7.0 SURFACE WATER RESOURCES

7.1 SCOPE OF ASSESSMENT

Surface Water Resources was selected as a valued component (VC) as it has the potential to both influence, and be influenced by, Project activities. Surface water is an integral part of the hydrological cycle and effects of the Project will be considered for both surface water quantity and quality, and how changes in these two areas may influence human and ecological use. Surface water is an integral part of the local environment, providing habitat for fish, vegetation and aquatic populations, and contributing to local socio-economic drivers.

Specifically, surface water resources was selected as a VC for the following reasons:

- Importance as an ecosystem function (recreation and aquatic life habitat)
- Provisions of the Newfoundland and Labrador (NL) *Water Resources Act* (discussed further in Section 7.1.1)
- Requirements within the Federal Environmental Impact Statement (EIS) Guidelines (Appendix 1A) and the Provincial EIS Guidelines (Appendix 1B)
- Potential for Project-related effects on both surface water quality and quantity, including or resulting from:
    - Potential changes to surface water quality associated with effluent releases (including hazardous materials), surface water runoff, process water management, as well as acid rock drainage and metal leaching (ARD/ML) associated with material storage and stockpiling
    - Potential changes to hydrological or hydrometric conditions, and effects of lowering the water table on aquatic ecosystems
    - Management of pit water quality during operation and post-closure

Surface water is closely linked to other VCs including Groundwater Resources (Chapter 6); Fish and Fish Habitat (Chapter 8); and Vegetation, Wetlands, Terrain and Soils (Chapter 9). The potential environmental effects of changes to surface water resources on these VCs are discussed in their respective sections of the EIS.

7.1.1 Regulatory and Policy Setting

In addition to the *Canadian Environmental Assessment Act, 2012* and the NL *Environmental Protection Act* (NL EPA), the Project is subject to other federal and provincial legislation, policies and guidance. This section identifies the primary regulatory requirements and policies of the federal and provincial authorities which influence the scope of the assessment on surface water resources. Federal EIS Guidelines (Appendix 1A) and Provincial EIS Guidelines (Appendix 1B) provide a list of required surface water information and a concordance table showing where these requirements are addressed in the EIS is provided in Tables E.1 and E.2.

7.1.1.1 Federal Regulatory Requirements

Federal Fisheries Act

There are several sections and subsections of the *Fisheries Act* that pertain to surface water and potential interactions with the Project; these are listed below:

- Section 32, 35 and 36 - The federal *Fisheries Act* requires the protection of fish habitat and prohibits deposit of deleterious substance in all watercourses that are fish bearing
- *Metal and Diamond Mining Effluent Regulations* (MDMER) – The MDMER, created under the *Fisheries Act,* provides exemptions to the general prohibition against depositing deleterious substances. The MDMER sets out the maximum allowable limits for specific metals and other parameter concentrations in discharge resulting from the Project. The MDMER also sets forth a variety of effluent monitoring requirements, as well as the Environmental Effects Monitoring (EEM) criteria to be implemented and reported on during the operational phase of the Project. MDMER limits for new metal and diamond mines (effective June 1, 2021) from Table 1 of Schedule 4 were used in this assessment.

Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CWQG-FAL), 1999

The Canadian Council of Ministers of the Environment (CCME) CWQG-FAL provide limits for contaminants in water and are intended to maintain, improve, and/or protect environmental quality, and human and ecological health for a variety of chemical parameters. The CCME *Canadian Water Quality Guidelines for the Protection of Aquatic Life* are applicable for freshwater at the site.

7.1.1.2 Provincial Regulatory Requirements

NL Environmental Protection Act

A Certificate of Approval (C of A) is issued by the Pollution Prevention Division of the Newfoundland and Labrador Department of Environment, Climate Change and Municipalities (NLDECCM) for both construction and operation phases and sets concentration limits for specific parameters in the discharge effluent. These limits are typically similar to those provided in the MDMER. The C of A(s) also grant approval for the construction and operation of the Project.

NL *Water Resources Act (2002)*

The *Water Resources Act* gives the Water Resource Management Division (WRMD) of the NLDECCM the responsibility for the management of water resources in the province. The *Environmental Control Water and Sewage Regulations,* under the *Water Resources Act* regulate the discharge of sewage and other effluent. Schedule C of the regulation also specifies that the metal mining industry shall comply with the MDMER.

7.1.2 The Influence of Engagement on the Assessment

As part of ongoing engagement and consultation activities, Marathon has documented interests and concerns about the Project received from communities, governments, Indigenous groups and stakeholders. An overview of Marathon's engagement activities are provided in Chapter 3. Documented interests and concerns have influenced the design and operational plans for the Project and the development of the EIS, including the scope of assessment on the VCs. Interests and concerns noted that specifically relate to surface water resources or routine Project activities that could affect surface water resources are provided below. Issues and concerns related to potential accidents or malfunctions are described in the assessment of accidental events (Chapter 21).

Questions and concerns raised by Qalipu through Marathon's engagement efforts include:

- Design and operation of the tailing management facility, including use of earthen dams, long-term plans for the tailings pond, nature of "detox tailings", use of a geo-membrane, and likelihood and consequences of a breach
- Processing onsite, including the use of cyanide and the heap leach process
- Whether Project infrastructure can be relocated to reduce the Project footprint
- Water quality and water treatment

Questions and concerns raised by Miawpukek through Marathon's engagement efforts include:

- The size of the Project footprint
- The need for treatment to protect water quality
- Tailings, including questions about treatment, accidental events, and rehabilitation and closure

Questions and concerns raised by communities and other stakeholders through Marathon's engagement efforts include:

- Project components and infrastructure including: if pits will be mined simultaneously; how many ponds there will be; if the mine will be open pit only or include underground; how ore will be transported to the mill and how and where it will be processed; use of cyanide; what will replace the heap leach process; whether other metals, like silver, are present; whether product will be tested at an on-site lab or externally; and what will happen to waste rock and overburden
- Tailings and potential risks, including how tailings will be managed, the treatment of effluent, understanding "detox tailings", the consideration of use of a geo-membrane liner, potential impact of the tailings pond and polishing pond on water resources, and the long-term plan [closure] for the tailings pond

Questions and concerns raised by fish and wildlife and civil society organizations through Marathon's engagement efforts include:

- Project description, including the size of the Project footprint, pit stability, the source of power for the Project, use of cyanide, the process that will replace the heap leach process, how tailings will be transported, and tailings management (and consideration of alternatives)
- Water quality including the potential for contamination, the potential for acid rock drainage, and the need for the protection of small ponds near the Project Area

7.1.3 Boundaries

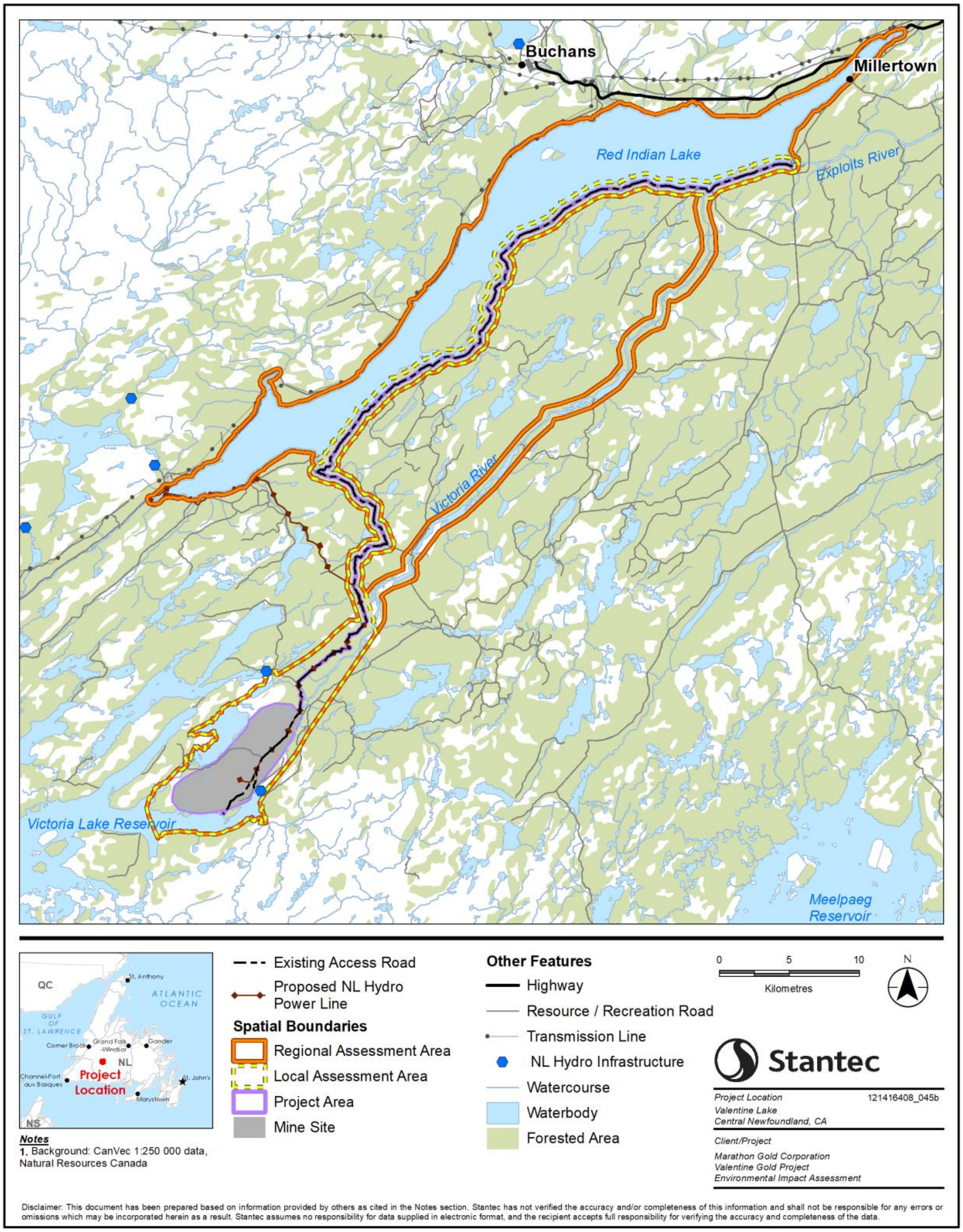
The scope of the assessment is defined by spatial boundaries (i.e., geographic extent of potential effects) and temporal boundaries (i.e., timing of potential effects). Spatial boundaries for the Surface Water Resources VC were selected in consideration of the geographic extent over which Project activities, and their effects, are likely to occur on the VC. Temporal boundaries are based on the timing and duration of Project activities and the nature of the interactions with the VC. The spatial and temporal boundaries associated with the effects assessment for surface water resources are described in the following sections.

7.1.3.1 Spatial Boundaries

The following spatial boundaries were used to assess Project effects, including residual environmental effects, on surface water resources in areas surrounding the mine site and access road (Figure 7-1):

Project Area: The Project Area encompasses the immediate area in which Project activities and components occur and is comprised of two distinct areas: the mine site and the access road. The mine site includes the area within which Project infrastructure will be located, and the access road is the existing road to the site, plus a 20-metre (m) buffer on either side. The Project Area is the anticipated area of direct physical disturbance associated with the construction, operation and decommissioning, rehabilitation and closure of the Project.

Local Assessment Area (LAA): The LAA for surface water resources was considered to incorporate the Project Area and watersheds that intersect with the Project Area, as shown in Figure 7-1. The LAA also includes portions of Victoria Lake Reservoir in the expected effluent mixing zones, which are typically considered to be up to several hundred metres from points of discharge in the lake. The LAA includes Valentine Lake and Victoria River to the point downstream where Project-affected tributaries converge with the main branch of the river and the Project access road extending from the Exploits River Crossing to the Project Area. It also includes a 500-m buffer around the access road.



Notes
1. Background: CanVec 1:250 000 data, Natural Resources Canada

Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Figure 7-1 Local Assessment Area and Regional Assessment Area for Surface Water Resources

Regional Assessment Area (RAA): The RAA for surface water resources was considered to incorporate the Project Area, LAA, and to extend to include where potential Project interactions may be observed, as shown in Figure 7-1. This was considered to include Valentine Lake, a portion of Victoria Lake Reservoir, Victoria River and Red Indian Lake, including its discharge at the head of the Exploits River. This area encompasses the potential downstream receivers of surface water that may flow from the Project Area. This is the area within which accidental effects (Chapter 21) are assessed, and it informs the assessment of cumulative effects (Chapter 20).

7.1.3.2 Temporal Boundaries

The temporal boundaries for the assessment of potential effects on the Surface Water Resources VC include:

- Construction Phase – 16 to 20 months, beginning in Q4 2021, with 90% of activities occurring in 2022
- Operation Phase – Estimated 12-year operation life, with commissioning / start-up and mine / mill operation slated to start Q2 2023. The first three years are expected to process 2.5 million tonnes per year (Mtpa), while the remaining years are expected to process 4 Mtpa. Active mining of ore is anticipated to cease by year 10 of operation. To account for this, surface water (quantity) has been considered under each of these two operational conditions.
- Decommissioning, Rehabilitation and Closure Phase – Closure rehabilitation to occur once it is no longer economical to mine or resources are exhausted. To facilitate the various modelling studies required to support the Surface Water VC, this phase has been subdivided into two distinct temporal phases;
  - Closure: The closure phase is generally the period during which the final rehabilitation activities are conducted with respect to buildings, equipment and infrastructure decommissioning and removal, and rehabilitation of disturbed areas, including waste rock piles and the Tailings Management Facility (TMF). For this Project, as mining will cease in Year 9 and milling will continue to Year 12, the open pits and waste rock piles can be rehabilitated prior to cessation of milling. The TMF will also cease to be required after Year 9 as tailings will be pumped to the exhausted Leprechaun pit. These key mine components with respect to surface water resources also have different closure activity durations. The waste rock piles and TMF will likely be fully rehabilitated in 2 to 3 years after operation of these facilities cease, which corresponds to Year 11/12 of operation. When processing ceases, it is expected that the primary period for closure of the mill, processing plant, buildings, equipment, and supporting infrastructure will take 16 to 20 months and at this point approximately 95% of closure activities will be completed. However, as further described below, it is expected to take eight years for the pits to flood, which would be five years after cessation of processing, and approximately three to five years after the primary closure activities cease
  - Post-closure: Corresponding to the semi-passive period following the rehabilitation work and closure activities at which point the closure and rehabilitation work is complete, and the mine pit(s) are flooded. Post-closure monitoring, which is completed once the closure activities are complete to ensure that the site is chemically and physically stable is generally six to 10 years for some components, and longer if dams are left in place for the TMF. Due to the variation in timing of closure of different site features, it is difficult to determine the schedule for post-closure

monitoring at this stage of the Project, and it will be determined during the development and future reviews of the formal Rehabilitation and Closure Plan and in the assessment of Marathon's mine closure undertaking under the NL EPA.

7.2 EXISTING CONDITIONS FOR SURFACE WATER

A characterization of the existing conditions within the spatial boundaries defined in Section 7.1.3 is provided in the following sections. This includes a discussion of the influences of past and present physical activities on the VC, leading to the current conditions. An understanding of the existing conditions for the VC within the spatial area being assessed is a key requirement in the prediction of potential Project effects provided in Section 7.5.

More detail pertaining to the existing surface water conditions are provided in the Hydrology and Surface Water Quality Monitoring Baseline Report (Attachment 3-C of Baseline Study Appendix 3: Water Resources [BSA.3]). Existing conditions for sediment quality are presented and discussed in detail in Chapter 8 (Fish and Fish Habitat).

7.2.1 Methods

Existing surface water conditions have been determined through both desktop methods and field programs. The methods used to acquire information on existing conditions relative to the Surface Water VC are presented in the following subsections.

7.2.1.1 Physiographic Setting

Information on the physiographic setting of the Project was gathered using historical and publicly available sources. The physiographic setting of the Project was compiled through a review of climate data (e.g., temperature and precipitation data, applicable intensity-duration-frequency (IDF) curves, evapotranspiration data, climate change predictions), as well as through a consideration of surface feature soils, topography and vegetation.

Climate

Climate factors have a defining influence on the hydrology of the Project Area as they have potential to affect both the quantity and timing of expected runoff and influence evapotranspiration and infiltration rates.

Temperature and Precipitation

Historical (74 years) and climate normal data from a meteorological monitoring station (Station ID 8400698) located northeast (NE) of the Project Area at Buchans were used to characterize climate conditions in the RAA. This station, maintained by Environment and Climate Change Canada (ECCC), provides comprehensive, year-round and longterm temperature and precipitation records.

Precipitation dry years are defined as years having annual precipitation less than climate normal and wet years are defined as years having annual precipitation greater than climate normal. Annual precipitation data were divided into wet and dry years and analyzed using the Hydrological Statistics Tool in AQUARIUS Software. AQUARIUS is the hydrometric software used by the Water Survey of Canada (WSC) in data analysis of the national Hydrometric Data National Water Data Archive (HYDAT) stream gauging network. Various wet and dry year return periods (5, 10, 25, 50, 100, 200 and 1,000-year) were estimated. The 50-year return period was selected as the representative wet and dry year for this location as this return period best corresponded to the wettest and driest years over the 74-year record.

The Climate Atlas of Canada's online tool (Prairie Climate Center 2019) was used to generate projected climate change precipitation and temperature data for the Red Indian Lake Region, the Region identified in the online tool where the Project will occur. This online data portal provides downscaled data projections of temperature and precipitation from an ensemble of 24 different climate models. Projected climate changes in temperature and precipitation associated with the Intergovernmental Panel on Climate Change (IPCC) Representative Concentration Pathway 4.5 (RCP4.5) scenario over a 30-year time horizon were selected. The RCP4.5 scenario was chosen as it was used in the development of various climate change IDF curves for NL (CRA 2015). An IDF curve provides precipitation intensity and return period information for a specific location. The RCP4.5 scenario reflects an intermediate stabilization scenario for the emission of greenhouse gases, in which radiative forcing is stabilized at approximately 4.5 Watts per metre squared (IPCC 2020) and is further discussed in BSA.3, Attachment 3-C.

IDF Curves

Design storm events are characterized by IDF curves used to predict rainfall intensity, which is used to predict volumes and flows of water that need to be managed. Typical design storm events used in water management infrastructure include the 24-hour duration storm that occurs every 10 years or the 24-hour duration storm that occurs every 100 years (Q100). There are no active IDF climate stations located in the central or northern areas of the Island nor in the NE hydrologic region that the Project falls into. As no monitoring of precipitation intensity is available for the Buchans climate station, the Stephenville climate station was used in this assessment (AMEC 2012). The Stephenville climate station IDF was selected as its annual precipitation is nearer to that reported at the Buchans station than other nearby climate stations with IDF data (e.g., Deer Lake).

In 2015, the government of NL commissioned a study to provide updated IDF curves that incorporated potential precipitation changes associated with climate change. The study was completed by Conestoga-Rovers & Associates (CRA) and followed the same methodology used by ECCC in the development of their IDF curves. IDF curves were developed based on the IPCC RCP 4.5 for three separate time horizons (2020s, 2050s, 2080s) and were used to establish design storm events for water management infrastructure design (CRA 2015).

Evapotranspiration

Evapotranspiration is the sum of evaporation and transpiration from terrestrial and aquatic environments to the atmosphere and is dependent on topography, latitude, solar radiation, wind, humidity, temperature, type and extent of vegetation, and availability of water. Potential evapotranspiration zones are defined in the Water Resources Atlas of Newfoundland (WRAN) (NLDOEC 1992) and are used to characterize the evapotranspiration at the site.

Surface Features

Surface features have an influence on surface water as they can affect both the quantity and quality of runoff in each affected watershed.

Vegetation and land cover classes within the LAA were determined based on an Ecological Land Classification Area (ELCA) study as outlined in Chapter 9 (Vegetation, Wetlands, Terrain and Soil). Vegetation communities / land cover classes are an important consideration in determining expected runoff resulting from rainfall in each relevant watershed.

Topography, Soils, and Surficial Geology

The topography of the Project Area was determined using available light detection and ranging (LiDAR) information and supplemented with provincially available topographic contour mapping. The topography across the RAA and within individual watersheds will affect surface water runoff. Publicly available geological and soils mapping were also reviewed to establish the expected surficial geology (Agriculture Canada 1988; Newfoundland and Labrador Department of Environment and Conservation [NLDOEC] 1992).

7.2.1.2 Regional Hydrology

Assessment of the regional hydrology included completion of a regional flow assessment (mean monthly flows [MMFs], mean annual flows [MAFs], peak return period runoff rate, and baseflow), flow duration curves (FDCs), as well as the calculation of low and environmental flows.

Regional Flow Assessment

A regional flow assessment was conducted to characterize hydrologic conditions in the RAA. No streamflow monitoring stations with long or continuous historical data records are available in the LAA; therefore, regional streamflow monitoring stations operated by the WSC on the Island of Newfoundland were selected to characterize regional hydrologic conditions. Considering hydrology at a regional scale allows for many years of flow data to be included in analyses and allows for extreme (high and low) flow events to be captured, thereby providing more confidence in mean flow statistics.

The Island is subdivided into four hydrologically homogeneous regions (NE, southeast [SE], southwest [SW] and northwest [NW]) and regional relationships for flows have been developed for each region (AMEC 2014). The LAA is in the NE hydrologic region, and near the confluence of the NE, SW and NW regions. The Stephenville climate station, used for IDF curve assessment, is in the SW region however, it is considered to be representative of the Project Area, as mean annual precipitation values reported at this station and the Buchans station are comparable.

Return period peak flow relationships to watershed area have been developed for the Island and updated most recently by AMEC (2014). AMEC also attempted to establish additional regression equations for small watersheds (<50 kilometres squared [km^2]) and found that there was a poor statistical fit. For this regional assessment, stations located in the NE hydrologic region were further refined to exclude stations located in regulated watersheds (i.e., unnatural flow regimes resulting from dams), those occurring in watersheds with areas >1,000 km^2, and those having heterogeneous unit flow data. Twelve stations were carried forward in the regional assessment.

The MAF and MMF for 12 WSC stations located in the NE hydrologic region were plotted against watershed areas to establish regression relationships. Peak flow frequency analyses was also completed using these 12 WSC stations.

The streamflow coefficient is defined as the percentage of precipitation in the form of groundwater discharge and overland flow that enters a flowing watercourse. Evapotranspiration can be considered to account for the difference between the streamflow coefficient and total precipitation. The streamflow coefficient for the RAA was calculated using climate normal precipitation data from Buchans and the RAA evapotranspiration rate.

Baseflow was also considered by calculating the base flow index (BFI) for a WSC station considered representative of conditions in the Project Area, Tributary to Gill's Brook (ID: 02YO014). The BFI is a ratio between stream baseflow and total flow and is further described in the baseline report (BSA.3, Attachment 3-E).

Flow Durations Curves

FDCs show the percentage of time a given discharge value is exceeded in a streamflow monitoring station's period of record. FDCs were developed for each of the WSC stations used in the regional analysis by comparing the mean daily flow with the MAF for each respective station.

Low and Environmental Flows

Low flow indices for the RAA were derived using a regional frequency analysis for NL (Zadeh 2012). Low flows for 1-day and 7-day durations were calculated for return periods of 2, 10, 20, 50 and 100-years using relationships based on watershed area developed by Zadeh (2012). This work to estimate low flows also relied on a spreadsheet provided by NLDECCM (then the Newfoundland and Labrador Department of Municipal Affairs and Environment) (NLDMAE 2017).

Environmental flows were established, as outlined in Zedeh (2012), using relationships between the MAF and in-stream flow needs for the winter and summer periods. The MAFs were developed as described above for the summer (April to September) and winter (October to March) periods. Recommended minimum flows for these periods are 50% MAF and 30% MAF respectively, based on 'excellent' river conditions, as per Zadeh (2012).

7.2.1.3 Local Hydrology

Information on the hydrology within the LAA was gathered using desktop methods and field-based assessments. Desktop methods included the development of an environmental water balance, a review of local and regional hydrogeology and a review of local water users. Field work included the installation and maintenance of hydrometric stations (HSs) and the collection of bathymetric data.

Environmental Water Balance

An environmental water balance was developed based on available data for climate normal, wet year and dry year conditions. Surplus runoff was calculated in the water balance model based on climate and physiographic characteristics.

The Thornthwaite monthly water balance model, refined by the United States Geological Survey (USGS), was used (McCabe and Markstrom 2007; Thornthwaite 1948). Surface runoff was estimated based on net precipitation less the evapotranspiration and infiltration losses. Input parameters were established based on latitude, local climate and soil conditions, and guidance provided by the USGS.

Local and Regional Hydrogeology

An overview of the local and regional hydrogeology is provided in the Groundwater Baseline Report completed by GEMTEC Consulting Engineers and Scientists (BSA.3, Attachment 3-F). BFI data determined during the regional assessment were also applied to the LAA to establish expected baseflow conditions in the Project Area.

Hydrometric Stations

The local hydrology assessment included a field hydrometric monitoring program completed by Stantec and Marathon staff between 2012 and 2019. Stantec and Marathon staff conducted equipment downloads and completed in-situ flow measurements at a total of twelve hydrometric monitoring stations established within the LAA (Figure 7-2). Summary details of the HSs are provided in Table 7.1 and a typical station setup is shown in Figures 7-3 and 7-4 below.

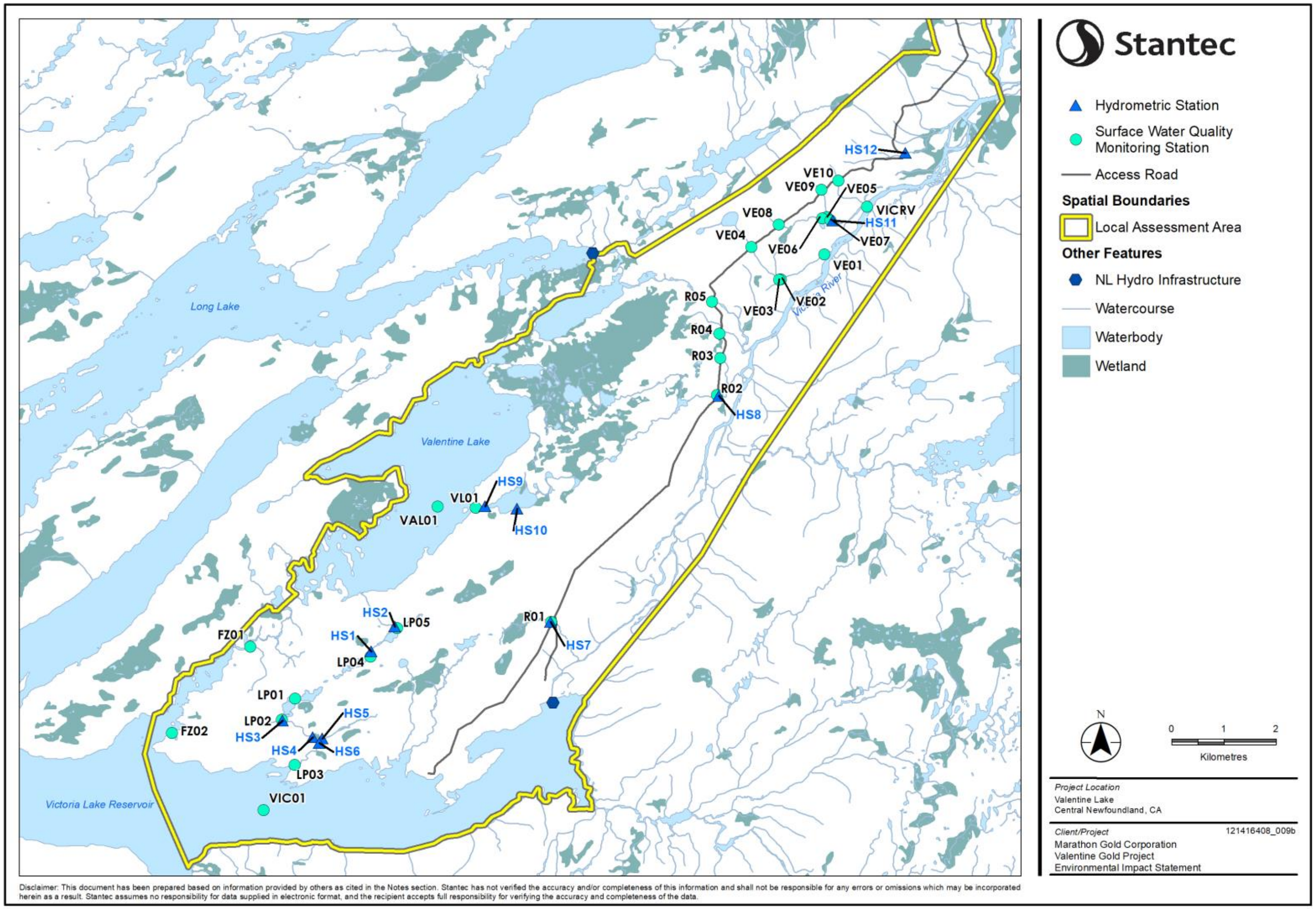


Figure 7-2 Surface Water Monitoring Locations

Table 7.1 Hydrometric and Flow Monitoring Stations (HS) (NAD 1983 UTM Zone 21N)

Station ID	Easting (m)	Northing (m)	Type of Gauge	Monitored Characteristics	Instrumentation	Period of Record
HS1	487695.3254	5356819.297	Riverine	Continuous water level, flows, air pressure and water temperature	Levelogger Barologger	October 2012 - Present
HS2	488143.8577	5357289.731	Riverine	Continuous water level, flows and water temperature	Levelogger	October 2012 - Present
HS3	486569.303	5355176.196	Riverine	Continuous water level, flows and water temperature	Levelogger	October 2012 - Present
HS4	486757.1732	5355149.184	Riverine	Spot flow measurement	N/A	N/A
HS5	486701.1127	5355063.371	Riverine	Spot flow measurement	N/A	N/A
HS6	485992.7819	5355490.165	Riverine	Spot flow measurement	N/A	N/A
HS7	494351.6243	5361700.61	Riverine	Continuous water level, flows, air pressure and water temperature	Levelogger Barologger	November 2018 - Present
HS8	489876.2624	5359593.404	Riverine	Continuous water level, flows and water temperature	Levelogger	November 2018 - Present
HS9	491128.6319	5357376.108	Riverine	Continuous water level, flows and water temperature	Levelogger	November 2018 - Present
HS10	490480.6791	5359541.825	Lake level	Continuous water level and temperature	Levelogger	June 2019 – Present
HS11	496534.4557	5365056.864	Riverine	Continuous water level, flows and water temperature	Levelogger	June 2019 – Present
HS12	497917.8448	5366352.437	Riverine	Continuous water level, flows and water temperature	Levelogger	June 2019 – Present

Note:
N/A indicates that no instrumentation and therefore period of record, exist for these locations as they were only used to collect spot flow measurements.

Figure 7-3 Typical Hydrometric Station Setup

Solinst® Leveloggers® were used to record continuous water levels and temperature and to facilitate the development of continuous stream flow records. Solinst Barologgers were used to barometrically compensate Levelogger water level data. Flow measurements were completed using a Sontek Flowtracker, which collects velocity measurements using acoustic doppler technology and computes discharge using the mid-section method (Terzi 1981).

Provisional rating curves were developed for HSs that had a continuous water level logger. The AQUARIUS software, developed by Aquatics Informatics, was used to develop rating curves and to convert the continuous water level data into discharge data (Aquatic Informatics 2020).

Figure 7-4 Flow measurement at HS9

Watershed Delineation and Statistics

Watershed areas upstream of each HS were delineated using ArcGIS software (ArcMap Version 10.6.1). Provincially available data layers for watercourses, waterbodies, roads and topography were used in conjunction with client supplied LiDAR topographic data to establish the watershed area for each station. These are presented in Section 7.2.2.

Watershed areas upstream of each planned final discharge point (FDP) associated with the Project water management infrastructure were also delineated using available topographic data and are presented in Section 7.2.2. Baseline flow statistics for the HS and FDP watersheds were generated based on relationships established in the regional hydrology assessment.

Bathymetry

Bathymetric data was collected using a combined Global Positioning System (GPS) / sonic transducer from a selection of small lakes and ponds within the Project Area, as well as in the potential effluent discharge receiving water bodies, Victoria Lake Reservoir and Valentine Lake. Vertical and horizontal resolutions achieved were approximately +/- 0.1 m and 4.0 m respectively. Bathymetric data collected was interpolated and presented using ArcGIS software.

Local Water Users

NL Hydro has been operating the Bay d’Espoir hydroelectric generating facility since 1967. Victoria Lake Reservoir forms the headwaters of this system and water from Victoria Lake Reservoir is directed to the generating facility through an array of anthropogenic dams and canals. One of these dams is located on the northern outlet of Victoria Lake Reservoir and dams the historical outlet to the Victoria River (NL Hydro 2020). The WSC operates a water level station (ID 02YN005) at this outlet structure and reports data in real-time, with historical water level data dating from 2004. This historical data was reviewed to establish the historical (2004 to 2017) mean monthly water levels in Victoria Lake Reservoir. A stage-storage curve, which shows the volume of water that corresponds to various water level elevations, for Victoria Lake Reservoir was also provided by NL Hydro.

7.2.1.4 Surface Water Quality

Information on the surface water quality of the Project Area was gathered using historical, publicly available information sources, as well as field-based assessments by Marathon between 2011 and 2019. Assessment of surface water quality included a review of both regional and local water quality.

Regional Water Quality

ECCC collects and manages long-term water quality monitoring data through their online data portal (ECCC 2020). Analytical parameters monitored in this network include temperature, pH, alkalinity, ions, nutrients and metals. Two stations near the Project Area were identified and used as regional water quality references (Station IDs NF02YN0001 and NF02YO0107). Station NF02YN0001 is located on the Lloyds River at Route 480, and Station NF02YO0107 is located on the Exploits River near Millertown. Location coordinates and periods of data availability are provided in Table 7.2.

The WRMD of NLDECCM initiated a province-wide real time water quality monitoring network in 2001. This program was developed to provide real time data from select waterbodies throughout the province and was considered necessary by the WRMD to help implement its regulatory mandate (NLDMAE 2019). This monitoring network also relies on industry partners, including Teck Resources Ltd., which reports on data from their Duck Pond Mine (now in the decommissioning phase), located near the Project Area. Two monitoring locations established at the Duck Pond Mine (Station IDs NF02YO0190 and NF02YO0192) were also used as regional water quality references. Station NF02YO0190 is located on a tributary to Gills Pond Brook and Station NF02YO0192 is located on East Pond Brook below East Pond. Location coordinates and periods of data availability are provided in Table 7.2.

Regional water quality was also compared to the surface water-sourced drinking water supplies for the communities of Buchans (Buchans Lake aka Sandy Lake) and Millertown (Millertown Water Pond) available from the NL Water Resources Portal (NLDMAE 2019). Location coordinates and periods of record for these locations are provided in Table 7.2.

Table 7.2 Regional Surface Water Quality Sampling Locations (NAD 1983 UTM Zone 21N)

Station ID	Waterbody Type	Easting (m)	Northing (m)	Period of Data Availability
NF02YN0001	River	535,881	5,410,892	2003 - 2019
NF02YO0107	River	534,644	5,406,745	2003 - 2019
NF02YO0190	Stream	447,886	5,350,749	2018 – 2019
NF02YO0192	Stream	530,704	5,400,926	2018 – 2019
Buchans Lake	Lake	534,770	5,387,621	1987 - 2017
Millertown Water Pond	Lake	536,044	5,392,231	2000 - 2017

Data from these stations were examined for standard water quality statistics, including minimum, maximum, and mean. Seasonal variation was also considered to assess temporal changes to water quality throughout the year.

Local Water Quality

Initial baseline water quality sampling took place in March 2011 and additional sampling locations were added throughout the baseline monitoring period for a total of 26 locations in 2019. Water quality samples were collected in clean laboratory-prepared containers specific to each analysis, and were stored and shipped in coolers at approximately 4 degrees Celsius (°C). Water samples were submitted under chain of custody protocols to Bureau Veritas Labs (formerly Maxxam Analytics Inc.) in St. John’s, NL for laboratory analysis of general water quality parameters, metals, mercury and total suspended solids (TSS).

The coordinates for each sampling location, waterbody type and the period of monitoring are summarized in Table 7.3 and monitoring locations are shown on Figure 7.2.

Table 7.3 Surface Water Quality Sampling Locations (NAD 1983 UTM Zone 21N)

Station ID	Easting (m)	Northing (m)	Waterbody Type	Period of Monitoring
LP01	486,228	5,355,908	Pond outlet stream	March 2011 – October 2019
LP02	485,980	5,355,505	Pond outlet stream	March 2011 – October 2019
LP03	486,225	5,354,638	Stream	March 2011 – October 2019
LP04	487,675	5,356,713	Pond outlet stream	March 2011 – October 2019
LP05	488,180	5,357,259	Pond outlet stream	March 2011 – October 2019
VE01	496,364	5,364,413	Stream	March 2011 – October 2019
VE02	495,531	5,363,937	Stream / Bog	March 2011 – October 2019
VE03	495,502	5,363,922	Stream / Bog	March 2011 – October 2019
VE04	494,970	5,364,554	Stream	March 2011 – October 2019
VE05	496,415	5,365,122	Stream / Bog	March 2011 – October 2019
VE06	496,321	5,365,101	Stream / Bog	March 2011 – October 2019
VE07	496,482	5,365,059	Stream / Bog	March 2011 – October 2019

Table 7.3 Surface Water Quality Sampling Locations (NAD 1983 UTM Zone 21N)

Station ID	Easting (m)	Northing (m)	Waterbody Type	Period of Monitoring
VE08	495,490	5,364,983	Stream / Bog	March 2011 – October 2019
VE09	496,306	5,365,644	Stream	May 2011 – October 2019
VE10	496,634	5,365,825	Stream	May 2011 – October 2019
R01	491,135	5,357,375	Stream	May 2011 – October 2019
R02	494,307	5,361,717	Stream	May 2011 – October 2019
R03	494,376	5,362,429	Stream	May 2011 – October 2019
R04	494,358	5,362,890	Stream	May 2011 – October 2019
R05	494,215	5,363,502	River	May 2011 – October 2019
VL01	489,694	5,359,562	Stream	May 2011 – October 2019
FZ01	485,376	5,356,901	Stream / Bog	October 2012 – October 2019
FZ02	485,630	5,355,252	Stream	October 2012 – October 2019
VICRV	497182	5,365,318	River	August – November 2019
VIC01	485,630	5,353,776	Large lake	August – November 2019
VAL01	488,960	5,359,583	Large lake	August – November 2019

7.2.2 Existing Conditions

This section provides a summary of information relevant to the Surface Water VC existing conditions. This section provides an overview of Physiographic Setting, Regional Hydrology, Local Hydrology and Water Quality. The baseline report (BSA.3, Attachment 3-C) provides more detailed information on the existing surface water conditions.

7.2.2.1 Physiographic Setting

An overview of the physiographic setting of the Project Area for both climate (temperature, precipitation, IDF Curves, evapotranspiration, and climate change predictions) and surface features (soils, topography and vegetation) was completed and findings are provided in the following subsections.

Climate

Climate affects the runoff characteristics and stream flows that define hydrologic conditions in the Project Area. The Project Area lies within the Western Mountains and Central Uplands climate zone of NL and is generally characterized by cloudy conditions, strong winds and heavy snowfall in winter (Heritage NL 2019).

Temperature and Precipitation

Climate normal statistics for the period from 1981 to 2010 at the Buchans climate station (Station ID 8400698) are presented in Table 7.4 (ECCC 2019). A review of the climate conditions recorded at Buchans over its entire period of record (1937 to 2011) was used to assess wet and dry year conditions.

Buchans station records indicate that 2000 was the wettest year on record and 1950 was the driest year on record. Table 7.4 also shows the monthly temperature and precipitation values recorded in these years.

Table 7.4 Climate Statistics for Buchans Climate Station (Station ID 8400698)

Month	Temperature (°C)			Precipitation (mm)		
	Climate Normal[1]	Wettest Year[2]	Driest Year[3]	Climate Normal[1]	Wettest Year[2]	Driest Year[3]
January	-8.2	-6	-10.1	122	187	76.9
February	-8.4	-7.2	-13.6	98.1	89.4	95.3
March	-4.8	-2.4	-8.9	95	167.8	55.2
April	1	2.4	-0.3	85.7	82	62.8
May	7	5.4	7.1	86.6	123	45.4
June	12.1	12.5	11.8	87.8	98.6	32.3
July	16.3	16.5	15	95.3	144.2	79.9
August	16.2	17.1	14.9	123	128.2	53.8
September	11.9	12.1	9.3	110.4	96	23.1
October	6	5.8	4.7	97.5	166.8	46.5
November	0.5	1.5	1.8	111.8	79	58.7
December	-4.5	-4.3	-2.6	123.1	200.8	53.3
Annual	3.8	4.5	2.5	1236.2	1562.8	683.2

Notes:
[1] Climate Normal period is 1981 – 2010
[2] Wettest year recorded at the Buchans station was 2000
[3] Driest year recorded at the Buchans station was 1950

Under climate normal conditions, the coldest month is February with an average temperature of -8.4°C and the warmest month is July with an average monthly temperature of 16.3°C. The average annual temperature is 3.8°C. Average monthly temperatures typically drops below freezing in December and remains below freezing until April. The climate normal annual precipitation amount is 1,236 mm. The highest mean monthly precipitation occurs in December (123.1 mm) and the lowest mean monthly precipitation occurs in April (85.7 mm).

Snowfall climate normal statistics are presented in Table 7.5 and show that average annual snowfall recorded at Buchans is 359.3 cm with month end snow depths typically highest in February. The largest snow depth recorded was in March 1982 at 210 cm.

Table 7.5 Snowfall Statistics for Buchans Climate Station 1980 - 2010 (Station ID 8400698)

Month	Snowfall (cm)	Snow Depth (cm)	Snow Depth at Month End (cm)	Extreme Snow Depth (cm)
January	88.3	55	62	162
February	72.5	67	71	207
March	55.5	60	42	210
April	26.2	22	3	127
May	4.4	0	0	38
June	0.1	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0.1	0	0	3
October	5	0	0	25
November	30.4	5	10	70
December	76.9	28	42	140
Annual	359.3			

Annual precipitation for various wet and dry year return periods is presented in Table 7.6. The wettest year (2000) recorded at Buchans Station, with annual precipitation of 1,562.8 mm, is representative of a between 25 and 50-year return period wet year. The driest year (1950) recorded at Buchans Station, with annual precipitation of 683.2 mm, is representative of a dry year of approximately a 50-year return period. This analysis shows that year to year total precipitation values can vary substantially.

Table 7.6 Total Annual Precipitation for Various Return Periods

Climate Normal Precipitation	Annual Precipitation (mm)	
	1,236.2	
Return Period (Year)	**Wet Year**	**Dry Year**
5	1354.9	918.5
10	1428.9	832.4
25	1539.0	735.9
50	1630.7	672.6
100	1729.7	616.0
200	1836.2	564.9
1000	2113.7	463.9

Note:

Based on 54 years of full year records from stations located at Buchans. 39 years reported values below the Climate Normal Annual Precipitation and were used in the Dry Year analysis while 15 years reported values above the Climate Normal Annual Precipitation and were used in the Wet Year analysis

Projected monthly precipitation and temperature data under climate change scenarios for the Red Indian Lake region of the Island are shown in Table 7.7. These data represent projected conditions as reported in the Climate Atlas of Canada (Prairie Climate Center 2019) and are based on the IPCC RCP4.5 emissions scenario, which corresponds to an intermediate greenhouse gas emissions scenario to 2100. The RCP4.5 emissions scenario was also used by CRA in the generation of climate change IDF curves, as discussed in the following subsection. Climate change predictions under the more intense emissions scenario, RCP8.5, are discussed in the baseline report (BSA.3, Attachment 3-C). Surface water quantity predictions in the LAA are considered under climate normal and climate change scenarios to provide an understanding of the range of conditions that may be present during mine operation.

The climate change projected temperatures are seen to increase for each month relative to climate normal conditions, with the largest increase occurring in the winter months (2.8ºC warmer in January). The climate change projected precipitation is seen to increase in the winter, spring and fall months while a decrease is predicted in the months of August and September. These changes can be summarized as warmer, drier summers accompanied with warmer and wetter conditions in fall, winter and spring.

Table 7.7 Climate Change Temperature and Precipitation Projections - Red Indian Lake Region (2021-2050) (Prairie Climate Center 2019)

Month	Temperature (°C)		Precipitation (mm)	
	Climate Normal	Climate Change (RCP4.5)	Climate Normal	Climate Change (RCP4.5)
January	-8.2	-5.4	122.0	128.0
February	-8.4	-6	98.1	107.0
March	-4.8	-3.2	95.0	103.0
April	1.0	1.9	85.7	86.0
May	7.0	7.3	86.6	92.0
June	12.1	12.6	87.8	93.0
July	16.3	16.9	95.3	101.0
August	16.2	16.9	123.0	109.0
September	11.9	12.5	110.4	110.0
October	6.0	7	97.5	121.0
November	0.5	2.2	111.8	129.0
December	-4.5	-2.6	123.1	136.0
Annual			1236.3	1315.0

IDF Curves

The IDF curves for the Stephenville climate station were developed by ECCC based on 48 years of rainfall data. These are presented in Table 7.8 (ECCC 2019).

Table 7.8 IDF Curve Statistics - Stephenville Climate Station (1967 – 2017) (ECCC 2019)

Duration	Total Rainfall (mm)					
	2-year Return Period	5-year Return Period	10-year Return Period	25-year Return Period	50-year Return Period	100-year Return Period
5 min	4.5	6.2	7.4	8.8	9.9	10.9
10 min	6.7	9.3	11.0	13.2	14.8	16.4
15 min	8.4	11.5	13.5	16.1	18.0	19.9
30 min	11.9	16.4	19.4	23.2	26.0	28.7
1-hour	16.7	22.3	26.0	30.7	34.2	37.7
2-hour	23.0	30.1	34.8	40.7	45.1	49.5
6-hour	38.5	50.3	58.2	68.1	75.5	82.8
12-hour	47.5	61.5	70.7	82.4	91.1	99.7
24-hour	59.1	78.2	90.8	106.7	118.5	130.3

The IPCC RCP4.5 emissions scenario was used to generate climate change IDF curves for Stephenville for the period of 2011-2040, as shown in Table 7.9. IDF curves for this timeframe were chosen based on the expected operational life of the Project. The average increase of IDF rainfall amounts associated with these projections is approximately 10% (CRA 2015).

Table 7.9 Climate Change IDF Projections - Stephenville Climate Station (2011 - 2040) (RCAP 4.5 Scenario) (CRA 2015)

Duration	Total Rainfall (mm)					
	2-year Return Period	5-year Return Period	10-year Return Period	25-year Return Period	50-year Return Period	100-year Return Period
5 min	5.1	7	8.2	9.8	10.9	12
10 min	7.2	10.1	12	14.4	16.1	17.8
15 min	9.2	12.4	14.6	17.3	19.3	21.2
30 min	13.5	18.3	21.5	25.5	28.4	31.3
1-hour	18.6	24.8	29	34.2	38.1	41.9
2-hour	25	31.7	36.2	41.8	45.9	50
6-hour	42.3	54.1	62	71.7	78.9	86
12-hour	51.8	67.3	77.7	90.6	100	109.4
24-hour	65.1	86.4	100.7	118.6	131.8	144.8

Evapotranspiration

Mean annual potential evapotranspiration for the Island has been mapped. The potential mean annual evapotranspiration for the Project Area ranges from 450 to 474 mm (NLDOEC 1992).

Surface Features

An overview of the effects of surface features is provided in the following subsections. Surface features can influence the surface water of the Project Area as they can affect both the quantity and quality of runoff in each relevant watershed.

Based on a review of soils, surficial geological maps and aerial photographs, the overburden material in the LAA generally consists of a discontinuous layer of till of variable thickness over exposed bedrock. The WRAN classifies the surficial geology as a veneer of glacial till (less than 1.5 m) over bedrock (NLDOEC 1992). The LAA is considered part of the Mountain pedoclimatic zone, which is characterized by stony, shallow, coarse textured soils (Agriculture Canada 1988). These soils are further described as imperfectly drained, commonly very shallow and associated with large areas of rock outcrops. Coarse textured soils are considered to correspond with sands and loamy sands.

Topography and Vegetation

The topography of the site is hilly with elevations in the local HS watersheds ranging from 273 to 437 metres above sea level (masl). A local ridge runs through the LAA in a NE to SW direction, with water draining south and east to the Victoria River and Victoria Lake Reservoir or north and west to Valentine Lake.

Based on the ELCA prepared for the Project, twelve vegetation communities (i.e., land cover classes) are present in the LAA. Of these, nine are vegetated and three are sparsely vegetated, naturally non-vegetated and/or anthropogenic. Ground cover generally consists of forest, wetland bogs, open water, shoreline and anthropogenic (exploration camp). Refer to Chapter 9 for additional information.

7.2.2.2 Regional Hydrology

An assessment of Regional Hydrology, including a regional flow assessment (MMFs, MAFs and return period peak flows), FDCs, and low and environmental flows are provided in the following subsections.

Regional Flow Assessment

The relationship between MAFs and watershed area for selected WSC stations located in the NE hydrologically homogeneous region suggests that 99% of the variability in the MAF can be explained by watershed area. WSC stations in the NE hydrologic region having a watershed area over 1,000 km^2, those on regulated watercourses, and those with heterogenous data were removed from the analysis, leaving 12 stations that were included in the regional assessment. Figure 7-5 shows the relationship between MAF and watershed area for these 12 stations and shows a backcasted trend line that can be used to predict MAFs in the LAA (Section 7.2.2.3).

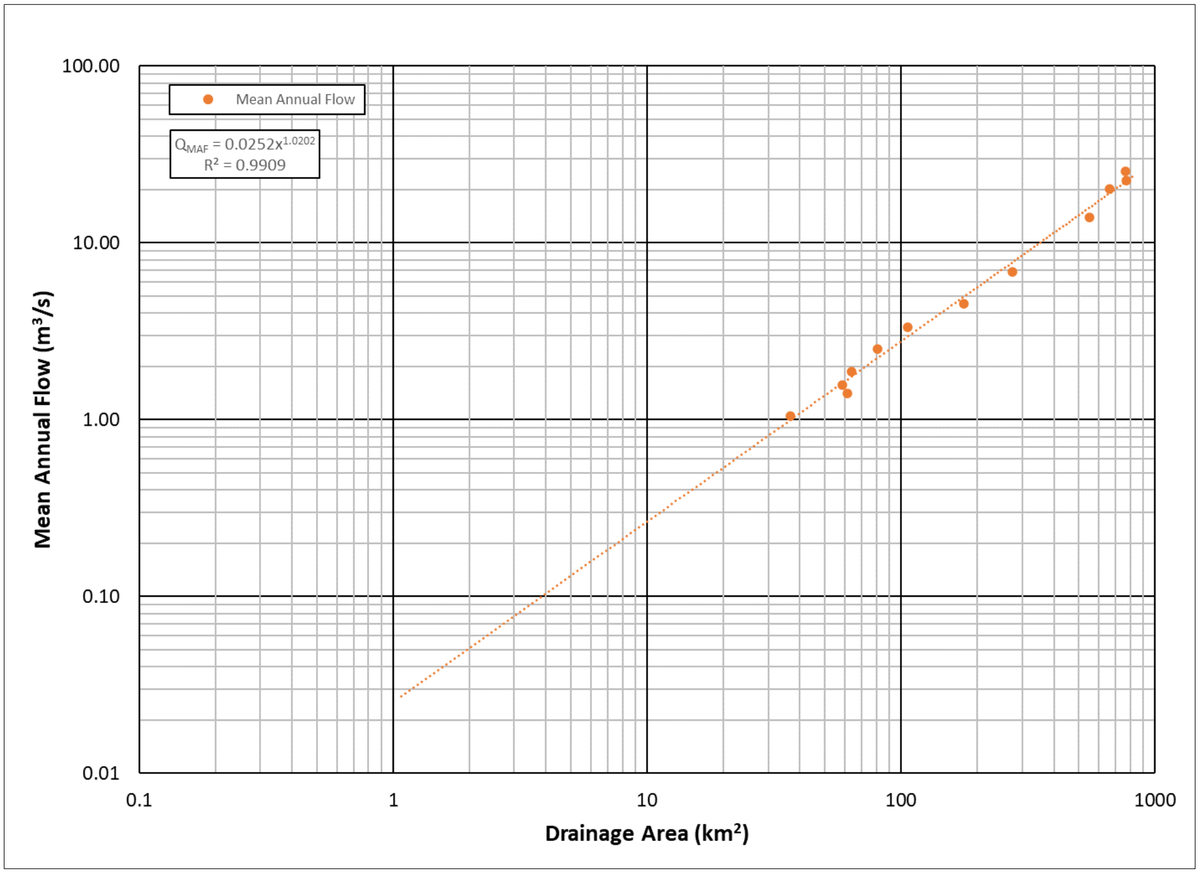


Figure 7-5 Watershed Area and Mean Annual Flow Relationship for WSC stations

The MMFs per unit area for the selected WSC stations are presented in Figure 7-6. Stream flow tends to peak twice a year, first in April/May due to snow melt, and again in November due to fall rainfall events. Minimum flows are observed during winter months from January to February and late summer between July and September.

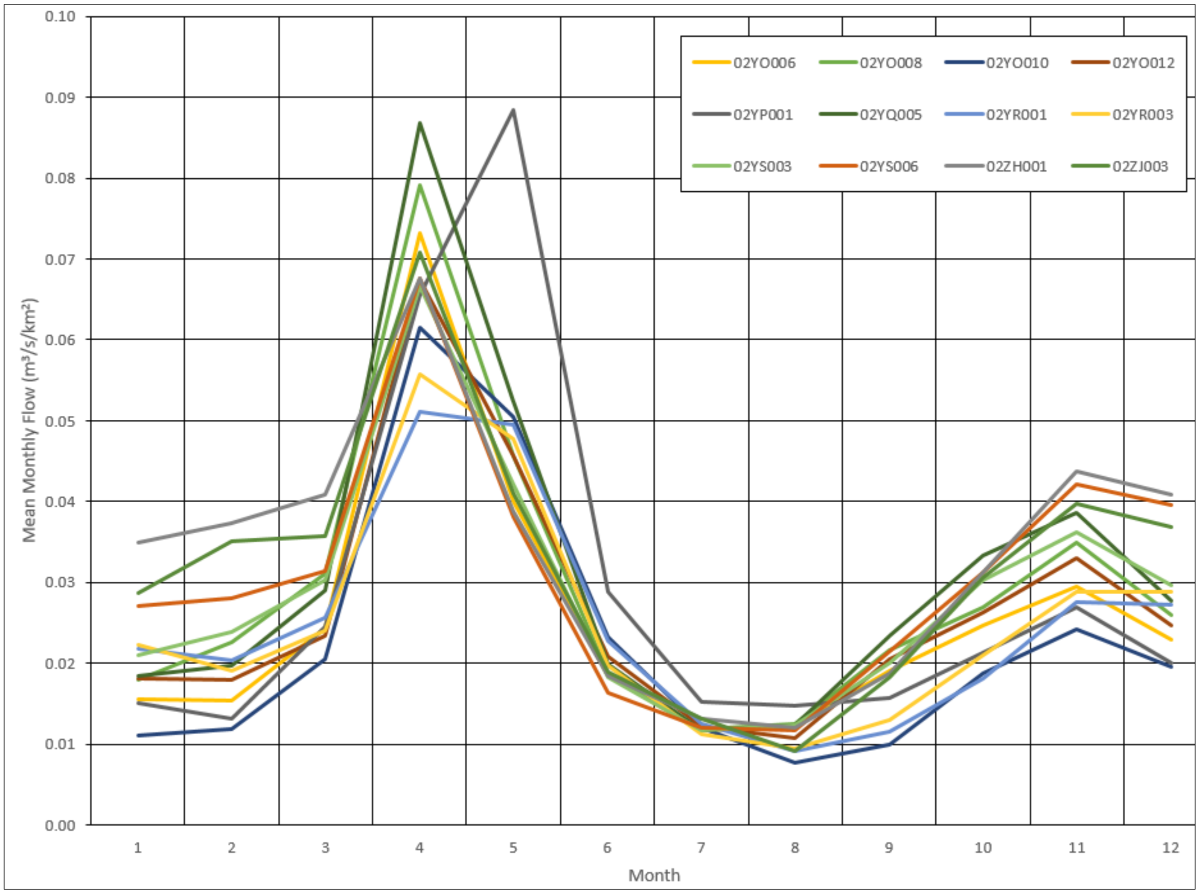


Figure 7-6 Mean Monthly Flows of NE Hydrologic Region WSC Stations

Regional relationships for peak flows were developed using the 12 WSC stations selected for the regional assessment. Figure 7-7 presents the relationships between peak flows and watershed areas for various return period events (2, 5, 10, 20, 50, 100 and 200-year).

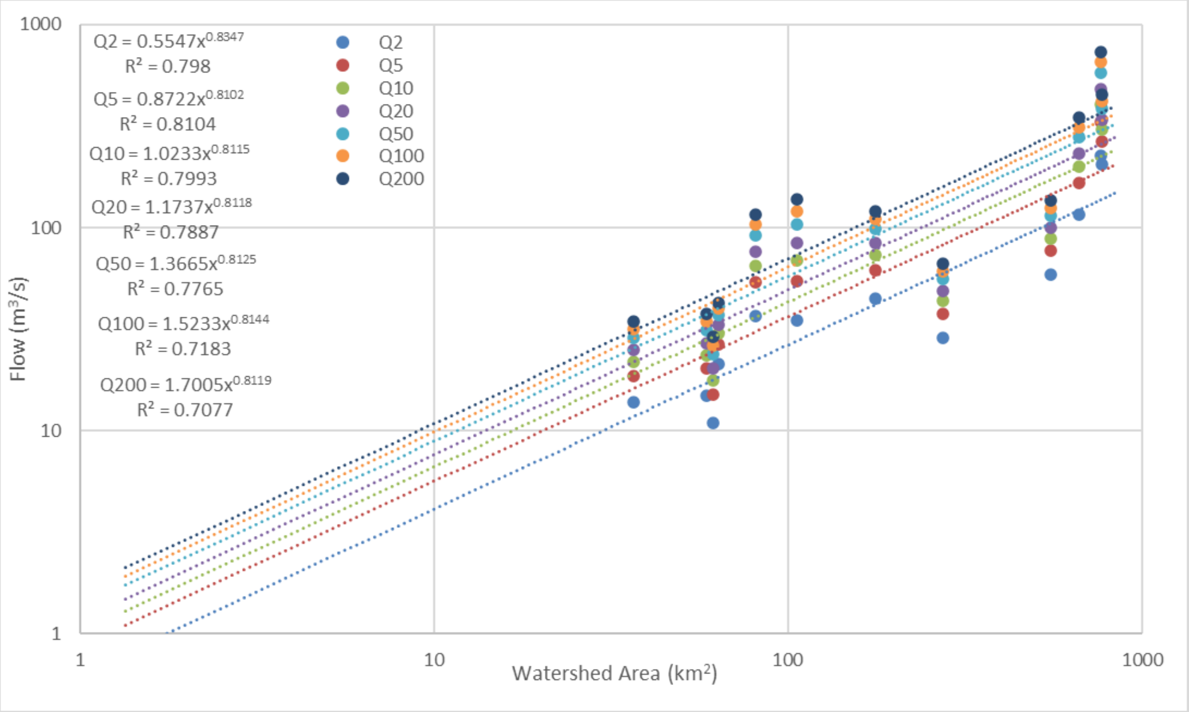


Figure 7-7 Peak Flow and Watershed Area Relationship for Regionally Selected WSC Stations

A streamflow coefficient for the RAA was calculated to be 62.5% and was determined using the climate normal precipitation data from Buchans and the evapotranspiration rate from the WRAN, as shown in Table 7.10. Streamflow coefficients were also calculated for the selected WSC stations using their calculated runoff depth, and an evapotranspiration rate of 463 mm. Coefficients were found to have an average of 65%, which aligns closely with that calculated in Table 7.10. Coefficients within the NE zone were found to vary from 58% to 71%.

Table 7.10 Streamflow Coefficient for LAA

Climate Normal Annual Precipitation (mm)	Annual Evapotranspiration (mm)	Streamflow (P–ET) (mm)	Streamflow Coefficient (%)
1,236	463	773	62.5

Flow Durations Curves

FDCs for selected WSC stations were developed and the results are shown in Figure 7-8. The FDCs are normalized for watershed area to present a range of flow durations and facilitate station to station comparison. The FDCs demonstrate reasonably good regional homogeneity.

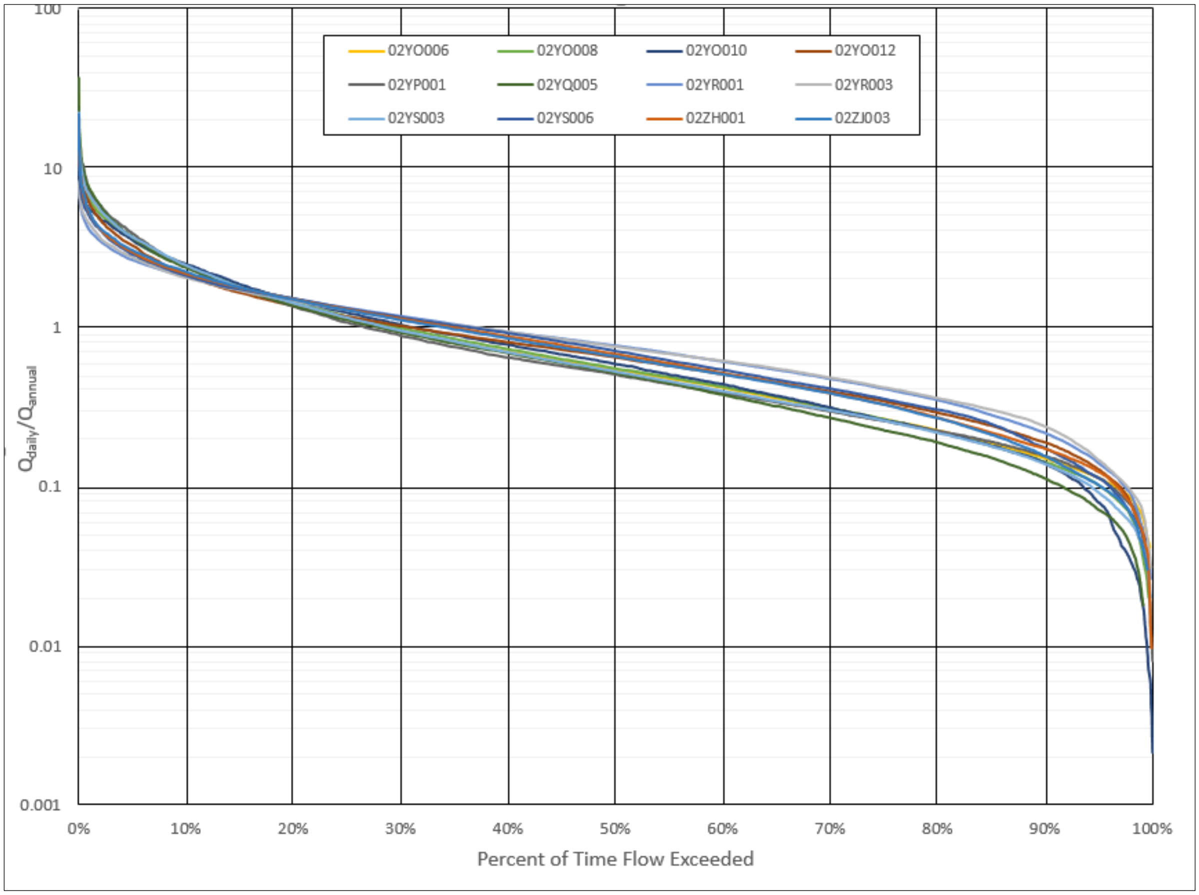


Figure 7-8 Flow Duration Curves of Select NE Hydrologic Region WSC Stations

Low and Environmental Flows

Low flow relationships were derived using the regional frequency analysis developed by Zadeh (2012) and put forward in the province's low flow calculation spreadsheet. Relationships were developed between low flows and watershed area using the province's low flow spreadsheet for various return periods. Table 7.11 provides a range of low and environmental flow statistics for a range of arbitrary watershed areas based on these regional relationships.

Table 7.11 Low and Environmental Flows for Various Watershed Areas

Flow Statistic (m^3/s)	Watershed Area (km^2)					
	1	5	10	25	50	100
1Q2	0.002	0.012	0.026	0.071	0.153	0.329
7Q2	0.003	0.015	0.031	0.085	0.180	0.383
1Q10	0.001	0.006	0.012	0.034	0.072	0.156
7Q10	0.001	0.007	0.015	0.041	0.087	0.185
1Q20	0.001	0.004	0.009	0.024	0.053	0.114

Table 7.11 Low and Environmental Flows for Various Watershed Areas

Flow Statistic (m^3/s)	Watershed Area (km^2)					
	1	5	10	25	50	100
7Q20	0.001	0.005	0.011	0.030	0.064	0.137
1Q50	0.000	0.003	0.005	0.015	0.032	0.070
7Q50	0.001	0.003	0.007	0.019	0.041	0.086
1Q100	0.000	0.002	0.003	0.009	0.020	0.042
7Q100	0.000	0.002	0.004	0.012	0.026	0.055
Summer Environmental Flow (50% MAF)	0.017	0.079	0.154	0.372	0.725	1.414
Winter Environmental Flow (30% MAF)	0.010	0.047	0.092	0.223	0.435	0.848

Regional Hydrology Summary

Regional hydrology was assessed to develop an understanding of climatic and hydrologic conditions that are best described using stations with a long period of record. Climate normal, wet year and dry year precipitation, and temperature data for the Buchans climate station were used to understand the range of conditions that may be expected in the Project Area. IDF curves for the Stephenville station were assessed to understand the rainfall intensity that may be expected during various return period events. Both IDF and climate data were also considered under RCP4.5 climate change scenarios.

Regional flow data from WSC stations located in the NE hydrologic region considered to be homogeneous were used to establish relationships between watershed area and flow statistics (MAF, MMF, low flows and environmental flows) to be used in the effects assessment for the Surface Water VC.

7.2.2.3 Local Hydrology

The following subsections provide findings of a review of the local hydrology including environmental water balance, HSs, watershed delineation, bathymetry and local water users.

Environmental Water Balance

The environmental water balance model was run on a monthly basis under three climate scenarios: climate normal, wet year and dry year. The input parameters included monthly precipitation, temperature, runoff factor, soil moisture storage capacity, and rain and snowfall temperature thresholds. These were established based on assumptions of local climate and soil conditions and guidance provided by USGS (McCabe and Markstrom 2007). Input parameters are further described in the baseline report (BSA.3, Attachment 3-C). Climate normal temperature inputs were used for each of the three scenarios. Climate normal precipitation values were used for the climate normal scenario. Precipitation values reported in 1950 were used for the dry year, as this year most closely aligns with the 1:50 dry year total precipitation. Precipitation values reported in 2000 were used for the wet year as this year most closely aligns with the 1:50 wet year total precipitation.

Results from the water balance under these three scenarios are presented in Tables 7.12, 7.13 and 7.14. An evaluation of the environmental water balance results in comparison to the regionally derived flow statistics for the watershed areas within the LAA is presented in the following subsection.

Table 7.12 Monthly Environmental Water Balance – Climate Normal (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	122	98.1	95	85.7	86.6	87.8	95.3	123	110.4	97.5	111.8	123.1
Actual Evapotranspiration	3.4	3.9	7.1	27.8	51.5	76	96.9	80	45.3	23.9	11.9	7.6
Soil Moisture Storage	146.6	142.7	135.6	300	300	300	300	300	300	300	300	292.4
Total Runoff	15.7	6	2.3	34.2	83.6	63.5	35.5	46.7	64	69.7	88.7	31.6

Table 7.13 Monthly Environmental Water Balance– 1:50 Wet Year (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	187	89.4	167.8	82	123	98.6	144.2	128.2	96	166.8	79	200.8
Actual Evapotranspiration	3.4	3.9	7.1	27.8	51.5	76	96.9	80	45.3	23.9	11.9	7.6
Soil Moisture Storage	146.6	142.7	135.6	300	300	300	300	300	300	300	300	292.4
Total Runoff	15.7	6	2.3	71.8	141.3	101.7	86	70.8	62	117.8	84.7	30.7

Table 7.14 Monthly Environmental Water Balance– 1:50 Dry Year (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation	76.9	95.3	55.2	62.8	45.4	32.3	79.9	53.8	23.1	46.5	58.7	53.3
Actual Evapotranspiration	3.4	3.9	7.1	27.8	51.5	76	96.6	78.3	43	23.9	11.9	7.6
Soil Moisture Storage	146.6	142.7	135.6	281.2	300	283.1	276.7	256.6	242.6	262.9	300	292.4
Total Runoff	15.7	6	2.3	4	21	8.7	6.7	3.7	1.5	2.5	7.2	1.6

These results show that expected annual evapotranspiration ranges from 431 mm in the dry year, to 435 mm in the climate normal and wet year. These evapotranspiration rates are within 4 to 8 % of the range given in the WRAN of 450 to 475 mm/year reported for the Project Area.

Local and Regional Hydrogeology

The depth to groundwater varies across the LAA and groundwater catchment areas are inferred to coincide closely with surface water catchment areas (BSA.3, Attachment 3-B). Groundwater levels in the overburden were lower during winter months due to frozen ground conditions and limited infiltration. The shallow overburden aquifer is noted to be unconfined and a direct response to rainfall events was observed. Vertical hydraulic gradients were used as an indication of groundwater recharge or discharge to local streams. Downward gradients and thus groundwater recharge were observed in areas of high elevation (drainage divides) and upward gradients and groundwater discharge were observed in areas of lower elevations (near waterbodies) (BSA.3, Attachment 3-C).

A monthly BFI was calculated using the SAAS software (V4.1) based on 13 years of continuous daily flow data from WSC station 02YO014. Baseflow contributions to total flow at this station for its period of record were found to vary from 23% (April) to 43% (March). The BFI calculated for the entire 13-year period of record was 35%. This BFI is considered applicable to the LAA with some potential variations that may include higher BFI in streams located in perched water tables (i.e., HS1 and HS2 which are located in or near bogs) and potentially lower BFI in streams located in areas of highly permeable bedrock (i.e., HS7 which exhibited very low summer flows).

Hydrometric Stations

Twelve HSs were established between 2011 and 2019. Of these stations, eight collected continuous water level data using a pressure transducer as well as spot flow measurements (HS1, HS2, HS3, HS7, HS8, HS9, HS11, HS12). Three stations collected only spot flow measurements (HS4, HS5, HS6), and one lake location collected continuous water level data and had no corresponding spot flow measurements (HS10). The location of each HS is shown on Figure 7-2.

A stage-discharge relationship (rating curve) was developed for applicable HSs, based on measured water level and discharge measurements. A minimum of eight discharge measurements were completed at each of the stations for which a rating curve was developed, except HS7 and HS9, which each had seven measurements. The recommended number of discharge measurements to develop a rating curve on a single segment is six, evenly distributed over the range of flows being rated (British Columbia Resources Information Standards Committee 2018). Discharge measurements were collected during the ice-free period when sites were accessible, and conditions were considered safe for data collection. Conditions during the summer of 2019 were exceptionally dry; therefore, the majority of flow measurements were taken between low flow and bank full conditions. Flows exceeding bank full were generally not measured due to either safe access concerns during these conditions and/or the occurrence of such events not aligning with field visits.

HS summary forms, providing an overview of information relating to each station are provided in the baseline report (BSA.3, Attachment 3-C). Flow monitoring results are further summarized for each station in Table 7.15.

Table 7.15 Summary of Hydrometric Stations Field Measured Flows (m^3/s)

Flow Measurement	Station ID										
	HS1	**HS2**	**HS3**	**HS4**	**HS5**	**HS6**	**HS7**	**HS8**	**HS9**	**HS11**	**HS12**
1	0.0226	0.0059	0.0616	0.0792	0.0736	0.1551	0.0137	0.071	0.0294	0.0112	0.0065
2	0.0178	0.0089	0.0123	0.014	0.076	0.082	0.0044	0.0475	0.0190	0.0088	0.0046
3	0.0054	0.0026	0.002	0.0153	0.017	0.035	0.3519	0.5159	0.0563	0.0016	0.0001
4	0.0047	0.0025	0.0009	0.0031	0.0011	0.0056	0.0008	0.0041	0.0004	0.0026	0.0027
5	0	0.0001	0	0.0041	0.0001	0.0042	0.0002	0.0027	0.0001	0.1433	0.1163
6	0.0446	0.11	0.0667	0.0001	0.1153	0.0001	0.1186	0.3139	0.1731	0.0728	0.0736
7	0.0199	0.041	0.0286	0.0981	0.0265	0.2899	0.0090	0.1108	0.1270	0.0399	0.0501
8	0.0042	0.0078	0.0037	0.0377	0.0001	0.0749	-	0.0403	-	0.0030	0.0048
min	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0002	0.0027	0.0001	0.0016	0.0001
max	0.0446	0.1100	0.0667	0.0981	0.1153	0.2899	0.3519	0.5159	0.1731	0.1433	0.1163

A rating curve was developed for each station in the AQUARIUS platform using the field measured flow rates and corresponding barometrically corrected water stage data collected for each separate HS. Rating curves are provided in the baseline report (BSA.3, Attachment 3-C). The continuous water level recorded at HS10, showing water level fluctuations during the summer of 2019, is shown in Figure 7-9.

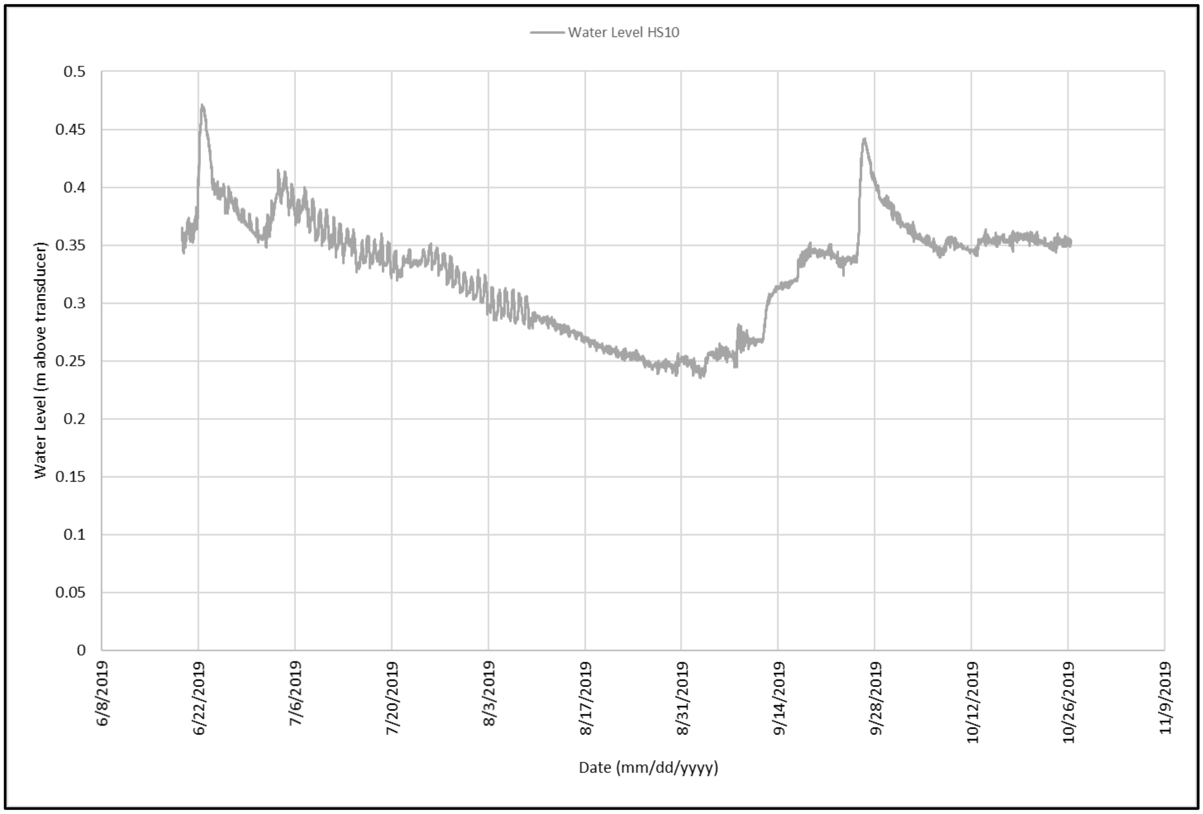


Figure 7-9 HS10 Water Levels for VALP3 Lake

Watershed Delineation and Statistics

Watersheds upstream of each of the HSs established during baseline monitoring were delineated using ArcGIS software (ArcMap 10.6.1). Delineated watersheds corresponding to each HS are shown in Figure 7-10. A summary of watershed areas and elevation range is provided in Table 7.16.

Table 7.16 Watershed Area for Hydrometric Stations

Station ID	Watershed Area (km^2)	Elevation at Headwaters (masl)	Elevation at Outlet (masl)
HS1	0.397	388	421
HS2	1.047	382	437
HS3	0.702	381	429
HS4	1.006	341	429
HS5	1.009	343	413
HS6	2.332	341	429
HS7	1.781	361	437
HS8	5.325	273	402
HS9	3.031	333	435
HS10*	3.031	333	435
HS11	1.756	258	360
HS12	1.099	260	348

Note:

* Watershed area for HS10 (Lake monitoring station) was assumed to be the same as HS9 (Lake outlet monitoring station)

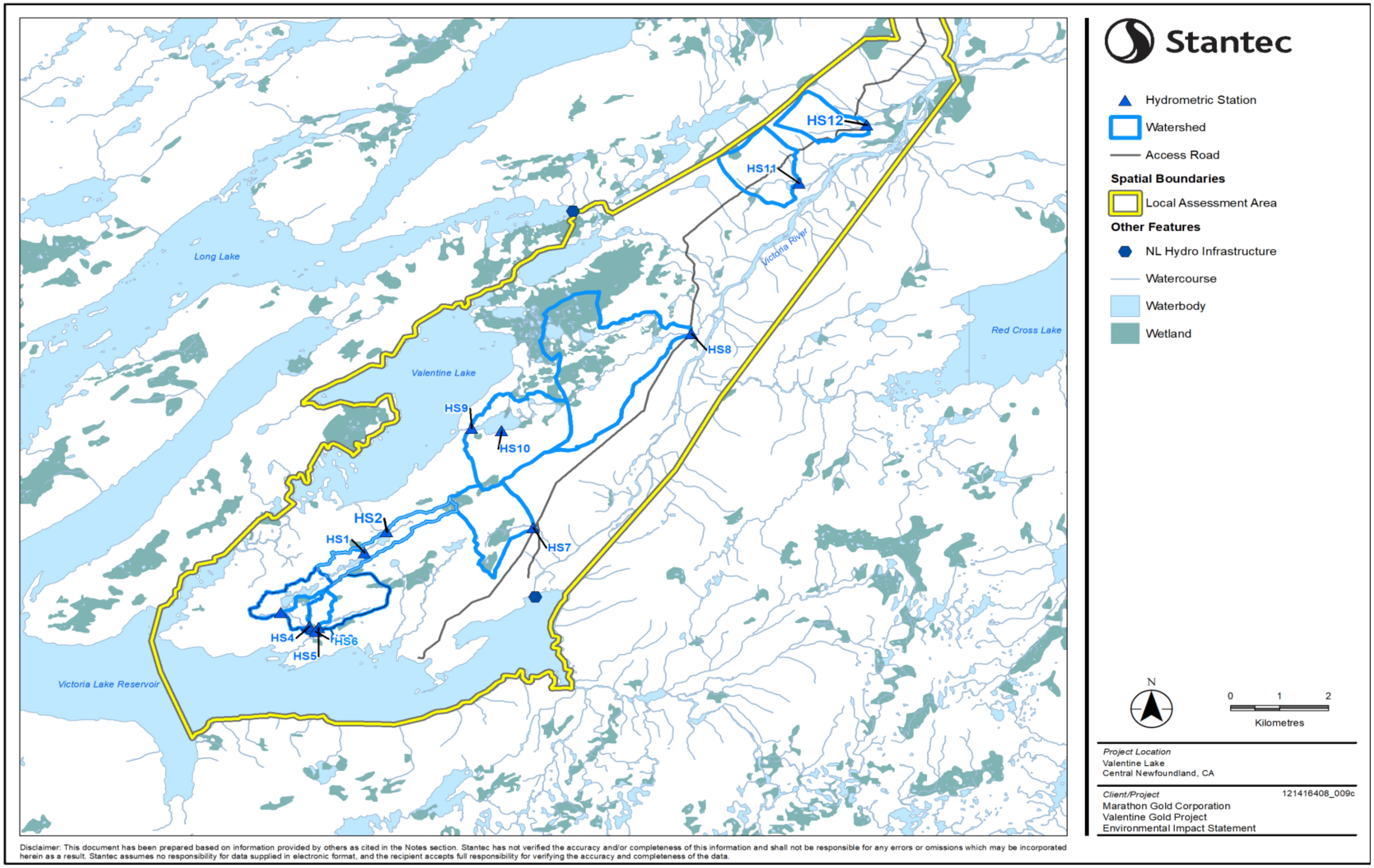


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Figure 7-10 Watershed Delineations Upstream of Hydrometric Stations

Watersheds were also delineated to capture the pre-development areas that will overlap the proposed mine infrastructure. These watersheds contain the entire area that will have runoff directed to an FDP as part of the Project water management infrastructure. These pre-development watersheds (referred to as watershed areas) capture the areas needed to quantify Project-related changes to surface water quantity and are shown in Figure 7-11. A summary of watershed areas and elevation ranges are provided in Table 7.17.

Table 7.17 Pre-development Watershed Areas

Watershed (WS) ID	Watershed Area (km^2)	Elevation at Headwaters (masl)	Elevation at Outlet (masl)
WS1	0.387	411	327
WS2	1.292	380	343
WS3	0.361	380	380
WS4	0.553	406	335
WS5	0.113	399	389
WS6	0.980	379	343
WS7	0.319	361	326
WS8	1.389	401	325
WS9	0.588	404	367
WS10	1.938	379	365
WS11	0.307	384	380
WS12	2.246	398	285
WS13	0.653	432	294
WS14	1.467	425	315
WS15	1.411	402	318
WS16	1.146	413	336
WS17	0.617	402	345
WS18	2.140	400	350
WS19	0.271	347	303
WS20	0.708	343	327
WS21	1.813	340	328
WS22	0.813	331	318
WS23	0.387		

Flow statistics for MAF, MMF and Return Period Flows for these watershed areas have been calculated by applying the relationships developed in the Regional Hydrology Assessment (Section 7.2.2.2).

Low and environmental flow statistics have also been calculated for each watershed area by applying the relationships developed in the regional hydrology assessment (Section 7.2.2.2). Table 7.18 presents these calculated flow statistics for each watershed area.

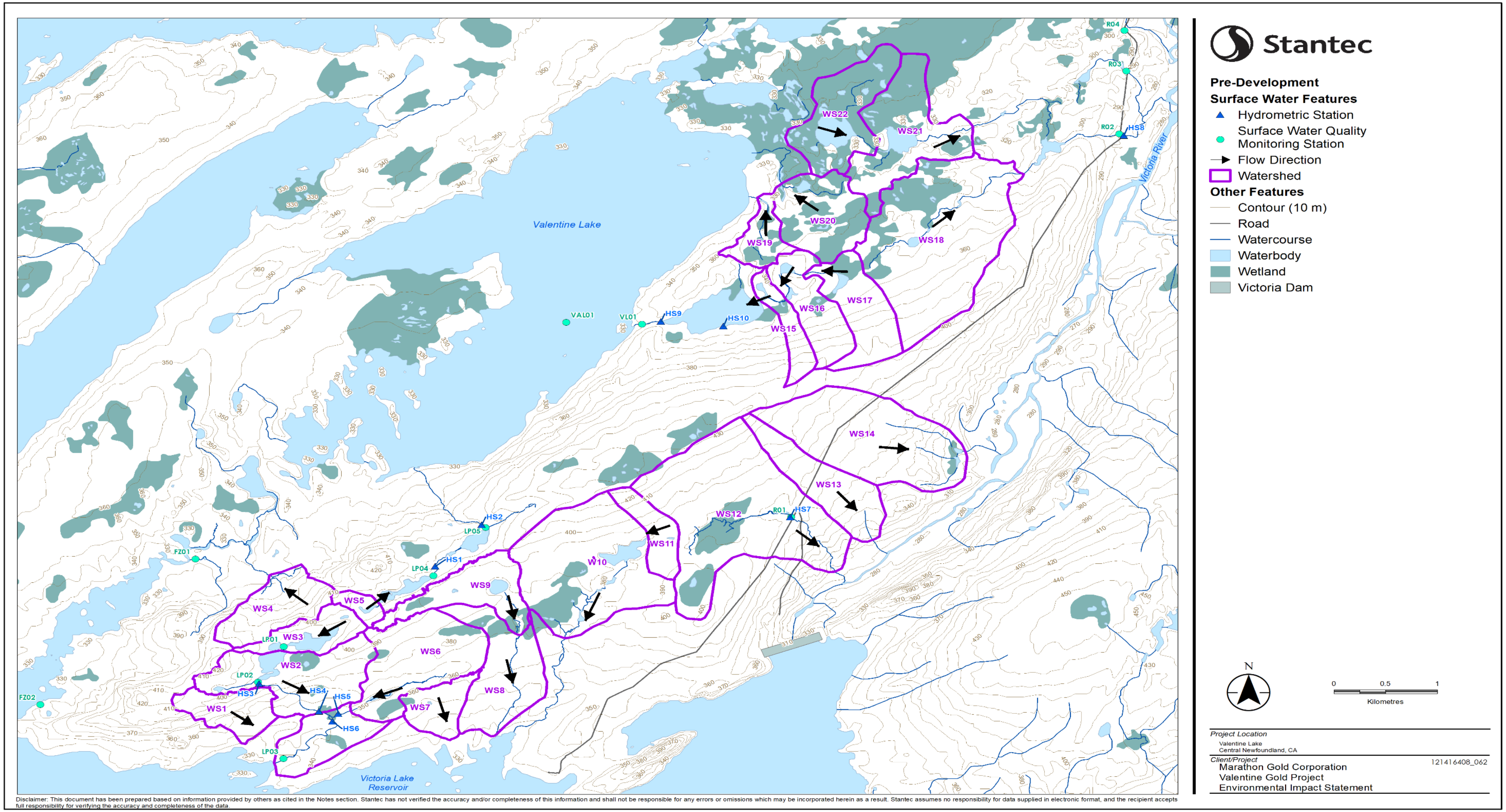


Figure 7-11 Pre-development Watershed Areas

Table 7.18 Calculated Flow Statistics for Pre-development Watershed Areas

ID	Area (km^2)	MAF m^3/s)	Q100	Mean Monthly Flows (m^3/s)											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
WS1	0.487	0.0121	0.8479	0.0102	0.0107	0.0138	0.0330	0.0235	0.0099	0.0060	0.0054	0.0087	0.0127	0.0164	0.0140
WS2	1.292	0.0327	1.8769	0.0271	0.0285	0.0367	0.0876	0.0624	0.0263	0.0160	0.0144	0.0230	0.0338	0.0436	0.0371
WS3	0.361	0.0089	0.6640	0.0076	0.0080	0.0103	0.0244	0.0174	0.0073	0.0045	0.0040	0.0064	0.0094	0.0122	0.0103
WS4	0.553	0.0138	0.9402	0.0116	0.0122	0.0157	0.0375	0.0267	0.0113	0.0068	0.0062	0.0098	0.0145	0.0187	0.0159
WS5	0.113	0.0027	0.2587	0.0024	0.0025	0.0032	0.0077	0.0055	0.0023	0.0014	0.0013	0.0020	0.0030	0.0038	0.0033
WS6	0.980	0.0247	1.4986	0.0206	0.0216	0.0279	0.0664	0.0473	0.0200	0.0121	0.0110	0.0174	0.0256	0.0331	0.0281
WS7	0.319	0.0079	0.6013	0.0067	0.0070	0.0091	0.0216	0.0154	0.0065	0.0040	0.0036	0.0057	0.0084	0.0108	0.0092
WS8	1.389	0.0352	1.9902	0.0292	0.0306	0.0395	0.0941	0.0671	0.0283	0.0172	0.0155	0.0247	0.0363	0.0469	0.0398
WS9	0.588	0.0146	0.9878	0.0123	0.0129	0.0167	0.0398	0.0284	0.0120	0.0073	0.0066	0.0104	0.0154	0.0198	0.0168
WS10	1.938	0.0495	2.6111	0.0407	0.0427	0.0551	0.1313	0.0936	0.0395	0.0240	0.0217	0.0345	0.0507	0.0654	0.0556
WS11	0.307	0.0076	0.5829	0.0065	0.0068	0.0087	0.0208	0.0148	0.0063	0.0038	0.0034	0.0055	0.0080	0.0104	0.0088
WS12	2.246	0.0575	2.9441	0.0472	0.0495	0.0638	0.1522	0.1085	0.0458	0.0278	0.0251	0.0399	0.0587	0.0758	0.0644
WS13	0.653	0.0163	1.0771	0.0137	0.0144	0.0186	0.0443	0.0316	0.0133	0.0081	0.0073	0.0116	0.0171	0.0221	0.0187
WS14	0.774	0.0194	1.2366	0.0163	0.0171	0.0220	0.0525	0.0374	0.0158	0.0096	0.0086	0.0138	0.0202	0.0261	0.0222
WS15	0.397	0.0098	0.7180	0.0083	0.0088	0.0113	0.0269	0.0192	0.0081	0.0049	0.0044	0.0071	0.0104	0.0134	0.0114
WS16	1.411	0.0358	2.0167	0.0296	0.0311	0.0401	0.0956	0.0682	0.0288	0.0175	0.0158	0.0251	0.0369	0.0477	0.0405
WS17	1.146	0.0290	1.7020	0.0241	0.0253	0.0326	0.0777	0.0554	0.0233	0.0142	0.0128	0.0204	0.0300	0.0387	0.0329
WS18	0.617	0.0154	1.0283	0.0130	0.0136	0.0175	0.0418	0.0298	0.0126	0.0076	0.0069	0.0110	0.0161	0.0208	0.0177
WS19	2.140	0.0548	2.8310	0.0450	0.0472	0.0608	0.1450	0.1034	0.0436	0.0265	0.0239	0.0381	0.0560	0.0723	0.0614
WS20	0.271	0.0066	0.5254	0.0057	0.0060	0.0077	0.0183	0.0131	0.0055	0.0033	0.0030	0.0048	0.0071	0.0091	0.0078
WS21	0.708	0.0177	1.1493	0.0149	0.0156	0.0201	0.0480	0.0342	0.0144	0.0088	0.0079	0.0126	0.0185	0.0239	0.0203
WS22	1.813	0.0462	2.4731	0.0381	0.0400	0.0515	0.1229	0.0876	0.0369	0.0224	0.0203	0.0322	0.0474	0.0612	0.0520
WS23	0.813	0.0204	1.2868	0.0171	0.0179	0.0231	0.0551	0.0393	0.0166	0.0101	0.0091	0.0145	0.0213	0.0274	0.0233

Table 7.19 Calculated Low Flow Statistics for Pre-development Watershed Areas

ID	Area (km^2)	1Q2	7Q2	1Q10	7Q10	1Q20	7Q20	1Q50	7Q50	1Q100	7Q100	Summer Env. Flow (50% MAF)	Winter Env. Flow (30%MAF)
WS1	0.487	0.0009	0.0012	0.0005	0.0005	0.0003	0.0004	0.0002	0.0003	0.0001	0.0002	0.0060	0.0036
WS2	1.292	0.0027	0.0034	0.0013	0.0016	0.0009	0.0012	0.0005	0.0008	0.0004	0.0005	0.0164	0.0098
WS3	0.361	0.0006	0.0009	0.0003	0.0004	0.0002	0.0003	0.0001	0.0002	0.0001	0.0001	0.0045	0.0027
WS4	0.553	0.0010	0.0014	0.0005	0.0006	0.0004	0.0005	0.0002	0.0003	0.0002	0.0002	0.0069	0.0041
WS5	0.113	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0014	0.0008
WS6	0.980	0.0020	0.0025	0.0010	0.0012	0.0007	0.0009	0.0004	0.0006	0.0003	0.0004	0.0123	0.0074
WS7	0.319	0.0006	0.0008	0.0003	0.0003	0.0002	0.0003	0.0001	0.0002	0.0001	0.0001	0.0039	0.0024
WS8	1.389	0.0029	0.0037	0.0014	0.0017	0.0010	0.0013	0.0006	0.0009	0.0004	0.0006	0.0176	0.0106
WS9	0.588	0.0011	0.0015	0.0006	0.0007	0.0004	0.0005	0.0002	0.0003	0.0002	0.0002	0.0073	0.0044
WS10	1.938	0.0042	0.0053	0.0021	0.0025	0.0015	0.0018	0.0008	0.0012	0.0006	0.0008	0.0247	0.0148
WS11	0.307	0.0005	0.0007	0.0003	0.0003	0.0002	0.0003	0.0001	0.0002	0.0001	0.0001	0.0038	0.0023
WS12	2.246	0.0049	0.0063	0.0024	0.0029	0.0017	0.0022	0.0010	0.0014	0.0007	0.0010	0.0288	0.0173
WS13	0.653	0.0012	0.0016	0.0006	0.0008	0.0004	0.0006	0.0002	0.0004	0.0002	0.0003	0.0082	0.0049
WS14	0.774	0.0015	0.0020	0.0008	0.0009	0.0005	0.0007	0.0003	0.0005	0.0002	0.0003	0.0097	0.0058
WS15	0.397	0.0007	0.0010	0.0004	0.0004	0.0003	0.0003	0.0001	0.0002	0.0001	0.0001	0.0049	0.0029
WS16	1.411	0.0029	0.0038	0.0015	0.0017	0.0010	0.0013	0.0006	0.0009	0.0004	0.0006	0.0179	0.0107
WS17	1.146	0.0023	0.0030	0.0012	0.0014	0.0008	0.0010	0.0005	0.0007	0.0003	0.0005	0.0145	0.0087
WS18	0.617	0.0012	0.0015	0.0006	0.0007	0.0004	0.0005	0.0002	0.0004	0.0002	0.0002	0.0077	0.0046
WS19	2.140	0.0046	0.0059	0.0023	0.0027	0.0016	0.0021	0.0009	0.0014	0.0007	0.0009	0.0274	0.0164
WS20	0.271	0.0005	0.0006	0.0002	0.0003	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0033	0.0020
WS21	0.708	0.0014	0.0018	0.0007	0.0008	0.0005	0.0006	0.0003	0.0004	0.0002	0.0003	0.0089	0.0053
WS22	1.813	0.0039	0.0050	0.0019	0.0023	0.0014	0.0017	0.0008	0.0011	0.0006	0.0008	0.0231	0.0139
WS23	0.813	0.0016	0.0021	0.0008	0.0010	0.0006	0.0007	0.0003	0.0005	0.0002	0.0003	0.0102	0.0061

Bathymetry

Bathymetric data were collected in localized areas of Valentine Lake, Victoria Lake Reservoir and several smaller lakes. Bathymetric data showed that Valentine Lake was generally less than 10 m deep along its southern shore. There were two deep zones (>20 m) noted from the bathymetry in the southwestern end of Valentine Lake (Figure 7-12). The maximum depth in Valentine Lake observed during the bathymetric survey was 25.4 m.

The localized areas where bathymetric data were collected in Victoria Lake Reservoir showed that it was generally less than 15 m deep along its northern shore. One deep zone (>40 m) was noted from the bathymetry in the southwestern end of the mapped area (Figure 7-13). The maximum depth observed during the bathymetric survey was 41.1 m.

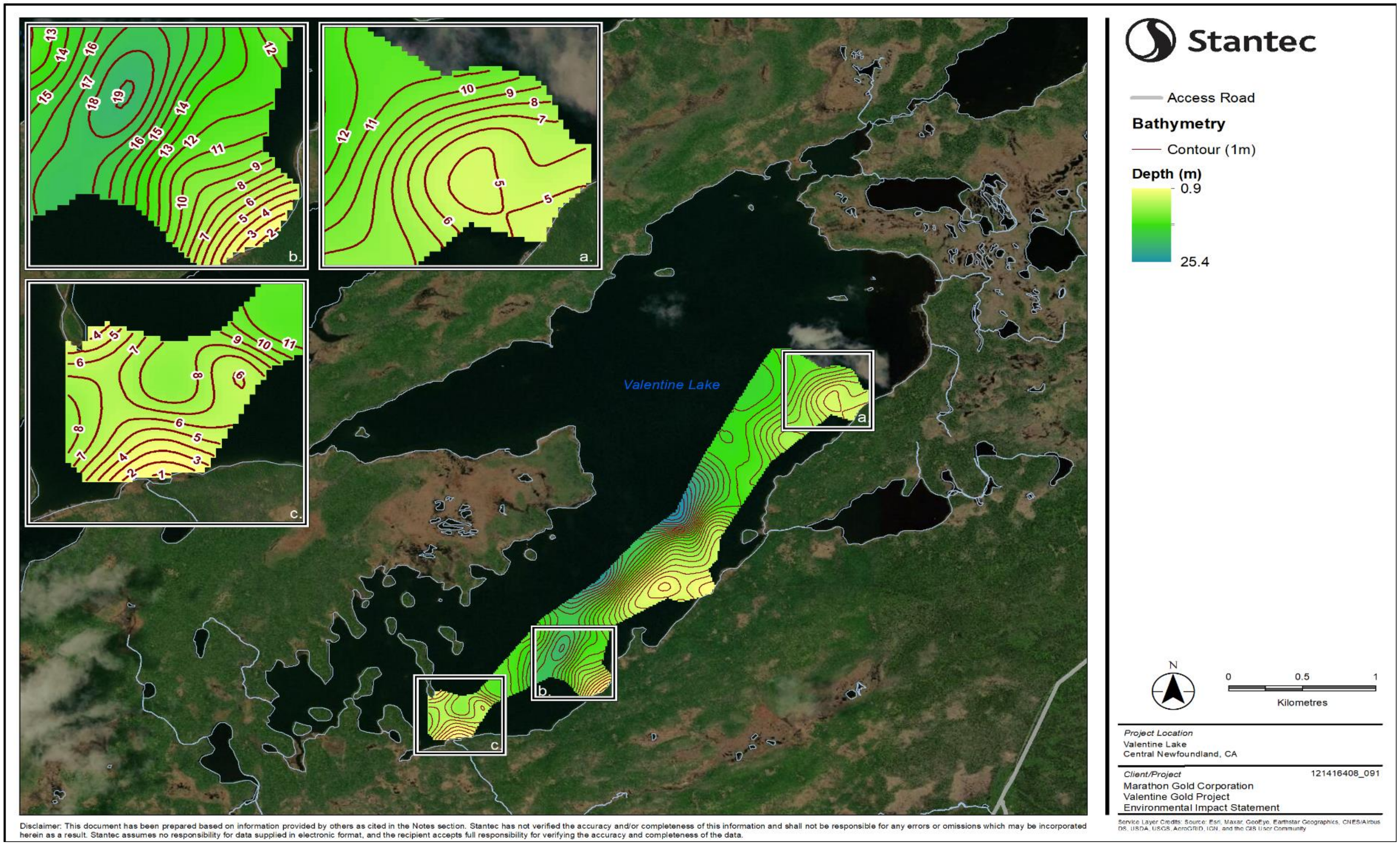
Bathymetric data were also collected in four smaller lakes within the Project Area: VALP1, VALP3, VICP1 and VICP2 (Figure 7-14). These waterbodies are generally shallow, with depths up to 1.5 m, with the exception of VICP1 which reported depths up to 4 m. Additional bathymetric data for selected streams is presented in the fisheries baseline report (Stream Habitat Classification Data Table – BSA.4, Attachment 4-C).

Local Water Users

There is substantial hydroelectric development near the Project Area; however, the only hydroelectric facilities within the LAA are the Victoria Dam and Spillway, which are part of the Bay d'Espoir Hydroelectric Development. The Bay d'Espoir Hydroelectric Generating Facility is the largest hydroelectric plant on the Island and includes three generating stations, six reservoirs, and associated dykes, dams, canals and hydraulic structures. The generating stations comprising the Bay d'Espoir Development were built in stages beginning in 1967. There are four remote hydraulic structures associated with the Bay d'Espoir development: Ebbegunbaeg Control Structure; Salmon River Spillway Structure; Victoria Control Structure; and Burnt Dam Spillway (NL Hydro 2012).

The Victoria Control Structure is a dam at the outlet of Victoria Lake Reservoir to the Victoria River, which naturally flowed north to Red Indian Lake. With a crest elevation of 326 m, this dam raised the natural lake elevation from 290 m to 325 m. The low supply level of the lake was set at 319 m by the Victoria Canal. In the late 1960s, Victoria Lake was diverted to the Victoria Canal which flows into the White Bear drainage basin to the south. The Victoria Canal was designed to convey between 34 m^3/s (at low supply level) and 170 m^3/s (at full supply level) (Read and Cole 1972).

Victoria Lake Reservoir water levels are recorded by a WSC station (ID 02YN005) and reported online. The Victoria Lake Reservoir is typically charged to maximum annual operating level following the spring melt (June) and subsequently is drawn down to a minimum operating level in the March and April. NL Hydro provided the stage storage relationship of the Victoria Lake Reservoir. This relationship and the Victoria Lake Reservoir WSC data are shown on Figure 7-15.



Project Location
Valentine Lake
Central Newfoundland, CA

Client/Project 121416408_091
Marathon Gold Corporation
Valentine Gold Project
Environmental Impact Statement

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Figure 7-12 Valentine Lake Bathymetry

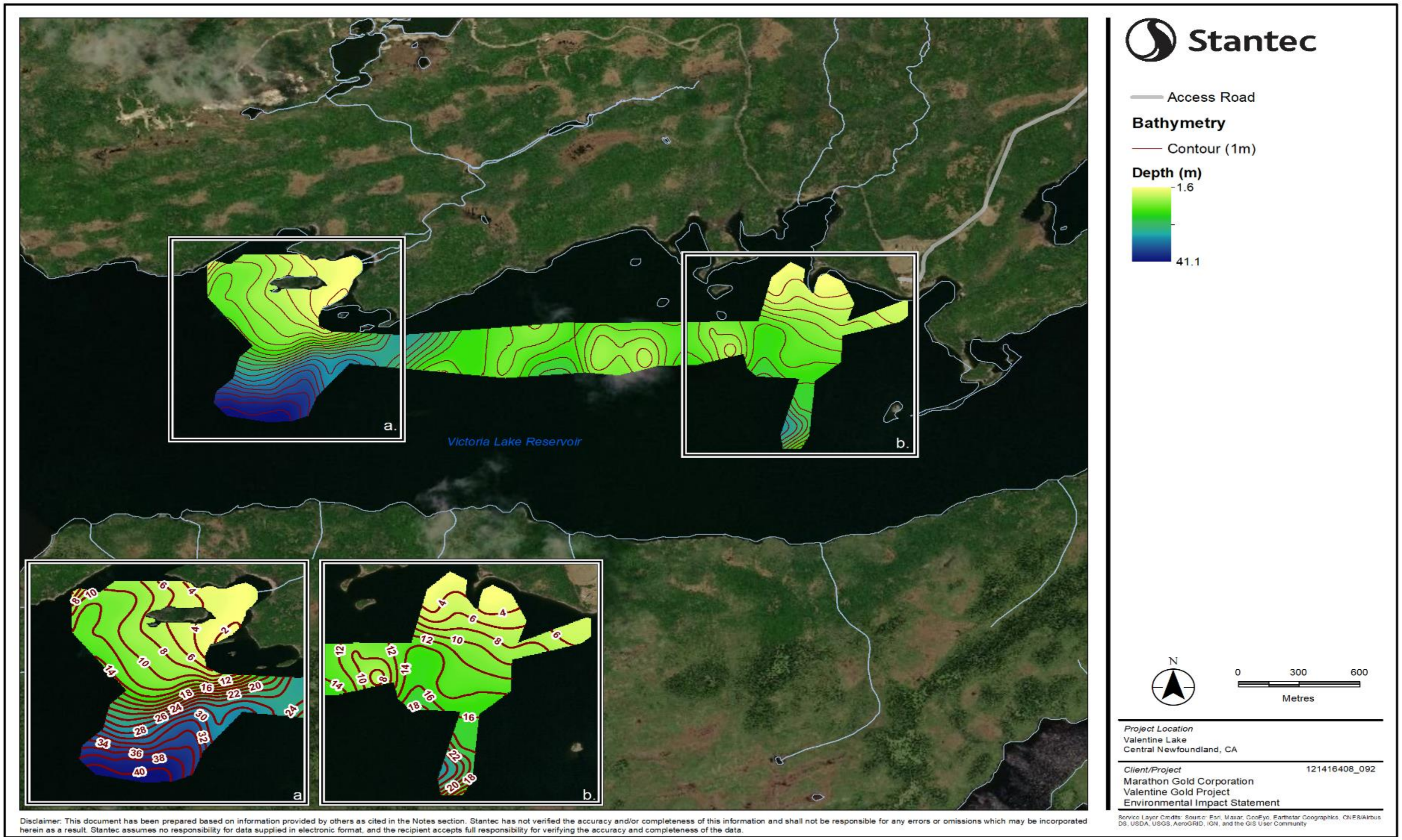

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Figure 7-13 Victoria Lake Reservoir Bathymetry

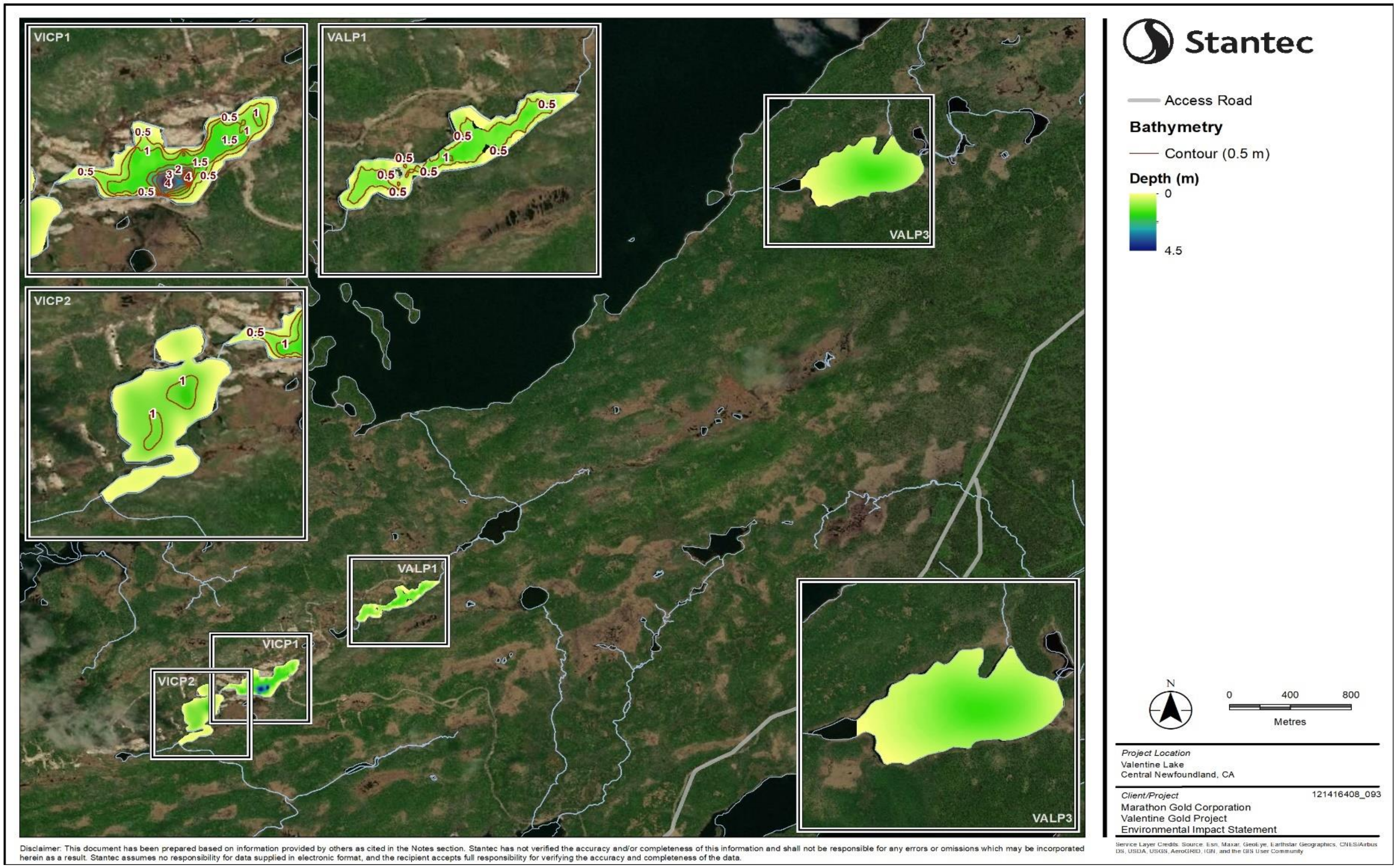

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Figure 7-14   Small Waterbodies Bathymetry

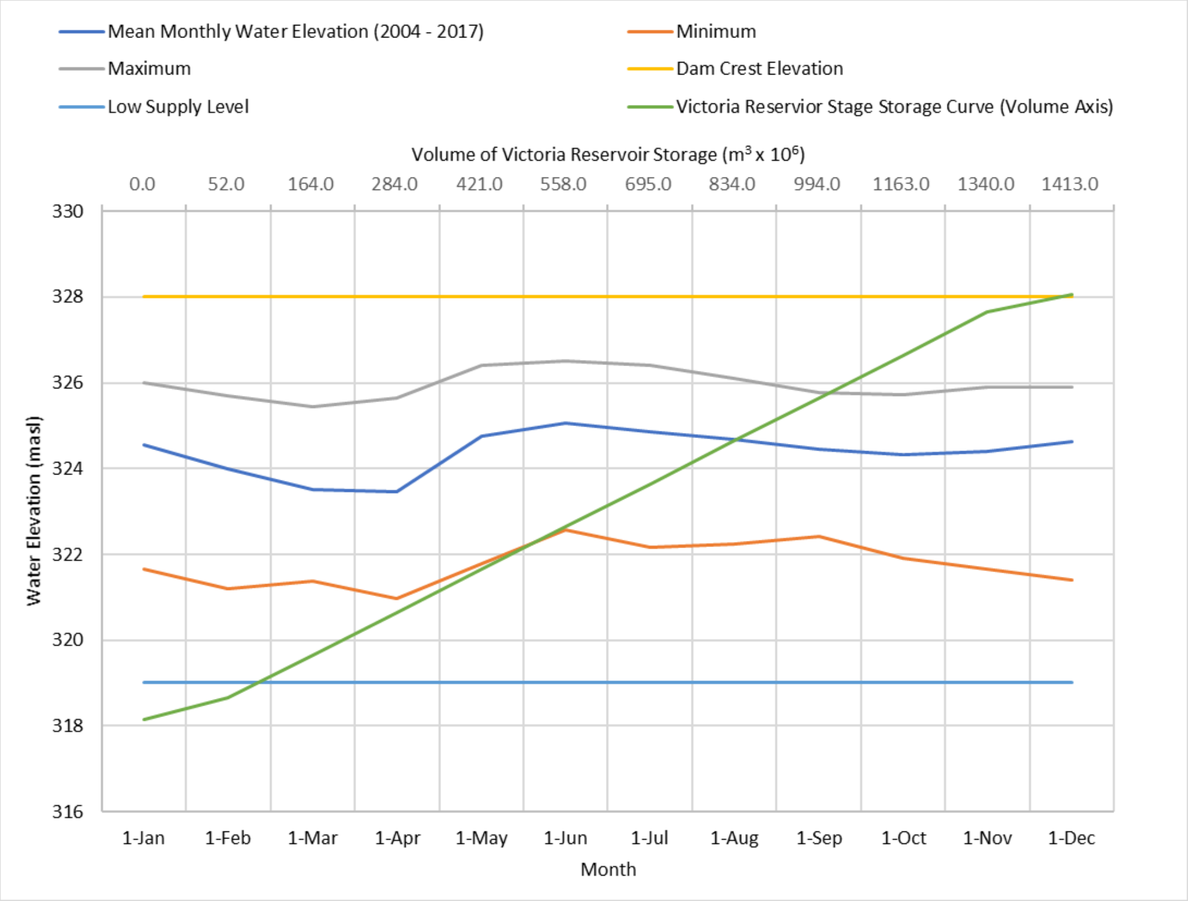

Figure 7-15 Victoria Lake Reservoir Stage Storage Relationship and WSC Reported Water Levels

Local Hydrology Summary

Local hydrology was assessed using both desktop and field methodologies. An environmental water balance was generated for climate normal, wet and dry year conditions to establish a range of expected annual runoff conditions. Twelve HSs were installed throughout the LAA to gather site specific flow and water level data. Field data was used to develop rating curves for eight of these stations. Baseline data collected at these stations will be useful in development and implementation of a surface water monitoring plan and will serve as a point of comparison between baseline, construction, operation and decommissioning, rehabilitation and closure.

Watershed areas for the HSs and watersheds associated with the proposed mine footprint were determined and used with the regionally developed flow relationships to establish watershed specific flow statistics. These flow statistics included MMF, MAF, return period flows, low flows, and environmental flows, and will be used to assess potential changes due to Project interactions.

Lake bathymetric data was also presented and will be used to determine assimilative capacity and expected mixing zones at the locations where Project runoff and effluent enter Victoria Lake Reservoir and Valentine Lake.

7.2.2.4 Surface Water Quality

Assessments of regional and local surface water quality are provided in the following subsections.

Regional Water Quality

Regional water quality data was obtained from both federally ECCC managed sites (ID NF02YN0001 and NF02YO0107) and provincially WRMD managed sites (ID NF02YO0190 and NF02YO0192). Regional water quality was also compared to water quality of the surface water sourced drinking water supplies for the communities of Buchans and Millertown, available from the NL Water Resources Portal.

Regional water quality parameters reported at the ECCC and NL Water Resources Portal websites include metals, nutrients and physical parameters. Data collected at these websites have a longer period of record than those reported at the WRMD sites.

Values reported for total dissolved solids (TDS) at the WRMD managed sites were seen to fluctuate seasonally, with two peaks associated with increased flows (spring melt and fall rains). While the magnitude of concentrations at these two locations varies, Figure 7-16 shows that average monthly concentrations follow the same seasonal trend of peaking during periods of increased flow (spring and fall).

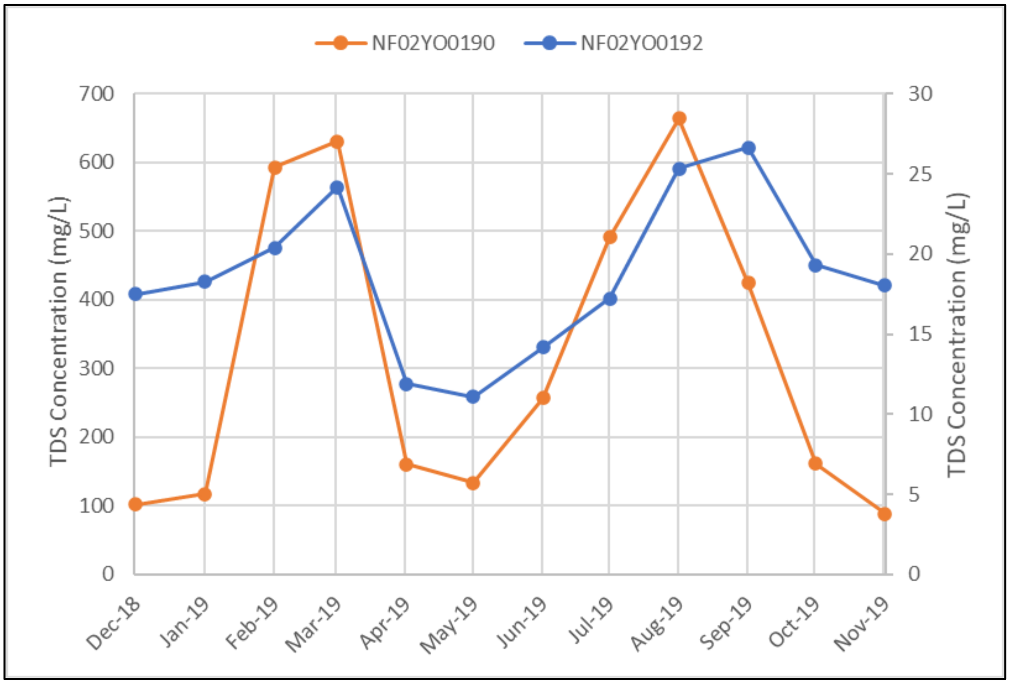

Figure 7-16 Seasonal Water Quality (TDS) at WRMD Regional Monitoring Stations

Iron concentrations at ECCC managed sites were seen to fluctuate throughout the year with two peaks associated with increased flows (spring melt and fall rains). While these peaks are not as evident as those associated with TDS, there does appear to be seasonal correlation, as shown in Figure 7-17.

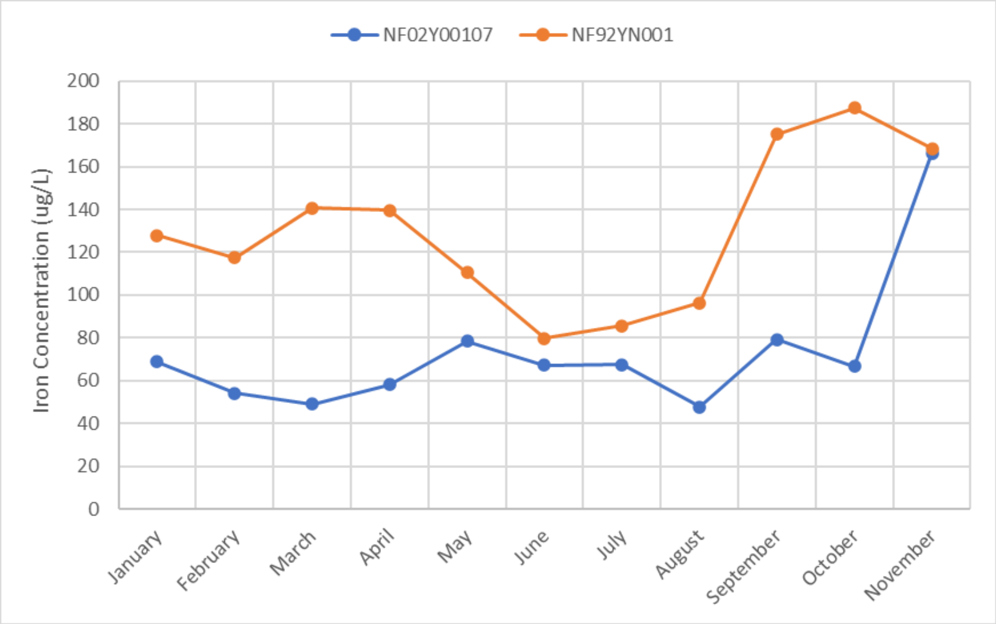

Figure 7-17 Seasonal Water Quality (Iron) at ECCC Regional Monitoring Stations

Water quality data from regional monitoring locations were compared across select indicator parameters (Table 7.20). This table shows aluminum and iron concentrations reasonably consistent across locations with slightly elevated values in lakes. TDS and hardness values also vary across the sites, with results showing similar magnitude (with the exception of elevated TDS values at one stream location).

Table 7.20 Regional Water Quality Comparison - Indicator Parameters

Station ID	NF02YN001	NF02YO0107	NF02YO0190	NF02YO0192	Buchans	Millertown
Waterbody Type	River	River	Stream	Stream	Lake	Lake
Aluminum (ug/L)	87.7	64.63	na	na	106.61	90.50
Iron (ug/L)	129.9	75.28	200	200	167.67	56.56
TDS (mg/L)	na	na	306	18.68	15.19	17.06
Hardness (mg/L)	9.5	7.7	na	na	5.06	8.49
Note: na = data not available						

Additional data from ECCC stations NF02YN0001 and NF02YO0107 and stations at the public water supplies for the Towns of Buchans and Millertown (NL Water Resources Portal) have been summarized in Table 7.21. Water quality parameters reported at the WRMD managed sites include in-situ field measurements (dissolved oxygen, pH, specific conductivity, TDS, turbidity, and temperature) for the period of December 2018 to December 2019. Data from these stations, as well as a more complete listing of analytical parameter results, are provided in the baseline report (BSA.3, Attachment 3-C).

Total alkalinity, as calcium carbonate ($CaCO_3$), ranges from below the reportable detection limit (RDL) to a maximum of 11 milligrams/litre (mg/L). Low alkalinity values suggest limited acid buffering potential in streams. The pH tended to be in the acidic range. Parameters were generally below the applicable CWQG-FAL, with at least one reported exceedance for aluminum, cadmium, copper, iron, and lead reported at station NF02YO0107, and for aluminum and selenium at station NF02YN0001.

Local Water Quality

Local water quality was assessed as the Project is considered to have the potential to affect water quality from baseline conditions. Local water is considered the surface water that flows from within the Project Area to the receiving environments of Valentine Lake, Victoria Lake Reservoir and the Victoria River. Local water quality data were collected between 2011 and 2019 at the locations shown on Figure 7-2. The following provides an overview of local water quality results for general chemistry, nutrients and metals, followed by a discussion of water quality seasonality, local geographic differences, local waterbody differences (i.e., rivers, ponds, peatbogs), and comparisons between local and regional water quality.

General Chemistry

Table 7.22 presents summary water quality statistics for the lab analytical general chemistry constituents. Lab analytical water quality results are also provided in the Baseline Report. The lab results indicated that pH ranged from 4.61 to 7.78. The pH value was less than the CWQG-FAL lower limit of 6.5 (CCME 2019) at 18 water quality monitoring stations, with the most exceedances (16 times) at water quality monitoring station VE08. At the other stations, acidity exceedances were reported five times. No alkalinity pH exceedance of the CWQG-FAL were observed.

Total alkalinity (as $CaCO_3$) ranged from below the of 5.0 mg/L to 99 mg/L with a mean of 14.7 mg/L, indicative of low alkalinity. Low alkalinity values suggest limited acid buffering potential in local waterbodies.

Hardness (as $CaCO_3$) values ranged from below the RDL of 5.0 mg/L to 110.0 mg/L with a mean of 16.3 mg/L. Hardness within the range of 0 to 60 mg/L is considered to be “soft” water. Concentrations of copper, cadmium, lead, and nickel are hardness-adjusted in the CWQG-FALs. For these metals, a lower hardness value results in lower CWQG-FALs thresholds.

Table 7.21 Regional Water Quality Summary Statistics for Stations NF02YN0001 and NF02YO0107, and Buchans and Millertown Public Water Supplies

Parameter	Units	NF02YN0001				NF02YO0107				Buchans				Millertown			
		count	**min**	**max**	**mean**	**count**	**min**	**max**	**mean**	**count**	**min**	**max**	**mean**	**count**	**min**	**max**	**mean**
Alkalinity total ($CaCO_3$)	mg/L	43	1.2	20.0	11.0	31	4.00	20.00	10.19	18	0.00	11.00	4.28	18	4.70	13.00	9.38
Aluminum total	µg/L	72	37.8	146.0	87.7	76	0.50	150.00	64.63	18	25.00	290.00	106.61	18	25.00	320.00	90.50
Antimony total	µg/L	67	0.0	0.0	0.0	69	0.00	0.03	0.02	7	0.00	0.50	0.14	12	0.00	0.50	0.08
Arsenic total	µg/L	72	0.1	0.9	0.4	76	0.01	1.53	0.30	12	0.00	5.00	0.80	14	0.00	5.00	0.46
Barium total	µg/L	72	2.1	3.7	2.8	76	0.05	87.30	41.44	9	0.00	25.00	7.11	14	10.00	25.00	18.21
Boron total	µg/L	67	0.1	3.1	2.0	69	0.10	2.60	1.70	9	0.00	25.00	8.89	14	0.00	25.00	5.71
Cadmium total	µg/L	67	0.0	0.0	0.0	69	0.00	0.30	0.05	18	0.00	1.00	0.36	18	0.00	1.00	0.29
Calcium dissolved	mg/L	55	1.3	5.3	2.8	62	0.90	4.45	2.46	18	0.50	4.00	1.61	18	1.68	4.80	3.04
Carbon dissolved organic	mg/L	62	3.7	9.0	5.9	69	4.00	9.60	5.08	17	3.30	7.70	5.09	18	3.20	10.70	6.61
Chloride total	mg/L	22	2.3	5.5	3.5	31	1.39	1.95	1.75	18	0.59	2.00	1.17	18	0.00	5.00	1.45
Chromium total	µg/L	67	0.1	0.2	0.2	69	0.01	0.37	0.10	18	0.00	5.00	1.65	18	0.00	5.00	1.47
Colour apparent	TCU[1]	74	25.6	80.6	49.1	77	24.00	59.30	30.32	18	20.00	57.00	41.61	18	16.00	62.00	32.28
Copper total	µg/L	72	0.0	0.9	0.2	76	0.00	2.25	1.40	18	0.00	8.00	2.50	18	0.00	5.00	1.67
Iron total	µg/L	72	52.7	224.0	129.9	76	0.50	504.00	75.28	18	20.00	310.00	167.67	18	0.00	150.00	56.56
Lead total	µg/L	67	0.0	0.2	0.1	76	0.01	6.43	1.85	18	0.00	3.00	0.79	18	0.00	0.50	0.22
Magnesium dissolved	mg/L	55	0.3	1.1	0.6	62	0.36	0.60	0.43	18	0.00	0.50	0.30	18	0.00	0.50	0.25
Manganese total	µg/L	72	2.4	16.5	8.1	76	0.05	70.30	9.90	18	5.00	87.00	31.22	18	0.00	50.00	6.37

Table 7.21 Regional Water Quality Summary Statistics for Stations NF02YN0001 and NF02YO0107, and Buchans and Millertown Public Water Supplies

Parameter	Units	NF02YN0001				NF02YO0107				Buchans				Millertown			
		count	min	max	mean	count	min	max	mean	count	min	max	mean	count	min	max	mean
Nickel total	µg/L	67	0.0	0.2	0.1	76	0.02	0.92	0.17	16	0.00	5.00	2.41	18	0.00	5.00	1.94
pH		74	6.1	7.5	6.9	77	6.40	7.23	6.87	18	6.03	7.08	6.50	18	6.00	7.14	6.70
Phosphorus total	mg/L	74	0.0	0.0	0.0	77	0.00	0.01	0.00	16	0.00	0.11	0.01	18	0.00	0.02	0.01
Potassium unfiltered	mg/L	40	0.1	0.5	0.2	50	0.00	0.38	0.16	18	0.00	0.50	0.19	18	0.00	0.50	0.12
Selenium total	µg/L	67	0.0	2.2	0.1	69	0.00	0.23	0.05	9	0.00	5.00	0.72	14	0.00	5.00	0.46
Sodium unfiltered	mg/L	40	1.7	3.2	2.3	50	1.11	1.62	1.41	18	0.50	3.00	1.18	18	0.00	3.00	1.15
Specific conductance	µS/cm	74	20.1	49.8	31.5	77	19.40	35.90	23.41	18	12.10	31.00	16.98	18	18.00	32.00	25.18
Sulphate total	mg/L	22	0.9	1.8	1.3	31	0.70	1.45	1.19	18	0.00	5.00	1.36	18	0.00	6.00	1.12
Turbidity	NTU[2]	73	0.2	1.0	0.5	77	0.11	8.60	0.63	18	0.08	5.20	0.86	18	0.18	1.20	0.66
Zinc total	mg/L	72	0.1	2.4	0.6	76	0.20	22.60	14.06	18	0.00	22.00	8.58	18	0.00	7.00	2.47

Notes:
[1] True Colour Unit
[2] Nephelometric Turbidity Unit

Table 7.22 Summary of General Constituents in Water Quality Monitoring Stations

Parameter	Units	CWQG-FAL	Number of Samples	Min[D]	Max[D]	Mean[D]	75th Percentile[D]	# of Exceedances	# of Non-detects
Anion Sum	me/L		686	0.03	2.14	0.37	0.45	-	0
Bicarb. Alkalinity (calc. as $CaCO_3$)	mg/L		686	5	98	15	19	-	42
Calculated TDS	mg/L		686	5	120	23	28	-	0
Carb. Alkalinity (calc. as $CaCO_3$)	mg/L		686	nd	nd	nd	0.5	-	686
Cation Sum	me/L		686	0.15	2.32	0.42	0.52	-	0
Conductivity	µS/cm		686	14	200	39	47	-	0
Colour	TCU	Note A	686	5	420	38	47	-	2
Dissolved Chloride (Cl)	mg/L		686	1	14	3	3	-	8
Hardness ($CaCO_3$)	mg/L		686	4.0	110.0	16.3	20	-	0
Ion Balance (% Diff.)	%		686	0.00	76.00	9.60	11.1	-	0
Langelier Index (@20C)	N/A		644	-4.22	0.01	-2.51	-1.87	-	0
Langelier Index (@4C)	N/A		644	-4.48	-0.24	-2.77	-2.28	-	0
pH	pH	6.5-9.0	686	4.61	7.78	6.93	6.59-7.36	55	0
Reactive Silica (SiO_2)	mg/L		686	0.5	10.0	2.6	3.7	-	45
Saturation pH (@20C)	N/A		644	7.77	10.40	9.49	-	-	0
Saturation pH (@4C)	N/A		644	8.02	10.60	9.74	-	-	0
Total Alkalinity ($CaCO_3$)	mg/L		686	5.0	99.0	14.7	19	-	42
Total Suspended Solids (TSS)	mg/L	Note B	686	1	880	3	2.1	-	320
Turbidity	NTU	Note C	686	0.1	24.0	1.0	0.945	-	37

Notes: N/A – not-applicable

[A] True Color: The mean absorbance of filtered water samples at 456 nm shall not be significantly higher than the seasonally adjusted expected value for the system under consideration.

[B] Maximum increase of 25 mg/L from background levels for any short term exposure (e.g., 24-h period). Maximum average increase of 5 mg/L from background levels for longer term exposures (e.g., inputs lasting between 24 hours and 30 days).

[C] Maximum increase of 8 NTUs from background levels for a short term exposure (e.g. 24-h period). Maximum average increase of 2 NTUs from background levels for a longer exposure (e.g. 30-d period)

[D] The statistical results here include water quality monitoring locations from October 2012 to October 2019. For statistical calculations, ½ of the nd value was used.

Nd – non-detect – below laboratory detection limit; “-“indicates no data in cell

The Langelier Saturation Index (LSI) values for most monitoring locations and events were negative, which is indicative of under-saturation and water that tends to dissolve solid $CaCO_3$. Therefore, water with negative LSI has limited scaling potential. The potential for scale formation is a necessary consideration in the selection and design of water infrastructure. A low LSI value and scaling potential align with the low hardness values also observed.

Electrical conductivity values for samples were generally low, and ranged from 14 µs/cm to 200 µs/cm, with a mean of 39 µs/cm. The maximum value of 200 µs/cm was observed at location LP04 and the minimum value of 14 µs/cm was observed at location R04.

Ionic balances for all monitoring locations were positive and ranged from 0% to 76%. This aligns with the soft water observations noted above. Concentrations of major cations, such as calcium, sodium, potassium, magnesium, manganese, ammonium, iron and aluminum, were low, as were concentrations of major anions, such as chloride, fluoride, sulphate and nitrate, thus resulting in relatively weak ionic strength.

Concentrations of TSS were low, ranging from below the RDL to a maximum of 88 mg/L, with a mean of 3 mg/L (320 non-detects). Turbidity levels observed were also low, ranging from below the RDL to a maximum of 24 Nephelometric Turbidity Units (NTUs) with a mean of 1.0 NTU. Colour ranged from below the RDL to a maximum of 150 True Colour Unit (TCU) with a mean of 38 TCU. The mean colour value is above the CWQG-FAL of 15 TCU. Colour in local surface water is expected to be derived from the decomposition of organic humic substances, such as tannins derived for soils and tree bark, and lignins from woody plants and trees giving local waters a tea-stained visual appearance.

Nutrients

Table 7.23 presents a summary for lab analytical nutrient results. The complete results are provided in the baseline report (BSA.3, Attachment 3-C).

Total ammonia-nitrogen ranged from below the RDL to a maximum of 0.31 mg/L and had a mean of 0.09 mg/L. Concentrations of total ammonia-nitrogen were consistently below the lowest calculated CWQG-FAL for the Project Area of 1.83 mg/L (based on a pH 7.5, temperature 15°C).

Nitrate concentrations ranged from below the RDL to a maximum of 1.20 mg/L, and had a mean of 0.11 mg/L. Reported concentrations were below the long-term CWQG-FAL for nitrate of 13 mg/L. Similarly, nitrite concentrations ranged from below the RDL to a maximum of 0.18 mg/L, with a mean and 75th percentile of 0.005 mg/L and were predominately below the CWQG-FAL of 0.06 mg/L (a single exceedance).

Table 7.23 Summary of Nutrients in Water Quality Monitoring Stations

Parameter	Units	CWQG-FAL	Number of Samples	Min[D]	Max[D]	Mean[D]	75th Percentile[D]	# of Exceedances	# of Non-detects
Nitrate + Nitrite	mg/L		686	0.05	1.20	0.11	0.12	-	263
Nitrate	mg/L	Note A	686	0.05	1.20	0.11	-	-	269
Nitrite	mg/L	0.06	686	0.005	0.18	0.005	0.005	1	667
Nitrogen (Ammonia Nitrogen)	mg/L	Note B	686	0.05	0.31	0.03	0.025	-	623
Dissolved Sulphate	mg/L		686	1.4	5.5	1	1	-	647
Orthophosphate	mg/L		686	0.01	0.06	0.01	0.005	-	665
Total Organic Carbon	mg/L		686	2.1	41.0	6.9	8.4	-	1
Total Phosphorus	µg/L	Note C	20	0.005	0.02	0.01	-	-	0

Notes:

[A] 550 mg/L for short term exposure and 13 mg/L for long term exposure

[B] Ammonia concentration under different pH and temperature, please see table at: http://st-ts.ccme.ca/en/index.html?chems=5&chapters=1

[C] Ultra-oligotrophic <4 µg/L, oligotrophic 4-10 µg/L, mesotrophic 10-20 µg/L, meso-eutrophic 20-35 µg/L, eutrophic 35-100 µg/L, hyper-eutrophic >100 µg/L

[D] The statistical results here include water quality monitoring locations from October 2012 to October 2019. For statistical calculations, ½ of the nd value was used.

“-“indicates no data in cell

Orthophosphate levels ranged from below the RDL to a maximum of 0.055 mg/L and had a mean of 0.01 mg/L. Total phosphorus values ranged from below the RDL to a maximum of 210 micrograms/litre (μg/L), with a mean of 54 μg/L. The CWQG-FAL indicate that a total phosphorus concentration higher than 100 μg/L is considered hyper-eutrophic and between 35-100 μg/L is considered eutrophic.

Sulphate concentrations ranged from below the RDL to a maximum of 5.5 mg/L, which is lower than the dissolved sulphate guideline of 128 mg/L for the protection of aquatic life given in the British Columbia *Ambient Water Quality Guidelines* for sulphate (British Columbia Ministry of Environment and Climate Change Strategy 2017). No CWQG-FAL guideline exists for sulphate.

Metals

Table 7.24 presents summary statistics for lab analytical metals results. Lab analytical metals results are also provided in the baseline report (BSA.3, Attachment 3-C).

Aluminum concentrations ranged from below the RDL to a maximum of 1,640 µg/L, with a mean of 106 µg/L and a 75th percentile of 106 µg/L. The CWQG-FAL for aluminum is 5 µg/L if pH < 6.5, and 100 µg/L if pH > 6.5. The aluminum concentrations were found to exceed the CWQG-FAL at many of the water quality monitoring stations at least once, aside from locations R01, VIC01 and VAL01 where concentrations were not exceeded.

Arsenic concentrations ranged from below the RDL of 1.0 µg/L to a maximum of 22.0 µg/L, with a mean of 1.2 µg/L and a 75th percentile of 1.3 µg/L. Arsenic concentrations were below the CWQG-FAL of 5 µg/L for most monitoring locations, with the exception of R01, R02, R03, R05, VL01, FZ01, and FZ02.

Cadmium concentrations ranged from below the RDL to a maximum of 2.25 µg/L, with a mean of 0.017 µg/L and a 75th percentile of 0.0085 µg/L. The hardness adjusted CWQG-FAL for cadmium ranged from 0.04 to 0.37 µg/L (long term). The total cadmium values exceeded the lower limit long term CWQG-FAL at stations VE02, VE05, VE06, VE07, VE09 VE10, RO3, RO5, VL01, and FZ01 at least once during the sampling period.

Copper concentration ranged from below the RDL to a maximum of 220 µg/L, with a mean of 1.4 µg/L and a 75th percentile of 1.0 µg/L. The CWQG-FAL for copper is based on hardness and is 2.0 µg/L when hardness is between 0 and 82 mg/L. Mean water hardness for the water quality monitoring stations was 16.7 mg/L. Reported copper concentrations were below the CWQG-FAL at most locations, except LP03, VE02, VE03, VE04, VE08, VE10, R02, R03, R04, VL01, VICRV, VIC01, and VAL01.

Lead concentrations ranged from below the RDL to a maximum of 2.72 µg/L, with a mean of 0.27 µg/L and a 75th percentile of 0.25 µg/L. The CWQG-FAL for lead is based on hardness and is 1 µg/L when hardness is less than 60 mg/L. Reported lead concentrations were below the CWQG-FAL for most locations except LP01, VE05, VE07, FZ01, and VIC01.

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Table 7.24 Summary of Metals for Water Quality Monitoring Stations

Parameter	Units	CWQG-FAL [A]	MDMER[B]	Number of Samples	Min[C]	Max[C]	Mean[C]	75th Percentile[C]	# of Exceedances	# of Non-detects
Total Aluminum (Al)	µg/L	Note D		619	9	1640	106	106.25	221	0
Total Antimony (Sb)	µg/L			619	DL	2	0.5	0.5	0	618
Total Arsenic (As)	µg/L	5	200	619	DL	22	1.2	1.3	16	413
Total Barium (Ba)	µg/L			621	DL	35	2.8	3.425	0	54
Total Beryllium (Be)	µg/L			619	DL	DL	0.5	0.5	0	619
Total Bismuth (Bi)	µg/L			619	DL	DL	1.0	1	0	619
Total Boron (B)	µg/L	1,500[E]		619	DL	DL	25	25	0	619
Total Cadmium (Cd)	µg/L	Note F		619	DL	2.250	0.017	0.0085	17	501
Total Calcium (Ca)	µg/L			619	1000	39000	5166	5640	0	0
Total Chromium (Cr)	µg/L			619	DL	160	2.2	2.625	0	505
Total Cobalt (Co)	µg/L			619	DL	6	0.27	0.2	0	556
Total Copper (Cu)	µg/L	Note G	200	619	DL	220	1.4	1	10	550
Total Iron (Fe)	µg/L	300		620	DL	8900	286	230.75	114	42
Total Lead (Pb)	µg/L	Note H	160	619	DL	3	0.27	0.25	3	607
Total Magnesium (Mg)	µg/L			619	240	3600	794	904.5	0	0
Total Manganese (Mn)	µg/L			619	4	10000	240.5	153.75	0	0
Mercury	µg/L	0.026		618	DL	0	0.007	0.0065	0	588
Total Molybdenum (Mo)	µg/L	73		619	DL	55	1.3	1	0	612
Total Nickel (Ni)	µg/L	Note I	500	619	DL	8	1.0	1	0	602
Total Potassium (K)	µg/L			623	DL	1240	183	195	0	117
Total Selenium (Se)	µg/L	1		620	DL	0	0.5	0.5	0	620
Total Silver (Ag)	µg/L	0.25		619	DL	0	0.05	0.05	0	619
Total Sodium (Na)	µg/L			619	896	5220	1842	1952.5	0	0

Table 7.24 Summary of Metals for Water Quality Monitoring Stations

Parameter	Units	CWQG-FAL [A]	MDMER[B]	Number of Samples	Min[C]	Max[C]	Mean[C]	75th Percentile[C]	# of Exceedances	# of Non-detects
Total Strontium (Sr)	µg/L			619	3	95	15.3	15.825	0	0
Total Thallium (Tl)	µg/L	0.8		619	DL	0	0.05	0.05	0	619
Total Tin (Sn)	µg/L			619	DL	0	1.0	1	0	619
Total Titanium (Ti)	µg/L			619	DL	115	3.3	3.2	0	331
Total Uranium (U)	µg/L	Note J		619	DL	0	0.05	0.05	0	599
Total Vanadium (V)	µg/L			619	DL	6	1.0	1	0	613
Total Zinc (Zn)	µg/L	Note K	800	620	DL	91	4.4	6.6	3	449

Notes:

DL – detection limit

[A] CWQG-FAL – Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life

[B] MDMER – Metal and Diamond Mining Effluent Regulations, values presented in the table are maximum authorized concentration in grab samples in Schedule 4 Table 1 (limits for new metal and diamond mines after June 1, 2021)

[C] The statistical results here include water quality monitoring locations from October 2012 to October 2019. For statistical calculations, ½ of the nd value was used.

[D] varies depending on pH: 5 µg/L if pH < 6.5 & 100 µg/L if pH ≥ 6.5

[E] Short term 29,000 ug/L, long term 1,500 ug/L

[F] Guideline Equation is based on hardness = 10{[0.83log(hardness)]-2.46} µg/L (minimum of 0.04 µg/L regardless of water hardness and maximum of 0.37 µg/L).

[G] Guideline Equation is based on hardness = 0.2 * e{0.8545[ln(hardness)]-1.465} µg/L (minimum of 2 µg/L regardless of water hardness and maximum of 4 µg/L)

[H] Guideline Equation is based on hardness = e{1.273[ln(hardness)]-4.705} µg/L (minimum of 1 µg/L regardless of water hardness and maximum of 7 µg/L)

[I] Guideline Equation is based on hardness = e {0.76[ln(hardness)]+1.06} µg/L (minimum of 25 µg/L regardless of water hardness and maximum of 150 µg/L)

[J] Short term 33 ug/L, long term 15 ug/L

[K] Guideline Equation is based on hardness = e{0.947[ln(hardness mg/L-1)]-0.815[pH] + 0.398[ln(DOC mg/L-1)]+4.625} µg/L (The CWQG-FAL equation is valid between hardness 23.4 and 399 mg $CaCO_3 \cdot L^{-1}$, pH 6.5 and 8.13 and DOC 0.3 to 22.9 $mg \cdot L^{-1}$)

Iron concentrations ranged from below the RDL to a maximum of 8,900 µg/L, with a mean of 286 µg/L and a 75th percentile of 231 µg/L. Most locations reported at least a single exceedance of the CWQG-FAL of 300 µg/L, except stations VIC01 and VAL01.

Zinc concentrations ranged from below the RDL to a maximum of 91.3 µg/L, with a mean of 4.4 µg/L and a 75th percentile of 6.6 µg/L. Zinc concentrations were below the CWQG-FAL limit of 30 µg/L for most locations, except LP01, VE04, VE05, and R04.

Concentrations of boron, molybdenum, selenium, silver, thallium, and uranium were consistently below the applicable CWQG-FAL.

Local Geographic Water Quality Differences

Water quality monitoring locations are clustered throughout the Project Area with three separate groups of locations identified: the northern cluster (R02 to R05 and VE01 to VE10); the southwestern cluster (R01, LP01 to LP05, FZ01, FZ02, and VL01); and the large waterbodies (VICRV, VAL01 and VIC01). Watercourses monitored in the northern cluster are primarily streams with some linear bogs and tend to flow quickly from a watershed divide towards the Victoria River. Watercourses monitored in the southwestern cluster flow out of or into larger ponds and lakes. Locations LP01 to LP05 are located on a line of ponds that drain north to Valentine Lake and south to Victoria Lake Reservoir. Differences in water quality are observed across the Project Area with locations in the SW generally showing elevated concentrations of metals and some inorganics. Both the north and southwestern clusters showed higher concentrations compared with the large lake cluster. Table 7.25 provides a summary of averages for select indicator parameters for these three clusters.

Table 7.25 Local Water Quality Geographic Comparison

Parameter	Units	Northern Cluster Average	Southwestern Cluster Average	Large Waterbodies Average
Iron	ug/L	277.84	310.17	42.17
Aluminum	ug/L	103.33	115.15	30.58
TDS	mg/L	21.95	25.66	11.58
Hardness	mg/L	14.99	19.10	6.71

Differences Between Waterbody Types

Water quality monitoring locations were located on a variety of waterbody types, including, streams, pond outlets, bogs (generally streams running through bogs), and larger lakes. Water quality was found to vary between waterbody type with pond outlets generally showing the most elevated concentrations of metals and solids as summarized in Table 7.26. An exception to this is for iron and manganese which were highest in the stream/bog waterbody type. Large lakes showed the most distinct water quality from the other waterbody types, being more dilute than the smaller watercourses.

Table 7.26 Local Water Quality Waterbody Type Comparison

Parameter	Units	Pond Outlets	Streams	Streams/Bogs	Large Lakes
Iron	ug/L	251.16	223.82	428.67	42.17
Aluminum	ug/L	141.21	76.37	138.53	30.58
TDS	mg/L	29.22	21.12	23.39	11.58
Hardness	mg/L	23.06	14.64	15.59	6.71

Local Water Quality Seasonality

Water quality was monitored throughout the year during the baseline monitoring period (2011 to 2019). The number of samples collected during each month over the course of the baseline monitoring program is summarized in Table 7.27.

Table 7.27 Monthly Water Quality Samples Collected During Baseline Monitoring

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of Samples	64	94	59	20	65	41	69	92	65	35	82	0

Monthly averages were calculated for the four selected parameters (iron, aluminum, hardness, and TDS) at each monitoring location, as well as for the northern and southwestern clusters. Figures 7-18 through 7-21 show the seasonal water quality for iron, aluminum, hardness, and TDS, respectively. These figures show elevated concentrations of hardness, TDS, aluminum, and iron in the fall (September to December) and winter (January to March) months. Iron appears to be at its lowest concentration during the spring freshet, indicating that the iron rich groundwater contributing to stream baseflows is diluted with snow melt (low iron). Hardness and TDS display this same trend. Aluminum concentration appears at its lowest in the late summer months, as surface water runoff reduces to its lowest.

Seasonal variation between the northern and southwestern clusters is also evident through the figures below. Concentrations in both clusters tend to be more varied during the winter months, with the SW cluster showing elevated levels of hardness, TDS, iron and aluminum in January and February. Iron concentrations in the northern cluster are noted to spike in July, possibly linked with low flow periods and a greater proportion of flow coming from groundwater.

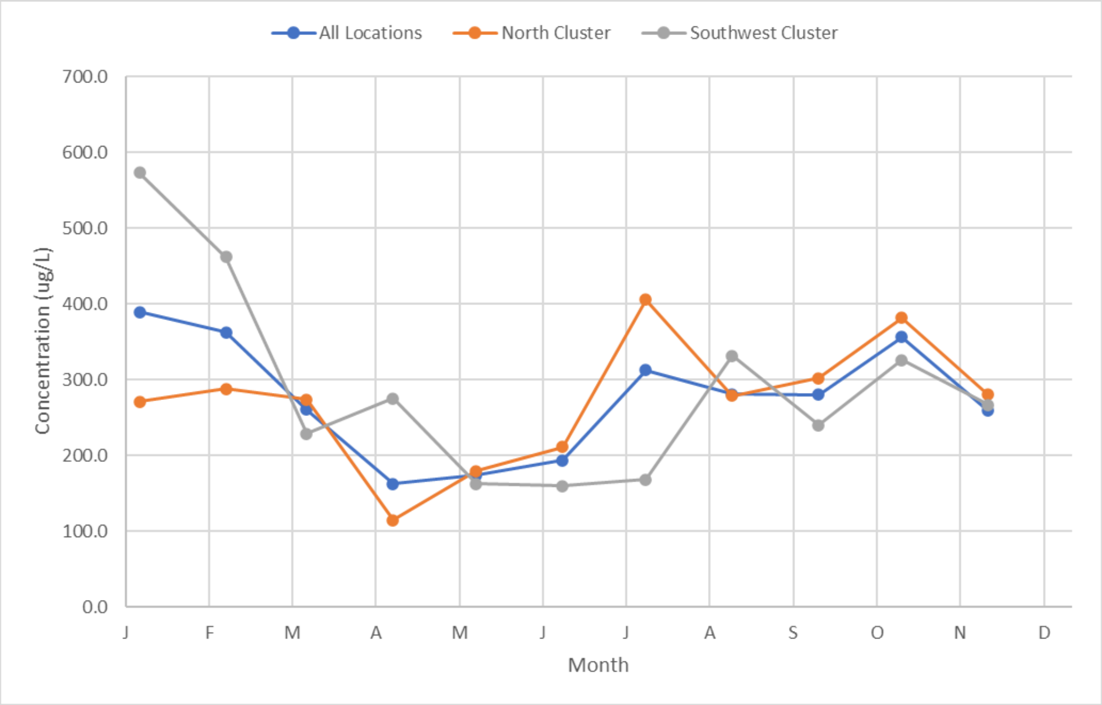

Figure 7-18 Comparison of Seasonal Water Quality Variations for Iron by Cluster

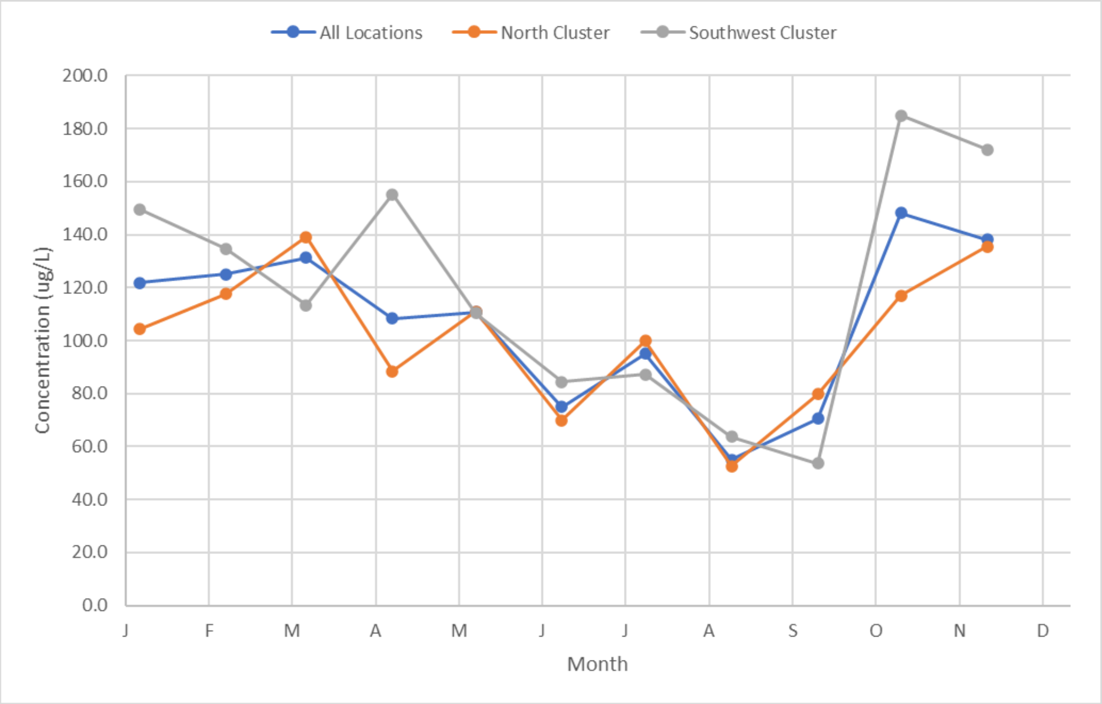

Figure 7-19 Comparison of Seasonal Water Quality Variations for Aluminum by Cluster

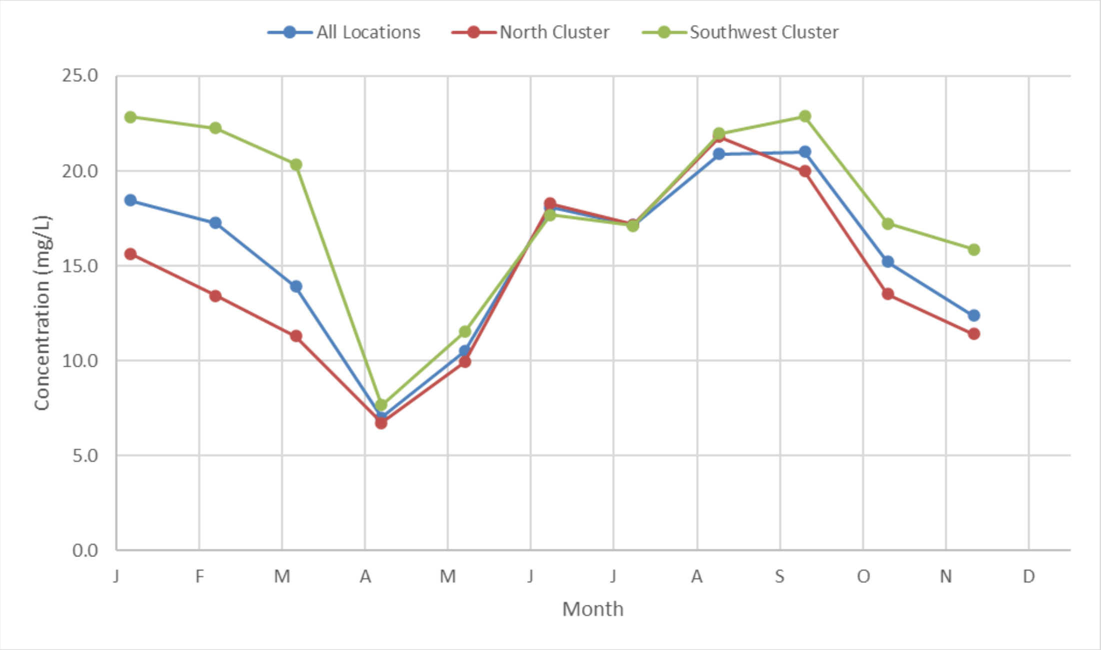

Figure 7-20 Comparison of Seasonal Water Quality Variations for Hardness by Cluster

Figure 7-21 Comparison of Seasonal Water Quality Variations for TDS by Cluster

Regional and Local Water Quality Comparison.

Local water quality was found to be similar to regional water quality in that both were found to have low pH and alkalinity, and therefore limited acid buffering potential. Several metals (aluminum, cadmium, copper, iron and lead) were also detected above CWQG-FAL at both the regional and local water quality monitoring locations. These results indicate that metals are found in naturally elevated levels in both local and regional surface water.

Surface Water Quality Summary

Local water quality data provides a robust baseline dataset, with over 600 samples collected for many parameters at various locations throughout the Project Area over the last nine years. Regional water quality data provides a greater areal coverage with less monitoring frequency over the same period. By considering both the regional and local surface water quality data, existing water quality conditions in the Project Area have been established.

A comparison between the regional and local water quality shows consistencies including low pH and alkalinity, with several metal concentrations above CWQG-FAL. The parameters identified as naturally occurring above CWQG-FAL are of potential concern as these are already at levels that may be harmful to aquatic life. These parameters of concern are aluminum and iron, which reported 221 and 114 exceedances, respectively. Five other metals also reported several exceedances and are considered parameters of potential concern. These include arsenic with 16 exceedances, cadmium with 17, copper with 10, lead with 3, and zinc with 3.

Water quality within the Project Area was also noted to vary relative to three site-specific elements. The first is geographic spread, with differences noted between northern and southwestern clusters of monitoring locations. The second is waterbody type, with large lakes exhibiting water quality distinct from other waterbody types monitored in the Project Area (streams, pond outlets and bogs). The third is seasonality, with decreased levels of some constituents noted during periods of increased flow (TDS levels decreasing during spring melt) and increased levels of others noted during periods of low flow (elevated iron in the northern cluster from increased groundwater input during summer low flows).

7.3 ASSESSMENT CRITERIA AND METHODS

This section describes the criteria and methods used to assess environmental effects on surface water resources. Residual environmental effects (Section 7.5) are assessed and characterized using criteria defined in Section 7.3.1, including direction, magnitude, geographic extent, timing, frequency, duration, reversibility, and ecological or socio-economic context. The assessment also evaluates the significance of residual effects using threshold criteria or standards beyond which a residual environmental effect is considered significant. The definition of a significant effect for surface water resources is provided in Section 7.3.2. Section 7.3.3 identifies the environmental effects to be assessed for surface water resources, including effect pathways and measurable parameters. This is followed by the identification of potential Project interactions with this VC (Section 7.3.4). Analytical assessment techniques used for the assessment of surface water resources are provided in Section 7.3.5.

7.3.1 Residual Effects Characterization

Table 7.28 presents definitions for the characterization of residual environmental effects on surface water resources. The criteria are used to describe the potential residual effects that remain after mitigation measures have been implemented. Quantitative measures have been developed, where possible, to characterize residual effects. Qualitative considerations are used where quantitative measurement is not possible.

Table 7.28 Characterization of Residual Effects on Surface Water Resources

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Direction	The long term trend of the residual effect of surface water.	**Neutral –** no net change in measurable parameters for surface water relative to baseline **Positive –** a residual effect that moves measurable parameters in a direction beneficial to surface water relative to baseline **Adverse –** a residual effect that moves measurable parameters in a direction detrimental to surface water relative to baseline
Magnitude	The amount of change in surface water quality and quantity relative to existing conditions.	**Negligible –** no measurable change to surface water relative to baseline **Low –** a measurable change is detectable and within the normal variability that would be expected (baseline) **Moderate –** a measurable change occurs that is considered elevated above baseline and within acceptable limits **High –** a measurable change occurs that is considered elevated above acceptable limits or regulatory objectives
Geographic Extent	The geographic area in which a residual effect occurs.	**Project Area –** residual effects are restricted to the Project Area **LAA –** residual effects are restricted to the LAA **RAA –** residual effects extend into the RAA
Frequency	Identifies how often the residual effect occurs and how often during the Project or in a specific phase.	**Single event -** occurs only once **Multiple irregular event –** occurs at no set schedule **Multiple regular event –** occurs at regular intervals **Continuous –** occurs continuously
Duration	The period of time required until surface water quantity or quality returns to its existing (baseline) condition, or the residual effect can no longer be measured or otherwise perceived.	**Short term –** residual effect restricted to construction or decommissioning, rehabilitation and closure phases **Medium term –** residual effect extends through Project operation and is expected to subside when operations cease **Long term –** residual effect extends beyond the life of the Project **Permanent** – recovery to baseline conditions unlikely

Table 7.28 Characterization of Residual Effects on Surface Water Resources

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Reversibility	Describes whether surface water quantity or quality can return to its existing condition after the project activity ceases.	**Reversible –** the residual effect is likely to be reversed after activity completion and rehabilitation **Irreversible –** the residual effect is unlikely to be reversed
Ecological and Socio-economic Context	Existing condition and trends in the area where residual effects occur	**Undisturbed –** area is relatively undisturbed or not adversely affected by human activity **Disturbed –** area has been substantially previously disturbed by human development or human development is still present

7.3.2 Significance Definition

Significant adverse residual environmental effects on surface water resources have been defined considering the federal and provincial regulations, policies and guidelines identified in Section 7.1.1, and the residual effects characterization criteria presented in Section 7.3.1.

A significant adverse residual effect on surface water quantity is defined as a measurable change in hydrological and/or sediment transport regime that:

- Does not meet established instream flow needs (environmental flow thresholds), and
- Contravenes a watershed management target including:
  - an uncompensated loss of fish habitat
  - changes to flow that increase sedimentation and erosion above regulatory guidance in waterbodies receiving surface water runoff
  - changes to flows that cause flooding downstream of the Project beyond existing conditions
  - changes to pond and lake levels outside the Project Area to a point that it affects their ability to support existing ecological functions

A significant adverse residual effect on surface water quality is defined as a measurable change in water quality that:

- Exceeds an implemented water quality requirement such as MDMER limits or a site-specific water quality guideline for the protection of aquatic life, or
- Contravenes a watershed management target including:
  - degrading water quality that causes acute or chronic toxicity to aquatic life
  - changes the trophic status of a lake or stream or
  - exceeds the generally accepted TSS monitoring guideline (the CCME CWQG-FAL) applied for Project activities

7.3.3 Potential Effects, Pathways and Measurable Parameters

Table 7.29 lists potential Project effects on surface water resources and provides a summary of the Project effect pathways and measurable parameters and units of measurement used to assess potential effects. Potential environmental effects and measurable parameters were selected based on review of recent environmental assessments (EAs) for mining projects in NL and other parts of Canada, comments provided during engagement, and professional judgment. The potential for Project interactions with surface water resources is considered to be measurable through a change in water quantity and a change in water quality.

Table 7.29 Potential Effects, Effect Pathways and Measurable Parameters for Surface Water Resources

Potential Environmental Effect	Effect Pathway	Measurable Parameter(s) and Units of Measurement
Change in surface water quantity	• Project activities may have an effect or alter the natural flow regime through changes to surface vegetation cover, imperviousness, topography and drainage divides, slopes, open pit dewatering, seepage from stockpiles, and management of surface water runoff.	• Stream discharge (variety of flow statistics including mean annual, monthly, and event-based discharges) • Lake water levels (mean and range of expected levels) • River morphology
Change in surface water quality	• Project activities may have an effect or alter water quality through changes to the natural flow regime, contact water seepage and runoff, sedimentation and erosion rates, process water discharges, and spills of hazardous materials.	• Water quality parameter concentrations (local and regional means concentrations and expected ranges) • Sedimentation and erosion potential and TSS loads

7.3.4 Project Interactions with Surface Water

Table 7.30 identifies the physical activities that might interact with the VC and result in the identified environmental effect. These interactions are indicated by checkmark and are discussed in detail in Section 7.5, in the context of effect pathways, standard and Project-specific mitigation / enhancement, and residual effects. Following the table, justification is provided for where no interaction (and therefore no resulting effect) is predicted.

Table 7.30 Project-Environmental Interactions with Surface Water

Physical Activities	Environmental Effects to be Assessed	
	Change in Surface Water Quantity	**Change in Surface Water Quality**
CONSTRUCTION		
Access Road Upgrade / Realignment: Where required, road widening and replacement / upgrades of roads and culverts.	✓	✓
Construction-related Transportation along Access Road	–	✓
Mine Site Preparation and Earthworks: Clearing and cutting of vegetation and removal of organic materials, development of roads and excavation and preparation of excavation bases within the mine site, grading for infrastructure construction. For the open pits, earthworks include stripping, stockpiling of organic and overburden materials, and development of in-pit quarries to supply site development rock for infrastructure such as structural fill and road gravels. Also includes temporary surface water and groundwater management, and the presence of people and equipment on site.	✓	✓
Construction / Installation of Infrastructure and Equipment: placement of concrete foundations, and construction of buildings and infrastructure as required for the Project. Also includes: • Installation of water control structures (including earthworks) • Installation and commissioning of utilities on-site • Presence of people and equipment on-site	✓	✓
Emissions, Discharges and Wastes[A]: Noise, air emissions / greenhouse gases (GHGs), water discharge, and hazardous and non-hazardous wastes.	✓	✓
Employment and Expenditures[B]	–	–
OPERATION		
Operation-related Transportation Along Access Road	–	✓
Open Pit Mining: Blasting, excavation and haulage of rock from the open pits using conventional mining equipment.	✓	✓

Table 7.30 Project-Environmental Interactions with Surface Water

Physical Activities	Environmental Effects to be Assessed	
	Change in Surface Water Quantity	Change in Surface Water Quality
Topsoil, Overburden and Rock Management: Five types of piles: • Topsoil • Overburden • Waste rock • Low-grade ore • High-grade ore • Rock excavated from the open pits that will not be processed for gold will be used as engineered fill for site development, maintenance and rehabilitation, or will be deposited in waste rock piles.	✓	✓
Ore Milling and Processing: Ore extracted from the open pits will be moved to the processing area where it will either be stockpiled for future processing or crushed and milled, then processed for gold extraction via gravity, flotation and leach processes.	–	–
Tailings Management Facility (TMF): Following treating tails via cyanide destruction, tailings will be thickened and pumped to an engineered TMF in years 1 to 9, then pumped to the exhausted Leprechaun open pit in years 10 through 12.	✓	✓
Water Management (Intake, Use, Collection and Release): Recirculated process water and TMF decant water will serve as main process water supply, and raw water (for purposes requiring clean water) will be obtained from Victoria Lake Reservoir. Site contact water and process effluent will be managed on site and treated prior to discharge to the environment. Where possible, non-contact water will be diverted away from mine features and infrastructure, and site contact and process water will be recycled to the extent possible for use on site.	✓	✓
Utilities, Infrastructure and Other Facilities • Accommodations camp and site buildings, including vehicle maintenance facilities • Explosives storage and mixing • Site road maintenance and site snow clearing • Access road maintenance and snow clearing • Power and telecom supply • Fuel supply	✓	✓
Emissions, Discharges and Wastes^{A}: Noise, air emissions/GHGs, water discharge, and hazardous and non-hazardous wastes.	✓	✓

Table 7.30 Project-Environmental Interactions with Surface Water

Physical Activities	Environmental Effects to be Assessed	
	Change in Surface Water Quantity	Change in Surface Water Quality
Employment and Expenditure[B]	–	–
DECOMMISSIONING, REHABILITATION AND CLOSURE		
Decommissioning of Mine Features and Infrastructure	✓	✓
Decommissioning, Rehabilitation and Closure-related Transportation Along Access Road	–	✓
Progressive Rehabilitation: Rehabilitating infrastructure or areas not required for ongoing operation (e.g., buildings, roads, laydown areas); covering and revegetating completed tailings areas, where practicable, including commencing closure of TMF beginning in Year 9 (when tailings deposition moves to Leprechaun open pit); erosion stabilization and re-vegetation of completed overburden and/or waste rock piles; infilling or flooding of exhausted mining areas; and completing revegetation studies and trials.	✓	✓
Closure Rehabilitation: Active rehabilitation based on successes of progressive rehabilitation activities. Includes: demolishing infrastructure (e.g., buildings, equipment, facilities, roads, laydown areas); grading and revegetating cleared areas, where practicable; breaching and regrading ponds to reestablish drainage patterns; completing closure of TMF (covering with overburden and revegetating); erosion stabilization and revegetation of completed overburden and/or waste rock piles; and infilling or flooding of open pits.	✓	✓
Post-Closure: long term monitoring	–	–
Emissions, Discharges and Wastes [A]	✓	✓
Employment and Expenditures [B]	–	–

Notes:

✓ = Potential interaction

– = No interaction

[A] Emissions, Discharges, and Wastes (e.g., air, waste, noise, light, liquid and solid effluents) are generated by many Project activities. Rather than acknowledging this by placing a checkmark against each of these activities, “Wastes and Emissions” is an additional component under each Project phase

[B] Project employment and expenditures are generated by most Project activities and components and are the main drivers of many socio-economic effects. Rather than acknowledging this by placing a checkmark against each of these activities, “Employment and Expenditures” is an additional component under each Project phase

In the absence of mitigation, the Project may interact with surface water resources in the following ways:

- Mine site preparation and earthworks including clearing of vegetation, stripping of soils, and creation of stockpiles will alter water quantity and quality related to runoff
- Construction and installation of infrastructure and equipment including buildings, milling and processing plants, overburden piles, waste rock piles, low-grade ore stockpiles, high-grade ore stockpiles and roads (upgrading and new construction) will alter the amount and quality of expected runoff
- The upgrading and realignment of the access road during construction may alter surface water flow patterns and water quality
- Transportation along the access road throughout the life of the Project will occur along defined corridors and may interact with surface water quality through dust creation and potential erosion and sedimentation
- Natural waterbodies will be lost as a result of mine site development
- Mine water management, contact water runoff and seepage will affect water quantity and water quality
- Open pit mining will alter the surface water quantity and quality entering local watersheds. Open pits will be dewatered during operation and allowed to fill during closure
- Discharges of surplus water via a treatment plant and polishing pond, and seepage through or beneath the TMF embankments, will affect surface water quality if not adequately contained or treated to comply with MDMER and water quality standards prior to entering the receiving environment
- Progressive and closure rehabilitation will alter water quantity and quality by changing runoff patterns and by reducing the amount of exposed rock

The primary Project-related effects on surface water resources will include changes to local watershed areas due to construction of stockpiles and open pits, dewatering during operation, flooding during closure of the open pits, and the introduction of treated contact water into the receiving environment through selected discharge points and indirectly through seepage. Accidental releases of hazardous substances can also affect surface water resources, and these are assessed in Accidental Events (Chapter 21).

Employment and expenditure throughout the Project will not directly result in changes to the physical environment, including surface water.

7.3.5 Analytical Assessment Techniques

The environmental effects analyses for changes in surface water quantity and surface water quality were carried out using a number of analytical methods and tools, and includes a site-wide water quantity and quality GoldSim^{TM} model, site-wide hydrogeological model, and a 3-dimensional steady state near-field Cornell Mixing Zone Expert System (CORMIX) model. Development of the models, inputs and results are described in detail in the Water Quantity and Water Quality Modelling Reports (Appendix 7A and 7B), and the Assimilative Capacity Assessment (Appendix 7C). The following subsections provide an overview of the methods used to complete the surface water resources effects assessment.

7.3.5.1 Analytical Assessment Techniques for Changes in Surface Water Quantity

Flows and water levels under pre-development conditions were used as the baseline against which Project-related changes during the construction, operation and decommissioning, rehabilitation and closure phases were assessed. Pre-disturbance (baseline) watershed areas are presented in Figure 7-9 and expected changes to these watersheds were delineated for subsequent phases of the mine life, as shown in Figures 7-22, 7-23 and 7-24. The changes in watershed areas are primarily a result of the construction of mine infrastructure and the implementation of the Water Management Plan (Appendix 2A).

Project-related changes in surface water quantity were assessed at the watershed scale using the following tiered approach:

- A site-wide water balance model was developed in GoldSim^{TM} to predict the water quantity changes through the Project phases. The water balance model includes the open pits, overburden stockpiles, waste rock piles, process plant, TMF, and ore stockpiles
- Change in MAF from pre-disturbance conditions was used as a screening threshold to determine whether further assessment of changes in flow were required. Changes in MAF were calculated for watersheds during each phase of mine development. MAF was calculated using regional relationships developed in the Baseline Report (BSA.3, Attachment 3-C). Watersheds with an expected change in MAF of greater than 10% were carried forward to subsequent assessment steps. The ±10% threshold is selected based on case studies presented by Richter et al. (2011), which indicate that a high level of ecological protection is provided when flow alterations are within 10% of the natural flow, and guidance provided by Fisheries and Oceans Canada (DFO) (2013)
- For watersheds with an expected decrease of over 10%, the MAF was compared with baseline environmental flows. The residual effect was considered to not be significant if the predicted MAF was greater than the baseline environmental flows. If the expected MAF was lower than the baseline environmental flows, a locally significant surface water quantity residual effect is expected within the LAA
- For watersheds with an expected increase in MAF of over 10%, expected flood flows (Q100) were compared with baseline conditions to assess the potential for flooding and erosion
- Changes in MAF were also assessed at the boundary of the LAA for Victoria River, Victoria Lake Reservoir and Valentine Lake. Pre-development watersheds at the extent of the LAA are shown in Figure 7-10. Figures 7-25, 7-26 and 7-27 show the LAA watersheds for construction and operation, closure, and post-closure mine phases. Expected MAFs for these phases were compared with pre-development conditions to establish expected changes in surface water quantity at the boundary of the LAA. If a residual effect for surface water is propagated to the boundary of the LAA and beyond, it is considered a significant residual effect.

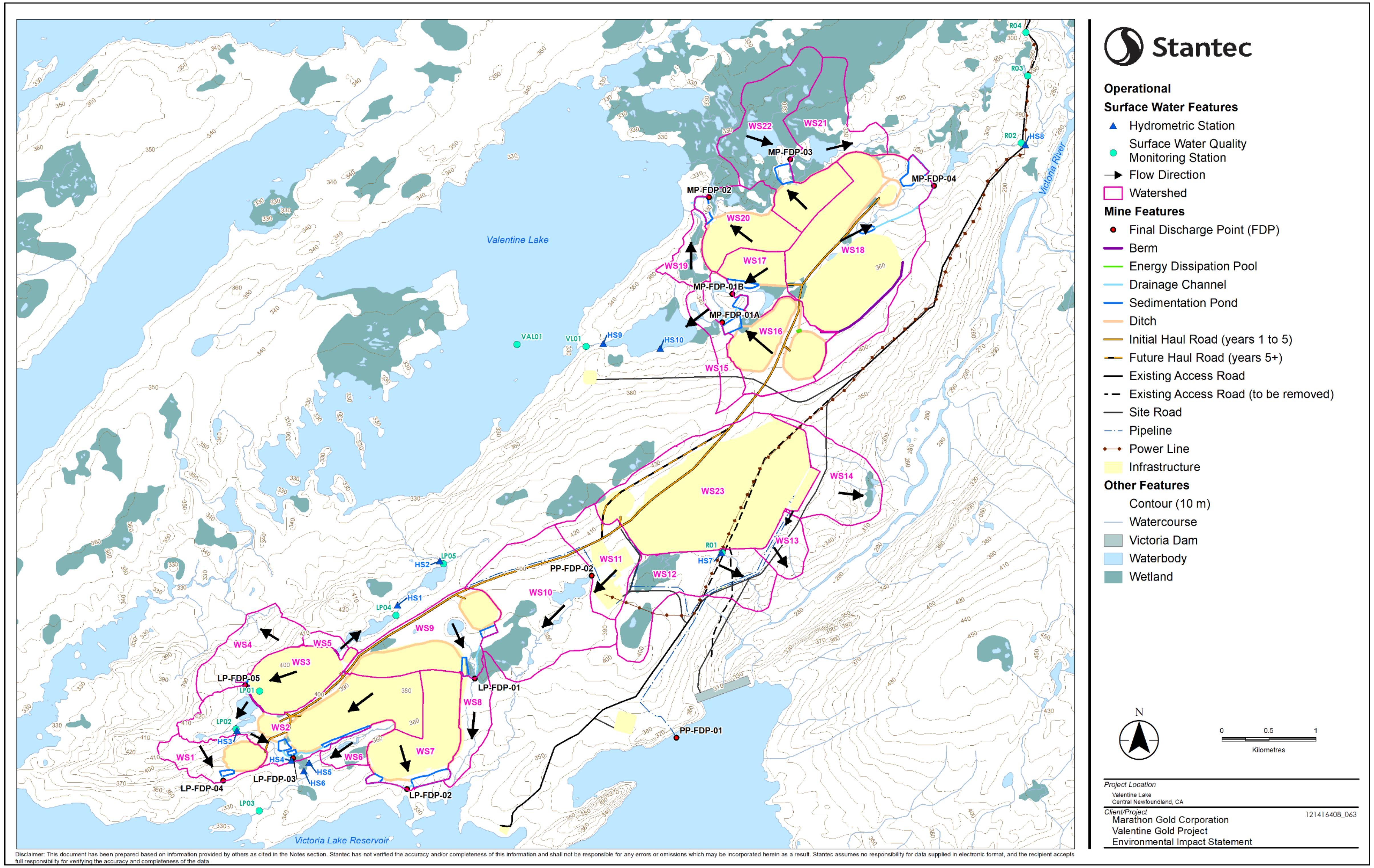

Figure 7-22 Mine Construction and Operation Watershed Areas

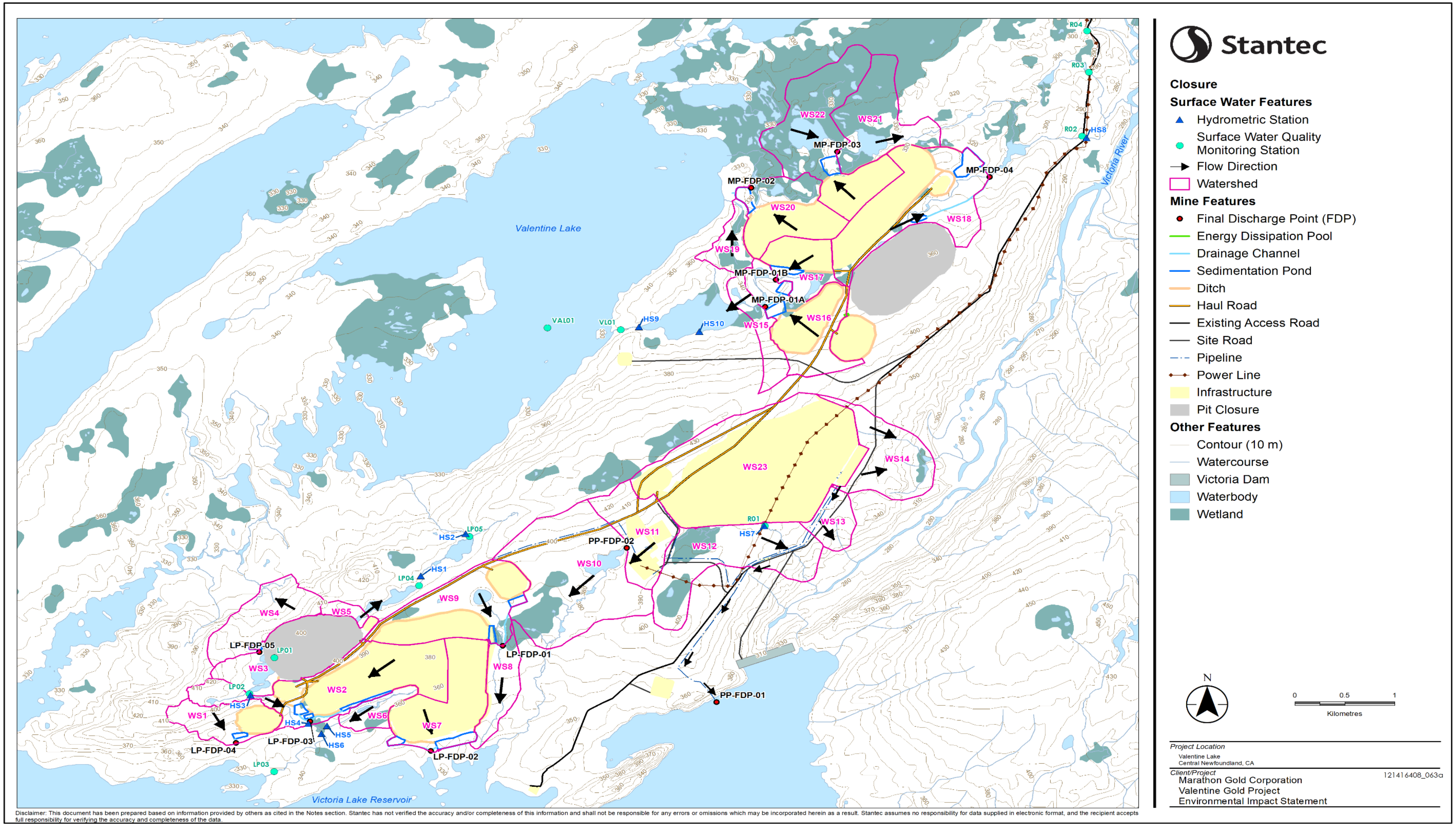

Figure 7-23 Mine Closure Watershed Areas

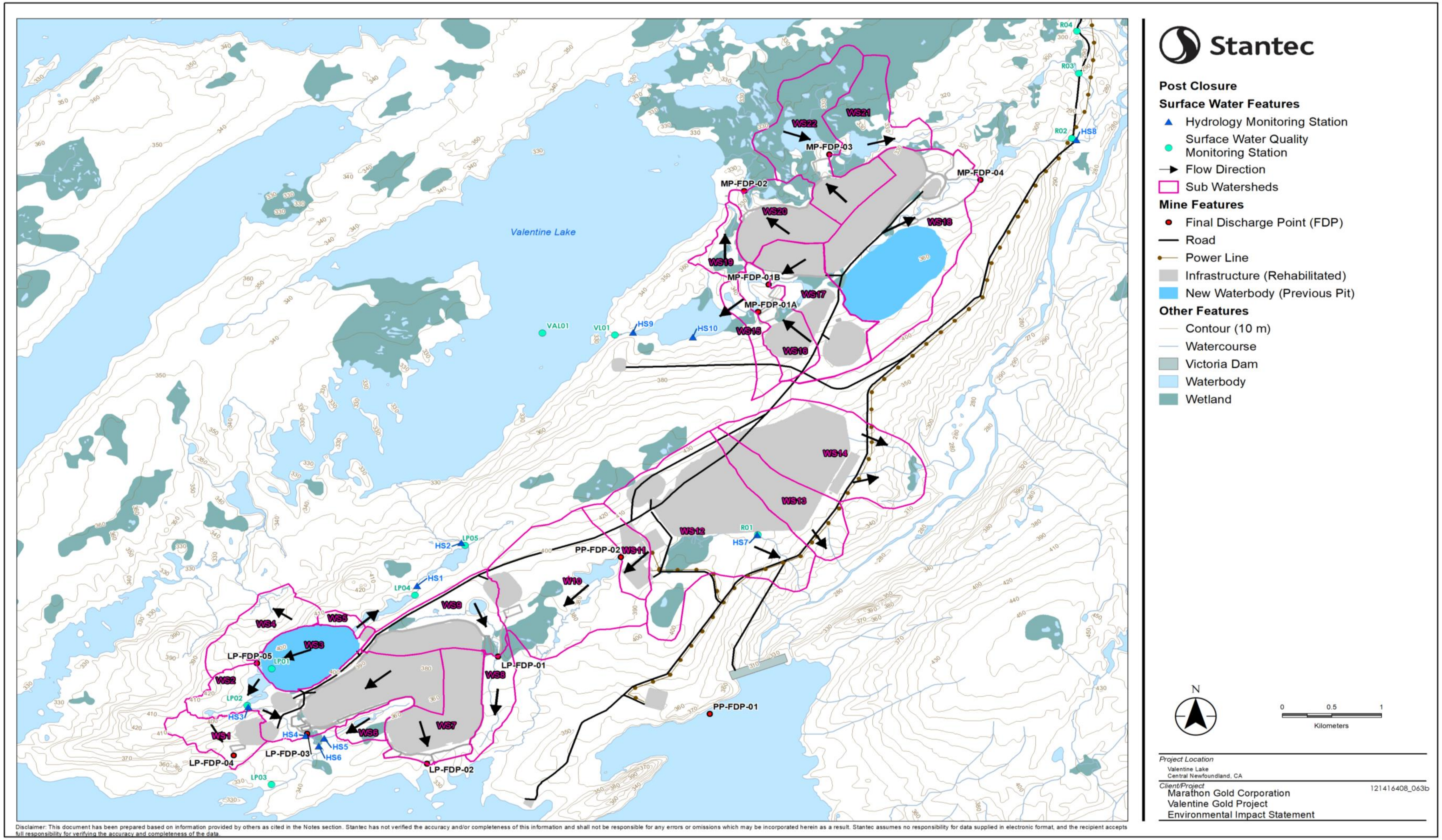

Figure 7-24 Mine Post-Closure Watershed Areas

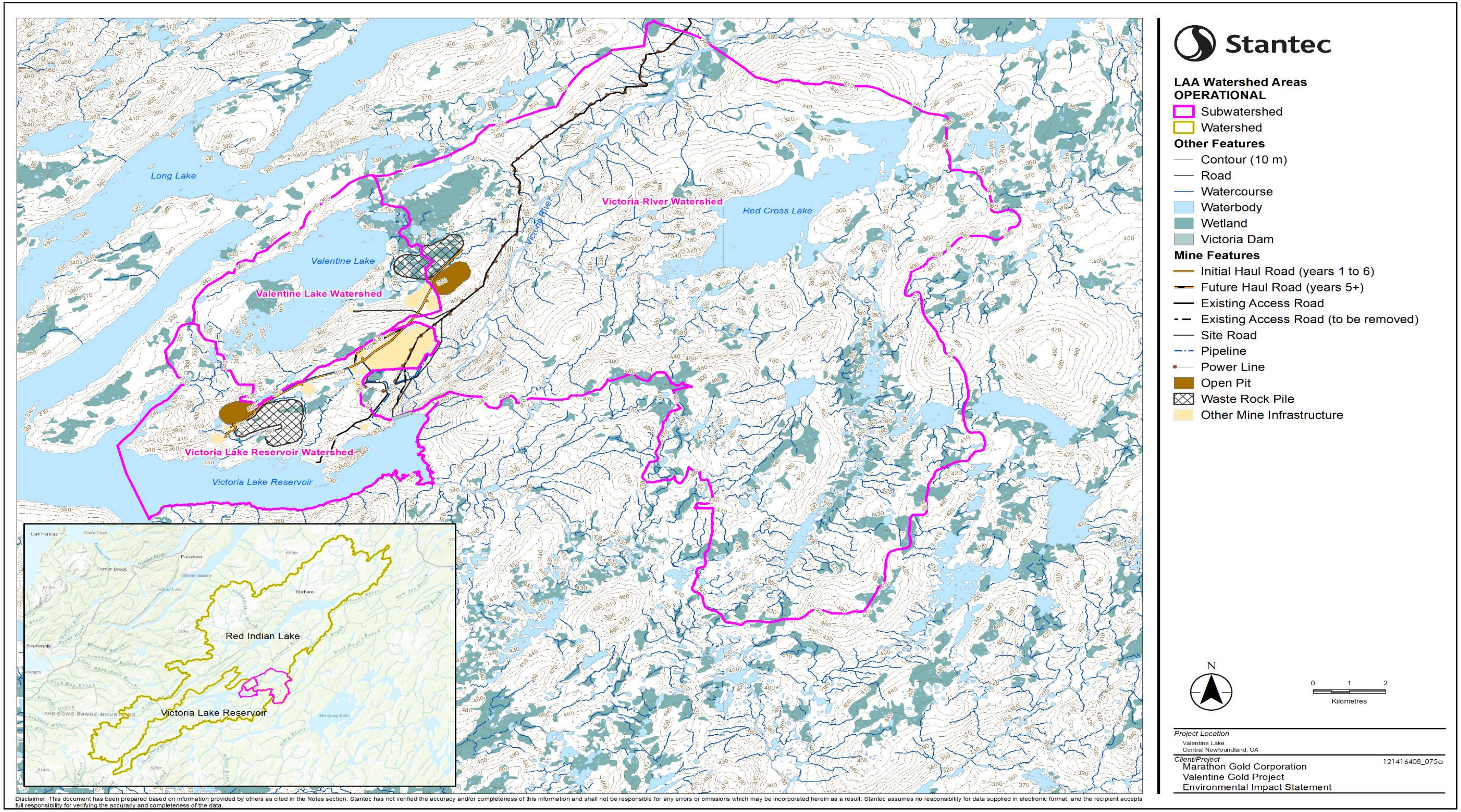

Figure 7-25 LAA Watersheds Construction and Operation

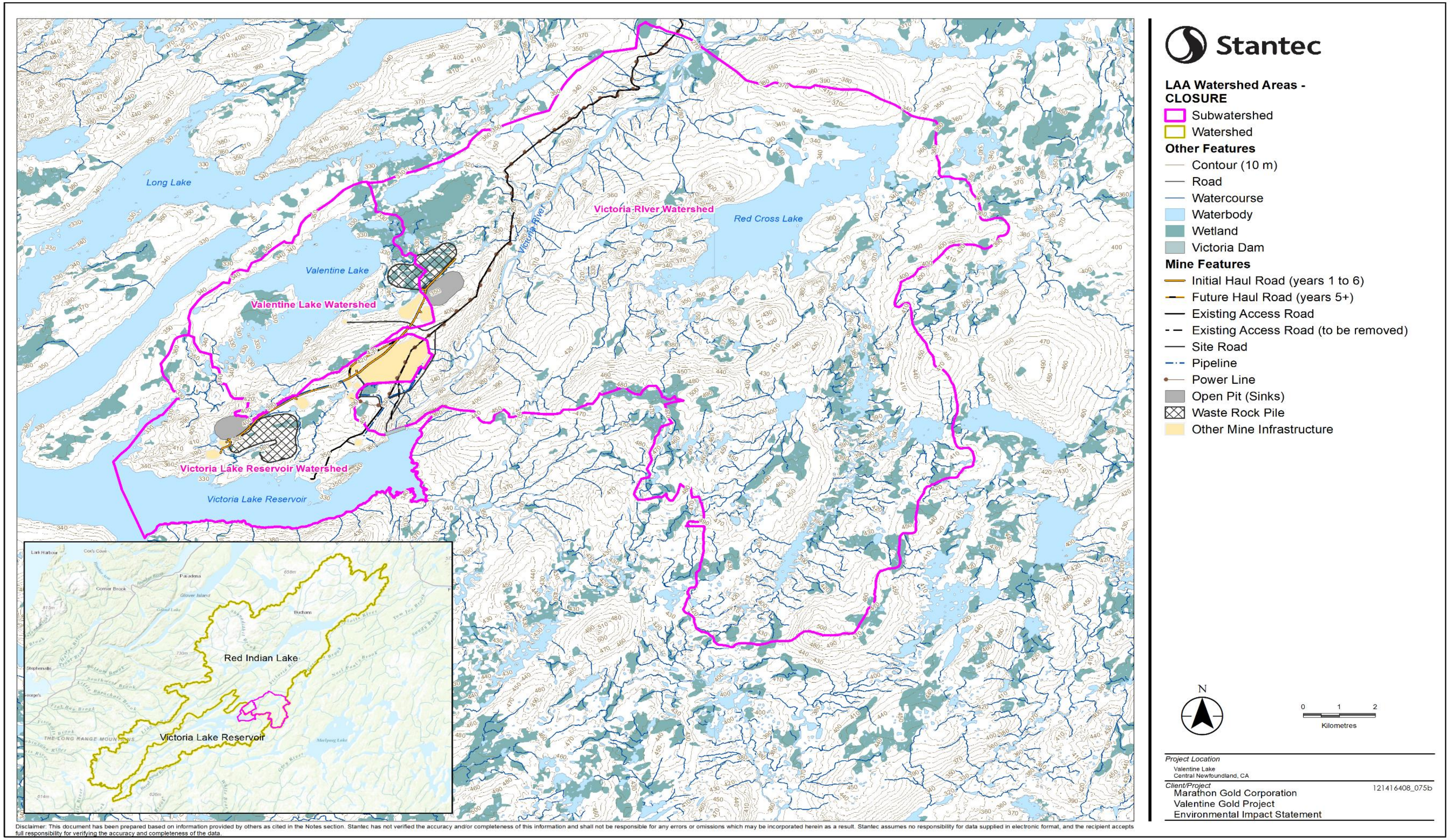

Figure 7-26 LAA Watersheds at Closure

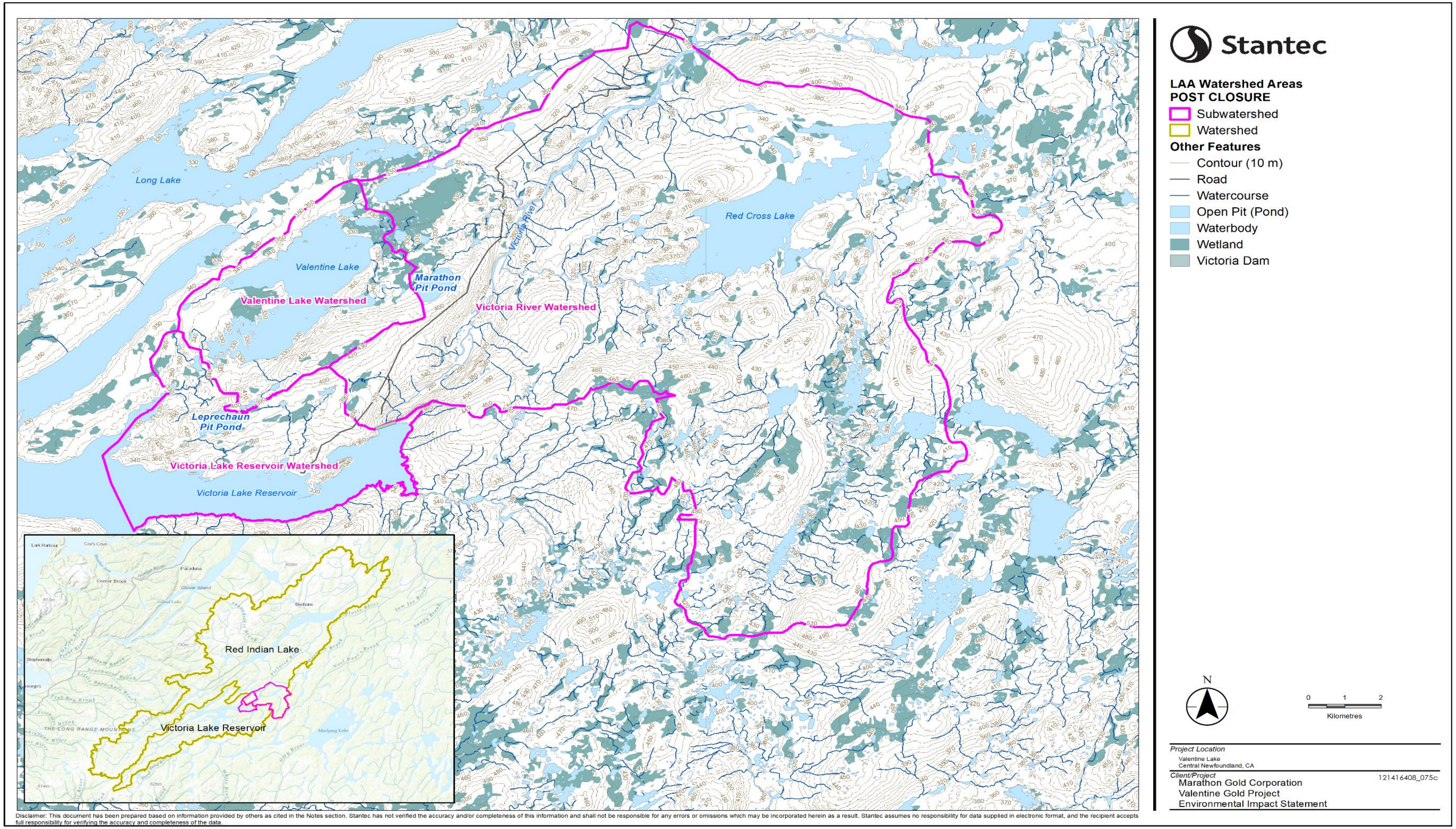

Figure 7-27 LAA Watersheds Post-closure

7.3.5.2 Analytical Assessment Techniques for Change in Surface Water Quality

Baseline surface water quality was used as the baseline against which changes to surface water quality during Project phases were assessed. As outlined in the Water Management Plan (Appendix 2A and Section 7.4.3), a design objective for water management infrastructure is to keep non-contact water and contact water separated. Contact water is directed to sedimentation ponds prior to discharge to the environment at the FDP locations shown in Figure 7.22. Non-contact water is directed to the environment has been assumed to be represented by baseline water quality. Contact water quality was predicted by integrating geochemical contact water predictions into the GoldSim^{TM} water balance model in a water quality module and is further discussed below.

A list of parameters of potential concern (POPC) was established and changes in these parameters were assessed to determine Project effects on surface water quality. Selection of the POPC is discussed in detail in the Water Quantity and Water Quality Modelling Reports (Appendix 7A and 7B) and the selection criteria are listed below:

- Parameters found to exceed CWQG-FAL in baseline monitoring (aluminum, cadmium, iron, arsenic, copper, lead, zinc, and nitrite)
- Parameters listed in MDMER considered to be at risk of being elevated (arsenic, copper, cyanide, lead, ammonia (unionized), zinc)
- Parameters considered potentially present in in mine effluent as a result of mining activities (cyanide (Weak Acid Dissociable [WAD]), fluoride, manganese, ammonia, phosphorus, sulphate)

Expected surface water quality for these POPC were assessed at each FDP location, 100 m and 250 m downstream of each FDP, and at the ultimate surface water receivers (Victoria Lake Reservoir, Valentine Lake, and Victoria River). Assessing the water quality at these points was done through a Water Quantity and Quality Model and an Assimilative Capacity Assessment and is further discussed below.

Water Quantity and Quality Model

Water quantity and quality modelling was conducted to simulate proposed water management for the Project and support site design and operation. The model was developed using the GoldSim ^{TM} software package with the contaminant transport module to predict water quality associated with the site-wide water balance model (quantity). GoldSim^{TM} is commonly used in the mining industry to develop water balance models and predict water quality at user-defined modelling nodes by combining system dynamics with discrete event simulations. As described in further detail in the Leprechaun and Marathon Water Quantity and Water Quality Modelling Reports (Appendix 7A and 7B), the model was run dynamically on a daily time step for the construction, operation and decommissioning, rehabilitation and closure (sub-divided into closure and post-closure) phases.

The water quantity (balance) model accounted for the precipitation and groundwater gains, and evaporation, transpiration and infiltration losses of each identified mine facility. These inflows and outflows are based on precipitation rates, catchment and facility areas and volumes, groundwater inflow rates, operational water management strategies, and the movement of materials within the site. The climate normal and probabilistic scenarios were considered to evaluate the potential effects of the Project on surface water resources.

The water quantity model for the TMF was based on a runoff coefficient approach. Runoff from the tailings and polishing ponds was estimated in the model based on the proportion of total precipitation (rainfall plus snow melt runoff) on the catchment multiplied by a runoff coefficient. This method is consistent with the prefeasibility level water balance model conducted by Golder for design (Golder 2020).

For conservatism in the model, it is assumed that the catchment area for mining features are at their ultimate stage at the start of construction. This assumes that contact water from stockpiles start flowing to the sedimentation ponds at the beginning of construction. However, the open pits are set as a gradual expanding area over the mine operation.

The water quality predictions are calculated at the model nodes by integrating source term development (loading sources) into the water balance. Results from this analysis and modeling are presented in the Leprechaun and Marathon Water Quantity and Water Quality Modelling Reports (Appendix 7A and 7B).

Sources of Potential Contaminants

The potential for development of ARD and ML in mined materials and the identification of POPC was completed to support planning and an assessment of potential environmental effects of the Project. This work is presented in the Phase II ARD/ML Assessment Report (BSA.5, Attachment 5-B).

The methods for the ARD/ML assessment generally followed the Mine Environment Neutral Drainage (MEND) publication entitled “Prediction Manual for Characterizing Drainage Chemistry from Sulphidic Geologic Materials” (Price 2009). The geochemistry baseline program included:

- Static testing of approximately 350 samples of waste rock, ore, overburden and tailings for Acid-Base Accounting, Shake Flask Extraction (SFE) and total metals
- Characterization of composite samples using the static tests and mineralogical methods
- Kinetic testing of composite samples including 14 humidity cells, two ageing tests and two sub-aqueous columns tests

Acid Potential (AP) was calculated from sulphide sulphur hosted in pyrite and marcasite. Neutralization Potential (NP) was calculated from Total Inorganic Carbon considering that calcite and dolomite are dominant acid neutralization minerals in the deposits. ARD classification is based on a Neutralization Potential Ratio (NPR=NP/AP) of samples compared to generic thresholds proposed by Price (2009). A sample is conservatively classified as Potentially Acid Generating (PAG) if NPR is below 2; otherwise, the sample is classified as non-PAG.

ML potentials were evaluated by comparing the concentrations of trace elements in the leachates from SFE and kinetic tests to the concentration limits prescribed in MDMER and to the CWQG-FAL. Concentrations exceeding MDMER and/or 10x CWQG in kinetic tests indicate parameters with high leaching potential, while concentrations between the CWQG and 10x CWQG value were arbitrarily assigned to moderate leaching potential.

Assimilative Capacity

An assimilative capacity assessment was conducted to estimate the water quality of watercourse and waterbodies receiving discharges directly from FDPs, as well as the three ultimate receivers of Valentine Lake, Victoria Lake Reservoir and Victoria River (Appendix 7C). Mass balance calculations of concentrations 100 m and 250 m downstream of the FDPs and the near-field mixing model CORMIX (Version 11.0) were used to predict water quality under both regulatory and normal operating conditions. The regulatory operating conditions are considered worst case and conservative, while normal operating conditions are considered representative of the expected average discharge conditions. Input parameters for these two conditions were:

- Regulatory Operating Conditions:
  - MDMER limits for POPC listed parameters for effluent
  - 95th percentile for POPC not listed in MDMER, generated from geochemical water quality modelling
  - 75th percentile baseline water quality in the receiving watercourses
  - 7Q10 flow receiver conditions (7-day low flow, 10-year return period)
  - Effluent discharge rates under representative low flow climate conditions
- Normal Operating Conditions
  - Mean concentrations for POPC generated from water quality modelling
  - Mean concentrations for baseline water quality in the receiving watercourses
  - MAF receiver and average effluent discharge conditions

The mixing zone assessment of the watercourses adjacent to the mine site was conducted using the predicted effluent and receiver flows and concentrations. The assessment of the watercourse mixing zones downstream of the FDPs included a review of the effluent quality at set distances (e.g., 100 and 250 m) from the FDPs. Many of the FDPs are located on small tributaries. In these cases, the mixing zone was defined to include the tributary from the FDP to an ultimate receiver downstream (i.e., larger lakes or rivers). In almost all cases, the effluent mixing zone extended into the ultimate downstream lake / river receivers. This is illustrated conceptually on Figure 7-28, which shows the FDP and mixing zone points 100 m and 250 m downstream in a watercourse. Water quality at these mixing zone points was calculated based on dilution ratios of the effluent and the background hydrology for the dry (regulatory) and normal flow conditions. The POPCs were determined at 100 m and 250 m, and at the confluence with the ultimate receiver for the dry and climate normal conditions.

The results of the CORMIX models provide an estimate of the POPCs concentrations within the effluent mixing zones under conservative conditions in the three ultimate receivers. The mixing zones were determined in terms of assimilation or dilution ratios for the maximum effluent flow rate expected to enter each receiving waterbody. Results of this model are presented in the Assimilative Capacity Assessment (Appendix 7C) and summarized in the Change in Surface Water Quantity (Section 7.5.1).

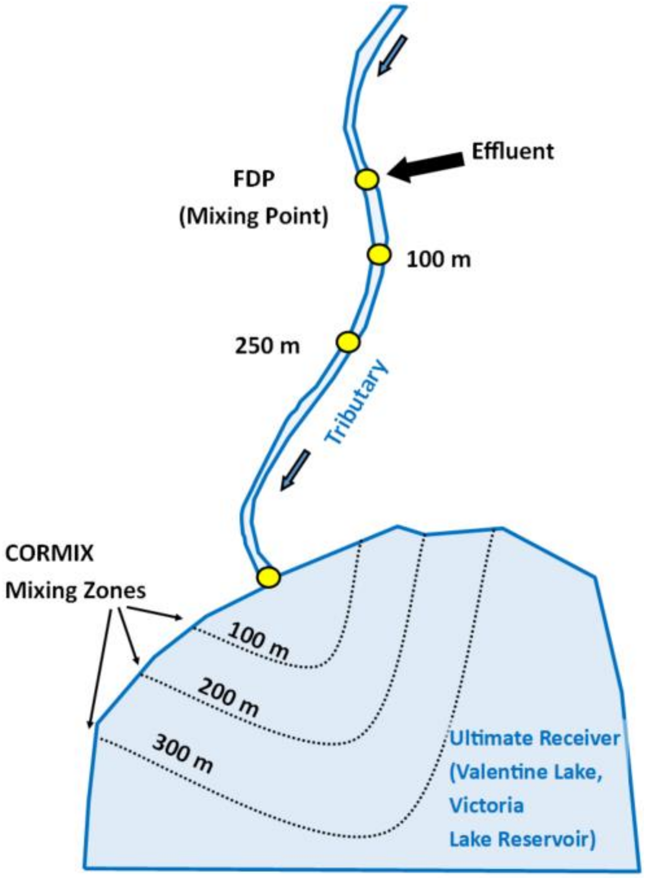

Figure 7-28 Conceptual Representation of Mixing Zone Assessment

7.3.5.3 Assumptions and the Conservative Approach

A conservative approach was applied in assessing changes in surface water quantity and quality. This approach leads to conservative predictions of potential effects, and corresponding mitigation to address those potential effects. The following assumptions regarding the conservative approach and uncertainty were applied in the assessment of potential changes in surface water quantity and quality:

- Watershed areas used to establish MAF relationships between pre-development, operation and decommissioning, rehabilitation and closure (sub-divided into closure and post-closure) phases were established at points along the receiving waterbody as close to the mine infrastructure as feasible. These points were chosen either because they aligned with FDPs or because they represented a point in the waterbody that would capture flow from the upgradient mine infrastructure. This allowed for a conservative approach in determining changes in MAF between pre-development and subsequent mine phases as relative changes to watershed areas were maximized. The screening threshold of 10% MAF is also considered conservative as Richter et al. (2011) indicates that a high level of ecological protection is provided at this level

- The prediction of effluent water quality entering the receiving environment is based on mass balance model run under two operating scenarios. The regulatory operating condition scenario assumes low receiver flow (7Q10), poor effluent water quality (MDMER limits or 95th percentile of modelled values for non-MDMER parameters), and poor background water quality (75th percentile of baseline conditions). This represents a conservative scenario and does not fully account for increased assimilation realized during higher flow events (which is more accurately captured in the normal operating conditions scenario). The normal operating conditions scenario was based on climate normal flow conditions and the maximum of monthly averages over the mine phase of development.
- Predictions of changes to water quality did not account for the natural degradation of ammonia. Similarly, predicted seepage water quality at the receivers did not account for the attenuation processes that naturally occur as groundwater flows through the aquifer

7.4 MITIGATION AND MANAGEMENT MEASURES

A series of environmental management plans will be developed by Marathon to mitigate the effects of Project development on the environment. A full list of mitigation measures to be applied throughout Project construction, operation and decommissioning, rehabilitation and closure is provided in Section 2.7.4. Project planning and design and the application of proven mitigation measures will be used to reduce adverse effects to surface water resources. The following mitigation measures (Table 7.31) will be employed to avoid or reduce adverse environmental effects of the Project on surface water resources.

Table 7.31 Mitigation Measures for Surface Water Resources

Category	Mitigation	C	O	D
Site Clearing, Site Preparation and Erosion and Sediment Control	• Project footprint and disturbed areas will be limited to the extent practicable.	✓	-	-
	• Construction areas will be routinely monitored to identify areas of potential erosion and to apply appropriate mitigation. Progressive erosion and sediment control measures will be implemented, as required.	✓	-	-
Vehicles / Equipment / Roads	• Haul roads, site roads and the access road will be maintained in good condition. This will include periodically regrading and ditching to improve water flow, reduce erosion, and to manage vegetation growth.	✓	✓	✓
Site Water Management	• Marathon will implement a Water Management Plan (Appendix 2A) for the site which will incorporate standard management practices, including drainage control, excavation and open pit dewatering which collectively comprise the water management infrastructure currently designed as part of the Project scope (Section 2.3.7). The Water Management Plan provides detail on runoff and seepage collection strategies and systems (e.g., local seepage collection ponds, berms, drainage ditches, pumps) to collect and contain surface water runoff and groundwater discharge from major Project components (open pit, waste rock piles, TMF, ore stockpile and overburden storage areas, process plant) during climate normal and extreme weather conditions.	✓	✓	✓

Table 7.31 Mitigation Measures for Surface Water Resources

Category	Mitigation	C	O	D
	• Progressive water management will be implemented over the life of the mine. This includes construction of water management infrastructure as an area is developed and decommissioning / rehabilitation of water management infrastructure as an area is decommissioned.	✓	✓	✓
	• Existing drainage patterns will be maintained to the extent feasible with the use of culverts and bridges.	✓	✓	-
	• Existing culverts along the site access road will be maintained or upgraded as necessary. This will include placement of culverts of the same size or larger, at the same inlet and outlet elevations, and in a manner to not cause flooding or ice jams.	✓	-	-
	• Project water storage features (i.e., sedimentation ponds) will be used to attenuate peak discharges to the environment.	✓	✓	✓
	• Culverts will be inspected periodically to remove accumulated material and debris upstream and downstream of the culverts.	✓	✓	✓
	• Perimeter grading and access roads will be used to divert runoff away from the open pit and reduce the amount of dewatering required.	✓	✓	-
	• Contact water collection ditches will be installed around the overburden stockpiles, ore stockpiles and waste rock piles to collect toe seepage. Contact water collection ditches will be designed to convey the 1:100-year storm event, and with positive gradients to limit standing water and maintain positive flow.	✓	✓	✓
	• Where possible, contact water will be recycled for use on-site (e.g., dust suppression).	✓	✓	✓
	• Non-contact water will be diverted away from developed areas, where possible. Channels and berms will be constructed around the crest of the open pits or uphill of waste rock piles and other developed areas to divert natural precipitation and surface runoff away from contact with mining operations, where practicable.	✓	✓	✓
	• Water withdrawals from Victoria Lake Reservoir and Valentine Lake, for the purposes of expediting the filling of the open pits, will be done in accordance with a pumping operations plan. This plan will be developed to reduce effects on the lakes.	-	-	✓
	• Runoff and groundwater seepage will be collected from the open pits, with water pumped to sedimentation ponds before being discharged to each pits' pre-development watershed area.	-	✓	-
	• Pond inlet and outlet structures will be configured to reduce inlet velocity and scour, and to meet sedimentation requirements. Pond outlets will be designed with subsurface inlets to mitigate against chemical stratification in ponds, thermal heating of discharge and ice blockage of outlets.	✓	✓	✓
	• Contact water sedimentation ponds will be designed to provide onsite storage of local runoff with the size and residence times designed to provide sediment removal to meet the *Metal and Diamond Mining Effluent Regulation* (MDMER) effluent total suspended solids criterion of 15 mg/L (monthly mean concentration limit), with removal of particles down to 5 micron (µ) in size for up to the 1:10 Annual Exceedance Probability (AEP) flows.	✓	✓	✓

Table 7.31 Mitigation Measures for Surface Water Resources

Category	Mitigation	C	O	D
	• Sedimentation ponds will be designed to contain (without discharge) runoff resulting from storm events up to the 1:100 year AEP with spring snowmelt event, including emergency spillways and maintaining minimum freeboard of 0.5 m. The emergency spillways will accommodate flows up to the 1:200 AEP flow.	✓	✓	✓
	• Sedimentation ponds will be designed with active water storage that considers ice thickness during winter. Under an extreme storm event, only the stormwater in excess of the available storage at that time will be discharged to the environment via the emergency spillway to protect the collection ponds.	✓	✓	✓
	• Effluent will be treated prior to discharge to the receiving water environment, as required, to meet regulatory effluent criteria as well as criteria developed through the receiving water Assimilative Capacity Assessment (Appendix 7C).	✓	✓	✓
	• Effluent discharge rates will be maintained to below the highest rate used in the Assimilative Capacity Assessment (Appendix 7C).	✓	✓	✓
Tailings Management	• The TMF dam will be designed to maintain water storage to contain the Environmental Design Flood, a 100-year return hydrologic event (24-hour storm or freshet event (75 mm)) with no discharge through the spillway (Golder 2020).	-	✓	✓
	• To address extreme weather events, an emergency spillway will be maintained to safely pass the Inflow Design Flood while maintaining minimum freeboards requirements to protect the structural integrity of the dam. The Inflow Design Flood is generated by the theoretical maximum precipitation that could fall in the area.	-	✓	✓
	• The TMF closure spillway will be upgraded to meet closure requirements developed during detailed design.	-	-	✓
	• Vegetation will be cleared within the TMF tailings containment zone prior to filling/flooding to reduce potential generation of methyl mercury (MeHg) water quality concerns.	✓	✓	✓
	• Shallow groundwater seepage from the TMF will be intercepted by seepage collection ditches and pumped back to the TMF via sump pumps.	✓	✓	✓
	• Contact and process water from the TMF will be recycled for ore processing to the extent possible.	-	✓	-
	• The tailings deposition strategy to deposit thickened tailings as beaches will reduce porewater lock-up in comparison to sub-aqueous deposition and will reduce the quantity of porewater seepage in closure.	-	✓	✓
	• A water treatment plant will receive discharge water from the tailings pond and use proven processes to treat the water to meet MDMER limits prior to discharge to the polishing pond and subsequent discharge to the environment.	-	✓	-
	• A polishing pond will receive discharge from the water treatment plant to further advance the treatment of water prior to discharge to the environment.	-	✓	✓

Table 7.31 Mitigation Measures for Surface Water Resources

Category	Mitigation	C	O	D
	• Reclaim water will be taken from the TMF during Years 10 to 12 and will subsequently be pumped to Leprechaun pit as part of the tailings slurry for deposition. Using reclaim water from the TMF in the process plant will reduce the amount of freshwater needed to be taken from Victoria Lake Reservoir.	-	✓	-
Materials Handling and Waste Management	• Sewage effluent will be treated and monitored in accordance with the NL *Environmental Control Water and Sewage Regulations* prior to discharge to the environment. Sludge generated as a by-product of the treatment of sewage will be disposed off-site by a licensed contractor.	✓	✓	-
	• Temporary use of existing sanitary sewage system at the exploration camp will be supplemented with mobile sanitary sewage storage facilities until the mine site system is operational.	✓	-	-
Rehabilitation and Closure	• Progressive rehabilitation (e.g., placement of soil cover and vegetation over waste rock piles, erosion stabilization and temporary vegetation of completed organics, topsoil, and overburden stockpiles) will be implemented.	-	✓	✓
	• Passive water quality treatment technologies will be employed, where and if required, for closure / post-closure including engineered wetlands to treat site seepage and runoff, as practicable.	-	-	✓
Notes: C – Construction Activities O – Operation Activities D – Decommissioning, Rehabilitation and Closure Activities				

7.4.1 Water Management Plan

The Water Management Plan (Appendix 2A) provides additional details on the key site-specific mitigation measures to reduce the potential for Project effects on surface water quantity and quality (Table 7.31). The Water Management Plan will be implemented during construction, operation and closure, and provides details on runoff and seepage collection strategies and systems (e.g., local seepage sedimentation ponds, berms, drainage ditches, pumps) to collect and contain surface water runoff, and groundwater discharge from major Project components (open pit, waste rock piles, TMF, ore stockpile and overburden stockpiles, process plant) during climate normal and extreme weather conditions.

The primary objectives of the Water Management Plan are to mitigate operational risks and environmental effects of the Project. These objectives include:

- Reduce water inventory through perimeter berms and promote overland flow of non-contact runoff
- Reduce the number of FDPs through grading of ditches and construction of diversion channels to combine discharge points of sedimentation ponds
- Maintain flow to fish bearing streams and wetlands by maintaining pre-development catchments and/or flows
- Reduce water management costs during operation through grading and gravitational drainage, thus reducing pumping requirements

7.4.1.1 Water Management Design

Design criteria used in the Water Management Plan were developed to mitigate possible effects of the Project on surface water resources and are based on the Project-specific guidance, industry best practices and Marathon corporate direction. Design criteria related to surface water quality are summarized below and include:

- Use accepted industry best practice geochemistry methods to predict mine contact runoff and seepage quality
- Manage water quality through collection ditches and collection (sedimentation) ponds, collecting water from Project components and draining locally
- Mean monthly and daily effluent water quality at FDPs to be below MDMER
- Assess water quality in the mixing zone downstream of an FDP using assimilative capacity of receiving waters, and define the mixing zone boundary as the point downstream in the receiving waters where ambient water quality meets the CCME CWQG-FAL, or returns to baseline concentrations
- If Project component effluent quality doesn’t meet MDMER limits through sedimentation ponds, implement further effluent treatment

Water quality control criteria applied in the design of sedimentation ponds include:

- Runoff from the project component areas for storm events up to 1:10 AEP to allow settlement of sediments to meet MDMER
- Sedimentation ponds were designed to treat a silt sized particle of 5.0 x 10^{-3} mm in diameter (British Columbia Ministry of Environment and Climate Change Strategy 1996), which is a typical particle size in design of a sedimentation pond
- Ponds were designed primarily to meet the minimum residence time required for sediment to settle 1 m, reaching a trapping efficiency of 80%
- Runoff from the water quality design storm event will be detained in the sedimentation pond for a minimum of 24 hours
- A submerged type low-level outlet will act as a hydrocarbon and Light Non-Aqueous Phase Liquids containment feature, as well as to reduce thermal discharge effects

Construction

The primary water management activity during construction will be erosion and sediment control measures and mine dewatering. Erosion and sediment control measures will be required for various construction phase activities including clearing, stripping and grubbing of vegetation, excavation and storage of topsoil and overburden, blasting and removal of mine rock and ore, and dewatering of the starter pits. The primary water management activities during construction for the process plant are expected to include collection, treatment and discharge of surface runoff from the construction area, as well as collection, treatment and discharge of surface runoff and groundwater inflow to foundation excavations. Other construction activities include ditch construction, road construction, borrow area development and operation, and preparation of surfaces for major Project facilities.

Erosion and sediment control measures will be implemented to reduce environmental effects involving earthwork activities during the development of the Project. The four basic principles to be adopted in implementation of these measures are:

- Direct runoff away from active work areas before construction commences, reducing the volume of sediment-laden water to be managed
- Limit the amount and timing of exposed soil left open at any one time to reduce the potential for erosion
- Control sediment-laden runoff leaving the site by following erosion and sediment control measures put in place for the construction of the Project
- Protect sensitive receptors from sediment-laden runoff by directing untreated runoff away from these areas

Operation

Water management functions will be carried out independently with decentralized treatment and control at each of the three mine complexes. The water management design is presented in Figure 7-29 for the Marathon complex, Figure 7-30 for the Process Plant and TMF complex, and Figure 7-31 for the Leprechaun complex. To reduce the mine water inventory, non-contact runoff is proposed to be diverted using perimeter berms to allow runoff to naturally flow offsite. Catchment areas for mine site components were delineated in AutoCAD based on the available project LiDAR (Aethon 2019).

The Project components were sited to avoid fish habitat to the extent practicable. In particular, the site plan was developed to avoid the deposition of mine waste in fish-bearing waters. During detailed design, the location of watercourses will be verified with results of ground-truthing and final siting of components will be adjusted as needed. Note that Figure 7-31 shows the Leprechaun waste rock pile overprinting water management infrastructure. During summer 2020 field work, it was determined that the NL 1:50,000 mapping contains an error in relation to the extent of Stream VIC-15, which extends eastward approximately 200 m farther than mapped. The Leprechaun waste rock pile has been adjusted to avoid this fish habitat; however, the design of the water management infrastructure could not be updated in time for the EIS submission. The water management design will be updated as part of the Feasibility Study that is scheduled to be completed in early 2021.

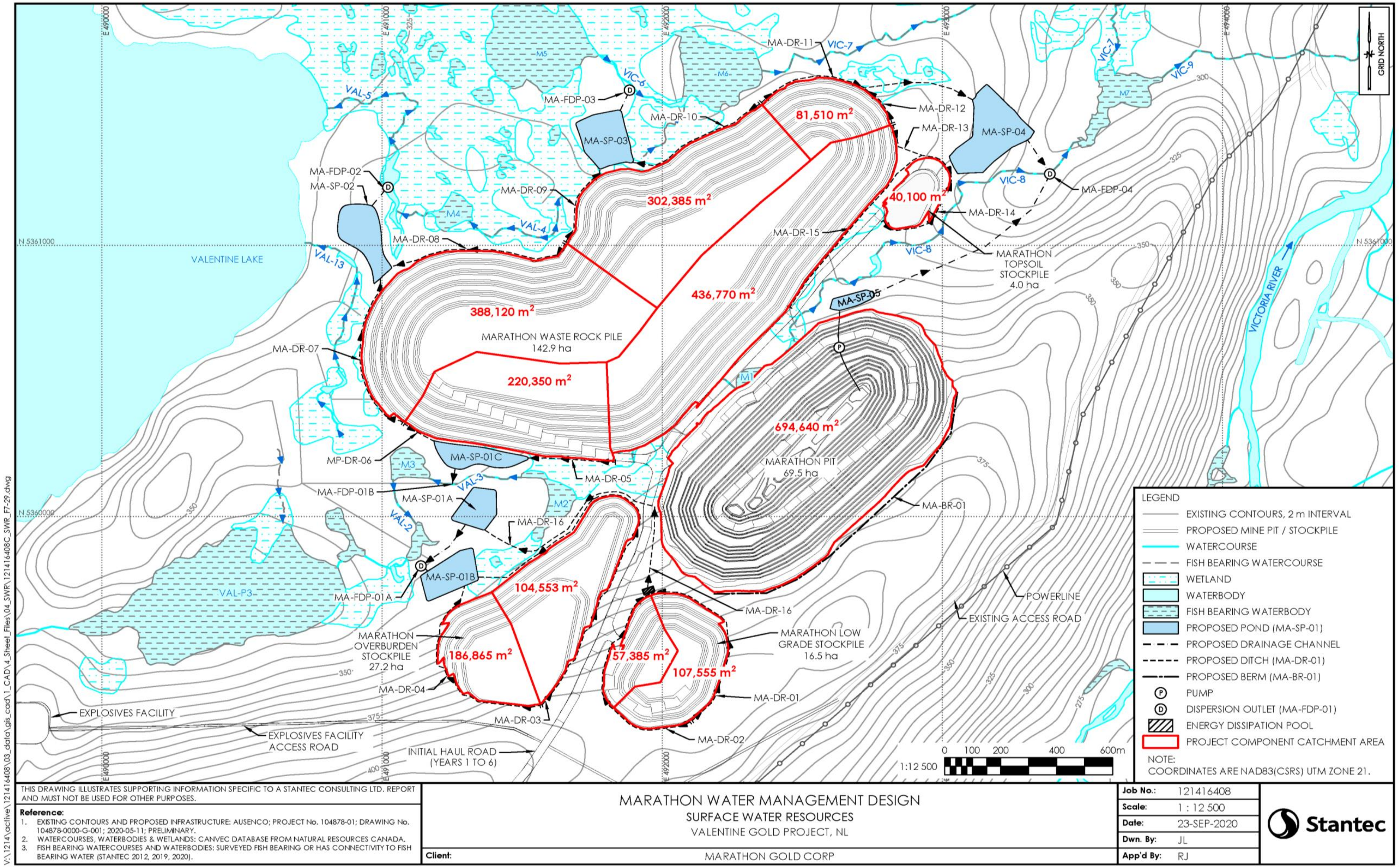

Figure 7-29 Marathon Water Management Design

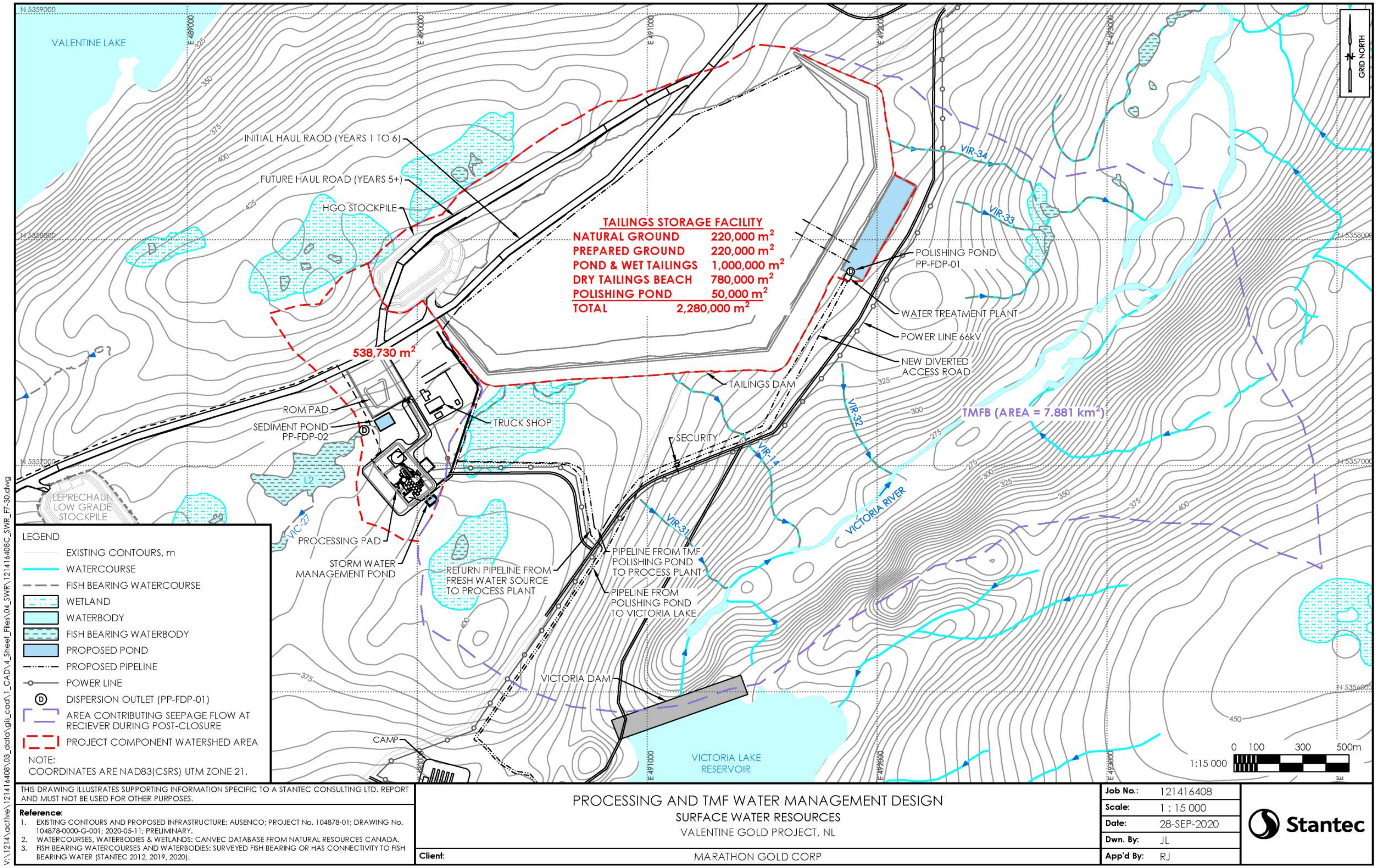

Figure 7-30 Processing and TMF Water Management Design

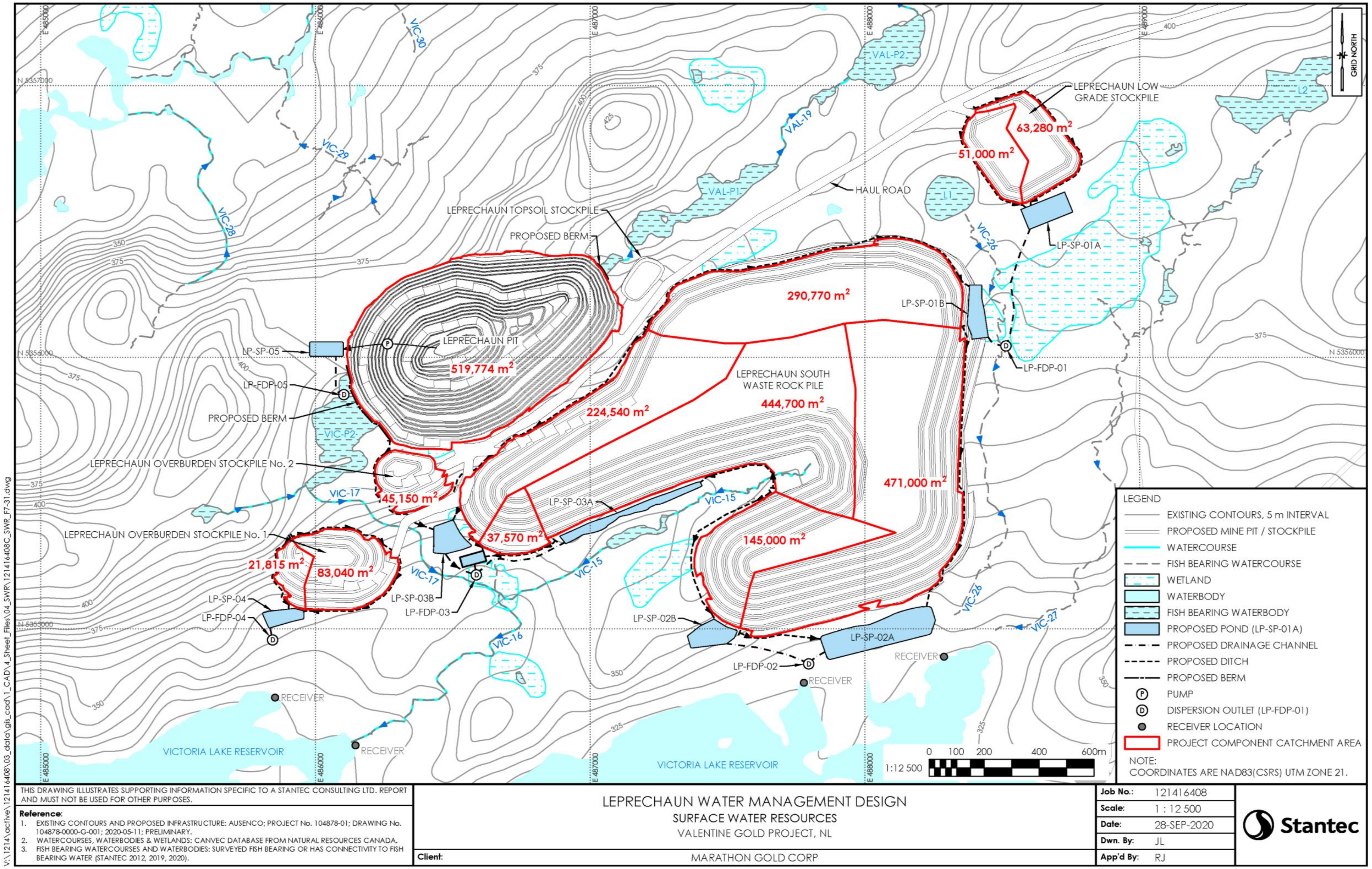

Figure 7-31 Leprechaun Water Management Design

The water management design diverts non-contact water from the mine facilities natural water drainage areas, where possible. Diversion of surface flows using channels and berms constructed around the crest of open pits or up-gradient of waste disposal piles and other developed areas will reduce the contact water inventory. Where possible, water collected in pits or in the sedimentation ponds will be used for other purposes on site rather than discharged to the environment.

The Project has a total of 11 FDPs. Four of the FDPs are associated with the Marathon Complex and drain to Valentine Lake or Victoria River. Five FDPs are associated with the Leprechaun Complex that ultimately drain to Victoria Lake Reservoir, either directly to the lake or through tributaries. The Process Plant and TMF Complex has an additional two FDPs that flow, or are pumped to Victoria Lake Reservoir, including the TMF effluent pipeline to Victoria Lake Reservoir and runoff from the Processing Plant and TMF complex. MDMER limits will be met at FDPs prior to release.

A total of 17 sedimentation ponds are designed to provide on-site storage of runoff, as summarized in Table 7.32. The ponds will provide controlled releases of discharge and are designed to provide adequate residence time for settling. Permanent pools in ponds will be excavated below grade, thus reducing the total berm height and improving berm safety. Effluent will be released slowly to enhance baseflow augmentation and reduce the potential for downstream scour and erosion. MDMER limits will be met at FDPs prior to release to the receiver.

Table 7.32 Sediment Pond and Ditch Design Management Infrastructure

Mine Facility [Facility Area]	Ditch Run	Ditch Length (m)	Sedimentation Pond	Final Discharge Point (FDP)	Discharge Location
Marathon Low-Grade Ore Stockpile [16.5 ha]	MA-DR-01	710	MA-SP-01A	MA-FDP-01A/B	Unnamed tributary that drains to Valentine Lake (VALP3)
	MA-DR-02	805			
	MA-DR-16	1165			
Marathon Overburden Stockpile [27.2 ha]	MA-DR-03	1515	MA-SP-01B		
	MA-DR-04	760			
Marathon Waste Rock Pile [142.9 ha]	MA-DR-05	330	MA-SP-01C		
	MA-DR-06	130			
	MA-DR-07	610	MA-SP-02	MA-FDP-02	Victoria Lake Reservoir
	MA-DR-08	655			
	MA-DR-09	310	MA-SP-03	MA-FDP-03	Wetland draining to Valentine Lake (Upgradient of M5)
	MA-DR-10	520			
	MA-DR-11	785	MA-SP-04	MA-FPD-04	Tributary to Victoria River (VIC8)
	MA-DR-12	160			
	MA-DR-13	315			
	MA-DR-15	365			

Table 7.32 Sediment Pond and Ditch Design Management Infrastructure

Mine Facility [Facility Area]	**Ditch Run**	**Ditch Length (m)**	**Sedimentation Pond**	**Final Discharge Point (FDP)**	**Discharge Location**
Marathon Topsoil Stockpile [4.0 ha]	MA-DR-14	735			
Marathon Pit [69.5ha]	MA-BR-01	1235	MA-SP-05		Tributary to Victoria River (VIC8)
Leprechaun Low-Grade Ore Stockpile [11.4 ha]	LP-DR-01	785	LP-SP-01A	LP-FDP-01	Unnamed tributary stream to Victoria Lake Reservoir (VIC-01)
	LP-DR-02	440			
Leprechaun Waste Rock Pile [161.5 ha]	LP-DR-03	1,370	LP-SP-01B		
	LP-DR-04	1,050	LP-SP-02A	LP-FDP-02	Victoria Lake Reservoir
	LP-DR-05	300			
	LP-DR-06	650	LP-SP-02B		
	LP-DR-07	345	LP-SP-03A	LP-FDP-03	Headwater stream that drains to Victoria Lake Reservoir (VIC17)
	LP-DR-08	270	LP-SP-03C		
	LP-DR-09	70			
	LP-DR-10	1,065	LP-SP-03B		
Leprechaun Topsoil Stockpile [4.5 ha]	LP-DR-11	495			
Leprechaun Overburden Stockpile [10.5 ha]	LP-DR-12	325	LP-SP-04	LP-FDP-04	Unnamed tributary stream to Victoria Lake Reservoir
	LP-DR-13	885			
Leprechaun Pit [52 ha]	LP-BR-01		LP-SP-05	LP-FDP-05	VIC-P2
TMF	PP-PR-01	Not Applicable	Polishing Pond	PP-FDP-01	Victoria Lake Reservoir
Process Plant Pad	PP-DR-01	100	PP-SP-01	PP-FDP-02	Victoria Lake Reservoir

Sedimentation ponds were designed based on particle settling characteristics. The minimum target particle size was 5 microns and the assumed settling velocity of the particles was 2×10^{-5} m/s (conservatively assuming the temperature of the water in the pond is close to freezing). Given a minimum vertical settling zone of 1 m, it will take 14 hours for a particle to reach the trapped sediment zone below the pond outlet invert. Ditches will be constructed along the perimeter of piles to convey the 1:100 AEP surface runoff and toe drainage to sedimentation ponds for water quality and quantity control. Trapezoidal geometry ditch runs were designed to convey flow through gravity and provide a minimum of 20 cm freeboard under design flows. Ditch excavation materials will be sidecast and berms constructed of the sidecast glacial till material. Ditches will be lined with rip-rap for erosion protection. In areas with ditch gradients steeper than 8%, sediment traps (i.e., check dams) will be installed at a spacing of 200 m per ditch grade % to provide energy dissipation and reduce erosional flow velocities in the ditch. For the same purpose, energy dissipation pools will be installed at the change in ditch gradient from slopes of 10% or higher to shallower slopes.

Pond storage, geometry and outlet configuration are summarized in Table 7.33. The inactive and 1:100 year active pond storage volumes below the spillway are summarized for each sediment pond. Pond geometry includes the designed pond bottom elevation and berm crest elevation, in addition to the pond width and length. Outlet configuration of the bottom draw pipes and associated orifice diameter needed to provide residence time and extended discharge attenuation, and spillway width were also provided as these dimensions change for each sediment pond. Pumps will be required to dewater the Marathon and Leprechaun pits. A pit dewatering pond was designed at a low-lying location adjacent to each pit. Pit dewatering discharge directed to the pit dewatering ponds at the surface will be subsequently drained to pre-development catchments.

Table 7.33 Pond Storage, Geometry and Outlet Configuration

Sediment Pond Name	Inactive Pond Storage (m³)	Active Pond Storage (m³)	Total Pond Storage (m³)	Pond Bottom Elev. (m)	Pond Berm Crest Elev. (m)	Pond Width (m)	Pond Length (m)	Orifice Diameter (mm)	Spillway Base Width (m)
MA-SP-01A	12,400	13,500	25,900	*337.5*	*340.0*	*125.0*	*135.0*	300	2
MA-SP-01B	20,600	22,400	43,000	337.0	339.5	120.0	215.0	450	3
MA-SP-01C	17,100	19,300	36,400	338.0	340.5	90.0	330.0	300	2
MA-SP-02	26,160	28,400	54,560	326.0	328.5	270.0	160.0	450	4
MA-SP-03	27,600	29,600	57,200	326.0	328.5	170.0	200.0	450	4
MA-SP-04	44,700	47,600	92,300	312.0	314.5	250.0	300.0	450	6
MA-SP-05	5,070	4,100	9,170	330.5	333.0	165.0	55.0	450	10
LP-SP-01A	9,570	11,600	21,170	377.0	379.5	75	160	300	2
LP-SP-01B	8,950	10,400	19,350	369.5	372.0	75	205	300	3
LP-SP-02A	30,000	45,000	75,000	326.0	328.5	115	420	450	4
LP-SP-02B	9,570	14,400	23,970	341.5	344.0	90	140	300	1
LP-SP-03A	10,200	13,500	23,700	352.0	354.5	35	550	450	3
LP-SP-03B	4,000	4,000	8,000	*347.0*	*349.0*	*40*	*100*	300	2
LP-SP-03C	9,570	3,800	13,370	349.0	351.5	110	120	300	1
LP-SP-04	4,790	7,200	11,990	338.5	341.0	60	145	300	2
LP-SP-05	4,390	2,400	8,890	335.5	338.0	60	130	450	8
PP-DR-01*	3,000	3,000	6,000	---	---	---	---	---	---

Note:
* = Pond geometry and outlet configuration will be finalized in detailed engineering design

The TMF pond will collect direct precipitation, runoff from the tailings surface, water discharged from the mill with the tailings (In Years 1 to 10), and water pumped back from the seepage collection sumps around the facility. During the operation phase, water will be pumped from the TMF pond via a reclaim pump system for the operation of the processing plant. Excess runoff from the TMF will be routed through a water treatment plant and polishing pond prior to discharge via a pipeline to Victoria Lake Reservoir.

The pipeline extends into Victoria Lake Reservoir at FDP, PP-PR-01. A minimum of 8% of clean make-up water is required in the process plant and will be supplied from Victoria Lake Reservoir.

In Year 10, when tailings deposition is switched from the TMF to the Leprechaun pit, process water will continue to be supplemented by TMF reclaim water, in addition to the minimum of 8% freshwater make-up from Victoria Lake Reservoir.

Seepage collection ditches will be constructed at the downstream toe of the TMF dams. Seepage from the ditches will be directed to sumps at various topographic low points around the dams and seepage and runoff collected in the sumps will be pumped back to the TMF. Excess water above the Environmental Design Flood in the TMF and polishing pond will spill through an emergency spillway and drain towards the Victoria River.

The process plant pad will be graded to allow surface runoff to drain naturally to the internal network of collection swales and ditches sized to handle peak flow resulting from the 1:25 year rainfall storm event. The collection ditches will convey the water to a stormwater sedimentation pond at 3,000 m^3 live capacity, west of the processing plant. The water in the sedimentation pond will be pumped into the process water tank as make-up water and excess water will drain toward Victoria Lake Reservoir.

Raw freshwater will be pumped from Victoria Lake Reservoir to supply fire water, cooling water, gland water for pumps, reagent make-up, feed for potable water plant, and the freshwater make-up process water demand. Raw water for the process demand will be pumped from Victoria Lake Reservoir to the tanks and distributed to the required points in the plant, and to supply the potable water treatment system. Demand for the process plant is 21 cubic metres per hour (m^3/h) in the pre-processing period (2.5 Mtpa) and 29 m^3/h at full production (4 Mtpa). The potable water plant will satisfiy the demand from the accommodation camps and other onsite building use. Sewage will be collected via an underground sanitary sewer network connected to an above-grade mechanical sewage treatment plant where it will be treated and discharged in compliance with provincial approvals. Sanitary sludge will be disposed of offsite by a licensed contractor.

Decommissioning, Rehabilitation and Closure

Water management during progressive rehabilitation and closure will be consistent with operation. However, due to the ground disturbance associated with the rehabilitation activities, standard erosion and sediment control measures for construction will also be implemented to supplement the existing water quality treatment infrastructure.

For the purposes of surface water resources, rehabilitation and closure activities will take place over a period of eight years as described in Section 7.1.3. However, treatment of effluent discharge will continue during rehabilitation and closure until monitoring demonstrates that water quality is acceptable to release directly to the environment.

During the post-closure and monitoring phase, the open pits will fill and eventually discharge to the environment. Natural pit infilling from precipitation and groundwater will be supplemented by pumped water from the tailings pond and Victoria Lake Reservoir (Leprechaun pit) and from Valentine Lake

(Marathon pit). This supplementation of pit filling flows is estimated to reduce the time to fill the pits from approximately 40 years to 8 years. Water management features will be removed, and drainage restored to natural, pre-development conditions to the extent possible. The water treatment plant downstream of the TMF will be decommissioned as effluent water quality meets discharge limits and closure measures are proven successful. The existing seepage collection ditches will be converted to infiltration ditches to promote infiltration into groundwater and natural attenuation.

Monitoring and maintenance of the reclaimed facilities will be carried out during operation and into closure. It is anticipated that monitoring and maintenance will be carried out during the active closure stage at frequencies similar to those required during operation. Post-closure monitoring and maintenance will be carried out at a reduced frequency depending on the results of the monitoring and the measures of success selected for closure.

7.5 ASSESSMENT OF ENVIRONMENTAL EFFECTS ON SURFACE WATER

For each potential effect identified in Section 7.3.3, specific Project activities that may interact with the VC and result in an environmental effect (i.e., a measurable change that may affect the VC) are identified and described. The following sections first describe the results of modelling used to support the Water Management Plan, and the pathways by which a potential Project effect could result from Project activities in the absence of mitigation during each Project phase during each Project phase (e.g., construction, operation and decommissioning, rehabilitation and closure). Mitigation and management measures (Section 7.4) are applied to avoid or reduce these potential pathways and resulting environmental effects. Residual effects are those remaining following implementation of mitigation, which are then characterized using the criteria defined in Section 7.3.1. A summary of predicted residual effects is provided in Section 7.5.3.

7.5.1 Change in Surface Water Quantity

7.5.1.1 Water Quantity and Quality Model Results

Water Management Infrastructure

Outflows and water quality from sedimentation ponds are forecasted in the water quantity and quality model, accounting for seepage and surface flow collected in the perimeter ditching of each project facility and dewatering of the open pits. Conceptual water management applied in the water balance model for the operational phase at the Leprechaun complex and Process Plant and TMF complex are presented in Figure 7-32 and at the Marathon complex in Figure 7-33.

Sediment pond outflow post closure is representative of the non-point discharge to the former sedimentation pond. The water quality model shows that the ponds become full during freshet of the first year, and overflow to the FDPs thereafter. Table 7.34 and 7.35 present the forecasted sedimentation pond outflows for the phases of development for the Marathon complex, and Leprechaun complex, respectively. As an example, Figure 7-34 presents flows and volume of LP-SP-03A, which captures flows from the Marathon waste rock pile.

The rest of the ponds present the same behavior as LP-SP-03A, except for LP-SP-05, which captures flows from pit dewatering. Flows to this pond come from the pit dewatering, which have a steadier flow due to the groundwater inflow to the pit. LP-SP-05 will commence discharge after a few days of starting the dewatering, as depicted in Figure 7-35.

The magnitude of the flow from the sedimentation ponds is dictated by pond volume, level, surface water flow into the pond, and the groundwater infiltration to the ponds.

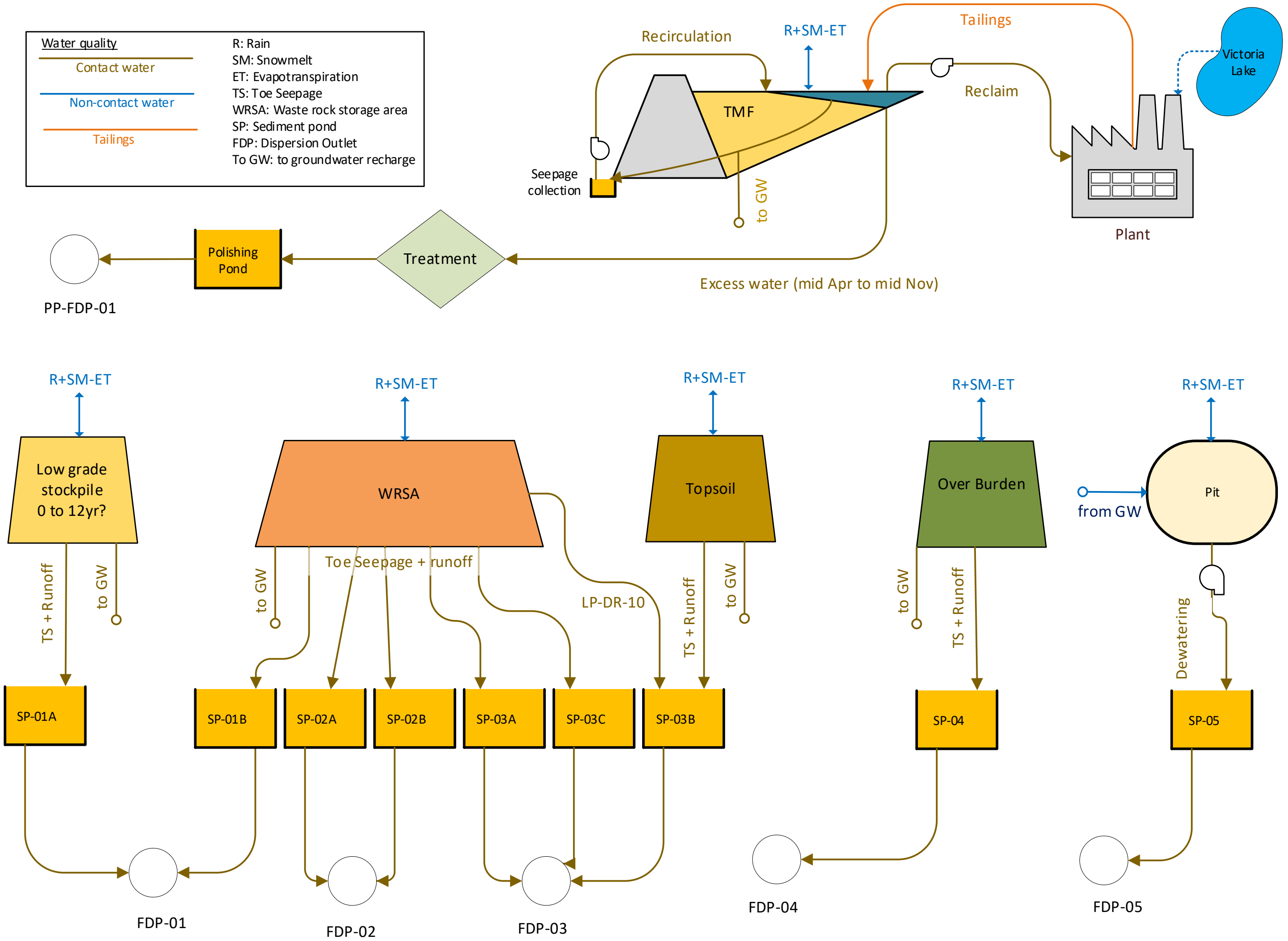

Figure 7-32 Conceptual Model of Mine Water Management – Leprechaun Complex and Process Plant and TMF Complex - Operation (Year 1 to 9)

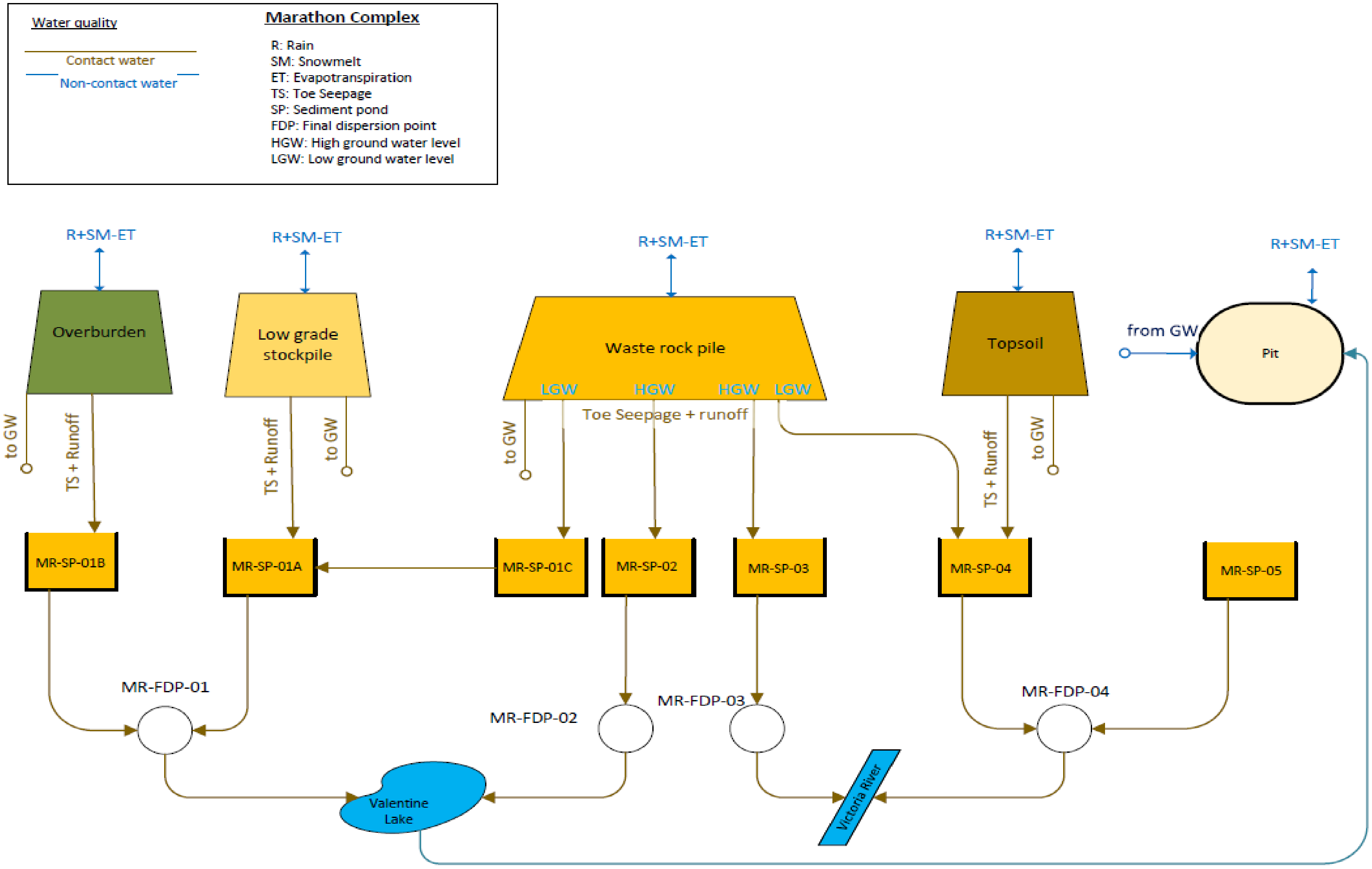

Figure 7-33 Conceptual Model of Mine Water Management – Marathon Complex - Operation (Year 1 to 9)

Table 7.34 Marathon Forecasted Sedimentation Pond Outflows (m^3/day)

Pond	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
MA-SP-01A	Operation (Year 1 to 9)	536	669	785	1849	539	280	192	527	667	702	875	690	690
	Operation (Year 10 to 12)	573	713	838	1976	579	303	209	569	717	752	937	738	740
	Closure (Year 13 to 17)	504	632	741	1745	505	258	176	490	623	658	823	650	648
MA-SP-01B	Operation (Year 1 to 9)	151	216	286	663	145	76	69	123	136	146	206	200	201
	Operation (Year 10 to 12)	151	216	286	663	145	76	69	123	136	146	206	200	201
	Closure (Year 13 to 17)	18	23	27	63	15	0	0	8	14	22	30	23	20
MA-SP-01C	Operation (Year 1 to 9)	193	277	366	848	191	107	100	167	181	189	264	256	260
	Operation (Year 10 to 12)	193	276	366	848	191	107	100	167	181	189	264	256	260
	Closure (Year 13 to 17)	248	319	379	898	232	103	55	210	282	305	394	321	311
MA-SP-02	Operation (Year 1 to 9)	1115	1345	1554	3605	1435	1115	1044	1692	1787	1669	1894	1421	1637
	Operation (Year 10 to 12)	1115	1340	1554	3605	1435	1115	1044	1692	1787	1669	1894	1421	1636
	Closure (Year 13 to 17)	953	1186	1373	3260	915	429	231	873	1168	1243	1564	1225	1197
MA-SP-03	Operation (Year 1 to 9)	816	992	1155	2678	1031	781	731	1195	1269	1199	1374	1041	1186
	Operation (Year 10 to 12)	816	988	1155	2678	1031	781	731	1195	1269	1199	1374	1041	1186
	Closure (Year 13 to 17)	714	890	1034	2450	681	311	167	641	862	926	1170	920	894
MA-SP-04	Operation (Year 1 to 9)	599	829	1069	2479	590	309	279	517	589	636	860	787	792
	Operation (Year 10 to 12)	599	825	1069	2479	590	309	279	517	589	636	860	787	792
	Closure (Year 13 to 17)	441	558	661	1554	407	159	91	353	485	550	711	588	544
MA-SP-05	Operation (Year 1 to 9)	3102	3402	3728	6128	3747	3612	3701	4247	4078	3761	3917	3450	3904
	Operation (Year 10 to 12)	14	17	21	47	11	0	0	6	11	17	23	18	15
	Closure (Year 13 to 17)	14	17	21	47	11	0	0	6	11	17	23	531	59

Table 7.35 Leprechaun Forecasted Sedimentation Pond Outflows (m^3/day)

Pond	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
LP-SP-01A	Operation (Year 1 to 9)	233	295	355	822	271	182	170	289	315	313	377	300	326
	Operation (Year 10 to 12)	233	293	355	822	271	182	170	289	315	313	377	300	326
	Closure (Year 13 to 17)	217	272	319	750	214	103	70	202	260	282	355	279	276
LP-SP-01B	Operation (Year 1 to 9)	285	400	521	1208	287	162	152	257	281	295	401	375	384
	Operation (Year 10 to 12)	285	398	521	1208	287	162	152	257	281	295	401	375	384
	Closure (Year 13 to 17)	323	415	496	1172	299	127	68	265	359	394	512	419	402
LP-SP-02A	Operation (Year 1 to 9)	416	603	805	1863	375	160	150	280	324	380	558	553	536
	Operation (Year 10 to 12)	416	601	805	1863	375	160	150	280	324	380	558	553	536
	Closure (Year 13 to 17)	553	710	850	2001	506	201	108	438	600	672	878	716	683
LP-SP-02B	Operation (Year 1 to 9)	235	303	372	862	268	180	168	282	305	302	369	304	328
	Operation (Year 10 to 12)	235	302	372	862	268	180	168	282	305	302	369	304	328
	Closure (Year 13 to 17)	240	303	357	844	225	97	52	205	277	303	389	303	298
LP-SP-03A	Operation (Year 1 to 9)	1184	1432	1658	3850	1533	1207	1130	1818	1909	1769	2004	1510	1747
	Operation (Year 10 to 12)	1184	1427	1658	3850	1533	1207	1130	1818	1909	1769	2004	1510	1747
	Closure (Year 13 to 17)	1007	1255	1453	3454	972	467	251	937	1247	1313	1651	1313	1272
LP-SP-03B	Operation (Year 1 to 9)	370	486	601	1397	403	256	228	409	454	455	569	480	507
	Operation (Year 10 to 12)	370	484	601	1397	403	256	228	409	454	455	569	480	507
	Closure (Year 13 to 17)	184	230	269	635	172	71	38	155	212	235	300	241	228
LP-SP-04	Operation (Year 1 to 9)	200	250	294	691	199	101	68	193	245	261	326	257	256
	Operation (Year 10 to 12)	200	249	294	691	199	101	68	193	245	261	326	257	256
	Closure (Year 13 to 17)	188	235	276	649	187	93	64	180	230	245	306	242	240
LP-SP-05	Operation (Year 1 to 9)	2305	2533	2781	4607	2773	2648	2714	3128	3015	2796	2925	2570	2898
	Operation (Year 10 to 12)	42	52	64	145	34	0	0	18	33	51	70	54	47
	Closure (Year 13 to 17)	42	53	64	145	34	0	0	18	33	51	70	536	88

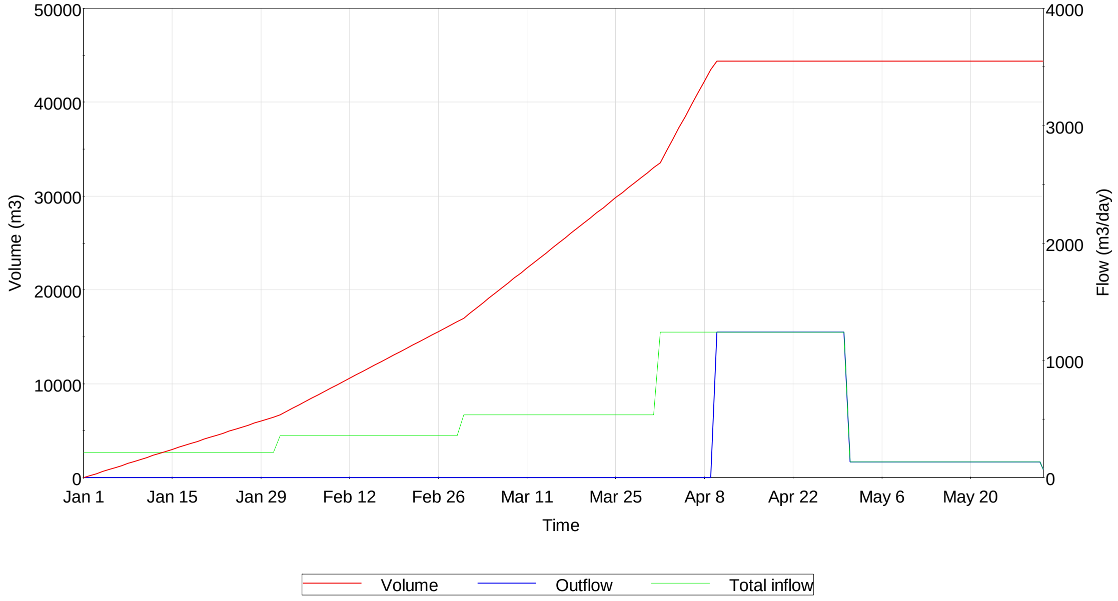

Figure 7-34 Forecasted Volume, Inflow and Outflow of Pond 3A Illustrating Pond Filling within Four Months of Operation

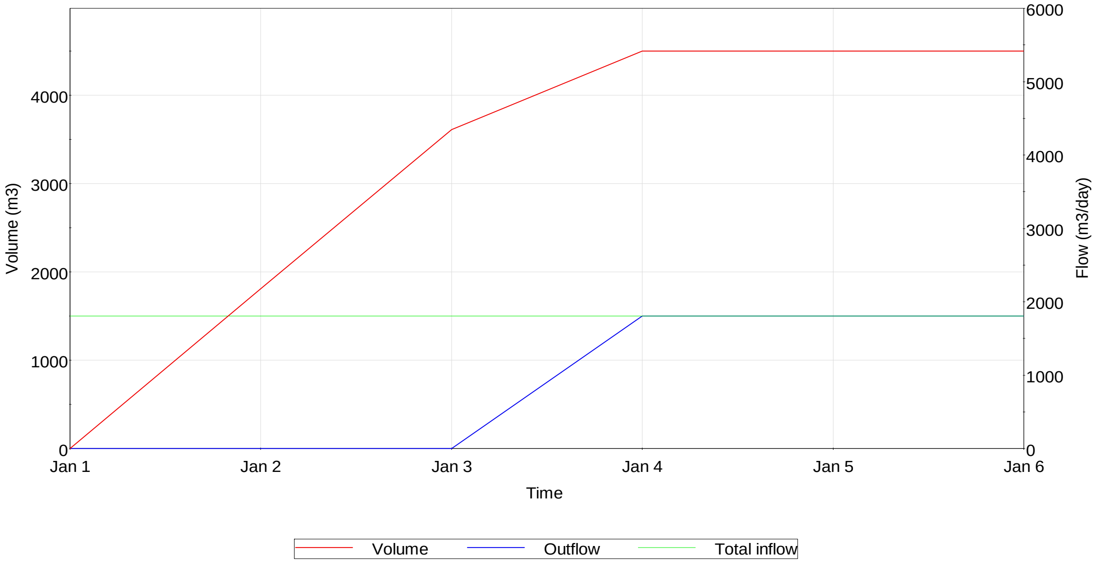

Figure 7-35 Forecasted Volume, Inflow and Outflow of Pond 5 Illustrating Pond Filling within Three Days of Operation

TMF

Figure 7-36 presents the simulated tailings pond volumes for the average climate scenario. Surplus water above the maximum storage volume is shown beginning in Year 14, with surplus water directed to the pit. The figure also shows the flows to the polishing pond, the reclaim water to the plant, the seepage collected flows, and the basal seepage. Based on the result of the preliminary water balance model (Golder 2020), the discharge rate from the water treatment plant will vary from 116 m^3/h to 190 m^3/h under climate normal conditions. The polishing pond balances inflows and outflows, and effluent discharge to FDP-01 follows the flow to the polishing pond.

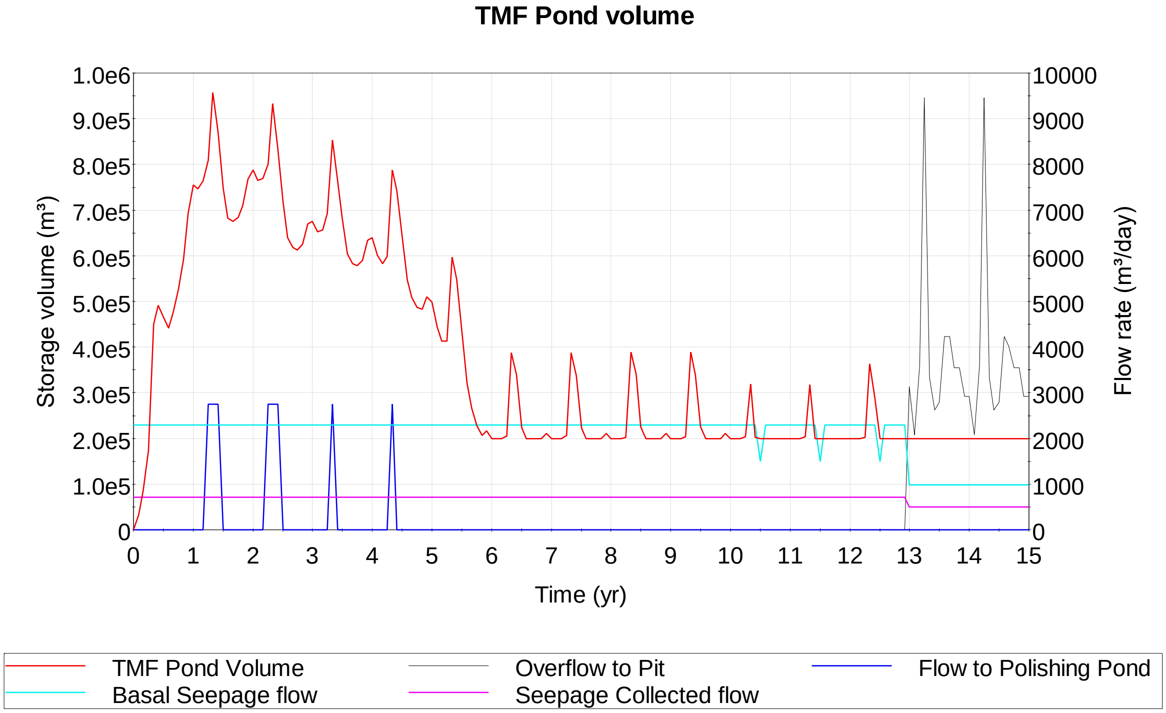

Figure 7-36 Tailings Modelled Pond Storage and Outflows - Average Climate Scenario

Pits

The Marathon and Leprechaun pits will be mined for the first 10 years of the Project. In these years, flow components into the open pits include groundwater seepage, precipitation, surface runoff from natural areas, evaporation, and dewatering. As noted previously, the Leprechaun pit will be operated as a tailings storage facility from Year 10 to the end of Year 12, and both pits will be filled with water to form pit lakes during closure.

The forecasted time to fill the pit lakes naturally with direct precipitation on pit and groundwater inflow is shown on Figure 7-37 for the Marathon pit, and on Figure 7-38 for the Leprechaun pit. Natural filling of the pits is forecasted to require from 34 to 38 (Marathon pit) and 37 to 42 (Leprechaun pit) years without supplementing inflow.

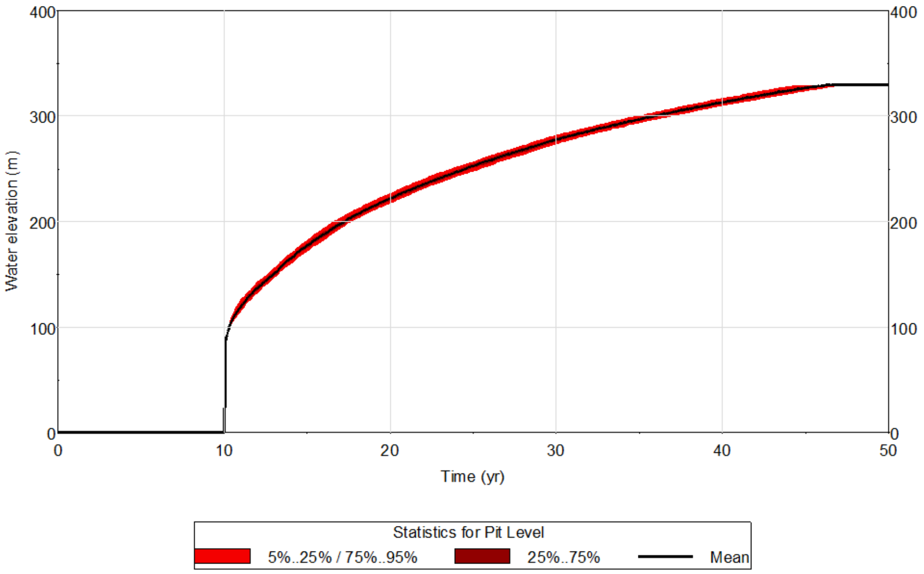

Figure 7-37 Marathon Natural Pit Filling

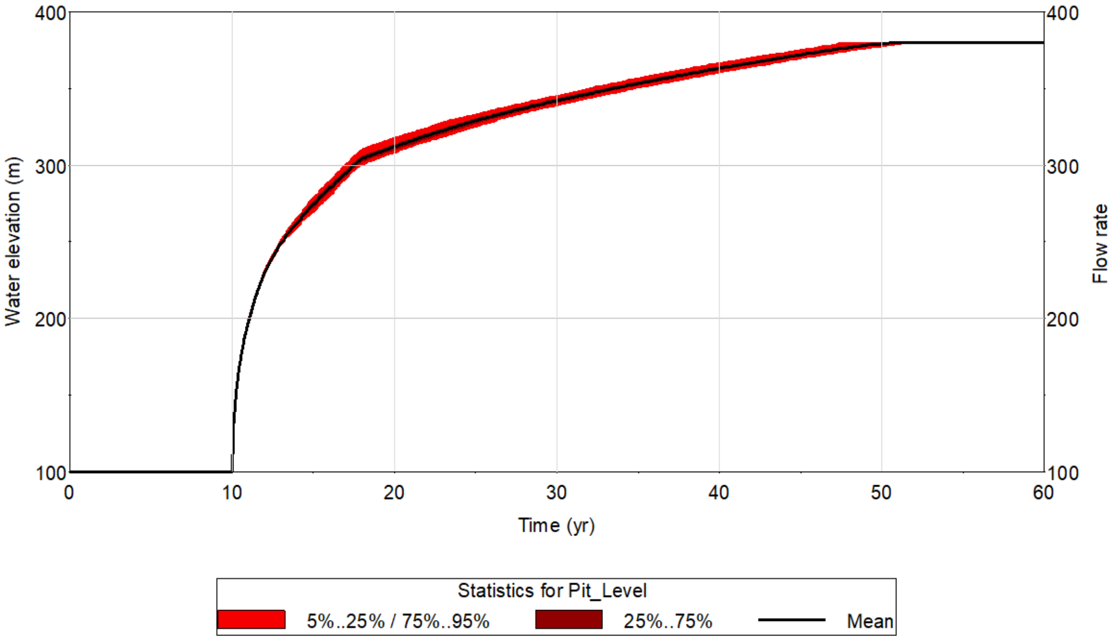

Figure 7-38 Leprechaun Natural Pit Filling

To accelerate pit filling, the perimeter berms installed during operation to keep natural drainage from entering the pits will be removed and these flows will be directed toward the pits. In addition, reclaim water from the tailings pond (as tailings slurry via the processing plant) and freshwater from Victoria Lake Reservoir were simulated to be pumped to the Leprechaun pit during late operation, rehabilitation and closure, and into post-closure. Similarly, freshwater from Valentine Lake was simulated to be pumped to the Marathon pit. The accelerated pit filling times are presented in Figure 7-39 for Marathon pit, and in Figure 7-40 for the Leprechaun pit. To fill the pits over a period of eight years post operation, a flow rate of 5.5 million cubic metres per year (Mm^3/year) or 178 Litres per second (L/s) from Valentine Lake for Marathon pit and a flow volume of 4.0 Mm^3/year from Victoria Lake Reservoir for Leprechaun pit is required. Accelerated pit filling will mitigate potential residual effects in that it will act to improve the water quality of the pit lake, reduce long term liability related to an extended period of natural pit filling, and expedites the submergence of PAG materials possibly exposed on the pit walls.

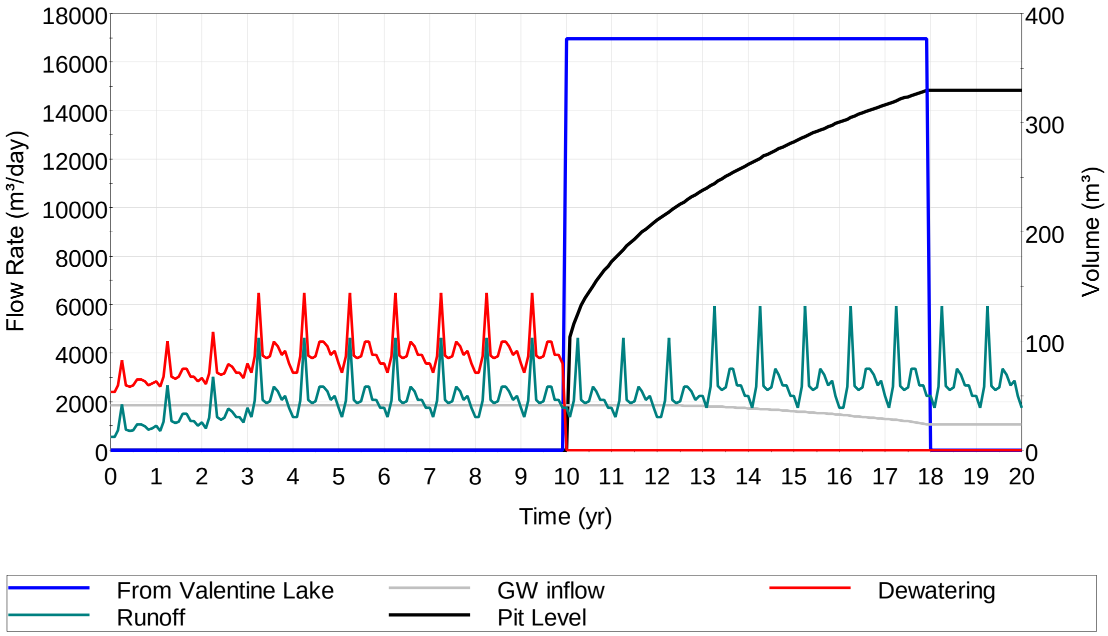

Figure 7-39 Marathon Pit Level, Inflows and Dewatering (Average Scenario)

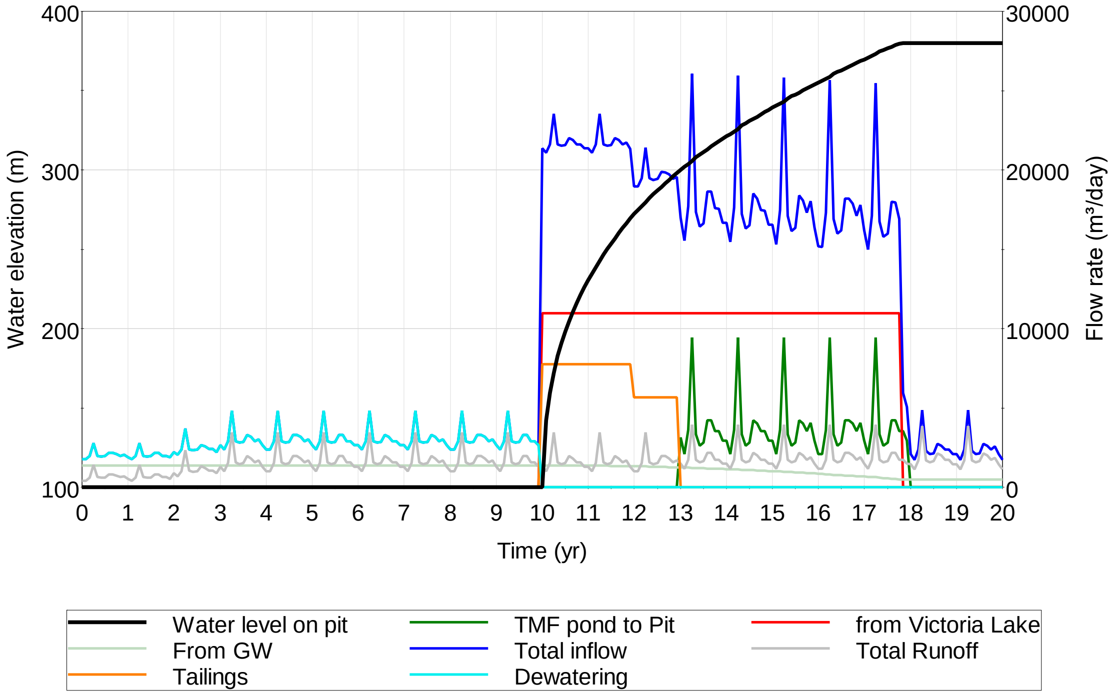

Figure 7-40 Leprechaun Pit Level, Inflows and Dewatering (Average Scenario)

The source of water for the primary process plant is reclaim water from the TMF, supplemented with a freshwater make-up from Victoria Lake Reservoir. When water storage in the TMF is inadequate to supply normal reclaim flow to the process, additional water will be withdrawn from the Victoria Lake Reservoir. A water deficit in the TMF for reclaim was forecasted to occur in some months in Year 10 to the end of Year 12, associated with the start of tailings deposition in the Leprechaun pit, thereby decreasing the water (effluent) inflow to the TMF. Victoria Lake Reservoir will also be used as a water supply to fill Leprechaun pit directly during pit filling. The maximum flow rate from Victoria Lake Reservoir during Years 1 to 10 is predicted to be approximately 34 L/s and from Year 10 to 12, the maximum flow rate under accelerated pit filling is predicted to be 185 L/s.

7.5.1.2 Project Pathways

Construction

During construction, in the absence of mitigation, the Project environmental effects identified in Table 7.29 can alter surface water quantity through changes in runoff, evapotranspiration, infiltration characteristics, changes in watershed areas, and watercourse alteration and realignment. Project activities that could result in a residual effect on water quantity within the LAA during the construction phase include:

- Site preparation and ground disturbance, which includes clearing and grubbing for the process plant, ore stockpiles, overburden stockpiles, waste rock piles, TMF, erosion and sediment control features, drainage infrastructure, site roads, and construction of the process plant and water treatment plant. These activities could change catchment areas, increase runoff and flooding potential, and reduce infiltration and evapotranspiration due to increases in imperviousness and reduction of vegetative cover
- Construction of site access roads and associated construction of new hydraulic structures (e.g., culverts, bridges)
- Temporary dewatering for the installation of foundations for buildings, ore stockpile, waste rock piles, and TMF starter dams, which could potentially alter groundwater discharge to surface water features.
- Construction of watercourse crossings, which have the potential to increase flooding and alter overland flow drainage patterns
- Construction of Project components that overprint some small watercourses and require watercourse diversion / realignment, including:
  - several streams and ponds, which will be overprinted during construction of the mine infrastructure (refer to Section 8.5 [Fish and Fish Habitat VC] for further details)
- Construction of trenches and excavations, which are likely to encounter shallow groundwater levels within the Project Area. This interaction could potentially affect surface water quantity by changing groundwater discharge to surface water features by altering preferential groundwater flows and lowering of groundwater levels as discussed in Chapter 6.0 (Groundwater Resources VC)
- Development of water management infrastructure, which will result in surface drainage changes related to contact water collection in perimeter collection ditches:
  - Flow reductions associated with watersheds that lose area to mine water management infrastructure
  - Increased flows from watersheds that gain area from the establishment of water management infrastructure, or gain flows due to increased imperviousness within its watershed
  - Potential flow reduction arising from water extraction for dust suppression and construction activities

Operation

The operation phase will extend over approximately 12 years. Pit filling will commence in Year 10. Due downstream raise dam construction and successive tailing deposition, the TMF will be rehabilitated during closure. The waste rock piles will be subject to progressive rehabilitation during the operation phase. The incorporation of progressive rehabilitation will serve to reduce the quantity of water requiring management. The activities that could potentially affect surface water quantity, in the absence of mitigation, include the following:

- Development of the waste rock piles and TMF, which will alter runoff, flooding potential, and infiltration and evapotranspiration
- Open pit development and dewatering, which can lower groundwater elevations around the pit perimeter in the groundwater zone of influence. The zone of influence around the pits can lower groundwater discharge to local receivers

- Ongoing water management, which will result in collection and treatment of contact water from waste rock piles, overburden stockpiles, ore stockpiles and the open pit discharge through various FDPs
- Overprinting of several small first-order watercourses by mine infrastructure over the course of their development during operation (refer to Section 8.5 [Fish and Fish Habitat VC] for further details)
- Process plant water demand to be met by internal recycling of contact water from the TMF, which results in less effluent discharge and reduced surface water demand for ore processing
- Water withdrawals from Victoria Lake Reservoir to meet processing needs not met by internal recycling of TMF treated water
- Linear facilities (roads) with accompanied drainage infrastructure (ditches, culverts), which may increase runoff potential due to changes in impervious cover, slope and vegetation management

Decommissioning, Rehabilitation and Closure

In the absence of mitigation, decommissioning, rehabilitation and closure and post-closure activities with the potential to affect surface water quantity are identified below:

- Closure
  - Decommissioning and removal of the process plant, ancillary buildings, and ore stockpiles and pads, which will involve demolition and ground disturbance that will affect surface water runoff, infiltration and evapotranspiration. However, the effect is considered smaller in scale than that during the construction phase as the time required to complete demolition is assumed to be less
  - Final rehabilitation of waste rock piles and other disturbed areas with appropriate cover materials and vegetation to stabilize soils, reduce overland flow and surface erosion, increase evapotranspiration, and reduce infiltration
  - Closure of water management facilities and removal of contact water collection systems that may result in groundwater originating from the waste rock piles, TMF and overburden storage discharging to the natural environment and subsequently affecting surface water quantity. Sedimentation ponds will remain in place during closure and be decommissioned as the mine infrastructure upgradient of them is rehabilitated. Rehabilitation will be completed, to the extent reasonably feasible, to direct surface water runoff towards an area's pre-development watershed
  - Re-establishment of drainage patterns, to the extent reasonably feasible, which could change the contributing areas of the local watersheds and subsequently affect surface water quantity
  - Open pits will be filled with groundwater inflows and direct precipitation, that had been pumped out during operation. In an attempt to accelerate pit filling, some watershed areas upgradient of each pit will also be allowed to naturally flow into the pits and will therefore no longer contribute to the downstream flows. Once the pit lakes reach their discharge elevations, the water levels will be controlled by an outlet channel / spillway, which will connect to the Victoria River (Marathon pit) and Victoria Lake Reservoir (Leprechaun pit)
  - As the open pits fill, groundwater levels will slowly rise and alter groundwater flow directions and discharge locations that had developed during operation, subsequently affecting surface water quantity. Once the pits are filled, water will be discharged to their respective receiving watersheds

  - Reclaim water from the tailings pond will be pumped to the process plant and subsequently to the Leprechaun pit (as tailings slurry) to expedite the filling of the open pit will provide an opportunity for the final rehabilitation efforts to be carried out at the TMF. While the TMF will be covered and vegetated after Year 9 when tailings are directed to the Leprechaun pit, excess water (reclaim) from the tailings pond will be pumped to the process plant while it is still operating, and then bypassing the process plant directly to the Leprechaun pit to support pit flooding. This will permit the removal of the TMF water treatment plant and will eliminate discharge from the TMF to Victoria Lake Reservoir, while the TMF drainage and seepage begins to balance naturally. Once the pit filling is complete, tailings pond drainage will be directed to the pre-development watersheds
  - Rehabilitation of mine infrastructure, including waste rock piles, to re-establish pre-development watershed areas will be completed to the extent feasible. The size and location of the waste rock piles means that there will be some watershed areas that differ from pre-development conditions
- Post-Closure
  - To facilitate monitoring activities at the site post-closure, some road infrastructure will remain and that may affect surface water quantity
  - Both pits will become pit lakes and drain to their pre-development watersheds post-closure. Increasing the proportion of the watershed that is a waterbody may change surface water runoff quantity

7.5.1.3 Residual Effects

Residual Project effects, following the incorporation of mitigation measures described in Section 7.4, are described below. Changes in watershed areas (Figure 7-22) and estimated changes in MAFs through the mine life phases are shown in Table 7.36. Where changes in MAF were projected to be less than 10%, no residual effect is anticipated. Where an increase of over 10% in MAF is predicted, increased flows during high flow events were considered a potential residual effect. Where a decrease of over 10% in MAF is predicted, decreased flows during low flow events (environmental flows) were considered a potential residual effect.

Table 7.36 Summary of Watershed Area, MAF and Environmental Flow Changes through Project Phases

Watershed ID	Watershed Area (km^2)				MAF (m^3/s)				Largest Change in MAF (%) (Phase)[3]	MAF % of Pre-Development Summer Environmental Flow (%)[4]			MAF % of Winter Environmental Flow (%)[4]		
	Baseline	Construction / Operation	Closure	Post-Closure	Baseline	Construction / Operation	Closure	Post-Closure		Construction / Operation	Closure	Post-Closure	Construction / Operation	Closure	Post-Closure
WS1	0.387	0.394	0.394	0.487	0.0096	0.0103	0.0103	0.0121	26 (PCl)	215%	215%	253%	358%	358%	421%
WS2	1.292	1.912	1.912	1.912	0.0327	0.0717	0.0333	0.0488	119 (Op)	438%	203%	298%	730%	339%	497%
WS3	0.361	0.558	0.558	0.558	0.0089	0.0326	0.0000	0.0192	-100 (Cl)	731%	0%	431%	1219%	0%	718%
WS4	0.553	0.514	0.514	0.514	0.0138	0.0128	0.0128	0.0128	-7 (All)	186%	186%	186%	310%	310%	310%
WS5	0.113	0.071	0.071	0.071	0.0027	0.0017	0.0017	0.0017	-38 (All)	124%	124%	124%	206%	206%	206%
WS6	0.980	0.180	0.180	0.180	0.0247	0.0044	0.0044	0.0044	-82 (All)	35%	35%	35%	59%	59%	59%
WS7	0.319	0.743	0.743	0.743	0.0079	0.0227	0.0227	0.0186	189 (Op/Cl)	577%	577%	473%	962%	962%	789%
WS8	1.389	1.225	1.225	1.225	0.0352	0.0331	0.0331	0.0279	-21 (PCl)	188%	188%	158%	313%	313%	264%
WS9	0.588	0.913	0.913	0.913	0.0146	0.0251	0.0251	0.0198	71 (Op/Cl)	343%	343%	271%	571%	571%	451%
WS10	1.938	2.047	2.047	1.938	0.0495	0.0523	0.0523	0.0495	6 (Op/Cl)	211%	211%	200%	352%	352%	333%
WS11	0.307	0.538	0.538	0.307	0.0076	0.0134	0.0134	0.0076	77 (Op/Cl)	354%	354%	200%	590%	590%	333%
WS12	2.246	0.987	0.987	2.246	0.0575	0.0249	0.0249	0.0575	-57 (Op/Cl)	86%	86%	200%	144%	144%	333%
WS13	0.653	0.231	0.231	0.653	0.0163	0.0056	0.0056	0.0163	-65 (Op/Cl)	69%	69%	200%	115%	115%	333%
WS14	1.467	0.613	0.613	1.467	0.0373	0.0153	0.0153	0.0373	-59 (Op/Cl)	82%	82%	200%	137%	137%	333%
WS15	1.411	1.580	1.370	1.580	0.0358	0.0439	0.0386	0.0402	24 (Op/Cl)	245%	215%	224%	409%	359%	374%
WS16	1.146	1.330	1.110	1.330	0.0290	0.0383	0.0328	0.0337	33 (Op/Cl)	264%	226%	233%	441%	377%	388%
WS17	0.617	0.370	0.370	0.840	0.0154	0.0114	0.0114	0.0211	-24 (PCl)	149%	149%	274%	248%	248%	456%
WS18	2.140	2.150	1.155	2.147	0.0548	0.0833	0.0324	0.0550	-41 (Cl)	304%	118%	201%	507%	197%	335%
WS19	0.271	0.212	0.212	0.212	0.0066	0.0051	0.0051	0.0051	-22 (All)	154%	154%	154%	257%	257%	2657%
WS20	0.708	0.630	0.630	0.630	0.0177	0.0178	0.0178	0.0157	-14 (PCl)	201%	201%	178%	336%	336%	296%
WS21	1.813	1.847	1.847	1.847	0.0462	0.0486	0.0486	0.0472	5 (Op/Cl)	210%	210%	204%	350%	350%	340%
WS22	0.813	1.150	1.15	1.150	0.0204	0.0306	0.0306	0.0291	51 (Op/Cl)	300%	300%	285%	499%	499%	475%
WS23	-	2.304	2.304	2.304	-	0.0697	0.0697	-	-	-	-	-	-	-	-

Notes:
1. Largest changes in mean annual flows (MAF) compared to the baseline conditions and the Project phase that this change will be experienced in.
2. Changes in % of the MAF refer to the conservative scenarios (refers to the Project phase which could result in the greatest change of effective contributing watershed area, effluent discharge, freshwater taking and/or changes in groundwater discharge/seepage.)
3. Op = Operation, Cl = Closure, PCl = Post-closure, All = all phases
4. Summer Environmental Flow (50% MAF) and Winter Environmental Flow (30% MAF) were used in this assessment

Construction and Operation

Details of predicted surface water quantity changes anticipated during the construction and operation phases from pre-development conditions are presented in Table 7.36 and discussed below. Residual effects for construction and operation were considered together as changes to water quantity are anticipated to be minimal through construction activities and the largest changes captured during the operation phase.

- WS-1, WS-4, WS-8, WS-10, WS-20, and WS-21 are expected to receive MAF within 10% of the pre-development MAF. No residual effect for water quantity is expected
- WS-2, WS-3, WS-7, WS-9, WS-11, WS-15, WS-16, WS-18, and WS-22 will receive an increase in MAF of greater than 10%. Water management infrastructure, further detailed in the Water Management Plan (Appendix 2A), will attenuate flows using berms, ditching and sedimentation ponds. Berms will be used to divert non-contact water from entering the water management infrastructure and to keep it in its pre-development watershed. Ditches will collect and convey contact water to sedimentation ponds. These ponds will attenuate peak runoff rates and allow water to be released over time to extend the period of baseflow augmentation released to the downstream watersheds. To the extent possible, water management infrastructure will keep surface water within the pre-development watershed. The mitigation measures applied through the Water Management Plan are anticipated to result in no residual effects downstream
- WS-5, WS-6, WS-12, WS-13, WS-14, WS-17, and WS-19 will receive a decrease in MAF of greater than 10%. The following provides a more detailed assessment of predicted flow reductions in respective watersheds:
  - WS-5 is a headwater watershed draining north towards Valentine Lake. Due to the conservative approach taken in this assessment of selecting the most upstream point on a watershed required to capture the upstream mine footprint (Section 7.5.1.3), the pre-disturbance watershed is relatively small (0.113 km^2) and taking even a small area out of this watershed results in a substantial change in expected flows. A reduction in MAF of 38% is projected. The revised MAF is projected to be 24% and 106% greater than the pre-development summer and winter environmental flows, respectively. WS-5 was selected at the inlet of a headwater pond (VALP1) and as an additional check, change in MAF from pre-development to construction and operation phases was also determined for the outlet of this pond. This assessment shows a smaller expected change in MAF of 12% at the outlet of VALP1. Thus, while the subsequent assessment confirmed that MAF would change by >10%, baseline environmental flows are expected to be maintained
  - WS-6 has much of its pre-disturbance watershed overlaid by the footprint of the waste rock pile. Water draining from the waste rock pile and its perimeter ditches is directed to a sedimentation pond located in an adjacent watershed (WS-2), and WS-6 therefore will lose a large portion of its flow. A reduction of 82% in MAF is projected. The revised MAF is projected to be 65% and 41% less than the baseline summer and winter environmental flows, respectively. The flow lost from WS-6 joins a larger watershed approximately 250 m downstream at the confluence of the WS-6 and WS-2 watersheds (Tributary ids 15 and 16). However, baseline environmental flows will not be maintained for the 250 m reach between WS-6 and WS-2

  - WS-12, WS-13 and WS-14 are predicted to receive a decrease in MAF of greater than 10%. Each of these watersheds have much of their pre-disturbance watershed overlaid by the footprint of the TMF. Excess water from the TMF (WS-23) will be directed to Victoria Lake Reservoir via a treatment plant, polishing pond and pipeline. A reduction in MAF of 57%, 65% and 59% is projected for these three watersheds, respectively. The WS-12 MAF is projected to be 14% less than pre-development summer environmental flows and 44% greater than pre-development winter environmental flows. The WS-13 MAF is projected to be 31% less than pre-development summer environmental flows and 15% greater than pre-development winter environmental flows The WS-14 MAF is projected to be 18% less than pre-development summer environmental flows and 37% greater than pre-development winter environmental flows
  - WS-17 is predicted to receive a decrease in MAF of 24% from pre-development conditions. WS-17 is inset within WS-16 which is delineated from a point about 750 m downstream of the outlet of WS-17. An increase of 33% in MAF is anticipated at WS-16 so the length of reach expected to receive a decrease in MAF is limited to the 750 m zone between these two WS points. The revised MAF is projected to be 51% and 152% greater than the pre-development summer and winter environmental flows, respectively
  - WS-19 is predicted to receive a decrease in MAF of 22% from pre-development conditions. This is a comparatively small watershed and the MAF is projected to be 56% and 160% greater than the pre-development summer and winter environmental flows, respectively
- WS-23 is a new watershed generated during the construction and operation phase. It is comprised of the TMF and polishing pond infrastructure, and would naturally drain towards the Victoria River through the pre-development watersheds WS-12, WS-13, and WS-14. During the construction and operation phases, flow from this watershed will be captured, treated and discharged via a pipeline to Victoria Lake Reservoir. Changes from pre-development flows in WS-12, WS-13 and WS-14 are described above
- Expected MAFs for the construction and operation phases were calculated for the LAA watersheds of Victoria Lake Reservoir, Victoria River and Valentine Lake. Victoria Lake Reservoir inflows will increase negligibly by <1%. The Victoria River at the LAA boundary will experience a 1% decrease in MAF, and Valentine Lake is not expected to experience a change in MAF. The increase in expected MAF to Victoria Lake Reservoir is driven primarily by the TMF area being discharged to Victoria Lake Reservoir, whereas the area of the TMF would have naturally drained to the Victoria River. The small decrease in MAF is expected in the Victoria River at the LAA boundary, due to its large size relative to changes attributed to the Project. Thus, at the LAA boundary, no substantial residual surface water quantity effects are anticipated
- There is potential for the drawdown cone of depression of the groundwater table created from pit dewatering to interact with adjacent watercourses. However, based on results of the groundwater flow model (further discussed in Chapter 6) the degree of interaction is expected to be negligible, as the decreases to streamflow are balanced by inflows from FDPs. Monitoring will be completed throughout the Project phases to identify effects to surface water from pit dewatering and to inform any required mitigation
- Upgrades and replacement of watercourse crossings along the site access road within the LAA will be completed as needed and will be further assessed during detailed design. Crossing upgrades and replacements will be done in a manner to ensure the same size crossing or larger is used, fish

passage is maintained (if present), flooding and ice jams are minimized, and channel slopes are maintained. A total of 67 crossings have been identified along the access road between the Exploits River and the Project Area and these crossings are shown on Figure 7-41 below and further discussed in the Project Description (Chapter 2) and the Fish and Fish Habitat VC (Chapter 8)

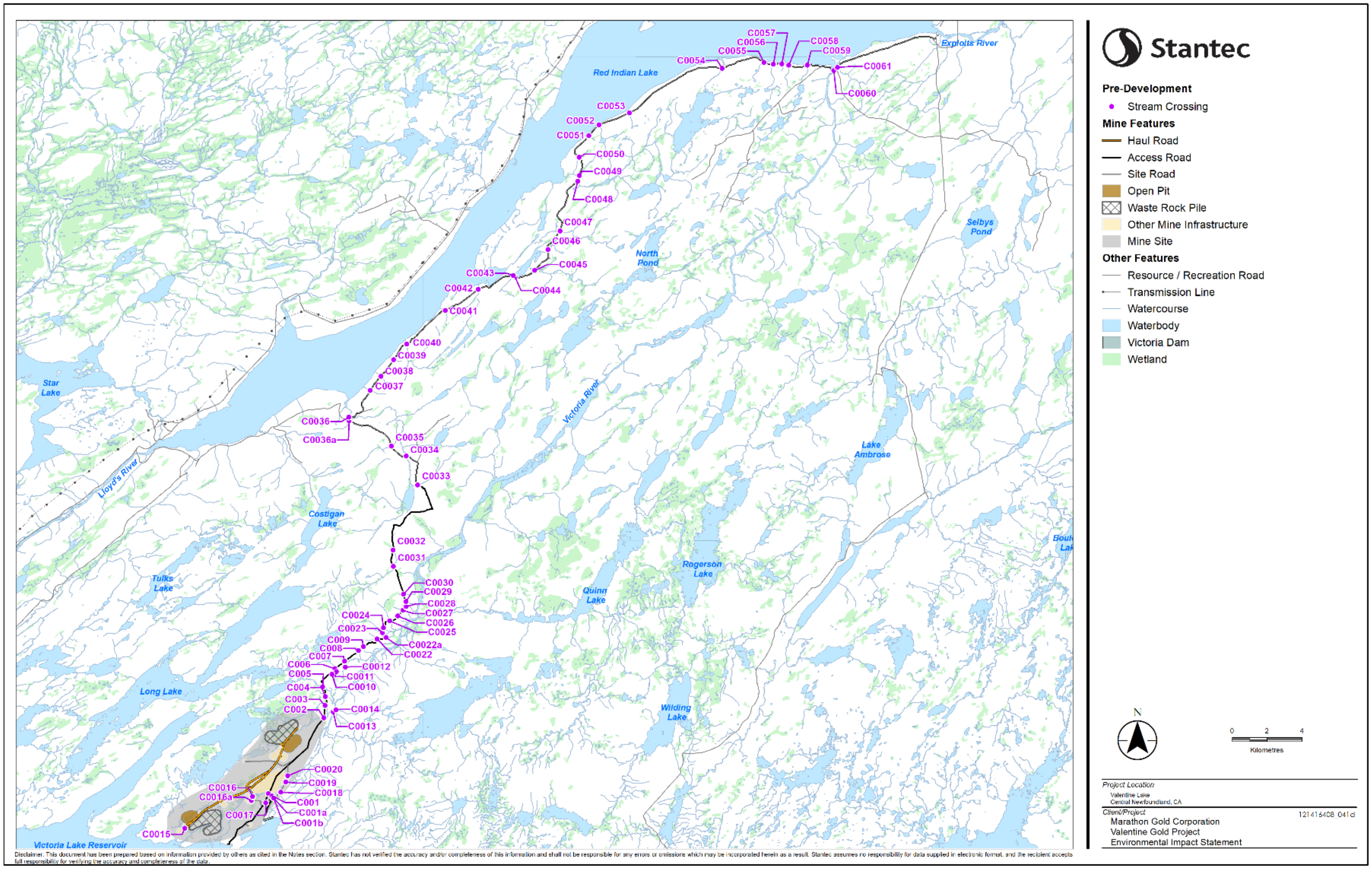

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Figure 7-41 Stream Crossing Locations Along Site Access Road

Decommissioning, Rehabilitation and Closure

At the end of the operation phase, the main features requiring rehabilitation will include the open pits, water management infrastructure, waste rock piles, TMF, site roads, buildings, and associated infrastructure. Details of surface water quantity changes anticipated during closure from pre-development conditions are presented in Table 7.36 and are discussed below. Anticipated changes in closure and post-closure are discussed in the following sub-sections:

Closure

- WS-1, WS-2, WS-4, WS-8, WS-10, WS-15, WS-20, and WS-21 are expected to receive MAF within 10% of the pre-development MAF. No residual effect for water quantity is expected
- WS-7, WS-9, WS-11, WS-16, and WS-22 are expected to receive an increase in MAF of greater than 10%. Water management infrastructure, further detailed in the Water Management Plan (Appendix 2A), will attenuate flows using berms, ditching and sedimentation ponds. As portions of the mine infrastructure are rehabilitated, the corresponding downstream water management infrastructure will also be rehabilitated and removed. Water management infrastructure will be removed as upstream areas are rehabilitated and revegetated and as discharge water quality meets applicable limits. Observed discharge and seepage water quality will dictate if any water management infrastructure is required to remain in place at the end of the closure phase (i.e., passive treatment ditches, constructed wetlands)
- WS-3, WS-5, WS-6, WS-12, WS-13, WS-14, WS-17, WS-18, and WS-19 are expected to experience a decrease in MAF of greater than 10%
  - WS-3 is not expected to have flows leaving the watershed during the closure phase due to the flooding of the Leprechaun pit. The berm along the pit’s southwestern rim will be removed to allow surface water runoff from the upstream area to flow into the pit. This will expedite the pit filling time by adding to the groundwater inflow and pumped water from the TMF, thereby contributing to pit filling
  - WS-5, WS-6, WS-12, WS-13, WS-14, WS-17 and WS-19 are expected to experience the same change in surface water quantity as described for the construction and operation mine phases. These changes will continue until upstream mine components are rehabilitated and water management infrastructure is removed, at which point post closure conditions will be returned.
  - WS-18 is expected to experience a decrease in MAF of 41% compared with pre-development conditions. This reduction is a result of allowing the Marathon pit to fill by ceasing dewatering operation, and by removing the berm along its SE extent to allow surface water runoff to flow into the pit. These measures will help expedite the time required to fill the pit. Once the pit is full (post-closure), it will begin to discharge towards its pre-development watershed again. As the reduction in MAF was greater than 10%, it was also compared with pre-development environmental flows. The MAF is projected to be 18% and 98% greater than the pre-development summer and winter environmental flows, respectively
- WS-23 is a new watershed generated during the construction and operation phase. It comprises the TMF and polishing pond infrastructure and would naturally drain towards the Victoria River through the pre-development watersheds WS-12, WS-13 and WS-14. Runoff from the TMF cover is expected

to be clean and will be directed to the polishing pond. Seepage collected at the toe of the TMF dam will be collected and pumped back to the tailings pond for treatment through the closure phase. Pumping will end at the end of the closure phase and observed seepage water quality will dictate if the seepage collection ditches are removed or converted to passive treatment (i.e., constructed wetland). Clean runoff and treated seepage will drain through pre-disturbance watersheds towards the Victoria River

- To expedite the time required to fill the Leprechaun and Marathon pits, water is proposed to be withdrawn from Victoria Lake Reservoir and Valentine Lake, respectively. Active mining from both the Leprechaun and Marathon pits will cease in Year 9 of operation. Starting in Year 10, pits were modelled to begin filling with water. However, natural filling of the Leprechaun and Marathon pits via meteoric and hydrogeological sources would take from 34 to 38 (Marathon pit) and 37 to 42 (Leprechaun pit) years to fill. To accelerate pit filling and reduce TMF volume requirements, tailings and tailings effluent generated from processing in Years 10 through 12 will be piped to the Leprechaun pit. Additionally, it is proposed to withdraw water from Victoria Lake Reservoir (0.178 m^3/s) and from Valentine Lake (0.145 m^3/s) over an eight-year period to aid in flooding the open pits. For Victoria Lake Reservoir, this corresponds to 0.5% of the Low Supply Level outlet flow and 0.1% of the High Supply Level outlet flow. For Valentine Lake, the proposed pumping rate corresponds to 21% of expected MAF. As the reduction in MAF was greater than 10%, it was also compared with pre-development environmental flows. The closure MAF is projected to be 59% and 164% greater than the pre-development summer and winter environmental flows, respectively. Accelerated pit filling will mitigate potential residual effects in that it will act to improve the water quality of the pit lake, reduce long-term liability related to an extended period of natural pit filling, and expedites the submergence of PAG materials possibly exposed on the pit walls

<u>Post-Closure</u>

At the end of the closure activities, the Project Area will enter post-closure. The start of this period will be marked by the completion of rehabilitation activities, and it will be characterized by the site being returned to as close to pre-development conditions as is feasible. Details of surface water quantity changes anticipated during the post-closure phase from pre-development conditions are presented in Table 7.36 and are discussed below:

- WS-4, WS-10, WS-11, WS-12, WS-13, WS-14, WS-18, and WS-21 are expected to receive MAF within 10% of the pre-development MAF and therefore no residual effects for water quantity are expected
- WS-1, WS-2, WS-3, WS-7, WS-9, WS-15, WS-16, WS-17, and WS-22 are expected to receive an increase in MAF of greater than 10%
- WS-5, WS-6, WS-8, WS-19, and WS-20 are expected receive a decrease in MAF of greater than 10%
  - WS-5, WS-6 and WS-19 are expected to experience the same change in surface water quantity from baseline conditions as experienced in the construction and operation mine phases. A reduction in MAF of 38% is projected
  - WS-8 is expected to experience a decrease in MAF compared with pre-development conditions of 21%. This is a result of the alteration in watershed areas created by the waste rock pile. As the

  - reduction in MAF was greater than 10%, it was also compared with pre-development environmental flows. The MAF is projected to be 58% and 164% greater than the pre-development summer and winter environmental flows, respectively
  - WS-20 is expected to experience a decrease in MAF of 14% compared with pre-development conditions. This is a result of the alteration in watershed areas created by the waste rock pile. As the reduction in MAF was greater than 10%, it was also compared with pre-development environmental flows. The MAF is projected to be 72% and 187% greater than the pre-development summer and winter environmental flows, respectively
- The TMF area, WS-23, will continue to drain to the tailings pond, however, the pond size will be significantly reduced. Water from this pond will continue to be pumped to the Leprechaun pit to supplement pit filling. The seepage collection ditches will be removed or converted to passive treatment in post-closure depending on the observed seepage water quality. WS-23 will no longer exist in post-closure as the TMF area will have been rehabilitated and surface water runoff from this area directed back to the pre-development watersheds of WS-12, WS-13 and WS-14

7.5.1.4 Summary of Residual Effects on Change in Surface Water Quantity

Surface water quantity changes assessed at the boundary of the LAA for the Victoria River, Valentine Lake and Victoria Lake Reservoir are predicted to be below 10% MAF.

During the construction and operation phases, it is expected that 15 WSs will maintain a MAF within 10% of, or above, pre-development conditions. Of the 7 WSs that experience a decrease in MAF of over 10%, environmental flows are expected to be maintained in all except four WSs (WS6, WS12, WS13, WS14).

During the closure phase, it is expected that 13 WSs will maintain a MAF within 10% of, or above, pre-development conditions. Of the 9 WSs that experience a decrease in MAF of over 10%, environmental flows are expected to be maintained in all except five (WS3, WS6, WS12, WS13, WS14).

During the post-closure phase, it is expected that 17 WSs will maintain a MAF within 10% of, or above, pre-development conditions. Of the 5 WSs that experience a decrease in MAF of over 10%, environmental flows are expected to be maintained in all except one (WS6) for which the reduction in flow will be permanent.

With the implementation of mitigation measures, the residual effect on surface water quantity is anticipated to be adverse, with the Project predicted to cause a reduction in surface water quantity at several watercourses downstream of mine infrastructure and within the LAA during all phases of mine life. Other watercourses will receive an increase in flow that may provide a positive change.

The predicted magnitude of residual adverse effects is low. Predicted changes in water quantity at the LAA boundary during construction, operation and post-closure phases are considered to be within the range of natural variability. The change in surface water quantity is predicted to extend to the boundaries of the LAA and be continuous and long term in duration. The natural seasonal variations including precipitation, surface runoff and groundwater flows could affect the surface water quantity within LAA. However, these variations would not be considered a Project-related effect. Changes to some watersheds within the LAA will be realized post-closure, therefore these are considered long term effects. Effects on water quantity for most of the watercourses / waterbodies assessed are considered reversible as conditions will return to predevelopment flow patterns for the majority of the site in post-closure. Effects on water quantity for watercourses overprinted by the Project components, such as the open pits, are considered irreversible. The ecological context is disturbed, with the ecological function considered typical compared to other lake systems in the region and pre-development conditions.

7.5.2 Change in Surface Water Quality

7.5.2.1 Water Quantity and Quality Model Results

Sources of Potential Contaminants

An assessment of ARD/ML to determine the absence / presence of PAG has been completed and is presented in BSA.5, Attachment 5-B. A summary of the ARD/ML assessment for the Leprechaun, Marathon, and Process Plant and TMF complexes is provided below with more detailed discussion provided in the Assessment Report (Attachment 5-B). Investigations of ML/ARD will continue, and will include field kinetic and laboratory kinetic testing, and additional sampling to develop an ARD block model.

Leprechaun Complex

Approximately 1.9 Mm^3 of overburden will be excavated from the Leprechaun open pit. Overburden is classified as non-PAG material with moderate leaching potential for aluminum, iron, lead, and zinc, and no exceedances of the MDMER limits (Schedule 4, Table 1).

Less than 0.5% of the approximately 50 Mm^3 of Leprechaun waste rock is classified as PAG. Overall, the waste rock pile is not expected to generate ARD due to the small amount of PAG material and significant excess of NP. Therefore, specific ARD management of waste rock is not required.

There are no exceedances of MDMER limits observed in humidity cell leachates. The waste rock pile will be covered during rehabilitation reducing the already low risk of ARD/ML. Waste rock lithologies show moderate ML potential for aluminum, phosphorus, copper, selenium, and zinc.

About 10% of low-grade ore is estimated to be PAG, however, overall is not expected to generate ARD. Kinetic testing suggests moderate leaching potential for Al and P. There are no exceedances of MDMER limits observed in these tests.

Marathon Complex

Approximately 4.4 Mm^3 of overburden will be generated from the Marathon open pit. Overburden is classified as non-PAG material, with moderate leaching potential for fluoride, aluminum, arsenic, cadmium, copper, iron, manganese, lead, selenium, and zinc based on SFE extracts. There are no exceedances of MDMER limits observed in leachates from overburden. Most of the stockpiled overburden will be used during rehabilitation.

Approximately 14% of the 60 Mm^3 of waste rock is conservatively estimated to be PAG. Blending PAG and non-PAG rock with excess of neutralization potential and/or encapsulation of PAG waste by non-PAG rock will be completed to neutralize acidity potentially generated in PAG pockets (i.e., zones of PAG rock). With application of these measures, the acidic pore water generated in pockets of PAG rock will be neutralized within the waste rock pile as the ARD migrates and interacts with the non-PAG rock that has an excess of NP and constitutes the majority of waste rock. Therefore, the final drainage from waste rock is not expected to be acidic. There are no exceedances of MDMER limits observed in leachates from the waste rock humidity cells. Overall, waste rock lithologies show moderate ML potential for aluminum, mercury, selenium, and zinc.

Approximately one-half of the low-grade ore is conservatively classified as PAG. The ARD onset time in PAG pockets of low-grade ore is approximately six years based on maximum laboratory leaching rates. The Marathon low-grade ore stockpile effluent has been segregated from other mine component flow streams in the overall mine design to facilitate collection and further ARD treatment, if required. There are no exceedances of MDMER limits observed in leachates from low-grade ore under neutral conditions. Based on kinetic testing, aluminum, phosphorus and zinc have moderate leaching potential.

Process Plant and TMF Complex

High-grade ore from the Leprechaun and Marathon deposits will be stockpiled together with 30% of the material originating from Leprechaun and the remainder from Marathon, on average. Approximately 13% and 67% of ore samples from Leprechaun and Marathon pits, respectively are conservatively classified as PAG. The overall mixture of Leprechaun and Marathon high-grade ores is non-PAG and the high-grade ore stockpile is not expected to generate ARD. Drainage from the high-grade ore stockpile flows to the TMF by gravity and any potential acidity will be neutralized in the decant pond or in the mill during pH adjustment required as a part of the gold recovery by cyanide process. No exceedances of MDMER are observed in SFE extracts. Moderate Al leaching was assigned for both Leprechaun and Marathon high-grade ores.

Approximately 41 megatonnes of tailings will be produced from both high-grade ore and low-grade ore with about 38% of the material originating from the Leprechaun pit and the remainder from the Marathon pit.

Composite samples of tailings from both deposits are classified as non-PAG and are not expected to generate ARD. During operation, tailings pond and pore water will likely exceed the MDMER limits for Cyanide (total), un-ionized ammonia, and Copper sourced from process water. In addition, high leaching potential is also determined for total ammonia (ammonia + ammonium), Cyanide $_{WAD}$ (surrogate for cyanide free), fluoride, mercury, phosphorus, and iron. After closure, covered tailings beaches are not expected to produce acidic runoff and/or have high or moderate leaching except for phosphorus. Seepage from the TMF is conservatively predicted to exceed MDMER limits for $CN_{(T)}$, un-ionized ammonia, and copper in post-closure.

Water Quality Management

Water quality management for the Project involves water quality treatment of surface runoff in contact with Project facilities and groundwater seepage. The water quality treatment process for excess TMF water includes the process plant cyanide destruction circuit, tailings pond, water treatment plant and polishing pond. This treatment process is designed to provide a final effluent that complies with MDMER and is summarized below. Water quality treatment for contact water from Project facilities outside of the TMF is also required and summarized below:

- Cyanide destruction circuit in the process plant, designed to reduce cyanide levels to below MDMER limits, prior to discharging to the TMF
- Sedimentation of suspended solids in the tailings slurry discharge and supplemental natural cyanide degradation in the TMF, with seasonal discharge to a process water treatment plant
- Copper and ammonia removal and pH adjustment in the water treatment plant situated downstream of the TMF
- Peak effluent flow equalization and sedimentation in the polishing pond to further reduce the concentrations of contaminants to below the MDMER limits, via further precipitation of copper and cyanide-metal solids and degradation of ammonia and cyanide
- Sedimentation in ponds to reduce TSS concentrations and the particulate fraction of metals of runoff collected from waste rock piles
- Additional erosion and scour protection (e.g., sediment berms, rip-rap lining of ditches, energy dissipation pools) installed in the collection ditches and downstream conveyance channel to further reduce TSS concentrations in the effluent

Water Quality Predictions

The mean and 95th percentile surface water quality statistics at the FDPs were predicted during the Project construction, operation, and decommissioning, rehabilitation and closure phases, and are summarized as follows:

- Water quality parameters (both monthly mean and 95th percentiles) are expected to comply with MDMER discharge limits at all discharge points during all mine phases
- CWQG-FAL is predicted to be exceeded for parameters such as aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, phosphorus, selenium, silver, uranium, zinc, nitrite, nitrogen ammonia, nitrogen unionized ammonia, fluoride and nitrate at some sediment ponds
- TMF discharge will be treated in a water treatment plant and discharged to the polishing pond. The tailings pond is predicted to have concentrations of unionized ammonia, total cyanide and copper above MDMER limits, but will be processed in the water treatment plant to comply with MDMER limits prior to discharge to the polishing pond. Cyanide degradation and sedimentation will occur in the polishing pond, further reducing their concentrations

- The effluent from the polishing pond is predicted to exceed CWQG-FAL for some POPCs and is further discussed in Section 7.5.2.3. Seepage quality during post-closure is predicted to have similar parameters that exceed CWQG-FAL. Once rehabilitation and closure activities have been completed and the water treatment plant ceases operation, there will no longer be surface water effluent in contact with the TMF facilities

The pit lakes are predicted to meet MDMER limits prior to filling and discharging to the environment. The water quality of the discharge during post-closure and monitoring may result in several POPC exceedances for the Marathon and Leprechaun pits. Similar to the predicted source terms for the waste rock piles, there is a potential for zinc concentrations to increase over time to a solubility cap. Predicted effluent / discharge water quality are further described in the Marathon and Leprechaun Water Quantity and Quality Modelling Reports (Appendix 7A and 7B).

7.5.2.2 Project Pathways

Construction

During construction, in the absence of mitigation, the project activities identified in Table 7.30 have the potential to affect surface water quality through the following pathways:

- Erosion and Sedimentation
  - Site preparation and ground disturbance, which includes clearing and grubbing for the process plant, ore stockpiles, overburden stockpiles, waste rock piles, TMF, erosion and sedimentation control features, water management facilities for contact water including collection ditches and ponds, site roads, and the TMF water treatment plant can increase runoff, which can convey sediment (as TSS) to receiving waters
- Contact Water
  - During construction, ground disturbance will expose loose soil and rock to precipitation and runoff that will be discharged to temporary ditching and ponds and ultimately to the receiving environment, Victoria Lake Reservoir (Leprechaun pit) and Valentine Lake (Marathon pit).
  - Blasting activities will expose rock and could affect water quality due to blasting residuals and ARD/ML potential

Operation

During operation, in the absence of mitigation, the physical works identified in Table 7.30 have the potential to affect surface water quality through the following pathways:

- Erosion and Sedimentation
  - Waste rock and ore handling, which increase TSS loading from disturbed and un-stabilized ground surfaces and active work zones
  - Progressive rehabilitation of waste rock piles, the TMF and other disturbed areas with installation of a soil cover and vegetation, to reduce surface erosion; however, during the installation and vegetation stabilization period there is a potential for increased erosion

- Contact Water
  - Surface water and inflows within the open pits that may be affected by geochemical reactions (ARD/ML) with the open pit walls and rubble on benches. Water within the pits will be pumped to sedimentation ponds and then to local surface water receivers and could affect surface water quality
  - Groundwater originating from the ore stockpiles and waste rock piles that is not captured by the contact water management infrastructure could discharge to surface water receptors
  - Use of explosives for the open pits, resulting in residual nitrogen (nitrate, nitrite and ammonia) from incomplete combustion of explosives materials in the waste rock piles and TMF, and therefore in contact water from the waste rock piles and TMF effluent
  - Sodium cyanide used in the mill to leach gold from the ore has the potential to persist to the tailings stream and ultimately to the TMF
  - The TMF will contain both tailings and process water used to create a pumpable tailings slurry The area submerged within the tailings impoundment has the potential to result in the conversion of mercury in organic soils to methyl mercury (MeHg)
  - Lowering of groundwater levels due to dewatering of the open pits will result in a change in groundwater quality by introducing unsaturated zones in the groundwater depression. Groundwater from beneath waste rock piles will be redirected to the open pit where it will be collected during dewatering and treated prior to discharge. This results in a reduction in loading from groundwater to some local surface water features and an increase to others, and therefore a potential change in surface water quality (such as temperature) for watercourses receiving a change in groundwater flow
  - Discharge of treated effluent from the TMF to Victoria Lake Reservoir

Decommissioning, Rehabilitation and Closure

During closure and post-closure, in the absence of mitigation, the Project activities identified in Table 7.30 have the potential to affect surface water quality through the following pathways:

- Erosion and Sedimentation
  - Closure
    - Removal of Project infrastructure and buildings could generate increases in suspended sediment in runoff
    - Rehabilitation of waste rock piles, the TMF, and other disturbed areas with a soil cover and vegetation to reduce surface erosion may increase erosion prior to vegetation growth
  - Post-Closure
    - Maintenance and use of site access roads to reach monitoring locations may cause erosion into adjacent watercourses

- Contact Water
  - Closure
    - The open pits will be filled naturally from incidental precipitation and groundwater inflows, as well as accelerated by directing runoff from upgradient portions of their watersheds, pumping from the TMF (Leprechaun pit), and pumping from Valentine Lake (Marathon pit) and Victoria Lake Reservoir (Leprechaun pit). The pit lakes will be filled to allow development of stratified pit lakes and eventual discharge to the Victoria River and Victoria Lake Reservoir
    - The amount of contact water seepage emanating from Project infrastructure will be reduced as the open pits are filled and groundwater flow directions return to conditions similar to baseline. Additionally, waste rock piles will be capped with soil covers and the amount of precipitation able to infiltrate and become contact water seepage will be reduced
  - Post-Closure
    - Seepage from the TMF, filled pits and waste rock piles will enter surface watercourses and bodies
    - When mine infrastructure is decommissioned, the water management infrastructure downstream of it will be decommissioned once water quality is determined to comply with MDMER and other appropriate water quality standards required for direct discharge. This will allow drainage patterns to return to baseline conditions to the extent possible. Some watersheds will not return to baseline conditions as a result of permanent mine infrastructure landscape alterations (i.e., waste rock piles)

7.5.2.3 Residual Effects

Construction and Operation

Residual project effects on surface water quality during construction and operation, and after mitigation measures are applied, are described below. Residual effects for construction and operation were considered together as changes to water quality are anticipated to be minimal through construction activities and the largest changes captured during the operation phase.

Erosion and Sedimentation

- Erosion and sedimentation have the potential to alter surface water quality from the initiation of earthworks related to site preparation during construction through to the end of operation. The Water Management Plan (Appendix 2A) provides details on the planned use of sedimentation ponds to receive and treat contact water prior to discharging to FDPs. Details of the sediment treatment capacity of these ponds are provided in Table 7.33
- Project infrastructure and ground disturbance activities will take place upstream of a sedimentation pond which will allow treatment before discharge to the receiving environment
- Sedimentation ponds will be constructed early and progressively as upstream mine infrastructure is constructed and will be initiated so they are functioning during construction activities to the extent possible

- Ponds are designed with adequate residence time to treat the expected TSS load resulting from a 1:10 AEP, attenuate flows from a 1:100-year storm event, and to safely pass flows resulting from a 1:200 year storm event. Details regarding proposed pond sizes and expected TSS treatment potential are provided in the Water Management Plan (Appendix 2A)
- As construction activities are completed and mine infrastructure moves into operation, the amount of sediment accumulation in sedimentation ponds will be monitored. Ponds with significant accumulation will be cleaned out prior to operation. Ponds will also be inspected throughout operation for sediment accumulation and cleaned out, as necessary
- Non-contact water will be diverted from mine infrastructure to reduce the load entering sedimentation ponds
- In addition to the large-scale erosion and sedimentation reduction measures outlined in the Water Management Plan, it is expected that localized control measures will be implemented when earth works and progressive rehabilitation occur (i.e., silt fences, reducing amount of time disturbed soil is exposed, grading controls, and advanced seeding of disturbed soils to enhance soil stabilization)

Mine Contact Water

Assessment of contact water used the following assessment sequence:

- Geochemical testing and modeling to determine water quality source terms and aging predictions
- Water Quantity and Water Quality Modelling (Appendix 7A and 7B) in GoldSim™ refined water movement throughout the Project at a monthly time scale and used contact runoff and seepage estimates, water management infrastructure storage/sedimentation characteristics, and geochemical results to predict contact water quality at the FDPs
- A mass balance model was developed to estimate water quality in the receiving water at the FDP, 100 m and 250 m downstream from the FDP
- Where local, small receiving watersheds discharged to the three ultimate receivers (Victoria Lake Reservoir, Valentine Lake and the Victoria River), a CORMIX model was run to determine the effluent mixing zone in the larger ultimate receiver (within the LAA)

As described in the Water Management Plan (Section 7.5.1 and Appendix 2A), contact water will be directed to sedimentation ponds for treatment prior to being discharged at an FDP. The water quality in the receiving environment is dependent on both the water quality and quantity of the effluent, and the background water quality and quantity expected to be in the receiver (baseline). The receiving water assessment was run for a conservative regulatory scenario (high effluent concentrations [95th percentile or MDMER limits] and low flow [7Q10]) and poor water quality (75th percentile) conditions in the receiving water. A normal operating condition scenario (mean effluent and receiver concentrations and MAF and discharge rates) was also run. Excess water from the TMF will be routed to the water treatment plant and polishing pond prior to being discharged via a pipeline to an FDP in Victoria Lake Reservoir.

As the FDPs drain to one of three ultimate receivers (Victoria Lake Reservoir, Valentine Lake or Victoria River), a mixing zone assessment of these receivers was also completed using CORMIX. The Assimilative Capacity Assessment (Appendix 7C) provides further details on the mass balance and CORMIX modelling results.

Tables 7.37 through 7.48 present a summary of the expected water quality for each FDP, 100 m and 250 m downstream, at the ultimate receiver, and 100 m into this receiver (i.e., Victoria Lake Reservoir, Valentine Lake, Victoria River). Generally, for both the regulatory and the normal operating scenarios, limited assimilative capacity is seen downstream of each FDP until reaching Victoria Lake Reservoir, Valentine Lake, or Victoria River. Mixing rapidly improves once discharge reaches these ultimate receivers due to the large volume of water available for mixing. The FDPs and these downstream assessment points are shown on Figures 7-42 through 7-44 and are discussed in detail below.

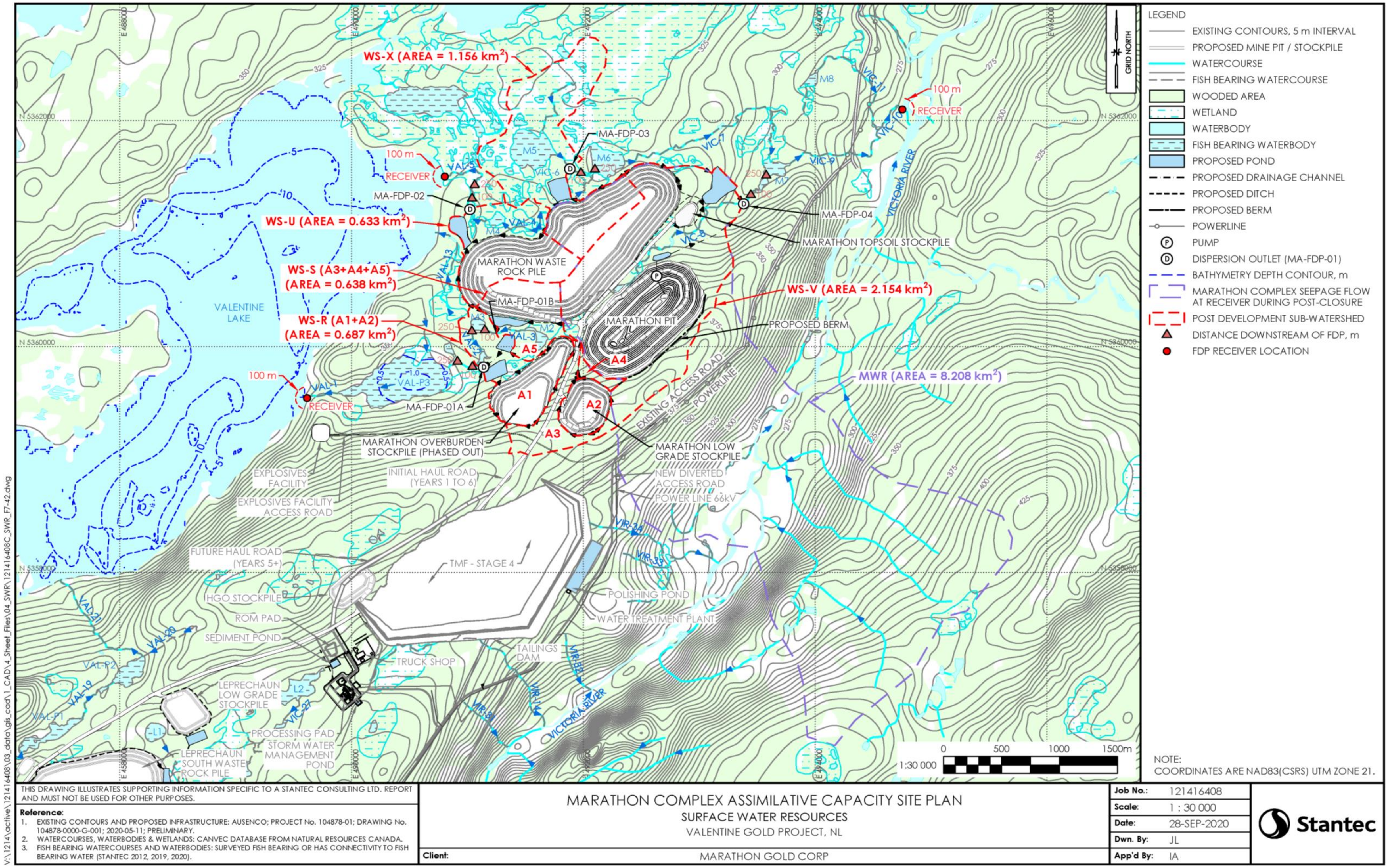
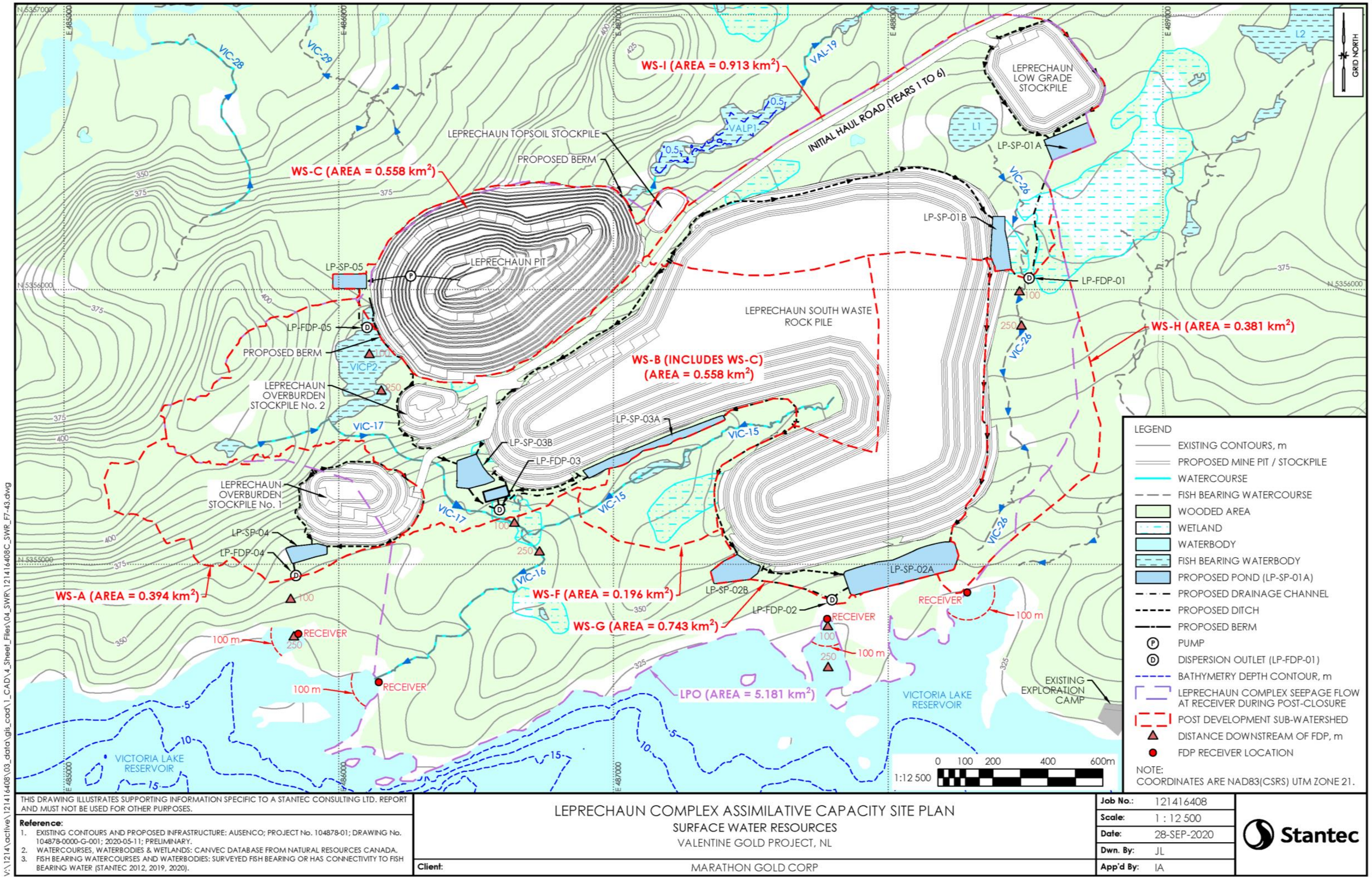


Figure 7-42 Marathon Complex Assimilative Capacity Site Plan



NOTE:
COORDINATES ARE NAD83(CSRS) UTM ZONE 21.

THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

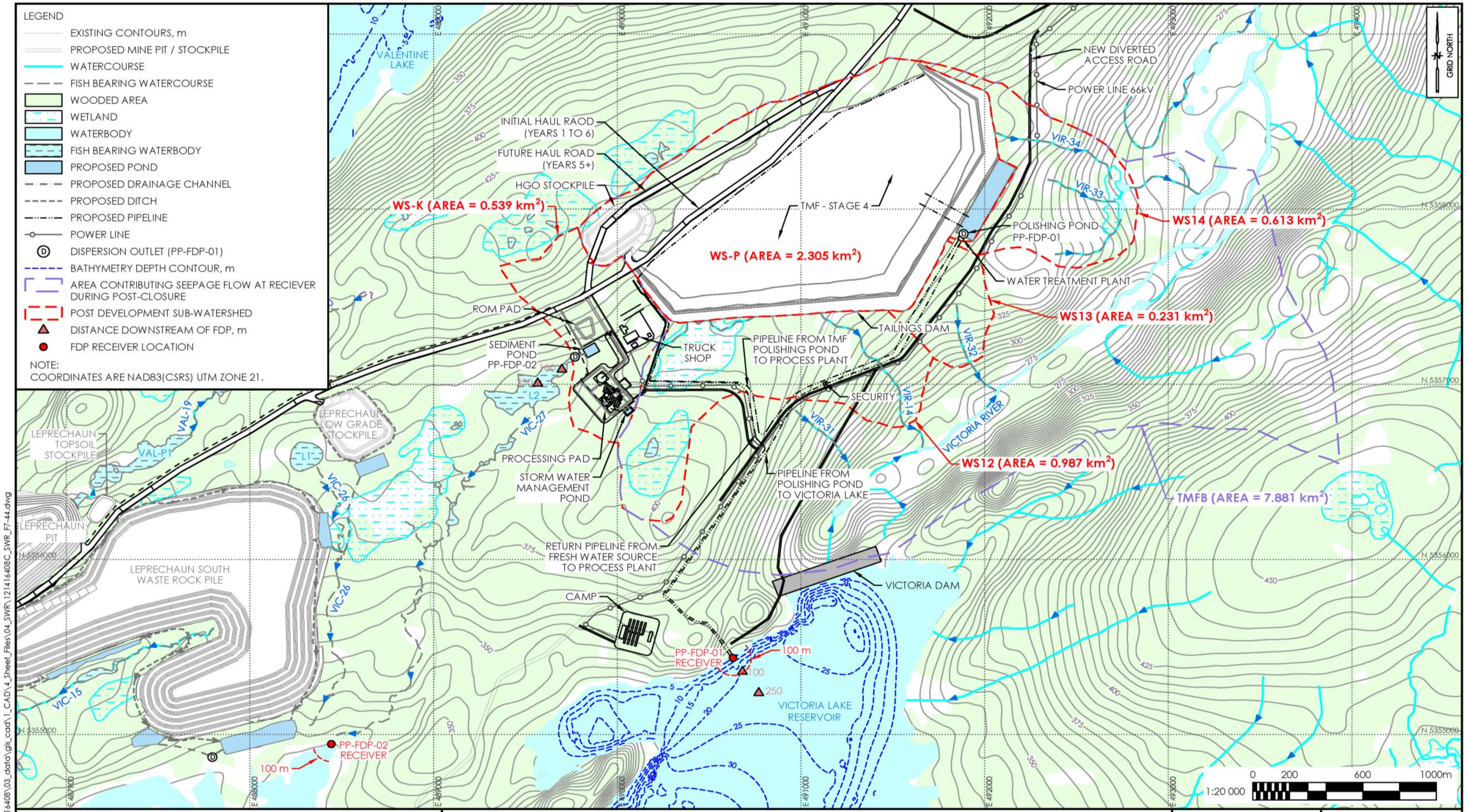
Reference:
1. EXISTING CONTOURS AND PROPOSED INFRASTRUCTURE: AUSENCO; PROJECT No. 104878-01; DRAWING No. 104878-0000-G-001; 2020-05-11; PRELIMINARY.
2. WATERCOURSES, WATERBODIES & WETLANDS: CANVEC DATABASE FROM NATURAL RESOURCES CANADA.
3. FISH BEARING WATERCOURSES AND WATERBODIES: SURVEYED FISH BEARING OR HAS CONNECTIVITY TO FISH BEARING WATER (STANTEC 2012, 2019, 2020).

LEPRECHAUN COMPLEX ASSIMILATIVE CAPACITY SITE PLAN
SURFACE WATER RESOURCES
VALENTINE GOLD PROJECT, NL

Client: MARATHON GOLD CORP

Job No.: 121416408
Scale: 1 : 12 500
Date: 28-SEP-2020
Dwn. By: JL
App'd By: IA

Figure7-43 Leprechaun Complex Assimilative Capacity Site Plan



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Reference:

1. EXISTING CONTOURS AND PROPOSED INFRASTRUCTURE: AUSENCO; PROJECT No. 104878-01; DRAWING No. 104878-0000-G-001; 2020-05-11; PRELIMINARY.
2. WATERCOURSES, WATERBODIES & WETLANDS: CANVEC DATABASE FROM NATURAL RESOURCES CANADA.
3. FISH BEARING WATERCOURSES AND WATERBODIES: SURVEYED FISH BEARING OR HAS CONNECTIVITY TO FISH BEARING WATER (STANTEC 2012, 2019, 2020).

PROCESS PLANT AND TMF COMPLEX ASSIMILATIVE CAPACITY SITE PLAN
SURFACE WATER RESOURCES
VALENTINE GOLD PROJECT, NL

Client: MARATHON GOLD CORP

Job No.:	121416408
Scale:	1 : 20 000
Date:	28-SEP-2020
Dwn. By:	JL
App'd By:	IA

Stantec

Figure 7-44 Process Plant and TMF Complex Assimilative Capacity Site Plan

Table 7.37 LP-FDP-01 Predicted POPC Concentrations in Receiving Environment

Parameter	Units	CWQG - FAL	Victoria Lake Reservoir Baseline		Regulatory Scenario						Normal Operating Scenario					
		Long term	Mean	75th Percentile	MDMER or 95th percentile	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m	Mean Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m
Dilution Ratios						1.37	1.39	1.64	365.1	1,046.3	-	2.54	2.63	3.67	64.2	73.7
Aluminum	µg/L	100	47	48	**600**	**483**	**479**	**433**	50	49	**600**	**315**	**309**	**258**	59	58
Arsenic	µg/L	5	0.5	0.5	**100.0**	**73.2**	**72.3**	**61.6**	0.8	0.6	**11.0**	5.0	4.9	3.8	0.7	0.7
Cadmium	µg/L	0.04	0.005	0.005	**0.120**	**0.091**	**0.090**	**0.078**	0.005	0.005	**0.085**	0.039	0.038	0.030	0.006	0.006
Copper	µg/L	2	0.57	0.81	**100.0**	**73.2**	**72.3**	**61.6**	1.1	0.9	**11.0**	**5.0**	**4.9**	**3.8**	0.8	0.7
Iron	µg/L	300	59.3	70.5	**800**	**688**	**685**	**640**	73	71	**400**	**333**	**332**	**320**	74	72
Lead	µg/L	1	0.39	0.25	**80.0**	**58.3**	**57.6**	**49.0**	0.5	0.3	0.9	0.5	0.5	0.5	0.4	0.4
Manganese	µg/L	210	9.7	12	**1,300**	**1,028**	**1,019**	**911**	16	13	**580**	**349**	**345**	**304**	26	24
Phosphorus	µg/L	4	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Zinc	µg/L	4	2.5	2.5	**400**	**293**	**289**	**247**	4	3	**29**	**14**	**14**	**11**	3	3
Nitrite	µg/L	60	14	16	**640**	**468**	**463**	**394**	18	17	**190**	**79**	**77**	58	16	16
Ammonia	µg/L	689	25	25	**3,500**	**2,571**	**2,541**	**2,172**	35	28	**1,100**	471	458	346	43	41
Ammonia (unionized)	µg/L	19	0.95	0.95	**500.0**	**97.7**	**96.6**	**82.5**	1.3	1.1	**42.0**	1.3	1.2	0.9	0.1	0.1
Cyanide	µg/L	-	10	10	500	367	362	309	11	10	10	10	10	10	10	10
Cyanide (WAD)	µg/L	5	1	1	0.0	0.3	0.3	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	1,000	1,000	54,000	39,900	39,443	33,836	1,147	1,051	69,000	28,212	27,382	20,118	2,092	1,951
Fluoride	µg/L	120	60	60	**1,600**	**1,181**	**1,167**	**1,001**	64	61	**760**	**335**	**326**	**251**	71	69

Notes:
Bold indicates value exceed CWQG-FAL and baseline concentrations in the ultimate receiver.

Table 7.38 LP-FDP-02 Predicted POPC Concentrations in Receiving Environment

Parameter	Units	CWQG - FAL	Victoria Lake Reservoir Baseline		Regulatory Scenario						Normal Operating Scenario					
		Longterm	Mean	75th Percentile	MDMER or 95th Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m	Mean Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m
					Dilution Ratios	-	-	1.19	658.0	1,806.8		-	-	1.47	25.6	95.2
Aluminum	µg/L	100	47	48	**600**	-	-	**530**	49	48	**600**	-	-	**450**	70	53
Arsenic	µg/L	5	0.5	0.5	**100.0**	-	-	**84.0**	0.7	0.6	**23.0**	-	-	**16.0**	1.4	0.7
Cadmium	µg/L	0.04	0.005	0.005	**0.120**	-	-	**0.102**	0.005	0.005	**0.100**	-	-	**0.071**	0.009	0.006
Copper	µg/L	2	0.57	0.81	**100.0**	-	-	**84.0**	1.0	0.9	**32.0**	-	-	**22.1**	1.8	0.9
Iron	µg/L	300	59.3	70.5	**800**	-	-	**733**	72	71	**800**	-	-	**637**	93	68
Lead	µg/L	1	0.39	0.25	**80.0**	-	-	**67.0**	0.4	0.3	**2.3**	-	-	**1.7**	0.5	0.4
Manganese	µg/L	210	9.7	12	**1,300**	-	-	**1,137**	14	13	**1,200**	-	-	**881**	60	23
Phosphorus	µg/L	4	50	50	50	-	-	50	50	50	50	-	-	50	50	50
Zinc	µg/L	4	2.5	2.5	**400**	-	-	**336**	3	3	**66**	-	-	**47**	**5**	3
Nitrite	µg/L	60	14	16	**640**	-	-	**537**	17	16	**440**	-	-	**302**	31	18
Ammonia	µg/L	689	25	25	**3,500**	-	-	**2,945**	30	27	**2,400**	-	-	**1,654**	119	50
Ammonia (unionized)	µg/L	19	0.95	0.95	**500.0**	-	-	**111.9**	1.2	1.0	**91.0**	-	-	4.5	0.3	0.1
Cyanide	µg/L	-	10	10	500	-	-	420	11	10	11	-	-	11	10	10
Cyanide (WAD)	µg/L	5	1	1	0.0	-	-	0.2	1.0	1.0	1.1	-	-	1.1	1.0	1.0
Sulphate	µg/L	-	1,000	1,000	54,000	-	-	45,576	1,081	1,029	41,000	-	-	28,495	2,580	1,424
Fluoride	µg/L	120	60	60	**1,600**	-	-	**1,350**	62	61	**1,500**	-	-	**1,041**	116	75

Notes:
Bold indicates value exceed CWQG-FAL and baseline concentrations in the ultimate receiver.
'-' indicates predicted concentrations not available as this downstream location does not exist due to the receiver being within 100 m of the FDP

Table 7.39 LP-FDP-03 Predicted POPC Concentrations in Receiving Environment

Parameter	Units	CWQG - FAL	Victoria Lake Reservoir Baseline		Regulatory Scenario						Normal Operating Scenario					
		Longterm	Mean	75th Percentile	MDMER or 95th Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m	Mean Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m
					Dilution Ratios	1.15	1.18	1.08	18.7	21.7	-	2.09	2.32	1.72	30.7	36.2
Aluminum	µg/L	100	47	48	**600**	**543**	**534**	**568**	78	74	**600**	**355**	**332**	**404**	67	64
Arsenic	µg/L	5	0.5	0.5	**100.0**	**87.0**	**84.9**	**92.6**	**5.8**	**5.1**	**22.0**	**11.1**	**10.1**	**13.3**	1.2	1.1
Cadmium	µg/L	0.04	0.005	0.005	**0.120**	**0.106**	**0.103**	**0.112**	0.011	0.010	**0.095**	**0.051**	**0.047**	**0.059**	0.008	0.008
Copper	µg/L	2	0.57	0.81	**100.0**	**87.0**	**84.9**	**92.6**	**6.1**	**5.4**	**30.0**	**14.9**	**13.5**	**17.9**	1.5	1.4
Iron	µg/L	300	59.3	70.5	**800**	**746**	**737**	**769**	111	105	**790**	**529**	**505**	**581**	88	84
Lead	µg/L	1	0.39	0.25	**80.0**	**69.5**	**67.8**	**74.0**	**4.5**	**3.9**	**2.3**	**1.3**	**1.2**	**1.5**	0.5	0.4
Manganese	µg/L	210	9.7	12	**1,300**	**1,168**	**1,147**	**1,225**	82	72	**1,100**	**630**	**587**	**724**	50	44
Phosphorus	µg/L	4	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Zinc	µg/L	4	2.5	2.5	**400**	**348**	**340**	**370**	**24**	**21**	**63**	**33**	**30**	**39**	**5**	**4**
Nitrite	µg/L	60	14	16	**640**	**557**	**543**	**593**	49	45	**410**	**200**	**181**	**242**	27	25
Ammonia	µg/L	689	25	25	**3,500**	**3,051**	**2,977**	**3,244**	211	185	**2,300**	**1,133**	**1,026**	**1,366**	100	89
Ammonia (unionized)	µg/L	19	0.95	0.95	**500.0**	**115.9**	**113.1**	**123.3**	8.0	7.0	**87.0**	3.1	2.8	3.7	0.3	0.2
Cyanide	µg/L	-	10	10	500	436	425	463	36	33	14	12	12	12	10	10
Cyanide (WAD)	µg/L	5	1	1	0.0	0.2	0.2	0.1	0.9	1.0	1.4	1.2	1.2	1.2	1.0	1.0
Sulphate	µg/L	-	1,000	1,000	54,000	47,184	46,060	50,117	3,839	3,444	37,000	18,633	16,950	22,306	2,190	2,010
Fluoride	µg/L	120	60	60	**1,600**	**1,397**	**1,364**	**1,485**	**142**	**131**	**1,400**	**701**	**637**	**841**	104	97

Notes:
Bold indicates value exceed CWQG-FAL and baseline concentrations in the ultimate receiver.

Table 7.40 LP-FDP-04 Predicted POPC Concentrations in Receiving Environment

Parameter	Units	CWQG - FAL	Victoria Lake Reservoir Baseline		Regulatory Scenario						Normal Operating Scenario					
		Longterm	Mean	75th Percentile	MDMER or 95th Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m	Mean Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m
Dilution Ratios						37.56	-	72.13	92,977	247,771		3.43	-	5.82	100.7	362.6
Aluminum	µg/L	100	47	48	**280**	**173**	**172**	**172**	48	48	**190**	**147**	**143**	**140**	52	48
Arsenic	µg/L	5	0.5	0.5	**100.0**	4.0	3.2	2.8	0.5	0.5	1.2	1.1	1.1	1.1	0.5	0.5
Cadmium	µg/L	0.04	0.005	0.005	0.015	0.012	0.012	0.012	0.005	0.005	0.010	0.010	0.010	0.010	0.005	0.005
Copper	µg/L	2	0.57	0.81	**100.0**	**4.0**	**3.2**	**2.8**	0.8	0.8	1.2	1.1	1.1	1.1	0.6	0.6
Iron	µg/L	300	59.3	70.5	**530**	**394**	**393**	**392**	71	71	290	290	290	290	73	63
Lead	µg/L	1	0.39	0.25	**80.0**	**2.4**	**1.7**	**1.4**	0.3	0.3	1.0	0.5	0.4	0.4	0.4	0.4
Manganese	µg/L	210	9.7	12	**440**	**304**	**303**	**302**	12	12	200	200	200	200	21	13
Phosphorus	µg/L	4	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Zinc	µg/L	4	2.5	2.5	**400**	**16**	**13**	**11**	3	3	**13**	**7**	**7**	**6**	3	3
Nitrite	µg/L	60	14	16	12	9	9	9	16	16	10	9	8	8	14	14
Ammonia	µg/L	689	25	25	130	89	89	89	25	25	69	65	64	64	27	26
Ammonia (unionized)	µg/L	19	0.95	0.95	**500.0**	3.4	3.4	3.4	1.0	1.0	2.6	0.2	0.2	0.2	0.1	0.1
Cyanide	µg/L	-	10	10	500	23	19	17	10	10	10	10	10	10	10	10
Cyanide (WAD)	µg/L	5	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	1,000	1,000	4,800	2,269	2,247	2,236	1,001	1,000	3,300	2,237	2,120	2,058	1,061	1,017
Fluoride	µg/L	120	60	60	60	60	60	60	60	60	60	60	60	60	60	60

Notes:
Bold indicates value exceed CWQG-FAL and baseline concentrations in the ultimate receiver.
'-' indicates predicted concentrations not available as this downstream location does not exist due to the receiver being within 100 m of the FDP

Table 7.41 LP-FDP-05 Predicted POPC Concentrations in Receiving Environment

Parameter	Units	CWQG - FAL	Victoria Lake Reservoir Baseline		Regulatory Scenario						Normal Operating Scenario					
		Long term	**Mean**	**75th Percentile**	**MDMER or 95th Effluent**	**100 m D/S**	**250 m D/S**	**Receiver**	**Receiver at 100 m**	**Receiver at 200 m**	**Mean Effluent**	**100 m D/S**	**250 m D/S**	**Receiver**	**Receiver at 100 m**	**Receiver at 200 m**
					Dilution Ratios	1.01	1.02	1.08	18.7	21.7	-	1.06	1.18	1.72	30.7	36.2
Aluminum	µg/L	100	47	48	**260**	**259**	**258**	**249**	60	58	**190**	**184**	**173**	**144**	52	52
Arsenic	µg/L	5	0.5	0.5	**100.0**	**99.5**	**98.5**	**92.9**	**5.8**	**5.1**	4.3	4.3	4.2	4.1	0.7	0.7
Cadmium	µg/L	0.04	0.005	0.005	0.024	0.024	0.024	0.023	0.006	0.006	0.020	0.019	0.019	0.016	0.006	0.006
Copper	µg/L	2	0.57	0.81	**100.0**	**99.5**	**98.5**	**92.6**	**6.1**	**5.4**	**5.4**	**5.2**	**4.8**	**3.6**	0.7	0.7
Iron	µg/L	300	59.3	70.5	**780**	**777**	**772**	**742**	109	104	**460**	**445**	**422**	**356**	76	73
Lead	µg/L	1	0.39	0.25	**80.0**	**79.6**	**78.8**	**74.0**	**4.5**	**3.9**	0.5	0.4	0.4	0.4	0.4	0.4
Manganese	µg/L	210	9.7	12	**1,000**	**996**	**988**	**942**	66	58	**620**	**593**	**549**	**424**	33	29
Phosphorus	µg/L	4	50	50	50	**51**	**51**	**51**	50	50	50	**51**	**52**	**55**	50	50
Zinc	µg/L	4	2.5	2.5	**400**	**398**	**394**	**370**	**24**	**21**	**10**	**10**	**9**	**8**	3	3
Nitrite	µg/L	60	14	16	**260**	**259**	**256**	**241**	29	27	**140**	**132**	**120**	**84**	18	17
Ammonia	µg/L	689	25	25	**1,600**	**1,592**	**1,576**	**1,485**	109	98	**970**	**916**	**832**	587	56	52
Ammonia (unionized)	µg/L	19	0.95	0.95	**500.0**	**60.5**	**59.9**	**56.4**	4.2	3.7	**37.0**	2.5	2.2	1.6	0.2	0.1
Cyanide	µg/L	-	10	10	500	497	492	463	36	33	10	10	10	10	10	10
Cyanide (WAD)	µg/L	5	1	1	1.2	1.2	1.2	1.2	1.0	1.0	1.2	1.2	1.2	1.1	1.0	1.0
Sulphate	µg/L	-	1,000	1,000	260,000	25,8646	25,5979	24,0629	14,851	12,922	170,000	160,150	144,635	99,619	6,509	5,674
Fluoride	µg/L	120	60	60	**320**	**319**	**316**	**301**	74	72	**280**	**267**	**247**	**188**	67	66

Notes:
Bold indicates value exceed CWQG-FAL and baseline concentrations in the ultimate receiver.

Table 7.42 MA-FDP-01a Predicted POPC Concentrations in Receiving Environment

Parameter	Units	CWQG - FAL	Valentine Lake Baseline		Regulatory Scenario						Normal Operating Scenario					
		Long term	Mean	75th Percentile	MDMER or 95th Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m	Mean Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m
					Dilution Ratios	2.56	2.98	8.46	871.1	2596.5	-	2.22	2.58	6.57	117.6	138.0
Aluminum	µg/L	100	14	15	**475**	**197**	**172**	73	16	15	**260**	**126**	**111**	53	16	16
Arsenic	µg/L	5	1	1	**100.0**	**39.4**	**33.9**	**12.3**	0.6	0.5	**16.0**	**7.5**	**6.5**	2.9	0.6	0.6
Cadmium	µg/L	0.04	0	0	**0.148**	**0.061**	**0.053**	0.022	0.005	0.005	**0.074**	0.036	0.032	0.016	0.006	0.006
Copper	µg/L	2	1	1	**100.0**	**39.6**	**34.1**	**12.5**	0.9	0.8	**18.0**	**8.4**	**7.4**	**3.3**	0.7	0.7
Iron	µg/L	300	25	25	**606**	252	220	94	26	25	**350**	171	151	74	28	27
Lead	µg/L	1	0	0	**80.0**	**31.4**	**27.0**	**9.7**	0.3	0.3	0.7	0.5	0.4	0.3	0.3	0.3
Manganese	µg/L	210	6	7	**953**	**377**	**324**	118	8	7	**340**	156	135	56	8	8
Phosphorus	µg/L	4	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Zinc	µg/L	4	3	3	**400**	**158**	**136**	**49**	3	3	**31**	**15**	**14**	**7**	3	3
Nitrite	µg/L	60	9	12	**411**	**168**	**146**	59	12	12	**130**	**64**	57	28	10	10
Ammonia	µg/L	689	25	25	**2271**	**903**	**778**	291	28	26	680	320	279	125	31	30
Ammonia (unionized)	µg/L	19	1	1	**500.0**	**34.3**	**29.6**	11.0	1.0	1.0	**26.0**	0.9	0.8	0.3	0.1	0.1
Cyanide	µg/L	-	10	10	500	202	174	68	11	10	13	11	11	10	10	10
Cyanide (WAD)	µg/L	5	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.3	1.1	1.1	1.0	1.0	1.0
Sulphate	µg/L	-	1,000	1,000	252,688	99,430	85,413	30,758	1,289	1,097	59,000	27,142	23,521	9,829	1,493	1,420
Fluoride	µg/L	120	60	60	**954**	**410**	**360**	**166**	61	60	**490**	**254**	**227**	**125**	64	63

Notes:
Bold indicates value exceed CWQG-FAL and baseline concentrations in the ultimate receiver.
D/S = Downstream

Table 7.43 MA-FDP-01b Predicted POPC Concentrations in Receiving Environment

Parameter	Units	CWQG - FAL	Valentine Lake Baseline		Regulatory Scenario						Normal Operating Scenario					
		Long term	Mean	75th Percentile	MDMER or 95th Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m	Mean Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m
					Dilution Ratios	3.35	3.54	8.46	871.1	2596.5	-	5.64	6.07	6.57	117.6	138.0
Aluminum	µg/L	100	14	15	**600**	**192**	**183**	88	16	15	**260**	59	56	53	16	16
Arsenic	µg/L	5	1	1	**100.0**	**30.2**	**28.6**	**12.3**	0.6	0.5	**16.0**	3.2	3.1	2.9	0.6	0.6
Cadmium	µg/L	0.04	0	0	**0.250**	**0.078**	**0.074**	0.034	0.005	0.005	**0.074**	0.017	0.016	0.016	0.006	0.006
Copper	µg/L	2	1	1	**100.0**	**30.4**	**28.8**	**12.5**	0.9	0.8	**18.0**	**3.7**	**3.5**	**3.3**	0.7	0.7
Iron	µg/L	300	25	25	**660**	215	204	100	26	25	**350**	83	79	74	28	27
Lead	µg/L	1	0	0	**80.0**	**24.1**	**22.8**	**9.7**	0.3	0.3	0.7	0.3	0.3	0.3	0.3	0.3
Manganese	µg/L	210	6	7	**1,300**	**393**	**372**	159	8	7	**340**	65	61	56	8	8
Phosphorus	µg/L	4	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Zinc	µg/L	4	3	3	**400**	**121**	**115**	**49**	3	3	**31**	**8**	**7**	**7**	3	3
Nitrite	µg/L	60	9	12	**670**	**208**	**198**	**90**	13	12	**130**	31	30	28	10	10
Ammonia	µg/L	689	25	25	**3,700**	**1,122**	**1,063**	460	29	26	680	141	133	125	31	30
Ammonia (unionized)	µg/L	19	1	1	**500.0**	**42.6**	**40.4**	17.5	1.1	1.0	**26.0**	0.4	0.4	0.3	0.1	0.1
Cyanide	µg/L	-	10	10	500	156	148	68	11	10	13	11	10	10	10	10
Cyanide (WAD)	µg/L	5	1	1	1.1	1.0	1.0	1.0	1.0	1.0	1.3	1.1	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	1,000	1,000	260,000	78,319	74,171	31,623	1,297	1,100	59,000	11,280	10,556	9,829	1,493	1,420
Fluoride	µg/L	120	60	60	**1,600**	**520**	**495**	**242**	62	61	**490**	**136**	**131**	**125**	64	63

Notes:
Bold indicates value exceed CWQG-FAL and baseline concentrations in the ultimate receiver.

Table 7.44 MA-FDP-02 Predicted POPC Concentrations in Receiving Environment

Parameter	Units	CWQG - FAL	Valentine Lake Baseline		Regulatory Scenario						Normal Operating Scenario					
		Long term	Mean	75th Percentile	MDMER or 95th Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m	Mean Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m
					Dilution Ratios	1.13	1.14	1.17	221.1	639.8	-	1.39	1.44	1.52	26.5	30.4
Aluminum	µg/L	100	16	19	**600**	**534**	**527**	**516**	18	16	**600**	**437**	**422**	**400**	36	33
Arsenic	µg/L	5	1	1	**100.0**	**88.6**	**87.4**	**85.5**	0.9	0.7	**11.0**	**8.1**	**7.8**	**7.4**	0.9	0.8
Cadmium	µg/L	0.04	0	0	**0.250**	**0.222**	**0.219**	**0.214**	0.006	0.005	**0.190**	**0.138**	**0.134**	**0.127**	0.012	0.011
Copper	µg/L	2	1	1	**100.0**	**88.6**	**87.5**	**85.6**	1.2	0.9	**48.0**	**34.8**	**33.5**	**31.8**	**2.3**	**2.1**
Iron	µg/L	300	25	25	**660**	**587**	**580**	**568**	28	26	**330**	245	237	226	37	35
Lead	µg/L	1	0	0	**80.0**	**70.9**	**69.9**	**68.4**	0.6	0.4	**1.9**	**1.4**	**1.4**	**1.3**	0.3	0.3
Manganese	µg/L	210	340	340	**1,300**	**1,152**	**1,137**	**1,112**	13	9	**870**	**628**	**606**	**574**	38	34
Phosphorus	µg/L	4	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Zinc	µg/L	4	3	3	**400**	**355**	**350**	**342**	**4**	3	**130**	**94**	**91**	**86**	**7**	**7**
Nitrite	µg/L	60	10	12	**670**	**595**	**587**	**574**	15	13	18	16	16	15	9	9
Ammonia	µg/L	689	25	25	**3,700**	**3,280**	**3,236**	**3,166**	42	31	76	62	60	59	27	27
Ammonia (unionized)	µg/L	19	0	0	**500.0**	**124.6**	**123.0**	**120.3**	1.6	1.2	2.9	0.2	0.2	0.2	0.1	0.1
Cyanide	µg/L	-	10	10	500	444	438	429	12	11	10	10	10	10	10	10
Cyanide (WAD)	µg/L	5	1	1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	1,000	1,000	260,000	230,371	227,281	222,376	2,171	1,405	140,000	101,152	97,593	92,397	6,253	5,570
Fluoride	µg/L	120	60	60	**1,600**	**1,424**	**1,405**	**1,376**	67	62	**1,400**	**1,025**	**991**	**941**	111	104
Notes: Bold indicates value exceed CWQG-FAL and baseline concentrations in the ultimate receiver.																

Table 7.45 MA-FDP-03 Predicted POPC Concentrations in Receiving Environment

Parameter	Units	CWQG - FAL	Victoria River Baseline		Regulatory Scenario						Normal Operating Scenario					
		Long term	Mean	75th Percentile	MDMER or 95th Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m	Mean Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m
Dilution Ratios						1.77	1.79	1.39	24.5	29.1	-	2.62	2.68	3.59	52.4	66.4
Aluminum	µg/L	100	77	103	**600**	**367**	**363**	**449**	**123**	**120**	**600**	**263**	**258**	**207**	85	84
Arsenic	µg/L	5	1	1	**100.0**	**58.6**	**57.8**	**73.0**	4.6	4.0	**23.0**	**11.0**	**10.8**	**9.0**	1.1	1.0
Cadmium	µg/L	0.04	0	0	**0.250**	**0.145**	**0.143**	**0.182**	0.015	0.013	**0.220**	**0.089**	**0.087**	**0.068**	0.009	0.008
Copper	µg/L	2	1	1	**100.0**	**57.1**	**56.3**	**72.0**	**4.8**	**4.1**	**70.0**	**27.3**	**26.7**	**20.2**	**2.0**	1.7
Iron	µg/L	300	168	239	**660**	**462**	**458**	**531**	255	253	**540**	**314**	**310**	276	175	173
Lead	µg/L	1	0	0	**80.0**	**45.4**	**44.8**	**57.5**	**3.5**	**3.0**	**2.1**	1.0	0.9	0.8	0.3	0.3
Manganese	µg/L	210	57	78	**1,300**	**749**	**738**	**941**	127	120	**1,200**	**491**	**480**	**373**	78	74
Phosphorus	µg/L	4	50	50	50	50	50	50	50	50	50	**52**	**52**	**52**	50	50
Zinc	µg/L	10	3	3	**400**	**228**	**224**	**288**	**19**	**16**	**140**	**55**	**54**	**41**	5	5
Nitrite	µg/L	60	9	10	**670**	**382**	**376**	**482**	37	33	**490**	**190**	**186**	**140**	18	16
Ammonia	µg/L	689	25	25	**3,700**	**2,107**	**2,077**	**2,662**	175	151	**2,700**	**1,049**	**1,024**	**773**	76	65
Ammonia (unionized)	µg/L	19	1	1	**500.0**	**80.1**	**78.9**	**101.2**	6.6	5.7	**100.0**	2.8	2.8	2.1	0.2	0.2
Cyanide	µg/L	-	10	10	500	288	284	362	30	27	10	10	10	10	10	10
Cyanide (WAD)	µg/L	5	1	1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	1,000	1,000	260,000	147,724	145,611	186,852	11,560	9,892	200,000	77,068	75,220	56,520	4,803	4,001
Fluoride	µg/L	120	60	60	**1,600**	**932**	**920**	**1,165**	**123**	113	**1,600**	**648**	**634**	**489**	89	83

Notes:
Bold indicates value exceed CWQG-FAL and baseline concentrations in the ultimate receiver.

Table 7.46 MA-FDP-04 Predicted POPC Concentrations in Receiving Environment

Parameter	Units	CWQG - FAL	Victoria River Baseline		Regulatory Scenario						Normal Operating Scenario					
		Long term	Mean	75th Percentile	MDMER or 95th Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m	Mean Effluent	100 m D/S	250 m D/S	Receiver	Receiver at 100 m	Receiver at 200 m
Dilution Ratios						1.05	1.06	1.39	24.5	29.1	-	1.42	1.55	3.59	52.4	66.4
Aluminum	µg/L	100	77	103	**439**	**422**	**417**	**333**	**116**	**114**	**590**	**432**	**400**	**204**	85	83
Arsenic	µg/L	5	1	1	**100.0**	**95.5**	**94.3**	**73.0**	4.6	4.0	**10.0**	**8.1**	**7.7**	**5.4**	0.8	0.8
Cadmium	µg/L	0.04	0	0	**0.127**	**0.122**	**0.120**	**0.094**	0.010	0.009	**0.120**	**0.087**	**0.080**	0.040	0.007	0.007
Copper	µg/L	2	1	1	**100.0**	**95.4**	**94.1**	**72.0**	**4.8**	**4.1**	**35.0**	**24.9**	**22.9**	**10.4**	1.3	1.2
Iron	µg/L	300	168	239	**738**	**713**	**706**	**586**	259	255	**380**	**319**	**307**	231	172	171
Lead	µg/L	1	0	0	**80.0**	**76.3**	**75.2**	**57.5**	**3.5**	**3.0**	**1.1**	0.8	0.8	0.5	0.3	0.3
Manganese	µg/L	210	57	78	**1,045**	**997**	**984**	**758**	117	111	**620**	**452**	**418**	**211**	67	65
Phosphorus	µg/L	4	50	50	50	50	50	50	50	50	50	**51**	**51**	**52**	50	50
Zinc	µg/L	10	3	3	**400**	**381**	**376**	**288**	**19**	**16**	**73**	**52**	**48**	**22**	4	4
Nitrite	µg/L	60	9	10	**437**	**417**	**411**	**315**	27	25	**130**	**93**	**86**	40	11	11
Ammonia	µg/L	689	25	25	**2,425**	**2,312**	**2,281**	**1,747**	123	107	**840**	600	551	254	41	37
Ammonia (unionized)	µg/L	19	1	1	**500.0**	**87.9**	**86.7**	**66.4**	4.7	4.1	**32.0**	1.6	1.5	0.7	0.1	0.1
Cyanide	µg/L	-	10	10	500	477	471	362	30	27	10	10	10	10	10	10
Cyanide (WAD)	µg/L	5	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulphate	µg/L	-	1,000	1,000	260,000	247,867	244,549	186,852	11,560	9,892	130,000	91,819	84,179	37,018	3,467	2,947
Fluoride	µg/L	120	60	60	**863**	**825**	**815**	**636**	93	88	**860**	**623**	**576**	**283**	75	72

Notes:
Bold indicates value exceed CWQG-FAL and baseline concentrations in the ultimate receiver.

Table 7.47 PP-FDP-01 Predicted POPC Concentrations in Receiving Environment

Parameter	Units	CWQG - FAL	Victoria Lake Reservoir Baseline		Regulatory Scenario						Normal Operating Scenario					
		Long term	**Mean**	**75th Percentile**	**MDMER or 95th Effluent**	**100 m D/S**	**250 m D/S**	**Receiver**	**Receiver at 100 m**	**Receiver at 200 m**	**Mean Effluent**	**100 m D/S**	**250 m D/S**	**Receiver**	**Receiver at 100 m**	**Receiver at 200 m**
Dilution Ratios						-	-	1.08	23.8	33.2	**-**	-	-	1.72	82	132
Aluminum	µg/L	100	47	48	**280**	-	-	**263**	58	55	**150**	-	-	**107**	48	48
Arsenic	µg/L	5	0.5	0.5	**100.0**	-	-	**92.5**	4.7	3.5	**6.3**	-	-	3.9	0.6	0.5
Cadmium	µg/L	0.04	0.005	0.005	**0.051**	-	-	**0.048**	0.007	0.006	0.036	-	-	0.023	0.005	0.005
Copper	µg/L	2	0.57	0.81	**100.0**	-	-	**92.6**	**5.0**	**3.8**	**77.0**	-	-	**45.1**	1.5	1.1
Iron	µg/L	300	59.3	70.5	**360**	-	-	**338**	83	79	210	-	-	147	61	60
Lead	µg/L	1	0.39	0.25	**80.0**	-	-	**74.0**	**3.6**	**2.7**	0.3	-	-	0.3	0.4	0.4
Manganese	µg/L	210	9.7	12	310	-	-	288	25	21	190	-	-	115	12	11
Phosphorus	µg/L	4	50	50	79	-	-	77	51	51	61	-	-	56	50	50
Zinc	µg/L	3.78	2.5	2.5	**400**	-	-	**370**	**19**	**14**	5	-	-	4	3	3
Nitrite	µg/L	60	14	16	**120**	-	-	**112**	20	19	**75**	-	-	50	15	14
Ammonia	µg/L	689	25	25	**4,500**	-	-	**4,165**	213	160	**4,500**	-	-	**2,632**	80	59
Ammonia (unionized)	µg/L	19	0.95	0.95	**500.0**	-	-	**158.3**	8.1	6.1	**170.0**	-	-	7.1	0.2	0.2
Cyanide	µg/L	-	10	10	500	-	-	463	31	25	330	-	-	196	14	12
Cyanide (WAD)	µg/L	5	1	1	**29.0**	-	-	**26.9**	2.2	1.8	**16.0**	-	-	**9.7**	1.2	1.1
Sulphate	µg/L	-	1,000	1,000	760,000	-	-	703,103	32,914	23,861	450,000	-	-	262,568	6,476	4,402
Fluoride	µg/L	120	60	60	**840**	-	-	**782**	93	83	**530**	-	-	**334**	66	64

Notes:
Bold indicates value exceed CWQG-FAL and baseline concentrations in the ultimate receiver.
'-' indicates predicted concentrations not available as this downstream location does not exist due to the receiver being within 100 m of the FDP

Table 7.48 PP-FDP-02 Predicted POPC Concentrations in Receiving Environment

Parameter	**Units**	**CWQG - FAL**	**Baseline**		**Regulatory Scenario**						**Normal Operating Scenario**					
		Long term	**Mean**	**75th Percentile**	**MDMER or 95th Effluent**	**100 m D/S**	**250 m D/S**	**Receiver**	**Receiver at 100 m**	**Receiver at 200 m**	**Mean Effluent**	**100 m D/S**	**250 m D/S**	**Receiver**	**Receiver at 100 m**	**Receiver at 200 m**
Dilution Ratios						1.39	1.44	5.00	258.2	880.1	-	3.09	3.38	19.55	348.1	412.6
Aluminum	µg/L	100	47	48	**280**	**232**	**228**	**144**	50	49	**150**	**102**	100	83	49	49
Arsenic	µg/L	5	0.5	0.5	**100.0**	**73.4**	**71.0**	**24.4**	1.0	0.6	**6.3**	4.6	4.5	3.9	0.7	0.7
Cadmium	µg/L	0.04	0.005	0.005	**0.051**	**0.041**	0.040	0.021	0.005	0.005	0.036	0.019	0.018	0.012	0.005	0.005
Copper	µg/L	2	0.57	0.81	**100.0**	**72.3**	**69.8**	**21.2**	1.2	0.9	**77.0**	**25.7**	**23.6**	**5.1**	0.8	0.8
Iron	µg/L	300	59.3	70.5	**360**	**335**	**332**	288	75	72	210	210	210	210	68	66
Lead	µg/L	1	0.39	0.25	**80.0**	**57.5**	**55.5**	**16.2**	0.6	0.3	0.3	0.3	0.3	0.3	0.4	0.4
Manganese	µg/L	210	9.7	12	**310**	**285**	**282**	**238**	16	13	190	163	162	152	18	16
Phosphorus	µg/L	4	50	50	**79**	**76**	**76**	**70**	50	50	**61**	**62**	**62**	**62**	**51**	**51**
Zinc	µg/L	3.78	2.5	2.5	**400**	**289**	**279**	**85**	**4**	3	**5**	**5**	**5**	**5**	3	3
Nitrite	µg/L	60	14	16	**120**	**88**	**85**	28	16	16	**75**	28	26	9	14	14
Ammonia	µg/L	689	25	25	**4,500**	**3,252**	**3,139**	**955**	43	30	**4,500**	**1,492**	**1,367**	280	39	37
Ammonia (unionized)	µg/L	19	0.95	0.95	**500.0**	**359.2**	**346.5**	**100.1**	2.9	1.5	**170.0**	**55.1**	**50.4**	8.9	1.4	1.3
Cyanide	µg/L	-	10	10	500	14	13	4	0	0	330	0	0	0	0	0
Cyanide (WAD)	µg/L	5	1	1	**29.0**	**21.1**	**20.4**	**6.6**	1.1	1.0	**16.0**	**5.9**	**5.4**	1.8	1.0	1.0
Sulphate	µg/L	-	1,000	1,000	760,000	546,376	527,102	153,177	3,949	1,865	450,000	146,534	133,954	24,342	2,311	2,106
Fluoride	µg/L	120	60	60	**840**	**620**	**600**	**216**	63	61	**530**	**212**	**199**	84	61	61

Notes:
Bold indicates value exceed CWQG-FAL and baseline concentrations in the ultimate receiver.

Baseline concentrations of phosphorus at the site are above the CWQG-FAL, due to the RDL of 100 ug/L, which is above the CWQG-FAL. As a result, surface water quality at the FDPs were predicted to exceed CWQG-FAL for phosphorus; however, these exceedances reflect baseline. No residual water quality effects associated with phosphorus are expected from the Project as predicted levels return to baseline for each FDP.

LP-FDP-01

LP-FDP-01 will receive contact water from sedimentation ponds downstream of the Leprechaun waste rock pile and the Leprechaun low grade stockpile. Of the POPCs found to be elevated above baseline conditions at the edge of the 100 m mixing zone of Victoria Lake Reservoir, none were elevated above CWQG-FAL.

LP-FDP-02

LP-FDP-02 will receive contact water from sedimentation ponds downstream of the Leprechaun waste rock pile. The confluence of the effluent discharge with Victoria Lake Reservoir is less than 100 m downstream from the FDP, so POPC concentrations are not predicted for the 100 m and 250 m downstream locations. In the regulatory scenario, POPC either return to baseline or to levels below CWQG-FAL at 100 m into Victoria Lake Reservoir.

In the normal operating conditions scenario, zinc was the POPC found to be elevated above baseline and also above CWQG-FAL. However, it is predicted to be below CWQG-FAL within 200 m of the discharge point to Victoria Lake Reservoir in the normal operating scenario.

LP-FDP-03

LP-FDP-03 will receive contact water from sedimentation ponds downstream of the Leprechaun waste rock pile, Leprechaun topsoil stockpile and discharge from LP-FDP-05 (Leprechaun Pit). In the regulatory scenario, the POPCs found to be above CWQG-FAL and above baseline levels were arsenic, copper, lead, zinc, and fluoride. These are considered the POPCs that will require the largest mixing zone in Victoria Lake Reservoir.

In the normal operating conditions scenario, POPCs either return to baseline or to levels below CWQG-FAL at 100 m into Victoria Lake Reservoir, with the exception of zinc which is just over CWQG-FAL and remains slightly above CWGQ-FAL at a point 200 m from the discharge point to Victoria Lake Reservoir.

Based on extrapolated dilution ratios for the normal operating and regulatory scenario, it is expected that within 300 m from the outfall no parameters will exceed the CWQG-FAL in Victoria Lake Reservoir.

LP-FDP-04

LP-FDP-04 will receive contact water from sedimentation ponds downstream of the Leprechaun overburden stockpile. The confluence of the effluent discharge with Victoria Lake Reservoir is less than 250 m downstream from the FDP, so POPC concentrations are not predicted for the 250 m downstream location.

Both scenarios found no POPCs that remained elevated above baseline conditions or above CWQG-FAL at the edge of the 100 m mixing zone in Victoria Lake Reservoir. No residual water quality effects are therefore expected at LP-FDP-04.

LP-FDP-05

LP-FDP-05 will receive contact water from sedimentation ponds downstream of the Leprechaun pit. In the regulatory scenario, the POPCs found to be above CWQG-FAL and elevated above baseline levels at 100 m into Victoria Lake Reservoir were arsenic, copper, lead and zinc. These are considered the POPCs that will require the largest mixing zone in Victoria Lake Reservoir. Additional water quality treatment for this FDP will be required, or concentrations of the above POPCs will need to be below MDMER so that background levels are reached within 200 m of the discharge point to Victoria Lake Reservoir. Based on extrapolated dilution ratios for the regulatory scenario, it is expected that within 300 m from the outfall no parameters will exceed the CWQG-FAL in Victoria Lake Reservoir.

In the normal operating conditions scenario, POPCs either return to baseline or to levels below CWQG-FAL at 100 m into Victoria Lake Reservoir.

MA-FDP-01a

MA-FDP-01a will receive contact water from sedimentation ponds downstream of the Marathon overburden stockpile and the Marathon low-grade ore stockpile. This FDP is also downstream of MA-FDP-01b. Both scenarios found no POPCs that remained elevated above baseline conditions or above CWQG-FAL at the edge of the 100 m mixing zone in Valentine Lake. No residual water quality effects are therefore expected at MA-FDP-01a.

MA-FDP-01b

MA-FDP-01b will receive contact water from sedimentation ponds downstream of the Marathon waste rock pile. Both scenarios found no POPCs that remained elevated above baseline conditions or above CWQG-FAL at the edge of the 100 m mixing zone in Valentine Lake. No residual water quality effects are therefore expected at MA-FDP-01b.

MA-FDP-02

MA-FDP-02 will receive contact water from sedimentation ponds downstream of the Marathon waste rock pile. In the regulatory scenario, the only POPC found to be above CWQG-FAL and above baseline levels was zinc. However, it is predicted to fall below CWQG-FAL within 200 m of the discharge point to Valentine Lake.

In the normal operating conditions scenario, POPCs found to be above CWQG-FAL and above baseline levels were copper, and zinc. These are considered the POPCs that will require the largest mixing zone in Valentine Lake. Based on extrapolated dilution ratios for the normal operating and regulatory scenario, it is expected that within 300 m from the outfall no parameters will exceed the CWQG-FAL.

MA-FDP-03

MA-FDP-03 will receive contact water from sedimentation ponds downstream of the Marathon waste rock pile. In the regulatory scenario, the POPCs found to be above CWQG-FAL and elevated above baseline levels at 100 m into Victoria River were aluminum, copper, iron, lead, zinc, and fluoride. These are considered the POPCs that will require the largest mixing zone in Victoria River. Based on extrapolated dilution ratios for the regulatory scenario it is expected that within 300 m from the outfall, no parameters will exceed the CWQG-FAL.

In the normal operating conditions scenario, POPCs either return to baseline or to levels below CWQG-FAL at 100 m into Victoria River.

MA-FDP-04

MA-FDP-04 will receive contact water from sedimentation ponds downstream of the Marathon waste rock pile, Marathon topsoil stockpile and the Marathon pit. In the regulatory scenario, the POPCs found to be above CWQG-FAL and elevated above baseline levels at 100 m into Victoria River were aluminum, copper, iron, lead and zinc and. Based on extrapolated dilution ratios for the regulatory scenario, it is expected that within 300 m from the outfall no parameters will exceed the CWQG-FAL.

In the normal operating conditions scenario, POPCs either return to baseline or to levels below CWQG-FAL at 100 m into Victoria River.

PP-FDP-01

PP-FDP-01 will receive contact water from the polishing pond. TMF excess water will be pumped to the water treatment plant which will discharge to the polishing pond. As the effluent will discharge directly to Victoria Lake Reservoir, the 100 m and 250 m downstream locations were not modelled.

In the regulatory scenario, the POPCs found to be above CWQG-FAL and above baseline levels were copper, lead, and zinc. These are considered the POPCs that will require the largest mixing zone in Victoria Lake Reservoir. Based on extrapolated dilution ratios for the regulatory scenario it is expected that within 300 m from the outfall no parameters will exceed the CWQG-FAL.

In the normal operating conditions scenario, POPCs either return to baseline or to levels below CWQG-FAL at 100 m into Victoria Lake Reservoir.

Sewage generated within the Project site will be collected via an underground sanitary sewer network to a common location, where it will be treated by an above-grade mechanical sewage treatment plant (vendor package). The treatment package will be conservatively designed and operated to meet regulatory criteria at the downstream end of the system and prior to discharge. The discharge from the treatment system will be combined with discharge from the TMF (resulting in further dilution) which will discharge to Victoria Lake Reservoir at PP-FDP-01. As with vendor package systems, the custom design is not completed at this early stage, however, sewage effluent will be treated and monitored in accordance with the NL *Environmental Control Water and Sewage Regulations* prior to discharge to the environment. Further details on the treatment system will be provided as part of the permit applications.

PP-FDP-02

PP-FDP-02 will receive contact water from the run-of-mine pad and processing plant. In the regulatory scenario, the POPC found to be above CWQG-FAL and elevated above baseline levels at 100 m into Victoria River was zinc. This POPC is predicted to be below CWQG-FAL within 200 m of the discharge point to Victoria Lake Reservoir. In the normal operating conditions scenario, POPCs either return to baseline or to levels below CWQG-FAL at 100 m into Victoria Lake Reservoir.

In addition to water quality considerations associated with Project identified FDPs, the following specific water quality subjects are presented:

Methyl Mercury

Inundation of land with organic soils and vegetation cover can liberate mercury and lead to increase in MeHg production. The TMF will contain Project tailings and porewater, and within the TMF perimeter dams will behave like a flooded area. Clearing and grubbing of vegetation and removal of organic soils are expected to largely mitigate the potential for MeHg production. However, the potential for MeHg production in the TMF was assessed in the absence of these organic source removals. MeHg generation occurs naturally in the environment through natural flooding and longer-term changes in watercourses, waterbodies and their associated floodplains. A common natural source of MeHg generation in Canada is beaver activity where beavers will move into a new waterbody with good organic food sources, build dams and flood the waterbody to gain underwater access to food sources through winter. Eventually the food sources are depleted, the beavers move on and in time the beaver dams will fail returning the waterbody to pre-flooding conditions. Thus, beaver activity creates a longer-term inundation pulse in the natural environment, and during the flooding, MeHg production can occur.

Extensive, long-term MeHg generation research was undertaken in the Experimental Lakes area of Ontario (St. Louise et al. 2004). In this study, a natural wetland was artificially flooded without vegetation / organic soil removal, and water quality monitoring was undertaken to subsequently observe changes in MeHg, both in the water column and sediments. The studies observed a distinct MeHg generation trend in which MeHg increased after initial inundation peaking within about two years, and subsequently declining in the following 8 to 10 years to baseline conditions. They also observed that a major MeHg vector was wetland bank erosion. These observations may be applied to MeHg generation potential at the TMF, where without vegetation and organic soil removal, MeHg would be expected to peak in the first 2 to 3 years of operation and then subsequently decline in the following 8 to 10 years. No erosion would be expected at the base of the tailings mass.

To mitigate against the potential release of MeHg to the natural environment the following measures and operational characteristics will be in place:

- Vegetation will be cleared from within the TMF tailings containment zone as part of site preparation.
- During operation and early closure, a TMF dam seepage collection system will be in place. The seepage collection system will consist of a series of perimeter ditches and sump pits around the perimeter of the TMF dams. TMF seepage will be pumped back to the TMF during this period and either reused as reclaim water or treated prior to discharge to Victoria Lake Reservoir, thus

addressing potential operation and early closure phase MeHg water quality concerns. MeHg production is anticipated to declined back to baseline conditions by the time the seepage collection ditches are rehabilitated and removed during closure.

Sodium Cyanide

Sodium cyanide is used to leach gold from ore. The Project will use a sodium cyanide gold leaching process. At the end of the process, a cyanide recovery / destruction circuit is planned to reduce cyanide concentrations to below MDMER limits prior to the tailings being sent to the TMF. The Project expects to follow the cyanide management guidance provided in the International Cyanide Management Code, which includes limits to cyanide concentrations in water open to the natural environment.

During operation, reclaim water will be recirculated from the TMF to the process plant. Excess water in the TMF not required for processing will be routed to water treatment prior to discharge to Victoria Lake Reservoir. Discharge concentrations will comply with MDMER limits for cyanide. From Years 10 to 12 of operation, tailings will be sent to the Leprechaun pit, reclaim water will be circulated from the TMF to the process plant and resulting tailings slurry will be pumped to the Leprechaun pit to expedite pit filling. Thus, cyanide releases to the environment during operation will be maintained within regulatory limits.

Ammonia Residuals from Incomplete Blasting

Ammonium Nitrate is the primary explosive component of Ammonium Nitrate Fuel Oil, the main mine explosives product. This emulsion explosive was selected as it will reduce residual ammonia. Ammonium nitrate will be delivered to the mine in solid (prill) format and will be combined with fuel oil to form an emulsion product at the Project explosive facility. While explosions will combust the fuel oil component, there is the potential for incomplete blasting in some cases to leave residual ammonium nitrate among waste rock and ore. Ore processed to tailings will form a contact water recirculation loop from the process plant to TMF, where excess TMF water will be treated prior to release to Victoria Lake Reservoir. Ammonia (unionized) concentrations are regulated by the MDMER. Concentrations of unionized ammonia discharging from sedimentation ponds during operation will comply with MDMER limits. Nitrate concentrations at waste rock FDPs will meet CCME CWQG-FAL concentrations within 100 m of the FDP.

Seepage Quality to Receivers

As described in the Groundwater VC (Chapter 6), seepage from the Marathon waste rock pile and TMF will flow toward Victoria River throughout the Project phases. Predictions of seepage quality reaching the receivers are included in the Groundwater VC. The seepage from the Leprechaun waste rock pile was modelled to discharge to Victoria Lake Reservoir. The water quality of seepage was predicted to comply with MDMER limits at the receiver as a result of mixing and natural degradation processes. Once mixed with the receiver, the estimated dilution of groundwater seepage to flow in the Victoria River is at least 10 times. At this level of dilution, the seepage quality is predicted to return to near baseline concentrations.

Lowering of Groundwater Levels

Lowering of groundwater levels due to dewatering of the open pits will result in a change in groundwater quality by introducing unsaturated zones in the zone of groundwater depression. Groundwater from beneath waste rock piles will be redirected to the open pits where it will be collected during dewatering and treated prior to discharge. This results in a reduction in loading from groundwater to some local surface water features and an increase to others, and therefore a potential change in surface water quality for watercourses receiving a change in groundwater flow. The change to surface watercourses and waterbodies, such as temperature, is expected to be negligible, however potential environmental effects will be monitored through the life of the Project.

Decommissioning, Rehabilitation and Closure

At the end of the operation phase (or earlier for some features), the main features requiring rehabilitation will include the open pits, water management infrastructure, waste rock piles, the TMF, site roads, buildings, and associated infrastructure. The closure concept is to rehabilitate the pits by flooding to create pit lakes and to cover the waste rock piles and the TMF with a vegetated soil cover, such that overland runoff will be non-contact and will not require further treatment. Water infiltrating through and seeping from the rehabilitated waste rock piles and TMF will be contact water. The closure concept for contact water seepage is monitored natural attenuation (MNA), whereby mine component seepage will converge with local groundwater migrating to local surface water receivers. During migration, seepage water quality will attenuate through subsurface soil / bedrock contact and mixing with background groundwater.

As discussed in Section 7.1.3, the closure phase has been sub-divided into closure and post-closure for the purposes of the Surface Water VC. The transition between these two phases will be marked by the completion of rehabilitation activities, and it will be characterized by the site being returned as close to pre-development conditions as is feasible. Details of surface water quality changes anticipated during the closure and post-closure phases are discussed below:

Erosion and Sedimentation

Closure

Erosion and sedimentation can alter surface water quality during the closure phase as rehabilitation activities occur. The water management infrastructure outlined in the Water Management Plan (Appendix 2A) will remain in place until upstream infrastructure has been decommissioned and rehabilitated. Sedimentation ponds will be among the last infrastructure to be rehabilitated at the Project site. Non-contact water will continue to be diverted from mine surface water infrastructure to reduce the load entering sedimentation ponds, and mine surfaces rehabilitated with a vegetated soil cover will produce non-contact runoff.

Post-Closure

Erosion and sedimentation can alter surface water quality during post-closure through the maintenance of mine monitoring infrastructure. Roads to access monitoring locations will be maintained to mitigate erosion and sedimentation.

Mine Contact Water

Closure

During closure, treatment of mine contact water will change to allow for the flooding of both open pits. Water will no longer be discharged from several FDPs (PP-FDP-01 and LP-FDP-05). Water that would have discharged from these locations during operation will contribute to filling of the open pits. Water from the TMF (PP-FDP-01) will be pumped to the Leprechaun pit to expedite the pit filling process. Seepage from waste rock piles not collected in water management infrastructure will route to natural groundwater flow paths downgradient to local surface water receivers. Seepage quality will be improved during downgradient migration via MNA.

Sedimentation ponds and associated ditching will continue to operate as upstream rehabilitation takes place and will only be removed once upstream rehabilitation works are complete.

The MeHg generation cycle (10 to12 years) is predicted to have run its course by the time the TMF is to be rehabilitated. With a rehabilitated soil cover and MeHg generating conditions having passed, toe seepage is expected to have low to negligible MeHg concentrations.

During closure, the TMF will be rehabilitated with a soil cover to separate non-contact runoff from infiltration that seeps through the tailings mass. The non-contact runoff from the soil cover will be routed to the receiving environment. The deposition of fresh tailings and slurry water with post-destruction residual cyanide will cease in the TMF in Year 9. Therefore, from Years 9 to 12 of operation, no new tailings or cyanide will be deposited in the TMF. Depending on the timing of TMF cover construction, additional years may pass before the cover is in place, allowing cyanide to age in tailings porewater. Mean cyanide concentrations in closure and post-closure for the TMF seepage are predicted to be 0.120 mg/L and 0.081 mg/L. The water treatment plant downstream of the TMF will be decommissioned and water management features will be removed and restored to natural, pre-development drainage conditions to the extent possible.

Post-Closure

Post-closure, seepage from the waste rock piles, TMF and overflow from the two filled pits will migrate toward the Victoria Lake Reservoir and Victoria River. The GoldSim^{TM} model predicted water quality of the seepage and overflow from the pits, and an Assimilative Capacity Assessment was completed for the post-closure period. It is expected that more seepage and pit overflow will occur post-closure than during closure, as seepage collection ditches and other water management infrastructure are removed.

Results of Assimilative Capacity Assessment for post-closure are presented in Table 7.49, including the seepage quality leaving Project infrastructure, receiving watercourse baseline water quality, and mixed water quality in the receiving watercourse. The results indicate that seepage from the Marathon waste rock pile will cause exceedances of certain CWQG-FAL and will be at concentrations above baseline for aluminum, copper and flouride after seepage mixes with the Victoria River. Seepage from the Leprechaun waste rock pile is expected to cause exceedances of certain CWQG-FAL and will be at concentrations above baseline for zinc and fluoride after seepage mixes with the Victoria Lake Reservoir. Seepage from the TMF is expected to cause exceedances of certain CWQG-FAL and will be at concentrations above baseline for copper and cyanide (WAD) after seepage mixes with the Victoria River. Mitigation measures may be required in the post-closure period to address seepage from the waste rock piles and TMF. For example, perimeter ditches can be maintained to collect seepage and to treat it passively using a constructed wetland.

Overflow from the Leprechaun and Marathon pits is expected to be at or below CWQG-FAL and baseline conditions.

Table 7.49 Results of Assimilative Capacity Assessment Post-Closure

Parameter	CWQG-FAL Long-term	Receiver - Victoria River							Receiver - Victoria Lake Reservoir				
		Baseline	TMF Seepage	TMF at Receiver	Marathon Waste Rock Pile	Marathon Waste Rock Pile at Receiver	Marathon Pit	Marathon Pit iat Receiver	Baseline	Leprechaun Waste Rock Pile	Leprechaun Waste Rock Pile at Receiver	Leprechaun Pit	Leprechaun Pit at Receiver
Aluminum (Total), µg/L	100	76.5	73	76.2	**600**	**129**	**120**	80.9	47	**600**	76.3	26	46.2
Arsenic (Total), µg/L	5	0.5	4.1	0.8	**8.8**	1.3	2.2	0.7	0.5	4.1	0.7	0.5	0.5
Cadmium (Total), µg/L	0.04	0.005	0.016	0.006	0.200	0.025	0.015	0.006	0.005	0.059	0.008	0.014	0.005
Copper (Total), µg/L	2	0.7	**96**	**8.8**	**48**	**5.5**	**2**	0.8	0.6	**15**	1.3	**19**	1.3
Iron (Total), µg/L	300	168	190	169	180	169	320	183	59	210	67	110	61.3
Lead (Total), µg/L	1	0.25	0.25	0.3	**2.1**	0.4	0.23	0.2	0.39	0.32	0.4	0.09	0.4
Manganese (Total), µg/L	210	57	190	68	**940**	146	200	71	10	**510**	36	190	17
Phosphorus (Total), µg/L	4	50	50	50	50	50	50	50	50	50	50	47	50
Zinc (Total), µg/L	4-10.2	2.5	4.5	2.7	**71.0**	9.4	5.3	2.8	2.5	**39**	**4.4**	1.5	2.5
Nitrite (N), µg/L	60	9	20	9.9	10	9.1	91	17	14	0.9	13.3	28	14.6
Ammonia (N), total, µg/L	689	25	**2,400**	228	32	25.7	130	35.6	25	5.1	23.9	**1,700**	91.4
Ammonia (N) Unionized, µg/L	19	0.95	**260**	0.61	3.5	0.07	14	0.10	0.95	0.56	0.06	**190**	0.25
Cyanide (Total), µg/L	-	10	81	16.1	10	10.0	8.7	9.9	10	0.22	9.5	2.6	9.7
Cyanide (WAD), µg/L	5	1.0	**64**	**6.4**	1.0	1.0	0.9	1.0	1.0	0.0	0.9	0.4	1.0
Sulphate, µg/L	128,000 [a]	1,000	94,000	8,938	**170,000**	18,088	49,000	5,853	1,000	4,200	1,170	**130,000**	6,114
Fluoride, µg/L	120	60	**190**	71	**1,600**	**216**	69	61	60	**1,600**	**142**	**190**	65

Notes:

Bold indicates value exceeds CWQG-FAL and baseline concentrations in the ultimate receiver.

7.5.2.4 Summary of Residual Effects on Change in Surface Water Quality

Mine contact water discharged from the FDPs will comply with MDMER requirements prior to entering the receiving environment and non-contact water is expected to remain at baseline conditions.

Localized effects are expected in the receiving watercourses and bodies immediately downstream of several FDPs. These local effects will extend into the ultimate receiving waterbodies (Victoria Lake Reservoir, Valentine Lake, Victoria River) for only several hundred meters before water quality is expected to return to either baseline levels or below CWQG-FAL. It is noted that these localized effects may be overestimated due to the conservative approach taken in the supporting water quality modelling and assimilative capacity assessment, further discussed in Section 7.3.5.2. Specific POPC that have been identified as having the largest required mixing zones (i.e., up to 300 m) include aluminum, arsenic, copper, iron, lead, manganese, zinc, and fluoride.

With the implementation of mitigation measures, the residual effects on surface water quality are anticipated to be adverse in direction. Taking into consideration proposed mitigation and management measures, it is predicted that the Project is likely to cause increased concentrations of some POPCs in watercourses downstream of some FDPs, and into the ultimate receivers within the LAA. The magnitude or residual adverse effects is considered low, as predicted changes in water quality at the LAA boundary during construction, operation and closure conditions are within the range of natural variability. The changes in surface water quality are predicted to extend to the boundaries of the LAA, with localized effects experienced within the LAA. Effects will be continuous and both short term (large storms, one-off events) and long term (seepage from waste rock piles and TMF) in duration. Effects on water quality for most of the watercourses / waterbodies assessed are considered reversible as conditions will return to baseline conditions once Project discharges cease. Irreversible effects may occur as a result of seepage from mine infrastructure (TMF and waste rock piles). The ecological context is considered to be disturbed. The ecological function is typical compared to other lake systems in the region and pre-development conditions.

7.5.3 Summary of Project Residual Environmental Effects

Residual environmental effects that are likely to occur as a result of the Project are summarized in Table 7.50. The significance of residual adverse effects is considered in Section 7.6. A proposed program for follow-up and monitoring for surface water resources is provided in Section 7.9.

Table 7.50 Project Residual Effects on Surface Water

Residual Effect	Residual Effects Characterization							
	Project Phase	**Direction**	**Magnitude**	**Geographic Extent**	**Duration**	**Frequency**	**Reversibility**	**Ecological and Socio-economic Context**
Change in Surface Water Quantity	C	A	L	LAA	LT	C	R / I	D
	O	A	L	LAA	LT	C	R / I	D
	D	A	L	LAA	LT	C	R / I	D
Change in Surface Water Quality	C	A	L	LAA	LT	C	R / I	D
	O	A	L	LAA	LT	C	R / I	D
	D	A	L	LAA	LT	C	R / I	D

KEY
See Table 7.28 for detailed definitions

Project Phase
C: Construction
O: Operation
D: Decommissioning

Direction:
P: Positive
A: Adverse
N: Neutral

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area

Duration:
ST: Short term
MT: Medium term
LT: Long term
P: Permanent

N/A: Not applicable

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Reversibility:
R: Reversible
I: Irreversible

Ecological/Socio-Economic Context:
D: Disturbed
U: Undisturbed

7.6 DETERMINATION OF SIGNIFICANCE

A significant adverse residual effect on surface water quantity is defined as a measurable change in hydrological and/or sediment transport regime that:

- Does not meet established instream flow needs (environmental flow thresholds), and
- Contravenes a watershed management target including:
  - an uncompensated loss of fish habitat
  - changes to flow that increase sedimentation and erosion potential in waterbodies receiving flows of surface water runoff exceeding regulatory limits
  - changes to flows that cause flooding downstream of the Project beyond existing conditions
  - changes to pond and lake levels outside the Project Area to a point that it affects their ability to support existing ecological functions.

A significant adverse residual effect on surface water quality is defined as a measurable change in water quality that:

- Exceeds an implemented water quality objective such as MDMER limits or a site-specific water quality guideline for the protection of aquatic life
- Contravenes a watershed management target including:
  - degrading water quality that causes acute or chronic toxicity to aquatic life
  - changes the trophic status of a lake or stream
  - exceeds the generally accepted TSS monitoring guideline (the CCME CWQG-FAL) applied for Project activities

7.6.1 Water Quantity

The residual effects on surface water quantity for the Valentine Lake, Victoria Lake Reservoir and Victoria River receivers are not significant as the predicted changes in MAFs is less than 10%. As discussed in Section 7.3.5.1, the ±10% threshold is selected based on case studies presented by Richter et al. (2011) and guidance provided by DFO (2013), which indicate that a high level of ecological protection is provided when flow alterations are within 10% of the natural flow.

Some predicted changes in MAF for the small tributary watercourses immediately downstream of the FDPs and pre-development watersheds associated with Project features and activities are over 10%, indicating a potential localized residual effect. The effect is considered significant if a decrease of over 10% in MAF is predicted, and the reduced flows do not meet the environmental flow threshold assigned as summer and winter environmental flows. A small number of WSs are not expected to provide sufficient summer and winter environmental flows during the Project phases, and thus experience localized residual effects. These include WS6, WS12, WS13, and WS14 during operation, WS3, WS6, WS12, WS13, and WS14 during closure, and WS6 post-closure. However, the effect on fish habitat from decreased surface water quantity will be mitigated and compensated with the implementation of an offsetting plan, as discussed in Section 8.9.

If changes of MAF are predicted to increase by more than 10% and contravenes a watershed management target, then the effect is considered significant. This includes where the MAF increase may cause flooding downstream of the Project beyond existing conditions, or causes changes to pond and lake levels outside of the Project Area to a point that it affects their ability to support existing ecological functions. These potential effects will be mitigated by constructing water management infrastructure that actuates peak flows through the use of berms, ditching and sedimentation ponds. These sedimentation ponds will attenuate peak runoff rates and allow water to be released over time to extend the period of baseflow augmentation released to the downstream watersheds.

At the LAA boundaries, with mitigation measures and environmental measures applied, residual water quantity changes are predicted to be not significant.

7.6.2 Water Quality

The predicted residual environmental effects on surface water quality are not predicted to be significant as effluent will comply with MDMER requirements at the FDPs and no watershed management targets will be contravened. Local water quality immediately downstream of some FDPs and points of seepage inflow will experience increases of POPC above baseline levels and CWQG-FAL, however, these changes are expected to be contained within the boundaries of the LAA and to be dissipated within 300 m of entering one of the three ultimate receiving waterbodies. .

With mitigation and environmental protection measures applied, the residual environmental effects on the surface water quality are predicted to be not significant.

7.7 PREDICTION CONFIDENCE

The level of confidence in the assessment of residual environmental effects on surface water resources is high. The predicted effects are common to mining operation and are well-understood. As discussed in section 7.3.5.3, a conservative approach to characterizing surface water quantity and quality effects was taken to represent a credible worst-case of environmental effects. However, it is likely that environmental effects of the Project will be less than predicted as a result of the assumptions and conservatism applied in the assessment.

Effects on surface water quantity are assessed based on runoff characterization, changes in effective contributing catchment areas, changes in groundwater discharges, and treated effluent discharges, and are founded upon extensive field monitoring that are supported by comprehensive empirical and deterministic modelling. The effects were quantified using a regional regression relationship developed between catchment areas and flows based on long-term flow records of selected WSC stations, hydrogeology modelling as well as site-wide water balance modelling. Potential effects on water quantity are addressed through standard and site-specific mitigation measures as discussed in Section 7.4.

Effects on surface water quality were assessed with respect to sedimentation and treated process and contact water discharge. Potential effects on water quality were quantified through extensive field monitoring, GoldSim™ water quality modelling, far-field RMA2 and RMA4 hydrodynamic and water quality modelling, and near-field CORMIX modelling. The inputs of the water quality models were generated using conservative approaches from hydrogeology modelling (Appendix 6A), the ARD/ML Phase II Report (BSA.5; Attachment 5-B) and surface water quality data collected from the baseline study (BSA.3, Attachment 3-C). The CORMIX model predicted the water quality within the mixing zone under conservative conditions. The results predicted using mass balance modelling are conservative, as the model does not account for reduction in concentrations due to processes such as sedimentation, reduction / oxidation reaction, absorption and biodegradation. The models used for quantifying the effects on surface water quantity and quality are considered reliable.

7.8 PREDICTED FUTURE CONDITION OF THE ENVIRONMENT IF THE UNDERTAKING DOES NOT PROCEED

The Project is in an area with a long history of mining and mineral exploration, and it is likely that other mining projects would occur in this area if this Project were not to proceed. Future projects are anticipated to have similar effects on surface water resources. Should mineral reserves associated with the Project remain undeveloped, the predicted future condition of surface water resources would be relatively unchanged from what is discussed in the existing environment portion of this assessment, although surface water resources could change over time as a result of climate change.

7.9 FOLLOW-UP AND MONITORING

As part of operation, mine water effluent discharge, recycled tailings water, freshwater makeup, process water, and potable water volumes will be recorded on a daily basis. Gauges will be installed in distribution lines to facilitate flow monitoring. Records will include a monthly total and average volumes. Select monitoring locations will be equipped with real-time monitoring equipment in consultation with the WRMD, NLDECCM, in accordance with a Real Time Water Quality Monitoring Agreement to be established for the Project.

Hydrometric monitoring will be conducted at the FDPs at a minimum accuracy of 15% of the total discharge, according to the flow measurement requirements outlined in MDMER. Flow monitoring will also be conducted at existing streams that are adjacent to the open pits.

Flow monitoring of pumping equipment will also be conducted. This includes the open pit dewatering, water withdrawal from Victoria Lake Reservoir, potable water to the water treatment plant, effluent discharge from TMF, and reclaim and tailings deposition rates. Water levels in sedimentation ponds will be monitored to estimate the daily flow volume discharged from each sedimentation pond. Temperature will also be monitored at FDPs and at watercourses adjacent to Project facilities to better understand effects of the Project on surface water resources.

7.9.1 Surface Water Monitoring Plan

Surface water quality will be affected by runoff in contact with the mine. While no formal limits are assigned in permitting or approvals, parameters listed in Table 7.51 must be monitored at surface water quality monitoring sites during the construction, operation and decommissioning, rehabilitation and closure phases of the Project. Pursuant to the MDMER (subsections 5, 14, and 17), monthly acute toxicity and bi-annual sublethal toxicity testing must also be completed for effluent from the FDPs to support EEM. Effluent and water quality MDMER monitoring requires routine toxicity testing, EEM, and equipment calibration and testing. MDMER monitoring is a regulatory requirement that will be implemented in addition to the preliminary monitoring plan presented here.

Surface water monitoring locations are described in Table 7.51 and shown on Figure 7-45 for the Marathon complex, Figure 7-46 for the Leprechaun complex, and Figure 7-47 for the Process Plant and TMF complex. The monitoring locations may require some adjustments in the field post-construction.

Monitoring locations will characterize water quality at both background and downstream locations (i.e., reference and exposure stations).

The sampling frequency at FDPs may be decreased from monthly to quarterly if the MDMER parameter concentrations are found to be less than 10% of the value set out in column 2 of Schedule 4 for 12 consecutive months. Water quality monitoring stations that are not associated with an FDP will be reevaluated after the first year of operation.

Table 7.51 Surface Water Monitoring Stations and Requirements

Site	Rational	Description	Water Quality Parameters	Monitoring Frequency
MDMER Required Monitoring Stations				
MA-FDP-01A/B	FDP	Stream Val-3 and Stream Val-2 at FDP	General^{A} Acute Toxicity Sublethal Toxicity Flow & Temp. pH	Weekly Monthly Bi-Annually Daily Weekly
MA-FDP-02	FDP	Stream Val-5 at FDP	General^{A} Acute Toxicity Sublethal Toxicity Flow & Temp. pH	Weekly Monthly Bi-Annually Daily Weekly
MA-FDP-03	FDP	Stream Val-6 at FDP	General^{A} Acute Toxicity Sublethal Toxicity Flow & Temp. pH	Weekly Monthly Bi-Annually Daily Weekly
MA-FPD-04	FDP	Stream ViR-8 at FDP	General^{A} Acute Toxicity Sublethal Toxicity Flow & Temp. pH	Weekly Monthly Bi-Annually Daily Weekly
LP-FDP-01	FDP	Wetland connected to Stream VIC-26 at FDP	General^{A} Acute Toxicity Sublethal Toxicity Flow & Temp. pH	Weekly Monthly Bi-Annually Daily Weekly
LP-FDP-02	FDP	Effluent Discharge to Stream VIC-26 at FDP	General^{A} Acute Toxicity Sublethal Toxicity Flow & Temp. pH	Weekly Monthly Bi-Annually Daily Weekly

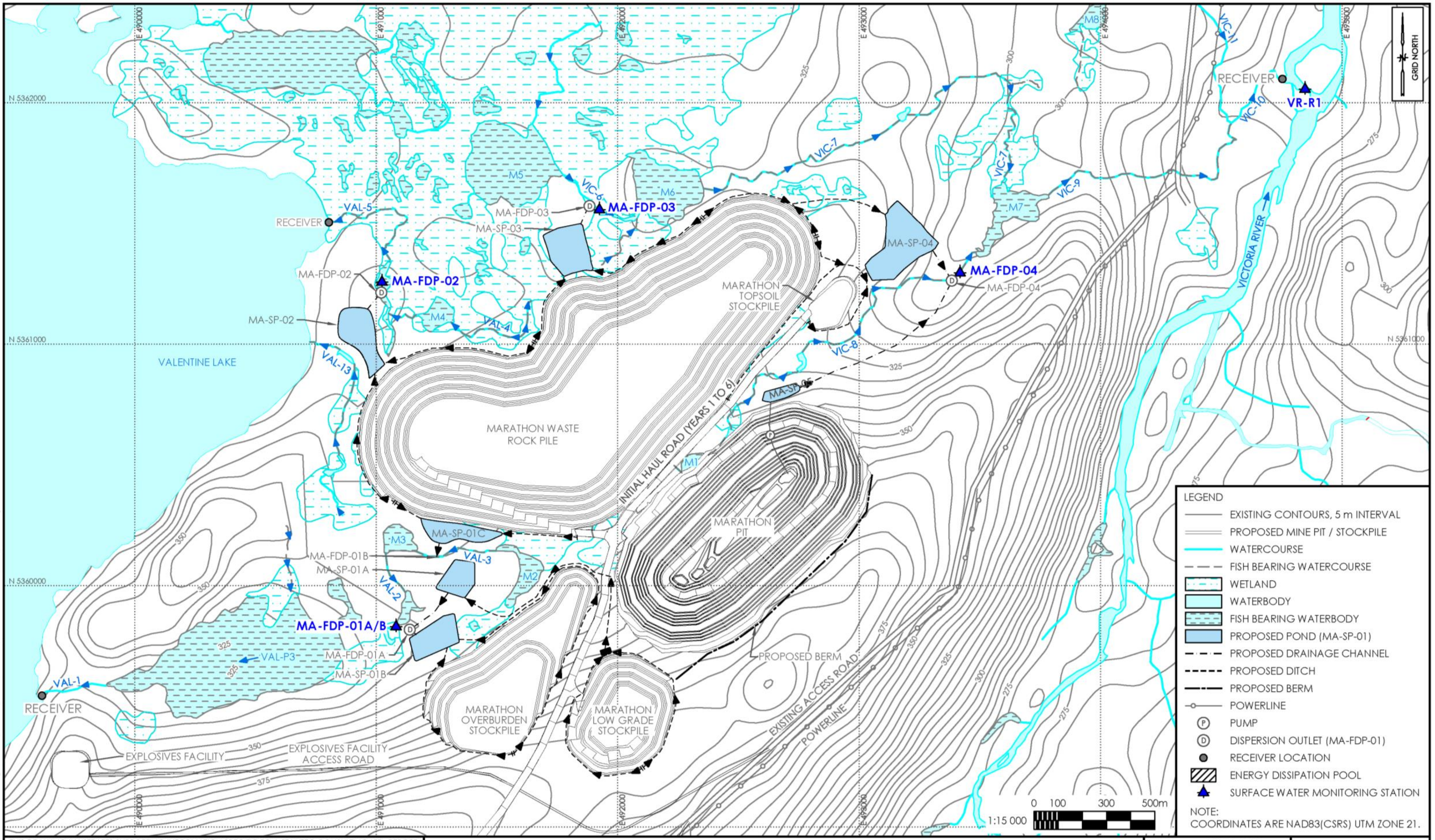
Table 7.51 Surface Water Monitoring Stations and Requirements

Site	Rational	Description	Water Quality Parameters	Monitoring Frequency
LP-FDP-03	FDP	Conveyance Channel to Victoria Lake Reservoir at FDP	General^{A} Acute Toxicity Sublethal Toxicity Flow & Temp. pH	Weekly Monthly Bi-Annually Daily Weekly
LP-FDP-04	FDP	Stream Vic-17 at FDP	General^{A} Acute Toxicity Sublethal Toxicity Flow & Temp. pH	Weekly Monthly Bi-Annually Daily Weekly
LP-FDP-05	FDP	Pond VIC-P2 at FDP	General^{A} Acute Toxicity Sublethal Toxicity Flow & Temp. pH	Weekly Monthly Bi-Annually Daily Weekly
PP-FDP-01	FDP	Polishing Pond	General^{A} Acute Toxicity Sublethal Toxicity Flow & Temp. pH	Weekly Monthly Bi-Annually Daily Weekly
PP-FDP-02	FDP	Pond Vic-L2 at FDP	General^{A} Acute Toxicity Sublethal Toxicity Flow & Temp. pH	Weekly Monthly Bi-Annually Daily Weekly
To Characterize Background and Reference Sites				
VR-R1	Reference	Victoria River – 100 m upstream of receiver location	General^{A}	Monthly
Val-R1	Background	Valentine Lake - upstream	General^{A}	Monthly
VIC-R1	Background	Victoria Lake Reservoir - upstream	General^{A}	Monthly
VR-R2	Background	East Tributary of Victoria River at headwaters	General^{A}	Monthly
To Assess Environmental Effects of Mine				
C001a	Downstream	Downstream of TMF site in stream ViR14	General^{A}	Monthly
TMF3	Downstream	Downstream of TMF site in stream ViR33	General^{A} and TSS	Monthly

Table 7.51 Surface Water Monitoring Stations and Requirements

Site	Rational	Description	Water Quality Parameters	Monitoring Frequency
SCD1	Downstream	Seepage Collection Ditch – East side of TMF	General[A] Flow & Temp.	Monthly Daily
SCD2	Downstream	Seepage Collection Ditch – South side of TMF	General[A] Flow & Temp.	Monthly Daily
SCD3	Downstream	Seepage Collection Ditch - South side of TMF	General[A] Flow & Temp.	Monthly Daily
SCD4	Downstream	Seepage Collection Ditch - West side of TMF	General[A] Flow & Temp.	Monthly Daily
VIC-27	Downstream	Downstream of FDP PP-FDP-01	General[A]	Monthly
VAL-19	Downstream	East of Leprechaun Pit	Flow & Temp.	Daily
VIC-29	Downstream	North of Leprechaun Pit	General[A] Flow & Temp.	Monthly Daily
VIC-25	Proximity to roadway	Adjacent to Haul Roads - Leprechaun Complex	TSS	Monthly

Notes:
A - General parameters to be monitored in accordance with MDMER:
Total Aluminum, Total Arsenic, Total Cadmium, Total Copper, Cyanide, WAD Cyanide, Fluoride, Total Fluoride, Total Iron, Total Lead, Total Manganese, Nitrite, Nitrogen Ammonia, Unionized Ammonia, pH, Phosphorus, Sulphate, TSS, Total and Dissolved Zinc, Hardness and Sodium



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Reference:

1. EXISTING CONTOURS AND PROPOSED INFRASTRUCTURE: AUSENCO; PROJECT No. 104878-01; DRAWING No. 104878-0000-G-001; 2020-05-11; PRELIMINARY.
2. WATERCOURSES, WATERBODIES & WETLANDS: CANVEC DATABASE FROM NATURAL RESOURCES CANADA.
3. FISH BEARING WATERCOURSES AND WATERBODIES: SURVEYED FISH BEARING OR HAS CONNECTIVITY TO FISH BEARING WATER (STANTEC 2012, 2019, 2020).

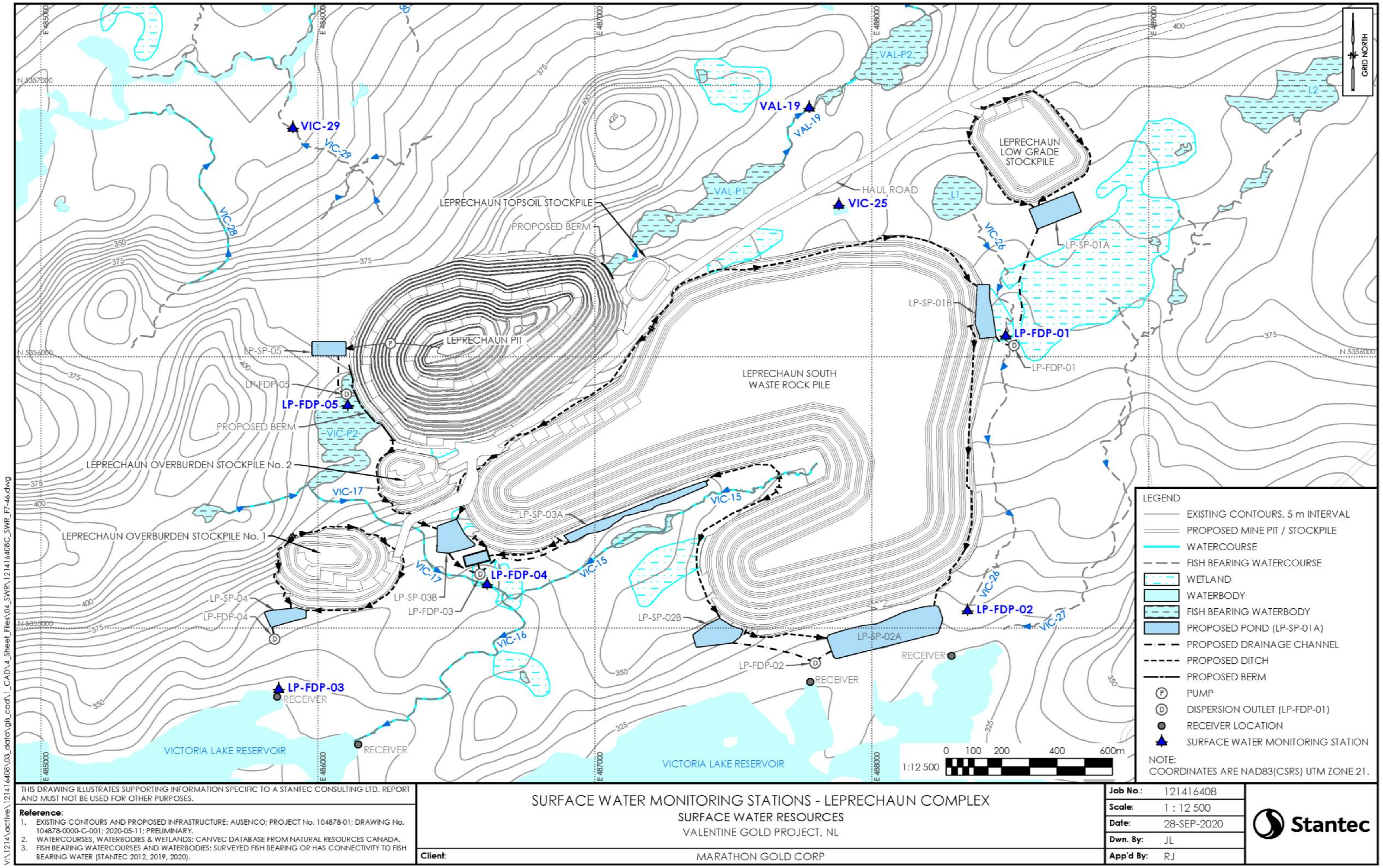
SURFACE WATER MONITORING STATIONS - MARATHON COMPLEX
SURFACE WATER RESOURCES
VALENTINE GOLD PROJECT, NL

Client: MARATHON GOLD CORP

Job No.:	121416408
Scale:	1 : 15 000
Date:	28-SEP-2020
Dwn. By:	JL
App'd By:	RJ

Stantec

Figure 7-45 Surface Water Monitoring Stations – Marathon Complex



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2. WATERCOURSES, WATERBODIES & WETLANDS: CANVEC DATABASE FROM NATURAL RESOURCES CANADA.
3. FISH BEARING WATERCOURSES AND WATERBODIES: SURVEYED FISH BEARING OR HAS CONNECTIVITY TO FISH BEARING WATER (STANTEC 2012, 2019, 2020).

SURFACE WATER MONITORING STATIONS - LEPRECHAUN COMPLEX
SURFACE WATER RESOURCES
VALENTINE GOLD PROJECT, NL

Client: MARATHON GOLD CORP

Job No.:	121416408
Scale:	1 : 12 500
Date:	28-SEP-2020
Dwn. By:	JL
App'd By:	RJ

Figure 7-46 Surface Water Monitoring Stations - Leprechaun Complex

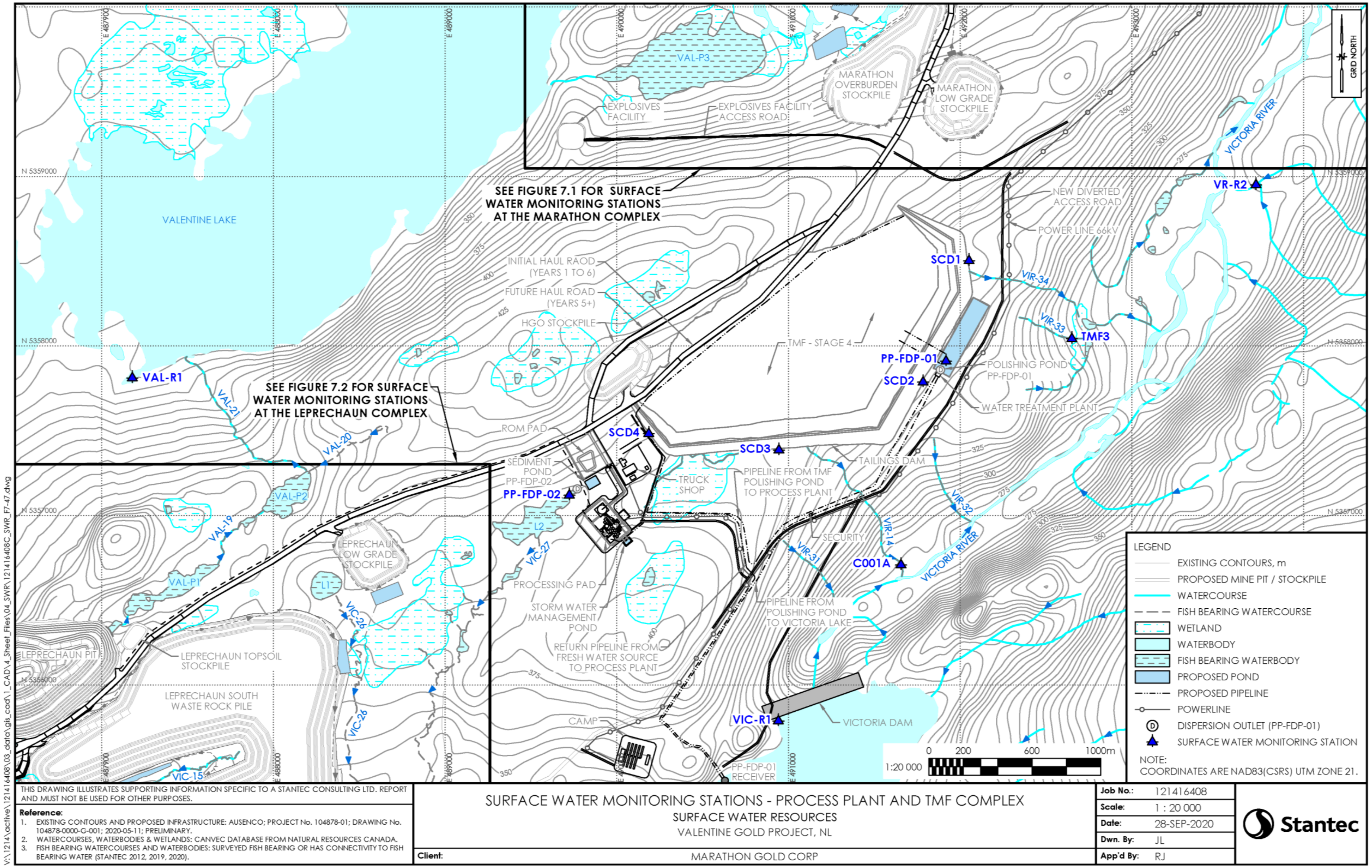

Figure 7-47 Surface Water Monitoring Stations – Process Plant and TMF Complex

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