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7 – WATER QUALITY

7.1 INTRODUCTION

7.1.1 Regional Setting

The proposed Casino Project will be an open pit mine and concentrator extracting the porphyry copper-molybdenum-gold deposit in the Dawson Range, approximately 300 km northwest from Whitehorse in the Yukon Territory. The project is located at about 1300 m elevation on the catchment divide between the Casino Creek and Canadian Creek watersheds. Casino Creek drains southwest into Dip Creek and eventually into the White River, a tributary of the Yukon River. Canadian Creek drains north into Britannia Creek and then into the Yukon River.

The Project is located within the Boreal Cordillera ecozone, which comprises much of the southern Yukon and a large portion of northern British Columbia. The Boreal Cordillera ecozone is characterized by the presence of several mountain ranges, including the Dawson Range, that trend in the north-westerly direction and include extensive plateau regions. The climate is characterized by long, cold, dry winters and short, warm, wet summers, with conditions varying according to altitude and aspect. Average annual precipitation is generally quite low, with values in the range of 300 mm to 450 mm (Smith, Meikle, and Roots 2004).

The current open pit layout is mostly located in the Casino Creek watershed with the northwestern footprint of the pit intercepting the headwaters of Canadian Creek at Year 10 of operations. The proposed major mine infrastructure including the mill and concentrator, gold heap leach facility, tailings/waste rock facility, power station, workshops and accommodation are all located in the Casino Creek watershed. Only the airstrip, located in the Dip Creek watershed, is located outside of the Casino Creek watershed. Gold will be extracted from the deep oxidised cap via a conventional cyanide heap leach operation which will cease stacking in Year 15. Copper, silver and molybdenum concentrates will be produced from a conventional grinding mill and flotation circuit capable of processing around 120,000 tonnes of ore per day. Access for the transport of equipment, fuel and supplies to site and transport of concentrate from site will be by a proposed upgrade and extension of the existing Freegold Road from Carmacks.

All waste rock, tailings and supernatant water will be stored in a valley-fill type tailings management facility (TMF) located in the headwaters of Casino Creek. The TMF has been sized to store sub-aqueously all of the tailings and waste rock, which are capable of leaching metals and are potentially acid generating (PAG). During operations the TMF will store all water originating from upstream of the TMF embankment, including decant from the concentrator, seepage from the ore stockpiles and runoff from its undisturbed catchment. Furthermore, seepage water losses from the TMF and runoff from the TFM embankment shell will be collected and pumped back into the TMF.

The area of the ore deposit, referred to as Patton Hill, has been greatly disturbed by exploration activity over the past several decades, which has had an effect on baseline water quality in Casino Creek. Numerous baseline studies have been conducted in the proposed Project area, including surface water and sediment quality (Appendix 7A), hydrology (Appendix 7B), and hydrogeology and groundwater quality (Appendix 7C), with the overall goal of assembling a comprehensive understanding of baseline conditions for the Project. This information then provides a basis for the quantitative assessment of effects of mine development, operations and closure on water quality.

The assessment of Project related effects on water quality relies upon the characterization of water quality related parameters and activities during all phases of the project. This information is presented in the YESAB Water Balance Report (Appendix 7E), Water Quality Predictions Report (Appendix 7F), Air Quality Effects Assessment (Section 8), Project Description (Section 4) and Water Management Plan (Appendix 4D). Set guidelines (i.e. Canadian Water Quality Guidelines for Protection of Aquatic Life from the Canadian Council of Ministers of the Environment (CCME 2013)) are used as key indicators during the assessment to determine whether or not an effect is likely to occur.

7.1.2 Rationale for VC Selection

Water quality was selected as a VC in order to assess the potential effects of the proposed Project on the health of aquatic ecosystems. Water quality forms one of the vital links between the abiotic and biotic environments, and is the foundation for supporting and maintaining healthy ecological processes for a rich and varied community of users (e.g., fish, wildlife, humans). Discharge of effluent from metal mines to surface waters is regulated under the *Fisheries Act* through the *Metal Mine Effluent Regulation* (MMER, 2002). Canadian Council of Ministers of the Environment (CCME) (1987; 1999a, b; 2001; 2002; 2003, 2011, 2012) and British Columbia Ministry of Environment (BC MOE) (1986, 1998, 2001a, b, 2011, 2013) have guidelines for the protection of freshwater aquatic life at a point downstream of a dilution zone. Guidelines are not regulatory instruments but are triggers for action if not met. Site-specific water quality objectives are alternative guidelines that may be set.

Changes in groundwater quality that may affect aquatic life water use is regulated under Yukon Contaminated Sites Regulation. It is important to note that a groundwater VC was not identified for the proposed Project (as described in Section 5). Results of the Hydrogeology Baseline Assessment (Section 7C) did not identify any groundwater users or significant groundwater resources in the Project area, and concluded that all groundwater flow would ultimately discharge to surface water or to the TMF. Therefore, potential effects from changes in groundwater quality will be captured in the surface water VC and addressed through the overall water quality effects assessment.

Sediment has been considered, and will be an important monitoring component, but is also not assessed as a VC. It is predicted that there will be limited potential for interaction between the Project discharges and sediment quality as the receiving water bodies for the Casino Project are streams with moderate or high flows. Flowing streams are not susceptible to changes in sediment quality as regular freshets flush fine-grained sediment from the stream bed. In addition, any discharge to the receiving environment would have metals in the dissolved phase and would therefore not settle out in receiving environment streams. While effects on sediment quality are unlikely, any potential effects would be covered through the assessment of surface water quality.

Results of the assessment of effects on water quality will be used to support the assessment of potential effects on fish and aquatic resources, wildlife, and human health. The indicators selected to assess changes in water quality are acidity, alkalinity, metals, sulphate, cyanide and nutrients.

7.2 ASSESSMENT BOUNDARIES

7.2.1 Spatial Boundaries

7.2.1.1 Local Study Area (LSA)

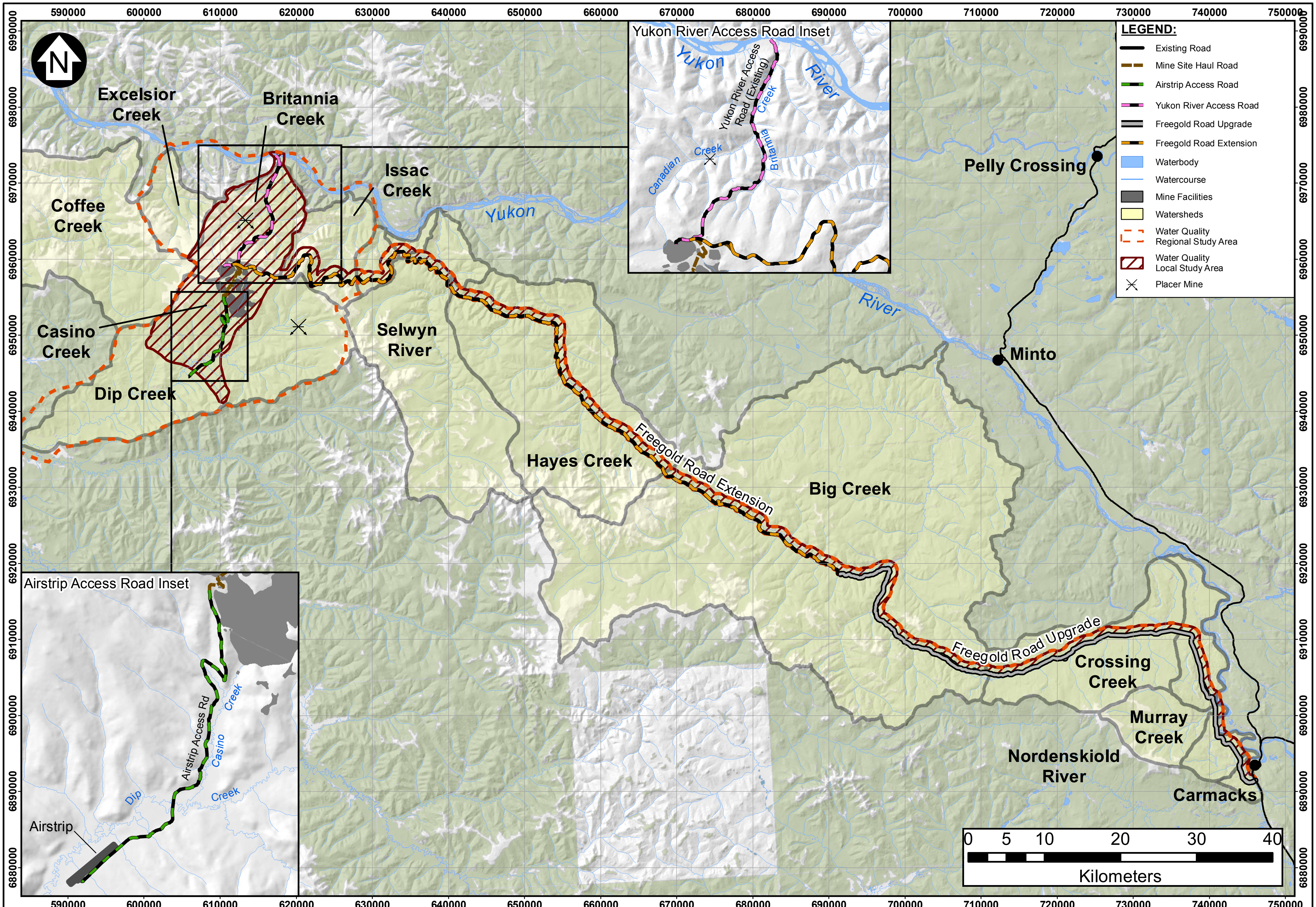
The LSA is the spatial area within close proximity to the project under review where direct effects are anticipated. For the Casino Project, the water quality LSA is defined by the boundaries of the two watersheds surrounding the Project deposit (also known as Patton Hill): the Britannia Creek watershed to the north and the Casino Creek watershed to the south. The LSA also includes a 5 km-long reach of Dip Creek downstream of its confluence with Casino Creek, several Dip Creek tributaries within the airstrip and airstrip access road footprint, and several watersheds along the Freegold Road corridor which extends from the Village of Carmacks to the Casino Project. The LSA surrounding the airstrip, airstrip access road, and Freegold access road is defined as 100 m upstream and 1000 m downstream of any stream crossing. The boundaries of the LSA are shown as the brown shaded area on Figure 7.2-1.

Most of the proposed mine infrastructure will be in the Casino Creek watershed, with some (e.g., the northern corner of the open pit) found within the Canadian Creek watershed. The northern part of the LSA is drained by Britannia Creek and its main tributary, Canadian Creek, which flow northward into the Yukon River. The southern part of the property is drained by Casino Creek which flows south to Dip Creek and thence to the Yukon River via the Klotassin, Donjek and White rivers. The Freegold Road corridor crosses several major and minor watersheds, beginning with the Nordenskoild River just west of Carmacks, followed by Crossing Creek, Big Creek, Selwyn River and Hayes Creek, and Sunshine Creek.

7.2.1.2 Regional Study Area (RSA)

The RSA is the spatial area within which cumulative effects are assessed; it extends a distance from the project footprint in which both direct and indirect effects are expected to occur (Hegmann et al. 1999). The RSA encompasses an area large enough to consider most regional pressures (YESAB 2006a).

The water quality RSA was defined as the LSA plus adjacent areas that have the potential to experience either indirect (mid-to-far field), or cumulative effects due to interactions with other projects. The boundaries of the RSA are delineated by the orange dashed line on Figure 7.2-1.



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NOTES:

1. BASE MAP: Digital Elevation Model and 1:250,000 and 1:50,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca)
2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:650,000

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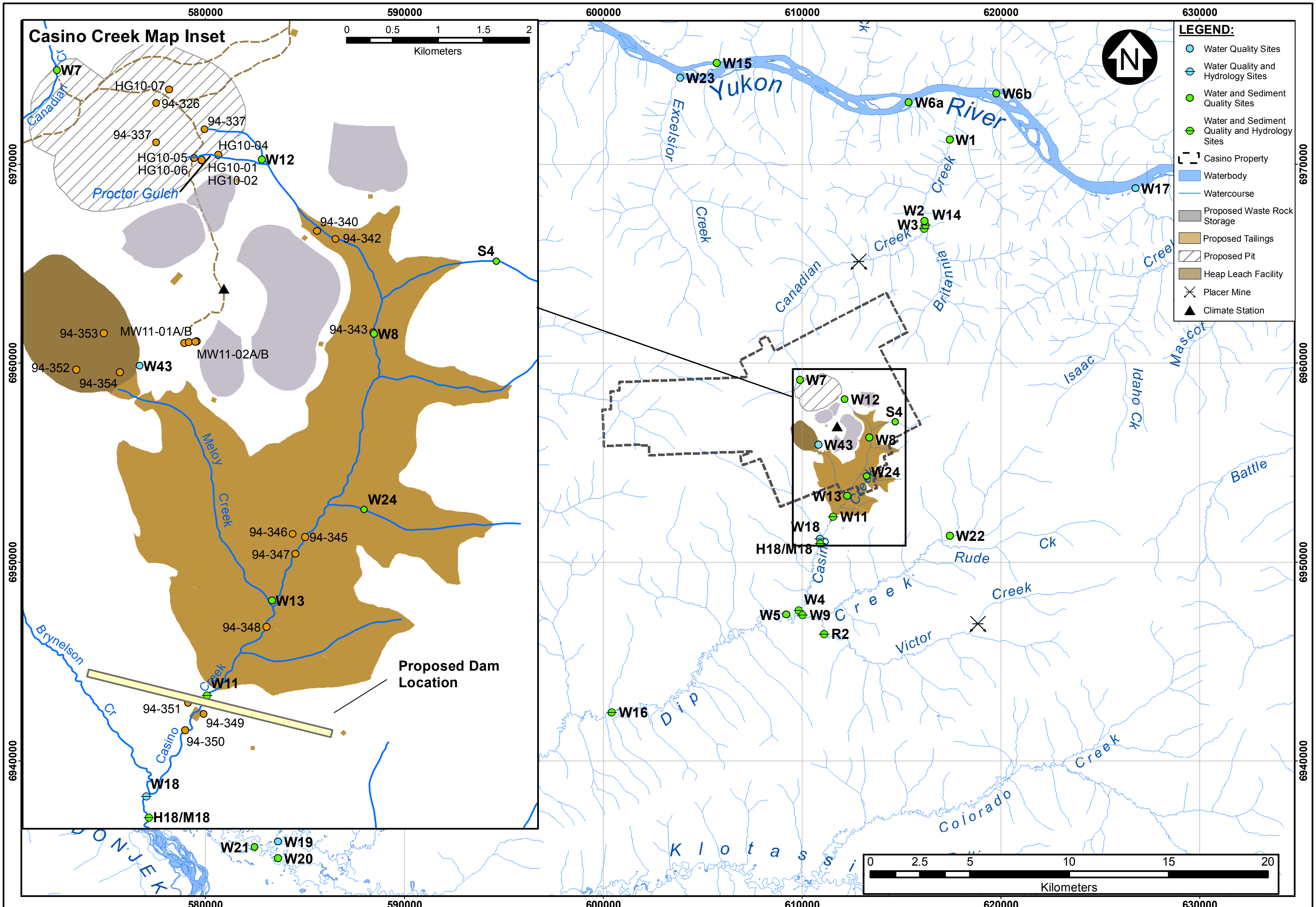
Water Quality Regional and Local Study Area

FIGURE 7.2-1

REF

P/A VA101-325/15



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3. COORDINATE GRID: METRES
4. SCALE: 1:250,000

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CASINO PROJECT

Surface Water Quality, Sediment Quality, Hydrology and Groundwater Quality Baseline Monitoring Sites

FIGURE 7.2-2

REF	REPORT 1
P/A	VA101-325/15

7.2.2 Temporal Boundaries

The temporal boundaries for the water quality effects assessment are the same as those defined in Section 5.2 of the Proposal as the life of the Casino Project. In addition, there are sub-phases to the Closure and Decommissioning and Post-Closure periods specific to water management and directly relevant to the water quality effects assessment (Appendix 4D). The overall temporal boundaries are:

- Construction (C): Years -4 to -1
- Operations (O): Years 1 to 22
- Closure and Decommissioning (CD): Years 23-25
- Post-Closure (PC): Years 26-30+
  - Water Management Plan (WMP) Closure Phase I (Years 23 to 30 – prior to TMF Discharge);
  - WMP Closure Phase II (Years 31 to 114+ - prior to Open Pit discharge); and
  - WMP Closure Phase III (Years 114 to 200).

Details on activities associated with these phases can be found in Section 4 and Appendix 4D.

7.3 BASELINE CONDITIONS

A complete understanding of baseline water quality conditions requires background information on climate, hydrology, hydrogeology, and surface water and sediment quality.

7.3.1 Climate

Climate data were collected on-site at the Casino Climate Station located in the upper Casino Creek watershed at an elevation of 1,200 m. The period of site record extends from 1993 to 1994, and from 2008 to present. The site temperature and precipitation data were compared to the long-term record from the Meteorology Service Canada (MSC) climate station at Pelly Ranch, located 80 km to the east at an elevation of 454 m, to develop long-term synthetic climate records for the Project. The long-term synthetic precipitation series was then refined using the Casino Watershed Model (Appendix 7E), and summary statistics were finally computed from the resultant data series.

Mean annual temperatures for the long-term regional stations range from -6°C to -3°C, while mean monthly temperature are warmest in July and coldest in January, with values ranging from 14°C to 16°C and -25°C to -28°C, respectively. The long-term mean annual temperature at the Casino climate station estimated from the synthetic temperature series is -3.2°C, which is at the upper end of the regional range. The mean July temperature at the Project site is 11.4°C, which is 3°C to 5°C cooler than the regional stations. The mean January temperature at the Project site is -18.0°C, which is 8°C to 11°C warmer than the regional stations. These differences between the Casino and regional temperature series are consistent with the much higher elevation of the Project site, compared to the regional stations. The maximum and minimum temperatures recorded at the Casino climate station between 2008 and 2012 are 26°C and -40°C, respectively. Based on the site data and the Pelly Ranch estimates, the estimated long-term extreme temperatures for the Casino climate station are 30°C and -50°C.

Mean monthly precipitation at all long-term regional stations is greatest during the summer months of June through August and lowest during the late winter months of February through April. Most of the precipitation falls in the form of snow during the months of November through March, and in the form of rain during the months of May through September. During the shoulder months of April and October, mixed rain and snow conditions occur, although typically snow is more common. The long-term estimated mean annual precipitation at the Casino climate station is estimated to be approximately 460 mm, of which 305 mm (66%) falls as rain and 155 mm (34%) falls as snow. Estimates of long-term mean monthly precipitation for the Project site range from 13 mm in April to 91 mm in July.

Mean annual wind speed at the Casino climate station is 2.3 m/s (8.3 km/hr). The mean monthly wind speeds are higher in the spring, summer and autumn and lower in the winter, with values ranging from 1.7 m/s in November to 2.7 m/s in May. The maximum hourly wind speed recorded between 2008 and 2012 was 14.9 m/s (53.6 km/hr). The predominant wind direction was northerly, followed by south-westerly.

Snow Water Equivalent (SWE) measurements recorded at Yukon Environment snow course 09CD-SC01 show that the mean annual maximum SWE over the period of record is 142 mm. The estimated mean monthly snowmelt volumes for the Casino snow survey station in April and May are 22 mm and 120 mm, respectively. The site wide estimate of mean monthly snowmelt for an elevation of 1200 m predicts a mean monthly May snowmelt of 87 mm and mean annual SWE of 100 mm. The lower site-wide SWE values are consistent with the differences in vegetative cover, and their associated effects on snow accumulation and sublimation, between the snow survey location and the greater project area. Detailed baseline information is contained in the Climate Baseline Report (Appendix 8A).

7.3.2 Hydrology

Ten hydrometric monitoring stations have been operated in the Project area at various times since 2008, with three located in the Canadian and Britannia Creek watersheds and seven in the Casino and Dip Creek watersheds. Station W16, located on lower Dip Creek, has the largest monitored watershed at 384 km^2, while stations W18 and W11, located within the Casino Creek watershed, are the smallest monitored watersheds at 25 km^2 and 39 km^2, respectively.

Long-term streamflow estimates in the Casino Project area were developed by comparing the available Project data (2008-2012) with regional streamflow stations operated by Water Survey of Canada (WSC). Mean annual unit runoff in regional watersheds range between 2.8 $l/s/km^2$ and 9.2 $l/s/km^2$. Streamflow in the region is typically highest in May due to melting of the winter snowpack. Flows are usually sustained at moderate to high levels in the summer months due to the influence of rainfall combined with melting permafrost, followed by receding and low flows in the colder fall and winter months. Flows decrease throughout the winter and minimum flows typically occur in March or early April.

The resulting mean monthly and mean annual long-term synthetic flow estimates illustrate the following patterns:

- Mean annual unit runoff at the nine active Project monitoring stations ranges between 4.3 $l/s/km^2$ and 5.8 $l/s/km^2$, with an average of 5.2 $l/s/km^2$ (~165 mm annual runoff); and
- Maximum monthly unit runoff occurs in May, June, or July depending on the station, with maximum mean monthly values ranging between 12.0 $l/s/km^2$ and 16.5 $l/s/km^2$.

Since the vast majority of the potential effects to water quality are assessed in the Casino and Dip Creek watersheds, the baseline mean monthly discharge at stations W4 on Casino Creek, and W5 on Dip Creek, are summarized in Table 7.3-1. Monthly average discharge for station W5, which is not a hydrometric station, was calculated by combining the average discharges at stations W9 (Dip Creek, upstream of Casino Creek) and W4 (Casino Creek, upstream of the confluence with Dip Creek). Detailed baseline information is contained in the Hydrology Baseline Report (Appendix 7B).

Table 7.3-1 Mean Monthly Discharge at Stations W4 and W5

Station	Mean Monthly Discharge (m^3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
W4	0.05	0.03	0.03	0.18	0.99	0.79	1.05	0.80	0.74	0.41	0.20	0.10	0.45
W5	0.12	0.08	0.07	0.53	3.42	3.13	4.25	3.02	2.42	1.21	0.51	0.24	1.58

7.3.3 Surface Water Quality

Detailed baseline information is contained in the Water and Sediment Quality Baseline Report (Appendix 7A). The Casino Project aquatic study area is defined by the boundaries of the two watersheds surrounding the ore body: the Britannia Creek watershed to the north and the Dip Creek watershed to the south. Current baseline sampling stations were based on sampling stations from the 1993-1995 baseline studies. A total of 26 stations between 2008 and 2012 were chosen for water quality sampling. Stations were concentrated in the Casino Creek (a tributary to Dip Creek) and Britannia Creek watersheds as they have the potential to be directly affected by the Project. Himmelright (1994) indicated natural sources of acid rock drainage (ARD) exist near the mineral deposit and that their effects are seen most clearly in Proctor Gulch, a tributary that flows into upper Casino Creek. Elevated metal concentrations and high acidity from Proctor Gulch are major contributors to the chemistry in the surface waters of Casino Creek. Other sources of ARD include groundwater that flows directly into upper Canadian Creek (a tributary to Britannia Creek) and groundwater that discharges from a historical adit via a pipe to upper Meloy Creek and onward to Casino Creek.

Water samples were collected and analyzed for the full suite of physical parameters, anions, nutrients and total and dissolved metals. Minimum, mean, median and maximum concentrations were calculated for each parameter at all stations. Exceedances of the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of freshwater aquatic life were observed for a total of ten parameters (copper, cadmium, aluminum, iron, uranium, fluoride, zinc, lead, pH and silver) throughout the project area. The number of exceedances was highest for aluminum, cadmium, copper and iron. With the exception of uranium, exceedances were most numerous in the summer season (May to October), indicating a seasonal trend likely related to hydrological factors.

Nutrient levels at all stations were below CCME guidelines, with approximately 20-70% of all ammonia, nitrite, nitrate, nitrate+nitrite-N, total phosphate and orthophosphate concentrations below analytical detection limits. Levels of many metals and anions were consistently low, with concentrations equal to or lower than analytical detection limits observed for 50% to 90% of the samples, including those for beryllium, boron, bismuth, bromide, chloride, mercury, tin, silver, titanium, thallium, vanadium and zirconium in all study areas.

The 2008-2012 water quality program confirmed the unique water chemistry of Proctor Gulch documented in Himmelright (1994). Exceedances of CCME guidelines for pH, copper, aluminum and iron were found in 100% of the 16 samples from Proctor Gulch. Fluoride, cadmium, lead and zinc were also elevated in samples from Proctor Gulch. Additionally, water quality at this station exhibited highest values for acidity (and lowest pH), hardness, conductivity, total dissolved solids and turbidity, as well as lowest values for alkalinity.

Spatially, it was observed that copper, aluminum and iron concentrations were highest at Proctor Gulch (W12) and decreased at each successive downstream station (W8, W11 and W4). This indicates that inflows from Casino Creek tributaries including Meloy Creek, Brynelson Creek and Austin Creek, effectively dilute the water from Proctor Gulch. Proctor Gulch consistently shows higher concentrations in the winter than in the summer for all the metals as groundwater is the major source of flow in the winter months.

An adit established as part of historical (between 1965 and 1980) access to a lead/zinc/silver deposit in the upper Meloy Creek watershed discharges groundwater mostly in the spring and summer months (approximately May to August). This station (W43) was found to have the highest concentrations of cadmium, lead, silver and zinc of all the stations sampled. However, due to the relatively small flow from the adit, only one cadmium sample (0.00004 mg/L in April 2011) resulted in the exceedance of CCME guidelines in the lower reach of Casino Creek at W4.

Some effects from Proctor Gulch and the historical adit are observed in Dip Creek at station W5, just downstream of Casino Creek, particularly for copper, cadmium, lead and zinc; however, the effects are greatly reduced in comparison with Casino Creek as background concentrations for these metals are much lower in the upstream Dip Creek watershed. Although less pronounced an overall similar spatial pattern of upstream to downstream decreasing concentrations of cadmium, zinc, copper, aluminum, iron and lead was also observed in Canadian Creek and Britannia Creek. The uppermost station on Canadian Creek (W7) is situated in close proximity to the ore body and therefore likely receives groundwater discharge with similar water quality to Proctor Gulch.

On the whole, hardness, conductivity and nitrogen based nutrients were higher in the winter months. Conversely, total suspended solids (TSS), phosphorus based nutrients, organic matter and metal concentrations were higher in the summer months for the majority stations, indicating a seasonal trend most likely related to the different primary sources of streamflow (surface runoff during the summer and groundwater discharge during the winter) between these two seasons.

7.3.3.1 Determination of Natural Baseline Conditions

The evaluation of potential effects on water quality often requires the development of alternative water quality objectives, such as site-specific water quality objectives (SSWQOs). However, before SSWQOs can be developed for potential contaminants of concern, it is necessary to determine whether or not the baseline water quality is actually natural. For the Casino Project, this determination focuses on the two acid rock drainage sources identified in the Water and Sediment Baseline Report (Appendix 7A), and discussed in Section 7.3.3. The two sources in question are the discharge from the historical adit (Site 43) located in upper Meloy Creek and the disturbances up slope from Proctor Gulch (Site W12), a tributary located in the headwaters of Casino Creek. Development of SSWQOs must be based on natural baseline conditions and not influenced by anthropogenic sources.

Proctor Gulch has been documented as a naturally occurring tributary that drains the south-eastern side of the mineralized zone of Patton Hill. According to a report prepared for Pacific Sentinel Gold Corporation on the effect of natural acid rock drainage on Casino Creek by Himmelright (1994), Proctor Gulch has a nearly neutral pH of around 6.4 before it intermittently disappears underground, where it is presumed to pass through the Casino Fault; when the water re-emerges, its chemistry changes considerably, with a drop in pH to pH 3.5 and increases in metal content. This natural acid rock drainage then flows into Casino Creek, where water is approximately neutral prior to mixing with Proctor Gulch discharge (pH 7.22 measured in 1994 and pH 7.16 measured in 2011). Since there doesn’t appear to be an anthropogenic cause for the water quality in Proctor Gulch, it is considered to be a natural contribution to the Casino Creek watershed.

The historical adit is located in upper Meloy Creek watershed. Water discharges via a pipe to surface only during the spring and summer months and is frozen from October to April. At the point of discharge it travels down the watershed for roughly two kilometres before joining Meloy Creek proper. The adit is a remnant of historical mining activities and as such, is considered an anthropogenic source of water. For development of SSWQOs, a preliminary analysis was conducted to assess whether or not the adit had any effects on the water quality of lower Casino Creek at Site W4.

Accounting for Loadings from the Adit

Quantifying the loading of the adit water to Casino Creek was carried out by comparing water quality data sets of the adit water (W43) and lower Casino Creek before discharge into Dip Creek (W4) on the two sampling events where flow and quality were measured at both sites, in August 2011 and October 2011. Flow at W43 was measured by filling a bucket with water from the adit and recording the number of seconds it took to fill it to a known volume. Average flow at W43 on August 23, 2011 was 0.8 L/s and October 4, 2011 was 0.41 L/s. Discharge at W4 was based on the streamflow record, which is calculated by applying the rating curve (developed from the manual point discharge measurements) to the continuous water level recorded at the station (Appendix 7B). Flow/discharge values were multiplied by the concentrations to obtain a load in milligrams per second. Loadings from W43 were then subtracted from W4 and an adjusted concentration was calculated.

With the exceptions of cadmium and zinc and to a lesser degree, dissolved lead, the adjusted concentrations were only marginally lower than the original concentrations. On average, the adjusted concentrations for all the other parameters were close to 100% of the unadjusted concentration (on average 99.7%, with a min to max range of 93.5% to 100.0%). This means that virtually no loading of these parameters are contributed by the adit and it appears that the adit has a negligible impact to Casino Creek for the majority of the parameters tested (i.e. the entire suite of parameters analysed for the 2008-2012 baseline program). Therefore, the concentrations of these parameters already represent natural baseline conditions and do not need to be adjusted.

It does appear, however, that the adit water is a significant contributor of cadmium and zinc and possibly dissolved lead. On both sampling events, estimated cadmium and zinc loadings at W4 are similar to loadings at W43, indicating that the adit is likely the major source of these metals (nearly 100% of the load is from the adit). Although it appears that the adit water contributes most of the cadmium and zinc loadings to Casino Creek, it is also important to consider that there may be some geochemical solubility control in Meloy or Casino Creek that is removing cadmium and zinc. Despite this unknown, it is abundantly clear that only cadmium, zinc and possibly lead, are influenced by the adit discharge. Therefore, any development of SSWQOs for the Casino Project will take into consideration that the current baseline conditions in Casino Creek incorporate a loading of cadmium, zinc and lead that is from an anthropogenic source.

7.3.4 Groundwater Quality

Detailed baseline information is contained in the Hydrogeology Baseline Report (Appendix 7C). Groundwater chemistry is variable throughout the Project area and has been characterized in terms of the proposed Open Pit area, the hillslope area, and the Casino Creek valley area. As shown in Figure 7.2-2, water quality samples were collected from 20 groundwater quality monitoring wells that were strategically installed in the vicinity of and down gradient of key proposed project facilities, which include the Ore Stockpiles, Open Pit, TMF, and Heap Leach Facility (HLF).

The ion characterization of the groundwater samples from the proposed Open Pit area identified calcium and sulphate as the dominant ions, and the dominant ion composition of samples collected from the hillslope area was calcium and bicarbonate. Groundwater chemistry of samples collected from the Casino Creek valley area were generally interpreted as intermediate to that of the hillslope and proposed Open Pit areas. The groundwater ion characterization varied along the Casino Creek valley but samples were generally dominated by calcium, bicarbonate, and sulphate in the upper limits of the valley, calcium, magnesium, bicarbonate, and sulphate through the middle of the proposed TMF area, and calcium and bicarbonate in the vicinity of the proposed TMF embankment.

The deposit is a sulphidic ore body and sulphate has been measured at very high concentrations in this area (up to 1,100 mg/L). Mean total dissolved solids (TDS) concentrations are indicative of groundwater that is moderately to highly mineralized. In the proposed Open Pit area, significant variability in groundwater metals and metalloid concentrations was observed between samples collected from the Proctor Gulch monitoring wells and from monitoring well 94-337. The variability in the ore body geochemistry results in groundwater with low pH and moderate hardness in the vicinity of 94-337 and neutral pH and very hard water in the Proctor Gulch area. In the samples from 94-337, cadmium, cobalt, copper and zinc were detected at concentrations that exceeded the Yukon Contaminated Sites Regulation (YCSR) limits, and aluminum and iron were detected at concentrations that exceed the Canadian Environmental Quality Guidelines - Water Quality Guidelines for the Protection of Aquatic Life (CCME). In the Proctor Gulch area groundwater samples, cadmium and cobalt were detected at concentrations that exceeded the YCSR limits and arsenic, iron, uranium, and zinc were detected at concentrations that exceeded the CCME limits.

In the hillslope area, mean TDS values in water collected from monitoring wells were indicative of slight to moderately mineralized groundwater. Samples from monitoring wells installed near the historic Meloy Creek mine adit reported higher mean TDS values than others from the hillslope area. Slightly higher mean TDS and higher concentrations of sulphate, sodium, fluoride, and chloride were reported in water samples obtained from the shallow groundwater well compared to the deep well. In samples from the hillslope area, cadmium, copper, and zinc were the only metals detected at concentrations that exceed the CCME guideline limits on a regular basis.

In the Casino Creek valley, mean TDS values for groundwater samples were indicative of slightly to highly mineralized conditions. Cadmium, copper, iron, and uranium were the only metals that were detected at concentrations exceeding the CCME guideline limits on a regular basis from the vicinity of the proposed TMF in the Casino Creek valley area. The elevated concentrations were not widespread and are reflective of relatively heterogeneous groundwater chemistry conditions that may result from localized variability in mineralization and from mixing with groundwater originating from the deposit area. Arsenic and zinc were also reported at concentrations that exceeded the CCME guideline limit, but the exceedances were infrequent.

7.3.5 Sediment Quality

Sediment samples were collected from a total of 21 stations during sampling periods 1993-1995 and 2008-2012. Highest concentrations of many of the metals analysed occurred in upper Casino Creek. These metals include antimony, arsenic, bismuth, cadmium, cobalt, copper, iron, lead, manganese, molybdenum, silver, thallium and zinc.

Total metals in stream sediments tend to decrease with increasing distance from the headwaters of Casino Creek. Station R2 in a tributary to Dip Creek has one of the lowest sediment metals concentrations of all the stations in the Casino project RSA and is representative of unmineralized background conditions. Stations W16 (mid-Dip Creek 27 km downstream of Casino Creek), and W20 and W21 on the Klotassin River, show similarly low metals concentrations.

Spatial trends indicate that the source of the elevated stream sediment concentrations in the study area is likely the mineralized zone on Patton Hill. For cadmium, copper and zinc, it also appears that a certain degree of deposition occurs at W8 below the Proctor Gulch confluence, and that this may be due to a precipitation of the metals in response to a pH shift in the water. Arsenic concentrations throughout the study area exceed the CCME Interim Sediment Quality Guideline (ISQG) and are reflective of natural sources from weathered rocks and soils. However, the elevated arsenic concentrations at most sites in upper Casino Creek and Canadian Creek exceed even the Probable Effects Level (PEL) guideline and are likely from the natural ARD in the groundwater near the ore body.

7.4 PROJECT-SPECIFIC EFFECTS

7.4.1 Project Interactions and Potential Effects

Several project components and activities were identified as having potential interactions with water quality in the LSA. Interactions between Project components and activities and water quality were identified using the matrix shown in Table 7.4-1.

Potential effects focused on three key areas for detailed discussion:

- Discharge, seepage and runoff from the TMF;
- Contaminate loading through blasting residues or atmospheric deposition; and
- General erosion and sedimentation processes.

Within each section, effects were further assessed by each project component and phase. All potential project effects were compiled within this framework (Table 7.4-2), assessed for residual impacts following mitigation and compensation measures (Section 7.4.3), and determined for significance (Section 7.4.4).

Table 7.4-1 Potential Interactions between the Project and Water Quality

Project Components and Activities	**Project Phase (C, O, CD, PC)**	**Potential Interaction** (Y/N)	**Mechanism of Interaction** (or Rationale for No Interaction)
Accommodations (Construction and Mine Staffing)	C, O, CD,	Y	• Human sewage and grey water
Aggregate sources / Borrow Sites	C	N	• An interaction is not anticipated as the vast majority of the potential borrow sites are within the mine footprint and therefore all water will be directed into the TMF
Airstrip and Airstrip Access Road	C, O, CD	Y	• Blasting residues leaching from excavated rock • Dust created from blasting • Increased erosion and sedimentation into Casino and Dip Creek drainages
Ancillary Buildings (Explosives Storage, Security Shed, Truck Shop etc.)	C, O	N	• An interaction is not anticipated as the explosives storage is over 1 km from the nearest watercourse
Concentrate Transport and Loading	O	Y	• Concentrate or chemical spills
Concrete Batch Plant Operation	C, O	N	• An interaction is not anticipated because all contact water will be collected and directed into the TMF
Contracted Employment	C, O, CD	N	• An interaction is not anticipated with contracted employment
Cyclone Sand Plant	C, O	N	• An interaction is not anticipated because all contact water will be collected and directed into the TMF
Dismantling of Facilities	CD	N	• An interaction is not anticipated with dismantling

Project Components and Activities	**Project Phase (C, O, CD, PC)**	**Potential Interaction** (Y/N)	**Mechanism of Interaction** (or Rationale for No Interaction)
			activities
Diversion of Canadian Creek	C, O	Y	• Increased erosion and sedimentation into Canadian Creek during construction of diversion
Drilling and Blasting (Noise, Fly Rock, Vibration)	C, O	Y	• Dust and nitrogen residues created from blasting
Fish Habitat Compensation Construction	C, O	Y	• Increased erosion and sedimentation at compensation construction sites
Freegold Road Extension	C, O, CD	Y	• Blasting residues leaching from excavated rock • Increased erosion and sedimentation at road crossings • Dust created from construction blasting and traffic
Freegold Road Upgrade	C, O, CD	Y	• Blasting residues leaching from excavated rock • Increased erosion and sedimentation at road crossings • Dust created from construction blasting and traffic
Fuel Storage and Distribution System	C, O	Y	• Fuel spill
Gold Extraction Plant / Oxide Ore Processing	C, O	N	• An interaction is not anticipated because all contact water will be collected and directed into the TMF
Ground Preparation Activities (e.g. cut, fill, grub, etc.)	C	Y	• Increased erosion and sedimentation into surface waters
Hazardous Materials Storage, Transport, and Disposal	C, O	Y	• Chemical spill
Heap Leach Facility	C, O	N	An interaction is not anticipated because: • Contact water contributes to process makeup requirements or directed to the TMF • Non-contact water is directed to the TMF • All leach solution is recirculated and there is no discharge during operations or closure.
Heap Leach Pad	C, O	Y	• Increased erosion and sedimentation into surface waters
Laydown Areas	C, O	N	• An interaction is not anticipated as the laydown area is not located near a watercourse
LNG Transport to site	C, O	N	• An interaction is not anticipated as in the event of a spill, LNG would rapidly vaporize and therefore in its gaseous state would not affect a watercourse

Project Components and Activities	**Project Phase (C, O, CD, PC)**	**Potential Interaction** (Y/N)	**Mechanism of Interaction** (or Rationale for No Interaction)
Main and Supplemental Power Plant (Gas Turbine and Diesel)	C, O	Y	• Diesel fuel spill
Maximum Disturbance Area	C, O, CD	N	• An interaction is not anticipated with the project footprint as a whole
Mine Development	C, O, CD	N	• An interaction is not anticipated with mine development in the socio-economic context
Mine Staffing	C, O, CD	N	• An interaction is not anticipated with mine staffing
On-site equipment and vehicle use	C, O, CD	Y	• Dust, emissions and road runoff
Open Pit Mining	C, O	Y	• Dust and nitrogen residues created from blasting Other typical interactions are not anticipated because: • During operations, all contact water will be collected and directed into the TMF • At closure, seepage from the Pit Lake is expected to discharge within the Casino Creek valley upslope of the TMF facility; no seepage will occur to Canadian Creek
Ore Conveyors	C, O	Y	• Dust created from ore on overland transfer conveyors
Ore Crushing	C, O	Y	• Dust created from the crushing of ore
Ore Hauling	C, O	Y	• Dust created from the transport of ore on roads
Ore Stockpiles	C, O	Y	• A small percentage of the seepage may pass under the TMF to the water management pond
Processing Facilities for Sulphide Ore	O	N	• An interaction is not anticipated because all mine contact water will be directed into the TMF
Reagent Storage and Distribution	C, O	N	• An interaction is not anticipated because reagents are not located near a watercourse
Site Reclamation / Re-Vegetation	O, CD	N	• An interaction is not anticipated with reclamation activities
Site Security and Fencing	C, O, CD	N	• An interaction is not anticipated with security and fencing
Surface Water Management (Contact Water)	C, O, CD	N	• An interaction is not anticipated because all contact water will be collected and directed into the TMF
Surface Water Management (Non-Contact Water)	C, O, CD	N	• All drainage entering watercourses will be un-altered with the exception of the Canadian Creek diversion
Tailings Management	CD	Y	• TMF foundation seepage by-passing the WMP

Project Components and Activities	Project Phase (C, O, CD, PC)	Potential Interaction (Y/N)	Mechanism of Interaction (or Rationale for No Interaction)
Facility			to Casino Creek • Discharge from the Winter Seepage Mitigation Pond (WSMP) to Casino Creek • Discharge from TMF Spillway to Casino Creek
Topsoil Stockpiles	CD	Y	• Increased erosion and sedimentation into Dip Creek tributaries
Traffic (Equipment and Materials to Site)	C, O, CD, PC	Y	• Dust, emissions and road runoff
Waste management: garbage and sewage waste facilities	C, O,	Y	• Spills from hazardous wastes, fuels and lubricants
Waste rock and Overburden Disposal	C, O, CD	N	• An interaction is not anticipated because all waste rock and overburden will be disposed in the TMF
Water Supply	C, O	N	An interaction is not anticipated because: • Initial water supply is within TMF footprint • Long-term supply is from a riverbank caisson and radial well system adjacent to the Yukon River. Extraction of groundwater will have a negligible impact on the Yukon River water table.

Note:

1. C (Construction), O (Operation), DC (Decommissioning and Closure) and PC (Post-Closure) represent the Project phases when the potential interaction between the Project and valued component is anticipated to occur.
2. Potential mechanism(s) of interaction between the Project components and activities and the valued component are carried forward into the assessment by characterizing the potential effect(s).

Table 7.4-2 Potential Effects on Water Quality

Mechanism of Interaction	Key Indicator(s)	Project Phase (C, O, CD, PC)	Potential Effect	Direction
TMF foundation seepage by-passing WMP and discharging into Casino Creek (unrecovered seepage)	CCME/BC MOE guidelines for all parameters tested	O, CD	Change in surface water quality in Casino Creek and Dip Creek	Adverse
TMF seepage from WSMP and TMF spillway discharging into Casino Creek (project discharge)	CCME/BC MOE/MMER guidelines for all parameters tested	CD,PC	Change in surface water quality in Casino Creek and Dip Creek	Adverse
Blasting residues from ore and waste rock carried into Casino	CCME guidelines for nitrate, ammonia and	C, O	Change in surface water quality in Casino Creek	Adverse

Mechanism of Interaction	Key Indicator(s)	Project Phase (C, O, CD, PC)	Potential Effect	Direction
Creek	nitrite			
Dustfall and acidic deposition in Canadian Creek and Casino Creek	Baseline levels of TSS, alkalinity and sulphate	O	Change in surface water quality in Canadian Creek and Casino Creek	Adverse
Increased erosion and sedimentation due to construction activities	CCME guidelines for TSS and turbidity	C, O	Change in surface water quality in creeks located in LSA	Adverse

Note:

1. Key indicators are defined as measurable parameters or attributes to qualitatively or quantitatively evaluate the potential effect.
2. C (Construction), O (Operation), DC (Decommissioning and Closure) and PC (Post-Closure) represent the Project phases when the potential interaction between the Project and valued component is anticipated to occur.

7.4.1.1 Discharges from the TMF

The water management plan for the mine site has been designed to direct all Project related discharges to the TMF, and therefore all discharges to the receiving environment are to Casino Creek and eventually Dip Creek. Mine components such as the Plant Site, HLF and Open Pit do not have any direct pathways to the receiving environment. Since all the contact water from these mine components ultimately ends up in the TMF, potential water quality effects focus on discharges from the TMF.

It should be noted that seepage from the ore stockpiles into the groundwater system has the potential to affect water quality through metals loading. As described in Appendix 7E, numerical groundwater modeling shows that the majority of groundwater seepage ends up in either the Open Pit or the TMF pond; however, a portion of groundwater seepage from some of the ore stockpiles is expected to remain below the TMF pond and eventually discharge to the Casino Creek drainage. Although these seepages have direct effects on groundwater quality, all this was eventually reaches surface and is incorporated into the surface water quality model (Appendix 7F).

Potential effects resulting from seepage from the Open Pit will only occur during the Post-Closure phase once the Open Pit is flooded to maintain a Pit Lake with a surface elevation above that of the TMF pond. Numerical groundwater model results indicate that all seepage from the Pit Lake will report to the upper Casino Creek groundwater system, and will discharge to Casino Creek upstream of the TMF. As with the seepages from the ore stockpiles, the effects to groundwater are reflected in the surface water quality model results.

A water management pond will be located downstream of the TMF main embankment during construction and operations that will collect runoff from the TMF embankment and TMF seepage, and pump it back to the TMF pond. At Closure, the water management pond will be decommissioned and a groundwater cut-off wall and seepage collection pond (Winter Seepage Mitigation Pond (WSMP)) will be constructed. During Post-Closure, the TMF pond will be allowed to discharge naturally downstream via the South TMF Wetland and TMF closure spillway to Casino Creek. Once the TMF is allowed to discharge pumping of seepage back to the TMF will cease, and the WSMP will store seepage from the TMF during the winter and release the stored water during the summer. Ultimately, the two discharge pathways from the TMF to Casino Creek are from the WSMP and the TMF spillway, which converge at a mixing point approximately 250 m above the confluence of Brynelson Creek.

7.4.1.2 Water Quality Model

A mass load balance model developed in GoldSim for surface water within and downstream of the Project footprint was prepared in support of this assessment. Development of the Water Quality Model (Appendix 7F) integrated several components:

- Background (baseline) water quality (Appendix 7A);
- Geochemical source terms (Appendix 7D) to predict the rate of mass loading from each source into the water management system and downstream environment; and
- Water balance model (Appendix 7E), which integrated baseline and Project phase groundwater analyses (Appendix 7C and 7E), baseline hydrology (Appendix 7B) and a mine operations water balance.

The water quality model was developed to predict receiving environment water quality within the mine area and downstream in Casino Creek (and then to Dip Creek), for the construction, operations, closure and post-closure phases of mine development. PHREEQC geochemical modelling software was also used in combination with GoldSim. The key assumptions used in the development of this model for the receiving environment predictions are:

- Model simulation was run for a time period beginning a few years prior to Construction and continued for 200 years following the beginning of Operations using monthly time steps
- Average environmental conditions were used:
  - Average monthly flows
  - Seasonal median baseline water quality
- Loadings to the receiving environment include:
  - Seepage bypass of the Water Management Pond
  - WSMP Discharge; and
  - TMF Spillway Discharge.
- Background loading to Casino and Dip Creeks was incorporated into the model using baseline concentrations.

The water management schedule, as it relates to the water quality model, is described below.

Construction (Year -4 to Year -1):

Construction of the TMF commences approximately 36 months prior to mill start-up in order to collect enough surface water runoff for mill start-up. Surface water runoff from the ore stockpiles, plant site and waste rock storage area will be collected behind the TMF once the starter embankment is constructed. The water management pond is established in Year -3 downstream of the starter Main embankment and will function as a sediment control pond where all sediment laden water generated during construction will be collected. Treated water will be discharged to Casino Creek during Year -3 and pumped back to the TMF pond in Years -2 and -1.

Operations (Year 1 to Year 22):

Tailings and process water will be actively deposited to the TMF during this phase. The water management pond, located downstream of the TMF main embankment, will collect and pump back the TMF embankment runoff and seepage to the TMF pond.

Runoff collection ditches downstream of the final footprints of the ore stockpiles will be established to route water to local collection ponds, which will then be directed to the TMF pond. Groundwater seepage from the low grade supergene oxide ore stockpile will be mitigated using a groundwater collection or infiltration suppression system that will direct the water to the TMF pond.

Closure and Decommissioning (Year 23 to 25); Post-Closure (Years 26+)

Closure Water Management Phase I (approximately Years 23 to 30)

Closure Water Management Phase I will consist of active water management. Passive treatment systems in the form of wetlands will be constructed in the northern reaches of the TMF footprint (North TMF Wetland) and adjacent to the TMF Main embankment (South TMF Wetland). The TMF pond will be pumped to the Open Pit for five years following operations, at a rate of approximately 1,200 m^3/hr, to draw down the TMF pond elevation for construction of the TMF wetlands. The WSMP will be constructed downstream of the TMF embankment, will include a groundwater cut-off wall, and will continue to recycle seepage and embankment runoff to the TMF pond. The heap leach facility will be rinsed and drained, and draindown water will be treated for selenium and mercury by a bioreactor prior to being discharged to the Open Pit. A cover will then be placed on the heap that will reduce infiltration to 20% of average annual net precipitation. Closure Water Management Phase I will end when the TMF pond has reached its maximum capacity.

Closure Water Management Phase II (approximately Years 31 to 114+)

Closure Water Management Phase II will consist of passive water management once the TMF pond begins spilling and prior to discharge of the Pit Lake to the North TMF Wetland. A spillway and downstream channel are required to convey excess water in the TMF to prevent overtopping of the embankments. The closure spillway will be constructed in the west abutment of the West embankment and a constructed channel and plunge pool will convey the spillway flow to Casino Creek downstream of the TMF. The WSMP will store TMF groundwater seepage during the winter low flow months. The collected seepage will then be discharged from the WSMP during the summer months when TMF spillway discharges.

Closure Water Management Phase III (approximately Years 114 to 220+)

Closure Water Management Phase III will begin when the Pit has been flooded and starts discharging to the TMF pond through the North TMF Wetland. Pit water will be stored in winter and only released to the North TMF Wetland during the summer when passive treatment is most effective. The TMF and WSMP will continue to operate as described in Closure Water Management Phase II.

7.4.1.3 Water Quality Model Predictions

Water Quality is predicted in Casino Creek at model point M18 (just downstream of the confluence of Brynelson and Casino Creek) and W4 (mouth of Casino Creek). W4 is a baseline water quality monitoring site, while M18 is a modeled site, although baseline hydrology was collected at M18. M18 represents the water quality at the point of discharge to the receiving environment. W4 represents the water quality at the mouth of Casino Creek just prior to discharge into Dip Creek. Water quality in Casino Creek between these two locations is gradational between these two sets of results. Water quality in Dip Creek is modeled at W5, a baseline monitoring site just downstream of the Casino Creek confluence. Estimated water quality predictions for the entire suite of 29 parameters are described in Appendix 7F; only the ones that exceed CCME or BC MOE guidelines and those listed under *MMER* Schedule 4 as a deleterious substance are discussed in detail in this assessment.

The water quality predictions were modelled from Construction through to Post-Closure with monthly outputs over a 200 year period. The predicted water quality parameters are presented in Table 7.4-3 and are compared to CCME guidelines for the protection of freshwater aquatic life. For parameters without a CCME guideline, the BC MOE working and approved 30 Day Averages and Maximum values are used. Where available, the 30 Day

Averages are used instead of the maximum values as a conservative measure. *MMER* authorized limits are applied to water quality at the combined effluent discharge point, which is a mixing point at the downstream end of the TMF spillway where the flow mixes with the WSMP discharge (approximately 250 m upstream of Brynelson Creek) at mine closure.

Table 7.4-3 Water Quality Model Parameters and CCME and BC MOE Guidelines

Species ID	Units	CCME	BC MOE	MMER
Hardness	mg/L $CaCO_3$	-	-	-
Acidity	mg/L	-	-	-
Alkalinity	mg/L $CaCO_3$	-	10 to 20, dependent on sensitivity to acid inputs	-
Sulphate (SO_4)[h]		-	128 @ hardness = 0-30 mg/L 218 @ hardness = 31-75 mg/L 309 @ hardness = 76-180 mg/L 429 @ hardness = 181-250 mg/L	-
Cyanide (Total CN)	mg/L	-	-	1
Cyanide (WAD)	mg/L	0.005	0.010	-
Chloride (Cl)	mg/L	120 (short-term)	-	-
Fluoride (F)[h]	mg/L	0.12 (interim)	0.4 @ hardness = 10 mg/L (max) 1.3 @ hardness = 100 mg/L	-
Aluminum (Al)	mg/L	0.005 if pH<6.5 0.1 if pH ≥6.5	0.05, dissolved, when pH≥6.5 0.1, dissolved (max)	-
Antimony (Sb)		-	0.02	
Arsenic (As)	mg/L	0.005	0.005	0.5
Barium (Ba)		-	1 (30-d average) 5 (max)	-
Cadmium (Cd)[h]	mg/L	0.000012 to 0.000083 for hardness 30 to 290 mg/L	0.000012 to 0.000083 for hardness 30 to 290 mg/L	-
Calcium (Ca)		-	-	-
Chromium (Cr)	mg/L	0.0010 for Cr(VI) 0.0089 for Cr(III)	0.0010 for Cr(VI) 0.0089 for Cr(III)	-
Cobalt (Co)		-	0.110 max 0.004 30-d average	-
Copper (Cu)[h]	mg/L	0.002 @ hardness < 90 mg/L 0.004 @ hardness > 180	0.013 to 0.019 from hardness 120 to 180 mg/L (30-d average)	0.3
Iron (Fe)[h]	mg/L	0.3	1 (total, short-term max) 0.35 (dissolved, short term max)	-
Lead (Pb)[h]	mg/L	0.001 to 0.007 (for hardness 60 to 180 mg/L)	0.004 @ hardness = 30 mg/L 0.016 @ hardness = 290 mg/L	0.2
Magnesium (Mg)	mg/L	-	-	-
Manganese (Mn)[h]	mg/L	-	0.7 @ hardness = 30 mg/L 1.9 @ hardness = 290 mg/L	-
Mercury (Hg)	mg/L	0.000026	0.00000125 to 0.00002, dependent on percentage of	-

Species ID	Units	CCME	BC MOE	MMER
			methyl mercury	
Molybdenum (Mo)	mg/L	0.073	1 (30-d average) 2 (max)	-
Nickel (Ni) [h]	mg/L	0.025 @ hardness < 60 mg/L to 0.15 @ hardness > 180 mg/L	0.025 @ hardness < 60 mg/L to 0.15 @ hardness > 180 mg/L (max)	0.5
Potassium (K)		-	-	-
Selenium (Se)	mg/L	0.001	0.002 (30-d average)	-
Silver (Ag) [h]	mg/L	0.0001	0.00005 @ hardness ≤100 mg/L 0.0015 @ hardness ≥100 mg/L (30-d average)	-
Sodium (Na)	mg/L	-	-	-
Thallium (Tl)	mg/L	0.0008	0.0008 (30-d average)	-
Uranium (U)	mg/L	0.033 short term 0.015 long term	0.3 (max)	-
Zinc (Zn) [h]	mg/L	0.03	7.5 @ hardness ≤ 90 mg/L to 240 @ hardness = 400 mg/L	0.5

Notes:
CCME: Freshwater Aquatic Life
BCMOE: 30-day Average and Maximum
MMER: Maximum Monthly Mean
h: hardness dependent

7.4.1.3.1 TMF Pond Water Quality

During Operations, all runoff from undisturbed areas within the TMF catchment will be directed to and collected in the TMF pond along with all contact and process water. During Closure Water Management Phase I, the TMF pond level will be managed to maintain a water cover over the saturated waste rock with all excess pond water pumped to the Open Pit to aid in the improvement of TMF supernatant pond water quality and wetland construction. During Closure Water Management Phase II, upward fluxes of water through the submerged waste rock are the dominant loads to the TMF Pond. During Closure Water Management Phase III, the Pit Lake discharge is an additional load to the TMF Pond. Table 7.4-4 shows the average concentrations for the modeled parameters during typical years of Operations, Closure Water Management Phase II (when the TMF is discharging but the Open Pit is not) and Closure Water Management Phase III (when the Open Pit is discharging).

Table 7.4-4 Water Quality of TMF Pond During Typical Operations and Post-Closure Years

	Operations (Year 13)	Closure Water Management Phase II (Year 100)	Closure Water Management Phase III (Year 120)
Hardness	1191	400	398
Acidity	2	4	15
Alkalinity	12	150	158
Sulphate	1259	275	296
Cyanide (Total)	<0.001	<0.001	<0.001
Cyanide (WAD)	<0.001	<0.001	<0.001
Bromide	0.01	0.22	0.41
Chloride	34	8	9
Fluoride	2.14	0.57	0.65
Aluminum	3.57	0.06	0.05
Antimony	0.006	0.010	0.011
Arsenic	0.006	0.003	0.004
Barium	0.067	0.085	0.083
Cadmium	0.00071	0.00021	0.00018
Calcium	472	131	145
Chromium	0.0028	0.0008	0.0011
Cobalt	0.003	0.022	0.039
Copper	0.36	0.10	0.09
Iron	0.0017	0.0002	0.0002
Lead	0.0015	0.0030	0.0027
Magnesium	3	20	19
Manganese	0.44	0.52	0.50
Mercury	0.000014	0.000013	0.000015
Molybdenum	0.34	0.07	0.07
Nickel	0.009	0.006	0.012
Potassium	68	6	6
Selenium	0.016	0.004	0.005
Silicon	0.37	2.34	2.12
Silver	0.00006	0.00004	0.00005
Sodium	35	14	14
Thallium	0.00048	0.00010	0.00010
Uranium	0.018	0.052	0.046
Zinc	0.04	0.02	0.02

7.4.1.3.2 Pit Lake Water Quality

Blasting in the Open Pit will leave the wall rock fractured and exposed to weathering processes. The exposed wall will eventually oxidize and its runoff will become a source of mass loading into the Pit Lake. Following active mining in the pit, dewatering will be discontinued, and the Open Pit will be allowed to fill with water by groundwater recharge, overland runoff, and direct precipitation. The formation of the Pit Lake will perpetually receive mass loading from the portion of the pit wall that remains exposed.

During the Closure Water Management Phase I (Year 23 to Year 30), the Marginal Grade Stockpile will be placed in the Open Pit, and TMF Pond water and heap draindown water will be pumped to the Open Pit. It is also assumed that 5% of the low grade ore will not be milled and will also end up being placed in the Pit. The Pit Lake will fill to its maximum water storage capacity around Year 113 and will discharge to the TMF North Wetland for treatment prior to discharge to the TMF Pond. Table 7.4-5 shows the average water quality of the Pit Lake upon initial discharge and at Post-Closure.

Table 7.4-5 Water Quality of the Pit Lake During Typical Post-Closure Years

	Closure Water Management Phase II (Year 113)	Closure Water Management Phase III (Year 199)
Hardness	464	334
Acidity	69	68
Alkalinity	185	194
Sulphate	478	351
Cyanide (Total)	<0.001	<0.001
Cyanide (WAD)	<0.001	<0.001
Bromide	1.34	1.09
Chloride	18	9
Fluoride	1.16	0.86
Aluminum	0.009	0.010
Antimony	0.019	0.010
Arsenic	0.006	0.004
Barium	0.076	0.061
Cadmium	0.00392	0.00350
Calcium	242	198
Chromium	0.0027	0.0024
Cobalt	0.130	0.078
Copper	0.37	0.36
Iron	0.0001	0.0001
Lead	0.0014	0.0009
Magnesium	14	13
Manganese	0.54	0.42
Mercury	0.000025	0.000022
Molybdenum	0.18	0.10
Nickel	0.047	0.029
Potassium	8	3
Selenium	0.008	0.005
Silicon	2.20	2.18

	Closure Water Management Phase II (Year 113)	Closure Water Management Phase III (Year 199)
Silver	0.00103	0.00054
Sodium	16	10
Thallium	0.00017	0.00012
Uranium	0.062	0.055
Zinc	0.39	0.37

7.4.1.3.3 Predicted Discharge Water Quality

Two sources make up the discharge effluent: the TMF Spillway water and the WSMP water. The WSMP water will only be released between May and November in order to mix with the TMF Spillway water. This discharge effluent will be the point of discharge into the receiving environment, which means *MMER* guidelines will be applicable, until the mine becomes a Recognized Closed Mine. Details on the water quality of the discharge sources throughout the mine life is discussed in Appendix F as this assessment focuses only on Post-Closure when water is discharged to the receiving environment.

MMER limits were compared with the maximum annual concentrations for the parameters regulated by *MMER*, which include As, CN (total), Cu, Pb, Ni and Zn. Predictions were not made for TSS as it is assumed that sediment control practices employed throughout construction and operations and ongoing monitoring will maintain TSS to less than detectable or at most <5 mg/L on a monthly basis. At closure and post-closure, TSS is assumed to remain very low in the receiving environment, which is attributable to the presence of the upstream TMF pond. Figure 7.4-1 below shows the predicted maximum annual concentrations for the *MMER* regulated parameters of the discharge at the mixing point of the TMF spillway and WSMP water. The figures clearly show that none of the parameters exceed *MMER* limits.

For all the figures below, these acronyms and short forms are used:

- C: Construction, O: Operations, CD: Closure and Decommissioning, PC: Post-Closure
- Phase I, II, III refer to "Closure Water Management Phase")

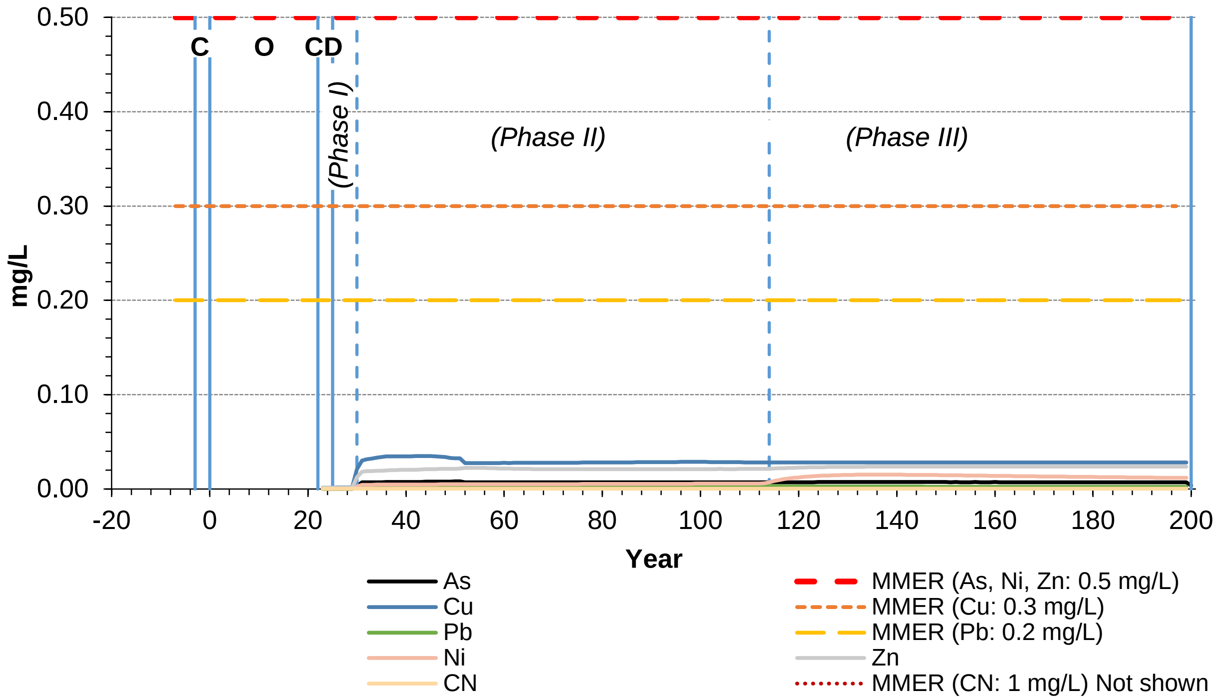


Figure 7.4-1 Predicted Maximum Annual Values for the Discharge at the Mixing Point

7.4.1.3.4 Predicted Water Quality in Casino Creek

Casino Creek is the main receiving water body throughout the life of mine. Predicted water quality in this creek is highly variable and is dependent on the mine schedule. The following discussion of predicted water quality is applicable to the entire length of Casino Creek, downstream of the Brynelson Creek confluence (i.e. from M18 to W4).

Construction

Water quality during construction is mainly a result of pre-existing baseline conditions, although seepage through the TMF starter dam may also be contributing loading at this phase. The modelled water quality results are characterized by low hardness and acidity. Copper and Al exceed CCME guidelines because they do naturally in the baseline.

Operations

During the operations phase, water quality predictions in Casino Creek are driven by the unrecovered TMF foundation seepage. According to the numerical groundwater modelling (Appendix 7E), approximately 90-95% of the TMF foundation seepage is predicted to be recovered by the water management pond assuming that the pond is maintained with as low of a water level as possible. The remaining 5-10% of foundation seepage (up to 2.2 L/s by the end of operations) is expected to bypass the pond and escape further downstream to Casino Creek. The foundation seepage is made up of mostly the tailings and waste rock seepage and the sand plant slurry underflow, with a potential minor contribution from stockpile seepage. It is important to note that the stockpile seepage was conservatively assumed to be un-altered by its passing through the TMF facility. Modeled concentrations steadily increase throughout the operations period with the same CCME exceedances as for construction plus the addition of Cd and F. Hardness also increases throughout the operations phase while alkalinity remains the same as during Construction.

Closure and Decommissioning and Post-Closure

Closure Water Management Phase I

TMF seepage continues to be pumped back to the TMF pond and therefore early in this phase downstream water quality is very similar to during Operations. After the WSMP is constructed, the cut-off wall results in 100% capture of TMF seepage and a resultant improvement in water quality in Casino Creek to pre-Operation levels.

Closure Water Management Phase II

Water quality during this phase is driven by discharge from the WSMP during May through November, and TMF Spillway discharge which will mix prior to entering Casino Creek. Water in the WSMP will be acidic and high in metals; however, mixing of WSMP flows with TMF spillway flows will result in neutral pH water entering Casino Creek, and metals that are soluble at low pH, such as Al, or soluble under anoxic conditions, such as Fe will precipitate out of solution. Modeled predictions that exceed CCME guidelines in Casino Creek include Cu, Cd and F, as during Operations, with the addition of Mo, Se and U. There are no CCME guidelines for sulphate but the BC MOE guideline is exceeded when using the baseline hardness to derive the calculated guideline.

Closure Water Management Phase III

The water quality predictions during this phase are driven by the same factors as WMP Closure Phase II plus the addition of the Pit Lake discharge into the TMF. The Open Pit is predicted to overflow at around Year 114, with the discharge first going through the North TMF wetland and then eventually the South TMF wetland before discharging into Casino Creek via the TMF spillway. The treatment wetlands effectively improve the water quality of a number of parameters from the TMF discharge to the point that very few parameters exhibit detectable spikes in Casino Creek throughout this phase. Modeled parameters: Cu, Cd, Mo, Se, U, SO_4 and F, continue to exceed CCME/BC MOE guidelines. A peak in predicted concentration for Se is clearly related to the overflow of the Open Pit at Year 114.

7.4.1.3.5 Predicted Water Quality in Dip Creek

Casino Creek flows into Dip Creek and thus water quality predictions follow the same patterns and are driven by the same sources as Casino Creek. Modelled concentrations in Dip Creek are generally improved due to the higher dilution and fewer parameters exceed CCME/BC MOE guidelines.

Construction

Cu is predicted to exceed CCME guidelines right at the beginning of the construction phase, since Cu exceeds CCME in the baseline at W5. Other parameters that exceed CCME during this phase are Cd and Fe, which can also be attributed to elevated background levels.

Operations

During Operations, Cd, Cu and Fe continue to exceed guidelines and hardness continues to increase.

Closure and Decommissioning and Post-Closure

Closure Water Management Phase I

There is very little change in water quality in all of the modelled parameters during this phase. A small reduction in water quality concentration occurs once the WSMP is in place and begins to collect all seepage and runoff from the TMF. The same three metals continue to exceed CCME guidelines.

Closure Water Management Phase II

As with water quality predictions in Casino Creek, a small spike in concentration occurs during the initial flush of the TMF spillway and WSMP. Cadmium, Cu and Fe continue to exceed CCME guidelines and F and Se begin to exceed CCME during this phase.

Closure Water Management Phase III

For the most part, modeled concentrations remain stable throughout this phase. Cu, Cd, Fe, Se and F are predicted to exceed CCME guidelines during this phase.

7.4.1.3.6 Water Quality Model Results Conclusions

Throughout the Project Phases, there are a total of seven parameters that exceed CCME/BC MOE guidelines in Casino Creek: Cd, Cu, Mo, Se, U, SO_4 and F. Of these parameters, only Cu, Cd, Se and F continue to exceed CCME guidelines at various Project Phases in Dip Creek. In this assessment, these seven parameters are considered to be the Contaminants of Concern (COC) because they exceed CCME guidelines (or BC MOE in the case of SO_4) in the Casino and Dip Creek receiving environments. Iron also exceeds CCME guidelines in Dip Creek but this is unrelated to the predicted project discharge. Baseline conditions show that upstream of the confluence with Casino Creek, Dip Creek has Fe concentrations that exceed CCME guidelines during the months of May and June.

7.4.1.4 Contaminant Loading through Blasting Residues, Dust and Emissions

7.4.1.4.1 Blasting Residues

The Casino Project requires the use of explosives during construction of the infrastructure site pads, construction of access roads, and production of the Open Pit. Blasting will be carried out using an ammonium nitrate and fuel oil emulsion (ANFO) product manufactured at the Casino mine site. Fixed emulsion and ammonium nitrate will be stored on site. Residues from blasting will contain nitrogen compounds that will remain on the surface of waste rock, tailings and excavated rock and be available for transport by contact water.

Generally, ANFO is made up of 94% NH_4NO_3 (of which 35% is nitrogen) and 6% fuel oil (Morin and Hutt, 2009). However, during blasting the reaction often does not completely consume the explosive, leaving behind residual nitrogen. The amount of nitrogen residue is dependent on many different factors including the handling of explosives and efficiency of the blast. Limited research exists on the prediction of nitrogen species in mine site drainages from explosive residues. The Ferguson and Leask (1988) case study is most relevant to the Casino Project as both are open pit mines, primarily use ANFO explosives, and are situated in cool, dry climates at higher elevations (1,000 m to 2,500 m). Ferguson and Leask (1988) found that 0.2% of explosives remain as residues and are lost to runoff in dry conditions and between 2% and 5% in wetter conditions. Considering the relatively dry climate at the Casino Project, it has been conservatively estimated that 1% of the explosives remain on site as blasting residue.

Total nitrogen in blasting residues is approximately apportioned as follows: 87% as nitrate-N, 11% as ammonia-N and 2% as nitrite-N (Ferguson and Leask 1988). Nitrate-N and ammonia-N are generated through blasting, whereas nitrite-N is an intermediate species of ammonia oxidation to nitrate.

The amount of nitrogen-based nutrient loss to the receiving environment from blasting at mines can be calculated as follows:

- Explosives Consumption (tonnes of ANFO per year) * 0.01 (Percent of explosives lost to drainages) * 0.94 (percent of ammonium nitrate in ANFO) * 0.35 (percent of nitrogen in ammonium nitrate) * 4 or 22 (years in Project Phase).

The estimated total nitrogen loads for the construction and operations phases are detailed in Table 7.4-6.

Table 7.4-6 Estimated Nitrogen Loads during Mine Construction and Operations

Description	Construction	Operations	Total
Waste Rock and Overburden (million tonnes)[1]	10	648	658
Powder Factor (kg ANFO/tonne)	0.25	0.25	-
ANFO Consumption (tonne)[1]	2500	162000	164500
ANFO lost to drainages (%)	1	1	-
Ammonium nitrate in ANFO (%)	94	94	-
Nitrogen in ammonium nitrate (%)	35	35	-
Total Nitrogen loss (tonne)	8	533	541
Tailings from Milled Ore (million tonnes)[1]	0	956	956
Powder Factor (kg ANFO/tonne)	0.25	0.25	-
ANFO Consumption (tonne)	0	239000	239000
ANFO lost to drainages (%)	1	1	-
Ammonium nitrate in ANFO (%)	94	94	-
Nitrogen in ammonium nitrate (%)	35	35	-
Total Nitrogen loss (tonne)	0	786	786
Total Blast Residue Generated (tonnes)			
Nitrate-N	7	1147	1154
Ammonia-N	1	145	146
Nitrite-N	0	27	27
Total-N	8	1319	1327

[1]Based on the production schedule values presented in KP letter VA13-00949 Revised Waste Deposition Strategy, May 2013.

1. Freegold Road Upgrade and Extension

Blasting residues have the potential to leach from excavated rock to access road watersheds. However, the vast majority of the explosives will be used for blasting ore at the mine site. Detailed calculation of nitrogen blasting residues are completed for the mine site only as it is expected that nitrogen loading from the excavated rock along the access roads will be minimal.

2. Open Pit and Tailings Management Facility

The vast majority of blasting at the mine site will take place in the Open Pit and almost all of the contact water during the 4-year construction phase and 22-year operations phase will end up in the TMF. Because of this linkage, these two components will be assessed together as described below.

Construction:

For the first two years of the construction phase (Year -4 and Year -3) blasting will be less as the main activities around the mine site will be site establishment and mobilization efforts, and the initial stripping of the Open Pit is mainly overburden and will require less blasting. The initial open pit stripping will generate approximately 2 to 3 million tonnes of non-reactive waste rock (leached cap) by shoveling and blasting. This material is either stockpiled as gold ore for processing by heap leaching in Year -3, used as fill material for the construction of the embankment shell zones of the TMF, or placed in the waste storage area of the TMF. Assuming a powder factor of 0.25 kg of ANFO/tonne of ore, up to 750 tonnes of ANFO will be consumed during the initial open pit stripping. Total nitrogen lost during this initial phase is therefore approximately 2.5 tonnes, assuming 1% of all explosive material remains behind as residues, and 33% (94% * 35%) of the residue is nitrogen. Water collected within the Open Pit footprint and contact water from the temporary stockpiles will be collected and transferred to the Mine Water Treatment Feed Pond for use by the process plant, which will ensure that all of the blasting residues that wash off of the waste rock will be captured before reaching nearby watercourses.

During the last two years of construction, (Year -2 and Year -1) the ore stockpiles and waste rock storage area will be established. Runoff not collected in the open pit will be collected in ditches and directed to the TMF pond.

As shown in Table 7.4-6, a maximum of 8 tonnes of total nitrogen is expected to be diverted to the TMF during the 4-year construction phase. Since all the contact water is collected and is either used by the process plant or diverted to the TMF, there are no potential effects to water quality.

Operations:

During operations, all of the waste rock and ore removed from the pit will be placed in the TMF, stockpiled and processed or stockpiled for placement in the pit (i.e. the marginal ore stock pile). As shown in Table 7.4-6, a maximum of 1,319 tonnes of total nitrogen is expected to end up in the TMF during the 22-year operations phase. Seepage from the TMF during operations will be collected by the water management pond downstream of the TMF embankment and be pumped back to the TMF; therefore no impacts to water quality in Casino Creek, resulting from nitrogen loading, are expected during the Operations phase.

Closure and Decommissioning and Post-Closure:

No blasting occurs during the Closure or Post-Closure phases, and therefore it is expected that a maximum total of 1,327 tonnes of nitrogen will be left within the TMF at closure. An estimate of the total concentration of nitrogen that accumulates over the life of mine before discharge commences can be calculated by dividing the maximum total of 1,327 tonnes of nitrogen by the total volume of water that accumulates over the life of mine. The total volume of water accumulated in the TMF facility, including the pond, waste rock voids and tailings voids, is approximately 347 Mm^3, as calculated in the YESAB Water Balance Model. Therefore, the maximum concentration of total nitrogen at the end of Operations is 1,327 tonnes divided by 347 M m^3, which is 3.8 mg/L.

After operations, the TMF pond will be pumped to the pit for a period of 5 years, and approximately 30 Mm^3 of contact water containing residual nitrogen will be removed from the TMF. This equates to a removal of approximately 114 tonnes of total nitrogen. The additional water circulated through, and used to fill up, the TMF during closure results in a total water volume of approximately 360 Mm^3 available to mix with the residual nitrogen load. The resultant maximum total nitrogen concentration in the TMF upon discharge to Casino Creek is 3.4 mg/L, which equates to concentrations of 3.0 mg/L nitrate, 0.37 mg/L ammonia, and 0.068 mg/L nitrite.

Casino Creek is oligotrophic (nutrient poor) and the 90^{th} percentile nitrate, ammonia and nitrite baseline levels at W4 are 0.26 mg/L, 0.08 mg/L and 0.003 mg/L, respectively. The addition of the maximum nitrogen concentrations calculated above would put nitrate, ammonia and nitrite levels in Casino Creek to 3.3 mg/L, 0.45 mg/L and 0.07 mg/L, respectively. Compared with CCME guidelines (13 mg/L, 0.5 mg/L, and 0.06 mg/L, respectively), only nitrite would have a marginal guideline exceedance. However, the nitrogen concentrations calculated above assume that all of the nitrogen that ends up in the TMF remains unchanged for 31 years, a highly unlikely and worst-case scenario. There are many pathways for the reduction in nitrogen loading during the 31 years of combined construction, operations and closure phases. Nitrogen is present as mostly ammonia and nitrate and both are subject to nitrification/de-nitrification reactions which remove nitrogen as N_2 gas. During the 31 years, a portion of the nitrogen will also likely become immobilized within the solids in the TMF. Furthermore, the remaining nitrogen in the TMF pond or on the dam shell is substantially diluted by local runoff. All of these ameliorating factors indicate that although there is potential for increased nitrogen loading to Casino Creek at Post-Closure, it is highly unlikely to result in increases in nitrogen concentrations to beyond CCME guidelines. It is therefore concluded that there will be negligible effects to the water quality of Casino Creek from nitrogen loading at Post-Closure, and it will not be assessed further.

7.4.1.4.2 Dust and Emissions

Project activities such as blasting, ore conveying, crushing and hauling, on-site equipment and vehicle use and traffic along the access roads have the potential to affect air quality and subsequently surface water quality from atmospheric deposition. The air dispersion model CALPUFF was used to assess potential effects to air quality, including rates of particulate deposition and air concentrations of NOx and SO_2. Detailed model results are presented in Section 8. The results of the CALPUFF model show that the dispersion of dust and emissions from project activities mainly affect upper Canadian Creek and Casino Creek.

Potential air quality interactions with water quality at the mine site are from dustfall, and theoretically from acid deposition. Acid deposition could occur if levels of NOx and SO_2 were predicted to be consistently high (ie. above guideline) and wide-spread, and effects of such deposition on the ecological environment would also need to consider the tolerance capacity of the existing environment. The primary sources of NOx and SO_2 emissions at the mine site will be the LNG power plant (NOx), and diesel exhaust from vehicles, equipment and the auxiliary power plant (SO_2). Dustfall, or total particulate matter, is generated at the mine site mainly from blasting in the open pit, ore conveying, crushing and hauling and traffic and equipment use on the access roads. Dust deposition can lead to increased TSS in waterbodies.

CALPUFF modelling indicates that the maximum annual dustfall deposition will occur in Year 11 of Operations due to peak equipment use and maximum waste material movements. Predicted maximum annual dustfall is between 1 and 1.7 mg/(dm^2-d) in upper Canadian Creek and between 0.6 and 0.7 mg/(dm^2-d) in lower Casino Creek. These values are below the BC annual air quality standard of 1.7 to 2.9 mg/(dm^2-d), and therefore potential effects of dustfall on TSS levels in Casino and Canadian Creek as expected to be minor, if not negligible.

Maximum annual SO_2 and NO_2 concentrations will also occur in Year 11 due to estimated peak activity and are also concentrated around the footprint of the Open Pit and TMF. Maximum annual concentrations of SO_2 are predicted to be between 1 and 5 $\mu g/m^3$ in lower Casino Creek and upper Canadian Creek, which is well below the Yukon Air Quality standard of 25 $\mu g/m^3$. Maximum annual NO_2 concentrations in lower Casino Creek are predicted to be between 30 and 60 $\mu g/m^3$ which is within the Yukon Air Quality standards of 60 $\mu g/m^3$. NO_2 concentrations in a small portion of the upper Canadian Creek watershed may be as high as 100 to 200 $\mu g/m^3$, which exceed Yukon Air Quality standards; however, based on the localized nature of the NO_2 exceedances, and the absence of SO_2 exceedances, acid deposition is considered negligible.

7.4.1.5 General Erosion and Sedimentation Processes

Erosion of stream banks and increased sedimentation from in-stream construction activities in waterbodies in the Casino Project area have the potential for adverse effects on water quality by exceeding guidelines for total TSS. The CCME guideline for TSS is defined for clear flow and high flow conditions. During clear flows, the guideline is a maximum of 25 mg/L increase from background levels for any short-term exposure (i.e. 24-h period), and a maximum average increase of 5 mg/L from background levels for longer term exposure (i.e. between 24 h and 30 d). During high flows, the guideline is a maximum increase of 25 mg/L from background during the period when background levels are between 25 and 250 mg/L, and a maximum increase of 10% of background levels when background is ≥ 250 mg/L (CCME, 1999).

Many of the activities conducted within the mine site and along the access roads have the potential to result in elevated TSS within nearby water bodies. The primary pathways by which sediment could end up in watercourses, and TSS could become elevated, include:

- Ground disturbance during construction and decommissioning of mine site infrastructure and access roads;
- Particulate matter deposition caused by vehicle and equipment traffic within the mine site area and along the access roads;
- Particulate matter deposition caused by open pit blasting and ore and waste rock handling; and
- Runoff from ore and topsoil stockpiles.

Any discharge of water that would result in a sizeable increase in flow within an existing watercourse would likely result in bank destabilization and an increase in TSS; however, no such discharges have been identified downstream of the Project. Furthermore, any sediment mobilized within the mine site during operations and decommissioning will end up in the TMF pond, where it will settle out of suspension.

7.4.2 Identification of Mitigation Measures and Potential Residual Effects

Mitigation measures were identified and compiled for each potential effect on water quality (Table 7.4-11). For the purposes of this assessment, mitigation measures include any action, project design feature, or monitoring and management plan that will reduce or eliminate effects on water quality in the LSA. Each mitigation measure was evaluated for its predicted effectiveness on reducing or eliminating impacts. Following the application of all potential mitigation measures, residual effects were identified and carried forward in the assessment to determine significance (Section 7.4.3).

7.4.2.1 Potential Residual Effects

Predicted water quality in Casino Creek and Dip Creek is predicted to exceed CCME guidelines for several parameters, as discussed in Section 7.4.1.3.3. Exceedances result from seepage from the TMF during Operations, and discharge from the Project during Post-Closure. Because CCME guidelines are exceeded as a result of the project, potential residual effects exist, and are identified as follows:

- Change in surface water quality in Casino Creek and Dip Creek due to unrecovered seepage; and
- Change in surface water quality in Casino Creek and Dip Creek due to TMF discharge.

7.4.2.2 General Mitigation Measures

All construction activities will adhere to CMC's Erosion and Sediment Control Plan, Air Quality Management Plan and Water Management Plan, and Transport Canada's Aerodrome Standards and Recommended Practices, which all aim to reduce or eliminate effects on water quality by incorporating Best Management Practices (BMPs), such as:

- Minimizing disturbances in and near watercourses (e.g., clearing, grubbing, grading);
- Monitoring of TSS and turbidity during construction to ensure compliance with regulatory guidelines (<25 mg/L increase if background levels are less than 250 mg/L, <10% increase if background levels are greater than 250 mg/L; CCME 2001);
- Stabilizing and re-vegetating disturbed areas following construction, as appropriate;
- Designing appropriate sediment settling ponds that conform to BC MELP (2001) guidelines;
- Designing appropriate diversion ditch systems to minimize contact water;
- Designing appropriate collection ditch systems to collect contact water; and
- Using dust suppressants and enforcing traffic speed limits along all access roads.

In addition to mitigation and compensation measures, an environmental monitoring plan will be designed and implemented to monitor water quality, fish habitat, and biological communities within the LSA, as required. Monitoring during the operations phase will aid calibration of the water quality model predictions and additional mitigation or compensation measures will be incorporated on an as-needed basis. Throughout the life of the Casino Project, water management will be the primary tool used to preserve water quality. Water management and general reclamation measures are discussed below.

7.4.2.2.1 Water Management

The objectives of the water management plan are to ensure sufficient water is available to support ore processing, while minimizing the potential for storm flows to cause damage to mine infrastructure and the potential for mining activities to cause adverse effects to downstream water quality. Water will be controlled in a manner that minimizes erosion in areas disturbed by construction activities and prevents the release of sediment laden water to the receiving environment. Highlights of key strategies from the water management plan are described below. A full description of the water management plan can be found in Appendix 4C.

Operational Water Management Strategy

The strategy to minimize contact water by diverting around Project infrastructure where possible, and maximize the use of the water within the project area by collecting and managing all site runoff from disturbed areas, recycling water within the HLF, storing surplus water within the TMF and recycling process water from the TMF to the mill and cyclone plant.

Sediment and Erosion Control Strategy

Design criteria for the various sediment control elements will be based on industry standard guidance documents (BC MELP, 2001; MEMNG, 1998). Sediment mobilization and erosion will be managed throughout the site by installing sediment controls prior to construction activities, limiting the disturbance as much as possible and reducing water velocity across the ground, particularly on exposed surfaces and in areas where flow tends to concentrate. During operations, diversion ditches will be established and disturbed land surfaces will be stabilized to minimize erosion. This will be achieved by implementing progressive rehabilitation of disturbed land, construction drainage controls to improve stability, promoting infiltration, constructing appropriate sediment control devices and restricting access to rehabilitated areas.

Numerous design elements were included to achieve the objectives of the water management plan, including:

- Coffer dams and pumping systems
  - A coffer dam will be constructed with the TMF starter footprint to capture all runoff from the upstream areas and route it to the sediment pond downstream.
- Sediment and erosion control elements and BMPs
  - Typical BMPs that will be used at the project are runoff collection ditches, energy dissipaters, sediment traps, slope drains, surface roughening, filter bags, water bars, diversion structures, silt fences, sediment basins, temporary seeding, and mulching.
- Sediment settling and water collection ponds
  - Temporary sediment settling ponds will be constructed downstream of all construction activities to treat sediment laden water and discharge to existing channels via energy dissipating structures. Collection ponds will also be constructed at the toe of all stockpiles
- Water management pond
  - This pond will collect surface runoff and seepage from the TMF embankments during operations and pump the water back to the TMF
- Winter seepage mitigation pond
  - This pond will function as a mitigation measure at closure to store seepage from the TMF during the winter months (December to April) when there is no dilution from surface water runoff in Casino Creek.

7.4.2.2.2 Reclamation

A Conceptual Closure Plan (Appendix 4B) has been developed for the project. Key aspects of the plan are summarized as follows:

- Place all marginal grade ore (MGO), residual low grade ore (LGO) and contaminated material from the footprint of the ore stockpiles into the Open Pit
- Flood the Open Pit. This will be achieved by temporarily pumping water from the TMF pond to the pit, allowing Canadian Creek to discharge directly to the pit, and allow natural runoff and precipitation to accumulate. Flooding the pit will minimize the potential oxidation of the pit walls.
- Restore all disturbed areas to original topography and re-vegetate
- Construction of an overflow channel (spillway) to allow surface water to discharge from the TMF
- Construction of two engineered wetlands (North TMF wetland and South TMF wetland) that will passively treat contaminants in the Pit Lake overflow and the TMF pond overflow prior to discharge to Casino Creek.
- Construction of a seepage interception pond downstream of the TMF embankment that will store TMF seepage during the winter and discharge it during the summer.

- Rinsing and treatment of the HLF water to remove cyanide. The heap will then be drained, and draindown water will be passed through a bioreactor for treatment of selenium and mercury prior to being pumped to the Open Pit. A cover designed to reduce infiltration to 20% of net precipitation will then be placed over the heap, all components of the HLF required for operations will be decommissioned and excess runoff will discharge naturally to the TMF pond.
- Long-term monitoring of the aquatic environment, the structural stability of infrastructure remaining in Post-Closure, and wetland functionality.

7.4.3 Determination of Residual Effects

7.4.3.1 Proposed Alternative Guidelines

7.4.3.1.1 Development and Rationale

Historically, Canadian water quality guidelines were derived using a safety factor approach, as described in CCME (1991). This approach involves application of a conservative safety factor (often tenfold) to the toxicological effect level for the most sensitive species in order to calculate the guideline. This method provides a conservative estimate of a parameter concentration that is expected to be safe across a broad range of environments in Canada. This precautionary approach does address the possibility that species exist that are more sensitive than those that have been tested; however, it can also result in an overly conservative guideline not directly applicable to environment in which it is being applied.

For the Casino Project, the CCME guidelines were used as the primary benchmark for comparing the potential effects of project discharges to the receiving environment waterbodies. As the water quality guidelines recommended by CCME are often based on the toxicological effects of the most sensitive species, this represents the most conservative approach for assessment of potential water quality effects.

As described in Section 7.4.3.3 and 7.4.3.4, Cu, Cd, Mo, Se, U, SO_4 and F are expected to exceed CCME guidelines in the receiving environment at some point during the mine life as a result of project discharges, and are therefore considered contaminants of concern (COCs). In order to assess whether these exceedances constitute a residual effect, not just a potential residual effect, each COC was further assessed by evaluating the applicability of the CCME guideline and determining whether or not an alternative guideline, such as a SSWQO or a guideline from another jurisdiction, i.e. BC MOE or the United States Environmental Protection Agency (US EPA) would be more appropriate. Derivation of SSWQO's for the seven COCs are presented below, and summarized in Table 7.4-7. The derivation of the copper and cadmium alternative guidelines is discussed in full detail below, while the other five COCs are summarized here but the specific effects to aquatic life are discussed in full detail in Section 10.4.1.3.

Copper

Development of a SSWQO was considered to be the most appropriate alternative guideline for cooper, due to the naturally high baseline concentrations. In British Columbia and Yukon, generic Water Quality Guidelines (WQG) provide a basis for assessing water quality conditions in most of the region. However, it is possible that those criteria are over or under protective at sites with unique conditions. Under these circumstances, it may be necessary to modify the generic water quality criteria to account for the conditions that occur at the site (i.e. physico-chemical properties or differences in biological communities between the site and those used to derive the generic WQG). This issue can be addressed by developing a SSWQO. The British Columbia Ministry of Environment Lands and Parks (BCMELP) (1997) outlines four methods for deriving SSWQOs, and two of these methods were selected: the Background Concentration Procedure (BCP) and the Water Effects Ratio Procedure (WERP). The BCP was used to derive the SSWQO and the WERP was used as secondary support.

The BCP is used in situations where surface waters have natural concentrations of substances that exceed generic guidelines. Section 7.3.3.1 verifies that baseline Cu concentrations in Casino Creek and Dip Creek are not influenced by the anthropogenic loading from the adit and are therefore considered to be representative of natural conditions. Therefore, the BCP method is an appropriate method for deriving a SSWQO for copper. Derivation of the SSWQO requires the use of available baseline data to determine an acceptable upper limit of background concentrations, which is then put forth as a SSWQO. There are many different approaches to defining the upper limit of background (BCMELP 1997; CCME 2003) including, but not limited to, the 95% confidence limit, 90^{th} or 95^{th} percentile, the maximum, and the mean plus 2 standard deviations. SSWQOs for copper in Casino Creek are developed based on water quality at site W4, as this site has the lowest concentrations of metals in Casino Creek and is therefore the most conservative. SSWQOs for copper in Dip Creek were developed at W5, immediately downstream of the confluence of Casino Creek. In Casino Creek, the 95^{th} percentile SSWQO (0.025 mg/L) would be protective during all project phases at both M18 and W4 although it is important to note that the 90^{th} percentile SSWQO (0.015 mg/L) is appropriate for W4 for the majority of the phases and is just slightly lower than the maximum annual copper predictions at M18. In Dip Creek, the 90^{th} percentile SSWQO (0.0065 mg/L) is proposed for copper.

The WERP evaluates the toxicity of a contaminant of concern that is spiked separately into the site water and the laboratory water studied in parallel. The toxicological endpoint from each test water, EC50 or IC25 values, can be compared, and the ratio between the values can be applied to derive a SSWQO. In this case, three toxicological tests were performed on water collected at W4 in lower Casino Creek on April 8^{th}, 2013, including both acute and chronic endpoints: 96-h rainbow trout acute test, 48-h *Ceriodaphnia dubia* acute test, and 7-d *Ceriodaphnia dubia* three brood reproduction test. WERP testing was completed using winter water samples as Cu is known to be more bioavailable when organic carbon concentrations are lowest; this results in development of a conservative Water Effects Ratio (WER). The results varied at 1.6 for both the rainbow trout and *Ceriodaphnia* acute tests and 2.8 for the *Ceriodaphnia* reproduction test. Despite the relatively small WER, these results still show that there is an incremental level of natural protection to the toxic effects of Cu in water from lower Casino Creek. Although this test was carried out on water from lower Casino Creek, the results can be applicable to Dip Creek as well, which has similar Cu and organic carbon concentrations to Casino Creek. Therefore, these WERP tests are supportive of the SSWQO developed for Cu in Casino and Dip Creeks using the BCP.

Cadmium

The evaluation of the adit loading to Casino Creek summarized in Section 7.3.3.1 indicates that one of the major sources of Cd to Casino Creek is from the adit. This means that a SSWQO approach using the BCP is not appropriate, although it is important to note that elevated cadmium concentrations are seen in baseline conditions in the local and regional study areas. Lower Dip Creek, Britannia Creek and the Yukon River all have cadmium concentrations that occasionally exceed CCME guidelines, especially in the winter months. However, to err on the conservative side, a different approach was taken to develop alternative water quality objectives for Cd by considering the applicability of a different jurisdictional guideline. Although the CCME guidance of Cd (CCME 1999) is generally appropriate for Canadian use, the US EPA criterion (National Recommended Water Quality Criteria, Aquatic Life Criteria from the US Environmental Protection Agency 2001) for Cd was considered as an alternative perspective because it uses a more recent and detailed guideline development process.

One of the key factors in determining Cd guidelines is the hardness levels. Water hardness is critical for understanding cadmium toxicity as it is a well-known toxicity modifying factor. The toxicity modification is a result of the chemical reaction of cadmium with hydroxide and carbonate in the water resulting in precipitation of the insoluble form, cadmium carbonate ($CdCaO_3$) (McCarty *et a*l. 1978). This occurs rapidly and quickly reduces the bioavailability of most of the total water column cadmium even before it has a chance to settle out into the sediment. Thus, the toxicity reduction occurs because much less bioavailable cadmium is present in the water column rather than from alterations in the mode/mechanism of toxic action.

Both CCME and US EPA criteria are hardness dependent. Using a median baseline hardness of 111 mg/L and 90 mg/L for Casino Creek and Dip Creek, respectively, the CCME criteria is 0.000036 mg/L and 0.000030 mg/L, respectively. In contrast, the US EPA criteria based on dissolved chronic Cd concentrations is 0.000270 mg/L and 0.000230 mg/L, respectively, which is close to an order of magnitude higher. Although this may appear to be a substantial deviation in guidelines, it is important to note that the US EPA guidance is more recent, based on much more thorough literature evaluation and analysis, and CCME has recognize their Cd guidance is outdated and has a revised guidance document currently under review.

For these reasons, the proposed alternative Cd guideline is to apply the US EPA criteria of 0.00027 mg/L for Casino Creek and 0.00023 mg/L for Dip Creek.

Molybdenum

British Columbia is currently the only province in Canada where Mo is mined, and consequently is also the only province with an approved molybdenum guideline. The BC MOE 30-day average for total Mo is 1 mg/L, which is almost 14 times higher than the CCME guideline of 0.073 mg/L (Fletcher et al. 1997). Considering the Casino mine will be producing copper, gold and molybdenum concentrate, it is proposed that the BC guideline of 1 mg/L is used as the alternative guideline for Mo.

Selenium

CCME, BC MOE and US EPA water quality guidelines are based on a lowest observed effect level (LOEL) of 0.01 mg/L of Se introduced by the International Joint Commission (IJC) to protect species in the Great Lakes (IJC 1981). For the CCME guideline, a safety factor of 10 was applied to the LOEL to end up with the guidance of 0.001 mg/L Se. The BC MOE guideline of 0.002 mg/L incorporates a safety factor of 5 to recognize that Se is an essential trace element for animal nutrition and that it is the bioaccumulation of Se through the food chain (chronic effects) that is the major source, not through the water column. The US EPA guideline of 0.005 mg/L is based on the same field studies cited in IJC (1981), but differs from the CCME and BC MOE guidelines in that it employs the Se concentration at which no effects were observed as the guideline, rather than using the LOEL multiplied by a safety factor. To err on the side of conservatism, the BC MOE guideline is proposed as the alternative guideline for Se.

Uranium

Although not as extreme as Cu, baseline levels of U are also elevated in Casino Creek and Dip Creek. U concentrations appear to be naturally elevated at several sites in the LSA and RSA, including upper Dip Creek and all sites on Britannia Creek. This is not surprising as British Columbian and Yukon stream levels of U are highest amongst all streams in Canada (Garrett, 2007). At the Casino mine site elevated U concentrations appear to be ubiquitous and unrelated to the ore body. Thus, a SSWQO based on the maximum value (0.019 mg/L) was considered to be the most appropriate as two out of six winter samples from the 2008-2012 water quality baseline study (Appendix 7A) exceeded the CCME long term guideline of 0.015 mg/L.

Sulphate

No approved federal water quality guidelines for the protection of freshwater aquatic life were identified for sulphate in Canada, the USA or elsewhere. In April 2013, BC MOE approved a chronic 30-day guideline, which was developed using the results of contemporary studies (Meays and Nordin, 2013). The influence of water hardness was clearly apparent from these studies and resulting sulphate water quality guidelines for the protection of aquatic life were developed based on the most sensitive species (rainbow trout) with a safety factor of 2 applied. Application of the approved 30-day average water quality guidelines using baseline median hardness of 111 mg/L and 90 mg/L for Casino Creek and Dip Creek, respectively, results in a sulphate guideline of 309 mg/L for both creeks.

Fluoride

For fluoride, the maximum BC MOE guideline was used as an alternative water quality guideline in place of CCME as it incorporates water hardness, which has a proven influence on fluoride toxicity. The maximum BC MOE guideline for fluoride produces guidelines of 1.4 mg/L and 1.3 mg/L for Casino and Dip Creeks, respectively.

Table 7.4-7 Proposed Alternative Water Quality Objectives

Creek	Parameter	CCME Guideline	Proposed Water Quality Objective	Source
Casino	Copper	0.003	• 0.025	• SSWQO-BCP based on the 95th percentile
Casino	Cadmium	0.000036	• 0.00027	• US EPA chronic dissolved (baseline hardness)
Casino	Molybdenum	0.073	• 1.0	• Approved BC MOE 30-day average
Casino	Selenium	0.001	• 0.002	• Approved (Interim) BC MOE 30-day average
Casino	Uranium	0.015	• 0.019	• SSWQO-BCP based on the maximum
Casino	Fluoride	0.12	• 1.4	• Approved BC MOE maximum
Casino	Sulphate	None	• 309	• Approved BC MOE 30-day average (baseline hardness)
Dip	Copper	0.0022	• 0.0065	• SSWQO-BCP based on 90th percentile
Dip	Cadmium	0.000030	• 0.00023	• US EPA chronic dissolved (baseline hardness)
Dip	Iron*	0.30	• 0.78 • 0.71	• SSWQO-BCP based on the 95th percentile for C, O and CD; • SSWQO-BCP based on the 90th percentile for PC.
Dip	Fluoride	0.12	• 1.3	• Approved BC MOE maximum

Notes:
CCME: Canadian Council of Ministers of the Environment
BC MOE: British Columbia Ministry of Environment
U.S. EPA: United States Environmental Protection Agency
SSWQO-BCP: Site-specific water quality objective – background concentration procedure
C: Construction, O: Operations, CD: Closure and Decommissioning, PC: Post-Closure

7.4.3.1.2 Application of Proposed Alternative Guidelines in Casino Creek

The maximum annual and monthly predicted water quality for each COC in Casino Creek is presented below, and compared against the corresponding SSWQO. Maximum annual water quality is presented by the worst (highest concentration) month for each year throughout the entire project phases. Monthly concentrations are presented during the worst year as the seasonal assessment. Where the year of highest concentrations differed between W4 and M18, W4 was chosen to represent the worst year in Casino Creek for that parameter.

For all the figures below, these acronyms and short forms are used:

- C: Construction, O: Operations, CD: Closure and Decommissioning, PC: Post-Closure; and
- Phase I, II, III refer to "Closure Water Management Phase".

Copper

The predictions for Cu concentrations at M18 and W4 in Casino Creek are presented on Figure 7.4-2. The water quality model predicts Cu concentrations to start at around baseline during the construction period, which is above CCME guidelines, and continue to increase annually throughout the operations phase to approximately 0.008 mg/L. The median copper concentration at post-closure is predicted to be about 0.015 mg/L. Both W4 and M18 Cu concentrations are above the 90^{th} percentile SSWQO during the first several years of Closure Water Management Phase II but drop below the 90^{th} percentile SSWQO at W4 for the rest of the post-closure phase. The slight elevation above the 90^{th} percentile SSWQO at M18 is due to the annual peaks in November when the WSMP is still discharging and at a time of anticipated lower flows. Concentrations stay well below the 90^{th} percentile SSWQO at both M18 and W4 for the rest of the months and throughout the all of the project phases.

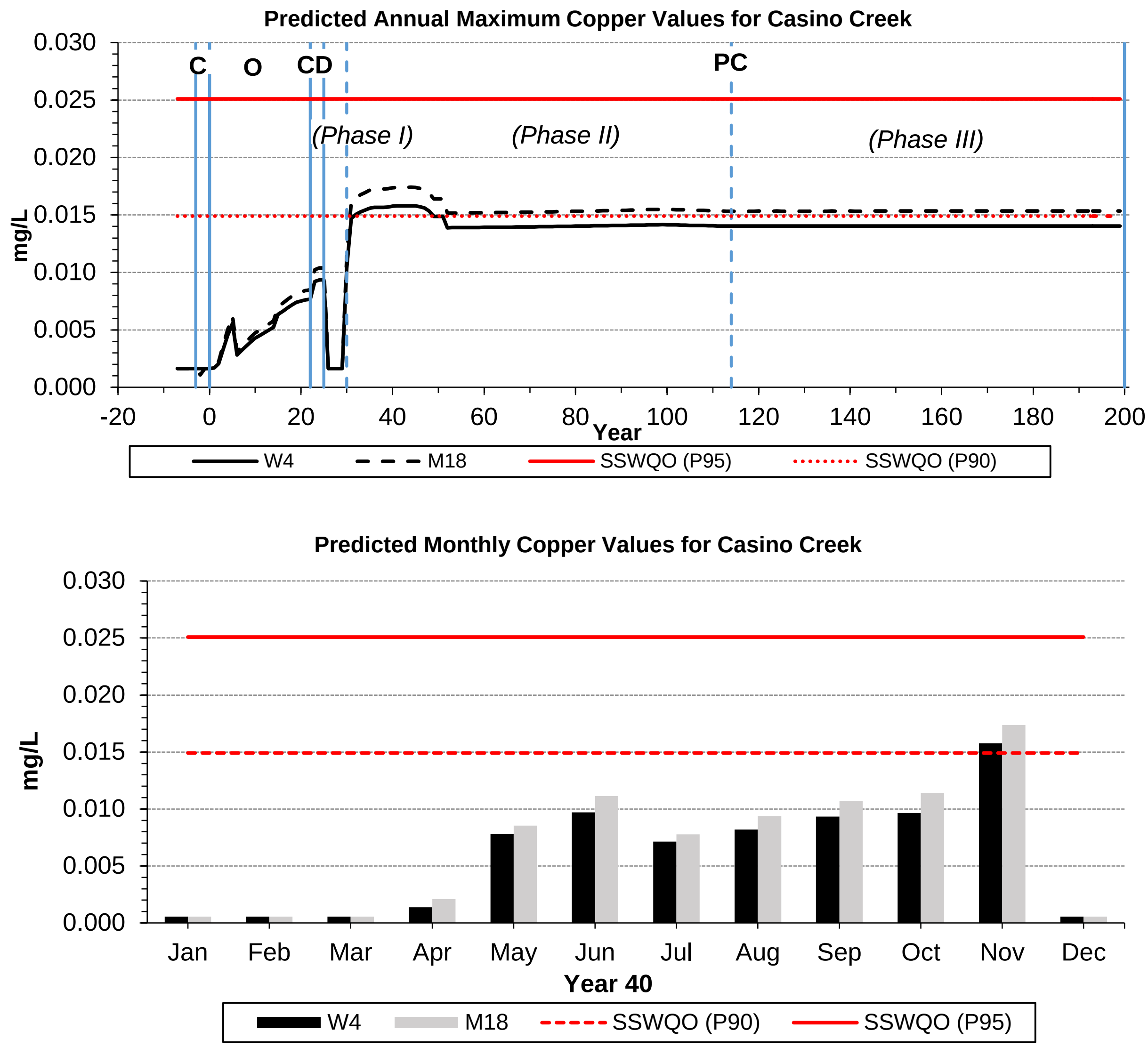
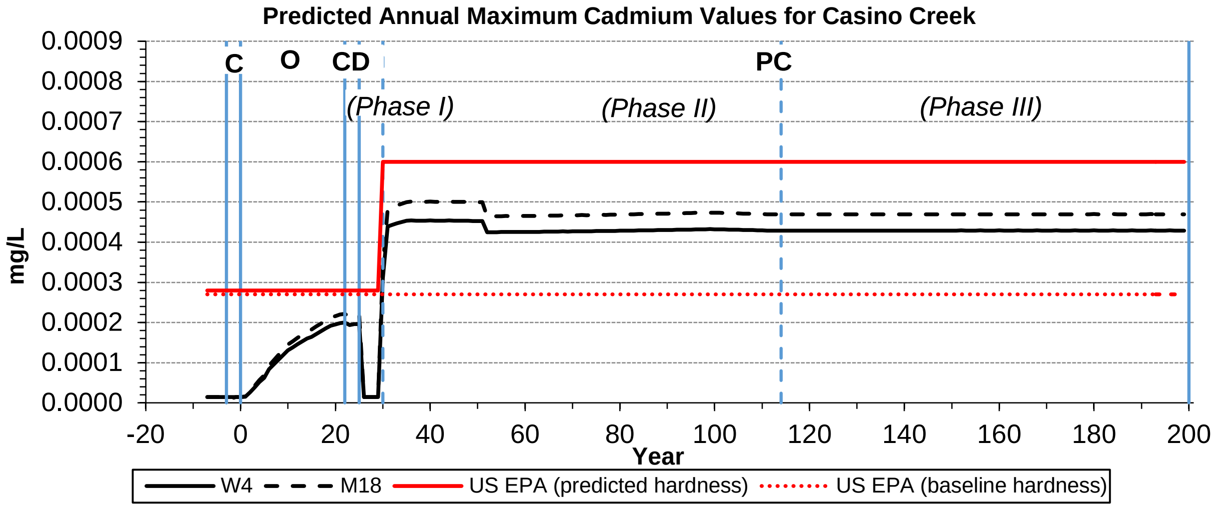


Figure 7.4-2 Predicted Annual Maximum and Monthly Copper Concentrations for Casino Creek

Cadmium

The predictions for dissolved Cd concentrations at M18 and W4 in Casino Creek are presented on Figure 7.4-3. The proposed guideline is the US EPA chronic guideline (0.000027 mg/L) for dissolved cadmium using baseline hardness (111 mg/L $CaCO_3$). The water quality model predicts dissolved cadmium concentrations in Casino Creek to increase annually throughout the operations phase to a maximum of around 0.00021 mg/L. The maximum cadmium concentration at post-closure is predicted to be 0.00050 mg/L at M18 and 0.00045 mg/L at W4, which is above the proposed US EPA chronic guideline, using baseline hardness. However, median predicted hardness during post-closure is 352 mg/L at M18 and 318 mg/L at W4. The corresponding US EPA chronic guideline for dissolved cadmium would be 0.00060 mg/L (using W4 hardness), which is well above the predicted Cd concentrations as shown in Figure 7.4-3. On a seasonal basis, predicted Cd is above US EPA guidelines during most of the open water season (June, August, September, October and November) but remain well below the US EPA guideline based on the predicted hardness.



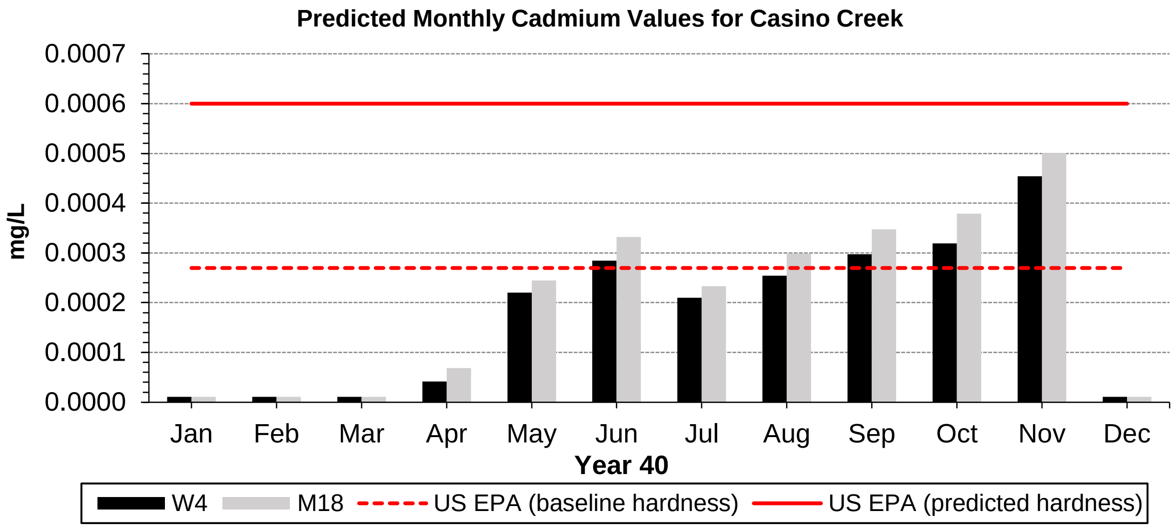
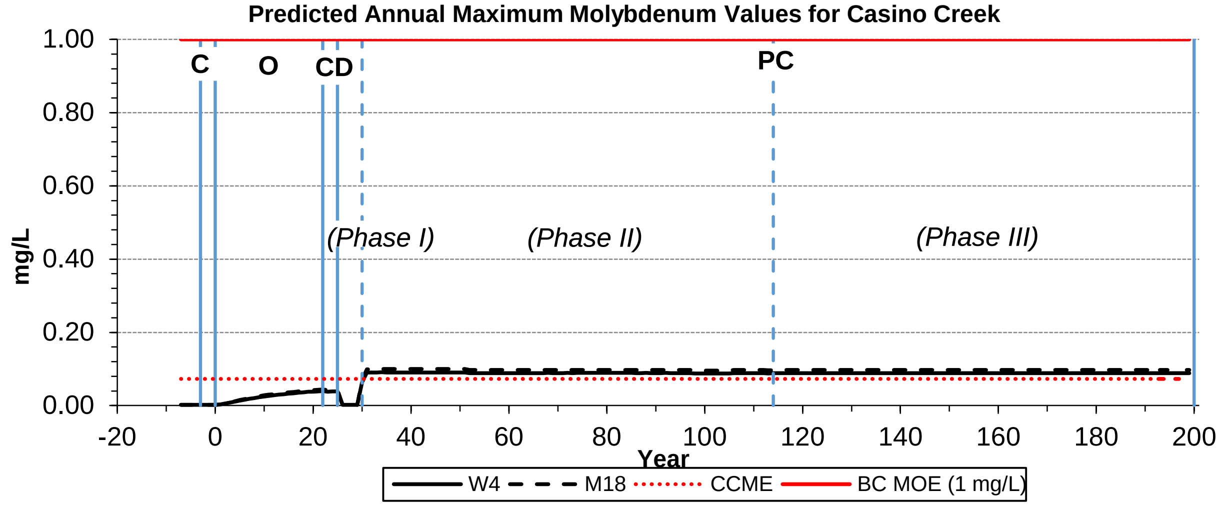


Figure 7.4-3 Predicted Annual Maximum and Monthly Cadmium Concentrations for Casino Creek

Molybdenum

The predictions for Mo concentrations at M18 and W4 in Casino Creek are presented on Figure 7.4-4. The water quality model predicts Mo concentrations to increase annually throughout the operations phase to approximately 0.042 mg/L. The maximum Mo concentration at post-closure is predicted to be about 0.100 mg/L. Concentrations at both M18 and W4 throughout all the project phases are predicted to remain well below the BC MOE guideline 30-day guideline of 1 mg/L. Predicted Mo concentrations are marginally above CCME (0.073 mg/L) only during June, Aug, Sep, Oct and peaking in November of each year.



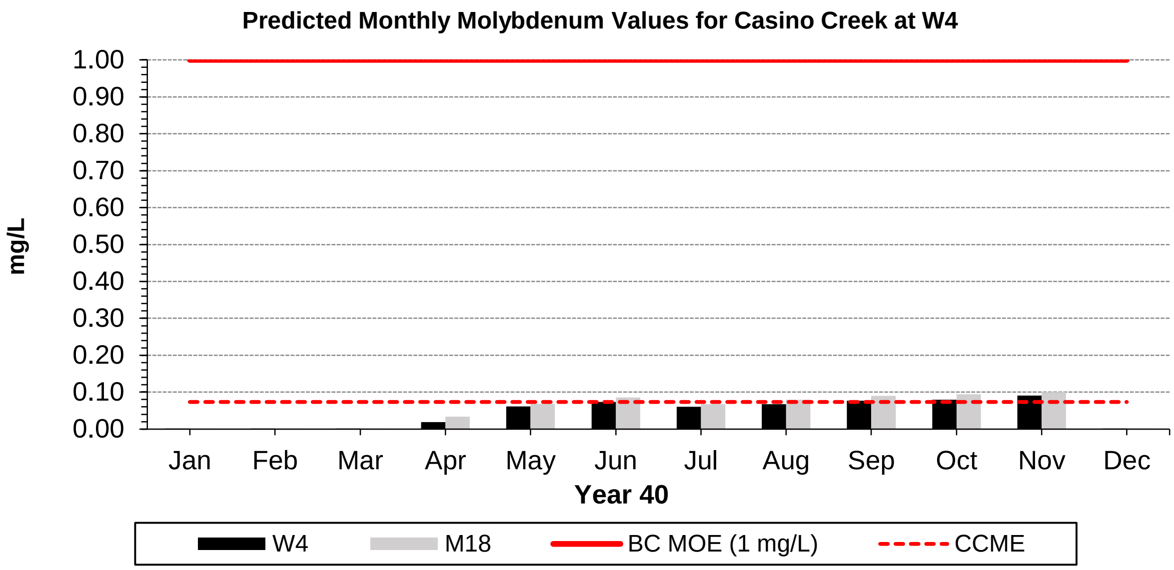
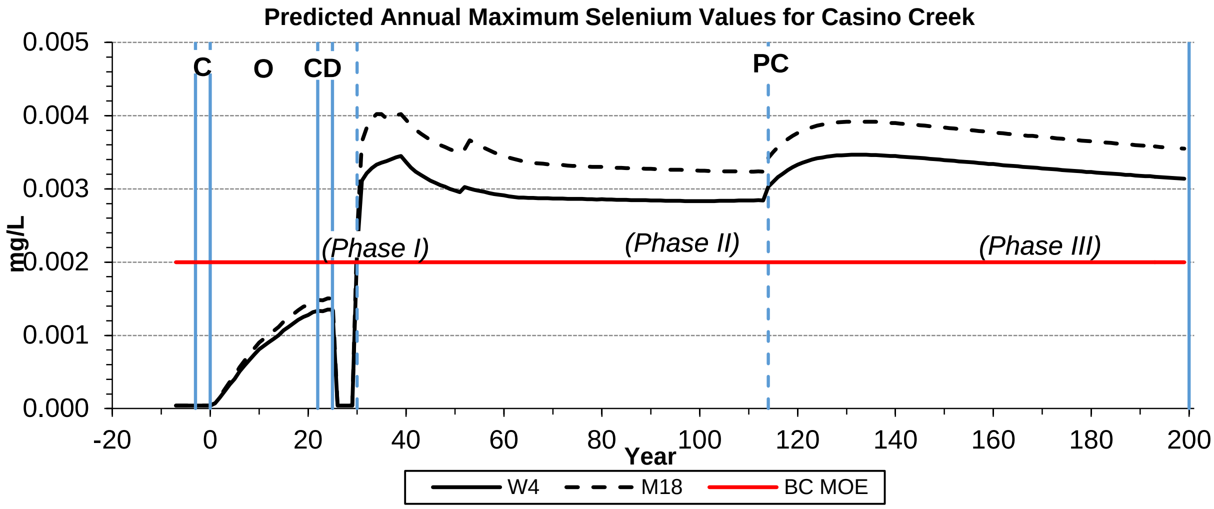


Figure 7.4-4 Predicted Annual Maximum and Monthly Molybdenum Concentrations for Casino Creek

Selenium

The predictions for Se concentrations at M18 and W4 in Casino Creek are presented on Figure 7.4-5. The water quality model predicts Se concentrations to increase annually throughout the operations phase to approximately 0.0015 mg/L. The maximum Se concentration at post-closure is predicted to be 0.0040 mg/L at M18. Se concentrations peak in Closure Water Management Phase II when the TMF starts to discharge via the spillway and again at the start of Closure Water Management Phase III when the Open Pit starts to discharge. Throughout the project phases, predicted annual maximum Se concentrations are above the proposed alternative BC MOE guideline of 0.002 mg/L although less than the US EPA guideline of 0.005 mg/L. Elevated Se concentrations occur during the period of discharge from the WSMP, which is between April and November at both W4 and M18.



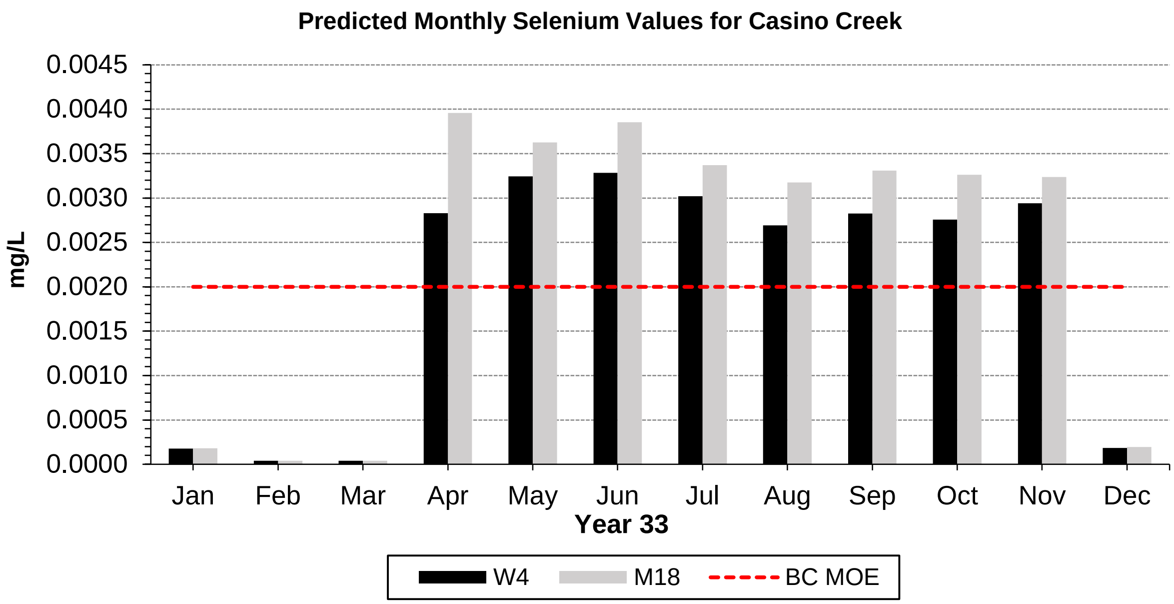
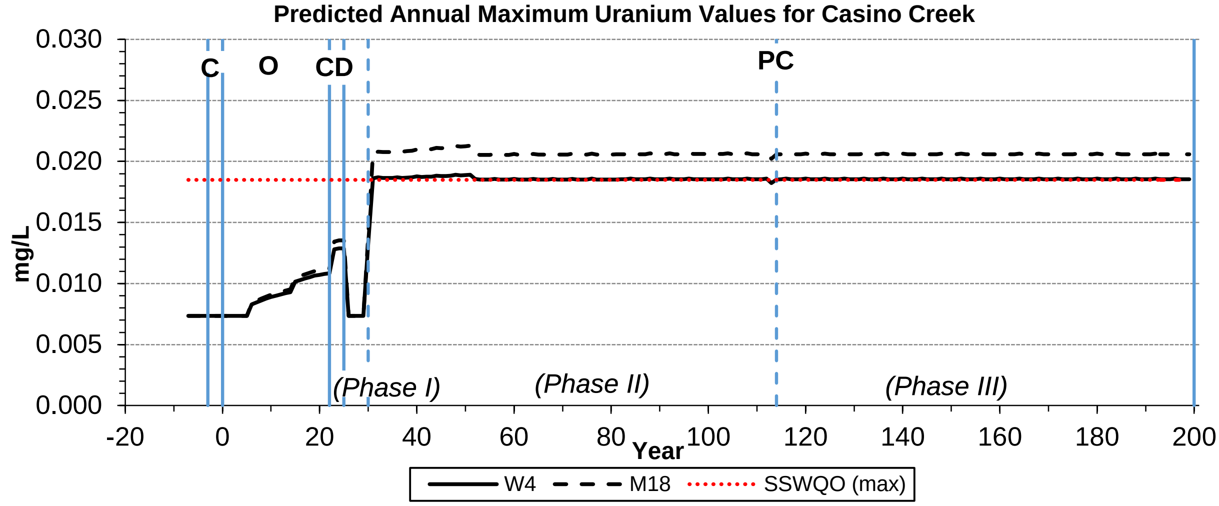


Figure 7.4-5 Predicted Annual Maximum and Monthly Selenium Concentrations for Casino Creek

Uranium

The predictions for U concentrations at M18 and W4 in Casino Creek are presented on Figure 7.4-6. The water quality model predicts U concentrations to increase annually throughout the operations phase to approximately 0.013 mg/L. The maximum U concentration at post-closure is predicted to be 0.021 mg/L at M18. The proposed SSWQO based on the maximum baseline value is exceeded at M18 at post-closure, which is due to the seasonal peak in November only. Predicted U concentrations are below the SSWQO for the rest of the year.



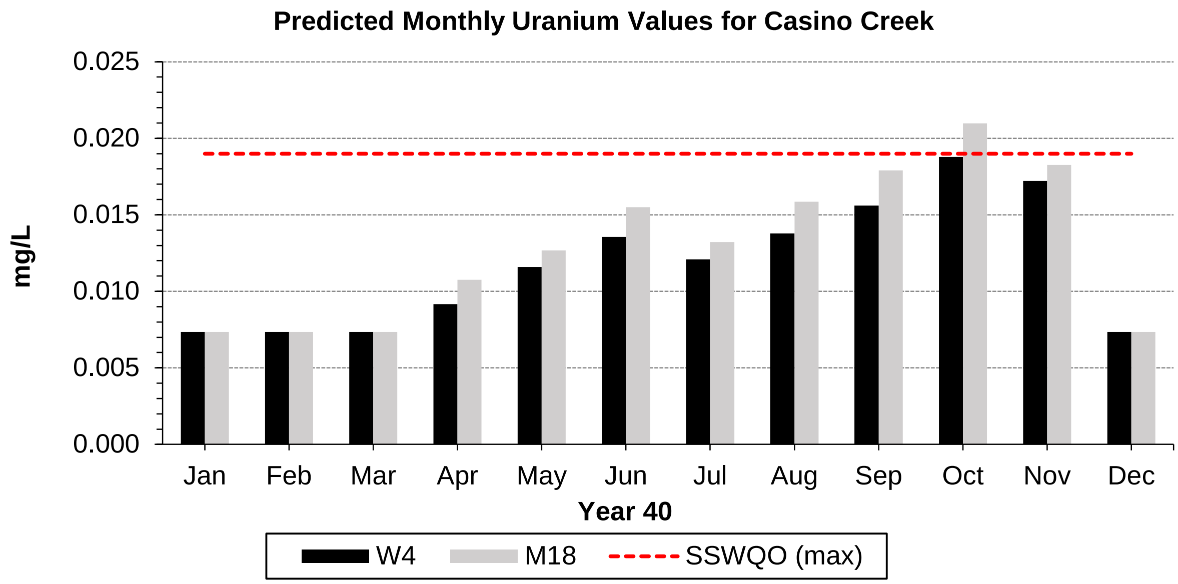
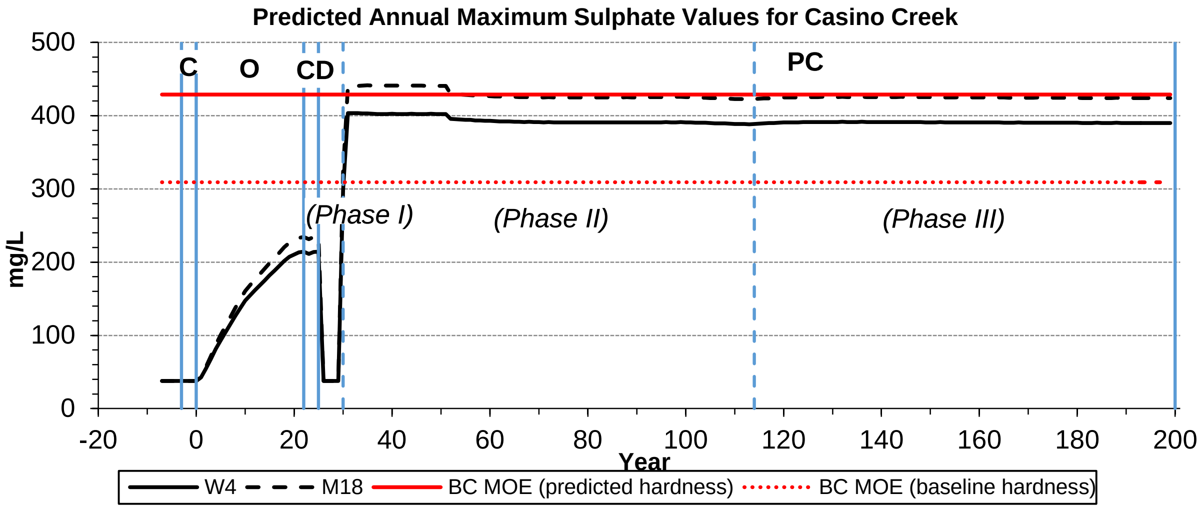


Figure 7.4-6 Predicted Annual Maximum and Monthly Uranium Concentrations for Casino Creek

Sulphate

The predictions for SO_4 concentrations at M18 and W4 in Casino Creek are presented on Figure 7.4-7. The water quality model predicts SO_4 concentrations to increase annually throughout the operations phase to approximately 225 mg/L. The maximum SO_4 concentration at post-closure is predicted to be about 441 mg/L at M18 and 404 mg/L at W4, with exceedances above the BC MOE guideline at M18 in November during the first few years of the post-closure phase. Seasonally, SO_4 is predicted to exceed the BC MOE guideline using baseline hardness during the open water season between April and November but will remain below the BC MOE guideline using predicted hardness for all months except of November.



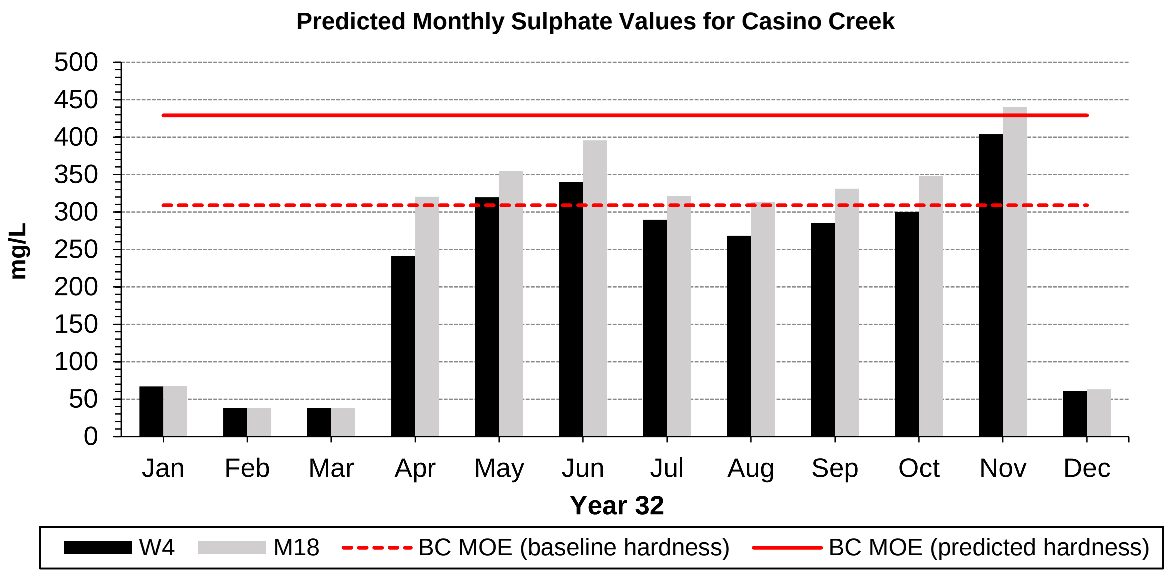
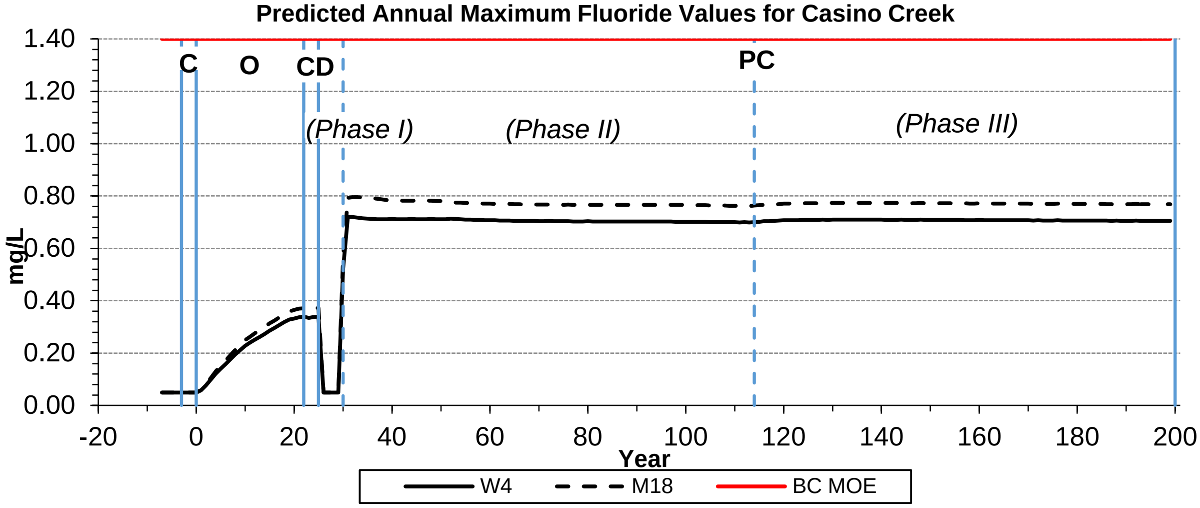


Figure 7.4-7 Predicted Annual Maximum and Monthly Sulphate Concentrations for Casino Creek

Fluoride

The predictions for F concentrations at M18 and W4 in Casino Creek are presented on Figure 7.4-8. The water quality model predicts F concentrations to increase annually throughout the operations phase to approximately 0.39 mg/L. The maximum F concentration at post-closure is predicted to be 0.80 mg/L at M18. Predicted F concentrations after the construction phase are above CCME guidelines but remain well below the proposed alternative guideline from BC MOE of 1.4 mg/L.



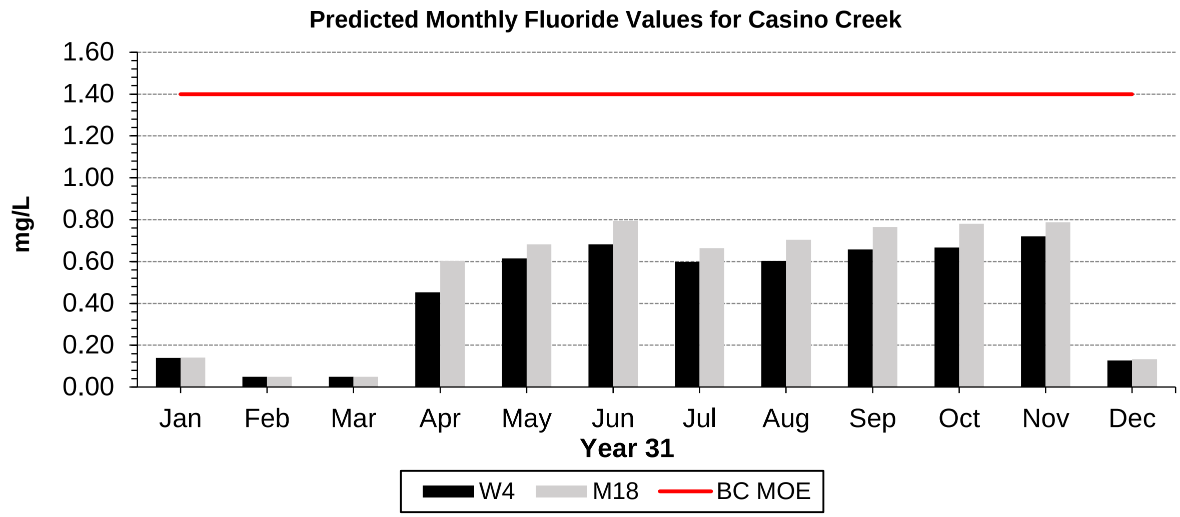


Figure 7.4-8 Predicted Annual Maximum and Monthly Fluoride Concentrations for Casino Creek

A summary of the predicted water quality in Casino Creek at M18 and W4 is shown in Table 7.4-8 and Table 7.4-9, respectively. Each project phase is represented by the range of concentrations in a typical year. The construction period was not included as there are no substantial deviations from baseline.

Table 7.4-8 Summary Predicted Water Quality in Casino Creek at M18 in Typical Years of Each Project Phase

Parameter	Proposed Water Quality Objective	Operations (Year 20)		Closure and Decommissioning (Year 25)		Post-Closure (Year 100)	
		min	*max*	*min*	*max*	*min*	*max*
Hardness		70	290	70	297	116	487
Acidity		0.62	1.49	0.61	1.49	0.72	3.40

Alkalinity		51	87	50	87	62	169
Sulphate	309	27	230	27	235	38	425
Cyanide (Total)		0.00025	0.00042	0.00025	0.00042	0.00010	0.00043
Cyanide (WAD)		0.00021	0.00025	0.00021	0.00025	0.00006	0.00025
Chloride		0.46	5.66	0.47	5.81	0.25	13.29
Fluoride	1.4	0.05	0.36	0.05	0.37	0.05	0.77
Aluminum		0.0072	0.0654	0.0071	0.0654	0.0079	0.0546
Antimony		0.00015	0.00055	0.00015	0.00055	0.00014	0.01452
Arsenic		0.00042	0.00094	0.00043	0.00096	0.00036	0.00376
Barium		0.040	0.066	0.040	0.065	0.058	0.079
Cadmium	0.00027	0.00002	0.00022	0.00002	0.00022	0.00001	0.00047
Calcium		20	100	20	102	31	178
Chromium		0.00009	0.00042	0.00009	0.00043	0.00005	0.00128
Cobalt		0.00011	0.00117	0.00013	0.00156	0.00001	0.01659
Copper	0.025	0.0014	0.0083	0.0017	0.0104	0.0006	0.0155
Iron	0.99	0.094	0.738	0.095	0.731	0.002	0.047
Lead		0.00004	0.00020	0.00004	0.00021	0.00002	0.00234
Magnesium		4.9	9.7	4.9	10.1	9.7	17.7
Manganese		0.016	0.323	0.016	0.329	0.004	0.688
Mercury		0.000005	0.000007	0.000005	0.000007	0.000005	0.000015
Molybdenum	1	0.0026	0.0425	0.0027	0.0432	0.0019	0.0960
Nickel		0.0002	0.0008	0.0002	0.0009	0.0001	0.0044
Potassium		0.94	1.36	0.94	1.36	1.39	5.20
Selenium	0.002	0.00007	0.00142	0.00008	0.00151	0.00004	0.00325
Silicon		4.88	5.29	4.80	5.24	1.99	5.24
Silver		0.000003	0.000010	0.000003	0.000010	0.000003	0.000035
Sodium		3.0	10.0	3.0	10.3	4.8	15.4
Strontium		0.11	0.35	0.11	0.38	0.18	0.64
Thallium		0.000007	0.000076	0.000007	0.000078	0.000001	0.000157
Uranium	0.019	0.0028	0.0111	0.0029	0.0135	0.0073	0.0206
Zinc		0.0014	0.0043	0.0015	0.0049	0.0011	0.0165

Notes:

[grey shading] *Exceeds Proposed WQO*

Sulphate: *Approved BC MOE 30-day average (baseline hardness)*
Fluoride: *Approved BC MOE maximum*
Cadmium: *US EPA chronic dissolved (baseline hardness)*
Copper: *SSWQO-BCP based on the 95th percentile*
Molybdenum: *Approved BC MOE 30-day average*
Selenium: *Approved (Interim) BC MOE 30-day average*
Uranium: *SSWQO-BCP based on the maximum*

Table 7.4-9 Summary of Predicted Water Quality in Casino Creek at W4 in Typical Years of Each Project Phase

Parameter	Proposed Water Quality Objective	Operations (Year 20)		Closure and Decommissioning (Year 25)		Post-Closure (Year 100)	
		min	*max*	*min*	*max*	*min*	*max*
Hardness		68	273	69	278	116	453
Acidity		0.63	1.49	0.63	1.49	0.72	2.68
Alkalinity		51	88	50	87	64	147
Sulphate	309	25	210	26	214	38	391
Cyanide (Total)		0.00025	0.00042	0.00025	0.00042	0.00012	0.00043
Cyanide (WAD)		0.00022	0.00025	0.00022	0.00025	0.00011	0.00025
Chloride		0.41	5.11	0.42	5.22	0.25	12.13
Fluoride	1.4	0.05	0.33	0.05	0.34	0.05	0.70
Aluminum		0.0072	0.0655	0.0072	0.0655	0.0079	0.0557
Antimony		0.00015	0.00051	0.00015	0.00051	0.00014	0.01237
Arsenic		0.00041	0.00088	0.00041	0.00090	0.00036	0.00327
Barium		0.040	0.065	0.040	0.065	0.058	0.074
Cadmium	0.00027	0.00002	0.00020	0.00002	0.00020	0.00001	0.00043
Calcium		20	93	20	95	31	164
Chromium		0.00008	0.00038	0.00008	0.00039	0.00005	0.00113
Cobalt		0.00010	0.00105	0.00011	0.00140	0.00001	0.01217
Copper	0.025	0.0012	0.0075	0.0014	0.0094	0.0006	0.0141
Iron	0.99	0.073	0.664	0.072	0.655	0.004	0.057
Lead		0.00003	0.00018	0.00003	0.00019	0.00002	0.00172
Magnesium		4.9	9.7	4.9	10.1	9.7	15.6
Manganese		0.013	0.291	0.013	0.295	0.004	0.627
Mercury		0.000005	0.000007	0.000005	0.000007	0.000005	0.000013
Molybdenum	1	0.0023	0.0384	0.0023	0.0389	0.0019	0.0876
Nickel		0.0002	0.0007	0.0002	0.0008	0.0001	0.0032
Potassium		0.94	1.37	0.94	1.37	1.39	4.18
Selenium	0.002	0.00006	0.00128	0.00006	0.00135	0.00004	0.00283
Silicon		4.91	5.29	4.88	5.26	2.86	5.24
Silver		0.000003	0.000009	0.000003	0.000009	0.000003	0.000027
Sodium		2.9	9.5	2.9	9.7	4.8	14.5
Strontium		0.11	0.34	0.11	0.36	0.18	0.59
Thallium		0.000006	0.000068	0.000006	0.000070	0.000001	0.000143
Uranium	0.019	0.0027	0.0107	0.0028	0.0129	0.0073	0.0185
Zinc		0.0013	0.0040	0.0014	0.0045	0.0011	0.0124

Notes:

(shaded) *Exceeds Proposed WQO*

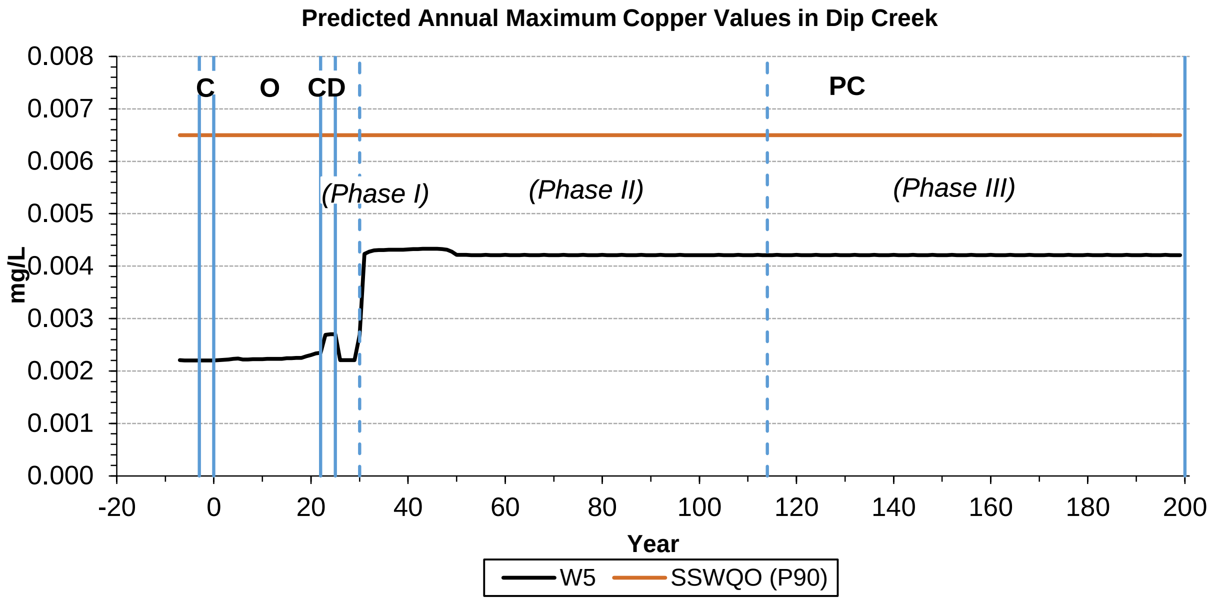
Sulphate: *Approved BC MOE 30-day average (baseline hardness)*
Fluoride: *Approved BC MOE maximum*
Cadmium: *US EPA chronic dissolved (baseline hardness)*
Copper: *SSWQO-BCP based on the 95th percentile*
Molybdenum: *Approved BC MOE 30-day average*
Selenium: *Approved (Interim) BC MOE 30-day average*
Uranium: *SSWQO-BCP based on the maximum*

7.4.3.1.3 Application of Proposed Alternative Guidelines in Dip Creek

The maximum annual and monthly predicted water quality for each COC in Dip Creek is presented below, and compared against the corresponding SSWQO. Maximum annual water quality is represented by the worst (highest concentration) month for each year. Monthly concentrations are presented during the worst year as the seasonal assessment.

Copper

The predicted Cu concentrations at W5 in Dip Creek are presented on Figure 7.4-9. The water quality model predicts Cu concentrations to start at around baseline during the construction period, which is above CCME guidelines, and remain stable throughout the operations phase at approximately 0.0028 mg/L. The maximum copper concentration at post-closure is predicted to be 0.0043 mg/L. Concentrations stay well below the 90th percentile SSWQO of 0.0065 mg/L throughout the all of the project phases.



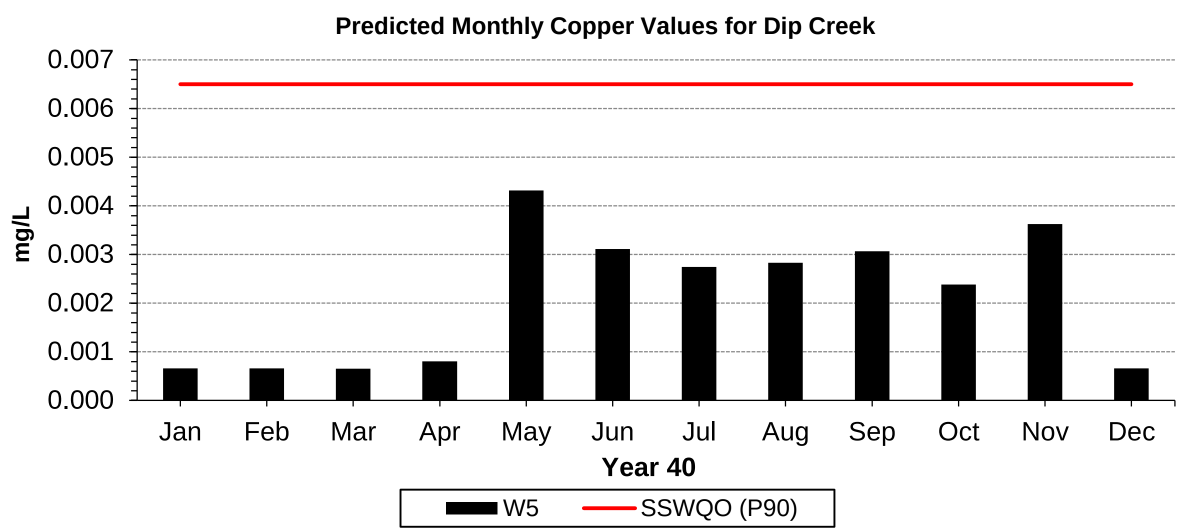
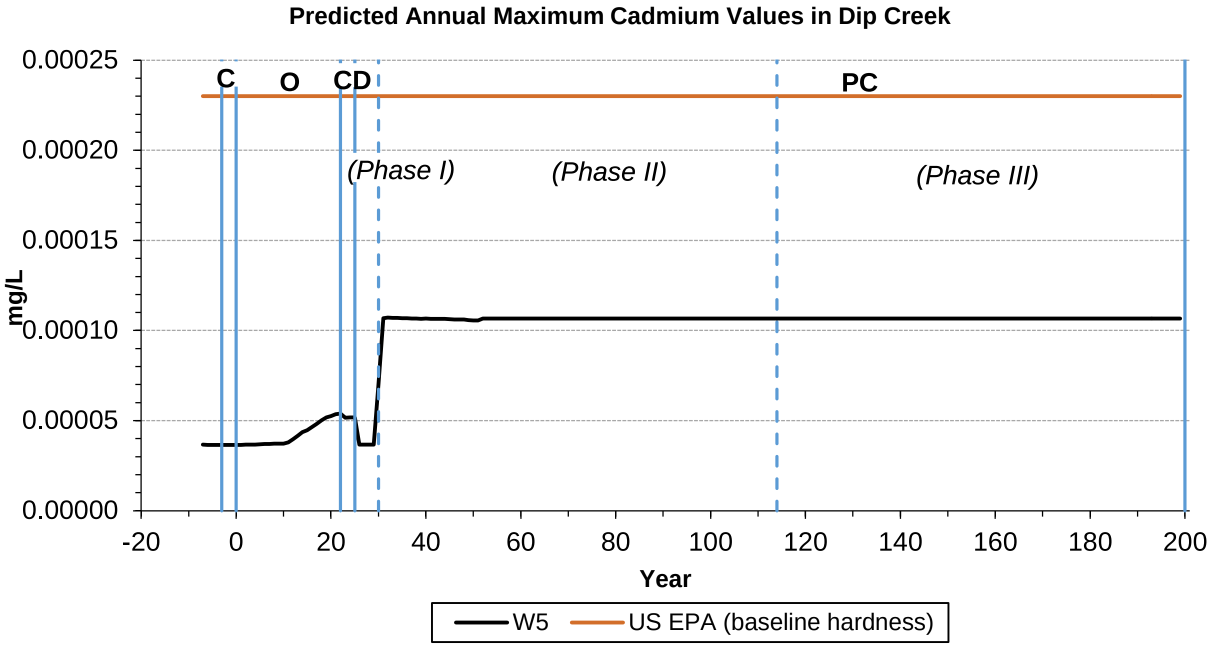


Figure 7.4-9 Predicted Annual Maximum and Monthly Copper Concentrations for Dip Creek

Cadmium

The predicted Cd concentrations at W5 in Dip Creek are presented on Figure 7.4-10. The proposed guideline is the US EPA chronic guideline (0.000023 mg/L) for dissolved cadmium using baseline hardness (90 mg/L $CaCO_3$). The water quality model predicts cadmium concentrations in Dip Creek to increase annually throughout the operations phase to a maximum of around 0.000054 mg/L. The maximum cadmium concentration at post-closure is predicted to be 0.00011 mg/L. Predicted Cd concentrations remain well below the US EPA guideline using baseline hardness throughout all the project phases and during all months of every year.



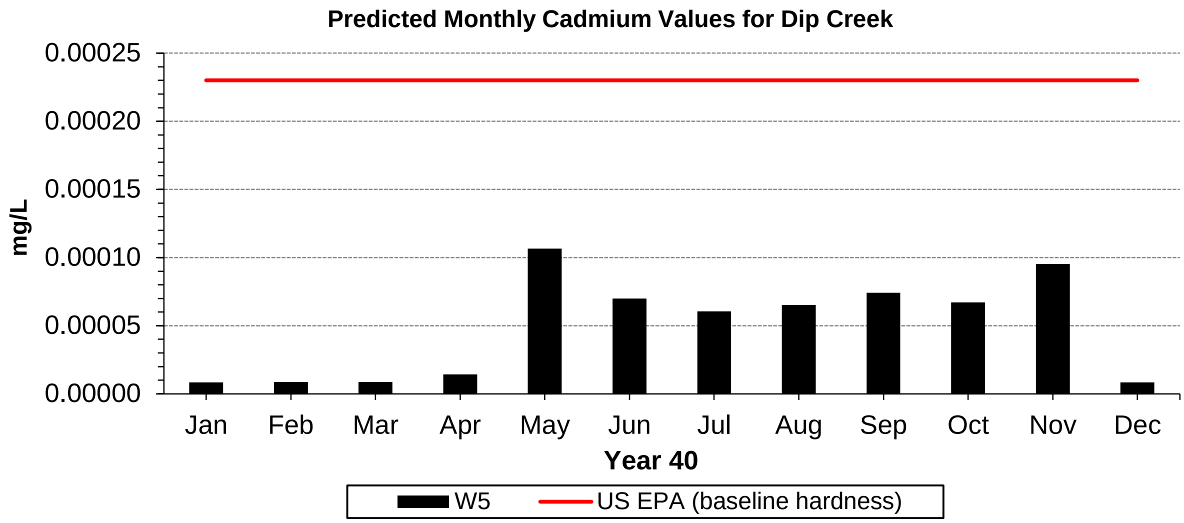
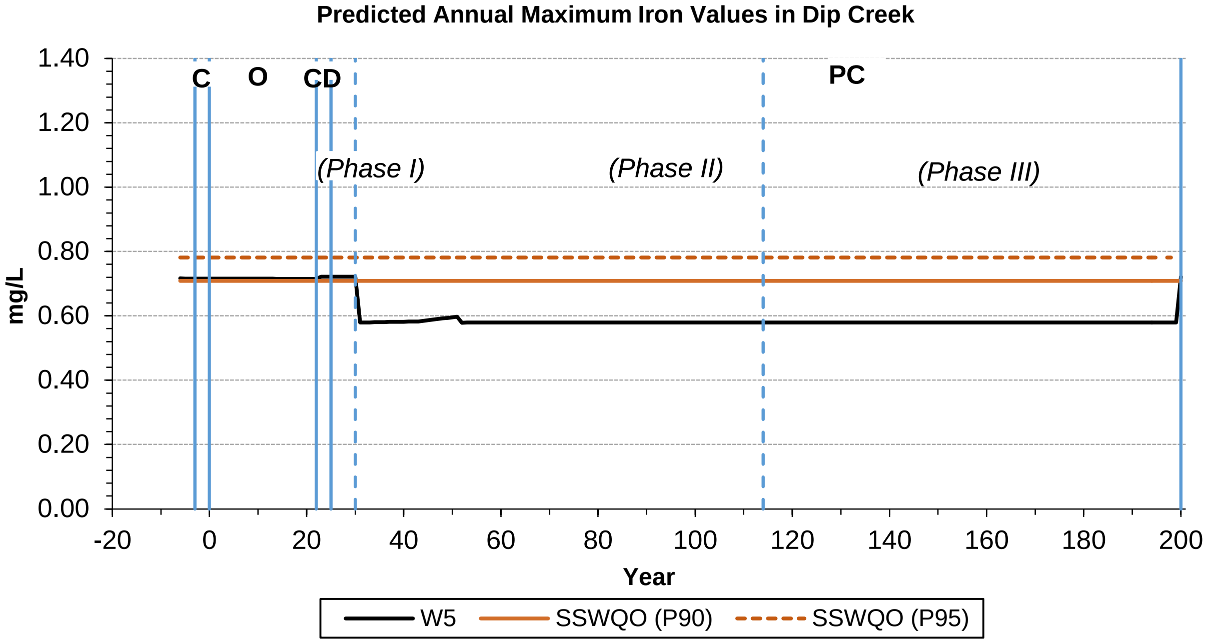


Figure 7.4-10 Predicted Annual Maximum and Monthly Cadmium Concentrations for Dip Creek

Iron

The predicted Fe concentrations at W5 in Dip Creek are presented on Figure 7.4-11. The water quality model predicts maximum Fe concentrations to exceed CCME guidelines because the background data used for the model has naturally elevated total Fe in May. Predicted maximum Fe concentrations are below the proposed 95th percentile SSWQO during the construction, operations and closure and decommissioning phases and decrease below the 90th percentile SSWQO for post-closure. Seasonally, it is clear that exceedance of the CCME guideline or SSWQO are restricted to the month of May only. Predicted maximum Fe concentration at post-closure, once the TMF begins to discharge and provide dilution to the elevated Fe in Dip Creek, is predicted to be 0.60 mg/L which is well below the proposed 90th percentile SSWQO of 0.71 mg/L.



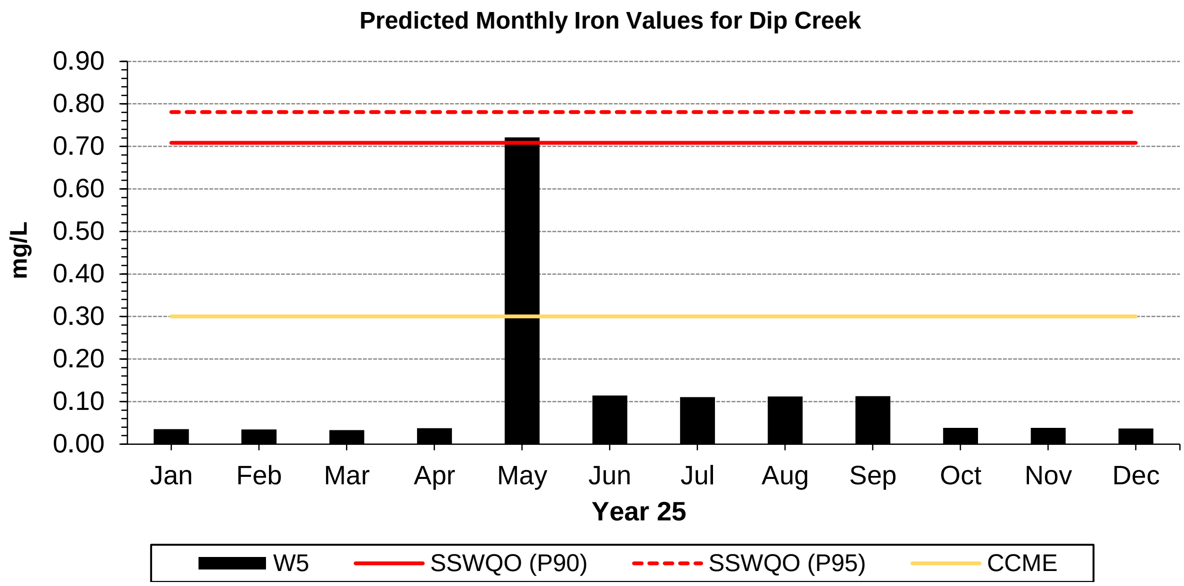
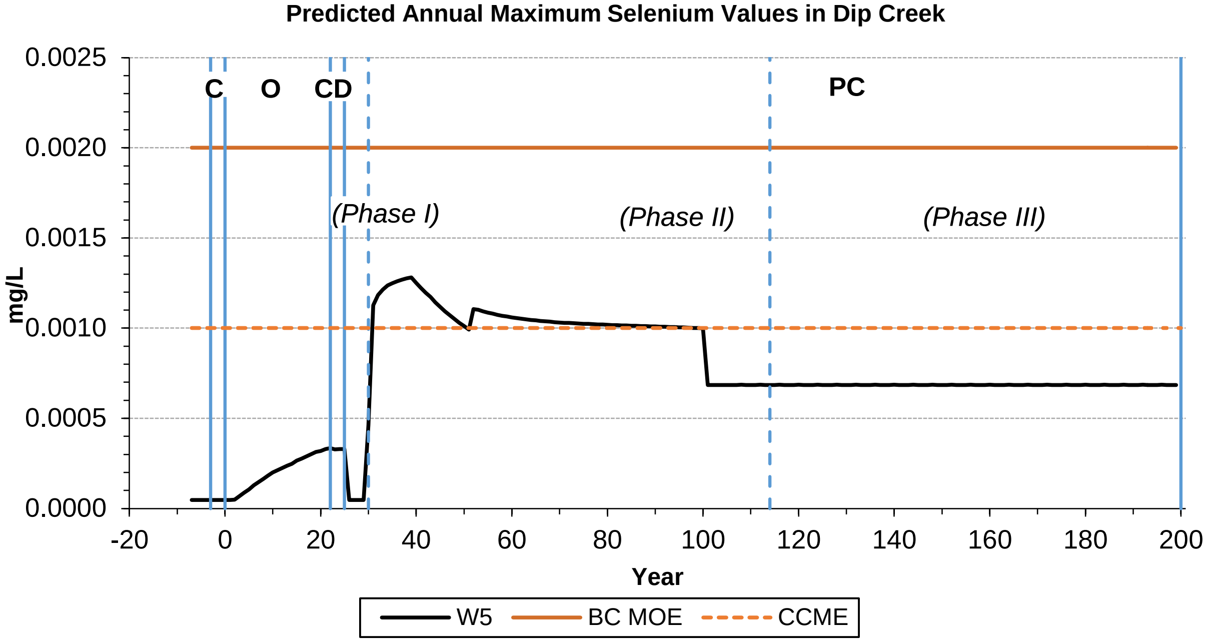


Figure 7.4-11 Predicted Annual Maximum and Monthly Iron Concentrations for Dip Creek

Selenium

The predicted Se concentrations at W5 in Dip Creek are presented on Figure 7.4-12. The water quality model predicts Se concentrations to increase annually throughout the operations phase to approximately 0.00048 mg/L. The maximum Se concentration at post-closure is predicted to be 0.0013 mg/L. Se concentrations are predicted to exceed CCME guidelines only during Closure Water Management Phase II when the TMF pond discharges into Casino Creek via the spillway. Seasonally, Se concentrations only exceed CCME guidelines during the month of May. For the rest of the year and for all of construction, operations and post-closure after discharge of the Open Pit, predicted Se concentrations remain well below both CCME and BC MOE guidelines.



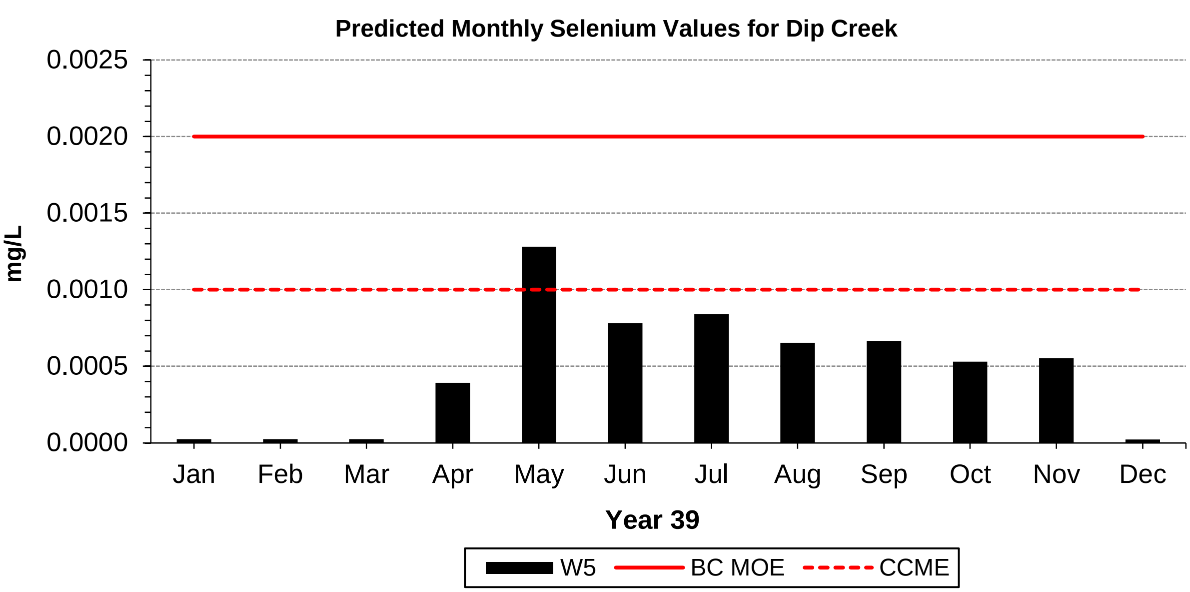
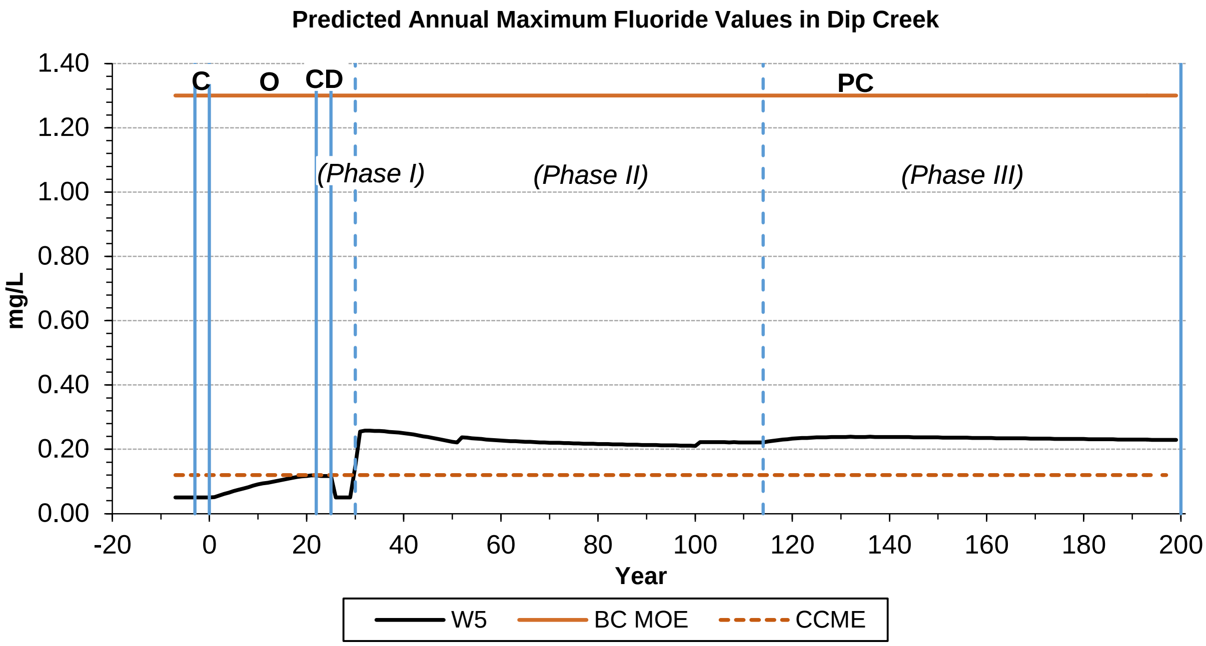


Figure 7.4-12 Predicted Annual Maximum and Monthly Selenium Concentrations for Dip Creek

Fluoride

The predicted F concentrations at W5 in Dip Creek are presented on Figure 7.4-13. The water quality model predicts F concentrations to increase annually throughout the operations phase to approximately 0.12 mg/L, which is also the CCME guideline. The maximum F concentration at post-closure is predicted to be 0.26 mg/L. The predicted maximum F concentrations are below the CCME guideline up to post-closure, after which time they exceed CCME but remain well below the proposed hardness adjusted alternative guideline from BC MOE of 1.3 mg/L.



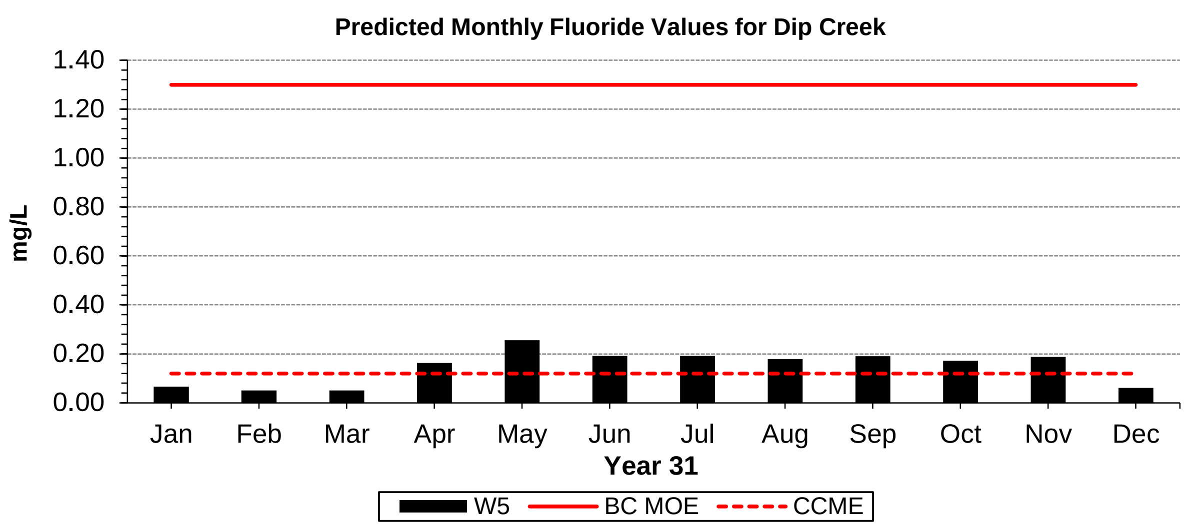


Figure 7.4-13 Predicted Annual Maximum and Monthly Fluoride Concentrations for Dip Creek

A summary of the predicted water quality in Dip Creek at W5 is shown in Table 7.4-10. Each project phase is represented by the range of concentrations in a typical year. The construction period was not included as there are no substantial deviations from baseline.

Table 7.4-10 Summary of Predicted Water Quality in Dip Creek at W5 in Typical Years of Each Project Phase

Parameter	Proposed Water Quality Objective	Operations (Year 20)		Closure and Decommissioning (Year 25)		Post-Closure (Year 100)	
		min	*max*	*min*	*max*	*min*	*max*
Hardness		57	156	57	157	119	189
Acidity		0.95	2.99	0.95	3.00	1.13	3.06
Alkalinity		47	107	47	107	66	121
Sulphate		8	67	8	67	25	98
Cyanide (Total)		0.00025	0.00049	0.00025	0.00049	0.00022	0.00039
Cyanide (WAD)		0.00024	0.00052	0.00024	0.00053	0.00021	0.00042
Chloride		0.27	1.41	0.27	1.41	0.25	3.42
Fluoride	1.3	0.05	0.12	0.05	0.12	0.05	0.21
Aluminum		0.0071	0.0942	0.0071	0.0944	0.0072	0.0849
Antimony		0.00008	0.00017	0.00008	0.00016	0.00007	0.00292
Arsenic		0.00023	0.00072	0.00023	0.00073	0.00023	0.00134
Barium		0.046	0.074	0.046	0.074	0.050	0.075
Cadmium	0.00023	0.00001	0.00005	0.00001	0.00005	0.00001	0.00011
Calcium		15	45	15	45	31	58
Chromium		0.00005	0.00058	0.00005	0.00058	0.00005	0.00070
Cobalt		0.00005	0.00041	0.00006	0.00042	0.00004	0.00389
Copper	0.0065	0.0008	0.0023	0.0008	0.0027	0.0007	0.0042
Iron	0.78/0.71	0.047	0.738	0.047	0.743	0.032	0.594
Lead		0.00002	0.00054	0.00002	0.00054	0.00002	0.00094
Magnesium		4.8	10.3	4.8	10.3	7.3	11.9
Manganese		0.015	0.088	0.015	0.088	0.021	0.205
Mercury		0.000005	0.000005	0.000005	0.000005	0.000005	0.000007
Molybdenum		0.0008	0.0096	0.0008	0.0095	0.0008	0.0219
Nickel		0.0003	0.0009	0.0003	0.0009	0.0002	0.0018
Potassium		0.68	1.00	0.68	0.99	1.01	1.85
Selenium	0.002	0.00003	0.00032	0.00003	0.00033	0.00002	0.00100
Silicon		4.04	5.29	4.02	5.28	3.47	5.29
Silver		0.000003	0.000004	0.000003	0.000004	0.000003	0.000012
Sodium		2.5	6.1	2.5	6.1	4.7	6.9
Strontium		0.11	0.27	0.11	0.27	0.23	0.32
Thallium		0.000002	0.000017	0.000002	0.000017	0.000001	0.000039

Uranium		0.0033	0.0091	0.0033	0.0096	0.0064	0.0106
Zinc		0.0006	0.0030	0.0006	0.0030	0.0006	0.0065

Notes:

(grey shading) Exceeds Proposed WQO
Fluoride: Approved BC MOE maximum
Cadmium: US EPA chronic dissolved (baseline hardness)
Copper: SSWQO-BCP based on the 95th percentile
Iron: Not a COC; SSWQO-BCP for natural elevated Fe based on the 90th percentile for PC and 95th
Selenium: Approved (Interim) BC MOE 30-day average

7.4.3.2 Discussion of Residual Effects

After consideration of the proposed alternative guidelines discussed in the previous sections, the only parameters that continue to exceed the proposed guidelines in Casino Creek are:

- **Cd**: at Post-Closure, Cd exceeds the US EPA guideline based on baseline hardness but not predicted hardness; exceedances occur in June, August, September, October and November at both M18 and W4.
- **Se**: at Post-Closure, Se exceeds the BC MOE guideline between April and November at both M18 and W4, but does not exceed the US EPA guideline.
- **U**: at Post-Closure, U exceeds the maximum BCP-SSWQO in October at M18 but not at W4.
- **SO_4**: at Post-Closure, SO_4 exceeds the BC MOE guideline based on baseline hardness but not predicted hardness; exceedances occur between April and November at M18 and in May, June and November at W4.

After consideration of the proposed alternative guidelines discussed in the previous sections, no parameters exceed proposed guidelines in Dip Creek.

Based on the continued exceedances in Casino Creek, residual water quality effects are predicted for this watercourse. Potential effects, mitigations, and residual effects for water quality are summarized below in Table 7.4-11.

Table 7.4-11 Identification of Mitigation Measures and Potential Residual Effects for Water Quality

Potential Effect	Project Phase (C, O, CD, PC)	Direction	Proposed Mitigation (*or Enhancement*) Measure[1]	Predicted Effectiveness	Residual Effect
Change in surface water quality in Casino Creek due to unrecovered seepage	O,CD	Adverse	The water management pond will intercept 90-95% of seepage and pump it back to the TMF.	High	No
Change in surface water quality in Dip Creek due to unrecovered seepage	O,CD	Adverse	The water management pond will intercept 90-95% of seepage and pump it back to the TMF.	High	No

Change in surface water quality in Casino Creek due to project discharge	PC	Adverse	Water Management and Passive Treatment (i.e. Construction of two engineering wetlands: North TMF wetland and South TMF wetland, construction of a WSMP to contain seepage during December to April and release during higher flows).	Low	Yes
Change in surface water quality in Dip Creek due to project discharge	PC	Adverse	Water Management and Passive Treatment (i.e. Construction of two engineering wetlands: North TMF wetland and South TMF wetland, construction of a WSMP to contain seepage during December to April and release during higher flows).	High	No
Changes in surface water quality due to blasting residues	O	Adverse	Divert all contact water to the TMF; BMPs for explosives selection, drilling, handling and loading.	High	No
Changes in surface water quality due to atmospheric deposition	O	Adverse	Divert all contact water to the TMF; BMPs for drilling, handling and loading ore; traffic speed limits, dust suppressants.	High	No
Change in surface water quality from increased erosion and sedimentation	C,O,CD	Adverse	Water management and BMPs for sediment control as outlined in the Erosion and Sedimentation Control Plan; modify culvert and bridge design for areas with increased sensitivity to disturbances	High	No

Notes

1. C (Construction), O (Operation), DC (Decommissioning and Closure) and PC (Post-Closure) represent the Project phases when the potential interaction between the Project and valued component is anticipated to occur.
2. For beneficial potential effects, opportunities, where possible, to enhance potential environmental and socio-economic benefits are included as proposed enhancement measures.

7.4.4 Significance of Residual Effects

Significance of residual effects was evaluated based on several criteria including: magnitude, geographical extent, duration, frequency, reversibility, context, and probability of occurrence, as defined for water quality (Table 7.4-11). Ratings were assigned to each individual residual effect and compiled in Table 7.4-12.

Table 7.4-11 Determining Significance of Residual Effects for Water Quality

Criteria	Rating	VC Specific Definitions
Magnitude	Low	Predicted effects on water quality are higher than baseline but less than Water Quality Guidelines (WQG)
	Medium	Predicted effects on water quality are above the threshold (WQG or if baseline is higher than WQG the threshold is baseline plus 10%) and less than 10x WQG
	High	Predicted effects on water quality are above 10x WQG
Geographical Extent	Localized	Effect limited to the LSA
	Widespread	Effect extends to the RSA
Duration	Short Term	Effect lasts <2 years
	Long Term	Effect lasts more than 2 years but less than 25 years (equivalent to estimated Life-of-Project (Construction, Operations, Closure and Decommissioning)
	Permanent	Effect continues beyond Post-Closure phase into the foreseeable future
Frequency	Infrequent	Effect occurs rarely (i.e. monthly to yearly)
	Frequent	Effect occurs intermittently or continuously (i.e. weekly or daily)
Reversibility	Reversible	Effect is reversed after the activity ceases
	Irreversible	Effect will not be reversed after the activity ceases
Context	Low resilience	Low resilience to imposed stresses, or will not easily adapt to the effect.
	High resilience	High resilience to imposed stresses, or will easily adapt to the effect.
Probability of occurrence	Low	Low likelihood that the predicted residual effect will occur.
	Moderate	Moderate likelihood that the predicted residual effect will occur.
	High	High likelihood that the predicted residual effect will occur.

Table 7.4-12 Significance of Residual Effects for Water Quality

Residual Effect	Predicted Degree of Effect After Mitigation (*or Enhancement*) Measures[1]								Significance of Residual Effect
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context	Probability of Occurrence	
Change in surface water quality in Casino Creek due to project discharge (PC)	Adverse	Medium	Local	Permanent	Frequent	Irreversible	Low Resilience	High	Not Significant

7.4.5 Discussion of Significance

Predicted water quality in Casino Creek exceeds CCME and BC MOE freshwater aquatic life guidelines for seven parameters: Cu, Cd, Mo, Se, U, SO_4 and F. Exceedances for several of these parameters were also predicted in Dip Creek. However, after assessment against proposed alternative guidelines, which include developed

SSWQO's and applicable guidelines from other jurisdictions, only Cd, Se, U and SO_4 concentrations continued to exceed, and only in Casino Creek during post-closure. Furthermore, three of the exceeding parameters could be considered to be lower than alternative guidelines not selected for application in this assessment, as described below, while U is only predicted to exceed in part of Casino Creek:

- Cd would not exceed the US EPA guideline if predicted hardness were used to calculate the post-closure guideline, rather than baseline hardness.
- Se would not exceed the US EPA guideline if it were applied in the assessment of Se.
- SO_4 would not exceed the BC MOE guideline if predicted hardness were used to calculate the post-closure guideline, rather than baseline hardness.

Based on this discussion, the overall residual effect of the proposed Project on surface water quality is rated as not significant, due to the low geographical extent, moderate magnitude of the anticipated effect and moderate probability of occurrence. The assessment of significance is contingent on the complete implementation of mitigation measures, including a successful water management plan and reclamation and closure plan. The level of confidence applied for the residual effect is defined in Section 5 and considered moderate (50% to 80%). This is based on the inherent nature of uncertainties associated with water quality modelling and the dependencies on numerous input sources.

Table 7.4-13 Summary of Residual Effects for Water Quality

Residual Effects	Direction	Significance	Level of Confidence
Change in surface water quality in Casino Creek due to project discharge (PC)	Adverse	Not Significant	Moderate

7.5 CUMULATIVE EFFECTS ASSESSMENT (CEA)

7.5.1 Introduction

Seepage and discharge from the TMF during Post-Closure have the potential for residual effects on water quality. In this section, identified residual effects were further assessed for their potential to cumulatively interact with other past, present, and future projects which overlap spatially and temporally with the Casino Project.

7.5.2 Identification of other Projects or Activities

Appendix 5B is a list of all potential past, present and likely future projects and activities that could reasonably be expected to have a spatial or temporal interaction with the residual effects of the Casino Project. Section 5 provides further details into the compilation of this list. The projects and activities in Appendix 5B include quartz mines, mineral and placer claims, heritage sites, and registered outfitting and trapline concessions. These projects and activities were assessed on whether or not they met three conditions, as outlined in Section 5, to warrant further assessment of cumulative effects. They are reiterated here:

1. Adequate qualitative and/or quantitative information which is publicly available to allow for spatial and temporal characterization;
2. Spatial overlap with the residual effects of the Casino Project; and
3. Temporal overlap with the residual effects of the Casino Project.

Of these projects and activities, potential overlap of water quality residual effects with the Casino Project includes (Table 7.5-1):

- Past mining in the Casino Creek watershed;
- Present mining at the Minto Copper Mine;
- Current development and future mining at the Carmacks Copper Mine;
- Past, present, and future mineral exploration around the Casino Mine site and within watersheds along the Freegold access corridor; and
- Past, present and future placer mining around the Casino Mine site and within watersheds along the Freegold access corridor.

While there are numerous other projects and activities outlined in Appendix 5B, insufficient data often precluded any assessment of a potential interaction with the Casino Project. Only projects for which data are available are reported herein. In addition, as the projects and activities that have potential for a cumulative effect are the same for fish and aquatic resources and they are for water quality, much of the assessment of cumulative effects are similar between the two VCs. Ultimately, any effects to water quality will be carried forward to the cumulative effects assessment to fish and aquatic resources and therefore, further details on the description of the potential cumulative effects are discussed in Section 10.5.

Table 7.5-1 Residual Effect Information for Other Projects or Activities – Water Quality

Projects or Activities	Status[1]	Assumed Residual Effect[2]	Spatial Extent of Assumed Residual Effect	Temporal Extent of Assumed Residual Effect
Mining				
• **Historic Casino Property Mining**	Past	• Cadmium, silver, lead, zinc loading into Casino Creek from historical adit	Casino Creek from confluence of Meloy Creek to confluence of Dip Creek	Life of mine
• **Minto Copper Mine**	Present	• Reduced water quality • Increased erosion and sedimentation	Yukon River, Big Creek, Wolverine Creek, Dark Creek, Unnamed Creek B and Minto Creek	2022
• **Carmacks Copper Mine**	Future	• Increased erosion and sedimentation	Yukon River, Williams Creek, Nancy Lee Creek, Merrice Creek, Crossing Creek, Murray Creek, Nordenskiold River	Project in review; Predicted 8-year mine life
Mineral Exploration				
• **Upper Canadian Creek and Canadian**	Past, Present and	• Reduced water quality • Increased	Canadian Creek	Unknown

Creek	Future	erosion and sedimentation • Disturbances from drilling and trail clearing		
• **Sonora Gulch**			Hayes Creek Watershed	
• **Prospector Mountain**			Hayes Creek and Big Creek Watersheds	
• **Nucleus**			Big Creek Watershed	
• **WS Total**			Big Creek and Crossing Creek Watersheds	
Placer Mining				
• See Appendix 5B for specific placer claim information	Past, Present and Future	• Increased erosion and sedimentation • Reduced water quality	• Canadian and Britannia Creeks • Rude Creek • Seymour Creek • Hayes Creek Watershed • Big Creek Watershed	Indeterminate

Note

1. Status refers to Past, Present or Likely Future project or activity.
2. Assumed residual effects of other projects or activities are derived from professional judgement and focus on the key issues of concern for the VC, thereby ensuring that the CEA remains focussed and the analysis remains manageable and practical.

7.5.3 Interactions and Potential Cumulative Effects

The water quality residual effects of the Casino Project were compared to residual effects of the mining, mineral exploration and placer mining projects and activities identified within the cumulative effects assessment boundaries (Table 7.5-2). Spatially and temporally, there is potential for these residual effects to interact with the water quality residual effects from the Casino project.

Table 7.5-2 Cumulative Effects Assessment Interactions Matrix – Water Quality

Casino Project Residual Effect	**Potential Spatial and Temporal Overlap**							
	Mining			**Mineral Exploration**			**Placer Mining**	
	Cadmium, silver, lead, zinc loading into Casino Creek from historical adit	Reduced water quality due to Minto Copper mining	Increased erosion and sedimentation	Reduced water quality	Increased erosion and sedimentation	Disturbances from drilling and trail clearing	Increased erosion and sedimentation	Reduced water quality
Change in Casino Creek water quality	YES	NO	NO	NO	NO	NO	NO	NO

Note

1 YES is used to indicate where a residual effect of the Casino Project has the potential to overlap spatially and temporal with an assumed residual effects of other projects and activities.

The Casino Property has had a long and varied exploration history. Between 1965 and 1980, silver-rich veins were explored and developed intermittently by underground and surface workings. Remnants of the past exploration activities include an adit with a pipe that discharges water to Casino Creek via surface runoff to Meloy Creek. This water is elevated in silver, lead, cadmium and zinc and has likely been discharging to Casino Creek for the past 33 to 48 years, subsequently lowering water quality Casino Creek (Refer to Appendix 7A). Current baseline conditions in Casino Creek downstream of Meloy Creek have already been altered by the water discharging from the historical adit. While there is a high potential for interaction between the residual effects of these projects, the predicted water quality in Casino Creek has already been discussed in detail in Section 7.4. In other words, any potential cumulative effects from the historic mine and the proposed Casino mine have already been incorporated into the model and assessed.

There are no other interactions present, or reasonably foreseeable Projects that could cause effects to water quality. Past mineral exploration and placer mining activities have already occurred and therefore any historical effects to surface water quality are reflected in the baseline water quality. Any future mineral exploration or placer mining in the area would be expected to adhere to all acts, laws and regulations to ensure no effects to water quality.

Table 7.5-3 Potential Cumulative Effects – Water Quality

Casino Project Residual Effect	Project or Activity	Potential Cumulative Effect
Change in Casino Creek water quality	Historic Mining	Reduced water quality in Casino Creek due to adit discharge and TMF discharge

7.5.4 Additional Mitigation Measures and Potential Residual Cumulative Effects

As discussed in Section 7.4.7, throughout the life of the Casino Project, water management would be the overarching principle to preserve water quality. Water management, best management practices and general reclamation and closure planning measures will be the primary mitigation measures.

Additional mitigation to be considered by CMC includes permanently sealing the adit pipe in the upper Casino Creek watershed. Although the adit was covered by CMC in 2007, the pipe discharging contaminated water to surface was not. Permanently sealing/plugging the adit to prevent the further discharge of water to surface will be a highly effective mitigation measure to address this potential cumulative effect. One effective approach to sealing the adit would be using a reinforced concrete plug with appropriate grouting. A suitable time to implement this measure may be during the construction of the heap leach facility, as the proposed footprint of the heap leach facility is adjacent to the historic adit.

Table 7.5-4 Additional Mitigation Measures and Residual Cumulative Effects – Water Quality

Potential Cumulative Effect	Mitigation Measures for Project-Specific Effects[1]	Additional Mitigation[2] (if possible)	Effectiveness of Additional Mitigation Measure (Low, Moderate, High, Unknown)	Residual Cumulative Effect (Yes/No)
Reduced water quality in Casino Creek due to adit discharge and TMF discharge	• Water Management Plan • Reclamation Plan	Control contaminate discharge from the historic adit in upper Casino Creek	High	Yes

Note

1. Mitigation measures for Project-specific effects include mitigation measures that have been proposed by CMC to eliminate, reduce or control similar adverse environmental or socio-economic effects.
2. Additional mitigations measures may be either Project-specific mitigation for which CMC can implement or recommended mitigation measures for which other parties could implement.

7.5.5 Significance of Residual Cumulative Effects

The development of the Casino Project would have a residual effect on the water quality VC. The water quality model (Appendix 7F) predicted surface water quality in the main receiving water body of Casino Creek and showed a change in the baseline condition to levels exceeding SSWQO's. The residual cumulative effect from the Casino Project and the adit discharge is incorporated into the water quality and potential effects considered in Section 7.4. Thus, for the same reasons discussed in Section 7.4.9, no significant residual cumulative effects are anticipated.

Table 7.5-5 Significance of Residual Cumulative Effects – Water Quality

Residual Cumulative Effect	Predicted Degree of Effect After Additional Mitigation Measures								Significance of Residual Cumulative Effect (Significant/Not Significant)
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context	Probability of Occurrence	
Reduced water quality in Casino Creek due to adit discharge and TMF discharge	Adverse	Low	Localized	Permanent	Frequent	Irreversible	Low resilience	High	Not Significant

7.5.6 Discussion of Significance of Residual Cumulative Effects

No significant cumulative effects (Table 7.5-6) on water quality are predicted to occur due to the Casino Project. All residual effects were considered non-significant due to the low geographical extent, and low magnitude of the anticipated impacts. The assessment of significance is contingent on the complete implementation of mitigation measures, including the sealing of the adit pipe, as outline in Section 7.5.4.

Table 7.5-6 Summary of Residual Cumulative Effects – Water Quality

Residual Cumulative Effect	**Direction** (Adverse/Beneficial)	**Significance** (Significant/Not Significant)	**Level of Confidence** (Low, Moderate, High)
Reduced water quality in Casino Creek due to adit discharge and TMF discharge	Adverse	Not Significant	High

7.6 SUMMARY AND CONCLUSIONS

No significant water quality change (Table 7.4-13) or cumulative effects (Table 7.5-6) are predicted to occur due to the Casino Project. All residual effects were considered non-significant due to the low geographical extent, and low to medium magnitude of the anticipated impacts. The assessment of significance is contingent on the complete implementation of mitigation measures, including an effective water management plan and reclamation plan, which are outlined in Appendix 4D.

While there will be detectable change in surface water quality from the natural range of variability in chemical characteristics in Casino Creek, the predictions fall within a reasonable threshold where alternative water quality guidelines that take into account site-specific water chemistry, such as high water hardness and elevated baseline metal concentrations, are appropriately protective. Residual effects from elevated metal and sulphate concentrations are limited to Casino Creek with vast improvements in water quality downstream in Dip Creek. The designation of non-significance is directly formulated on results from the water quality model (Appendix 7F). Limitations that are associated with the water quality assessment are based on the uncertainties in the water quality model.