# Hydrogeological Modelling Report

## Antrim Gypsum Project Nova Scotia

CertainTeed Canada, Inc.

15 August 2024

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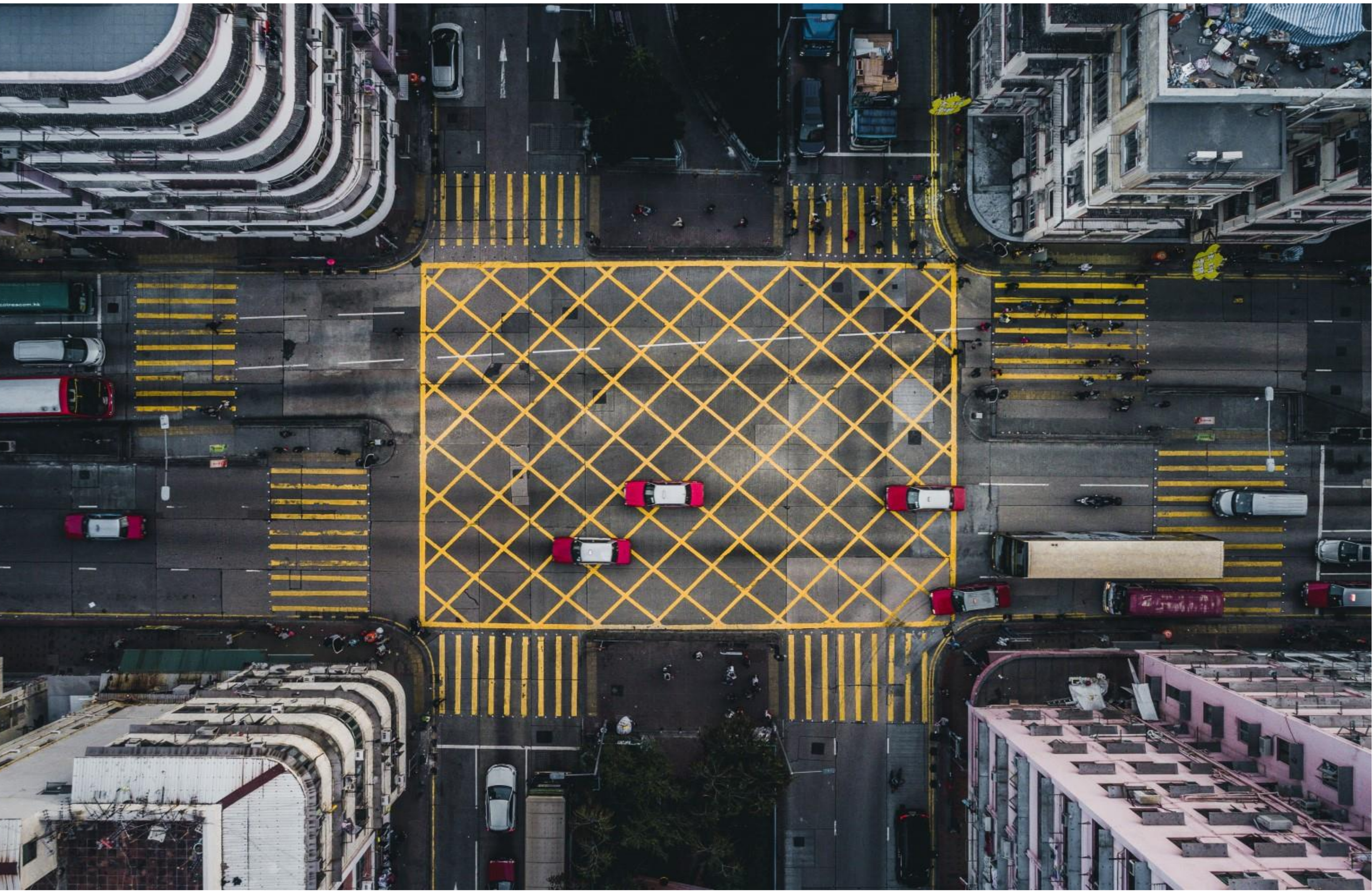

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# 1. Introduction

## 1.1 Background

GHD Limited (GHD) was retained by CertainTeed Canada Inc. (CertainTeed) to develop a three-dimensional groundwater flow model, based on available data, to estimate potential groundwater quantity impacts for the Antrim Gypsum Project (Project). At the date of groundwater model development, groundwater monitoring data collected at the Project was limited to three monitoring well locations which was insufficient to calibrate the groundwater flow model to baseline conditions because baseline conditions (groundwater elevations) were not well defined over Project Area (PA). To address this limitation, GHD developed the groundwater model to provide a conservative estimate of potential Project impacts through assigning a biased high hydraulic conductivity to overburden and assigning net groundwater recharge towards the bottom of the expected range, such that the groundwater flow model would tend towards overpredicting potential impacts from the Project on groundwater resources. GHD also conceptually calibrated the model to confirm that it simulated depth to groundwater was within the range indicated by regional data and the limited Project data. Through this approach, GHD developed groundwater flow model is suitable for the purpose of developing a conservative estimate of potential Project impacts.

The Project is located approximately 50 km northeast from Halifax, Nova Scotia (NS), near Gays River, along Lake Egmont Road in the community of Cooks Brook, NS. The Project location is presented on Figure 1.1, For the purpose of this groundwater/hydrogeologic assessment, a PA was defined as the footprint of Project related infrastructure and includes the following parcels of land: PID 40228389, 40228371, 40212409, 40229676, 40959983, 40959975, 40228009, 40228017, 41517319, 40767014, and 41152893. CertainTeed proposes to develop the Project as a conventional gypsum mining operation including an open pit quarry, till and organic stockpiles, overburden storage area, rock processing plant, as well as water management infrastructure. The proposed features and spatial boundaries are presented on Figure 1.2. The Project will produce crushed gypsum and anhydrate at an estimated average rate of production of 1.5 million tonnes per year. The gypsum and anhydrate products will be transported via trucks to an existing port facility in Sheet Harbour, NS, approximately 82 km from the Project Area, for shipment to manufacturing facilities either in Canada or the United States.

The scope of the Project includes activities associated with construction, operation, and closure. Project construction activities will include clearing and grubbing the topsoil stockpiles, overburden, and waste rock stockpile, mine pit, run-of-mine (ROM) stockpile, construction of the processing facility (i.e. sizer buildings, conveyor, screening building, etc.,) access roads, fuelling infrastructure, surface water management, and other Project infrastructure. The operation phase will include extraction (surface miner, loading, and hauling), processing, and waste management. Blasting may be used for extraction, if required. Gypsum will be screened while stockpiled. Waste rock, not used for construction or backfill, will be stockpiled. Progressive reclamation will be completed through backfilling of the pit from the north end as mining gypsum mining progresses to the south. The closure phase will include earthworks and demolition required to return the Project Area to a safe, stable, and vegetated state, and all monitoring and treatment, if required. Reclamation and Closure Plan requirements are governed by the *Nova Scotia Mineral Resources Act*.

## 1.2 Purpose of this report

The purpose of this Report is to document GHD's development of a numerical 3D groundwater flow model to represent the hydrogeologic conditions observed at the Project and surrounding area. Model development was based on available Project and regional hydrologic, geologic, and hydrogeologic data, recognizing that Project hydrogeological studies are ongoing. The model was applied to provide conceptual estimates of changes in groundwater flow and groundwater/surface water interactions between four key stages of Project development. Specifically, the groundwater flow model was applied to simulate changes in groundwater quantity between the four stages of Project operations. These stages include:

- **Baseline Conditions (Baseline)**[1]: Project conditions prior to project construction/development
- **Phase 1b Mine Development**: Partial extraction of the proposed pit with partial backfilling using overburden material
- **Phase 2 End-of-Mine (EOM)**: Full extraction of the proposed pit with partial backfill consisting of overburden, rejects, and waste rock
- **Phase 2 Post-Closure (PC)**: Reclamation of the Project area including partial pit backfill consisting of overburden, rejects, and waste rock, and subsequent filling of the remaining pit volume with water to form a pit lake

Simulated groundwater conditions at Phase 1b, EOM, and PC are compared to simulated Baseline groundwater conditions to estimate the potential impacts to groundwater quantity, including groundwater elevations and drawdown, and baseflow (i.e., groundwater discharge/recharge to/from surface water bodies). The assessment of groundwater conditions throughout project development support the surface water and fish and habitat assessments and are incorporated in the Environmental Assessment Registration Document (EARD) prepared for the Project.

## 1.3 Scope of Work

GHD developed the groundwater flow model based on available Project and regional data including surface water features, topography, water well and drill hole records, and geologic information. The scope of work completed by GHD to develop the groundwater flow model and to apply the model to estimate potential impacts to groundwater and surface water flow regimes included the following:

- Compiled, reviewed, and interpreted the hydrologic, geologic, and hydrogeologic data available for the Project and surrounding area.
- Developed a hydrogeologic conceptual site model (hCSM) for the Project and surrounding area based on available Project and regional data.
- Constructed a numerical 3D groundwater flow model based on the hCSM to provide a conservative basis for estimating potential Project impacts.
- Conceptual calibration the groundwater flow model under steady-state conditions to approximate the range of observed groundwater elevations.
- Applied the conceptually calibrated groundwater flow model to evaluate potential changes in groundwater quantity conditions with respect to groundwater flow and groundwater/surface water interactions in the Project area at Phase 1b, EOM, and PC.
- Evaluated the uncertainty related to model input parameters.
- Documented the groundwater flow model development and its application in this Report.

## 1.4 Limitations

GHD has prepared this Report and the documented groundwater flow Model for the benefit and sole use of, CertainTeed to support the assessment of potential Project impacts to groundwater quantity as laid out in Section 1.2 of this Report and must not be used for any other purpose or by any other person.

GHD otherwise disclaims responsibility to any entity other than CertainTeed arising in connection with Report. GHD also exclude implied warranties and conditions, to the extent legally permissible. The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the Report.

The Model documented by this Report is a representation only and does not reflect reality in every aspect. The Model contains simplified assumptions to derive a modelled outcome. The actual variables will inevitably be different to those

[1] Baseline Conditions discussed herein are developed for the purpose of providing a conservative estimate of potential project impacts since the paucity of data within the PA precludes developing a model that can be determine representative of baseline hydrogeologic conditions.

used to prepare the Model. Accordingly, the outputs of the Model cannot be relied upon to represent actual conditions without due consideration of the inherent and expected inaccuracies. Such considerations are beyond GHD's scope.

The information, data and assumptions ("Inputs") used as inputs into the Model are from publicly available sources or provided by or on behalf of CertainTeed, (including possibly through stakeholder engagements). GHD has not independently verified or checked Inputs beyond its agreed scope of work. GHD's scope of work does not include review or update of the Model as further Inputs becomes available.

The Model is limited by the mathematical rules and assumptions that are set out in the Report or included in the Model and by the software environment in which the Model is developed.

The Model is a customised model and not intended to be amended in any form or extracted to other software for amending. Any change made to the Model, other than by GHD, is undertaken on the express understanding that GHD is not responsible, and has no liability, for the changed Model including any outputs.

The opinions, conclusions and any recommendations in this Report are based on conditions encountered and information received and reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

## 1.5 Terms and Acronyms

| Term | Definition |
|---|---|
| Access Road | Road off Lake Egmont Road to provide access for mine employee and maintenance suppliers |
| Anhydrate | Product when water is removed from gypsum. |
| Ausenco | Ausenco Engineering Canada Inc. |
| Black Ash Exclusion Zone | Defined core habitat (200 m buffer zone) surrounding identified black ash species inhibiting Project development and/or activity in this area. The buffer helps to protect habitat and biological value of the black ash. |
| CertainTeed | CertainTeed Canada Inc. |
| Closure | Project phase including reclamation and post-closure stages |
| Construction | Project phase including clearing, grubbing, and construction of site infrastructure |
| Crown Land | Crown Land PIDs in the Project Area include: 40228389, 40228371, 40229676, 40212409, 40959983, 40959975 |
| EARD | Environmental Assessment Registration Document required for a Class I undertaking under Section 9(1) of the Regulations |
| GHD | GHD Limited |
| Haul Road | Road accessed from Lake Egmont Road to provide access for haul trucks |
| McCallum / MEL | McCallum Environmental Ltd. |
| Mercator | Mercator Geological Services |
| MMTS | Moose Mountain Technical Services |
| Operations | Project phase including extraction, processing, and waste management |
| Overburden Stockpile | Overburden material stripped and stockpiled for Progressive Reclamation and Closure |
| Private Land | Private Land PIDs in the Project Area include: 40228009 (MacPhee), 40228017 (Glenmore Industries Limited), 40767014 (Rammo-Barney), 41152893 (Pettipas), 41517319 |
| Port Facility | Existing Port Facility in Sheet Harbour, Port of Sheet Harbour located at 605 Marine Gateway Road, Sheet Harbour, NS B0J 3B0 |

| Term | Definition |
|---|---|
| Process Rejects | Remaining material that is left after resource (Gypsum) is screened (mud, non-gypsum rock) |
| Progressive Reclamation | Reclamation activities completed during the Operations stage |
| Project | The Antrim Gypsum Project |
| Project Area | The boundary of the studies related to the Environmental Assessment Registration Document |
| Rock Storage Area | Non-gypsum or anhydrate rock storage location |
| ROM Stockpile | Run of Mine Stockpile |
| Scotia Mine | Scotia Mine is a lead-zinc resource mine owned by Scotia Mine Limited, located adjacent to the Project Area |
| Settling pond | Water management infrastructure designed to remove settleable material by sedimentation |
| Topsoil stockpile | Topsoil removed from infrastructure footprints and stored for Progressive Reclamation and Closure |
| Trucking Route / Haul Route | The route to haul material to the Port Facility |
| Waste Rock Stockpile | Extracted material that is not a resource |
| Water Management Infrastructure | All ditching, collection, and treatment of contact water |

## 1.6 Report Organization

This Report is organized as follows:

– **Section 1 – Introduction:** Presents the introduction, purpose, and scope of work of the hydrogeologic modelling conducted for the Project
– **Section 2 – Summary of Hydrologic, Geologic, and Hydrogeologic Conditions:** Presents a summary of observed regional and site-specific hydrologic, geologic, and hydrogeologic conditions at the Project
– **Section 3 – Hydrogeologic Conceptual Site Model:** Presents the hCSM developed for the Project area that forms the basis for the construction of the numerical groundwater flow model
– **Section 4 – Simulation Program Selection:** Presents a description of the simulation programs selected to conduct the hydrogeologic modelling
– **Section 5 – Groundwater Flow Model Construction:** Presents details regarding construction of the numerical groundwater flow model to represent the key components of the hCSM
– **Section 6 –Conceptual Groundwater Flow Model Calibration:** Presents the conceptual calibration of the numerical groundwater flow model to observed groundwater flow conditions at the Project
– **Section 7 – Groundwater Flow Model Application:** Presents the application of the calibrated groundwater flow model to evaluate potential impacts to the groundwater and surface water flow regimes at the Project at EOM and PC, and the accompanying uncertainty analyses
– **Section 8 – Summary and Recommendations:** Presents a summary of the hydrogeologic modelling conducted for the Project and the conclusions reached
– **Section 9 – References:** Lists the references cited in this Report

# 2. Summary of Hydrologic, Geologic, and Hydrogeologic Conditions

GHD reviewed regional and Project-specific hydrologic, geologic, and hydrogeologic conditions within and surrounding the Project Area, that were available at the date of the preparation of this Report. This analysis forms the basis for developing a hCSM that characterizes key groundwater flow conditions, including groundwater sinks (i.e., conditions that remove groundwater from the groundwater flow system) and groundwater sources (i.e., conditions that introduce/recharge groundwater into the groundwater flow system) near the Project. Understanding these groundwater flow conditions allows for the development of a groundwater flow model that can be applied to estimate groundwater flow and groundwater/surface interactions within the degree of uncertainty supported by the reviewed and incorporated information. The details of the regional and Project-specific hydrologic, geologic, and hydrogeologic conditions, based on available data, are summarised below.

## 2.1 Hydrologic Conditions

The hydrologic conditions at the Project are affected by climate, regional physiography, topography, and surface water features. Each of these are briefly described in the following sections.

### 2.1.1 Climate

The Project is located approximately 50 km northeast of Halifax, NS, near Gays River, along Lake Egmont Road in the community of Cooks Brook, NS. The climate at the Site is variable due to the mixed continental and maritime weather patterns at Gays River (Westminer Canada Limited Seabright Operations [WCLSO], 1992). The nearest climate station with regionally representative historical data is Environment and Climate Change Canada's (ECCC) Halifax Stanfield International Airport (Climate ID: 8202250). The Halifax Stanfield International Airport is located approximately 21 km southwest of the Site at an elevation of 145.4 masl. Based on the 50-year record of daily precipitation and average temperature data from 1964 to 2023, the daily mean temperature at Halifax Stanfield International Airport ranges from -5.6 degrees Celsius (°C) in January to 18.8 °C in July. Average annual precipitation is 1459.2 millimetres (mm). On average 239.3 centimetres (cm) of snowfall is recorded per year. Most of the snowfall occurs between December and March.

Potential evapotranspiration (PET) values were calculated using the Hamon method, which estimates PET based on the empirical relationship between mean daily air temperature, saturated water vapour concentration and day length (hours of sunshine). Daily average temperature values from the Halifax Stanfield climate record were used to calculate daily PET values. The daily PET values were then input into a soil-water balance model to calculate Actual Evapotranspiration (AET) for the corresponding 50-year climate record.

Table 2.1 summarizes the monthly precipitation totals, average temperatures, and potential evapotranspiration rates used in the analysis.

### 2.1.2 Physiography

Based on areas of similar macroclimate, physiographic and geological features, and vegetation, NS has been divided into unique ecological levels. The largest Ecological Land Classification, ecozones, describe ecological features at a sub-continental level. Ecozones are subdivided into ecoregions which are further divided into ecodistricts that refined distinctive assemblages of relief, geology, landforms and soils, vegetation, water, fauna, and land use (Neily et al., 2017). The PA is located within the Central Lowlands ecodistrict. This ecodistrict is dominated by mainly Carboniferous rocks (shale, limestone, sandstone, gypsum). Karst topography is often evident in areas underlain by evaporites such as gypsum and limestone. Soils derived mainly from glacial outwash are abundant, especially alongside rivers (Roland, 1982); however, much of the ecodistrict has deep, reddish-brown fine textured soils comprised of loams, silts, and clays.

The Central Lowlands are fairly level with an undulating topography from lowland plains to rolling hills; rarely exceeding 90 masl. The central basin is drained by several large rivers that are affected by the tidal movements of the Bay of Fundy, with the exception of the Musquodoboit River which flows south to the Atlantic Ocean. A few lakes dot the landscape but not nearly as abundantly as the Atlantic Interior or Southern Uplands.

The climate is conductive to farming; mainly beef or dairy herds, and forage and cereal crops. Forest are generally comprised of softwood, but tolerant hardwoods are found on well drained hills.

The PA is classed as well drained, fine textured soil on hummocky terrain that lies to the southern extent of the Central Lowlands, adjacent to the Rawdon/Whittenburg Bills and the Eastern interior Ecodistricts (Neily et al 2003)

Ecodistricts can often be subdivided into hydrologic units (basins) of common drainage areas. The Site is located in Shubenacadie River watershed. The Shubenacadie River watershed occupies approximately 205 $km^2$ in NS and drains to the north towards Cobequid Bay and the Bay of Fundy.

The Project has documented black ash across the PA, including a concentration of trees within the northwest corner, and several individual trees within the southern portion of the PA. One tree is located within the extents of the proposed open pit. This tree is proposed to be transplanted, in collaboration with the Mi’kmaq of Nova Scotia, in keeping with several other recent projects where transplantation of black ash has been allowed to support industrial and infrastructure development projects (Touquoy Gold Mine, Highway 104 and 107 upgrade projects).

A comprehensive monitoring program will be established to support Project development which will act as a research project relating to the required hydrologic regime required for the remaining black ash (all but one individual tree) that will be avoided by the Project.

### 2.1.3 Topography

Regionally, the PA is located between topographic highs of approximately 160 to 180 masl to the northeast and the southwest as shown on Figure 2.1a. In general, the regional topography slopes gently from the south in Central NS towards sea level (0 masl) at Cobequid Bay and along the lower reaches of the Shubenacadie River. Locally the PA topography is dominated by elliptical ridges of overburden and comparatively broad, flat areas along the flood plain of the Gays River, as shown on Figure 2.1b.

Locally, Project infrastructure is located on/near two topographic ridges that trend south to north and reach elevations of 50 to 75 masl. The area of the proposed open pit generally slopes to the west and to the north towards the Tailings Management Facility (TMF) for the Scotia Mine Limited (SML) property located directly north of the Project. The location of the proposed waste rock stockpile generally slopes to the east to northeast towards the Gays River.

In general, the Gays River flow along topographic lows with their flood plains ranging from approximately 14 to 16 masl. The river flood plains range from approximately 50 to 300 m in width (WCLSO, 1992). The largest flood plain is located within the main branch of the Gays River Valley downstream and to the northeast of the Site.

### 2.1.4 Surface Water Features

Figure 2.2 presents the surface water features surrounding in the Project and surrounding area. Regional surface water drainage is generally to the north along several stream/river channels and shallow lakes, and there are several low-lying wetlands adjacent to the Gays River and the SML’s TMF.

The PA is located within the Shubenacadie/Stewiacke watershed (Figure 2.3), a primary watershed mapped by Nova Scotia Environment and Climate Change (Nova Scotia Environment, 2021). Surface water in the PA and surrounding area is drained by the tributaries of the Gays River and South Branch Gays River. The Gays River and South Branch Gays River merge northwest of the PA and the Gays River continues to flow northwest, joining the Shubenacadie River which then flows to the tidal Minas Basin of the marine Bay of Fundy. The Gays River, TMF, and Lake Egmont are the most significant surface water features near the Project.

Subcatchment areas for the surface water features in the Project and surrounding area have been developed and are presented on Figure 2.3.

## 2.2 Geologic Conditions

GHD reviewed available regional and Project borehole logs (Appendix A) and reports to summarize geologic conditions encountered at the Site and surrounding area. In general, geologic conditions in the Project Area consist of variable Holocene to Cretaceous overburden deposits overlying bedrock that ranged in age from the Carboniferous aged Windsor Group to the Cambrian-Ordovician aged Goldenville Group of the Meguma Terrane. In the PA, the Windsor Group consists primarily of the carbonates of the Gays River Formation, and the gypsum/anhydrite of the Carrolls Corner Formation. The overburden geology and bedrock geology are discussed in Sections 2.2.1 and 2.2.2, respectively.

### 2.2.1 Surficial Geology

Regional surficial geology developed by the Nova Scotia Department of Natural Resources and Renewables (NSDNRR) (NSDNRR 2006a) is presented on Figure 2.4. As shown on Figure 2.4, the surficial geology generally consists of silty compact glacial till. The till is typically 3 to 30 m in thickness; however, greater thicknesses of till, in excess of 50 m, have been identified locally. Glaciolacustrine, glaciofluvial, alluvial and organic deposits are also identified along surface water bodies in low-lying areas. Near the PA, alluvial and organic deposits are most prevalent along the Gays River.

Consistent with the regional surficial geologic mapping, boreholes advanced through the overburden within the PA identified fine grained, compact and hard surficial soils consisting of silty sand to silt and clay, often brown to reddish brown in colour, which are interpreted to represent the regional glacial till (Appendix A). At TGI-GT-06, a shallow deposit of loose to compact sand and gravel was identified, however no other deposits of this kind were encountered in the PA. To the north of the PA, where alluvial deposits have been mapped along the Gays River, extensive sand units have been identified and mapped on SML Property. However, these units have not been mapped to extend into the PA.

Overburden thickness across the PA was estimated through extending the interpolated overburden thickness developed by Mercator (2023) using regional drillhole records obtained from the NS Drillhole and Drill Core Database (NSDNRR, 2024). The interpolated bedrock surface elevation is presented on Figure 2.5 and the estimated overburden thickness is presented on Figure 2.6. In general, the overburden thickness in the PA decreases along surface water features and increases in areas of higher elevation.

### 2.2.2 Bedrock Geology

Nova Scotia is divided into two distinct geologic parts, the Avalon Terrane to the north and the Meguma Terrane to the south. The two terranes are separated by the Minas Geofracture (commonly referred to as the Cobequid-Chedabucto Fault System) (Sangster and Smith, 2007). The oldest known rocks of the Meguma Terrane are the greywackes and argillites of the Cambrian to Ordovician aged Meguma Group, which were intruded by granitic plutons during the Devonian Acadian Orogeny (Duncan, 1987; and FSS International Consultants (Australia) Pty Ltd. [FSSI], 2015).

The Meguma Terrane consists of two major stratigraphic units: the basal greywacke dominated Goldenville Group; and the overlying, finer grained, argillite dominated Halifax Group. The Goldenville Group is at least 5,600 m thick, while the overlaying Halifax Formation averages approximately 4,400 m in thickness (FSSI, 2015).

The surface of the Goldenville Group has significant topographic relief within the PA and on SML property to the north. Where encountered during underground mining on the SML, the Goldenville Group was generally impervious and dry, with the exception of rare fracture zones (McKee and Hannon, 1985). The Goldenville Group forms a northeast to southwest trending ridge to the north of the PA as shown on Figure 2.7. This northeast to southwest trending ridge separates the Shubenacadie Basin to the northeast and the Musquodoboit Basin to the south (Kontak, 1998; Savard and Chi, 1998).

The Goldenville Group is conformably overlain by the Halifax Group which subcrops to the north and south of the PA. The Halifax Group consists of argillite, slate, siltstone, and minor sandstone. Along the contact between the predominantly metasandstone Goldenville Group and predominantly metasiltstone Halifax Group there is often a transition zone consisting of interbedded slate, metasiltstone, and metasandstone, in approximately equal amounts (Prime and White, 2007). Within the PA, the Halifax Group is not identified, and the Goldenville Group is unconformably overlain by the Carboniferous Windsor Group carbonates and gypsum/anhydrite evaporites of the Gays River and Macumber Formations, and the Carrolls Corner Formations respectively (WCLSO, 1992).

The Gays River Formation and its lateral equivalent, the Macumber Formation, form the basal carbonate units of the Windsor Group and consist primarily of dolostone and limestone. They formed as a coral reef facies on top of the erosional surface of the Goldenville Formation. A Basal breccia unit is often identified in drillhole logs at the contact of the Goldenville Group and Gays River Formation. North of the PA, the reddish brown fine-to-coarse grained sandstone of the Horton Group and Coldstream Formation are identified in drillhole records and bedrock geology maps; however, these geologic units are of limited extent compared to major geologic units identified within the PA.

The carbonate rocks of the Gays River and Macumber Formations are overlain by the evaporites of the Carrolls Corner Formation, which consists of gypsum, anhydrite, halite, and minor potash (Stantec, 2018). The evaporites are generally impervious but are soluble and prone to karst processes which create void spaces. To the south of the PA, as shown on Figure 2.7, the Meaghers Grant Formation is present in limited areas located between the Gays River and Carrolls Corner Formations. The Meaghers Grant Formation generally consists of sandstone, siltstone, and dark grey locally dolomitic shale. Numerous interbeds of gypsum or anhydrite occur in the transition zone with the Carrolls Corner Formation (NSDNRR, 2006).

Boreholes advanced into the bedrock in the PA (Appendix A) encountered gypsum of the Carrolls Corner Formation overlying alternating units of anhydrite, gypsum, and dolomite, belonging to the Gays River Formation. None of the boreholes advanced in the PA encountered bedrock belonging to the Goldenville formation. The boreholes in the PA were advanced to depths of 48 to 84 m below ground surface (BGS). Based on the lithological descriptions in the borehole logs, a thin layer of fractured, weathered bedrock is present at the bedrock/overburden contact.

Mercator (2023) developed a 3D geologic block model for the PA to represent the spatial variability of the bedrock units and to estimate the grade and tonnage of available mineral resources. The 3D block model was developed using regional geologic data obtained from exploration boreholes. GHD supplemented the 3D geologic model with additional geologic data from PA boreholes (Appendix A) and regional drillhole records obtained from the NS Drillhole and Drill Core Database (NSDNRR, 2024).

### 2.2.3 Structural Geology

The PA is located within the Cooks Brook Syncline which was defined by Giles and Boehner (1981) and run parallel to Chaswood Fault (Figure 2.7) located approximately 1 km north of the fault. The location of the northeast-trending Chaswood Fault passes through the PA; however, it has not been encountered through Project drilling to date and its location is poorly constrained.

## 2.3 Hydrogeologic Conditions

Regionally, the gently rolling topography of the Gays River watershed is the driving force behind groundwater flow. Groundwater recharge generally occurs on hills at higher elevations and discharges to surface water features in low lying areas. The highest hills in the southwest and northeast corners of the Gays River watershed likely act as significant recharge areas. WCLSO (1992) estimated that the topographic gradients vary between 0.015 to 0.15 and likely generate flow paths from recharge to discharge locations that are kilometres long and potentially hundreds of metres deep.

Within the local groundwater flow system, the geologic units identified in Sections 2.1 and 2.2 make up hydrostratigraphic units consisting of aquifers (which transmit groundwater) and aquitards (which provide resistance to groundwater flow). Based on the geologic and hydrogeologic data for the PA, groundwater flow in the area is inferred to take place within two main hydrostratigraphic units: a shallow overburden aquifer within the till, and a deeper aquifer within the carbonates and evaporites of the Gays River and the Carrolls Corner Formations. Groundwater flow within the deeper bedrock aquifer likely takes place in areas where karst processes have formed interconnected voids in the evaporites. These voids create preferential pathways which can transmit significant volumes of groundwater. The crystalline bedrock of the Goldenville Formation acts as an aquitard, restricting the lateral and vertical flow of groundwater.

Hydrogeologic investigations within the PA were ongoing at the date of preparation of this Report and the associated groundwater flow Model. Available groundwater elevation data within the PA consisted of two rounds of groundwater elevation monitoring at TGI-GT-02, TGI-GT-04, and TGI-GT-05. The first round of groundwater elevations were collected from August 16 through September 2, 2023, and the second round was completed on March 25, 2024. TGI-GT-02 is screened across the overburden/bedrock contact in sandy silt and gypsum while TGI-GT-04, and TGI-GT-05 are screened in the overburden in silt and silt/clay. Based on the available data, groundwater elevation in the overburden ranges from 25.4 to 43.76 masl (1.33 to 14.57 m below top of riser [BTOR]) and groundwater elevation in the upper bedrock ranges from 25.8 to 29.2 masl (5.84 to 9.24 m BTOR). Based on the two rounds of groundwater monitoring, average groundwater elevations were calculated at each PA monitoring location as presented in Table 2.2 Additional monitoring wells are being installed in the PA to expand the current monitoring well network and to further define hydrogeologic conditions in the PA. Pressure transducers will be installed in monitoring wells to support the future understanding of groundwater flow conditions in the PA, including seasonal variations in groundwater elevations.

To assess hydrogeologic conditions in the area surrounding the PA, GHD compiled groundwater elevation data collected between 2007 and 2022 at monitoring wells on the SML property. The SML monitoring wells range in location from within several hundred meters of the PA to over three kilometres away to the north.

Groundwater elevations at the SML monitoring wells were affected by pit dewatering activities between 2007 and 2009. Based on the long-term groundwater elevation monitoring data, groundwater elevations stabilized in 2012; therefore, to define average hydrogeologic conditions for the area, average annual water levels were calculated for 25 SML monitoring well locations from 2012 to 2022. Where a single groundwater elevation observation demonstrated a significant departure from the typical range in water elevations observed at a given location that observation was excluded from the average. Due to difference in measurement frequency at groundwater monitoring well locations, average annual groundwater elevations were calculated as the average groundwater elevation measurements collected during the wet season (January – June) and dry season (July – December) for each year, and an overall annual average was calculated for each well using the set of yearly annual averages. Table 2.2 presents estimated average annual groundwater elevations for SML monitoring wells.

Observed groundwater elevations at SML monitoring wells were also examined to estimate seasonal variations in groundwater elevations near the PA. On average, seasonal variations in groundwater elevations are typically on the order of one to two metres.

### 2.3.1 Hydrostratigraphic Units and Hydraulic Properties

For the specific purpose of hydrogeological modeling, hydrostratigraphic units were developed to group/simplify the geologic units described in Section 2.3 into hydrostratigraphic units of similar geologic characteristics and hydrogeologic properties. Hydraulic conductivity of the till overburden, fractured bedrock, and Carrolls Corner Formation were estimated using single well response tests and packer tests completed in PA boreholes and monitoring wells. The hydraulic conductivity estimates are presented in Table 2.3. The hydrostratigraphic units at and near the PA are summarized below.

**Till Overburden**

Hydraulic conductivity testing using single well response tests (i.e., slug tests) was completed by Ausenco in the monitoring wells installed in TGI-GT-02, TGI-GT-04, and TGI-GT-05. TGI-GT-04, and TGI-GT-05 are screened within the till overburden within sandy silt and silt and clay respectively. Hydraulic conductivity for the overburden at TGI-GT-04, and TGI-GT-05 was estimated by Ausenco (2024) to be $5.3 \times 10^{-7}$ m/s and $8.2 \times 10^{-8}$ m/s respectively, which is consistent with the hydraulic conductivity testing results completed within the till on the SML property to the north which ranged from $7.3x10^{-5}$ m/s to $1x10^{-10}$ m/s (WCLSO , 1992).

**Sand and Gravel Overburden**

As shown on Figure 2.4, glaciolacustrine, glaciofluvial, alluvial and organic deposits have also been identified along surface water bodies in low-lying areas; however, these units are generally located beyond project infrastructure. In particular, a large sand deposit was identified on the SML property that impacts groundwater elevation north of the PA as described by WCLSO (1992). Hydraulic conductivity testing was conducted on the glaciofluvial sand and gravel units encountered on the SML property and in general, the estimated hydraulic conductivity for the sands and gravels ranged from $2x10^{-4}$ m/s to $9x10^{-8}$ m/s.

**Weathered Fractured Bedrock**

TGI-GT-02 is screened at the base of the overburden across both a layer of sandy silt overburden and into the underlying gypsum. Hydraulic conductivity at TGI-GT-02 was estimated to be $1.9x10^{-4}$ m/s, which is over an order of magnitude higher than the range of hydraulic conductivity testing results from $1x10^{-5}$ m/s to $1x10^{-11}$ m/s for the gypsum at the SML property (WCLSO , 1992), and also above the range of hydraulic conductivity testing results for monitoring wells completed entirely within the till overburden.

The high hydraulic conductivity testing result at TGI-GT-02 suggests that there is potentially a layer of weathered fractured bedrock at the overburden/bedrock interface which is of higher hydraulic conductivity than the overlying overburden and the underlying competent bedrock. Therefore, the upper portion of bedrock is assigned is assumed to be a unique hydrostratigraphic unit consistent the hydraulic conductivity test results at TGI-GT-02 and the general trend that weathering is observed in the upper portion of the bedrock.

For the purpose of hydrogeological modelling the range of hydraulic conductivity values in the weather fracture bedrock is assumed to be between an order of magnitude above and two orders of magnitude below the hydraulic conductivity testing result at TGI-GT-02; however, additional hydraulic conductivity testing is strongly recommended to confirm the presence and extent of a higher hydraulic conductivity zone within the weathered, fractured upper bedrock.

**Carrolls Corner Formation**

A total of seven packer tests were complete in the bedrock were completed by Terrane Geoscience Inc. in boreholes TGI-PFS-GT-01, TGI-PFS-GT-05, and TGI-PFS-GT-06. The packer tests were performed at various depth intervals to estimate a potential range of hydraulic conductivity values within the dolomite, gypsum, karst fill, and anhydrite of the Carrolls Corner Formation. Hydraulic conductivity of the bedrock was estimated to be between $1.3x10^{-7}$ m/s and $4.1x10^{-10}$ m/s, with a geometric mean of $3.7x10^{-9}$ m/s.

**Gays River Formation**

No hydraulic conductivity testing was conducted in the Gays River Formation with the PA; however, hydraulic conductivity ranges are available from testing completed on the SML property to the north. Based on the hydraulic conductivity testing information presented by WLSCO (1992), the range in hydraulic conductivity values for the carbonates of the Gays River Formation is from approximately $1.6x10^{-4}$ m/s to $2.8x10^{-7}$ m/s.

**Goldenville Group**

No hydraulic conductivity testing was conducted in the Goldenville Group within the PA; however, hydraulic conductivity ranges are available from testing completed at the presented by WLSCO (1992) estimates that the range of hydraulic conductivity values for the quartzites and slates of the Goldenville Group is approximately from 2.2 $x10^{7}$ m/s to $6.4x10^{-9}$ m/s. Extensive hydraulic conductivity testing has been completed within the quartzites and slates of the Goldenville Group (GHD, 2022) which confirms that range of hydraulic conductivity values presented by WLSCO (1992) and demonstrates that, in general, the hydraulic conductivity of the Goldenville Group decreases with depth.

## 2.3.2 Groundwater Sinks

A groundwater sink is any feature that removes groundwater from the flow system. Within the PA area, the primary groundwater sinks correspond to groundwater discharge to surface water features. Groundwater discharge to surface water features is discussed in more detail in the following section.

### 2.3.2.1 Evapotranspiration

Evapotranspiration removes groundwater from the shallow groundwater flow system through transpiration by plants whose roots extend into the water table (i.e., phreatophytes) when groundwater is near ground surface. The rate of groundwater removal by evapotranspiration (which is the volume of water removed from the groundwater flow system per unit surface area of water table per day and near the Site has units of $m^3$/day) decreases with depth to groundwater as soils provide insulating conditions and plant root volumes diminish. That is to say that the maximum evapotranspiration rate occurs when the water table equals or exceeds the ground surface elevation. The evapotranspiration is zero when the water table is below the root zone. This depth is referred to as the extinction depth (EXD). Between ground surface and EXD the volumetric rate of water loss due to evapotranspiration varies linearly. The maximum potential evapotranspiration rates vary seasonally as presented in Table 2.1, and the average annual potential evapotranspiration rate is approximately 529.4 mm/yr with a annual range from approximately 476 mm/yr to 609 mm/yr across the 50-year historical climate dataset. Therefore, the groundwater loss due to evapotranspiration will vary seasonally, and based on the depth to the groundwater table, up to a maximum potential evapotranspiration rate of approximately 476 mm/yr to 609 mm/yr.

### 2.3.2.2 Discharge to Surface Water Features

Groundwater flow typically follows topographic relief, flowing towards surface water features in low lying areas. As presented on Figure 2.2, there are several surface water features located in the PA, including small streams and major features including the Gays River, SML's TMF, and Lake Egmont.

A set of surface water subcatchment areas were mapped for the Project and surrounding area to assess surface water flow under baseline conditions and potential changes that could result from the Project. The subcatchment areas are presented on Figure 2.3.

### 2.3.2.3 Discharge to the Mine Pit

The Project will involve excavation of a mine pit, which will extend below the groundwater table. The pit will act as a groundwater sink, receiving groundwater discharge. Under Post Closure (PC) conditions, the mine pit will be partially backfilled and allowed to fill with water, creating a lake.

## 2.3.3 Groundwater Sources

A groundwater source is any feature that contributes groundwater to the groundwater flow system. At the PA, the primary groundwater source is from groundwater recharge through precipitation infiltration. In some areas it is expected that groundwater will receive recharge from surface water bodies; however, surface water bodies overall are expected to receive net discharge from the groundwater flow system.

### 2.3.3.1 Net Recharge Through Precipitation Infiltration

As described in Section 2.1.1, the average annual precipitation in the area is 1459.2 mm per year. Precipitation falling onto the Site and surrounding area recharges the groundwater flow system through infiltration into the surficial soils. The amount of precipitation reaching the groundwater table (i.e., net recharge equal to precipitation infiltration minus actual evapotranspiration) is typically considered to range from approximately 10 to 40% of the average annual precipitation (Arnold et al., 2000; and Rushton and Ward, 1979). Based on the total annual precipitation of 1459.2 mm, the expected infiltration rate is 145.9 mm to 583.7 mm.

Baseflow often is used to estimate recharge rates, with the caveats that: 1) baseflow probably represents some amount less than that which recharges the aquifer; and 2) baseflow is best applied to provide a reasonable estimate of recharge occurring over long time periods (1-year or more) (Risser et al., 2005). To estimate recharge from baseflow, typically the total baseflow is divided by the area of the watershed.

Using a similar method, the NSDNR estimated recharge for primary watersheds across Nova Scotia (Kennedy et al., 2010). The average annual recharge rate calculated for the primary watershed within which the PA is located was estimated to be 180-220 mm per year. This range corresponds to approximately 13-16% of total annual precipitation.

#### 2.3.3.2 Recharge from Surface Water Features

In general, surface water bodies are expected to be a net groundwater sink, although there will be some losing reaches (i.e., sections where surface water recharges groundwater) along some surface water features. Surface water features will recharge groundwater in areas where groundwater levels fall below adjacent surface water elevations.

# 3. Hydrogeologic Conceptual Site Model

Understanding the hydrologic, geologic, and hydrogeologic conditions forms the basis for developing a conceptual understanding of the groundwater flow system. This conceptual understanding is the hCSM and it facilitates the assessment of potential impacts to groundwater resources that could result from development of the Project. Based on the available regional and Site-specific information, the hydrogeologic characteristics presented in Section 2 are summarized as follows:

– Based on available borehole records, and regional and Site-specific reports, the bedrock geologic conditions at the Site consist of the highly jointed quartzite of the Goldenville Formation overlain by the carbonates of the Gays River and Macumber Formations and the evaporites of the Carrolls Corner. The bedrock formations are generally overlain by a silty compact glacial till; however, significant glaciofluvial sand and gravel deposits have been identified in some areas along the Gays River. In general, the major hydrostratigraphic units at near the PA consist of the following:
    - Till overburden
    - Sand and gravel overburden
    - Weathered fractured bedrock
    - Carrolls Corner Formation
    - Gays River Formation
    - Goldenville Group
– Groundwater flow directions are interpreted to follow the rolling topography, from highland to lowland areas.
– The groundwater flow system receives recharge from precipitation infiltration.
– Surface water features are a net groundwater sink; however, changes to the groundwater flow system resulting from excavation of the mine pit may result in an increase of recharge from surface water features to groundwater, as groundwater levels near surface water features are reduced.
– Groundwater is removed through evapotranspiration.
– Throughout Project development, the proposed pit will act as a groundwater sink.

# 4. Simulation Program Selection

The simulation program selection to develop the numerical groundwater flow model for the Site was based on the following considerations:

– The ability of the program to represent key components of the hCSM.
– The demonstrated verification that the program correctly represents the hydrogeologic process being considered.
– The proven acceptance of the program by regulatory agencies and the scientific/engineering community.
– The ability of the program to represent proposed Project infrastructure.
– The ability of the program to provide a reasonable numerical solution in consideration of the complexity of the hydrogeological considerations at the Site.

## 4.1 Groundwater Flow Model

MODFLOW, developed by the United States Geological Survey (USGS), is capable of simulating steady-state or transient groundwater flow in one, two or three dimensions. MODFLOW uses a finite-difference method leading to a numerical approximation that allows for a description and solution of complex groundwater flow problems. A rectangular grid is superimposed over the study area to horizontally subdivide the region of interest into a number of rectangular cells. Layers are used to subdivide the study area vertically into units of common hydrogeologic properties. Groundwater flow is formulated as a differential water balance for every model cell and hydraulic head is solved at the center of every model cell. MODFLOW allows for the specification of flows associated with wells, areal groundwater recharge, rivers, drains, streams, and other groundwater sources/sinks.

MODFLOW-NWT (Niswonger, 2011) was selected to simulated groundwater flow for this modelling study due to its ability to efficiently solve complex groundwater flow simulations characterized by drying and rewetting of model cells such as that encountered in the simulation of pit dewatering. MODFLOW-NWT is a standalone version of MODFLOW-2005 (Harbaugh, 2005), which is an update to the original MODFLOW (McDonald and Harbaugh, 1988) and MODFLOW-2000 (Harbaugh et al., 2000). MODFLOW has been extensively verified and is readily accepted by many regulatory agencies throughout North America and Europe. MODFLOW-NWT is capable of representing the hydrogeologic components of the hCSM for the Project. The Newton Solver (NWT) and the Upstream Weighting (UPW) package included in MODFLOW-NWT was employed to solve the groundwater flow equation. For convergence, the solution technique required the satisfaction of both hydraulic head and flow residual criteria providing a rigorous and reliable simulated water balance throughout the model domain.

## 4.2 Parameter Estimation

The calibration of the groundwater flow model was aided through the use of the parameter estimation program PEST, which is an acronym for Parameter Estimation (Watermark Numerical Computing, 2018a and 2018b). PEST is a model-independent parameter estimator that has become a groundwater industry standard for groundwater model calibration. It has a powerful inversion engine, which provides the ability to set bounds on model input parameters such as hydraulic conductivity and groundwater recharge. PEST serves to convey input parameters at variable values within their bounds collectively to MODFLOW-NWT for the purpose of establishing optimal input parameter values for the specific groundwater model under development. For each run of input parameters, PEST calculates objective function values (OFVs) at model observation points or cells. OFVs represent the error of calculated versus observed groundwater elevations the numerous runs, PEST selects the run that exhibits the lowest overall OFVs as the optimal solution.

## 4.3 Graphical User Interface

The graphical user interface (GUI) Groundwater Vistas (Environmental Simulations, Inc., 2020) was used as the interface between the assembled hydrogeologic data and the required MODFLOW-NWT input files. The GUI facilitates pre- and post-processing of MODFLOW-NWT input/output files.

# 5. Groundwater Flow Model Construction

Groundwater flow model construction is the process of developing the horizontal and vertical discretization of the selected model domain, specifying hydraulic properties consistent with the hydrostratigraphic units, and implementing boundary conditions consistent with the hCSM. The groundwater flow model construction relative to these aspects is presented in the following sections.

## 5.1 Groundwater Flow Model Spatial Domain and Discretization

### 5.1.1 Spatial Domain

A groundwater flow model domain should extend to where reasonably defensible boundary conditions can be established. Model domain limits, and the associated boundary conditions, should be based on regional-scale natural hydrogeologic features where possible. The model domain limits, and the associated boundary conditions should be selected to minimize potentially incorrect bias in model predictions over the area of interest within the interior of the model domain[2].

The model domain developed for this modelling study is presented on Figure 5.1. As presented on Figure 5.1, the model domain extends to a maximum of approximately 14.7 km in the north-south direction and a maximum of 13 km in the east-west direction. The model domain is oriented with its axes aligned north-south and east-west.

No-flow boundary conditions are applied along the edges of the model domain. The no-flow boundary along the eastern and southern edges of the model corresponds roughly with the boundary of the Shubenacadie/Stewiacke watershed, and the western and no-flow boundaries along the western and northern edges correspond to the boundaries of surface water catchment areas as presented on Figure 2.3.

Vertically, the model domain extends from ground surface to elevations of approximately -352 to -527 m , where a no-flow boundary is inferred within the Meguma Group bedrock as the hydraulic conductivity of the Meguma Group typically decreases with depth and vertical groundwater flow is assumed negligible. Recharge and evapotranspiration boundary conditions are applied at the top of the model domain.

### 5.1.2 Spatial Discretization

A rectangular finite-difference grid was extended over the groundwater flow model domain. Details of the finite-difference grid are illustrated on Figure 5.2. Horizontally, the model domain is discretized into rows and columns. The finite-difference grid is extended over the model domain described in Section 5.1.1. A refined finite difference grid spacing of 10 m was applied over the PA. The grid spacing progressively increases to a maximum of 200 m to reduce computation time. The model domain is discretized horizontally into 494 rows and 448 columns.

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2 For example, specifying a constant head boundary condition located in close proximity to a pumping well when there is no physical basis to do so, such as in the absence of a major river or other surface water body nearby, could supply an unlimited amount of water to the well, thus introducing a reduced effect (i.e., a potentially incorrect bias) of the pumping on the simulated groundwater flow field.

Vertically, the model domain extends downward from ground surface. The vertical discretization of the model consists of 26 model layers to represent the major changes in lithology as represented in the 3D geologic model as well as to provide sufficient vertical resolution to represent proposed Project infrastructure including the pit. For model layer 1, the layer top corresponds to ground surface and the layer bottom corresponds to the interpolated top of bedrock surface. For model layers 2-26, uniform thicknesses were applied as follows:

- Layers 2-14 (5 m)
- Layers 14-17 (10 m)
- Layer 18 (20 m)
- Layers 19-20 (30m)
- Layers 21-22 (40 m)
- Layers 23-26 (60 m)

An east-west cross-section through the PA showing the vertical discretization of the finite difference grid is presented on Figure 5.3.

## 5.2 Groundwater Flow Model Boundary Conditions

Model boundary conditions are assigned in the groundwater flow model to represent the groundwater sources and sinks described in Sections 2.3.2 and 2.3.3. Model boundary conditions applied to represent baseline conditions are shown on Figure 5.4. Figures 5.5 through 5.7 show the model boundary conditions used to represent the proposed Phase 1b features. Figures 5.8 through 5.11 show the boundary conditions used to represent the proposed end of mine (EOM) conditions. Figures 5.12 through 5.15 show the boundary conditions used to represent the proposed post closure (PC) conditions.

The boundary conditions for the groundwater flow model consist of the following:

- River boundary conditions to represent surface water features that could potentially receive groundwater discharge or supply groundwater recharge (e.g., Gays River, SML's TMF, Lake Egmont, and streams greater than 1 m in width)
- Drain boundary conditions to represent surface water features that could potentially receive groundwater discharge but are unlikely to act as a supply of groundwater recharge (e.g., small ephemeral streams less than 1 m in width).
- Horizontal no-flow boundary conditions to represent the inferred edges of the active groundwater flow system along the watershed boundaries as discussed in Section 5.1.1.
- Recharge and evapotranspiration over the top of the model domain to represent net groundwater recharge due to precipitation infiltration.
- Vertical no-flow boundary condition at depth corresponding to the inferred base of the active groundwater flow system within the Goldenville Group bedrock.

With respect to the predictive simulations of the open pit conditions (EOM), and pit lake conditions (PC), the following additional boundary condition types are used:

- A drain boundary condition was used to represent the seepage face of the open pit mine under EOM conditions, and to represent the seepage face of the open pit above the specified pike lake elevation under PC conditions.
- A constant head boundary is specified to simulate pit lake elevations under PC conditions. The constant head boundary cells were assigned a stage equal to the expected water level of the pit lake (25 m AMSL).

### 5.2.1 River Flux Boundary Conditions

A river boundary can simulate the interaction between surface water and groundwater. It can represent both groundwater discharge to surface water (i.e., a gaining stream) and groundwater recharge from surface water (i.e., a losing stream). If a specified river stage elevation is lower than the simulated groundwater elevation, the river boundary receives discharge from groundwater. If the specified river stage elevation is higher than the simulated groundwater elevation, the river boundary serves as a source of recharge to groundwater. The quantity of surface and groundwater exchange is equal to the difference between the simulated groundwater elevation within the river cell and the specified head within the river cell multiplied by a conductance term. The conductance term reflects the relative ease of groundwater flow through sediments or bedding material that form the base of the surface water body.

As shown on Figure 5.4, river boundary conditions were assigned to represent natural surface water features located within the active model domain. The river cell stage elevations were assigned as 1 m below ground surface elevation. The conductance term for the river cells was estimated using:

$$C_{River} = \frac{KA}{M}$$

Where:

| | | |
|---|---|---|
| $C_{River}$ | = | river cell conductance (square metres per day [$m^2$/d]) |
| K | = | hydraulic conductivity of streambed sediments (metres per day [m/d]) |
| A | = | area of the river cell (square metres [$m^2$]) |
| M | = | thickness of the riverbed material (m) |

For larger surface water bodies (i.e., wider water bodies like the Gays River) that encompass multiple model cells, the river cell area was calculated as the model cell area, or the portion of the surface water body contained by the river cell. For narrow surface water bodies (i.e., small streams), the river cell area was calculated as the length of the stream within the river cell multiplied by the stream width estimated from satellite imagery. The streambed thickness was assumed to be 1 m for lakes and 0.3 m for rivers and streams. The hydraulic conductivity of the streambed sediments was adjusted during model calibration.

### 5.2.2 Drain Boundary Conditions

A drain boundary condition simulates groundwater/surface water interaction in terms of groundwater discharge only. Unlike a river boundary condition, a drain boundary condition cannot represent a losing stream condition where surface water recharges groundwater. The drain boundary condition is active if the specified drain stage elevation is lower than the simulated groundwater elevation, and inactive when the specified drain stage elevation is higher than the simulated groundwater elevation. Similar to river cells, the quantity of groundwater discharge to the drain boundary is equal to the difference between the simulated groundwater elevation within the drain cell and the specified drain stage elevation multiplied by a conductance term.

Drain boundary conditions were applied to simulate the small ephemeral streams in the area surrounding the PA. satellite imagery was reviewed to identify streams less than 1 m in width, which were assumed to be ephemeral.

The conductance term for drain cells assigned to represent the small streams was determined during Model calibration. The area of the drain cell was calculated based on the length of the stream specified within the drain cell multiplied by an assumed width of 1 m. The hydraulic conductivity used to calculate the conductance term is the same as that used for the river cell streambed sediments and the thickness of streambed sediments is assumed to be 0.3 m.

A drain boundary condition was also applied to represent the seepage face of the open pit mine under Phase 1b, EOM, and PC conditions.

A drain boundary condition was applied along the seepage face of the open pit wall to simulate the open pit above specified pit lake stage elevations. The drain cell stage elevations above the specified pit lake stage were set based on the elevation of the proposed pit walls. The drain conductance was set to a high value of 1,000 $m^2$/d to ensure that any groundwater entering a drain cell along the open pit wall would discharge to the open pit without resistance (when the groundwater elevation is above the drain stage elevation).

### 5.2.3 Constant Head Boundary Condition

A constant head boundary (CHB) condition was assigned to represent the open pit below the simulated pit lake stage elevation under PC conditions. The CHB condition requires specifying a hydraulic head value and a conductance term for each model cell where the boundary is applied. The hydraulic head values were set equal to the simulated pit lake stage elevation, and the conductance term was set to a high value of 1,000 $m^2$/d to ensure that any groundwater entering a CHB cell along the open pit wall would discharge to the open pit without resistance (when the groundwater elevation is above the hydraulic head value).

### 5.2.4 No-Flow Boundary Conditions

No-flow boundary conditions were applied where negligible groundwater flow across a model boundary can reasonably be expected.

No-flow boundary conditions are specified at the boundaries of the watershed and surface water catchments as described in Section 5.1.1. These boundaries represent topographic highs where groundwater is expected to flow downslope creating a groundwater flow divide with negligible groundwater flow across the divide (the divide is assumed to correspond to a line drawn between the watersheds/catchments). A no-flow boundary is assigned at the bottom of the model domain where it is assumed that the permeability of Goldenville Group bedrock is sufficiently low such that vertical flow is negligible.

### 5.2.5 Recharge and Evapotranspiration

Recharge from precipitation infiltration and evapotranspiration are applied as the top model domain boundary condition. As described in Section 2.3.2.1, potential evapotranspiration is expected to range from 476 mm/yr to 609 mm/yr. Net groundwater recharge (i.e., recharge minus actual evapotranspiration) is expected to range from between 145.9 mm to 583.7 mm (Section 2.3.3.1) and is likely towards the lower end of that range based on the precipitation infiltration estimate for the watershed developed by Kennedy (2010) which ranged from 180-220 mm/year.

The amount of precipitation reaching the groundwater table depends on factors including topography, shallow soil types, ground cover and land use (i.e., vegetation, or building/pavement coverage), season, and weather conditions. The ground cover and land use is consistent throughout the PA; therefore, a single uniform recharge rate was applied over the entire model domain. The recharge rate applied in the model was adjusted during model calibration as described in Section 6.

## 5.3 Model Hydraulic Conductivity Distribution

The hydraulic conductivity zones were assigned in the model to represent each of the major hydrogeologic units identified in the hydrogeologic conceptual site model. Two hydraulic conductivity zones was assigned in model layer 1, one zone to represent the till overburden and a second zone to represent the area of the SML property where surficial sands have been identified. Hydraulic conductivity zones were assigned for each of the bedrock units identified in the 3D geologic model, representing the evaporites, carbonates, and crystalline bedrock of the Carrolls Corner, Gays River, and Halifax/Goldenville Formations, respectively. The hydraulic conductivity value for each unit was adjusted during model calibration within reasonable bounds based on the results of the hydraulic conductivity testing conducted within each hydrogeologic unit (see Tables 2.2), as well as values available in published literature consistent with the geological materials that make up each unit.

## 5.4 Groundwater Flow Simulation Method

As described in Section 6, groundwater flow was simulated under transient conditions during model calibration. The steady-state groundwater flow equation was solved using the GMG solver implemented in MODFLOW-NWT. The convergence criteria for the NWT solver were specified as 0.0001 metres for the maximum head change criteria and 160 cubic metre per day for the maximum flow residual throughout the model domain.

# 6. Conceptual Groundwater Flow Model Calibration

A conceptual groundwater flow model calibration was conducted to select parameter values that provide a conservative bias with respect to the prediction of potential Project impacts on groundwater quantity and represent the range of groundwater elevations observed near the Project.

## 6.1 Calibration Targets

Selection of calibration target datasets normally considers whether the available groundwater elevation monitoring captures the following:

– Represents the range in groundwater flow conditions (i.e., seasonal variations) observed at the PA area, typically consisting of a base case (i.e., average) condition, and wet and dry conditions.
– Groundwater stresses/boundary conditions represent the range of conditions affecting groundwater elevations and flow directions.
– Provides spatial coverage of the model domain with measurements at the majority of the available monitoring well locations.
– Includes the key area of interest within the model domain.

As described in Section 2.3, within the key area of interest (i.e., the PA), groundwater elevation data available for model calibration consisted of two rounds of groundwater elevation monitoring completed at three monitoring well locations in August/September 2023 and March 2024. Due to variation in observed groundwater elevations and the collection data during two monitoring periods in separate years, seasonal variation in groundwater elevations cannot be determined from present PA groundwater monitoring data. Therefore, the groundwater elevations collected at the PA were averaged to develop assumed steady-state targets.

Groundwater elevation data is also available for the adjacent SML property. The SML monitoring wells are applicable to the PA because several wells on the SML property are installed in close proximity to the PA near SML's tailings management facility (TMF) within the same overburden deposit which overlies the PA. SML monitoring wells located farther from the PA also provide regional context for groundwater elevations overserved with the PA. Groundwater elevation data has been collected on the SML property from 2007 to 2022 on a monthly to semi-annual basis. Dewatering occurred in the open pit on the SML property from 2007 to 2009, and recovery of groundwater elevations continued through 2011. Since 2012, groundwater elevations have remained relatively consistent on the SML property (GHD, 2024). Therefore, average groundwater elevations from 2012 through 2022 were calculated and combined with average PA groundwater elevations to develop steady-state groundwater elevation targets for calibration. The locations of the calibration targets are presented on Figure 6.1.

As shown on Figure 6.1, good coverage of the model domain is provided to the northwest of the PA by data collected on the SML property; however, available groundwater elevation targets provide poor coverage over the PA with only three target locations. The limitations of the calibration dataset are addressed through the calibration methodology discussed in Section 6.3. Since the steady-state calibration dataset does not include seasonal variation, a sensitivity analysis is conducted to examined potential ranges in model prediction related to seasonal changes in groundwater recharge as described in Section 7.4.

Given the limitations of the calibration dataset due to the number of monitoring wells installed within the PA and only having two sets of manual measurements collected at each well, groundwater elevations within the PA are not well defined. Therefore, the model calibration was completed solely to confirm that groundwater elevations were within reasonable ranges. Model parameters were adjusted to approximately observed groundwater elevations while providing a conservative bias in model predictions through increasing overburden hydraulic conductivity towards the upper bounds. As such that calibration should be considered conceptual in nature and for the specific purpose of providing a conservative estimate of potential impacts of the Project, and not to provide a robust representation of the PA groundwater flow system.

## 6.2 Conceptual Calibration Methodology

To address limitations in the model calibration dataset, related to the spatial coverage over the PA and the number of groundwater elevation monitoring events completed in the PA, the model calibration was conducted to provide a conservative bias with respect to the prediction of potential Project impacts on groundwater quantity. To provide a conservative bias in model predictions, an emphasis was placed on selecting higher hydraulic conductivity values for the till overburden. The nearest receptors to the Project are surface water bodies, which are located within the till overburden. The lower permeability till overburden can hydraulically isolate surface water bodies from Project infrastructure including the open pit. Increasing the hydraulic conductivity of the till overburden increases the interaction of those surface water bodies with the open pit, thereby providing a conservative bias with respect to the prediction of Project impacts on surface water bodies. Therefore, the model calibration is referred to as “conceptual” as emphasis is placed on selecting model parameters that will provide a conservative bias with respect to model prediction versus placing emphasis on representing the limited PA to the extent practicable. The model calibration targets are only applied to confirm that the simulated groundwater elevations are, in general, within the range of observed groundwater elevations near and within the PA.

The groundwater flow field throughout the model domain was simulated under steady-state conditions for the steady-state calibration target dataset. The solution to the groundwater flow equation was obtained using a numerical solver with specified convergence criteria. As described in Section 4.1, the NWT solver and the UPW package implemented in MODFLOW-NWT was used. The convergence criteria between successive solver iterations was specified as 0.0001 m for the maximum hydraulic head change, and 160 $m^3$/d for the maximum flow residual throughout the model domain.

Model calibration was performed in an iterative manner by adjusting the hydraulic conductivity values per geologic unit, recharge rate, and the hydraulic conductivity of the streambed sediments for river cell boundary conditions. PEST was applied to aid the model calibration process as an automated means to optimize model input parameter values within reasonable or expected ranges.

The model calibration was evaluated both qualitatively and quantitatively. Qualitative evaluations included visually comparing the simulated versus observed groundwater elevations and conceptual groundwater flow directions, as well as the spatial distribution of calibration residuals, or error in matching the calibration targets. Calibration residuals are calculated as the observed groundwater elevation minus the simulated groundwater elevation at each calibration target location. A negative residual value indicates that the observed groundwater elevation is over-predicted, and a positive residual value indicates that the observed groundwater elevation is under-predicted. Qualitative measures also included reviewing model parameter values to ensure that they were within expected ranges and selected to provide a conservative bias with respect to model predictions.

The quantitative assessment of the calibration was conducted by examining the calibration residual statistics. Statistics such as the mean residual, absolute mean residual, sum of the residual values squared (referred to as the 'residual sum of squares'), and residual standard deviation, were calculated to quantify an overall measure of the discrepancy between observed and simulated groundwater elevations provided by the calibrated model. The objective of the model calibration is to minimize these residual statistics while maintaining parameter values that are within expected ranges and provide a conservative bias with respect to model predictions.

A further quantitative measure of the calibration was provided by the simulated volumetric water budget report by MODFLOW-NWT, indicating the quantities of flow into and out of the model domain via groundwater flow components specified in the model. The volumetric budget was reviewed to ensure that the total inflows and outflows were consistent with the hCSM (i.e., there is a net outflow of groundwater to the surface water bodies) and to ensure that the discrepancy between simulated inflows and outflows is less than 1%, indicating that a satisfactory numerical convergence was obtained for the solution of the groundwater flow equation.

## 6.3 Calibration Results

Figure 6.2 and Table 6.1 present the calibration targets and residuals at each target location. A scatter plot of observed versus simulated groundwater elevations are presented on Figure 6.3. The residuals are calculated as the observed groundwater elevations minus the simulated groundwater elevations. Figure 6.3 shows that there is a reasonable distribution between positive and negative residuals; however, groundwater elevations are on average overpredicted.

The residual statistics for the calibrated baseline model are summarized on Figure 6.3. the calibrated model produced a residual mean of -1.96 m (i.e., overprediction compared to observed target values), an absolute residual mean of 2.77 m, a residual sum of squares of 316 $m^2$, with a residual standard deviation of 3.58 m. These residual statistics were minimized during the model calibration process while maintaining a reasonable representation of observed groundwater conditions consistent with the hCSM and foremost, selecting parameter values that provided a conservative bias with respect to model predictions.

The residual standard deviation of the calibrated baseline model is approximately 12% of the range of measured groundwater elevations, as indicated on Figure 6.3. Spitz and Moreno (1996) suggest that the residual standard deviation should be less than about 10% of the range in measured target groundwater elevations. The residual standard deviation for the calibrated model lies slightly above this metric, which is generally reasonable given the conceptual nature of the model calibration given the sparsity of observed groundwater elevations within the PA and the emphasis on selecting model parameter values to provide a conservative bias with respect to model predictions.

The volumetric water budget for the calibrated baseline model was examined for the model calibration. A discrepancy of close to zero occurs in the water budget between the simulated inflow and outflows, which demonstrates that good numerical convergence was achieved throughout the model domain. The calibrated model estimated that the effective or net recharge over the entire model domain is equal to 150 mm/year which is comparable with the estimated recharge in the area (180 – 220 mm/year).

Table 6.2 shows the calibrated parameter values applied during model calibration. In general, the bounds for hydraulic conductivity values were determined from the hydraulic conductivity values obtained from the slug tests, packer tests conducted at monitoring wells in the PA, and literature values. The recharge bounds were set based on the expected recharge value described in Section 2.3.3.1. The hydraulic conductivity of the overburden was adjusted to $3.47 \times 10^{-6}$ m/s, which is within the estimated parameter range considering hydraulic conductivity testing data from the SML property, and approximately an order of magnitude above the hydraulic conductivity test results for monitoring wells installed entirely within the overburden in the PA. A higher hydraulic conductivity value is conservative with respect to the simulation of potential Project impacts as it increases simulated inflow into the pit, thereby increasing the simulated baseflow reduction in surface water bodies and the extent of the simulated radius of influence.

A horizontal to vertical hydraulic conductivity anisotropy ratio of 10:1 was applied in the overburden to represent horizontal stratification of the till overburden. A horizontal to vertical hydraulic conductivity anisotropy ratio of 2:1 was applied in bedrock to represent the relatively uniform vertical to horizontal hydraulic characteristics of the bedrock.

In summary, the groundwater flow model was conceptually calibrated to provide a conservative bias with respect to potential Project impacts while providing an approximation of observed groundwater elevations within the limitations of the observed data. Thus, the conceptually calibrated groundwater model is appropriate for the purpose of simulating potential Project impacts. The conceptually calibrated groundwater model should not be applied for other purposes.

# 7. Groundwater Flow Model Application

As described in Section 1.2, the primary objectives of this modeling effort include simulating predictive scenarios to estimate the following:

1. Groundwater drawdown under Phase 1b, EOM, and PC conditions
2. Changes in groundwater discharge to surrounding surface water bodies under Phase 1b, EOM, and PC conditions

GHD implemented the Phase 1b, EOM, and PC scenarios in the calibrated model to simulate potential impacts of the Project. Where appropriate, predictive simulation results are compared against spatial boundaries to assess the extent and significance of potential impacts. Implementation of the Phase 1b, EOM, and PC scenarios in the calibrated groundwater flow model is described in Sections 7.1. Sections 7.2 and 7.3 present the definition of spatial boundaries to assess the potential impacts of the Phase 1b, EOM, and PC scenarios. Section 7.4 presents the results of the predictive simulations.

## 7.1 Predictive Scenario Implementation

Phase 1b, EOM, and PC conditions were simulated by incorporating the proposed mine pit into the calibrated model. The proposed pit was represented by specifying drain boundary cells along the perimeter of the pit and setting internal model cells within the pit to no-flow boundaries. An additional hydraulic conductivity zone (zone 11) was added to the predictive models to represent the backfill material that will be added to the pit. The zone representing backfill was assigned a hydraulic conductivity of 10x the till overburden based on the assumption that the backfill material will be composed partially of excavated backfill material.

For the predictive simulations representing PC conditions, constant head boundary cells were added to the perimeter of the pit to represent the pit lake. The constant head boundaries were assigned a stage of 25.1 m, consistent with the water level elevation of the proposed pit lake.

Each predictive scenario was completed assuming steady-state conditions to simulate the maximum potential changes to groundwater conditions under each scenario. Steady-state conditions are considered conservative because the actual groundwater elevation drawdown may not reach steady-state conditions during operations and subsequent filling of the pit.

### 7.1.1 Estimation of Drawdown under Phase 1b, EOM, and PC Conditions

Simulated drawdown was estimated by comparing simulated groundwater elevation contours under the calibrated baseline conditions against groundwater elevations simulated for Phase 1b, EOM, and PC conditions. Each comparison was completed assuming steady-state conditions to simulate the maximum potential drawdown under each scenario. Steady-state conditions are considered conservative because the actual drawdown may not reach steady-state conditions during operations and subsequent filling of the pit. To estimate drawdown for each condition, simulated groundwater elevation contours under Phase 1b, EOM, and PC conditions were subtracted from simulated groundwater elevation contours for the calibrated baseline model.

### 7.1.2 Simulated Change in baseflow under Phase 1b, EOM, and PC Conditions

Changes in baseflow (i.e., groundwater discharge) to surface bodies in the PA and surrounding area were estimated by comparing simulated groundwater discharge rates to surface water bodies under the calibrated baseline conditions against the Phase 1b, EOM, and PC conditions. The simulated baseflow was calculated through a mass balance of river and drain boundary conditions within each of the surface water catchment areas shown on Figure 2.3 (i.e., baseflow is equal to the net discharge of groundwater to the river and drain boundary conditions within each subcatchment area). The simulated baseflow at Phase 1b, EOM, and PC was subtracted from the simulated baseflow of the calibrated baseline conditions to estimate potential changes.

# 7.2 Spatial Boundaries

The spatial boundaries considered in the evaluation of potential groundwater impacts resulting from the Project are the PA, LAA, and RAA. The PA, LAA, and RAA boundaries are presented on Figure 1.2. The PA encompasses the proposed mine features including the open pit, stockpiles, and on-site Haul Road. The LAA encompasses an 800 m buffer from the PA, typically applied by the Province of Nova Scotia with respect to blasting for mining and construction projects. The RAA aims to account for the maximum extent of potential groundwater impacts, and roughly corresponds to the extent of the active groundwater flow domain.

# 7.3 Scenario Simulation Results

## 7.3.1 Simulated Drawdown

Figures 7.1, 7.2, and 7.3 present the simulated drawdown under Phase 1b, EOM, and PC conditions. As shown on Figures 7.1, 7.2, and 7.3, the greatest drawdown extent (i.e., radius of influence) is simulated under EOM conditions. This is expected as the EOM conditions correspond to the maximum extraction and dewatering. As shown on Figure 7.2, the maximum drawdown extent under EOM conditions extends approximately 800 m to the northeast and 700 m to the southwest of the proposed pit and is generally confined to within the LAA. The maximum drawdown extent under all three conditions is contained within the RAA and does not overlap with any nearby water supply wells. As shown on Figure 7.3, the maximum predicted drawdown extent decreases under PC conditions compared to EOM conditions due to the partial filling of the pit with water under PC conditions.

## 7.3.2 Simulated Change in Baseflow

Table 7.1 presents the simulated changes in baseflow relative to the conceptually calibrated baseline model for each surface water subcatchment area under Phase 1b, EOM, and PC conditions. A shown on Table 7.1, the simulated change in baseflow ranges from 0 to 587% for Phase 1b, 0 to 652% for EOM, and 0 to 100% for PC conditions. The largest changes in baseflow are simulated under EOM conditions, which is expected as EOM conditions correspond to maximum extraction and dewatering and are simulated to result in the largest groundwater elevation drawdown.

The largest relative changes in baseflow occur in subcatchments S05 and S04A. There is only one surface water feature represented in subcatchment S05, a small pond located northwest of the pit. Under baseline conditions, the pond is simulated to have a net baseflow of -5 $m^3$/day (i.e., the pond is discharging to groundwater). Under Phase 1b, EOM, and PC conditions, the net baseflow of the pond is -38 $m^3$/day, -41 $m^3$/day and -11 $m^3$/day respectively, indicating that the rate of discharge to groundwater increases, but the overall rate of discharge to groundwater remains low. Subcatchment S04A is located immediately to the northwest of the proposed pit and includes the SML Polishing Pond and surrounding streams. Under baseline conditions, the surface water features in S04A receive a net baseflow of 103 $m^3$/day. Under Phase 1b and EOM conditions, simulated groundwater elevation drawdown in this area creates a strong hydraulic gradient in the area between S04A and the open pit. The drawdown and hydraulic gradient away from S05 result in a net baseflow of -154 $m^3$/day and -302 $m^3$/day for Phase 1b and EOM conditions respectively. Under PC conditions, S04A experiences a simulated baseflow reduction of 86% but maintains a net baseflow of 15 $m^3$/day.

The largest absolute predicted changes in baseflow occur in subcatchment S03 is located in the southeastern portion of the PA. simulated baseflow in S03 decreases from 785 $m^3$/day in the calibrated baseline model to 261 $m^3$/day under phase 1b, 60 $m^3$/day under EOM, and 136 $m^3$/day under PC conditions. Subcatchment S03 contains several small streams within the footprint of the proposed pit. The large change in baseflow rates in S03 partially attributed to the removal of drain boundary cells representing streams in the proposed pit footprint.

Subcatchments S01, S02, S06, S07, S10, S12, and S17 experience simulated baseflow reductions of 3% to 98% under Phase 1b, 12% to 102% under EOM, and 4% to 63% under PC conditions. These subcatchments are located within and immediately surrounding the PA and proposed pit footprint and are expected to experience reductions in baseflow as they are within the groundwater elevation drawdown radius for the simulations as presented on Figures 7.1, 7.2, and 7.3. With the exception of the S17 subcatchment, which has a simulated net baseflow of -2 $m^3$/day under EOM conditions, all of these subcatchments maintain positive baseflow rates under Phase 1b, EOM, and PC conditions.

Minimal changes in baseflow are estimated for the subcatchments that are not located immediately adjacent to the proposed pit. Baseflow reductions of 0 to 6% are estimated for subcatchments S04B, S04C, S04D, S08, S09A, S09B, S09C, S11, S13A, S13B, S13C, S14A, S14B, S14C, and S15. These subcatchments are not expected to experience significant changes in baseflow due to their distance from the proposed pit and the simulated groundwater elevation drawdown extent.

## 7.4 Scenario Simulation Uncertainty Analysis

GHD conducted an uncertainty analysis of the calibrated model to evaluate the potential impact of parameter changes on the calibrated model results and to address uncertainties associated with the model input parameters. A total of 3 model input parameters were considered in the uncertainty analysis: recharge, evapotranspiration, and hydraulic conductivity representing the overburden, fractured bedrock, and Carrolls Corner Formation.

A series of uncertainty simulations were conducted for the baseline, Phase 1b, Phase 2 EOM, and Phase 2 PC conditions. Each input parameter value was adjusted while holding all other input parameter values constant with those specified in the calibrated model. The value of each parameter was adjusted by a specified percentage above and below the value specified in the calibrated model.

A total of 10 uncertainty simulations were conducted for each of the four conditions:

1. Recharge increased by 25%
2. Recharge decreased by 25%
3. Evapotranspiration increased by 25%
4. Evapotranspiration decreased by 25%
5. Overburden hydraulic conductivity increased by 20%
6. Overburden hydraulic conductivity decreased by 20%
7. Fractured bedrock hydraulic conductivity increased by 20%
8. Fractured bedrock hydraulic conductivity decreased by 20%
9. Carrols Corner hydraulic conductivity increased by 20%
10. Carrols Corner hydraulic conductivity decreased by 20%

### 7.4.1 Baseflow

The simulated baseflow reduction for each subcatchment under the uncertainty analysis simulations discussed in Section 7.4 are presented in Table 7.2. The results presented in Table 7.2 indicate that baseflow rates to surface water features in most subcatchments are sensitive to recharge, evapotranspiration, hydraulic conductivity of the overburden units (zones 1 and 10), and hydraulic conductivity of the fractured bedrock unit (zone 9). Baseflow rates are insensitive to hydraulic conductivity of the Carrolls Corner unit (zones 3, 4, 5, 6).

As shown in Table 7.2, predicted changes in baseflow under Phase 1b, EOM, and PC conditions vary slightly compared to the calibrated model with changes to the input parameters. With the exception of subcatchment S04A and S05, the simulated changes in baseflow in all subcatchments is within 20% of the predicted changes under the calibrated model. As discussed in Section 6.3.2, subcatchments S04A and S05 are predicted to experience large changes in baseflow under Phase 1b, EOM, and PC conditions due to the changes in hydrogeologic conditions around the SML Polishing Pond (S04A) and removal of small surface water features within the proposed pit footprint (S05).

For most subcatchments, an increase in the recharge rate or decrease in the evapotranspiration rate (which result in more water added to the model) results in smaller reductions in baseflow compared to baseline conditions. Decreasing recharge or increasing evapotranspiration (which results in less water added to the model) results in larger reductions in baseflow for most subcatchments. Decreasing the recharge rate or increasing the evapotranspiration rate would be a conservative approach as it would result in larger predicted baseflow reduction; however, as presented in Table 6.2, the effective recharge rate of the calibrated model (150 mm/year) is at the low end of the expected range (145.9 – 583.7 mm/year). Decreasing the recharge rate of increasing the evapotranspiration rate would reduce the effective recharge of the model to a level outside of the expected range.

Increases to the hydraulic conductivity of the overburden units (zones 1 and 10) and fractured bedrock (zone 9) similarly result in small changes to predicted baseflow change for most subcatchments. The relative change in predicted baseflow varies from subcatchment to subcatchment and is influenced by the relative thickness of the overburden layer. Changes to the hydraulic conductivity of the Carrolls Corner unit (zones 3, 4, 5, 6) have minimal effects on predicted changes in baseflow). As presented in Table 6.2, the calibrated hydraulic conductivity values of the overburden and fractured bedrock units are within their expected ranges. Increasing the hydraulic conductivity of either unit would likely result in unrealistic dewatering the overburden under baseline conditions, inconsistent with observed groundwater elevations which indicate that the groundwater table is generally within the overburden under baseline conditions.

# 8. Summary

GHD developed a 3D numerical groundwater flow model to represent the geologic and hydrogeologic conditions within the overburden and bedrock observed at the Project and surrounding area for the specific purpose of providing a conservative estimate of potential Project impacts. The 3D groundwater flow model is based on a hCSM GHD developed for the Project area to facilitate representation of the observed hydrogeological conditions. The groundwater flow model was developed using the USGS's MODFLOW NWT groundwater flow computer program. The sparsity of groundwater elevation data within the PA precluded the development of a robust model calibration to represent baseline conditions; therefore, GHD conceptually calibrated the groundwater flow model to provide a reasonable representation of observed ranges in groundwater elevations with an emphasis placed on applying a hydraulic conductivity value for the overburden towards the upper end of the observed range to provide a conservative bias with respect to the prediction of potential Project impacts on groundwater quantity.

The model input parameters (e.g., hydraulic conductivity and recharge) applied in the calibrated model are consistent with observed Project conditions, with the overburden hydraulic conductivity assigned a value an order of magnitude above the observed range in the PA, but within the range of till overburden hydraulic conductivity values for the region.

GHD applied the conceptually calibrated model to simulate changes to hydrogeological conditions under Phase 1b, EOM, and PC conditions. The conceptually calibrated model was applied to estimate the extent of groundwater elevation drawdown resulting from excavation of the proposed pit, and changes in baseflow to surface water features in the surrounding area. Model simulations representing EOM conditions resulted in the largest simulated groundwater elevation drawdown extent (i.e., radius of influence) and changes to baseflow in surface water subcatchment areas.

GHD conducted an uncertainty analysis on changes in simulated baseflow to assess potential impacts of model parameters on baseflow results. The analysis demonstrates that the percent change in baseflow from simulated baseline conditions under Phase 1b, EOM, and PC conditions is sensitive to model input parameters including recharge, evapotranspiration, and hydraulic conductivity of the overburden and fractured bedrock units. Changes to these input parameters would significantly affect predicted baseflow reduction but would result in model parameters that diverge from expected rates or calibration results that diverge further from observed groundwater elevation conditions.

Model development and predictive scenario analysis is based on data available at the time of model development. As discussed in Section 6, model development and calibration were completed with a limited set of groundwater elevation data from the PA which was supplemented with available data from the SML property. The groundwater flow model should be updated if additional groundwater elevation data collected within the PA demonstrates that it is warranted.

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# Tables

**Table 2.1**

**Monthly and annual average climate data calculated from the ECCC Halifax Stanfield climate station**
**CetainTeed Canada Inc.**
**Antrim Gypsum Project**
**Lake Egmont, Halifax CO, Nova Scotia**

| Month | Precipitation (mm) | Rainfall (mm) | Snowfall (mm) | Mean Temperature (°C) | PET (mm) |
|---|---|---|---|---|---|
| January | 144.4 | 85.2 | 59.2 | -5.6 | 3.9 |
| February | 122.1 | 67.9 | 54.2 | -5.5 | 3.9 |
| March | 124.3 | 81.6 | 42.7 | -1.4 | 12.1 |
| April | 115.7 | 96.9 | 18.8 | 4.1 | 33.5 |
| May | 105.3 | 103 | 2.3 | 9.8 | 59.2 |
| June | 100.8 | 100.8 | 0 | 15.0 | 82.5 |
| July | 93.3 | 93.3 | 0 | 18.8 | 104.1 |
| August | 99.0 | 99 | 0 | 18.7 | 95.3 |
| September | 105.4 | 105.4 | 0 | 14.6 | 64.4 |
| October | 131.2 | 129.7 | 1.5 | 9.0 | 41.1 |
| November | 153.9 | 139.6 | 14.4 | 3.5 | 21.3 |
| December | 163.7 | 117.5 | 46.2 | -2.2 | 8.0 |
| **Total** | **1,459.2** | **1,219.9** | **239.3** | **N/A** | **529.4** |

Notes
mm - millimeter
°C - degrees Celsius
PET - potential evapotranspiration
Data from Halifax Stanfield International Airport and Truro, Nova Scotia Environment Canada Climate Station

**Table 2.2**

**Average Groundwater Elevations**
**CetainTeed Canada Inc.**
**Antrim Gypsum Project**
**Lake Egmont, Halifax CO, Nova Scotia**

| Monitoring Well ID | Model Layer | Observed GW Elevation (m AMSL) |
|---|---|---|
| **SML Property Average Annual Groundwater Elevation** | | |
| GA-04 | 1 | 13.92 |
| GA-07 | 17 | 14.13 |
| GA-09 | 1 | 13.63 |
| GA-10 | 4 | 13.71 |
| GA-11 | 1 | 14.54 |
| GA-12 | 1 | 14.32 |
| GA-13 | 1 | 14.72 |
| GA-14 | 1 | 13.68 |
| GA-18 | 7 | 15.17 |
| GA-22 | 1 | 14.36 |
| GA-32 | 5 | 16.29 |
| GR-P1 | 1 | 18.62 |
| GR-P2 | 1 | 19.97 |
| GR-P6 | 1 | 13.92 |
| MW-41 | 1 | 12.73 |
| MW-43 | 2 | 12.79 |
| **PA Targets - Aug/Sep 2023 - March 2024** | | |
| TGI-GT-02 | 2 | 27.51 |
| TGI-GT-04 | 1 | 43.67 |
| TGI-GT-05 | 1 | 25.46 |

**Table 2.3**

**Hydraulic Conductivity Testing Results**
**CetainTeed Canada Inc.**
**Antrim Gypsum Project**
**Lake Egmont, Halifax CO, Nova Scotia**

| Borehole | Lithology | Test Interval (m bgs) | Average K (m/s) | Average K (m/d) |
|---|---|---|---|---|
| **Overburden - Slug Tests** | | | | |
| TGI_GT_04 | Sandy Silt (till) | ~3.7-6.2 | 5.3E-07 | 4.6E-02 |
| TGI_GT_05 | Silt and Clay (till) | ~13.8-16.3 | 8.2E-08 | 7.1E-03 |
| TGI_GT_02 | Sandy Silt (till) and Gypsum Contact | ~11.6-14.5 | 1.9E-04 | 1.6E+01 |
| **Becrock - Packer Tests** | | | | |
| TGI_PFS_GT_01 | Gypsum / Karst Fill | 42-45 | 1.2E-09 | 1.1E-04 |
| TGI_PFS_GT_01 | Gypsum / Karst Fill | 57-60 | 9.7E-10 | 8.3E-05 |
| TGI_PFS_GT_01 | Gypsum / Anhydrite | 69-84 | 4.1E-10 | 3.5E-05 |
| TGI_PFS_GT_06 | Gypsum / Anhydrite / Dolomite | 36-75 | 6.9E-09 | 6.0E-04 |
| TGI_PFS_GT_06 | Dolomite / Anhydrite | 57-75 | 2.2E-09 | 1.9E-04 |
| TGI_PFS_GT_05 | Gypsum / Anhydrite / Dolomite | 30-33 | 1.1E-08 | 9.8E-04 |
| TGI_PFS_GT_05 | Gypsum / Anhydrite / Dolomite | 33.7-48 | 1.3E-07 | 1.1E-02 |
| | | **Geometric Mean** | 3.7E-09 | 3.2E-04 |
| | | **Minimum Value** | 4.1E-10 | 3.5E-05 |
| | | **Maximum Value** | 1.3E-07 | 1.1E-02 |

Notes
m bgs - meters below ground surface
m/s - metres per second
m/d - metres per day

**Table 6.1**

**Model Calibration Targets and Residuals**
**CetainTeed Canada Inc.**
**Antrim Gypsum Project**
**Lake Egmont, Halifax CO, Nova Scotia**

| Monitoring Well ID | Model Layer | Observed GW Elevation (m AMSL) | Simulated GW Elevation (m AMSL) | Residual[1] (m) |
|---|---|---|---|---|
| **SML Property Average Annual Groundwater Elevation Targets** | | | | |
| GA-04 | 1 | 13.92 | 14.69 | -0.76 |
| GA-07 | 17 | 14.13 | 25.01 | -10.88 |
| GA-09 | 1 | 13.63 | 17.40 | -3.77 |
| GA-10 | 4 | 13.71 | 13.72 | -0.01 |
| GA-11 | 1 | 14.54 | 15.37 | -0.83 |
| GA-12 | 1 | 14.32 | 14.20 | 0.12 |
| GA-13 | 1 | 14.72 | 15.07 | -0.35 |
| GA-14 | 1 | 13.68 | 15.59 | -1.91 |
| GA-18 | 7 | 15.17 | 18.18 | -3.02 |
| GA-22 | 1 | 14.36 | 13.49 | 0.87 |
| GA-32 | 5 | 16.29 | 19.64 | -3.34 |
| GR-P1 | 1 | 18.62 | 20.73 | -2.12 |
| GR-P2 | 1 | 19.97 | 21.35 | -1.37 |
| GR-P6 | 1 | 13.92 | 13.74 | 0.18 |
| MW-41 | 1 | 12.73 | 16.81 | -4.09 |
| MW-43 | 2 | 12.79 | 15.88 | -3.09 |
| **PA Targets - Aug/Sep 2023** | | | | |
| TGI-GT-02 | 2 | 27.51 | 27.89 | -0.38 |
| TGI-GT-04 | 1 | 43.67 | 37.10 | 6.57 |
| TGI-GT-05 | 1 | 25.46 | 34.50 | -9.04 |

Notes:

(1) "Residual is calculated as observed groundwater elevation minus the simulated groundwater elevatic

0.34 Positive groundwater elevation residual - over prediction of observed groundwater elevation.

-0.14 Negative groundwater elevation residual - under prediction of observed groundwater elevation.

**Table 6.2**

**Calibrated Parameter Values**
**CetainTeed Canada Inc.**
**Antrim Gypsum Project**
**Lake Egmont, Halifax CO, Nova Scotia**

| Parameter | Zone | Parameter Value (m/s) | Parameter Value (m/d) | Estimated Parameter Range Minimum (m/s) | Estimated Parameter Range Maximum (m/s) |
|---|---|---|---|---|---|
| Overburden Till $K_H$ (1) | 1 | 3.47E-06 | 3.00E-01 | 1.0E-10[a] | 7.5E-05[a] |
| Carroll's Corner Formation (anhydrite, gypsum, dolomite) $K_H$ (1) | 2, 3, 4, 5 | 3.74E-08 | 3.23E-03 | 4.10E-10 | 1.30E-07 |
| Gays River Formation $K_H$ (1) | 6 | 2.40E-06 | 2.07E-01 | 2.8E-07[a] | 1.6E-04[a] |
| Goldenville Group $K_H$ (1) | 7 | 3.60E-08 | 3.11E-03 | 6.7E-09[b] | 2.2E-07[b] |
| Fractured Bedrock $K_H$ (1) | 9 | 1.90E-05 | 1.64E+00 | 1.90E-02 | 1.90E-05 |
| Surficial Sand Overburden $K_H$ (1) | 10 | 1.16E-05 | 1.00E+00 | 9.0E-08[a] | 2.0E-04[a] |
| | | (mm/yr) | | (mm/yr) | |
| Recharge | 1 | 258 | | | |
| Effective Recharge | n/a | 150 | | 145.9 | 583.7 |
| Evapotranspiration | 1 | 548 | | 609 | 476 |

Notes:

m/s Metres per second
m/d Meters per day
mm/yr Millimetres per year
(1) $K_H$ - horizontal hydraulic conductivity
[b] - (WCLSO, 1992)
[a] - (GHD, 2022)

**Table 7.1**

**Comparison of Various Simulated Baseflows**
**CetainTeed Canada Inc.**
**Antrim Gypsum Project**
**Lake Egmont, Halifax CO, Nova Scotia**

| Scenario | Base-case | Phase 1b | | Phase 2 EOM | | Phase 2 PC | |
|---|---|---|---|---|---|---|---|
| Unit | $m^3$/day | $m^3$/day | % change from baseline | $m^3$/day | % change from baseline | $m^3$/day | % change from baseline |
| **Subcatchments** | | | | | | | |
| S01 | 483 | 296 | -39% | 251 | -48% | 269 | -44% |
| S02 | 499 | 516 | 3% | 437 | -12% | 468 | -6% |
| S03 | 785 | 261 | -67% | 60 | -92% | 136 | -83% |
| S04A | 103 | -154 | -249% | -302 | -392% | 15 | -86% |
| S04B | 51 | 51 | 0% | 48 | -6% | 50 | -2% |
| S04C | 273 | 270 | -1% | 268 | -2% | 272 | 0% |
| S04D | 63 | 63 | 0% | 63 | -1% | 63 | 0% |
| S05 | -5 | -38 | -587% | -41 | -652% | -11 | -100% |
| S06 | 245 | 118 | -52% | 79 | -68% | 210 | -14% |
| S07 | 129 | 107 | -17% | 102 | -21% | 124 | -4% |
| S08 | 259 | 256 | -1% | 254 | -2% | 258 | 0% |
| S09A | 729 | 732 | 0% | 729 | 0% | 732 | 0% |
| A09B | 216 | 216 | 0% | 215 | 0% | 216 | 0% |
| S09C | 14,778 | 14,778 | 0% | 14,776 | 0% | 14,778 | 0% |
| S10 | 389 | 238 | -39% | 232 | -40% | 240 | -38% |
| S11 | 45 | 45 | 0% | 45 | 0% | 45 | 0% |
| S12 | 390 | 248 | -36% | 238 | -39% | 261 | -33% |
| S13A | 304 | 293 | -4% | 287 | -6% | 302 | -1% |
| S13B | 79 | 79 | 0% | 78 | 0% | 79 | 0% |
| S13C | 698 | 700 | 0% | 699 | 0% | 701 | 0% |
| S14A | 92 | 90 | -2% | 89 | -3% | 92 | -1% |
| S14B | 415 | 414 | 0% | 414 | 0% | 414 | 0% |
| S14C | 10,591 | 10,591 | 0% | 10,591 | 0% | 10,591 | 0% |
| S15 | 481 | 479 | 0% | 479 | 0% | 481 | 0% |
| S17 | 73 | 1 | -98% | -2 | -102% | 27 | -63% |

**Table 7.2**

**Scenario Simulation Uncertainty Analysis**
**CetainTeed Canada Inc.**
**Antrim Gypsum Project**
**Lake Egmont, Halifax CO, Nova Scotia**

**Subcatchments**

| Total Flows | Unit | S01 | S02 | S03 | S04A | S04B | S04C | S04D | S05 | S06 | S07 | S08 | S09A | A09B | S09C | S10 | S11 | S12 | S13A | S13B | S13C | S14A | S14B | S14C | S15 | S17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Baseline Conditions** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Calibated Model Results** | | 483 | 499 | 785 | 103 | 51 | 273 | 63 | -5 | 245 | 129 | 259 | 729 | 216 | 14778 | 389 | 45 | 390 | 304 | 79 | 698 | 92 | 415 | 10591 | 481 | 73 |
| Zone 1 Recharge +25% baseflow | m³/day | 676 | 656 | 997 | 212 | 88 | 361 | 90 | -2 | 319 | 164 | 313 | 914 | 590 | 19241 | 501 | 52 | 486 | 351 | 107 | 926 | 112 | 613 | 13692 | 566 | 125 |
| Zone 1 Recharge -25% baseflow | m³/day | 307 | 341 | 574 | -11 | 14 | 193 | 38 | -9 | 169 | 93 | 202 | 542 | -170 | 10215 | 278 | 38 | 291 | 252 | 52 | 468 | 71 | 210 | 7368 | 394 | 33 |
| Zone 1 Evapotranspiration +25% baseflow | m³/day | 425 | 453 | 727 | 43 | 32 | 206 | 46 | -6 | 224 | 116 | 241 | 631 | 22 | 12843 | 340 | 43 | 359 | 282 | 57 | 619 | 81 | 330 | 9340 | 440 | 65 |
| Zone 1 Evapotranspiration -25% baseflow | m³/day | 551 | 550 | 853 | 164 | 70 | 349 | 84 | -4 | 269 | 144 | 279 | 835 | 419 | 16847 | 448 | 48 | 423 | 329 | 105 | 784 | 105 | 511 | 11911 | 527 | 82 |
| Zone 1 and 10 (Overburden) +20% baseflow | m³/day | 492 | 506 | 804 | 78 | 50 | 307 | 67 | -7 | 249 | 134 | 273 | 775 | 124 | 15219 | 404 | 48 | 407 | 330 | 88 | 709 | 98 | 403 | 10885 | 523 | 65 |
| Zone 1 and 10 (Overburden) -20% baseflow | m³/day | 472 | 486 | 760 | 127 | 51 | 236 | 58 | -4 | 238 | 122 | 241 | 676 | 305 | 14206 | 370 | 42 | 369 | 274 | 69 | 680 | 85 | 419 | 10198 | 435 | 80 |
| Zone 9 (Fractured Bedrock) +20% baseflow | m³/day | 476 | 499 | 798 | 113 | 47 | 272 | 66 | -6 | 242 | 132 | 263 | 750 | 202 | 14962 | 400 | 47 | 395 | 315 | 81 | 700 | 97 | 418 | 10687 | 494 | 65 |
| Zone 9 (Fractured Bedrock) -20% baseflow | m³/day | 492 | 498 | 771 | 92 | 55 | 273 | 60 | -5 | 247 | 125 | 254 | 704 | 228 | 14568 | 377 | 43 | 384 | 292 | 76 | 694 | 87 | 410 | 10491 | 468 | 81 |
| Zones 3,4,5,6 (Bedrock) +20% baseflow | m³/day | 482 | 499 | 785 | 105 | 51 | 273 | 63 | -6 | 244 | 129 | 260 | 729 | 214 | 14778 | 389 | 46 | 390 | 305 | 79 | 697 | 93 | 412 | 10593 | 485 | 71 |
| Zones 3,4,5,6 (Bedrock) -20% baseflow | m³/day | 485 | 498 | 785 | 101 | 51 | 273 | 64 | -5 | 246 | 129 | 258 | 728 | 217 | 14777 | 389 | 45 | 389 | 303 | 78 | 699 | 92 | 417 | 10589 | 477 | 74 |

| | | S01 | S02 | S03 | S04A | S04B | S04C | S04D | S05 | S06 | S07 | S08 | S09A | A09B | S09C | S10 | S11 | S12 | S13A | S13B | S13C | S14A | S14B | S14C | S15 | S17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Phase 1b Conditions** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Calibrated Model** | | 296 | 516 | 261 | -154 | 51 | 270 | 63 | -38 | 118 | 107 | 256 | 732 | 216 | 14778 | 238 | 45 | 248 | 293 | 79 | 700 | 90 | 414 | 10591 | 479 | 1 |
| Zone 1 Recharge +25% baseflow | m³/day | 393 | 683 | 352 | -55 | 88 | 358 | 90 | -36 | 192 | 141 | 310 | 919 | 590 | 19241 | 306 | 52 | 312 | 343 | 107 | 929 | 111 | 612 | 13692 | 565 | 4 |
| Change from Baseline Conditions | % | -42% | 4% | -65% | -126% | 0% | -1% | 0% | -1350% | -40% | -14% | -1% | 1% | 0% | 0% | -39% | 0% | -36% | -2% | 0% | 0% | -1% | 0% | 0% | 0% | -97% |
| Zone 1 Recharge -25% baseflow | m³/day | 205 | 350 | 176 | -253 | 13 | 190 | 37 | -40 | 47 | 72 | 199 | 543 | -170 | 10216 | 171 | 38 | 187 | 237 | 52 | 468 | 68 | 210 | 7368 | 392 | -2 |
| Change from Baseline Conditions | % | -33% | 3% | -69% | -2172% | -3% | -1% | -1% | -335% | -72% | -23% | -2% | 0% | 0% | 0% | -39% | 0% | -36% | -6% | 0% | 0% | -4% | 0% | 0% | -1% | -106% |
| Zone 1 Evapotranspiration +25% baseflow | m³/day | 257 | 463 | 218 | -208 | 31 | 203 | 46 | -38 | 105 | 97 | 238 | 632 | 22 | 12843 | 211 | 43 | 219 | 271 | 57 | 620 | 79 | 329 | 9340 | 438 | 12 |
| Change from Baseline Conditions | % | -40% | 2% | -70% | -581% | -1% | -1% | 0% | -488% | -53% | -16% | -1% | 0% | 0% | 0% | -38% | 0% | -39% | -4% | 0% | 0% | -2% | 0% | 0% | 0% | -82% |
| Zone 1 Evapotranspiration -25% baseflow | m³/day | 345 | 579 | 318 | -98 | 70 | 346 | 84 | -37 | 132 | 118 | 275 | 841 | 419 | 16848 | 273 | 48 | 285 | 318 | 105 | 788 | 103 | 510 | 11911 | 525 | 13 |
| Change from Baseline Conditions | % | -37% | 5% | -63% | -160% | 0% | -1% | 0% | -747% | -51% | -18% | -1% | 1% | 0% | 0% | -39% | 0% | -33% | -3% | 0% | 0% | -2% | 0% | 0% | 0% | -84% |
| Zone 1 and 10 (Overburden) +20% baseflow | m³/day | 313 | 525 | 273 | -197 | 50 | 304 | 67 | -38 | 110 | 110 | 270 | 778 | 124 | 15219 | 245 | 48 | 266 | 316 | 88 | 712 | 95 | 402 | 10885 | 521 | 1 |
| Change from Baseline Conditions | % | -36% | 4% | -66% | -351% | 0% | -1% | 0% | -467% | -56% | -18% | -1% | 0% | 0% | 0% | -39% | 0% | -35% | -4% | 0% | 0% | -3% | 0% | 0% | 0% | -99% |
| Zone 1 and 10 (Overburden) -20% baseflow | m³/day | 275 | 501 | 247 | -109 | 51 | 233 | 58 | -37 | 124 | 103 | 238 | 679 | 305 | 14206 | 228 | 42 | 228 | 265 | 69 | 682 | 84 | 418 | 10198 | 433 | 2 |
| Change from Baseline Conditions | % | -42% | 3% | -67% | -185% | -1% | -1% | 0% | -806% | -48% | -16% | -1% | 0% | 0% | 0% | -38% | 0% | -38% | -3% | 0% | 0% | -2% | 0% | 0% | 0% | -98% |
| Zone 9 (Fractured Bedrock) +20% baseflow | m³/day | 298 | 518 | 267 | -166 | 46 | 269 | 66 | -39 | 100 | 106 | 260 | 753 | 202 | 14962 | 246 | 47 | 255 | 301 | 81 | 702 | 94 | 417 | 10687 | 492 | 0 |
| Change from Baseline Conditions | % | -37% | 4% | -66% | -247% | 0% | -1% | 0% | -545% | -59% | -19% | -1% | 0% | 0% | 0% | -39% | 0% | -35% | -4% | 0% | 0% | -3% | 0% | 0% | 0% | -100% |
| Zone 9 (Fractured Bedrock) -20% baseflow | m³/day | 292 | 513 | 253 | -141 | 55 | 270 | 60 | -36 | 136 | 107 | 251 | 707 | 228 | 14569 | 229 | 43 | 241 | 283 | 76 | 696 | 86 | 409 | 10491 | 466 | 2 |
| Change from Baseline Conditions | % | -41% | 3% | -67% | -253% | 0% | -1% | 0% | -638% | -45% | -15% | -1% | 0% | 0% | 0% | -39% | 0% | -37% | -3% | 0% | 0% | -2% | 0% | 0% | 0% | -97% |
| Zones 3,4,5,6 (Bedrock) +20% baseflow | m³/day | 296 | 516 | 261 | -156 | 51 | 270 | 63 | -38 | 115 | 106 | 256 | 732 | 214 | 14779 | 238 | 46 | 249 | 293 | 79 | 699 | 91 | 412 | 10592 | 483 | 1 |
| Change from Baseline Conditions | % | -39% | 3% | -67% | -248% | -1% | -1% | 0% | -584% | -53% | -17% | -1% | 0% | 0% | 0% | -39% | 0% | -36% | -4% | 0% | 0% | -2% | 0% | 0% | 0% | -98% |
| Zones 3,4,5,6 (Bedrock) -20% baseflow | m³/day | 296 | 515 | 262 | -152 | 51 | 270 | 63 | -37 | 120 | 108 | 255 | 731 | 217 | 14778 | 238 | 45 | 248 | 292 | 78 | 701 | 90 | 416 | 10589 | 476 | 1 |
| Change from Baseline Conditions | % | -39% | 3% | -67% | -250% | 0% | -1% | 0% | -591% | -51% | -16% | -1% | 0% | 0% | 0% | -39% | 0% | -36% | -4% | 0% | 0% | -2% | 0% | 0% | 0% | -98% |
| Calibrated model Phase 1b (table 7.1) | | -39% | 3% | -67% | -249% | 0% | -1% | 0% | 587% | -52% | -17% | -1% | 0% | 0% | 0% | -39% | 0% | -36% | -4% | 0% | 0% | -2% | 0% | 0% | 0% | -98% |
| Minimum from sensitivity analysis | | -33% | 5% | -63% | -126% | 0% | -1% | 0% | -335% | -40% | -14% | -1% | 1% | 0% | 0% | -38% | 0% | -33% | -2% | 0% | 0% | -1% | 0% | 0% | 0% | -82% |
| Maximum from sensitivity analysis | | -42% | 2% | -70% | -2172% | -3% | -1% | -1% | -1350% | -72% | -23% | -2% | 0% | 0% | 0% | -39% | 0% | -39% | -6% | 0% | 0% | -4% | 0% | 0% | -1% | -106% |

**Table 7.2**

**Scenario Simulation Uncertainty Analysis**
**CetainTeed Canada Inc.**
**Antrim Gypsum Project**
**Lake Egmont, Halifax CO, Nova Scotia**

**Subcatchments**

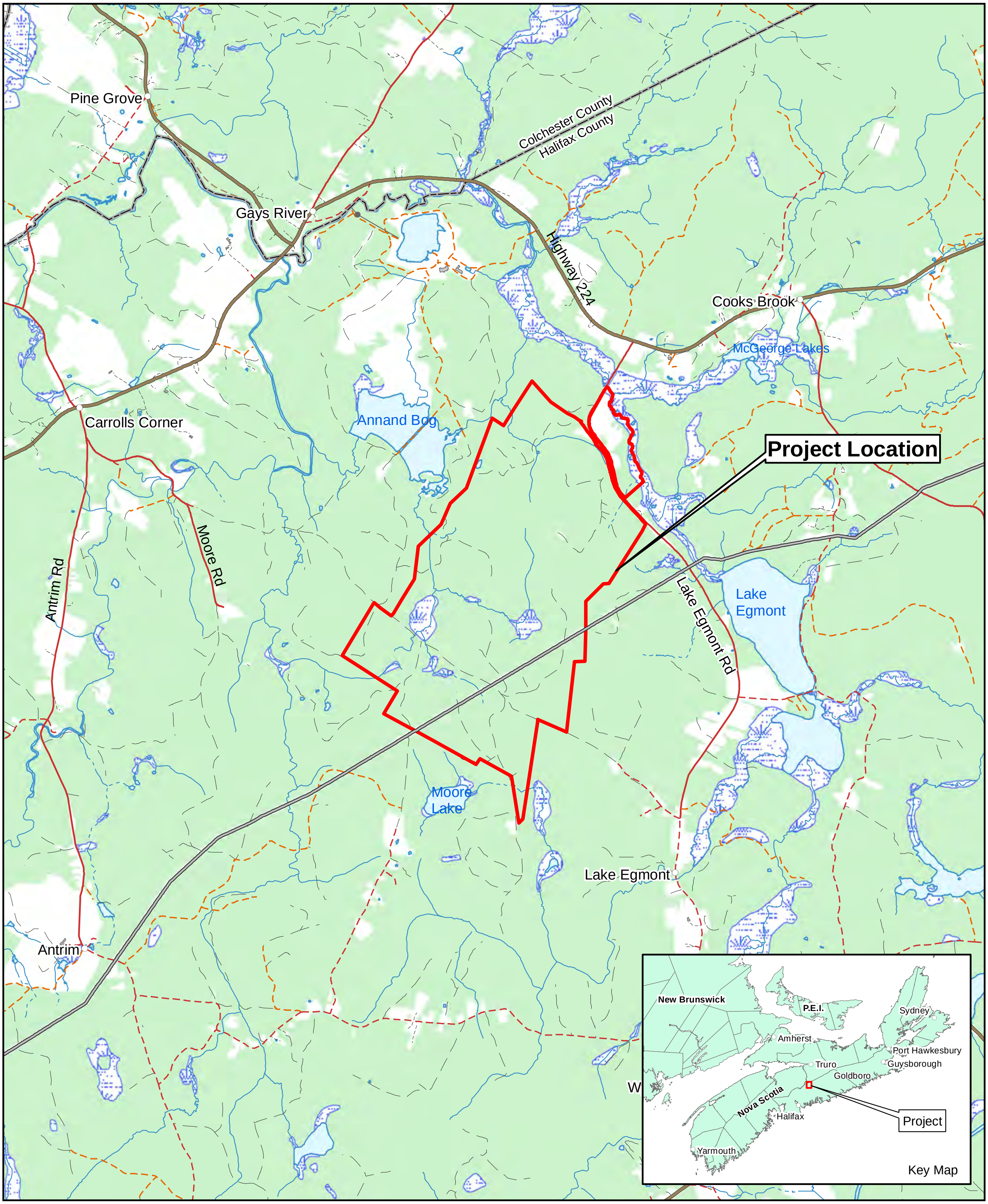
| | | S01 | S02 | S03 | S04A | S04B | S04C | S04D | S05 | S06 | S07 | S08 | S09A | A09B | S09C | S10 | S11 | S12 | S13A | S13B | S13C | S14A | S14B | S14C | S15 | S17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EOM Conditions** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Calibrated Model** | | 251 | 437 | 60 | -302 | 48 | 268 | 63 | -41 | 79 | 102 | 254 | 729 | 215 | 14,776 | 232 | 45 | 238 | 287 | 78 | 699 | 89 | 414 | 10,591 | 479 | -2 |
| Zone 1 Recharge +25% baseflow | m³/day | 333 | 594 | 103 | -200 | 85 | 356 | 90 | -38 | 158 | 137 | 309 | 916 | 590 | 19239 | 299 | 52 | 299 | 338 | 107 | 928 | 110 | 612 | 13692 | 565 | 2 |
| Change from Baseline Conditions | % | -51% | -10% | -90% | -195% | -3% | -1% | 0% | -1445% | -50% | -16% | -1% | 0% | 0% | 0% | -40% | 0% | -38% | -4% | 0% | 0% | -2% | 0% | 0% | 0% | -99% |
| Zone 1 Recharge -25% baseflow | m³/day | 165 | 283 | 24 | -408 | 11 | 188 | 37 | -45 | 22 | 64 | 197 | 540 | -171 | 10212 | 165 | 38 | 176 | 230 | 52 | 467 | 67 | 209 | 7367 | 391 | -7 |
| Change from Baseline Conditions | % | -46% | -17% | -96% | -3564% | -22% | -3% | -1% | -390% | -87% | -31% | -3% | 0% | 0% | 0% | -41% | 0% | -40% | -9% | -1% | 0% | -6% | -1% | 0% | -1% | -123% |
| Zone 1 Evapotranspiration +25% baseflow | m³/day | 220 | 399 | 54 | -351 | 29 | 201 | 46 | -41 | 69 | 92 | 237 | 630 | 22 | 12841 | 206 | 43 | 210 | 266 | 57 | 619 | 78 | 329 | 9340 | 438 | -2 |
| Change from Baseline Conditions | % | -48% | -12% | -93% | -914% | -9% | -2% | -1% | -544% | -69% | -20% | -2% | 0% | -1% | 0% | -39% | 0% | -42% | -6% | 0% | 0% | -3% | 0% | 0% | 0% | -103% |
| Zone 1 Evapotranspiration -25% baseflow | m³/day | 288 | 480 | 66 | -252 | 67 | 344 | 84 | -41 | 91 | 112 | 274 | 837 | 419 | 16844 | 265 | 48 | 271 | 312 | 105 | 786 | 102 | 510 | 11910 | 524 | -1 |
| Change from Baseline Conditions | % | -48% | -13% | -92% | -254% | -4% | -2% | -1% | -827% | -66% | -22% | -2% | 0% | 0% | 0% | -41% | 0% | -36% | -5% | 0% | 0% | -3% | 0% | 0% | -1% | -102% |
| Zone 1 and 10 (Overburden) +20% baseflow | m³/day | 264 | 440 | 59 | -346 | 47 | 302 | 67 | -41 | 72 | 105 | 269 | 775 | 123 | 15216 | 239 | 48 | 254 | 310 | 87 | 710 | 94 | 402 | 10885 | 521 | -2 |
| Change from Baseline Conditions | % | -46% | -13% | -93% | -541% | -6% | -2% | -1% | -515% | -71% | -22% | -2% | 0% | 0% | 0% | -41% | 0% | -38% | -6% | 0% | 0% | -3% | 0% | 0% | 0% | -103% |
| Zone 1 and 10 (Overburden) -20% baseflow | m³/day | 232 | 429 | 60 | -255 | 48 | 231 | 58 | -41 | 86 | 98 | 236 | 676 | 304 | 14203 | 223 | 42 | 219 | 261 | 68 | 681 | 83 | 418 | 10197 | 432 | -1 |
| Change from Baseline Conditions | % | -51% | -12% | -92% | -300% | -6% | -2% | -1% | -902% | -64% | -20% | -2% | 0% | 0% | 0% | -40% | 0% | -41% | -5% | 0% | 0% | -3% | 0% | 0% | 0% | -101% |
| Zone 9 (Fractured Bedrock) +20% baseflow | m³/day | 247 | 427 | 49 | -328 | 43 | 267 | 65 | -42 | 63 | 101 | 258 | 750 | 202 | 14959 | 239 | 47 | 244 | 295 | 80 | 701 | 93 | 417 | 10687 | 491 | -3 |
| Change from Baseline Conditions | % | -48% | -14% | -94% | -389% | -7% | -2% | -1% | -594% | -74% | -23% | -2% | 0% | 0% | 0% | -40% | 0% | -38% | -6% | 0% | 0% | -4% | 0% | 0% | -1% | -104% |
| Zone 9 (Fractured Bedrock) -20% baseflow | m³/day | 252 | 446 | 72 | -274 | 53 | 268 | 60 | -40 | 98 | 102 | 250 | 705 | 228 | 14566 | 225 | 43 | 232 | 278 | 76 | 695 | 85 | 409 | 10491 | 466 | -1 |
| Change from Baseline Conditions | % | -49% | -10% | -91% | -397% | -5% | -2% | -1% | -721% | -60% | -18% | -2% | 0% | 0% | 0% | -40% | 0% | -40% | -5% | 0% | 0% | -3% | 0% | 0% | 0% | -101% |
| Zones 3,4,5,6 (Bedrock) +20% baseflow | m³/day | 250 | 436 | 57 | -305 | 48 | 268 | 62 | -41 | 77 | 101 | 255 | 730 | 214 | 14776 | 232 | 46 | 238 | 288 | 79 | 698 | 90 | 411 | 10592 | 482 | -2 |
| Change from Baseline Conditions | % | -48% | -13% | -93% | -391% | -6% | -2% | -1% | -646% | -68% | -21% | -2% | 0% | 0% | 0% | -40% | 0% | -39% | -6% | 0% | 0% | -3% | 0% | 0% | -1% | -103% |
| Zones 3,4,5,6 (Bedrock) -20% baseflow | m³/day | 252 | 438 | 62 | -298 | 48 | 268 | 63 | -41 | 81 | 103 | 254 | 728 | 217 | 14775 | 233 | 45 | 238 | 287 | 78 | 700 | 89 | 416 | 10589 | 475 | -2 |
| Change from Baseline Conditions | % | -48% | -12% | -92% | -394% | -5% | -2% | -1% | -659% | -67% | -20% | -2% | 0% | 0% | 0% | -40% | 0% | -39% | -5% | 0% | 0% | -3% | 0% | 0% | 0% | -102% |
| Calibrated model Phase 2 EOM (table 7.1) | | -48% | -12% | -92% | -392% | -6% | -2% | -1% | 652% | -68% | -21% | -2% | 0% | 0% | 0% | -40% | 0% | -39% | -6% | 0% | 0% | -3% | 0% | 0% | 0% | -102% |
| Minimum from sensitivity analysis | | -46% | -10% | -90% | -195% | -3% | -1% | 0% | -390% | -50% | -16% | -1% | 0% | 0% | 0% | -39% | 0% | -36% | -4% | 0% | 0% | -2% | 0% | 0% | 0% | -99% |
| Maximum from sensitivity analysis | | -51% | -17% | -96% | -3564% | -22% | -3% | -1% | -1445% | -87% | -31% | -3% | 0% | -1% | 0% | -41% | 0% | -42% | -9% | -1% | 0% | -6% | -1% | 0% | -1% | -123% |

| | | S01 | S02 | S03 | S04A | S04B | S04C | S04D | S05 | S06 | S07 | S08 | S09A | A09B | S09C | S10 | S11 | S12 | S13A | S13B | S13C | S14A | S14B | S14C | S15 | S17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PC Conditions** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Calibrated Model** | | 269 | 468 | 136 | 15 | 50 | 272 | 63 | -11 | 210 | 124 | 258 | 732 | 216 | 14,778 | 240 | 45 | 261 | 302 | 79 | 701 | 92 | 414 | 10,591 | 481 | 27 |
| Zone 1 Recharge +25% baseflow | m³/day | 355 | 623 | 184 | 106 | 87 | 360 | 90 | -9 | 285 | 158 | 312 | 919 | 590 | 19240 | 307 | 52 | 324 | 351 | 107 | 930 | 112 | 613 | 13692 | 566 | 40 |
| Change from Baseline Conditions | % | -47% | -5% | -82% | -50% | -1% | 0% | 0% | -264% | -11% | -4% | 0% | 1% | 0% | 0% | -39% | 0% | -33% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | -68% |
| Zone 1 Recharge -25% baseflow | m³/day | 186 | 315 | 90 | -77 | 13 | 192 | 38 | -13 | 138 | 90 | 202 | 543 | -170 | 10215 | 174 | 38 | 200 | 249 | 52 | 469 | 70 | 210 | 7368 | 394 | 16 |
| Change from Baseline Conditions | % | -40% | -8% | -84% | -592% | -5% | 0% | 0% | -42% | -19% | -4% | 0% | 0% | 0% | 0% | -37% | 0% | -31% | -1% | 0% | 0% | -1% | 0% | 0% | 0% | -52% |
| Zone 1 Evapotranspiration +25% baseflow | m³/day | 236 | 427 | 124 | -40 | 31 | 205 | 46 | -11 | 192 | 112 | 241 | 633 | 22 | 12842 | 213 | 43 | 229 | 280 | 57 | 621 | 81 | 330 | 9340 | 440 | 25 |
| Change from Baseline Conditions | % | -44% | -6% | -83% | -193% | -2% | 0% | 0% | -77% | -14% | -3% | 0% | 0% | 0% | 0% | -37% | 0% | -36% | -1% | 0% | 0% | -1% | 0% | 0% | 0% | -62% |
| Zone 1 Evapotranspiration -25% baseflow | m³/day | 309 | 515 | 151 | 70 | 70 | 348 | 84 | -10 | 231 | 138 | 278 | 841 | 419 | 16847 | 275 | 48 | 298 | 328 | 105 | 789 | 104 | 511 | 11911 | 527 | 29 |
| Change from Baseline Conditions | % | -44% | -6% | -82% | -57% | -1% | 0% | 0% | -137% | -14% | -4% | 0% | 1% | 0% | 0% | -38% | 0% | -29% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | -64% |
| Zone 1 and 10 (Overburden) +20% baseflow | m³/day | 285 | 473 | 137 | -12 | 49 | 306 | 67 | -12 | 211 | 129 | 273 | 778 | 124 | 15218 | 248 | 48 | 280 | 327 | 88 | 712 | 97 | 402 | 10885 | 523 | 26 |
| Change from Baseline Conditions | % | -42% | -6% | -83% | -116% | -2% | 0% | 0% | -76% | -15% | -4% | 0% | 0% | 0% | 0% | -39% | 0% | -31% | -1% | 0% | 0% | -1% | 0% | 0% | 0% | -59% |
| Zone 1 and 10 (Overburden) -20% baseflow | m³/day | 249 | 458 | 134 | 42 | 51 | 235 | 58 | -10 | 207 | 117 | 240 | 679 | 305 | 14205 | 230 | 42 | 238 | 273 | 69 | 683 | 85 | 418 | 10198 | 434 | 27 |
| Change from Baseline Conditions | % | -47% | -6% | -82% | -67% | -1% | 0% | 0% | -144% | -13% | -4% | 0% | 0% | 0% | 0% | -38% | 0% | -35% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | -66% |
| Zone 9 (Fractured Bedrock) +20% baseflow | m³/day | 269 | 464 | 134 | 24 | 46 | 271 | 66 | -11 | 205 | 126 | 262 | 754 | 202 | 14961 | 249 | 47 | 269 | 313 | 81 | 703 | 96 | 418 | 10687 | 493 | 25 |
| Change from Baseline Conditions | % | -43% | -7% | -83% | -79% | -2% | 0% | 0% | -86% | -15% | -4% | 0% | 0% | 0% | 0% | -38% | 0% | -32% | -1% | 0% | 0% | -1% | 0% | 0% | 0% | -61% |
| Zone 9 (Fractured Bedrock) -20% baseflow | m³/day | 268 | 471 | 137 | 5 | 55 | 272 | 60 | -11 | 215 | 121 | 253 | 707 | 228 | 14568 | 231 | 43 | 252 | 291 | 76 | 697 | 87 | 410 | 10491 | 467 | 28 |
| Change from Baseline Conditions | % | -45% | -5% | -82% | -95% | -1% | 0% | 0% | -118% | -13% | -4% | 0% | 0% | 0% | 0% | -39% | 0% | -34% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | -65% |
| Zones 3,4,5,6 (Bedrock) +20% baseflow | m³/day | 269 | 468 | 136 | 16 | 50 | 272 | 63 | -11 | 209 | 124 | 259 | 733 | 214 | 14778 | 240 | 46 | 262 | 303 | 79 | 700 | 92 | 412 | 10593 | 484 | 26 |
| Change from Baseline Conditions | % | -44% | -6% | -83% | -85% | -2% | 0% | 0% | -99% | -14% | -4% | 0% | 0% | 0% | 0% | -38% | 0% | -33% | -1% | 0% | 0% | -1% | 0% | 0% | 0% | -63% |
| Zones 3,4,5,6 (Bedrock) -20% baseflow | m³/day | 269 | 468 | 137 | 13 | 50 | 272 | 64 | -11 | 211 | 124 | 257 | 731 | 217 | 14777 | 240 | 45 | 260 | 302 | 78 | 702 | 91 | 417 | 10589 | 477 | 27 |
| Change from Baseline Conditions | % | -44% | -6% | -83% | -87% | -1% | 0% | 0% | -102% | -14% | -4% | 0% | 0% | 0% | 0% | -38% | 0% | -33% | -1% | 0% | 0% | -1% | 0% | 0% | 0% | -64% |
| Calibrated model Phase 2 PC (table 7.1) | | -44% | -6% | -83% | -86% | -2% | 0% | 0% | -100% | -14% | -4% | 0% | 0% | 0% | 0% | -38% | 0% | -33% | -1% | 0% | 0% | -1% | 0% | 0% | 0% | -63% |
| Minimum from sensitivity analysis | | -40% | -5% | -82% | -50% | -1% | 0% | 0% | -42% | -11% | -3% | 0% | 1% | 0% | 0% | -37% | 0% | -29% | 0% | 0% | 1% | 0% | 0% | 0% | 0% | -52% |
| Maximum from sensitivity analysis | | -47% | -8% | -84% | -592% | -5% | 0% | 0% | -264% | -19% | -4% | 0% | 0% | 0% | 0% | -39% | 0% | -36% | -1% | 0% | 0% | -1% | 0% | 0% | 0% | -68% |

**Note**

Negative (-) percentage (%) indicates a reduction in flow

# Figures




Paper Size ANSI A

0 500 1,000 1,500

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983 CSRS
Grid: NAD 1983 CSRS UTM Zone 20N

GHD

CERTAINTEED CANADA INC.
LAKE EGMONT, HALIFAX CO, NOVA SCOTIA
ANTRIM GYPSUM PROJECT

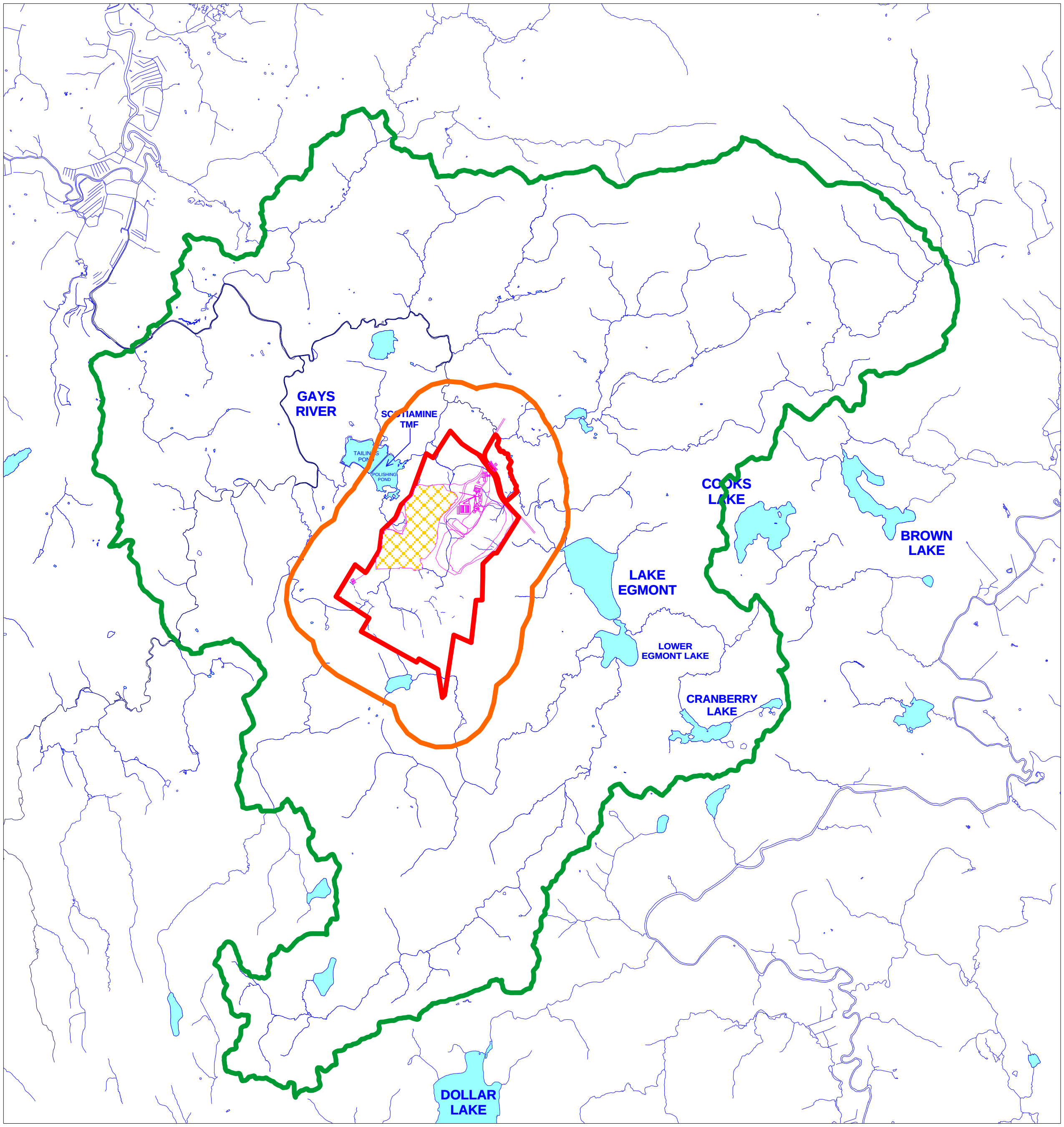
PROJECT LOCATION

Project No. 12601021
Revision No. -
Date July 23, 2024

FIGURE 1.1

N:\CA\Halifax\Projects\661\12601021\GIS\Maps\Deliverables\RPT006\12601021-RPT006-HX001-Fig 1 Site Location.mxd
Print date: 23 Jul 2024 - 13:47


Created by: cbudakli




## LEGEND

- SURFACE WATER FEATURES
- MAJOR RIVERS
- PROPOSED MINE FEATURES
- PROPOSED OPEN PIT
- SURFACE WATER BODY
- REGIONAL ASSESSMENT AREA (RAA)
- LOCAL ASSESSMENT AREA (LAA)
- PROJECT AREA (PA)

0 1000 2000 3000m

N

GHD

**CERTAINTEED CANADA INC**
**LAKE EGMONT, HALIFAX CO, NOVA SCOTIA**
**ANTRIM GYPSUM PROJECT**

SITE FEATURES AND
SPATIAL BOUNDARIES

Project No. **12601021**
Date **July 2024**

**FIGURE 1.2**

Filename:Z:\HEG\12601021\06_DOCUMENTATION\RPT\RPT\FIG\Figure 1.2 - Site Features.srf
Plot Date: July 23 2024 11:07 AM

Data Source