mean across the selected elements and layers surrounding the 100-m mixing zone at each time step. As shown, average dilutions are consistently well above 20:1, indicating robust mixing at the edge of the mixing zone for typical operating conditions.

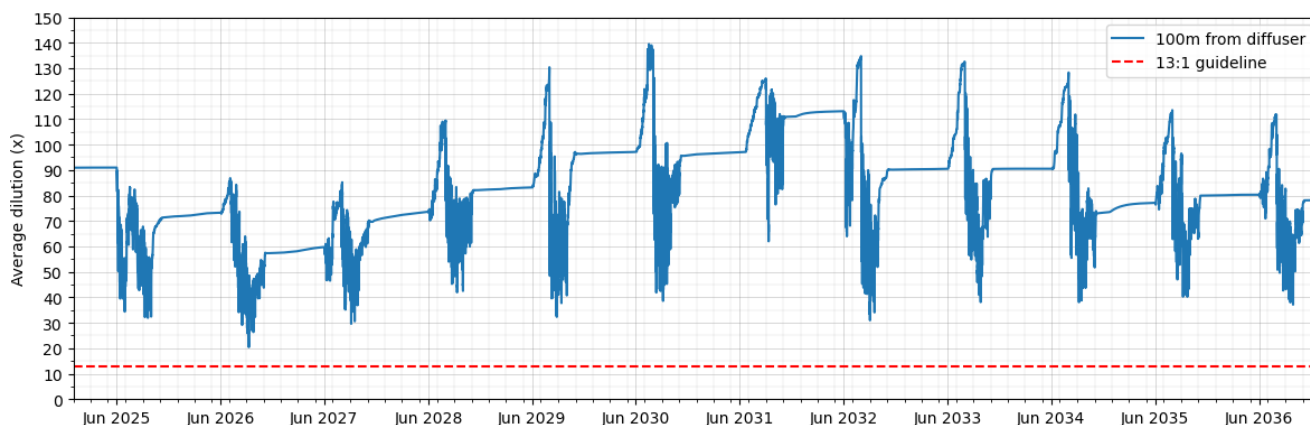


Figure C.2 Time Series of Average Dilution at Edge of Mixing Zone for the Period 2025–2036. The 13:1 Target Dilution is shown for Reference. Dilutions above 13:1 are in Compliance.

Table C.1 provides a summary of both minimum and average dilution at the edge of the mixing zone. Over the forecast discharge period from 2025 to 2036, the lowest dilution occurs in 2026, with a minimum value of 14:1, which remains above the 13:1 target threshold; therefore indicating compliance with water quality guidelines. Average dilution ranges from approximately 56:1 to 98:1 across the simulation period, indicating sustained mixing performance at the MZB.

Table C.1 Annual Minimum and Average Dilutions at MZB

Year	Minimum Dilution at Edge of MZB (2025-2036)	Average Dilution at Edge of MZB (2025-2036)
2025	18:1	75:1
2026	14:1	63:1
2027	15:1	61:1
2028	17:1	76:1
2029	16:1	85:1
2030	19:1	95:1
2031	21:1	114:1
2032	17:1	126:1
2033	16:1	127:1
2034	16:1	120:1
2035	20:1	78:1
2036	19:1	78:1

Figure C.3 summarizes the distribution of minimum dilutions at the edge of the MZB for each forecast year from 2025 to 2036, presented as box-and-whisker plots. Similarly, Figure C.4 summarizes the distribution of dilutions along the MZB. For each year, the figure illustrates the statistical variability of minimum dilution values, including the median, mean, interquartile range (25th–75th percentile), and the min–max range, providing an overview of both typical and less-frequent low-dilution conditions.

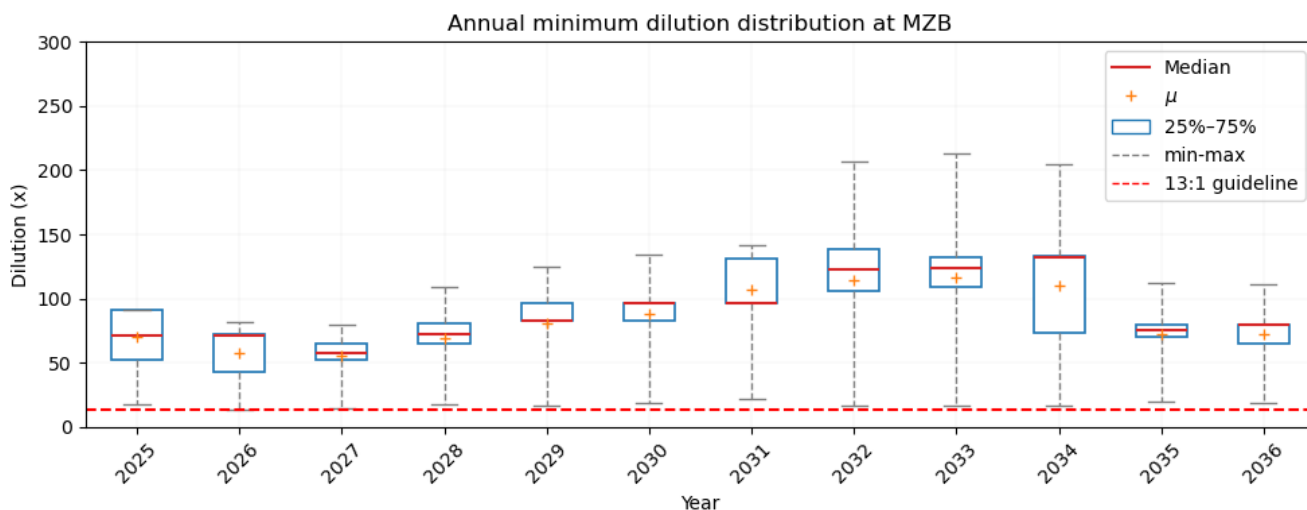


Figure C.3 Box-and-Whisker Plot Showing the Year-by-Year Distribution of Minimum Dilution Ratios at the Edge of the MZB for the Forecast Period 2025–2036. Dilutions above 13:1 are in Compliance.

The plots display the median, mean, interquartile range (25th–75th percentile), and min–max range of minimum dilution for each year.

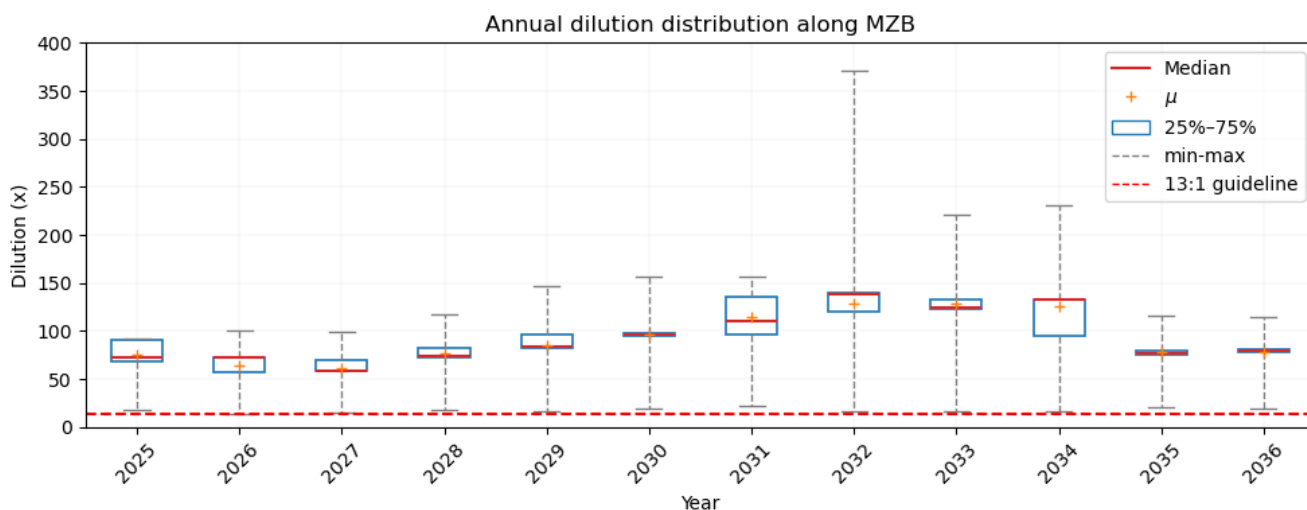


Figure C.4 Box-and-Whisker Plot Showing the Year-by-Year Distribution of Dilution Ratios along the MZB for the Forecast Period 2025–2036.

The plots display the median, mean, interquartile range (25th–75th percentile), and min–max range of dilution for each year.

Consistent with the evaluation of TDS concentrations at the mine’s intake location, dilution conditions were also assessed at the water intake in the narrows region to verify the degree of mixing under forecast discharge conditions. As for the TDS analysis, dilution values were extracted from the model layer nearest the lakebed, representing conservative intake conditions. The resulting time series indicates that dilution ratios at the intake location generally range between approximately 52:1 and 480:1 over the 2025–2036 simulation period (Figure C.5). These relatively high dilution levels confirm that the effluent plume is substantially mixed before reaching the intake area and are fully consistent with the low TDS

concentrations presented previously. Overall, the dilution results demonstrate that the effluent impact at the intake location is minimal and well attenuated under forecast operating conditions.

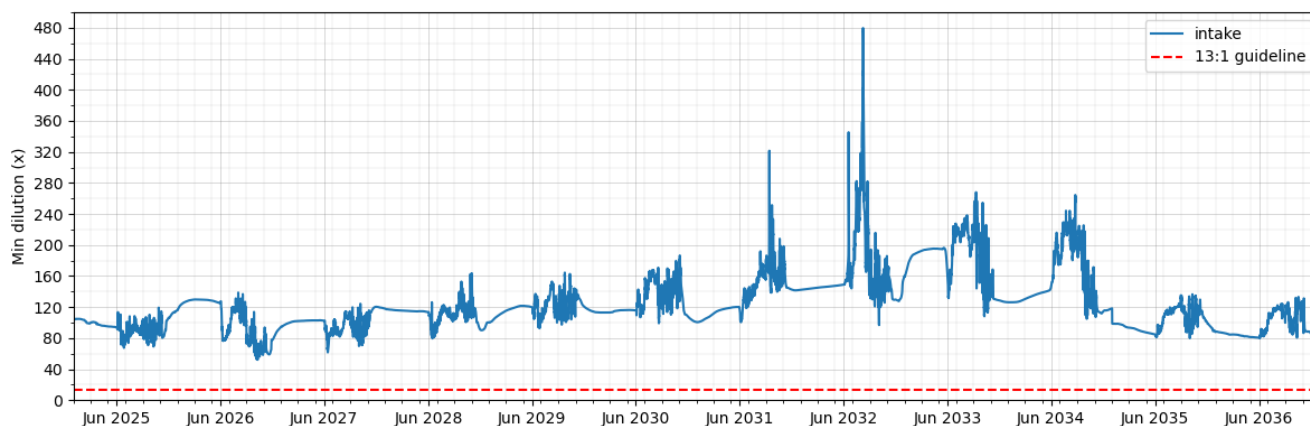


Figure C.5 Time Series of Minimum Dilution at the Water Intake Location for the Period 2025–2036
The 13:1 Target Dilution is shown for Reference.