Appendix 6.2.7-A

Mine Site Water Balance and Water Quality

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1.0 INTRODUCTION

A water balance model has been developed for the mine life of the Shore Gold Star and Orion South Diamond Project (the Project) to provide a tool for quantifying the volume of water at various nodes within the mine's water management system at any time. Results from the water balance were used to help determine if there is a risk of having water in excess of the volume that can be managed by the current design and if there is a risk of not having enough water for mine operations. The water balance results were also used to assess the effects of the mining developments on the environmental and social components of the local and regional study areas.

The water balance model developed for the Project tracks the volume of water that is gained and lost on a monthly basis for a period of approximately 24 years. The period modeled begins a year prior to the start of construction to determine the baseline conditions and ends at the completion of the Operations Phase. Figure 1.1 illustrates the project facilities and surface drainage basins during Construction and Operations Phases of the project.

The mine closure hydrology and water balance summarizes hydrological conditions within the Project area after mining ceases. This includes the analysis of post-closure changes to local streamflow and the recovery of groundwater baseflow after dewatering operations cease. In addition, a water balance of each mine pit was created to simulate post-closure pit filling. Inflows to the pit lakes include surface water, groundwater, and direct precipitation on both the pit walls and pit lake. Outflows include evaporation and groundwater. Figure 1.2 illustrates the drainage basins during the closure Phase of the Project.

A mine site water quality model for the mine life was built based on the mine site water balance model. The water quality model provides a tool for predicting the water quality at various project facilities within the mine's water management system using a mass balance method.

Results from the mine site water quality model are used as an input to predict water quality at receiving waterbodies (e.g., Saskatchewan River) at discharge and downstream locations of the project area. These water quality results can also be used to assess the effects of the Project on the other receptors in the local and regional study areas.

The following sections describe the water balance and water quality models methodology, assumptions, and results.

2.0 MINE SITE WATER BALANCE MODELLING

2.1 METHODOLOGY

2.1.1 Construction and Operations

During mining at the Star Pit, fine PK will be placed in the Fines PK Containment Facility (PKCF). From Year 8 to Year 18 both Star Pit and Orion South Pit will be in operation, but

ore will only be produced from Star. This period will have a water management system similar to the system for the operation of Star Pit only, but with some inputs from the Orion South dewatering. In Year 19 when mining in the Star Pit is complete and mining in the Orion South Pit is underway, all Fine PK and process water from Orion South will be placed in the Star Pit. Therefore the Project water management system will change in Year 19. Upper collection ditches will be constructed in both pits during the first year of their respective construction. At Star Pit, the upper collection ditch will be constructed at an elevation of approximately 390 masl. This ditch will collect surficial residual passive inflows and any runoff from direct precipitation on pit walls above the collection ditch. A similar collection ditch will be constructed for Orion South Pit, at an elevation of approximately 400 masl. If necessary, water collected in these ditches will be available to supplement creek flows throughout construction and operations. Schematics for the period of mining from Year 1 to Year 8, from Year 8 to Year 18 and from Year 19 to the end of mining (Year 24) are illustrated Figures 2.1, 2.2 and 2.3, respectively.

The water sources for the Project were determined from design information provided by Shore Gold. Where information was unavailable, assumptions were made. Key assumptions include:

- Water from upstream extents of East Ravine will be used on site or pumped to Duke Ravine beginning in the construction phase of the project;
- The area of East Ravine contributing runoff to the Saskatchewan River will diminish during Star Pit development and at full build out of Star Pit, the area is assumed to be negligible;
- 90% of seepage from the PKCF and runoff from the exterior slopes of the PKCF will be captured in ditches around the toe of the facility and pumped back into the PKCF;
- 10% of seepage from the PKCF will bypass the ditches around the toe of the facility and report to wetlands in Duke Ravine, FalC Ravine and Wapiti Ravine;
- During the Star Mine operation (Years 4 to 18) water for operating the plant will be recycled from the PKCF; during the Orion South Mine operation (Years 19 to 24) water for operating the plant will be taken from the Mannville dewatering system;
- The rate of recycle flow from the PKCF will be constant and when additional water is required for the processing plant it would be supplied from the Process Water Storage Tank (Process Tank);
- Runoff from the side slopes and floor of the pits and residual groundwater flow into the pits will be collected and pumped to the Process Tank;
- Runoff from the Overburden Stockpile and Coarse PK Pile areas were distributed based on the proportion of the watershed overlapped by each pile (i.e., 47% of the Overburden Stockpile is in the Caution Creek watershed, therefore 47% of the runoff from the Overburden Stockpile is distributed to Caution Creek); and

- Catchment areas for the Overburden Stockpile, Coarse PK Pile and PKCF assumed that the facilities would be at full footprint at the start of Operations.

The water balance links all of the Project water inflows and outflows to determine the volumes of flow listed below in each month:

- Processing Plant bypass water/recycle water;
- PKCF water storage;
- Inflow to wetlands around the PKCF;
- Runoff Pond;
- Star Pit water storage (post operation);
- Water available to supplement creek flows; and
- Discharge to the Saskatchewan River via the diffuser.

The Project water sources and sinks are described in the sections below. Values and dates provided reflect our understanding of conditions from information provided by others.

2.1.1.1 Deep Wells

Deep wells will be installed around the mine pits to draw down the water level in the Mannville aquifer, thereby reducing groundwater seepage into the pits. It is estimated that the dewatering wells will pump at a rate that will vary from 98 000 m^3/day to 131 000 m^3/day over the life of the mine. The peak Mannville aquifer dewatering rate will occur in Year 19.

The dewatering wells will pump directly to the Saskatchewan River via the diffuser or to the Process Tank if make-up water is needed for the processing plant and or other site facilities.

2.1.1.2 Residual Passive Inflow

Residual Passive Inflow (RPI) is the groundwater that seeps into the mine pits. It is comprised of a shallow groundwater and deep groundwater component. This water will be collected in the pit collection systems and pumped out of the mine pits. The Star Pit and Orion South Pit water collection systems will pump to the Process Tank for use in the plant and placement in the PKCF. Star Pit RPI stops being managed actively in Year 19, when mining switches to the Orion South Pit.

The Star Pit RPI is estimated to range from 4 900 m^3/day to 18 700 m^3/day between Year 1 and Year 18. The Orion South Pit RPI is estimated to range from 3 400 m^3/day to 12 800 m^3/day between Year 10 and Year 24.

2.1.1.3 Shallow Recovery Wells

Wells will be installed in the shallow aquifer at the Project site. These wells will pump water to the Processing Plant where the water will be filtered prior to use in the recovery process. These wells will pump groundwater to the processing plant at a rate of approximately 11 500 m^3/day.

2.1.1.4 Direct Precipitation and Evaporation

Regional climate data was used to define the precipitation and evaporation for the Project site. The nearest regional meteorological station with the longest period of record is the Atmospheric Environment Service (AES) "Prince Albert A" station. The Prince Albert A climate data was assumed to be representative of that of the Project site.

Three precipitation cases were considered in the water balance analysis:

- Mean Case: Mean annual precipitation (468 mm) in all years;
- Wet Case: Mean annual precipitation in all years, except Year 19, when 1:20 year return period (wet) precipitation (656 mm) occurs; this year was selected as it is the year with the highest groundwater contribution and when the expected diffuser outflow is greatest under normal conditions, hence this year represents the minimum required flows to the water management system; and
- Dry Case: Mean annual precipitation in all years, except Year 7, when 1:20 year return period (dry) precipitation (318 mm) occurs; this year was selected as it is the year with the lowest groundwater contribution and when the expected diffuser outflow is lowest under normal conditions, hence this year represents the greatest potential demand for process/make-up water supply over the life of the project.

The operation phase of the mine will be approximately 20 years, thus the analysis of the 1:20 year dry and wet conditions were considered to be the most reasonable.

The distribution of the precipitation for each month was based on the typical precipitation distribution observed at the Prince Albert A station. It was assumed that snowfall in the winter months (November to March) would accumulate and experience a sublimation loss of approximately 10%. The accumulated snow was assumed to melt in April.

In all cases the median annual lake evaporation was used (630 mm). The distribution of the lake evaporation for each month of the year was based on the computed median gross lake evaporation for each month, based on the climatic record for Prince Albert A.

Net monthly direct precipitation inputs to surface water bodies were computed as precipitation minus evaporation. The net change in water volumes resulting from net monthly direct precipitation was computed as the net precipitation depth times the surface

area of the water body. The water surfaces on the Project site of significance to the water balance are:

- ponded water in the PKCF;
- Runoff Pond; and
- Star Pit Lake (during Orion Pit operation only).

The surface area of the PKCF and Runoff Pond were assumed to be constant. The Star Pit Lake will form in the Star Pit as soon as Fine PK and process water is placed, beginning in Year 19. For this model, since the area of the Star Lake begins at zero, and grows slowly throughout later operations, it was assumed that the area of this pond was negligible for operations. Other small water ponds, such as the Recycle Pond, were also assumed to have negligible catchment areas.

2.1.1.5 Surface Runoff

Surface runoff from the majority of the Project developed areas and natural runoff intercepted by these areas will be collected in ditches and sumps and routed to Duke Ravine either directly or via the Runoff Pond. The exception is the runoff from the Overburden Pile, which will discharge directly to the watersheds that it occupies (i.e., Caution Creek, Caution Creek East, Caution Creek South, Unnamed Tributary 1 (UT-1), Unnamed Tributary 2 (UT-2) and 101 Ravine).

Estimates of runoff coefficients for the various land types on the Project site were developed based on engineering judgement and experience from other projects. There is limited runoff data available for disturbed land surface types and thus there is uncertainty associated with these numbers. The estimate for the runoff coefficient for natural areas was developed using recorded data for regional watersheds and monitoring information from watersheds in the local study area (i.e., Caution Creek, 101 Ravine, West Perimeter Ravine, East Ravine and English Creek). Table 2.1 summarizes the runoff coefficients used for the various land types.

Table 2.1: Summary of Runoff Coefficients

Runoff Coefficient						
Mine Pit	**OBP**	**Coarse PK Pile**	**PKCF Slopes**	**Plant Site & Site Facilities**	**Road**	**Natural Upland**
0.6	0.3	0.04	0.2	0.7	0.6	0.04

Surface runoff from the following areas will be directed to the Duke Ravine:

- Portion of Coarse PK Pile located in Duke Ravine;
- Portion of PKCF Exterior Slopes located in Duke Ravine;

- Process Plant Runoff; and
- Flow from Runoff Pond.

Runoff from many other areas of the site will be collected in the Runoff Pond prior to being diverted to Duke Ravine. There areas include:

- Portion of Coarse PK Pile located in East Ravine; and
- East Ravine watershed upstream of Star Pit.

2.1.1.6 Seepage

Water will seep from the site facilities into the ground. For the PKCF the rate of seepage is estimated to be 1000 m^3/day. A combination of active and passive interception structures will be installed around the PKCF, including perimeter ditches, to collect about 90% of the seepage from this facility. From the collection points, the seepage would be pumped back into the PKCF, unless water quality is acceptable for discharge to the Duke Ravine. The remaining 10% of seepage from the PKCF is assumed to bypass the collection system and report directly to the local wetlands.

There was no available data quantifying the rate of seepage loss at the various other facilities. It was assumed that seepage from the Runoff Pond & Coarse PK Pile would occur at the natural recharge rate of 19 mm/year (distributed equally over each month). It is likely that the seepage rate would be in excess of this rate due to the pressure head. For all other site facilities it was assumed that there would be no seepage in excess of the infiltration considered as part of the runoff calculation.

2.1.2 Closure

2.1.2.1 General Approach

Information from Section 7 describing mine closure and reclamation plans was used to describe the surface water hydrology of the watersheds after mining ceases and how surface water and groundwater hydrology will affect the mine pits after closure. A water balance model was established with an annual time-step to predict mean annual runoff approximately 20 to 25 years after mining ceases. The assumption was made that vegetation within the reclaimed areas would be fully established and relatively stable after this period. Runoff was not evaluated for the assumed 25-year long transition period following the end of Operations; i.e., the water balance for Closure did not cover this transition period. Annual runoff was calculated as the sum of surface runoff (assumed invariant; average annual conditions would prevail for the entire period being assessed) and baseflow (varies with time). Groundwater information from SRK (2011) was used to represent baseflow changes in the streams. To model water levels in the pits, relationships were established between water elevation and volume of water stored, groundwater flow, pit wall area and pit lake area.

Runoff from reclaimed overburden, coarse PK, and site facilities was distributed back to the watersheds based on natural watershed boundaries. For PKCF, the runoff from inside the entire bermed area was directed to Duke Ravine. The runoff from the outer berms was distributed into English Creek, Wapiti Ravine, and FalC Ravine based on their respective natural watershed boundaries.

The water balance for each pit determined the change of storage on an annual basis by subtracting the outputs from the inputs. The inputs include surface runoff, pit wall runoff, direct precipitation (on lake surface), and groundwater inflows. The outputs include evaporation and groundwater outflows. Allowance in the model was made for pumping water from the Saskatchewan River to reduce the pit filling duration but the pumping rate was assumed to be zero for this analysis.

Although each pit was modeled separately, the potential for the Orion South pit to spill into the Star Pit via East Ravine was taken into account. As well, the potential for the Star Pit to spill to the Saskatchewan River via East Ravine was also considered.

The Orion South pit is contained within the upstream portions of101 Ravine and East Ravine. Should the water level within the Orion South pit reach a sufficiently high elevation that spill occurs, the outflow will go to East Ravine; however, this discharge is not expected. There would be no outflow from Orion South Pit to 101 Ravine. Should the water level within the Star Pit reach a sufficiently high elevation that spill occurs, the outflow will go to the downstream portion of East Ravine. No overflow will go into West Perimeter Ravine, West Ravine, or Duke West Ravine.

A schematic of the closure period is illustrated in Figure 2.4.

2.1.2.2 Closure Assumptions

The following list summarizes assumptions made in creating the closure water balance:

- The landscape is fully reclaimed;
- The basis for selecting runoff coefficients was based on fully reclaimed conditions;
- Extreme events were not considered. Examples of these events are extreme rainfall events, drought events, wild fires which could destroy vegetation, and forestry clearing;
- Runoff coefficients for adjacent basins and pit walls were invariant with tim;
- Groundwater flows into and out of the pits were varied, based on information provided in the groundwater model (SRK 2011); and
- Existing topography determined the elevations of spill points along pit walls.

It is assumed that the PKCF, Coarse PK Pile, Overburden Pile, and all Site Facilities will be reclaimed to appropriate land use categories upon mine closure according to provincial regulations. With the exception of PKCF, it is assumed the natural watershed boundaries

will be restored as close to natural (pre-development) conditions as possible. The PKCF berms will remain at a higher elevation than the interior of the PKCF at closure, thus runoff from within this area will be collected and directed into Duke Ravine. The outer slopes of the berms will direct runoff into the respective natural watersheds.

The runoff coefficients for reclaimed areas were based on the final reclamation land/vegetation types planned in each area. A runoff coefficient for each land/vegetation type was assigned, then weighted runoff coefficients were calculated for each reclaimed area based on the area of each land type. A summary of the runoff coefficients for each land/vegetation type is presented in Table 2.2. All treed land/vegetation types were given the same runoff coefficient.

Table 2.2: Summary of Runoff Coefficients

Reclaimed Land/Vegetation Type	Runoff Coefficient
Grassland	0.08
Dry Shrubland	0.06
Pine - lichen	0.04
Pine - feathermoss	0.04
Pine - aspen - feathermoss	0.04
Aspen - Rose - Grass	0.04
Aspen - Hazelnut	0.04
Aspen - Birch	0.04
White Spruce - Aspen	0.04
Aspen - White Spruce	0.04
White Birch - White Spruce	0.04
Jackpine - Black Spruce	0.04
Black Spruce	0.04
Balsam Poplar	0.04
Black Spruce	0.04
Willow fen	0.10
Marsh/Emergents	0.30
Open Water	0.99

Based on the area of each of the above land types in the reclamation areas, weighted runoff coefficients were calculated for each of the areas being reclaimed. These are summarized in Table 2.3.

Table 2.3: Weighted Runoff Coefficients

Reclaimed Area	Weighted Runoff Coefficient
Coarse PK	0.044
PKCF	0.041
Runoff Pond	0.300
Site Facilities	0.040
Overburden	0.047

2.2 MINE SITE WATER BALANCE RESULTS

2.2.1 Construction and Operations

The water balance results indicate that during mine operations there will be a surplus of water on site for use in operating the processing plant, thus there will be water available to supplement creek flows. Under mean precipitation conditions during Star Pit operation the PKCF recycle can maintain the water needs of the processing plant with only limited contingency to take water from the Mannville or other sources. Years 7 and 19 were selected for comparison with the 1:20-year dry case and the 1:20-year wet case, respectively. Table 2.4 present the results for both the 1:20-year dry case and the 1:20-year wet case. This surplus characteristic is also observed for both the 1:20-year dry case and the 1:20-year wet case.

Table 2.4: Summary of Diffuser Flows in 1:20-Year Dry and 1:20-Year Wet Cases

Description	Annual Volume (Mm^3)			
	1:20-Year Dry Case	1:20-Year Wet Case	Mean Case	
	Year 7	Year 19	Year 7	Year 19
Outflow to Diffuser	36.15	32.10	36.49	31.09

Note: The 1:20-year dry and 1:20-year wet cases were considered in different years and are not directly comparable because they occur during different stages of mine development; i.e., Star Pit only in Year 9 versus Orion South Pit in Year 19. They should be compared to the mean case in each respective year to determine the effect of Wet or Dry conditions versus average conditions.

Figure 2.5 illustrates the outflow from the diffuser for the life of the mine.

Figure 2.6 compares the outflow from the diffuser for the mean case against the outflow for the 1:20-year dry case in Year 7. The figure illustrates the largest reduction in outflow occurring in April of Year 7. By November of Year 7 outflows from the diffuser under the low precipitation conditions have returned to mean conditions.

Figure 2.7 compares the outflow from the diffuser for the mean case against the outflow for the 1:20-year wet case in Year 19. The flow to the diffuser will exceed the mean case in

April under the extreme wet conditions. By November of Year 19 outflows from the diffuser under the high precipitation conditions have returned to mean conditions.

2.2.2 Closure

2.2.2.1 Runoff

A summary of average annual runoff volume in each watershed after reclamation is in Table 2.5. These runoff volumes are based on average climatic conditions.

Table 2.5: Comparison and Baseline and Closure Runoff

Watershed	Baseline		Closure		Change in Annual Runoff from Baseline
	Drainage Area	Annual Runoff Volume	Drainage Area	Annual Runoff Volume	
	km^2	Mm^3	km^2	Mm^3	%
Caution Creek	93.2	2.54	92.9	2.54	0.01
Caution Creek East	5.73	0.20	5.73	0.20	0.37
Caution Creek South	9.16	0.26	9.16	0.27	0.28
UT-1	7.20	0.23	7.20	0.23	0.18
UT-2	1.63	0.13	1.63	0.13	0.01
UT-3	3.75	0.16	3.75	0.16	0.02
101 Ravine	24.3	0.88	21.1	0.82	-6.42
West Perimeter Ravine	3.44	0.52	3.15	0.51	-1.06
West Ravine	3.45	0.52	0.86	0.47	-9.29
Central-East Ravine	1.10	0.47	0.53	0.46	-2.25
East Ravine	16.9	0.77	0.00	0.00	-100
FaLC Ravine	2.47	0.50	1.96	0.49	-1.92
Duke Ravine	11.7	0.67	14.57	0.72	7.22
Duke Ravine West	0.81	0.47	0.45	0.46	-1.43
Wapiti Ravine	3.75	0.52	1.76	0.48	-7.10
English Creek	81.2	3.59	80.29	3.57	-0.50

The watersheds which will experience the largest decrease in runoff from baseline values are those affected by the presence of the mine pits. Primarily, East Ravine, 101 Ravine, West Ravine and Wapiti Ravine see significant decreases in annual runoff. East Ravine will

have negligible annual flows until the water in Star Pit starts to spill. This is discussed in further detail in Section 2.2.2.2.

Wapiti Ravine and FalC Ravine, where the PKCF is situated, also see decreases in annual runoff since some of their drainage areas will be directed to Duke Ravine. Due to this, Duke Ravine will experience a 7% increase in flows from baseline to post-mining reclaimed conditions.

Watersheds within the reclaimed overburden area (Caution Creek, Caution Creek East, Caution Creek South, UT-1, UT-2, and UT-3) will see very small changes from baseline flows under the assumption that this area will be reclaimed based on natural watershed boundaries. 101 Ravine, which is affected by both the Overburden area and Orion South pit which takes up a portion of the upstream drainage area of this watershed, will see a decrease in annual runoff of approximately 6% due to the presence of the Orion South pit within the headwaters of this basin.

2.2.2.2 Mine Pit Water Balance

STAR PIT

The starting elevation for the Star Pit closure water balance was taken from the SRK model. The Star Pit receives backfill up to an elevation of 267 m in years 10 to 17 of mining. PK material and process water continue to fill the pit until the end of mining at which point the water surface elevation reaches 307 m. This elevation is the starting point for the closure pit water balance. The spill elevation based on existing topography is 378 m. This is illustrated in Figure 2.8.

Based on the closure water balance modeling, the Star Pit will spill into East Ravine 326 years after mining. The average annual spill volume into East Ravine thereafter will be approximately 1.22 Mm^3.

ORION SOUTH

The starting elevation for Orion South Pit closure water balance is the bottom of pit elevation which is 145 m. Dewatering of the pit occurs until the end of mining, at which point the closure water balance begins. The spill elevation based on existing topography is 436 m.

Based on the closure water balance modeling, the Orion South pit does not spill within the timeframe of 1000 years post-mining, as shown in Figure 2.8. Over time, the rate at which the Orion South pit fills slowly decreases. It is likely that the pit will reach a state of equilibrium far into the future in which the total inflow equals the total outflow and spill into Star Pit via East Ravine would not occur.

3.0 SURFACE WATER QUALITY MODELLING

3.1 METHODOLOGY

3.1.1 Construction and Operation

The water quality model was built based on the water balance model described in Section 2.0 and Figures 2.1 to 2.3. Water quality at each of the project facilities were calculated by using a fully-mixed reservoirs (boxes), and chemical species are considered conservative - no chemical reaction or decay within the system. The time step in the model was one month. No storage within time was considered, meaning that all sources within a month were well mixed and represented the resultant water quality for that month. This approach is usually used in such models and represents the worst case scenario. The main case was modelled as water quality at mean climatic conditions. Other two scenarios were run for comparison purpose, namely dry (1:20 wet) and wet (1:20 wet) climate conditions, predicated according to the water balance model. Inflows sources and outflow destinations to each of the project facilities during operation are listed in Table 3.1.

Table 3.1: List of inputs and outputs sources of the project facilities during operation

Facility	Loading	Source	
Bypass to Diffuser / Diffuser	Inflow	Star Pit	Pit wall runoff above upper collection ditches
			Mannville Deep wells
			Residual Surficial groundwater flow
		Orion South Pit	Pit walls runoff above upper collection ditches
			Mannville Deep wells
			Residual Surficial groundwater flow
	Outflow	Saskatchewan River through the diffuser	
Process Tank	Inflow	Residual Mannville groundwater flow	
		Pit wall runoff below upper collection ditches	
		PKCF (decant water)	
	Outflow	Process plant	
Process plant	Inflow	Process Tank	
		Freshwater wells	
	Outflow	Coarse PK water content	
		Fine PK water content	
Coarse PK pile	Inflow	Coarse PK water content/coarse PK free drain losses	
		Coarse PK runoff	
		Coarse PK seepage	
	Output	Coarse PK pile output	
Runoff pond	Inflow	Coarse PK runoff	
		Coarse PK seepage	

Facility	Loading	Source
		East Ravine runoff (from upstream of Star Pit)
		Atmospheric precipitation
		Coarse PK water content/coarse PK free drain losses
		Plant and site runoff
		Road runoff
	Outflow	Evaporation
		Duke Ravine
PKCF	Inflow	Fine PK slurry water from process plant
		PKCF interior slope runoff
		Pit wall runoff below upper collection ditches
		Residual Mannville groundwater flow
		PKCF pond precipitation
		Return of seepage from seepage reduction in PKCF perimeter
	Outflow	PKCF seepage
		PKCF decant water
		Evaporation
PKCF Perimeter Ditch	Inflow	PKCF seepage
		PKCF exterior wall runoff
	Outflow	Duke Ravine wetland
		English Creek wetland
		Wapiti Ravine wetland
Overburden	Inflow	Runoff
	Outflow	Caution Creek
		Caution Creek East
		Caution Creek South
		Unnamed Tributary 1
		Unnamed Tributary 2
		Unnamed Tributary 3
		101 Ravine

The background information for the water quality model was developed using the baseline conditions in streams within the local study area of the Project. Baseline water quality information was available for most of the watersheds in the study area. For those watersheds which baseline water quality information was not available, water quality data from a nearby, similar geographic and similar size of watershed is used. A list of the watershed and the respective baseline water quality source used in the model are presented in Table 3-2. The location of all watersheds and facilities within the study area are presented in Figure 1.1.

Table 3.2: Baseline water quality data source for the watersheds in the local study area

Watershed	Baseline data available?	Baseline water quality data source
Caution Creek	Yes	Caution Creek
Caution Creek East	No	West Perimeter Ravine
Caution Creek South	No	West Perimeter Ravine
Unnamed Tributary 1	No	West Perimeter Ravine
Unnamed Tributary 2	No	FalC Ravine
Unnamed Tributary 3	No	West Perimeter Ravine
101 Ravine	Yes	101 Ravine
West Perimeter Ravine	Yes	West Perimeter Ravine
West Ravine	Yes	West Ravine
Central East Ravine	No	FalC Ravine
East Ravine	Yes	East Ravine
Duke Ravine	Yes	Duke Ravine
Duke Ravine West	No	Wapiti Ravine
FalC Ravine	Yes	FalC Ravine
Wapiti Ravine	Yes	Wapiti Ravine
English Creek Ravine	Yes	English Creek Ravine

Discharge to the Saskatchewan River from deep dewatering wells, surficial groundwater and runoff within mine pits was modelled separately. The diffuser outflow discharge was predicted in water balance model (see Figure 2.5) and 2D dispersion model was applied to determine rate of concentration decrease in the Saskatchewan River (see details in Memo: *Saskatchewan River Dispersion Modelling – Diffuser Plume Estimates, July 2011*). It was found that in the low flow conditions the diffuser provides a reduction of concentration in a distance of 40 m from 65 to 80 times depending on plume lateral zone that was close to full mixing conditions. In the calculations of diffuser contribution to the water quality loadings from all streams within the study area to the Saskatchewan River the diffuser portion was assumed to be fully mixed in the river.

3.1.2 Closure

Closure modelling includes evaluation of water quality in streams and end pit lakes water quality assessment. Closure water quality model was based on the closure water balance model as shown in Figure 2.4. Inflows sources and outflow destinations to each of the project facilities during closure are listed in Table 3.3.

Table 3.3: List of inputs and outputs sources of the project facilities during closure

Facility	Loading	Source
Star Pit	Inflow	East Ravine runoff
		Reclaimed Coarse PK pile runoff
		Duke Ravine West runoff
		Pit wall leach
		Pond Area/precipitation
		Shallow groundwater

Facility	Loading	Source
		Deep groundwater
		Spill from Orion South Pit
	Outflow	Evaporation
		Spill to East Ravine
Orion South Pit	Inflow	East Ravine runoff
		101 Ravine runoff
		Reclaimed runoff pond
		Pit walls leach
		Pond area/precipitation
		Shallow groundwater
		Mannville groundwater
		Pump
	Outflow	Evaporation
		Spill to Star Pit
		Flow into Mannville groundwater formation

The closure water balance for pit lakes was presented in Section 2.2.2.2. The Star Pit will be partially backfilled with overburden following placing PK material and process water from Orion South pit mining. During the Orion South mining phase neither PK nor process water will be placed into PKCF. It is assumed that by the time of Orion South pit is mined out the PKCF facility will be dry and ready for reclamation. There will be no water in this facility. During closure, the water quality of the runoff from reclaimed land, including reclaimed coarse PK pile and reclaimed runoff pond, was assumed to be the average of the baseline water quality of all watersheds in the study area.

3.2 ASSUMPTIONS

3.2.1 Construction and operation

The water quality model was based on the assumptions stated in the water balance model. Additional assumptions used in the water quality model for construction and operations phases are presented in Table 3.4.

Table 3.4: Water quality model assumptions during operation

Model area	Assumption
General	• Where background concentration was below the method detection limit (MDL), value of half of MDL was used in the water quality model. • Arithmetic mean of the baseline water quality data collected at each of the sources was used in the model where multiple water quality measurements were available. • Predicted water quality results are compared to the 95th percentile of the baseline water quality data.

Model area	Assumption
Precipitation water quality	• Concentrations of chemicals in atmospheric precipitation were assumed to be zero for all parameters. Chemical species were assumed to be conservative in the mass balance calculations.
Star and Orion South Pit	• Deep groundwater quality at Star and Orion South was assumed to be the same as Mannville water. • Explosives are used during the operation phase of the mine in both Star and Orion South pits. Explosives used are projected to be ANFO of 0.1% slurry-explosives. Explosives used are: o 70 tonnes/week at Star Pit between 2015 and 2027; o 35 tonnes/week at Orion South Pit between 2028 and 2035. • Explosives loss as inorganic nitrogen is 0.2%, of which 87% as nitrate-N, 11% as ammonia-N and 2% and nitrite-N (Ferguson and Leask, 1988) • Leaching rates from the pit walls were based on processed kimberlite leaching rates and surface area to mass ratio of the material. Pit wall leaching rates were also provided by AMEC
Processed Kimberlites Containment Facility (PKCF)	• Processed kimberlites leaching rates were obtained from the results of kinetic tests of processed materials at the Star and Orion South pits conducted by AMEC. Leaching rates from the pit walls were based on processed kimberlite leaching rates and surface area to mass ratio of the material. Pit wall leaching rates were also provided by AMEC. • Runoff from PKCF exterior wall and seepage from PKCF is assumed to be collected and mixed in the PKCF perimeter ditch, and then further diverted to English Creek, Wapiti Ravine, and Duke Ravine wetlands, respectively, according to the proportion of the length of the perimeter ditch on each wetland, based on the water balance model.
PKCF Wetlands	• Wetland treatment efficiencies are incorporated for certain parameters (see Table 3.5).
Coarse PK wetland	• Wetland treatment efficiencies are incorporated for certain parameters (see Table 3.5).

Seepage from PKCF will be collected in perimeter ditches and depending on water quality released, treated in wetlands, or pumped back. An assumption of 90% water will be pumped back and 10% of the seepage will be released through wetland undergoing passive treatment was applied. Coarse PK pile runoff will be collected in the ditches and an assumption of wetland treatment was applied as well. Probable wetland removal efficiencies were derived from the literature and presented in Table 3.5.

Table 3.5: Passive Water Quality Treatment Efficiencies using Constructed Wetlands

Parameters	Probable Wetland Removal Efficiency	Information Source	References to Information Source
Total alkalinity	79%	2	1. Eckhardt, D.A.V., J.M. Surface, and J.H. Peverly. 1999. A Constructed Wetland System for Treatment of Landfill Leachate, Monroe County, New York. in. Mulamoottil, G., E. A. McBean, and F. Rovers, eds., Constructed Wetlands for the Treatment of Landfill Leachates. Boca Raton, Fla.: Lewis Publishers, Inc. 2. Interstate Technology & Regulatory Council. 1993. Technical and Regulatory Guidance Document for Constructed Treatment Wetlands. ITRC Wetlands Team. 3. Kadlec, R.H. and R.L. Knight, 1996, Treatment Wetlands. New York: Lewis Publishers, Inc. 4. Kropfelova, L., J.Vymazal, J. Svehla, and J.Stıchova. 2009. Removal of trace elements in three horizontal sub-surface flow constructed wetlands in the Czech Republic. Environmental Pollution 157: 1186–1194 5. Lizama, K. A., T.D. Fletcher, and G.Sun. 2011. Removal processes for arsenic in constructed wetlands. Chemosphere 84:1032–1043 6. Loer,J. K. Scholz-Barth, R. Kadlec, D. Wetzstein, and J. Julik. 1999. An integrated Natural System for Leachate Treatment, in Mulamoottil, G., E. A. McBean, and F. Rovers, eds., Constructed Wetlands for the Treatment of Landfill Leachates. Boca Raton, Fla.: Lewis Publishers, Inc. 7. Simon, S.M. 2003. Phosphorus Retention and Release of Soils in a Constructed Wetland fo Wastewater Treatment. MS Thesis. University of Florida
Bicarbonate	79%	1	
Calcium	63%	1, 2	
Carbonate	79%	1, 2	
Potassium	83%	1, 2	
Sodium	43%	3	
Sulfate	62%	1, 2	
Ammonia as nitrogen	91%	1, 2	
Nitrate	88%	3	
Aluminum	99%	1	
Antimony	71%	4	
Arsenic	89%	6	
Barium	49%	1, 2	
Beryllium	54%	4	
Bismuth	89%	5	
Boron	15%	4	
Cadmium	65%	2, 6	
Chromium	67%	2, 6	
Cobalt	8%	4	
Copper	89%	1, 2	
Iron	97%	1, 2	
Lead	80%	1, 2	
Manganese	91%	1, 2	
Mercury	75%	1, 2	
Molybdenum	56%	4	
Nickel	19%	1, 2	
Selenium	100%	1	
Silver	76%	2	
Strontium	6%	4	
Thallium	1%	7	
Tin	46%	4	
Uranium	72%	4	
Vanadium	24%	4	
Zinc	**99%**	**1**	

3.2.2 Closure

The water quality model was based on the assumptions stated in the closure water balance model. Additional assumptions used in the closure water quality model in addition to applicable ones for construction and operations phases are presented in Table 3.6.

Table 3.6: Water quality model assumptions during closure

Model area	Assumption
General	• Where background concentration was below the method detection limit, value of half of method detection limit was used in the water quality model. • Arithmetic mean of each of the sources was used in the model where multiple water quality measurements were available. • Predicted water quality results are compared to the 95th percentile of the baseline water quality data
Precipitation water quality	• Concentrations of chemicals in atmospheric precipitation were assumed to be zero for all parameters.
Star and Orion South Pit	• Deep groundwater quality at Star and Orion South was assumed to be the same as Mannville water. • Where deep groundwater input volume is negative, water from the pit is assumed to be recharged to the deep aquifer after mixing. • Leaching from the pit walls will reach steady state between 20 weeks to 80 weeks (varies among parameters), and that leaching of metals from pit walls is assumed to cease during end of operations and closure. It is assumed that no addition loading is introduced from the leaching of the pit walls during closure. • Initial storage volume and loadings in Star Pit (at the end of 2035) is based on the last seven years during operation in Star Pit. • The Star Pit is backfilled by the beginning of the year 18. • Initial volume of process water in the Star Pit is 28,511 Mm^3 on top of saturated processed kimberlite. This creates an initial lake 3 m deep. • The Star Pit lake assumed is fully mixed at the end of infilling and has depth of approximately 50 m. • Initial volume of water in the Orion South pit is assumed to be 0 at closure. • The Star Pit lake (when water level reaches its crest) has depth of approximately 230 m. Two scenarios were considered: fully mixed and stratified lake.
Reclaimed Areas	• Water quality inputs at closure for the reclaimed areas (overburden, coarse PK, PKCF, internal basin) are assumed to be the average baseline water quality of all streams (ravine) in the study area.

The Star pit during infilling is considered as a fully mixed basin. This is the most simplistic assumption and is the most conservative. At the same time, this is usually the least likely scenario, as deep pit lakes natural stratify and create meromictic conditions when the upper active layer of the lake is sitting on the stagnant dynamically passive layer. The morphology

of pit lakes supports that as pit lakes tend to be deep with smaller surface area in comparison to natural lakes surface area. The surface of pit lakes is usually surrounded by high pit walls that shelter the surface area from wind action. This reduces wind velocity of the pit lake surface and downward mixing force in the lake water body.

The relationship between the surface area and maximum depth of lakes was quantified by Hutchinson (1957) and represents an ability of a lake to stratify. It is based on relative depth evaluation (Z_r), which express the ratio of the maximum depth (Z_m) to the mean diameter of the lake surface (D) as a percentage:

$$Z_r = \frac{Z_m}{D} * 100\%$$

There are few pit lakes in the Saskatchewan with different depth, surface area, and corresponding relative depth (a ratio between maximum depth and mean diameter of the surface area) that experience seasonal turnover or have meromictic conditions (Doyle, Runnells, 1997). The relative depth calculations for Orion South pit showed that the pit unlikely to stratify due to low relative depth (13%) compare to Gunnar Lake with relative depth of 37%. At the same time Orion South pit lake will be twice as deep as Gunnar lake. Some lakes (e.g., Big Soda Lake in Nevada) with a similar surface area as Orion South, but less maximum depth (65 m) and less relative depth (5%) are stratified and have meromictic conditions according to lake stratification review provided by Doyle and Rennells (1997).

The scenario of modelling fully mixed lake was applied to Orion South pit that produces more conservative water quality outputs as well as stratified option with top layer that is fed by mostly surface runoff, groundwater, and precipitation since the lake reaches initial depth of 80 m.

3.3 BACKGROUND CONCENTRATIONS

Background concentrations in streams within the study area derived from existing baseline information. The Tables 3.7 to 3.9 listed the background concentrations of the chemical parameters in the various water sources for the mass balance calculation. Inflow sources, which were provided as a basis for mass calculation, include Mannville water, shallow groundwater, overburden leachate, East Ravine and Duke Ravine water quality. The sources of each of the inflows are listed in the following:

- Mannville water obtained from deep water well MWS-01. Mannville water came from the exploration water discharge at the end of pipe to settling ponds;
- Shallow groundwater was obtained from the monitoring well MW06-01 at the surficial sand layer;
- Overburden leachate background concentrations were calculated based on the background water quality at the overburden OB53-61 and 78-88;

- East Ravine background concentrations were adopted from the water quality results from sampling location ERS-01; and
- Duke Ravine background concentrations were adopted from the water quality results from sampling location DSS-01.

Table 3.7: Background concentrations for conventional parameters of Mannville water, shallow groundwater, overburden leachate, East and Duke Ravine flow.

		Mannville water	Shallow GW	Overburden	East Ravine	Duke Ravine
Conventional Parameters						
Chemical Oxygen Demand	mg/L	58.5	6	6[a]	19.6	16.4
pH	pHunit	9.05	7.95	8.6	8.156	8.279
Specific conductivity	uS/cm	7747.5	382	609	404.5	403.5
Sum of Ions	mg/L	4590	330	542.5	241.4	352.7
Total alkalinity	mg/L	246.56	237	322.5	224.0	213.7
Total dissolved solids	mg/L	4420.8	242	351.5	235.7	217.9
Total hardness	mg/L	149.67	226	275.5	208.5	218.2
Major Ions						
Bicarbonate	mg/L	178.29	240	374	270.6	253.2
Calcium	mg/L	15.11	59	75	63.4	61.6
Carbonate	mg/L	48.04	<1	9.5	1.8	4.0
Chloride	mg/L	2193.3	7	2	1.5	2.4
Fluoride	mg/L	0.702	0.13	0.325	0.120	0.123
Hydroxide	mg/L	4.5	<1	<1[a]	0.6	0.5
Magnesium	mg/L	27.24	13	21.5	14.2	14.9
Potassium	mg/L	60.92	1	4.45	2.0	1.66
Sodium	mg/L	1627.5	4.2	29.5	3.9	4.45
Sulfate	mg/L	423.3	5.4	26.7	4.7	7.9
Nutrients						
Ammonia as nitrogen	mg/L	1.94	0.02	0.02[a]	0.095	0.03
Dissolved organic carbon	mg/L	6.68	1.2	1.2[a]	4.6	4.93
Nitrate	mg/L	7.85	0.35	<0.04	0.2	2.9
Nitrite+Nitrate, nitrogen	mg/L	1.82	n/a	n/a	0.034	0.66
Total Kjeldahl nitrogen	mg/L	2.2	0.9	0.9[a]	0.73	20.5
Total nitrogen	mg/L	16.56	n/a	n/a	12.9	-
Total organic carbon	mg/L	7.91	1.5	1.5[a]	5.7	5.15
Total phosphorus	mg/L	0.75	0.0028	0.0028[a]	0.062	0.038

Note: [a] Overburden leachate water chemistry for the specific parameters were not available. Values adopted from shallow groundwater.

Table 3.8: Background concentrations of total metals of Mannville water, shallow groundwater, overburden leachate, East and Duke Ravine flow

		Mannville water	Shallow GW *	Overburden*	East Ravine	Duke Ravine
Total Metals						
Aluminum-T	mg/L	8.18	<0.0005	0.905	0.117	0.213
Antimony-T	mg/L	0.000225	<0.0002	<0.0002 [a]	0.00012	0.0001
Arsenic-T	µg/L	1.25	0.2	7.2	4.7	2.8
Barium-T	mg/L	0.173	0.31	0.16	0.43	0.205
Boron-T	mg/L	3.158	<0.01	0.155	0.028	0.029
Cadmium-T	mg/L	0.00014	<0.0005	<0.0005	0.00006	0.00006
Chromium-T	mg/L	0.275	<0.005	0.006	0.0039	0.00167
Cobalt-T	mg/L	0.0457	0.0001	0.0001 [a]	0.00050	0.00039
Copper-T	mg/L	0.0271	<0.0002	0.0052	0.0024	0.00129
Iron-T	mg/L	31.68	0.001	4.15	1.3	1.08
Lead-T	mg/L	0.00908	<0.0001	0.00545	0.00051	0.00051
Manganese-T	mg/L	0.448	0.0037	0.15	0.34	0.047
Molybdenum-T	mg/L	0.0034	0.001	0.001 [a]	0.00106	0.0032
Nickel-T	mg/L	0.847	<0.0001	<0.0001 [a]	0.0030	0.00148
Selenium-T	mg/L	0.000492	0.0001	0.0004	0.00011	0.00019
Silver-T	mg/L	0.000221	<0.0001	<0.0001 [a]	0.00006	0.00005
Strontium-T	mg/L	0.699	0.08	0.08	0.17	0.159
Thallium-T	mg/L	0.000183	<0.0002	<0.0002 [a]	0.00010	0.0001
Tin-T	mg/L	0.000433	<0.0001	<0.0001 [a]	0.0001	0.0144
Titanium-T	mg/L	0.709	<0.0003	<0.0003 [a]	0.0036	0.0070
Uranium-T	µg/L	0.9889	0.0004	3.8	0.38	0.63
Vanadium-T	mg/L	0.164	<0.0001	<0.0001 [a]	0.00095	0.0017
Zinc-T	mg/L	0.0634	0.069	0.509	0.016	0.0073

Note: * Total metals concentrations were not provided for overburden leachate, assumed total metals concentrations equals to dissolved metals concentrations. [a] Overburden leachate water chemistry for the specific parameters were not available. Values adopted from shallow groundwater.

Table 3.9: Background concentrations of dissolved metals of Mannville water, shallow groundwater, overburden leachate, East and Duke Ravine

	unit	Mannville water *	Shallow GW	Overburden	East Ravine	Duke Ravine
Dissolved Metals						
Aluminum-D	mg/L	8.177	<0.0005	0.905	0.0102	0.083
Antimony-D	mg/L	0.000225	<0.0002	<0.0002 [a]	0.0001	0.00012
Arsenic-D	µg/L	1.254	0.2	7.2	2.02	2.38
Barium-D	mg/L	0.173	0.31	0.16	0.396	0.199
Boron-D	mg/L	3.158	<0.01	0.155	0.027	0.028
Cadmium-D	mg/L	0.000142	<0.0005	<0.0005	0.00005	0.00025
Chromium-D	mg/L	0.275	<0.005	0.006	0.065	0.0276
Cobalt-D	mg/L	0.0457	0.0001	0.0001 [a]	0.00013	0.00089
Copper-D	mg/L	0.0271	<0.0002	0.0052	0.0009	0.0028
Iron-D	mg/L	31.68	0.001	4.15	0.032	0.57
Lead-D	mg/L	0.00908	<0.0001	0.00545	0.00007	0.00051
Manganese-D	mg/L	0.448	0.0037	0.15	0.093	0.062
Molybdenum-D	mg/L	0.00344	0.001	0.001 [a]	0.0011	0.00099
Nickel-D	mg/L	0.847	<0.0001	0.00005 [a]	0.00137	0.0124
Selenium-D	mg/L	0.000492	0.0001	0.0004	0.00011	0.00012

	unit	Mannville water *	Shallow GW	Overburden	East Ravine	Duke Ravine
Silver-D	mg/L	0.000221	<0.0001	0.00005 [a]	0.00005	0.00005
Strontium-D	mg/L	0.699	0.08	0.08 [a]	0.153	0.163
Thallium-D	mg/L	0.000183	<0.0002	0.0001 [a]	0.0001	0.0001
Tin-D	mg/L	0.000433	<0.0001	0.00005 [a]	0.00006	0.00011
Titanium-D	mg/L	0.709	<0.0003	0.00015 [a]	0.00044	0.003
Uranium-D	µg/L	0.9889	0.0004	3.8	0.29	0.56
Vanadium-D	mg/L	0.164	<0.0001	0.00005 [a]	0.05	0.05
Zinc-D	mg/L	0.0634	0.069	0.509	0.0065	0.015

Note: *Dissolved metals concentrations were not provided for Mannville water, assumed dissolved metal concentrations equals to total metals concentrations.

The background water quality for creeks was presented in the model as averages of baseline concentrations and thus free of spikes and uncertainties that might be caused by differences in detection limits. The below detection concentrations of certain parameters were replaced by ½ MDL levels. This has to be taken into account in results interpretation as in some cases it might overestimate a background level for a parameter.

Some of small streams (e.g. few unnamed tributaries) were represented with water quality data taken from studied watersheds of similar size and location with the study area. This is a valid assumption that followed hydrological similarity and thus, similar surface-groundwater interaction pattern that reflects in water quality of streams as well.

3.4 WATER QUALITY MODELLING RESULTS

The chemical parameters which were modelled are listed in Table 3.10:

Table 3.10: Chemical parameters predicted in the water quality model

Conventional parameters	**Major Ions**	**Total and Dissolved Metals**	
Total dissolved solids	Bicarbonate	Aluminum	Manganese
Specific conductivity	Calcium	Antimony	Molybdenum
Total alkalinity	Carbonate	Arsenic	Nickel
Chemical Oxygen Demand	Chloride	Barium	Selenium
Nutrients	Fluoride	Boron	Silver
Ammonia as nitrogen	Hydroxide.	Cadmium	Strontium
Nitrate	Magnesium	Chromium	Thallium
Total phosphorus	Potassium	Cobalt	Tin
Total organic carbon	Sodium	Copper	Titanium
Dissolved organic carbon	Sulfate	Iron	Uranium
		Lead	Vanadium
			Zinc

The results were compared to applicable water quality guidelines that are as follows:

The source water quality was compared to Mineral Mining Industry Authorized Concentration of Pollutants in Liquid Effluents. These guidelines were applied to water quality directed to the diffuser, PKCF seepage, runoff from Coarse PK pile.

Water quality in streams was compared to applicable aquatics life guidelines (Saskatchewan and CCME) and Health Canada Drinking Water Quality Guidelines.

Additionally to guidelines criteria background upper level (95% percentile) of natural variability was applied through all parameters.

The summary of water quality criteria for streams is presented in Table 3.11.

Table 3.11: Summary of water quality criteria

Parameter	Units	Guidelines			
		Liquid Effluent	Aquatic Life		Drinking Water
Conventional Parameters		**Mineral Industry (1996)**	**CCME (2011)**	**SK MOE (2006)**	**Health Canada (2008)**
Total dissolved solids	mg/L		-	-	≤500 (d1)
Chloride	mg/L		120	-	≤250 (d1)
Sodium	mg/L		-	-	≤200 (d1)
Sulfate	mg/L		-	-	≤500 (d1)
Ammonia as nitrogen	mg/L		7.0 - 48.3 (a1)	-	-
Un-ionized Ammonia	mg/L	0.5 (c1)			
Nitrate	mg/L		2.9 (a2)	-	45 (d3)
Aluminum	mg/L		0.005 or 0.1 (a4)	-	0.1 (d4)
Antimony	mg/L		-	-	0.006 (d2)
Arsenic	mg/L	0.5 (c1)	0.005	-	0.01 (d2)
Barium	mg/L		-	-	1 (d2)
Boron	mg/L		1.5	-	5 (d2)
Cadmium	mg/L		0.00006 (a5)	0.000017 to 0.0001 (b1)	0.005 (d2)
Chromium	mg/L		0.001 (a6)	-	0.05 (d2)
Cobalt	mg/L		-	-	-
Copper	mg/L	0.3 (c1)	0.004 (a7)	-	≤1 (d1)
Iron	mg/L		0.3	-	≤0.3 (d1)
Lead	mg/L	0.2 (c1)	0.007 (a8)	-	0.01
Manganese	mg/L		-	-	≤0.05 (d1)
Mercury	mg/L		0.00003	0.00003	0.001
Molybdenum	mg/L		0.073	-	-
Nickel	mg/L	0.5 (c1)	0.15 (a9)	-	-

Parameter	Units	Guidelines			
		Liquid Effluent	Aquatic Life		Drinking Water
Conventional Parameters		Mineral Industry (1996)	CCME (2011)	SK MOE (2006)	Health Canada (2008)
Selenium	mg/L		0.001	-	0.010 (d2)
Silver	mg/L		0.0001	-	-
Thallium	mg/L		0.0008	-	-
Uranium	mg/L	2.5 (c1)	0.015	0.015 (b2)	0.02
Zinc	mg/L	0.5 (c1)	0.03	-	≤5 (d1)

Canadian Environmental Quality Guidelines - CEQG (CCME 2011)

a1 = Guideline is dependent on temperature and pH. The value ranges between 6.98 mg/L (pH= 7.0, temperature= 15oC) and 48.3 mg/L (pH= 6.5, temperature= 5oC).
a2 = Guideline is converted to Nitrate-N.
a3 = Guideline is converted to Nitrite-N.
a4 = Guideline = 5 µg/L at pH < 6.5, $[Ca^{2+}]$ < 4 mg/L and DOC < 2 mg/L; Guideline = 100 µg/L at pH ≥ 6.5, $[Ca^{2+}]$ ≥4 mg/L and DOC ≥ 2 mg/L.
a5 = Cadmium guideline = $10^{[0.86\ [\log(\text{hardness})]\ -\ 3.2]}$. Conservatively, the lowest median hardness for this site was used to calculate the guidelines.
a6 = Guideline is for hexavalent chromium (Cr_{VI}) because its guideline is more stringent than the trivalent chromium (Cr_{III}) guideline of 8.9 µg/L.
a7 = Copper guideline is dependent on [CaCO3] with a minimum of 2 µg/L. Guideline = $e^{0.8545[\ln(\text{hardness})]-1.465}$*0.2. Conservatively, the lowest median hardness for this site was used to calculate the guidelines.
a8 = Lead guideline is dependent on [CaCO3]. Guideline = $e^{1.273[\ln(\text{hardness})]-4.705.}$ Conservatively, the lowest median hardness for this site was used to calculate the guideline.
a9 = Nickel guideline is dependent on [$CaCO_3$]. Nickel guideline is dependent on [CaCO3]. Guideline = $e^{0.76[\ln(\text{hardness})]+1.06}$. Conservatively, the lowest median hardness for this site was used to calculate the guideline.

Saskatchewan Surface Water Quality Objectives (MOE 2006)

b1 = Cadmium Objective: 0.017 ug/L where hardness is 0 - 48.5 mg/L; 0.032 ug/L where hardness is 48.5 - 97; 0.058 where hardness is 97 - 194; 0.10 ug/L where hardness is >194.
b2 = The objective was developed by the Industrial, Uranium and Hardrock Mining Unit of Saskatchewan Environment.

The Mineral Industry Environmental protection Regulations, 1996

c1 = Maximum monthly arithmetic mean concentration.

Guideline for Canadian Drinking Water Quality - GCDWQ (Health Canada 2008)

d1 = Aesthetic objective.
d2 = Maximum allowable concentration (MAC).
d3 = Equivalent to 10 mg/L as nitrate-nitrogen. Where nitrate and nitrite are determined separately, levels of nitrite should not exceed 3.2 mg/L.
d4 = A health-based guideline for aluminum in drinking water has not been established. Operational guidance values of less than 100 µg/L total aluminum for conventional treatment plants and less, than 200 µg/L total aluminum for other types of treatment systems are recommended.

The modelling outputs were plotted as timeseries and presented in a set of figures with applicable guidelines, background levels, and criteria.

Water quality during construction and operations is shown in Figures 3.1 through Figure 3.41. The results are presented for each parameter modelled and all creeks as shown in Figure 1.1.

A comparison of water quality during different climatic conditions at a representative year in each climatic condition scenario Year 6 after closure for mean vs. 1:20 dry conditions; and Year 18 after closure for mean vs.1:20 wet conditions) is presented in a set of Figures 3.42 through Figure 3.95. These results cover watersheds occupied by overburden pile, coarse PK pile and PKCF as potentially the most affected by changes in climate conditions and runoff from these facilities. The streams assessed in this case were Caution Creek, 101 Ravine, and Duke Ravine (including water diverted from east Ravine).

The closure results are presented for both Star and Orion South pit lakes from the starting date of their infilling. The water balance details and evaluation of time for pits infiling with groundwater and surface runoff are presented in Section 2 above.

The Orion South pit lake after 1,000 years and 2,500 years since closure will be still closed lake with no outflow. The annual changes of water quality in Star pit and Orion South pit (non stratified case) are presented as mass balance model output during and post infilling period in a set of Figures 3.96 through Figure 3.138.

The Star pit lake will be filled in and the predicted water quality at the time of spill over to the Saskatchewan River in approximately 320 years from closure is shown on each parameter plot.

The Orion South Pit will never spill and water quality will continue to improve with exception of a few parameters which concentration slowly increases until reaching a plateau.

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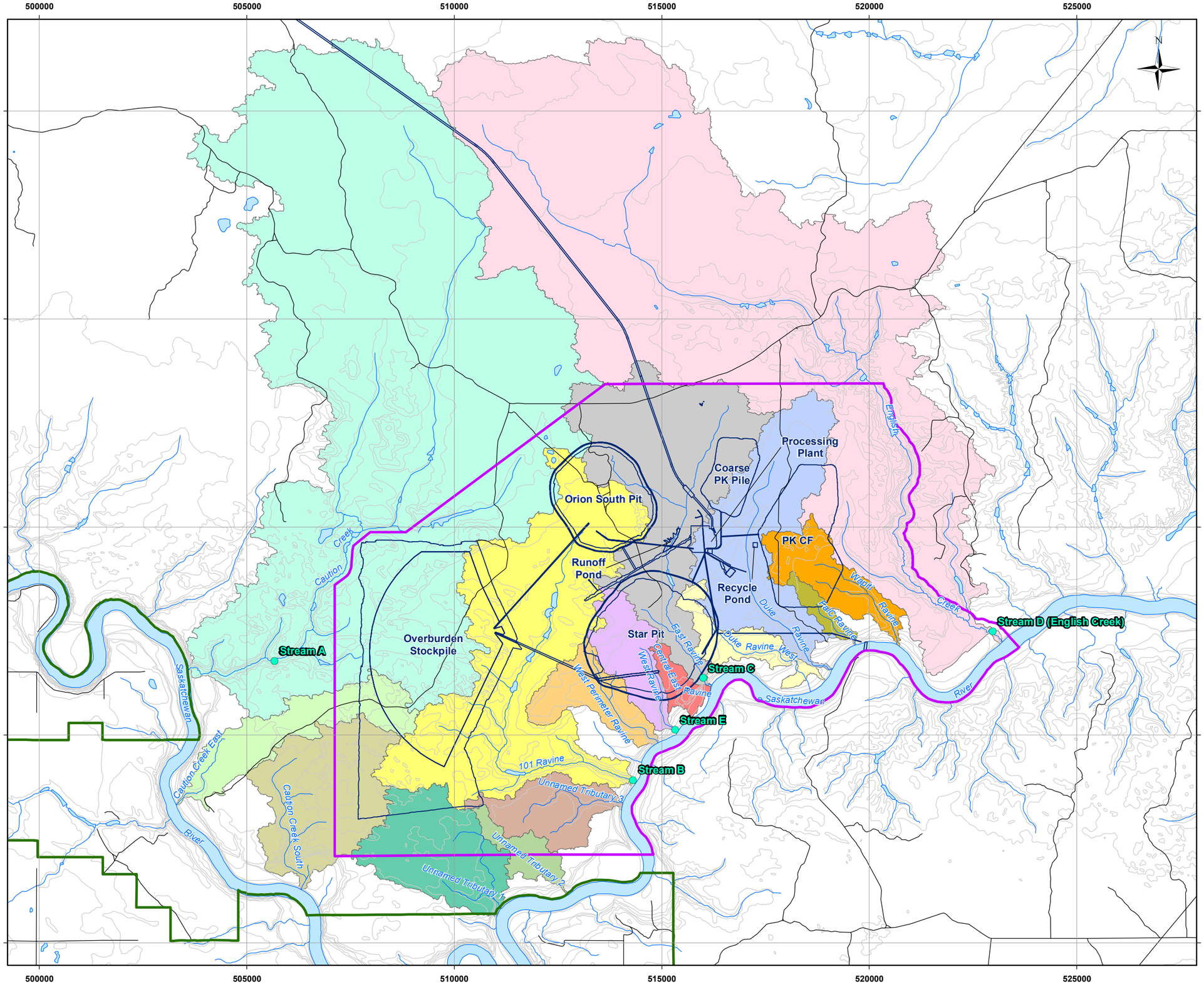
Project facilities and surface drainage basins



Legend

- Local Study Area
- Regional Study Area
- Project Footprint
- Elevation Contour (10 m)
- Road
- Streamflow Monitoring Station

Watersheds

- 101 Ravine Watershed
- Caution Creek East Watershed
- Caution Creek South Watershed
- Caution Creek Watershed
- Central-East Ravine Watershed
- Duke Ravine Watershed
- Duke Ravine West Watershed
- East Ravine Watershed
- English Creek Watershed
- FalC Ravine Watershed
- Unnamed Tributary 1 Watershed
- Unnamed Tributary 2 Watershed
- Unnamed Tributary 3 Watershed
- Wapiti Ravine Watershed
- West Perimetre Ravine Watershed
- West Ravine Watershed

1 0.5 0 1 2
Kilometres
Scale: 1:90,000

Reference
Base data: NRCan National Road Network
NTS 1:50,000 scale: GeoSask

CLIENT: Shore Gold Inc.

PROJECT: Star - Orion South Diamond Project

Project Facilities and Drainage Basin Map

DATE:	ANALYST:	
April 2012	TM	**Figure 1.1**
JOB No: SX0373306.10	QA/QC: MY	PDF FILE: Fig1.1 Drainage 12-04-27.pdf
GIS FILE: Fig1.1 Drainage.mxd		
PROJECTION: UTM Zone 13	DATUM: NAD27	amec

S:\Gis\Projects\SX\Shore_Gold\2011\ArcGIS\Report\Water\Fig1.1 Drainage.mxd

500000 505000 510000 515000 520000 525000

5910000 5905000 5900000 5895000 5890000

N

Orion South Pit (Open Water)

Reclaimed Coarse PK Pile

Reclaimed Processing Plant

PKCF Reclaimed to Duke Ravine Watershed

Star Pit (Open Water)

Reclaimed Overburden Stockpile

English Creek

Caution Creek

Saskatchewan River

Caution Creek East

Caution Creek South

East Ravine

Central-East Ravine

West Ravine

West Perimeter Ravine

Duke Ravine

Duke Ravine West

FalC Ravine

Wapiti Ravine

101 Ravine

Unnamed Tributary 1

Unnamed Tributary 2

Unnamed Tributary 3

Stream A

Stream B

Stream C

Stream D (English Creek)

Stream E

Legend

- Local Study Area
- Regional Study Area
- Project Footprint
- Elevation Contour (10 m)
- Road
- Drainage Boundary
- Surface Water Flow Direction
- Streamflow Monitoring Station
- Closure (Reclaimed to Underlying Watershed)

Watersheds

- 101 Ravine Watershed
- Caution Creek East Watershed
- Caution Creek South Watershed
- Caution Creek Watershed
- Central-East Ravine Watershed
- Duke Ravine Watershed
- Duke Ravine West Watershed
- East Ravine Watershed
- English Creek Watershed
- FalC Ravine Watershed
- Open Water
- Unnamed Tributary 1 Watershed
- Unnamed Tributary 2 Watershed
- Unnamed Tributary 3 Watershed
- Wapiti Ravine Watershed
- West Perimetre Ravine Watershed
- West Ravine Watershed

1 0.5 0 1 2

Kilometres

Scale: 1:90,000

Reference

Base data: NRCan National Road Network
NTS 1:50,000 scale: GeoSask

CLIENT: Shore Gold Inc.

PROJECT: Star - Orion South Diamond Project

Closure Drainage Basin Map

DATE:	ANALYST:	
April 2012	NH	**Figure 1.2**
JOB No: SX0373306.10	QA/QC: MY	PDF FILE: Figure1.2 Closure Drainage 12-04-27.pdf
GIS FILE: Figure 1.2 Closure Drainage.mxd		
PROJECTION: UTM Zone 13	DATUM: NAD27	amec

S:\Gis\Projects\SX\Shore_Gold\2011\ArcGIS\Report\Water\Fig1.2 Closure Drainage.mxd

Mine site water balance

Figure 2.1 Star Pit Operation Water Balance Flow Chart

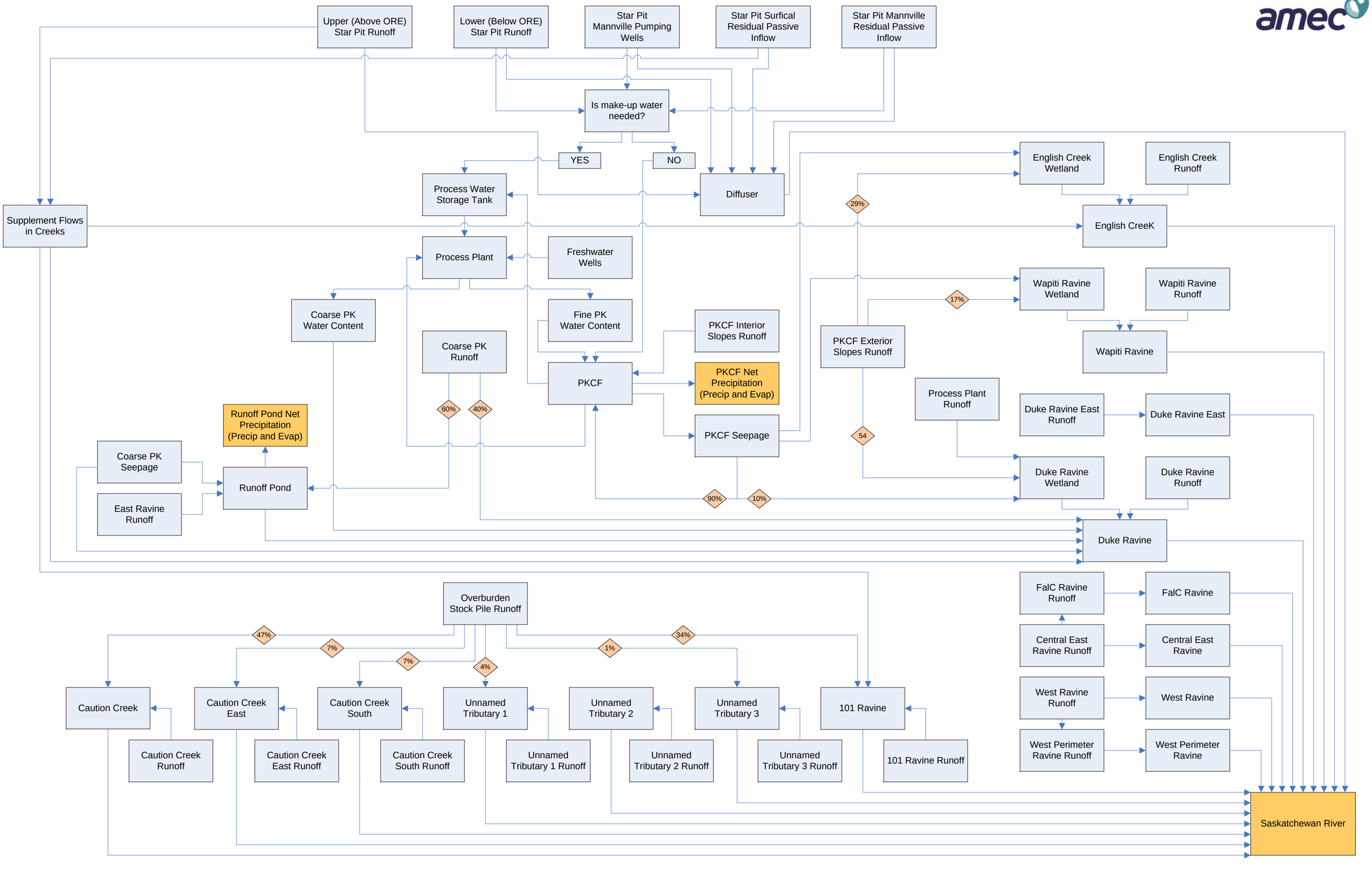


Figure 2.2 Star Pit and Orion South Pit Operation Water Balance Flow Chart

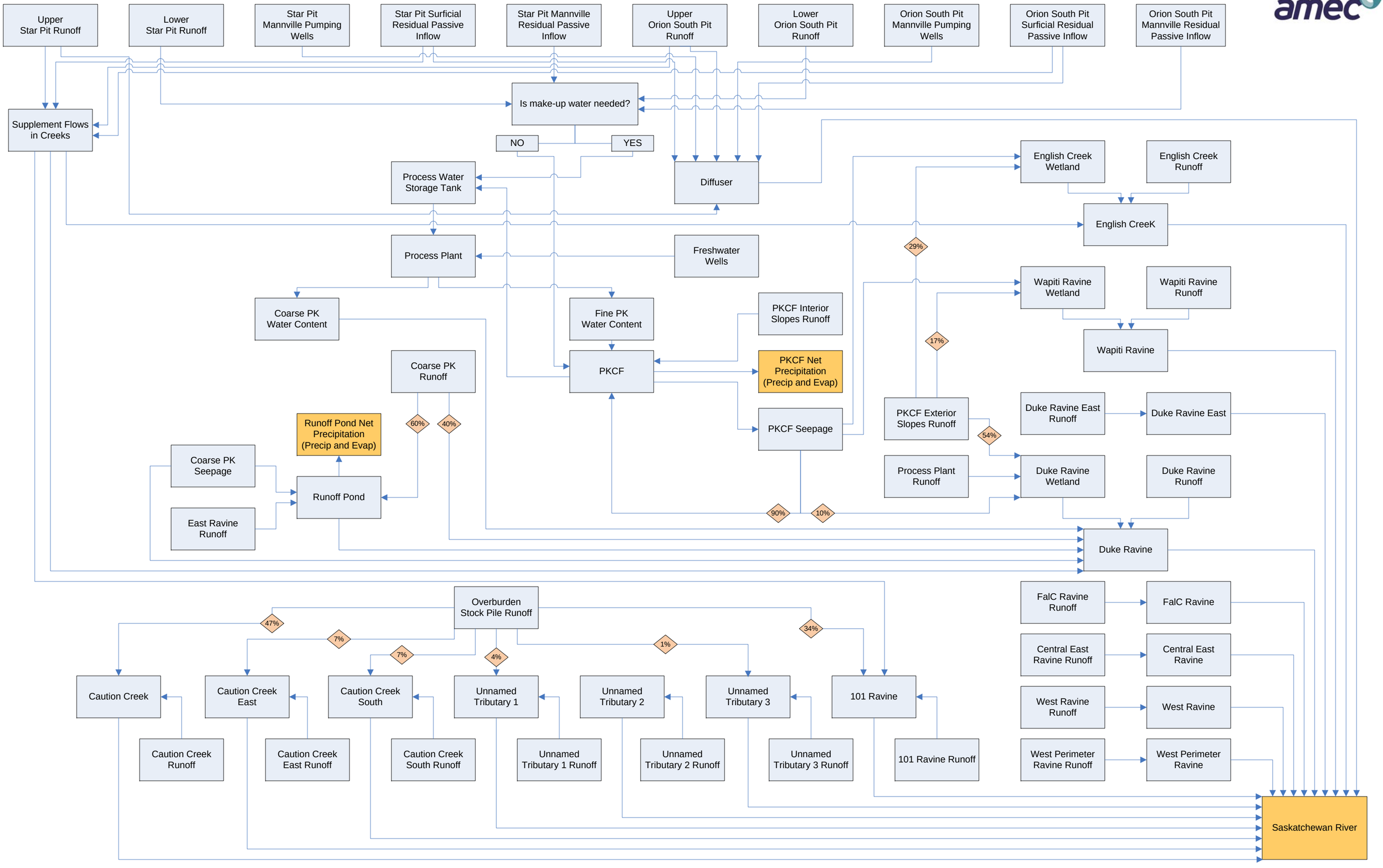


Figure 2.3 Orion South Pit Operation Water Balance Flow Chart

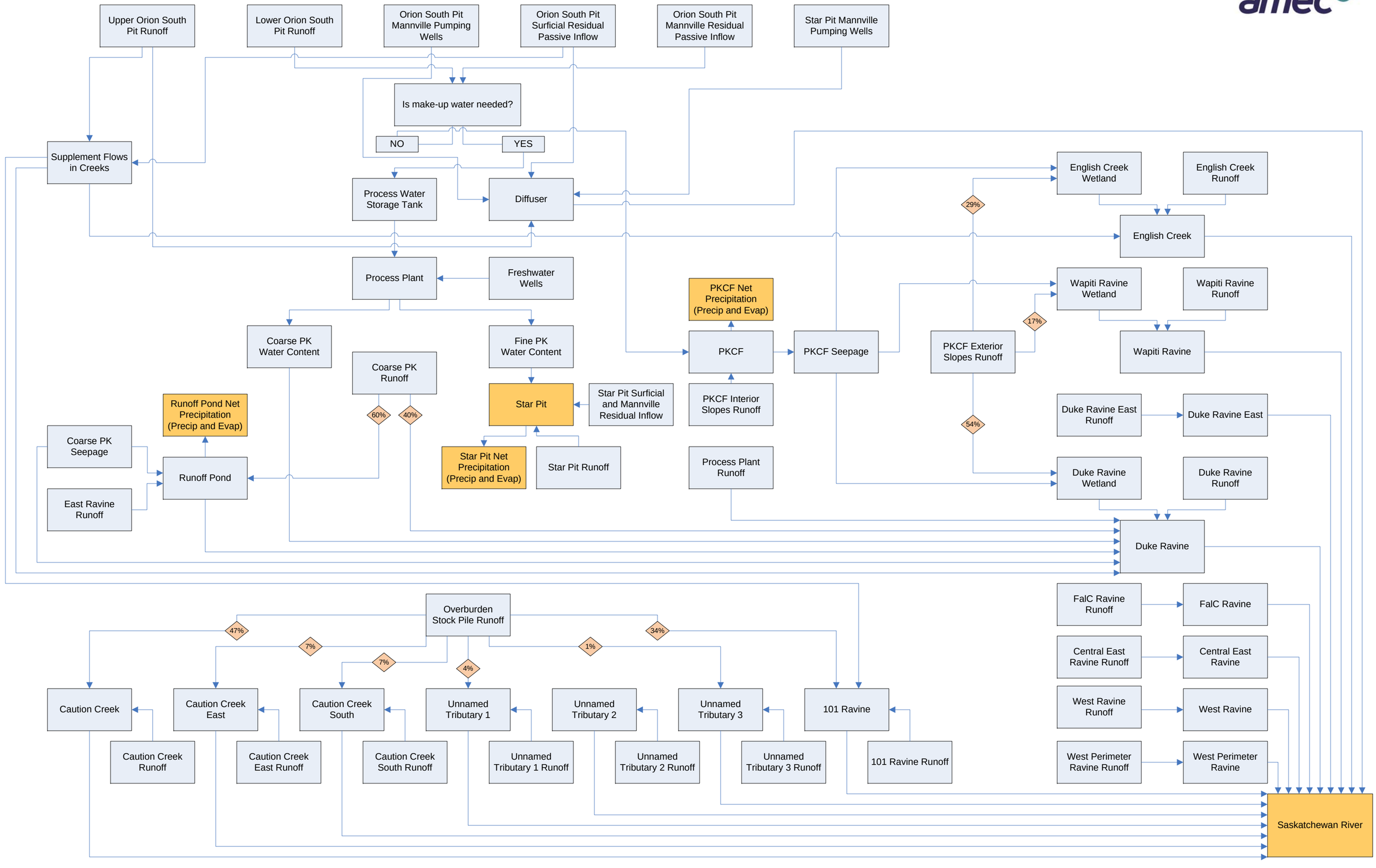
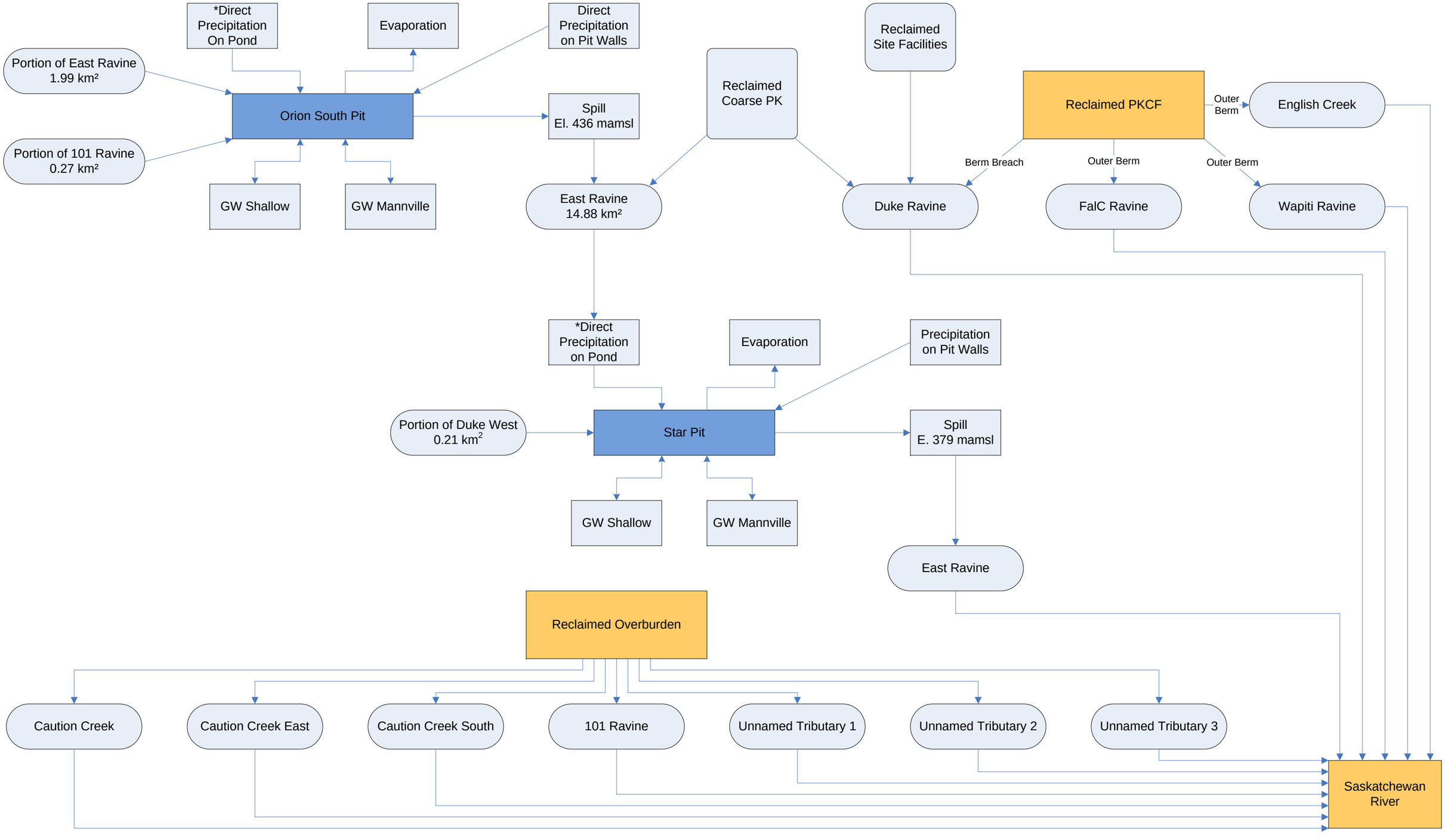
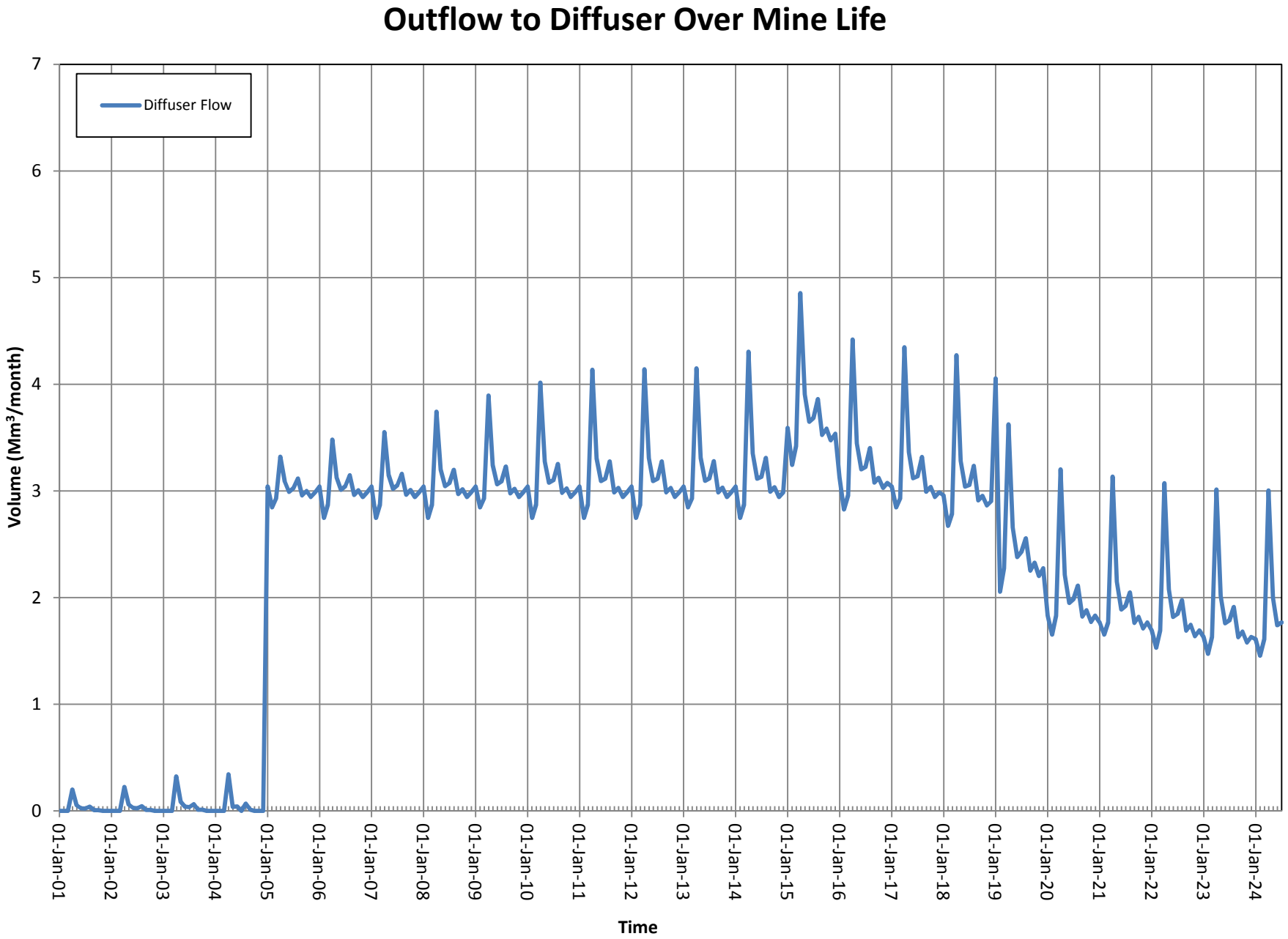


Figure 2.4 Closure Water Balance Schematic



* Pond and Pit wall areas change annually in water balance.



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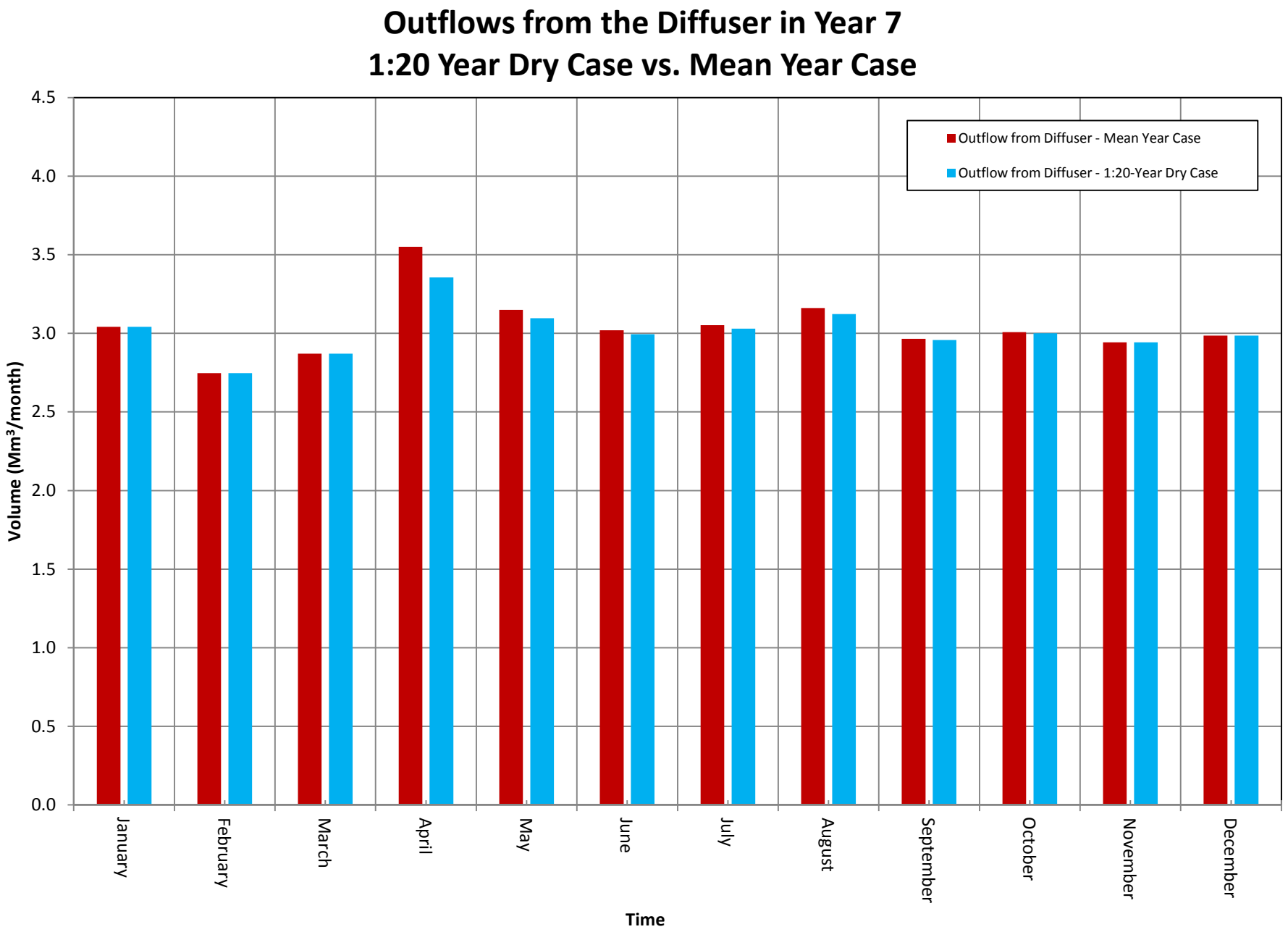
19/07/20129:11 AM

Figure 2.5



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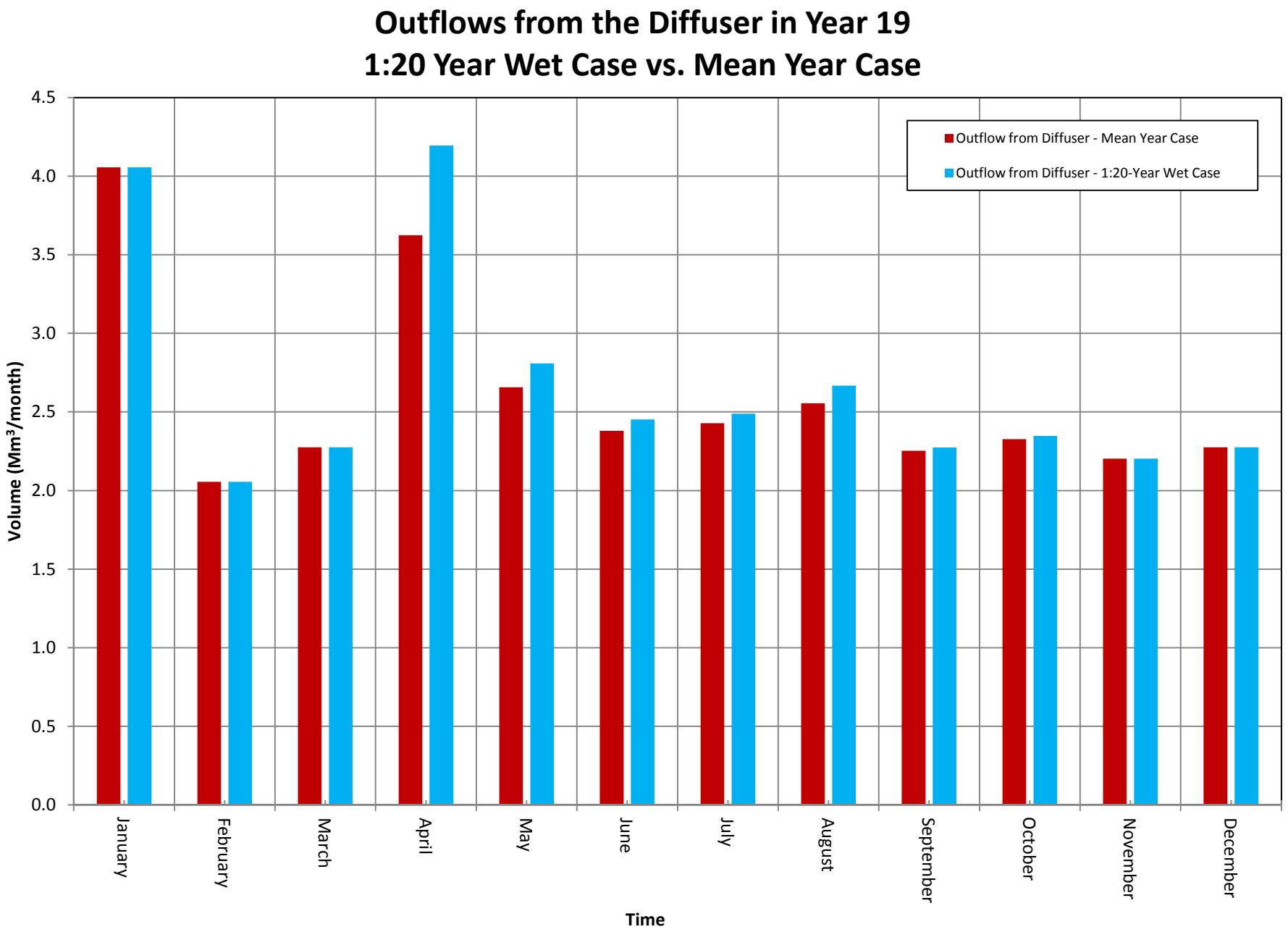

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Figure 2.7

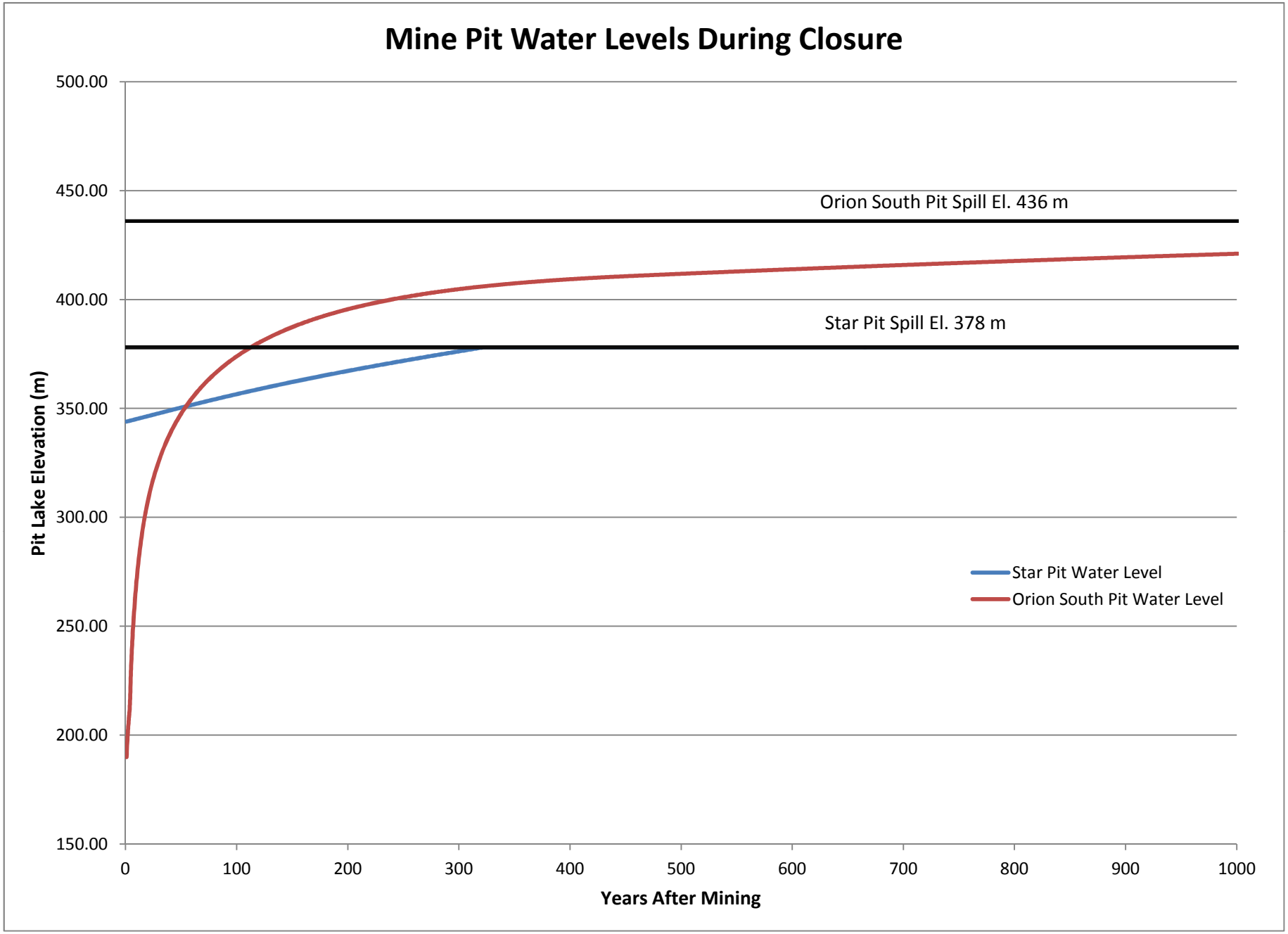

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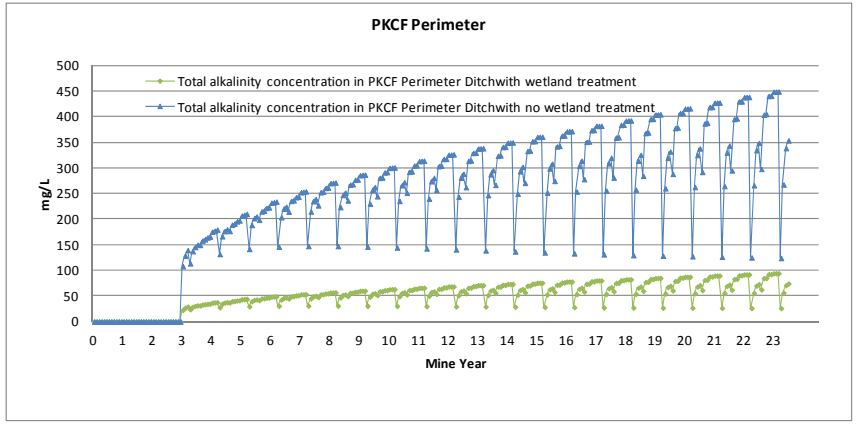
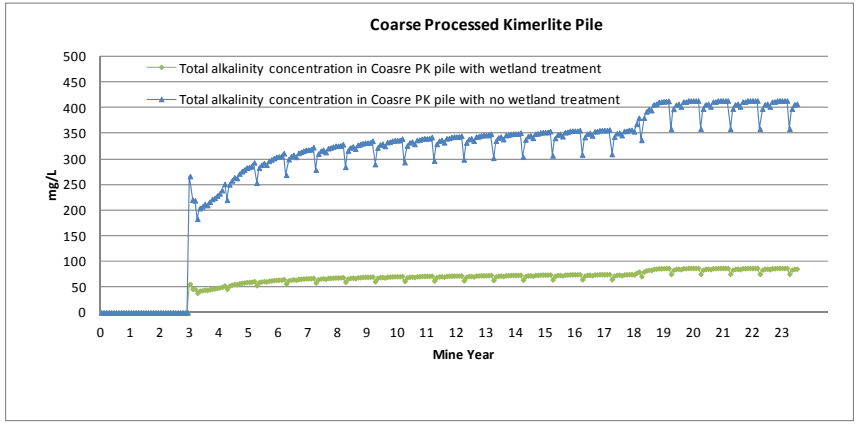
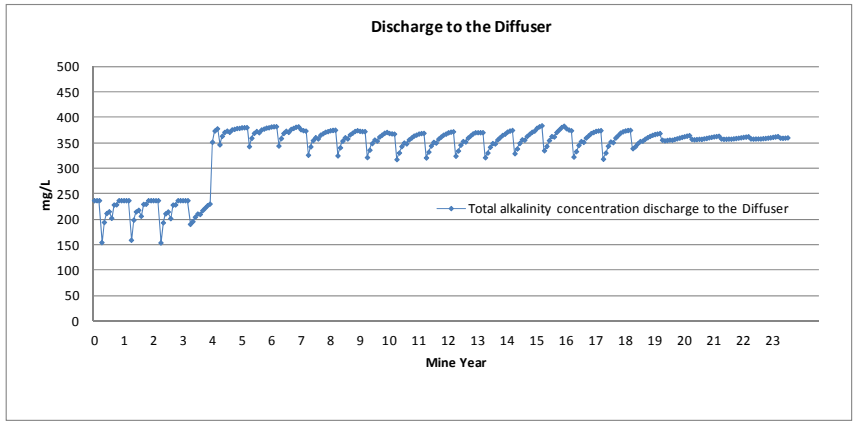
Figure 2.8

Water Quality during construction and operations

Figure 3-1 Predicted alkalinity concentrations during construction and operation







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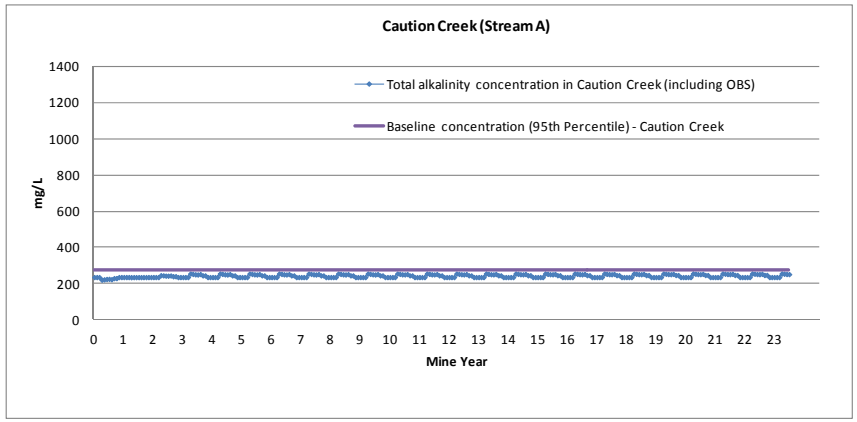

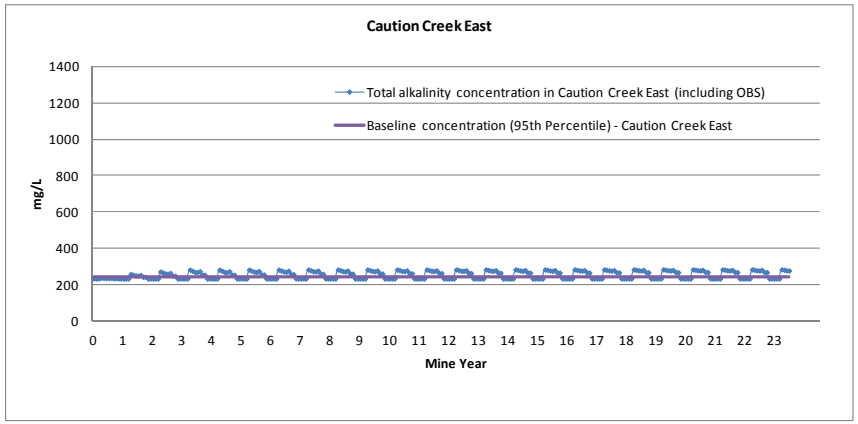

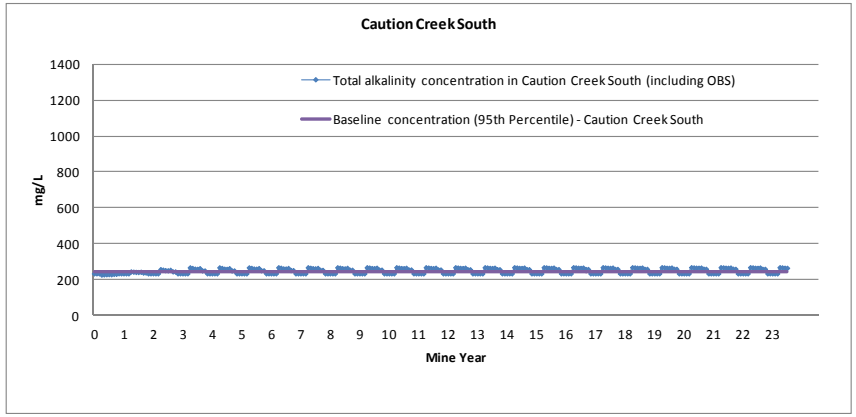

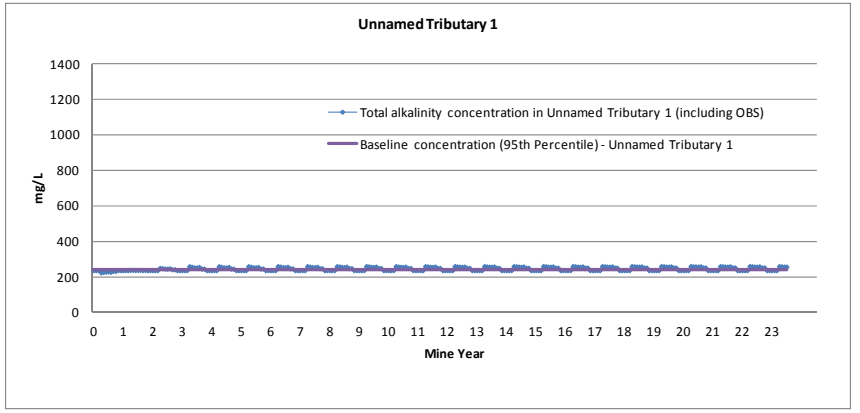

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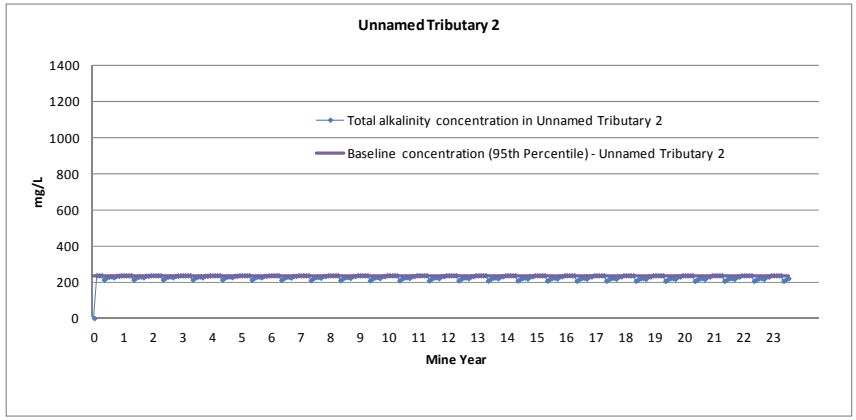

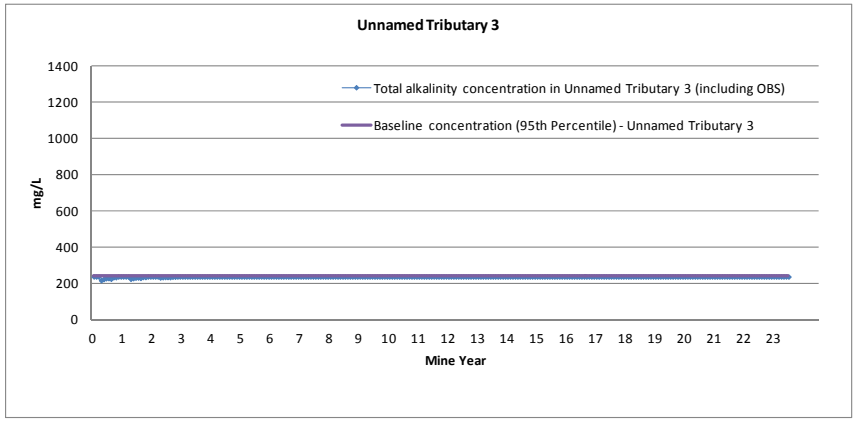

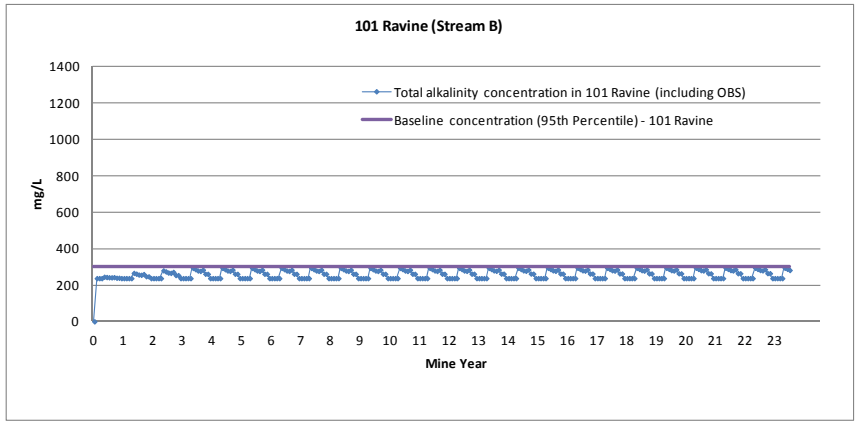

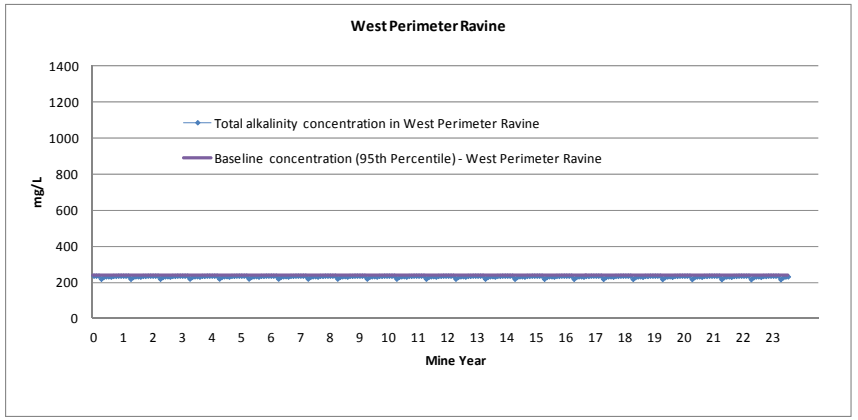

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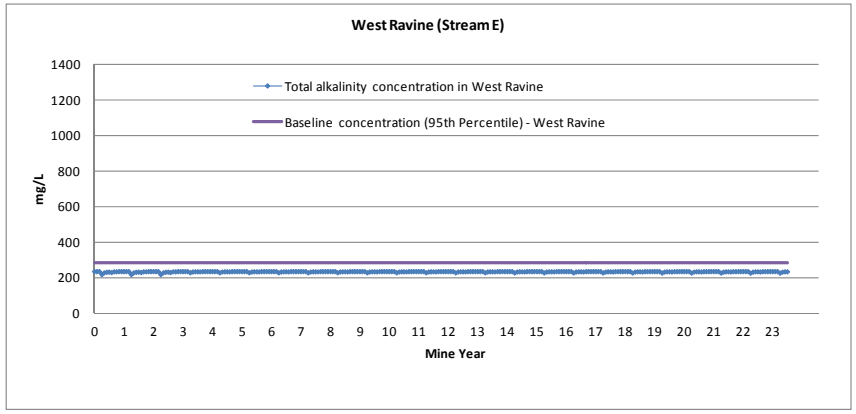

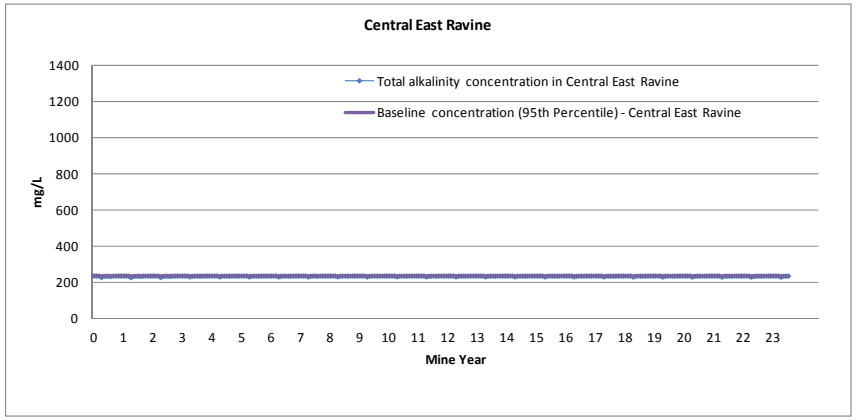

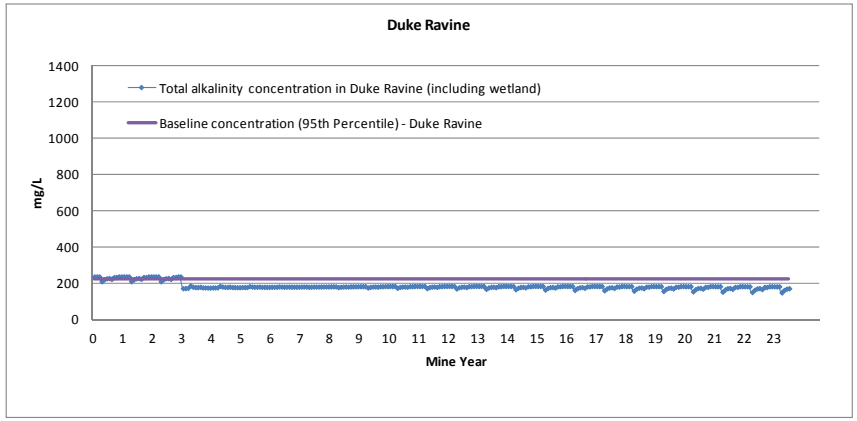

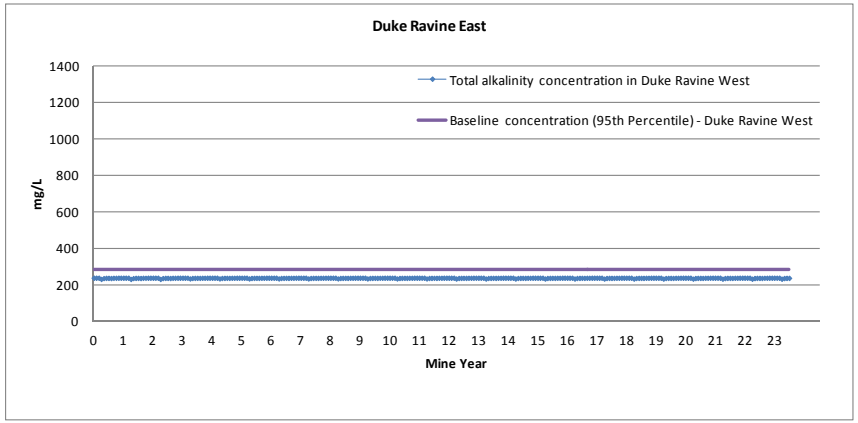

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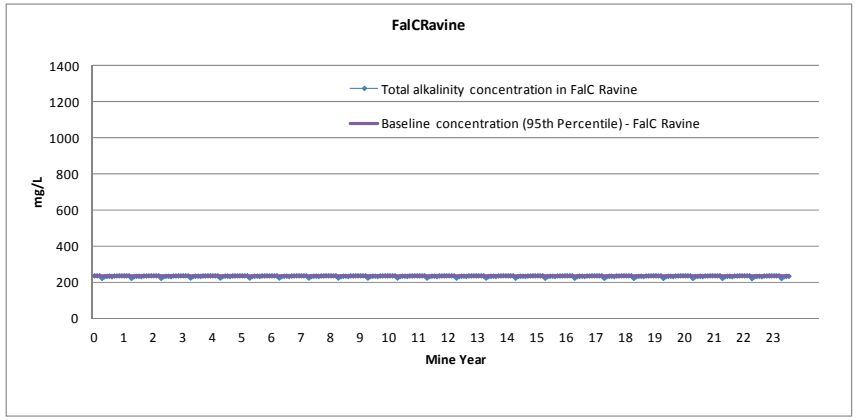
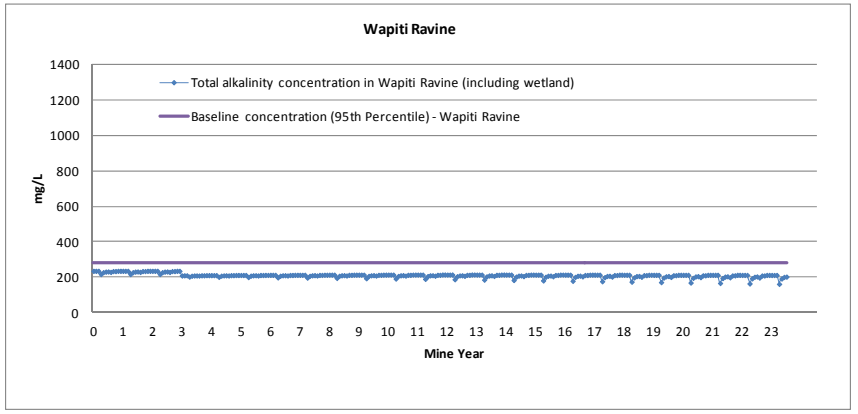
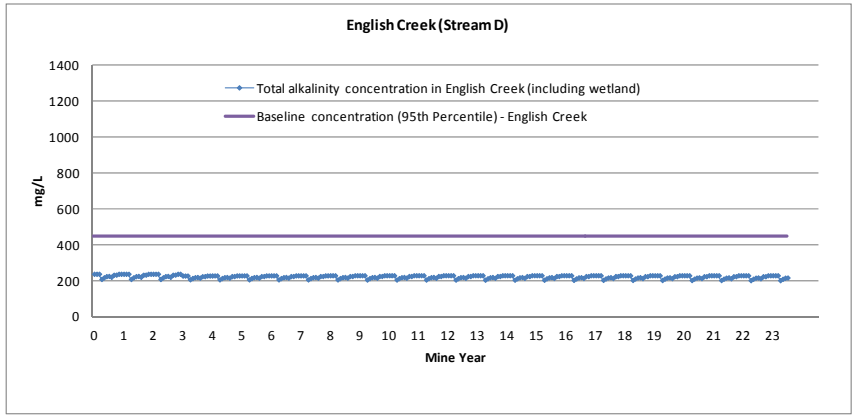






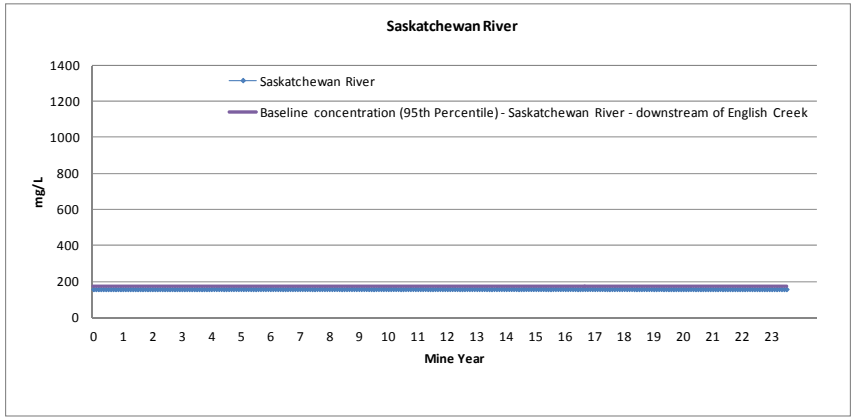
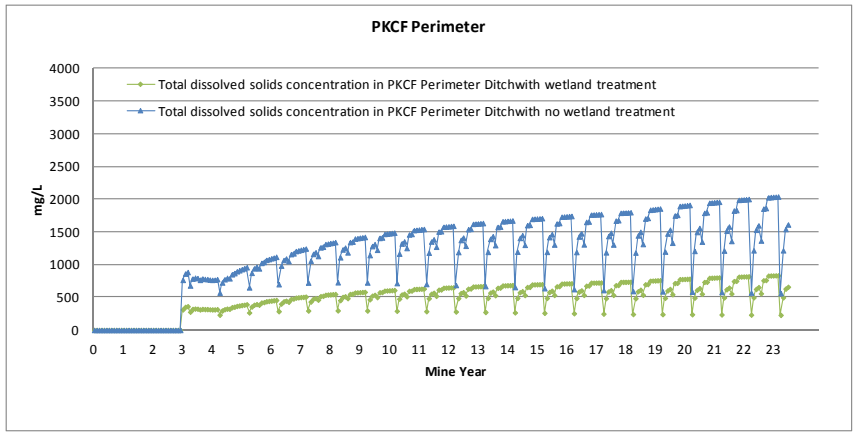
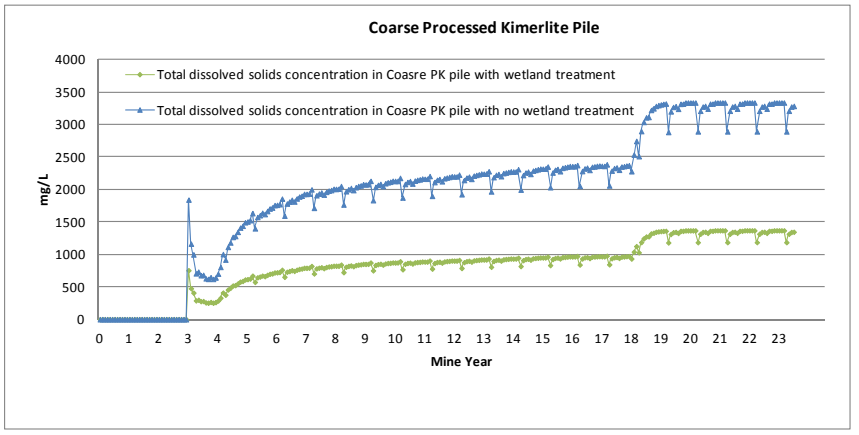
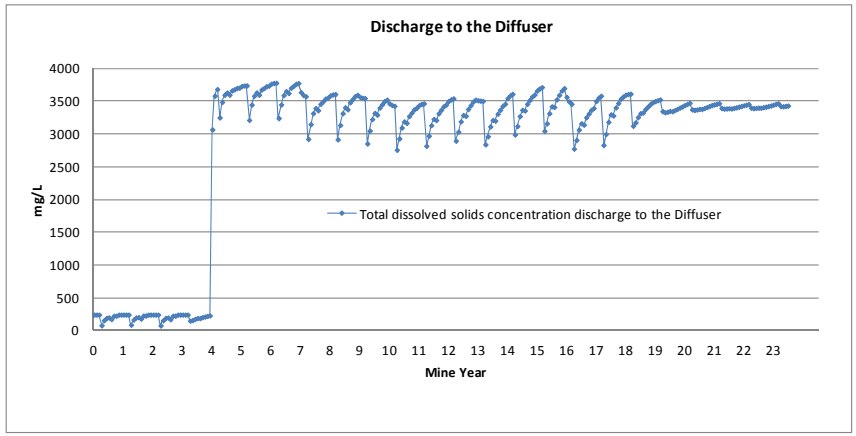


Figure 3-2 Predicted total dissolved solids concentrations during construction and operation







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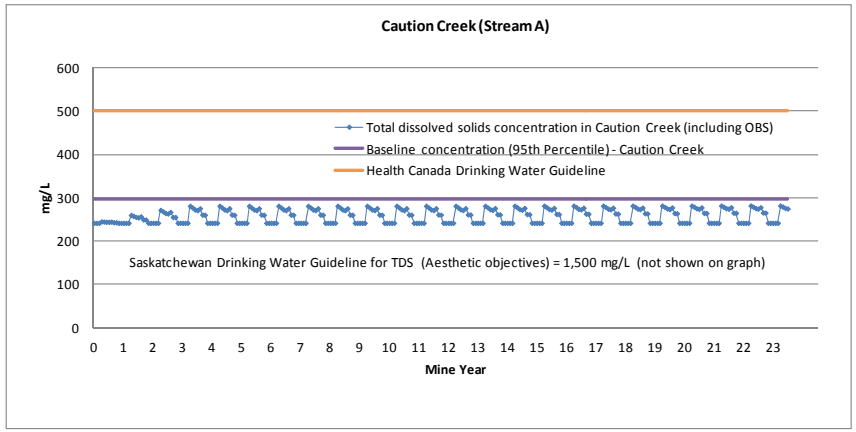

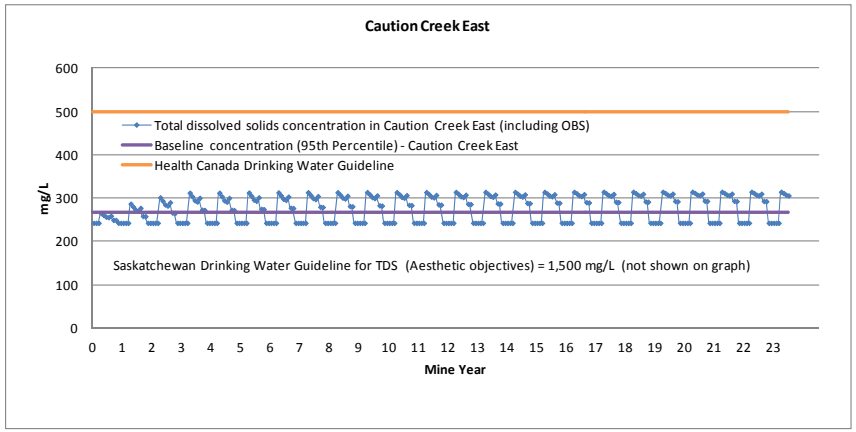

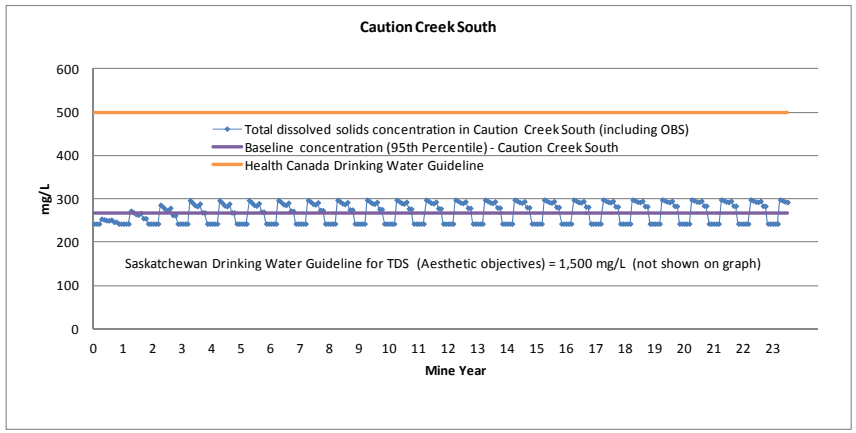

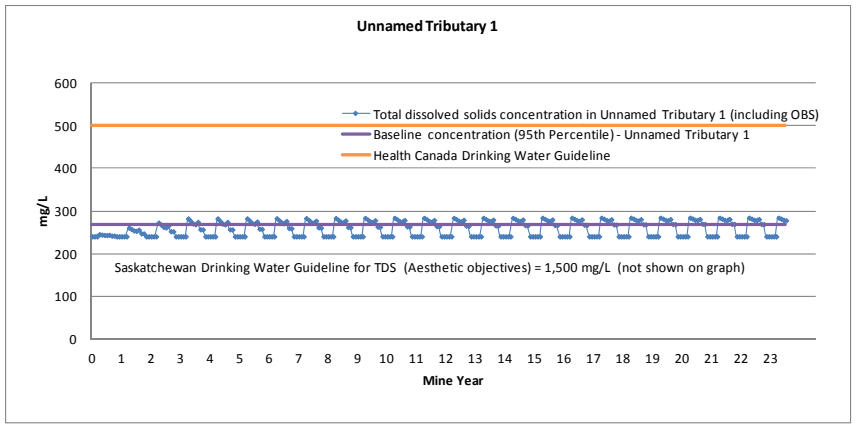

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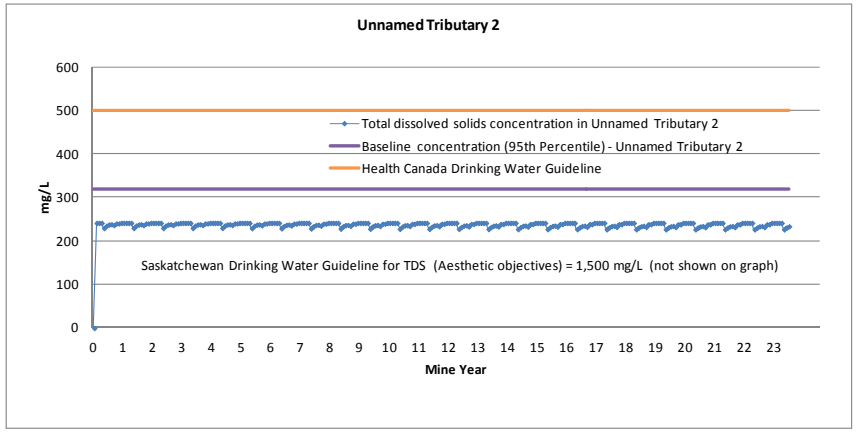

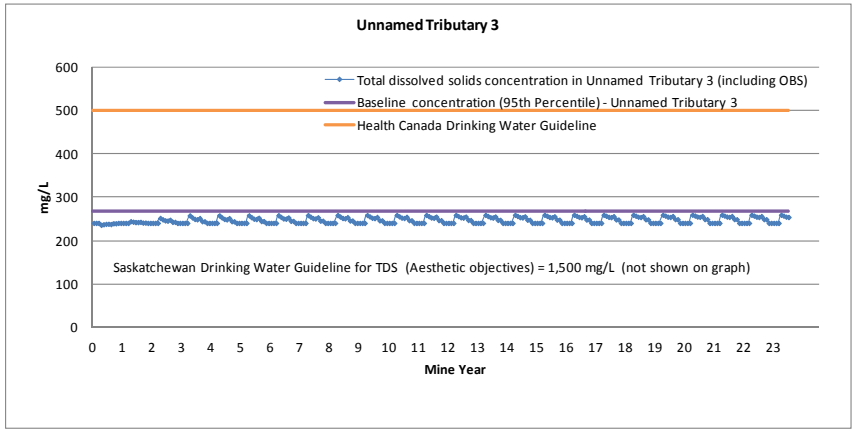

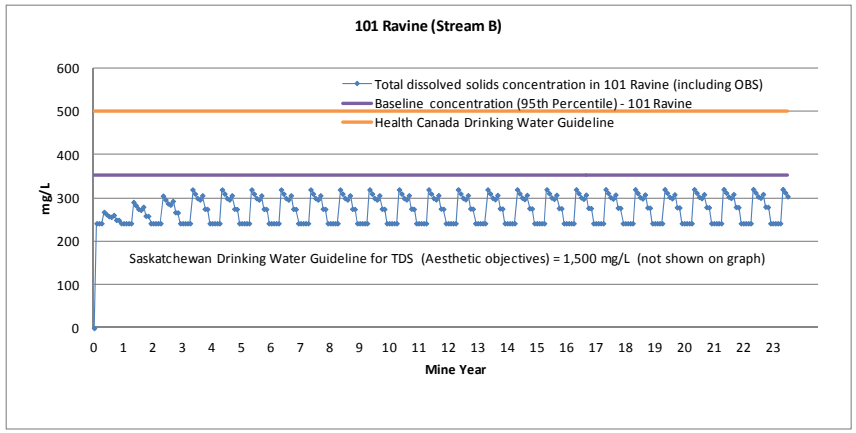

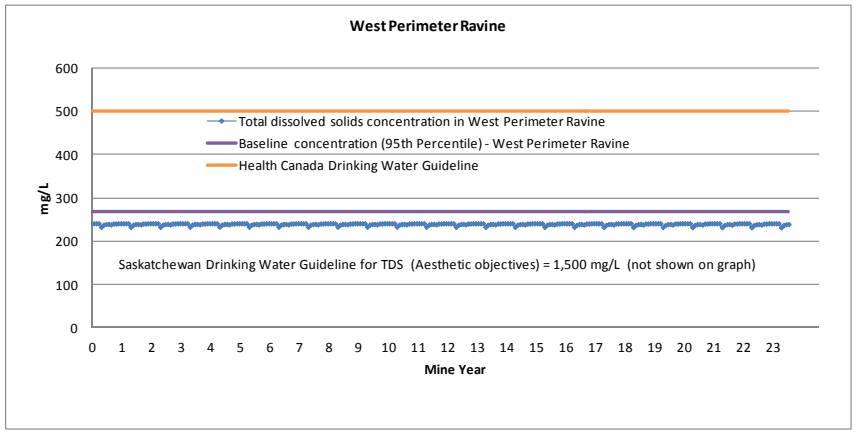

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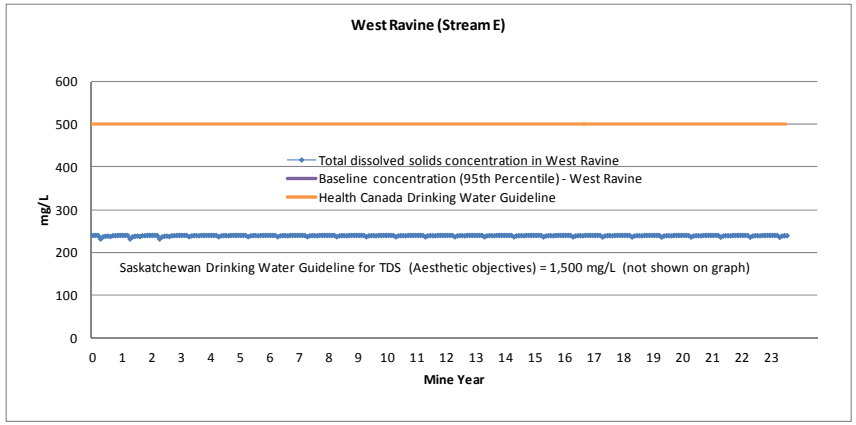

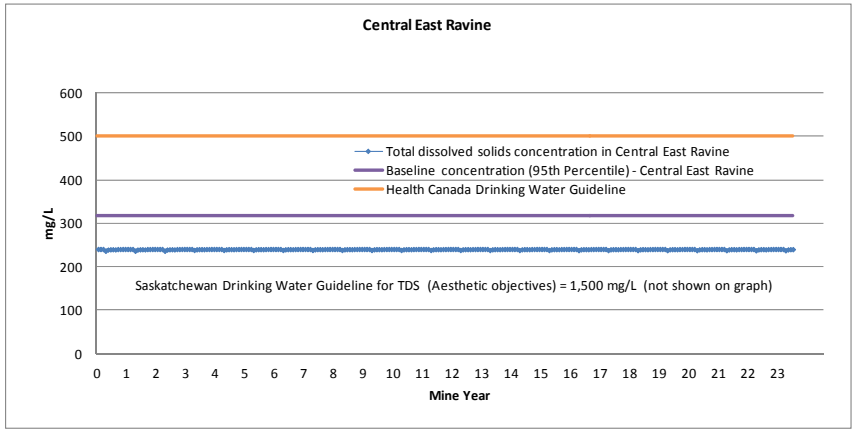

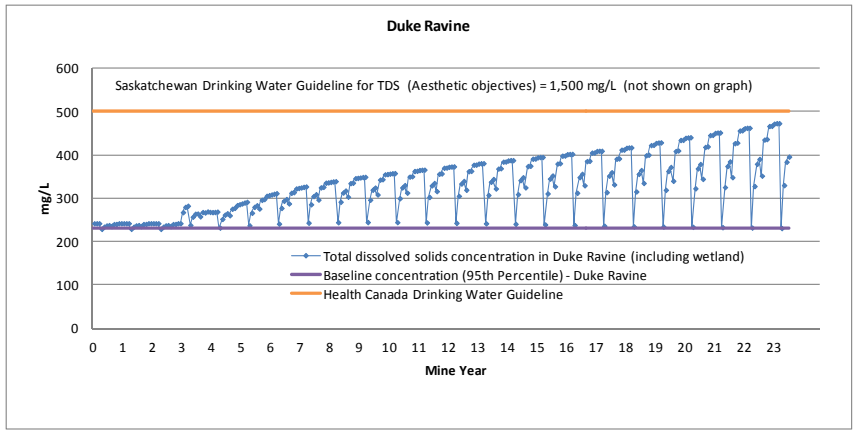

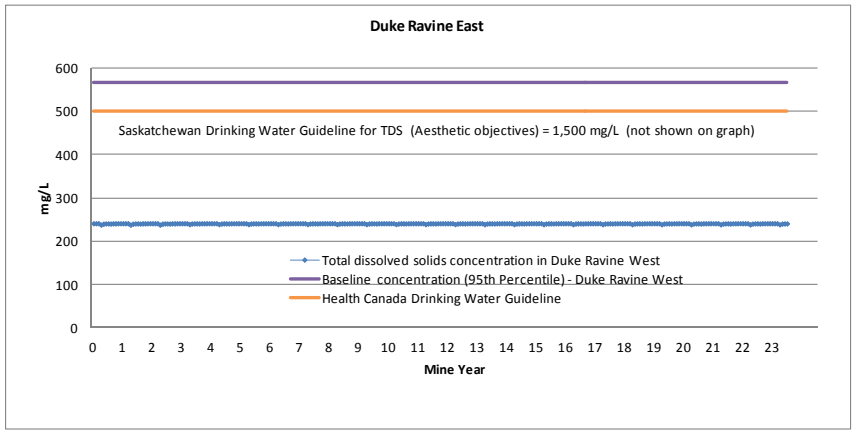

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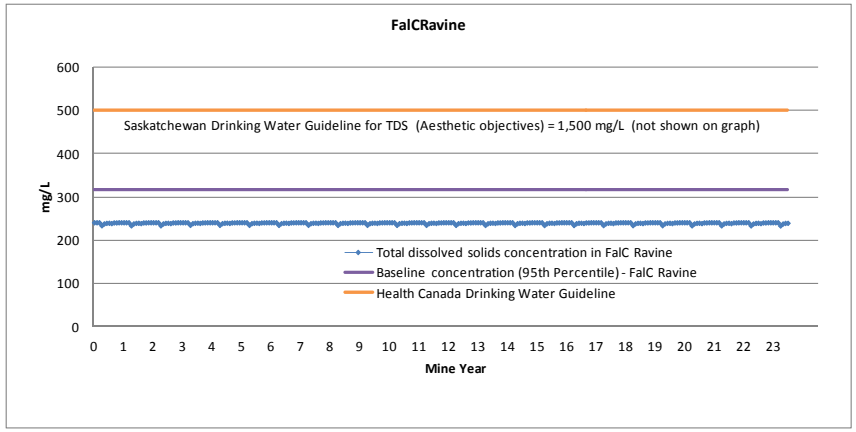
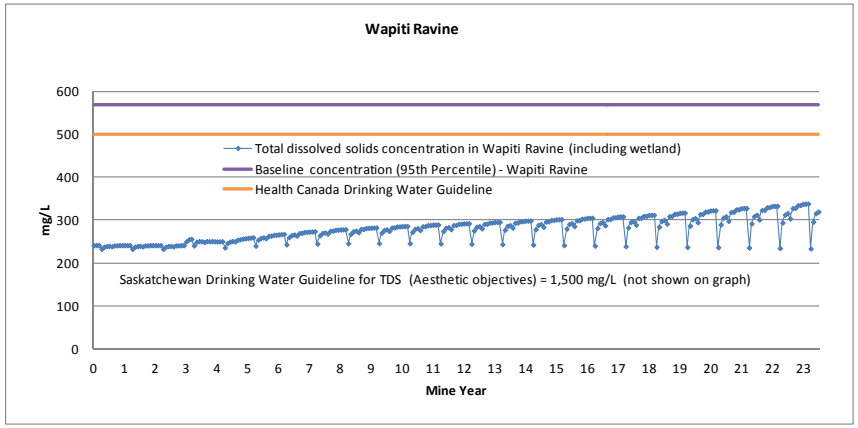
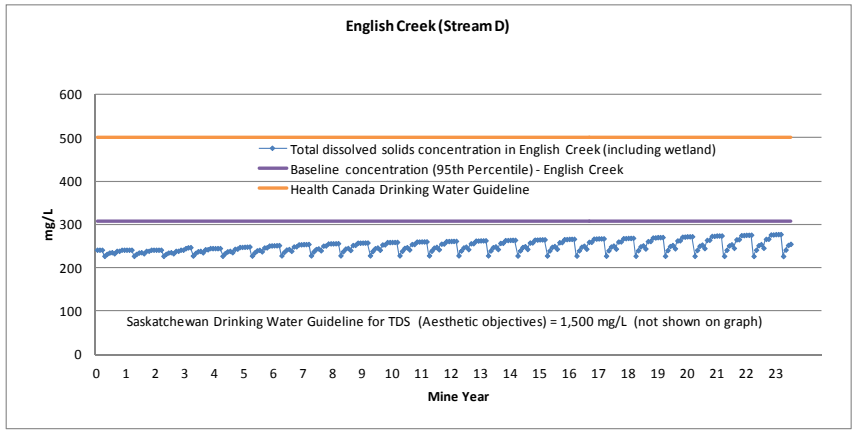






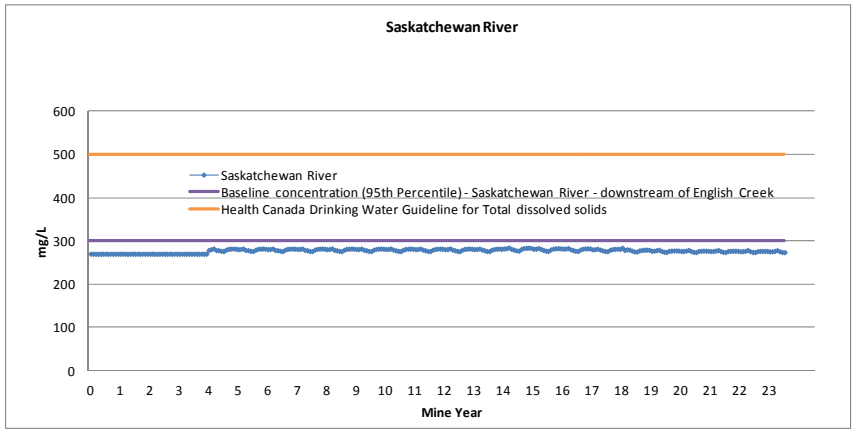
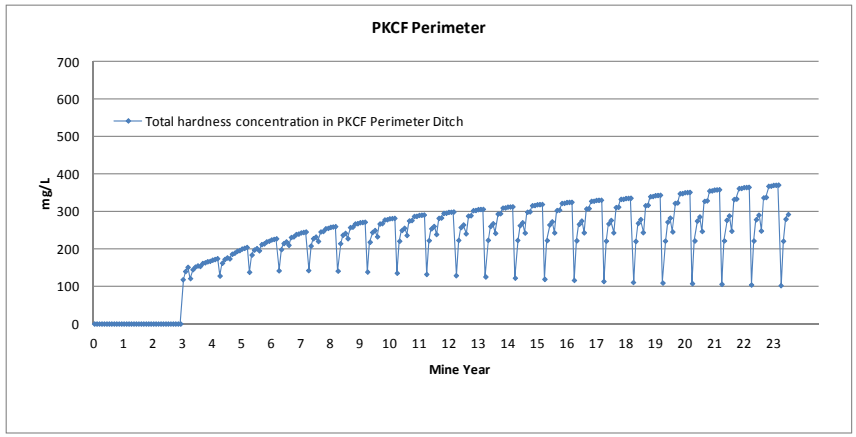
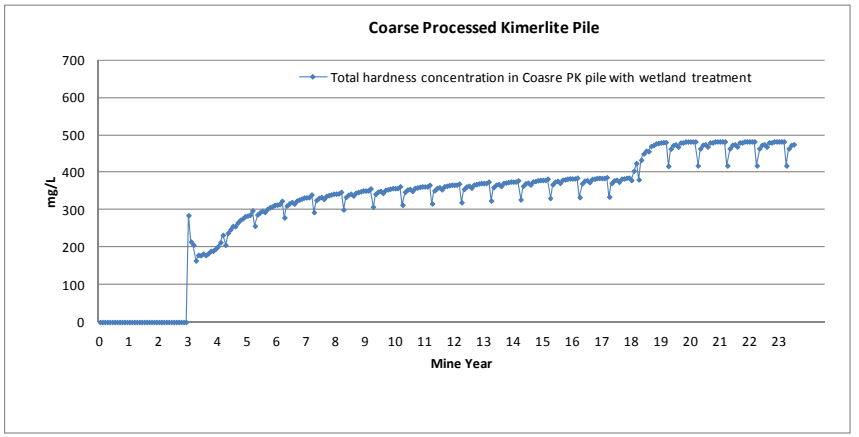
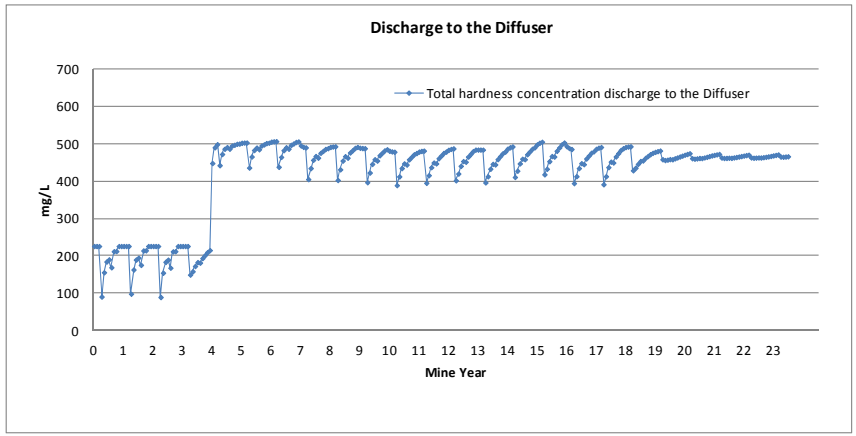


Figure 3-3 Predicted hardness concentrations during construction and operation







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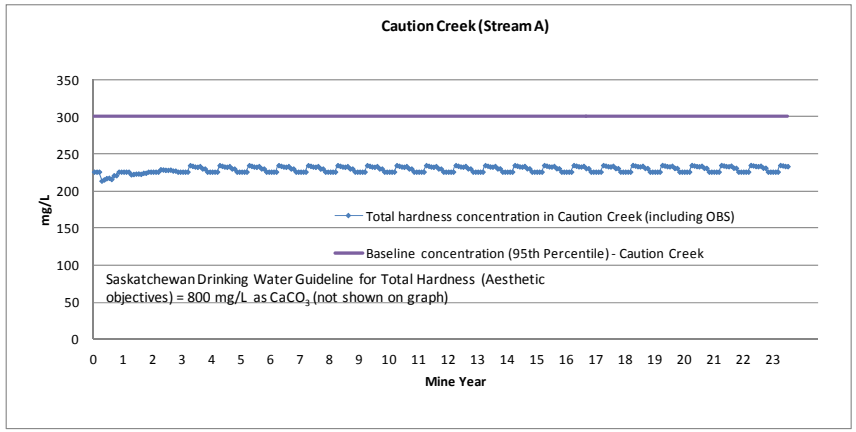

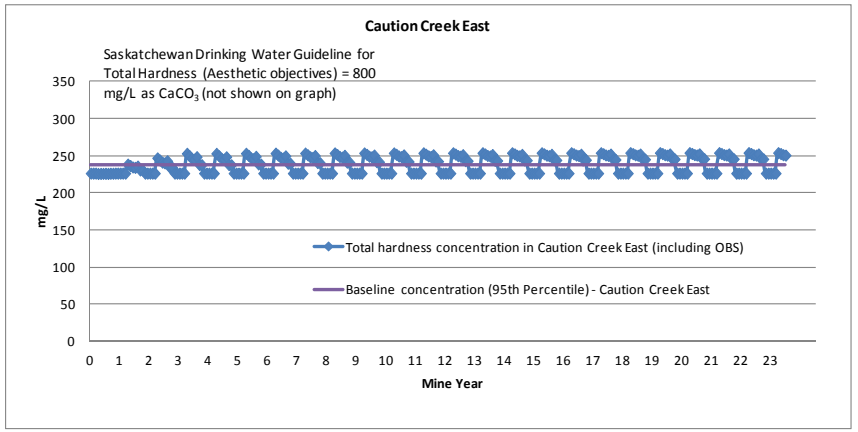

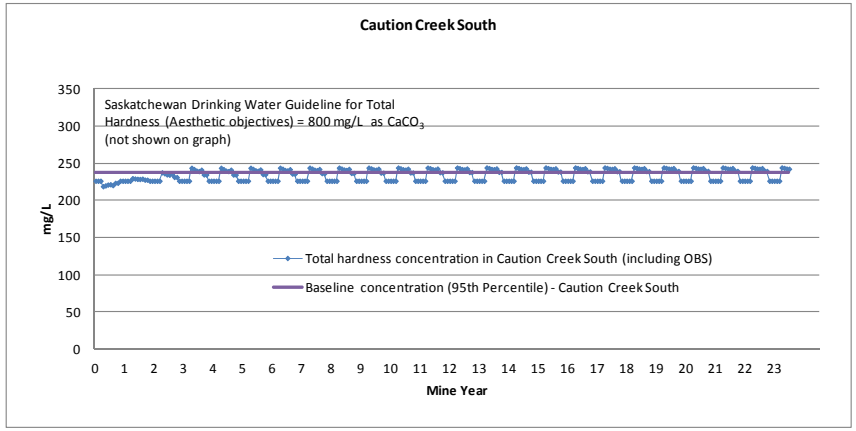

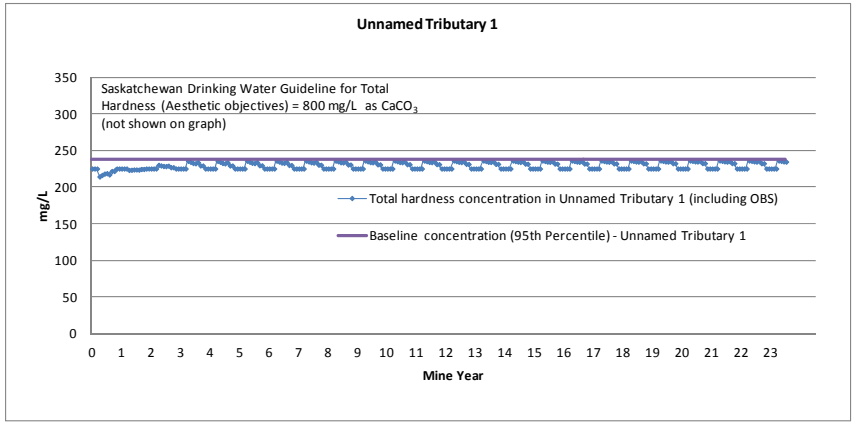

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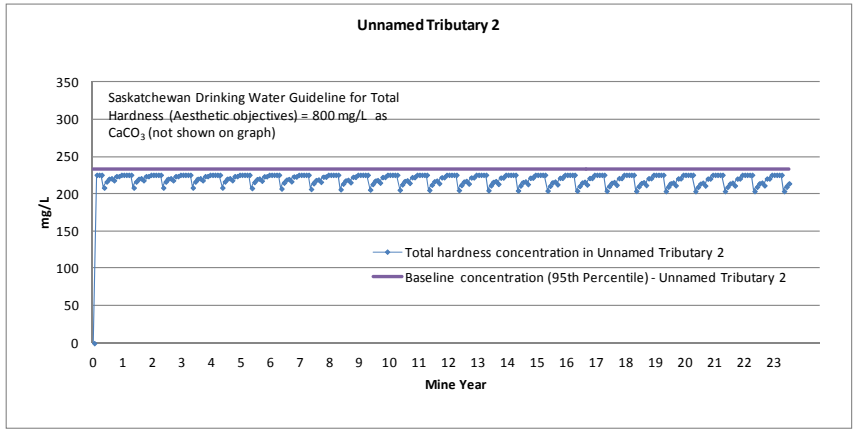

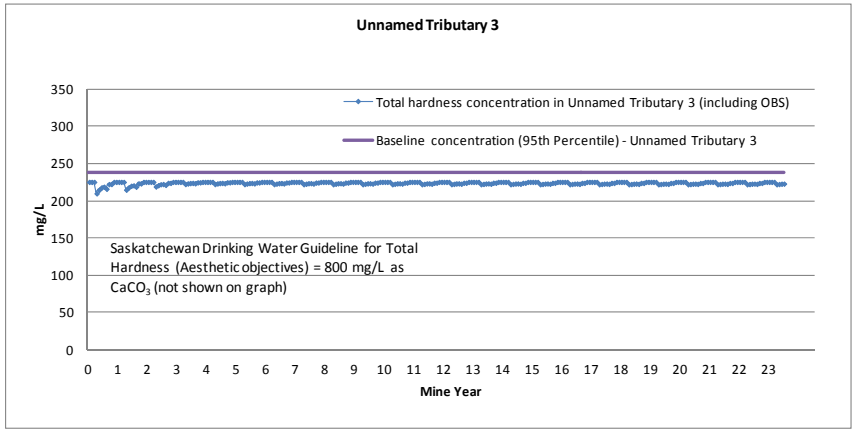

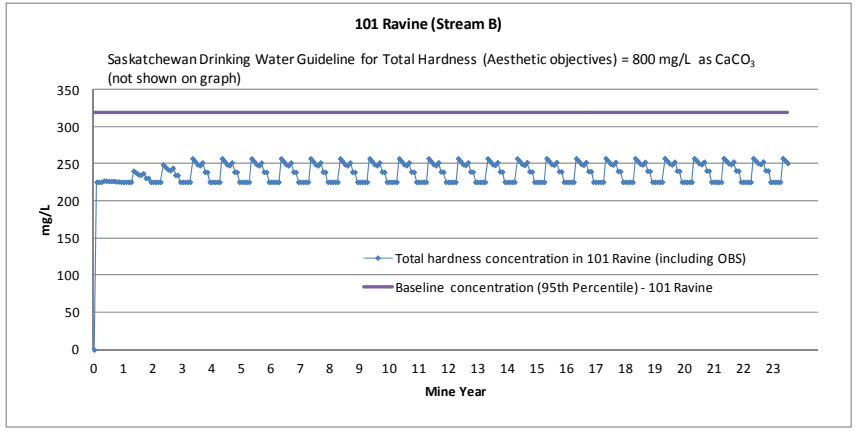

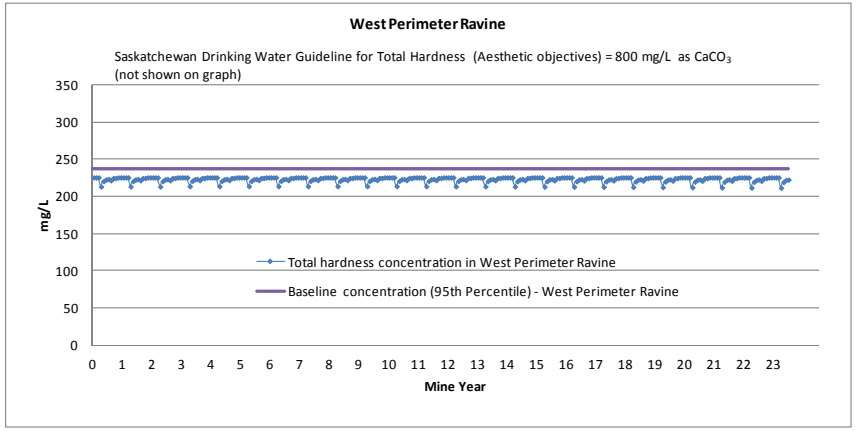

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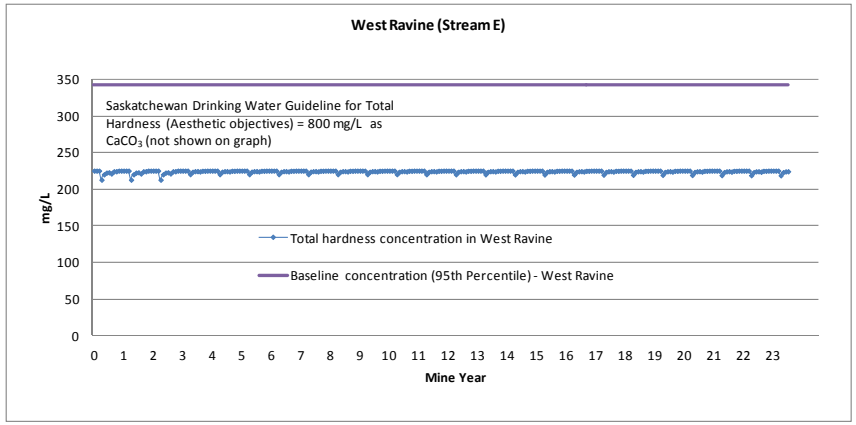

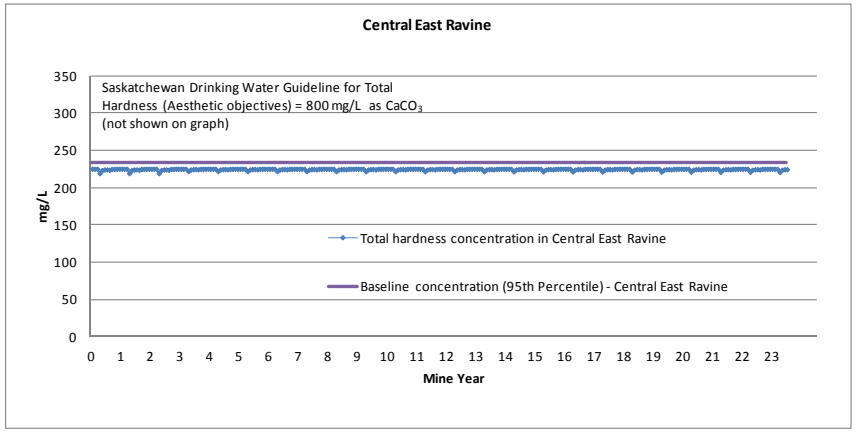

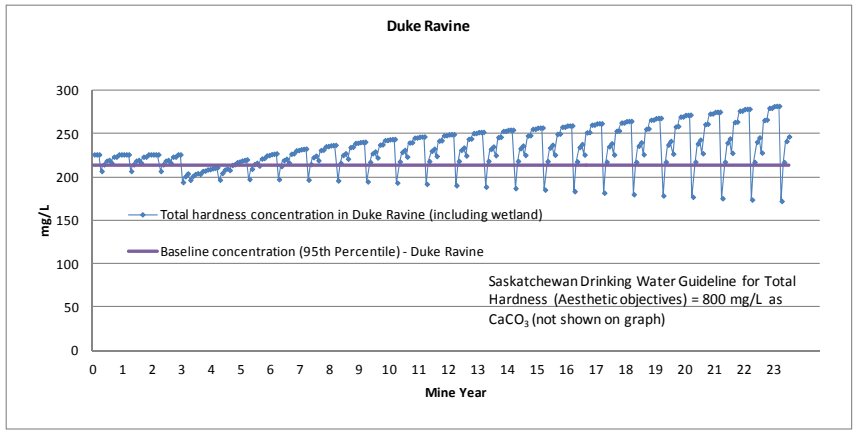

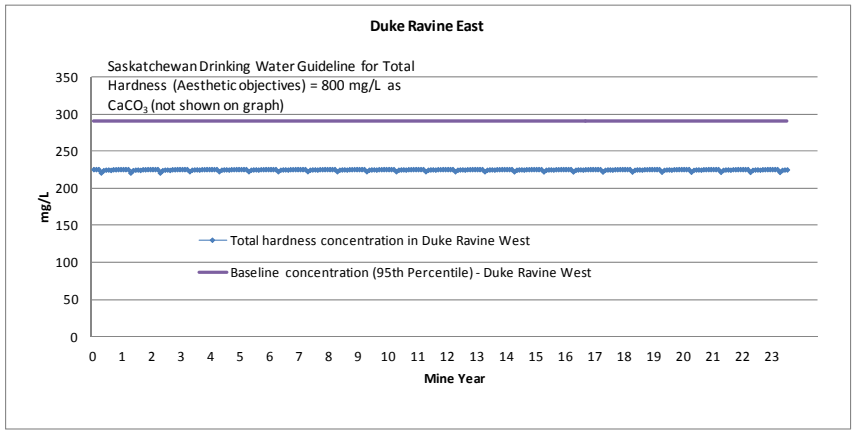

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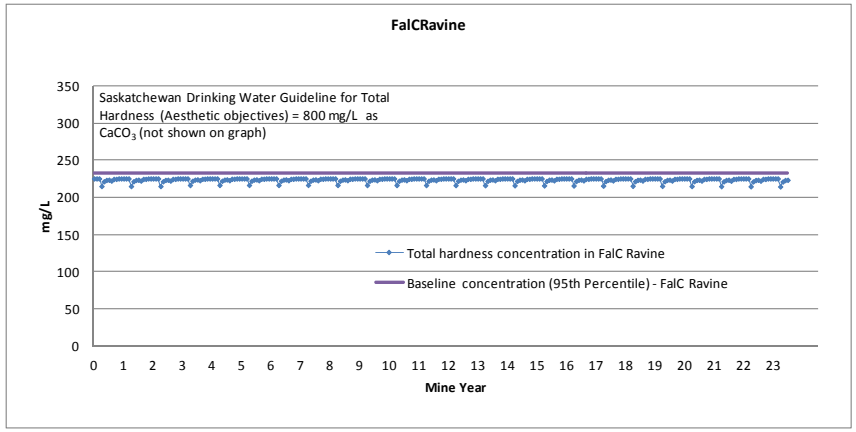
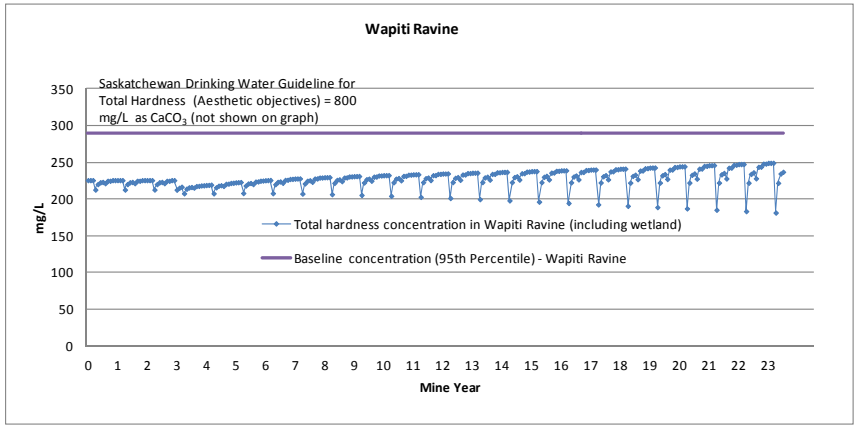
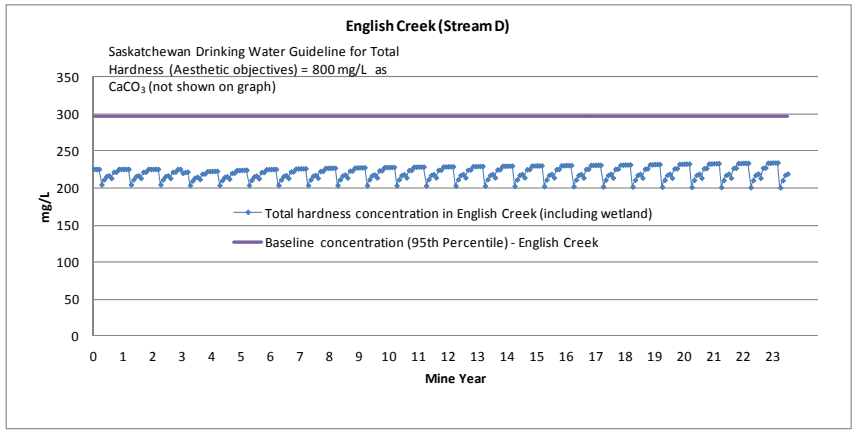






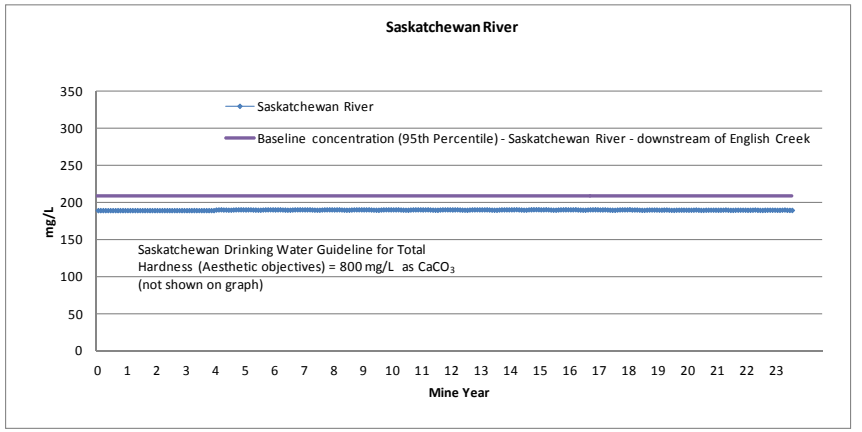
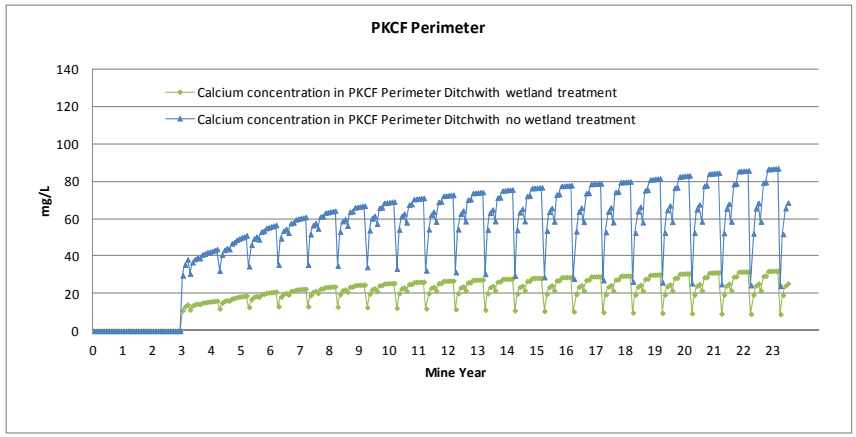
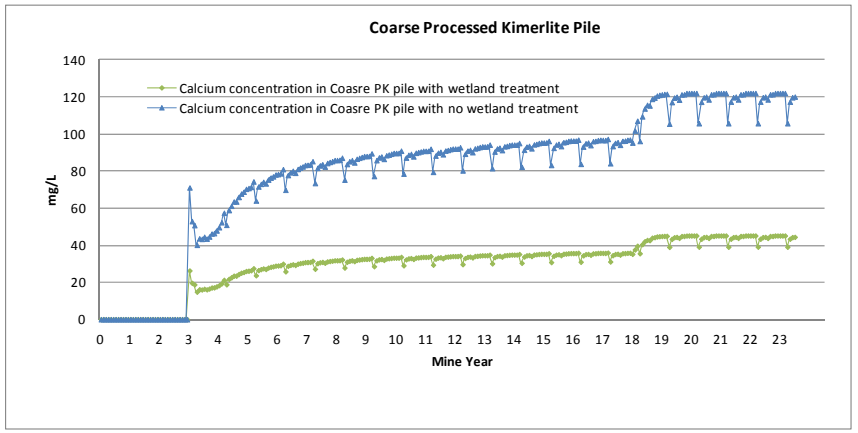


Figure 3-4 Predicted calcium concentrations during construction and operation





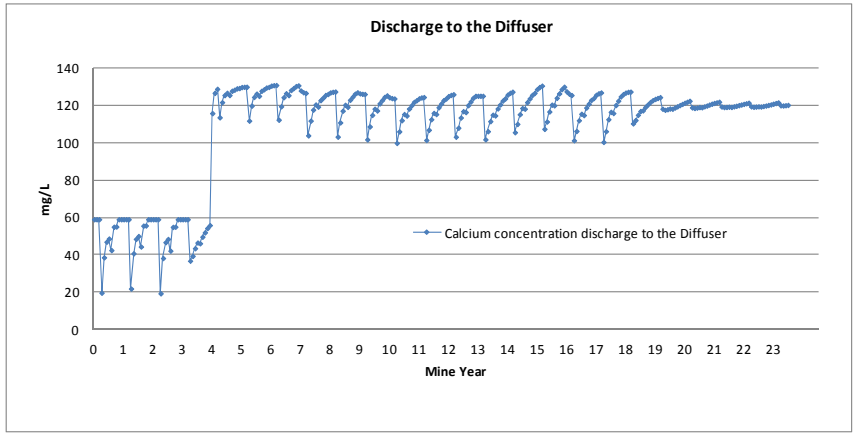
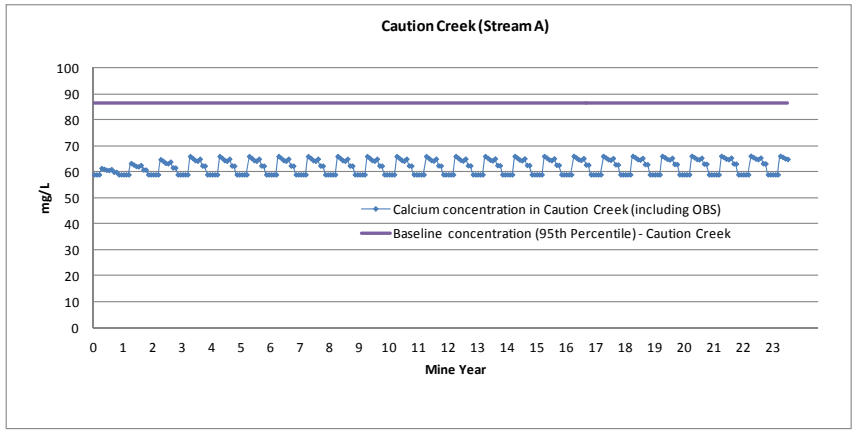
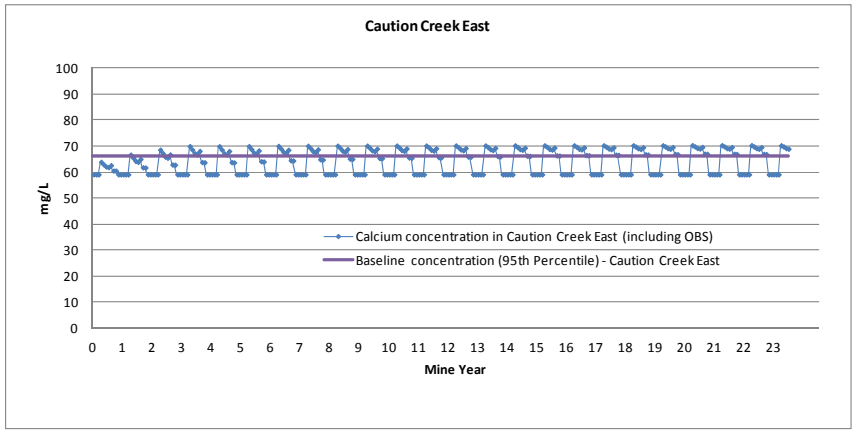
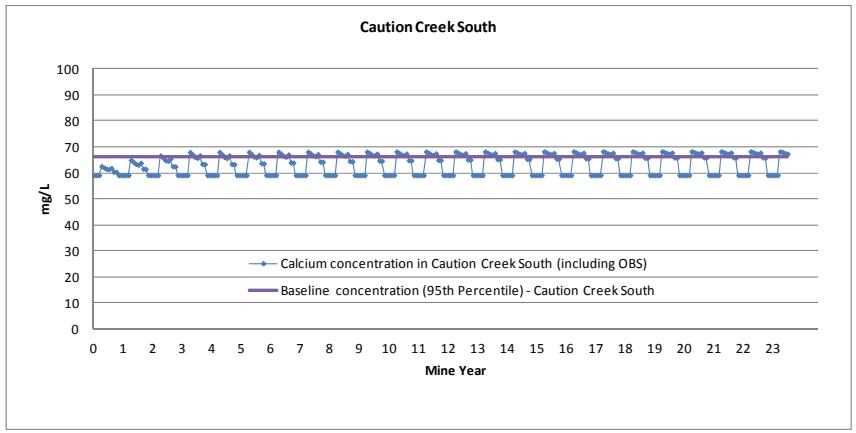


Figure 3-4 Continued







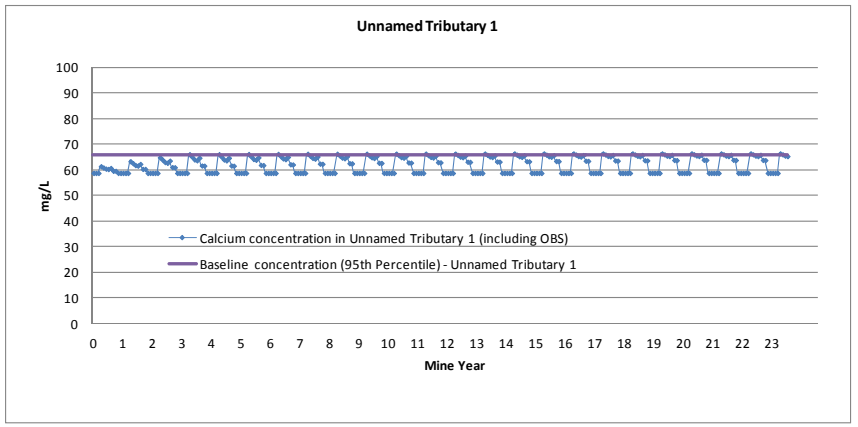
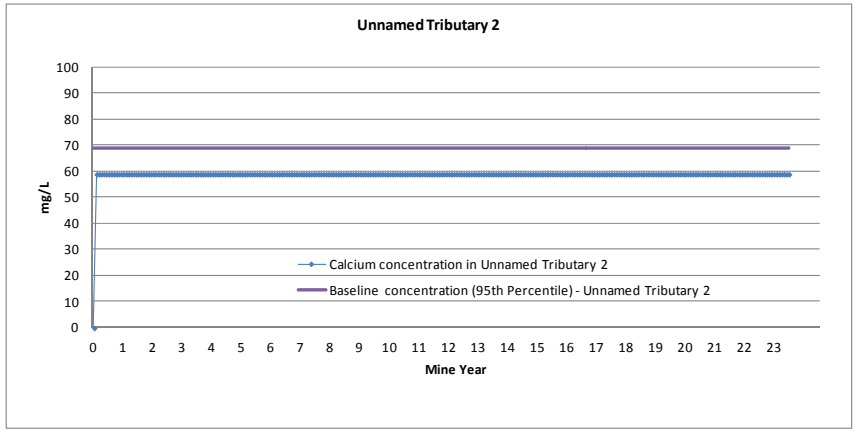
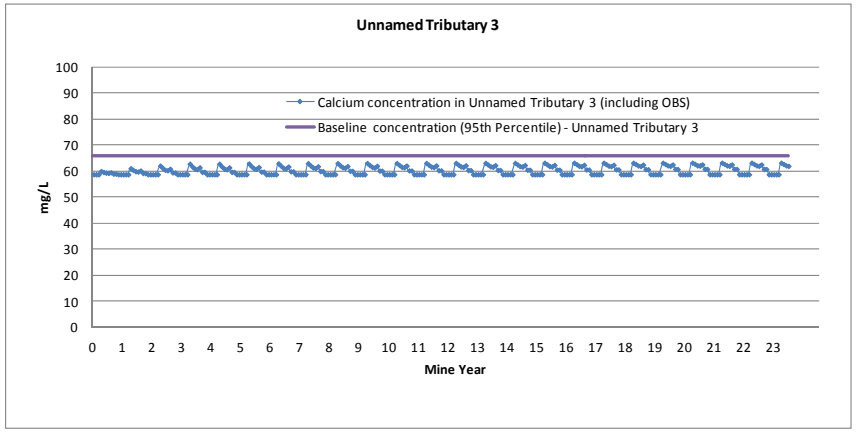
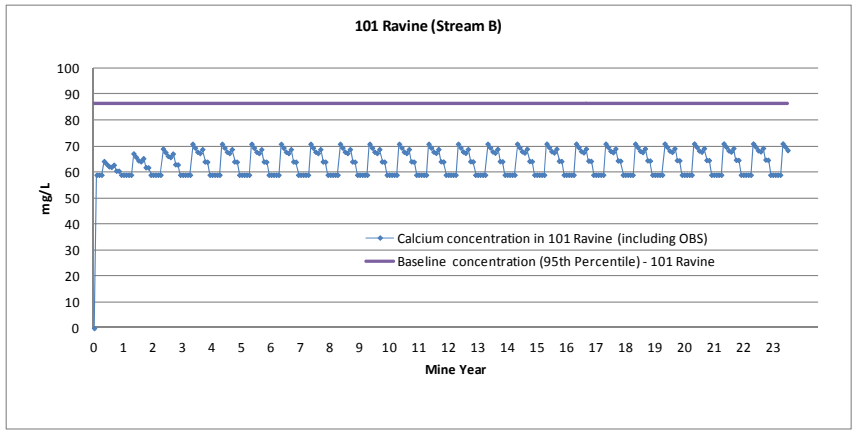


Figure 3-4 Continued







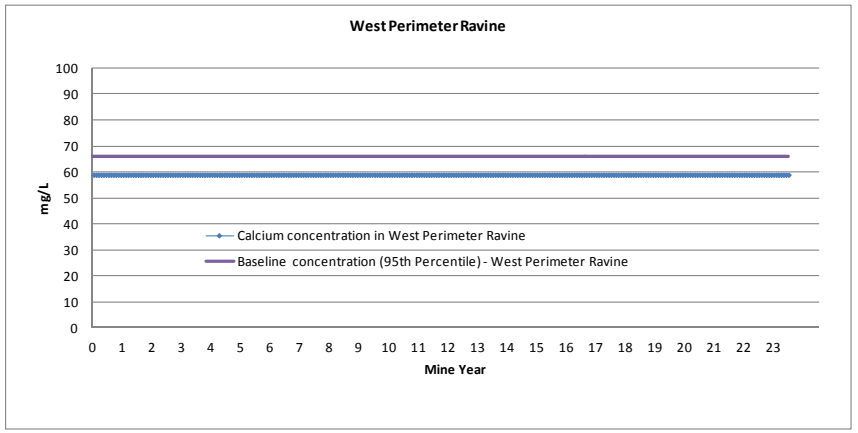
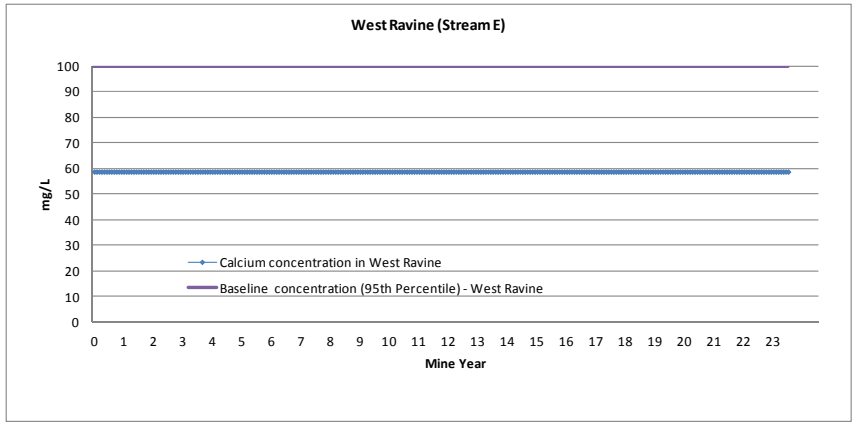
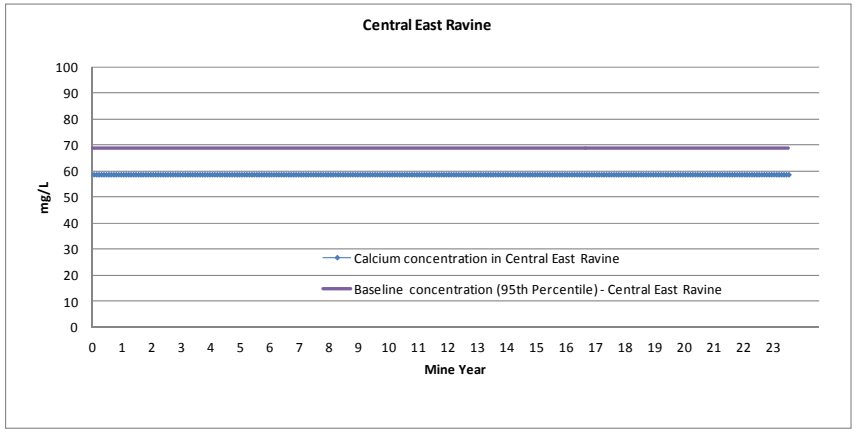
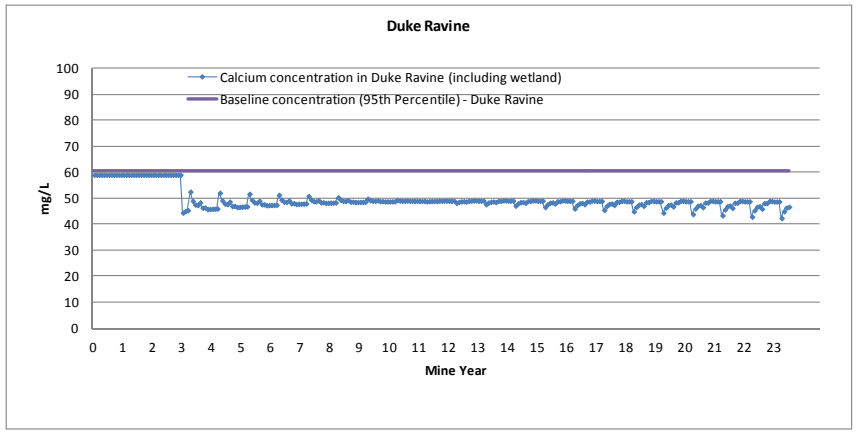


Figure 3-4 Continued







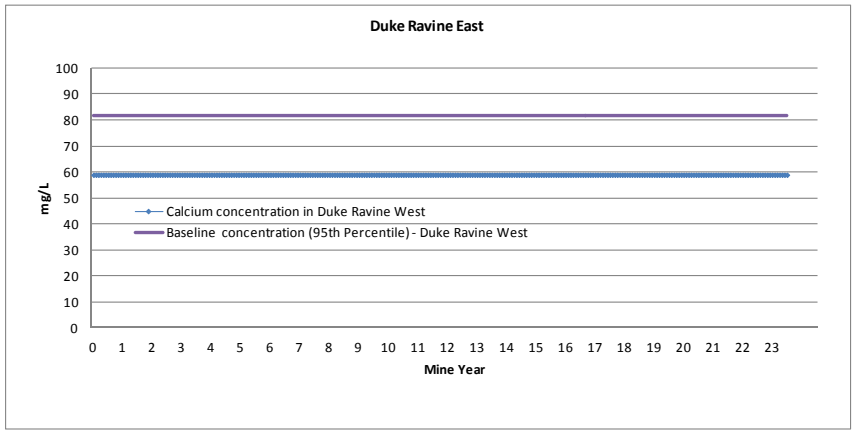
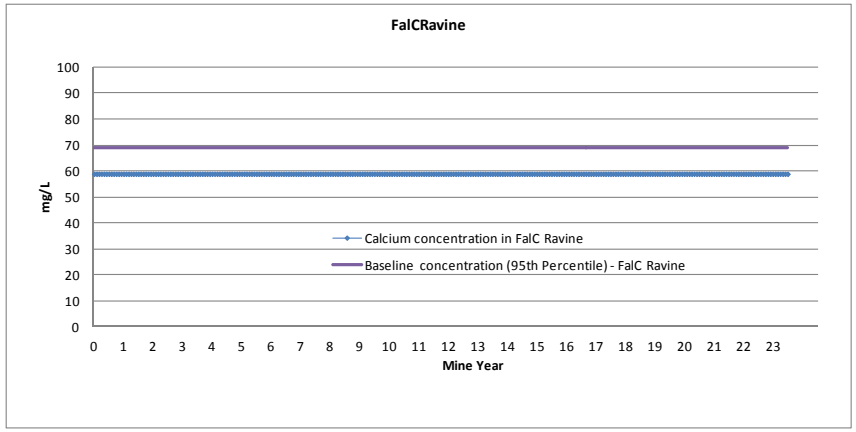
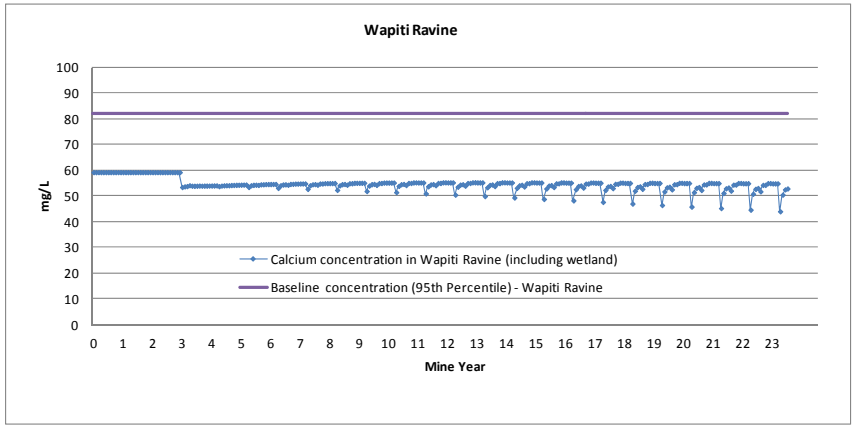
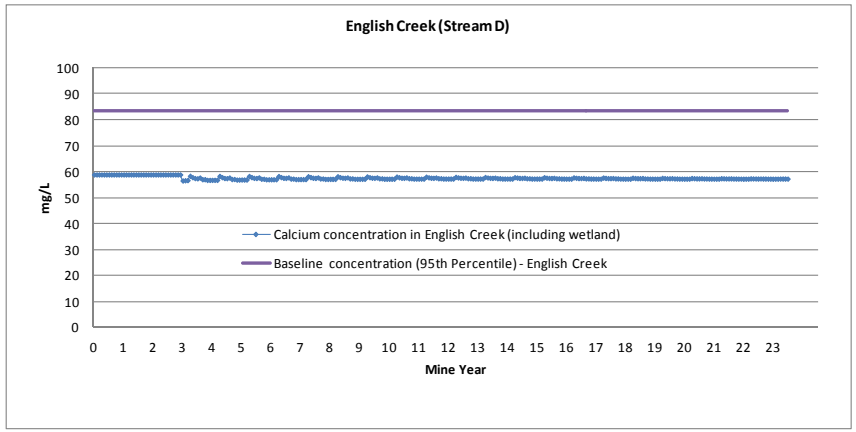


Figure 3-4 Continued







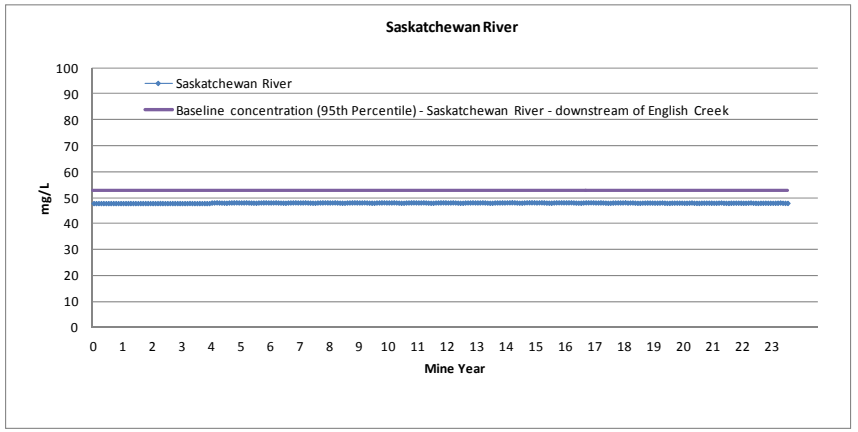
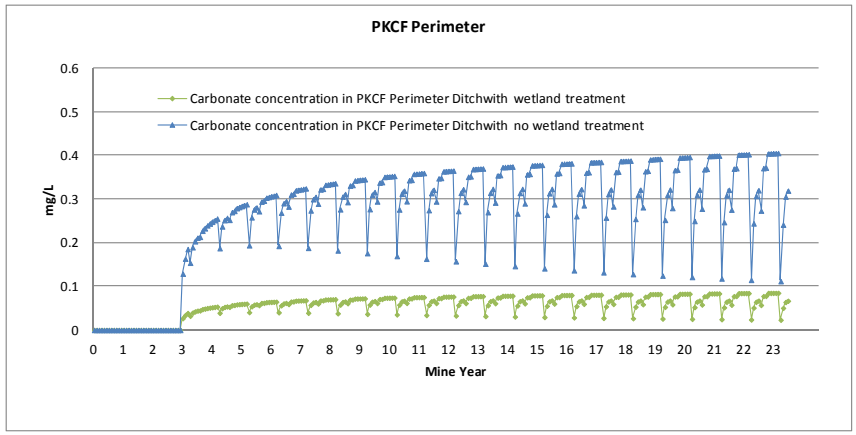
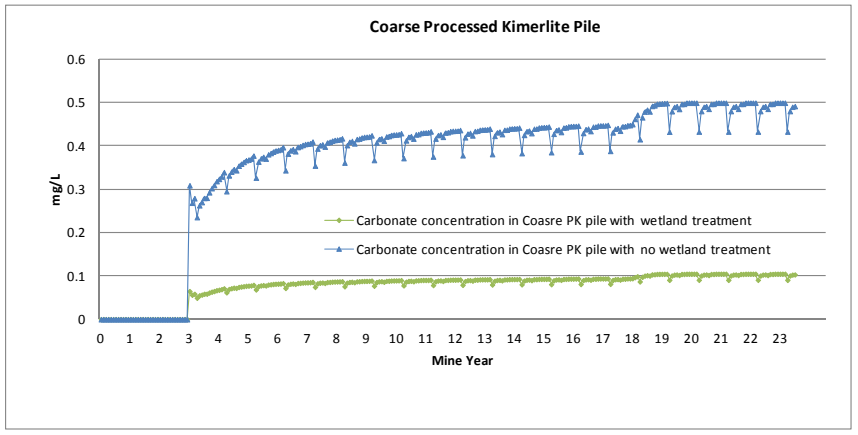


Figure 3-5 Predicted carbonate concentrations during construction and operation





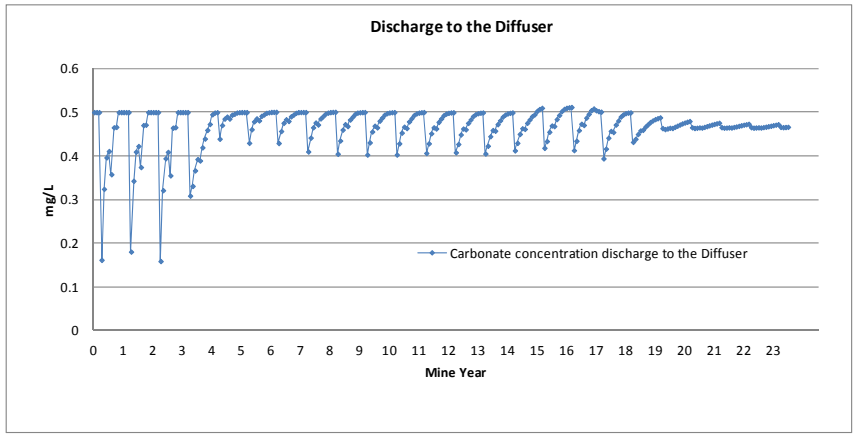
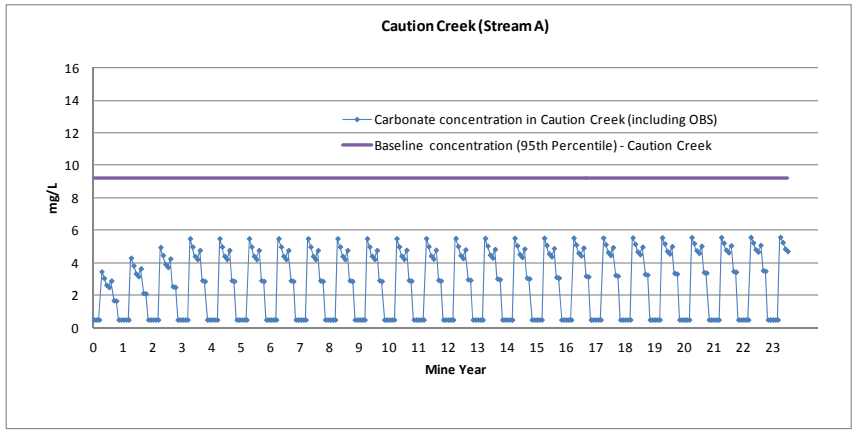
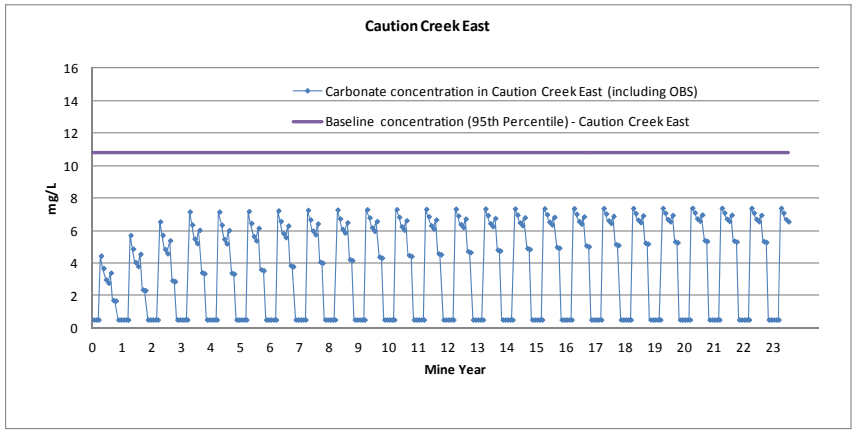
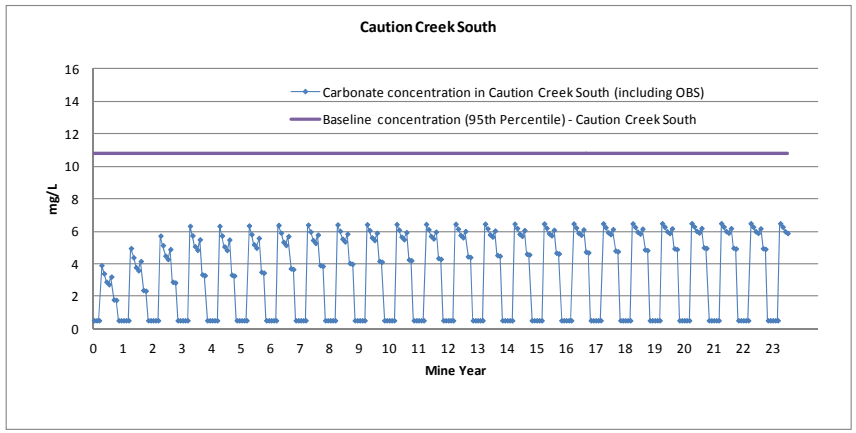
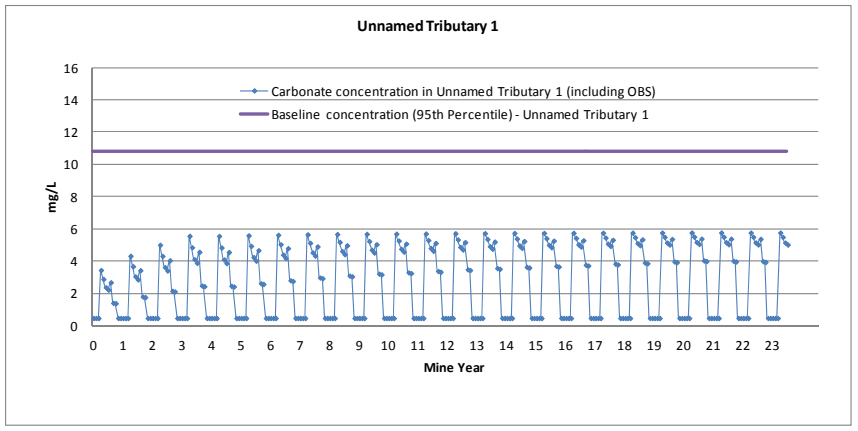


Figure 3-5 Continued









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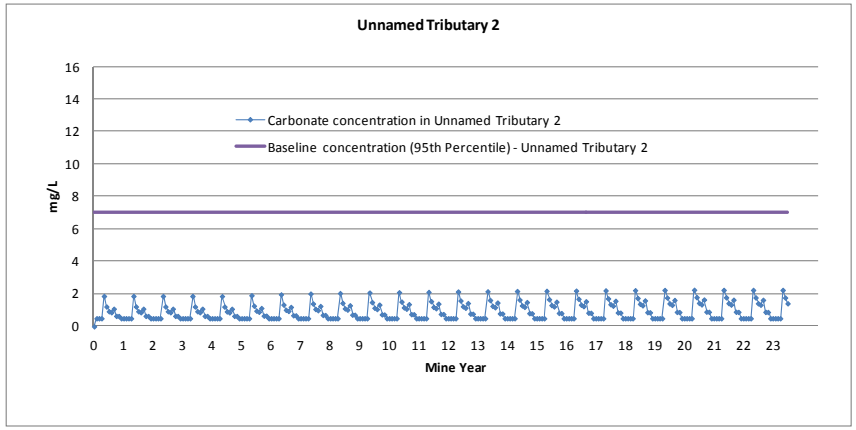
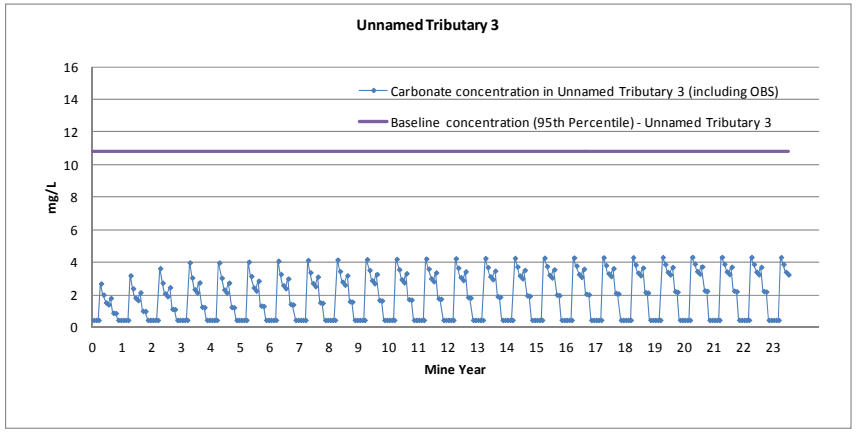
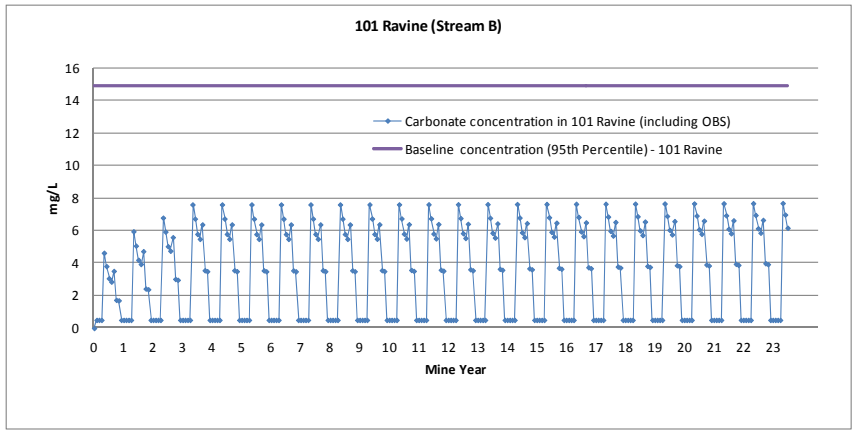






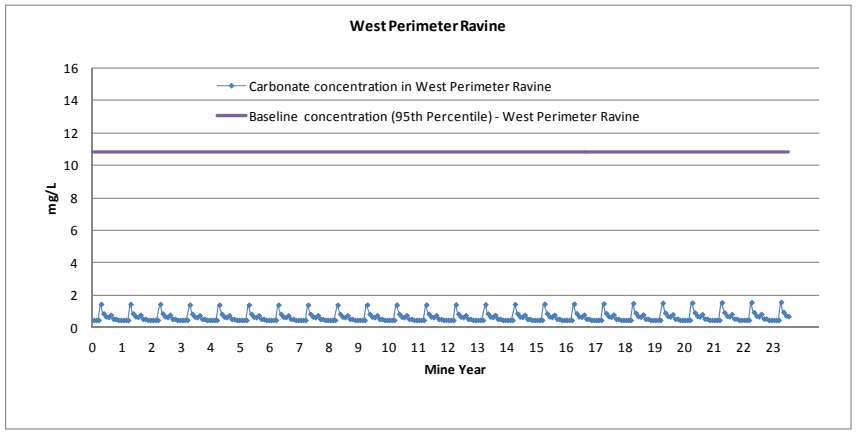
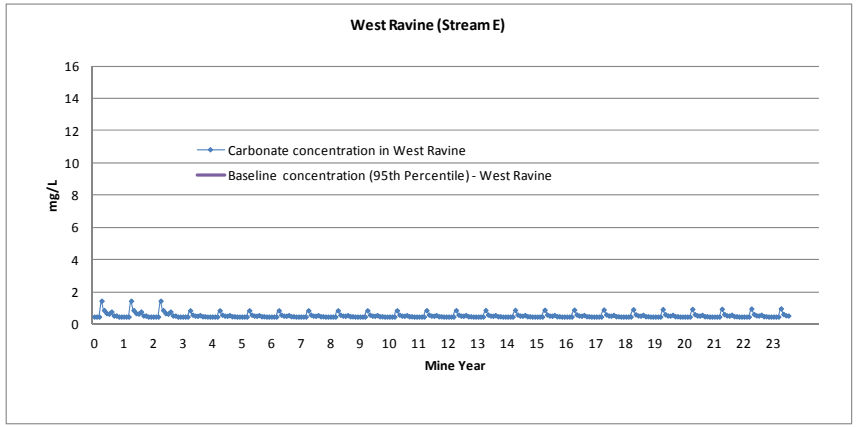
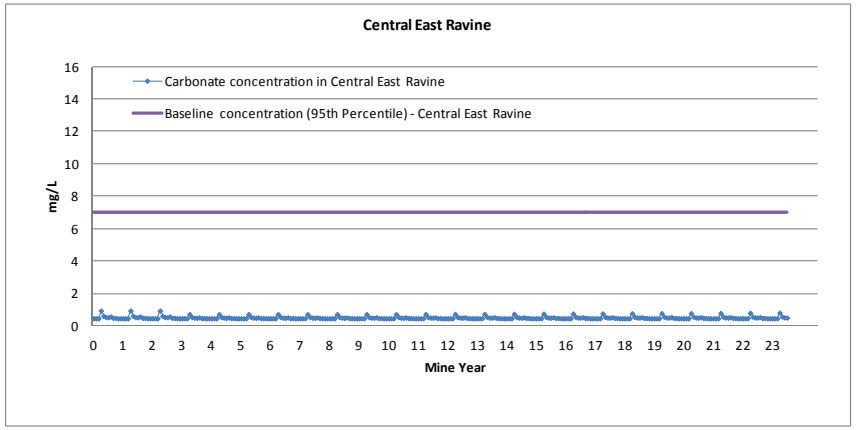
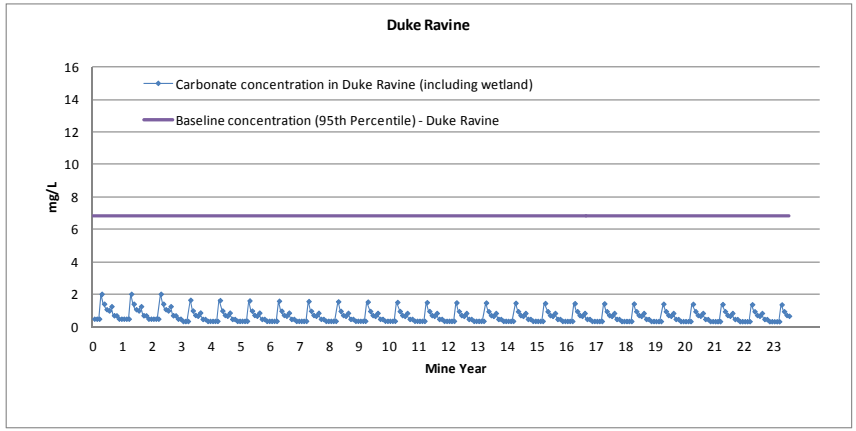


Figure 3-5 Continued







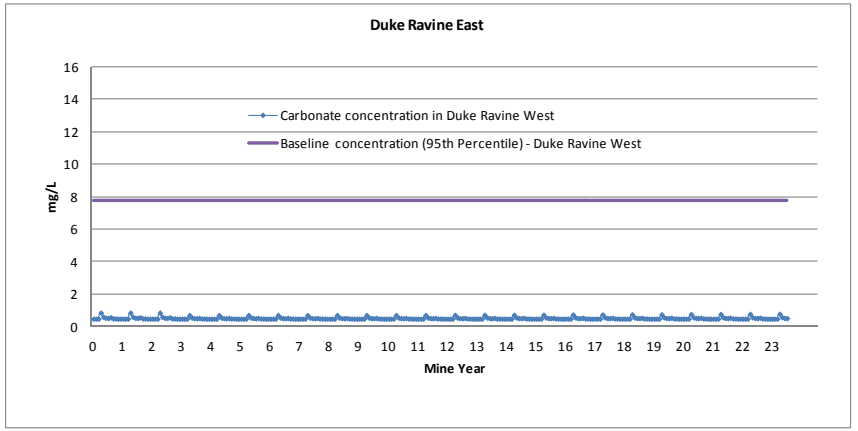
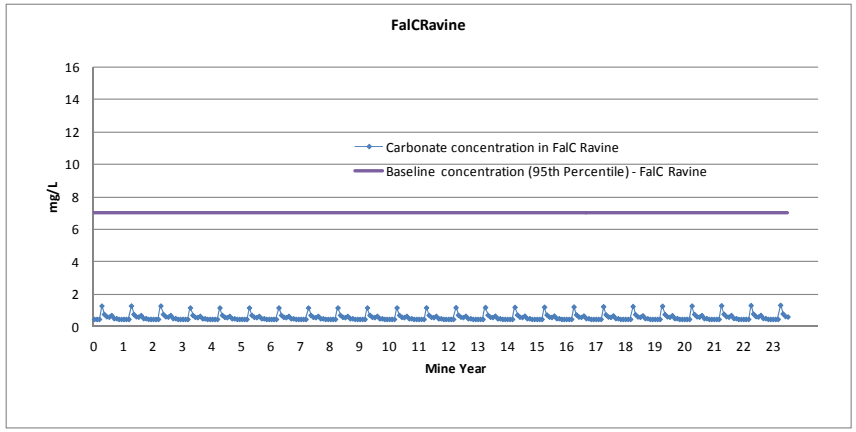
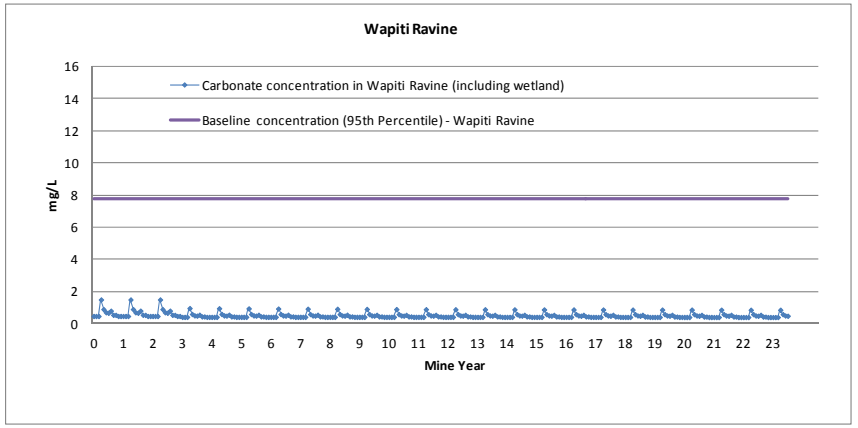
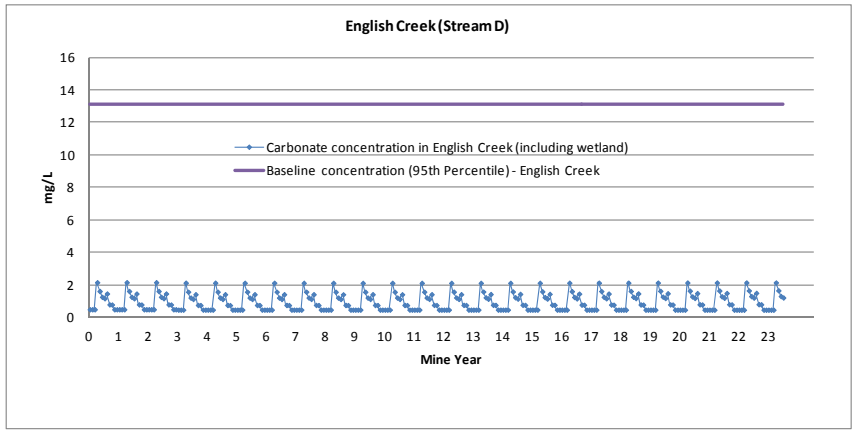


Figure 3-5 Continued







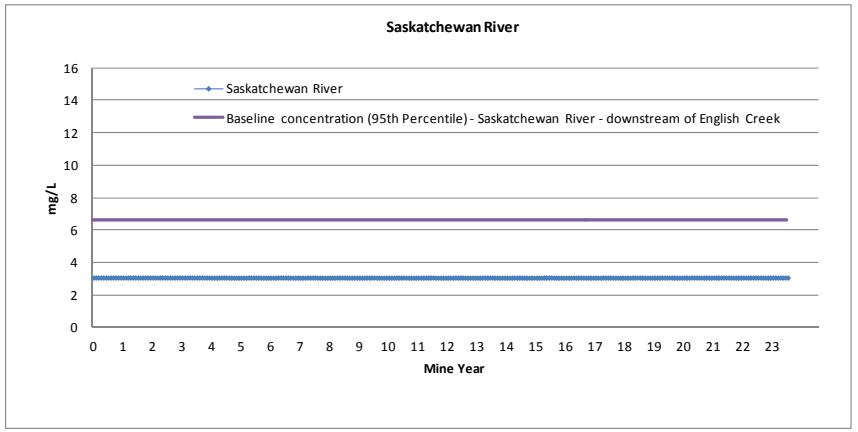
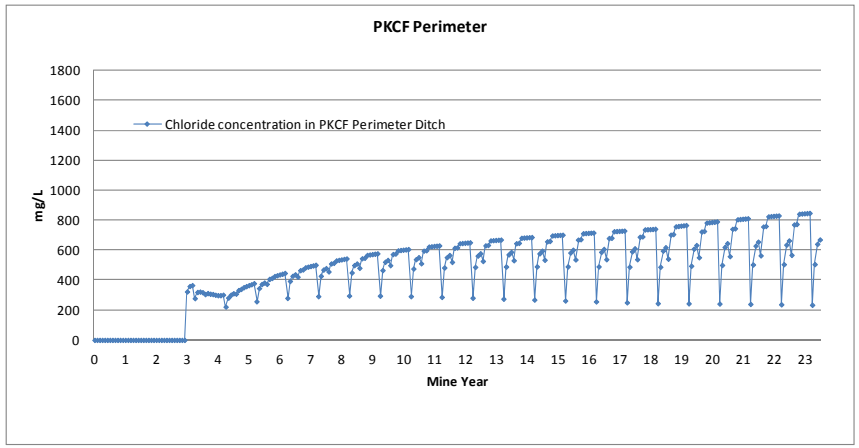
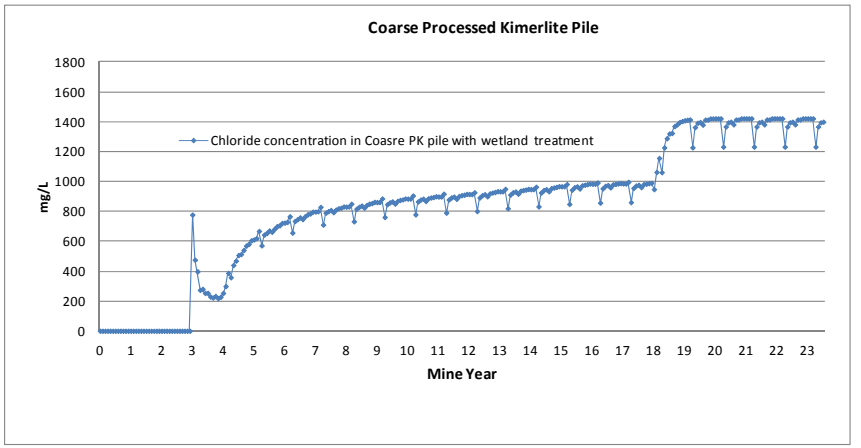


Figure 3-6 Predicted chloride concentrations during construction and operation





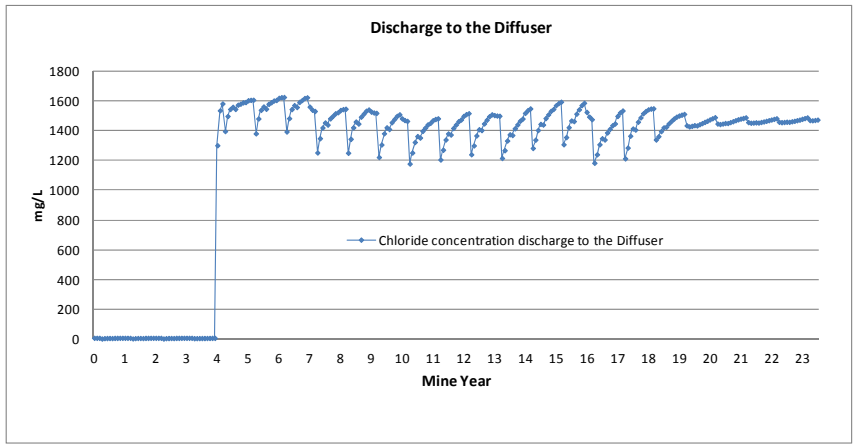
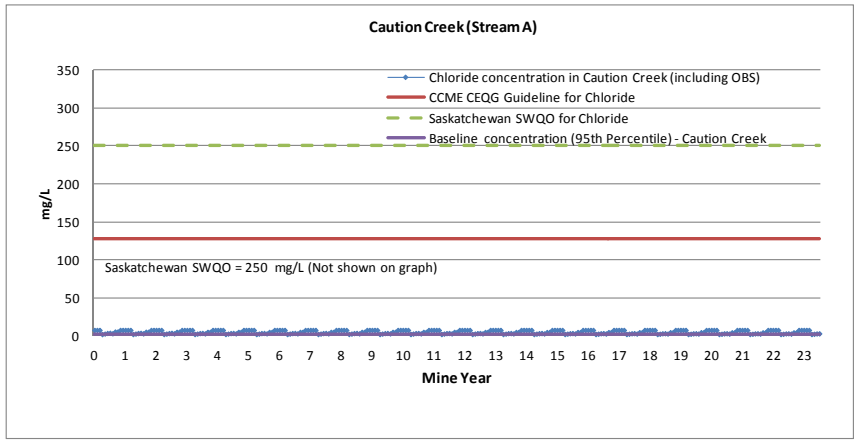
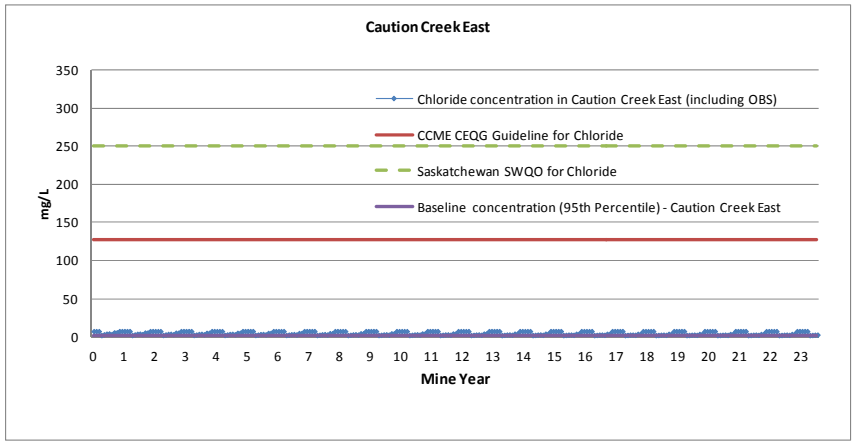
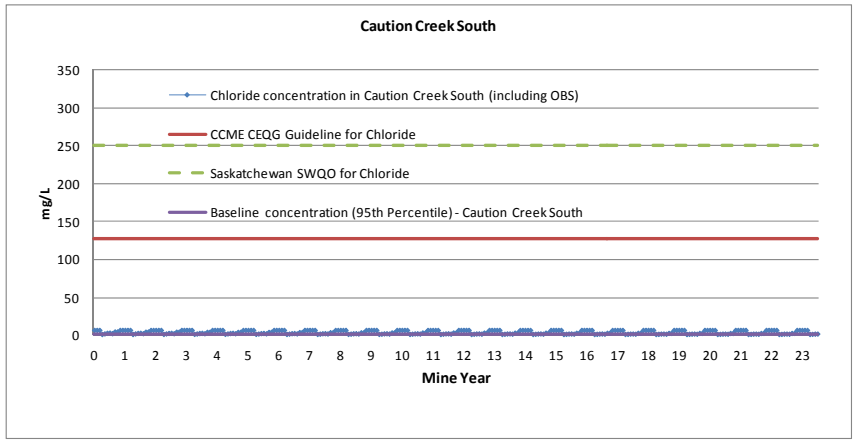


Figure 3-6 Continued







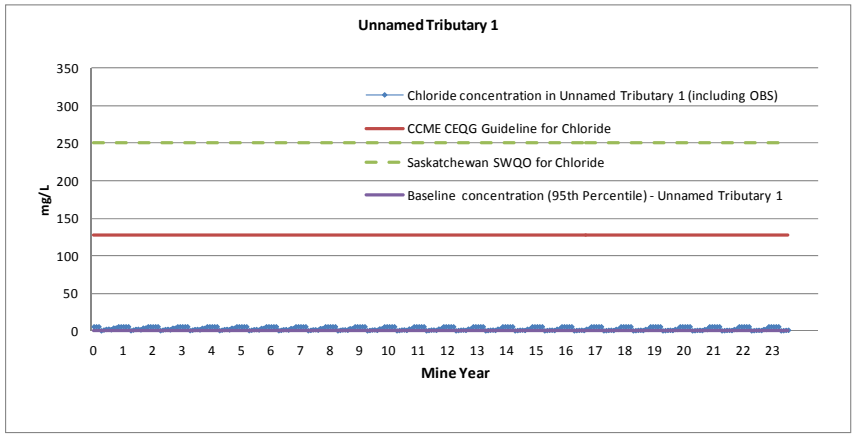
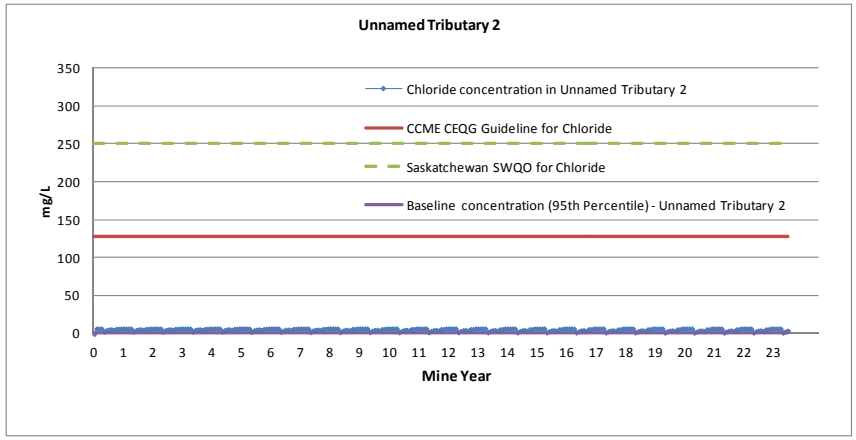
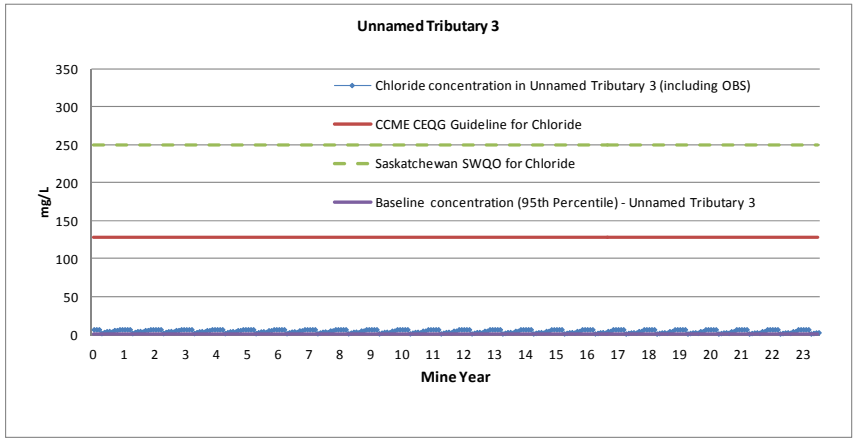
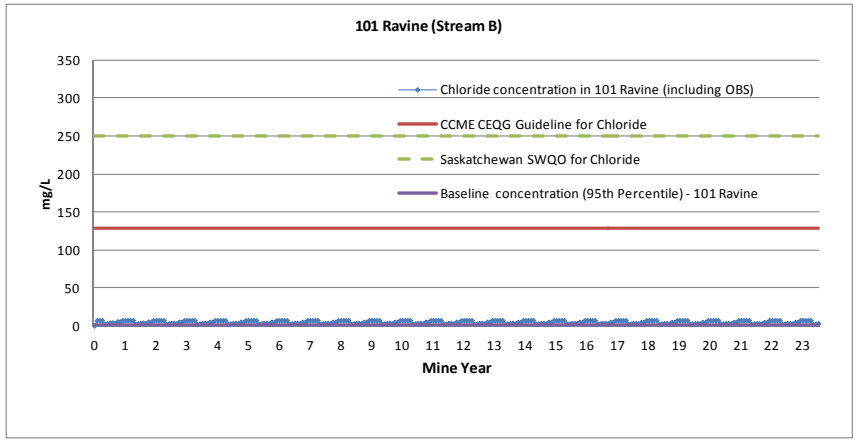
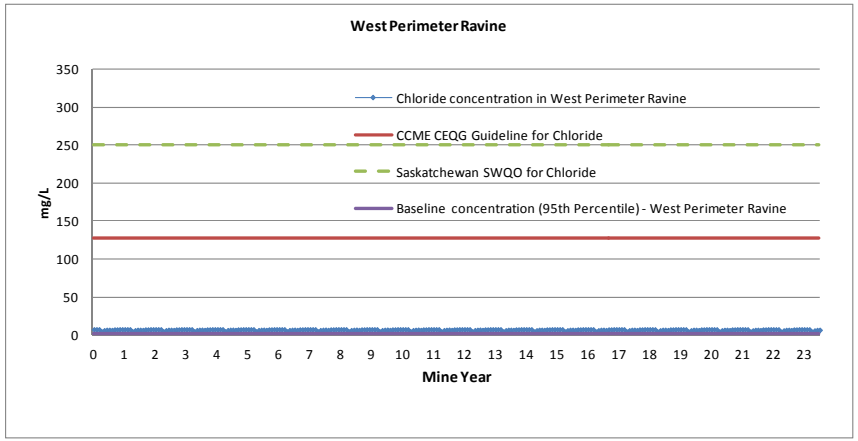


Figure 3-6 Continued









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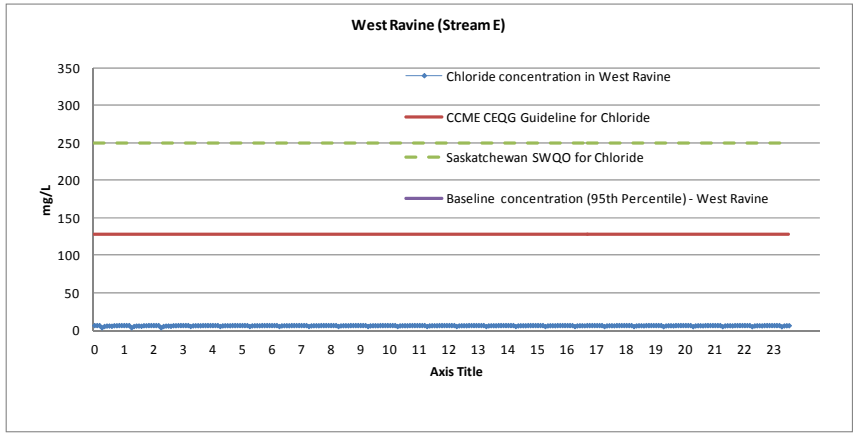

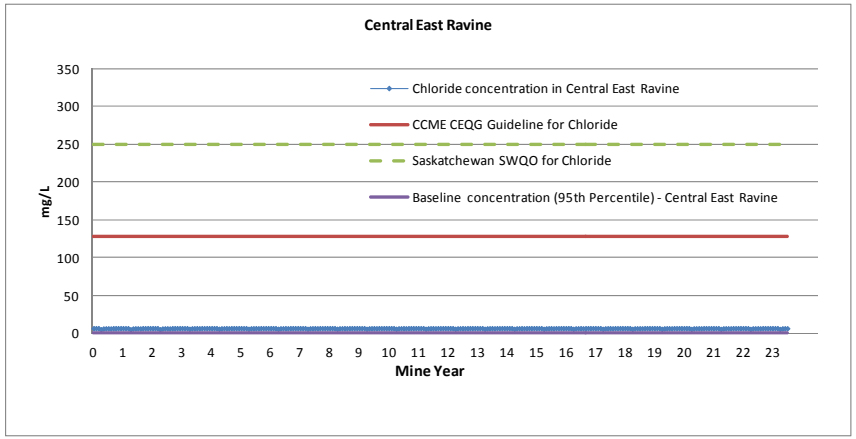

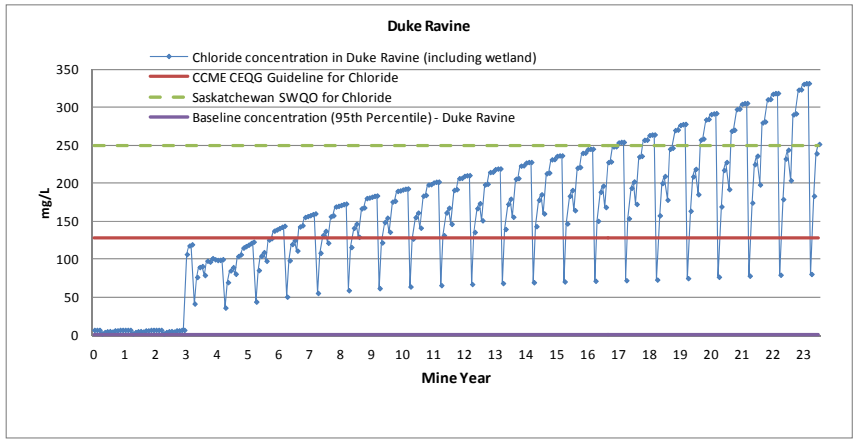

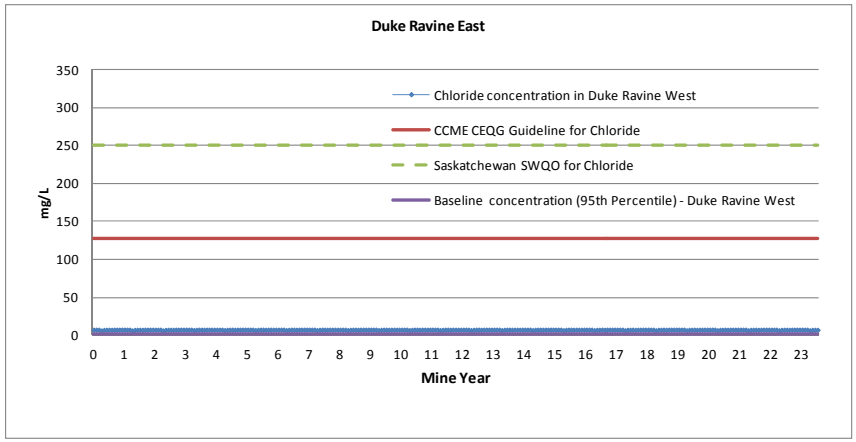

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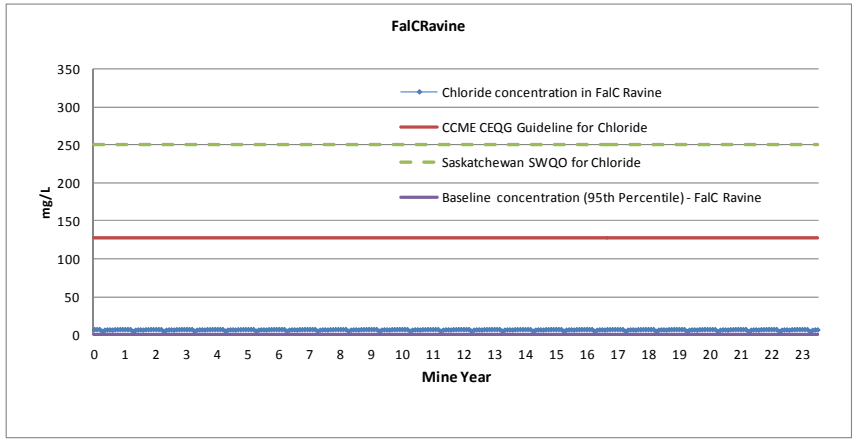
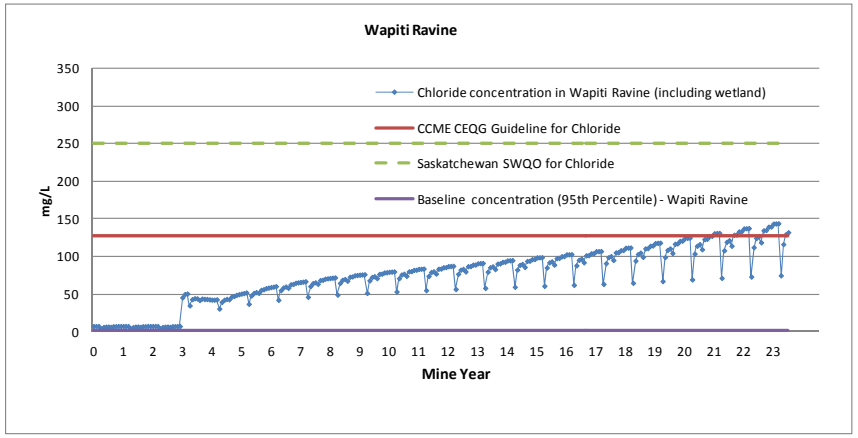
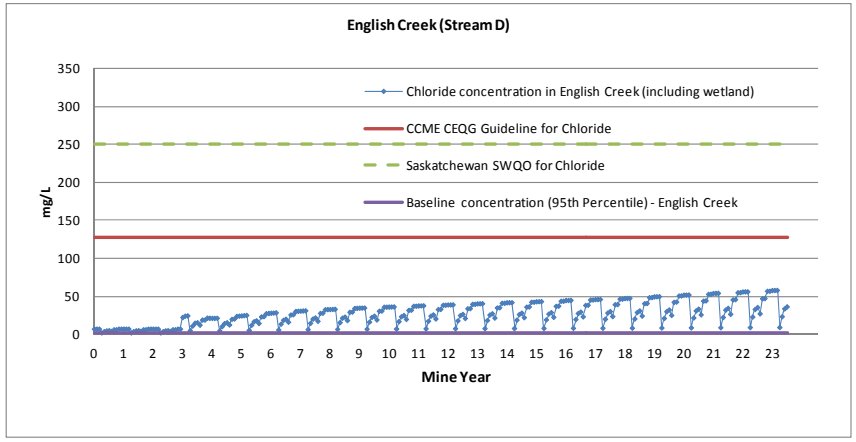






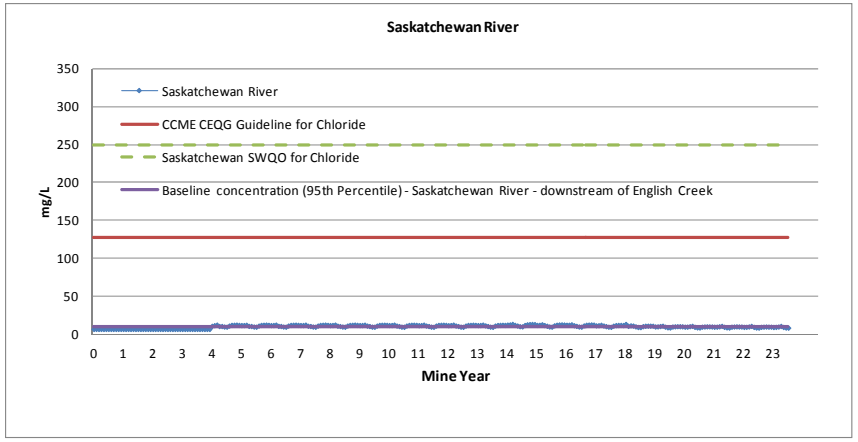
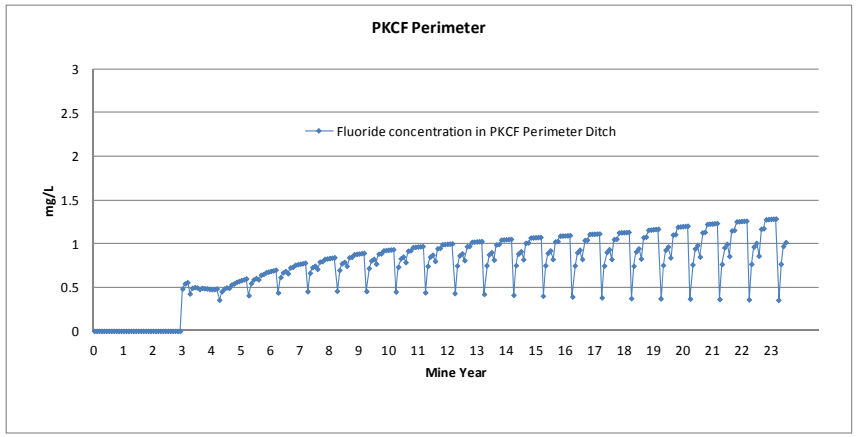
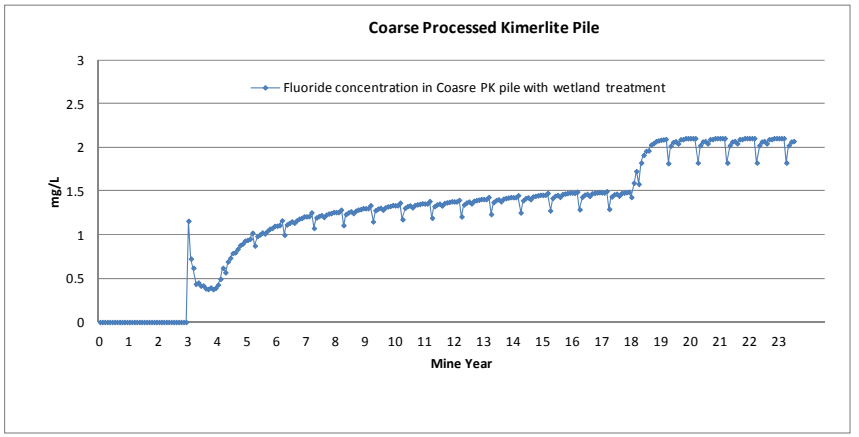


Figure 3-7 Predicted fluoride concentrations during construction and operation





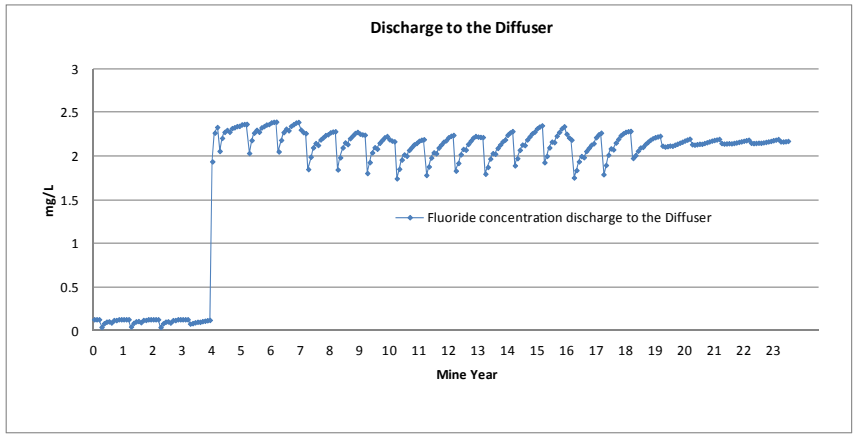
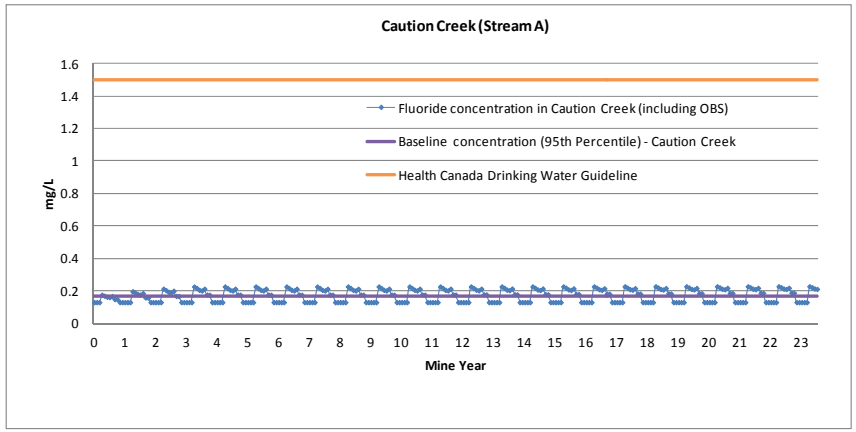
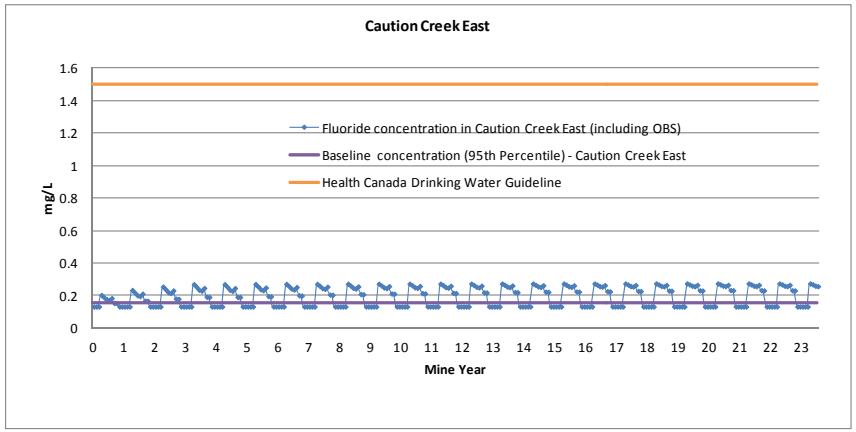
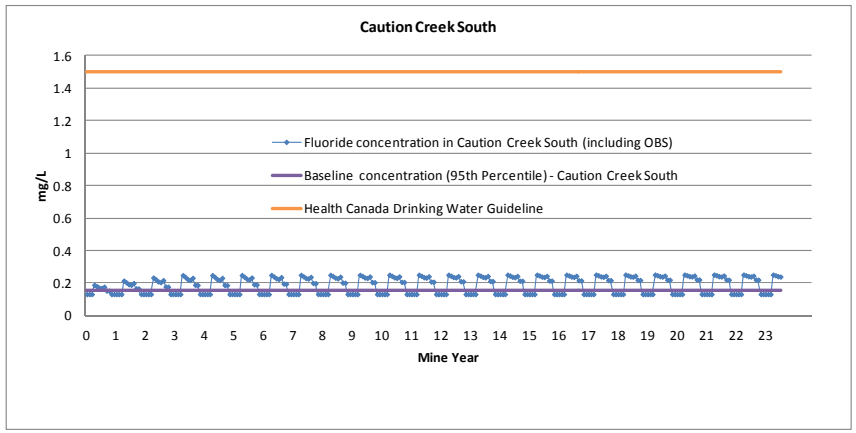


Figure 3-7 Continued







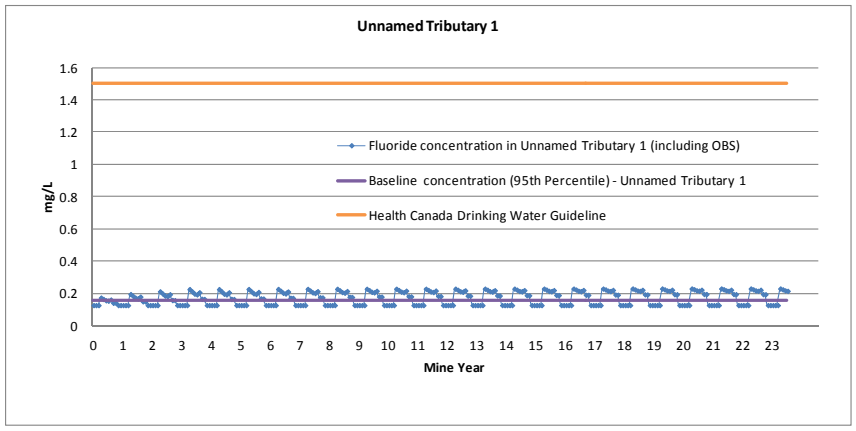
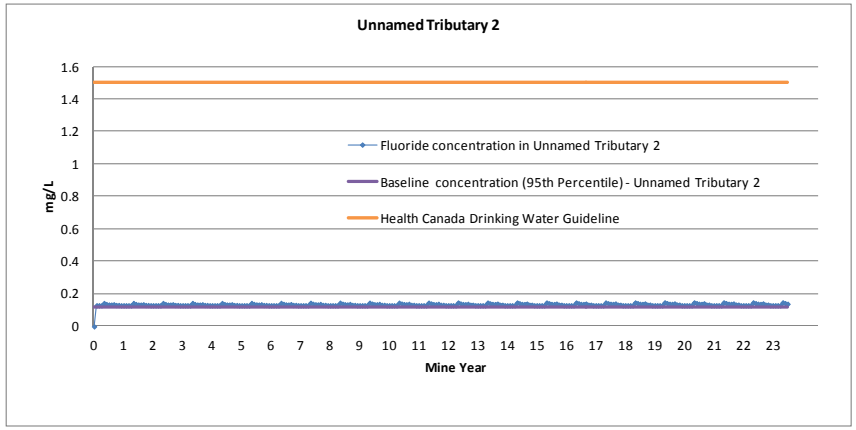
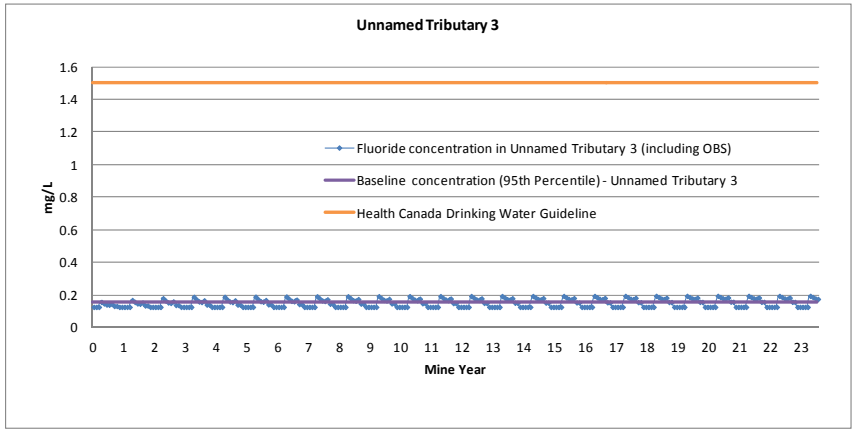
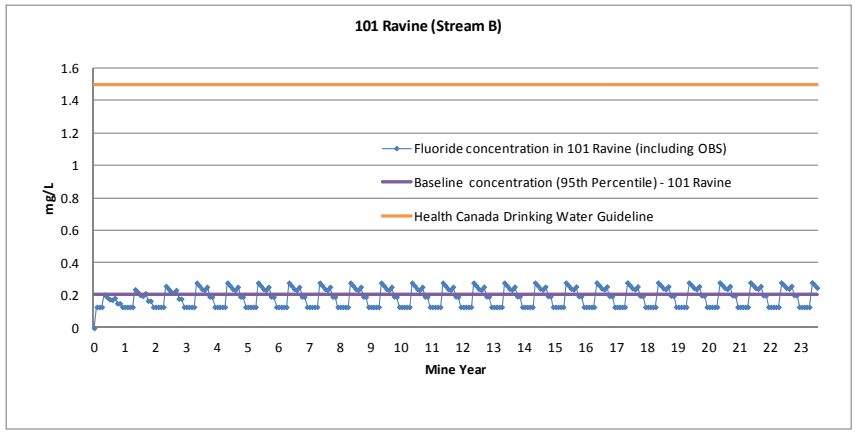


Figure 3-7 Continued







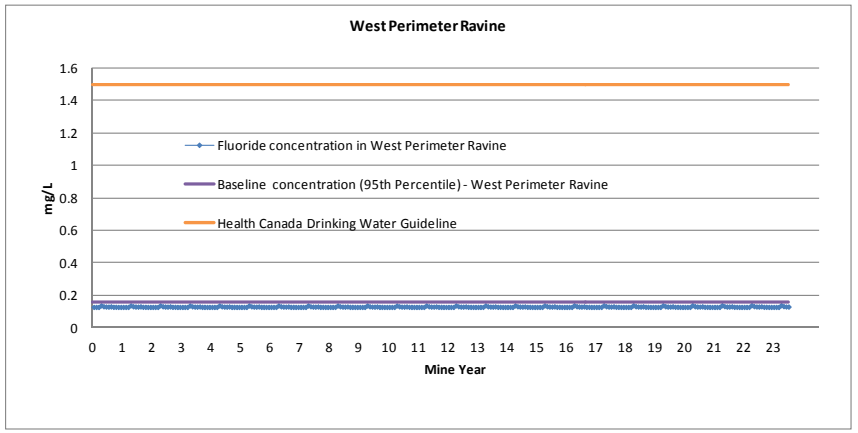
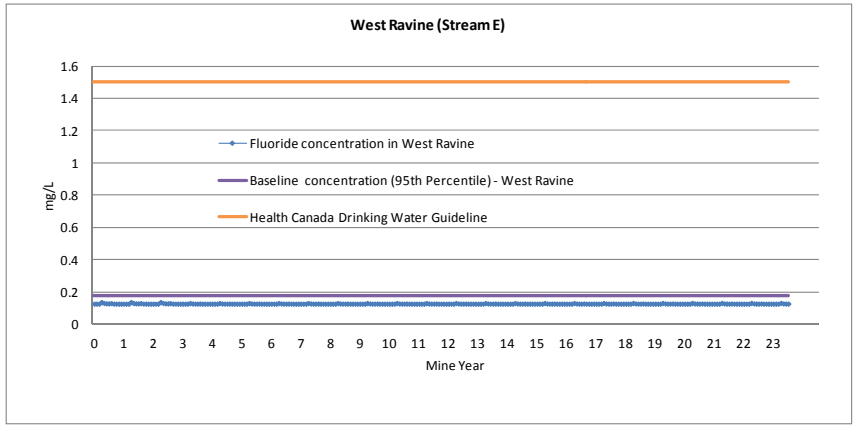
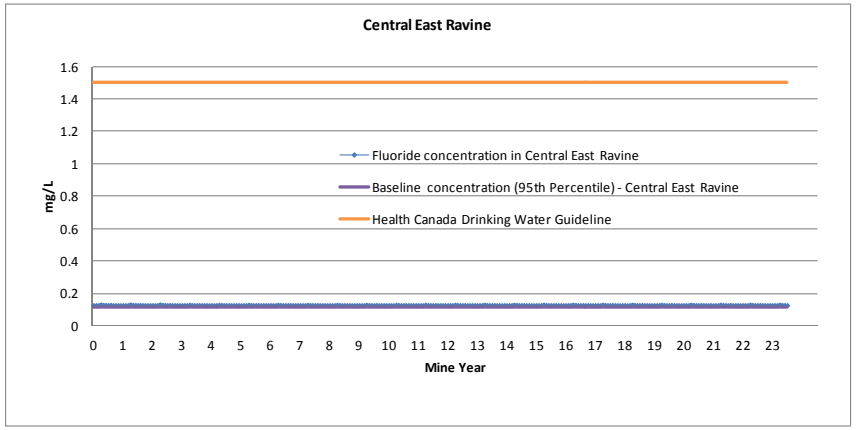
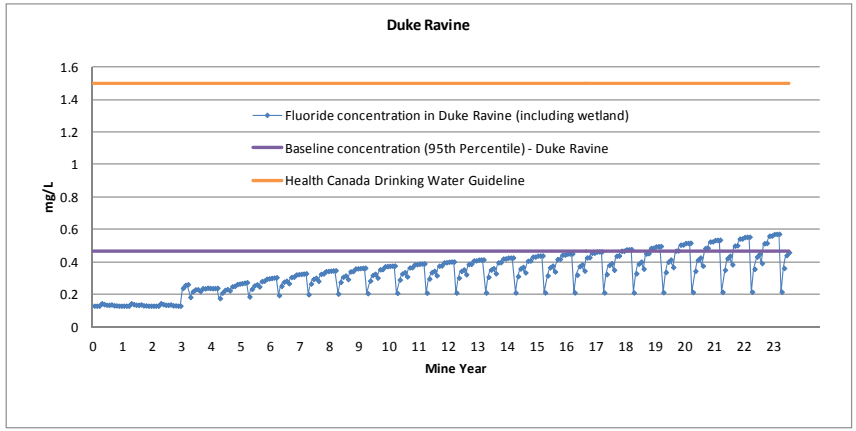


Figure 3-7 Continued







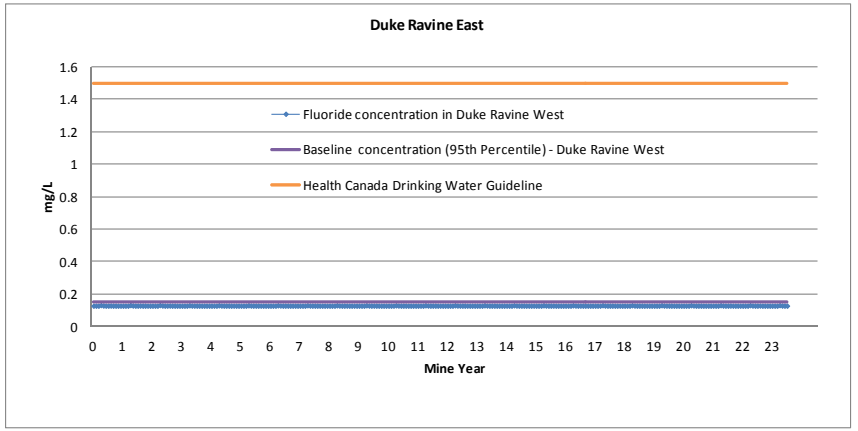
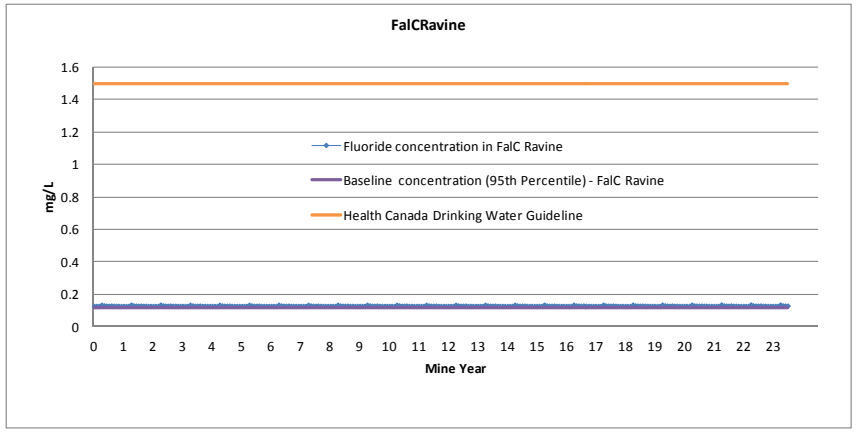
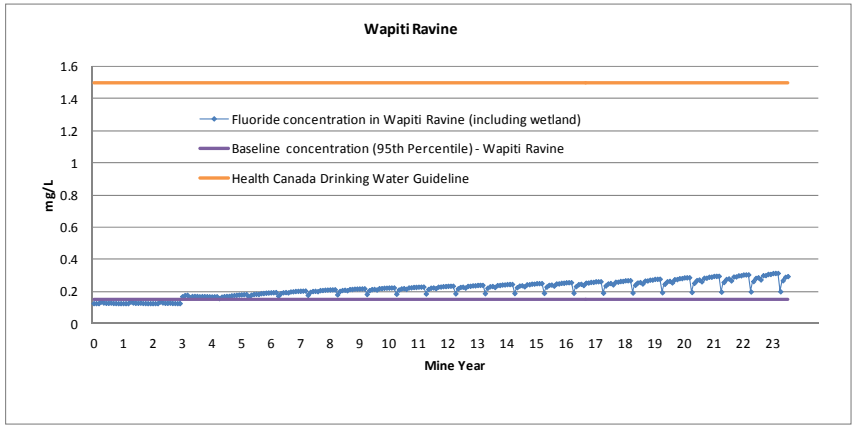
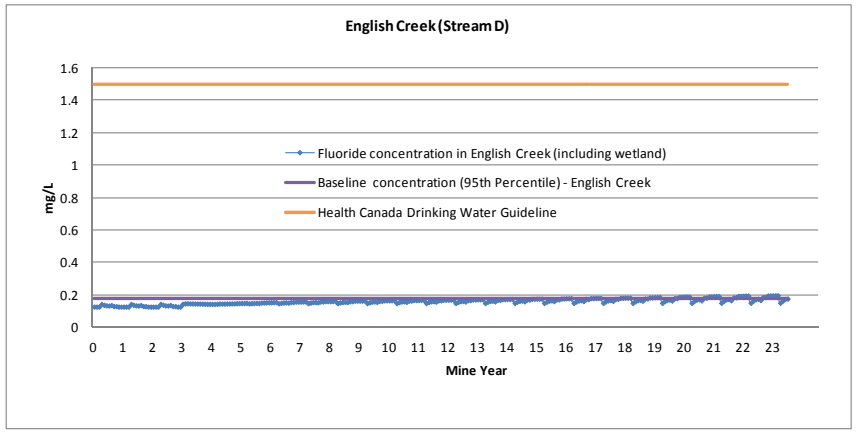


Figure 3-7 Continued







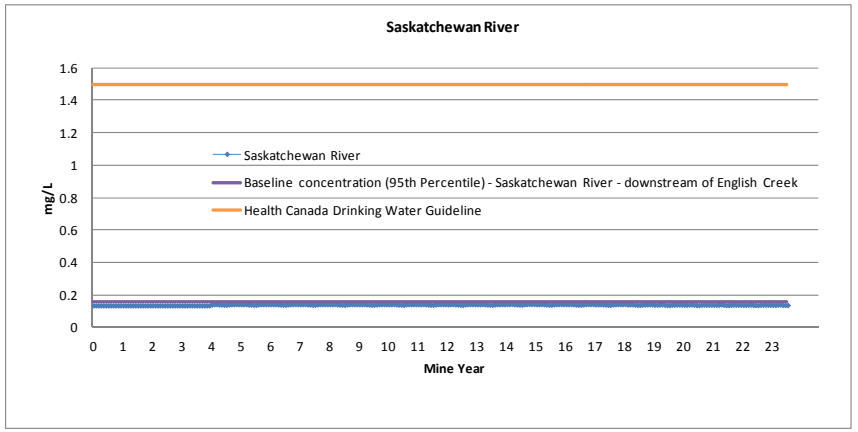
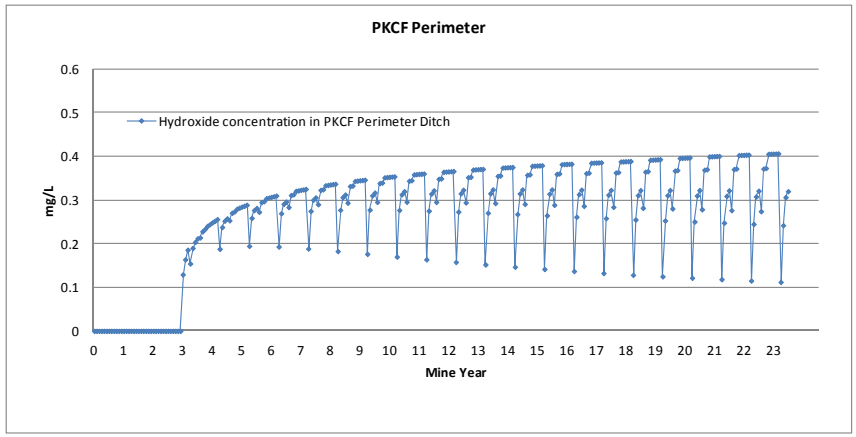
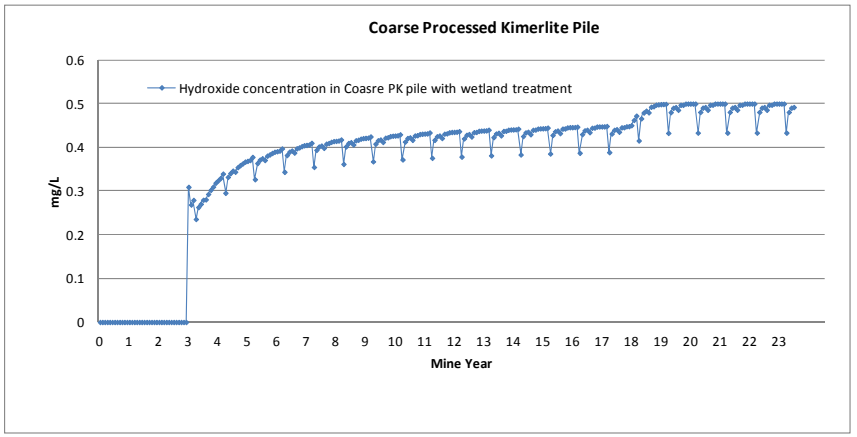


Figure 3-8 Predicted hydroxide concentrations during construction and operation





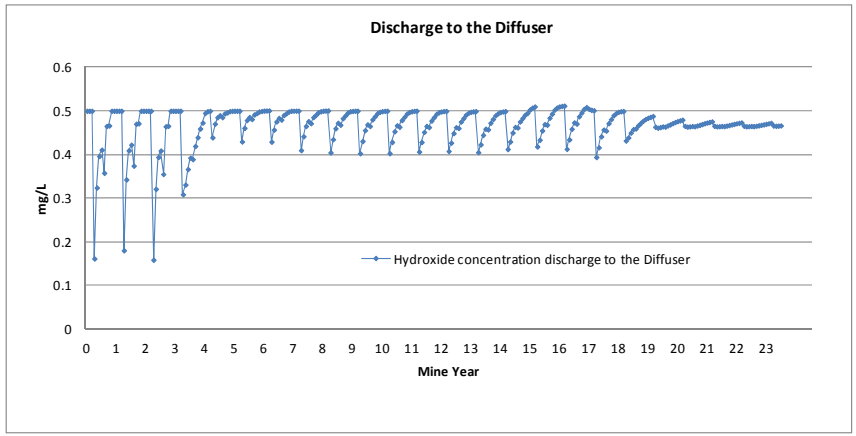
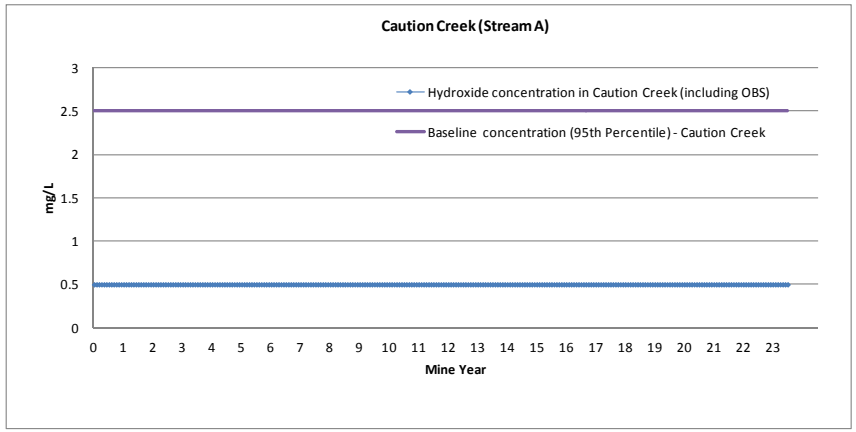
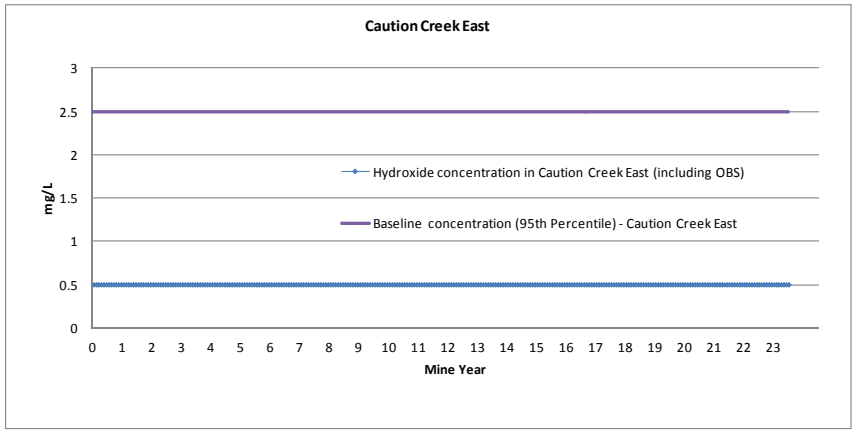
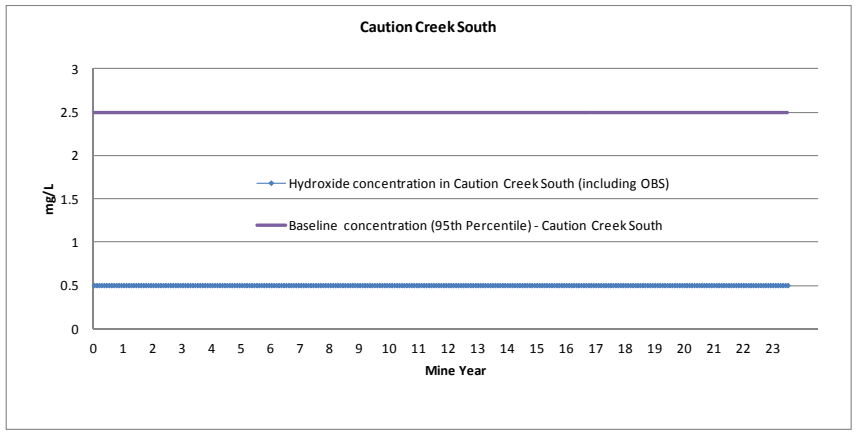


Figure 3-8 Continued







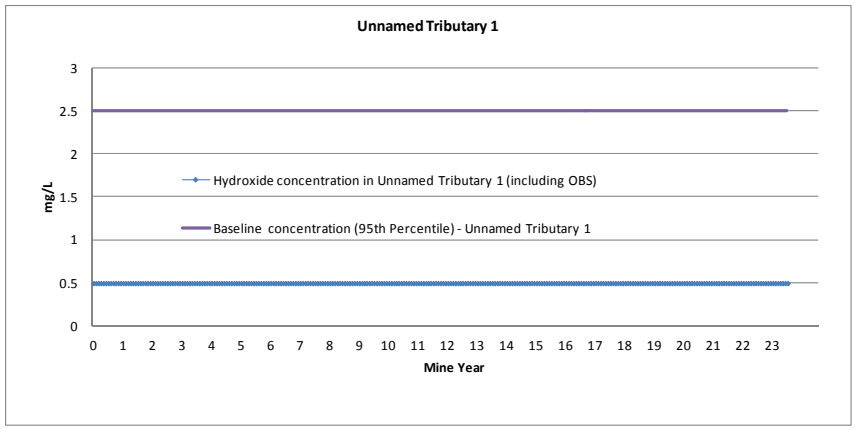
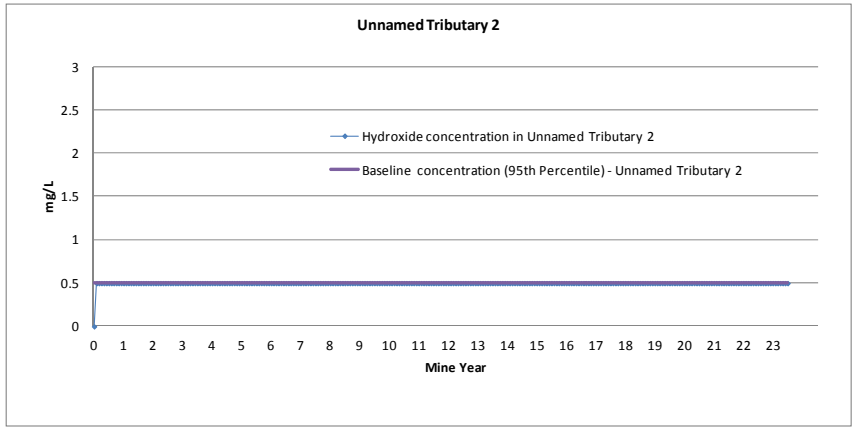
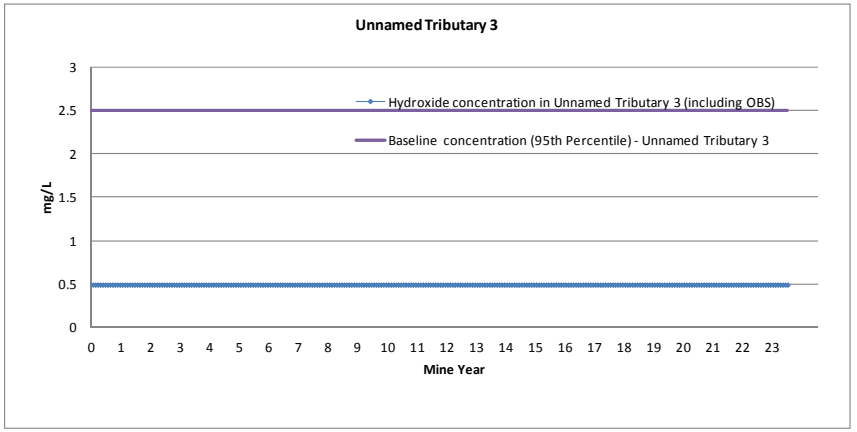
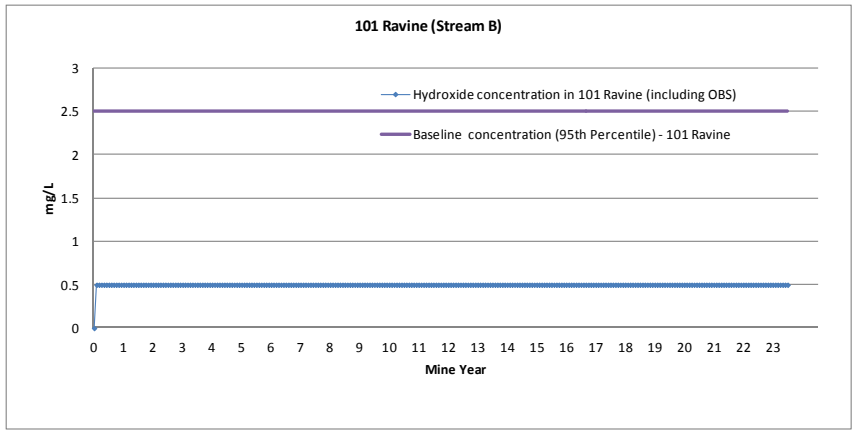
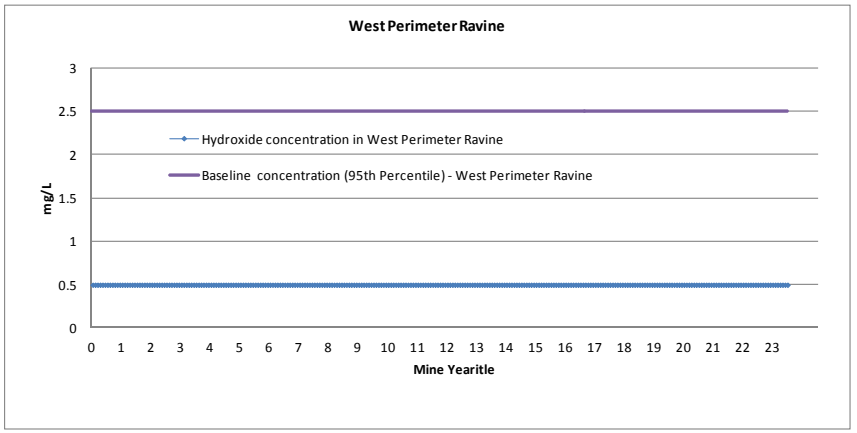


Figure 3-8 Continued









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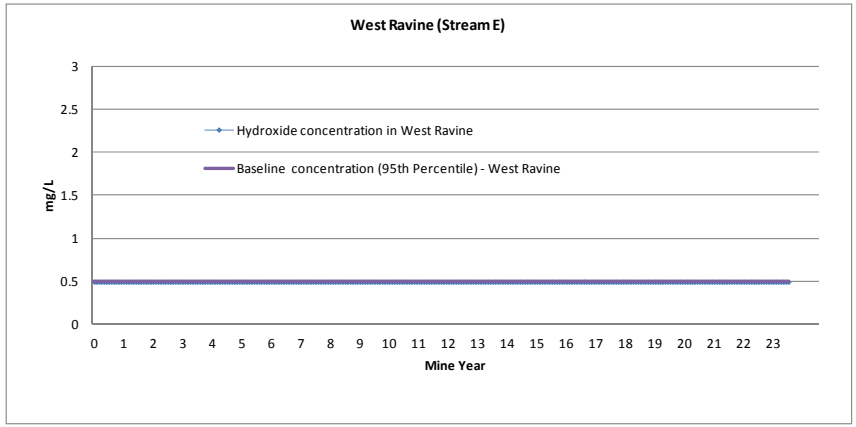
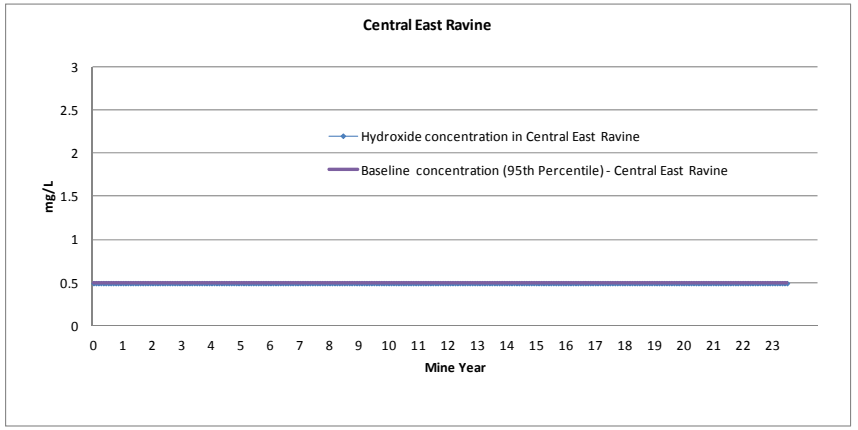
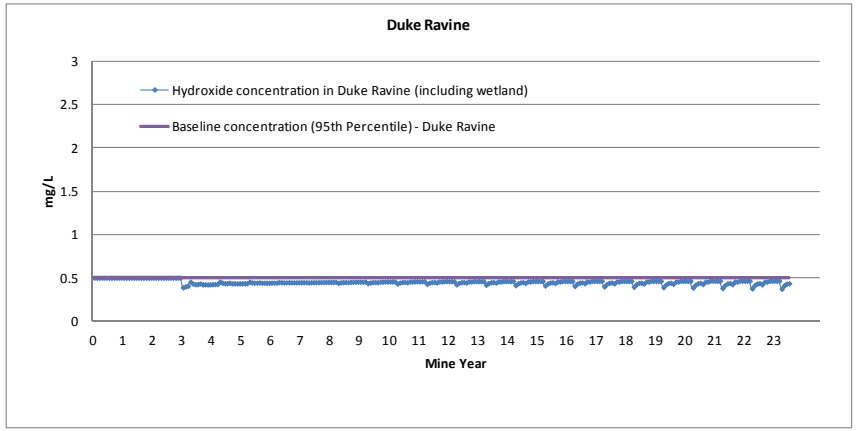






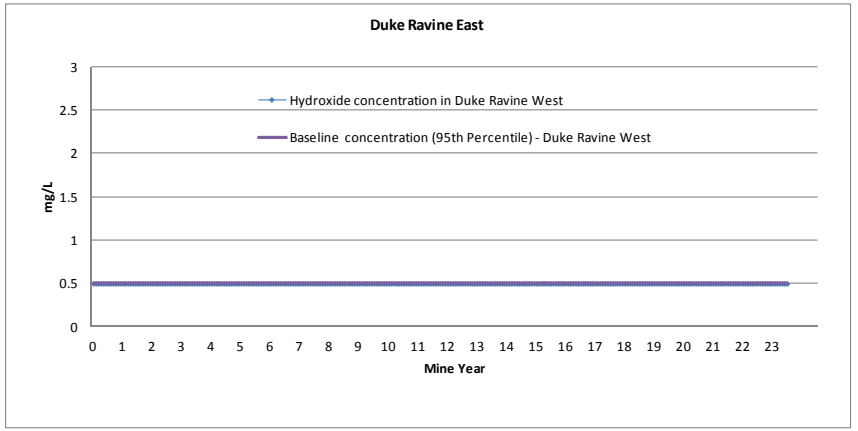
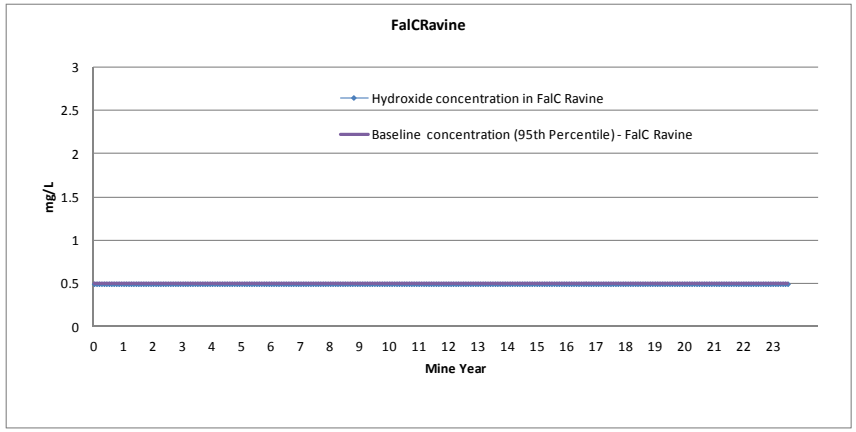
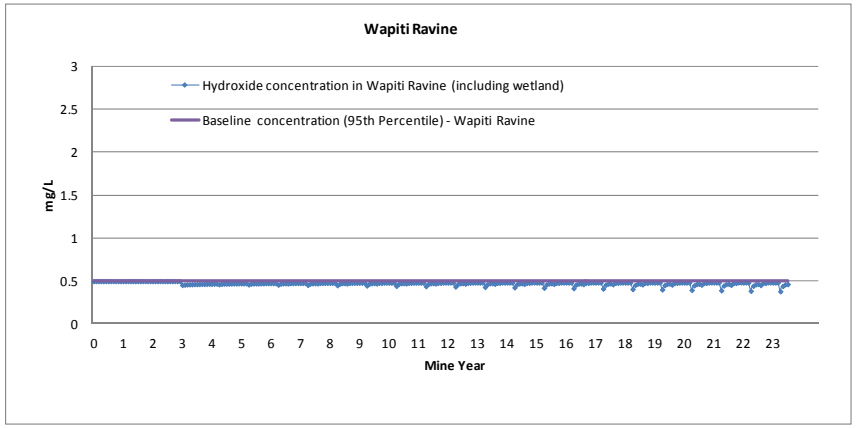
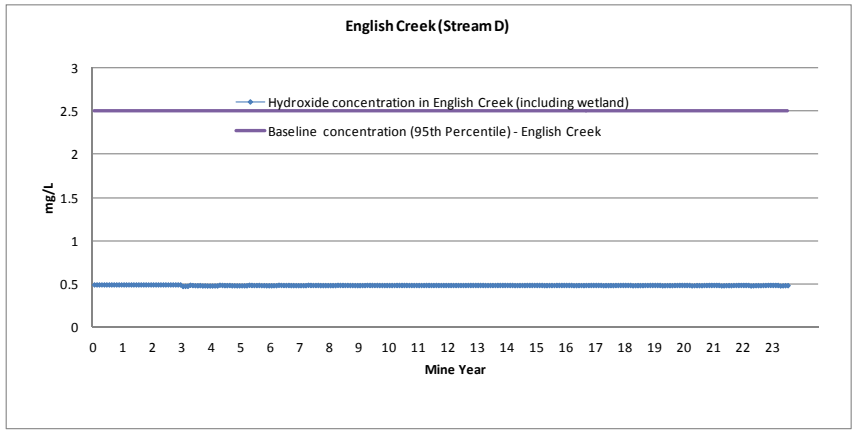


Figure 3-8 Continued







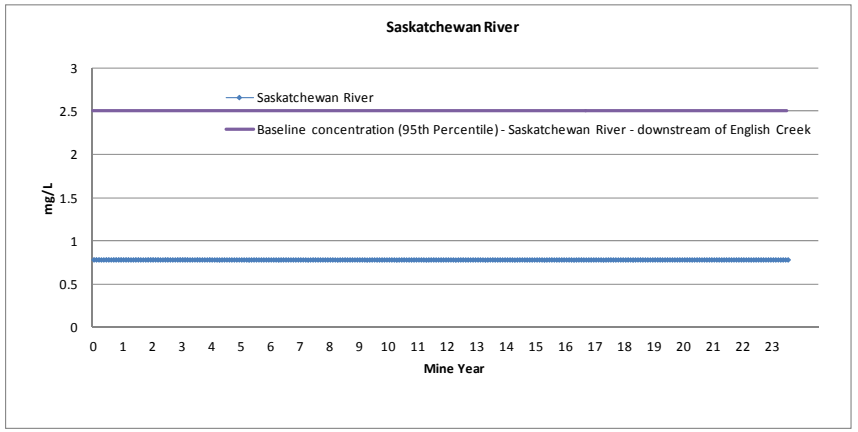
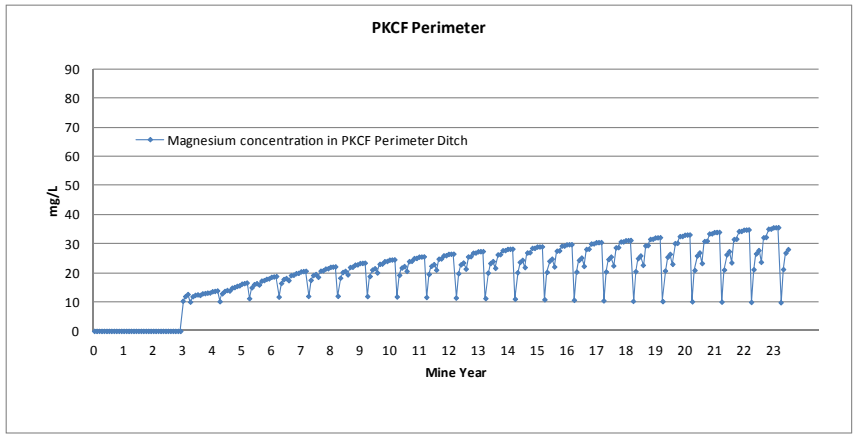
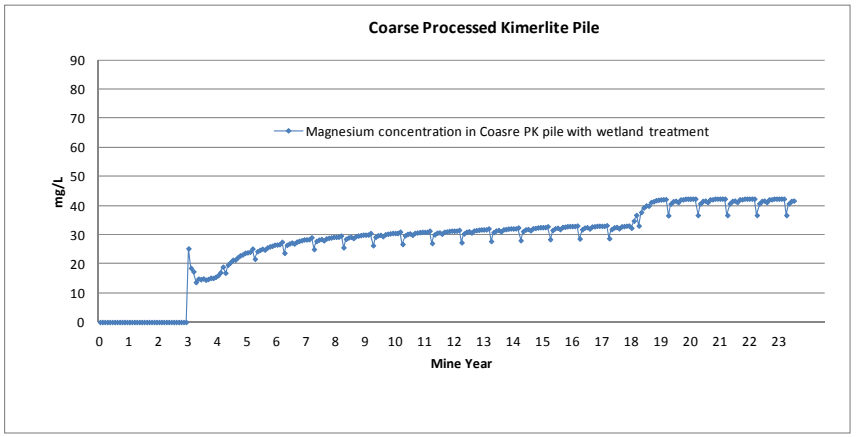


Figure 3-9 Predicted magnesium concentrations during construction and operation





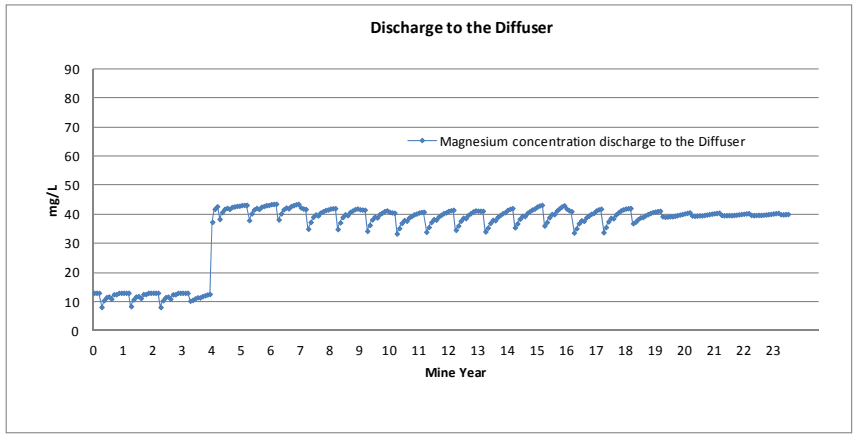
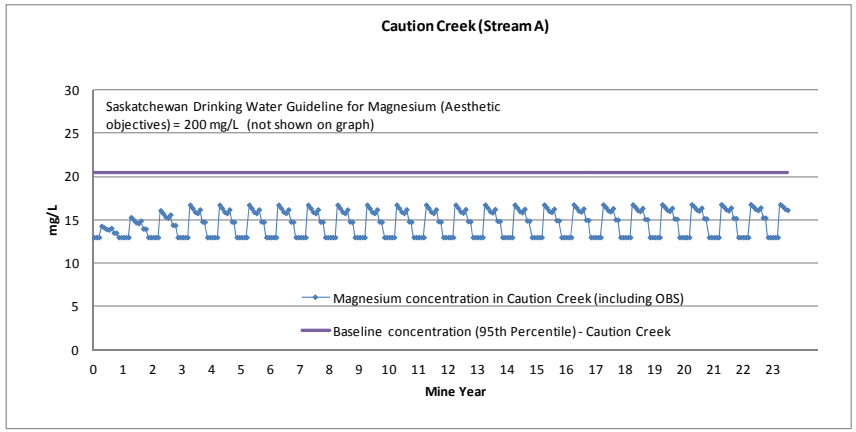
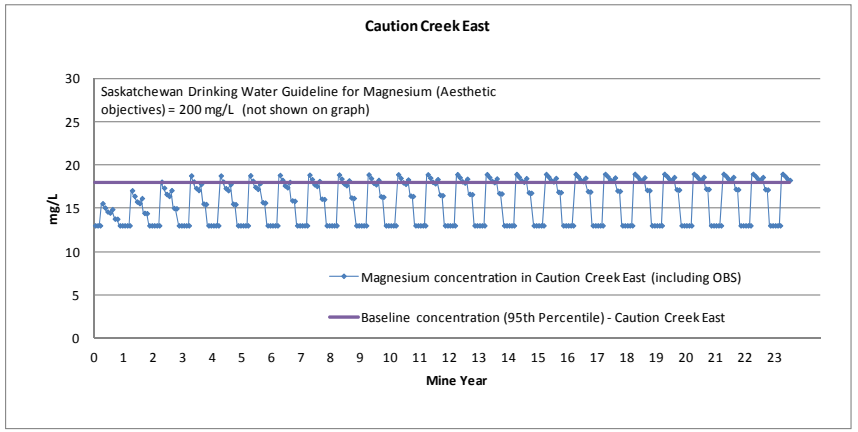
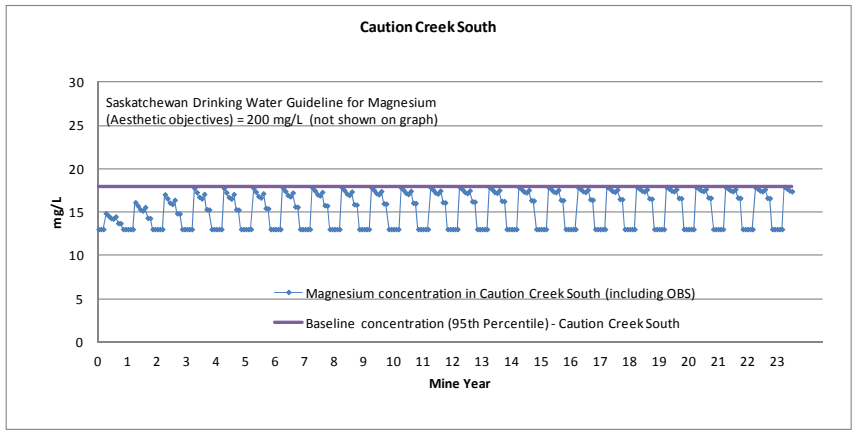


Figure 3-9 Continued







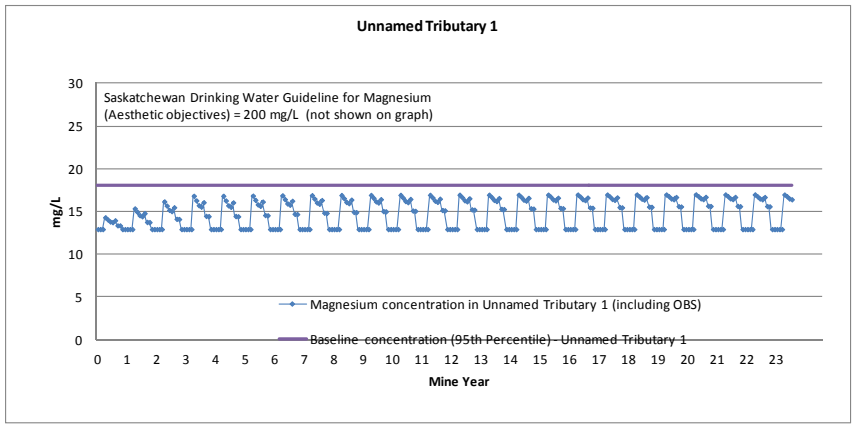
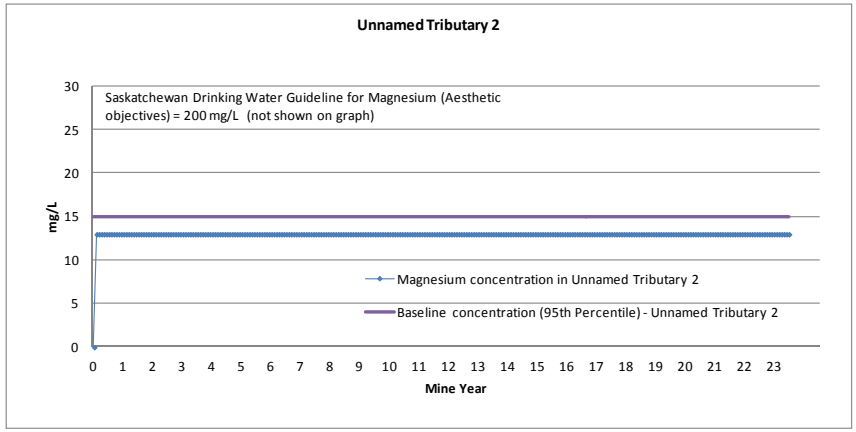
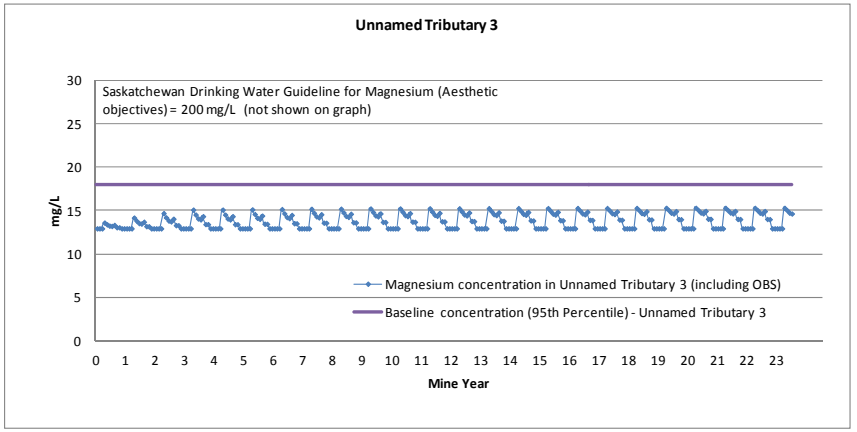
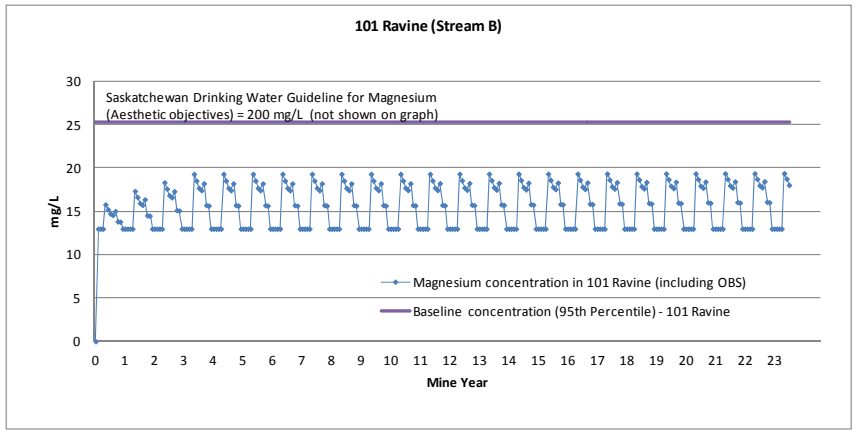


Figure 3-9 Continued







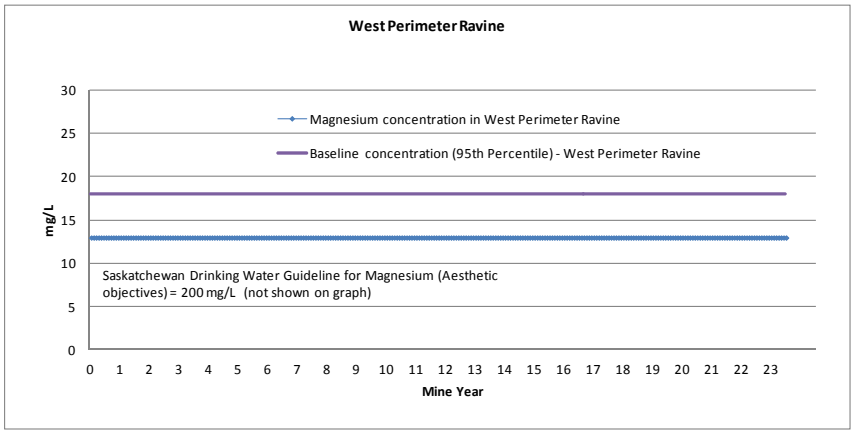
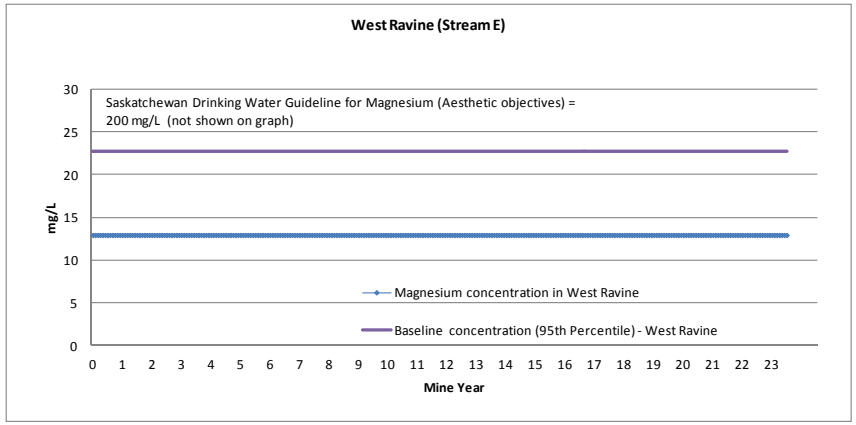
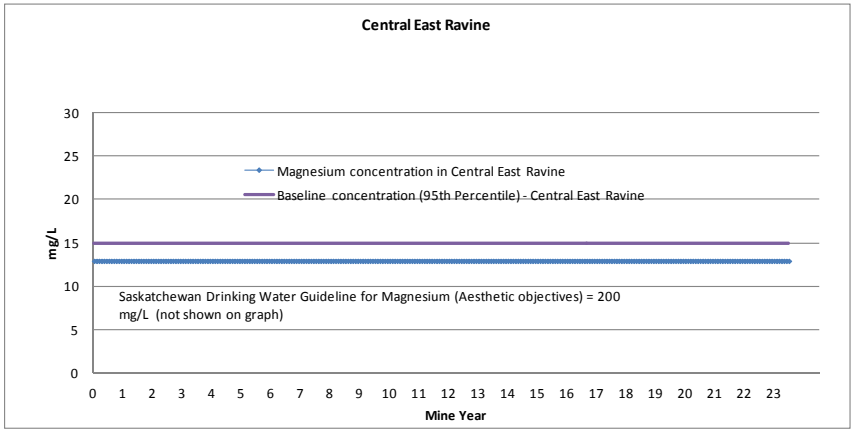
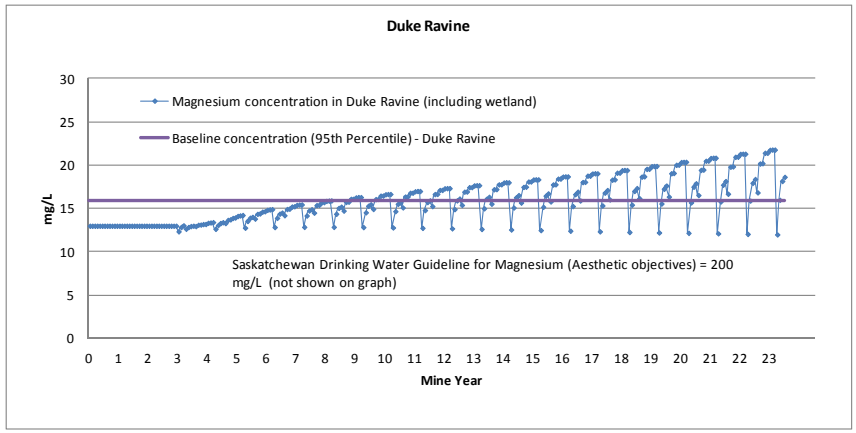


Figure 3-9 Continued







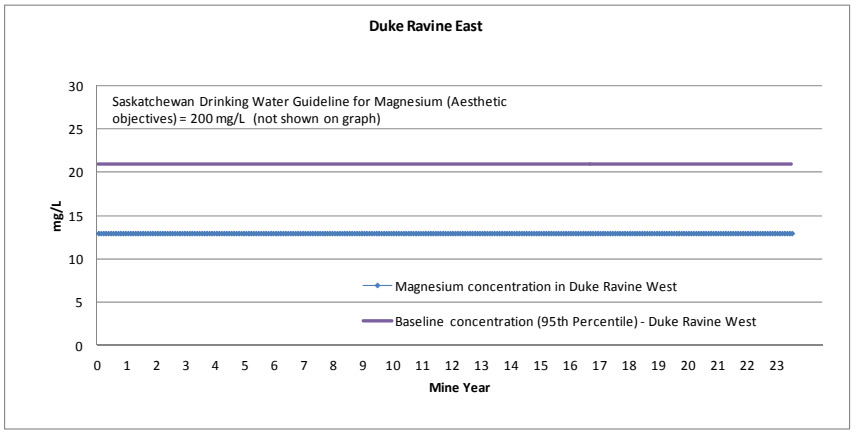
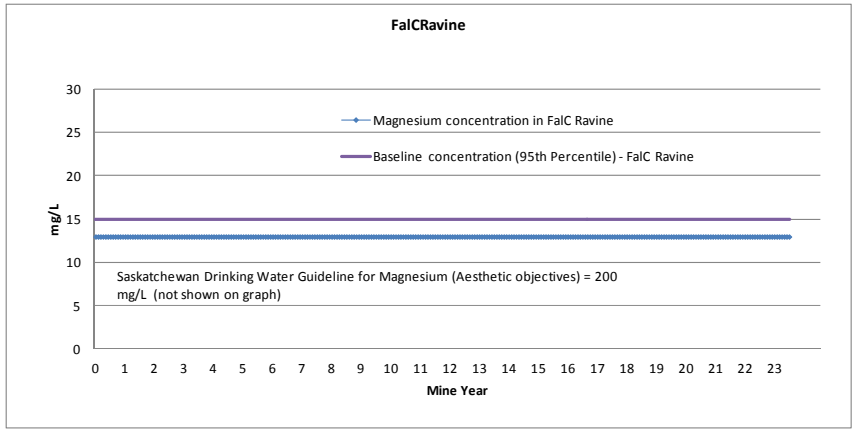
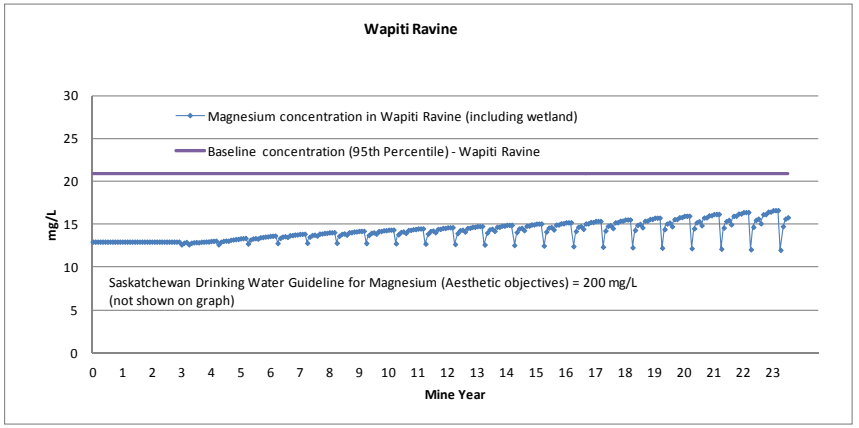
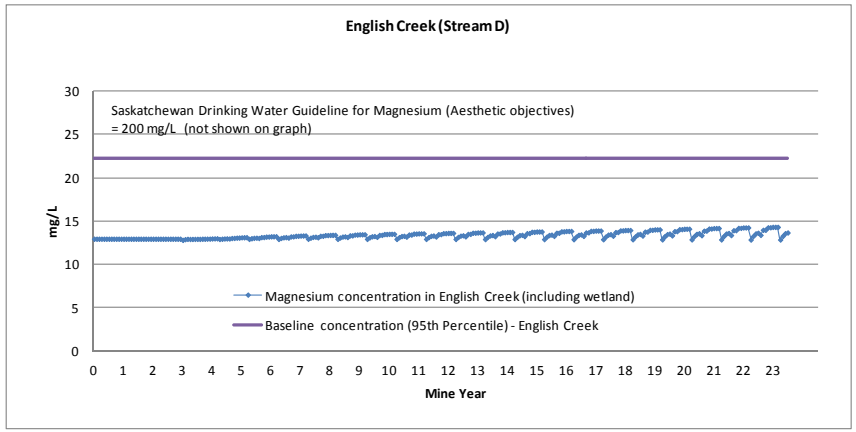


Figure 3-9 Continued







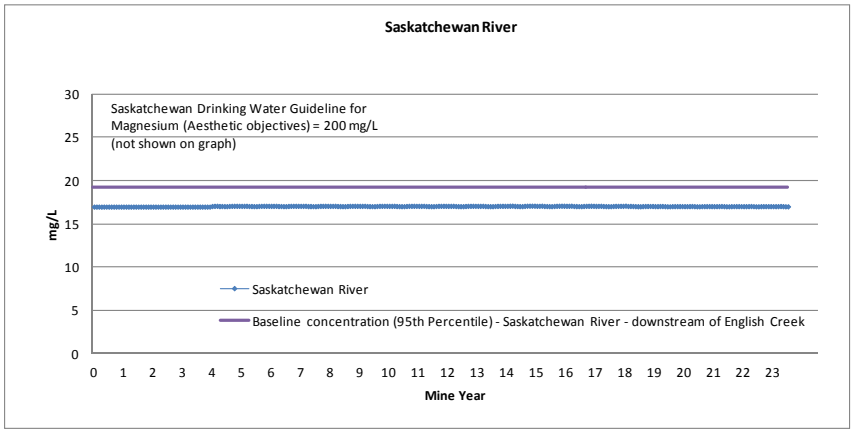
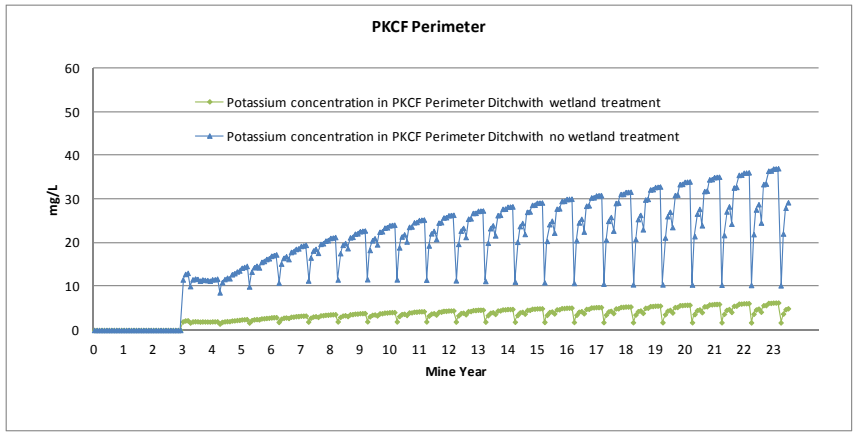
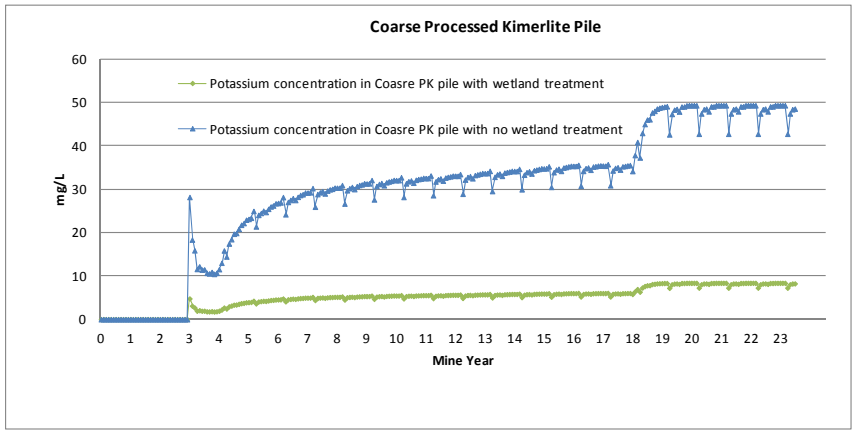


Figure 3-10 Predicted potassium concentrations during construction and operation





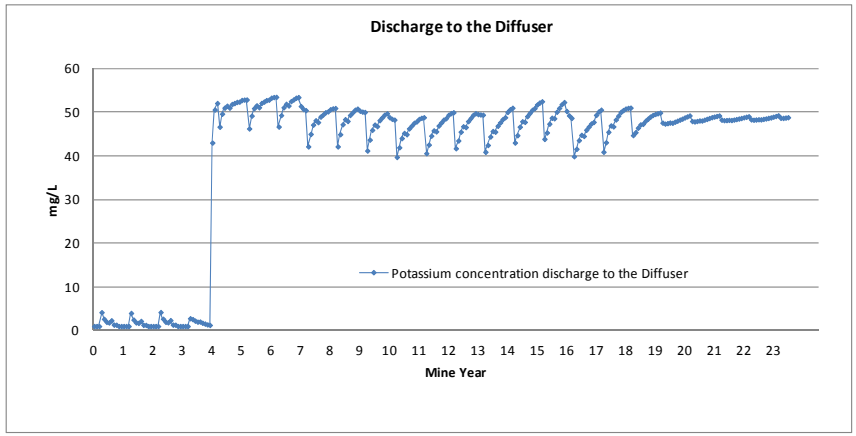
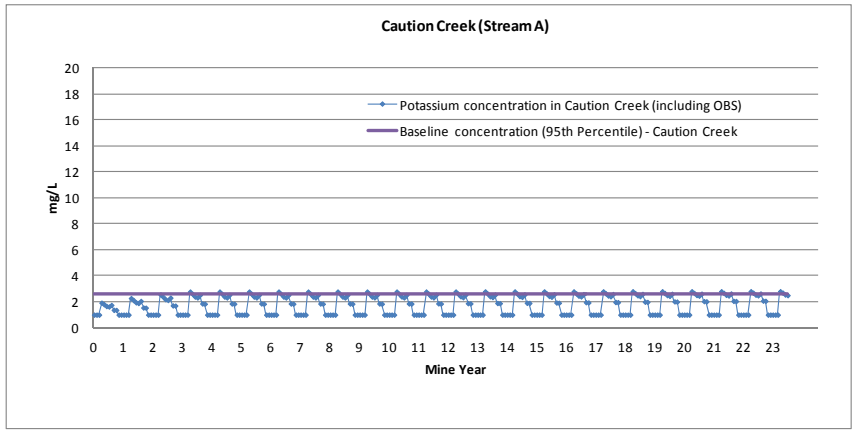
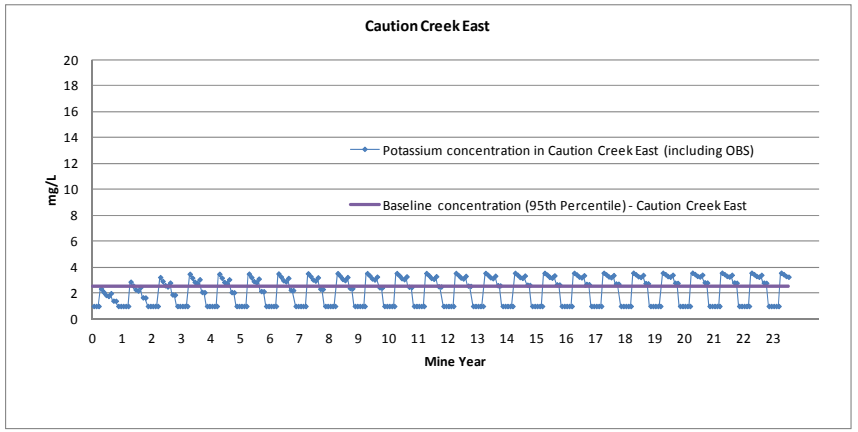
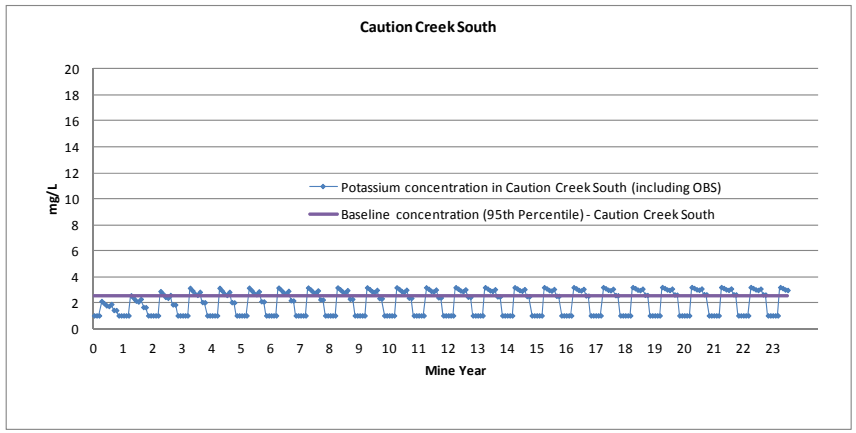


Figure 3-10 Continued







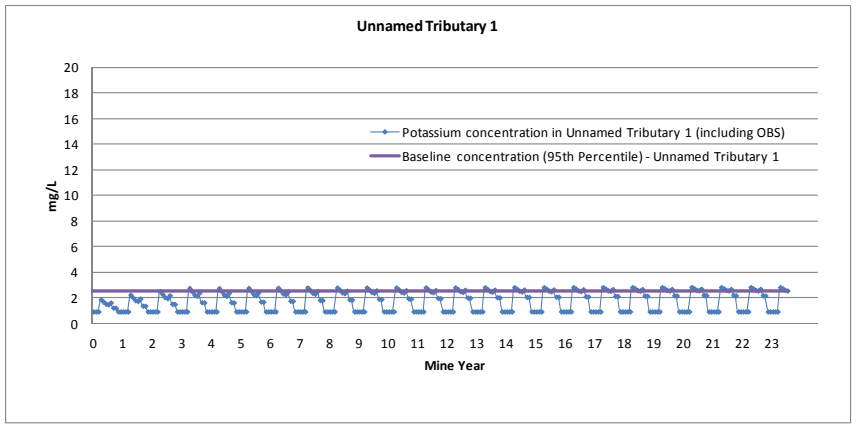
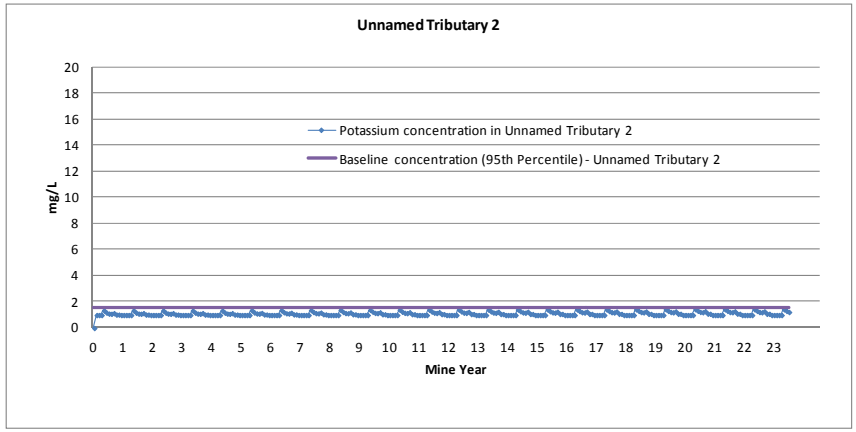
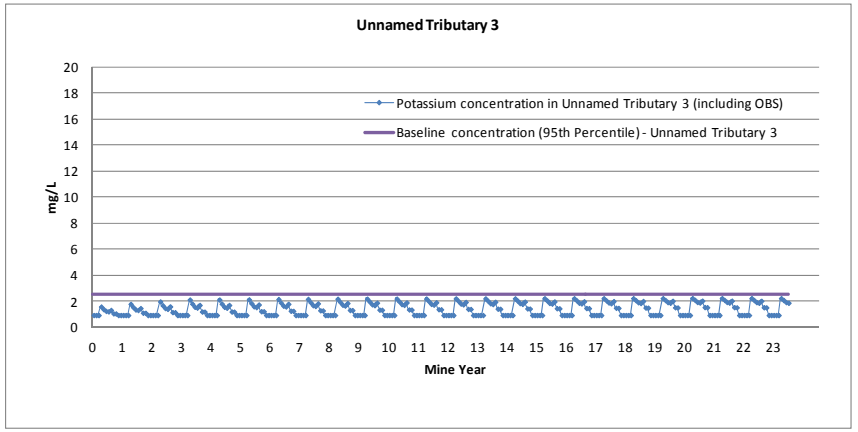
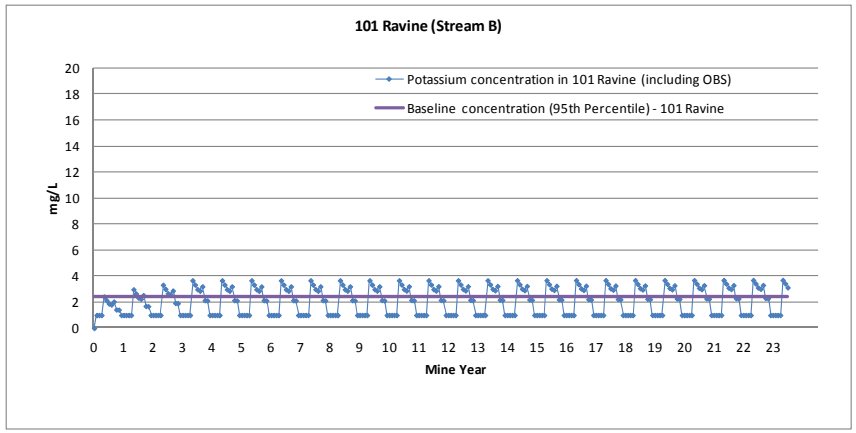


Figure 3-10 Continued







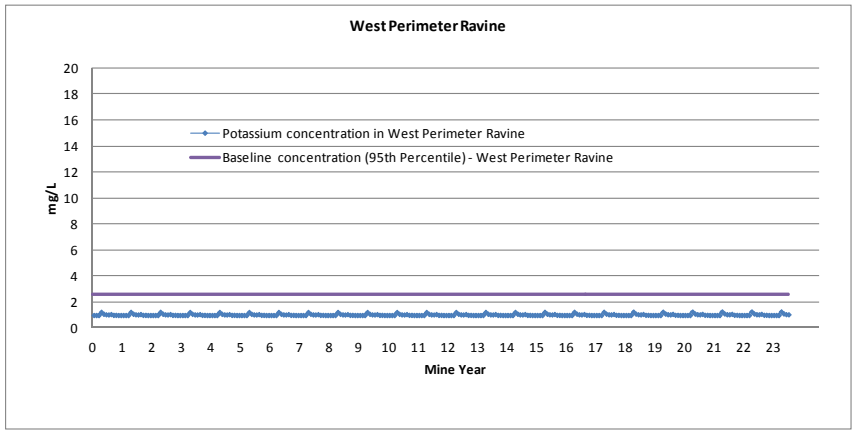
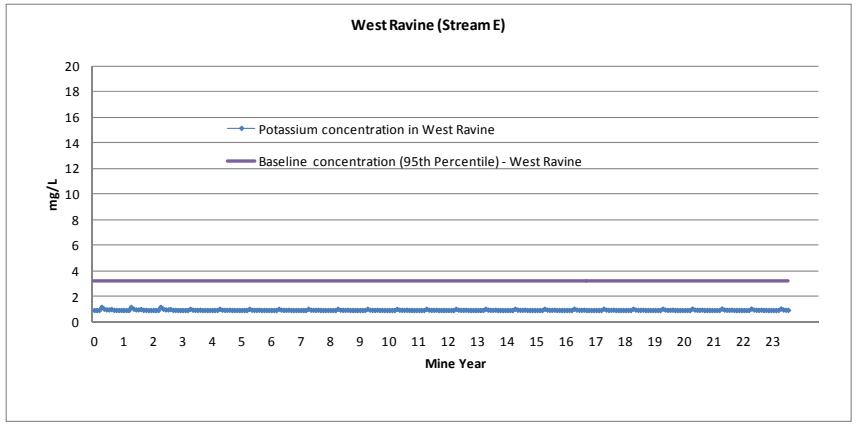
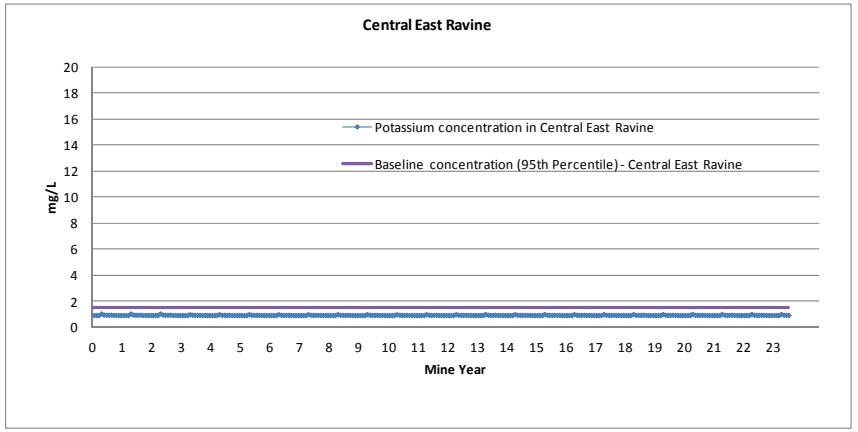
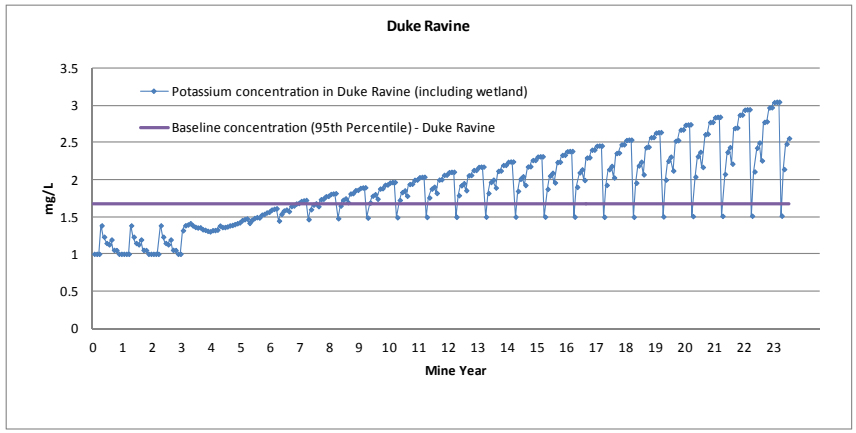


Figure 3-10 Continued







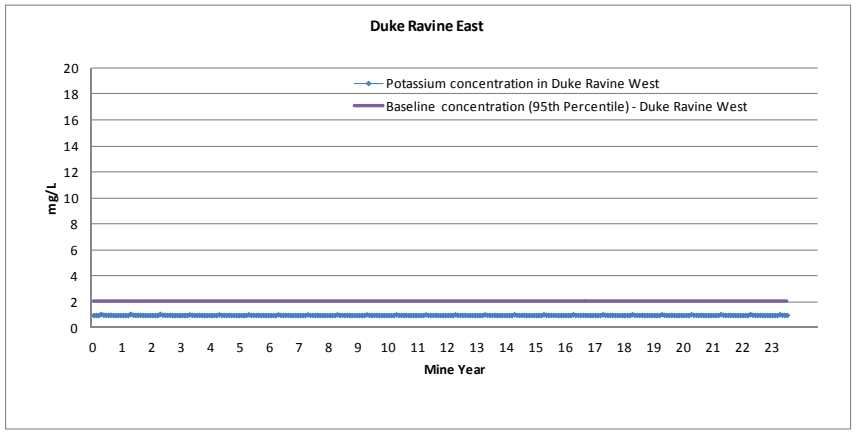
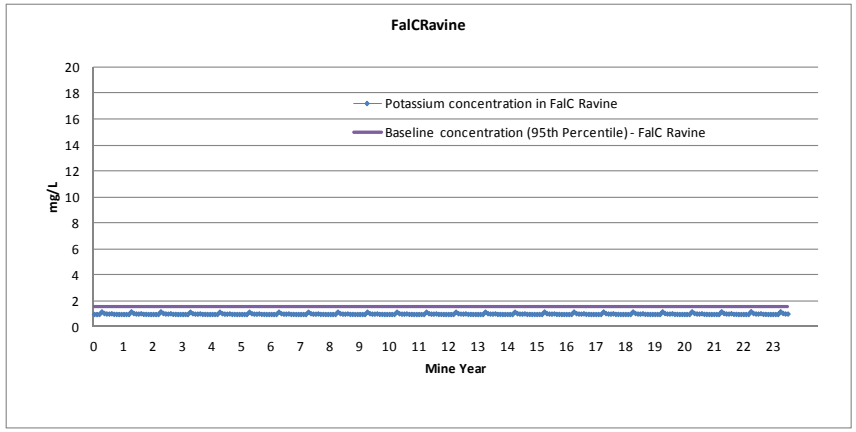
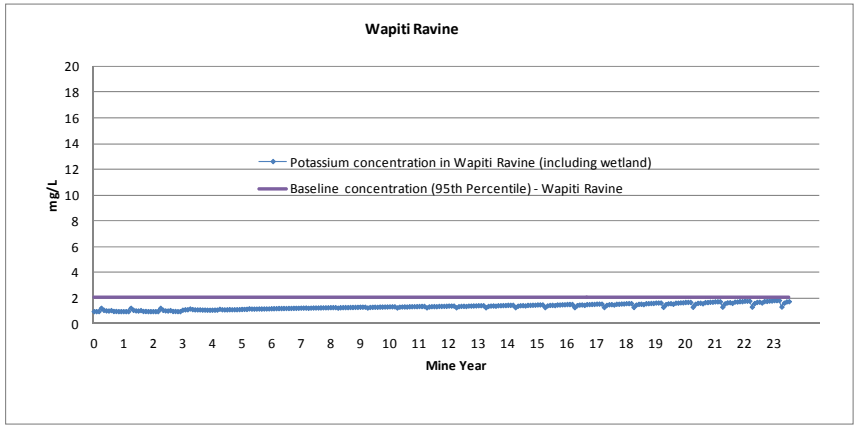
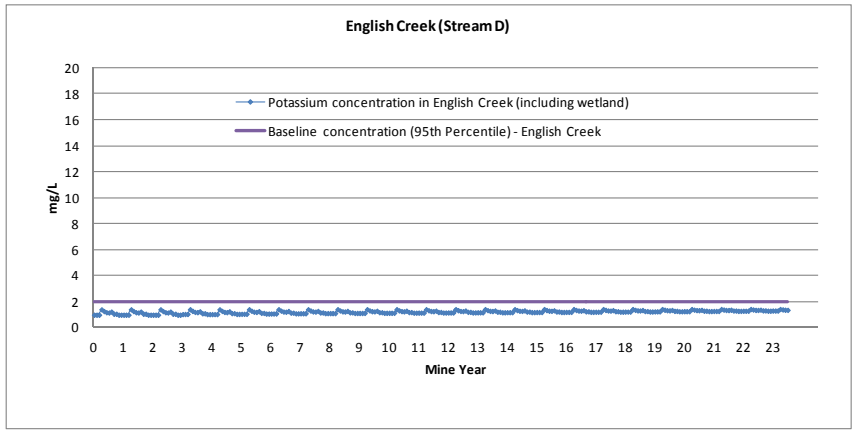


Figure 3-10 Continued







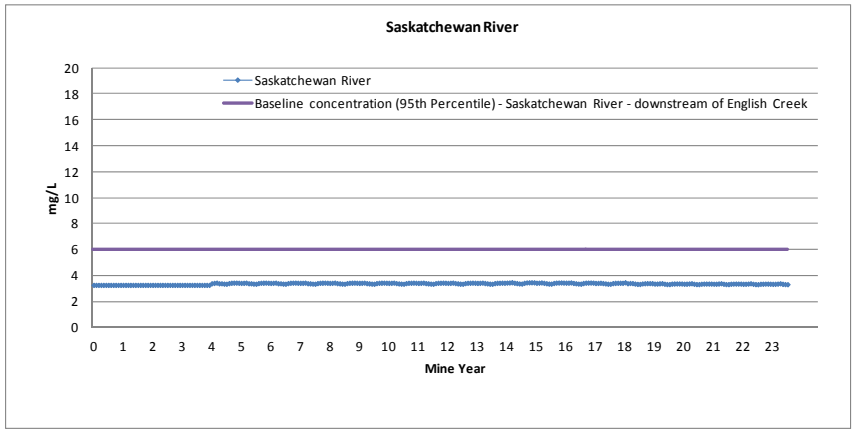
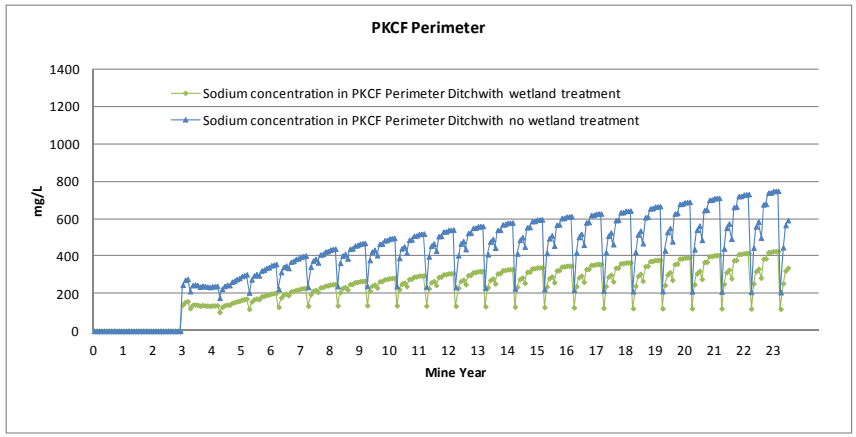
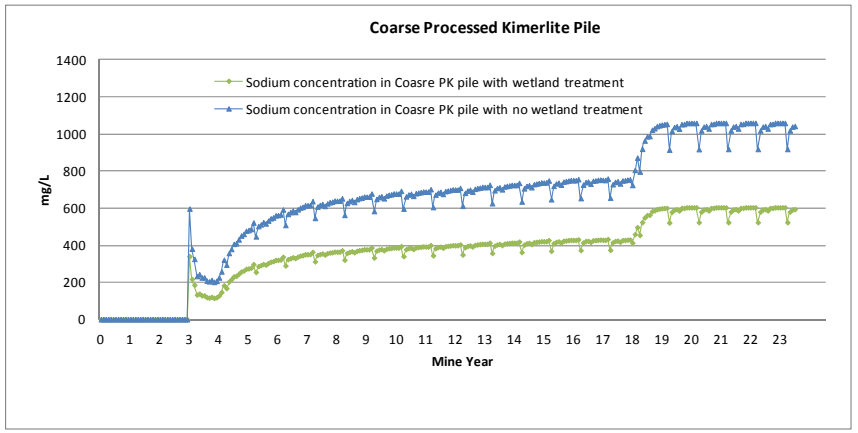


Figure 3-11 Predicted sodium concentrations during construction and operation





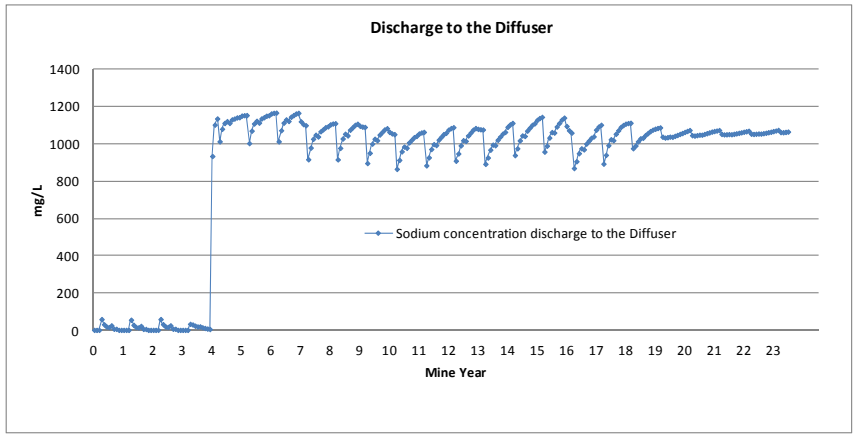
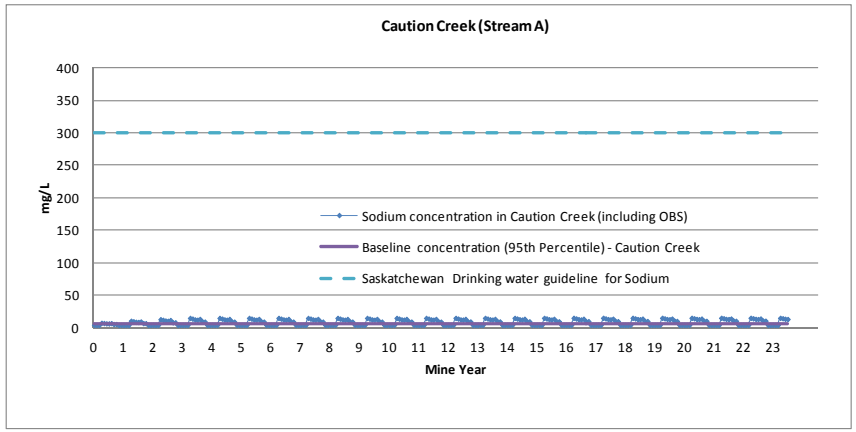
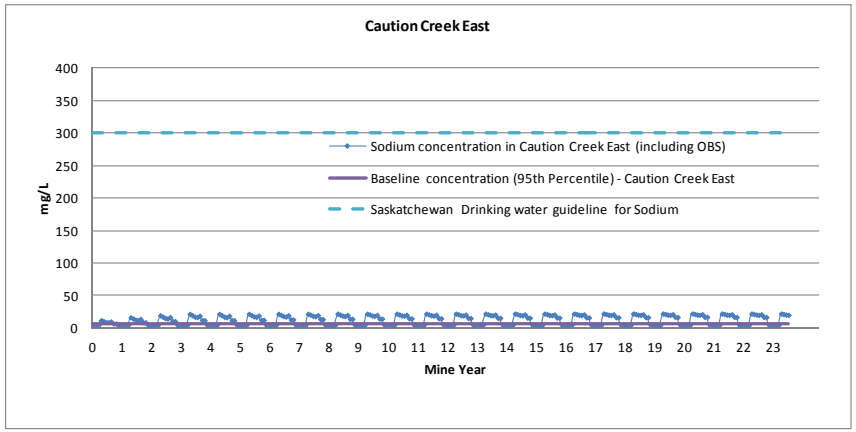
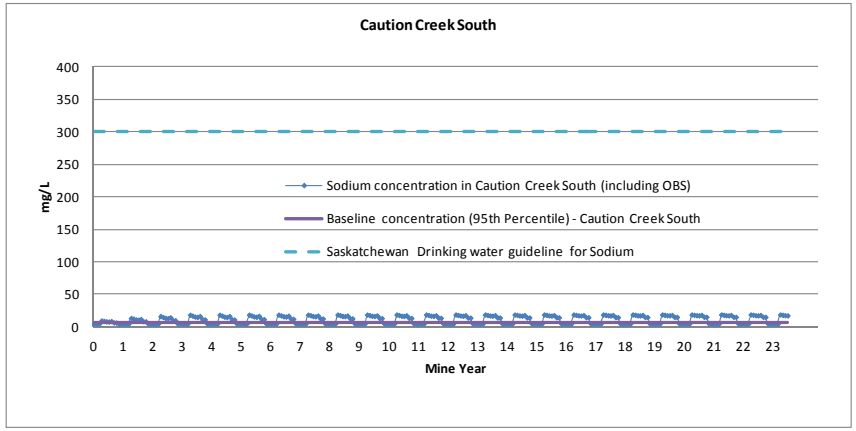


Figure 3-11 Continued







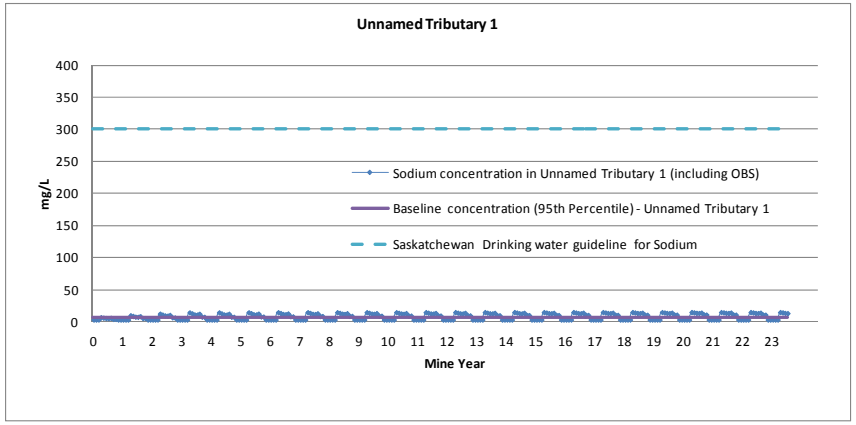
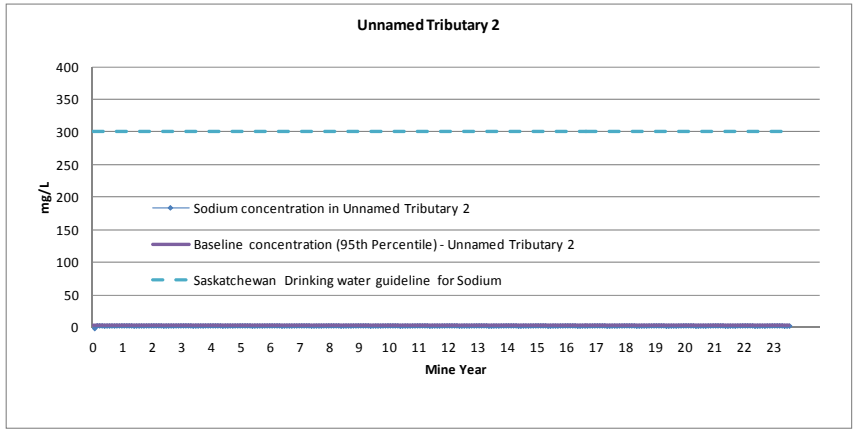
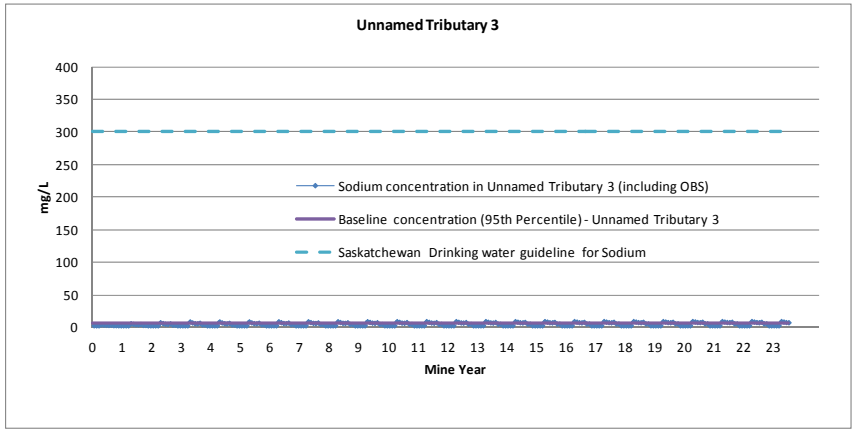
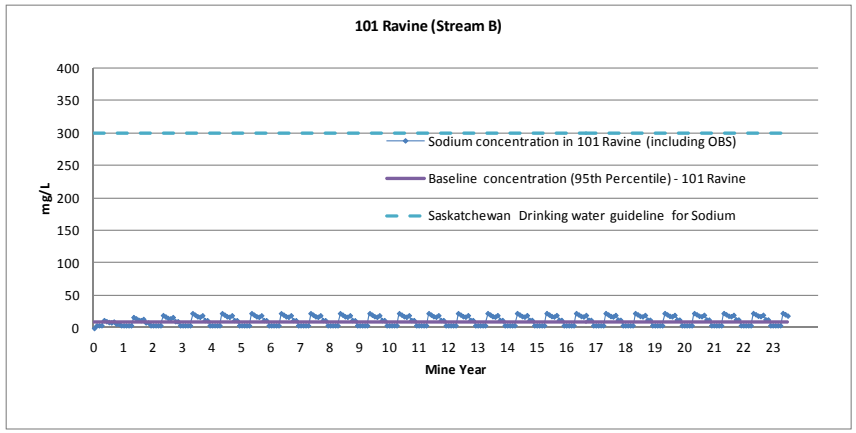


Figure 3-11 Continued







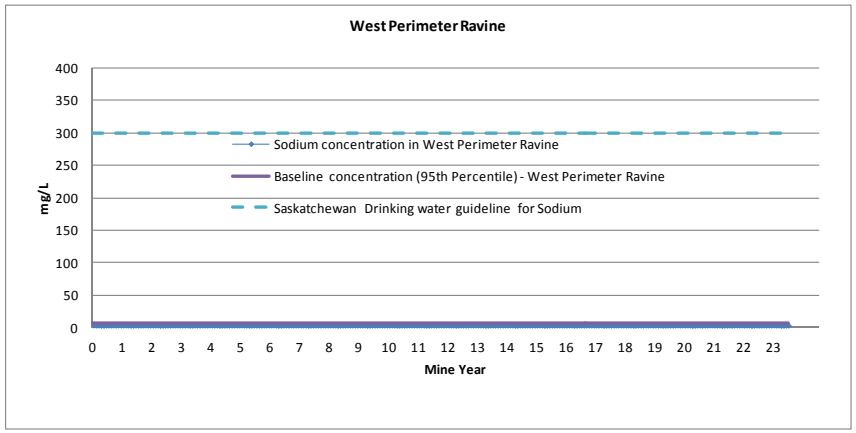
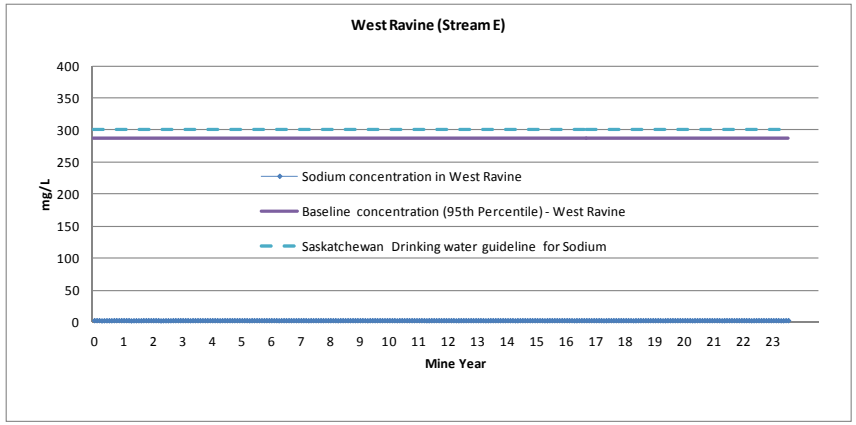
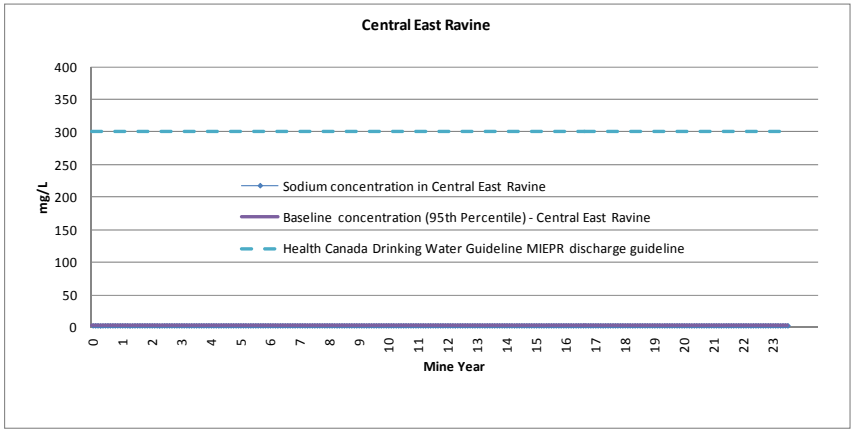
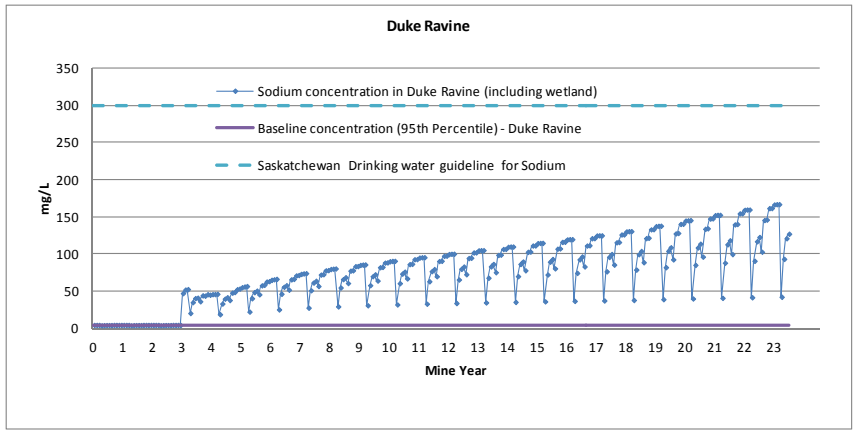


Figure 3-11 Continued







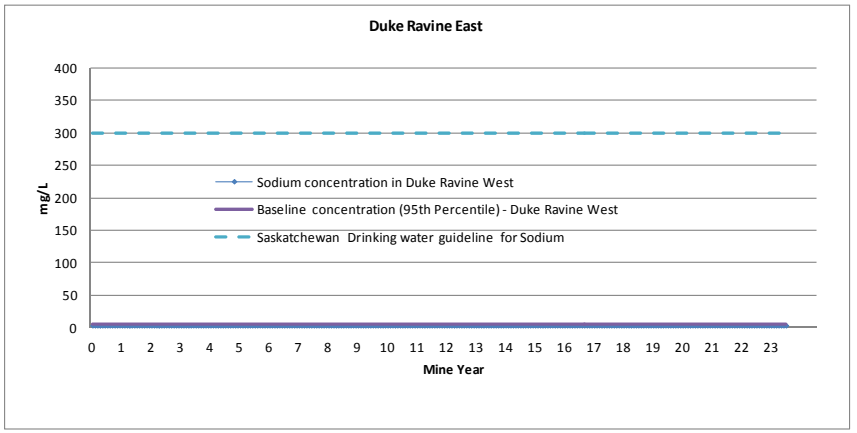
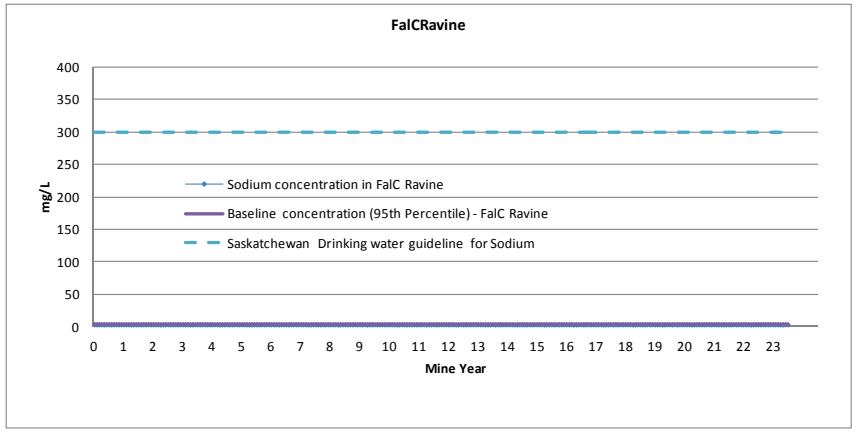
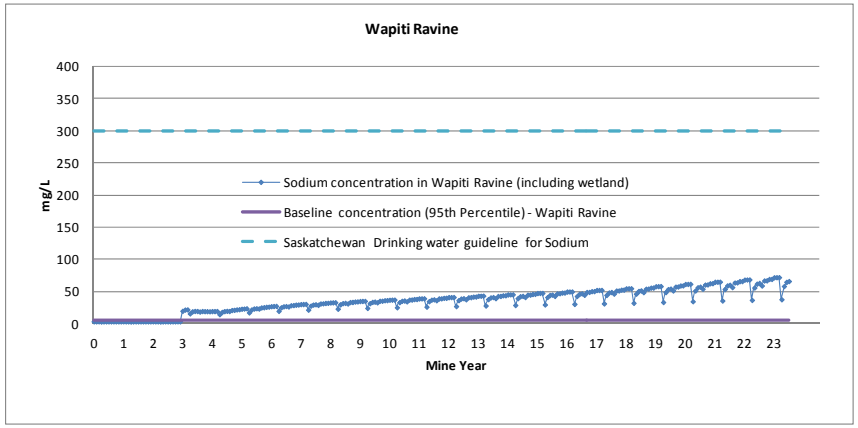
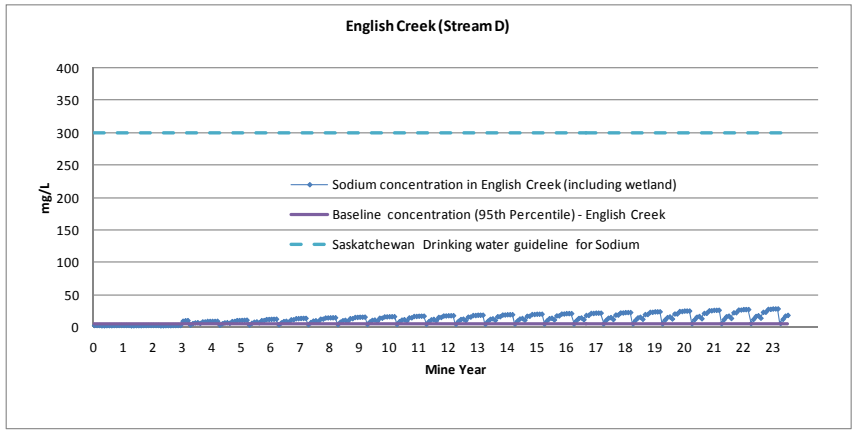


Figure 3-11 Continued







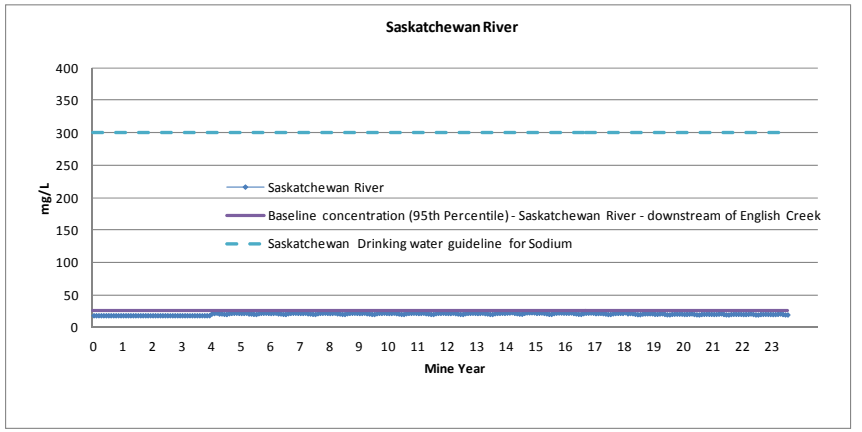
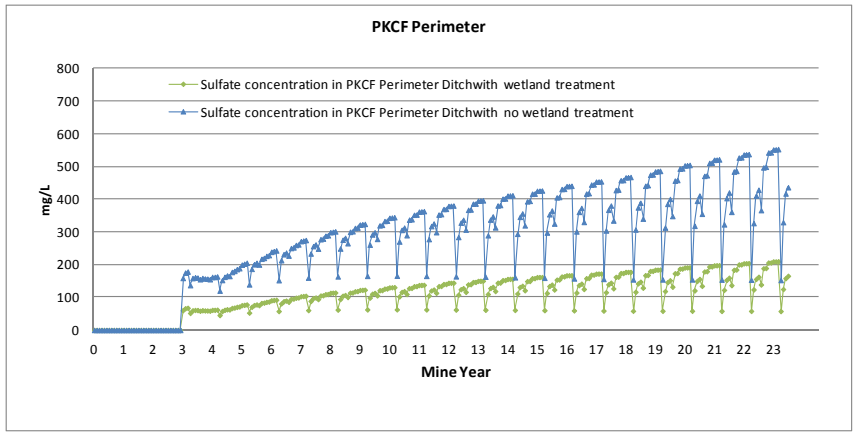
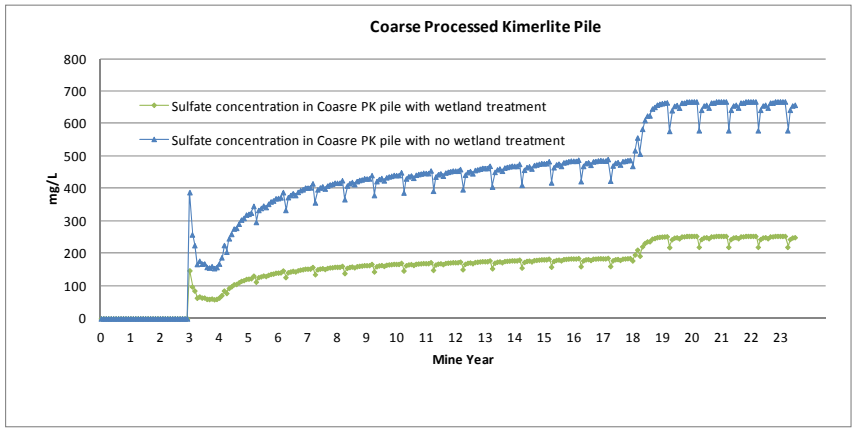


Figure 3-12 Predicted sulphate concentrations during construction and operation





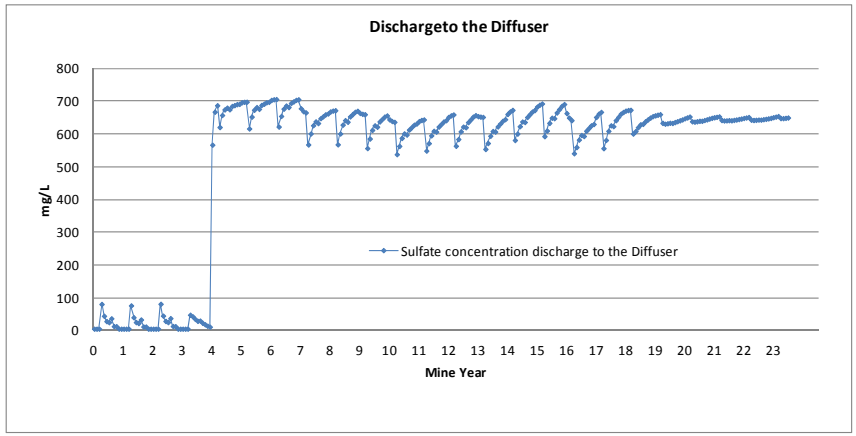
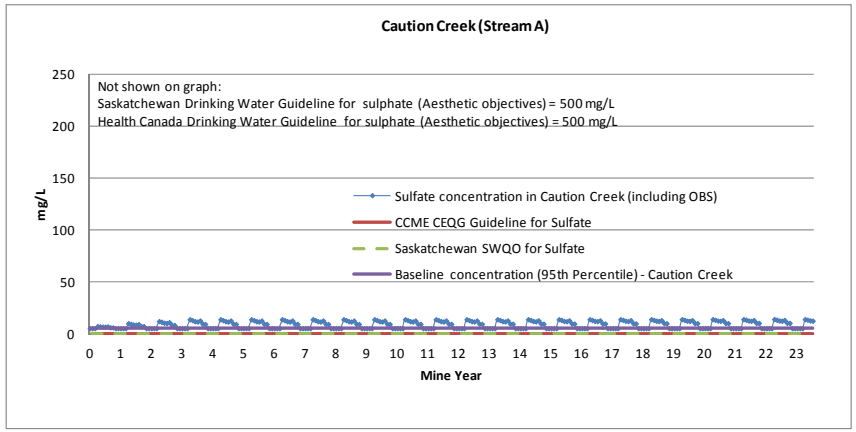
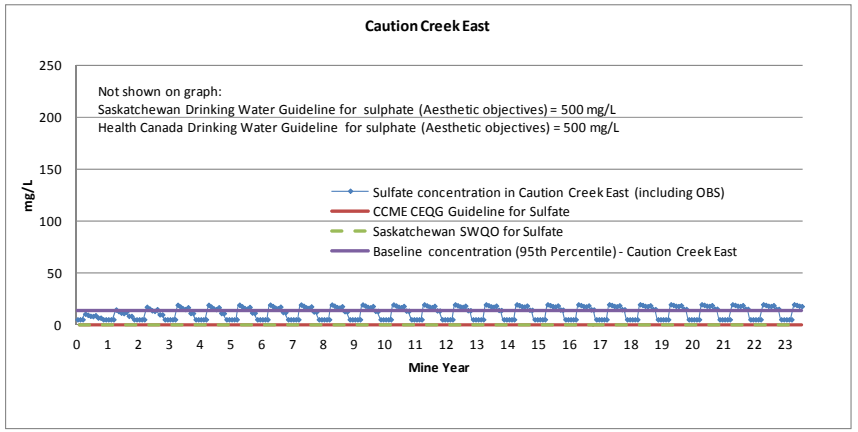
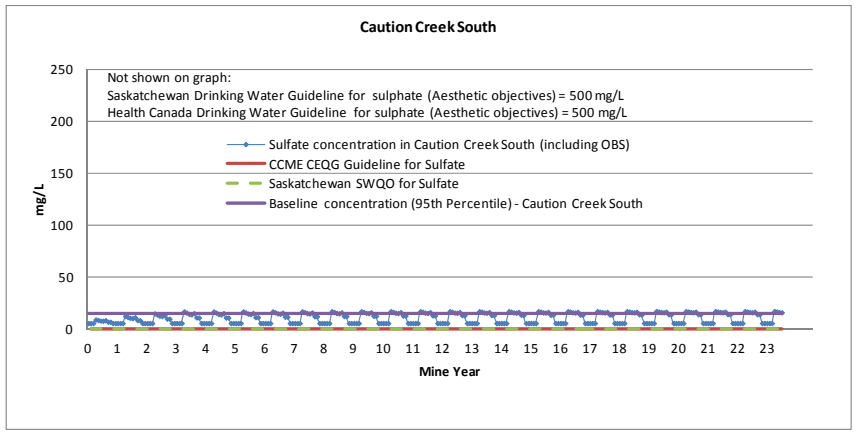


Figure 3-12 Continued







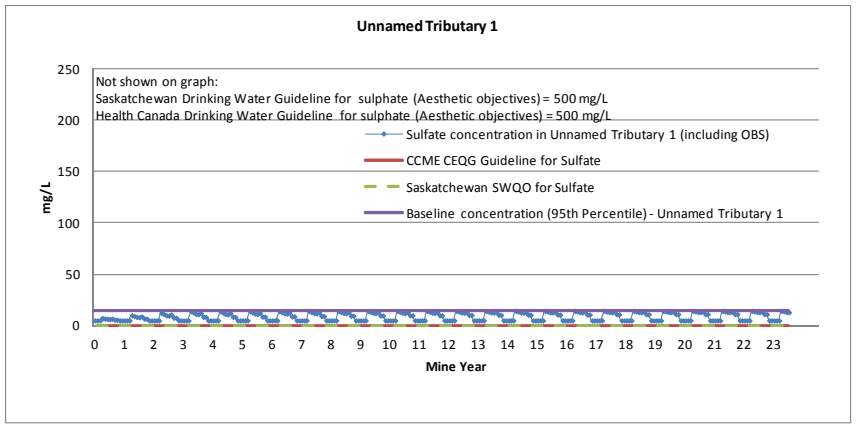
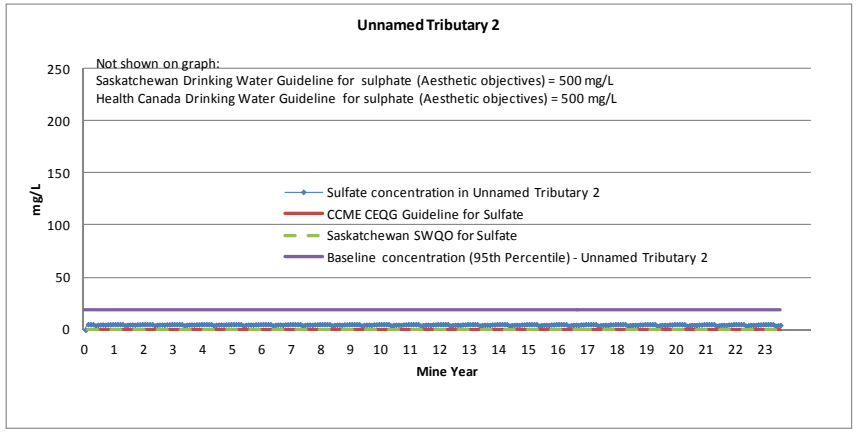
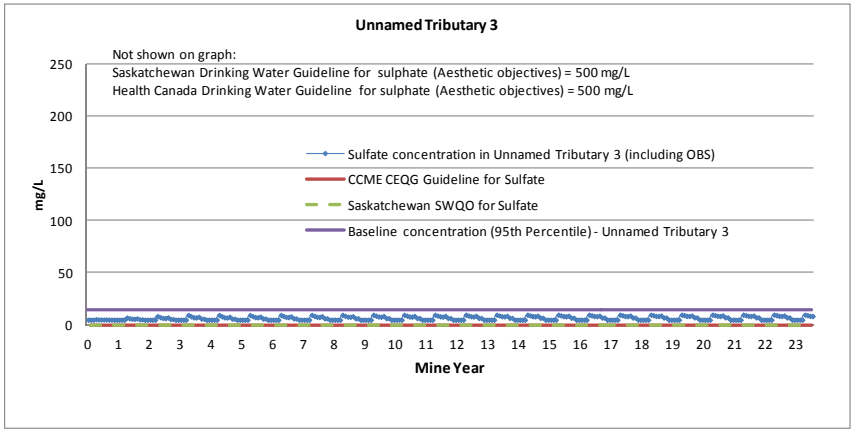
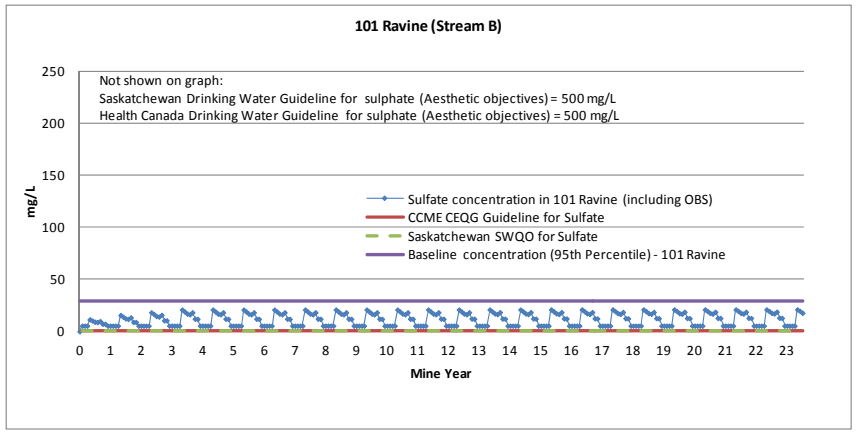


Figure 3-12 Continued







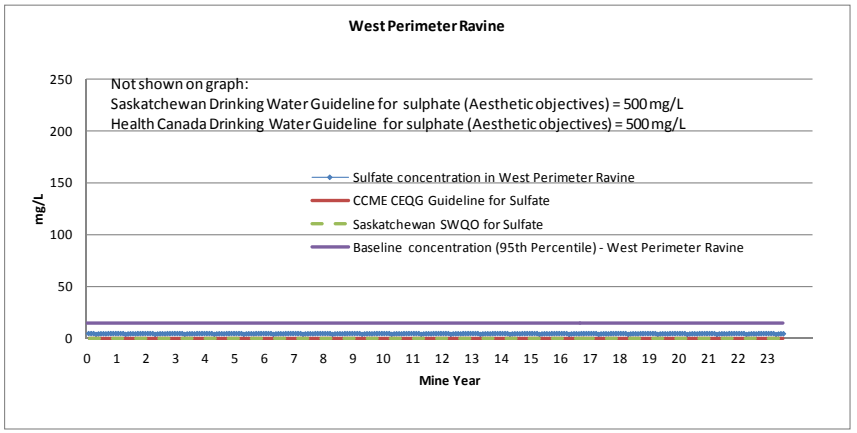
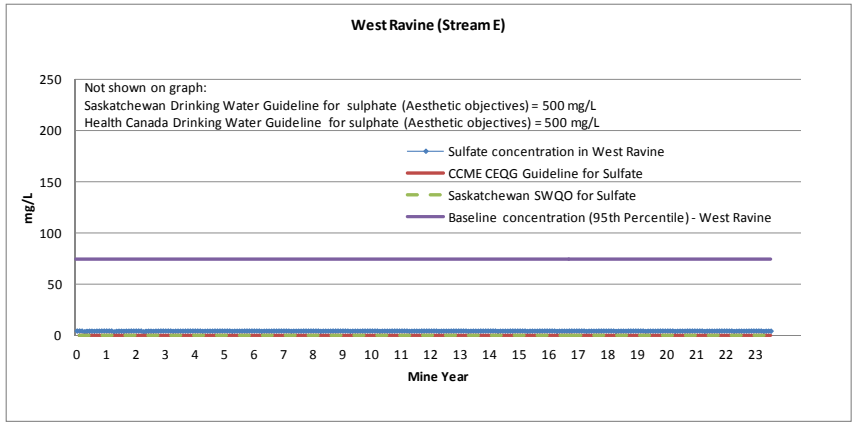
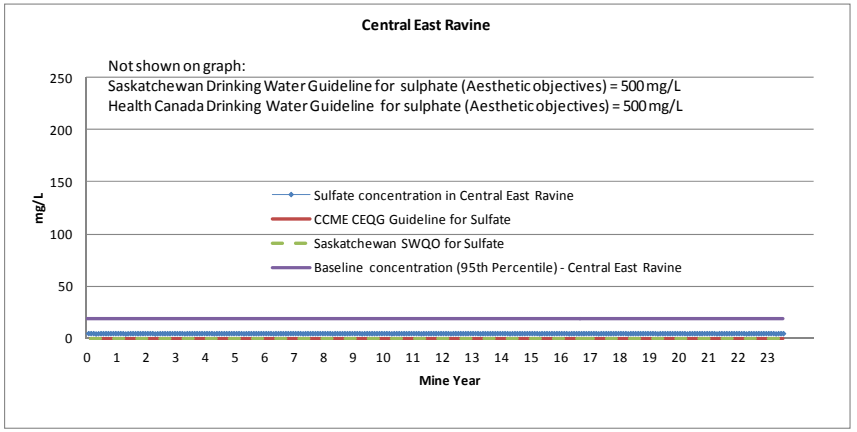
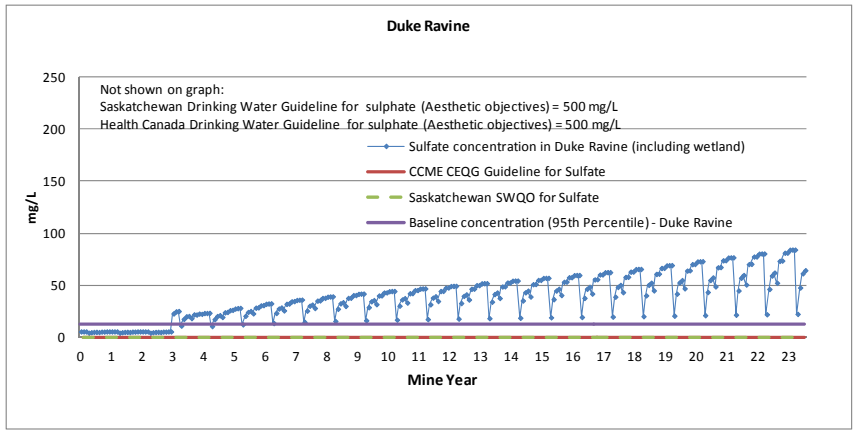


Figure 3-12 Continued







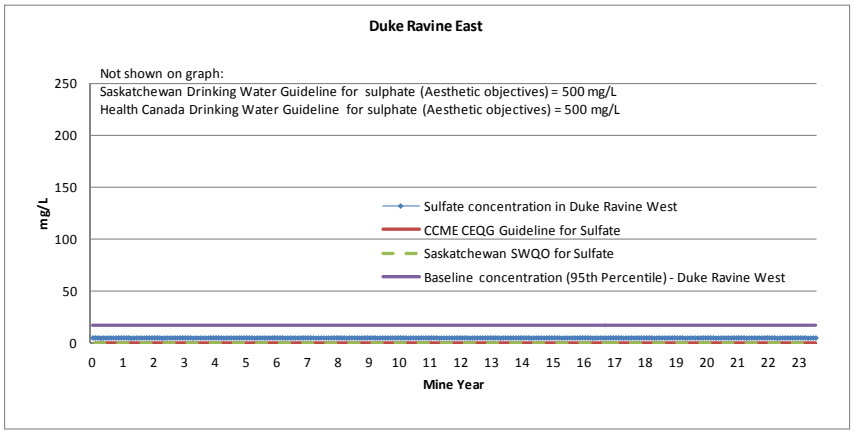
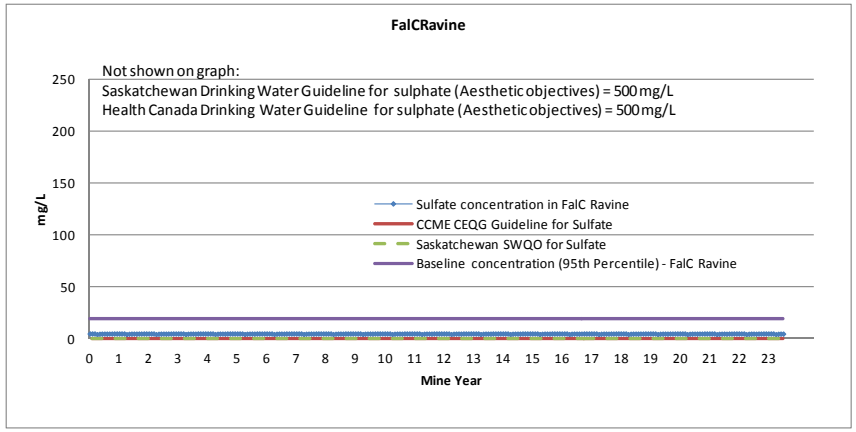
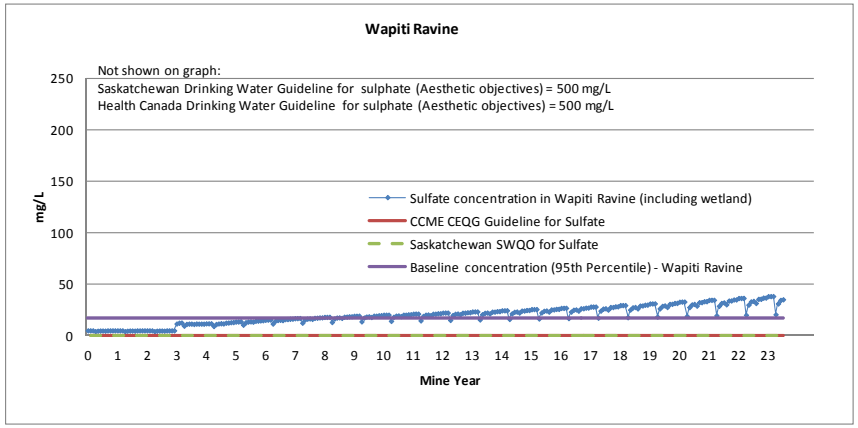
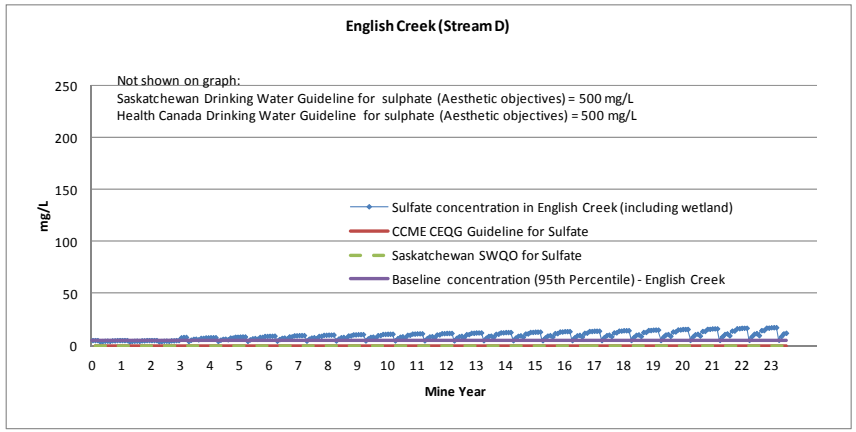


Figure 3-12 Continued







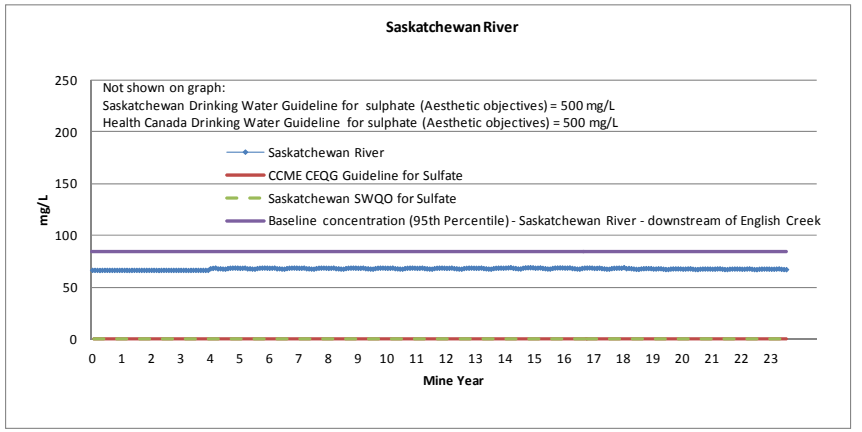
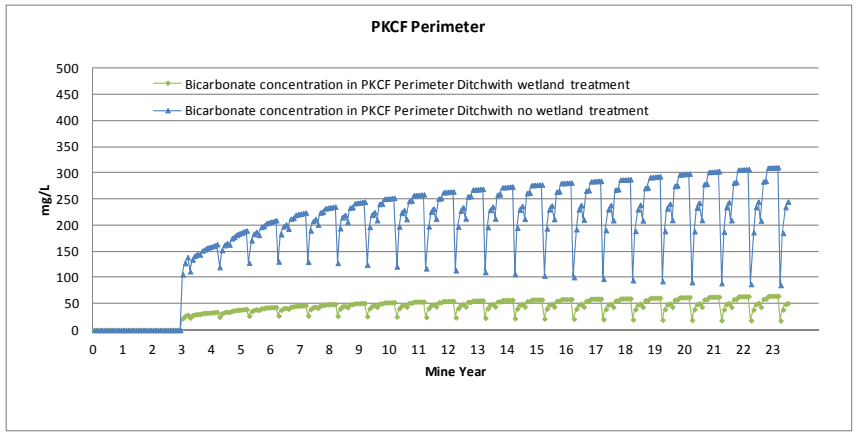
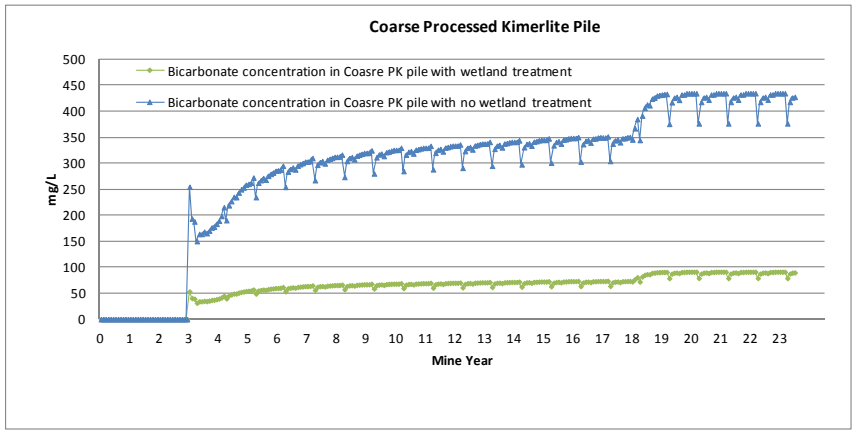


Figure 3-13 Predicted bicarbonate concentrations during construction and operation





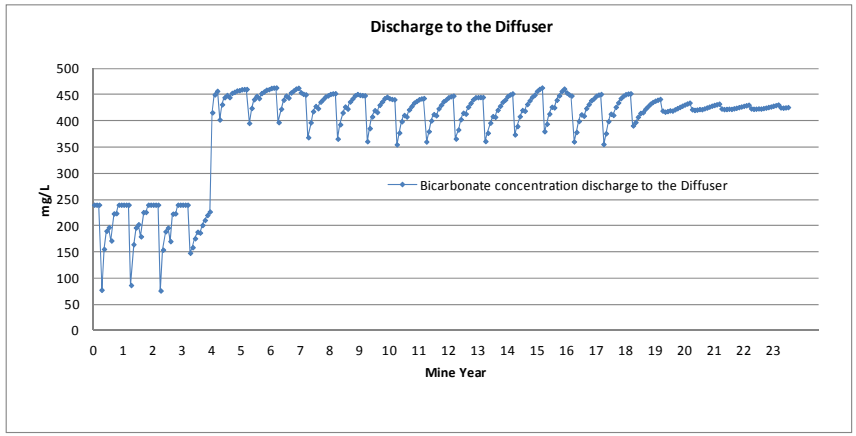
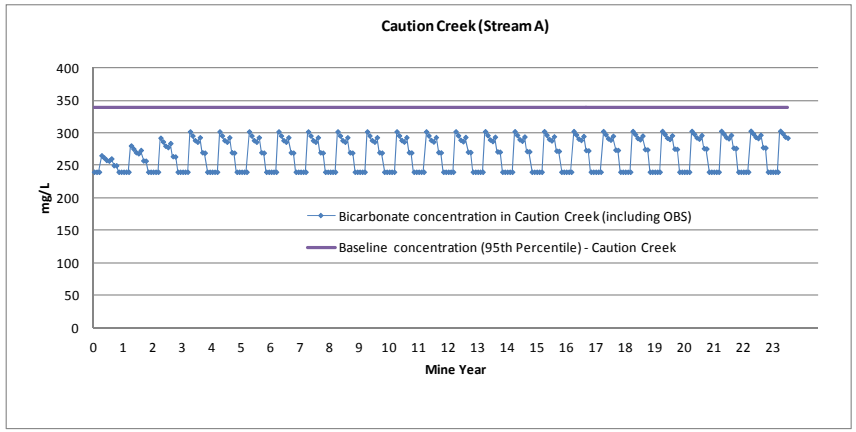
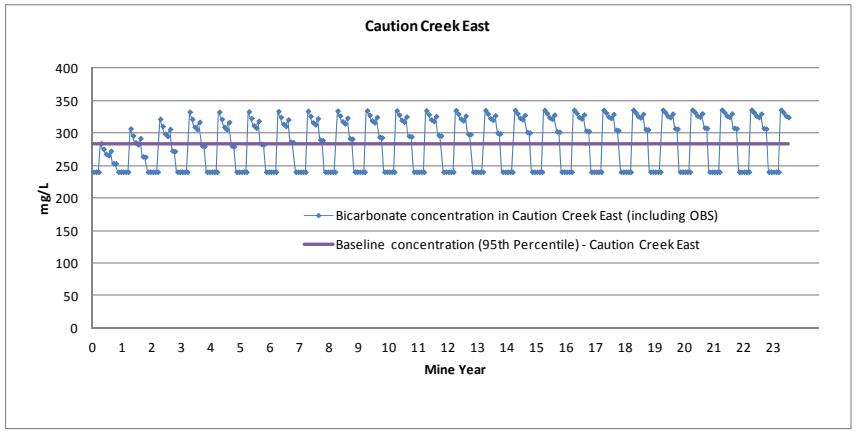
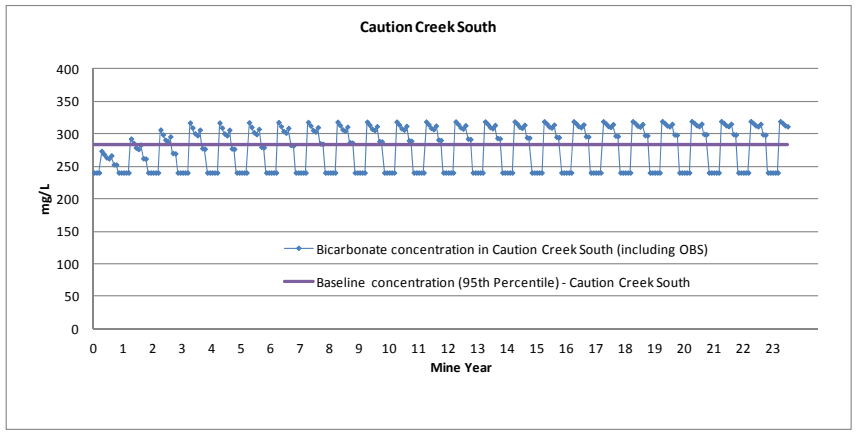


Figure 3-13 Continued







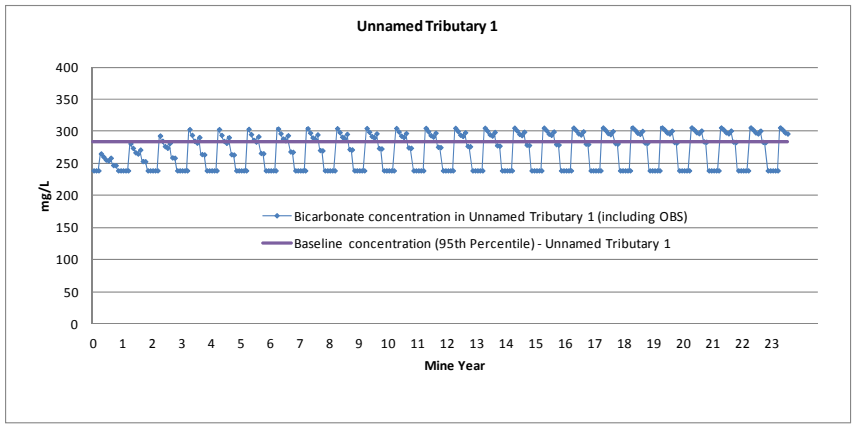
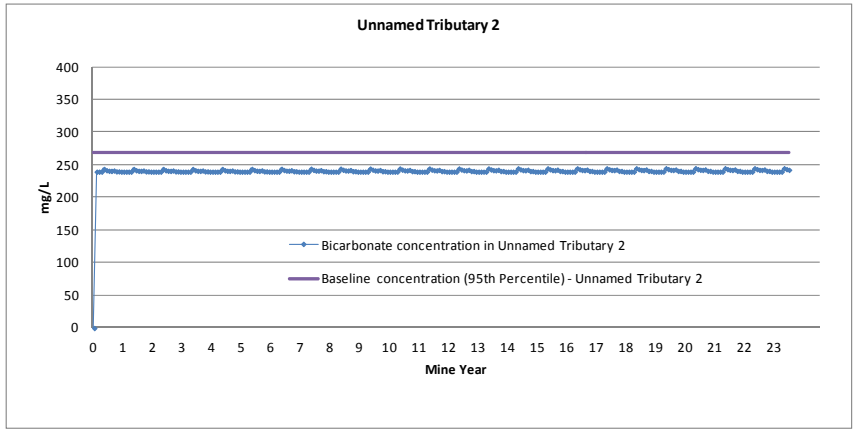
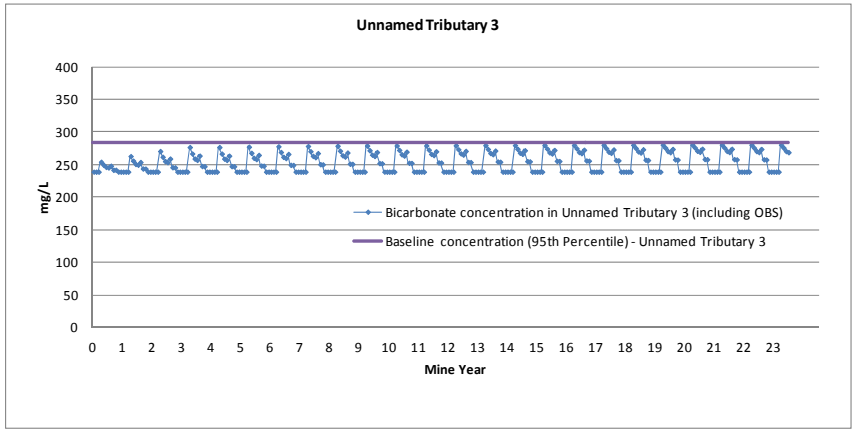
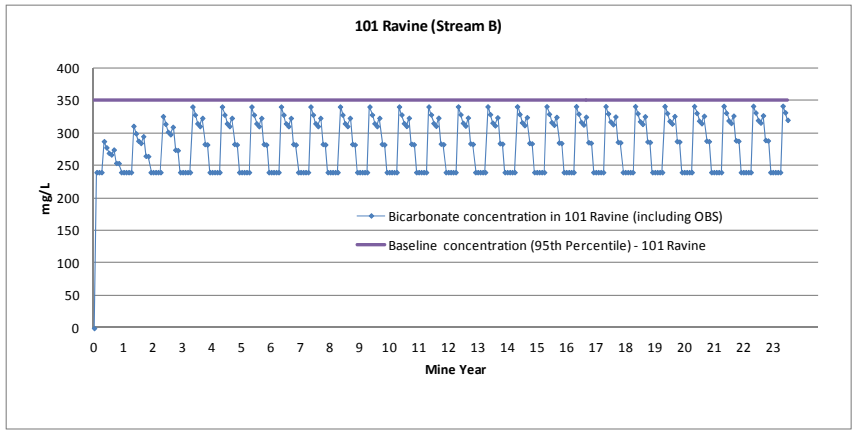


Figure 3-13 Continued







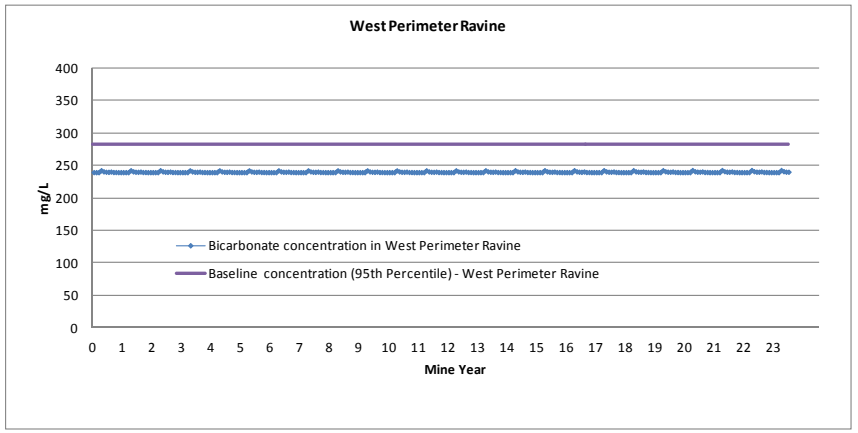
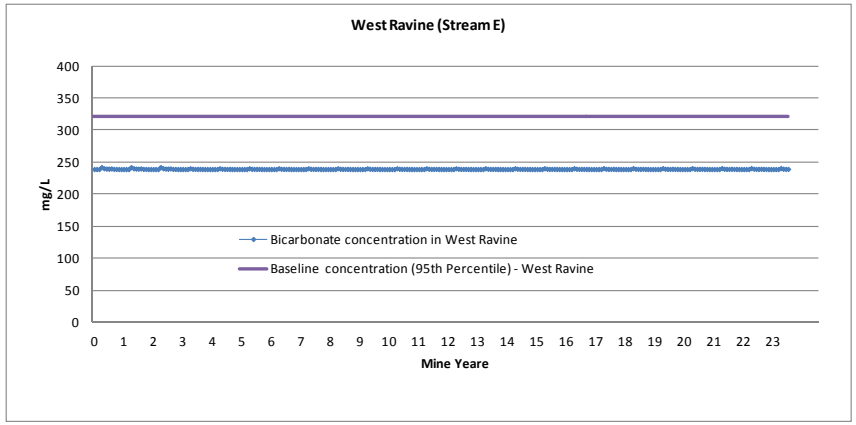
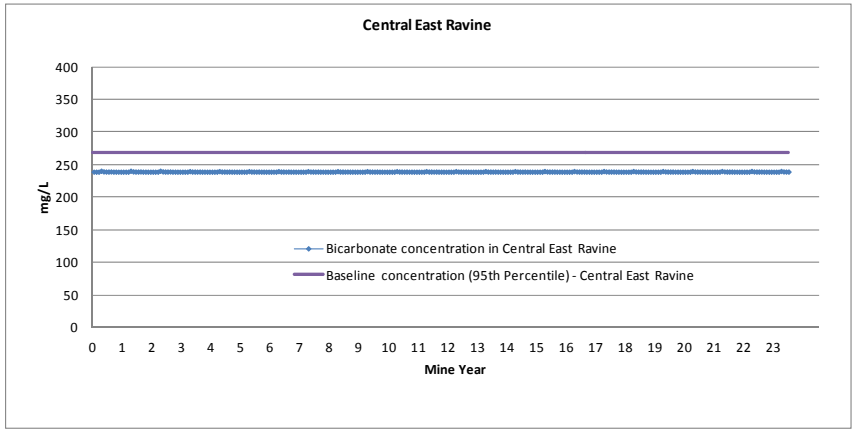
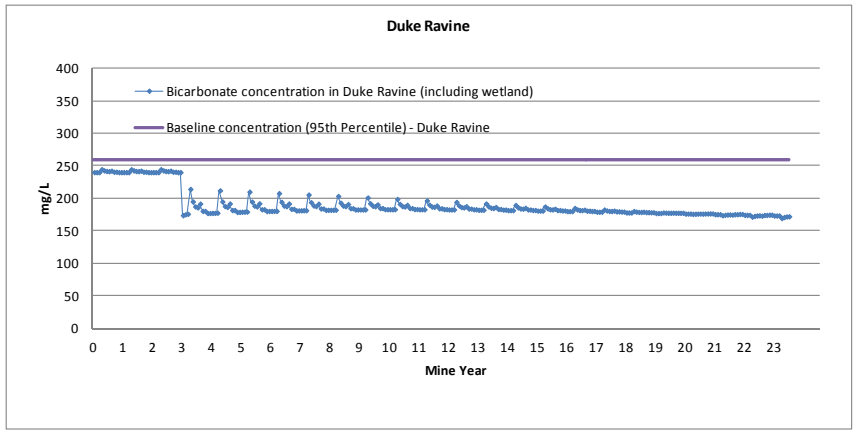
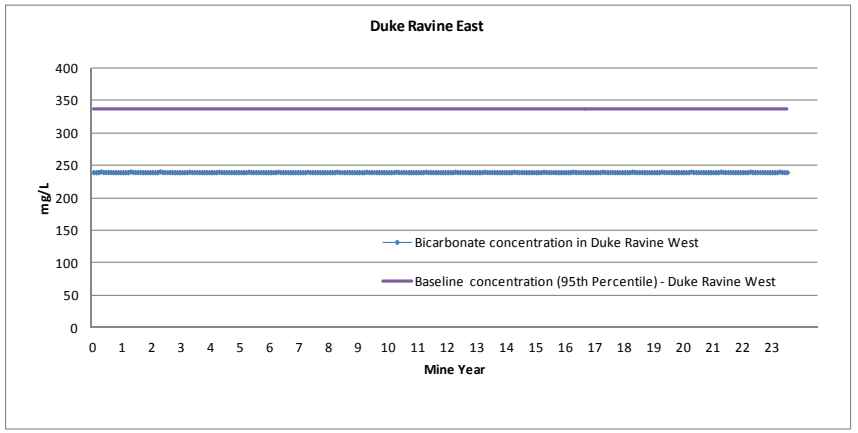


Figure 3-13 Continued









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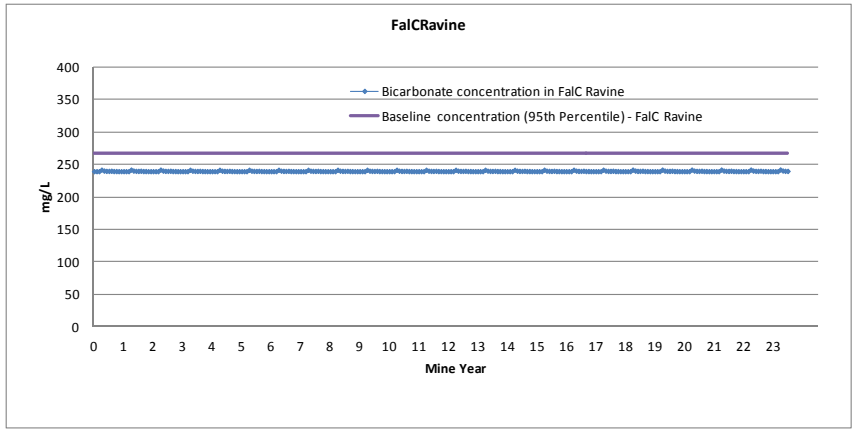
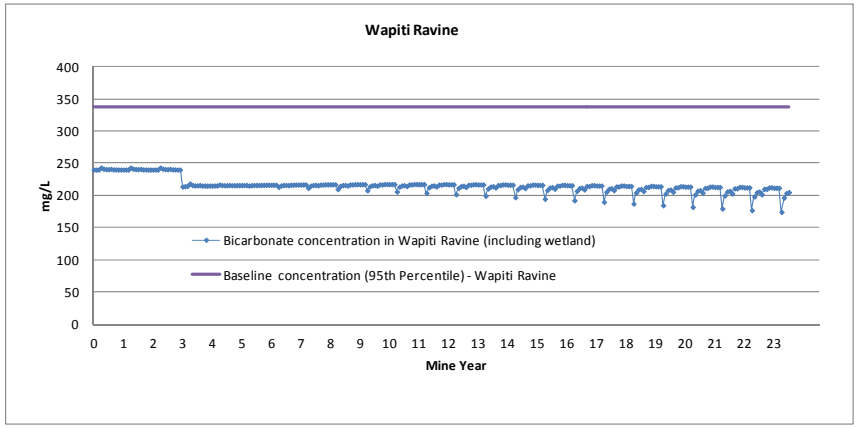
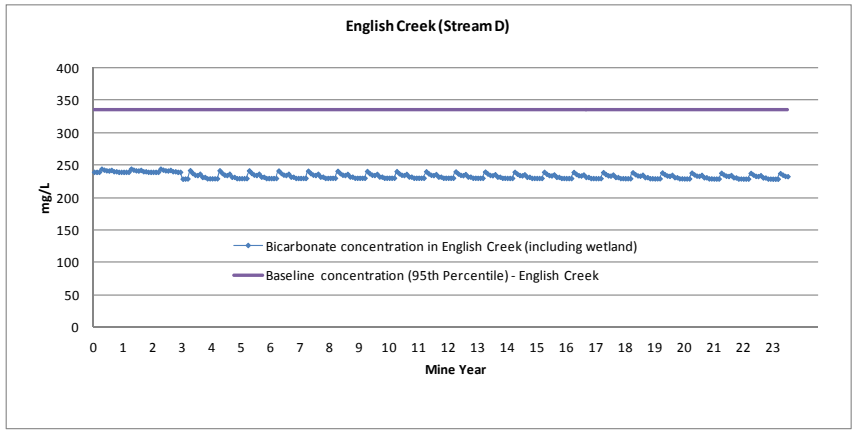






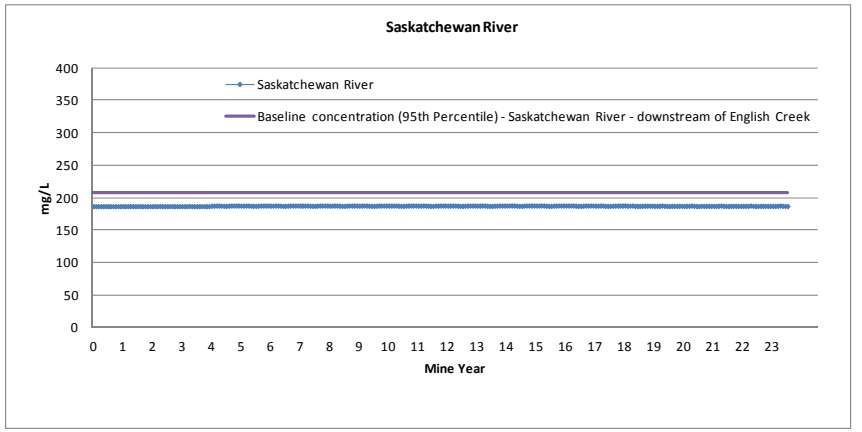
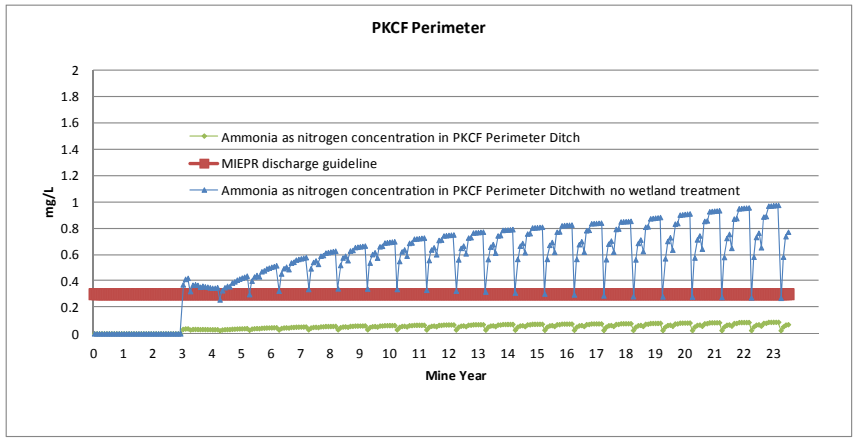
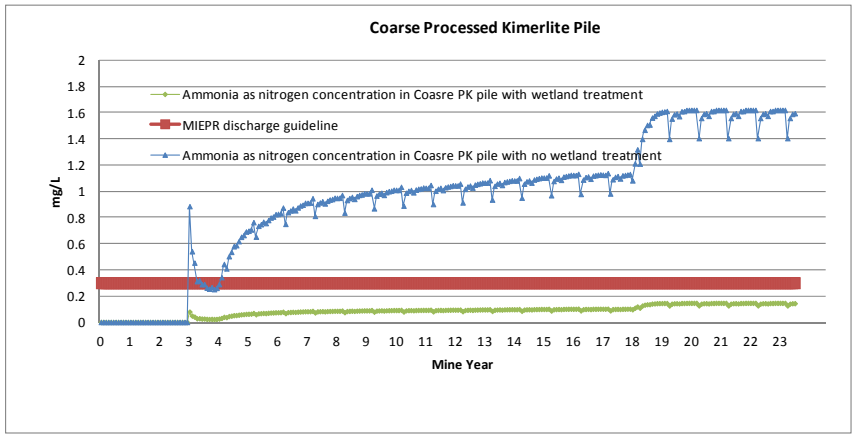


Figure 3-14 Predicted ammonia concentrations during construction and operation





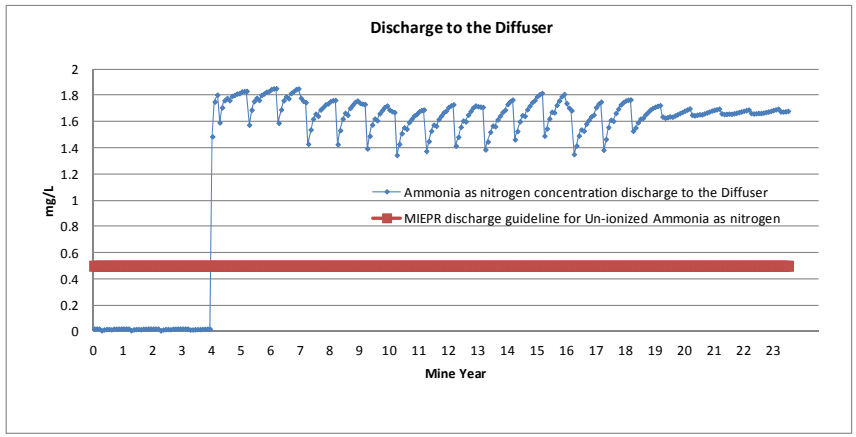
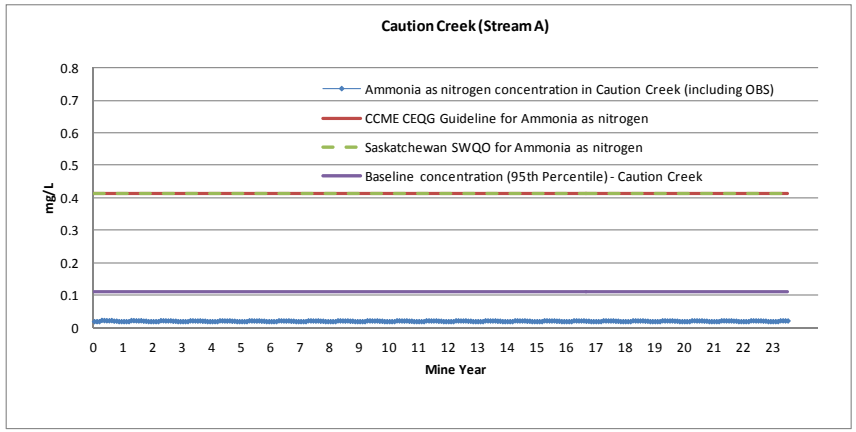
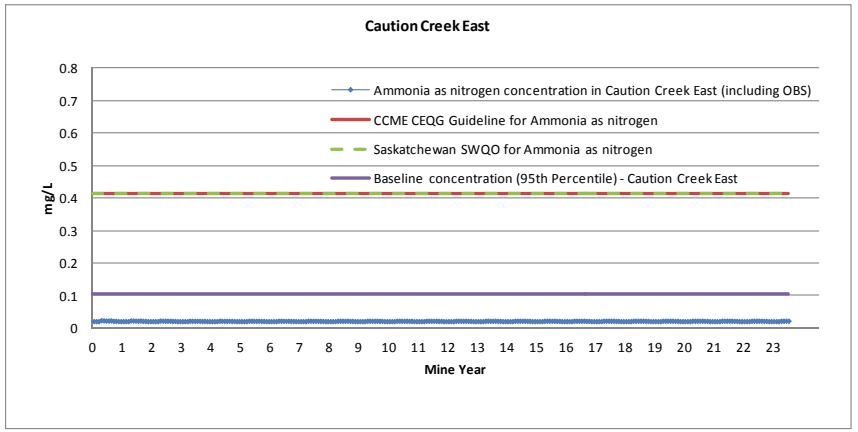
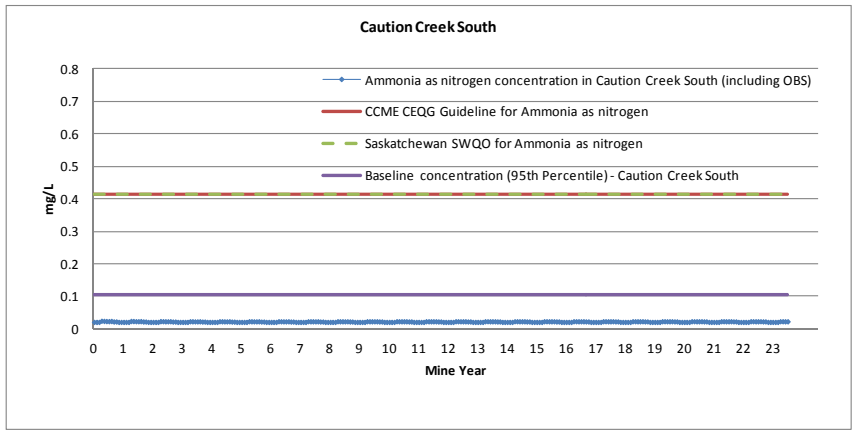


Figure 3-14 Continued







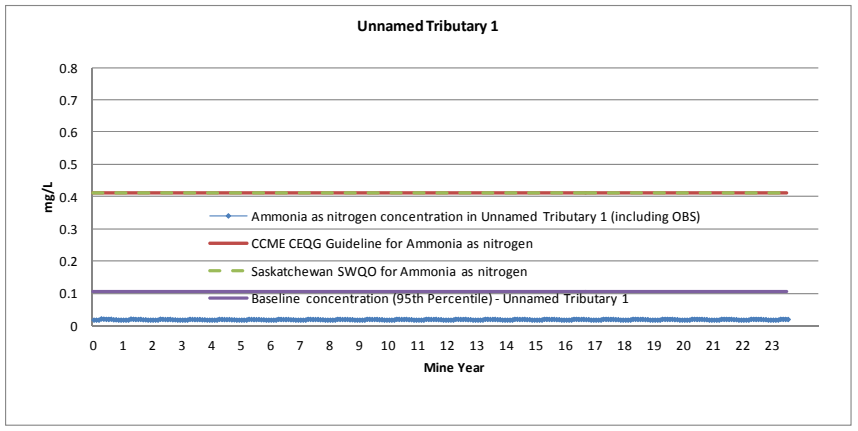
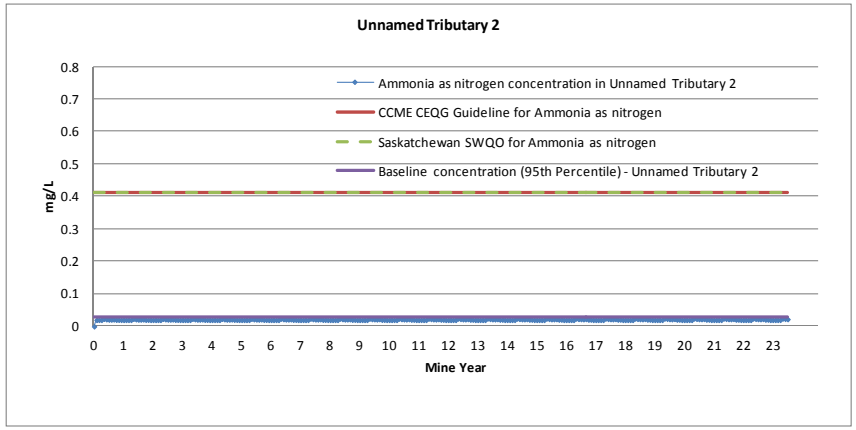
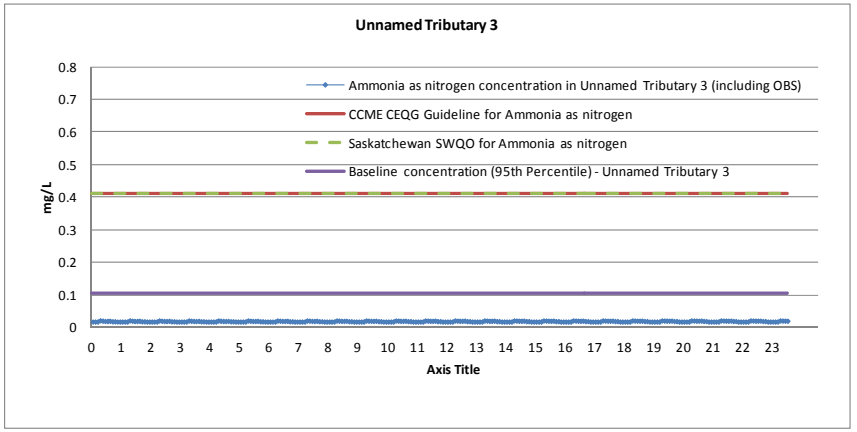
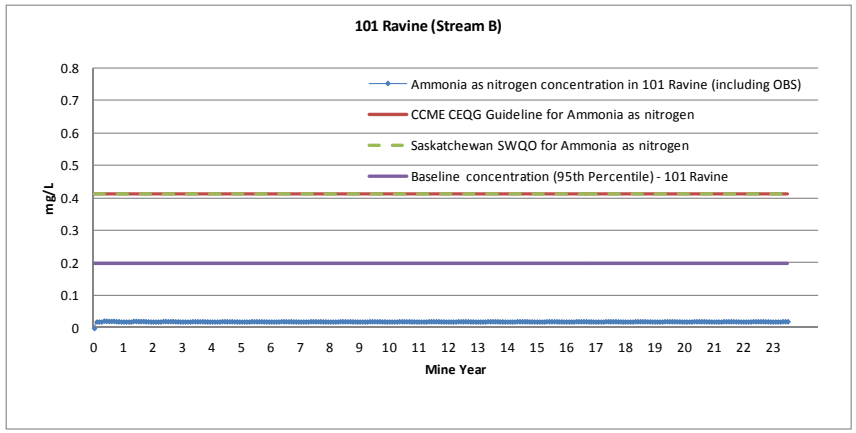


Figure 3-14 Continued







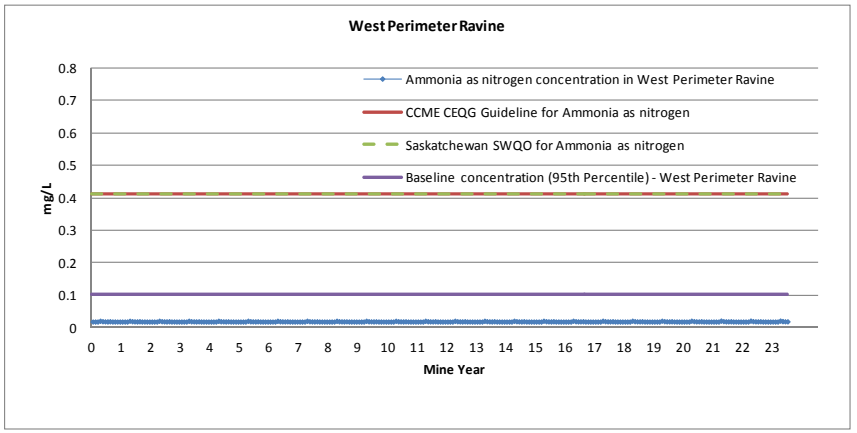
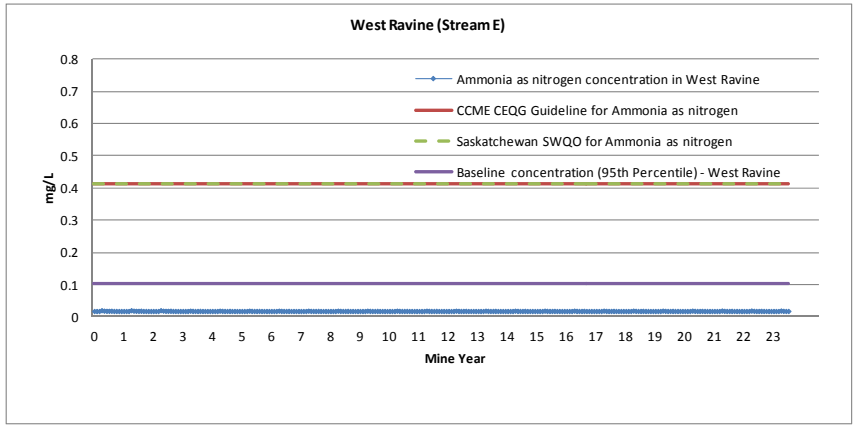
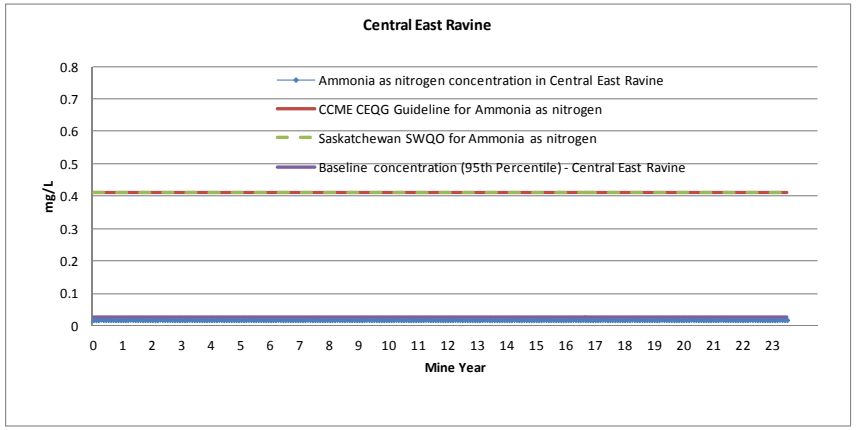
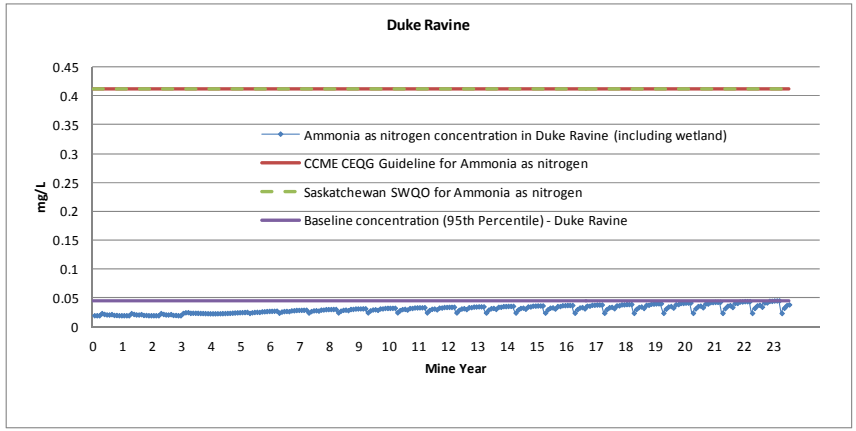


Figure 3-14 Continued







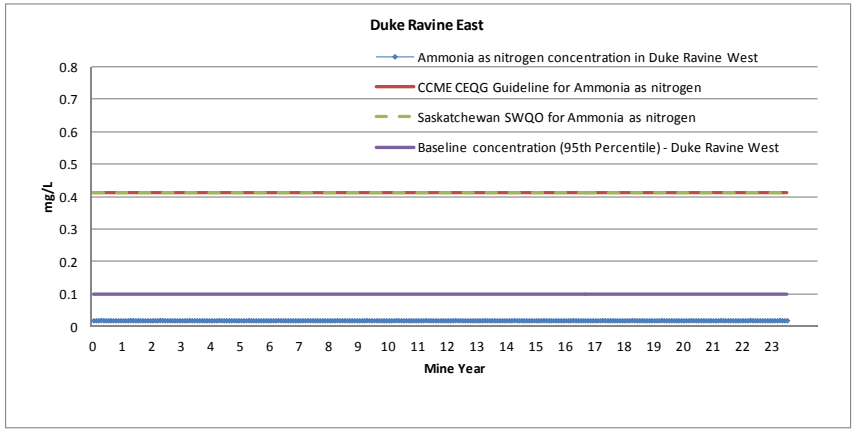
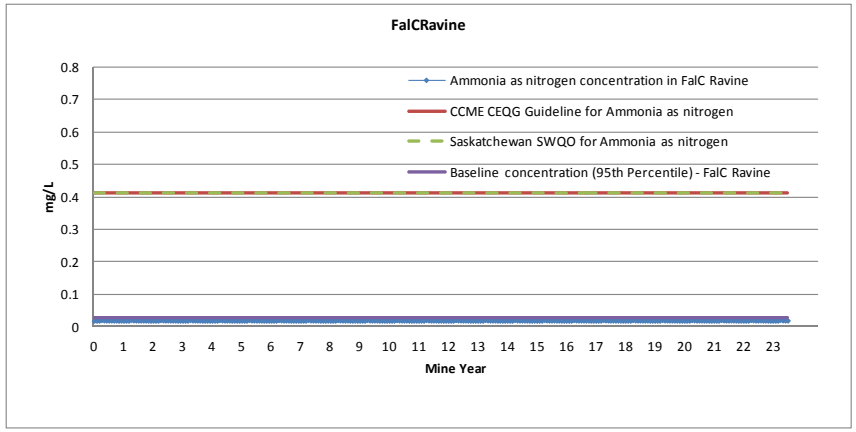
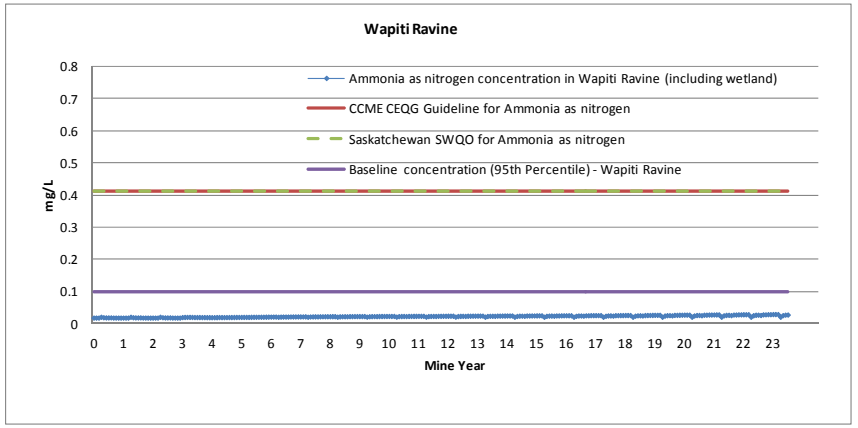
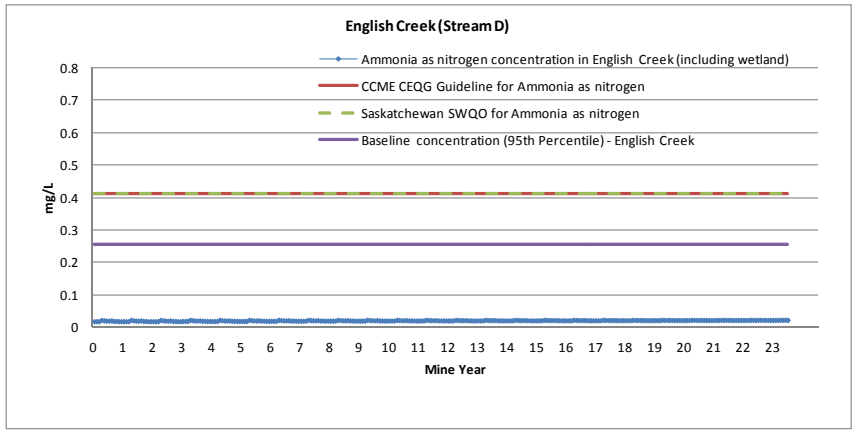


Figure 3-14 Continued







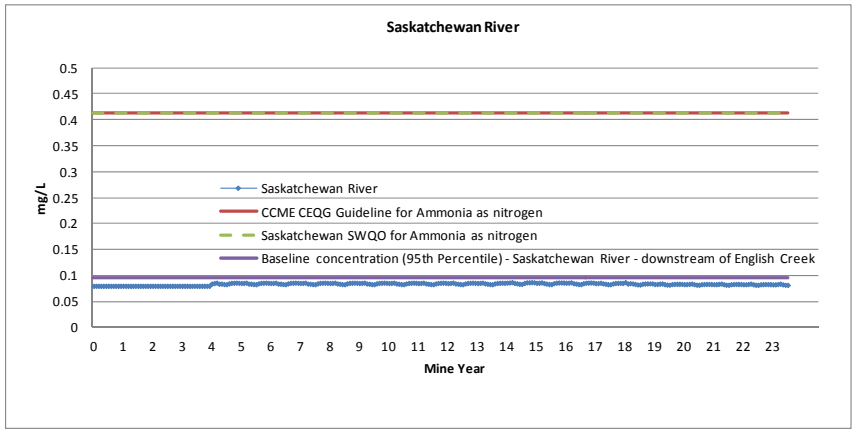
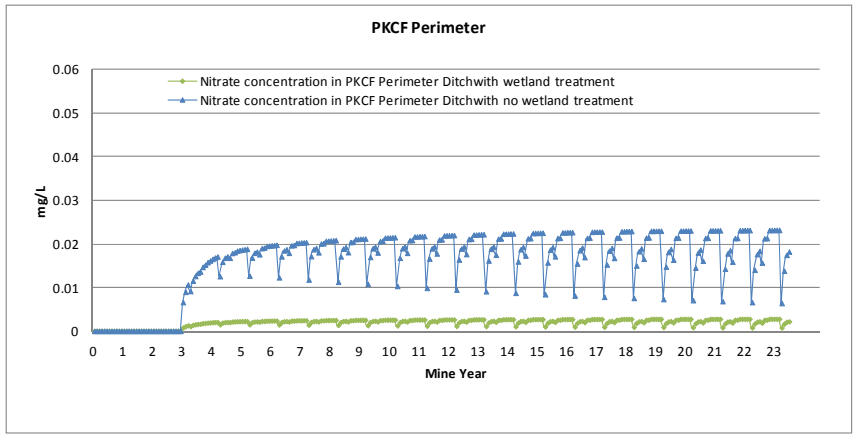
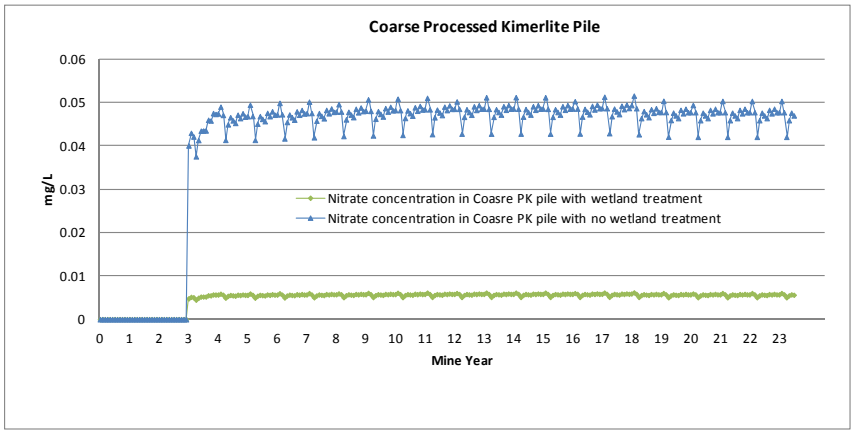


Figure 3-15 Predicted nitrate concentrations during construction and operation





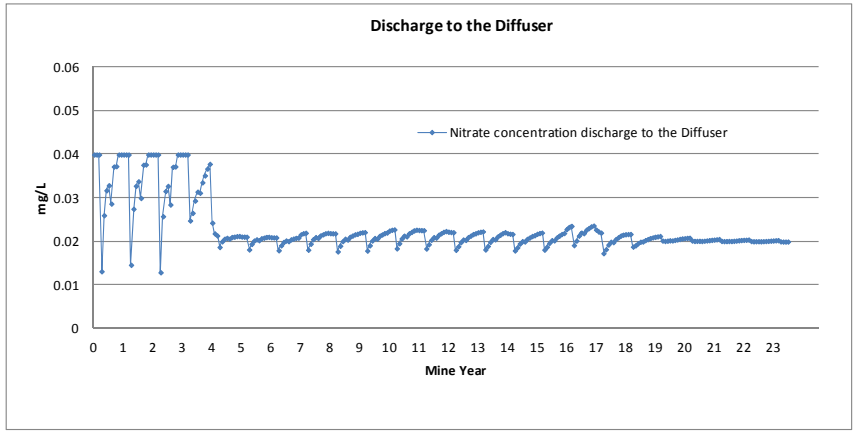
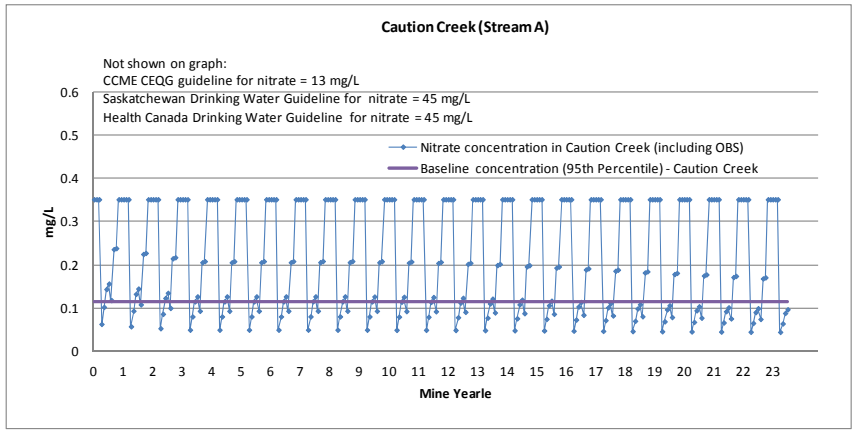
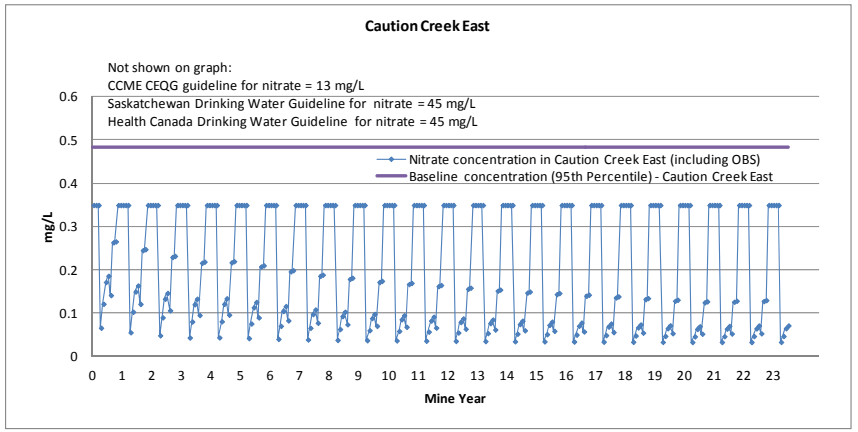
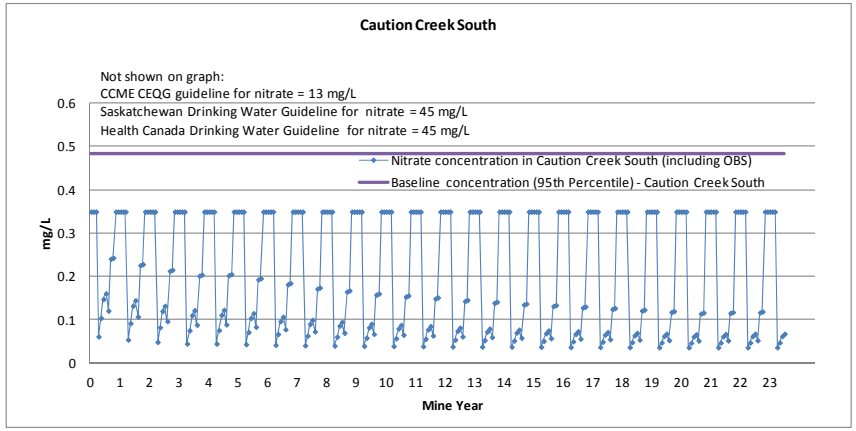


Figure 3-15 Continued







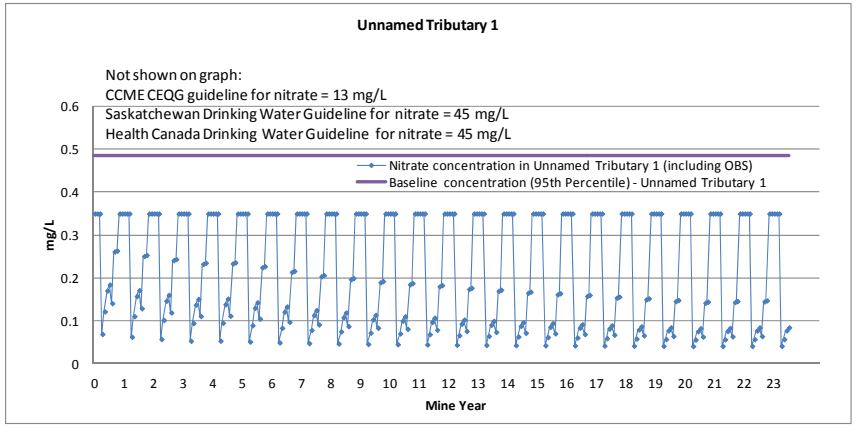
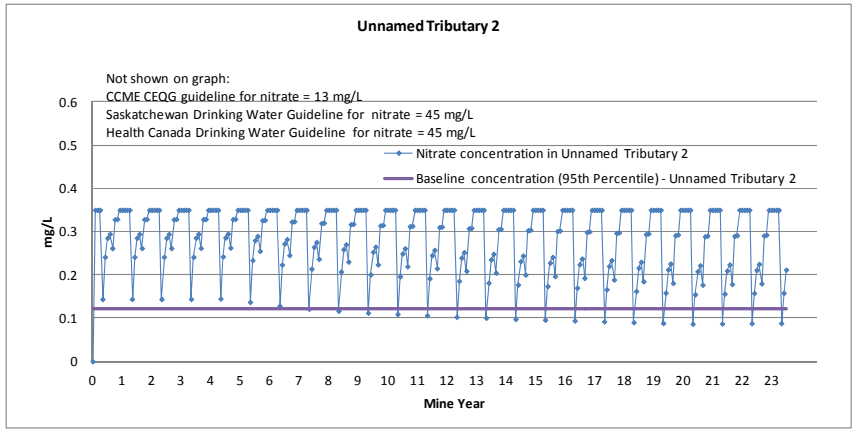
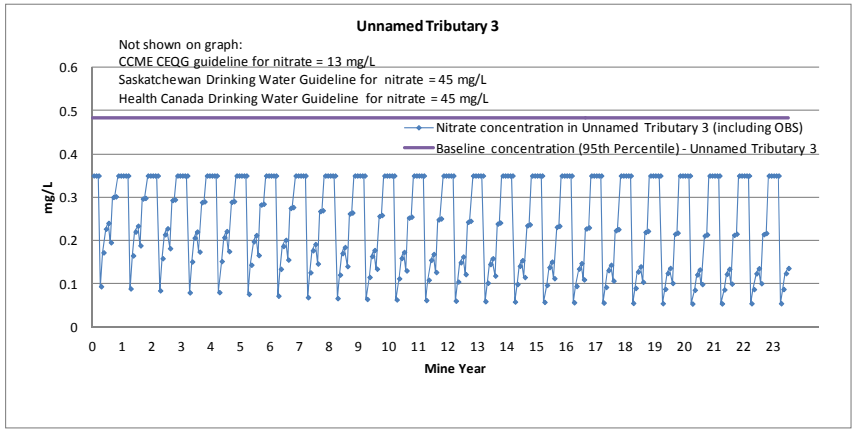
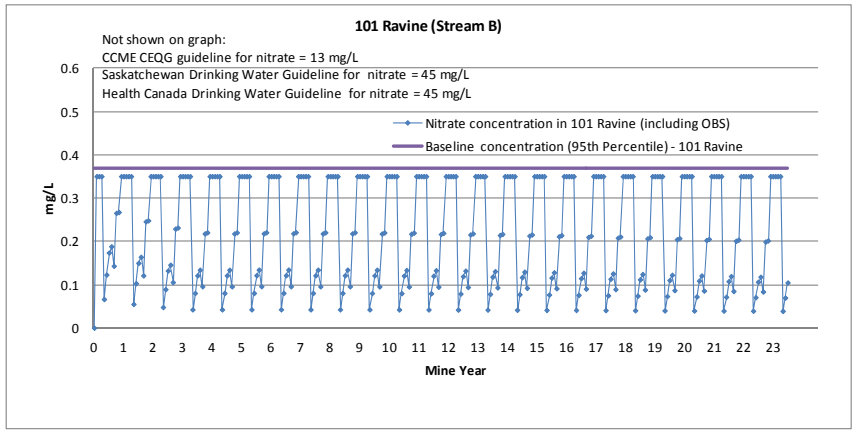
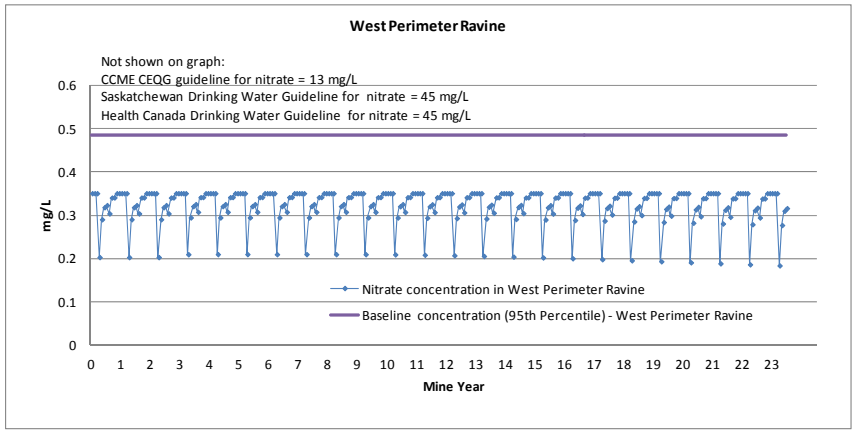


Figure 3-15 Continued









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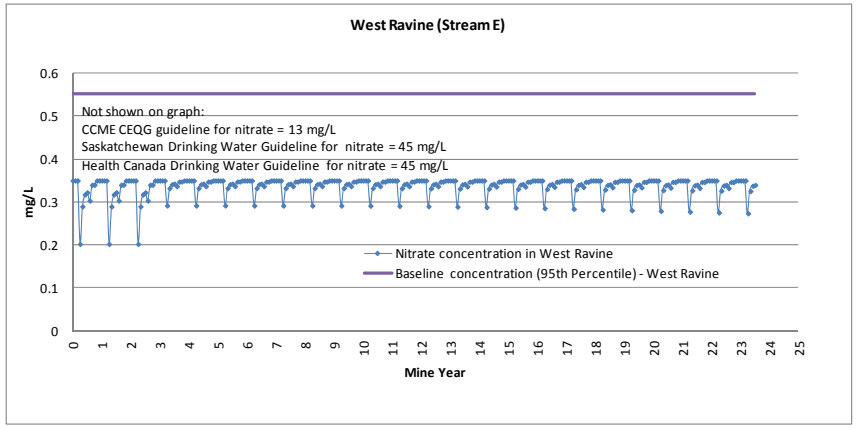
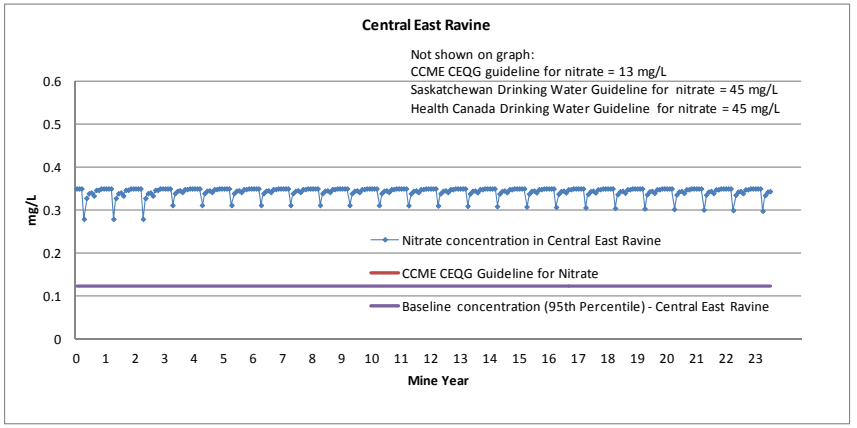
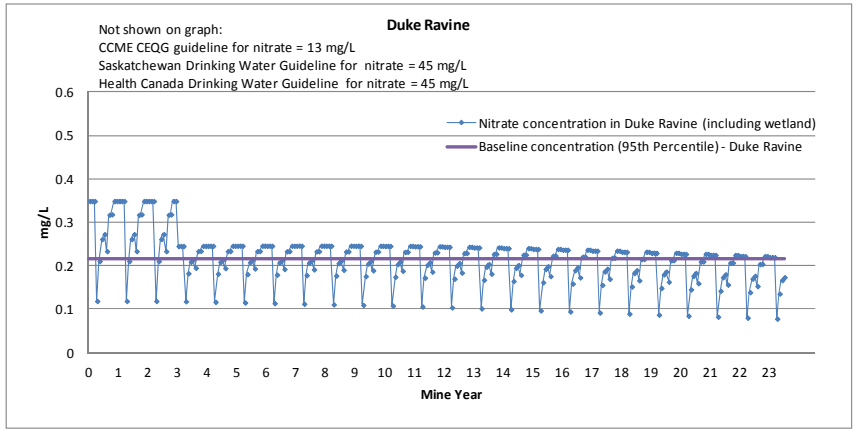






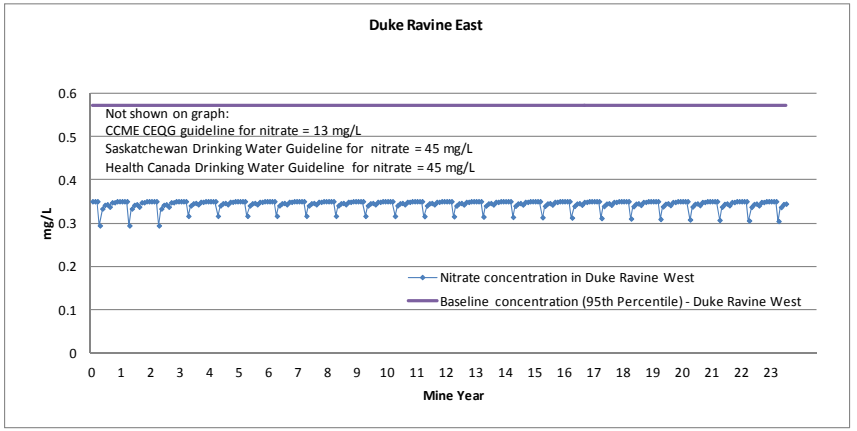
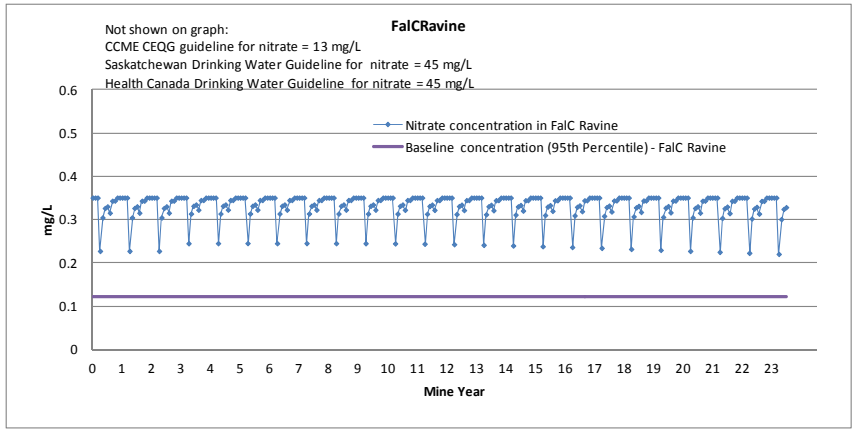
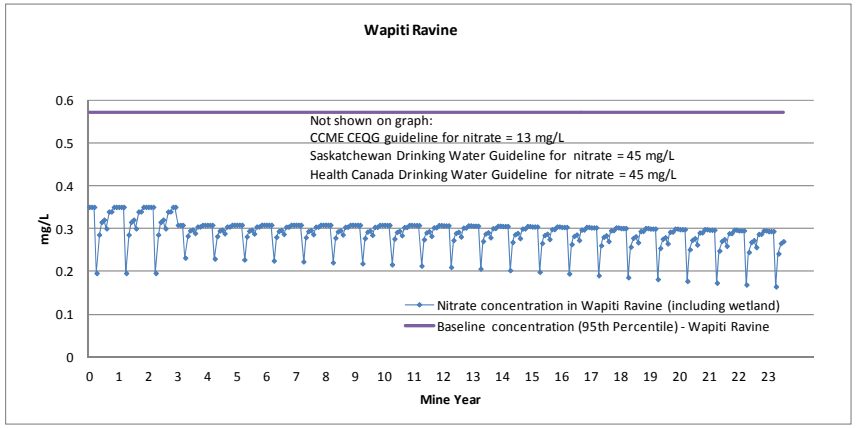
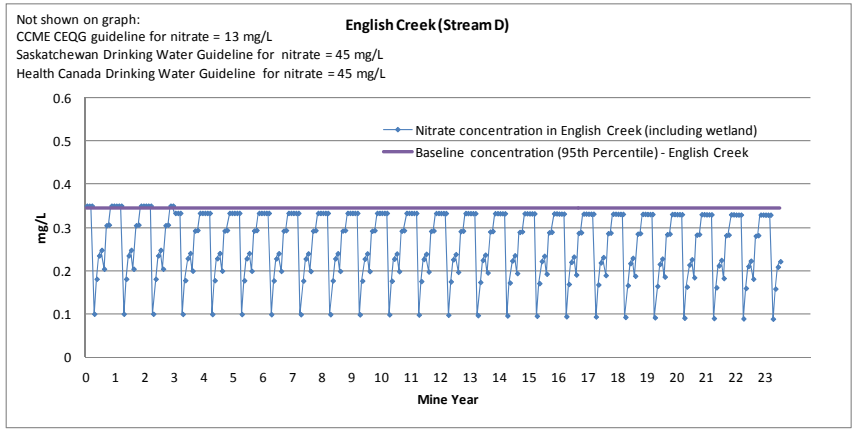


Figure 3-15 Continued







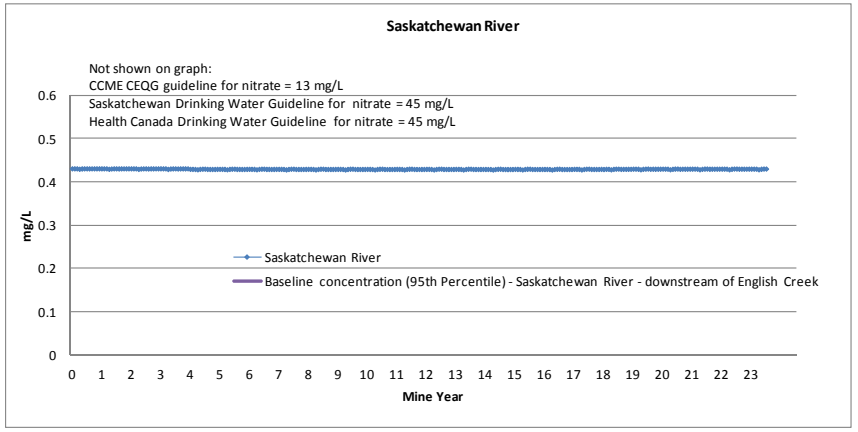
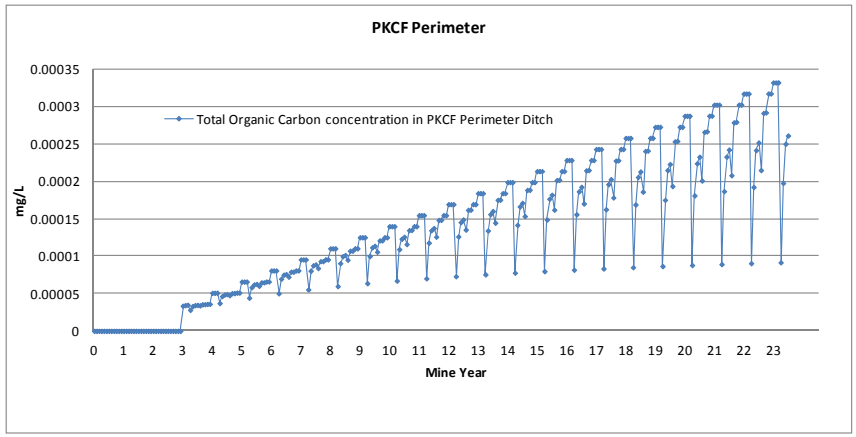
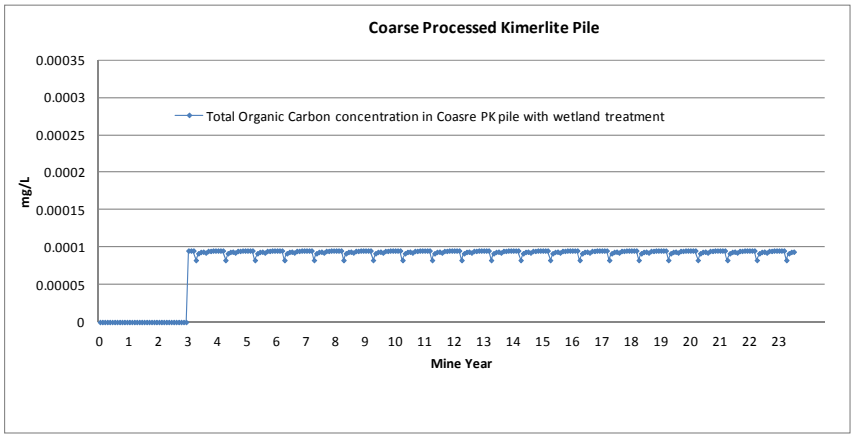


Figure 3-16 Predicted total organic carbon concentrations during construction and operation





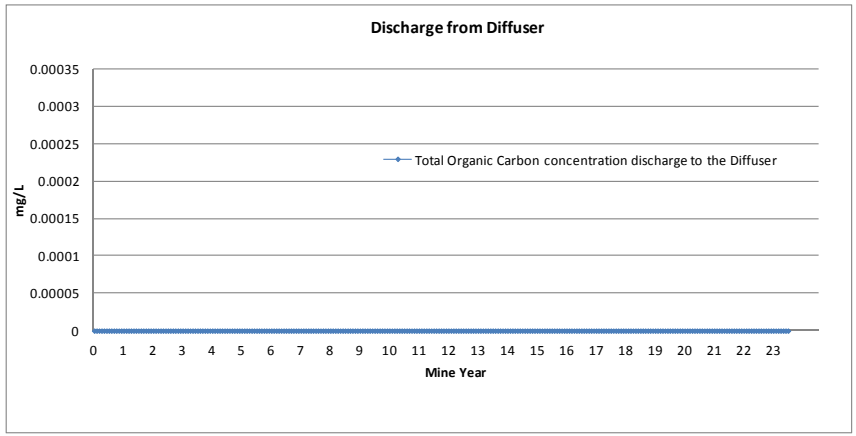
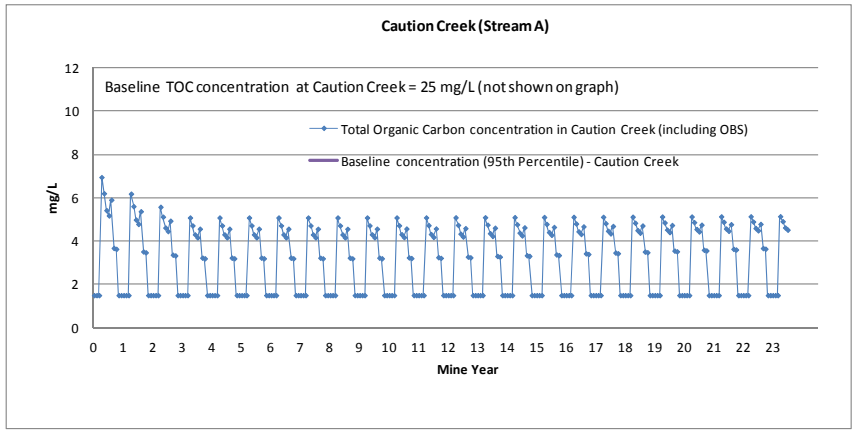
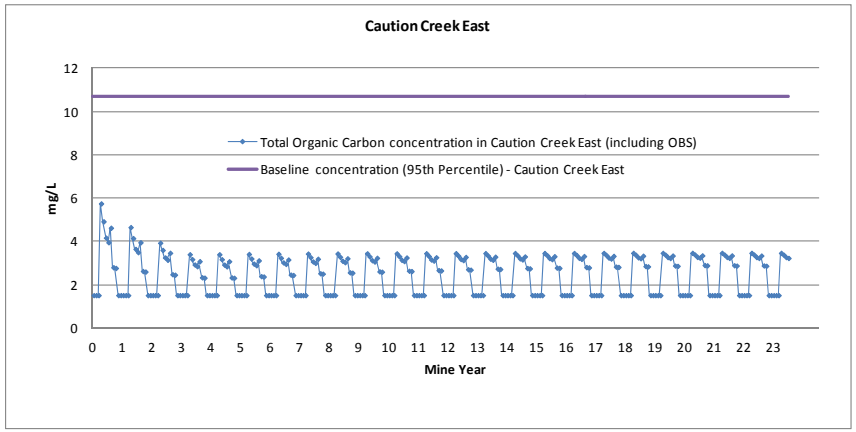
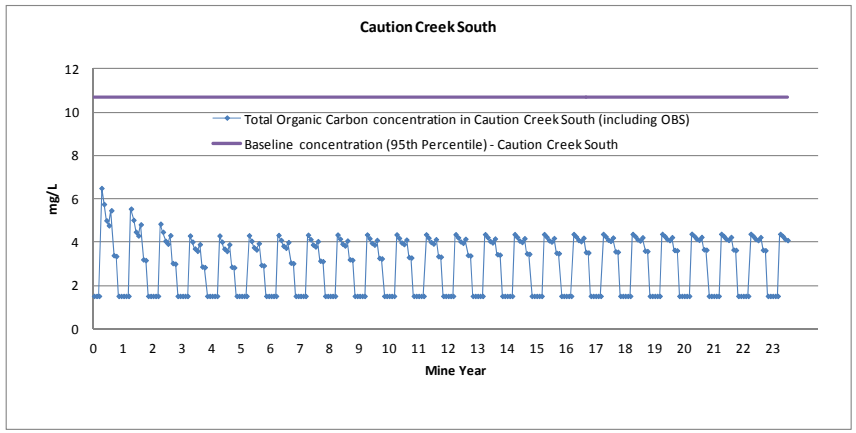


Figure 3-16 Continued







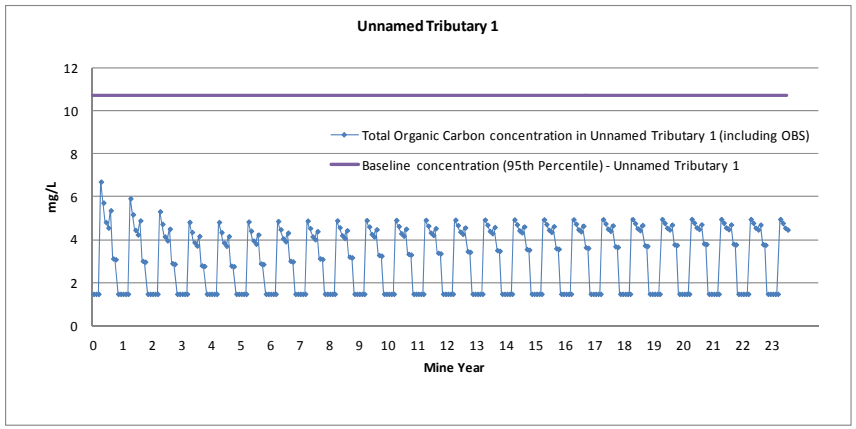
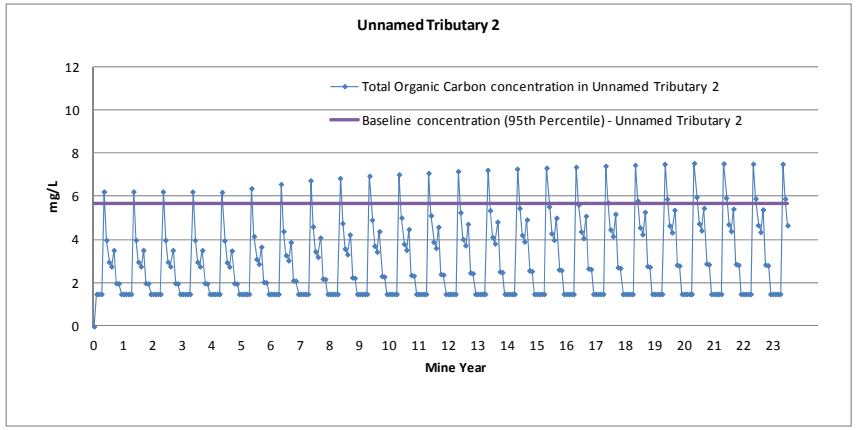
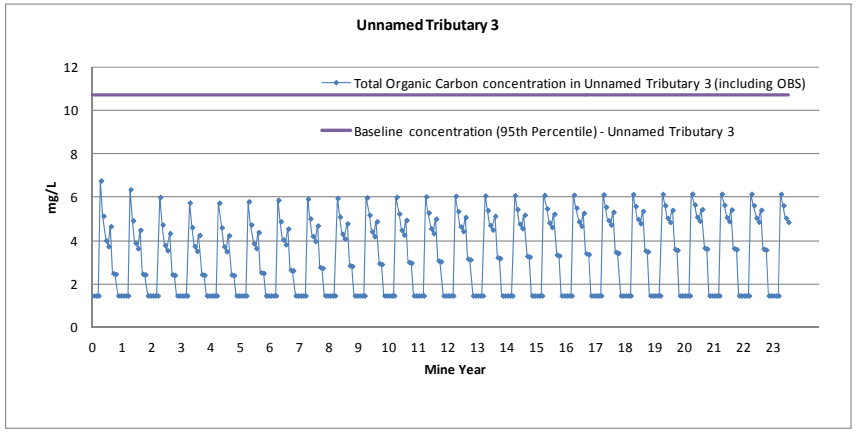
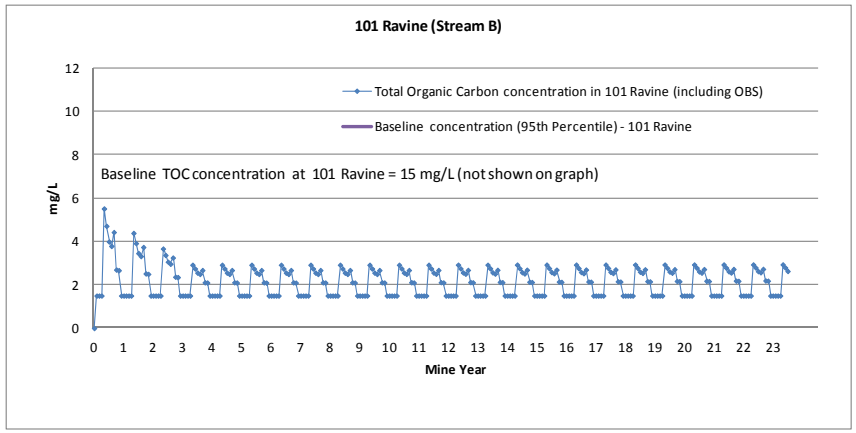


Figure 3-16 Continued







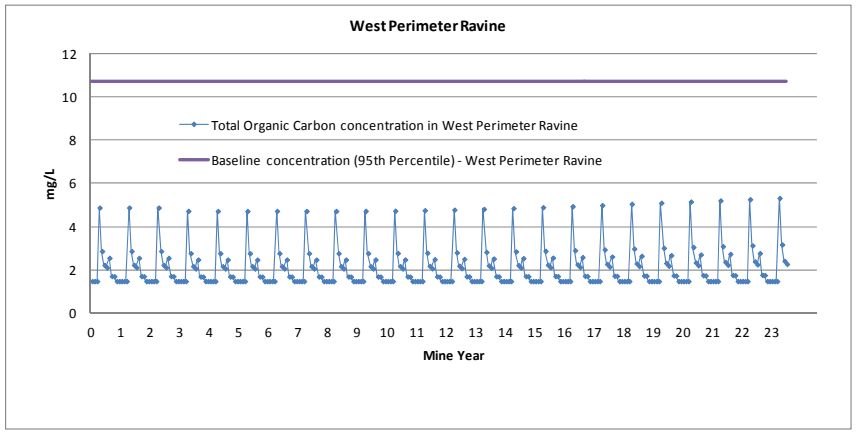
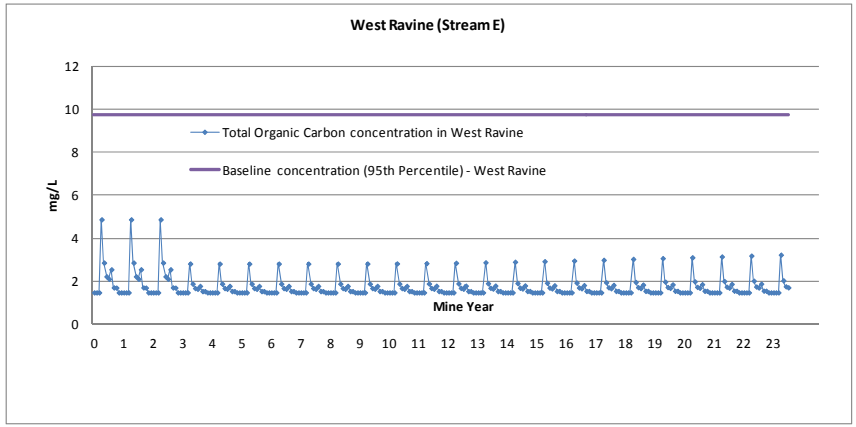
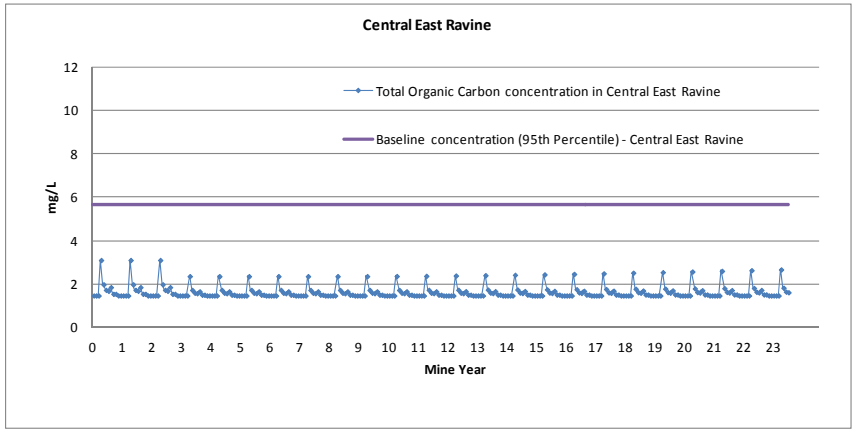
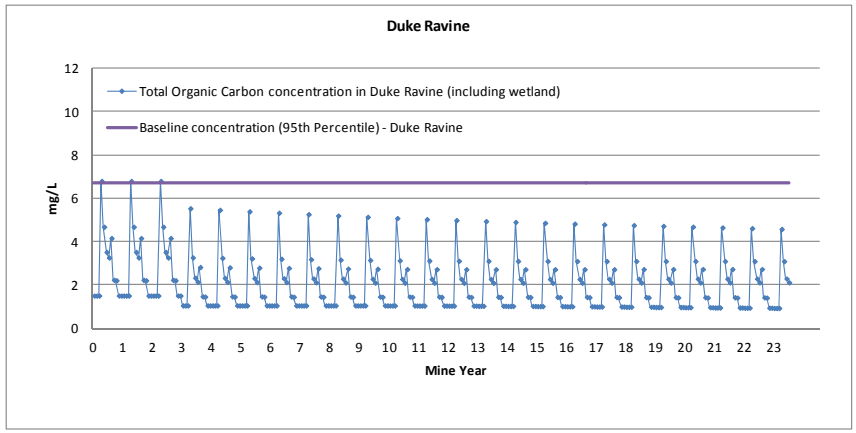


Figure 3-16 Continued







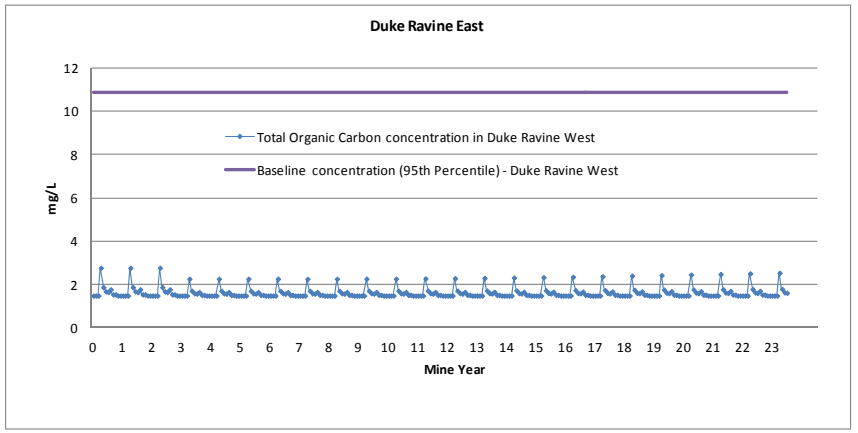
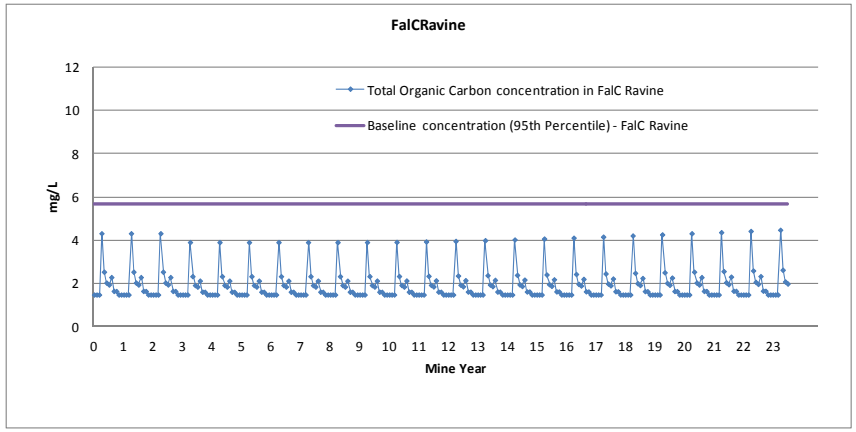
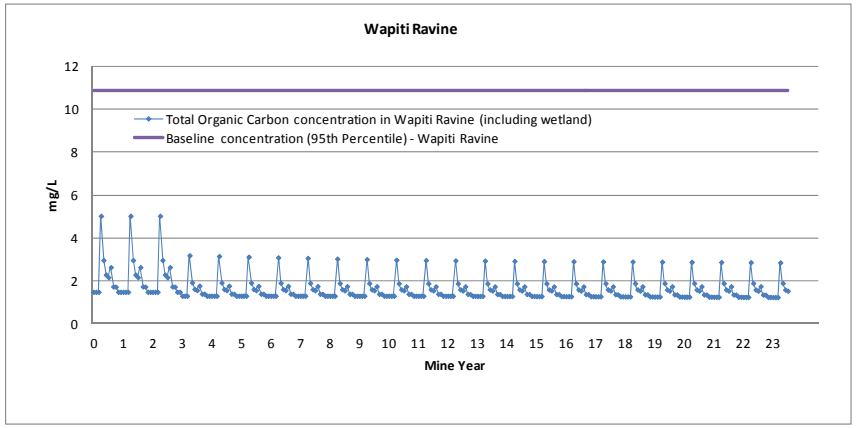
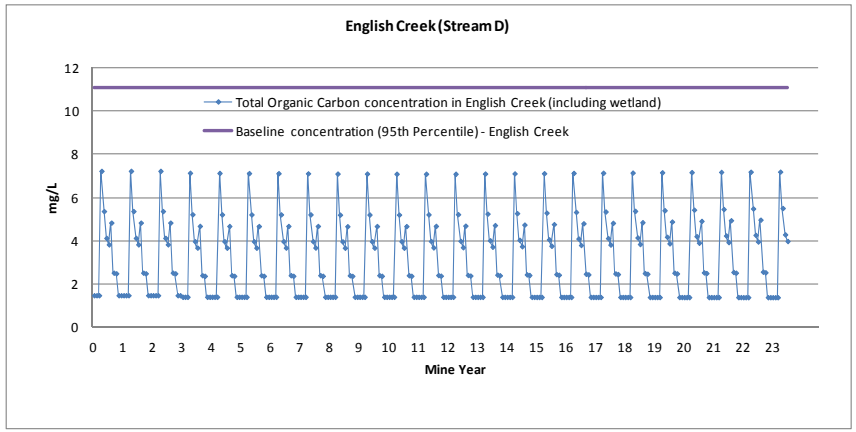


Figure 3-16 Continued







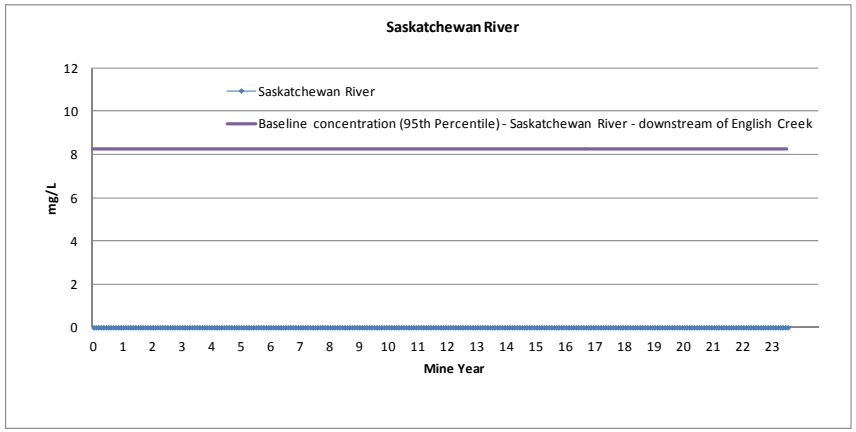
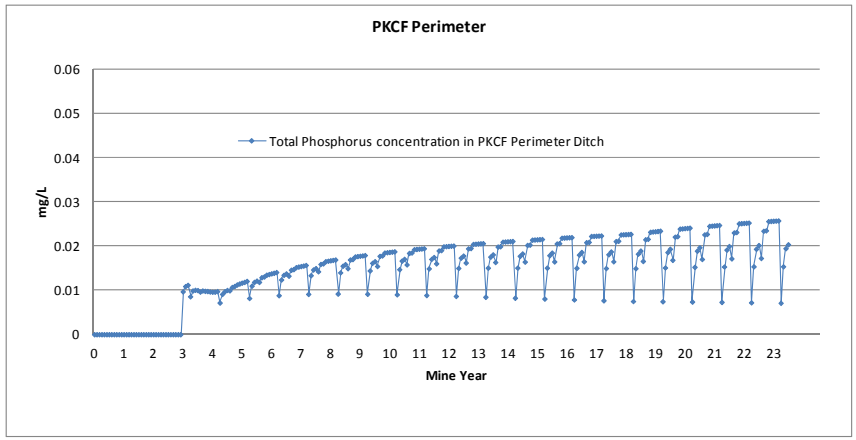
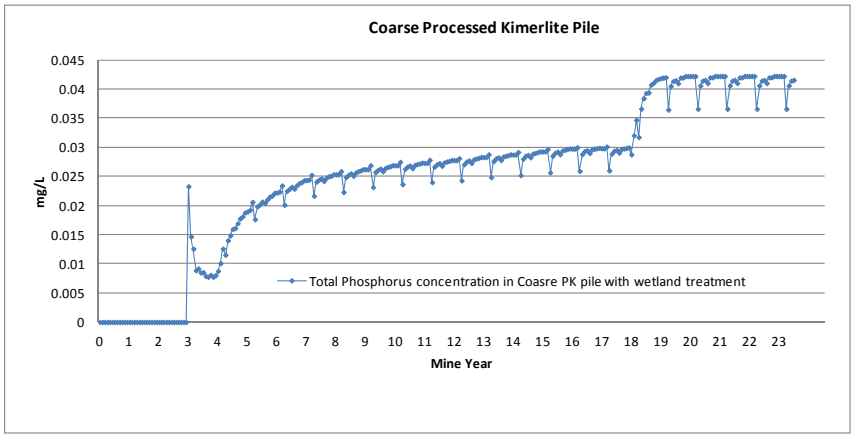


Figure 3-17 Predicted phosphorus concentrations during construction and operation





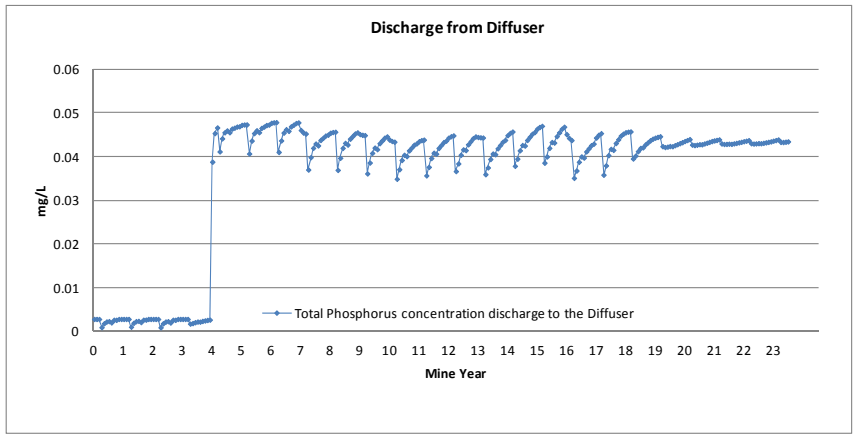
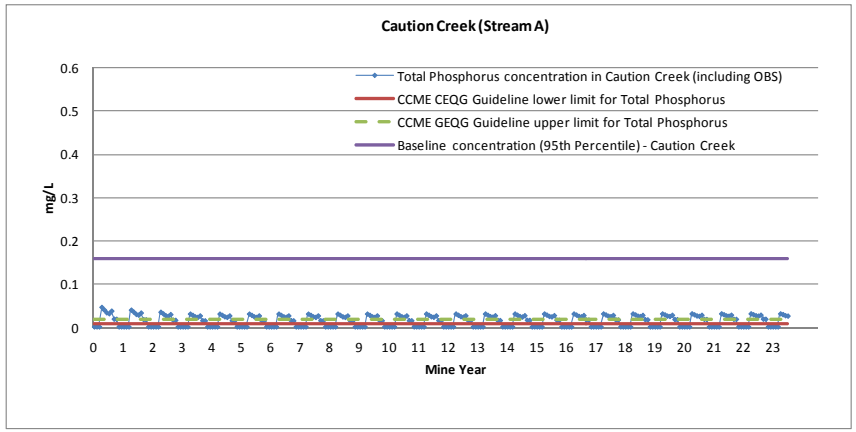
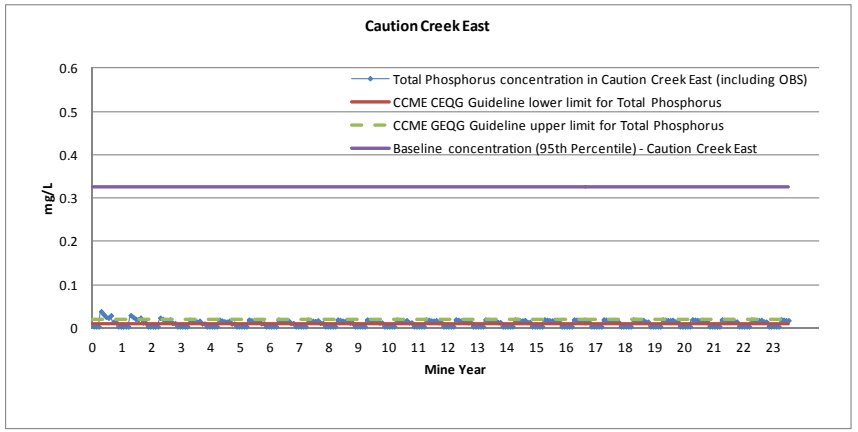
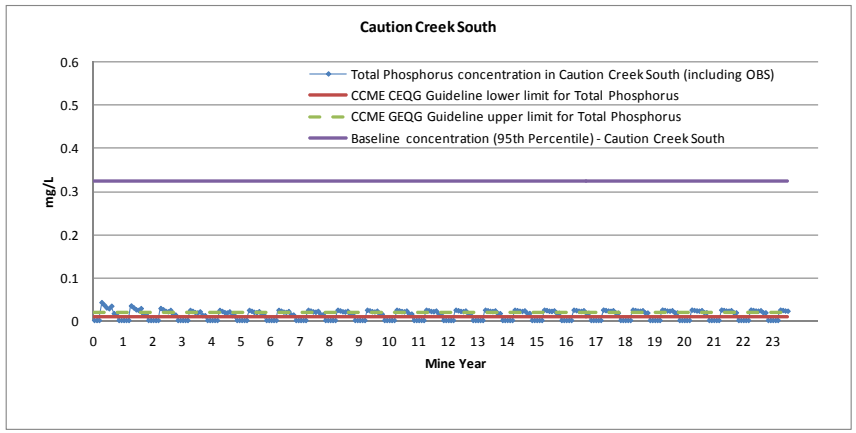


Figure 3-17 Continued







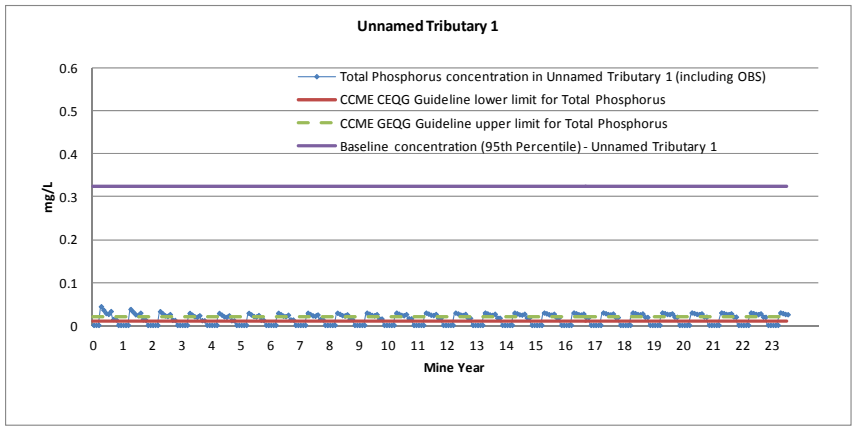
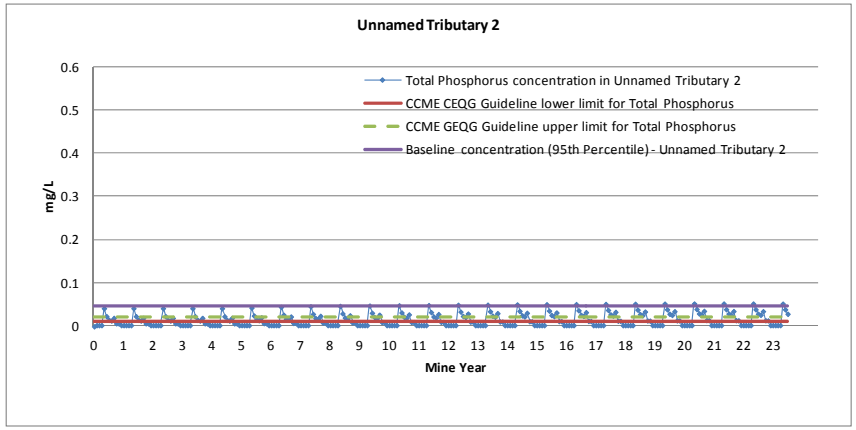
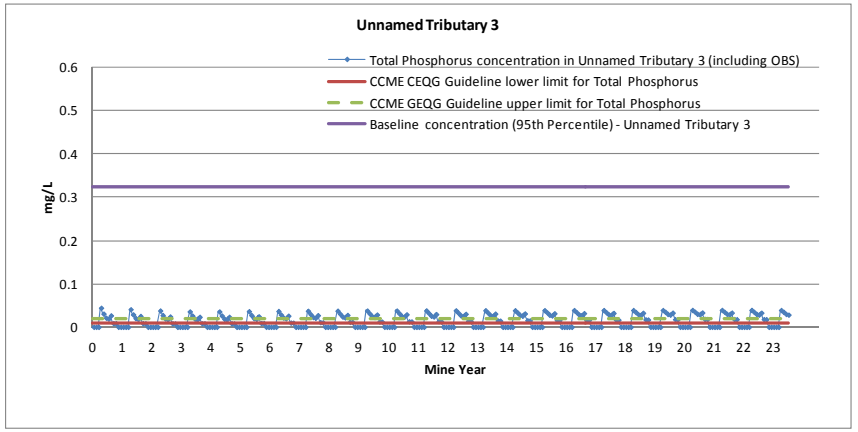
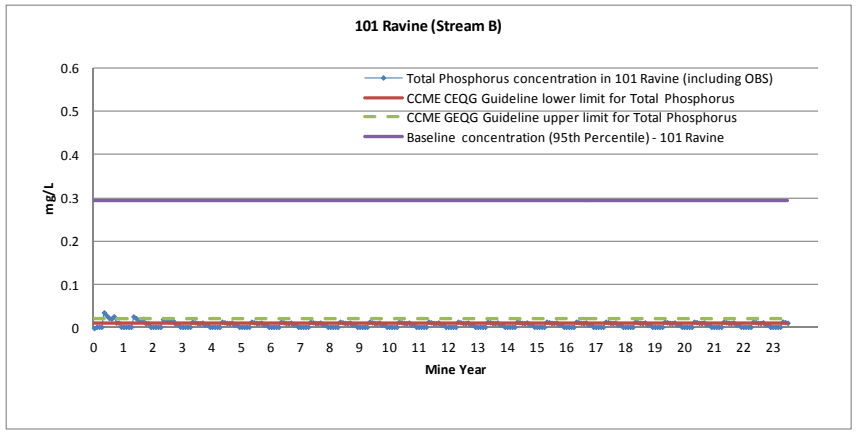


Figure 3-17 Continued







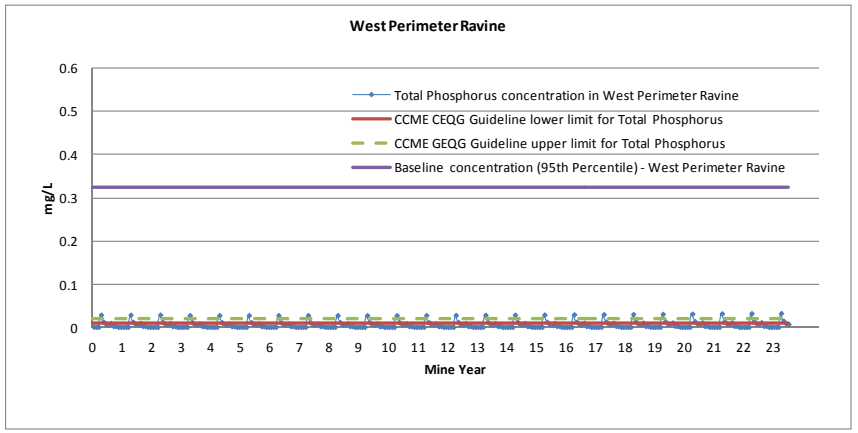
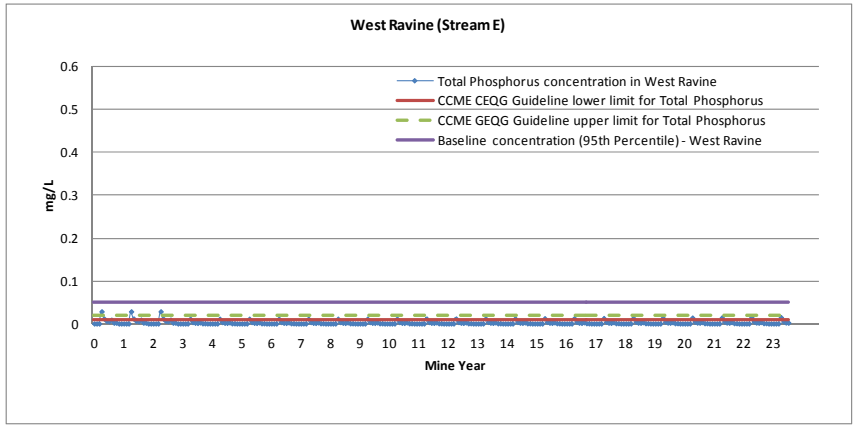
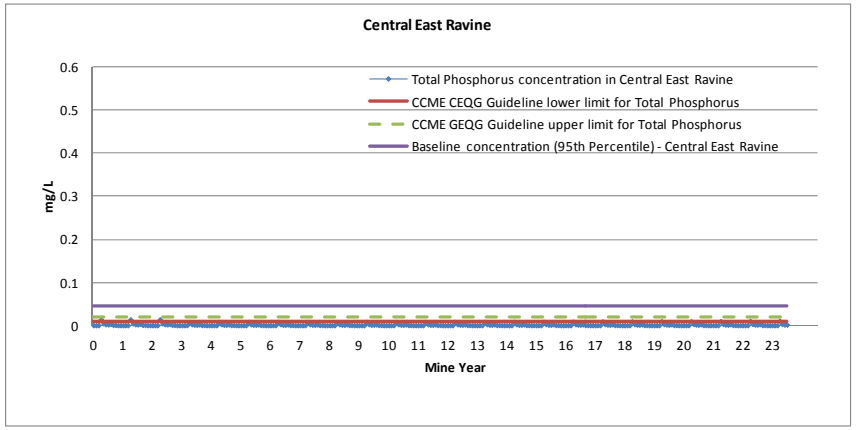
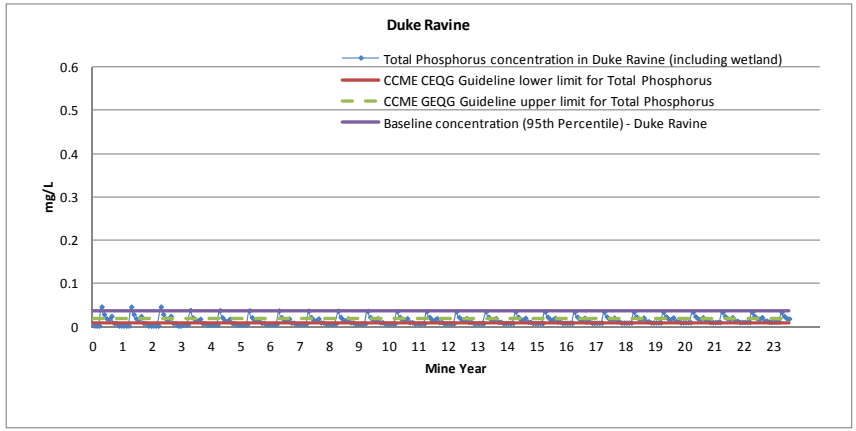


Figure 3-17 Continued







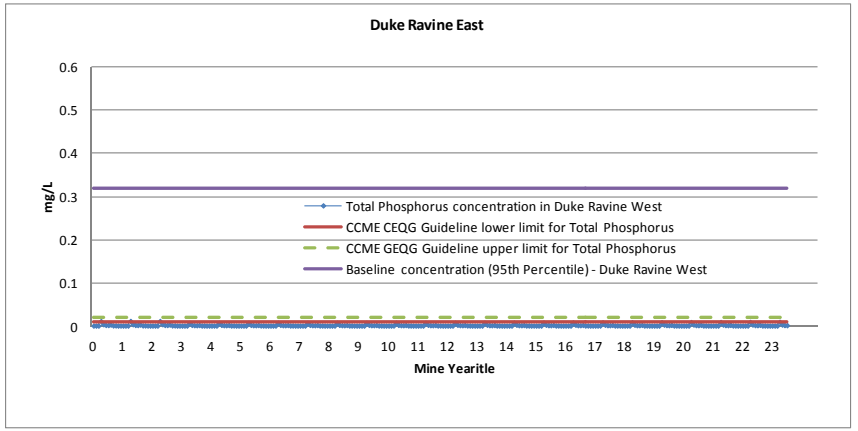
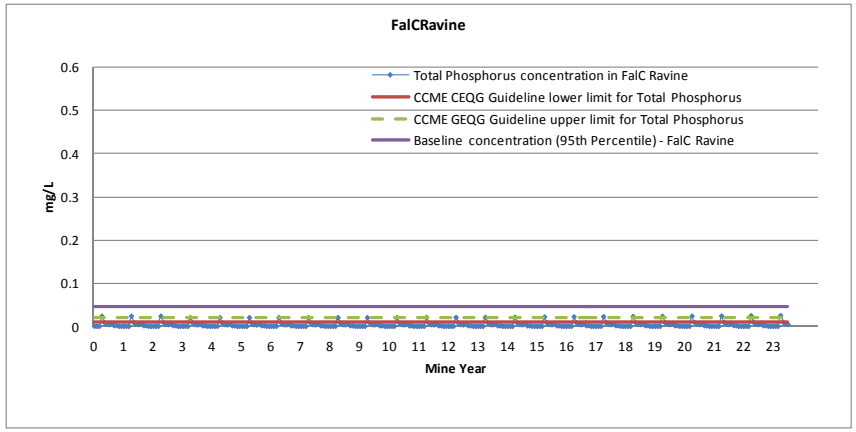
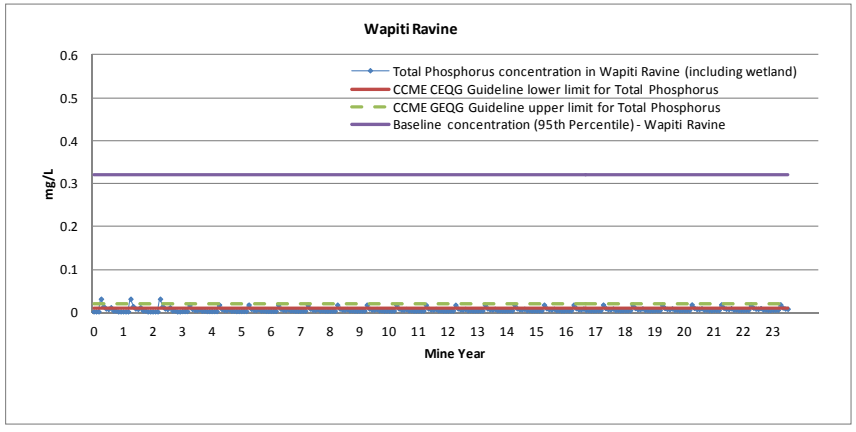
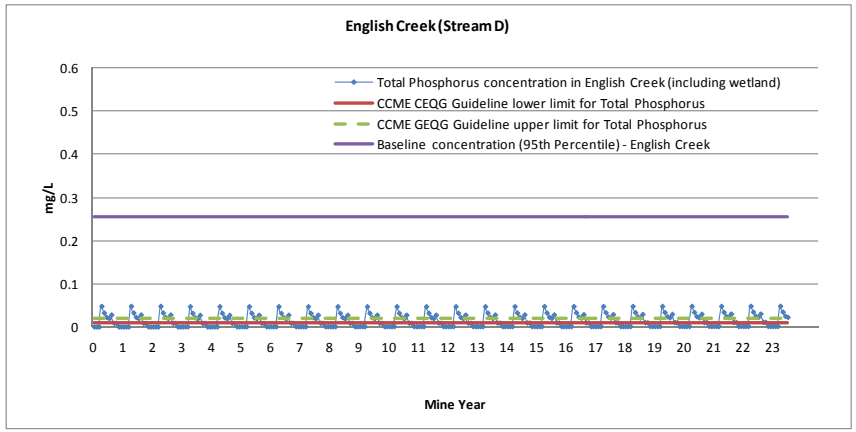


Figure 3-17 Continued







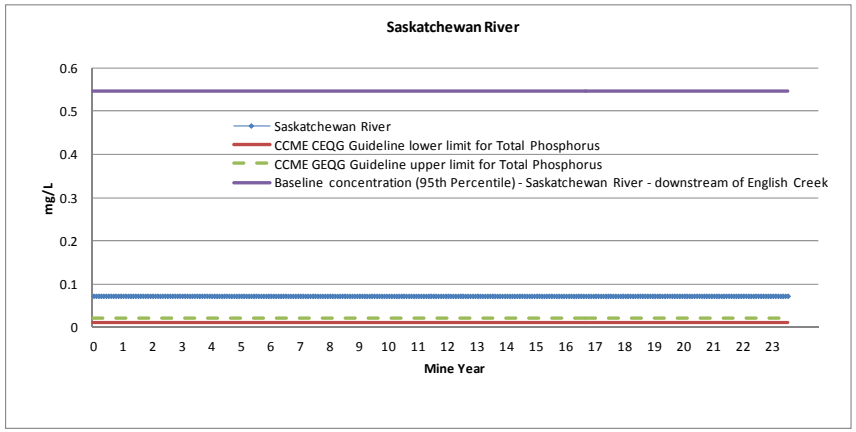
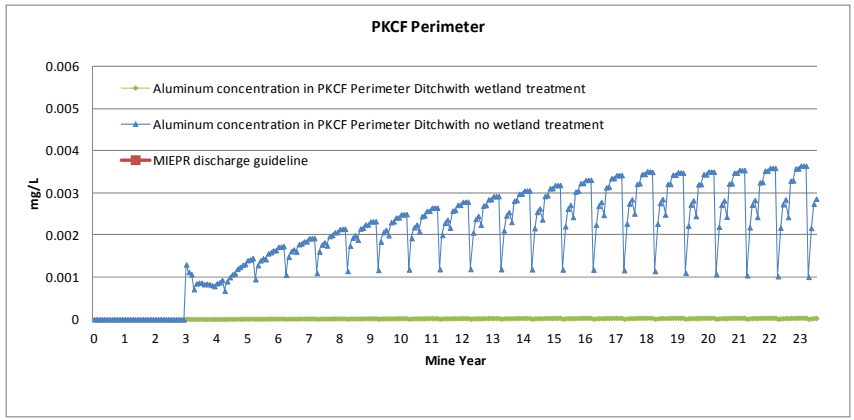
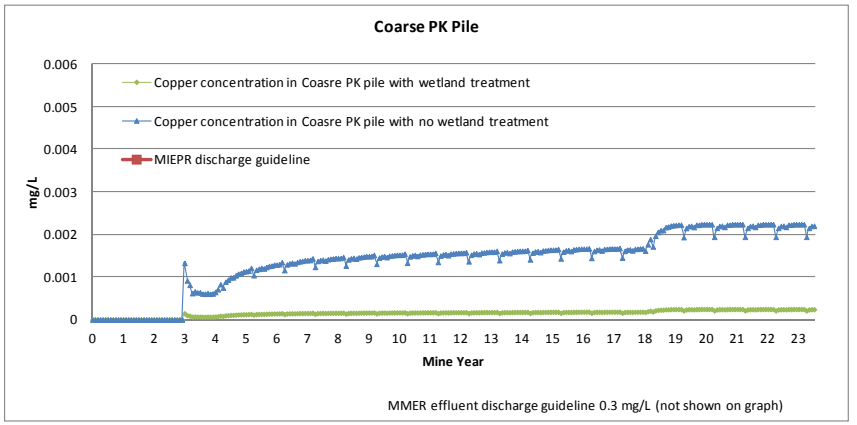


Figure 3-18 Predicted aluminum concentrations during construction and operation





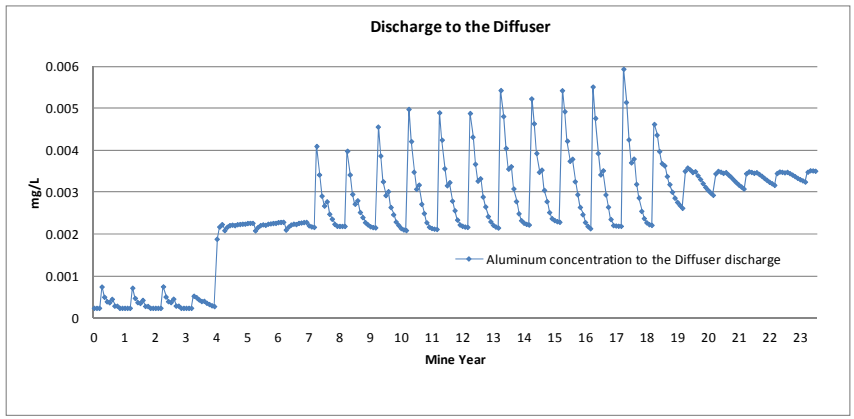
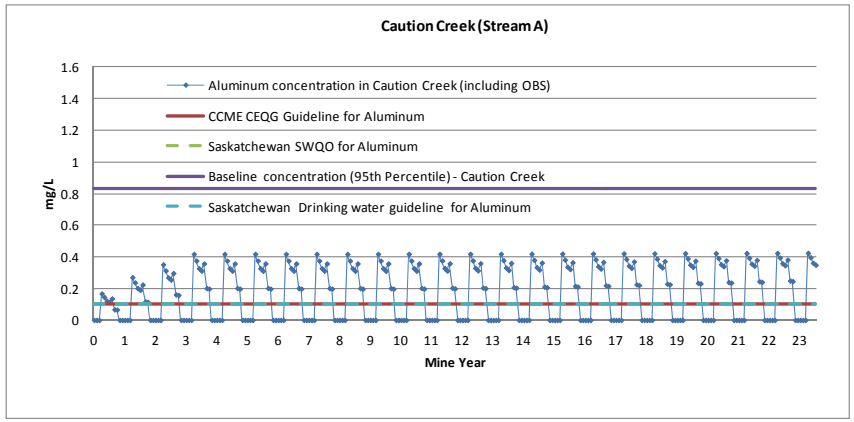
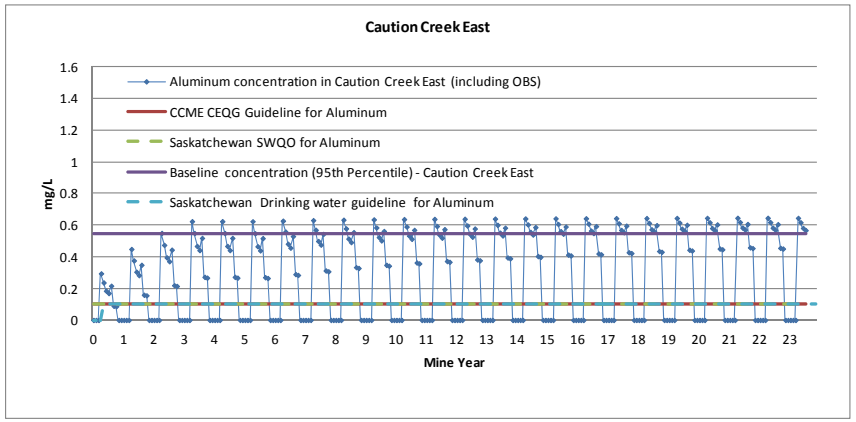
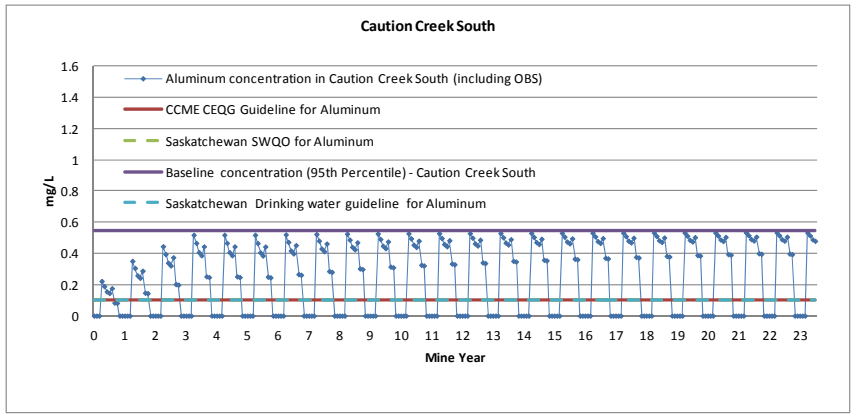


Figure 3-18 Continued







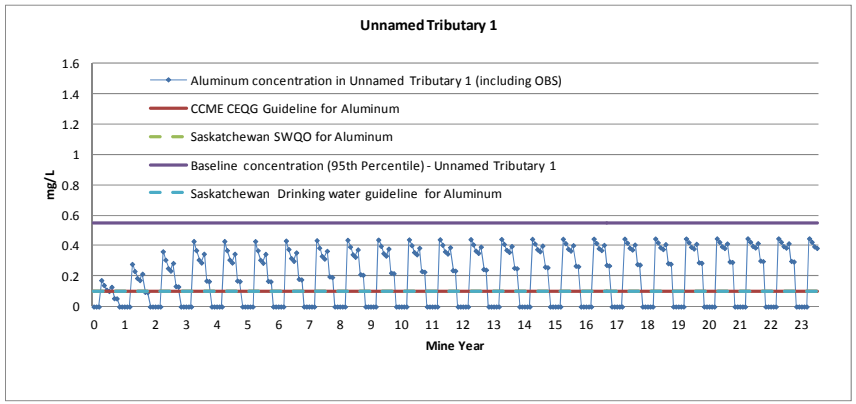
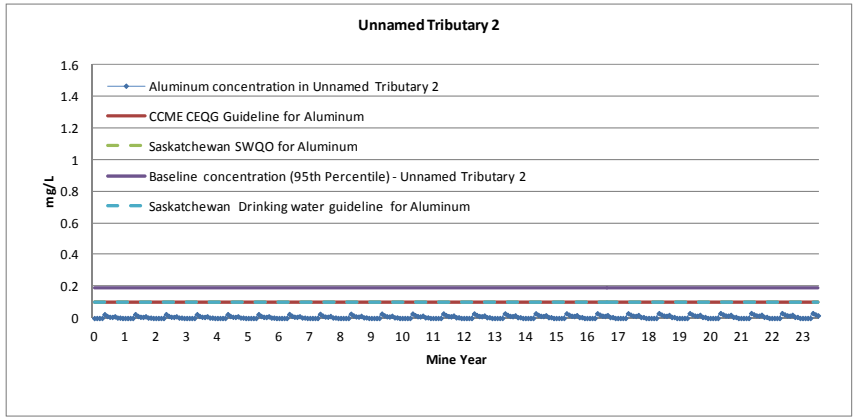
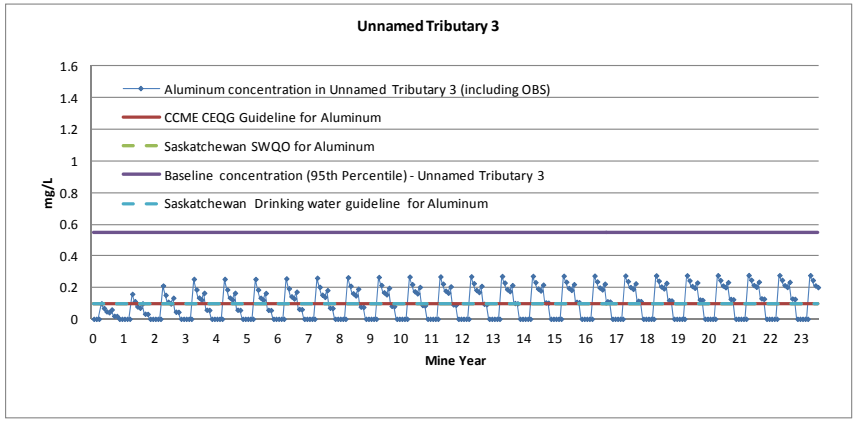
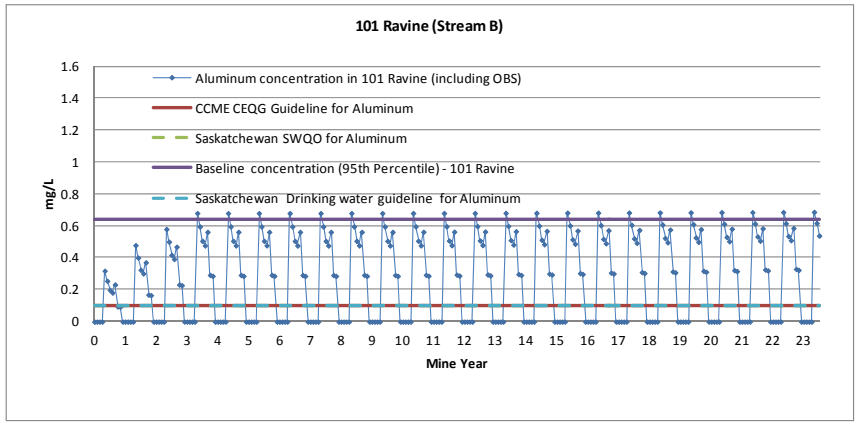


Figure 3-18 Continued







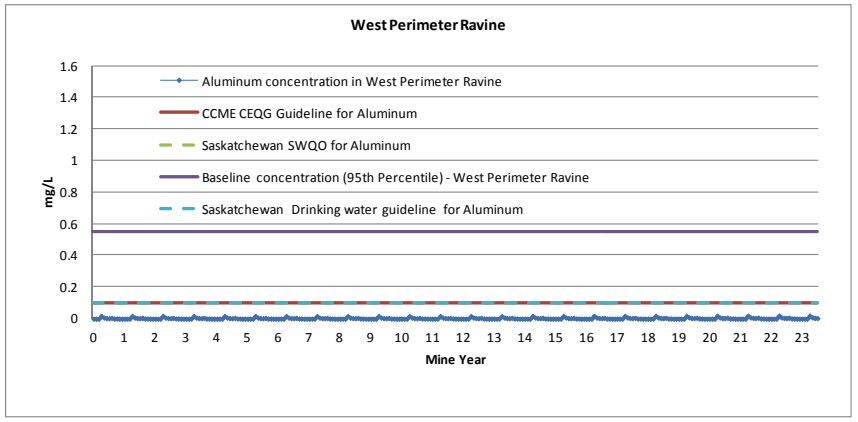
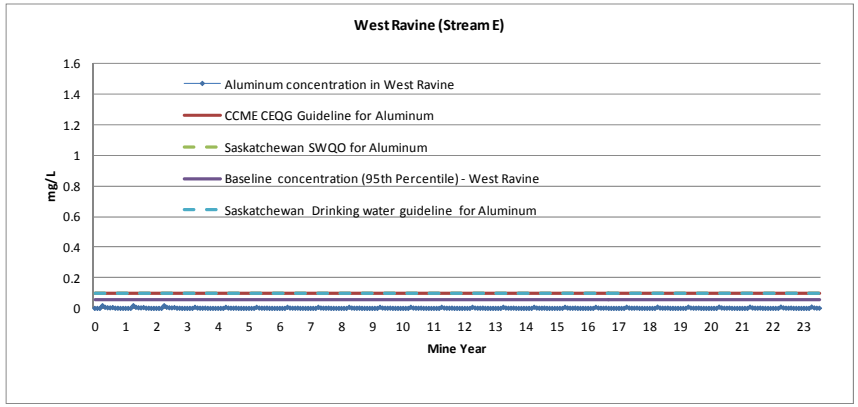
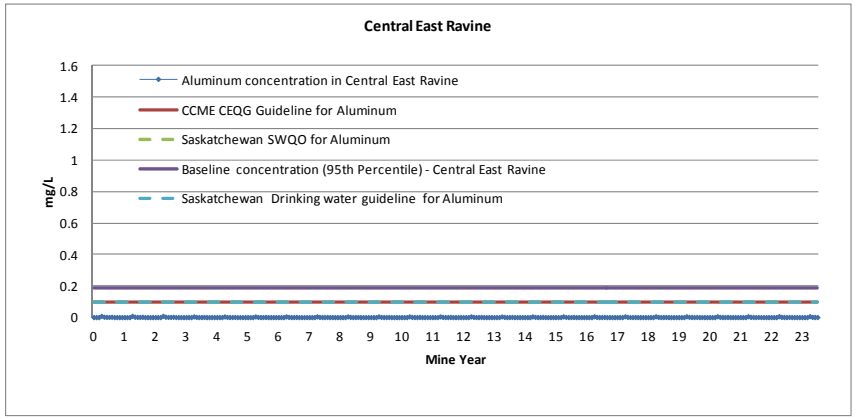
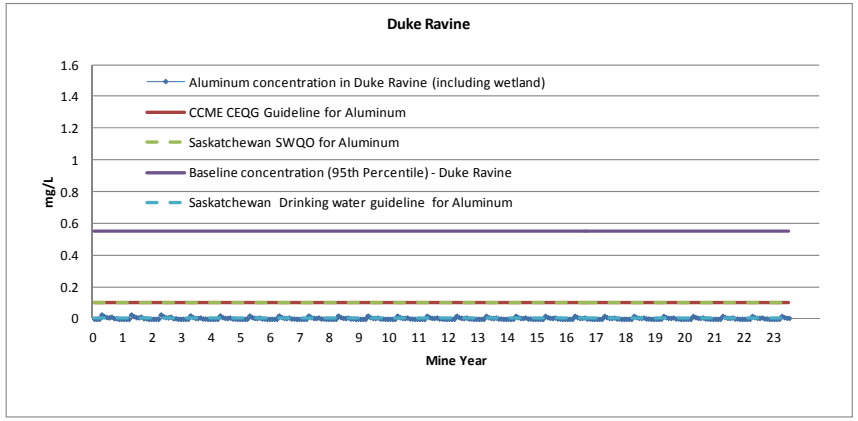


Figure 3-18 Continued







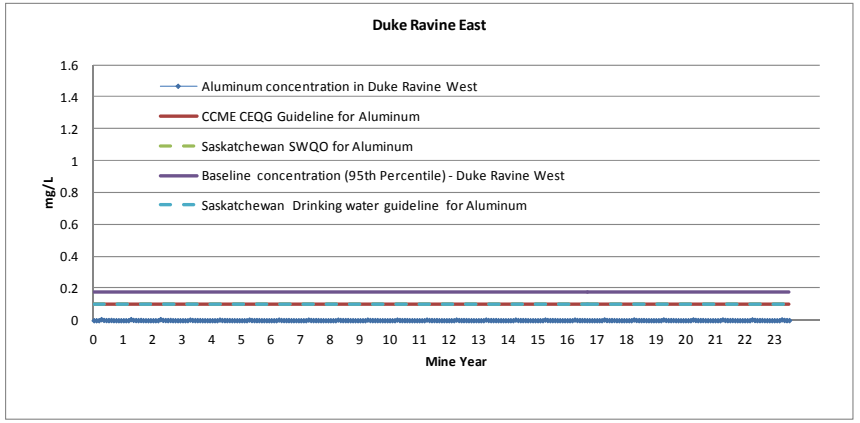
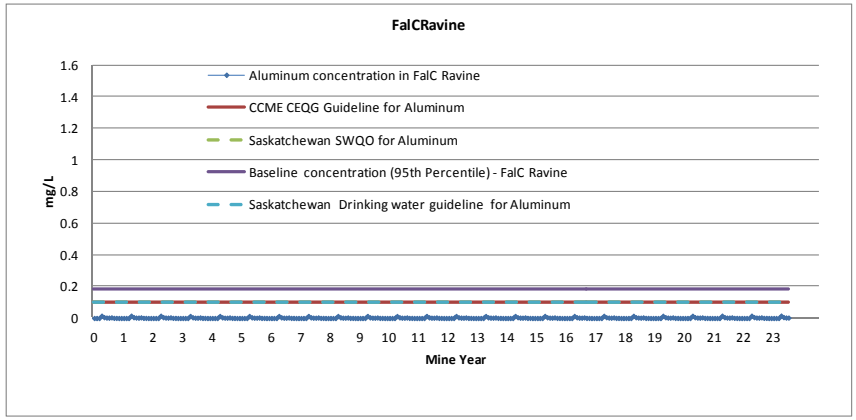
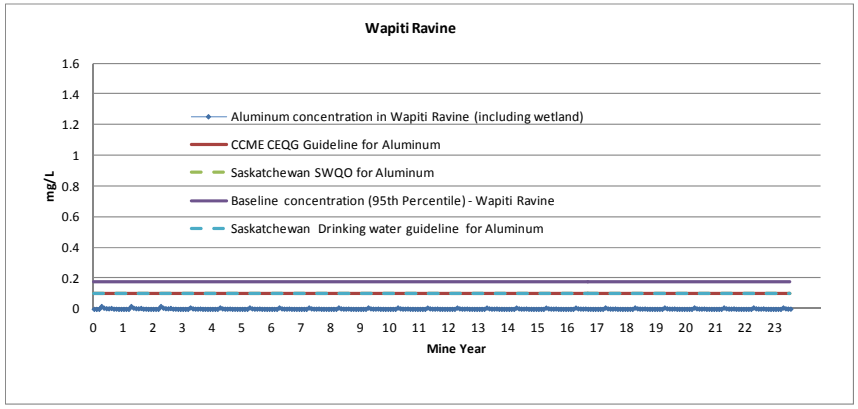
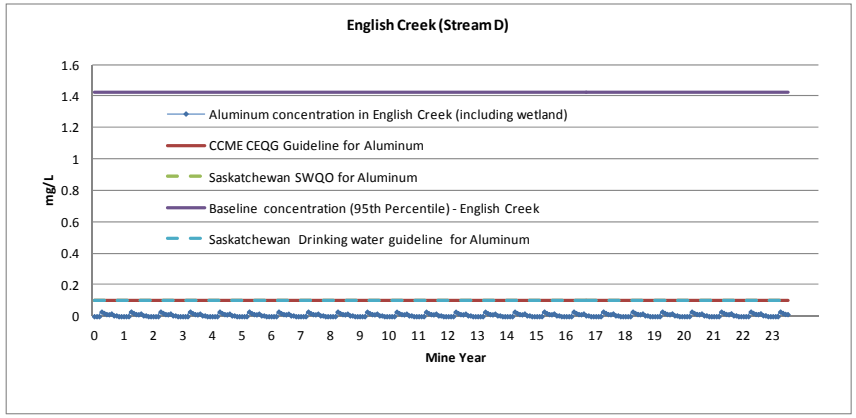


Figure 3-18 Continued







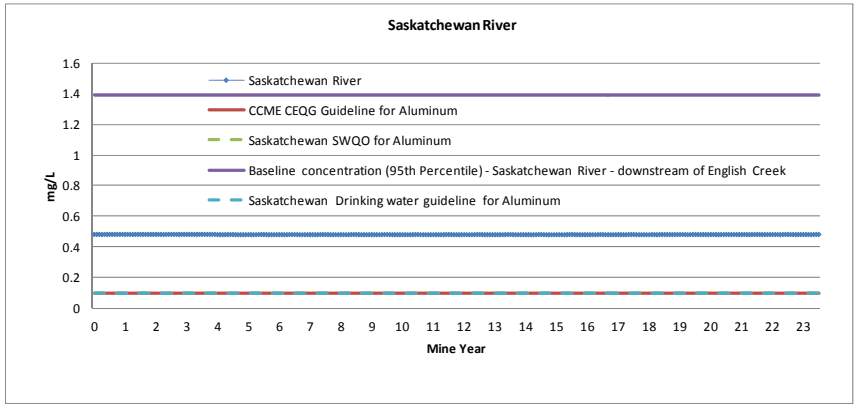
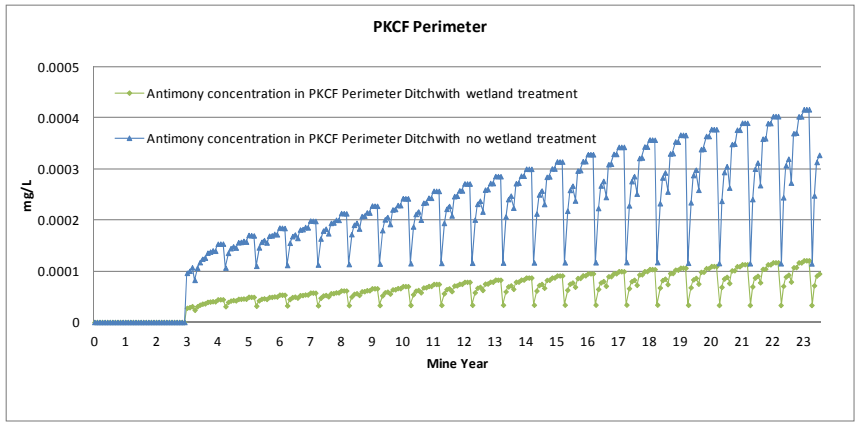
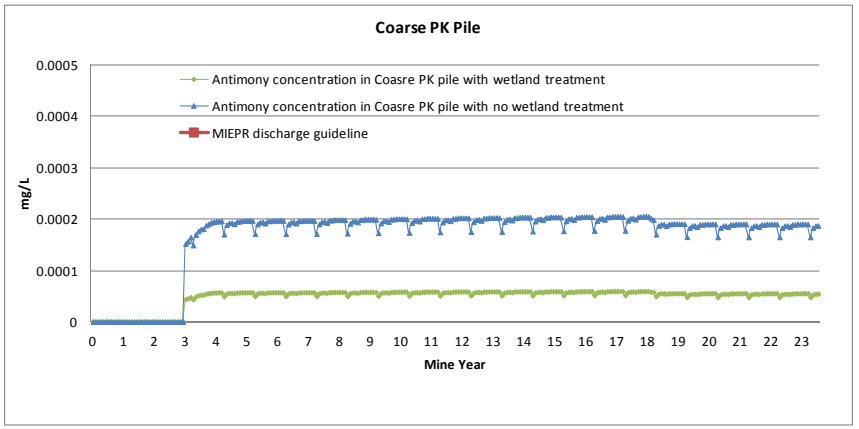


Figure 3-19 Predicted antimony concentrations during construction and operation





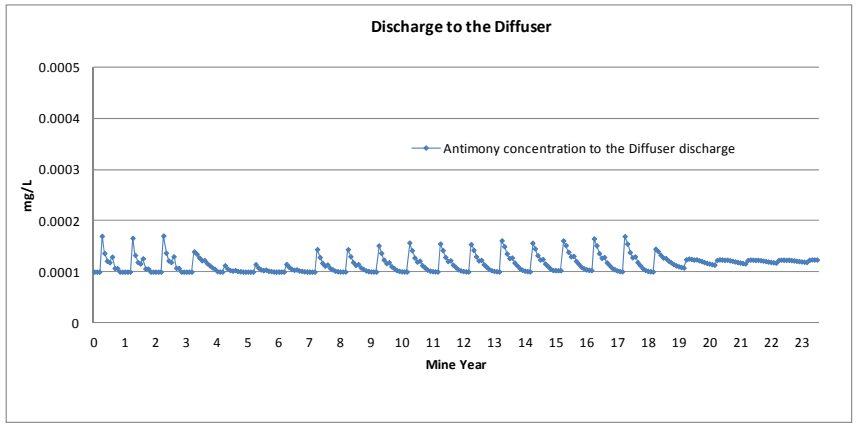
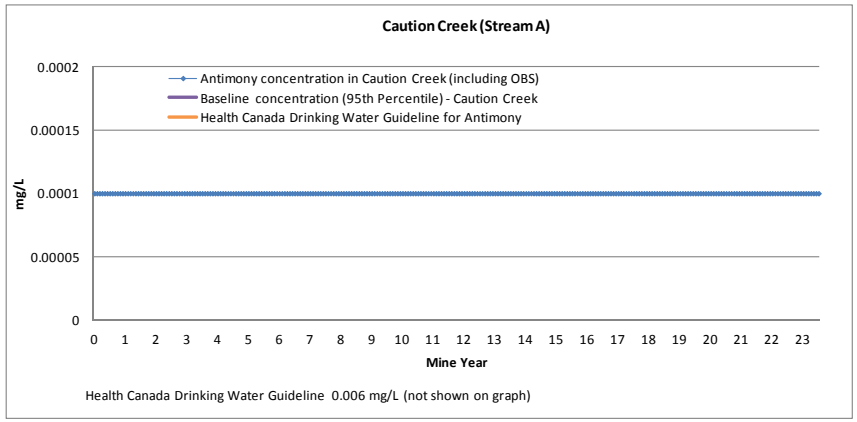
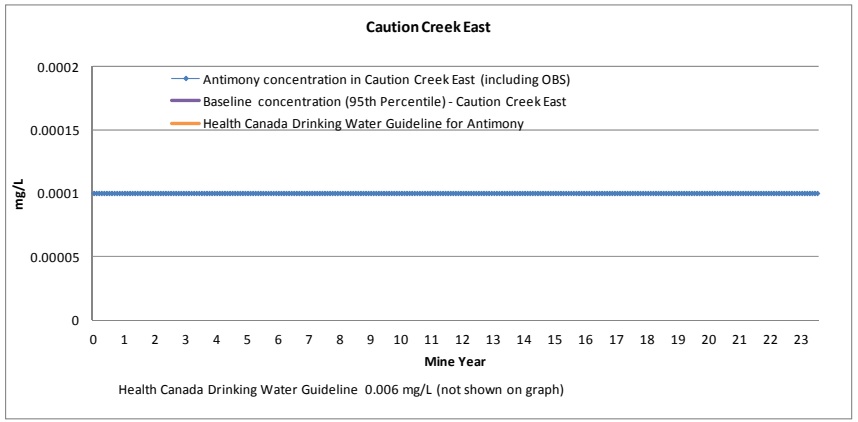
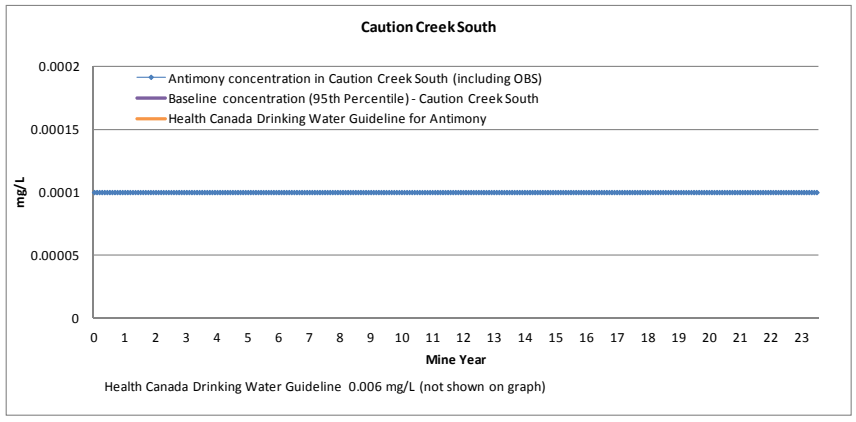


Figure 3-19 Continued







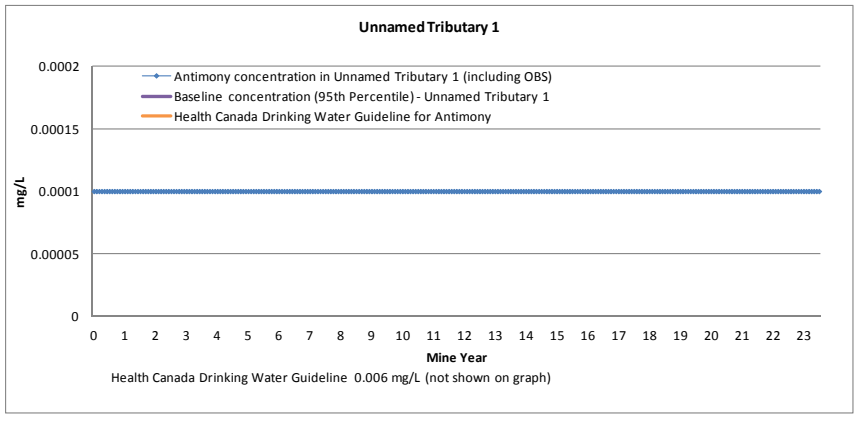
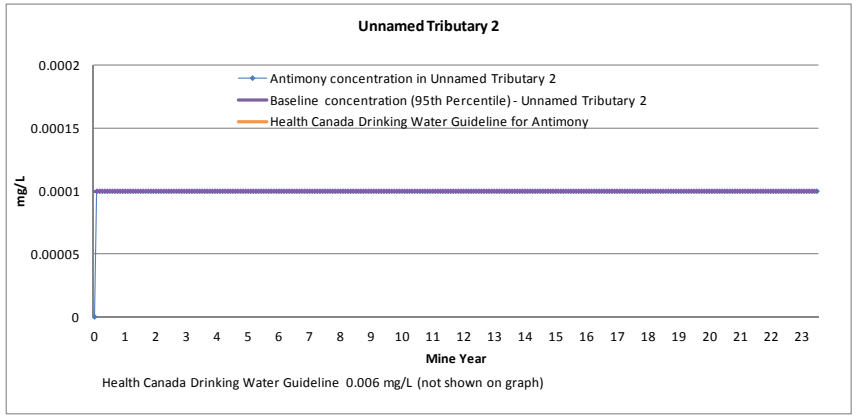
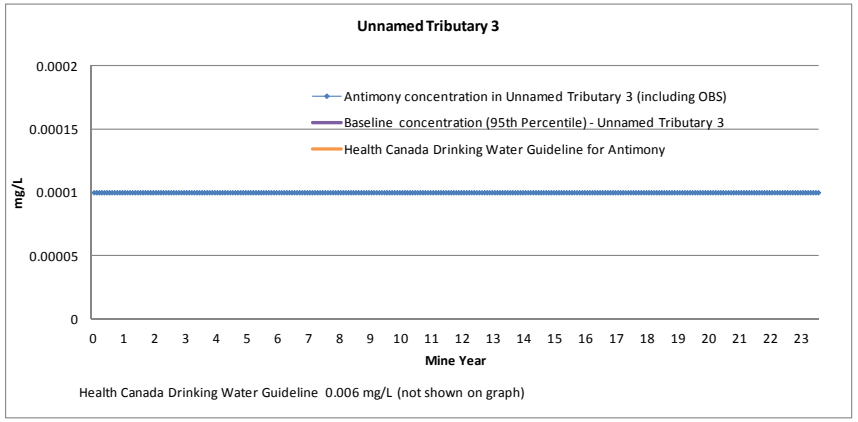
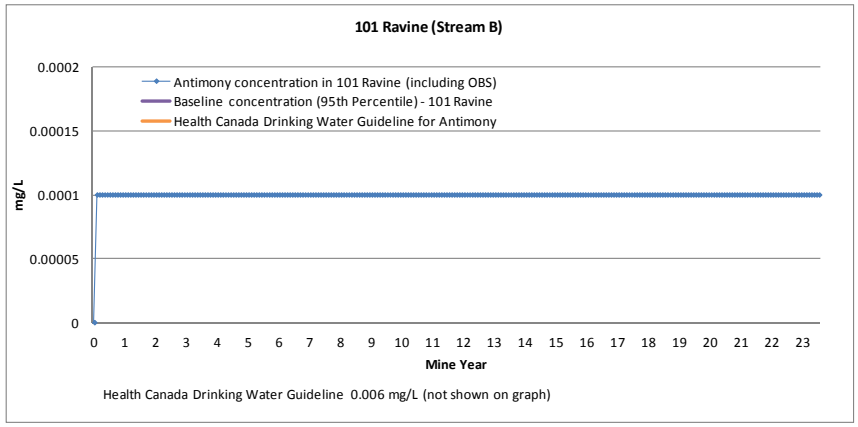
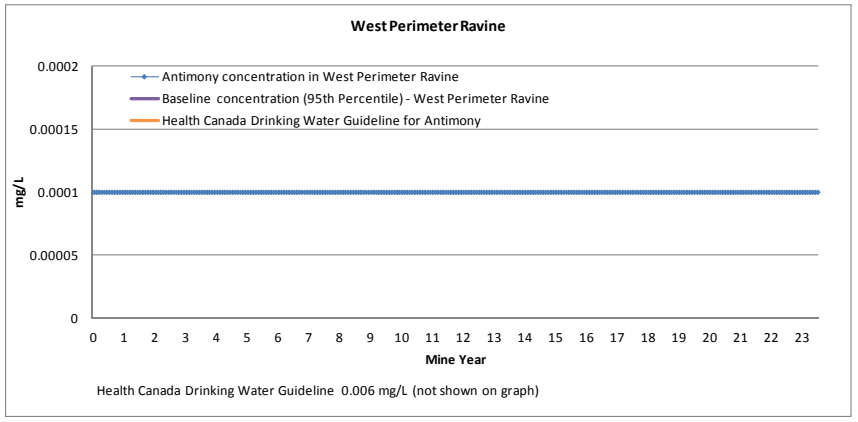


Figure 3-19 Continued









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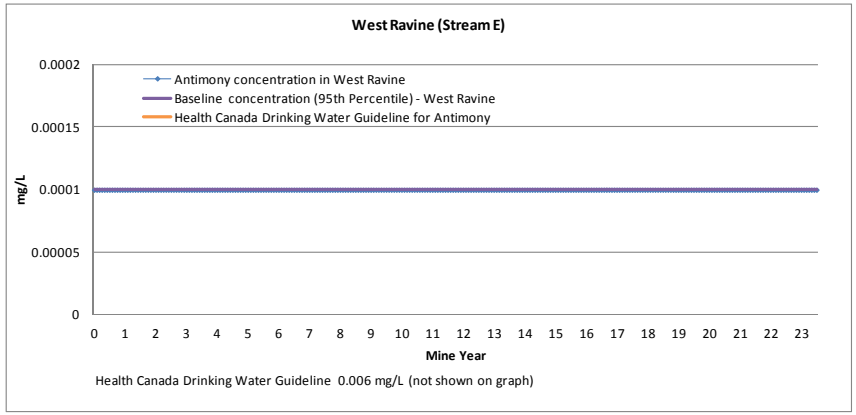
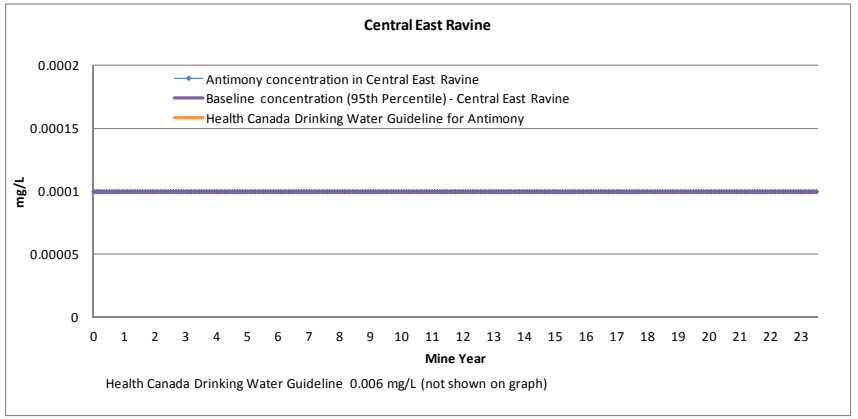
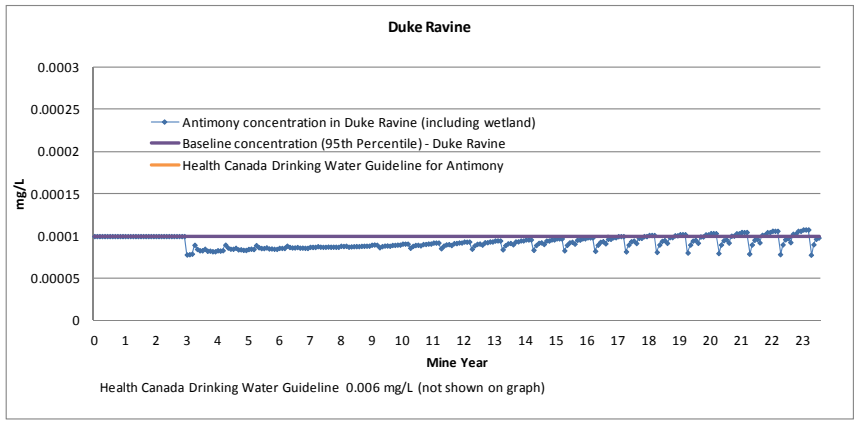






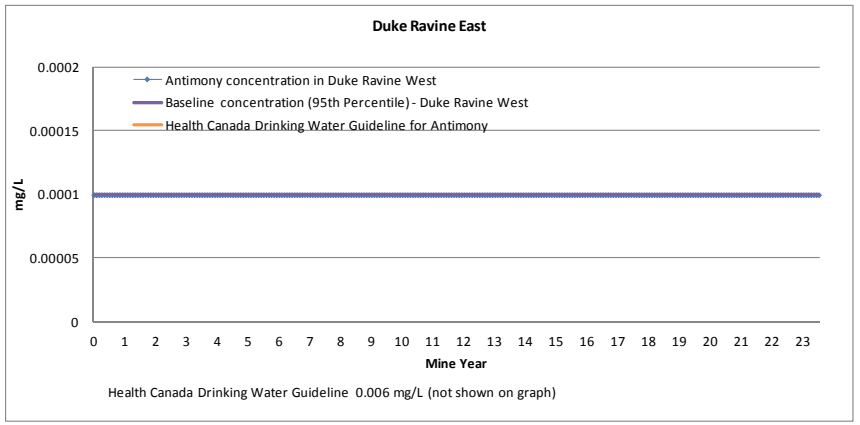
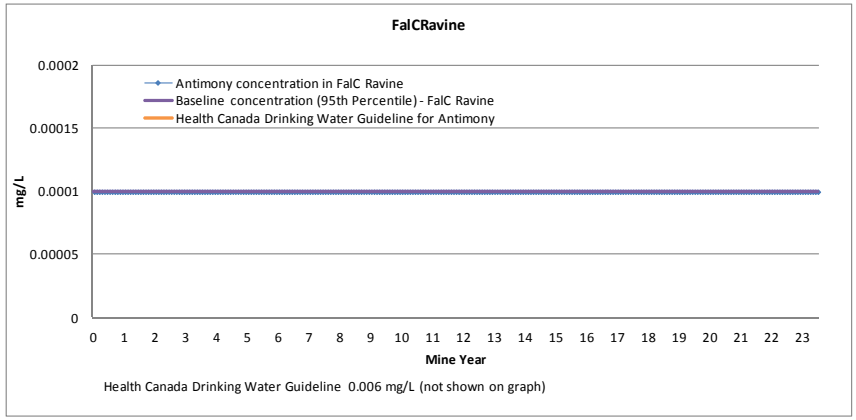
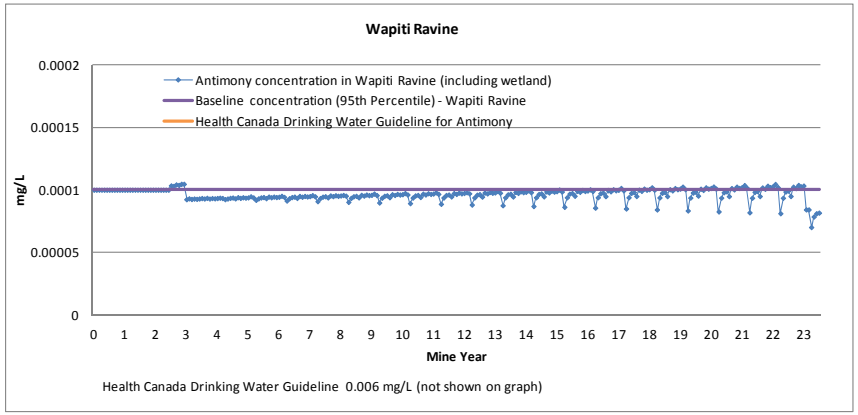
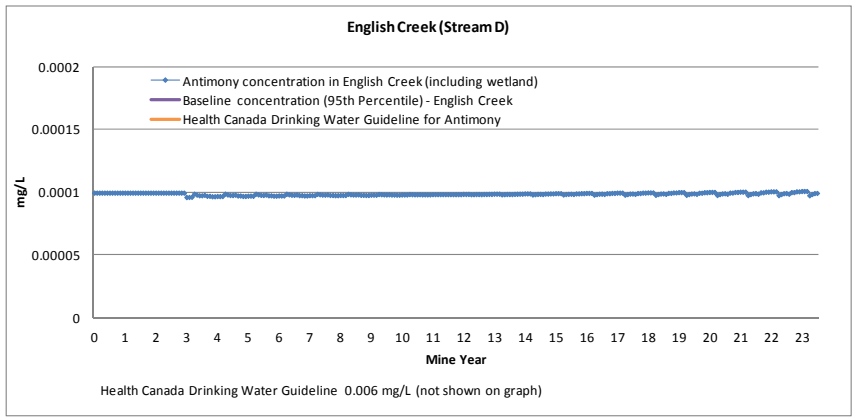


Figure 3-19 Continued







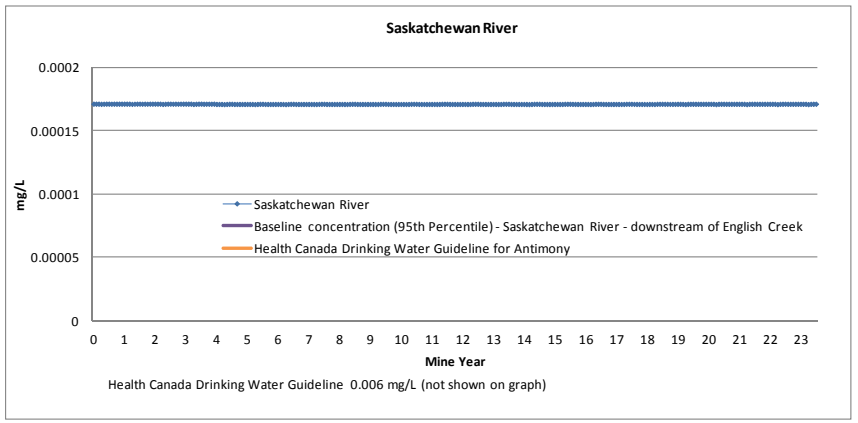
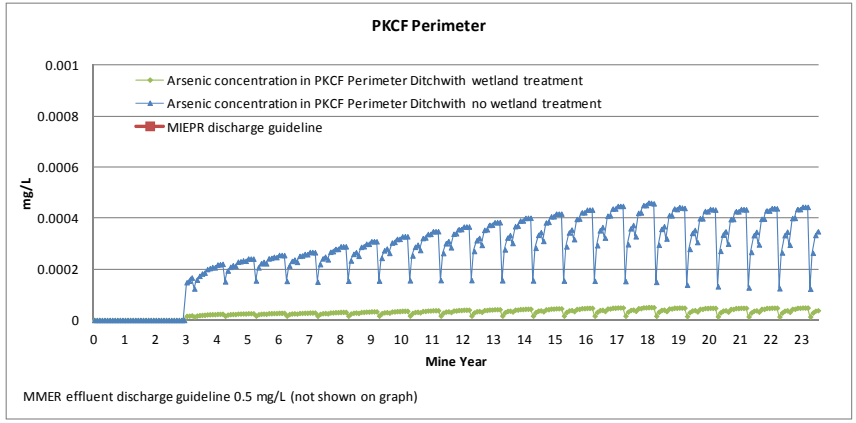
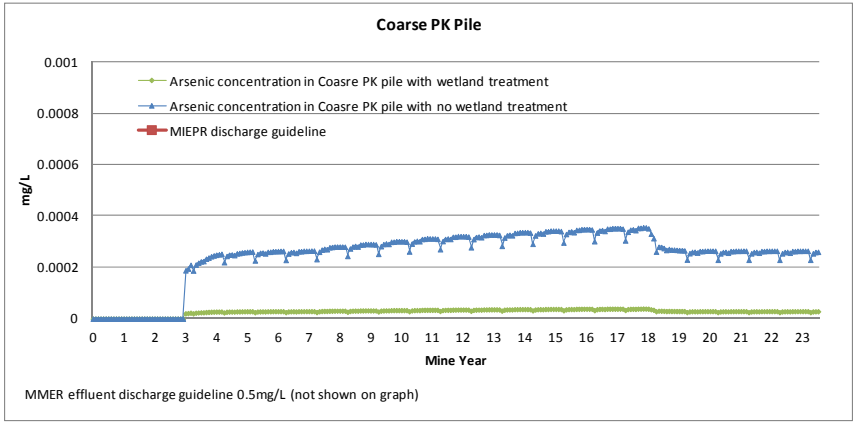


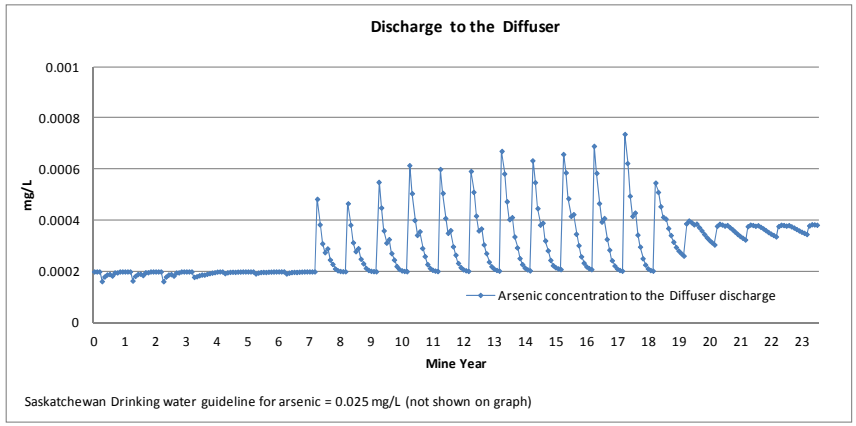
Figure 3-20 Predicted arsenic concentrations during construction and operation



MMER effluent discharge guideline 0.5 mg/L (not shown on graph)

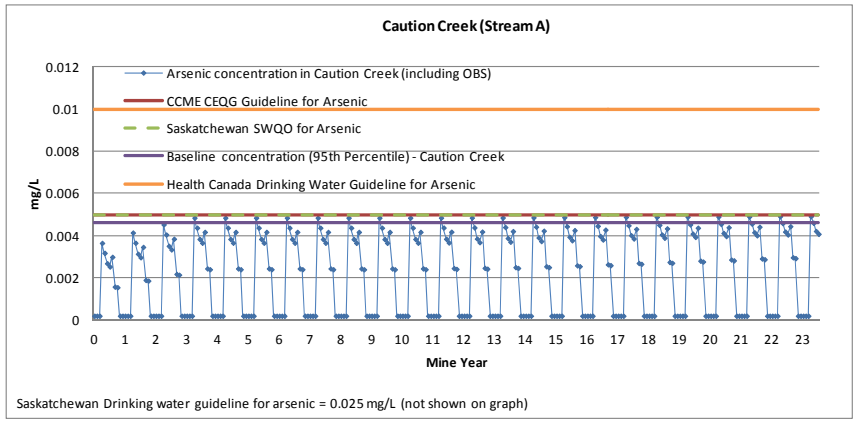


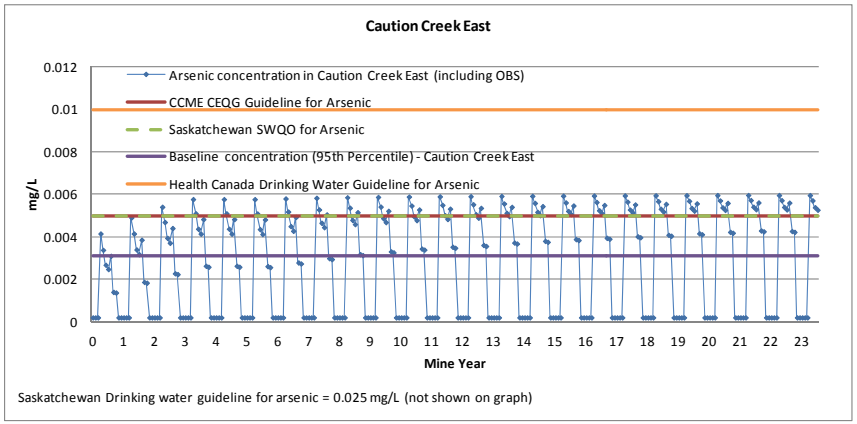
MMER effluent discharge guideline 0.5mg/L (not shown on graph)

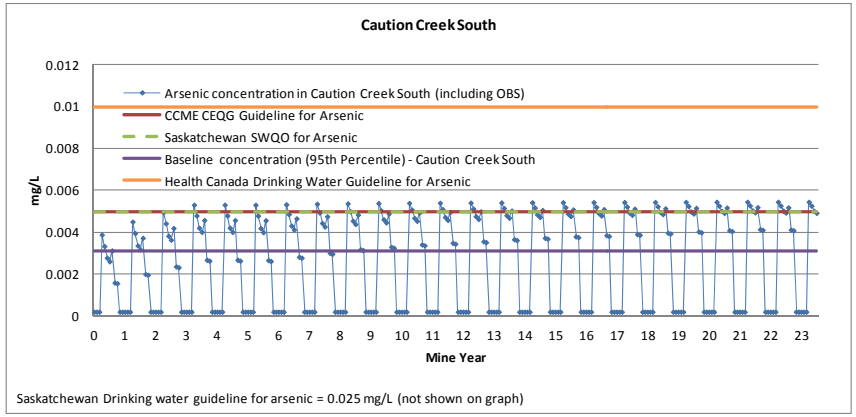


Saskatchewan Drinking water guideline for arsenic = 0.025 mg/L (not shown on graph)

Figure 3-20 Continued







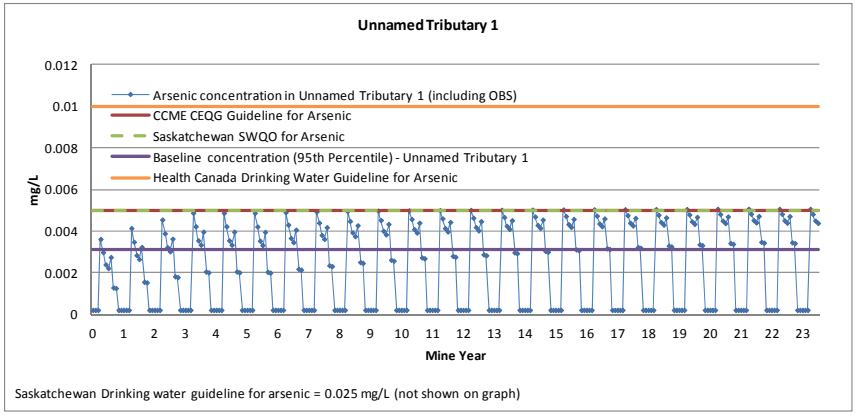
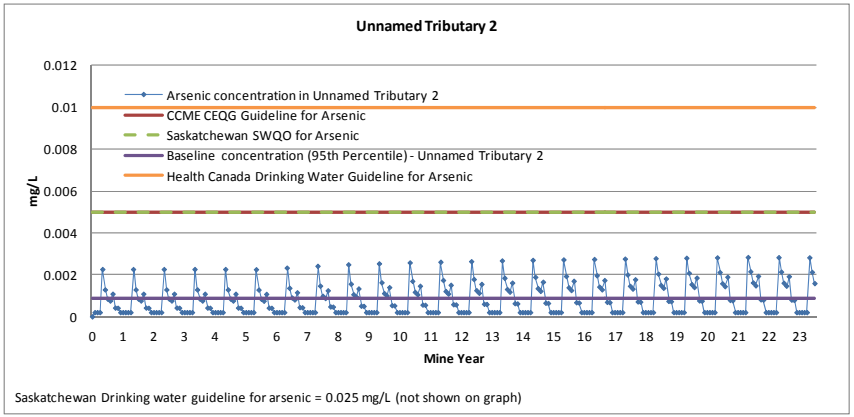
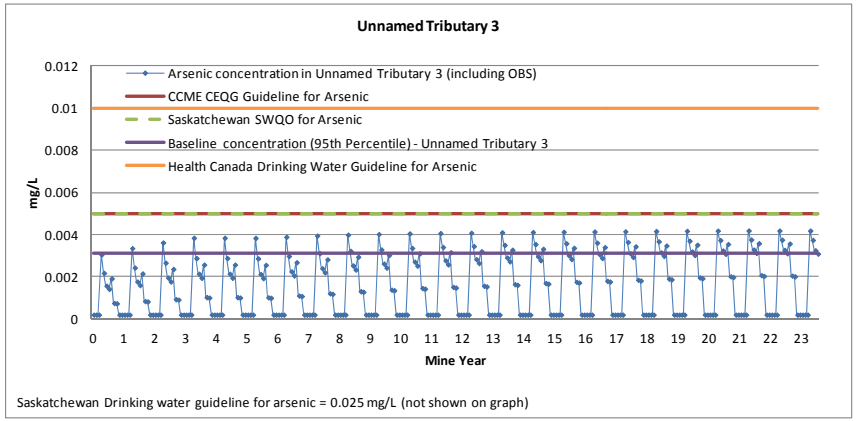
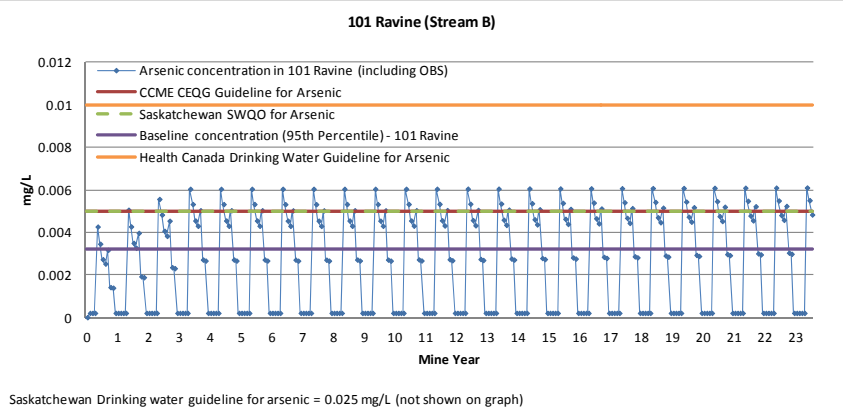


Figure 3-20 Continued







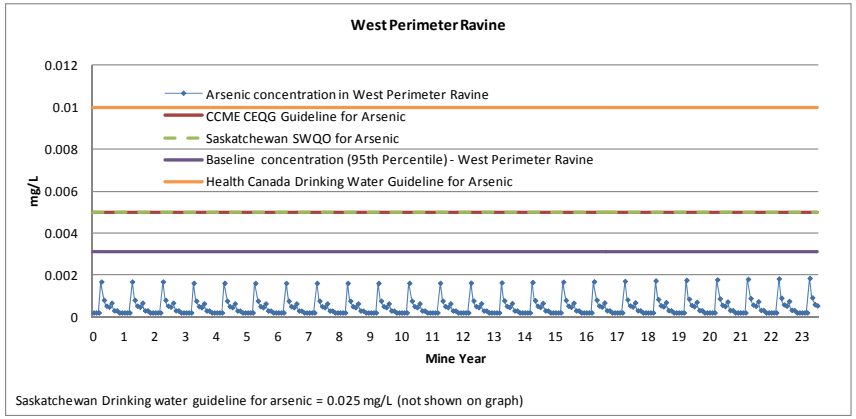
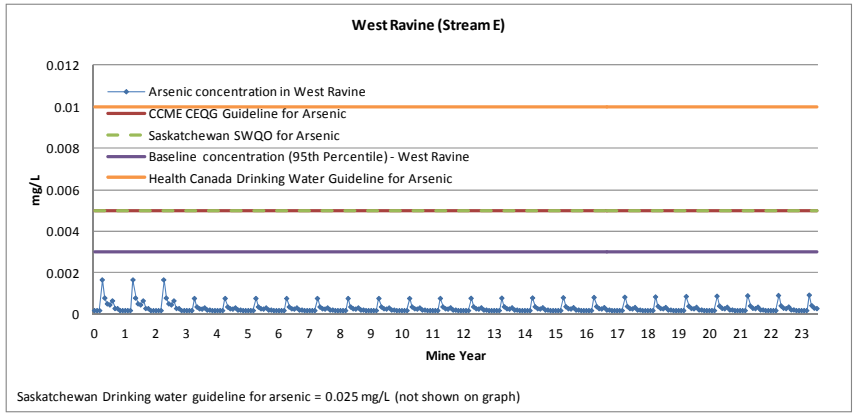
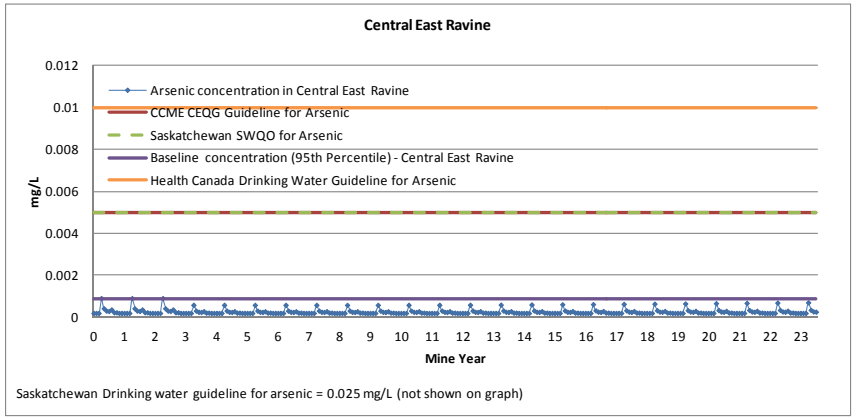


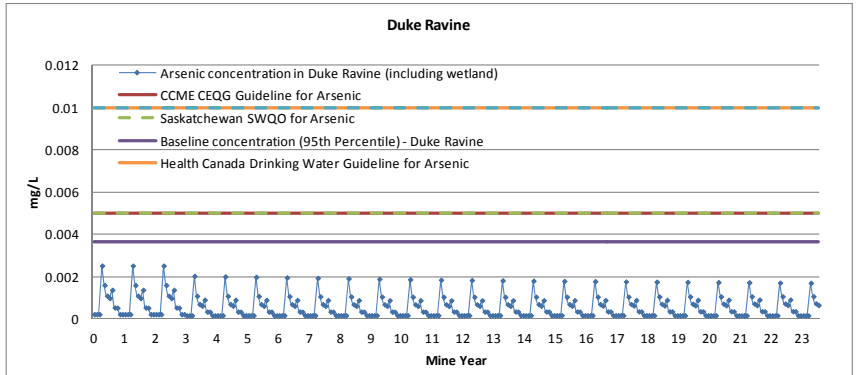
Figure 3-20 Continued



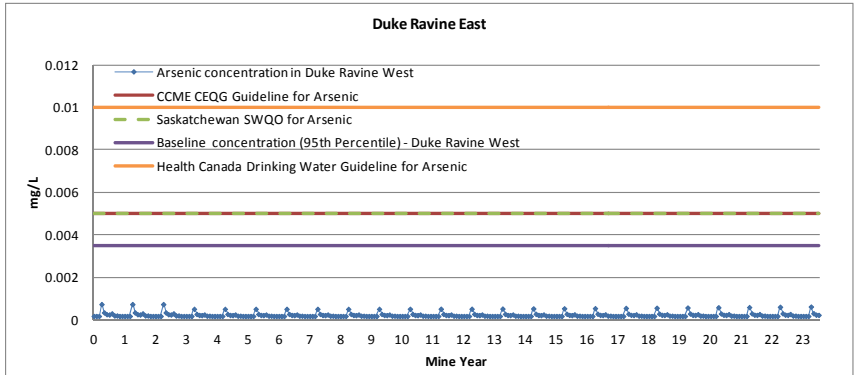
Saskatchewan Drinking water guideline for arsenic = 0.025 mg/L (not shown on graph)



Saskatchewan Drinking water guideline for arsenic = 0.025 mg/L (not shown on graph)

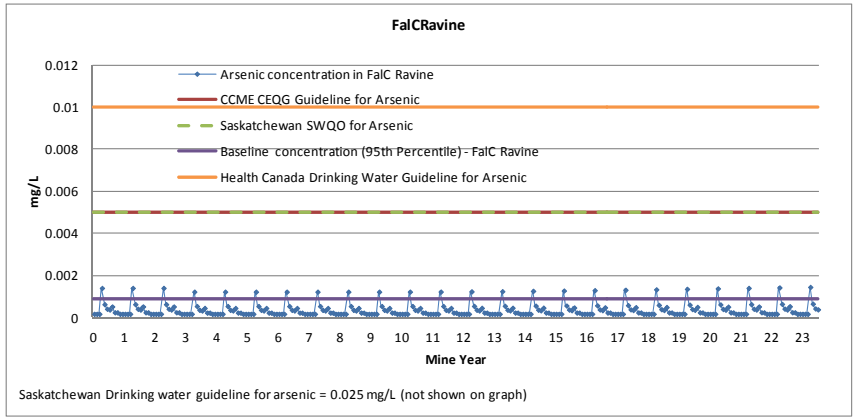


Saskatchewan Drinking water guideline for arsenic = 0.025 mg/L (not shown on graph)

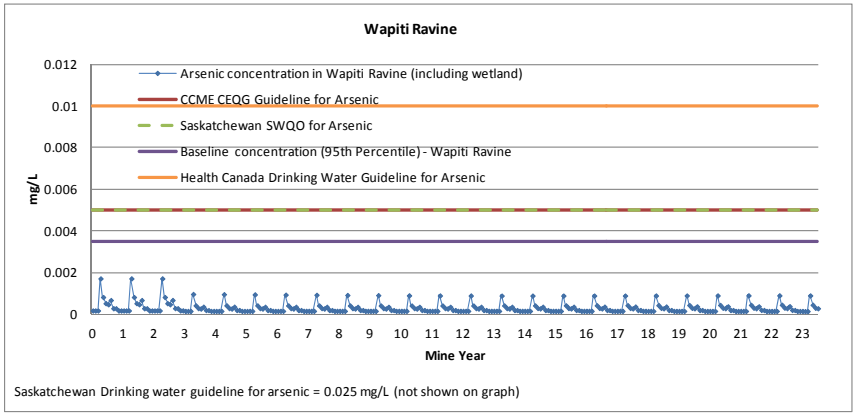


Saskatchewan Drinking water guideline for arsenic = 0.025 mg/L (not shown on graph)

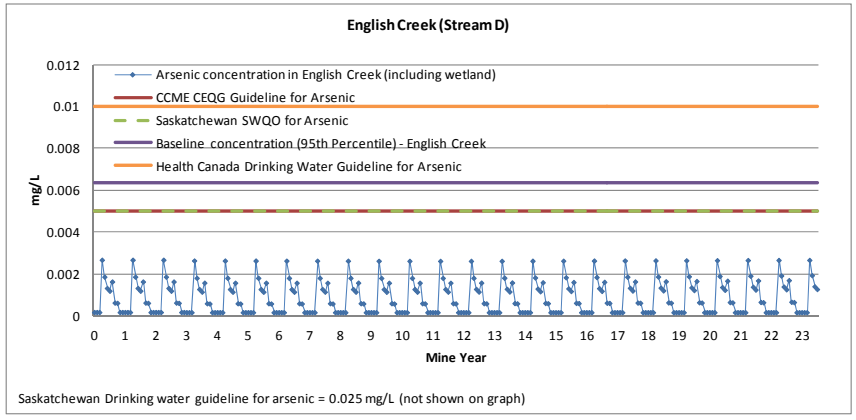
Figure 3-20 Continued



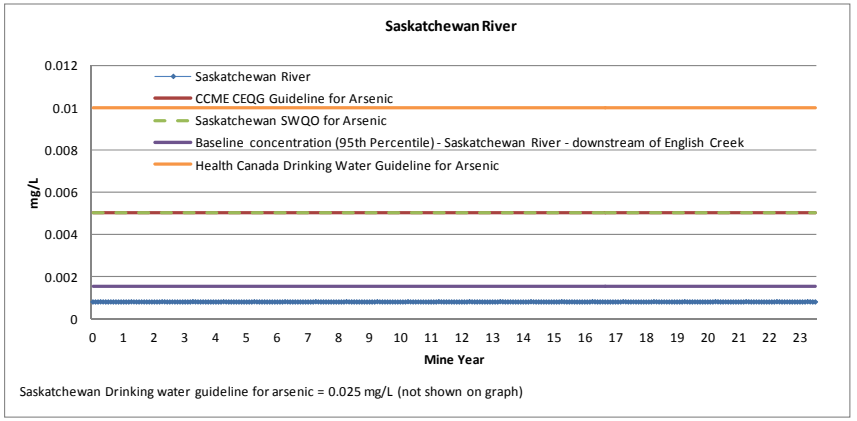
Saskatchewan Drinking water guideline for arsenic = 0.025 mg/L (not shown on graph)



Saskatchewan Drinking water guideline for arsenic = 0.025 mg/L (not shown on graph)

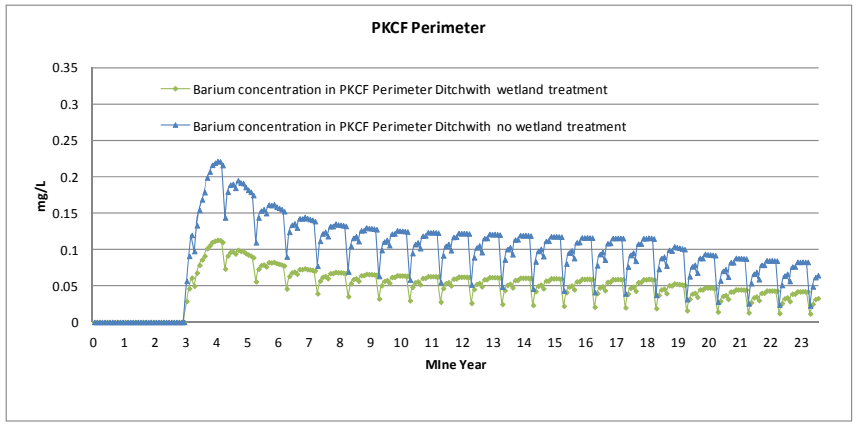


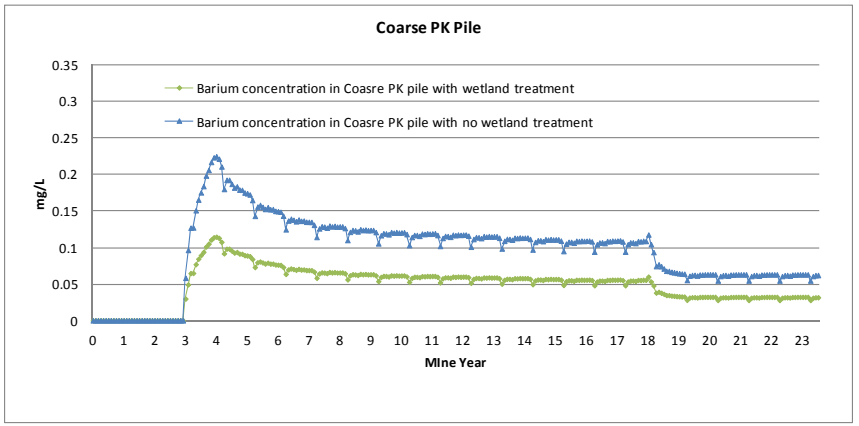
Saskatchewan Drinking water guideline for arsenic = 0.025 mg/L (not shown on graph)



Saskatchewan Drinking water guideline for arsenic = 0.025 mg/L (not shown on graph)

Figure 3-21 Predicted barium concentrations during construction and operation





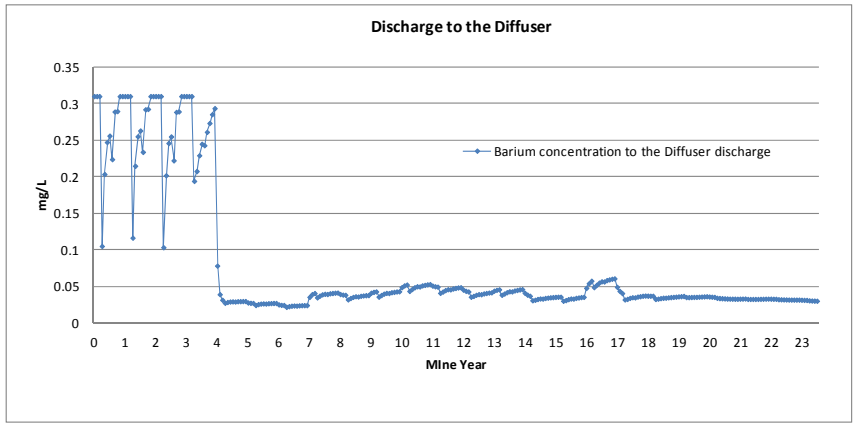
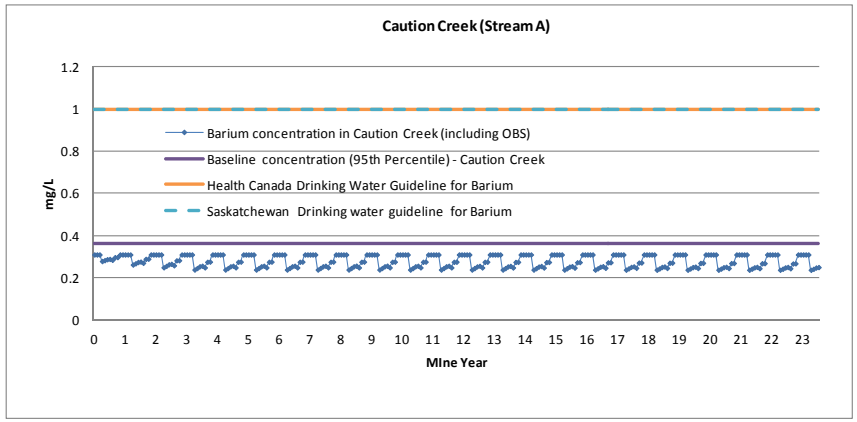
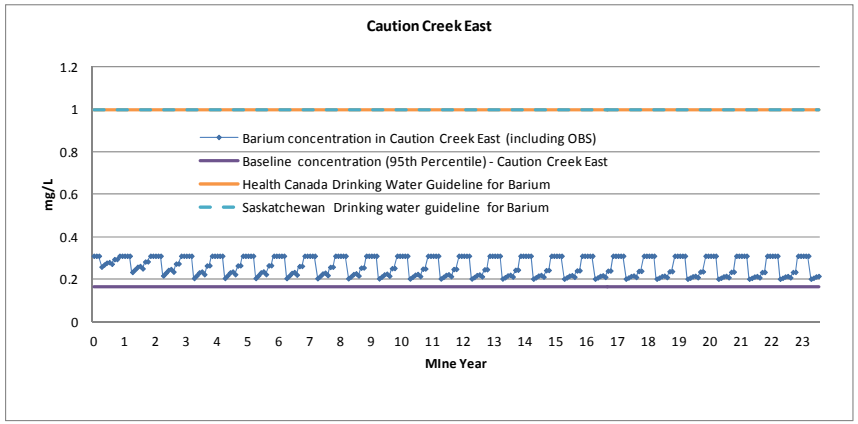
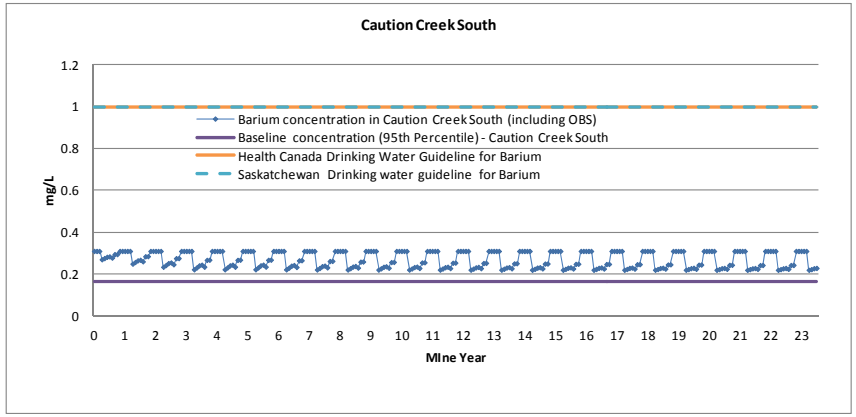


Figure 3-21 Continued







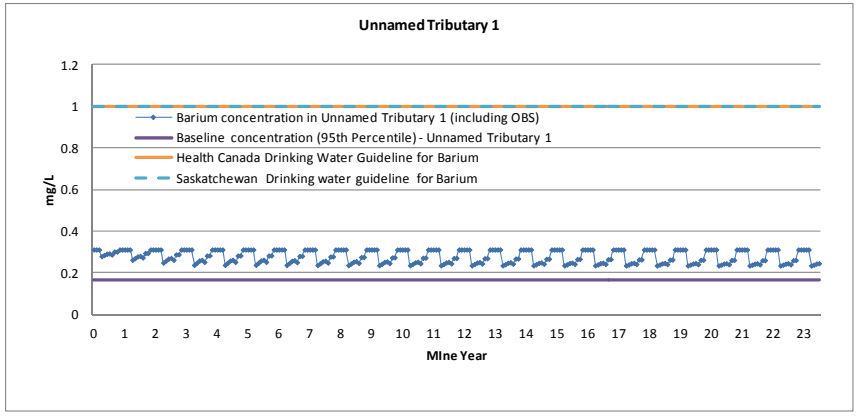
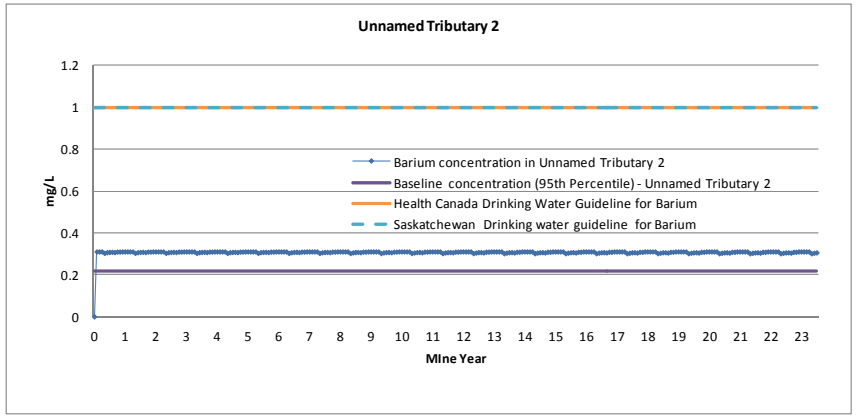
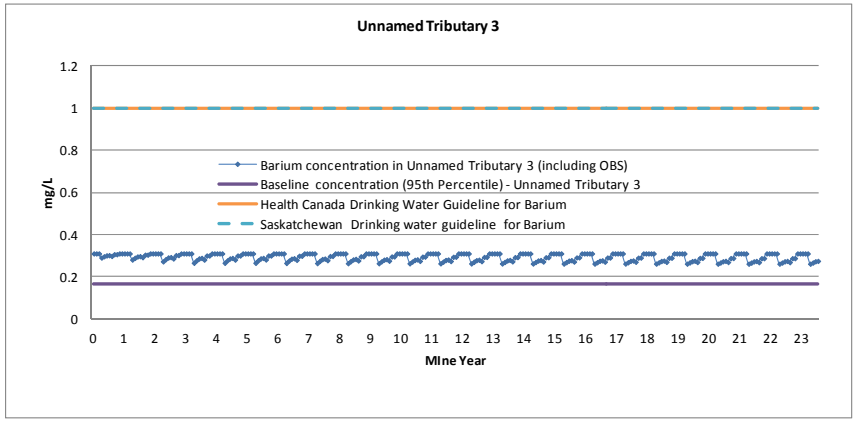
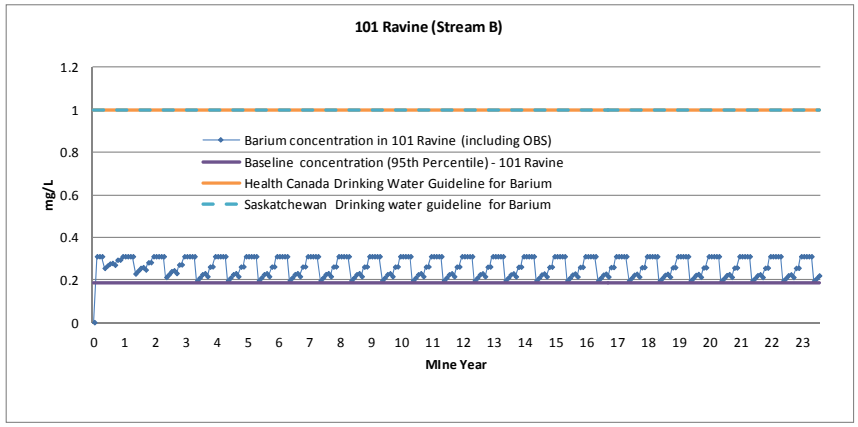


Figure 3-21 Continued







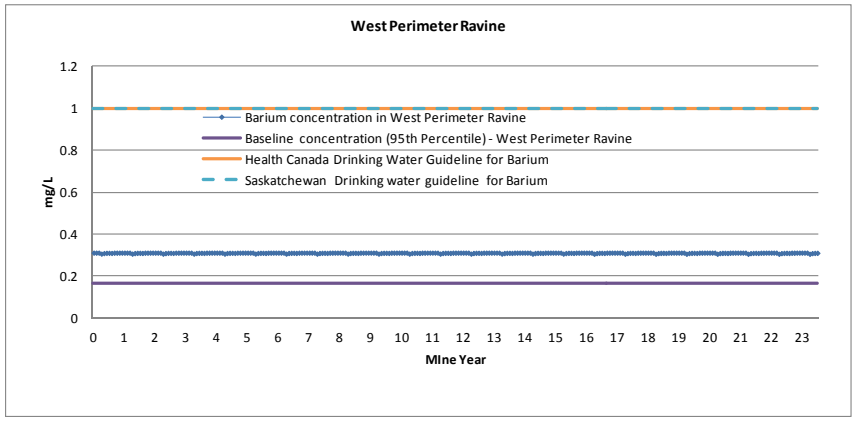
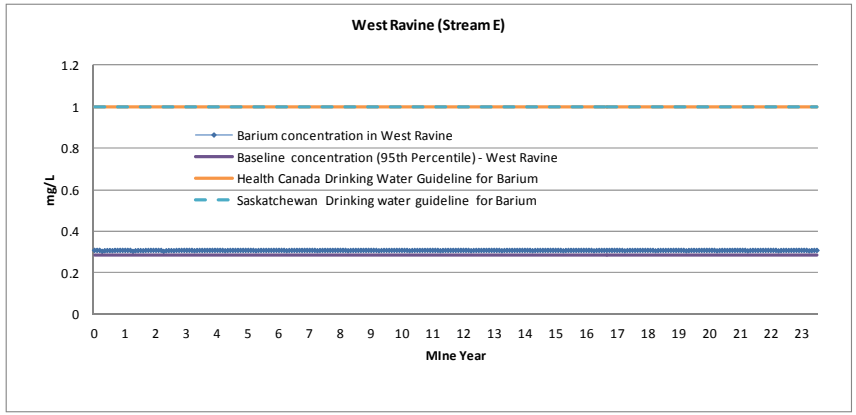
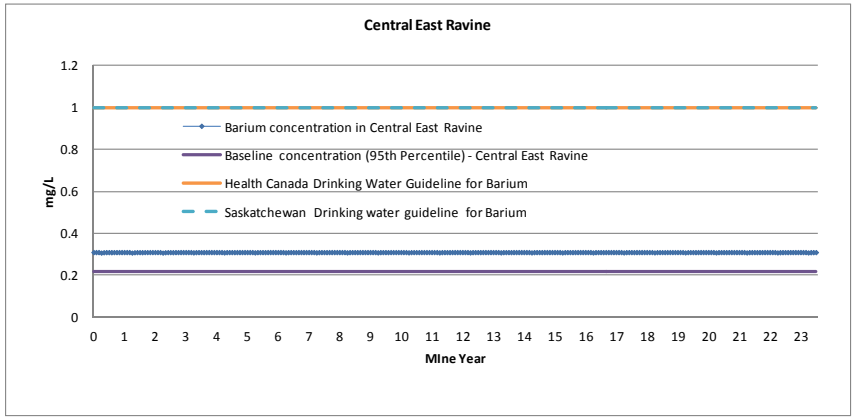
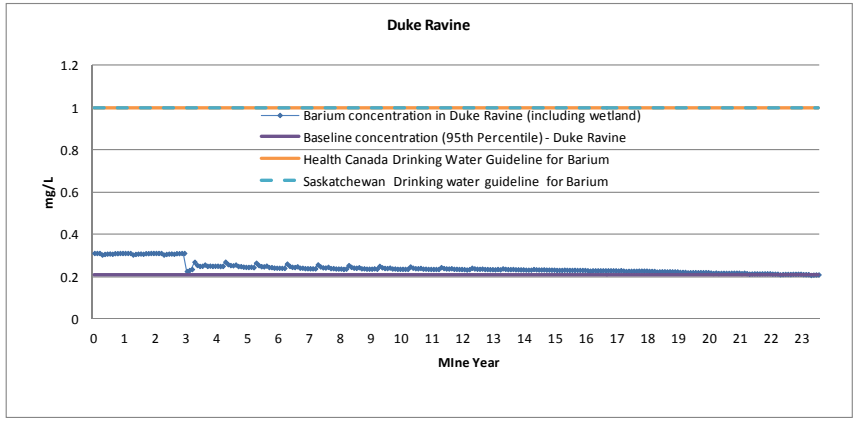


Figure 3-21 Continued







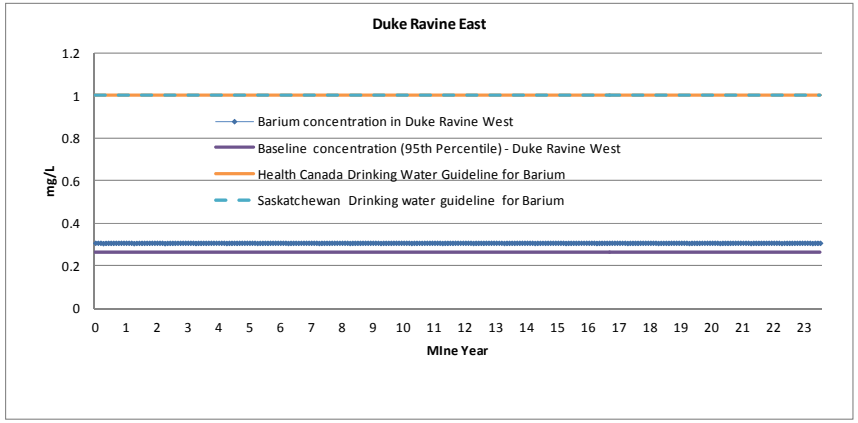
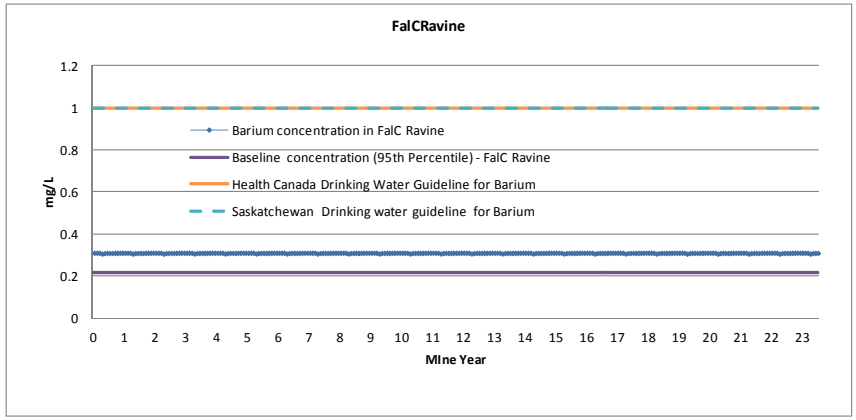
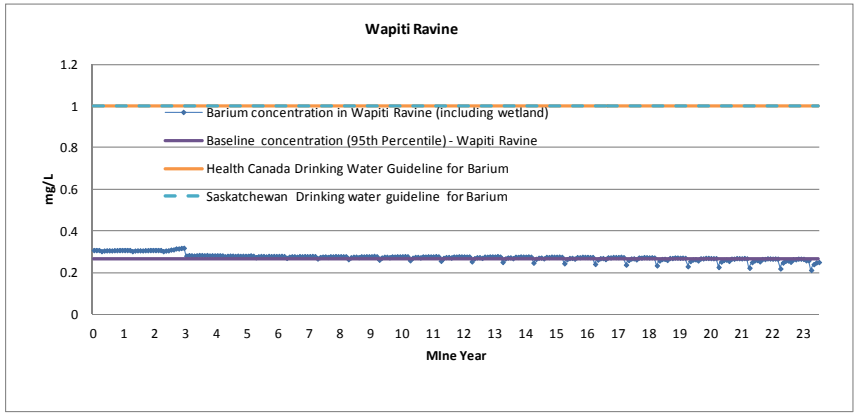
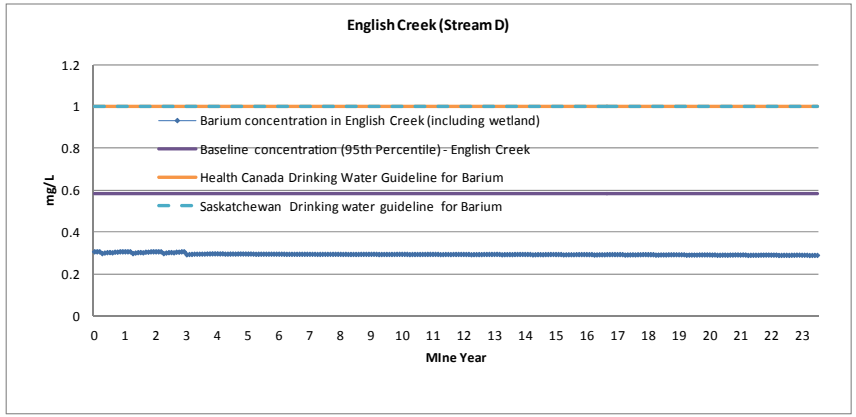


Figure 3-21 Continued







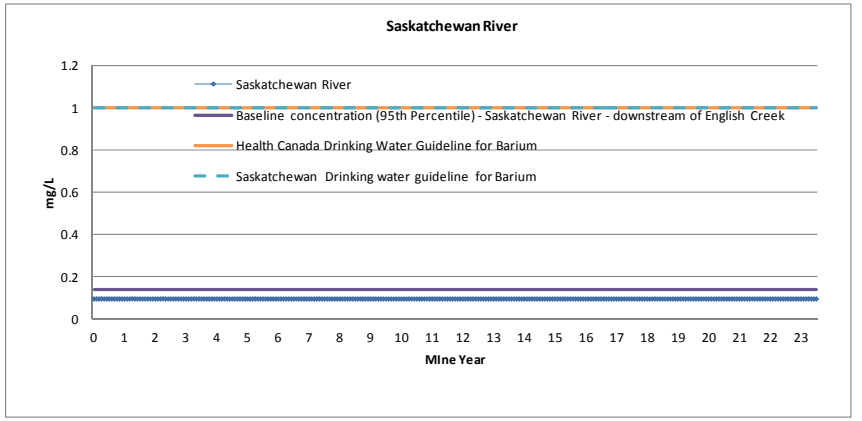
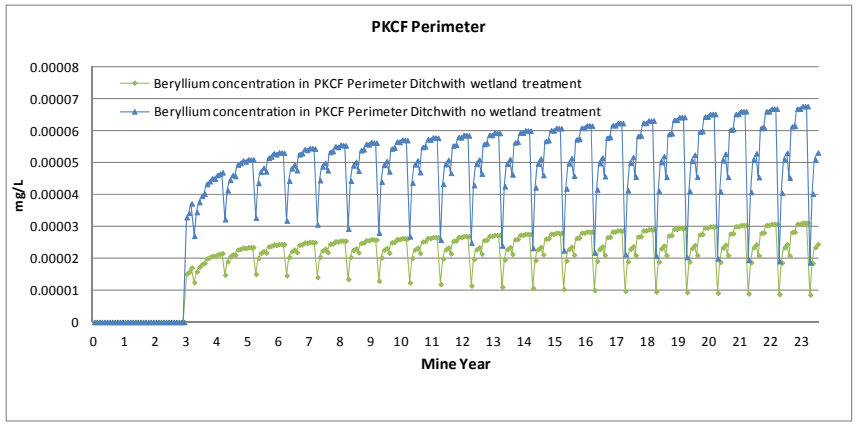
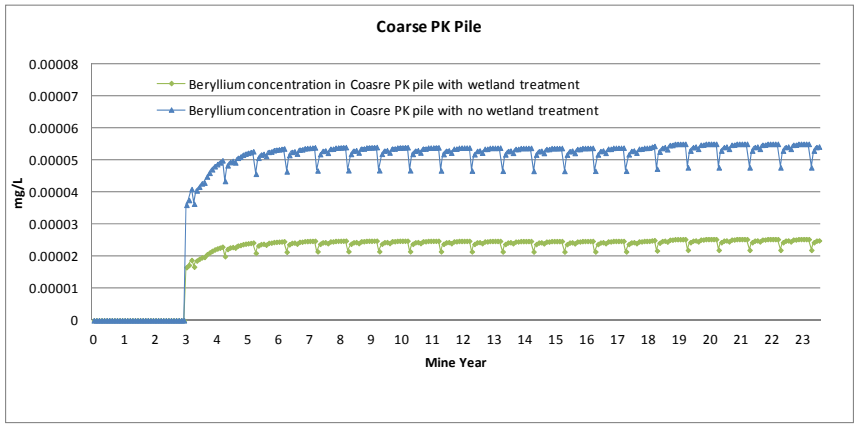


Figure 3-22 Predicted beryllium concentrations during construction and operation





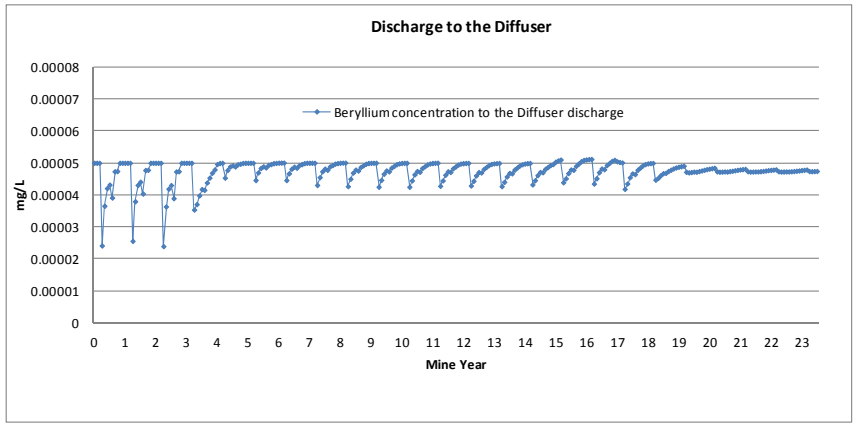
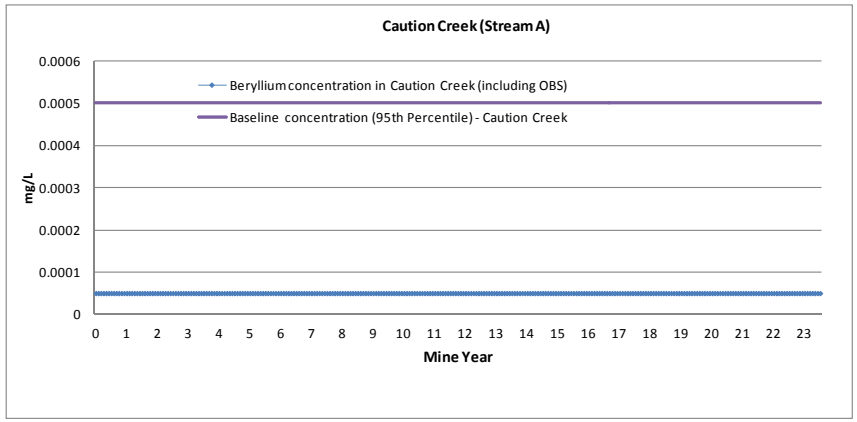
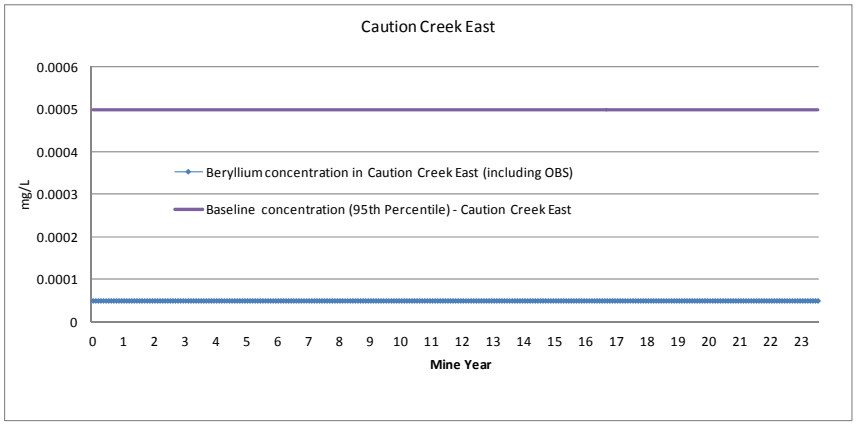
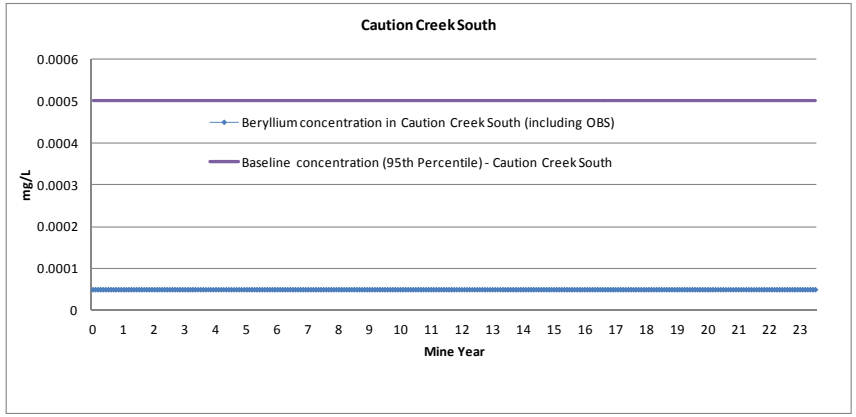


Figure 3-22 Continued







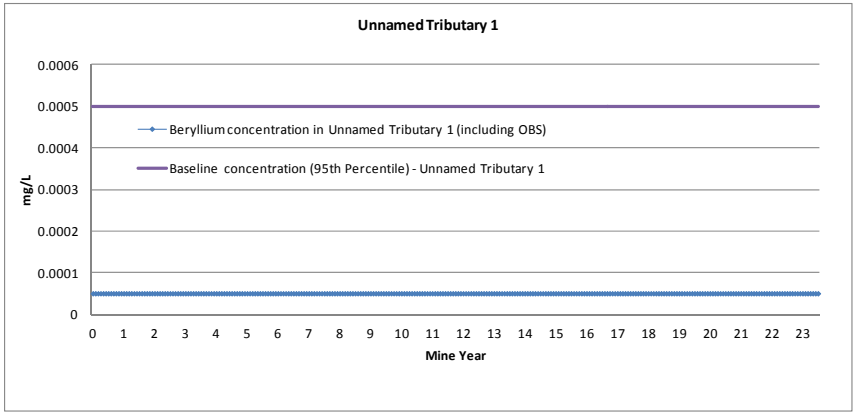
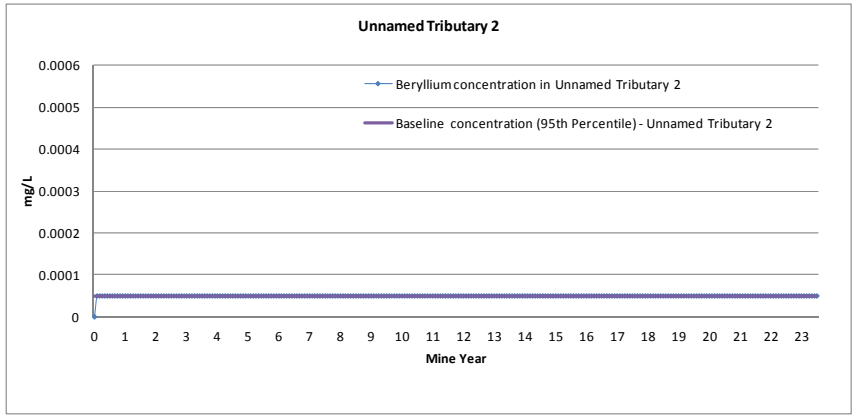
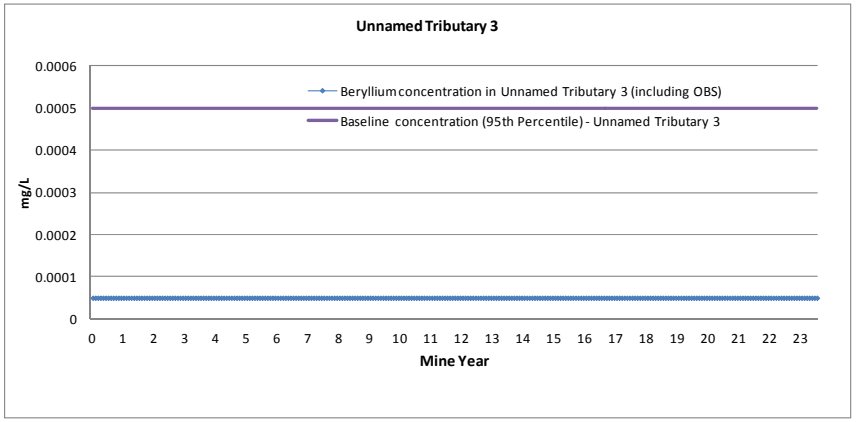
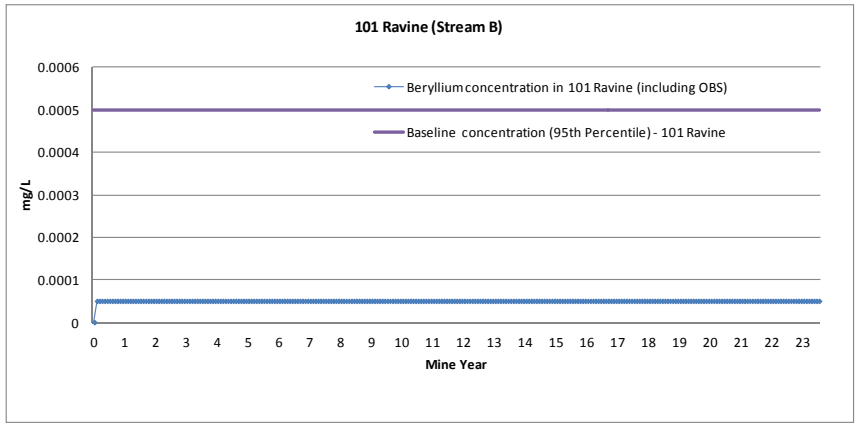


Figure 3-22 Continued







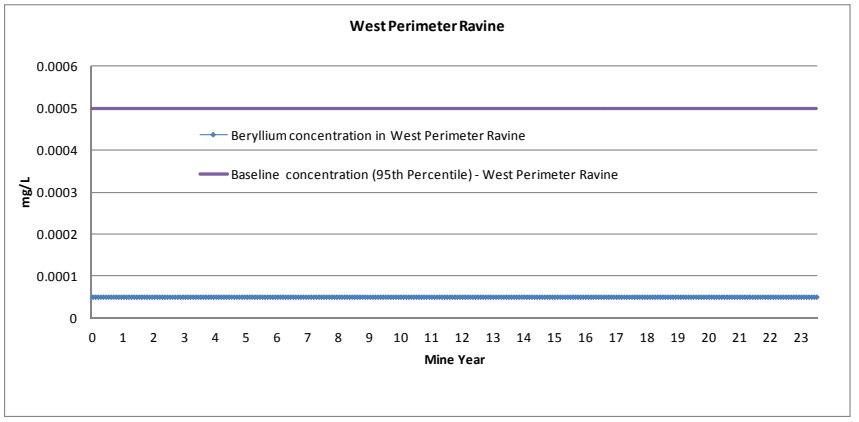
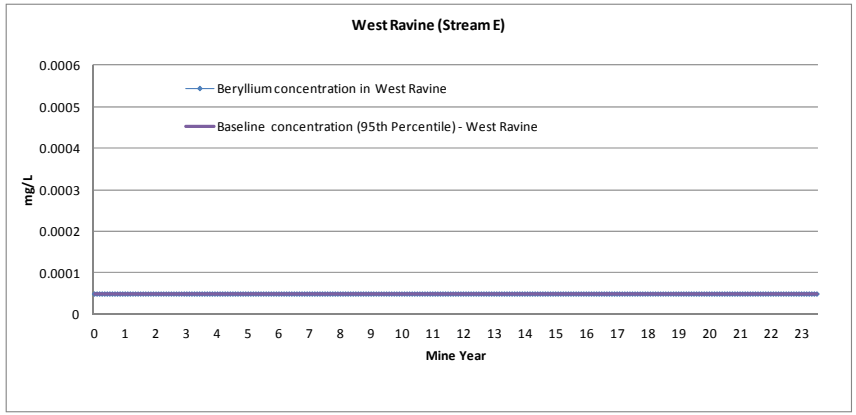
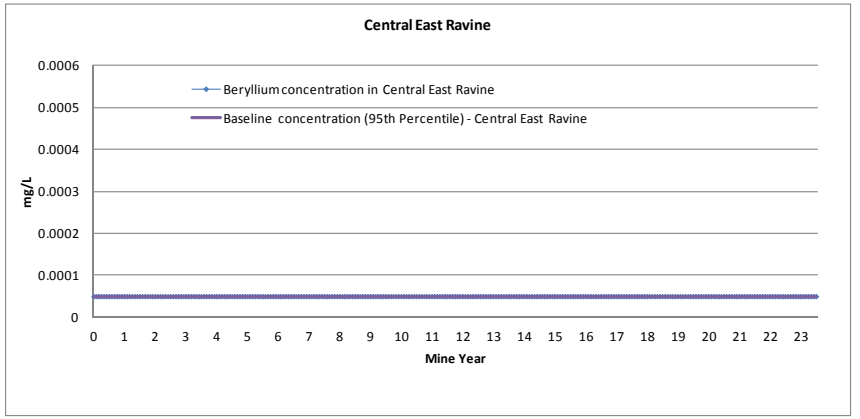
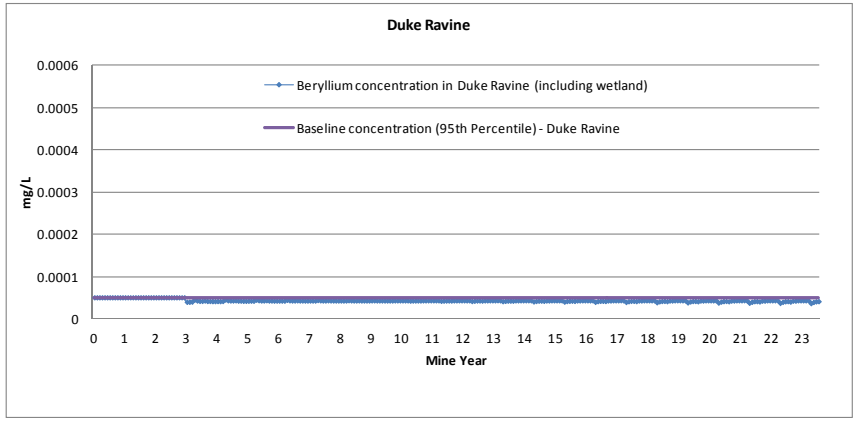


Figure 3-22 Continued







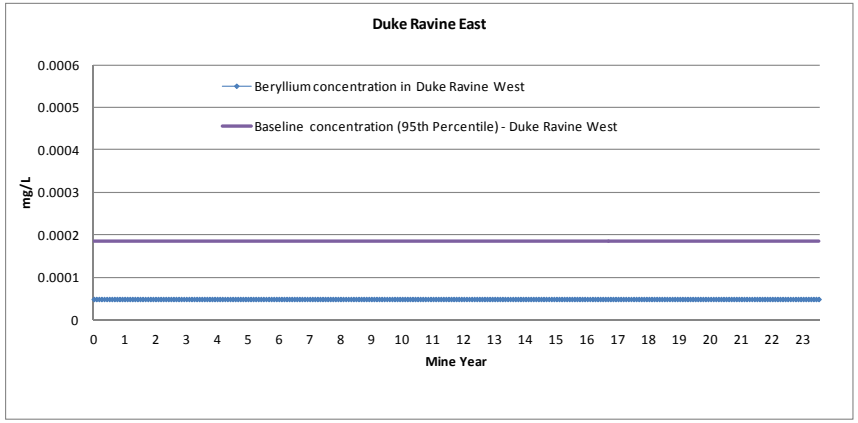
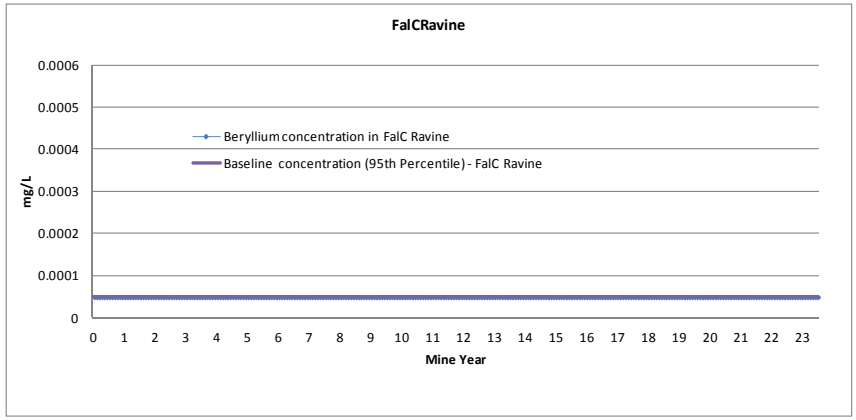
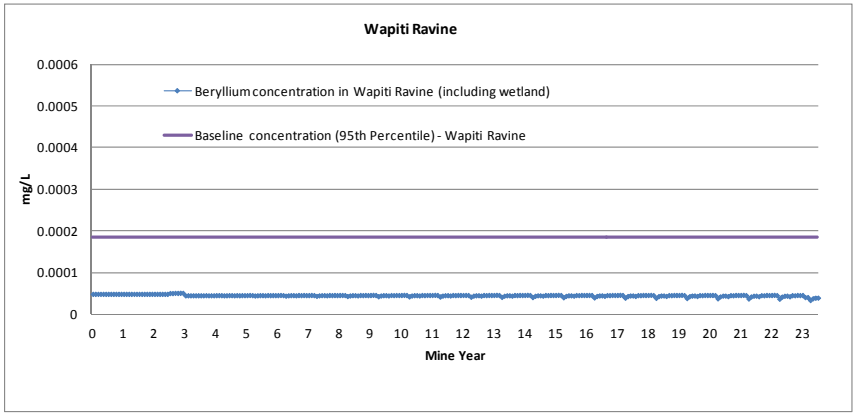
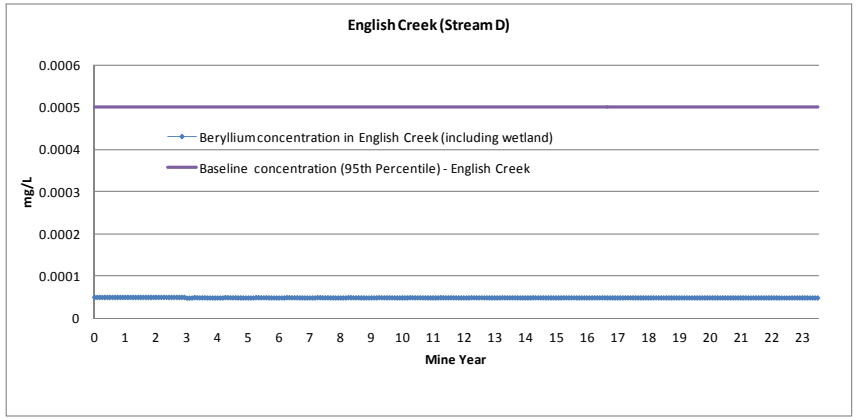


Figure 3-22 Continued







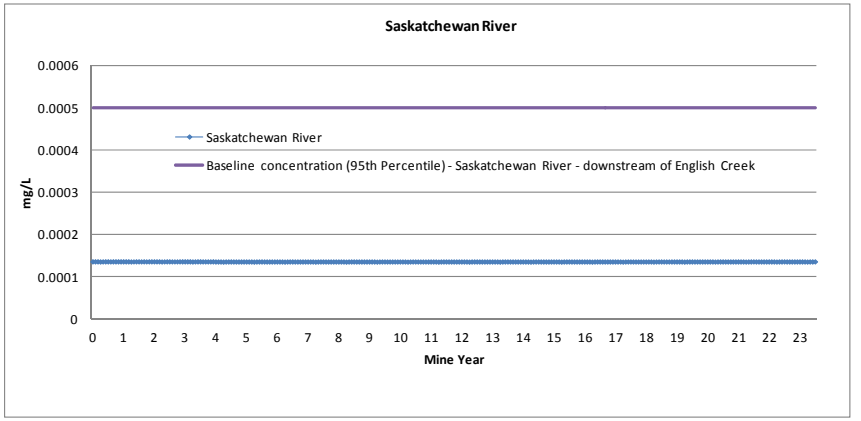
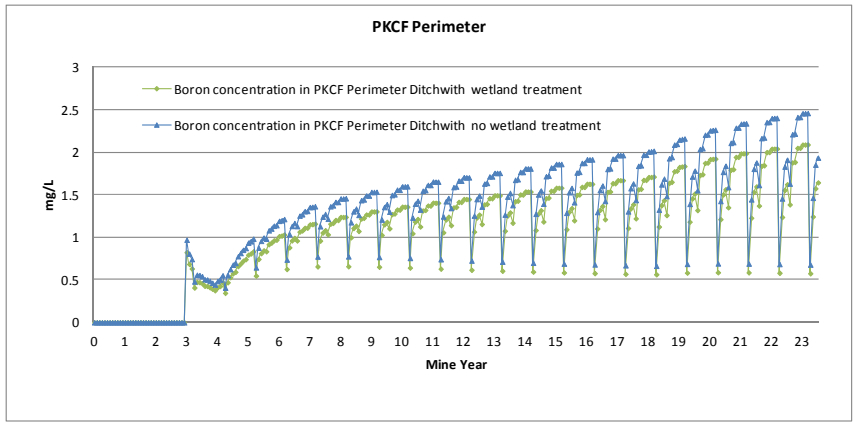
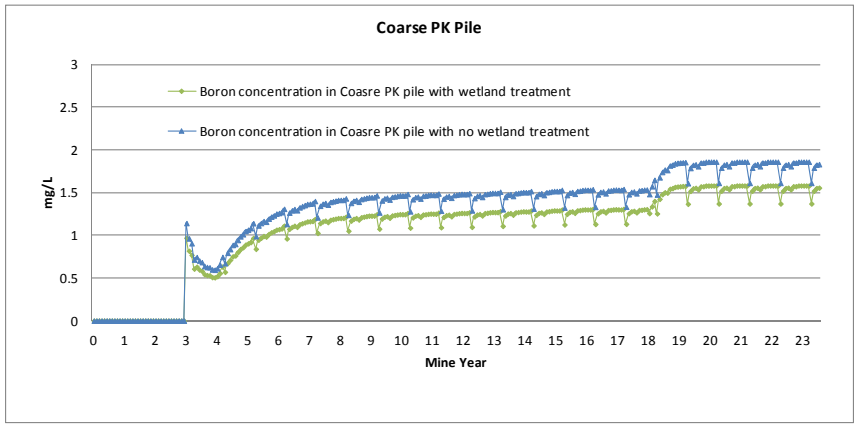


Figure 3-23 Predicted boron concentrations during construction and operation





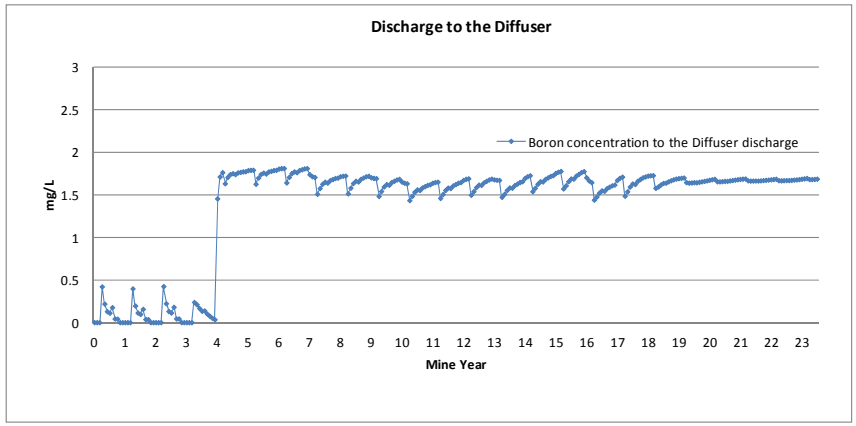
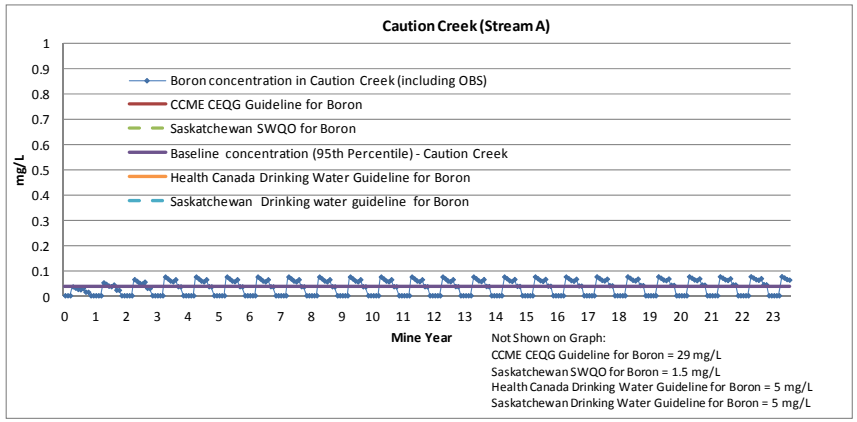
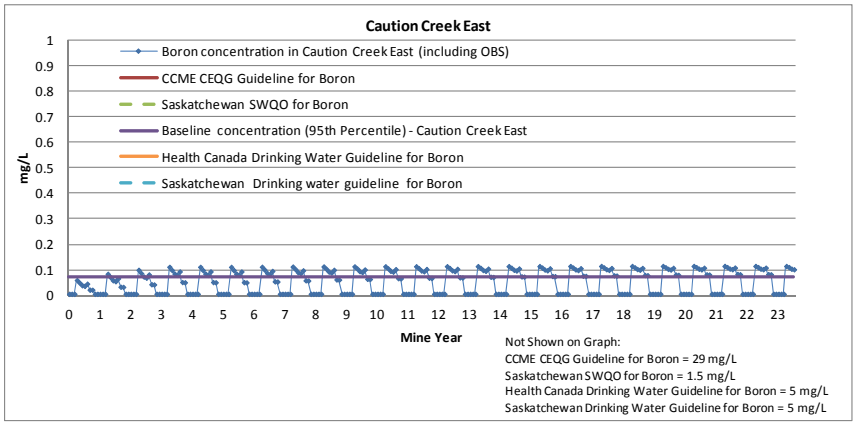
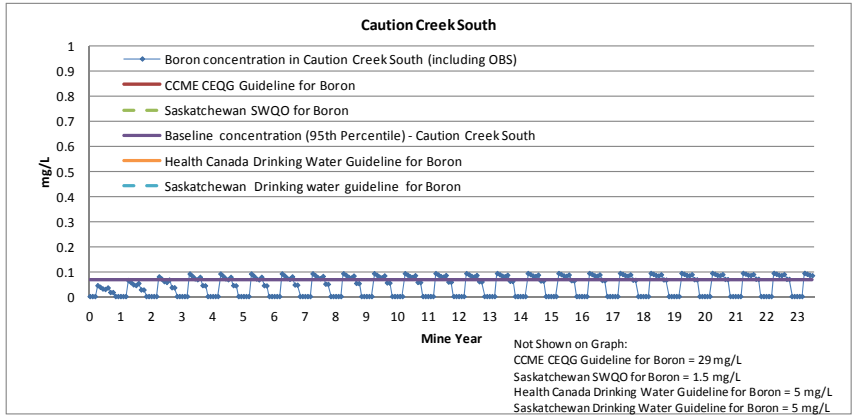
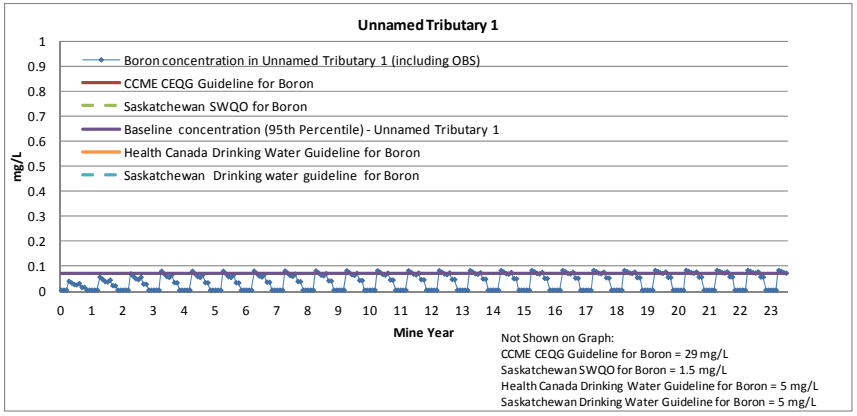


Figure 3-23 Continued









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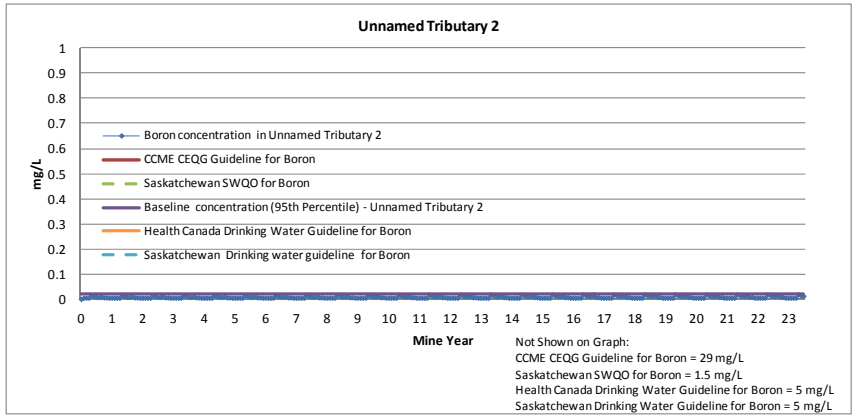
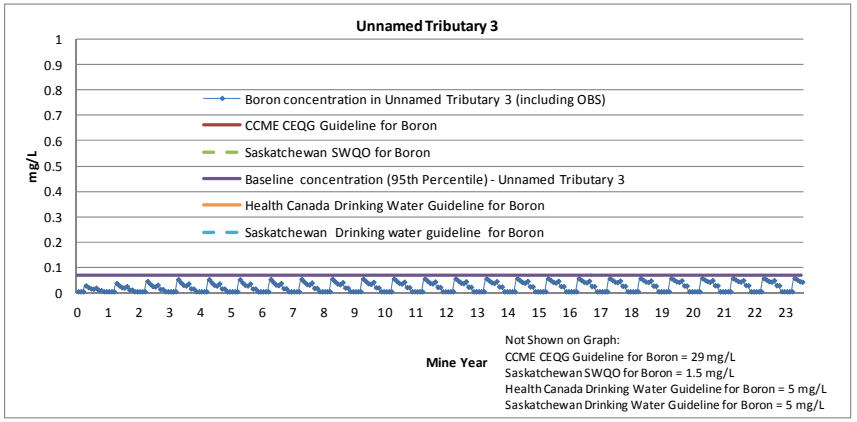
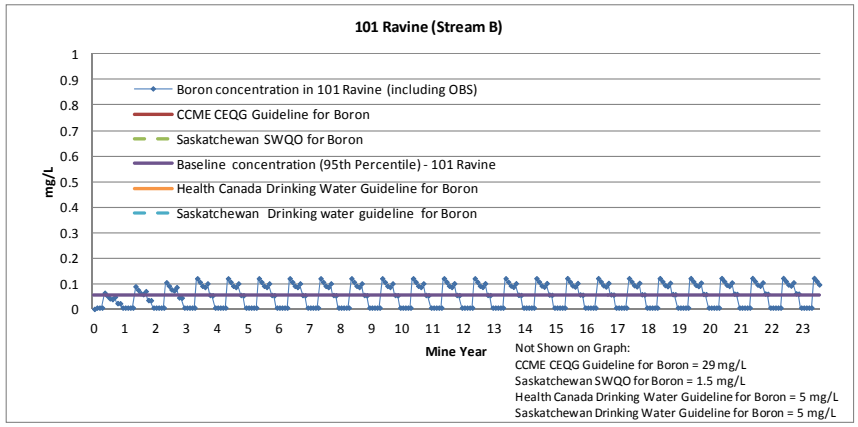






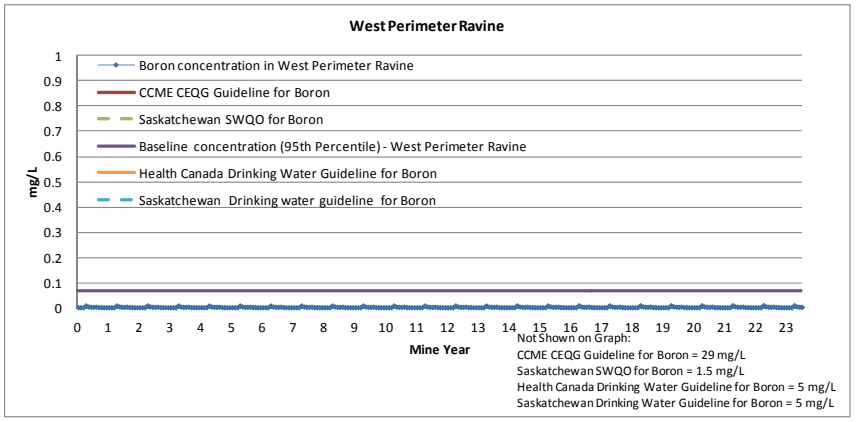
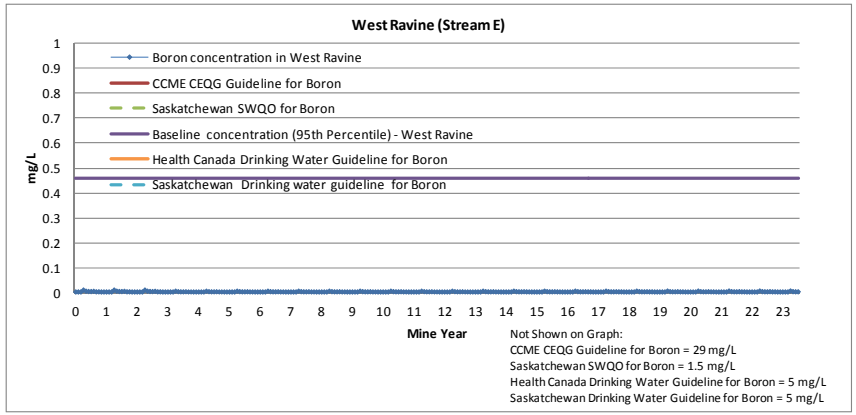
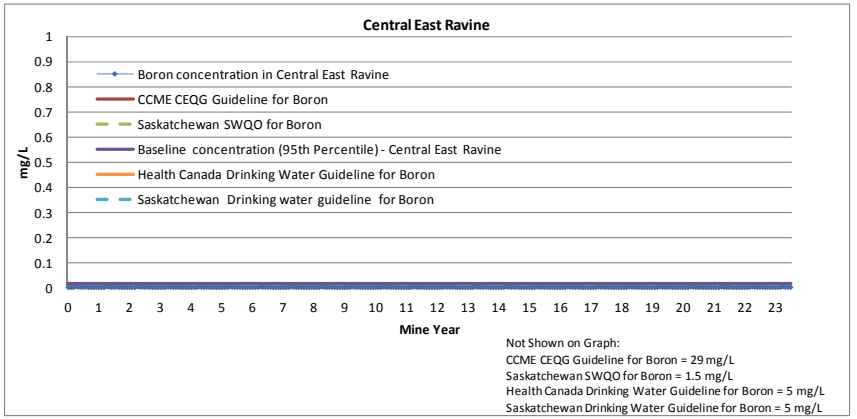
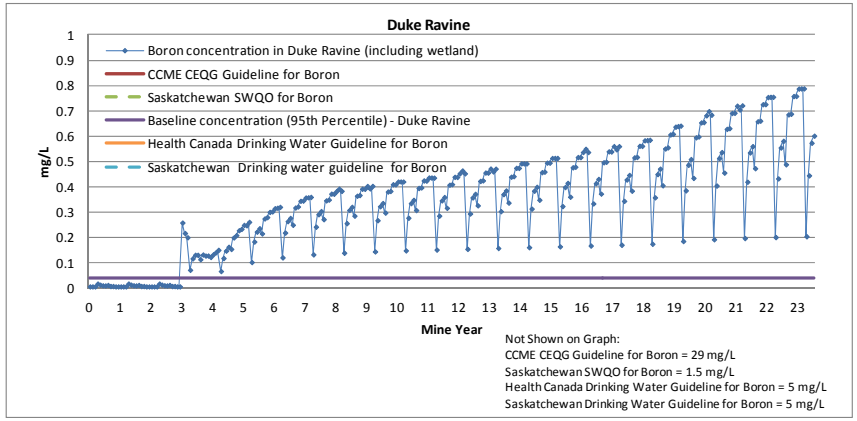


Figure 3-23 Continued







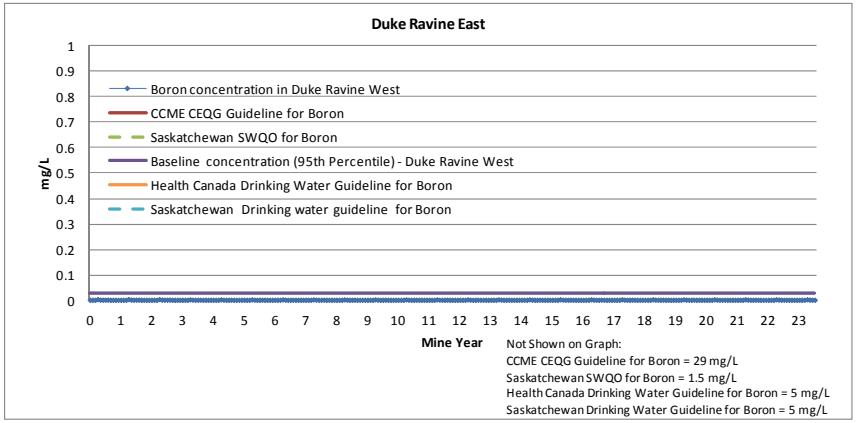
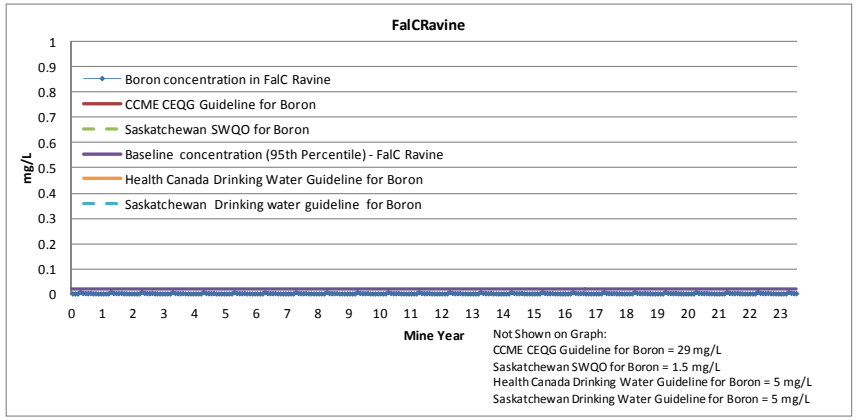
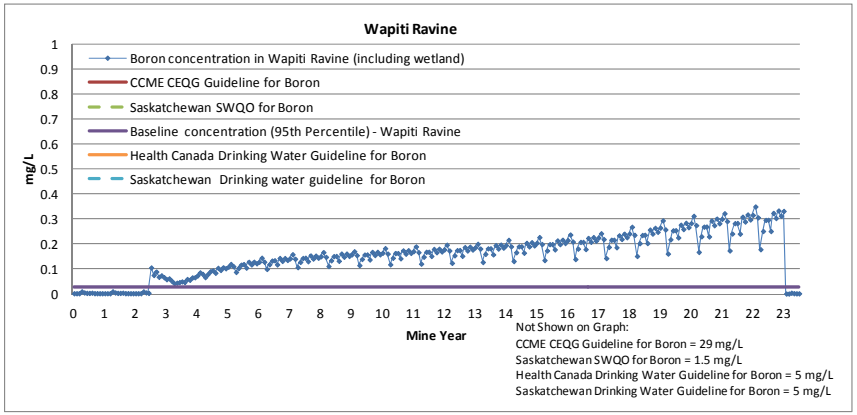
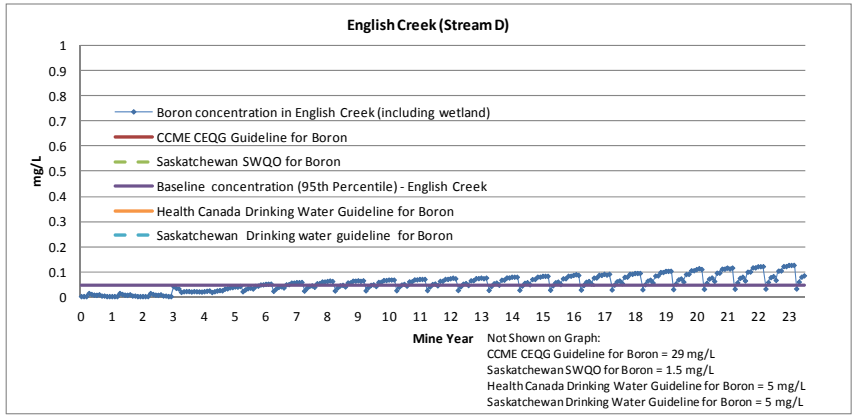


Figure 3-23 Continued







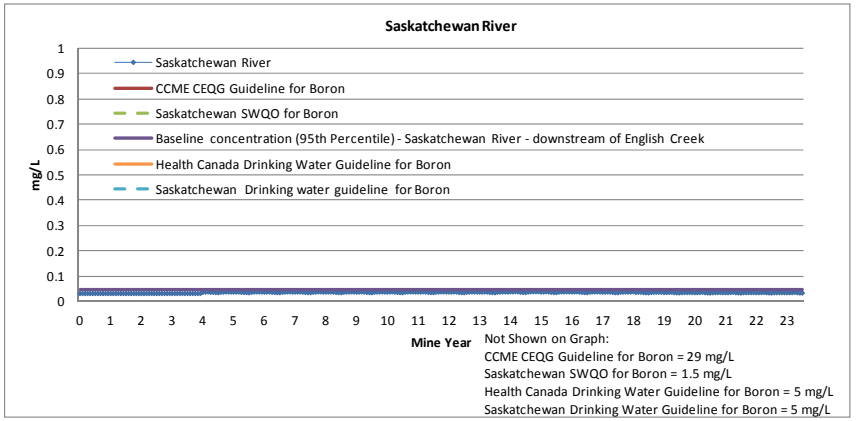
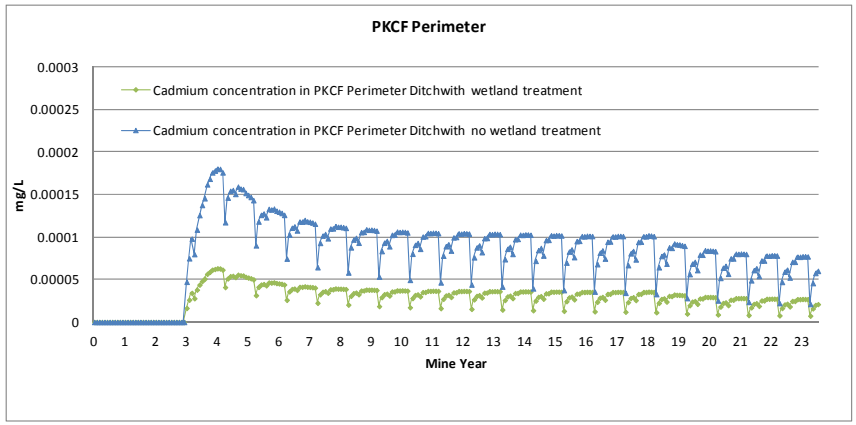
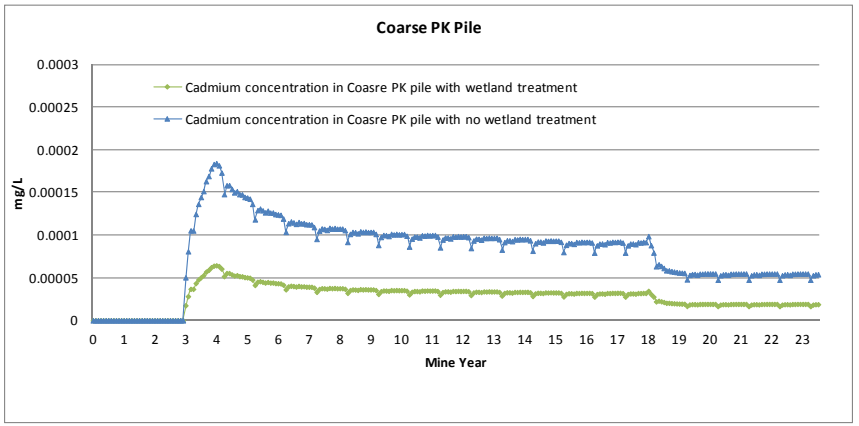


Figure 3-24 Predicted cadmium concentrations during construction and operation





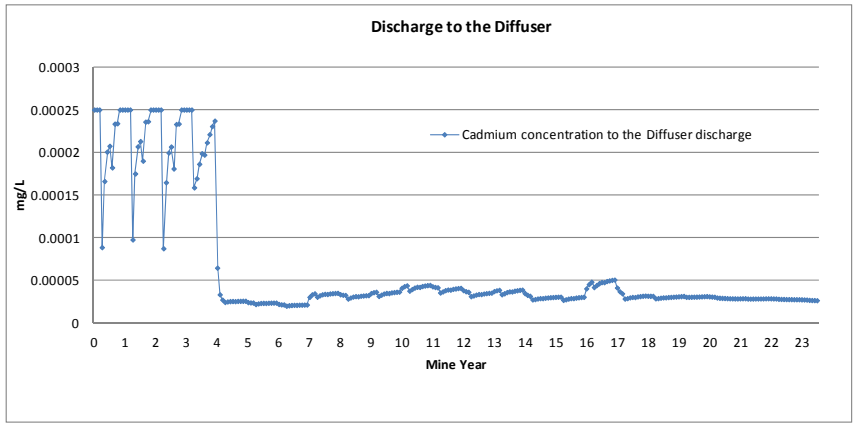
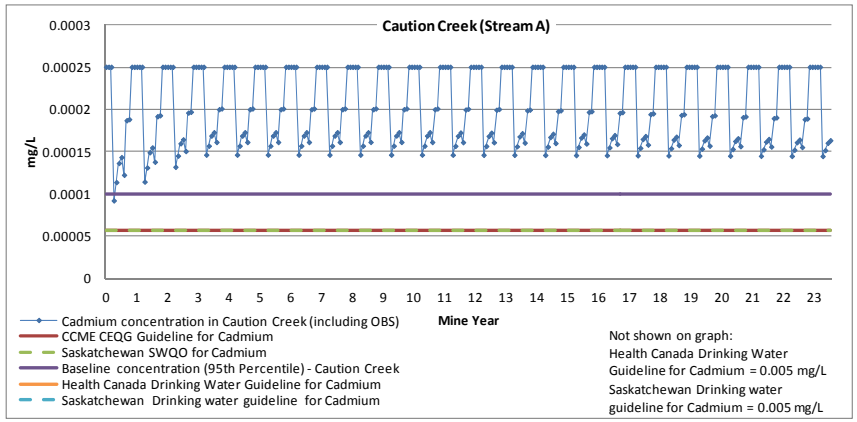
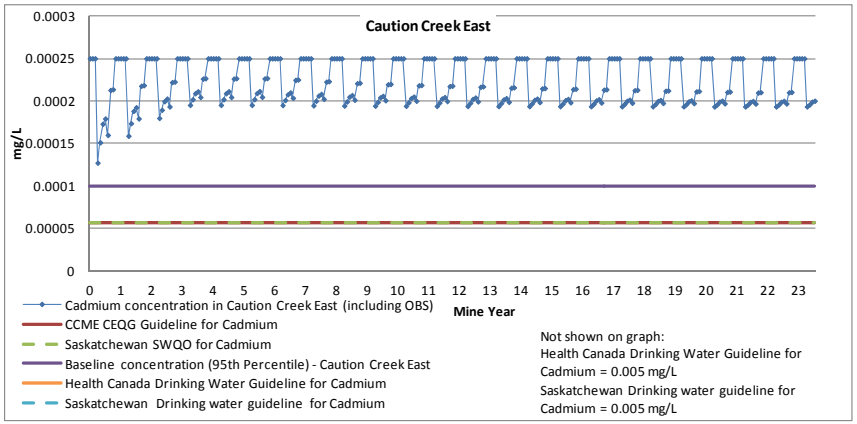
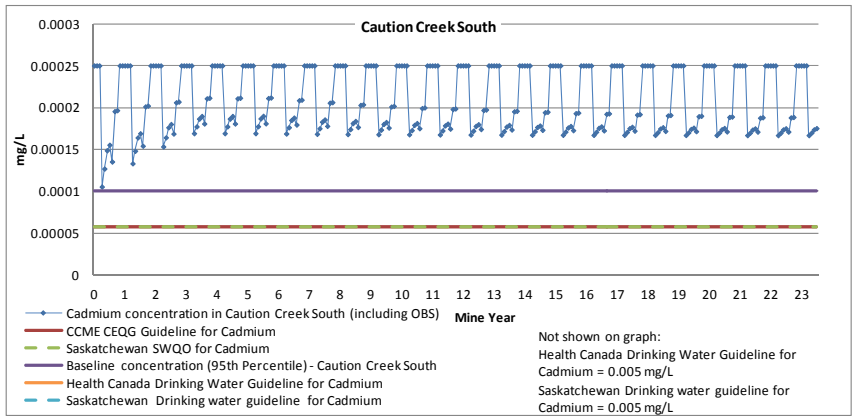


Figure 3-24 Continued







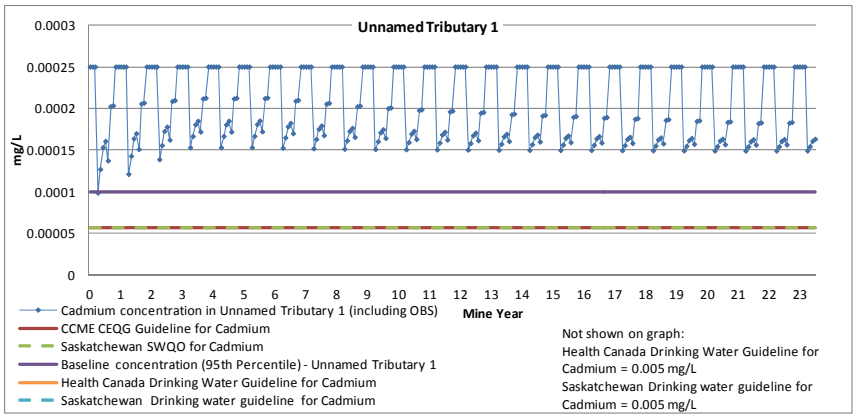
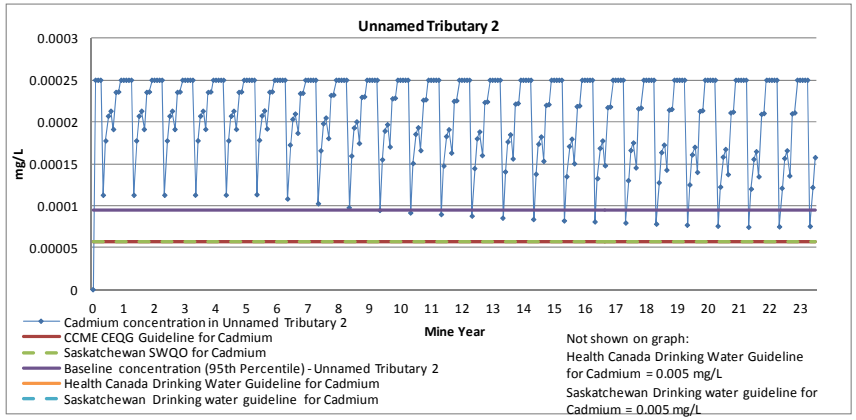
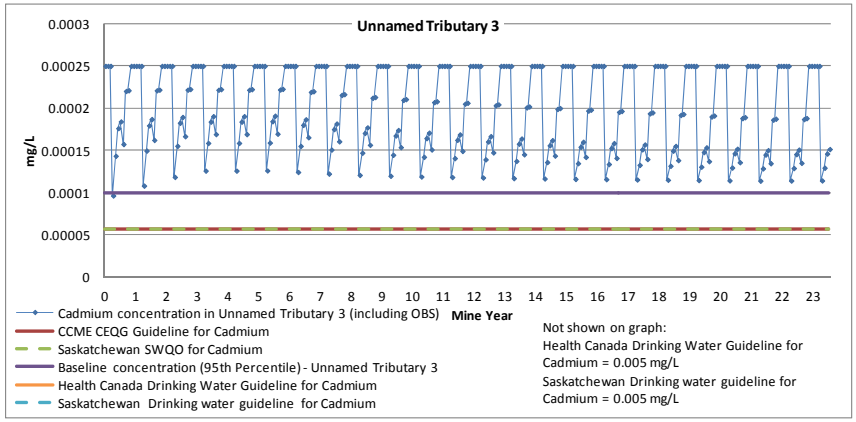
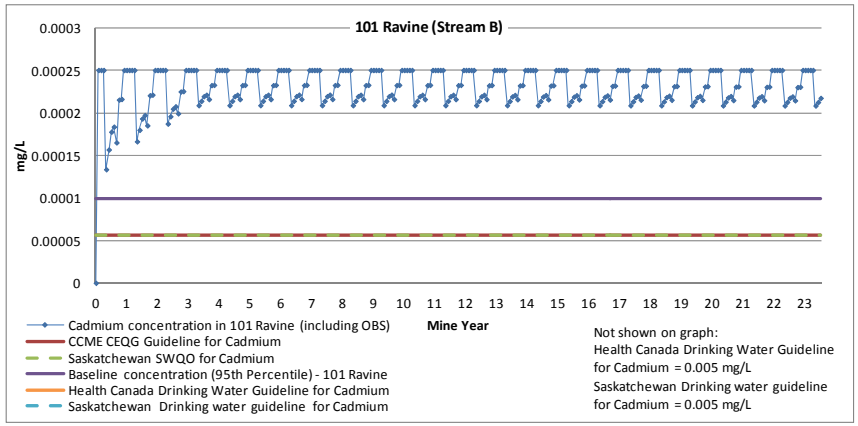


Figure 3-24 Continued







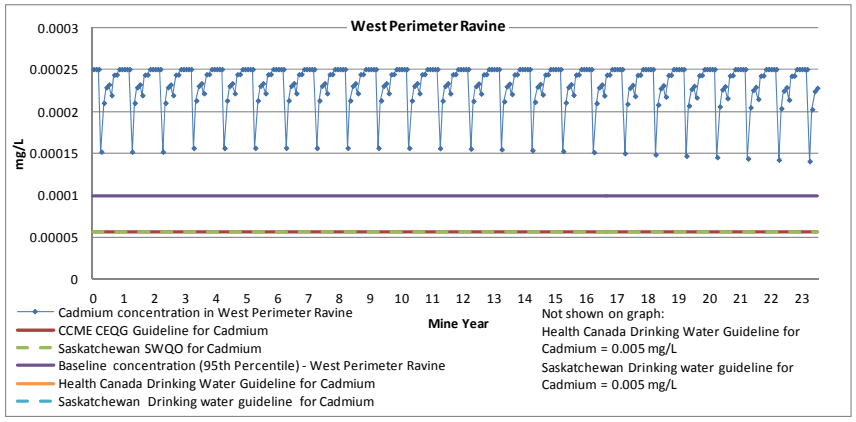
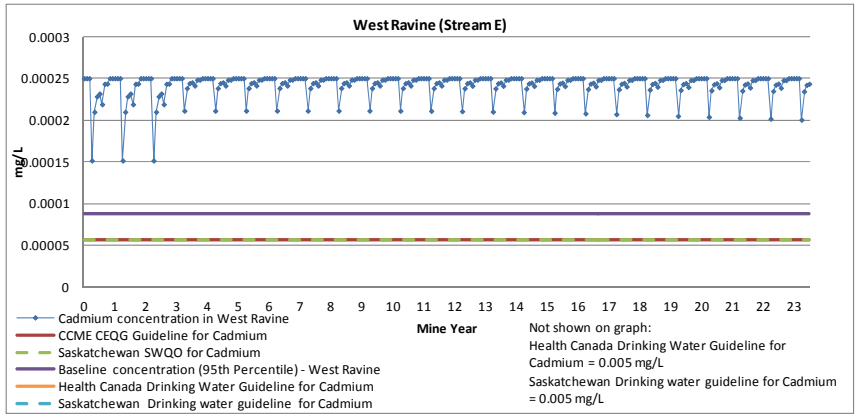
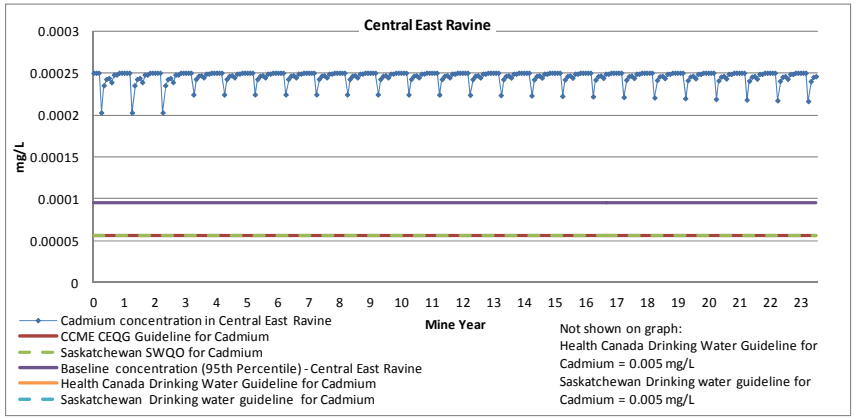
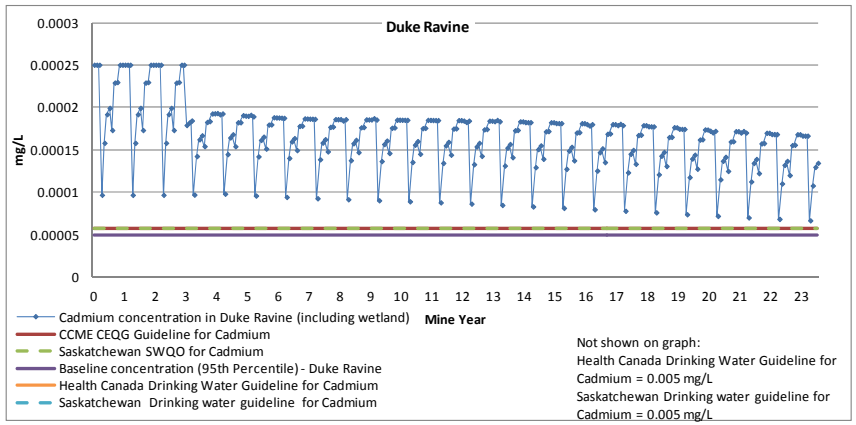


Figure 3-24 Continued







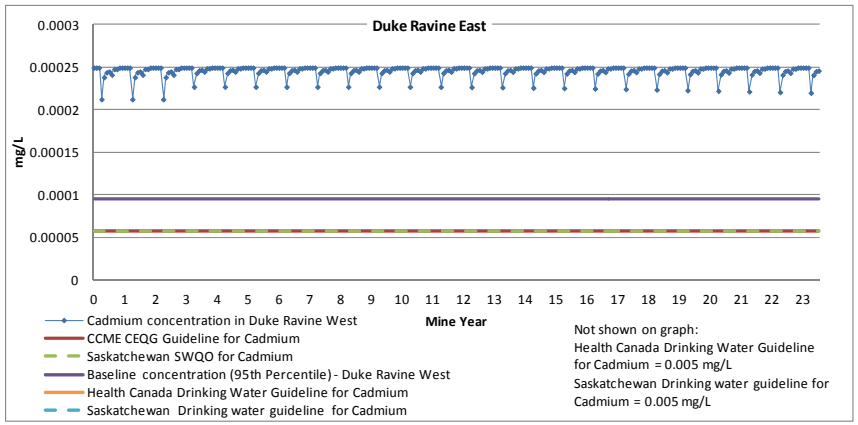
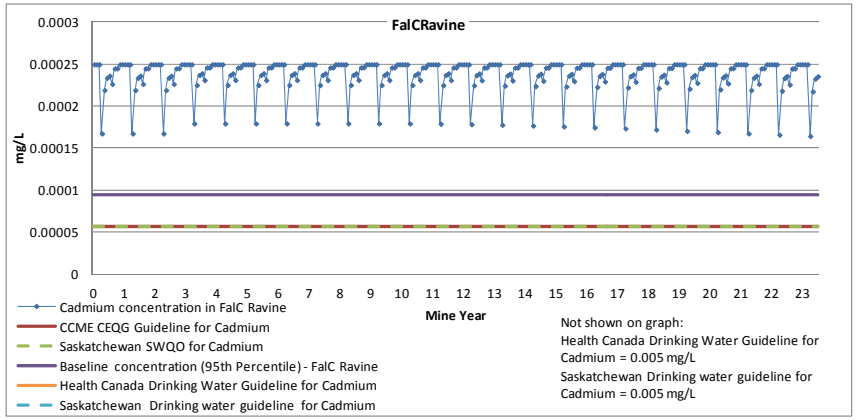
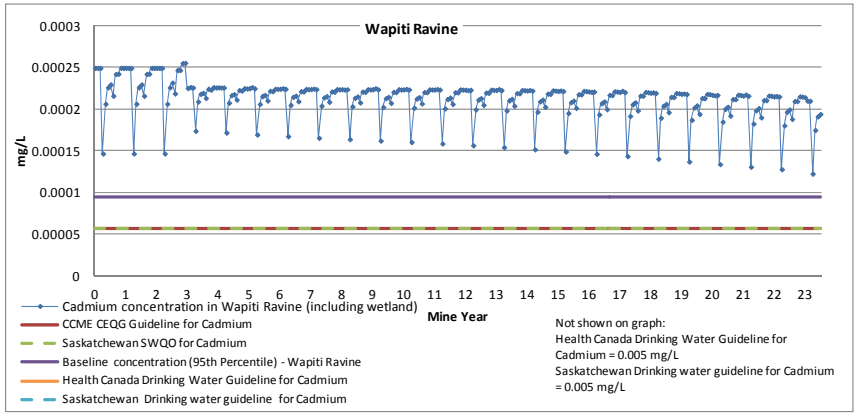
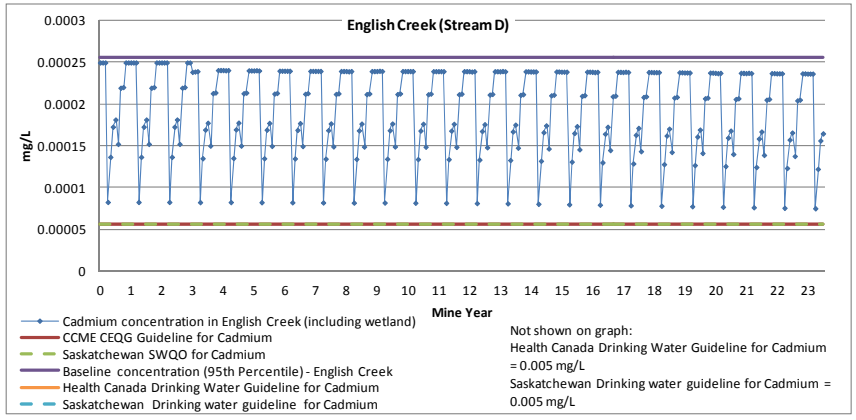


Figure 3-24 Continued







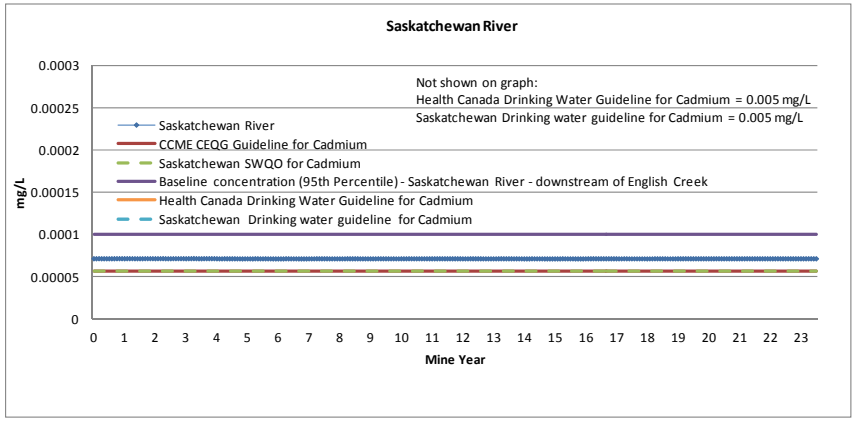
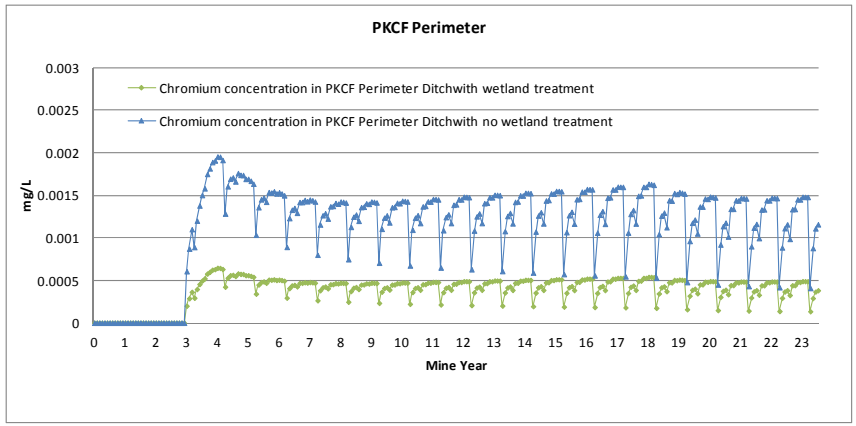
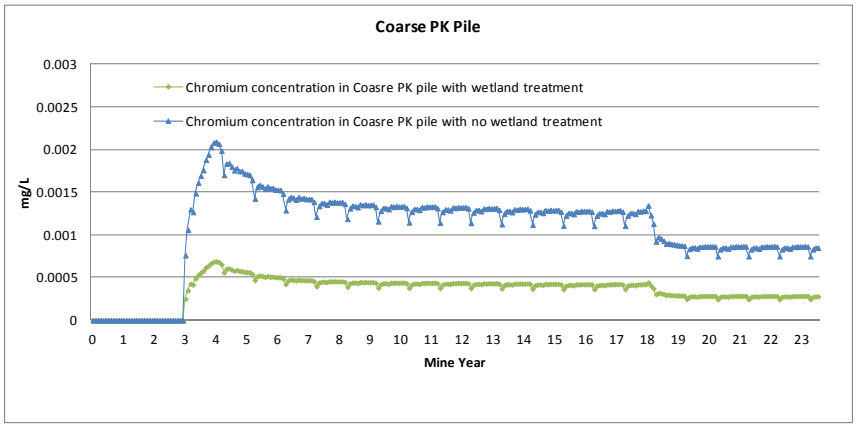


Figure 3-25 Predicted chromium concentrations during construction and operation





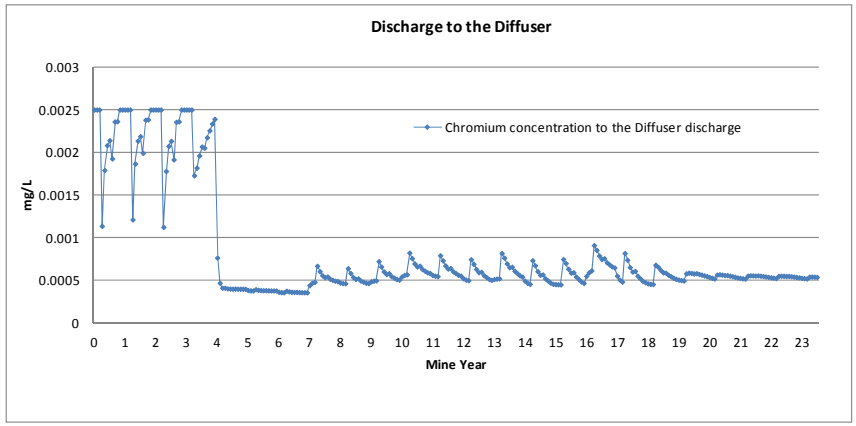
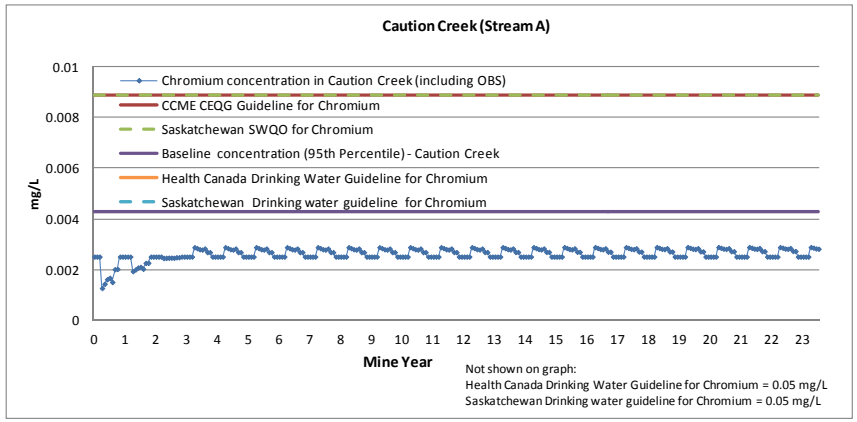
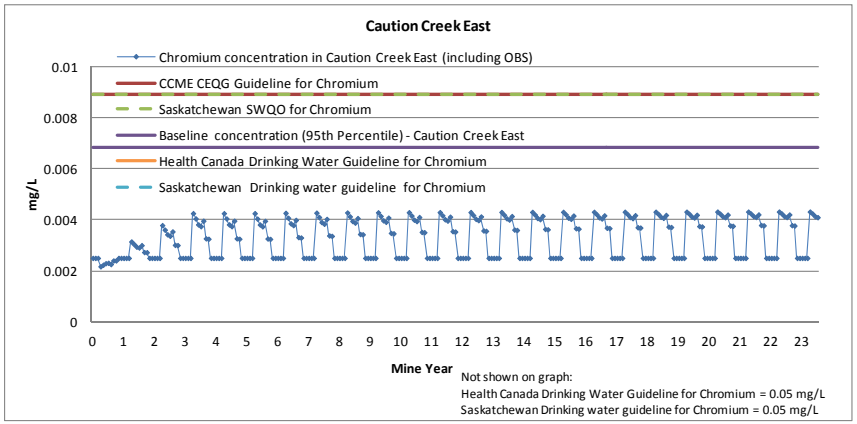
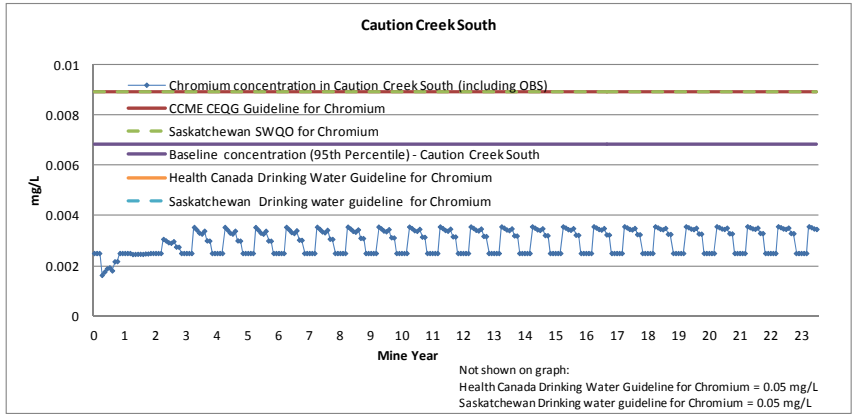
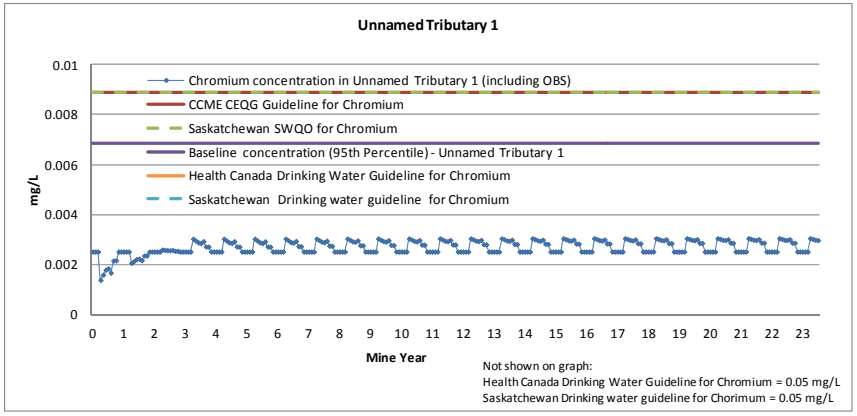


Figure 3-25 Continued









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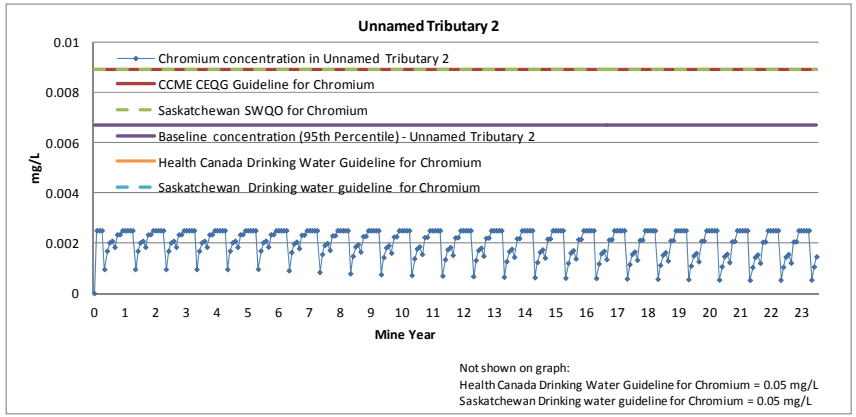

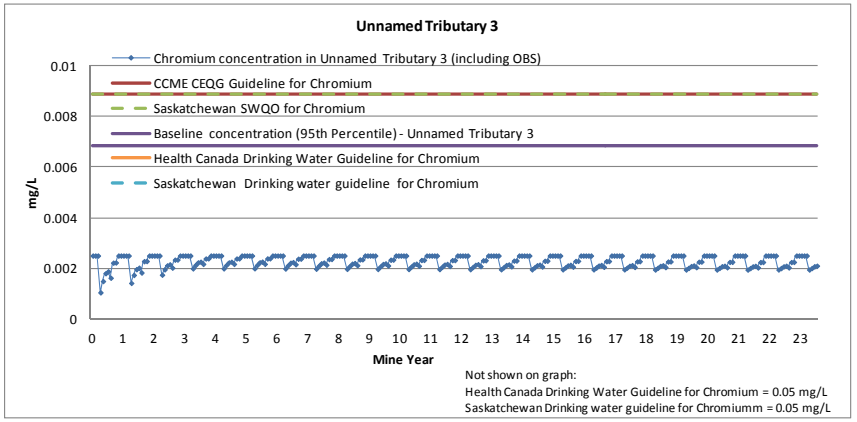

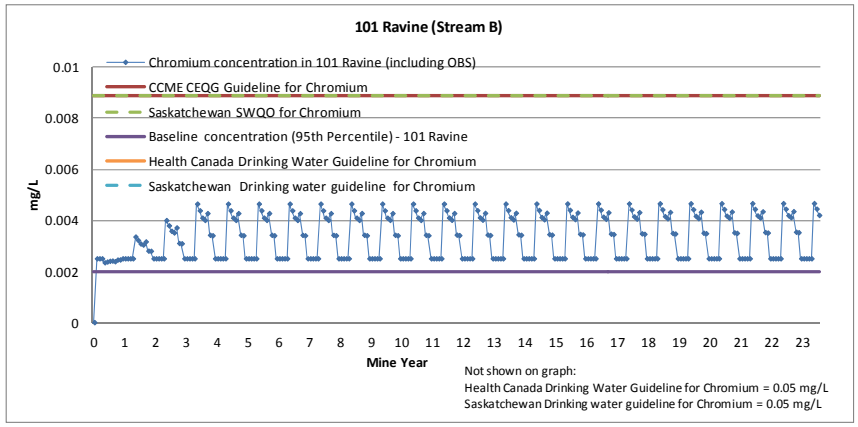

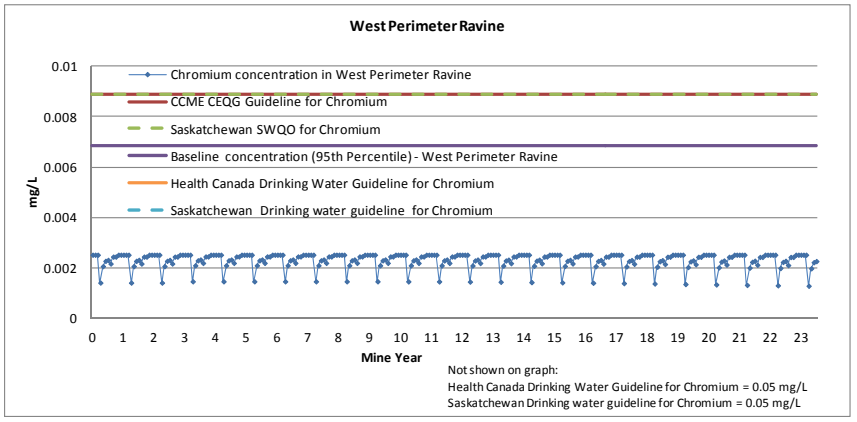

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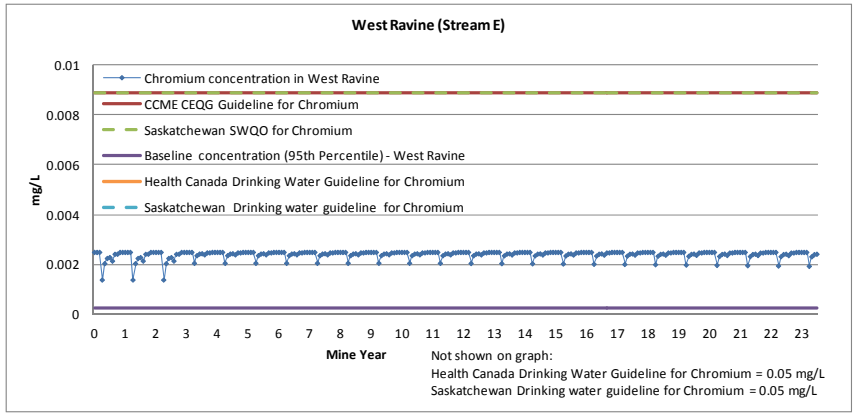
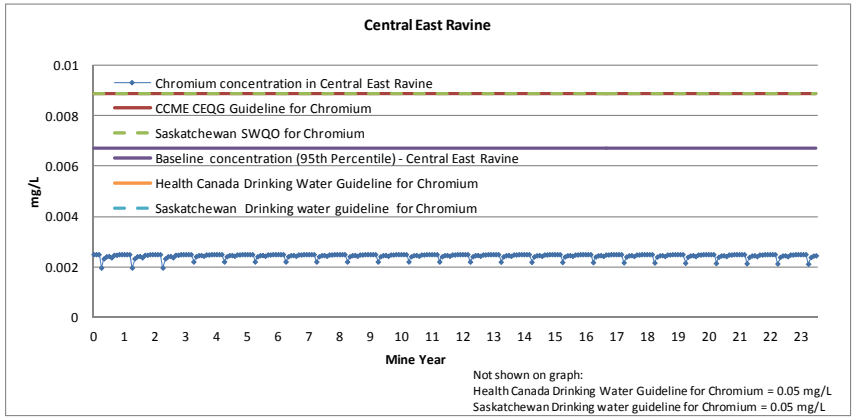
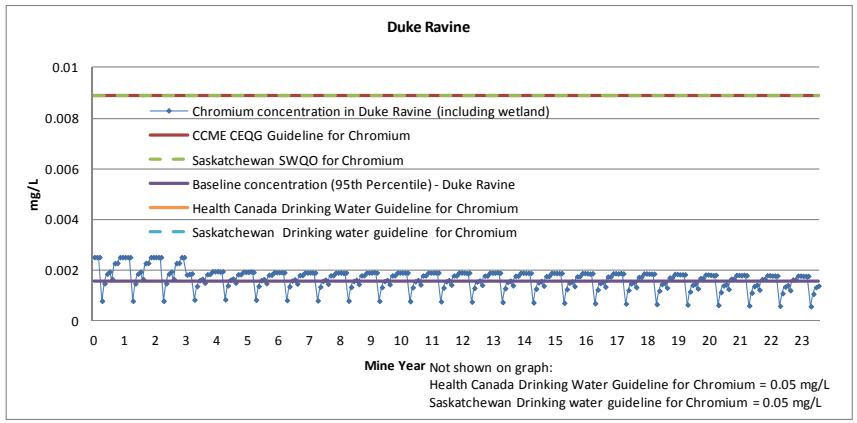






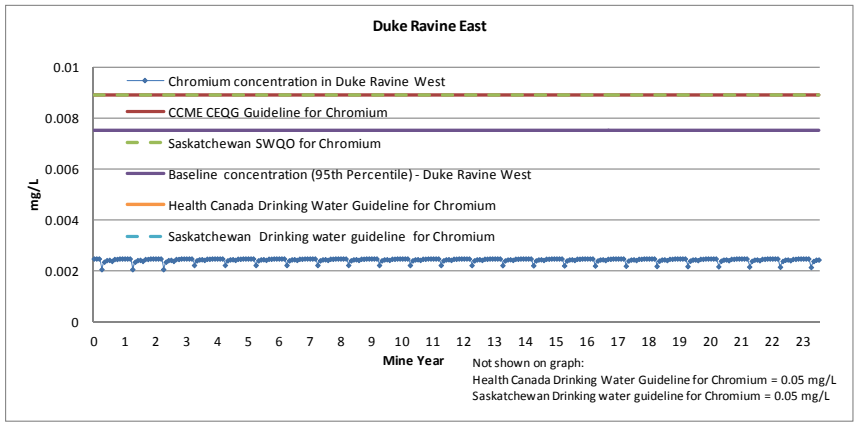
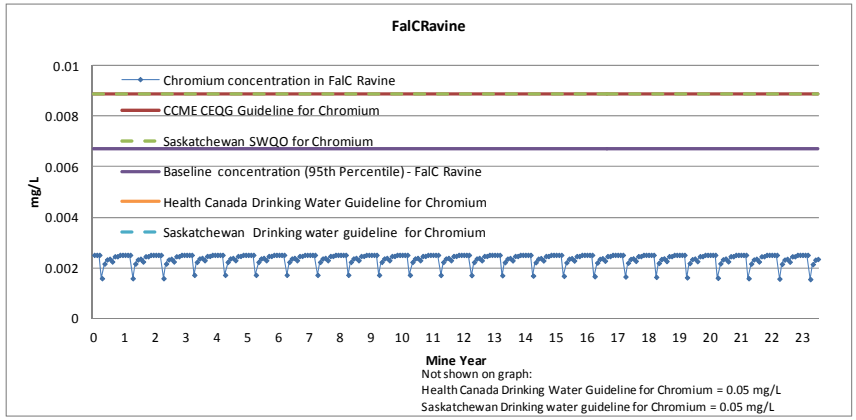
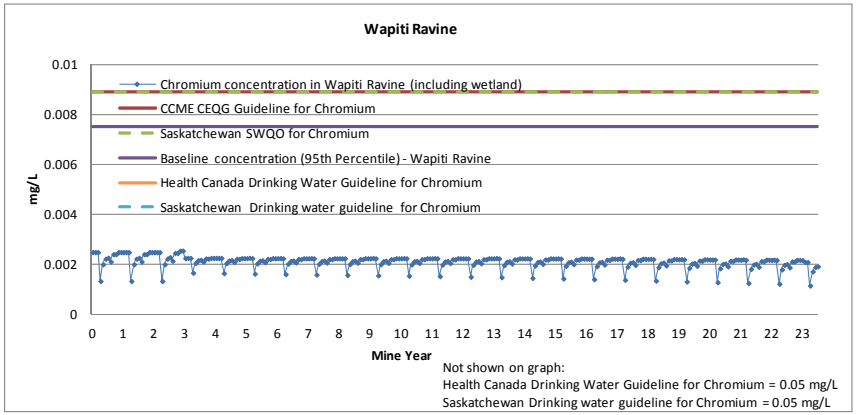
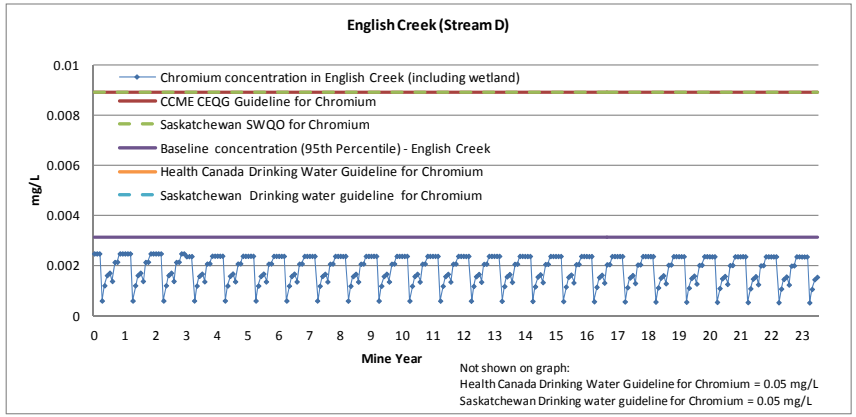


Figure 3-25 Continued







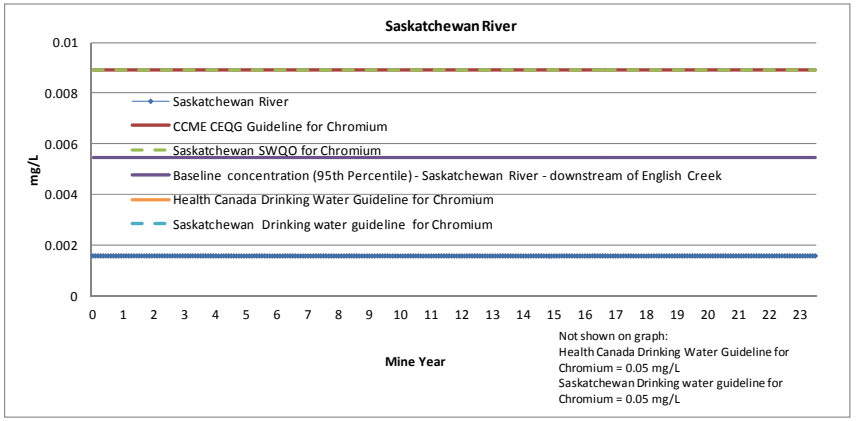
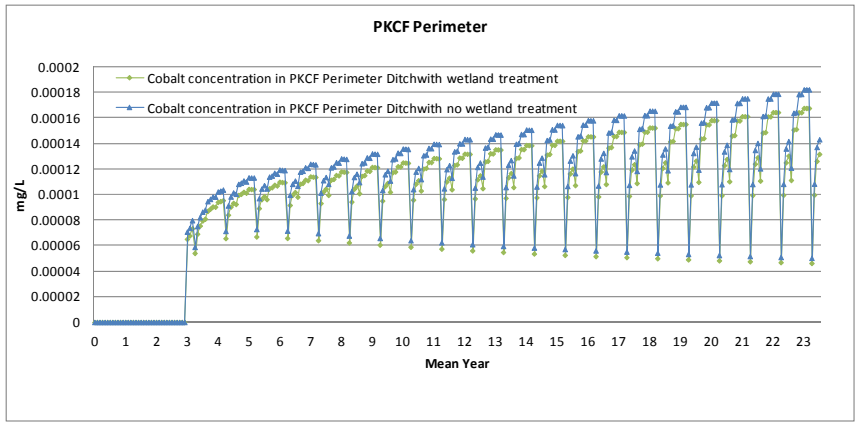
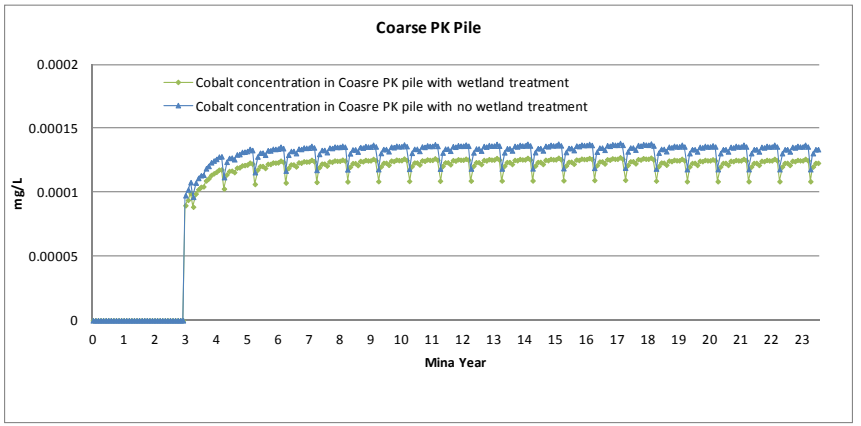
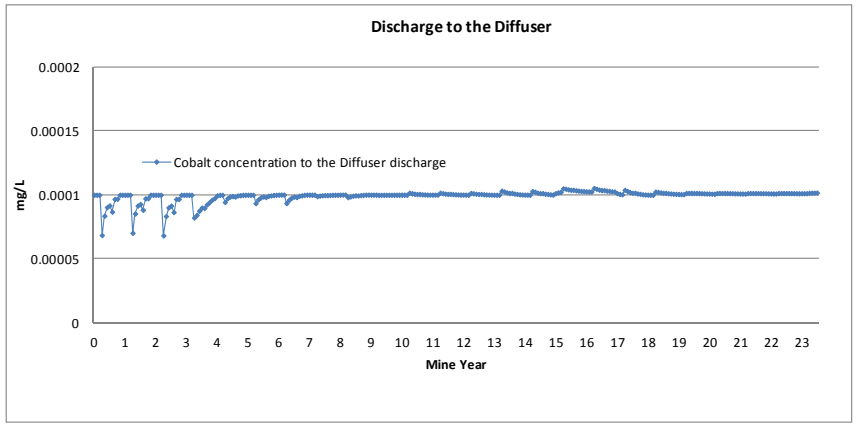


Figure 3-26 Predicted cobalt concentrations during construction and operation







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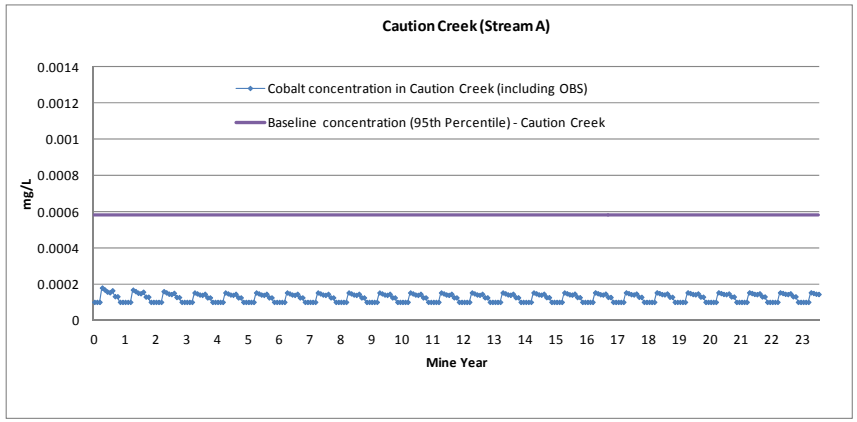
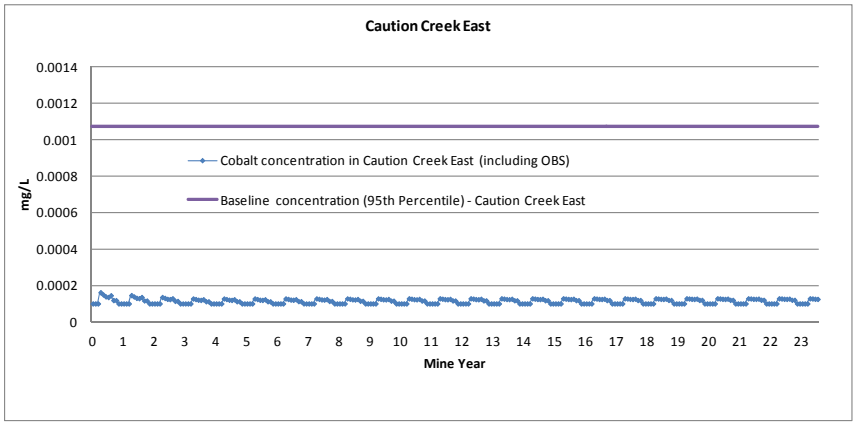
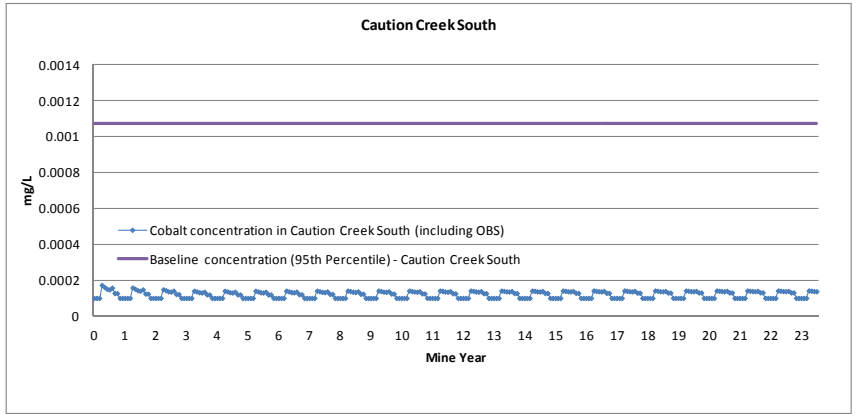






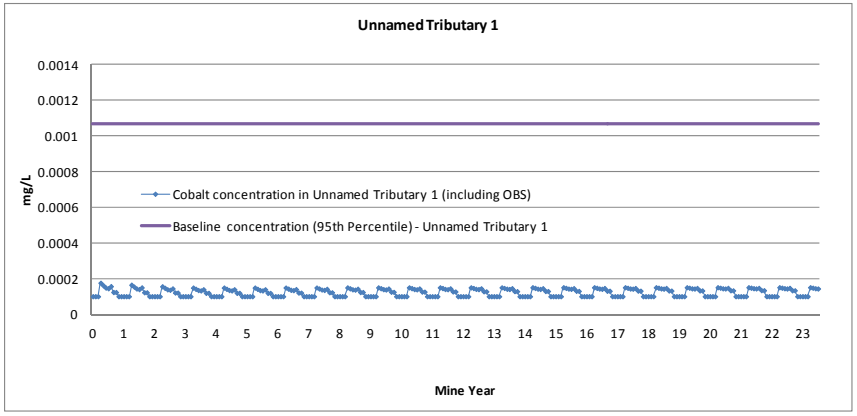
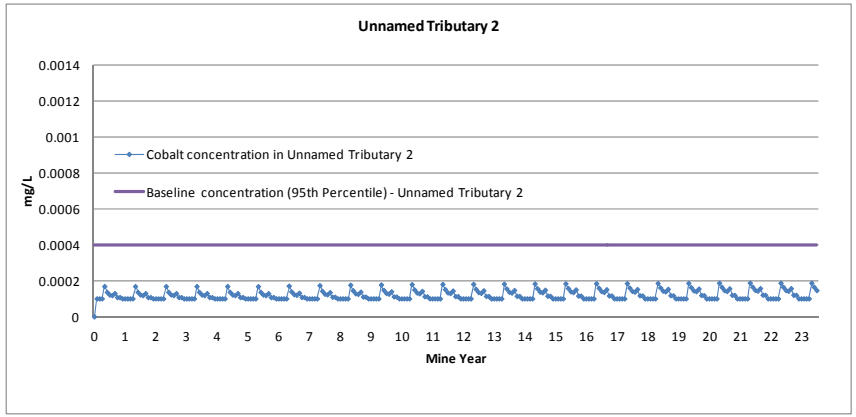
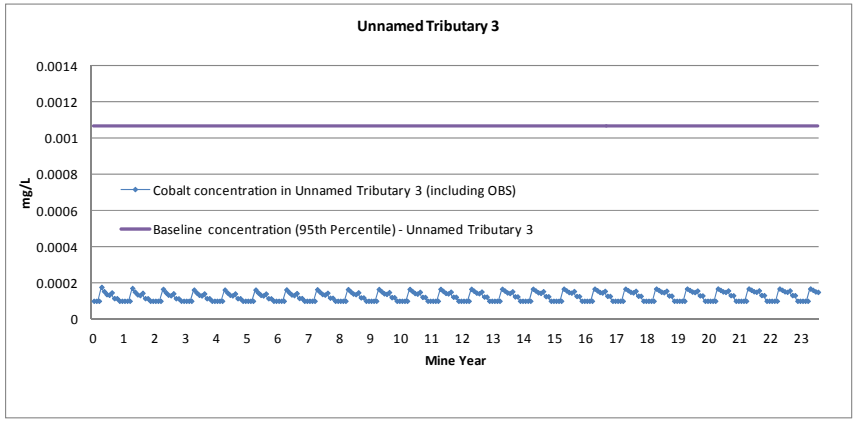
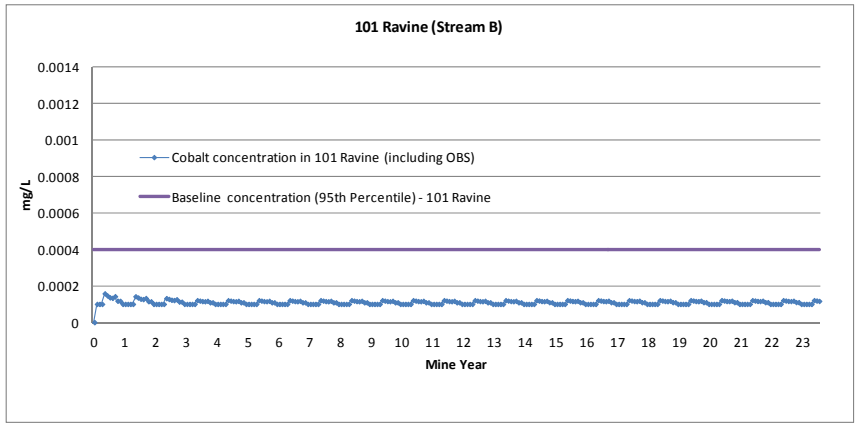


Figure 3-26 Continued







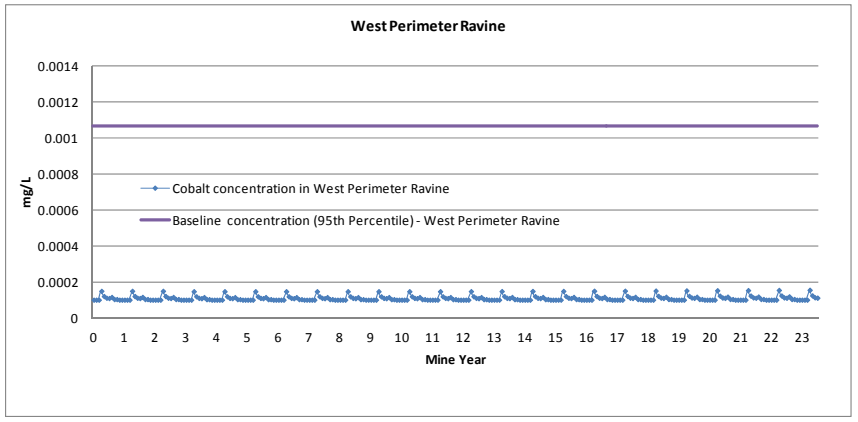
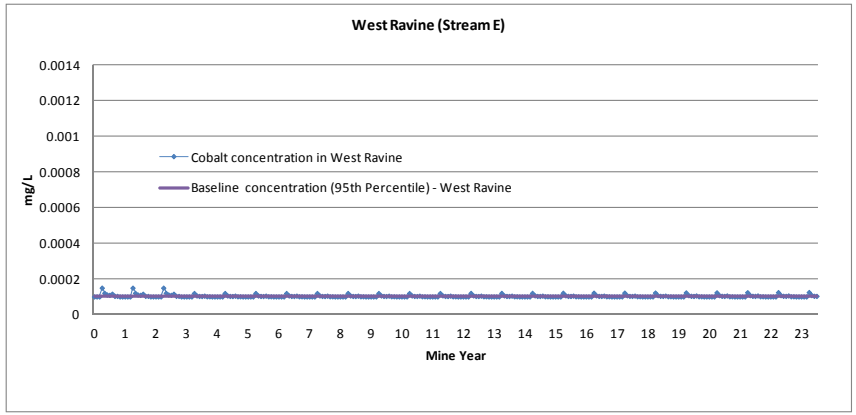
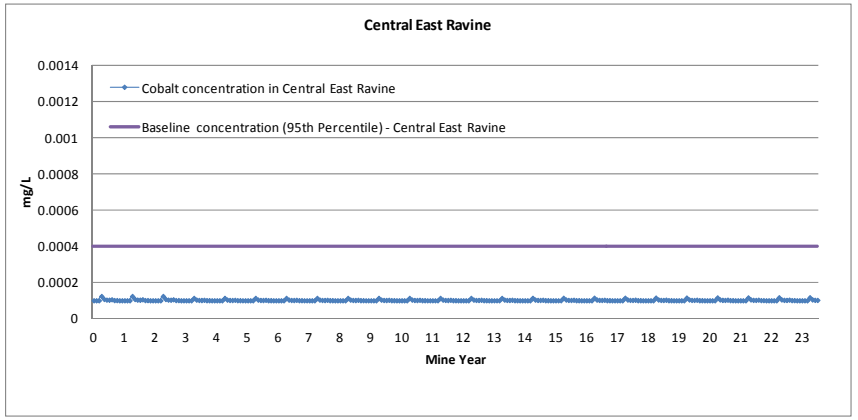
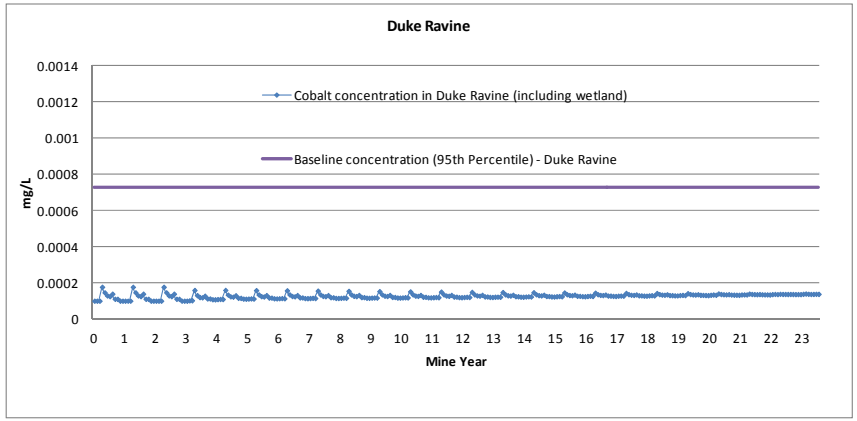


Figure 3-26 Continued







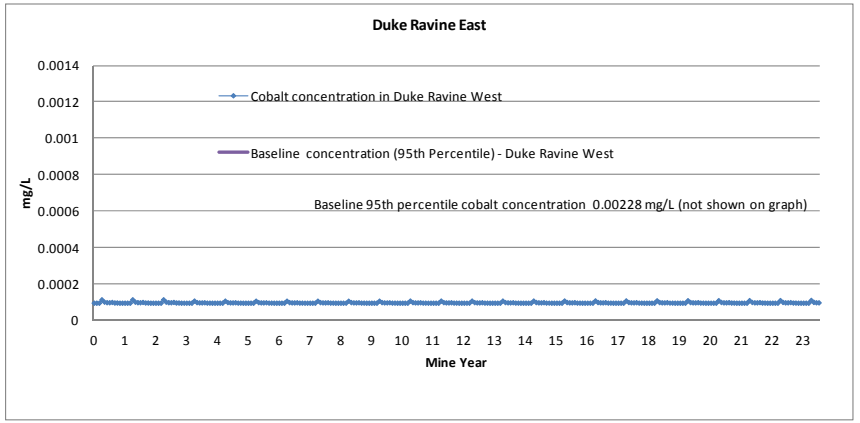
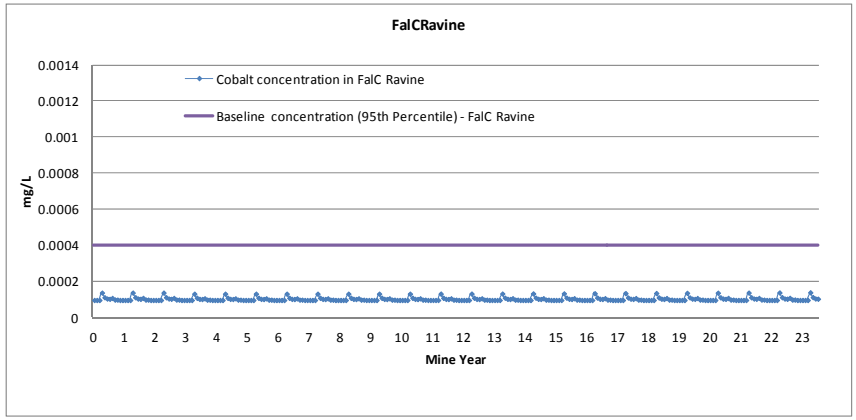
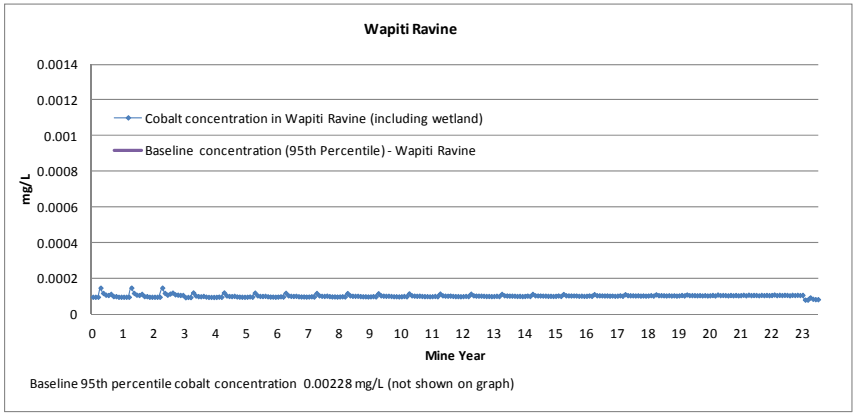
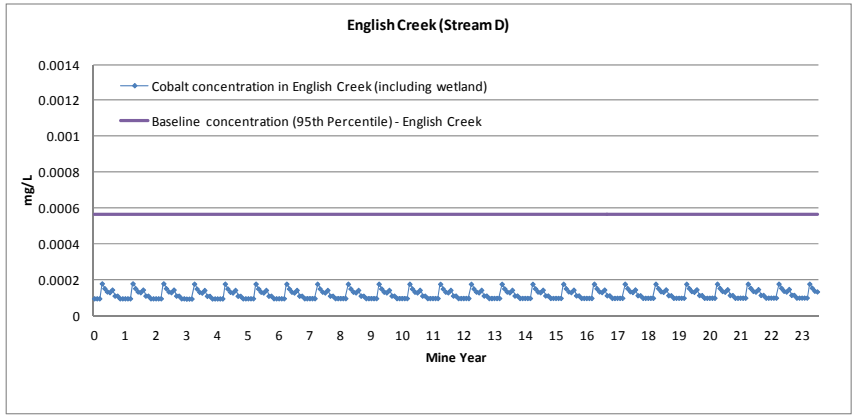


Figure 3-26 Continued





Baseline 95th percentile cobalt concentration 0.00228 mg/L (not shown on graph)



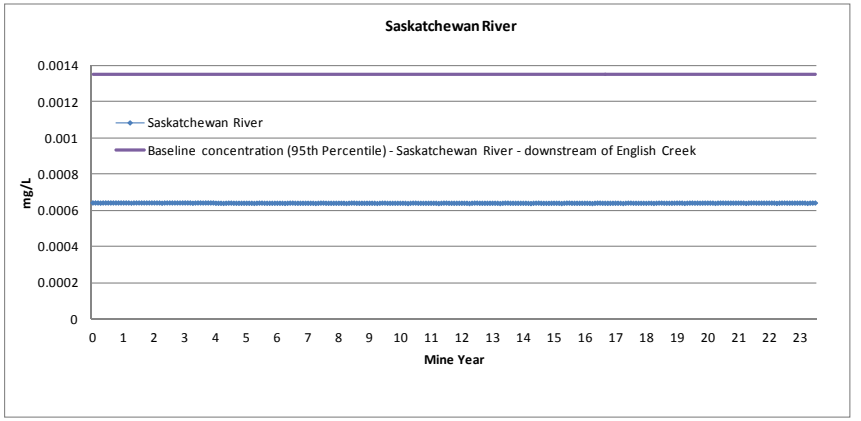
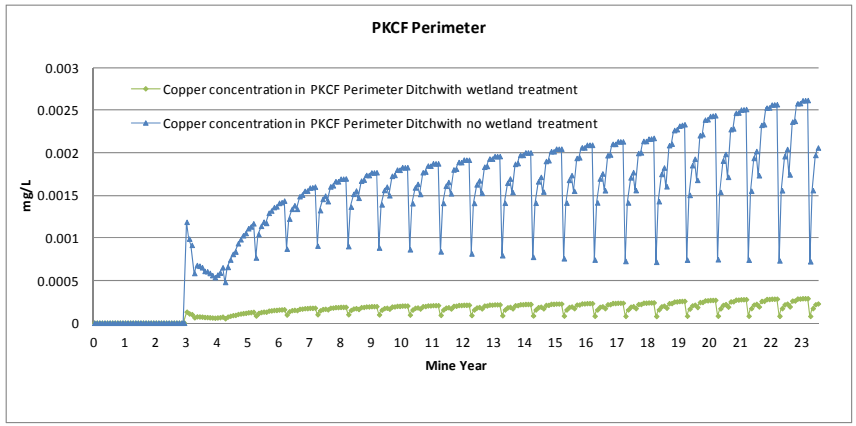
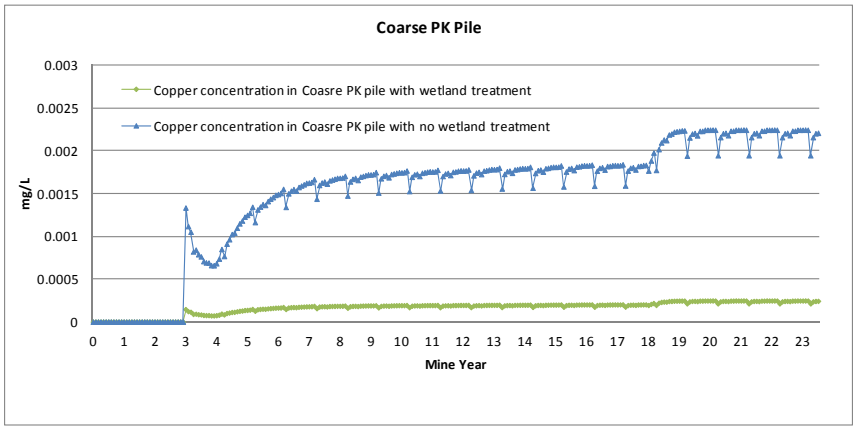


Figure 3-27 Predicted copper concentrations during construction and operation





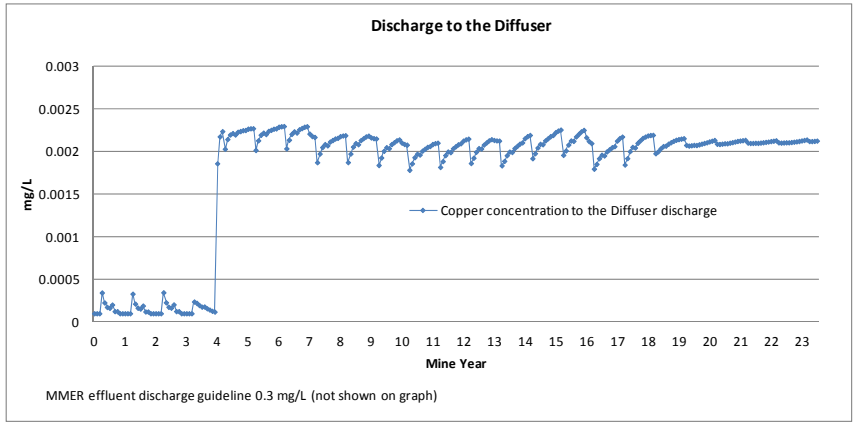
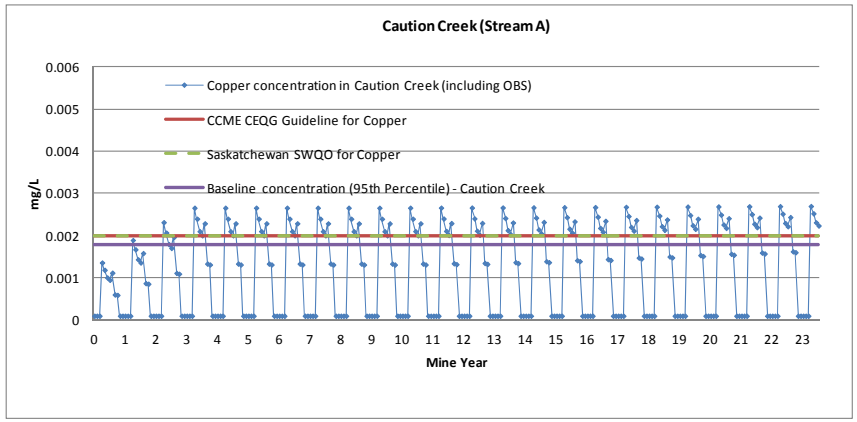
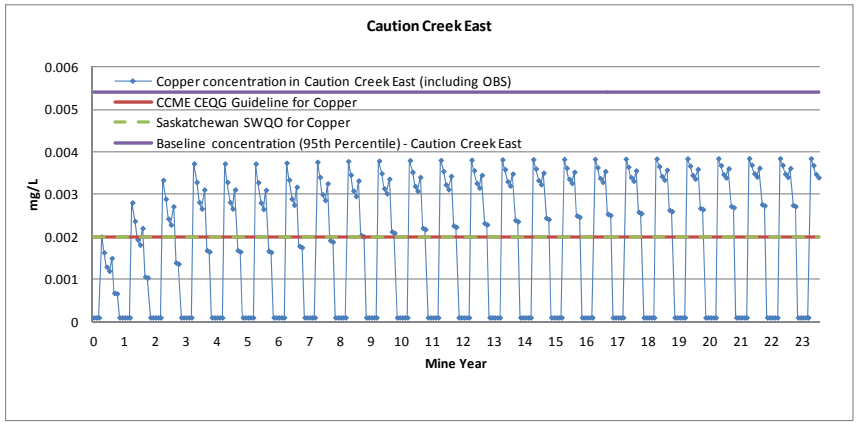
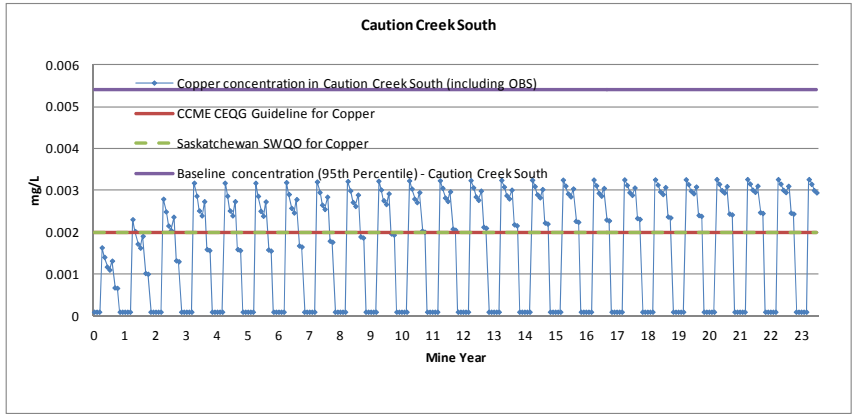


Figure 3-27 Continued







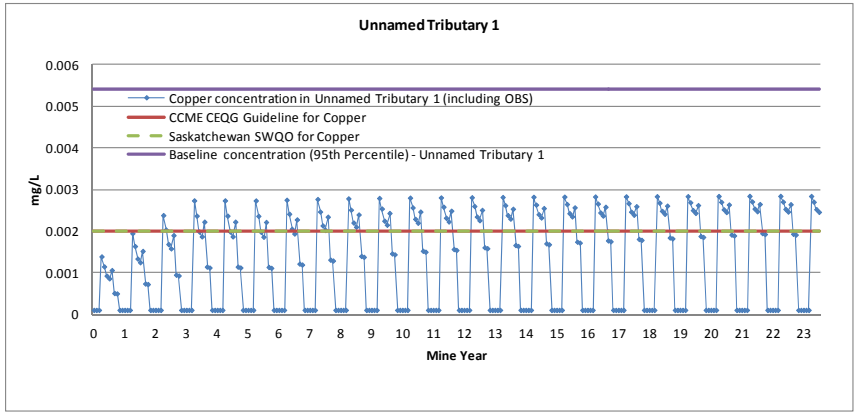
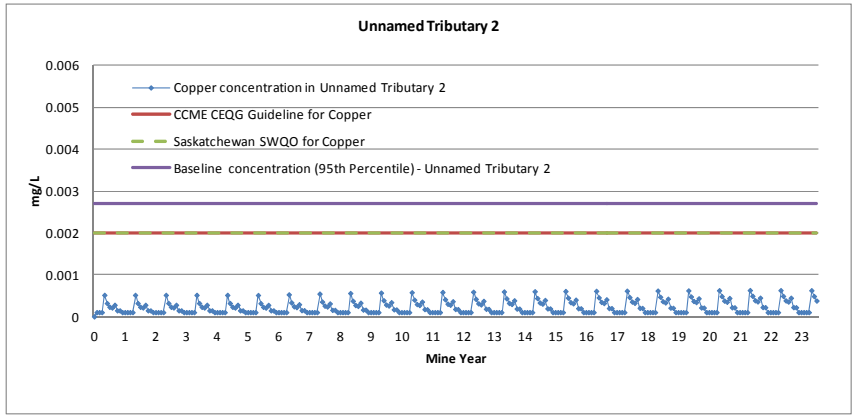
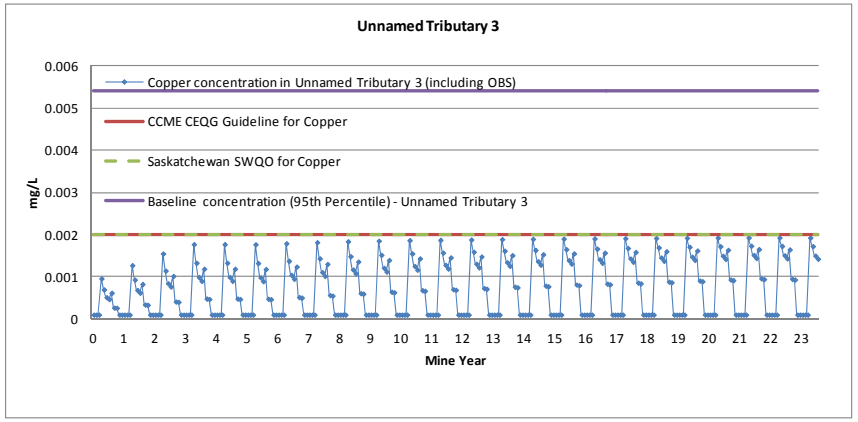
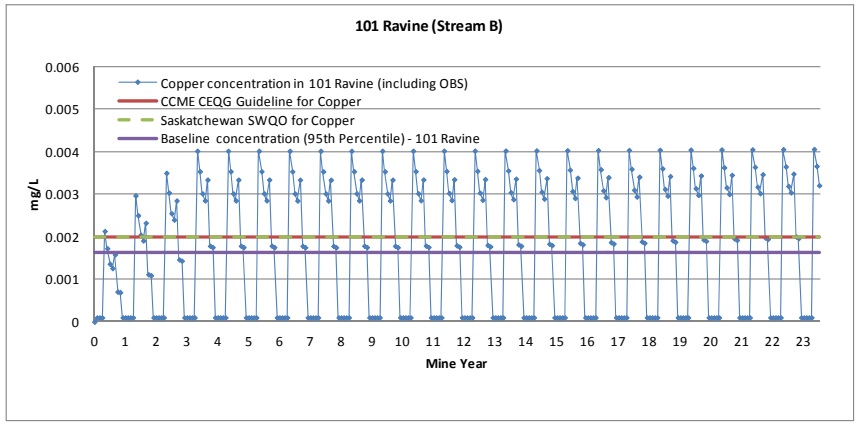
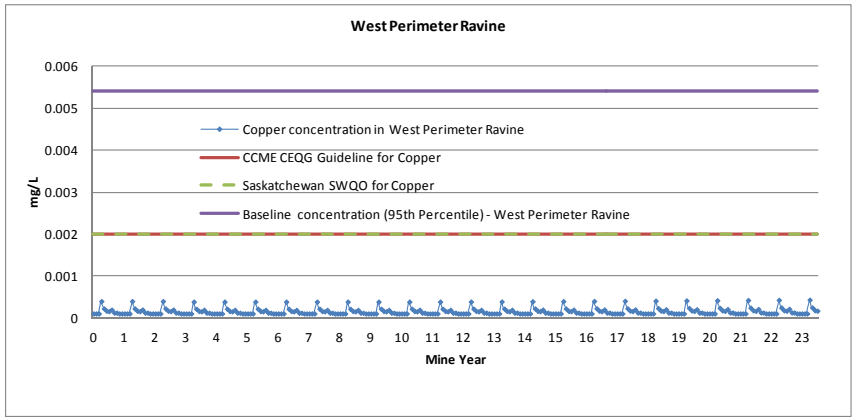


Figure 3-27 Continued









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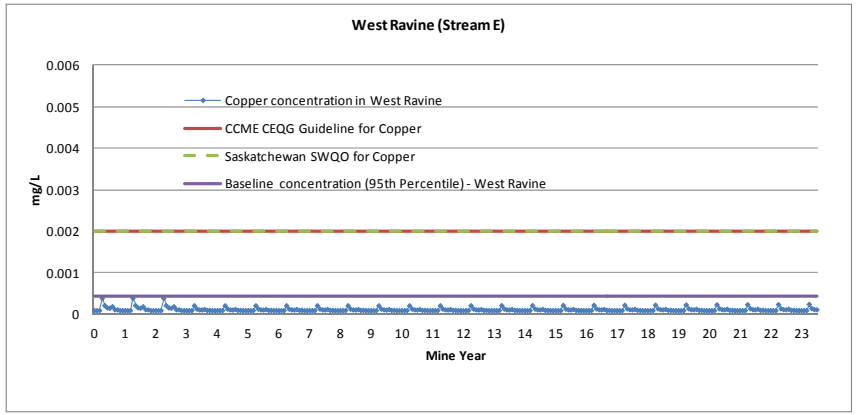
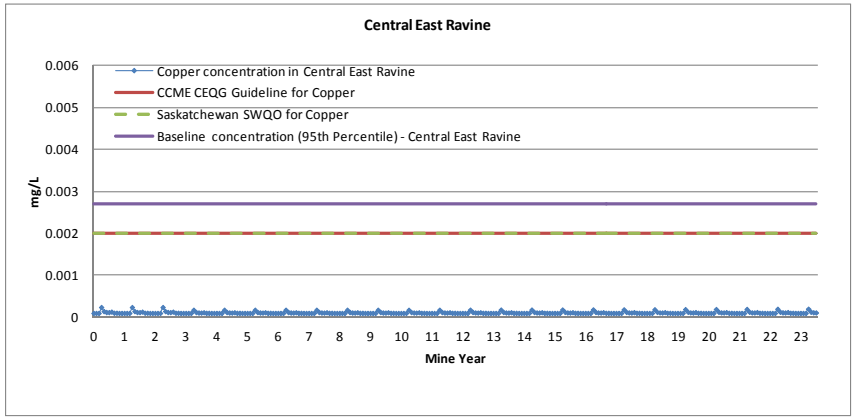
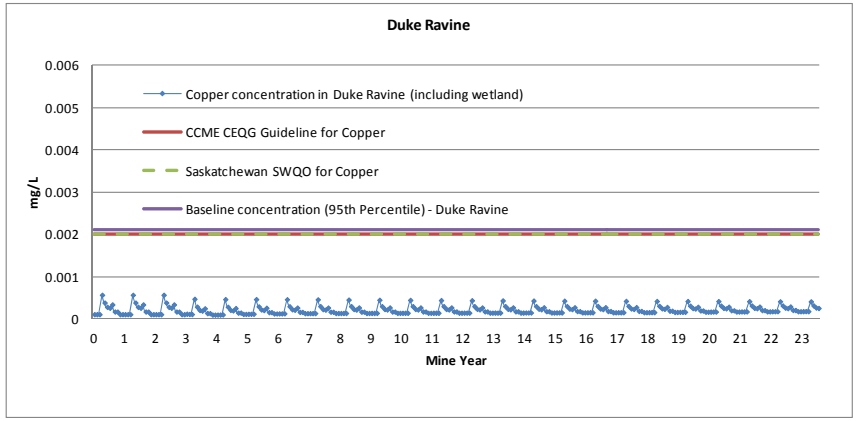






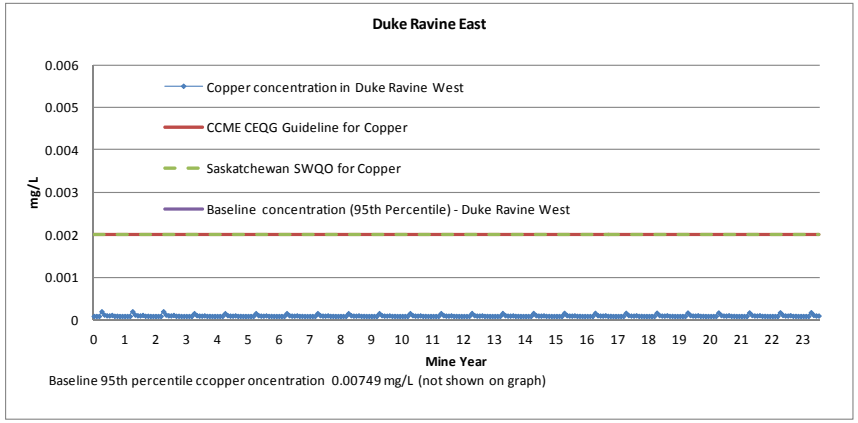
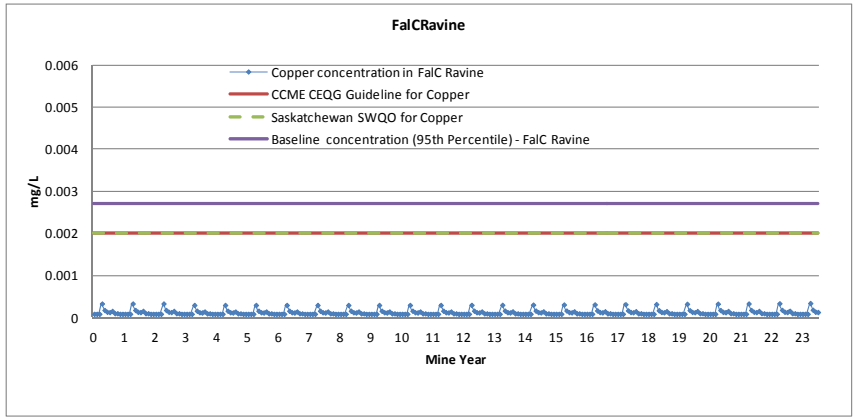
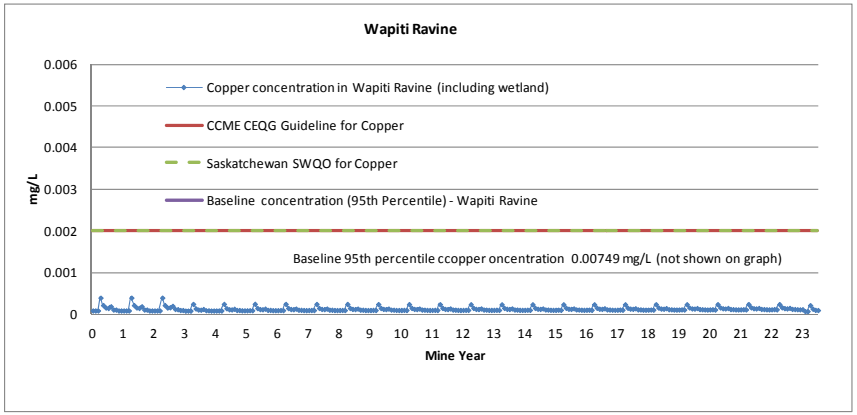
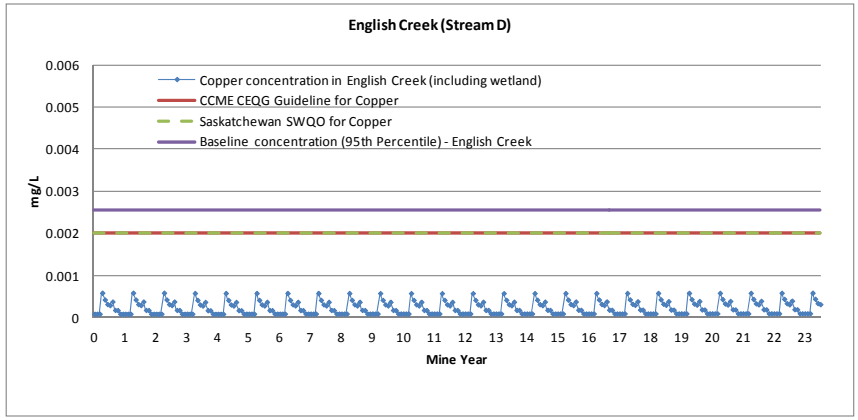


Figure 3-27 Continued







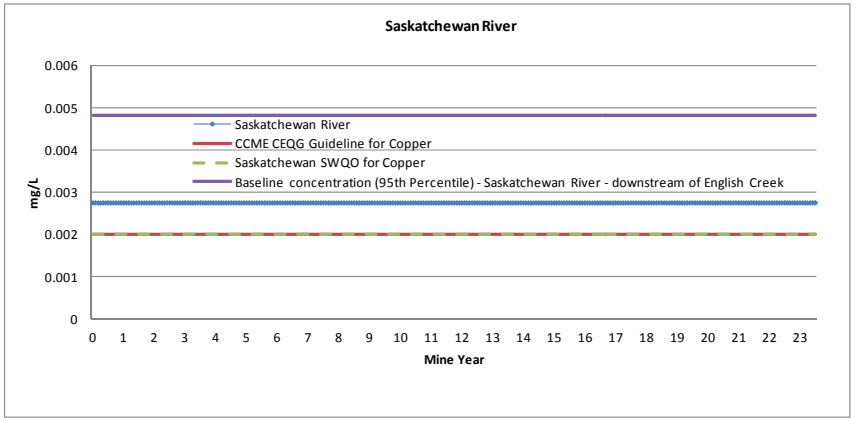
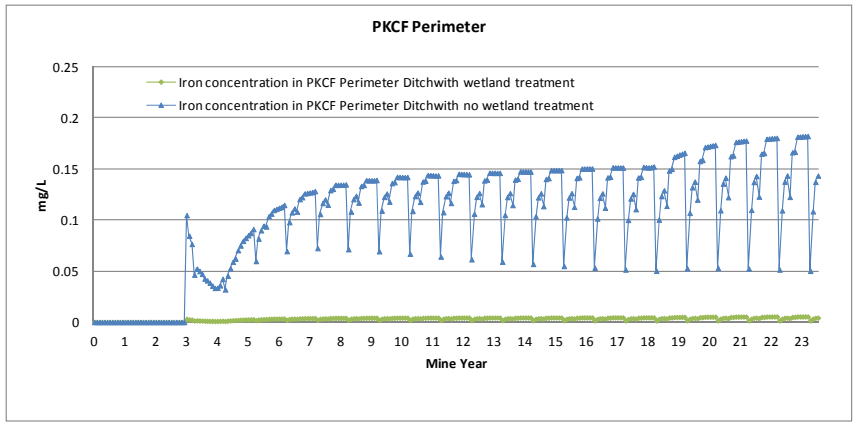
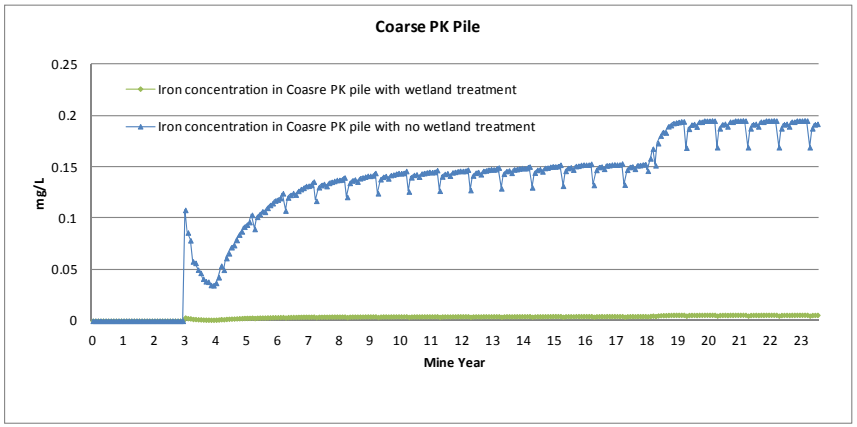


Figure 3-28 Predicted iron concentrations during construction and operation





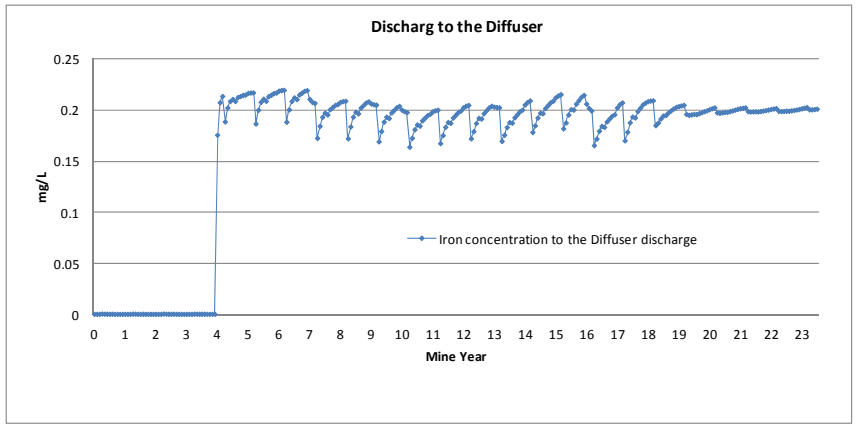
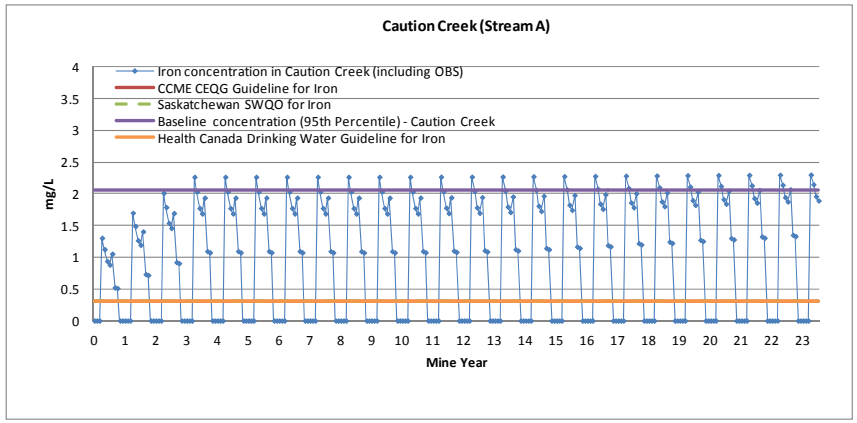
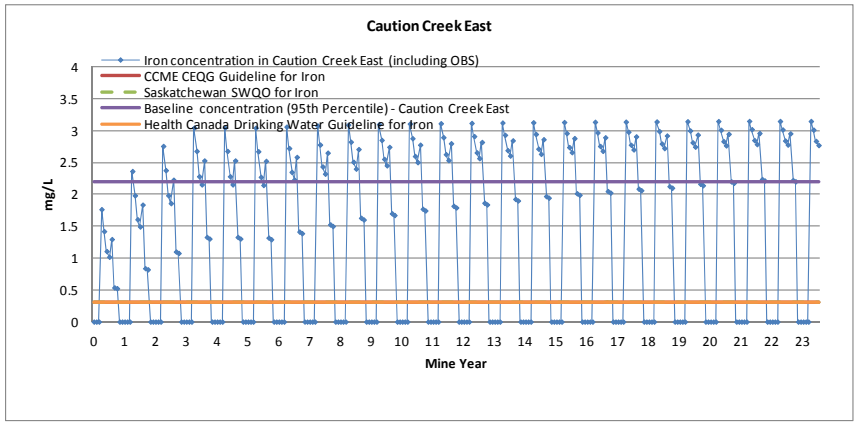
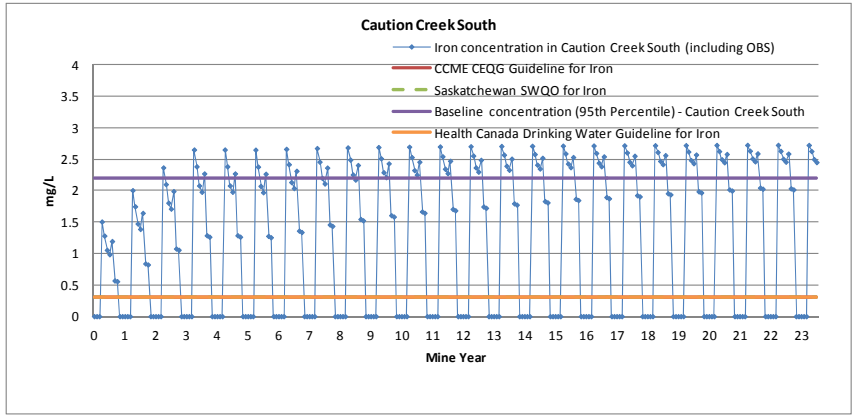


Figure 3-28 Continued







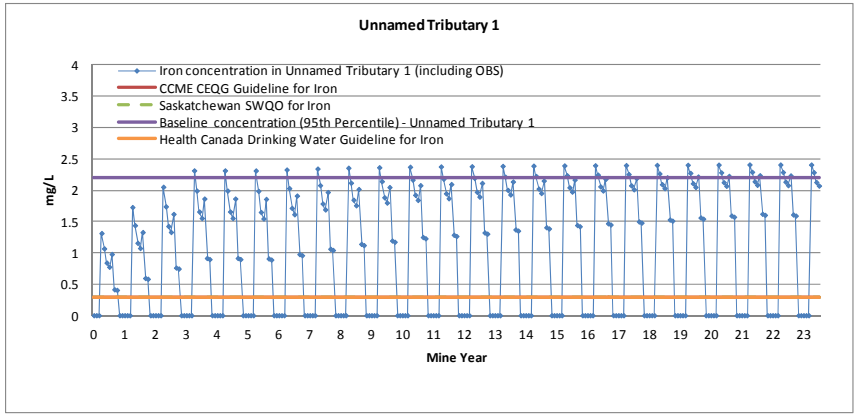
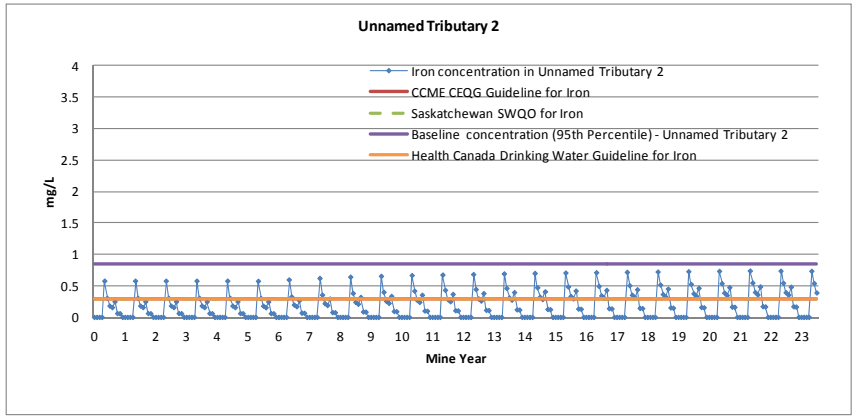
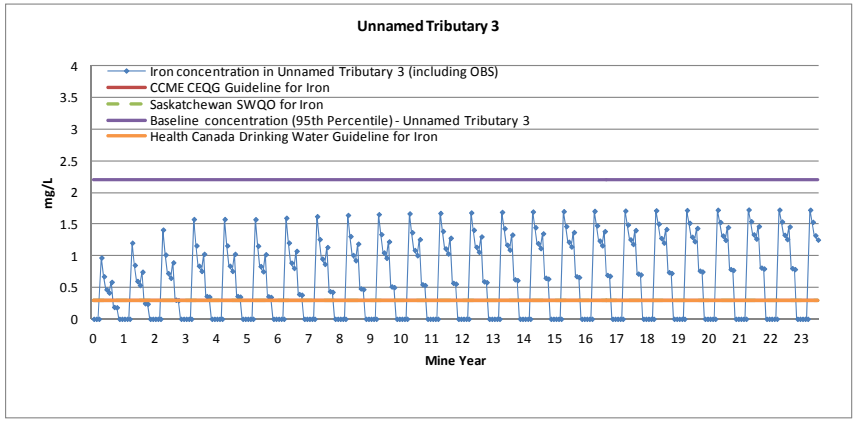
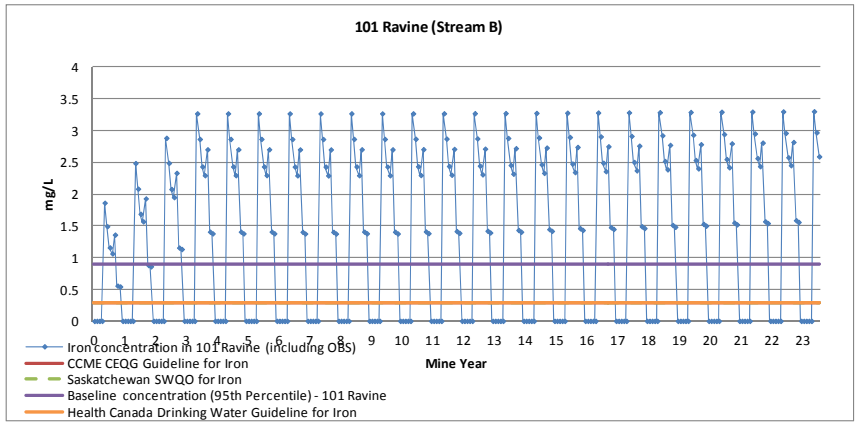


Figure 3-28 Continued







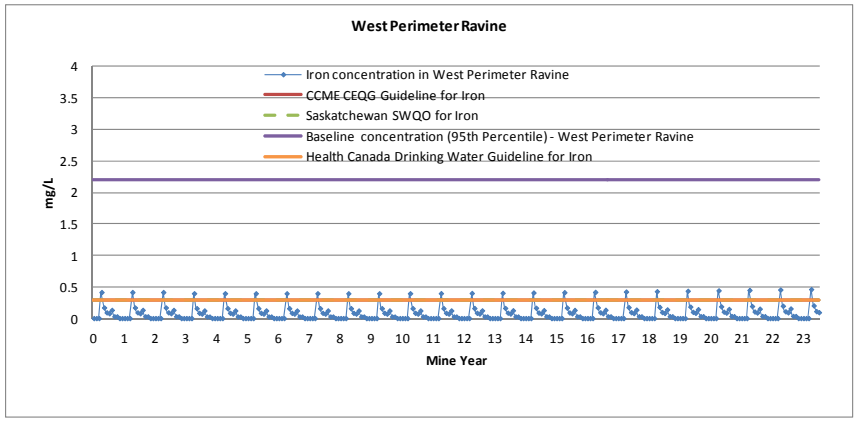
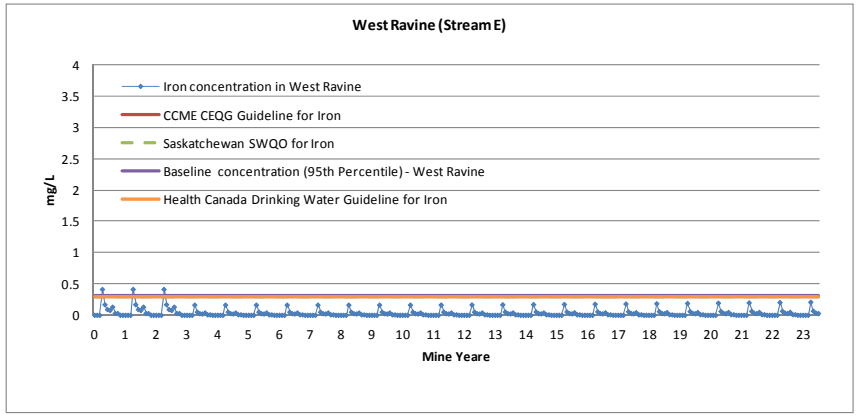
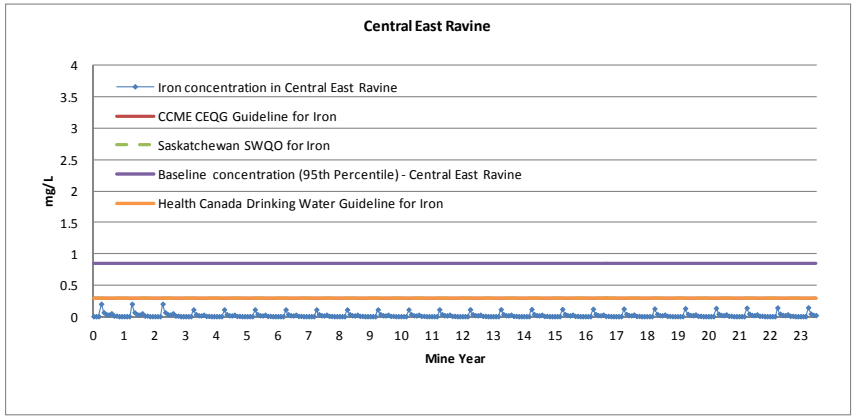
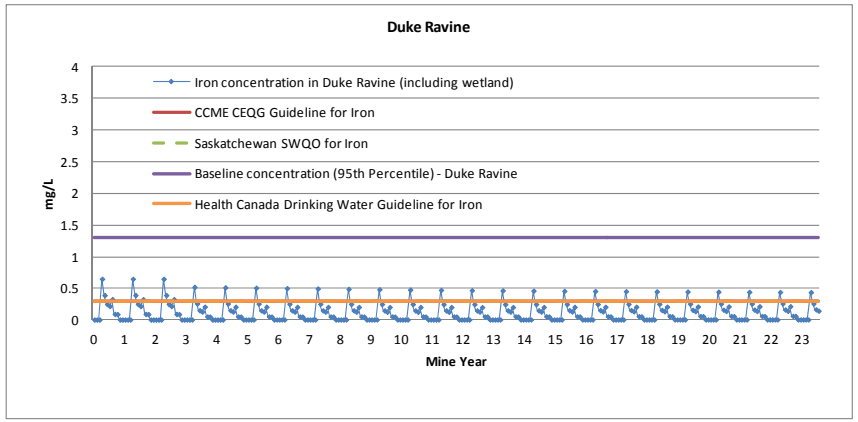


Figure 3-28 Continued







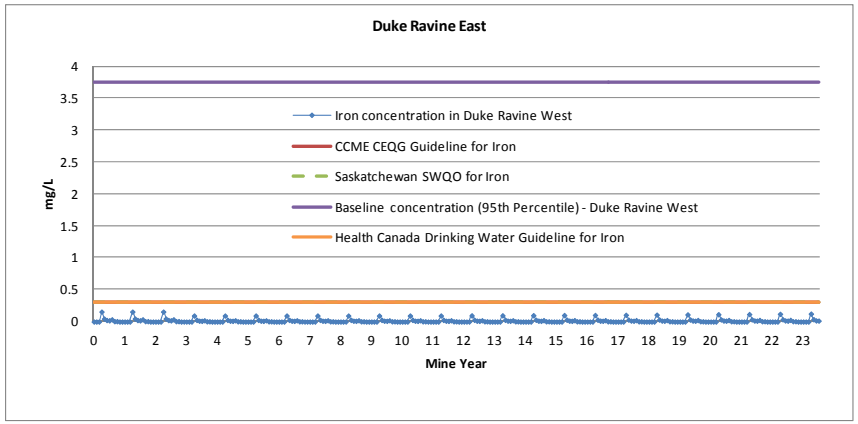
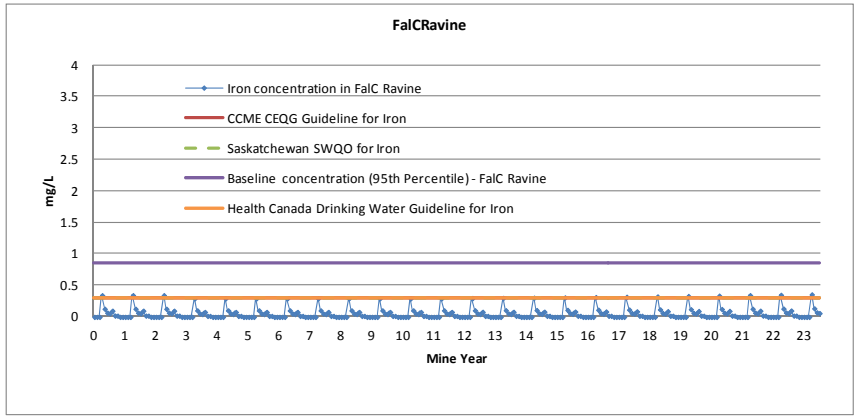
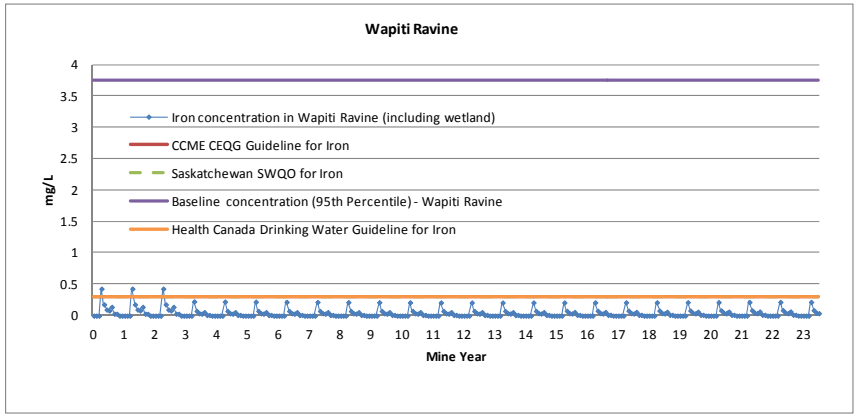
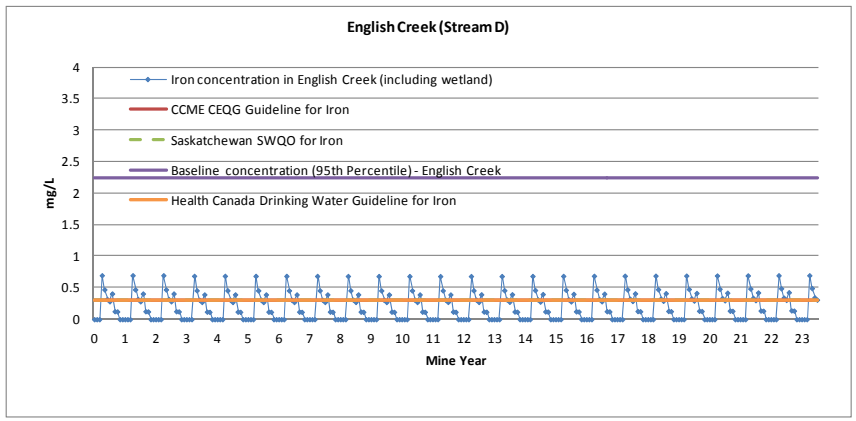


Figure 3-28 Continued







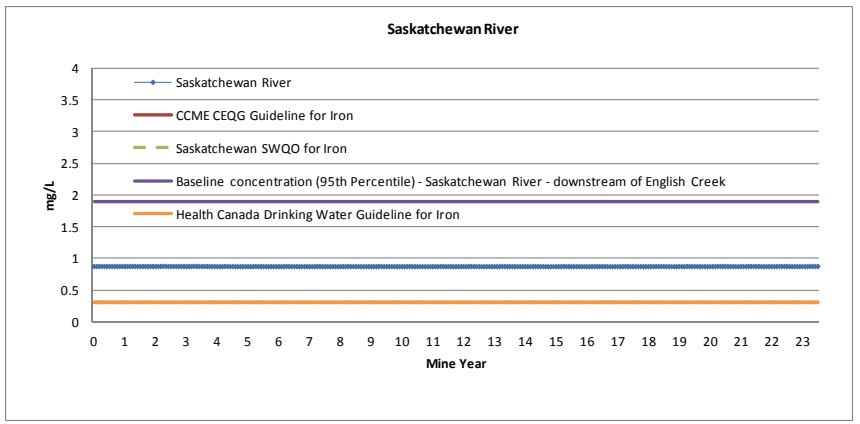
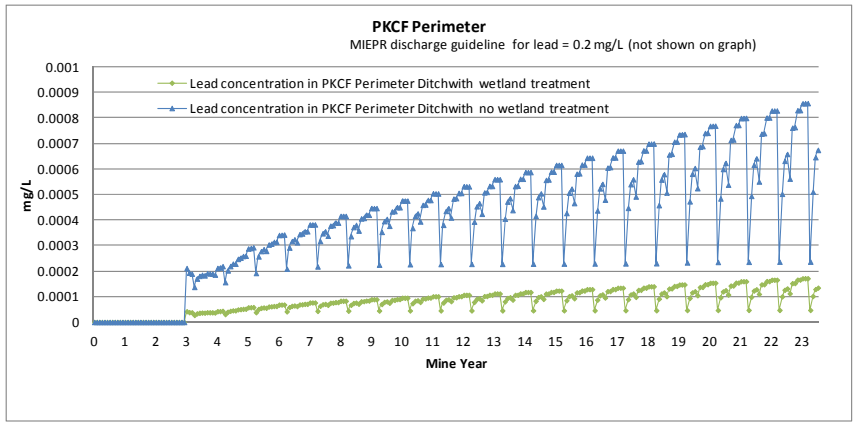
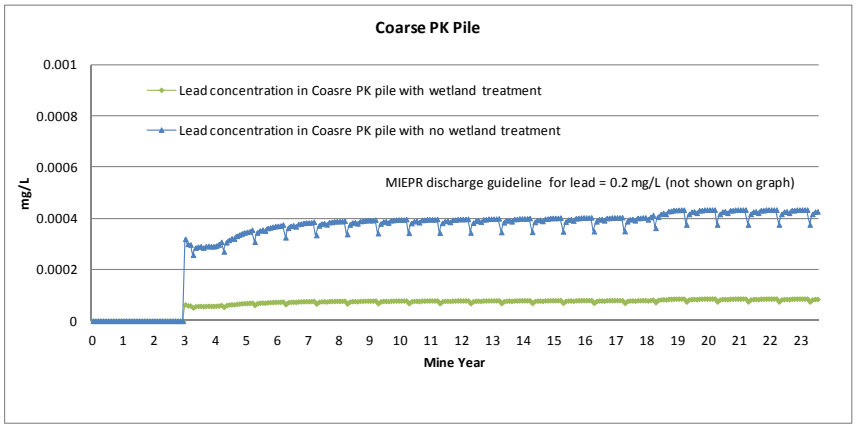


Figure 3-29 Predicted lead concentrations during construction and operation





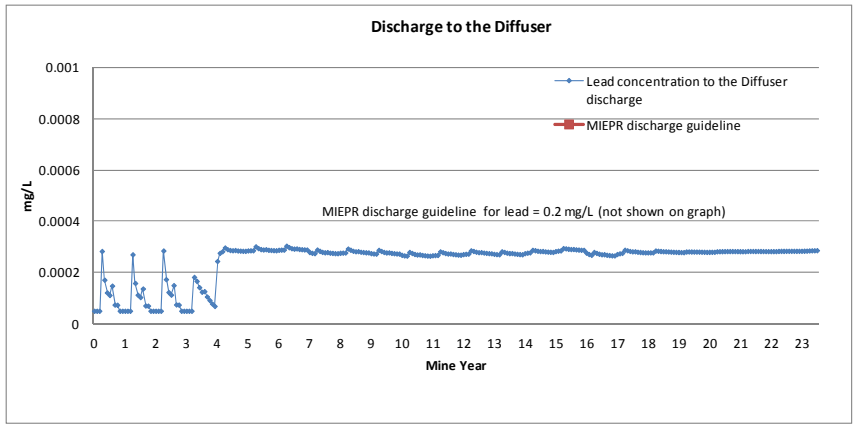
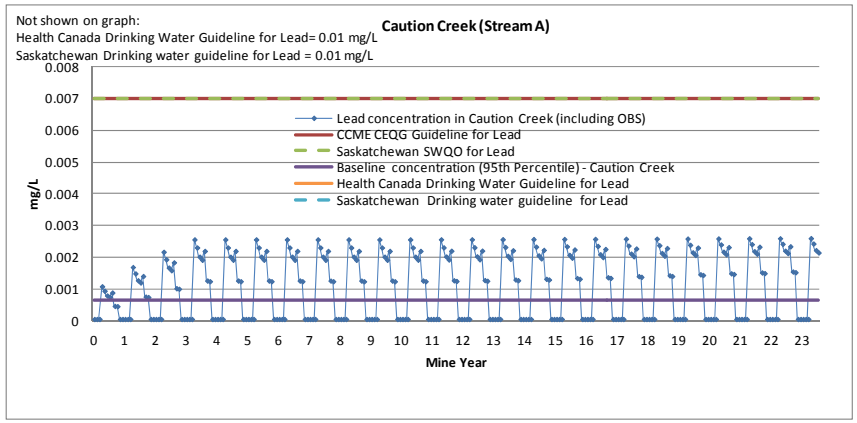
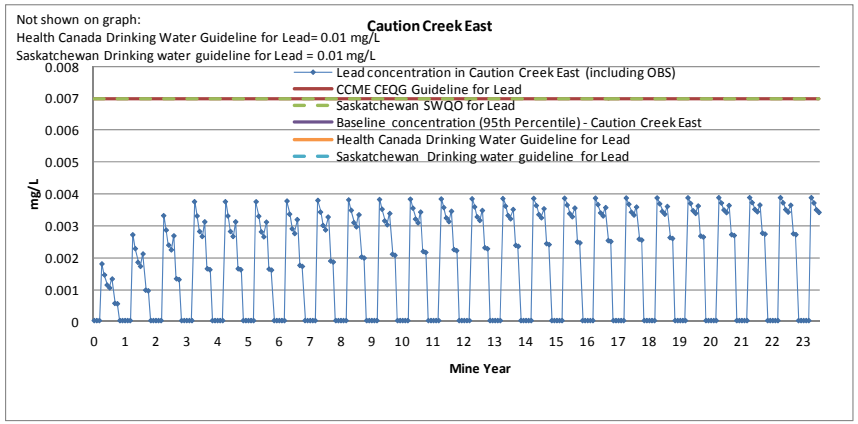
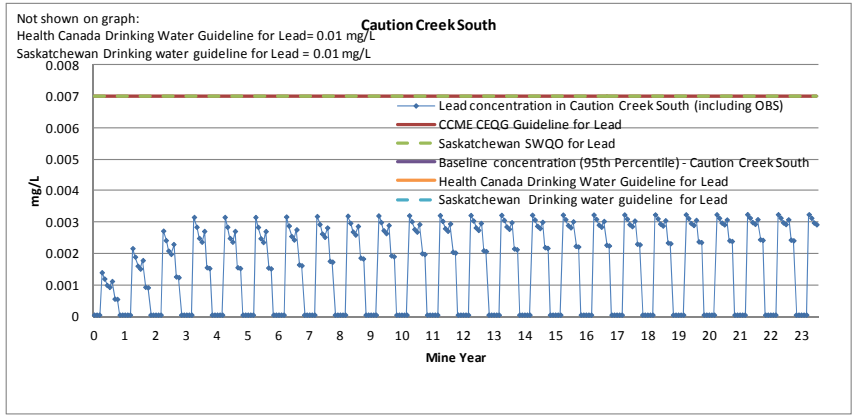


Figure 3-29 Continued







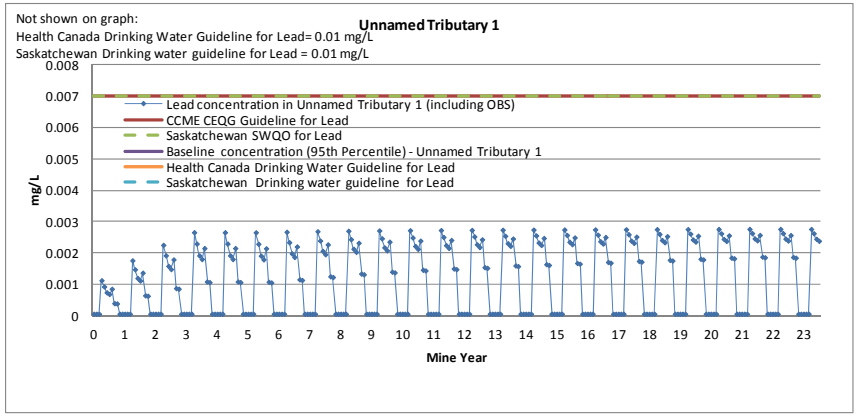
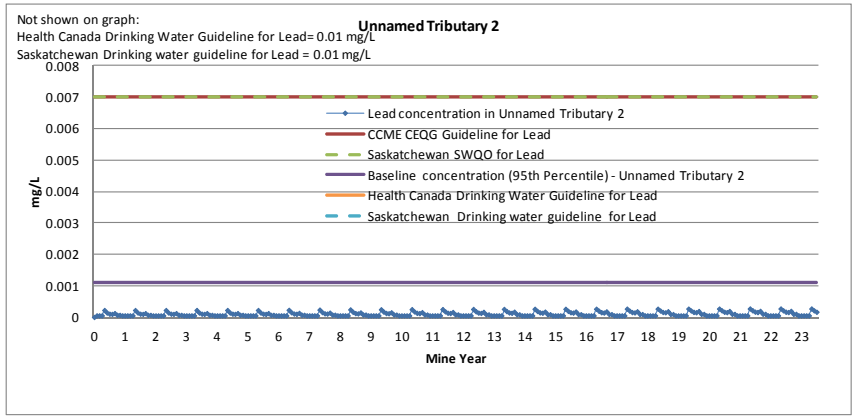
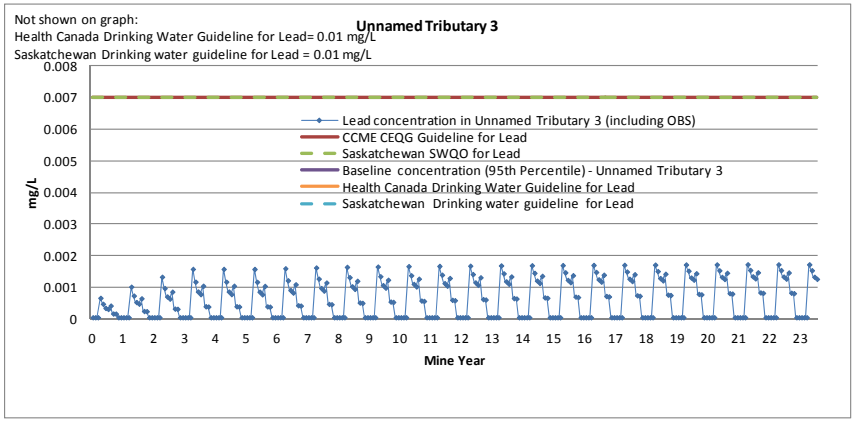
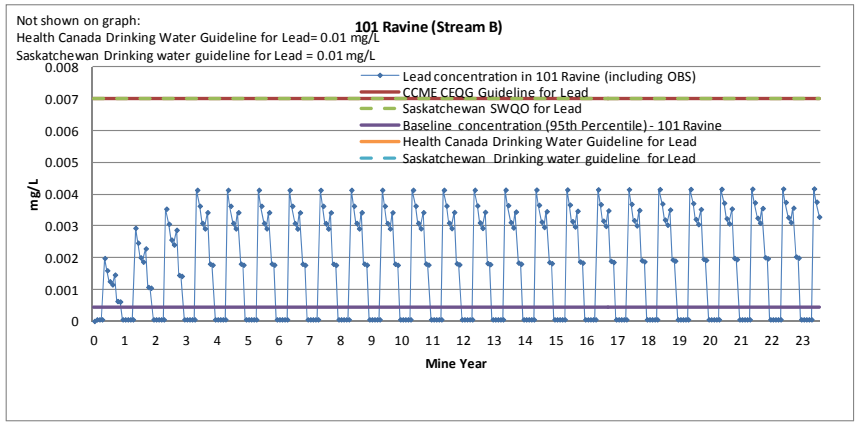


Figure 3-29 Continued







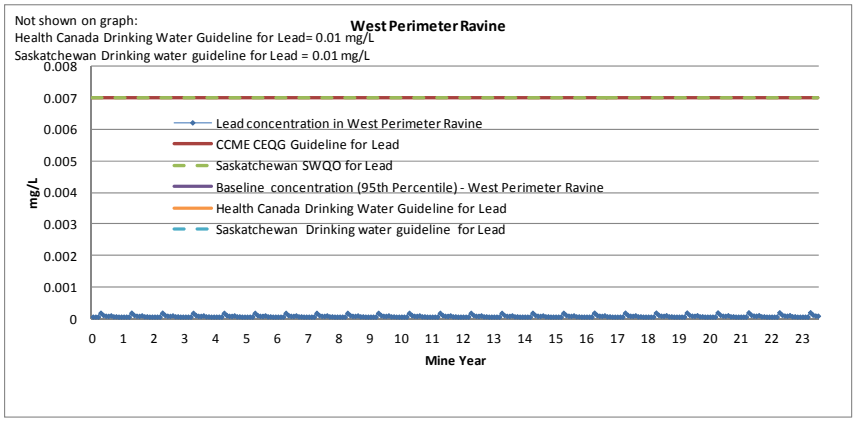
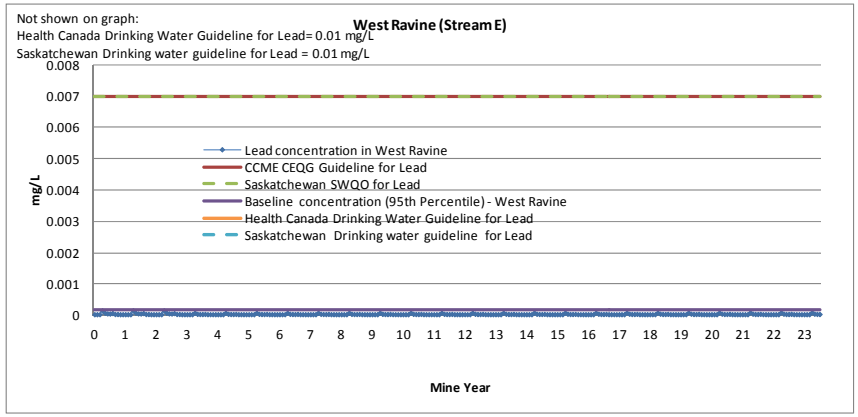
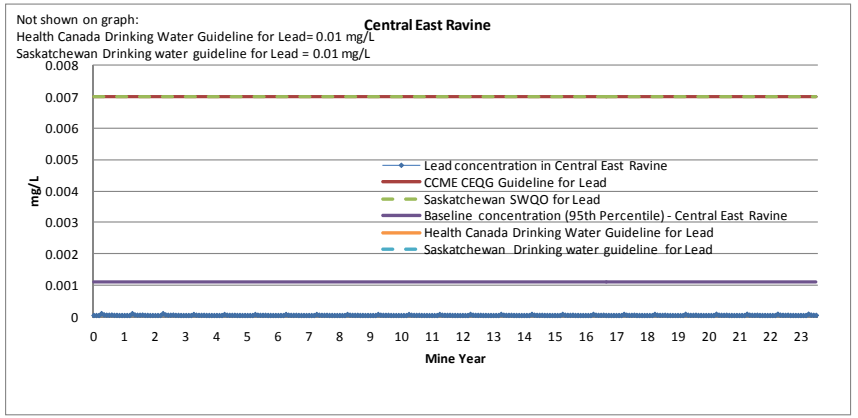
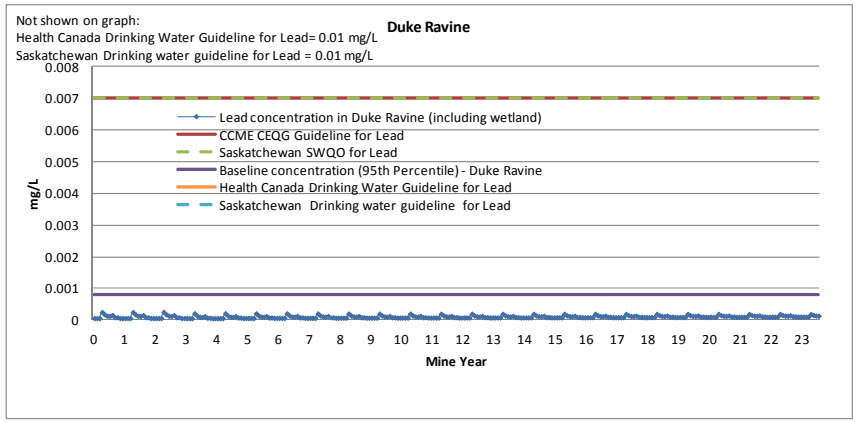


Figure 3-29 Continued







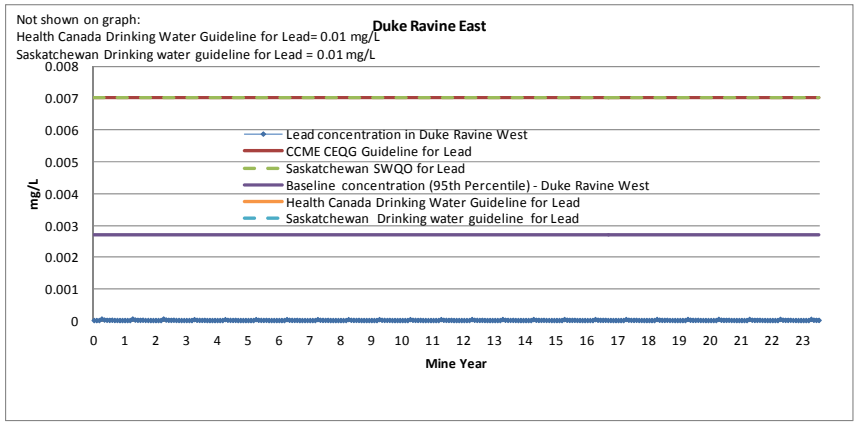
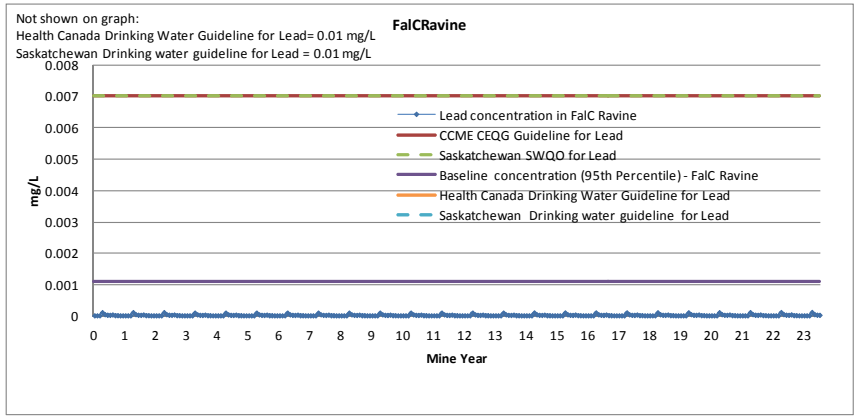
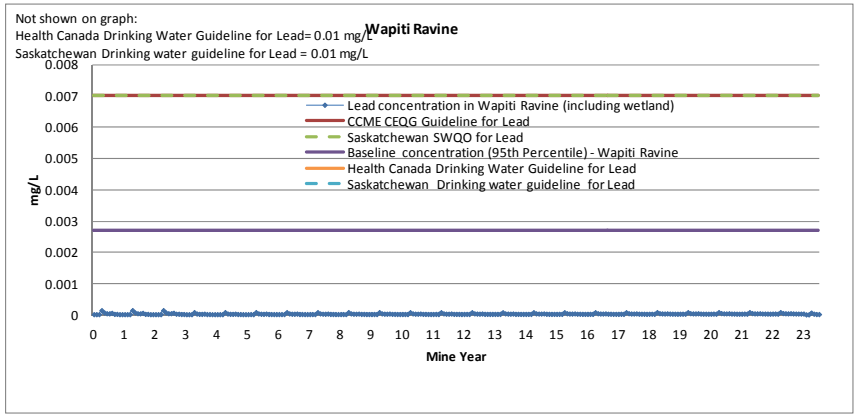
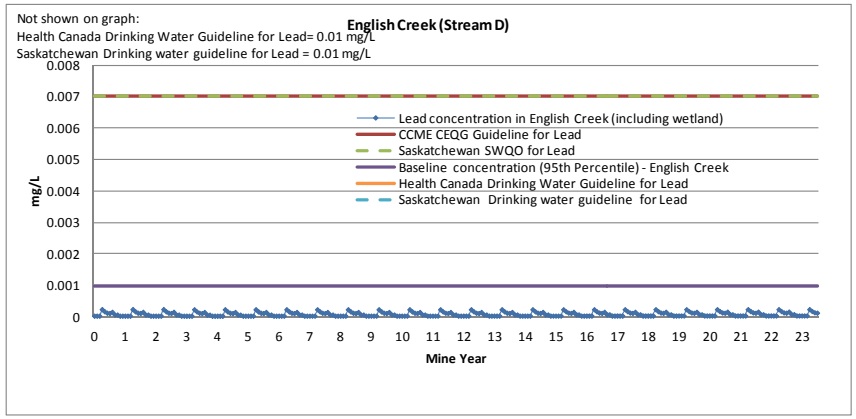


Figure 3-29 Continued







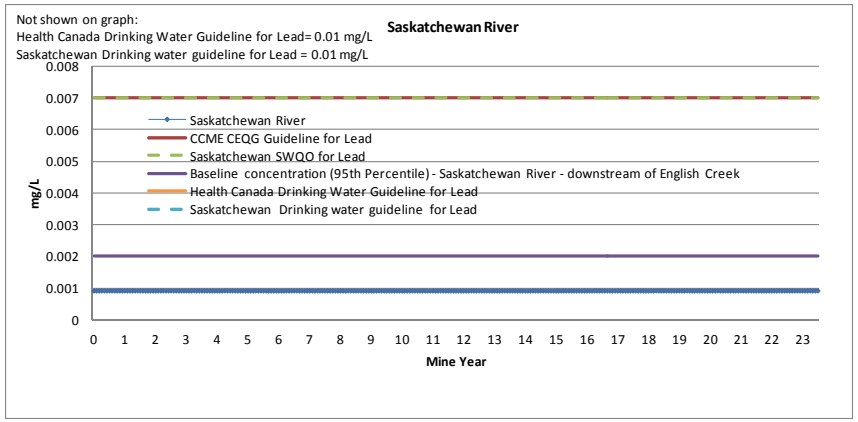
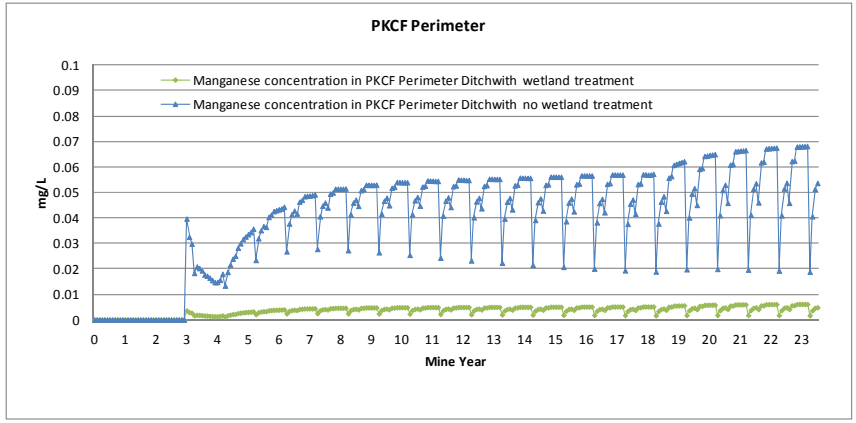
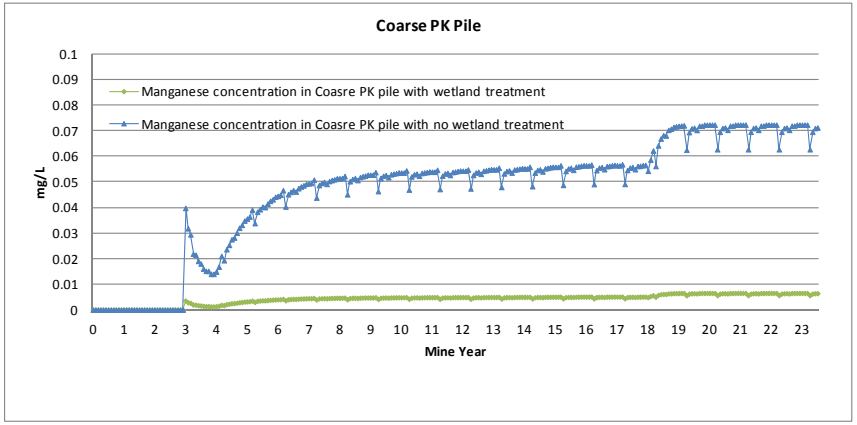


Figure 3-30 Predicted manganese concentrations during construction and operation





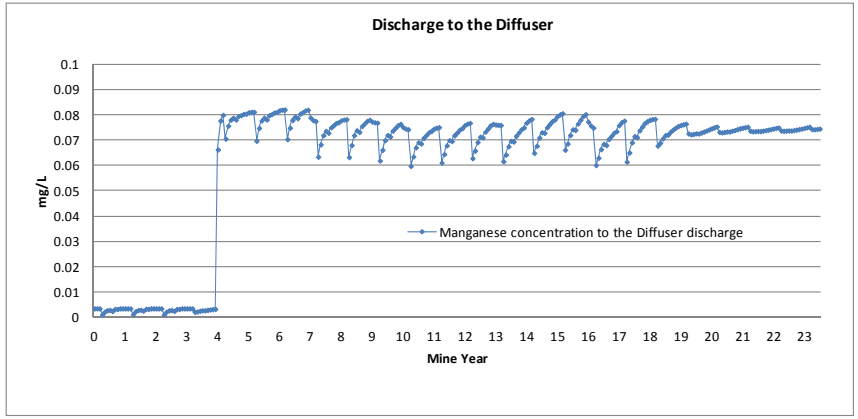
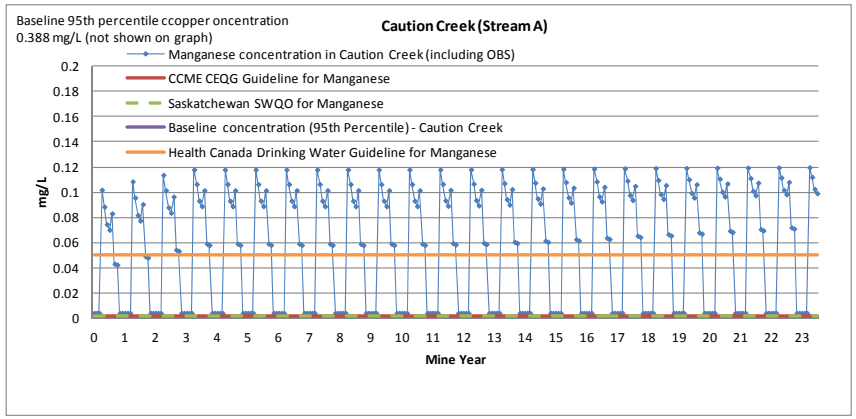
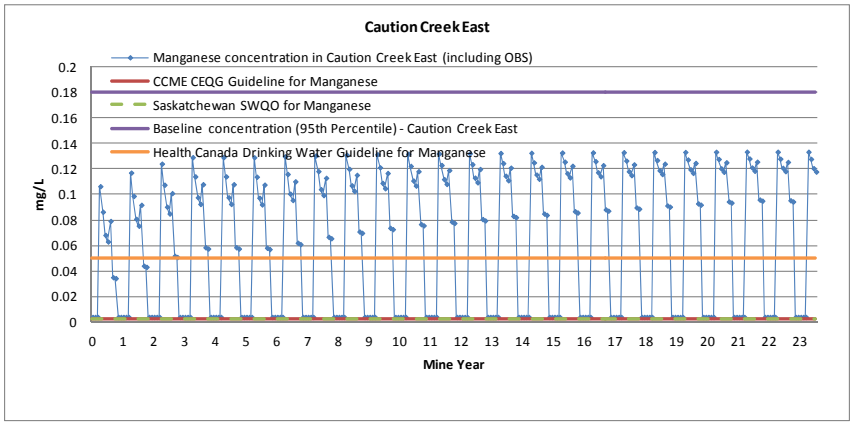
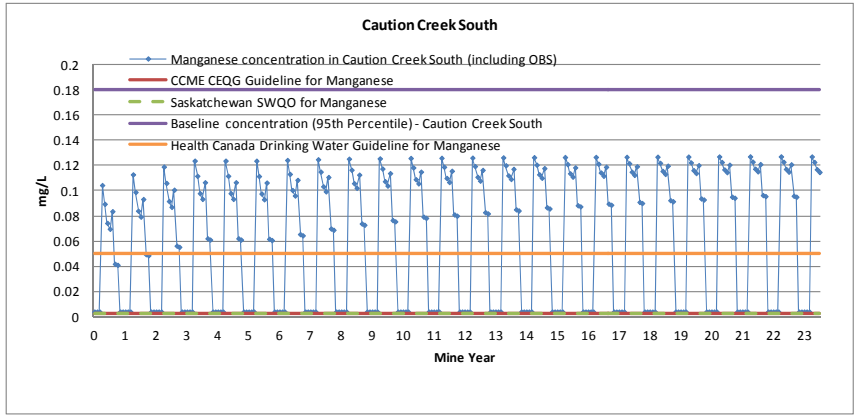


Figure 3-30 Continued







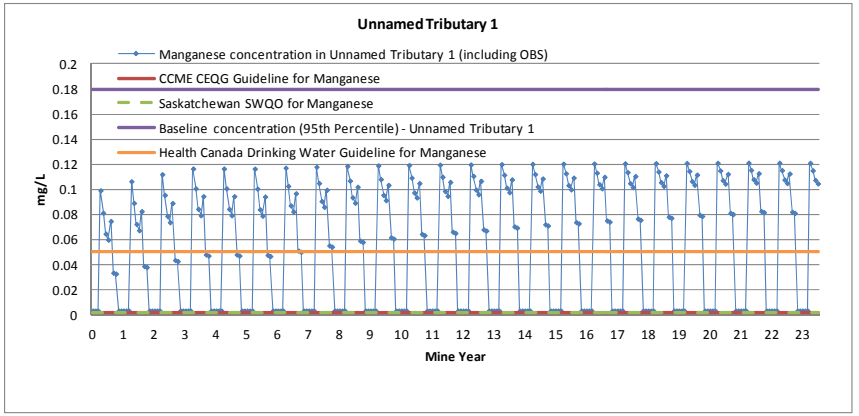
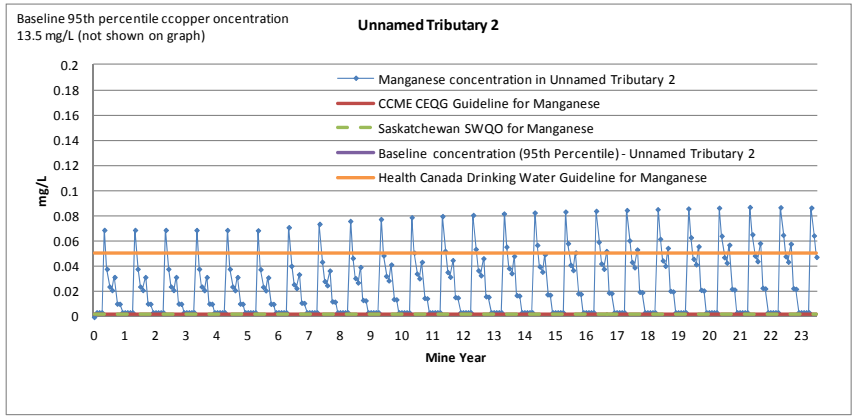
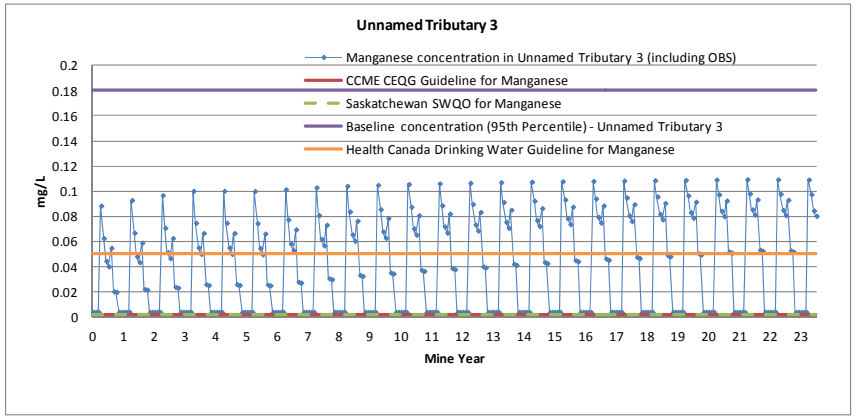
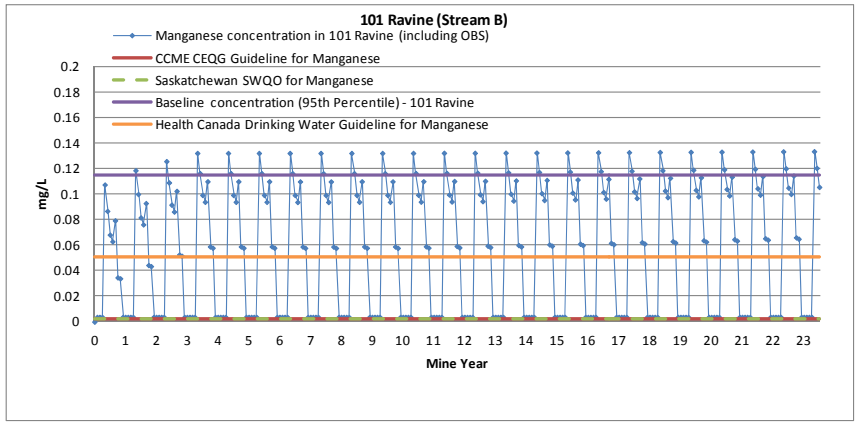


Figure 3-30 Continued







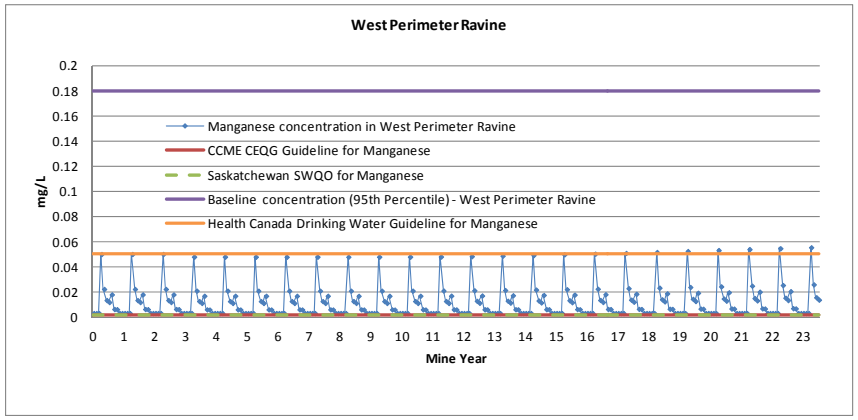
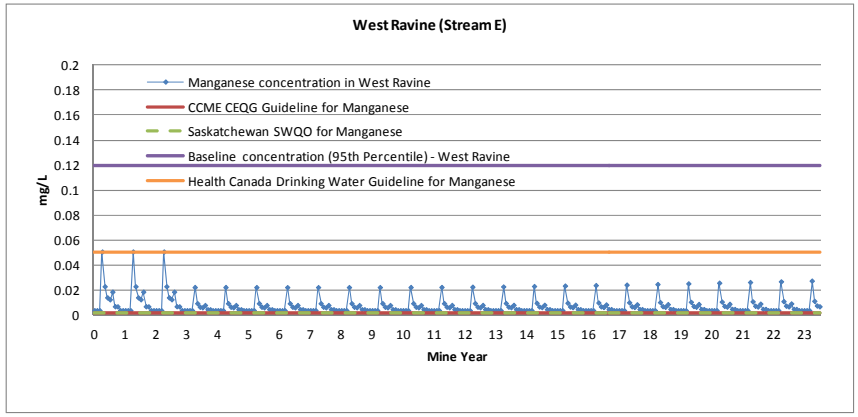
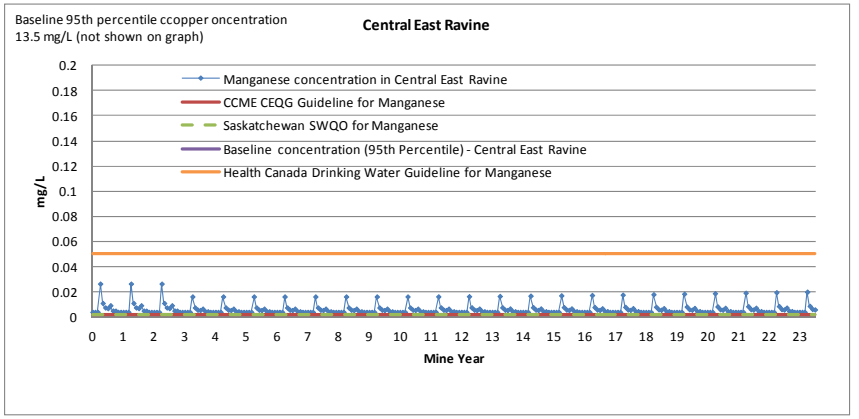
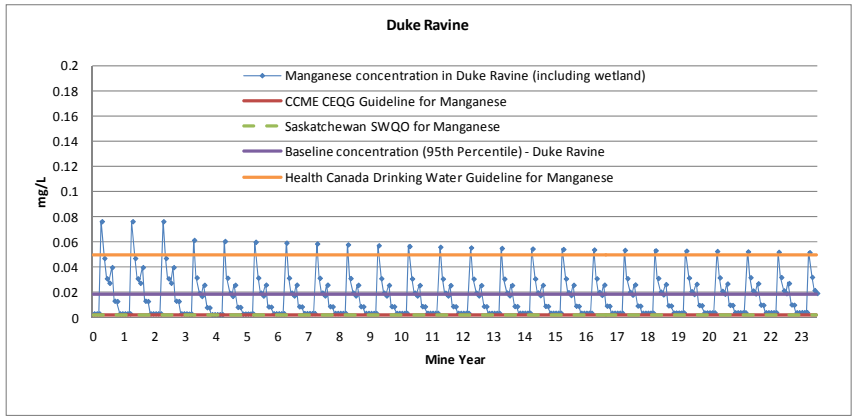


Figure 3-30 Continued







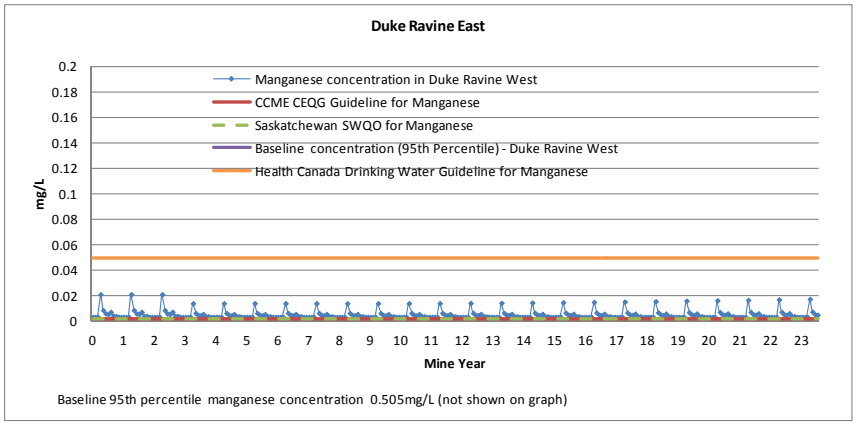
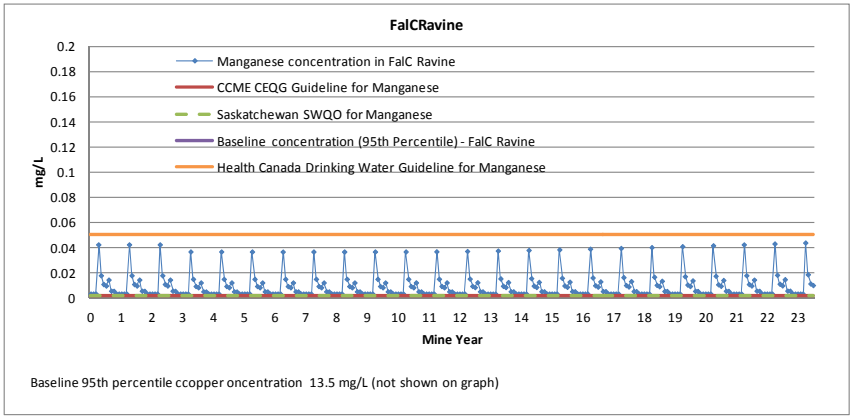
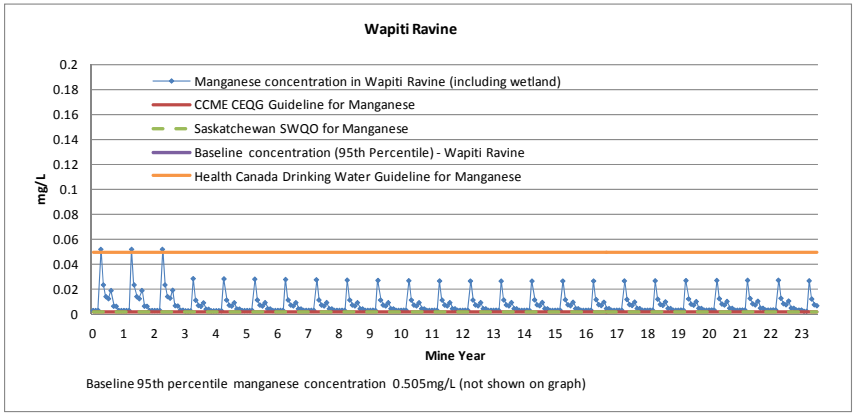


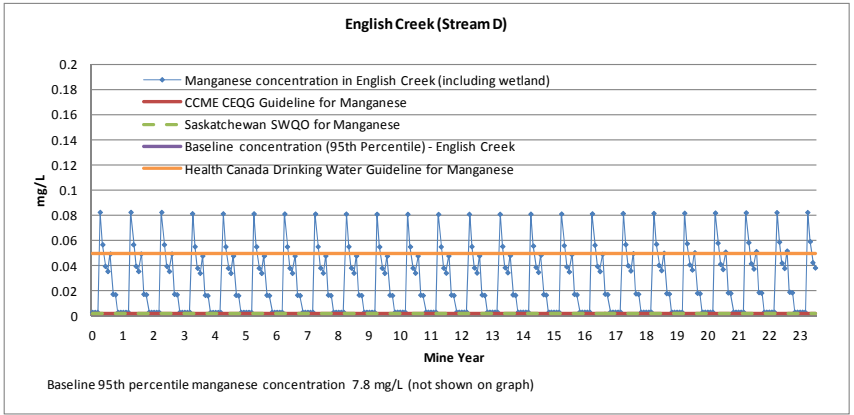
Figure 3-30 Continued



Baseline 95th percentile ccopper oncentration 13.5 mg/L (not shown on graph)



Baseline 95th percentile manganese concentration 0.505mg/L (not shown on graph)



Baseline 95th percentile manganese concentration 7.8 mg/L (not shown on graph)

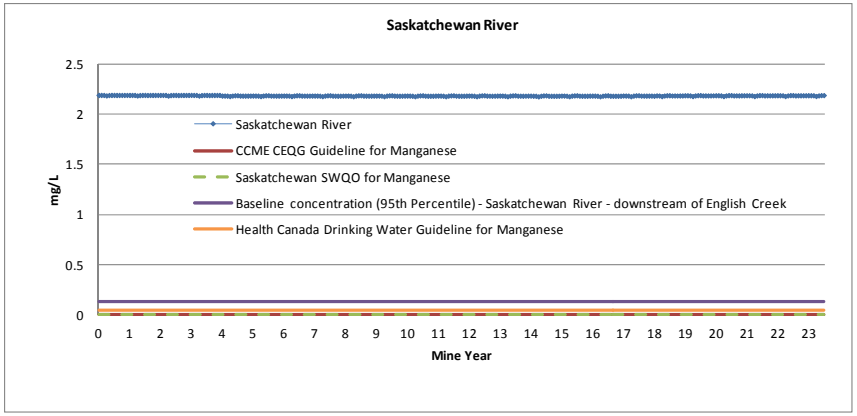
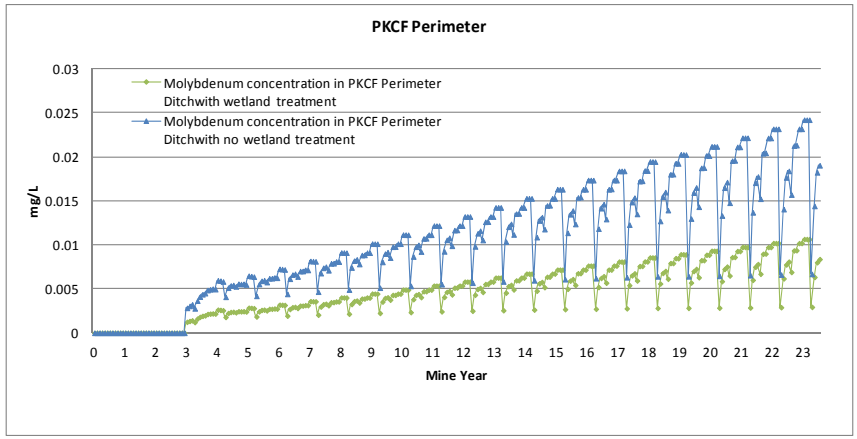
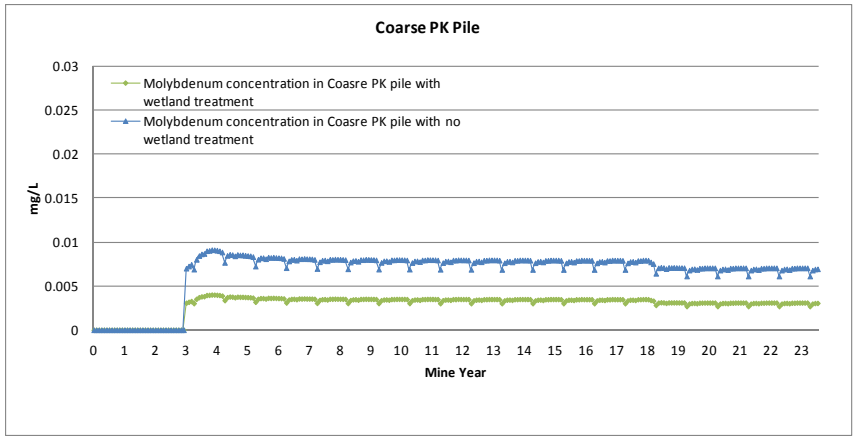


Figure 3-31 Predicted Molybdenum concentrations during construction and operation





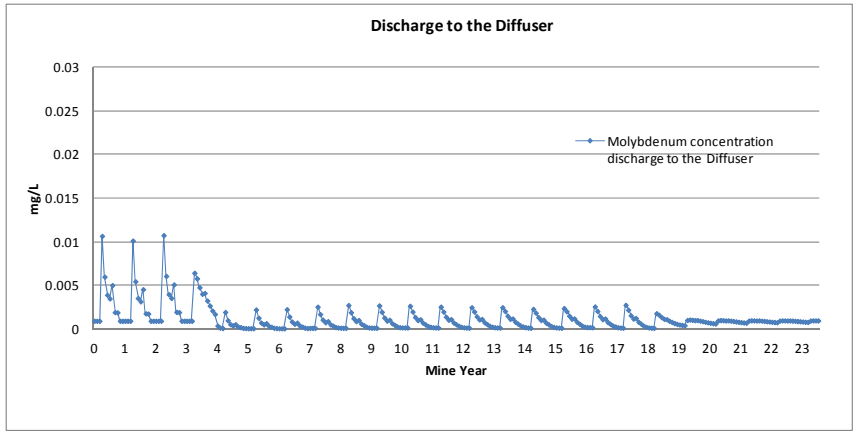
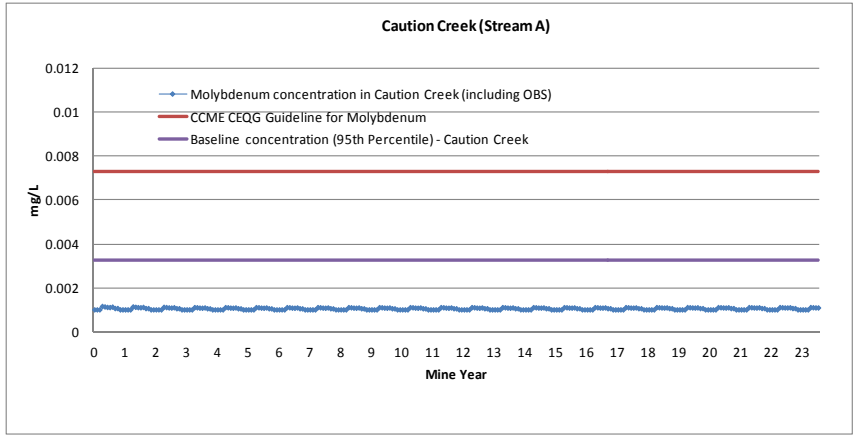
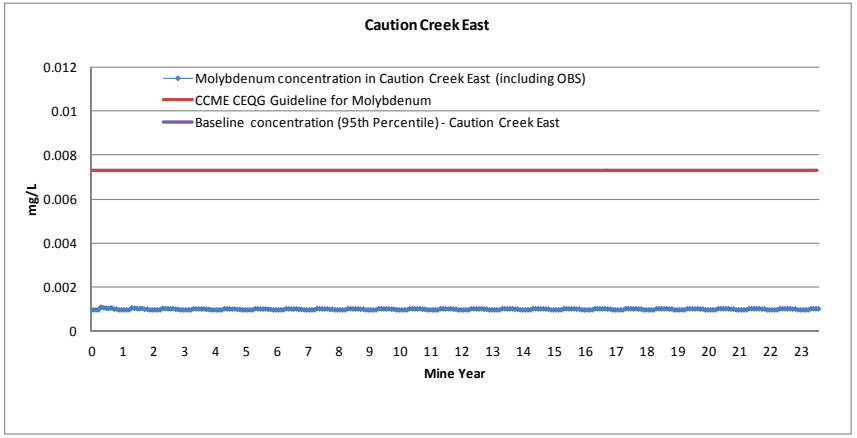
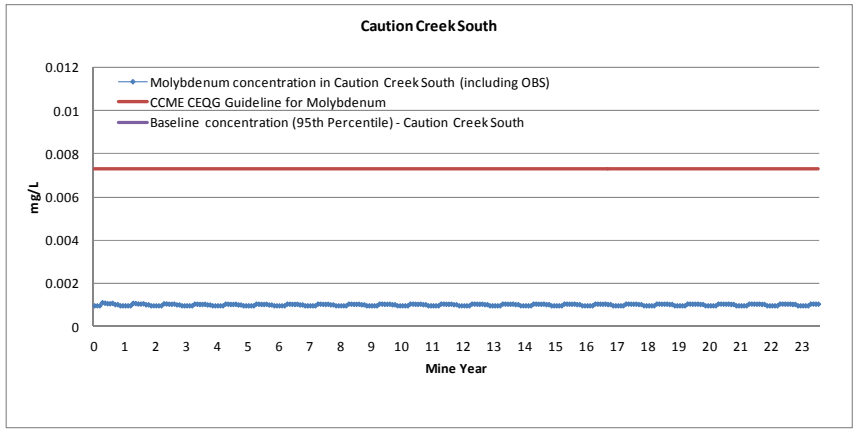


Figure 3-31 Continued







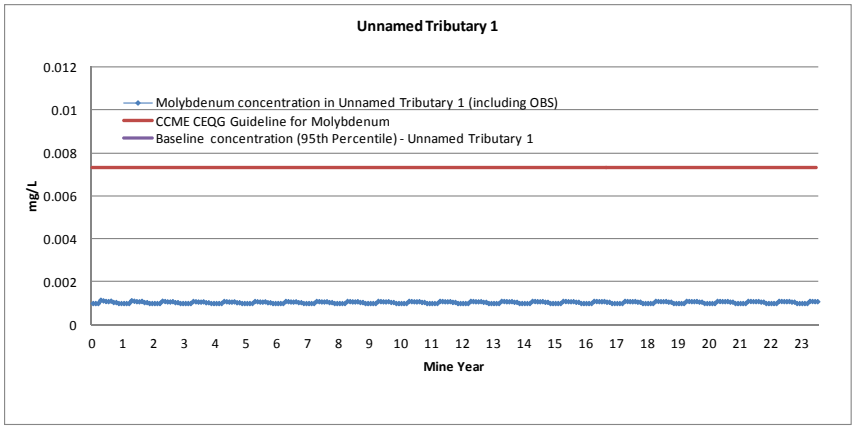
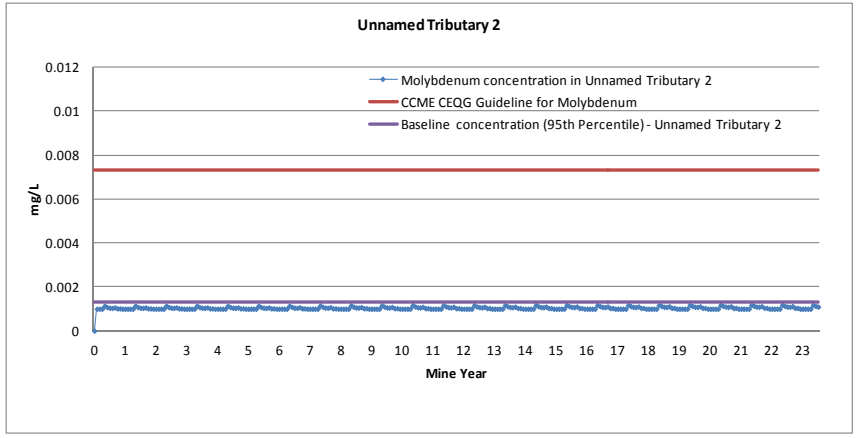
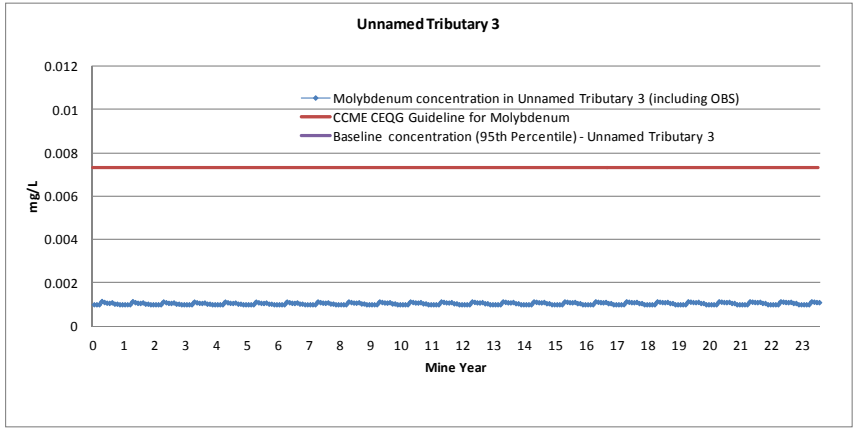
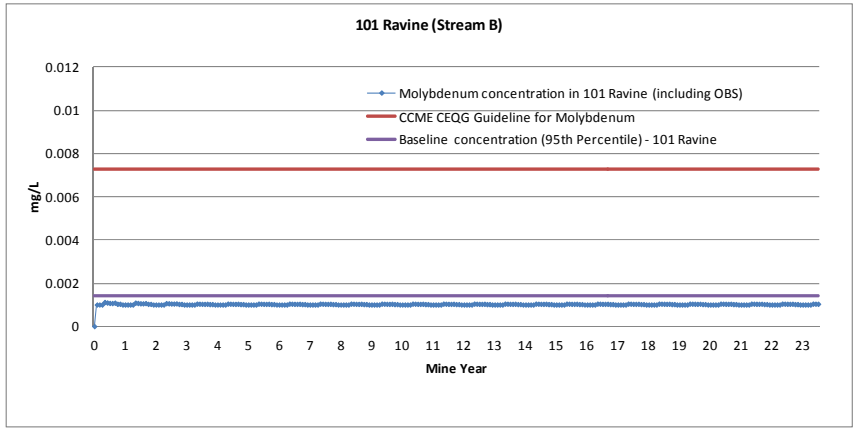


Figure 3-31 Continued







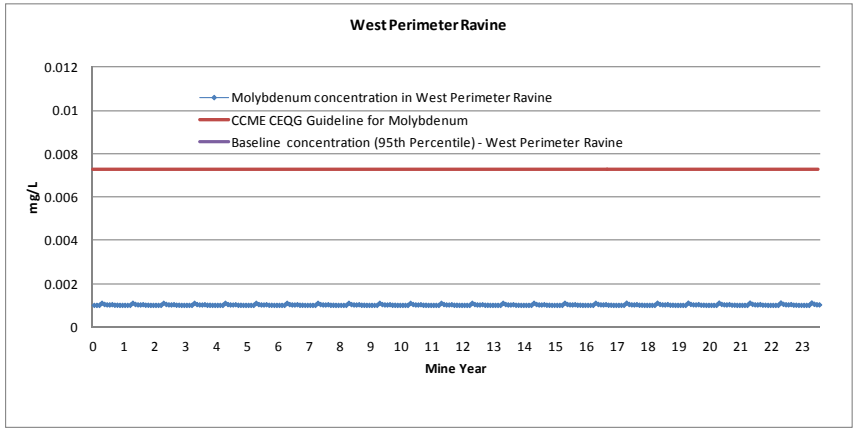
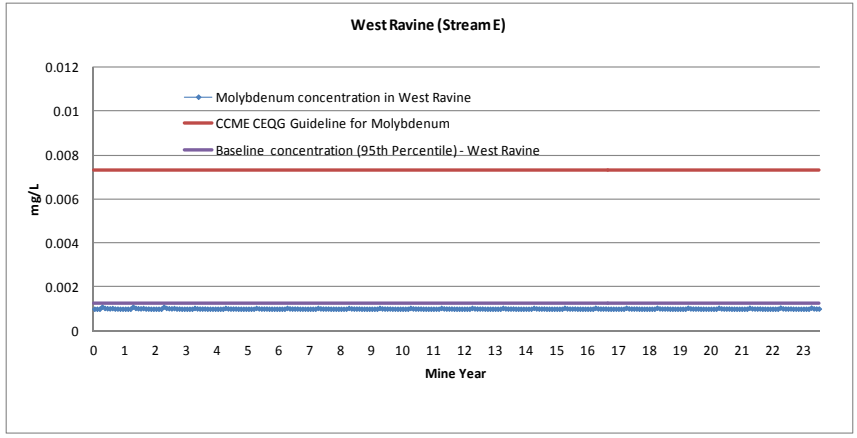
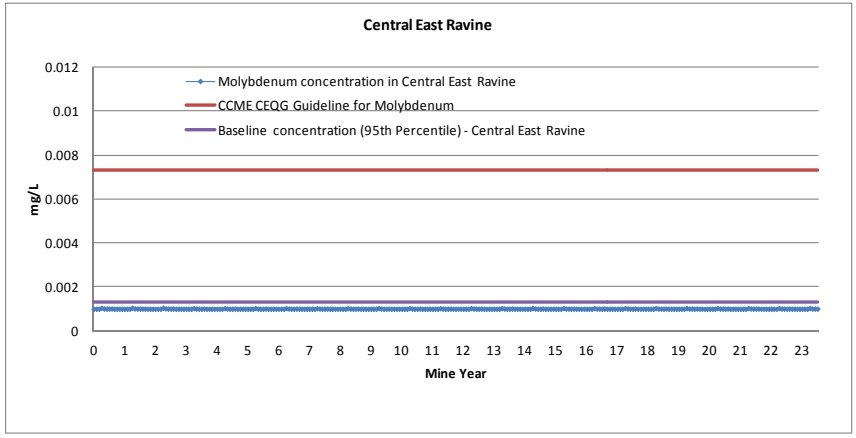
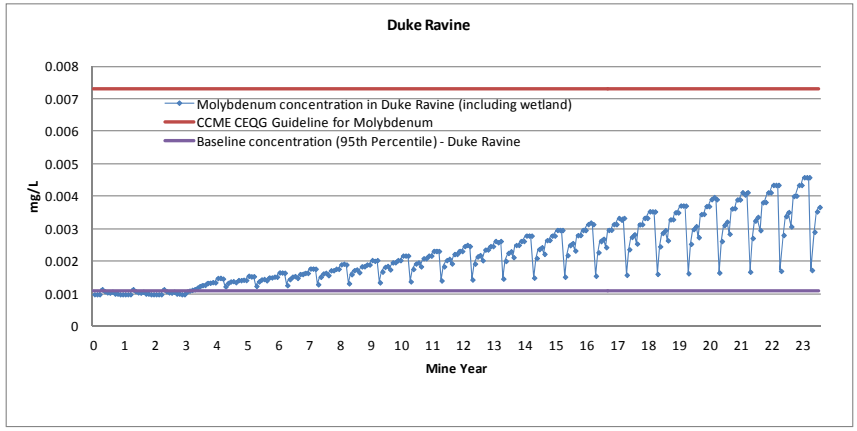


Figure 3-31 Continued







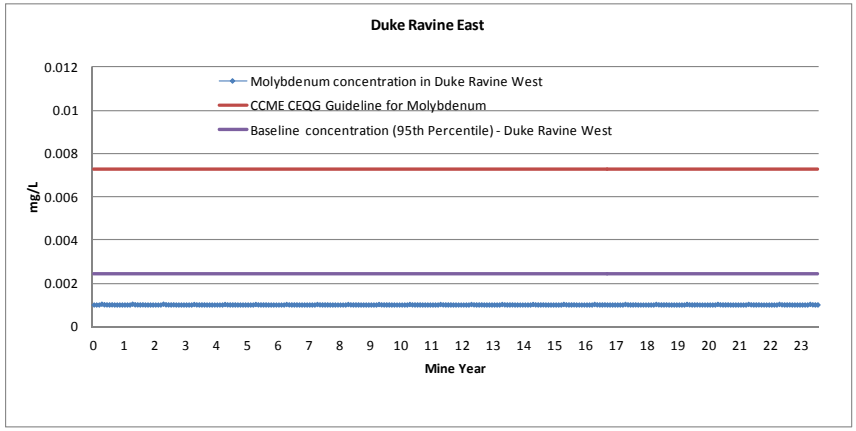
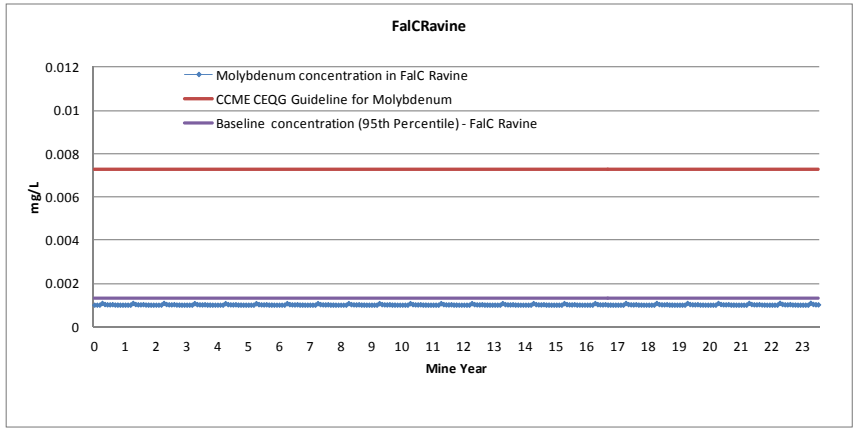
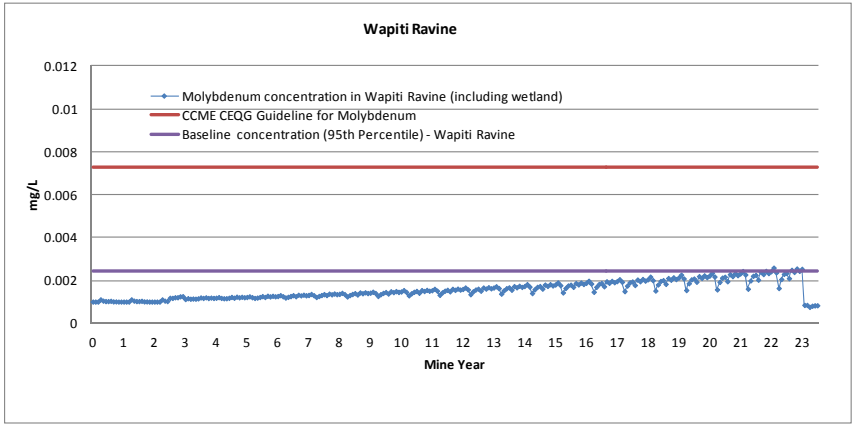
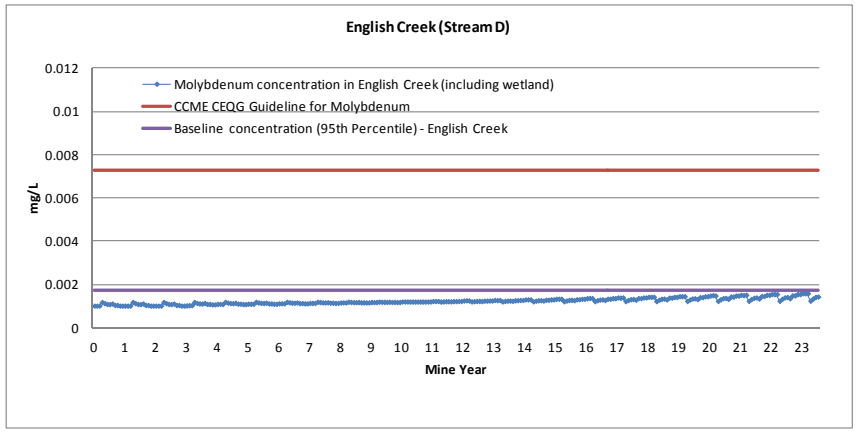


Figure 3-31 Continued







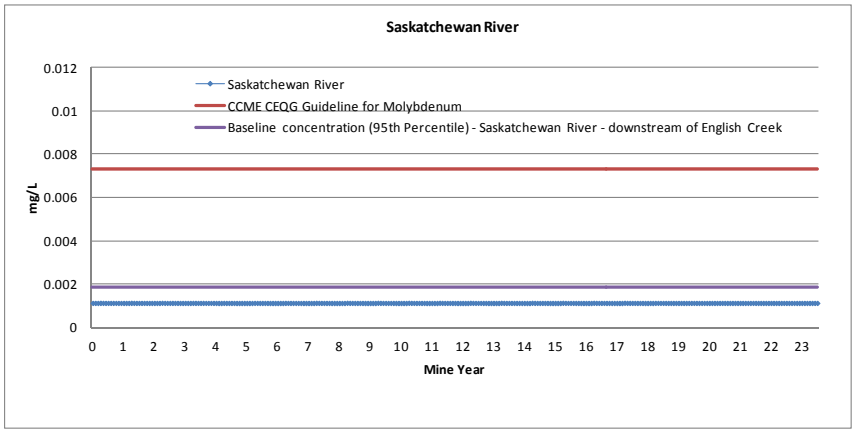
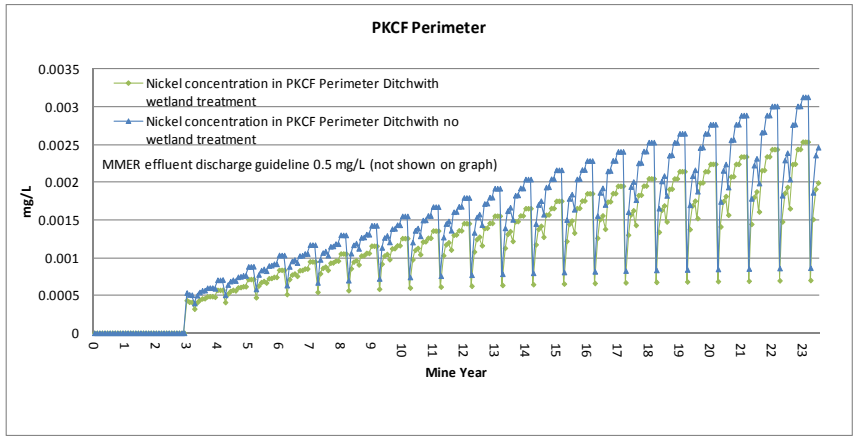
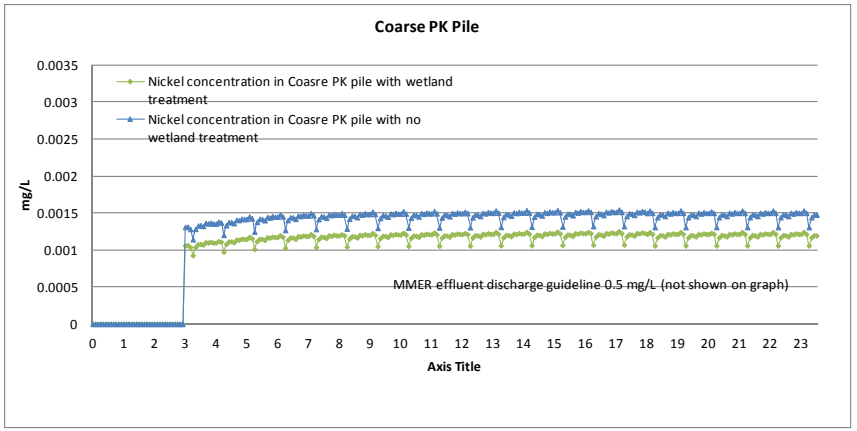


Figure 3-32 Predicted Nickel concentrations during construction and operation





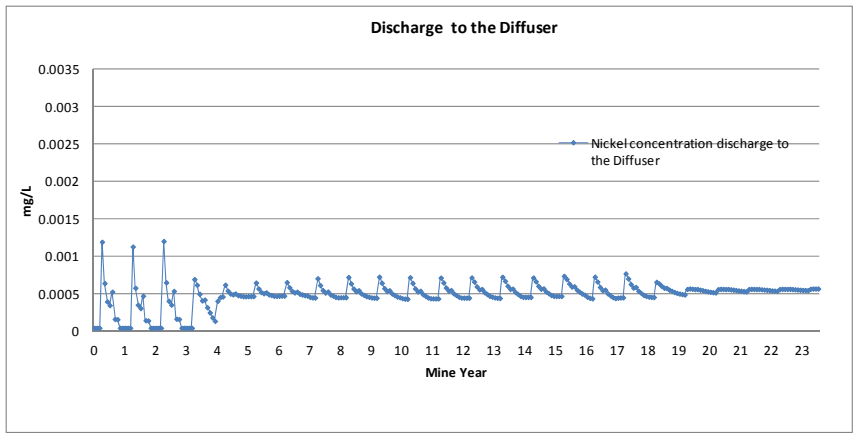
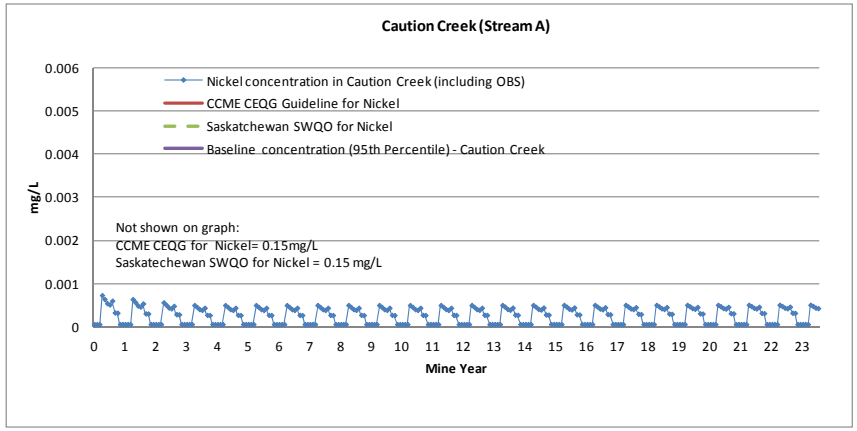
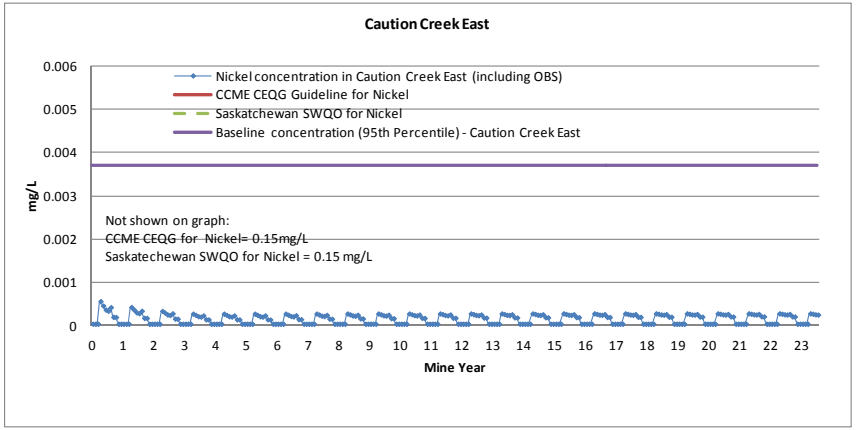
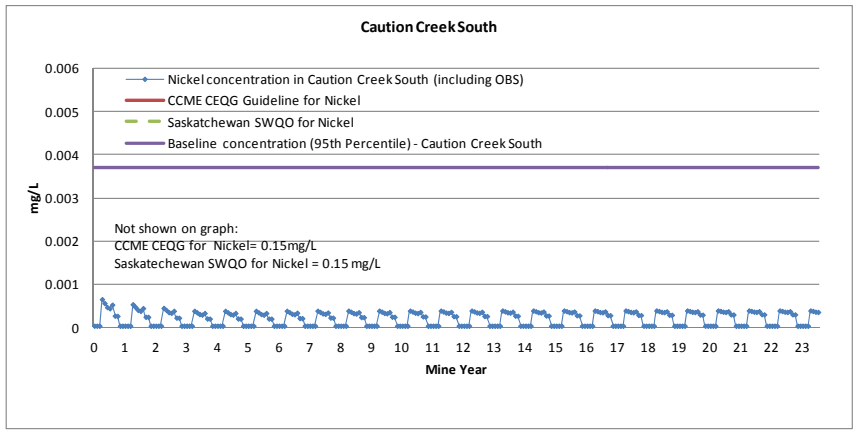


Figure 3-32 Continued







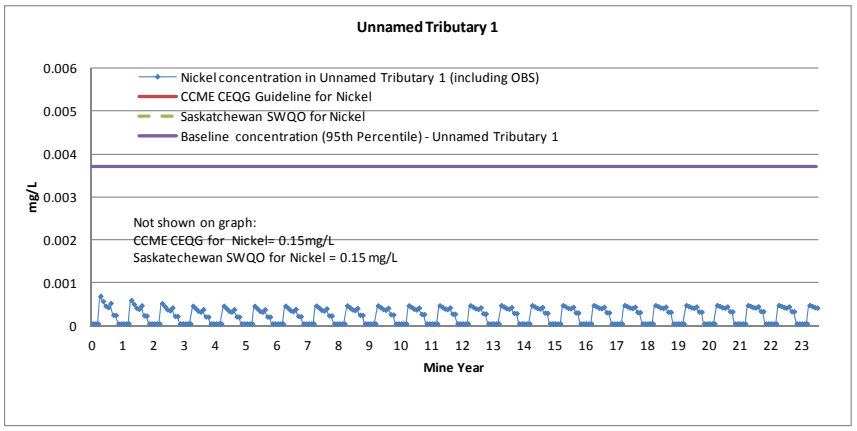
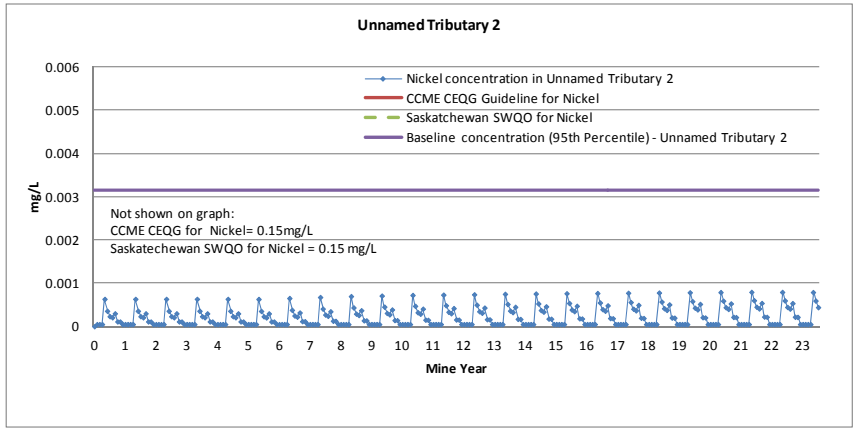
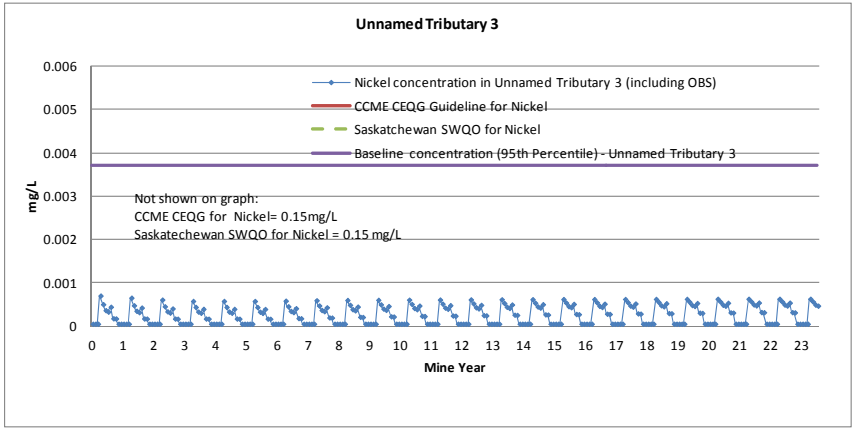
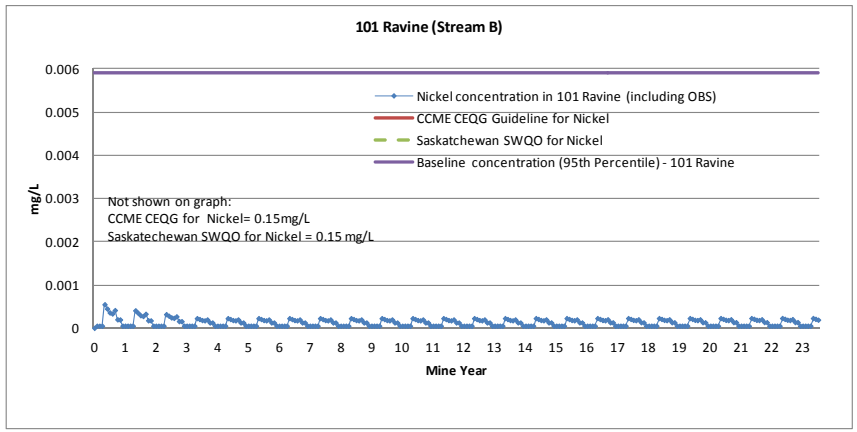


Figure 3-32 Continued







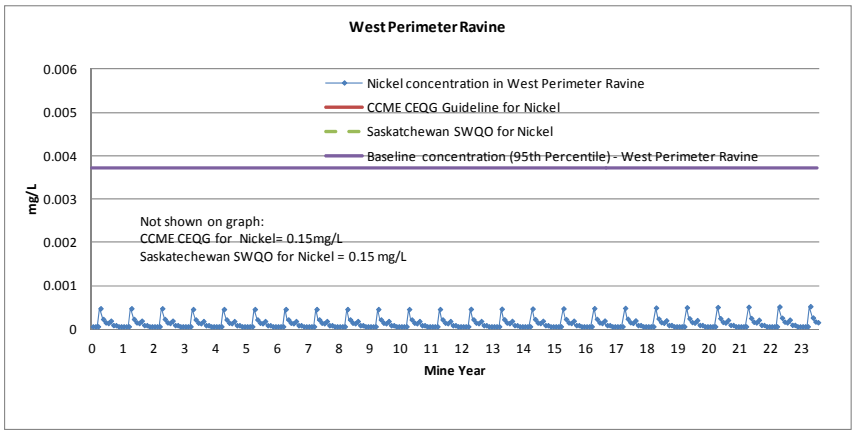
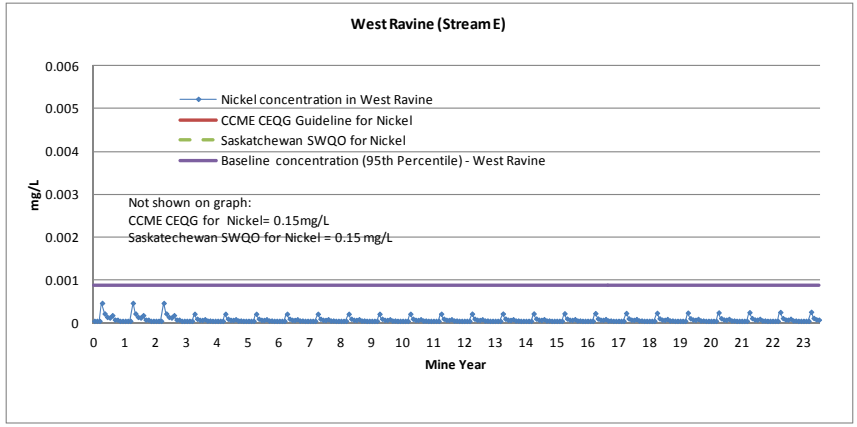
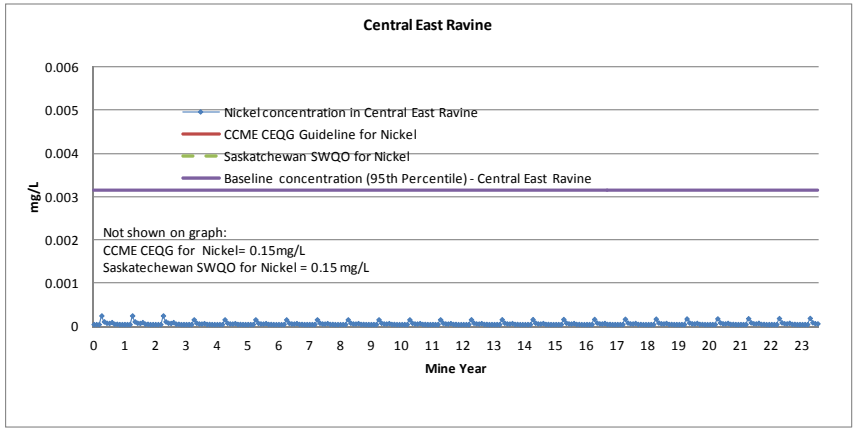
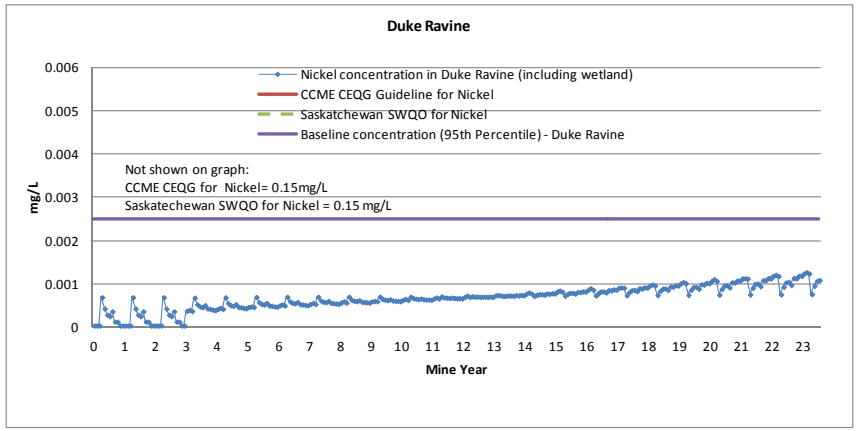


Figure 3-32 Continued







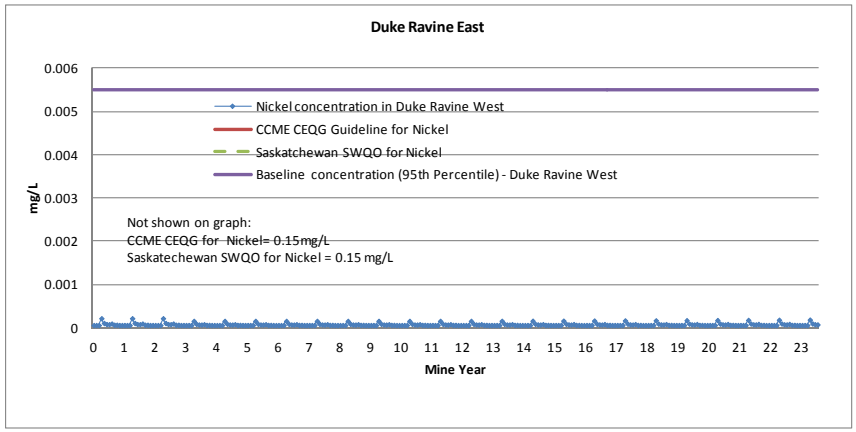
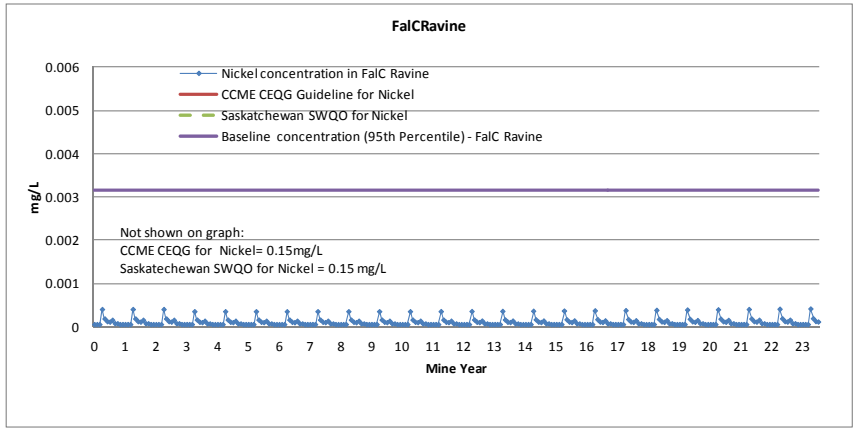
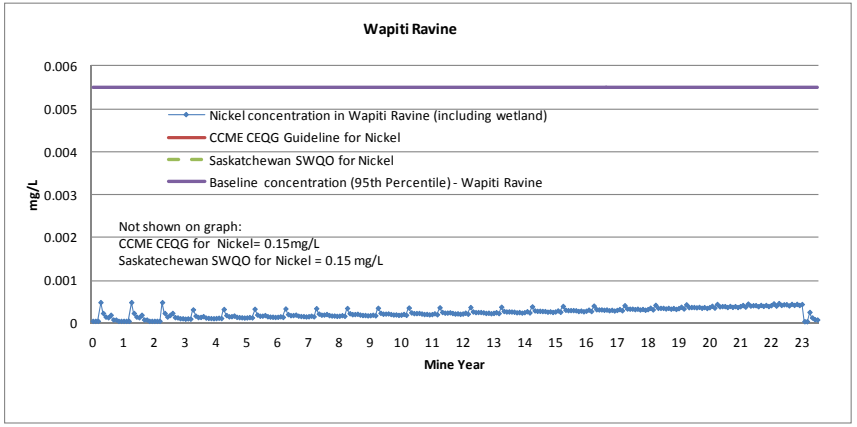
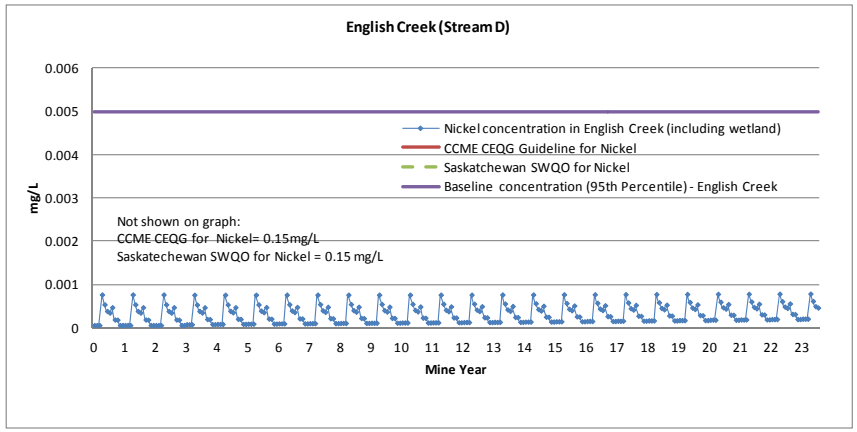


Figure 3-32 Continued







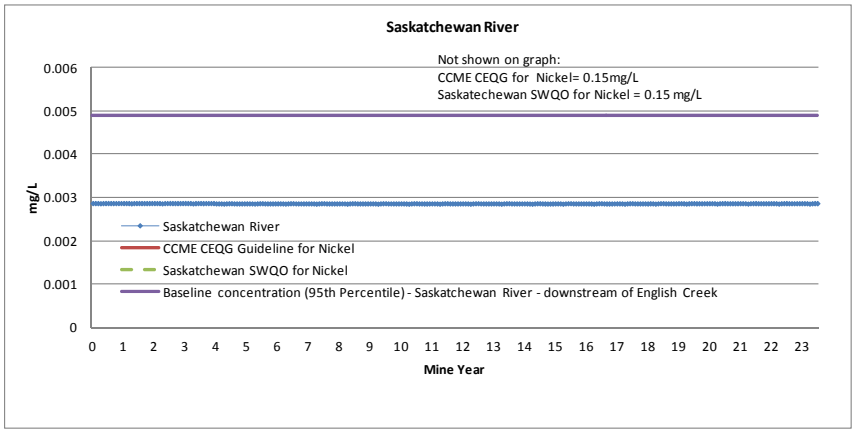
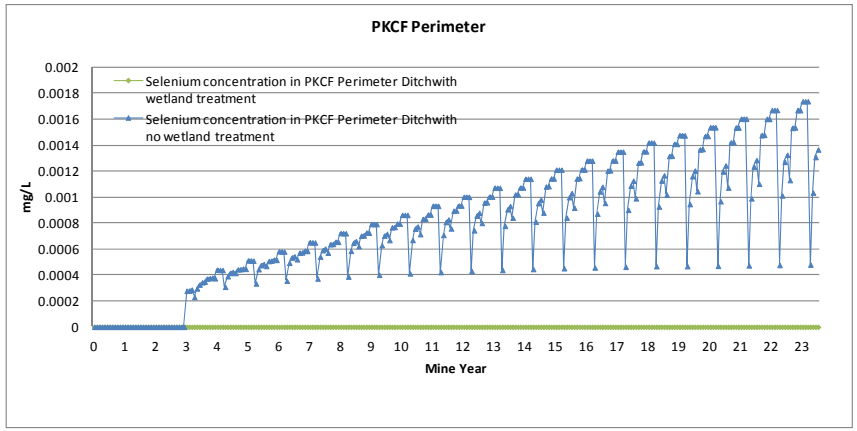
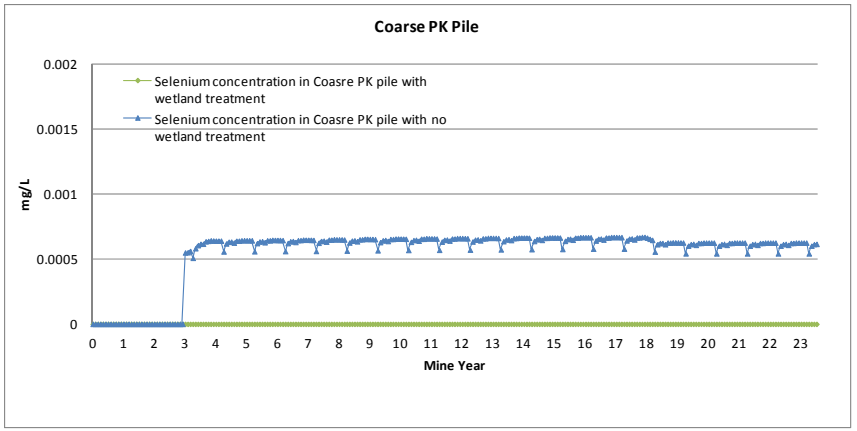


Figure 3-33 Predicted Selenium concentrations during construction and operation





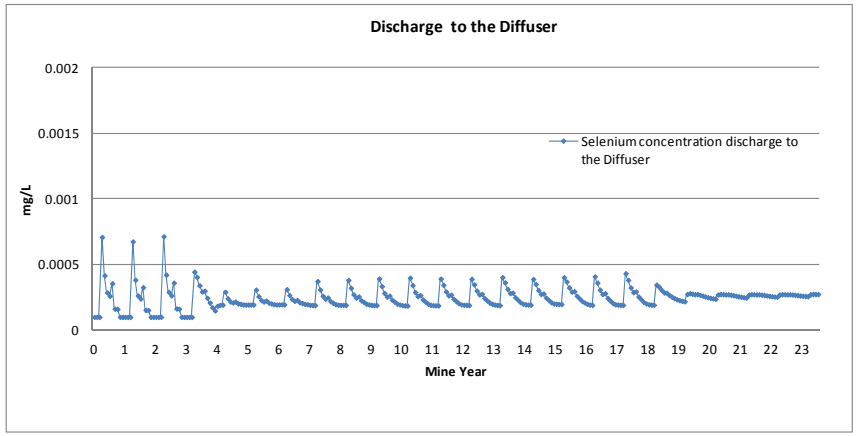
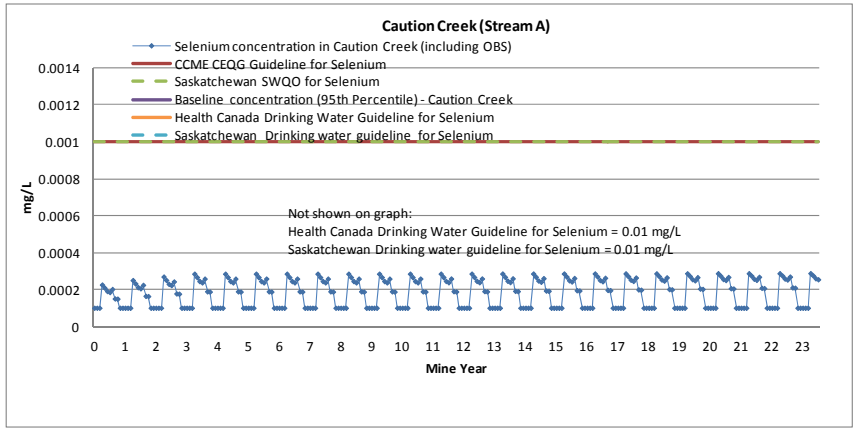
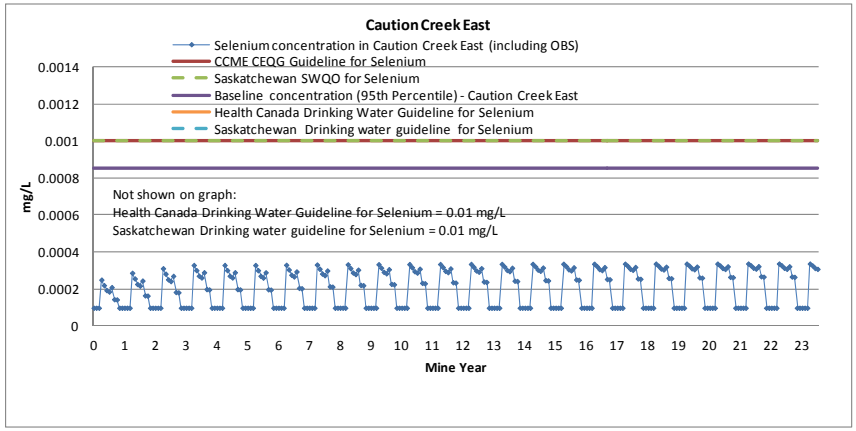
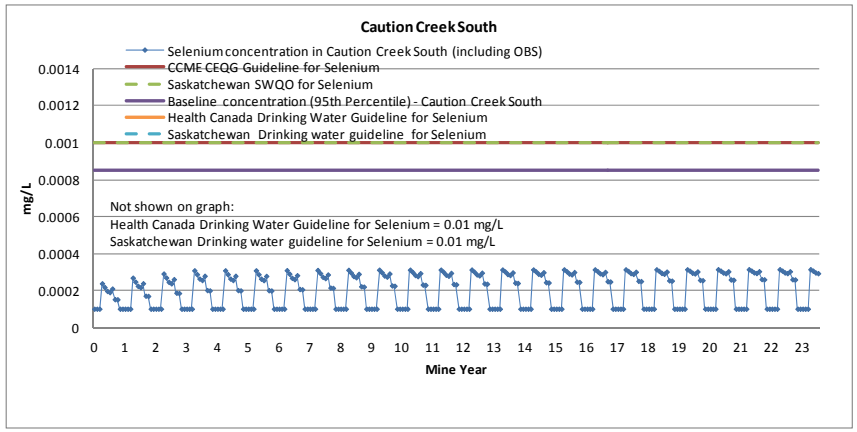


Figure 3-33 Continued







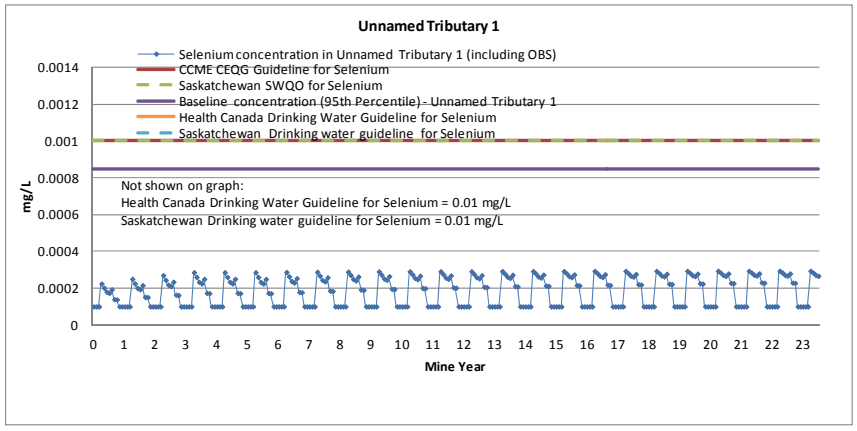
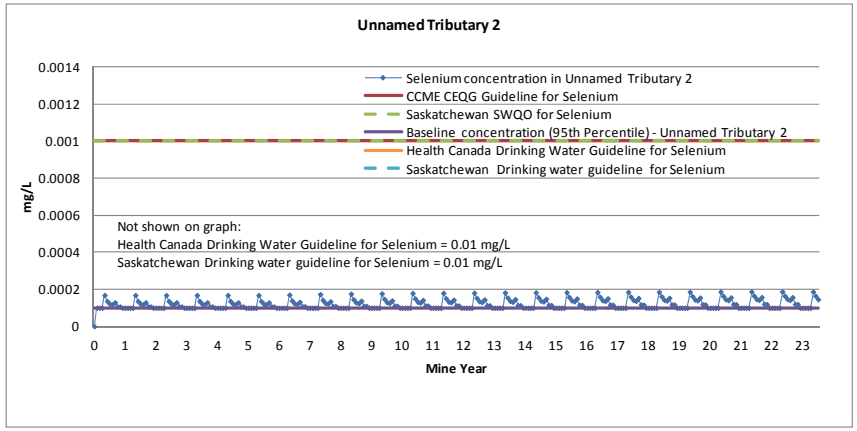
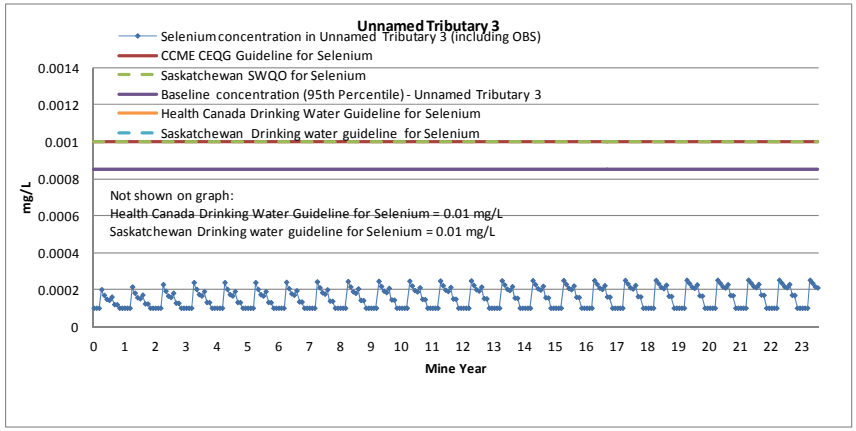
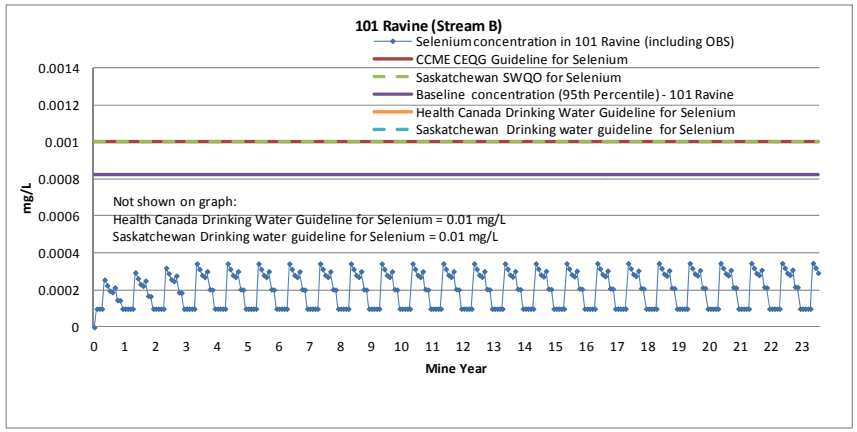


Figure 3-33 Continued







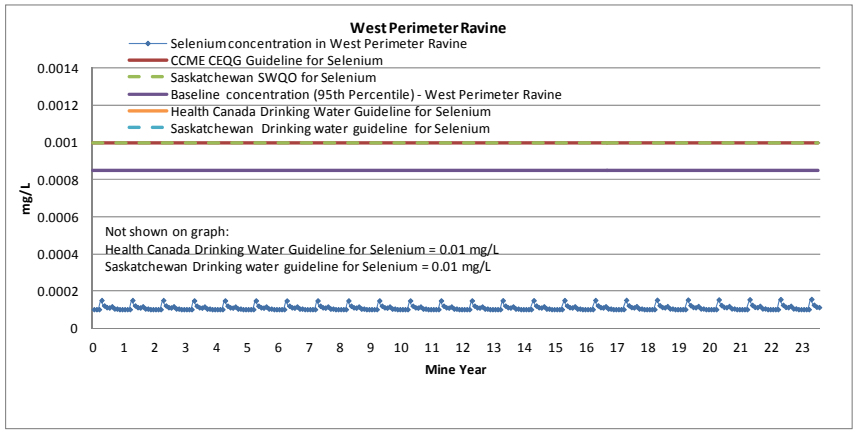
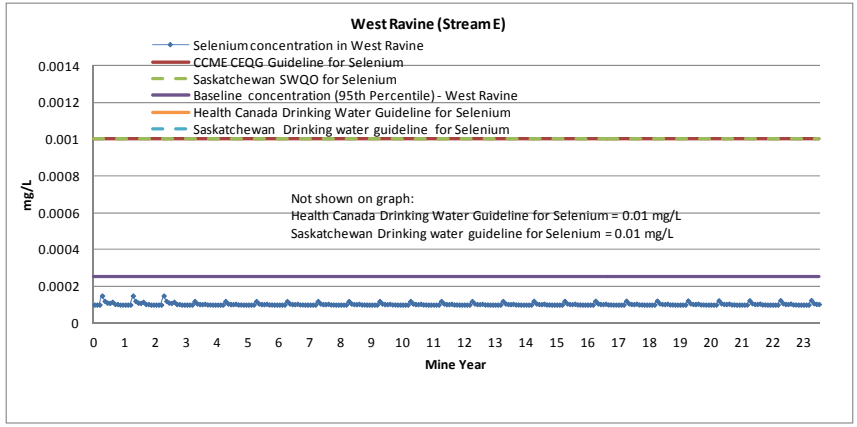
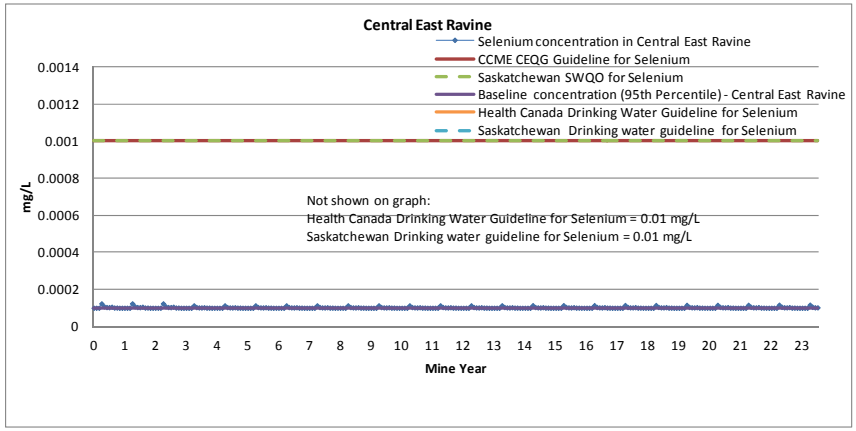
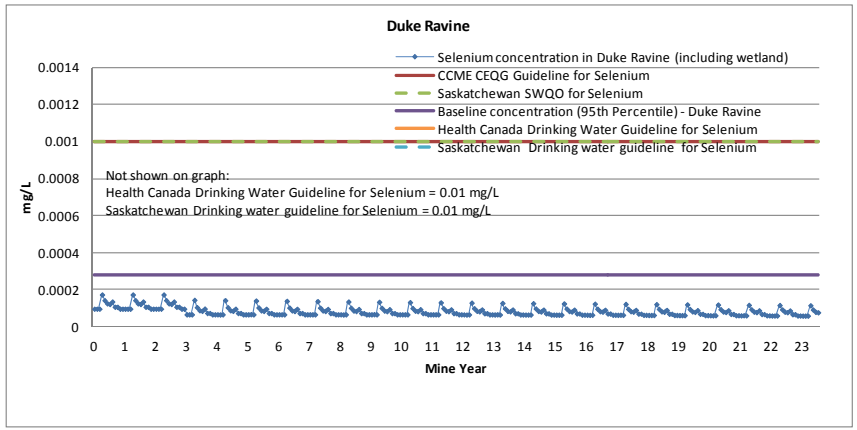


Figure 3-33 Continued







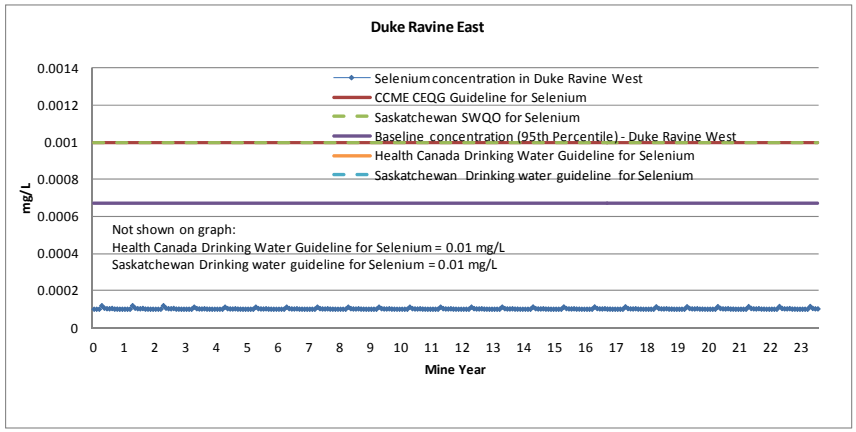
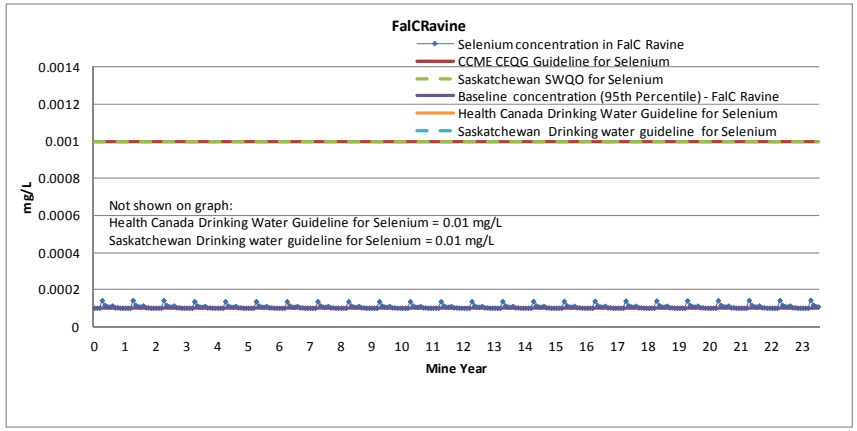
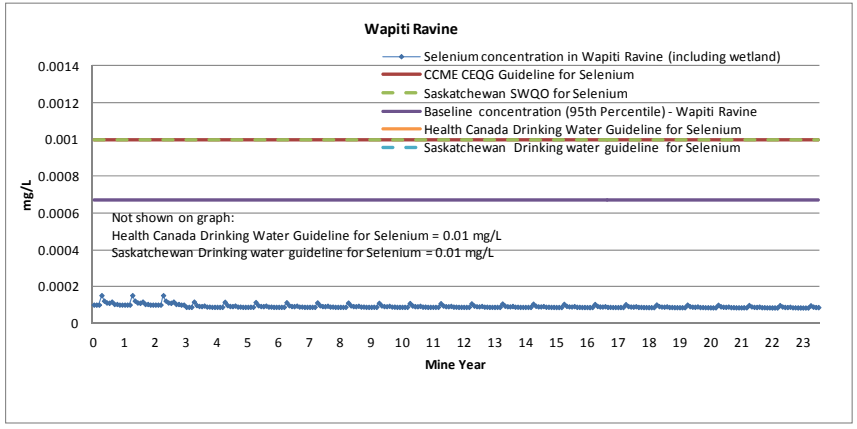
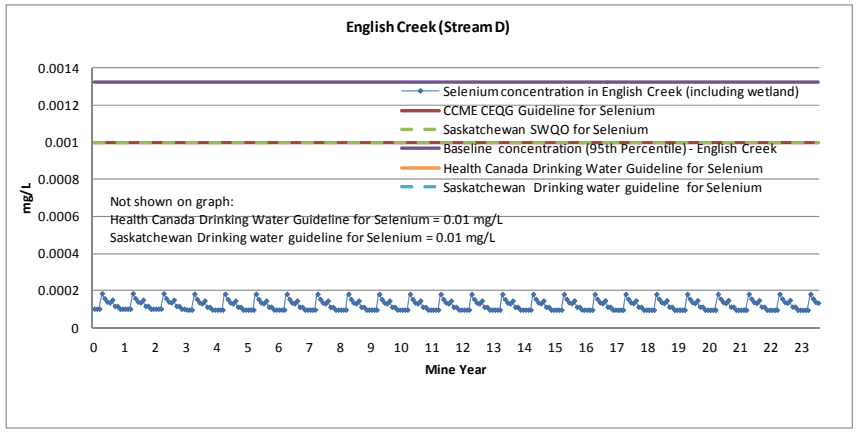


Figure 3-33 Continued







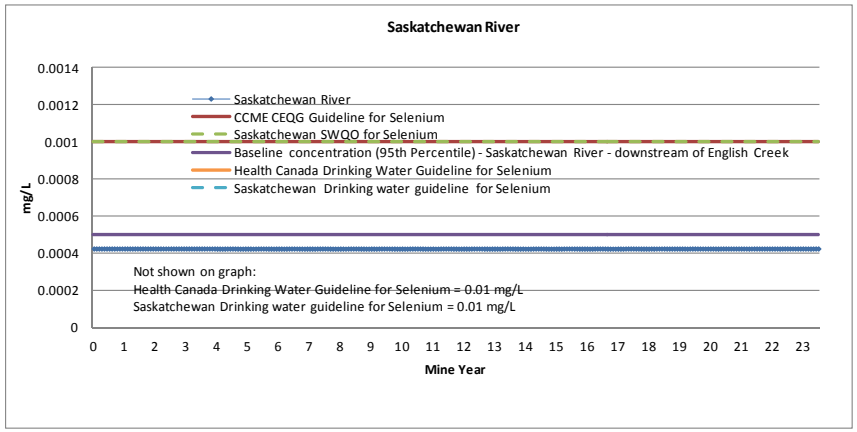
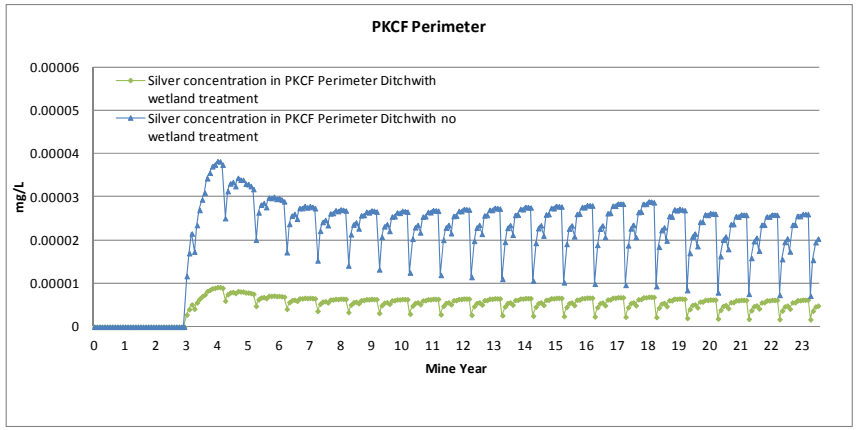
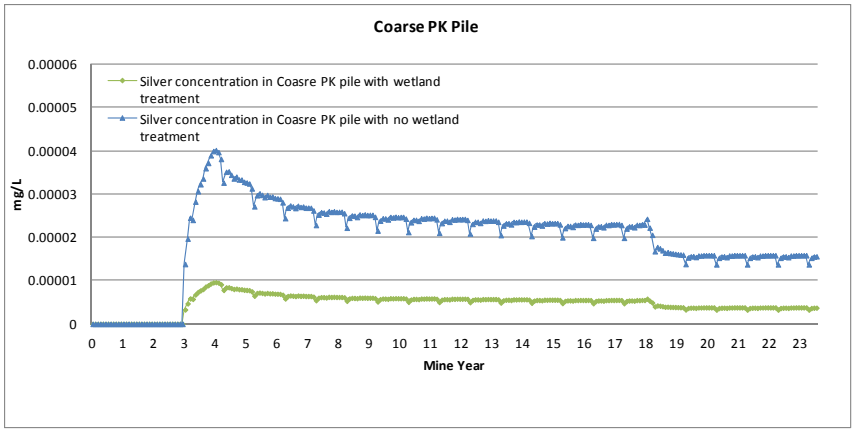


Figure 3-34 Predicted Silver concentrations during construction and operation





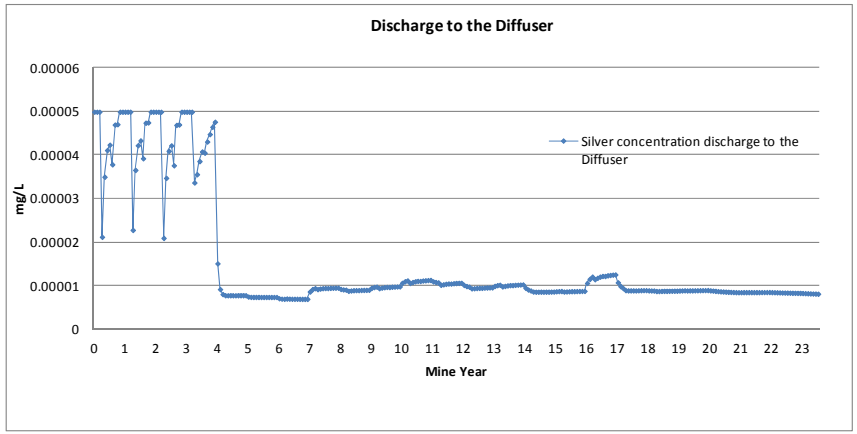
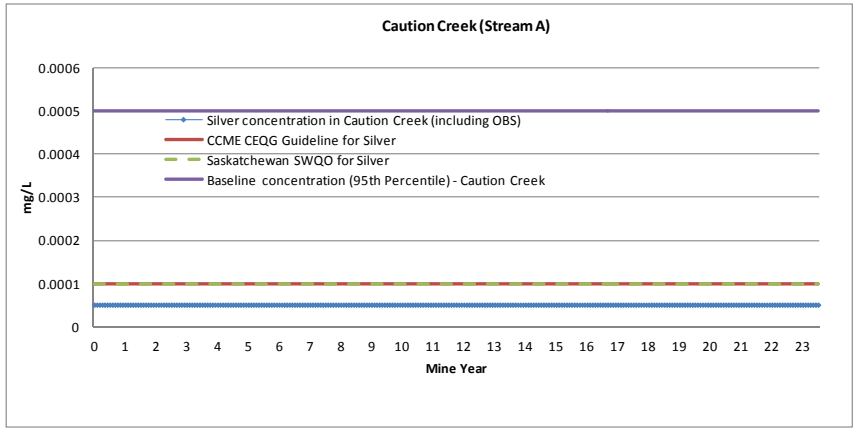
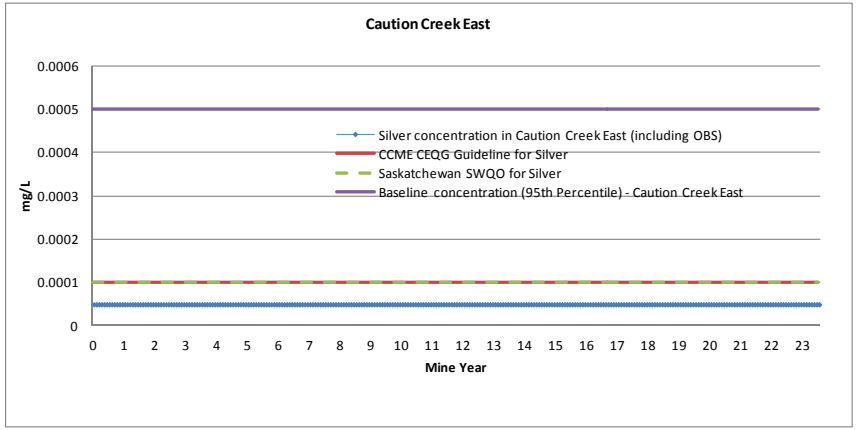
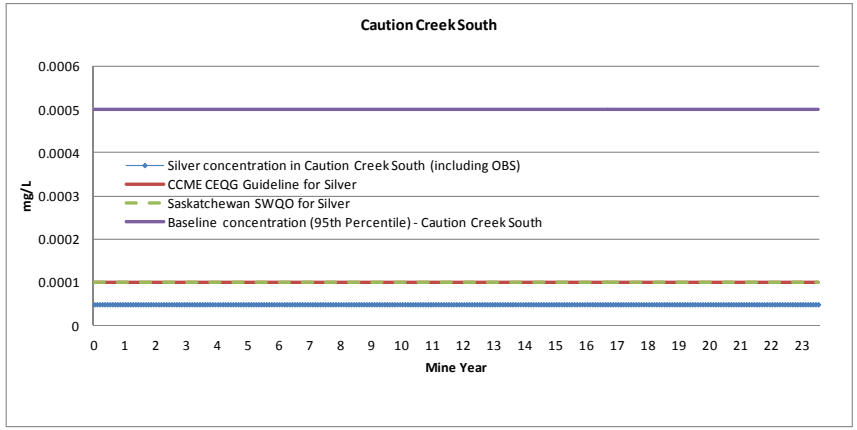


Figure 3-34 Continued







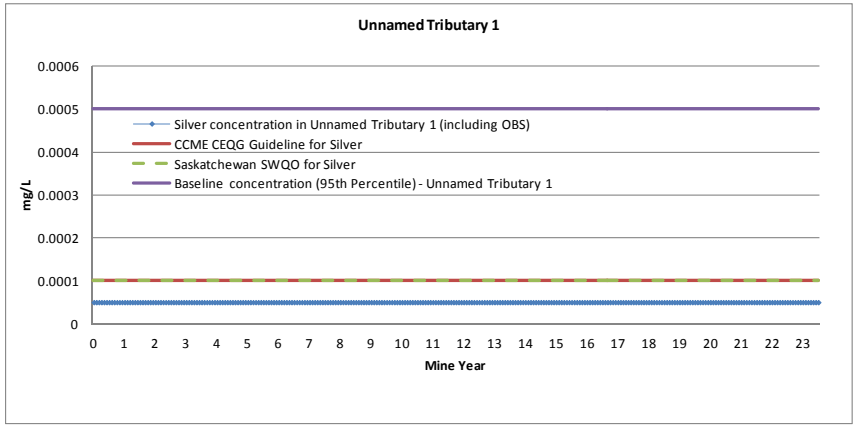
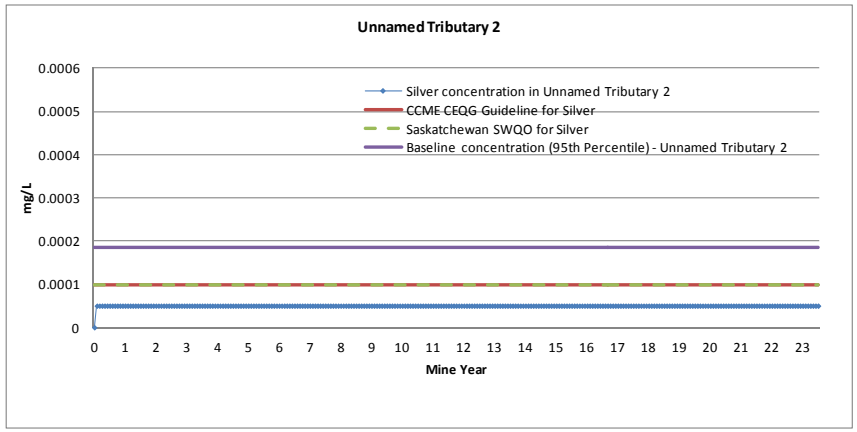
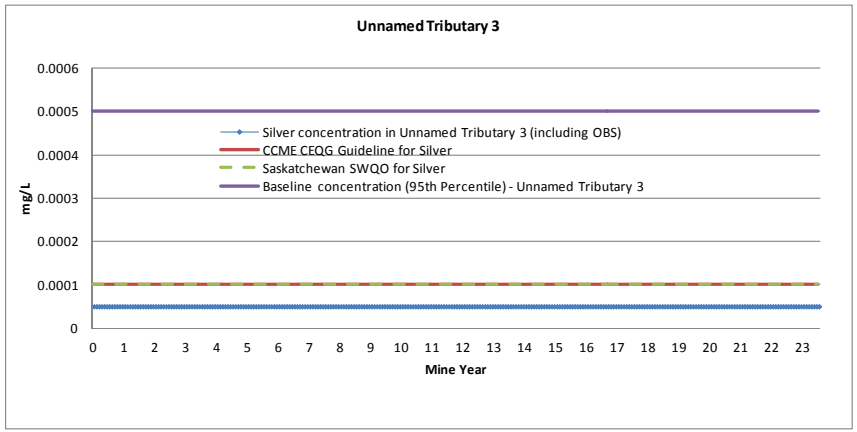
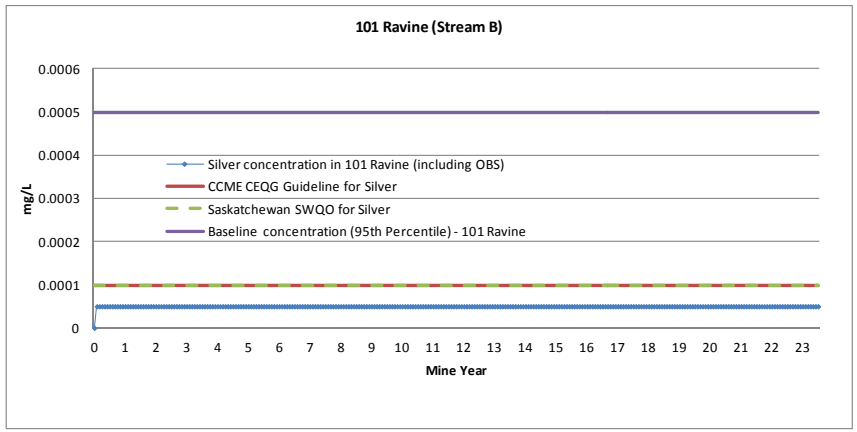


Figure 3-34 Continued







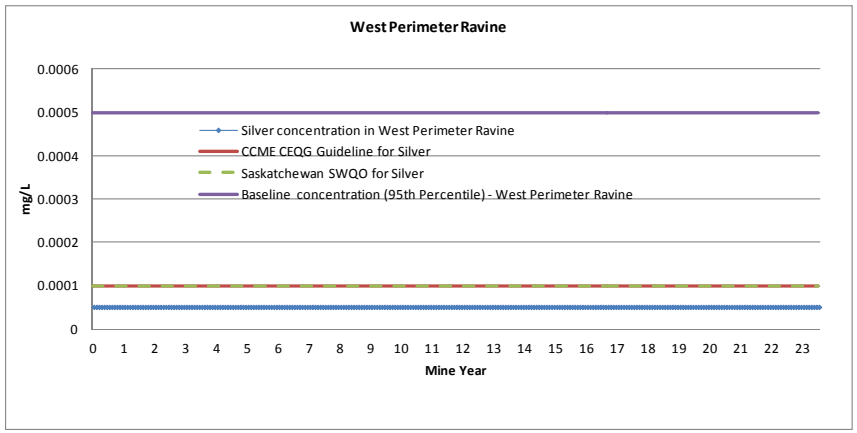
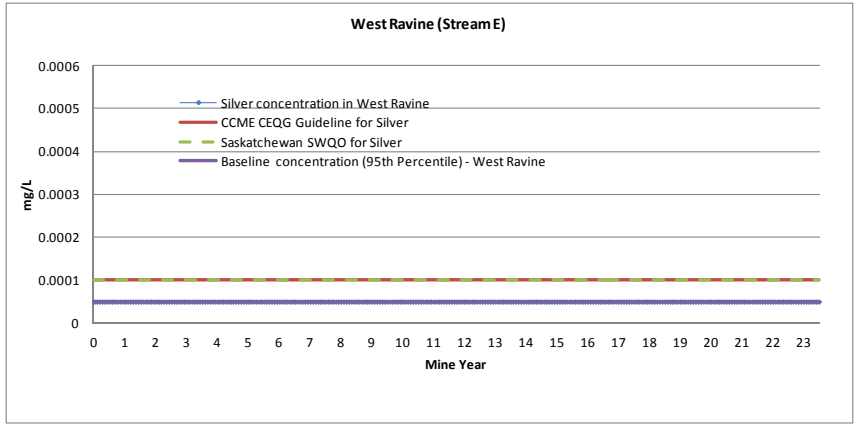
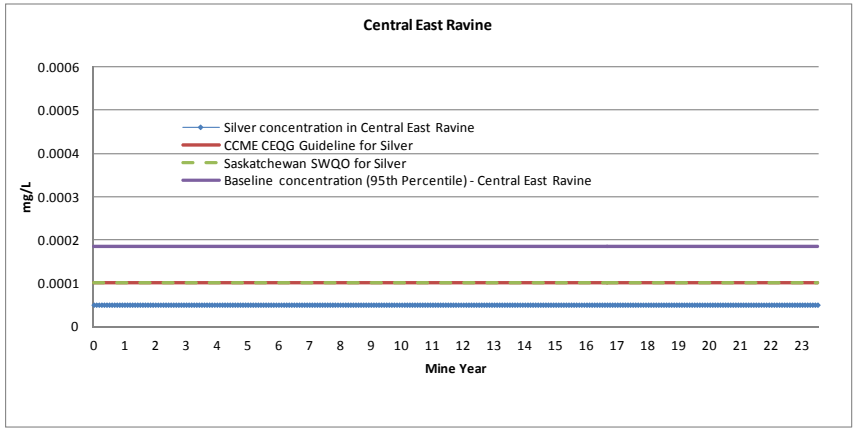
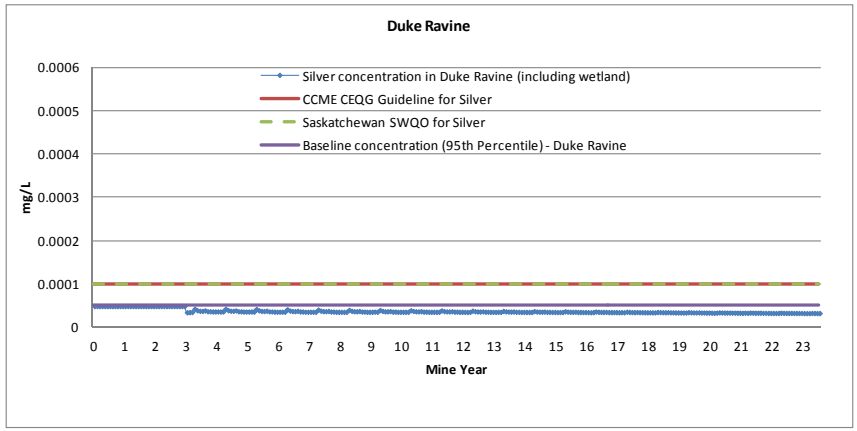


Figure 3-34 Continued







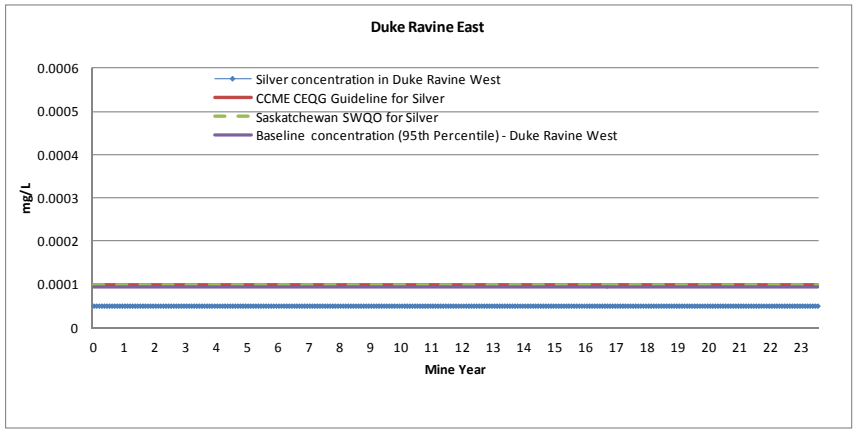
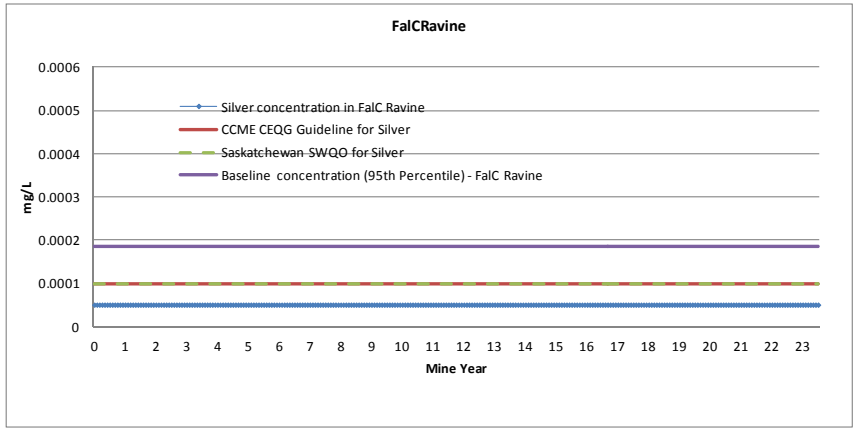
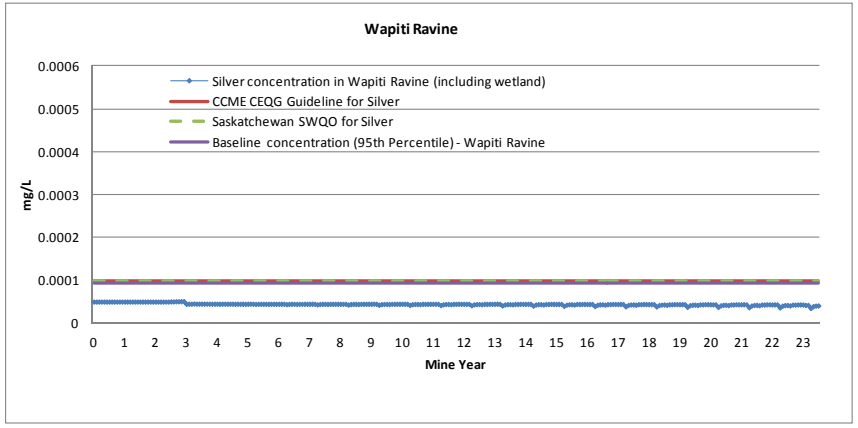
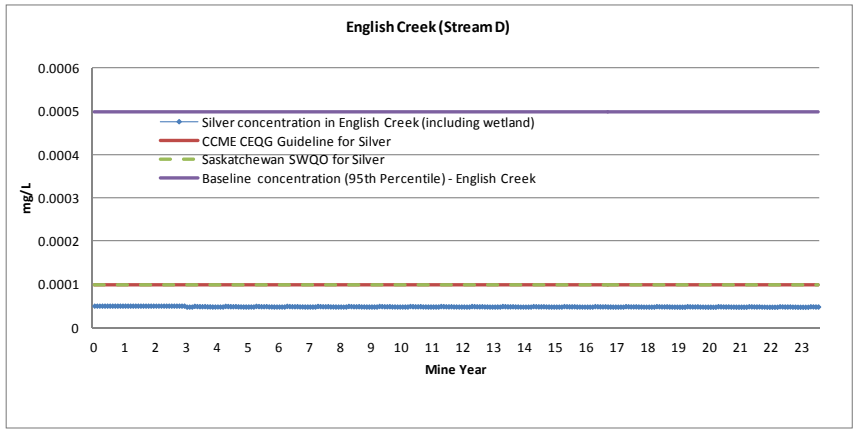


Figure 3-34 Continued







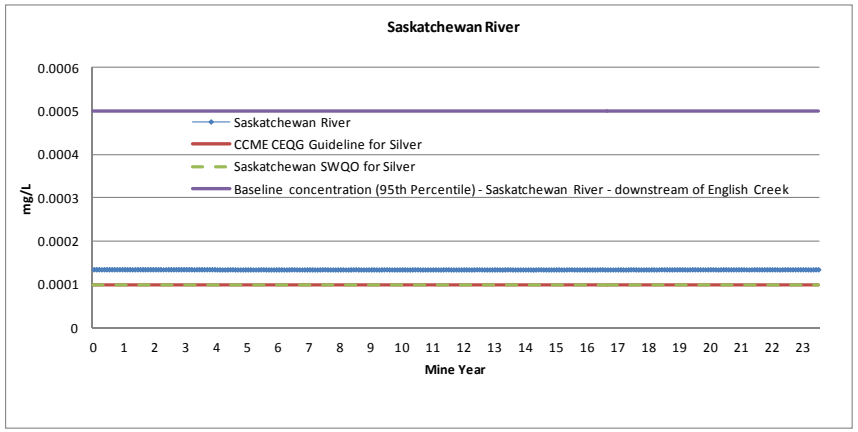
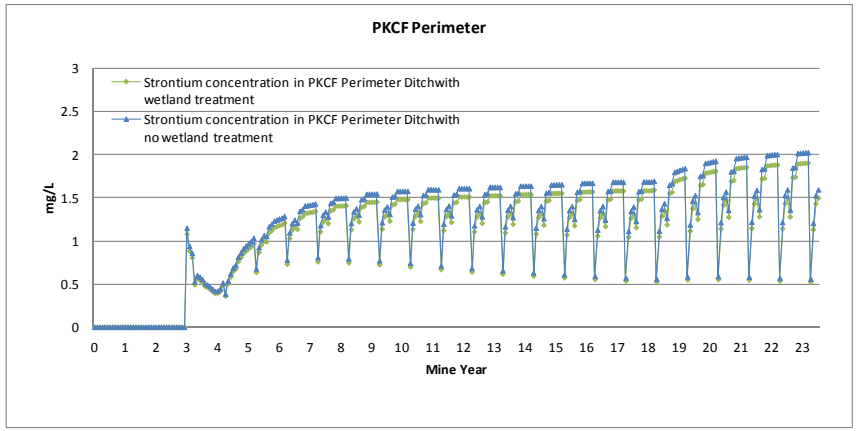
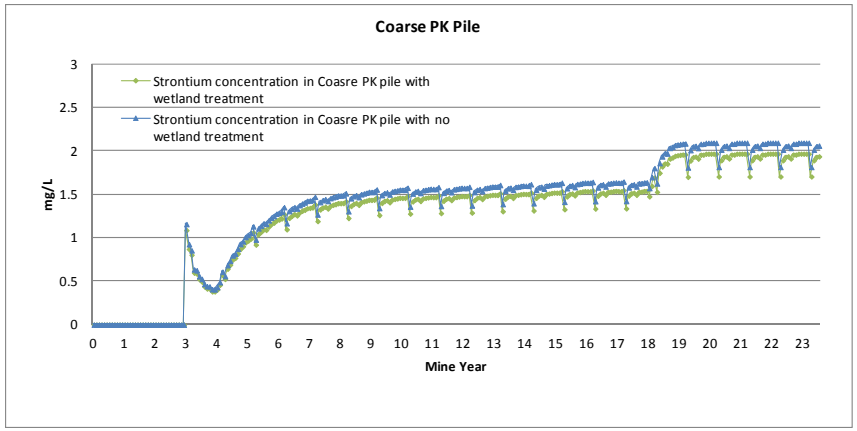


Figure 3-35 Predicted Strontium concentrations during construction and operation





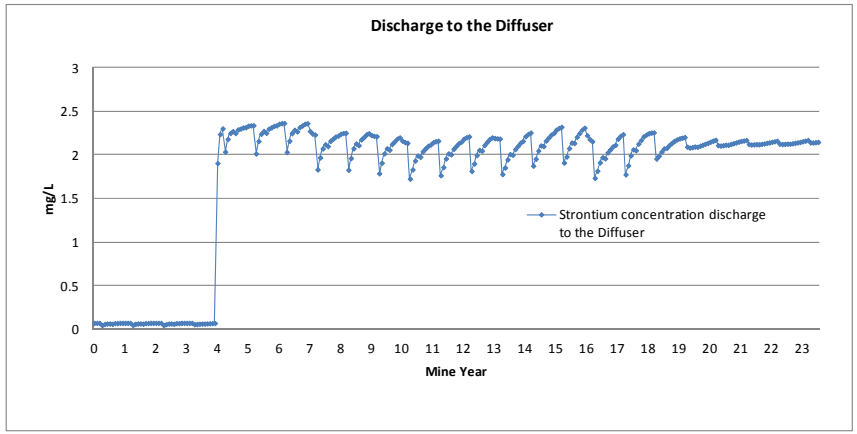
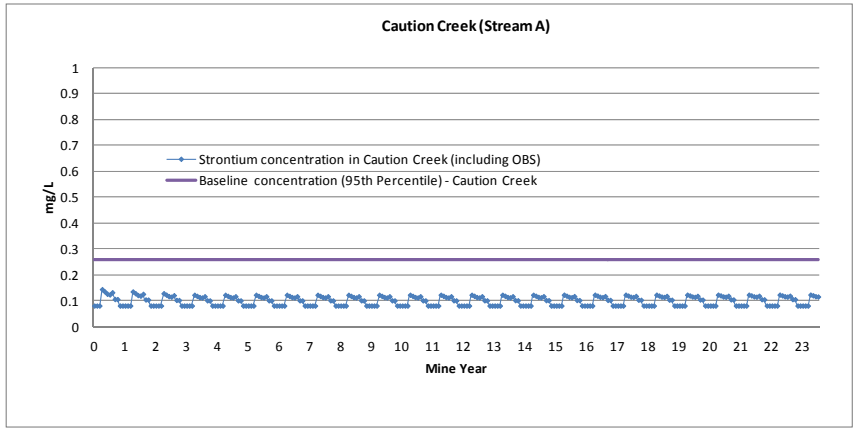
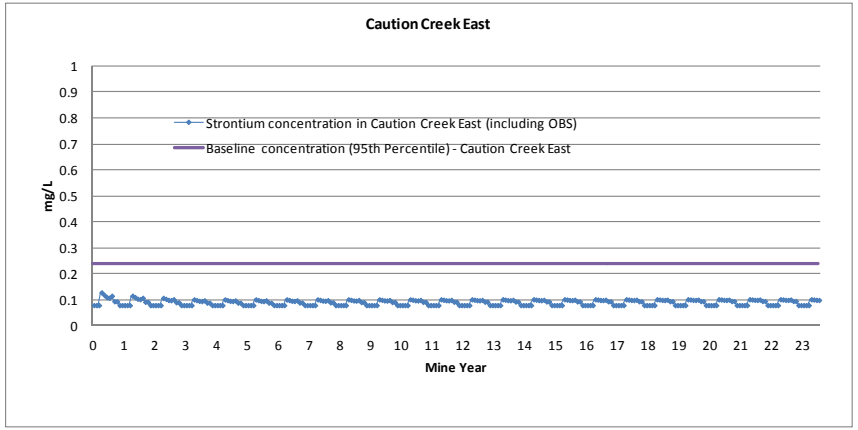
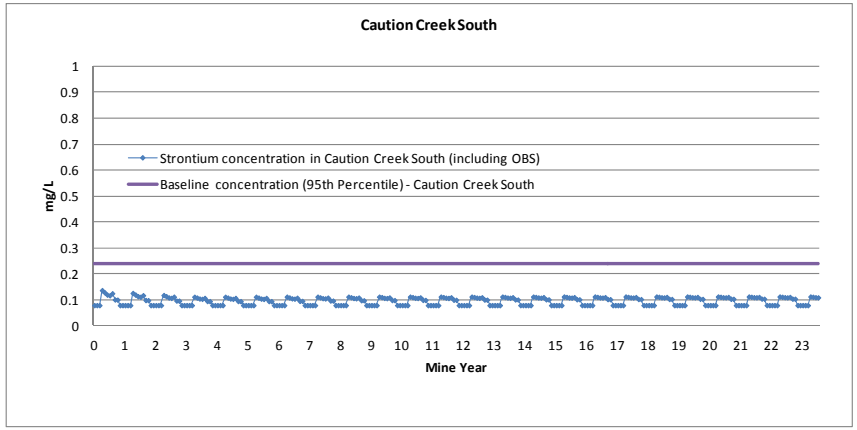


Figure 3-35 Continued







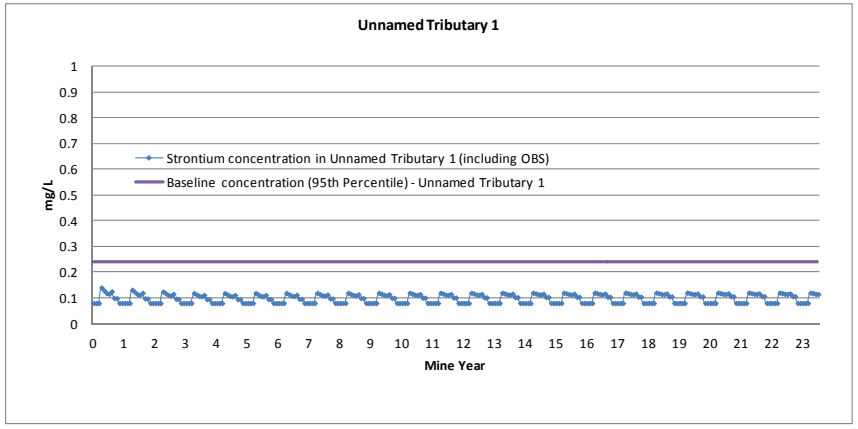
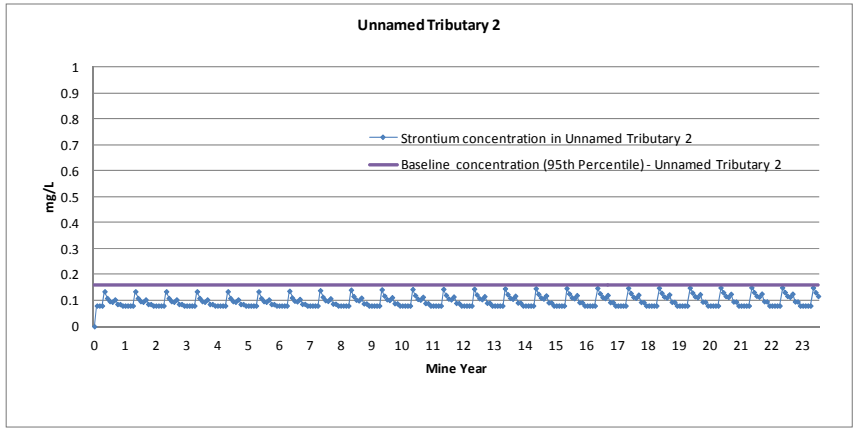
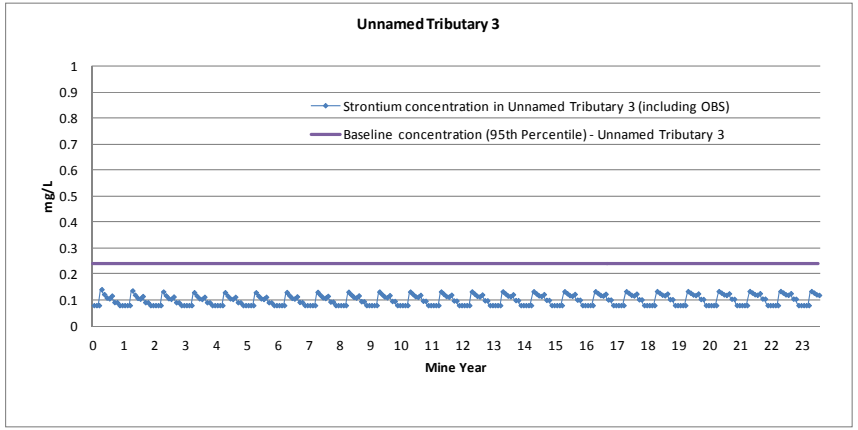
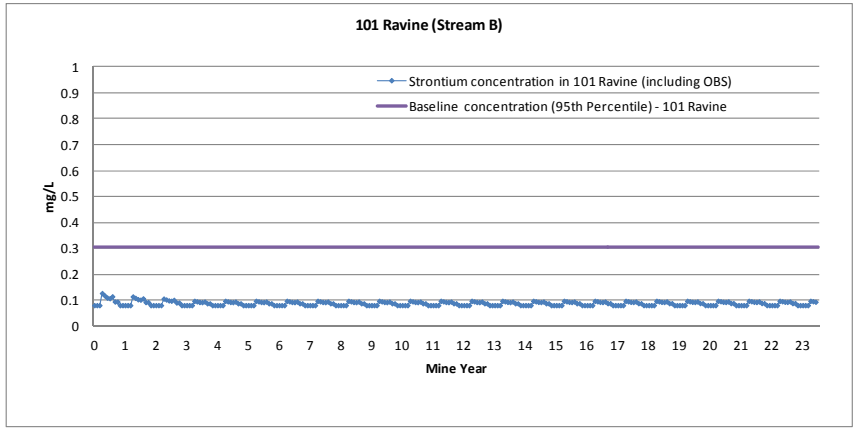


Figure 3-35 Continued







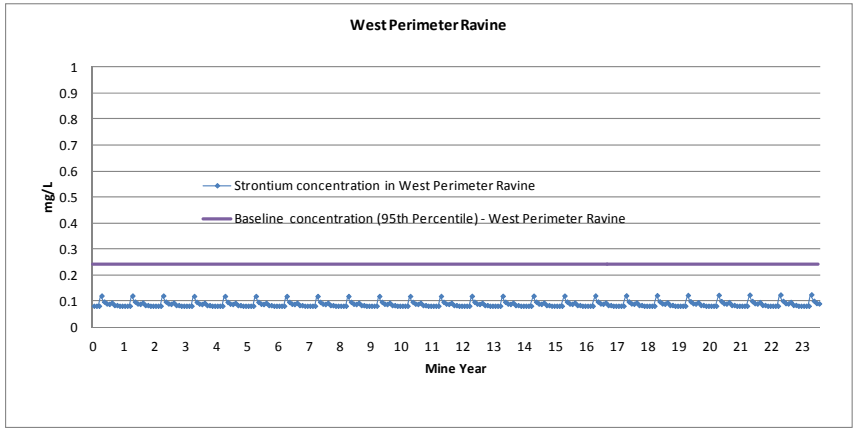
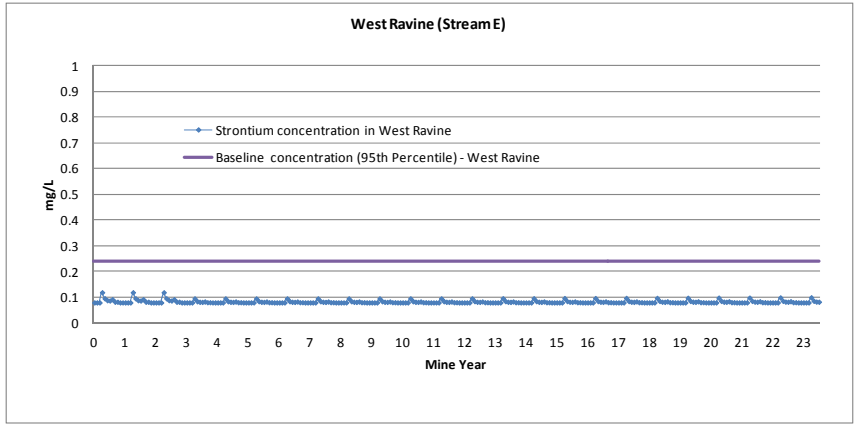
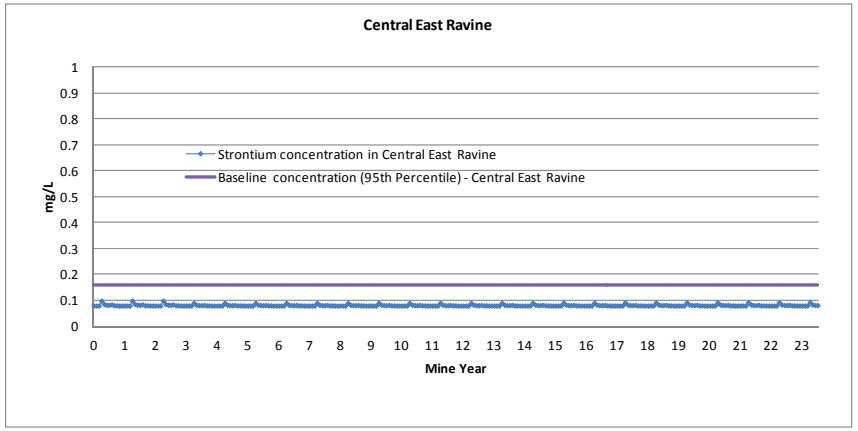
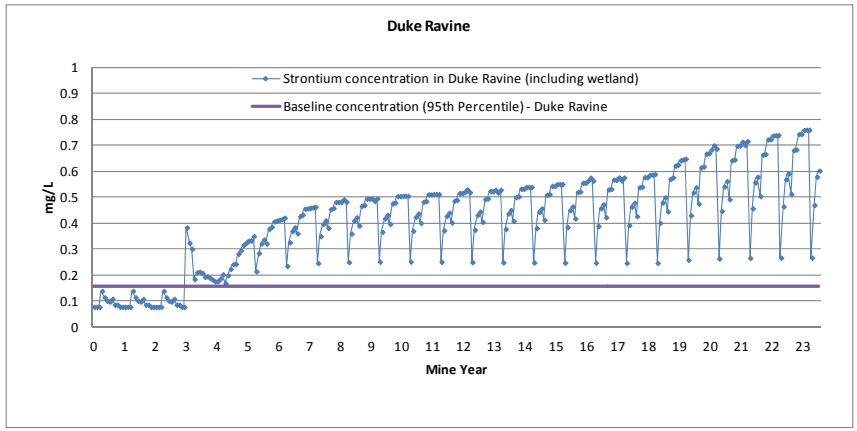


Figure 3-35 Continued







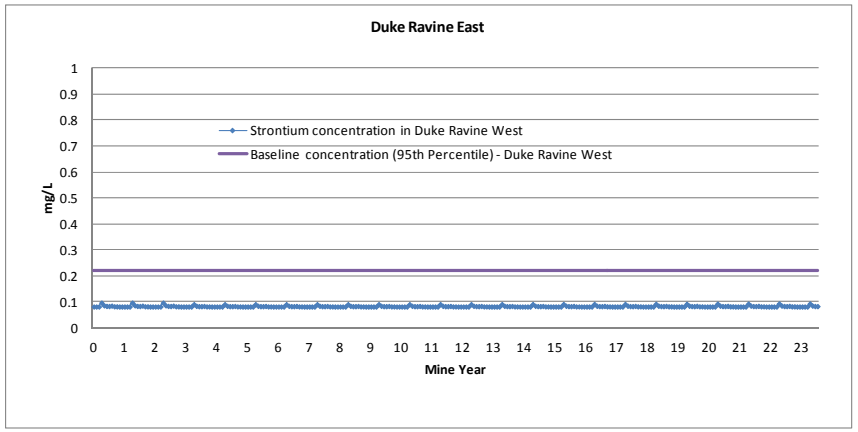
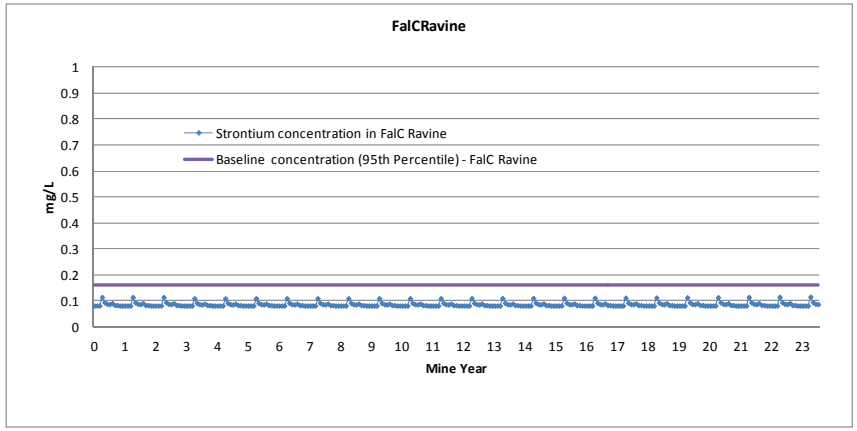
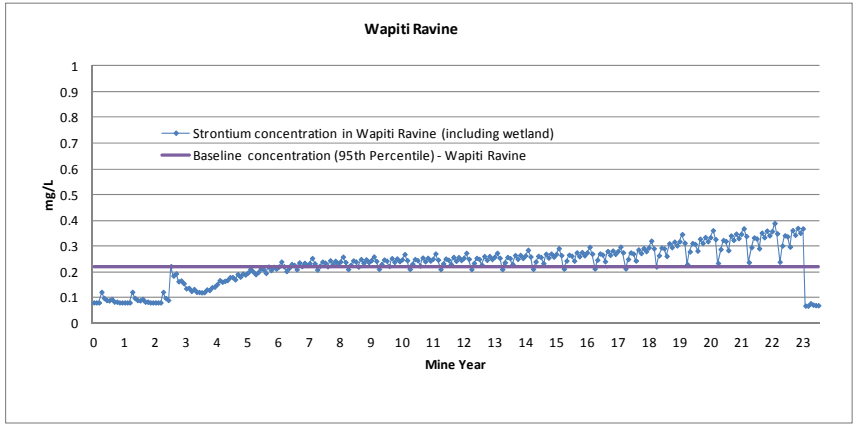
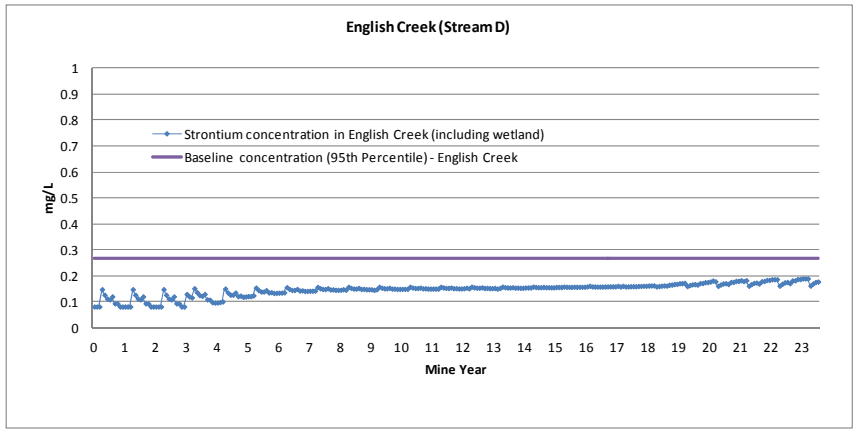


Figure 3-35 Continued







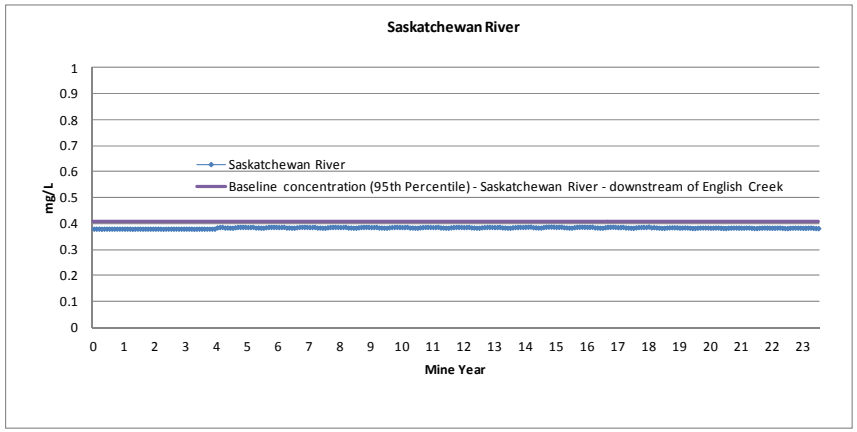
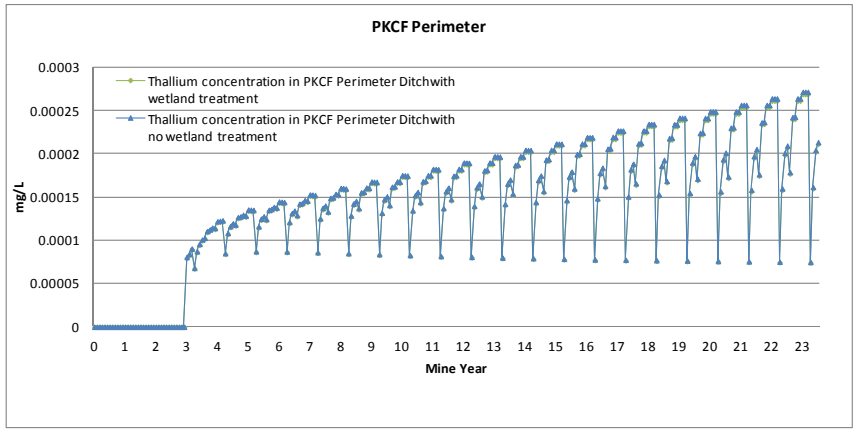
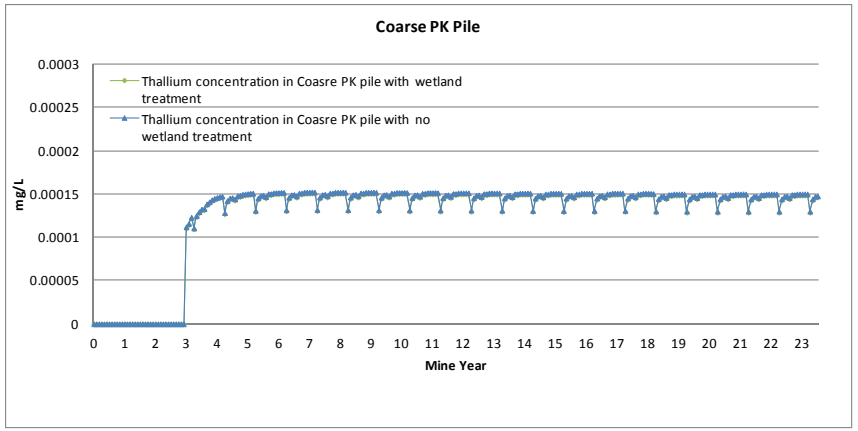


Figure 3-36 Predicted Thallium concentrations during construction and operation





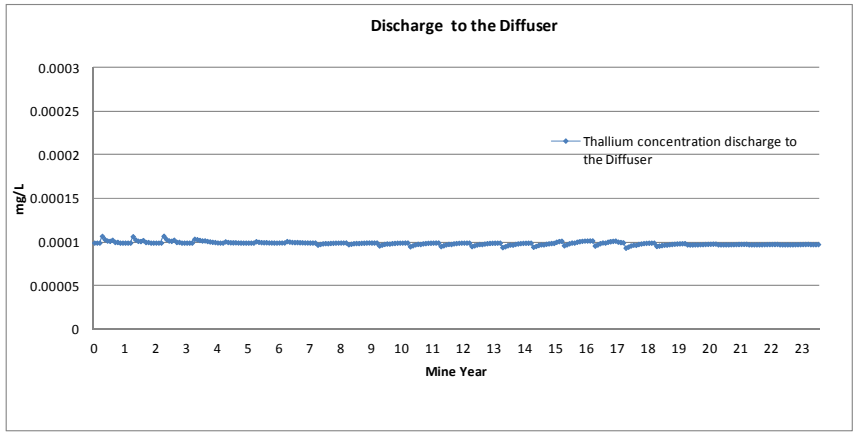
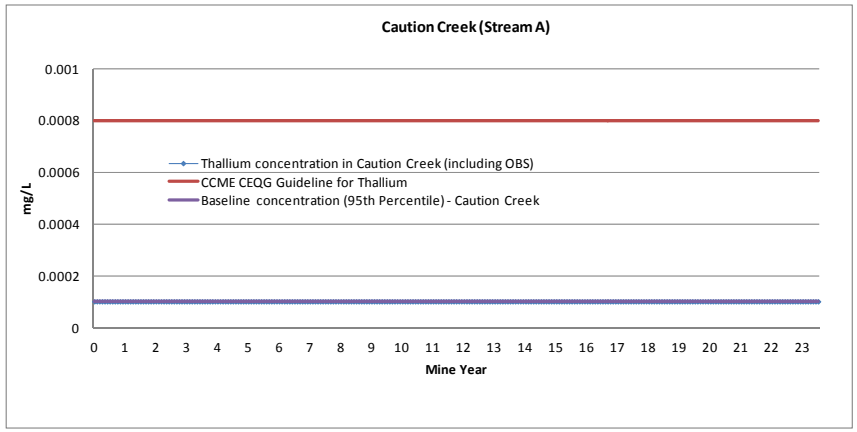
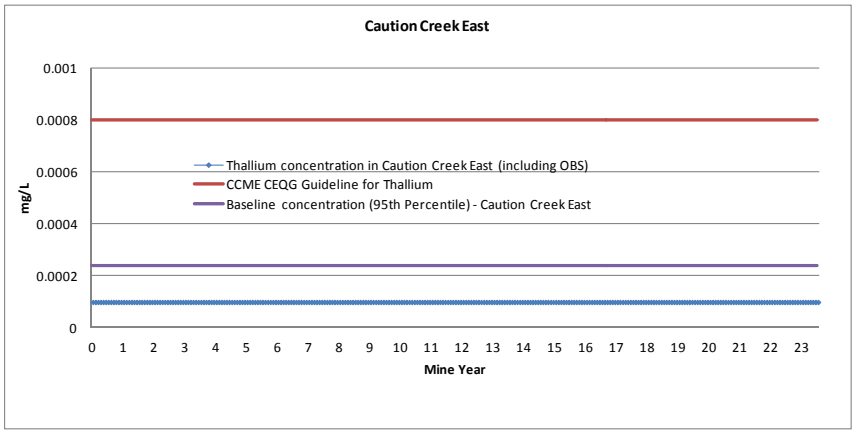
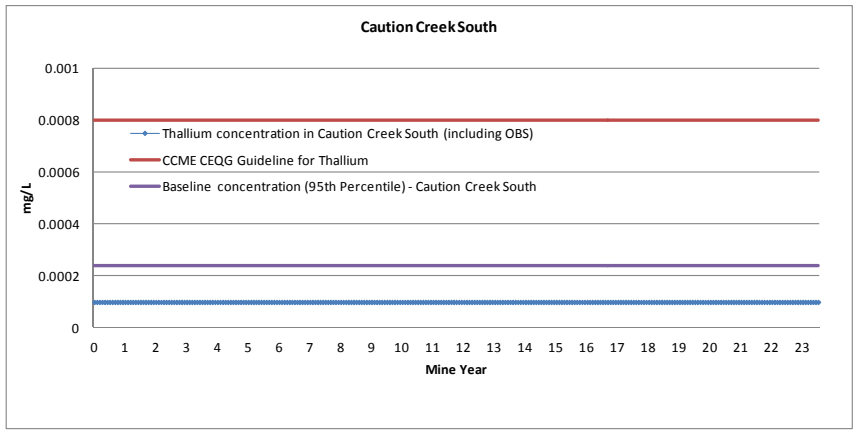


Figure 3-36 Continued







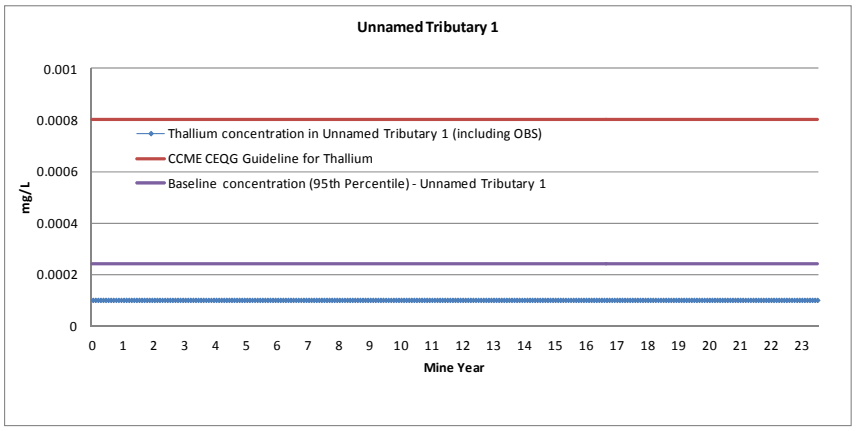
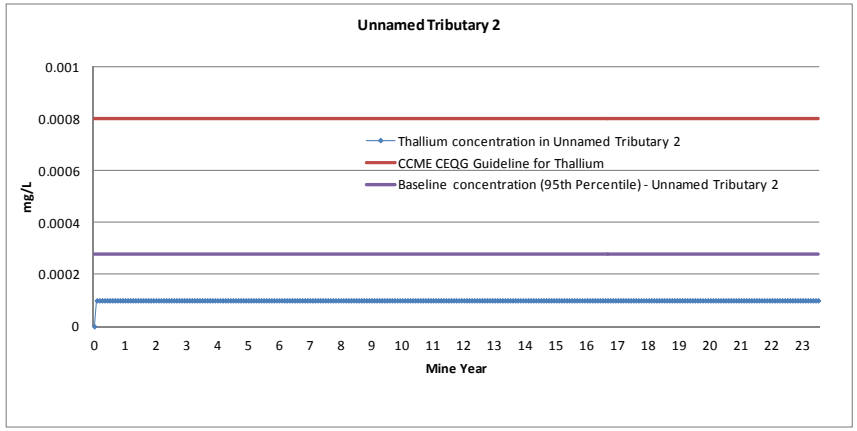
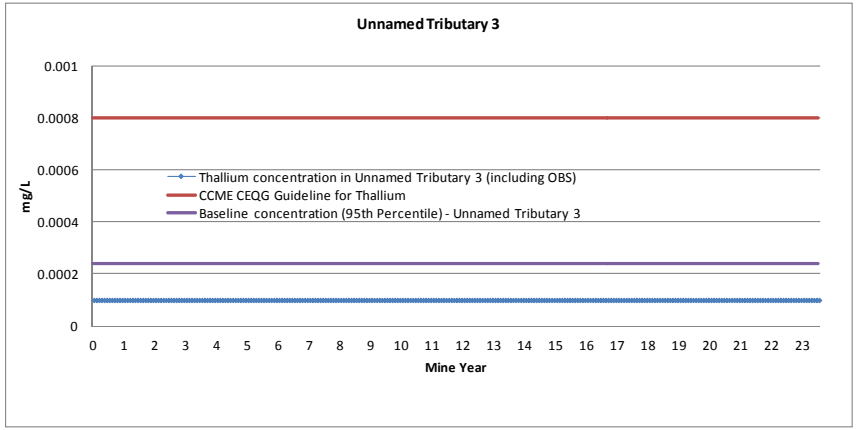
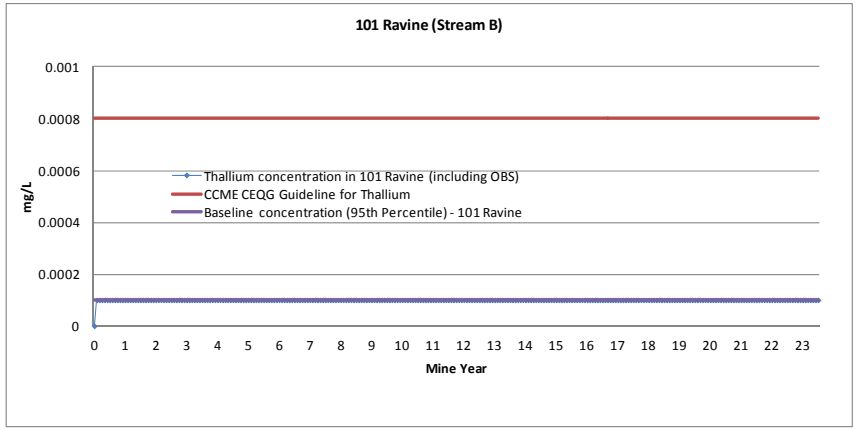


Figure 3-36 Continued







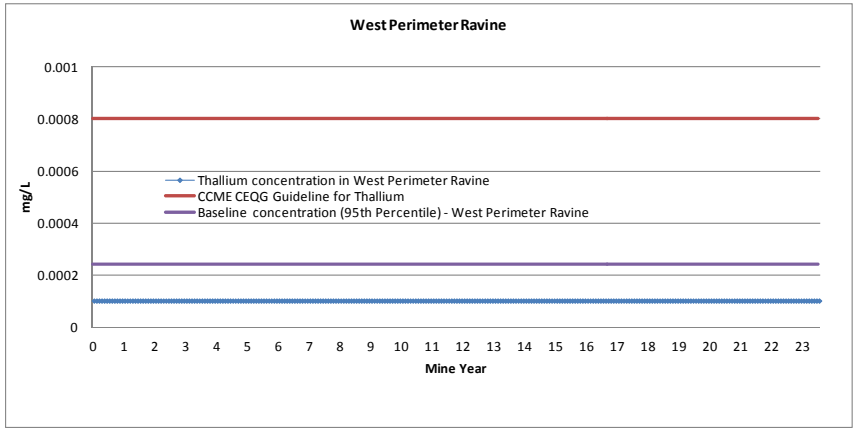
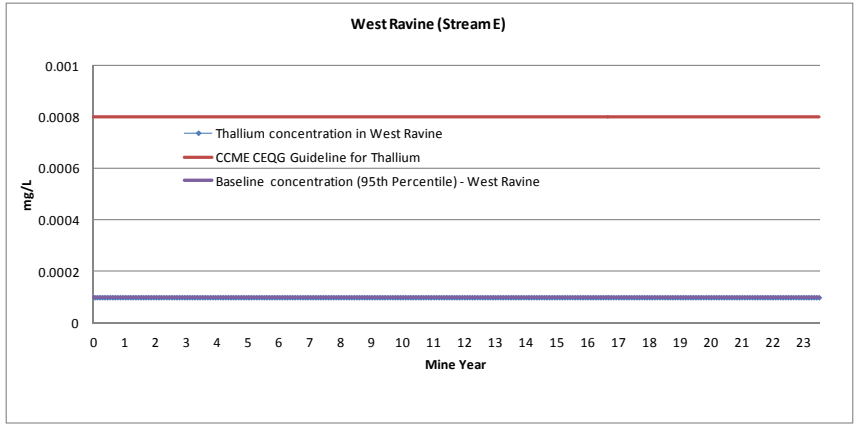
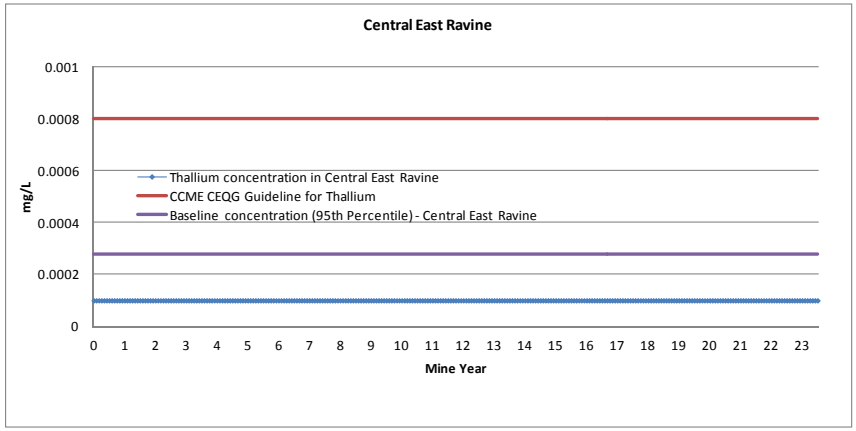
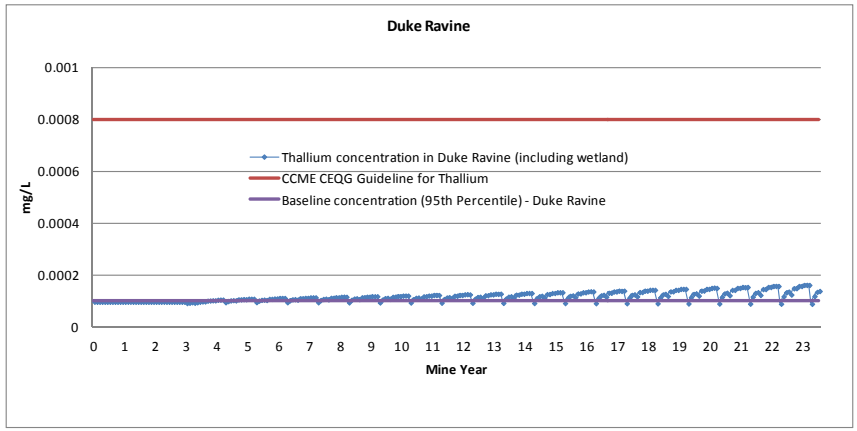


Figure 3-36 Continued







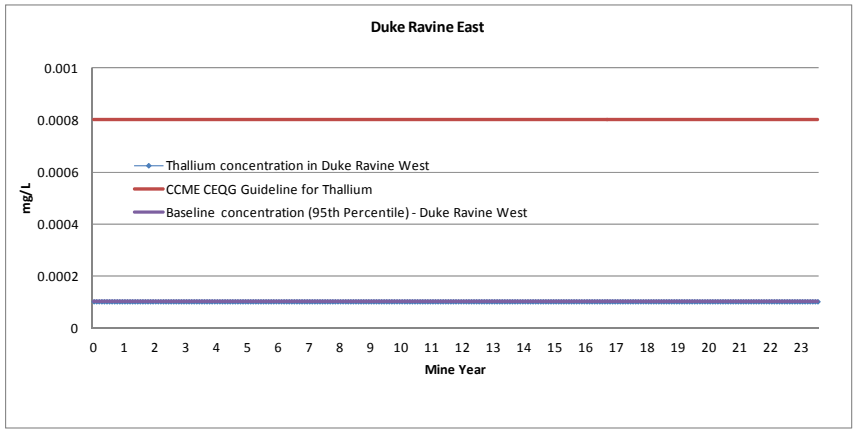
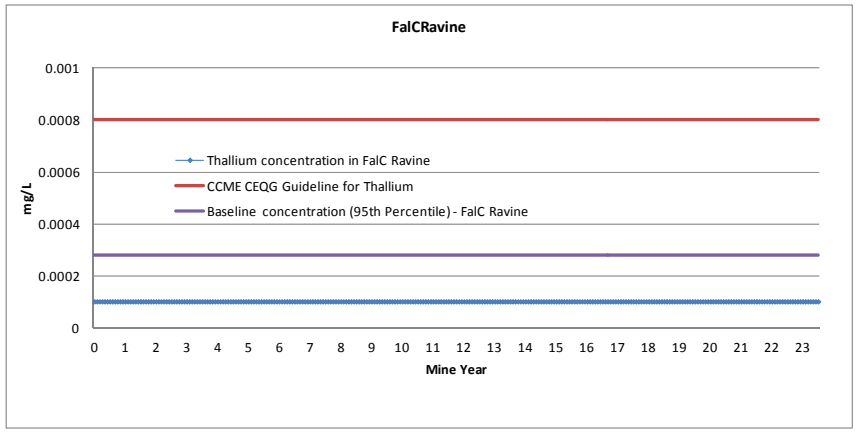
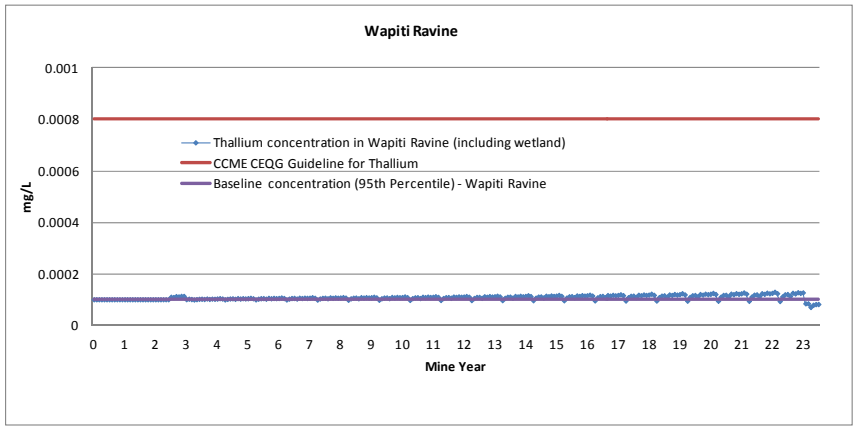
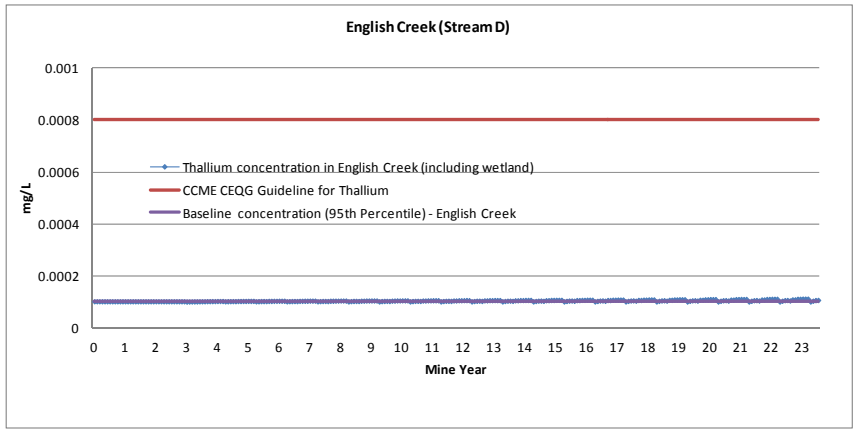


Figure 3-36 Continued







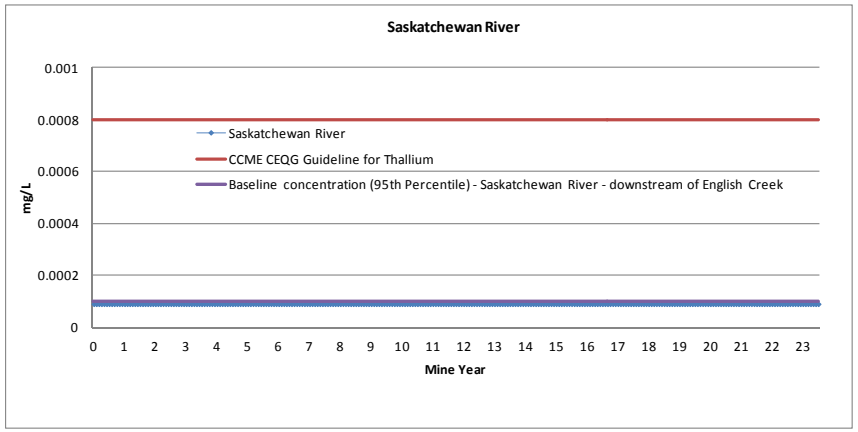
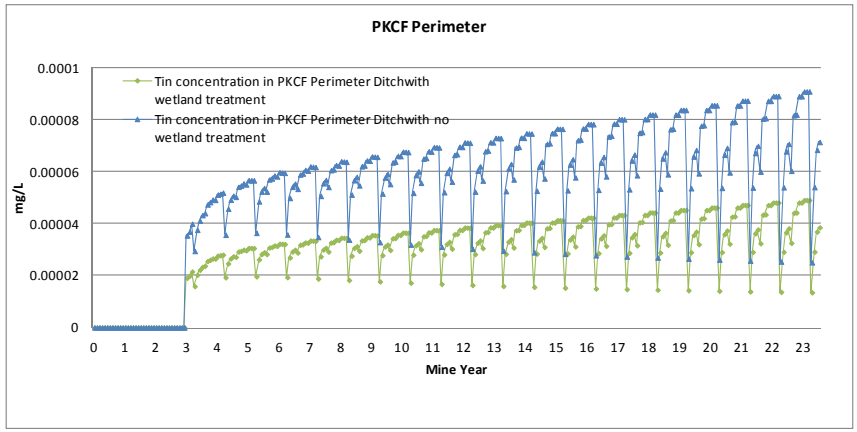
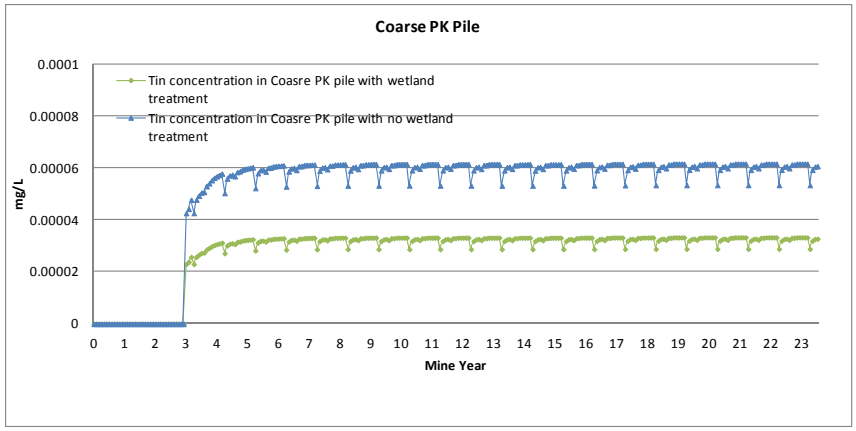


Figure 3-37 Predicted Tin concentrations during construction and operation





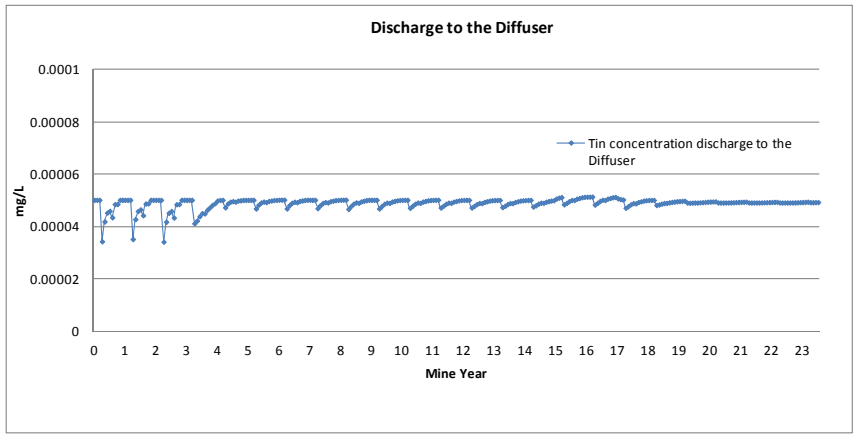
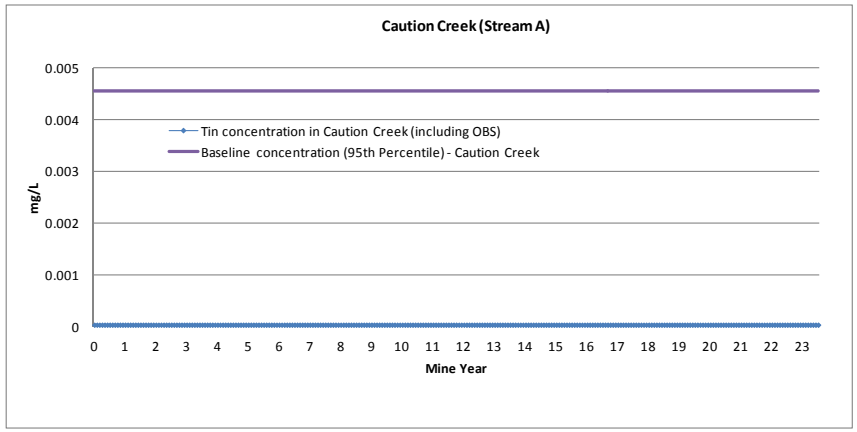
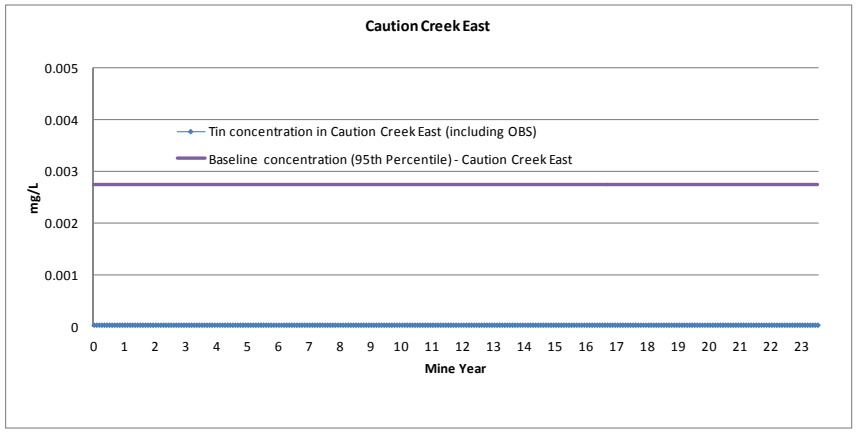
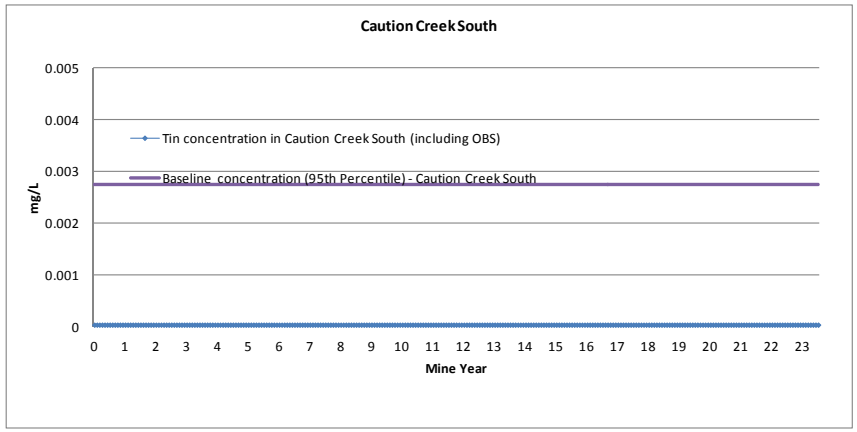


Figure 3-37 Continued







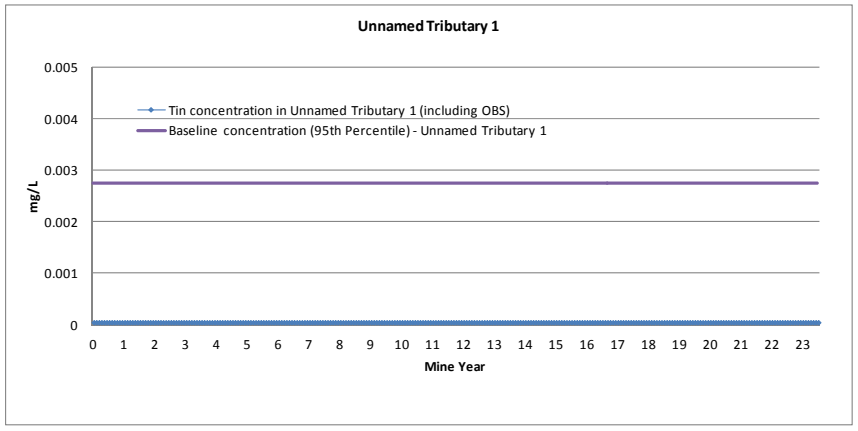
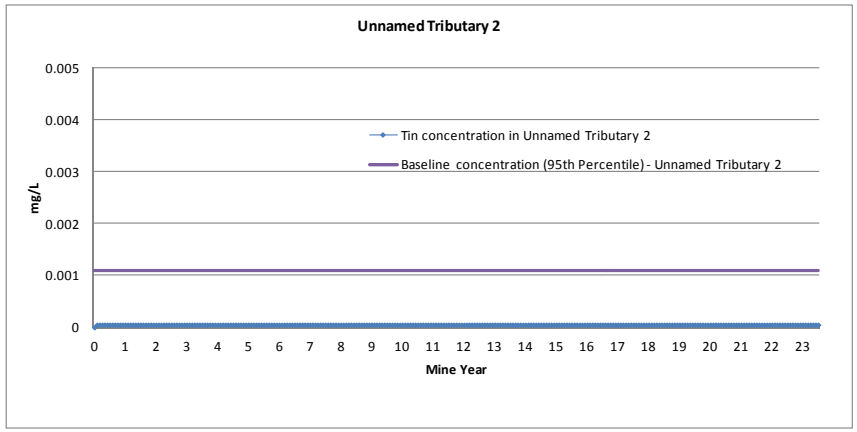
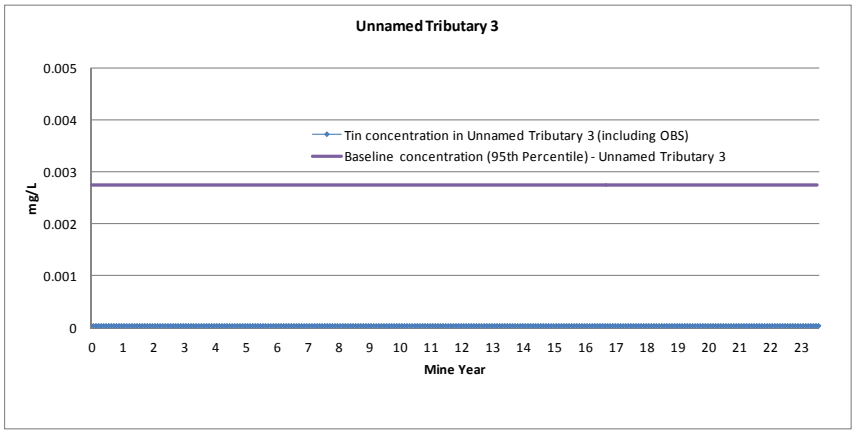
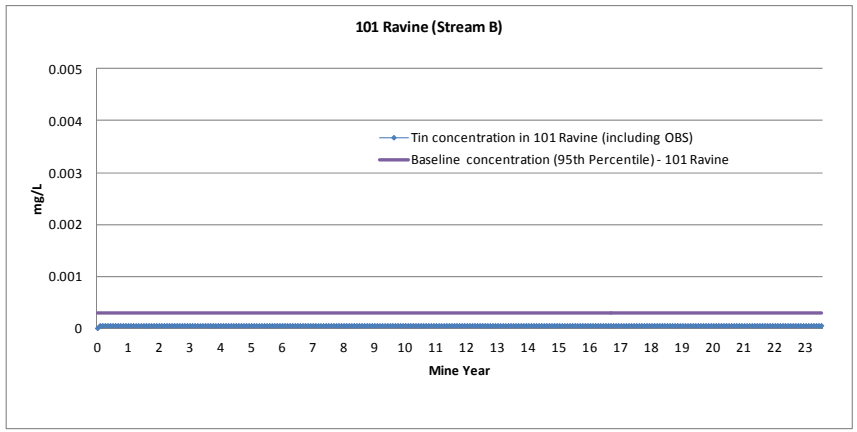
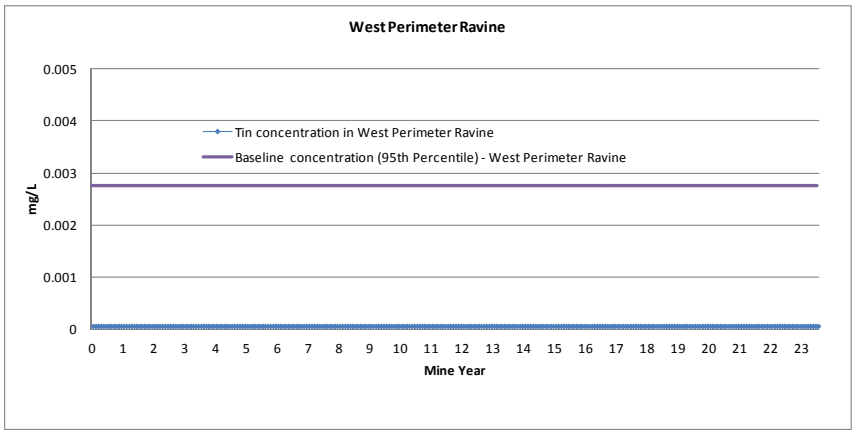


Figure 3-37 Continued









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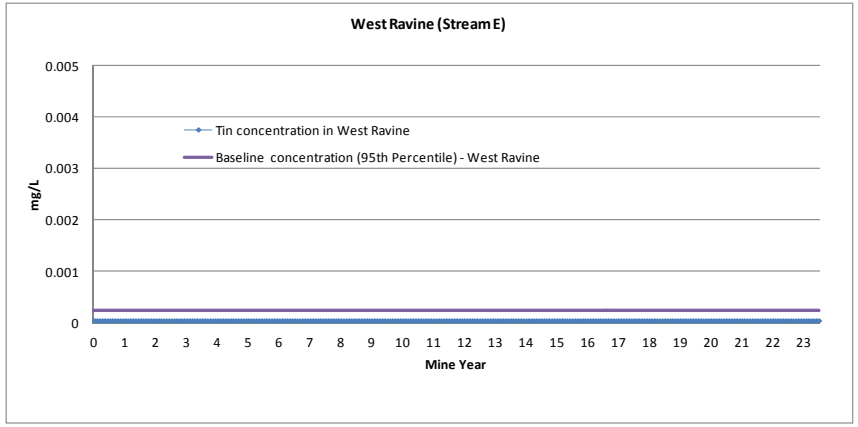
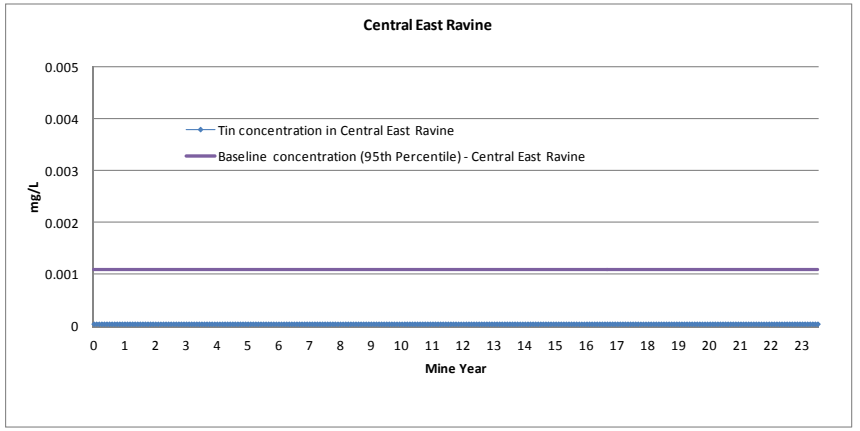
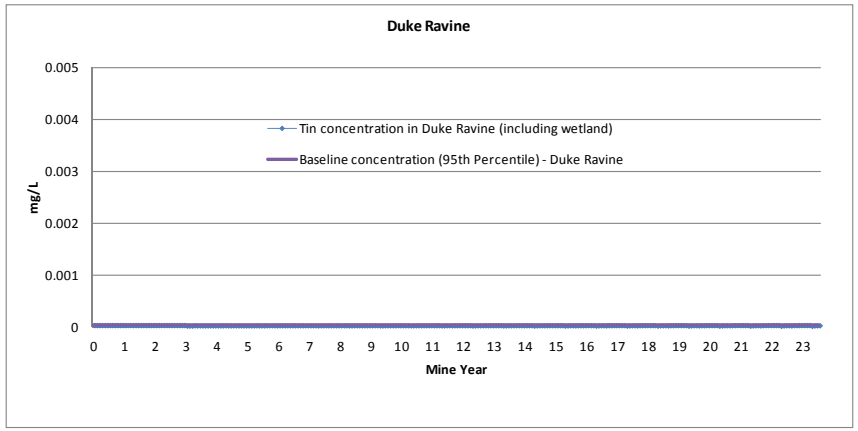






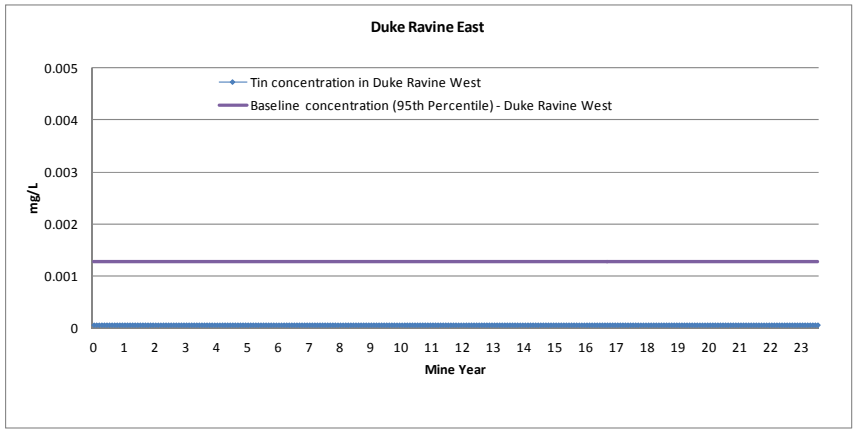
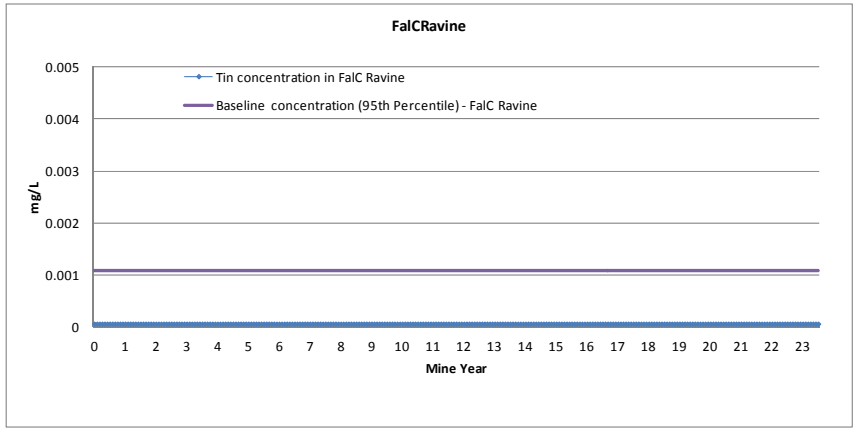
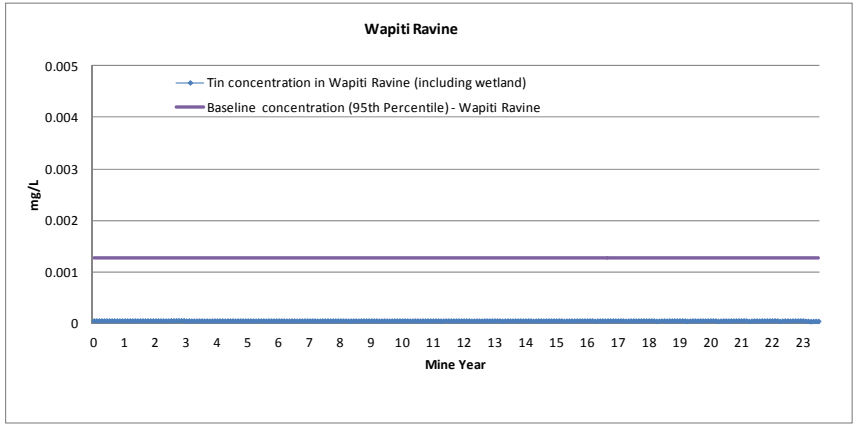
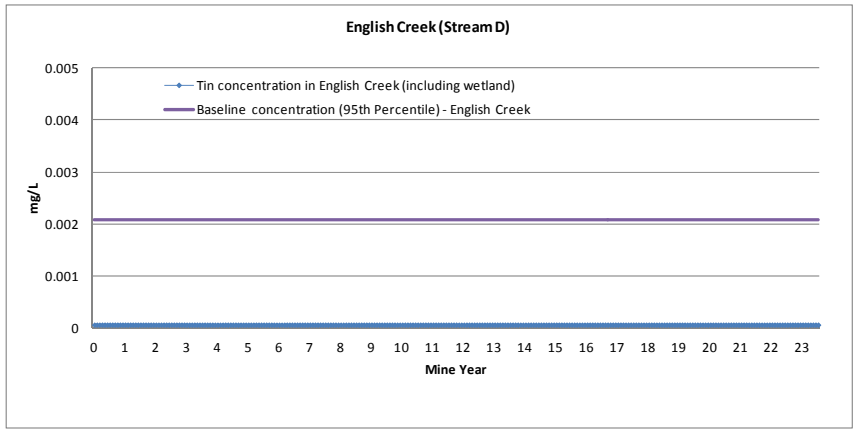


Figure 3-37 Continued







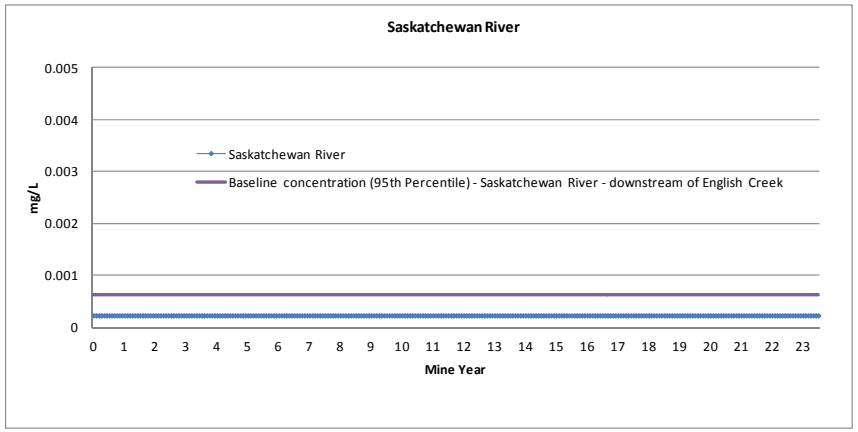
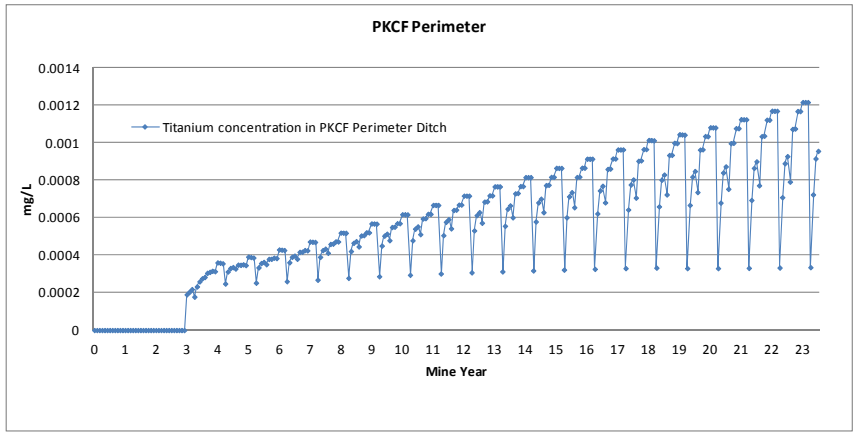
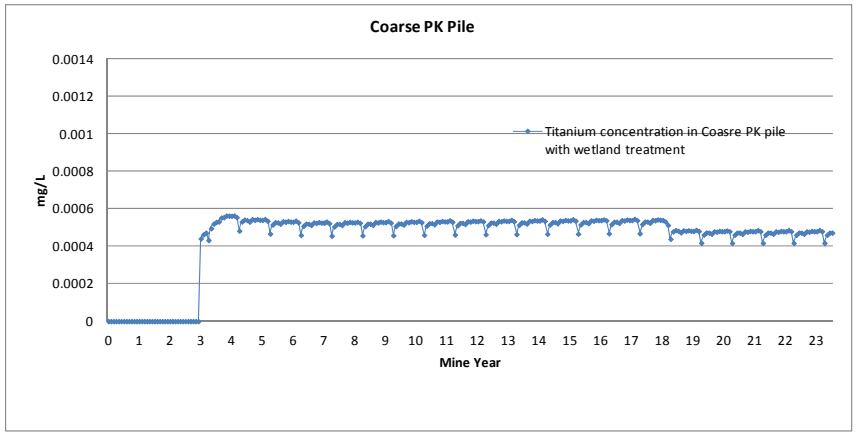


Figure 3-38 Predicted Titanium concentrations during construction and operation





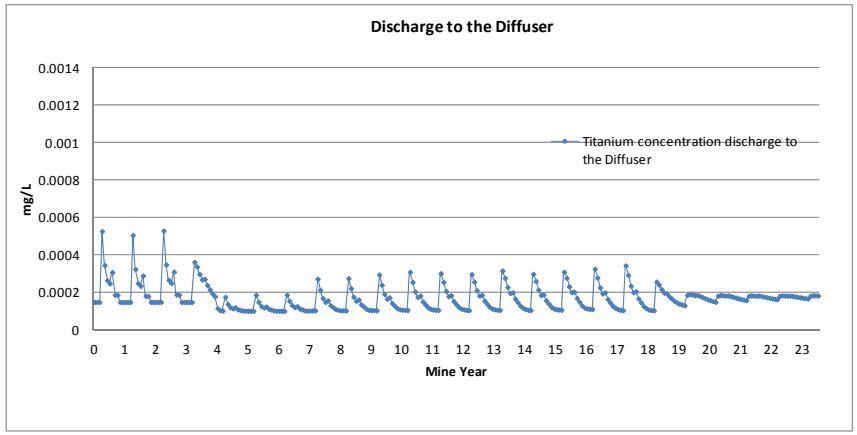
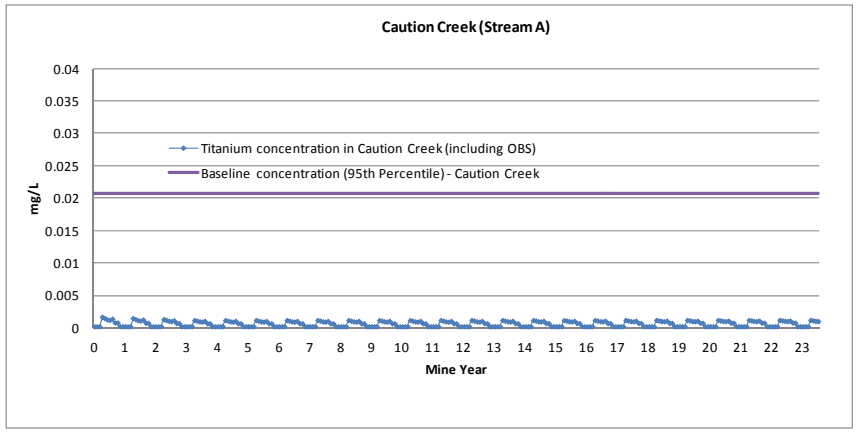
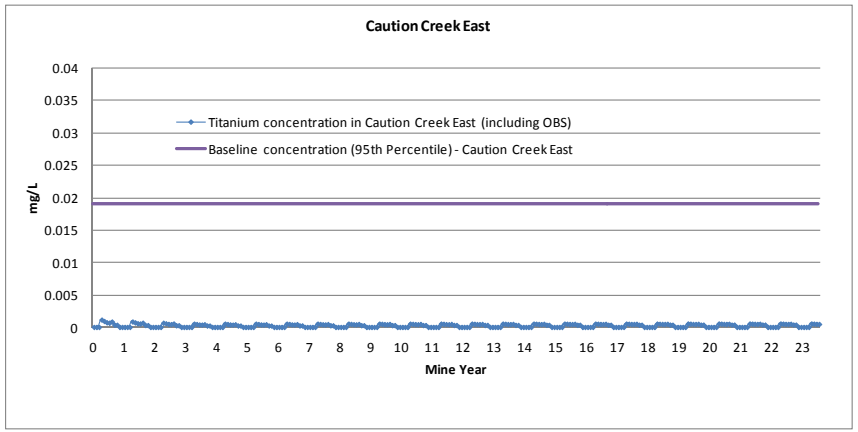
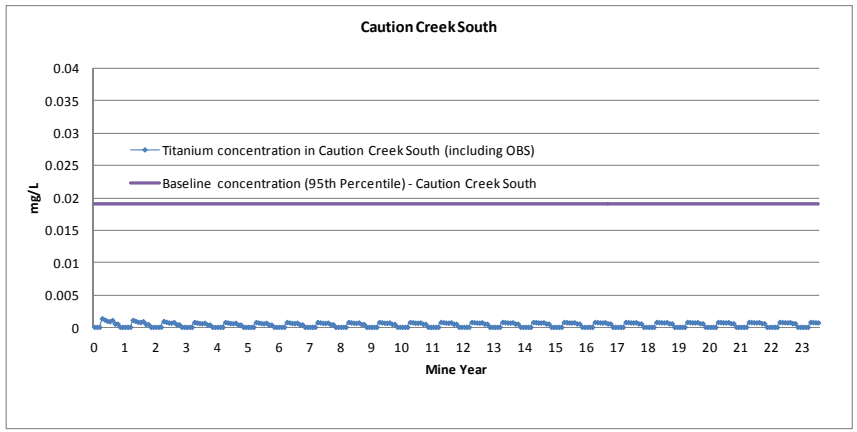


Figure 3-38 Continued







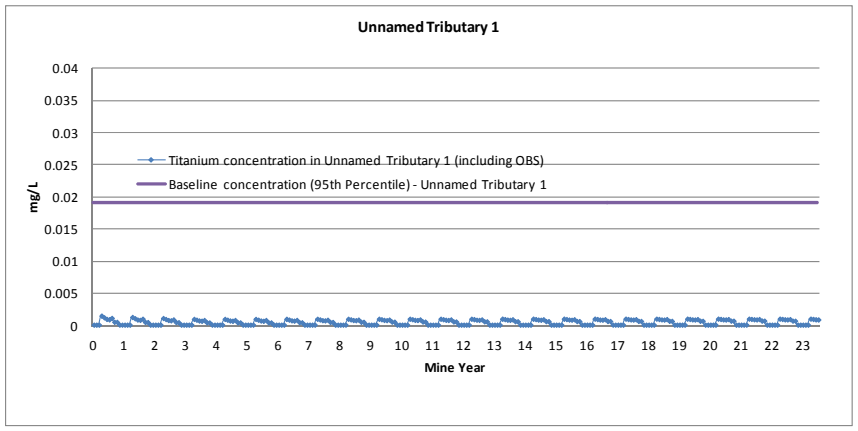
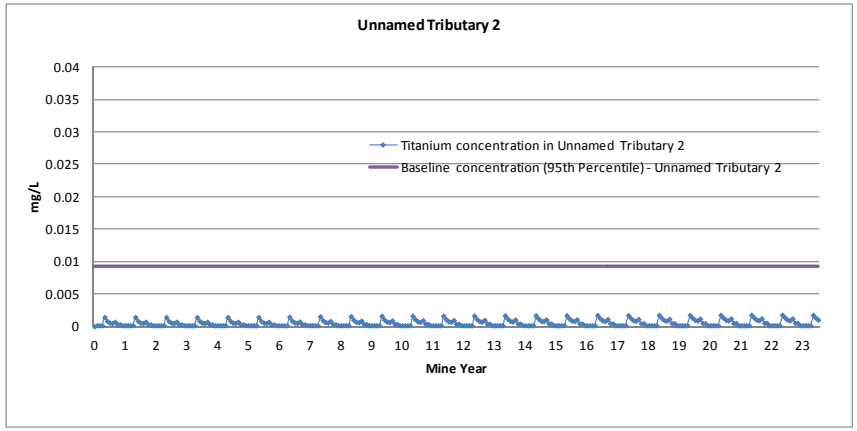
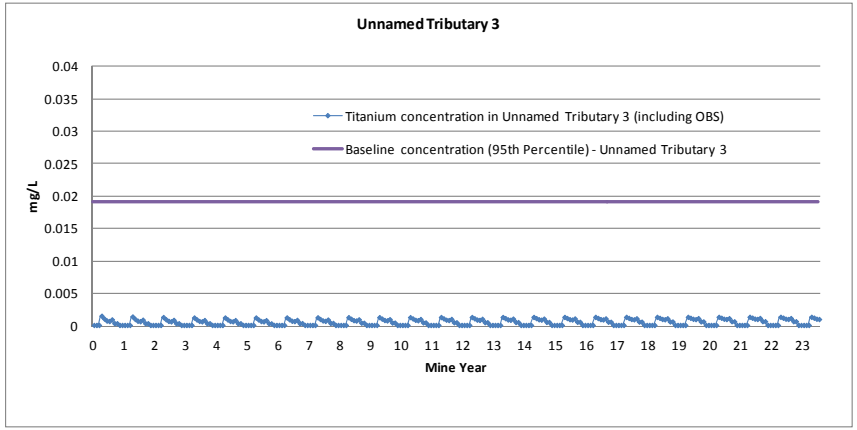
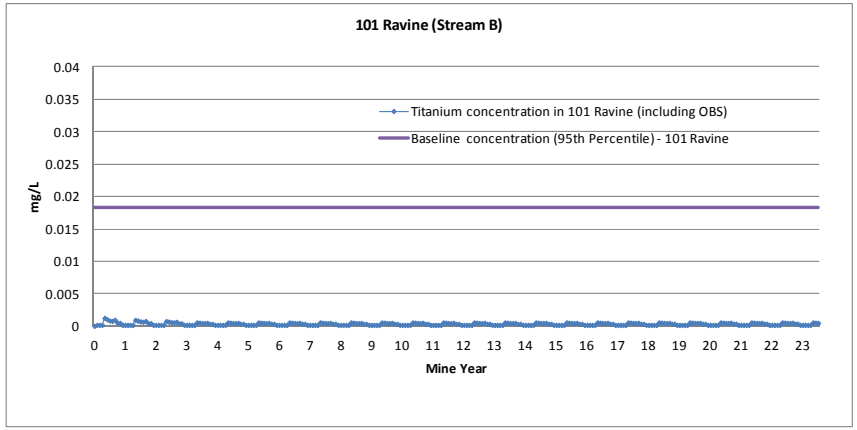


Figure 3-38 Continued







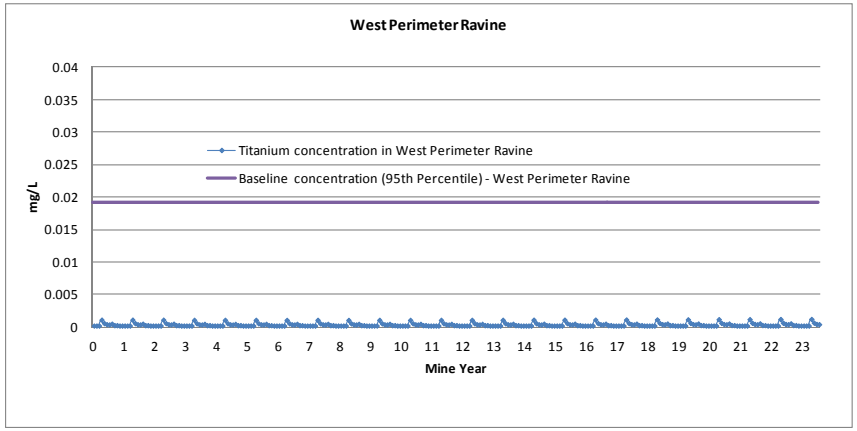
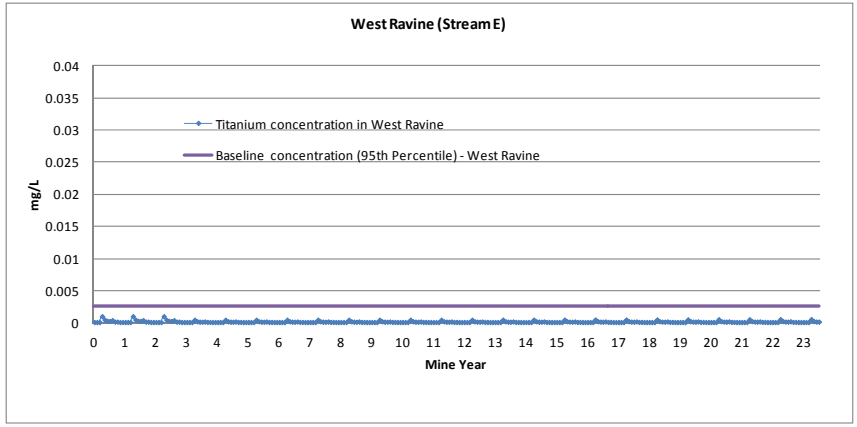
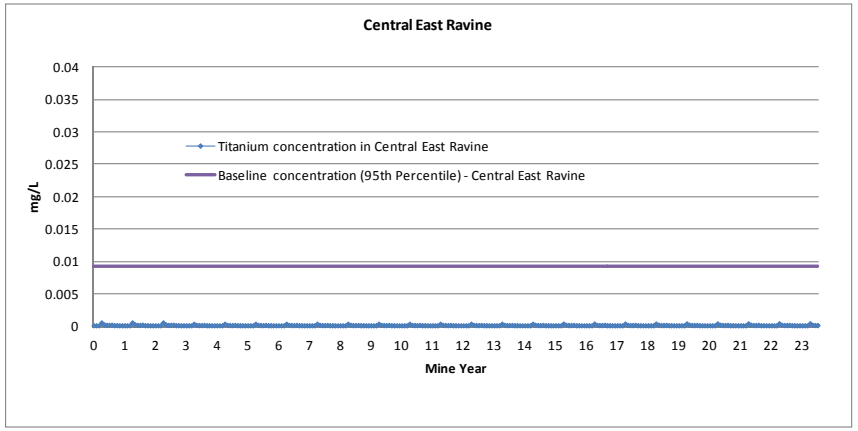
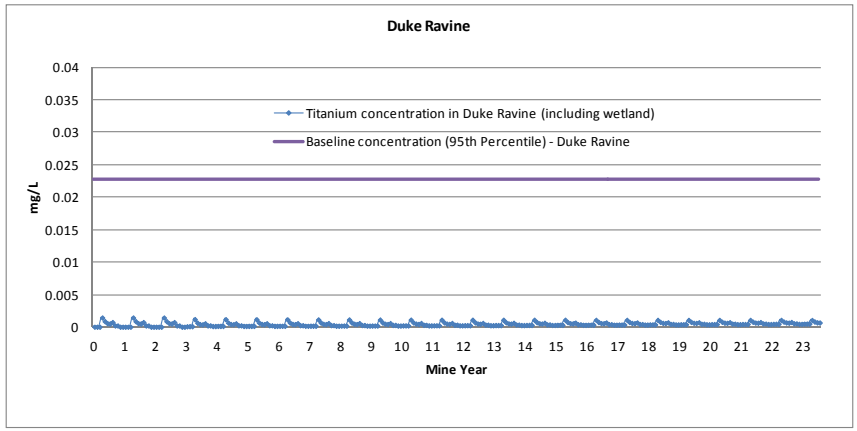


Figure 3-38 Continued







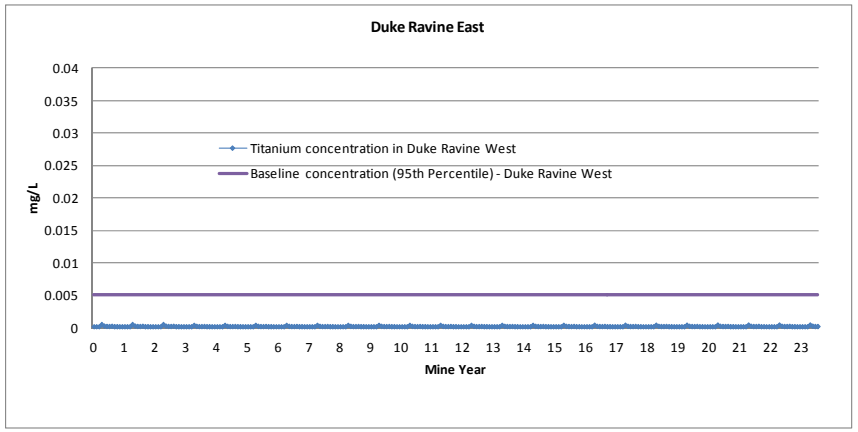
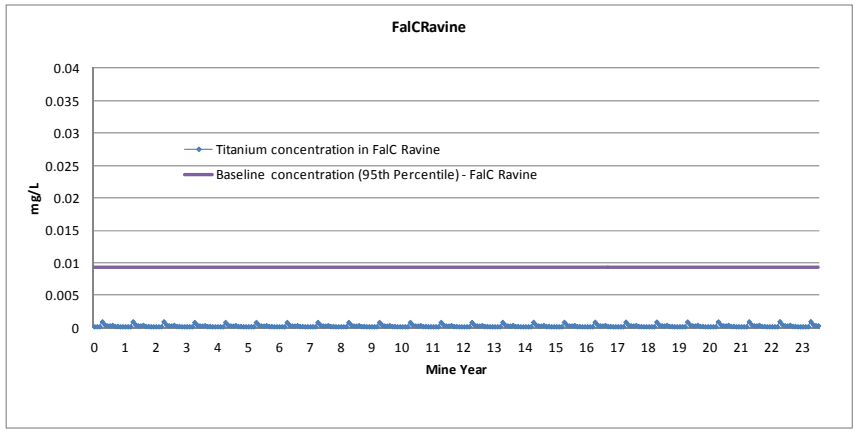
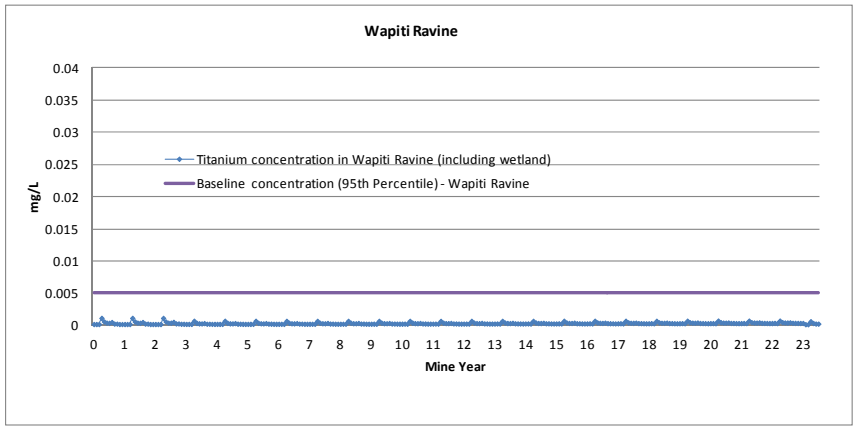
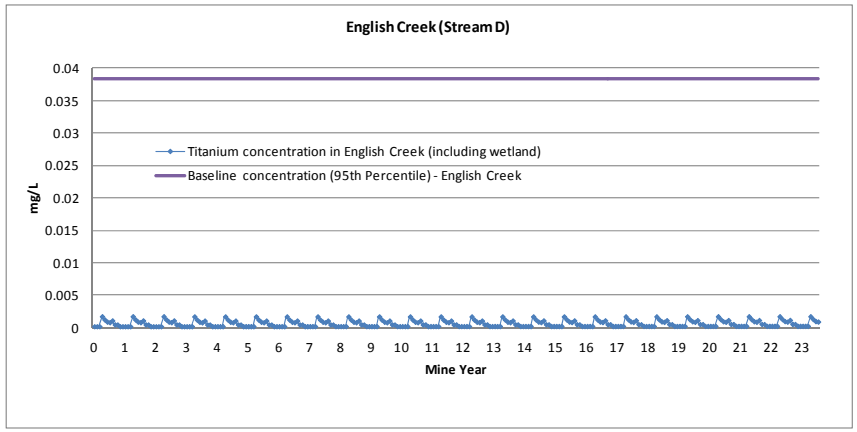


Figure 3-38 Continued







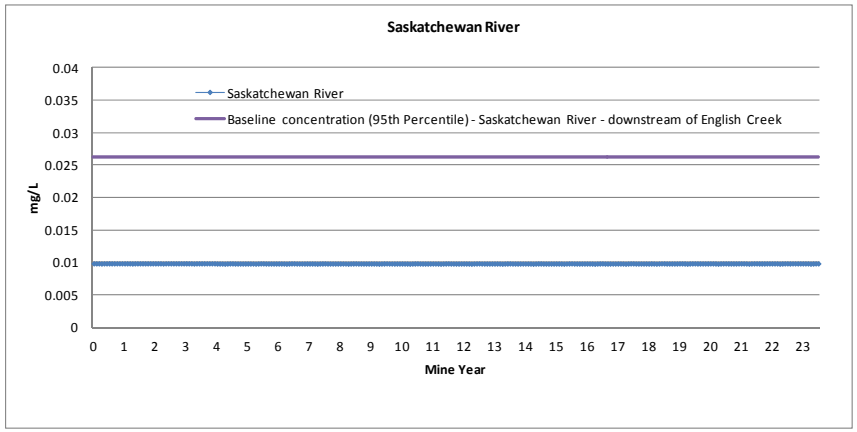
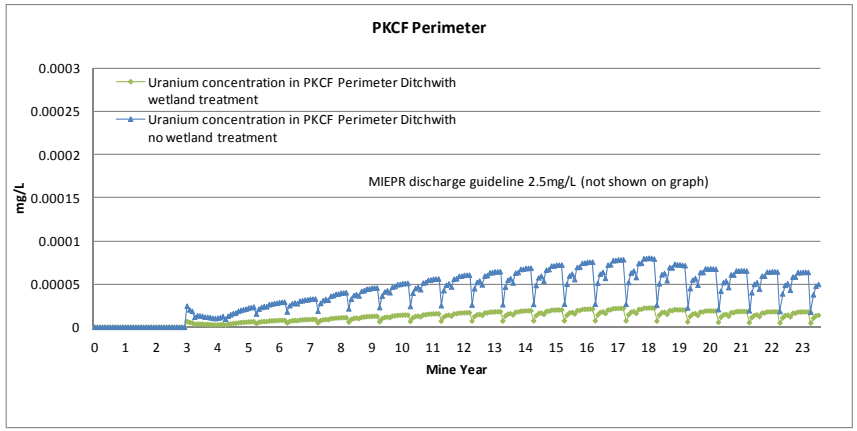
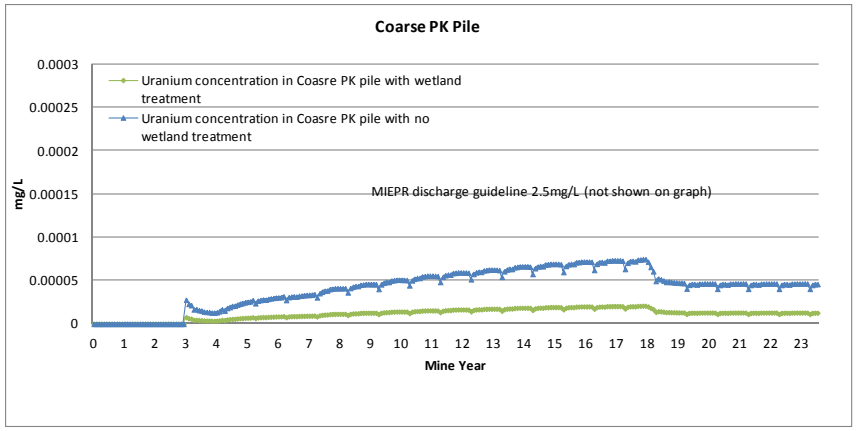


Figure 3-39 Predicted Uranium concentrations during construction and operation





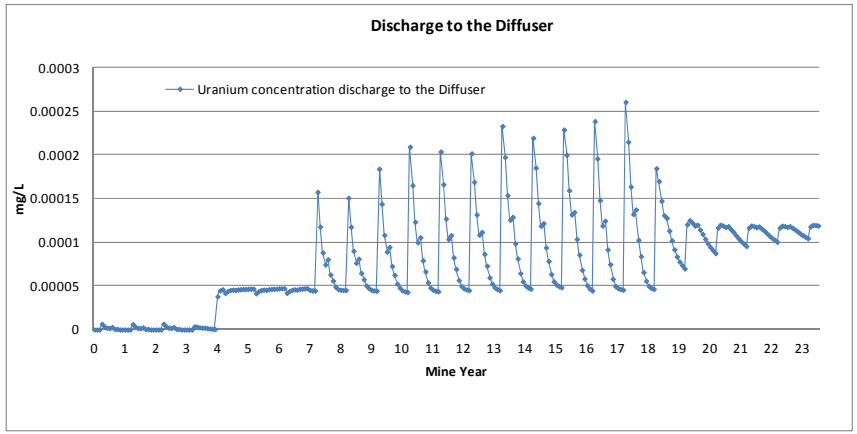
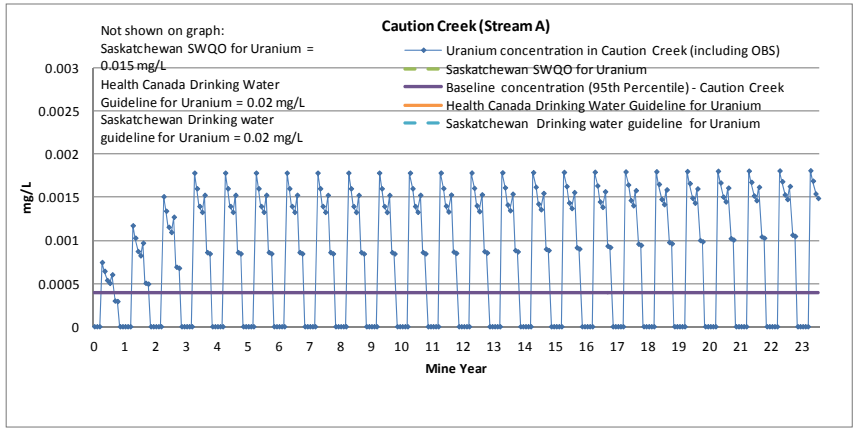
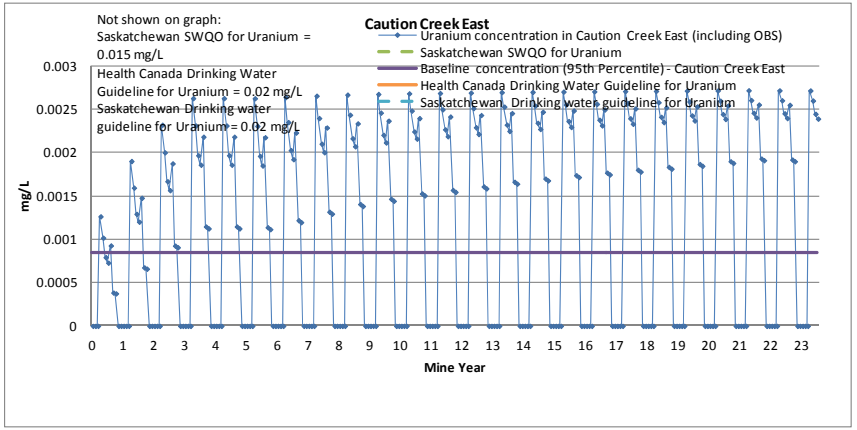
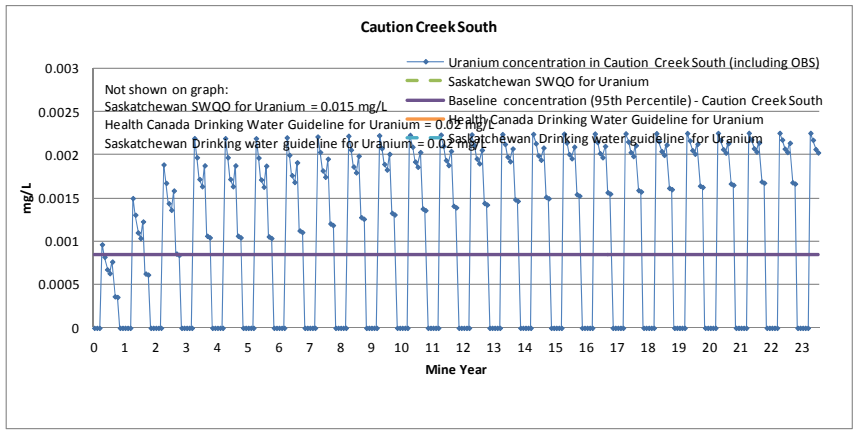


Figure 3-39 Continued







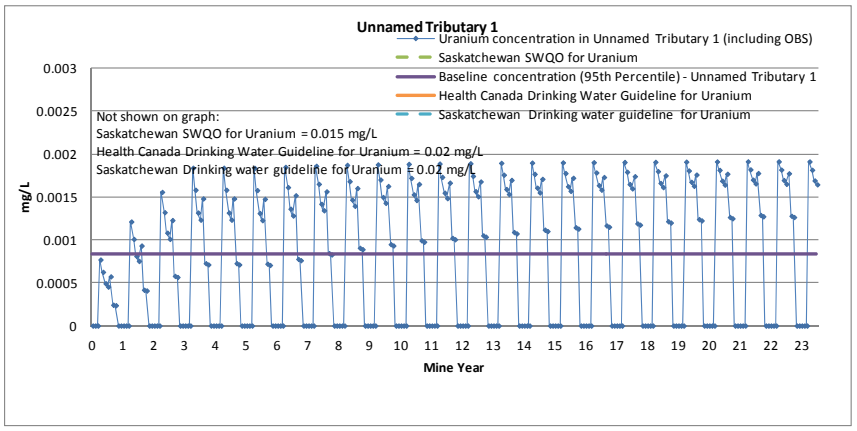
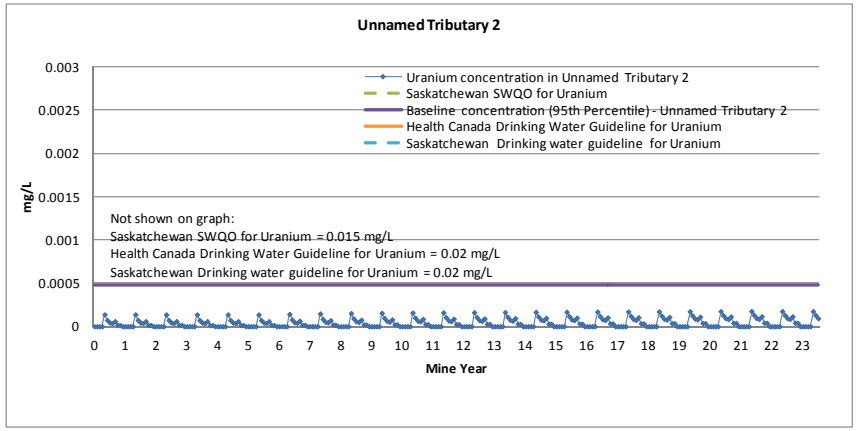
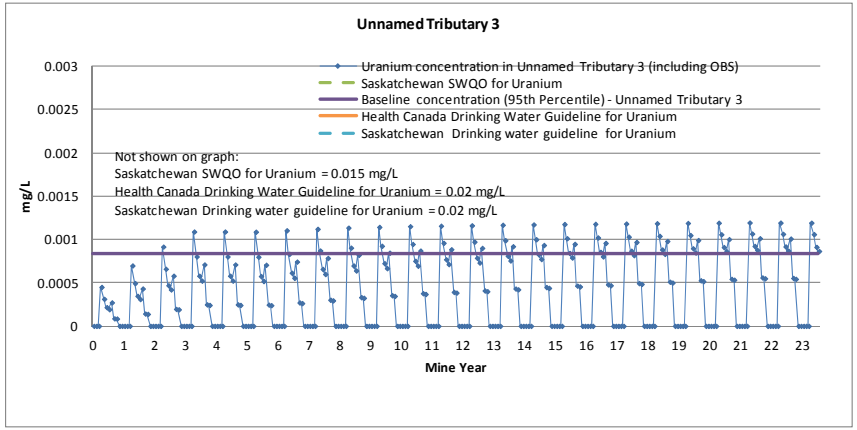
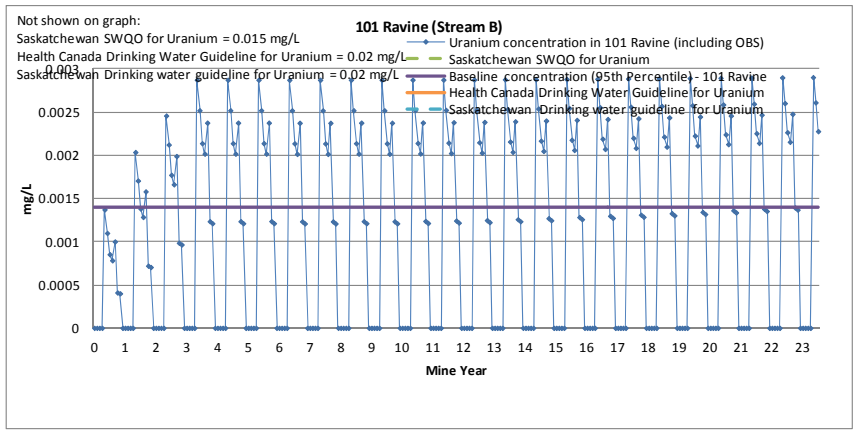


Figure 3-39 Continued







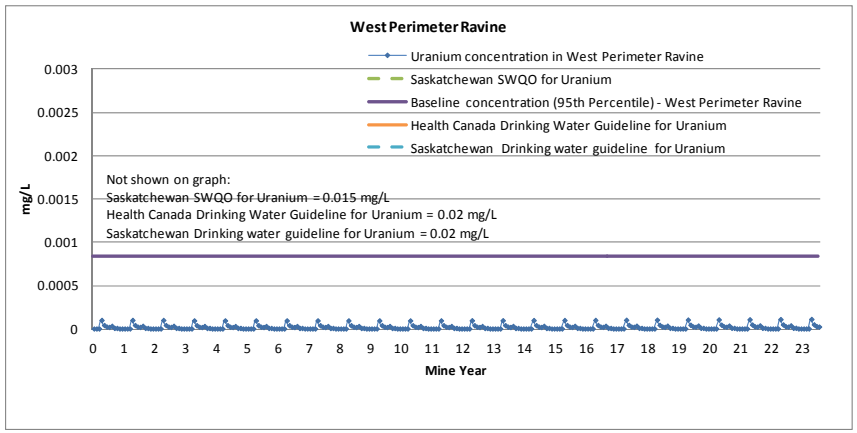
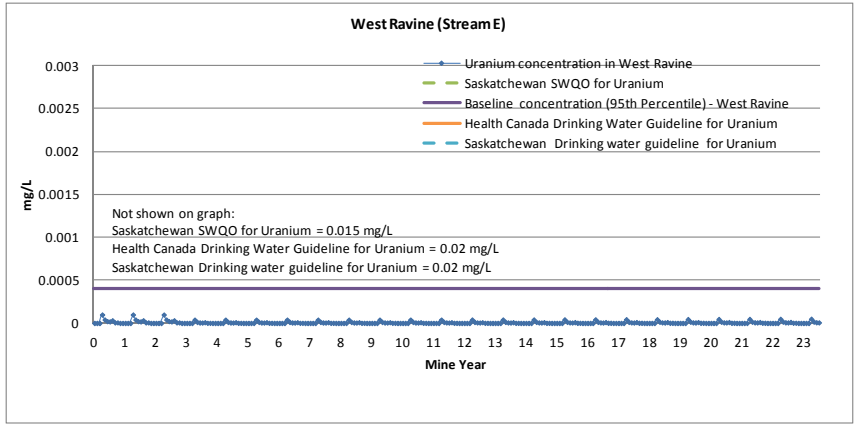
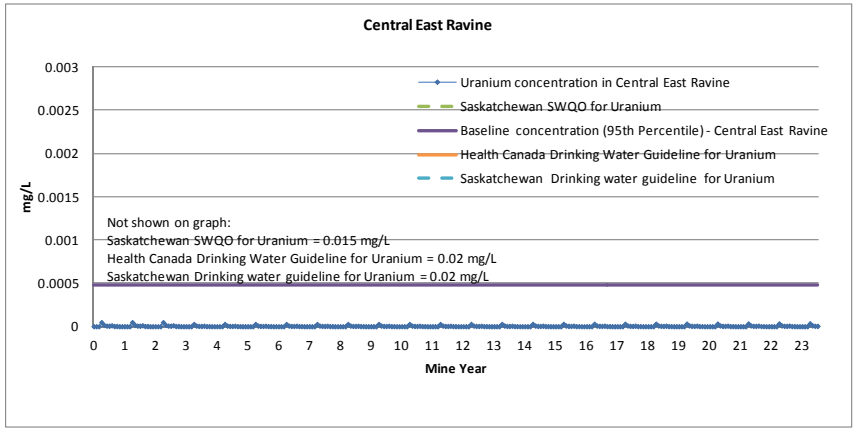
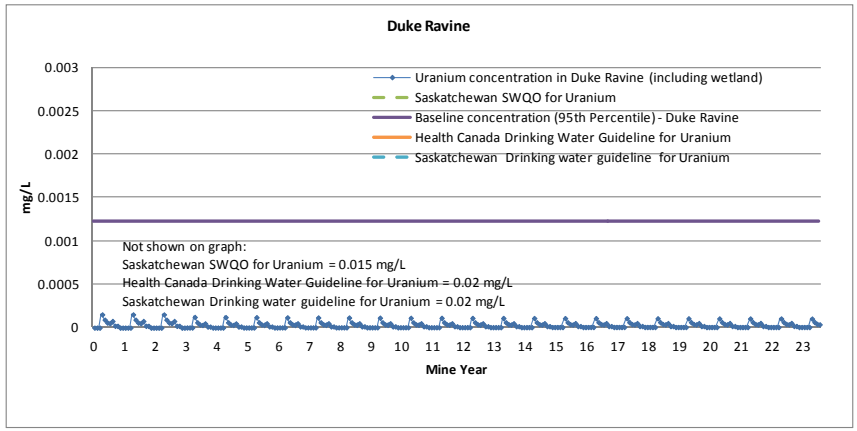


Figure 3-39 Continued







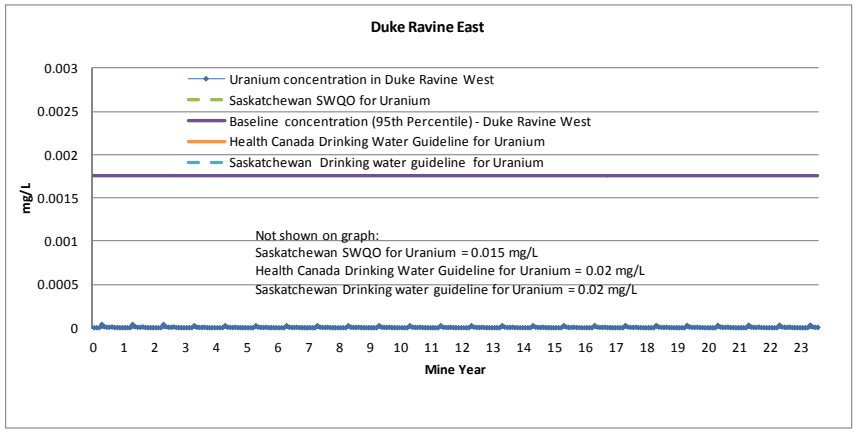
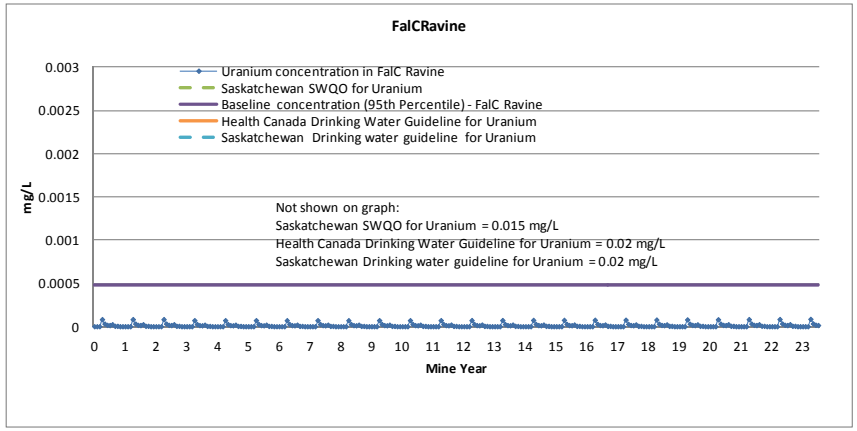
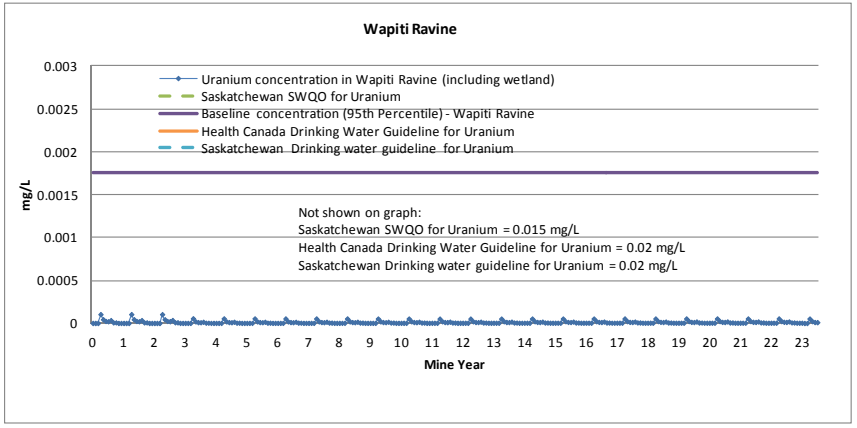
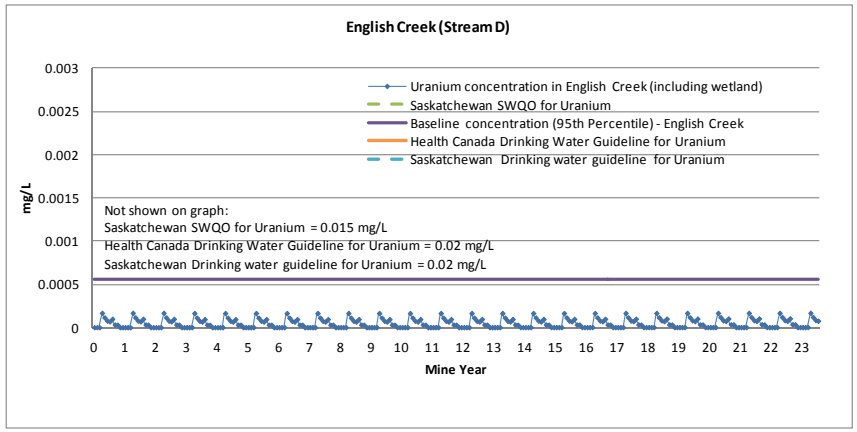


Figure 3-39 Continued







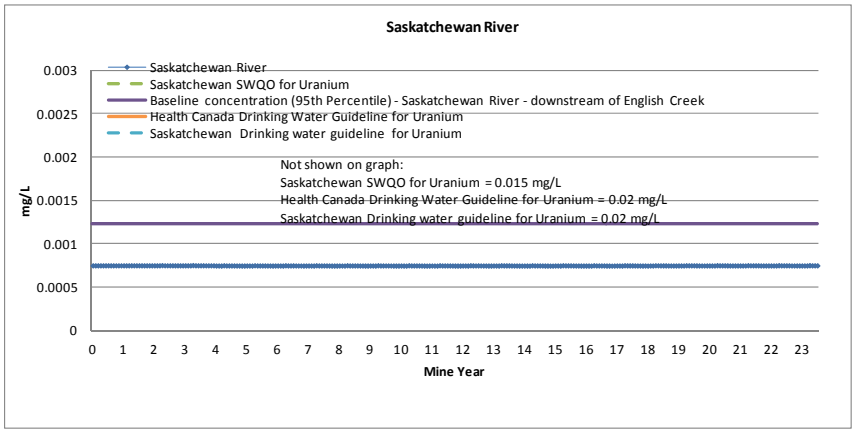
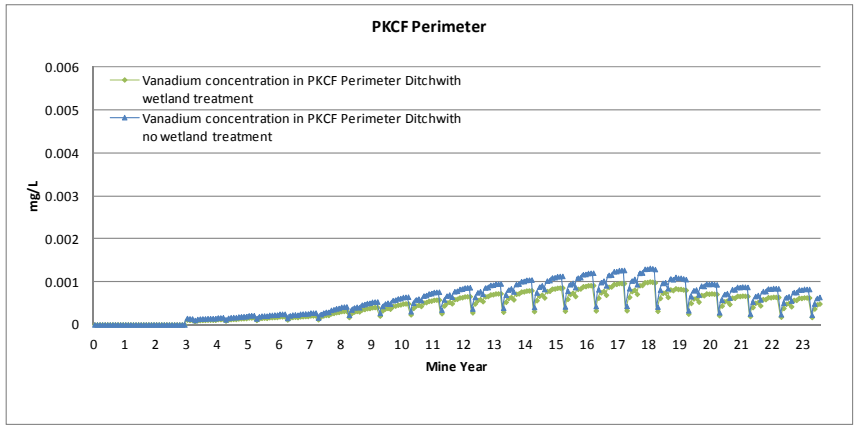
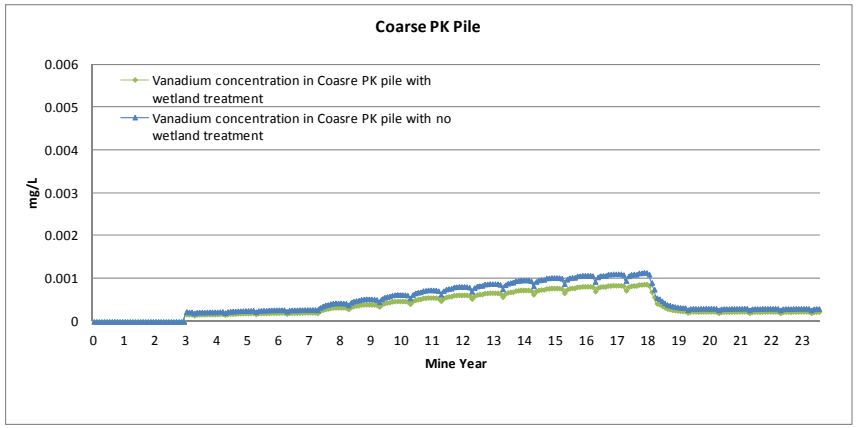


Figure 3-40 Predicted Vanadium concentrations during construction and operation





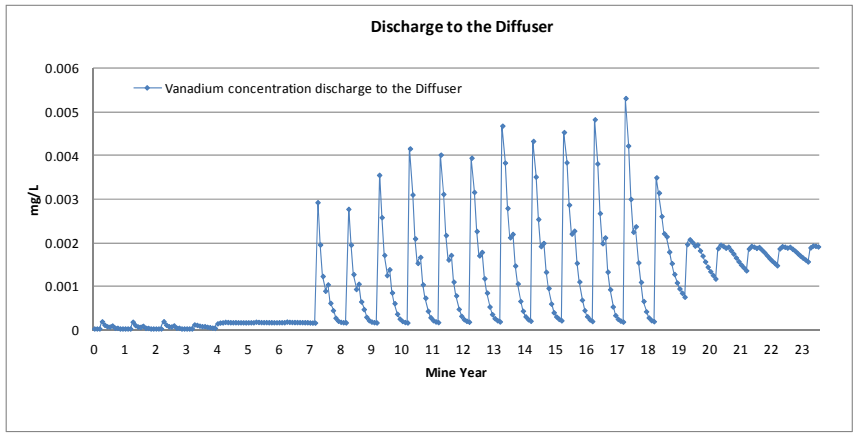
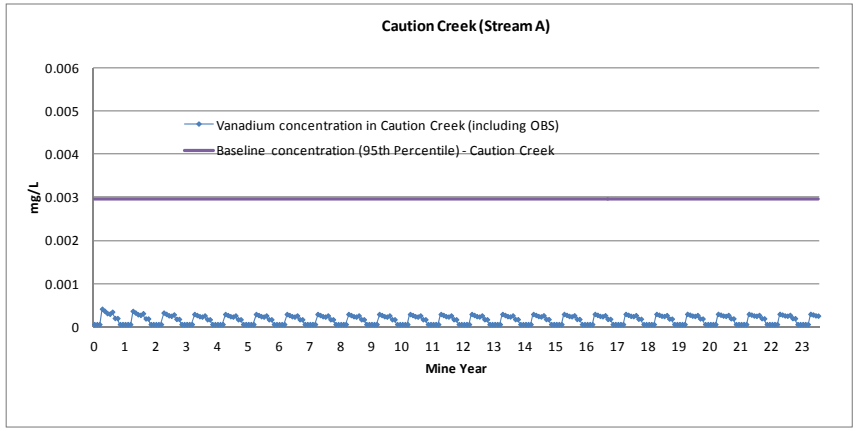
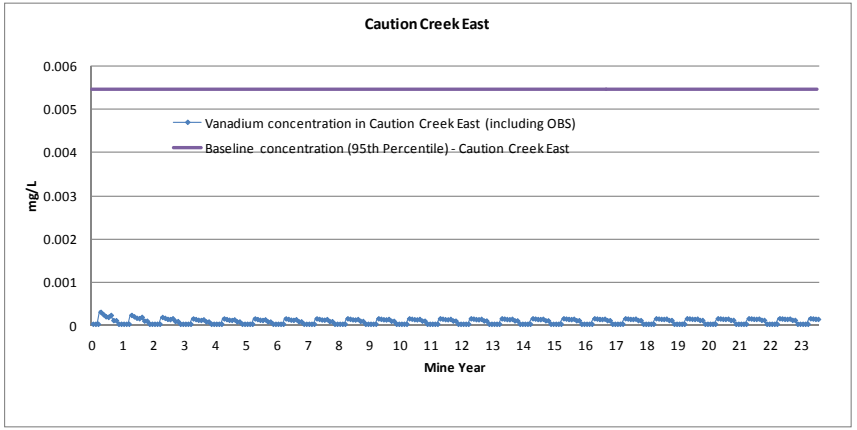
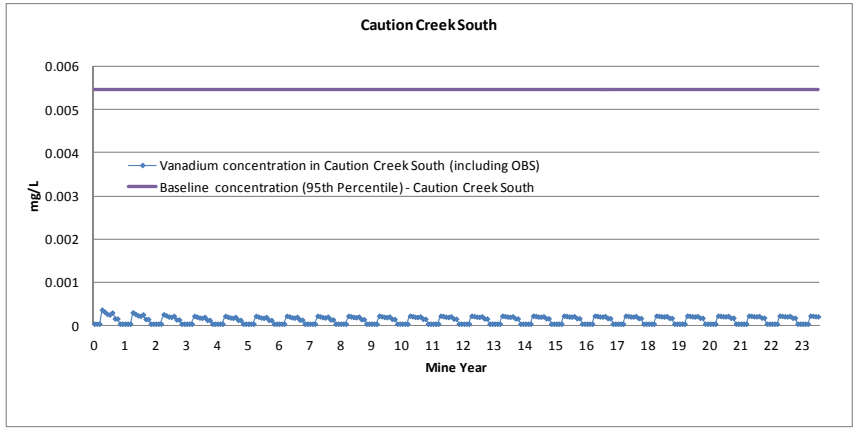


Figure 3-40 Continued







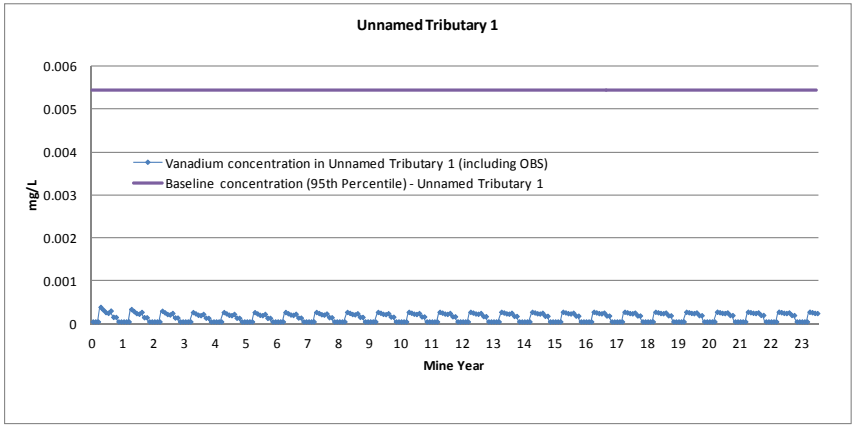
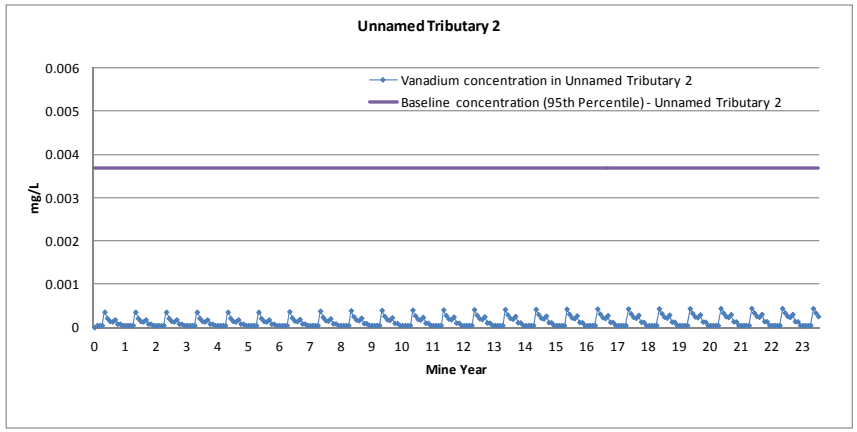
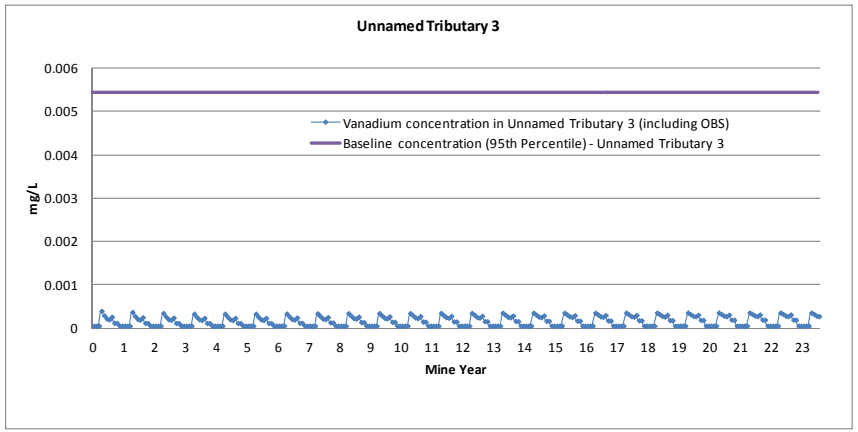
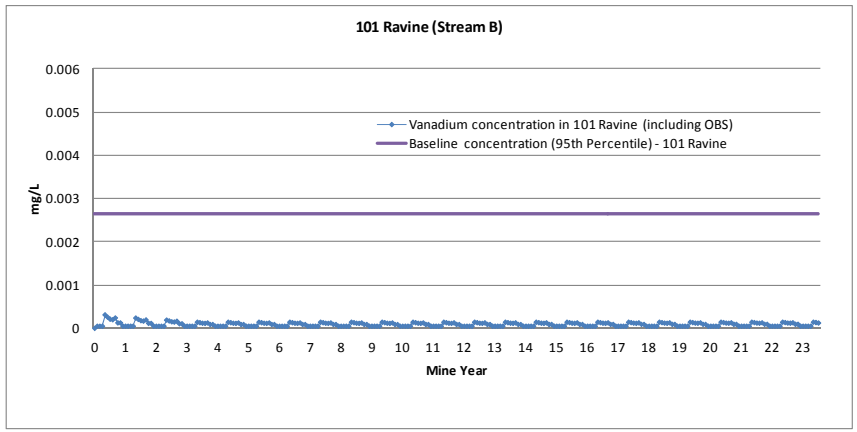


Figure 3-40 Continued







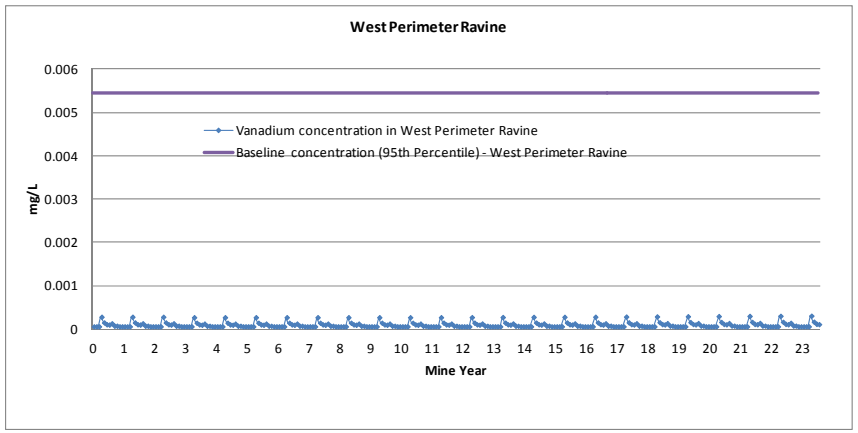
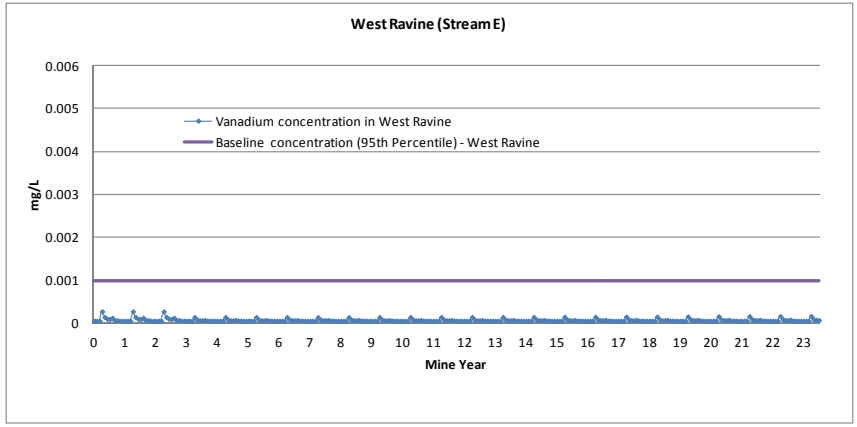
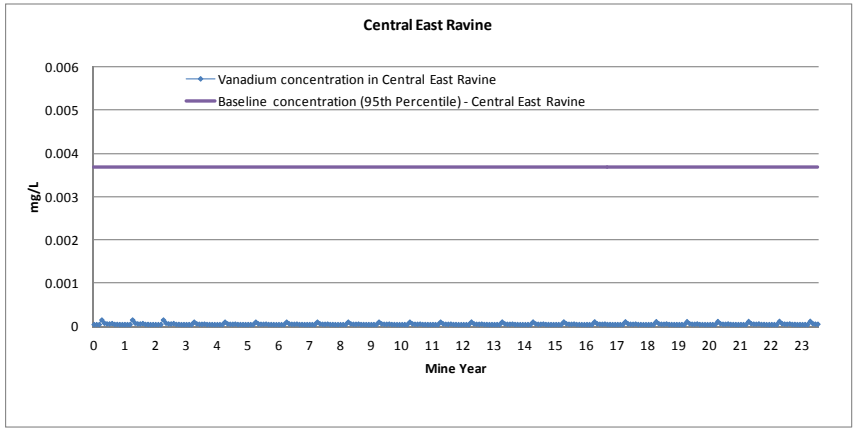
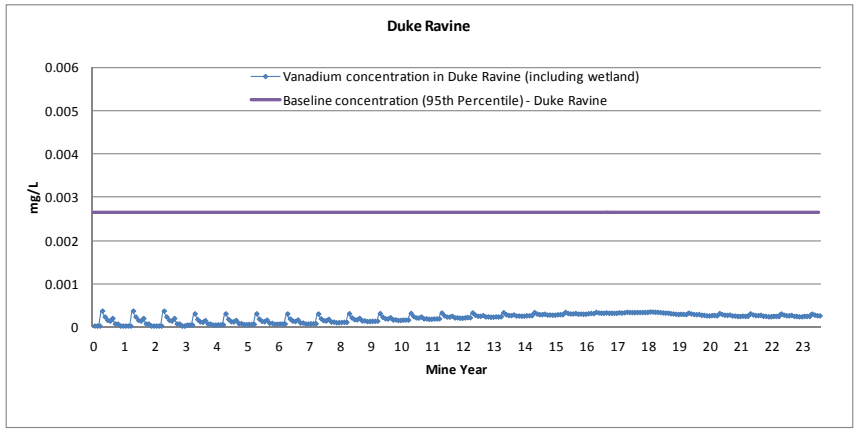
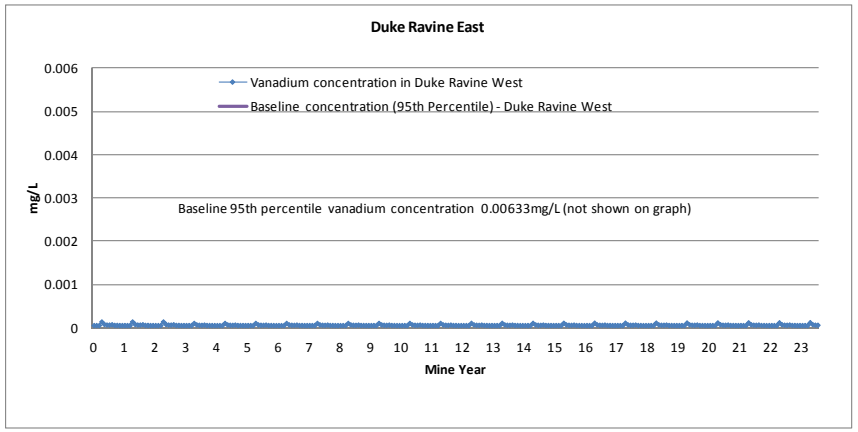


Figure 3-40 Continued









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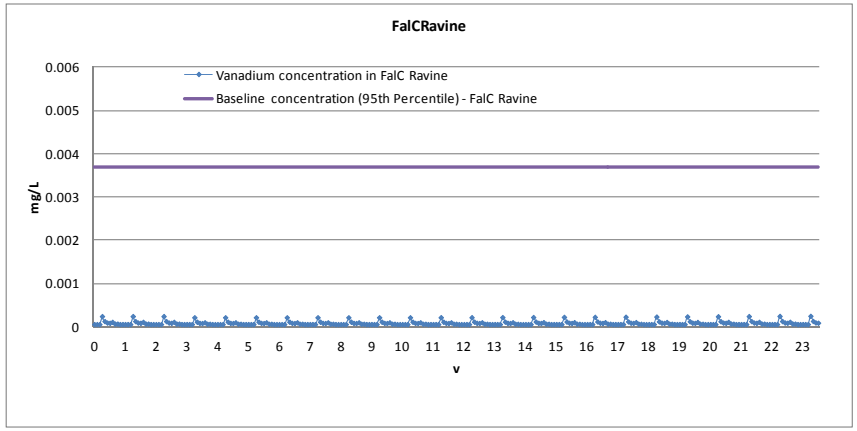
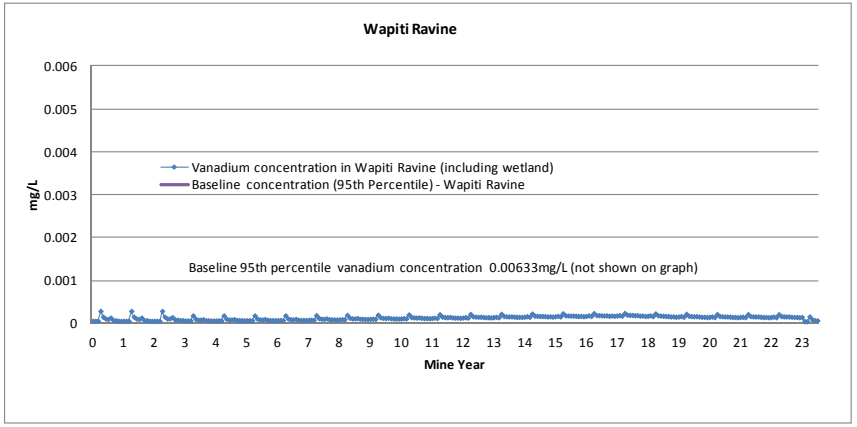
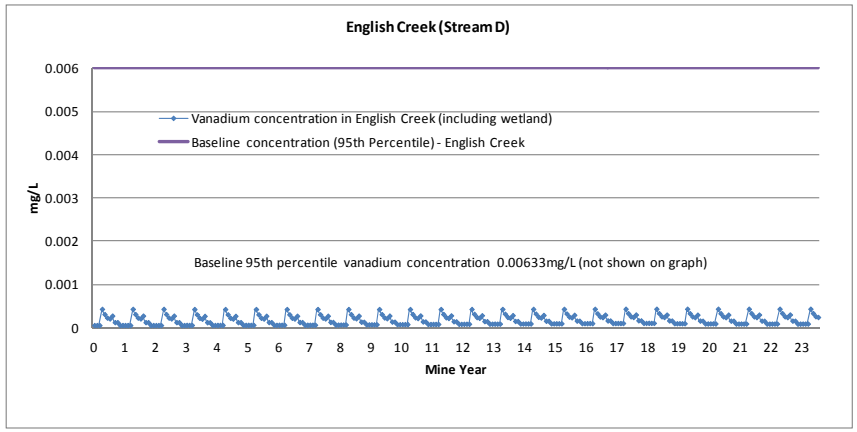






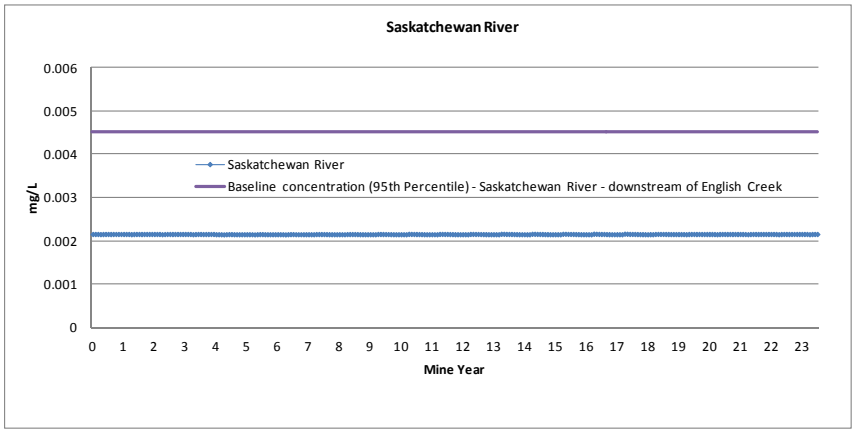
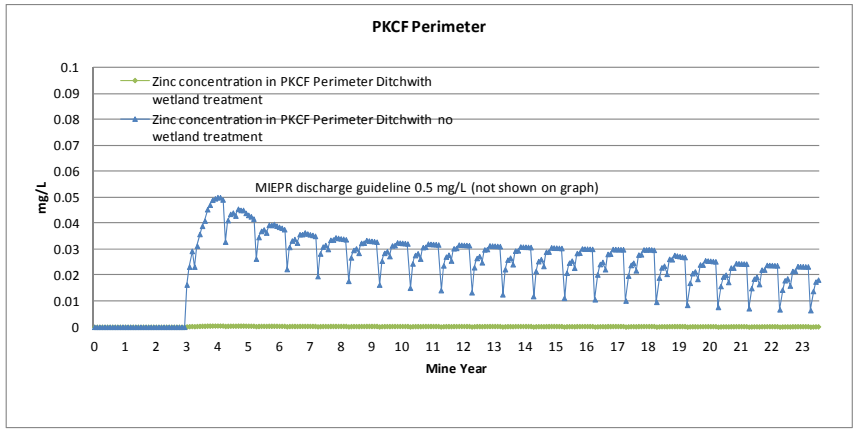
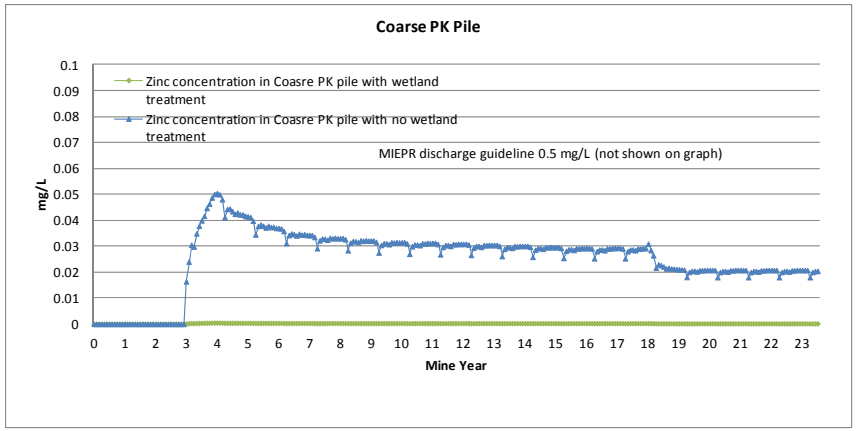


Figure 3-41 Predicted Zinc concentrations during construction and operation





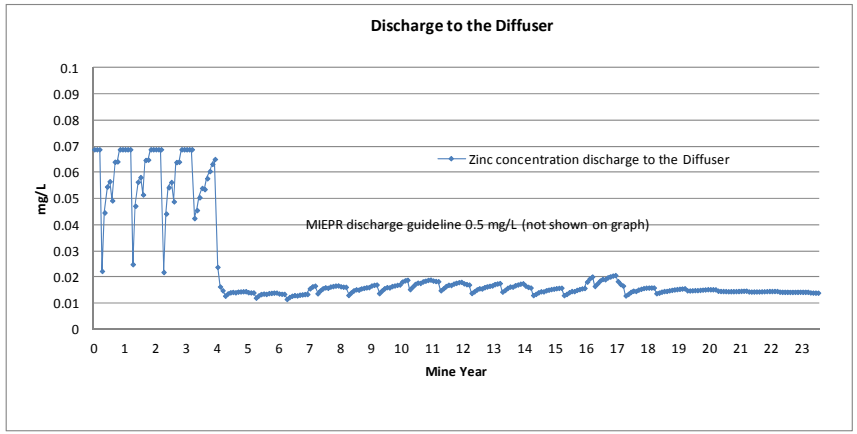
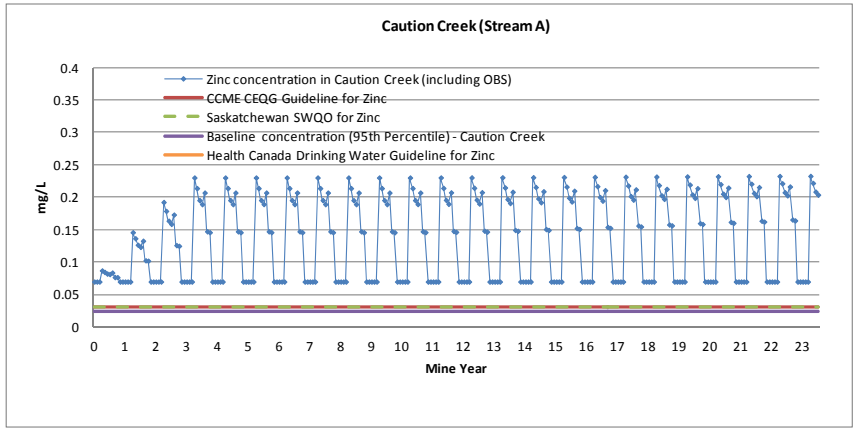
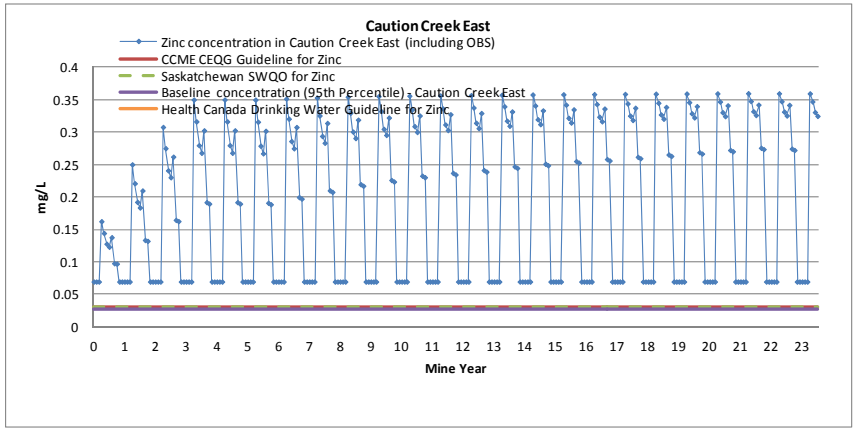
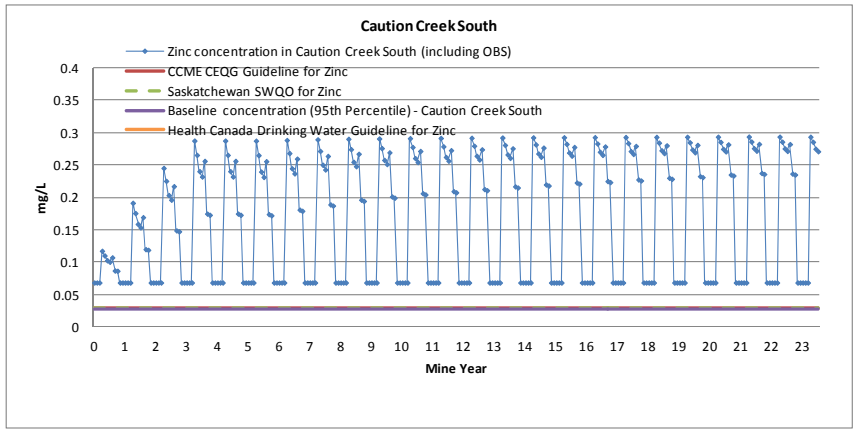
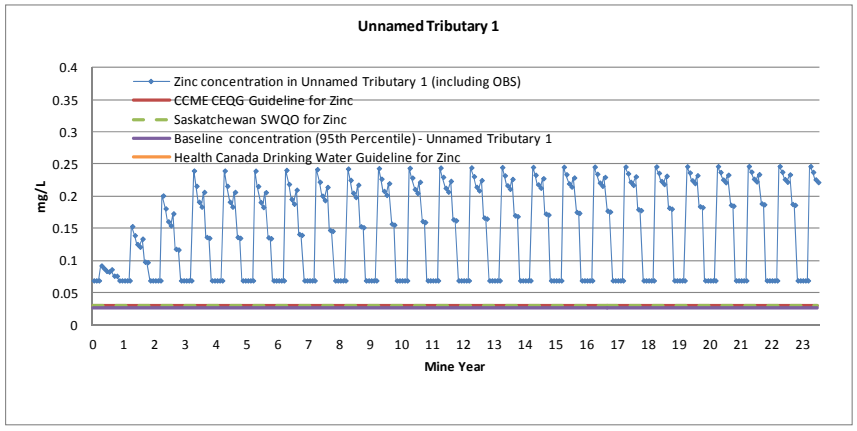


Figure 3-41 Continued









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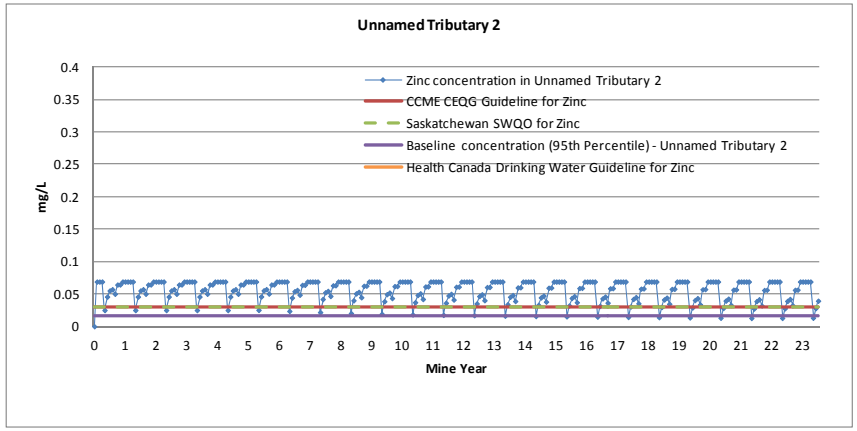
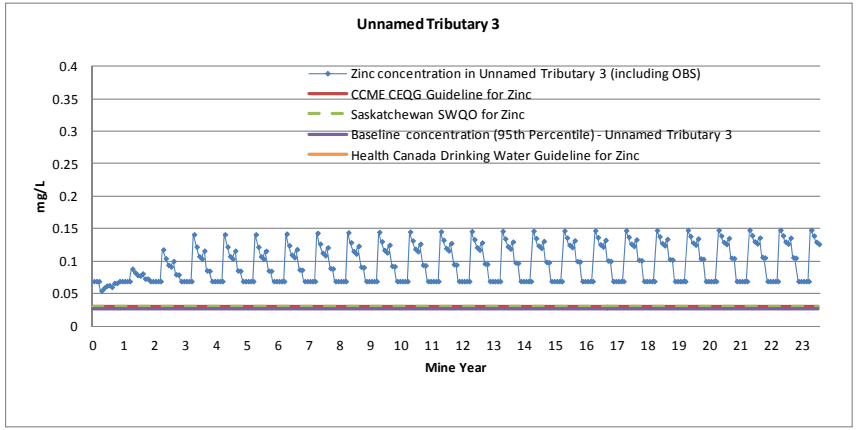
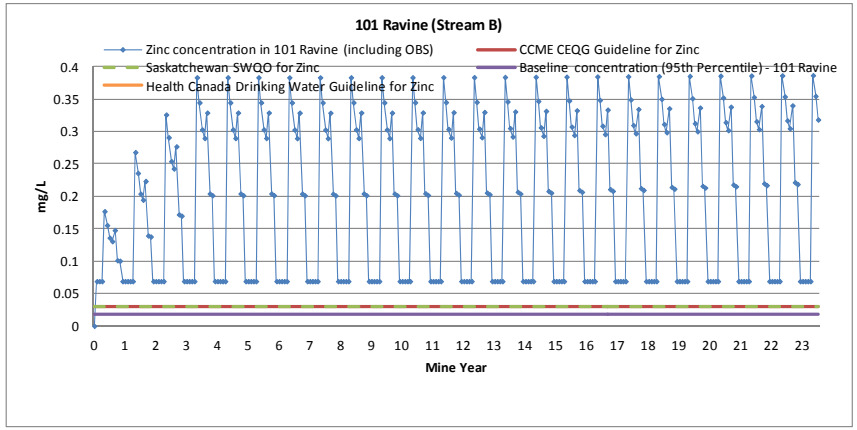






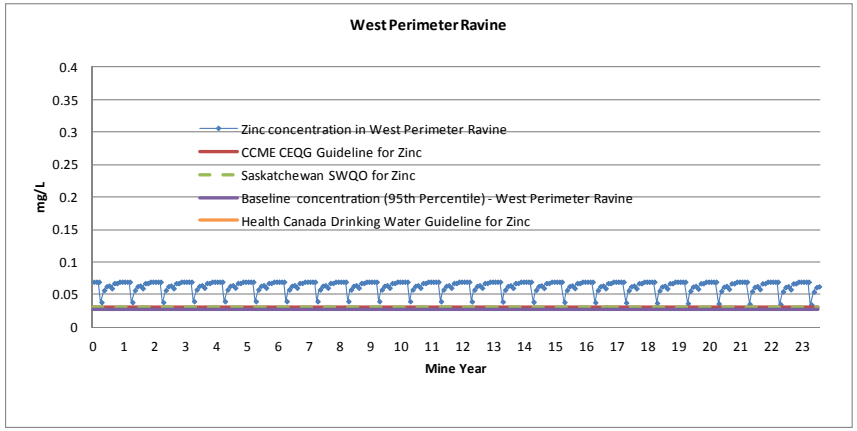
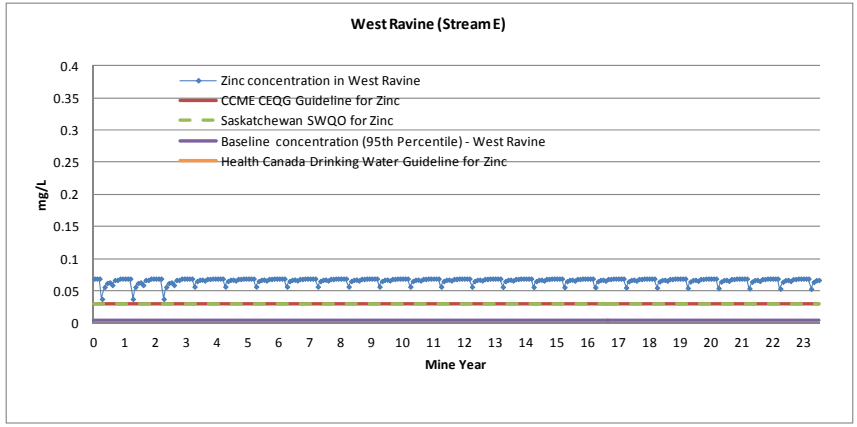
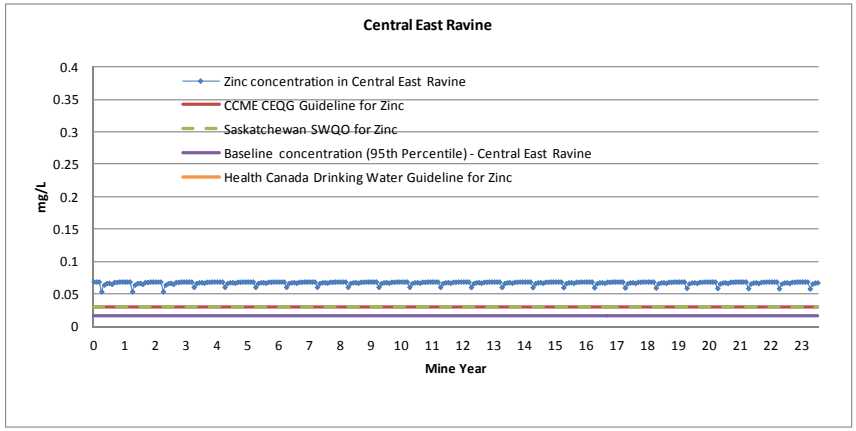
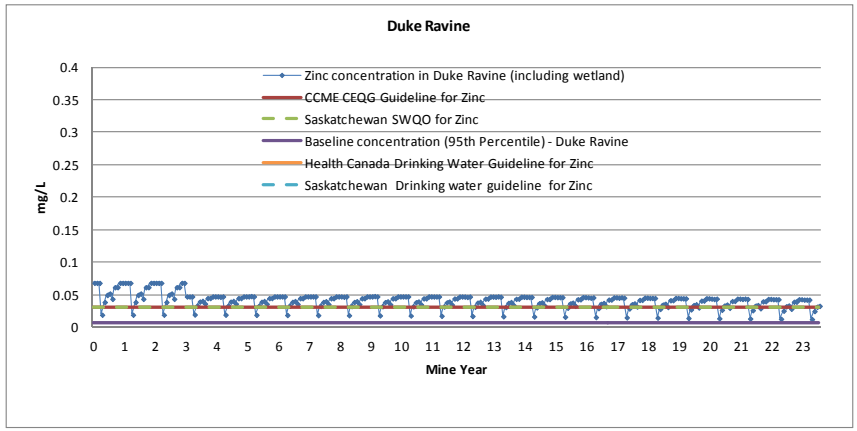
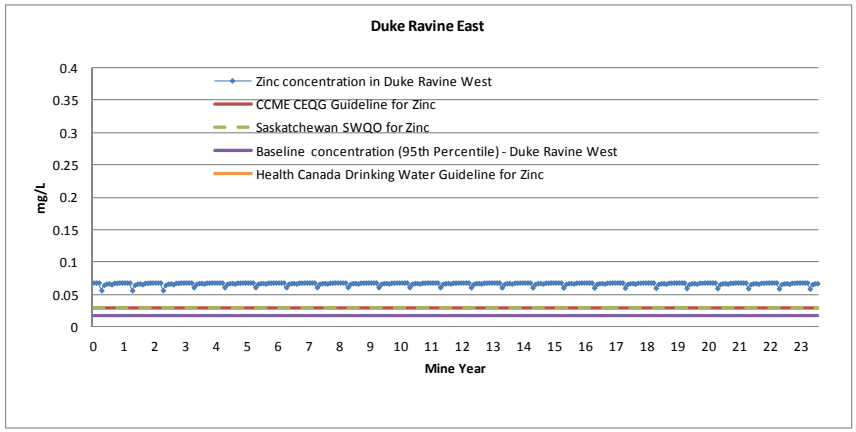


Figure 3-41 Continued









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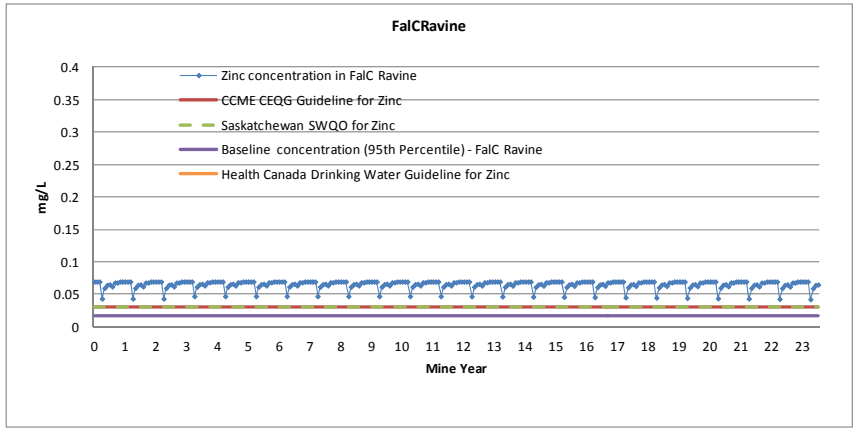
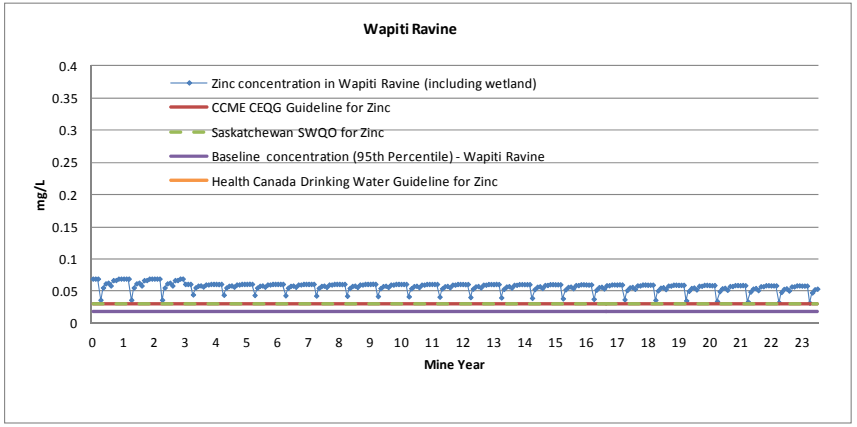
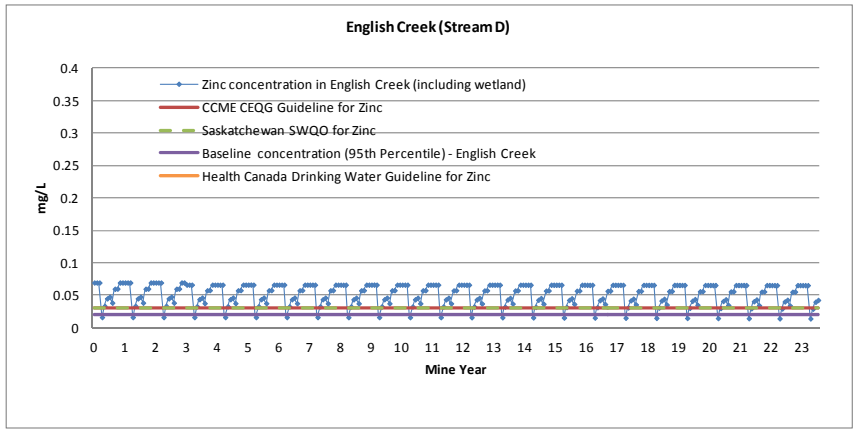
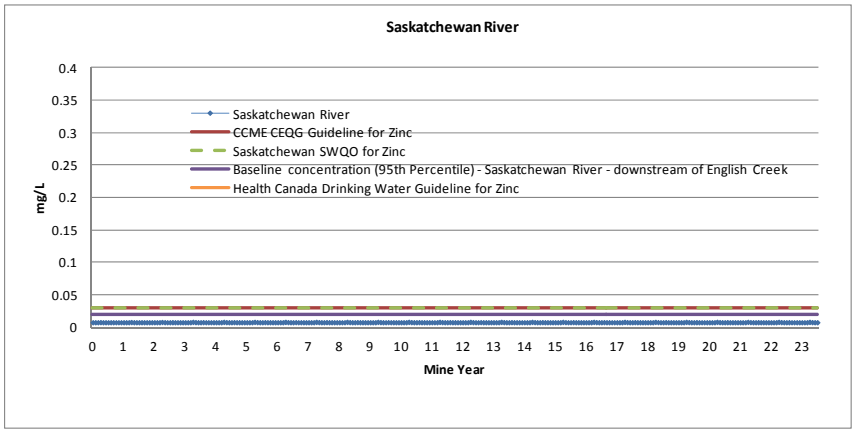


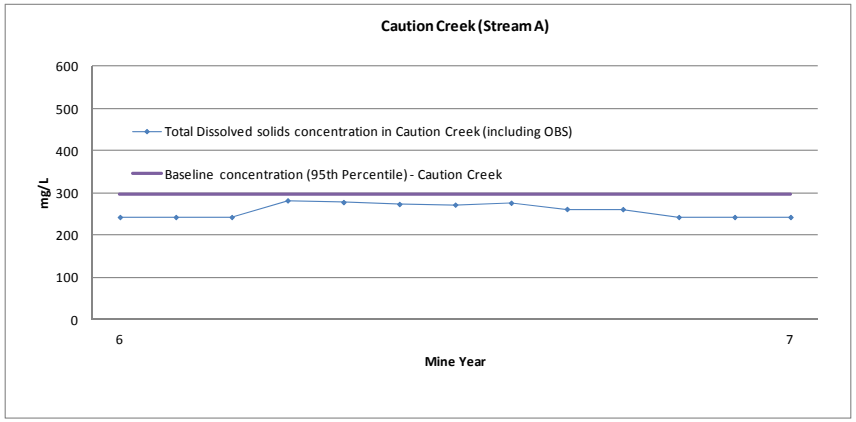






A comparison of water quality during different climatic conditions

Figure 3-42 Comparison of predicted TDS concentrations in a median and dry rainfall scenario in Caution Creek



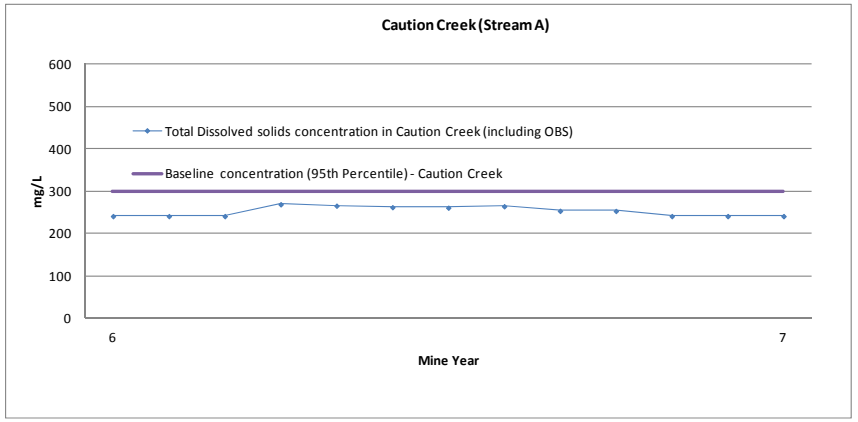
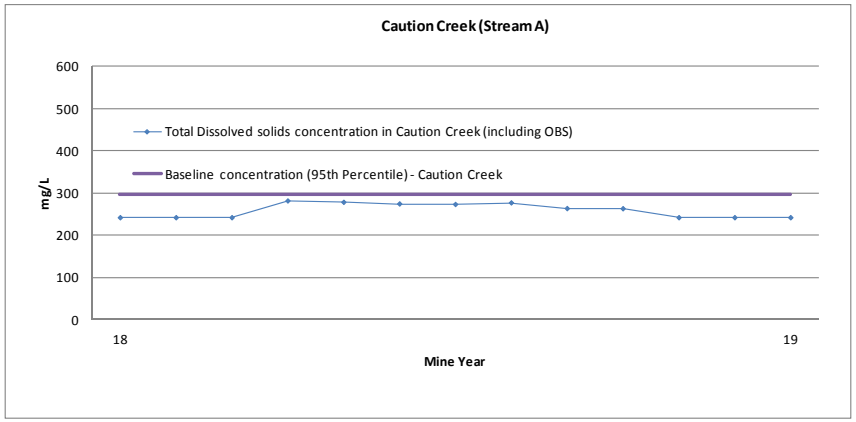


Figure 3-43 Comparison of predicted TDS concentrations in a median and wet rainfall scenario in Caution Creek



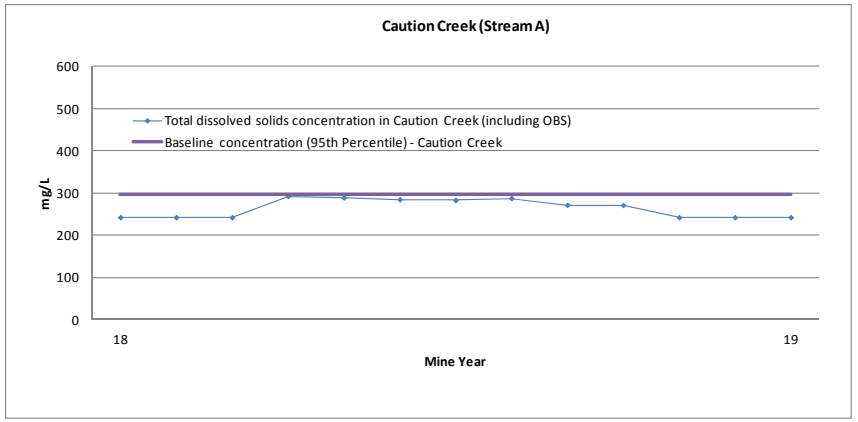
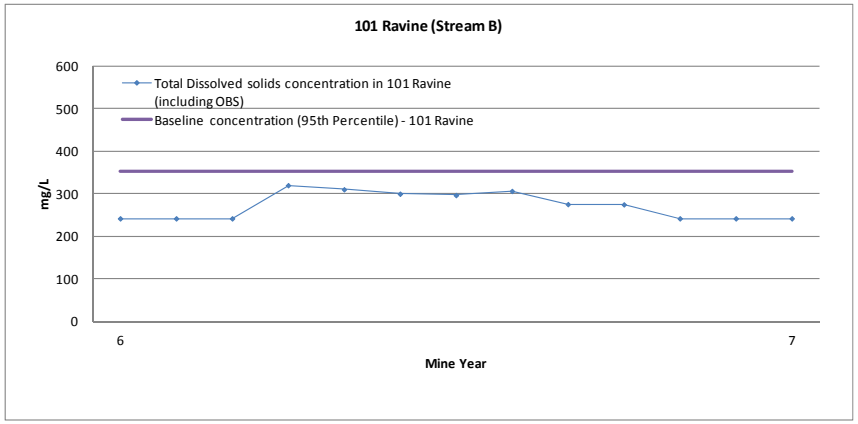


Figure 3-44 Comparison of predicted TDS concentrations in a median and dry rainfall scenario in 101 Ravine



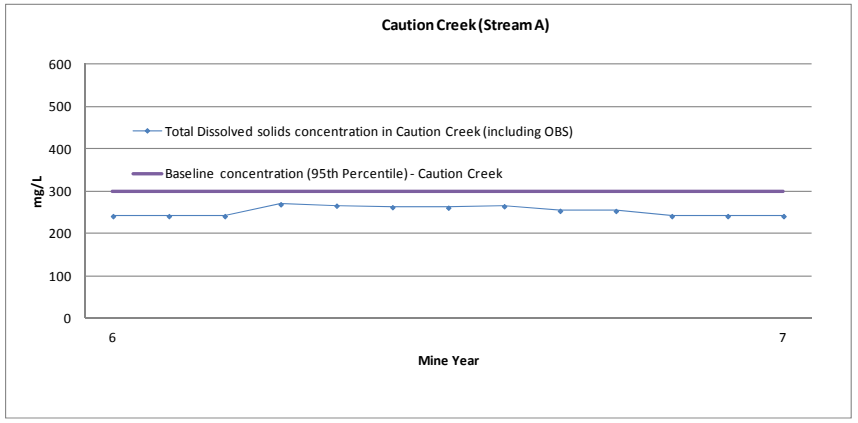
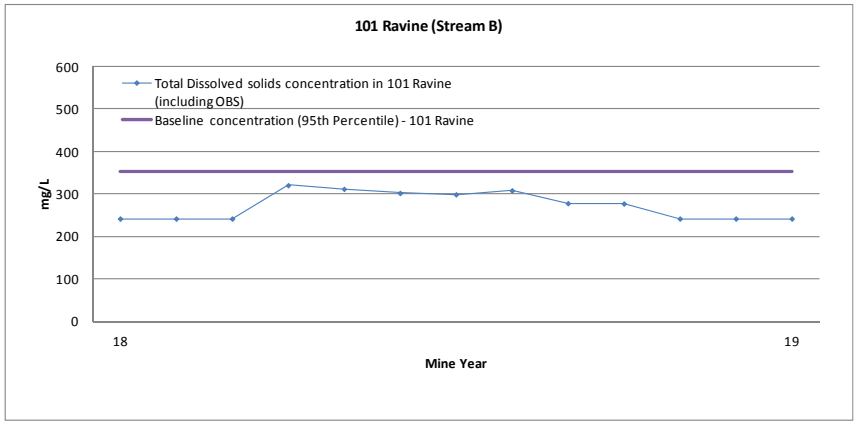


Figure 3-45 Comparison of predicted TDS concentrations in a median and wet rainfall scenario in 101 Ravine



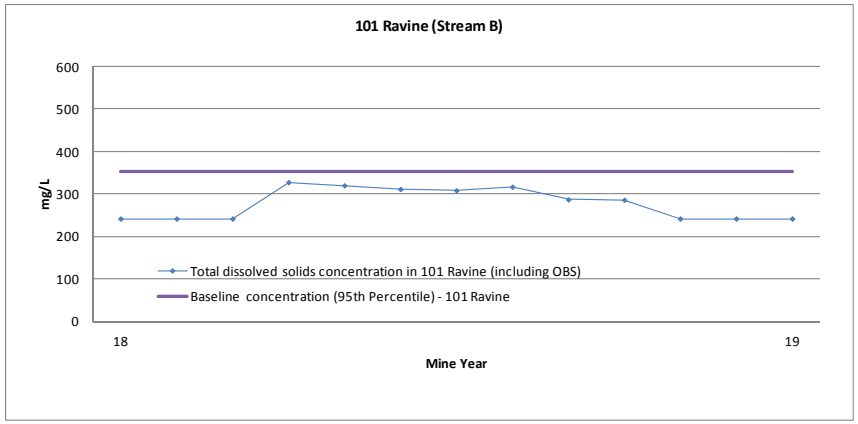
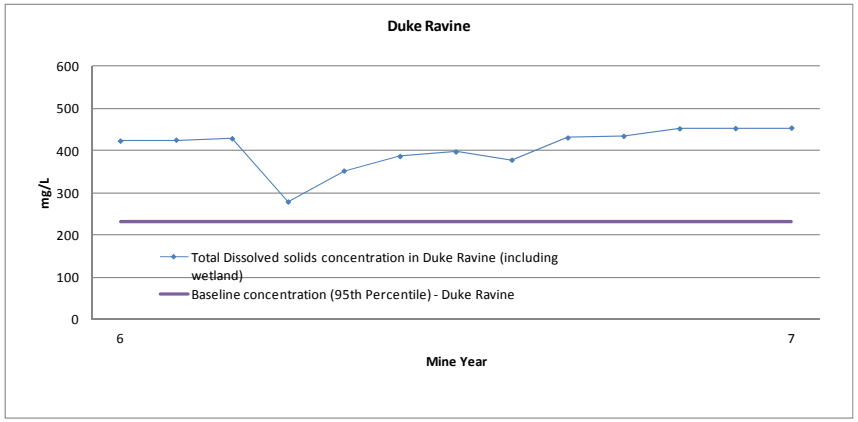


Figure 3-46 Comparison of predicted TDS concentrations in a median and dry rainfall scenario in Duke Ravine



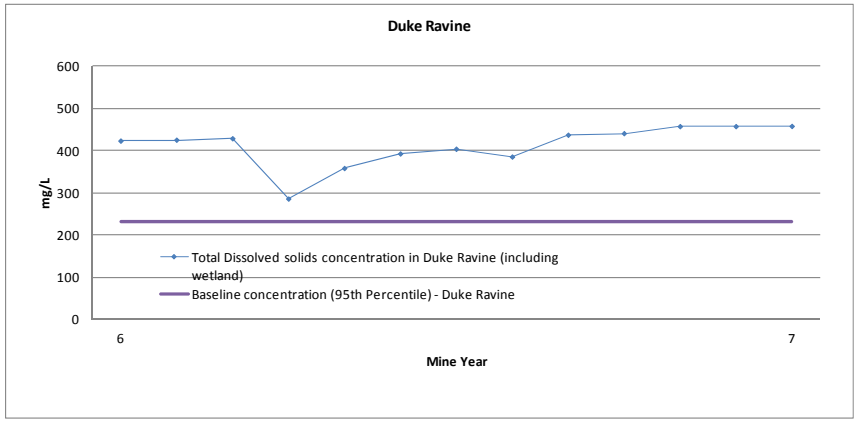
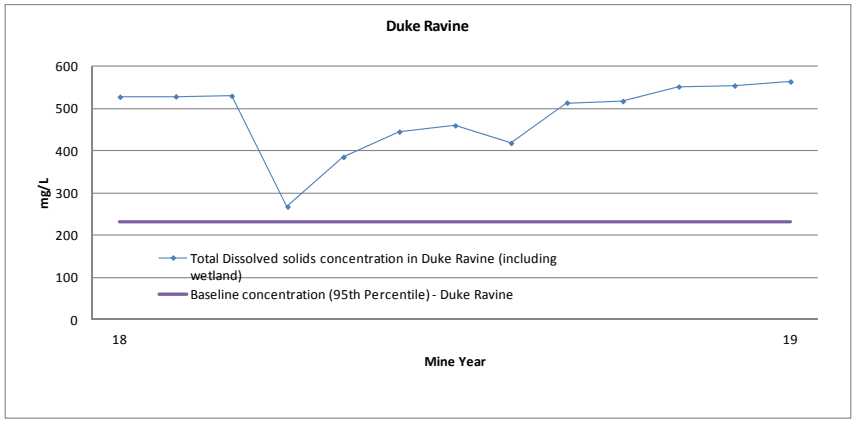


Figure 3-47 Comparison of predicted TDS concentrations in a median and wet rainfall scenario in Duke Ravine



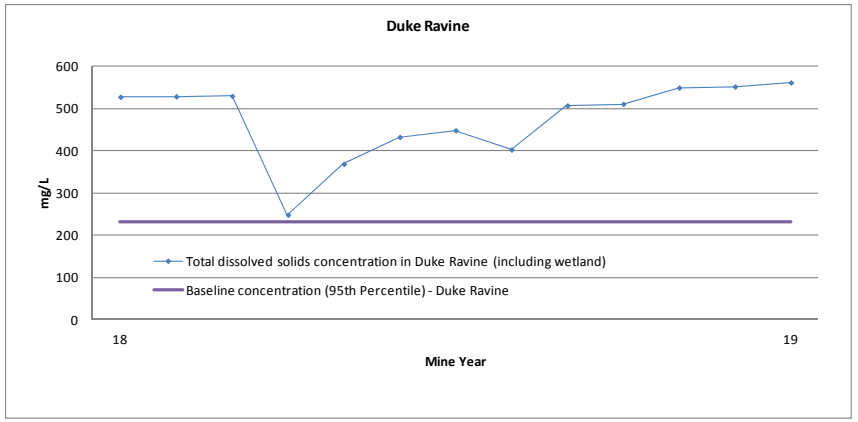
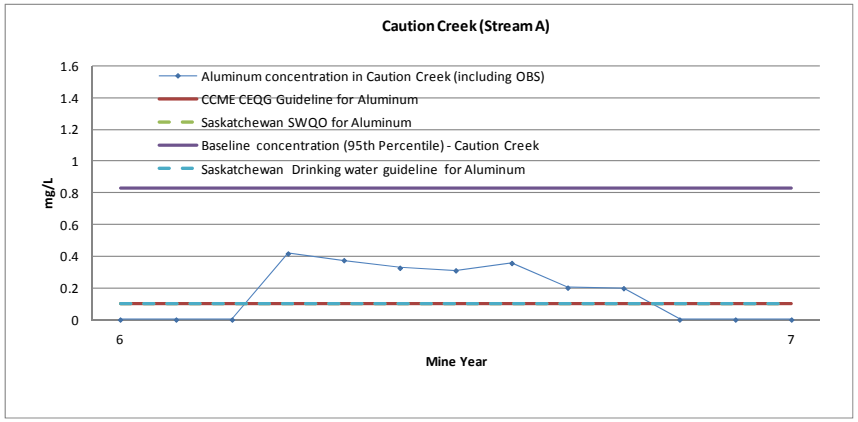


Figure 3-48 Comparison of predicted aluminum concentrations in a median and dry rainfall scenario in Caution Creek



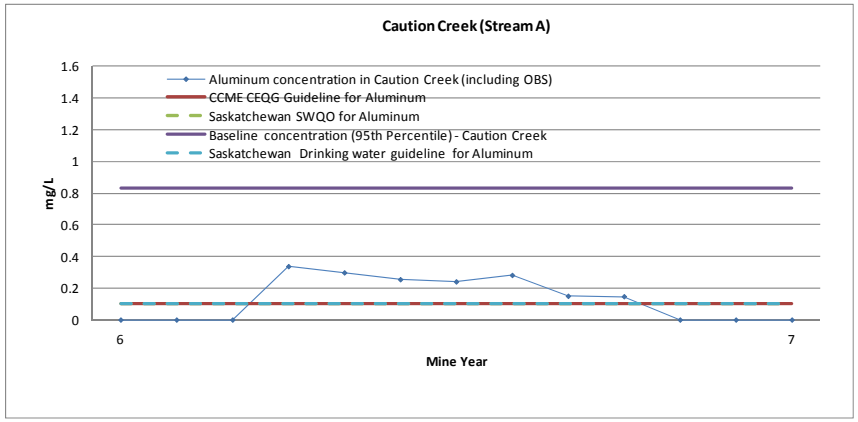
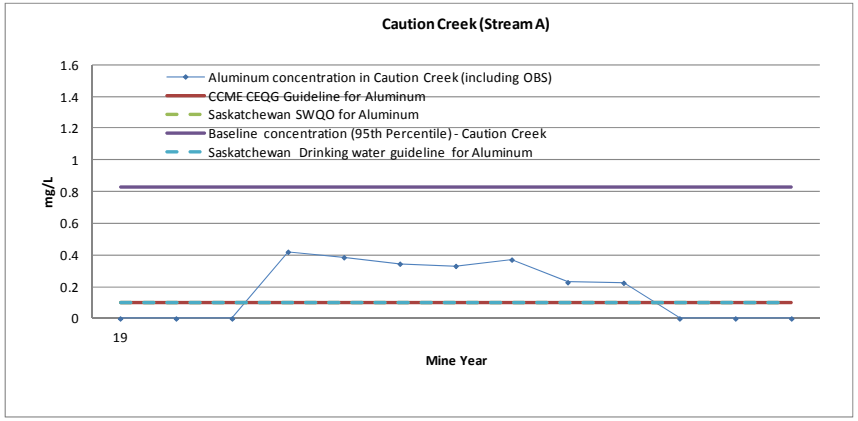


Figure 3-49 Comparison of predicted aluminum concentrations in a median and wet rainfall scenario in Caution Creek



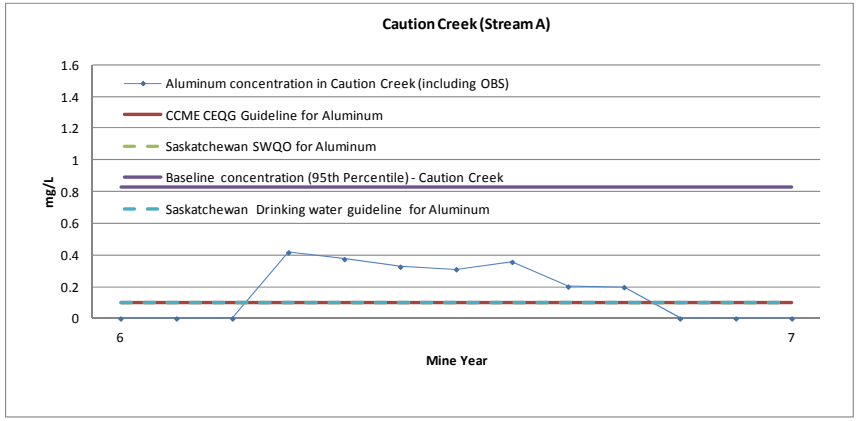
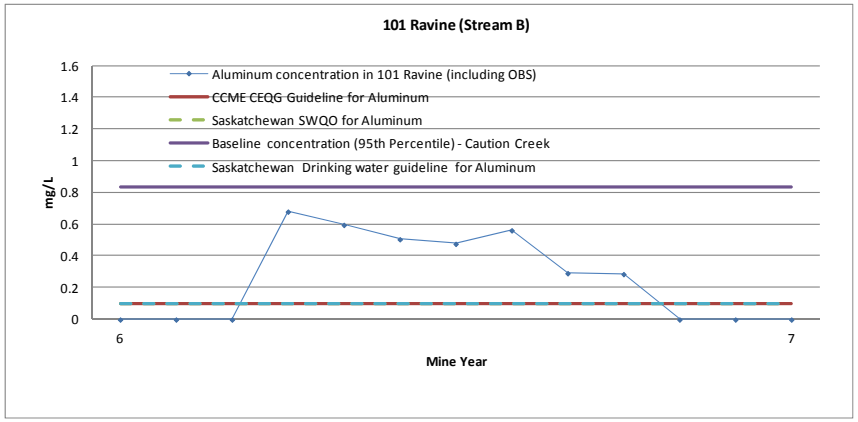


Figure 3-50 Comparison of predicted aluminum concentrations in a median and dry rainfall scenario in 101 Ravine



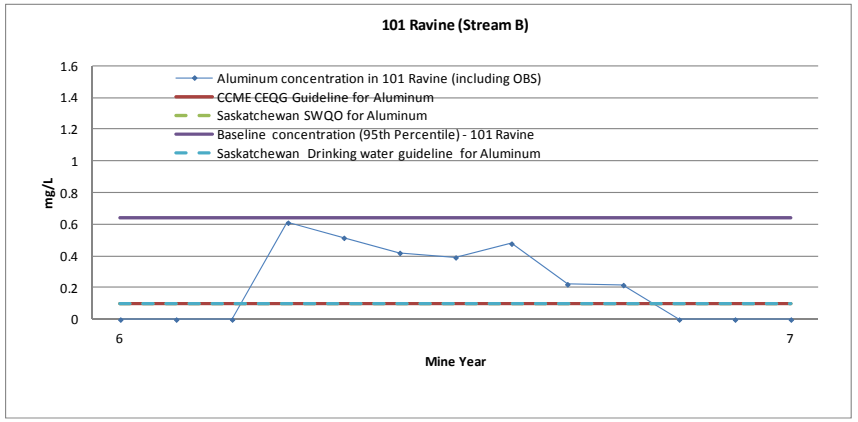
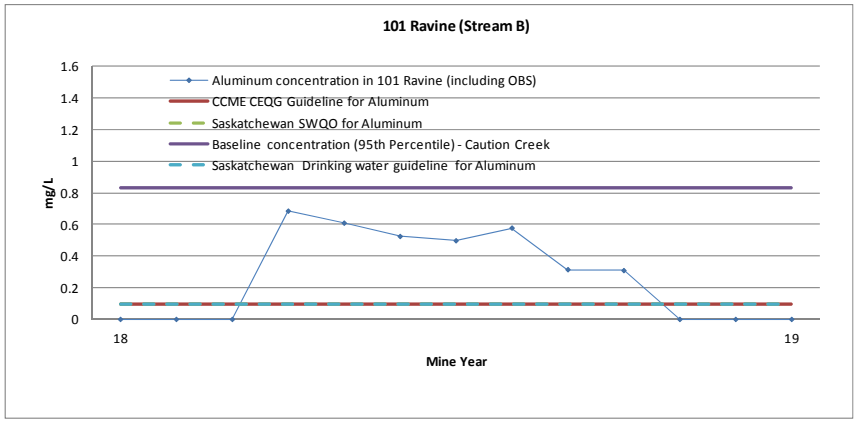


Figure 3-51 Comparison of predicted aluminum concentrations in a median and wet rainfall scenario in 101 Ravine



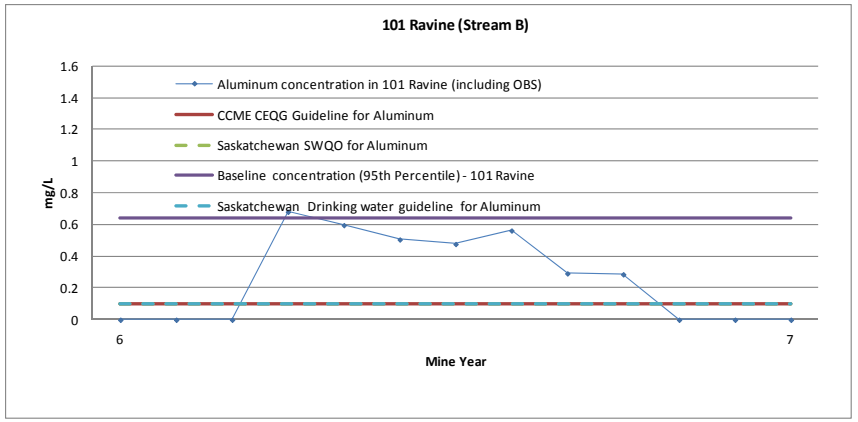
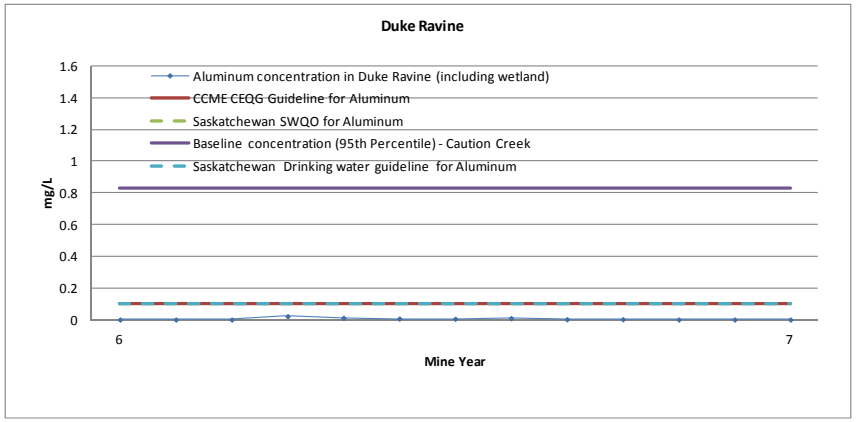


Figure 3-52 Comparison of predicted aluminum concentrations in a median and dry rainfall scenario in Duke Ravine



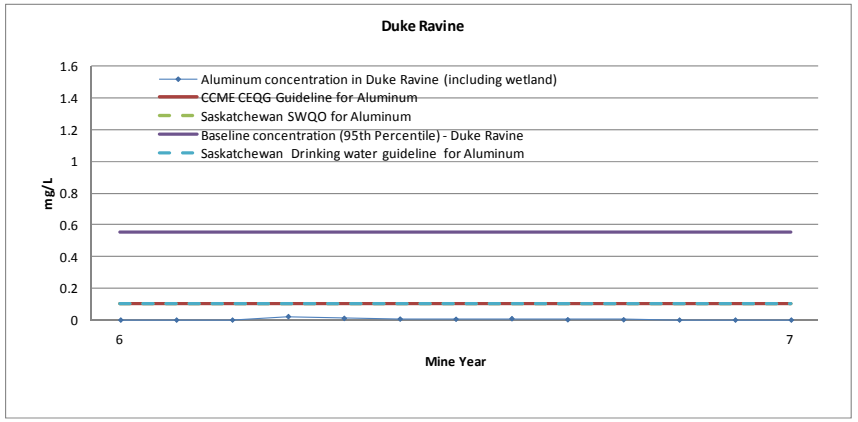
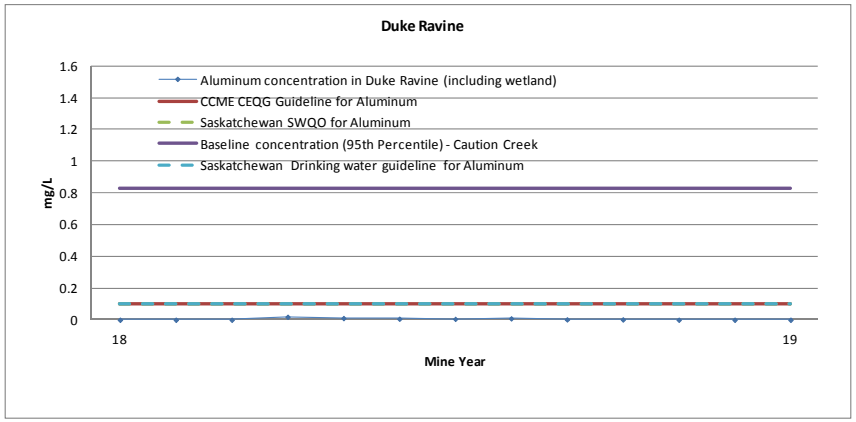


Figure 3-53 Comparison of predicted aluminum concentrations in a median and wet rainfall scenario in Duke Ravine



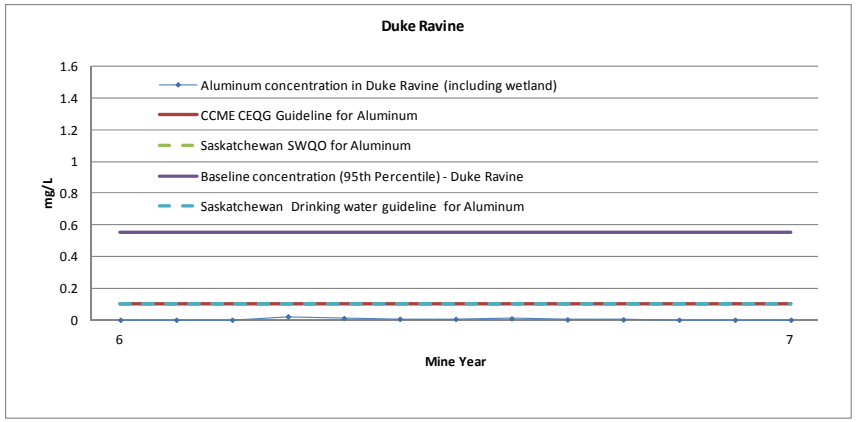
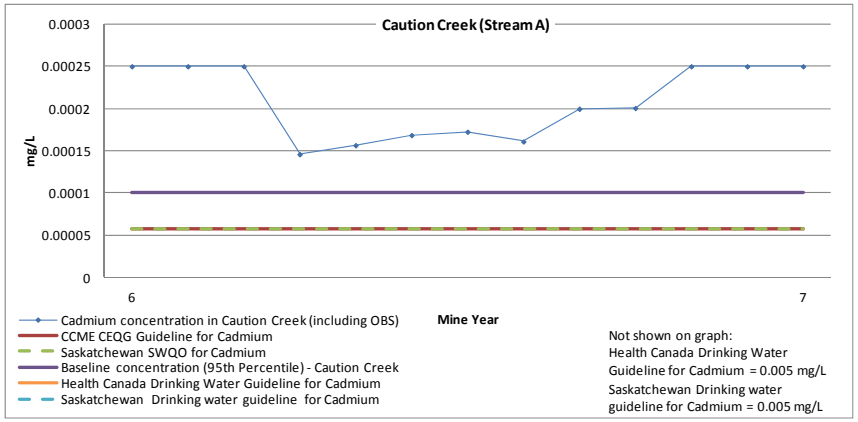


Figure 3-54 Comparison of predicted Cadmium concentrations in a median and dry rainfall scenario in Caution Creek



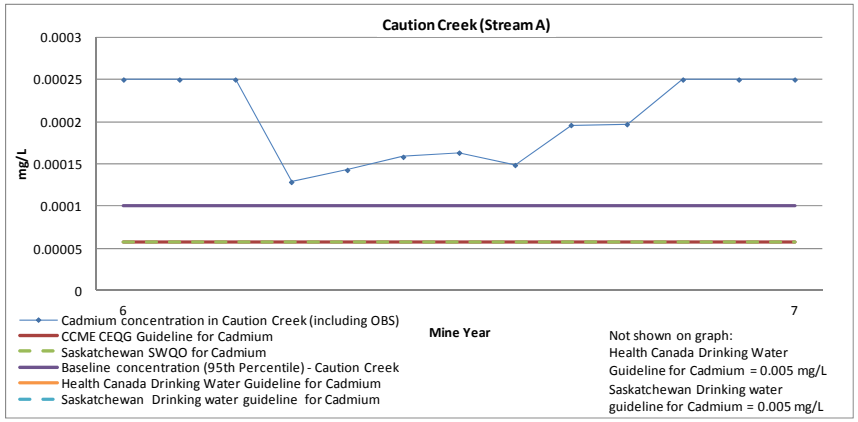
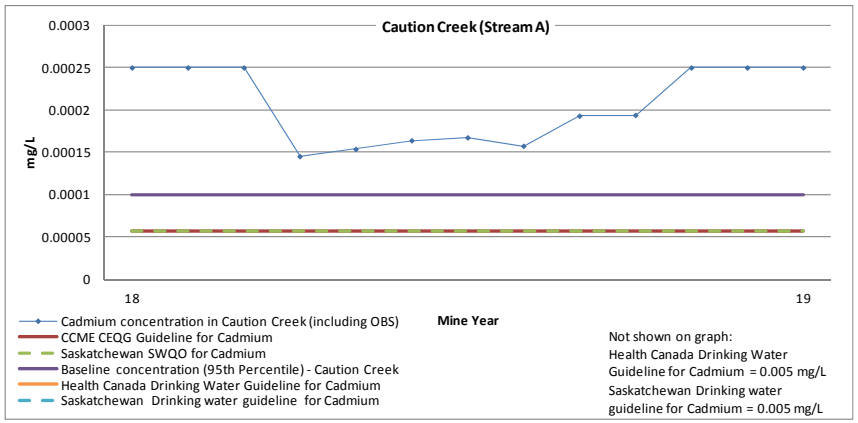


Figure 3-55 Comparison of predicted Cadmium concentrations in a median and wet rainfall scenario in Caution Creek



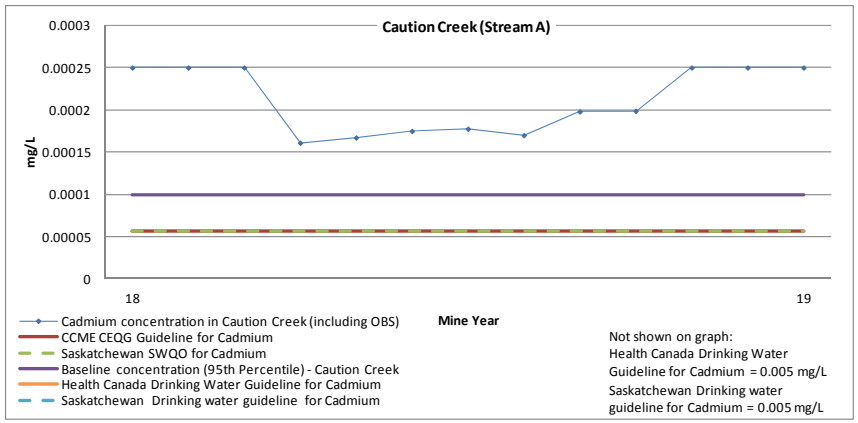
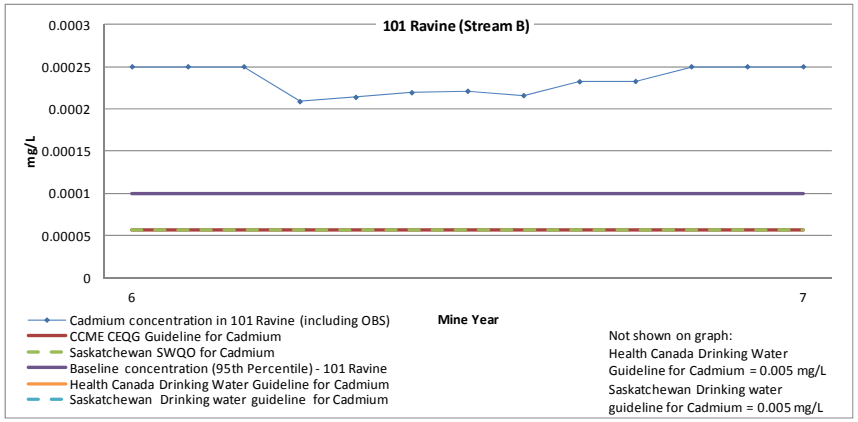


Figure 3-56 Comparison of predicted Cadmium concentrations in a median and dry rainfall scenario in 101 Ravine



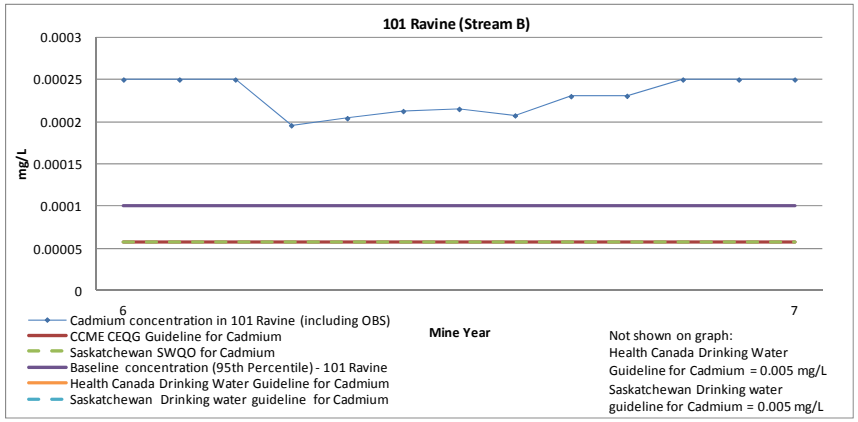
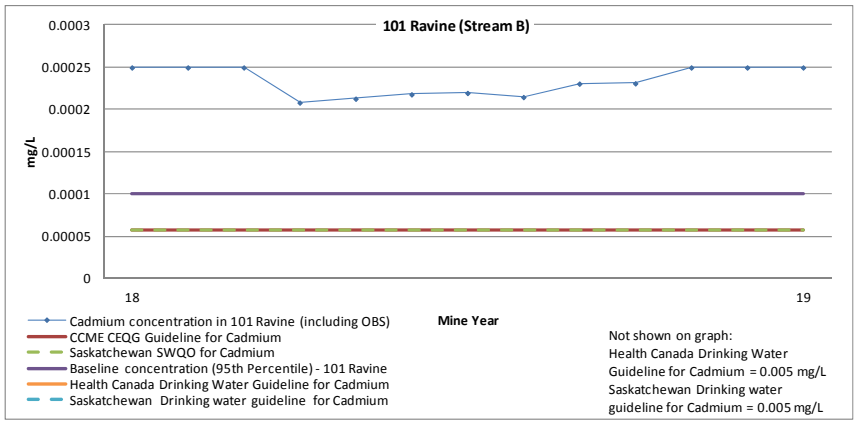


Figure 3-57 Comparison of predicted Cadmium concentrations in a median and wet rainfall scenario in 101 Ravine



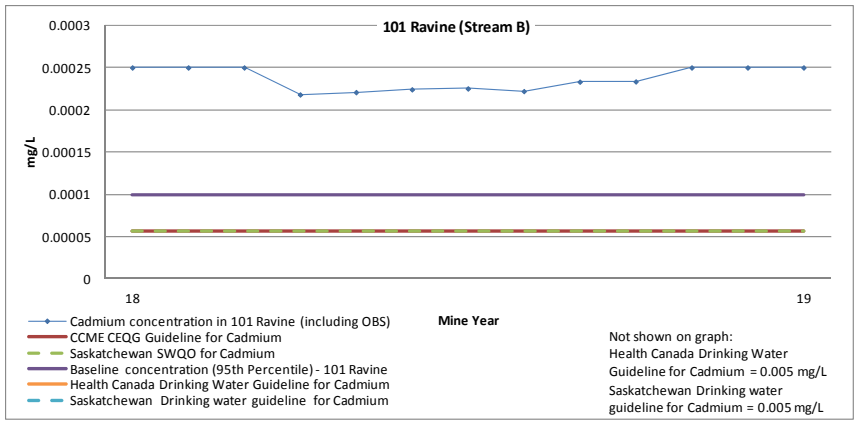
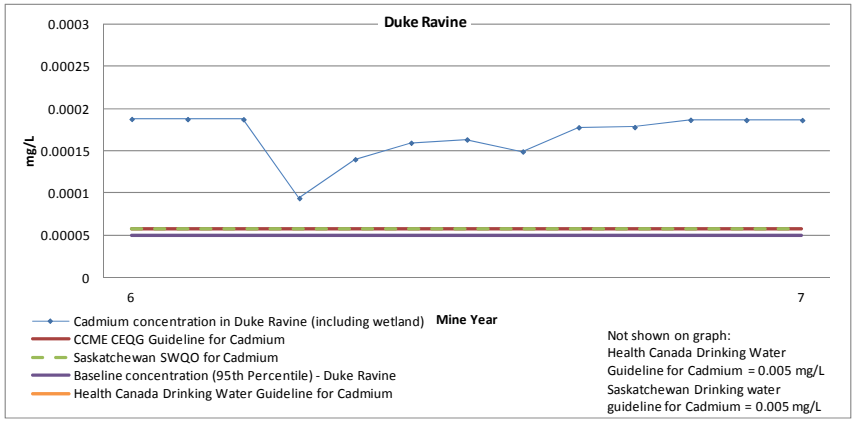


Figure 3-58 Comparison of predicted Cadmium concentrations in a median and dry rainfall scenario in Duke Ravine



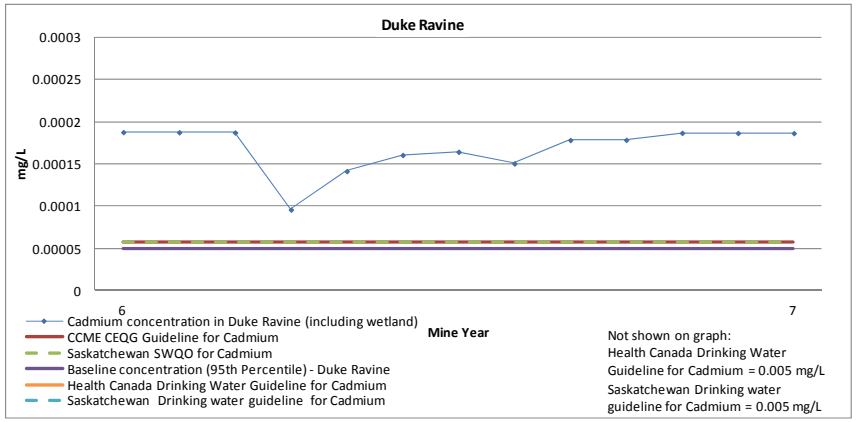
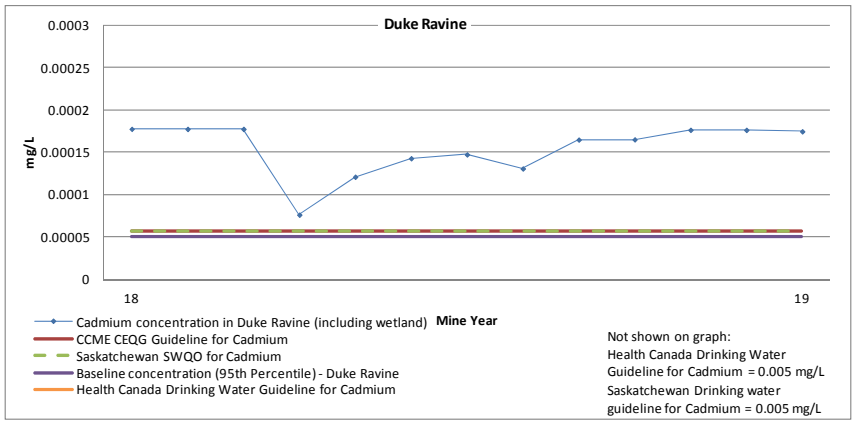


Figure 3-59 Comparison of predicted Cadmium concentrations in a median and wet rainfall scenario in Duke Ravine



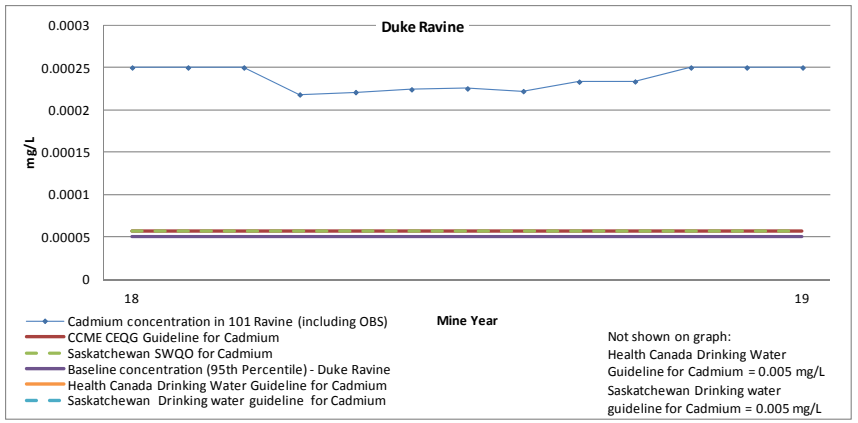
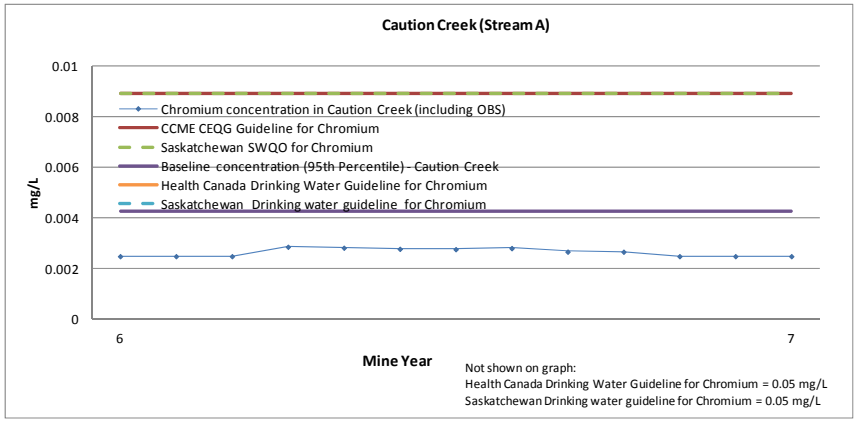


Figure 3-60 Comparison of predicted Chromium concentrations in a median and dry rainfall scenario in Caution Creek



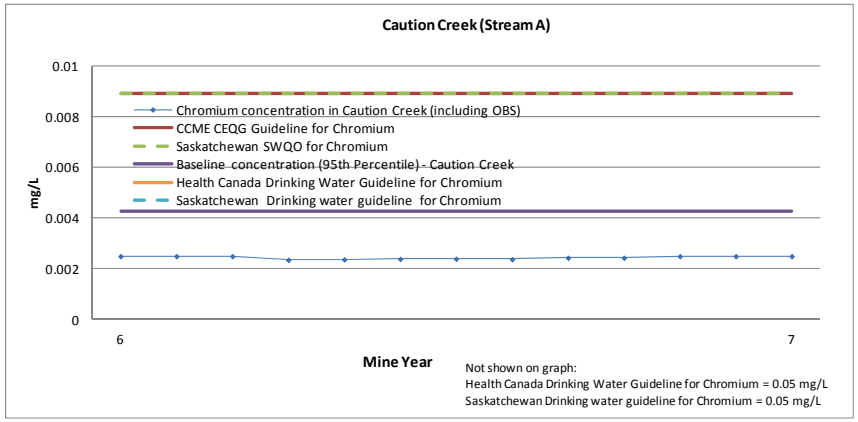
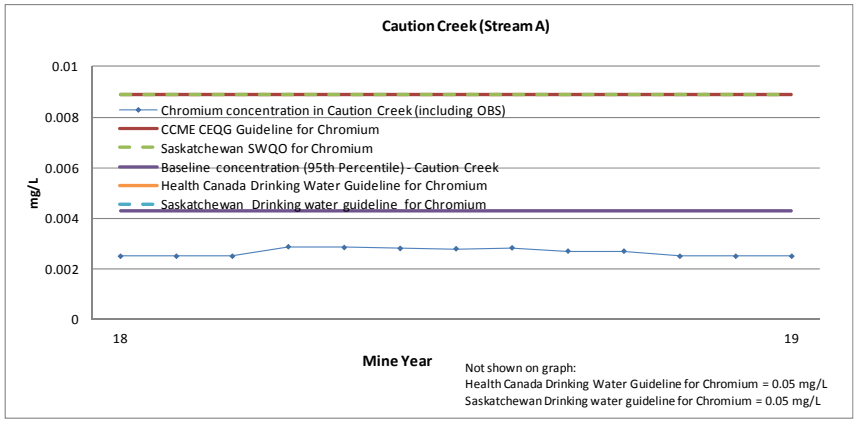


Figure 3-61 Comparison of predicted Chromium concentrations in a median and wet rainfall scenario in Caution Creek



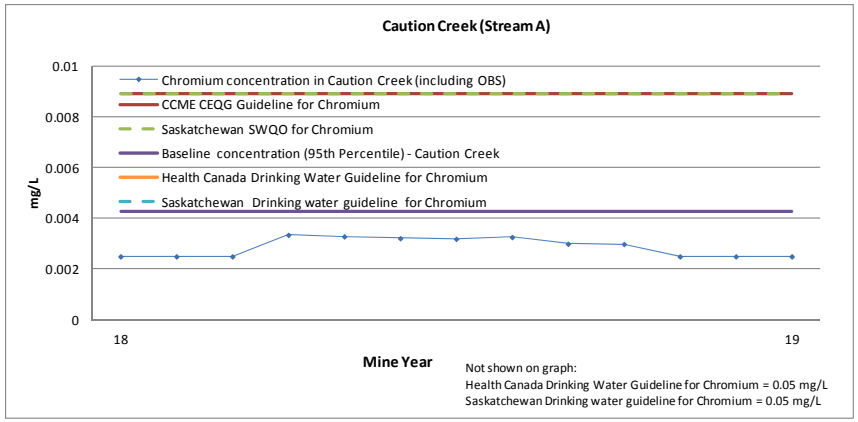
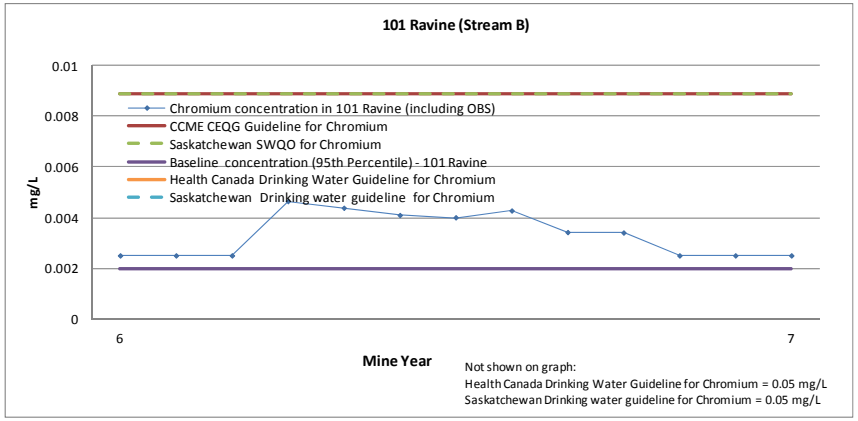


Figure 3-62 Comparison of predicted Chromium concentrations in a median and dry rainfall scenario in 101 Ravine



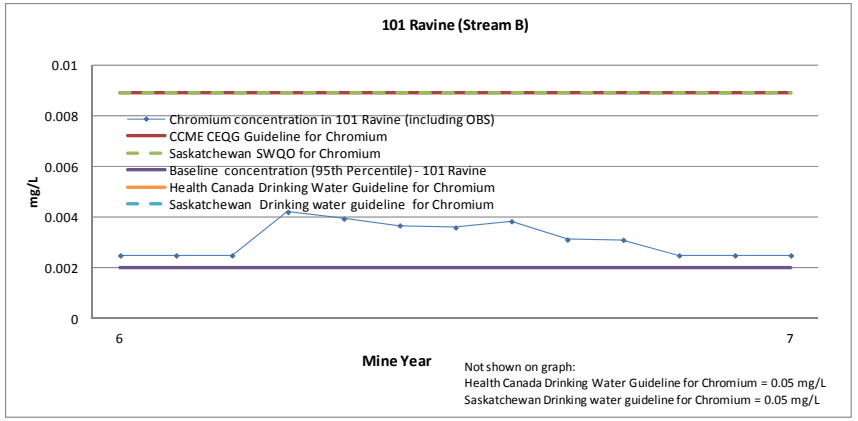
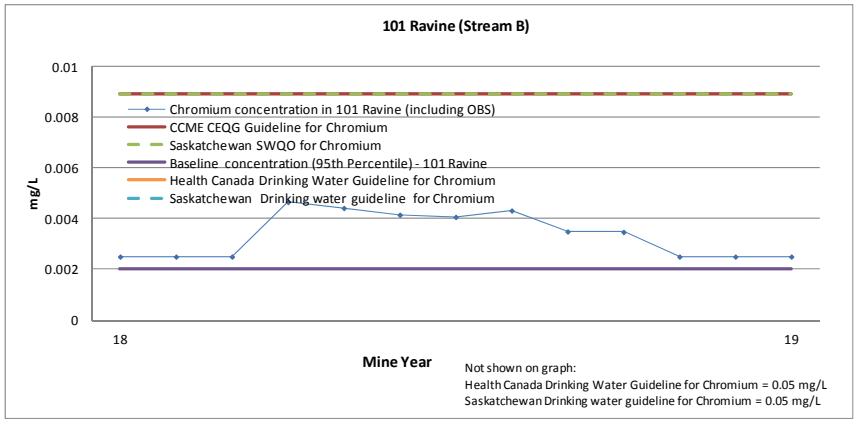


Figure 3-63 Comparison of predicted Chromium concentrations in a median and wet rainfall scenario in 101 Ravine



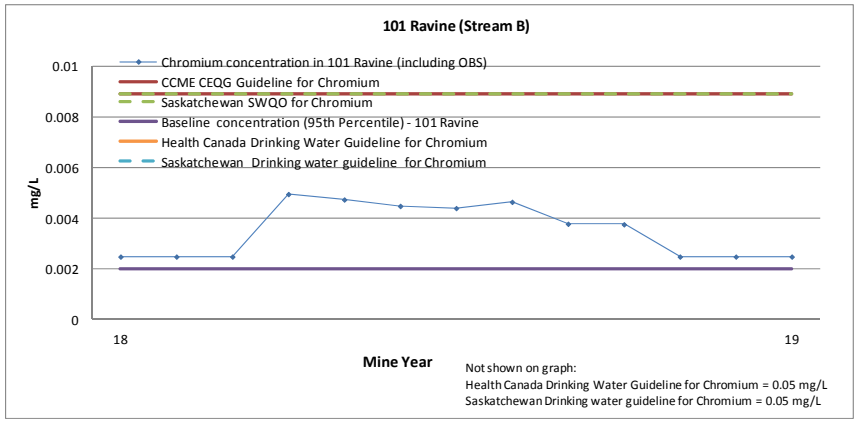
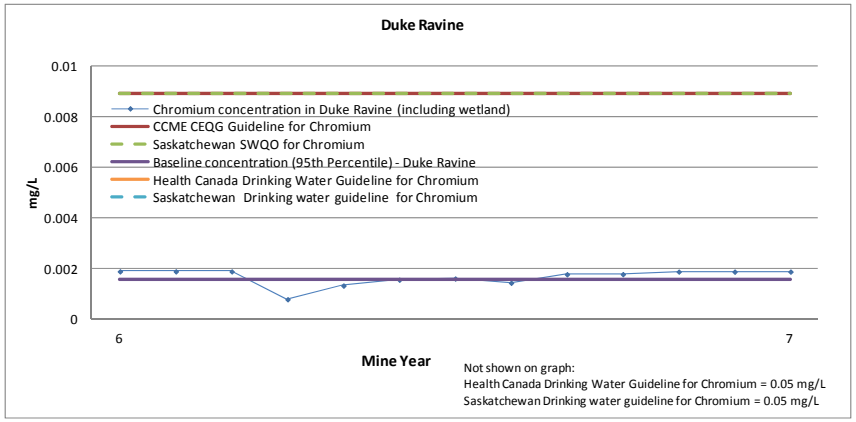


Figure 3-64 Comparison of predicted Chromium concentrations in a median and dry rainfall scenario in Duke Ravine



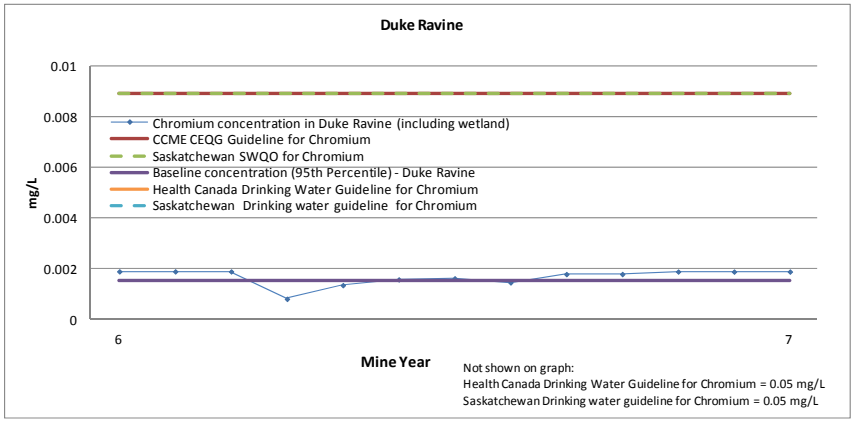
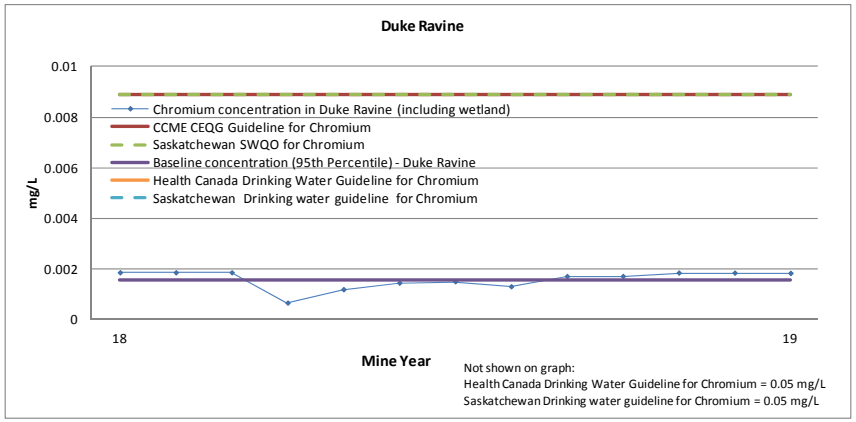


Figure 3-65 Comparison of predicted Chromium concentrations in a median and wet rainfall scenario in Duke Ravine



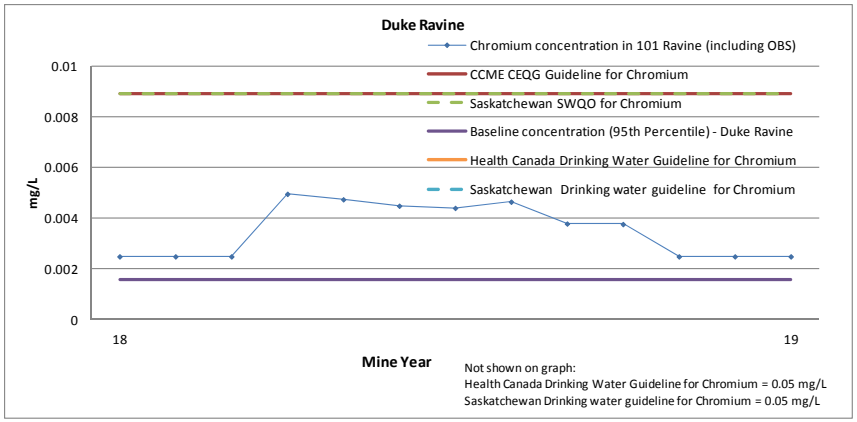
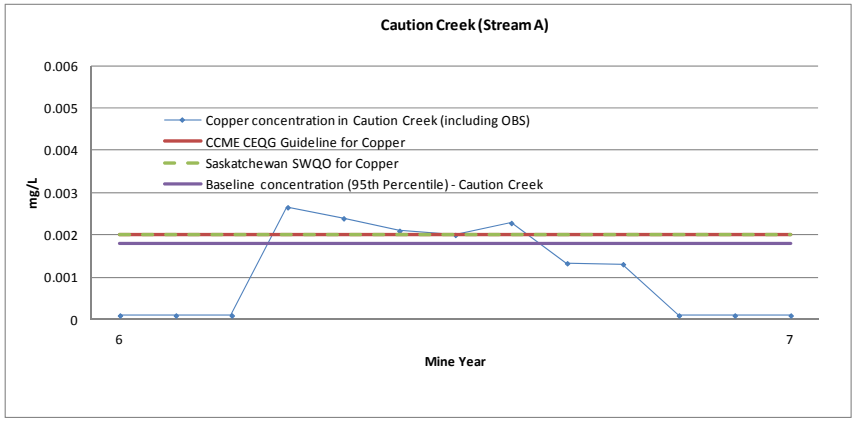


Figure 3-66 Comparison of predicted copper concentrations in a median and dry rainfall scenario in Caution Creek



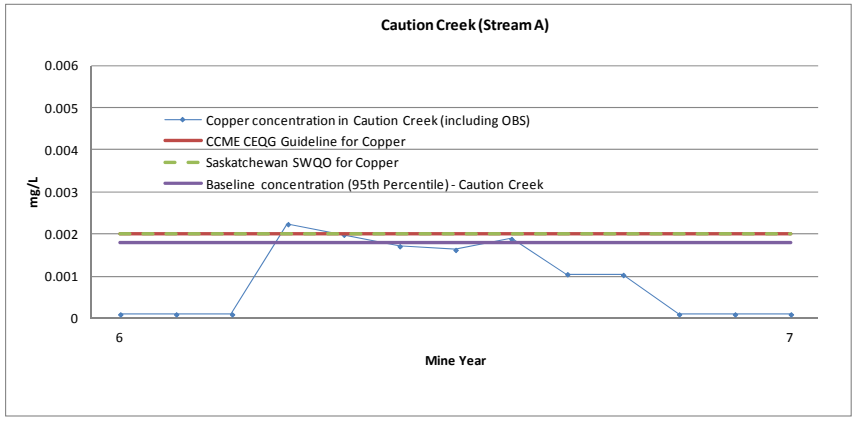
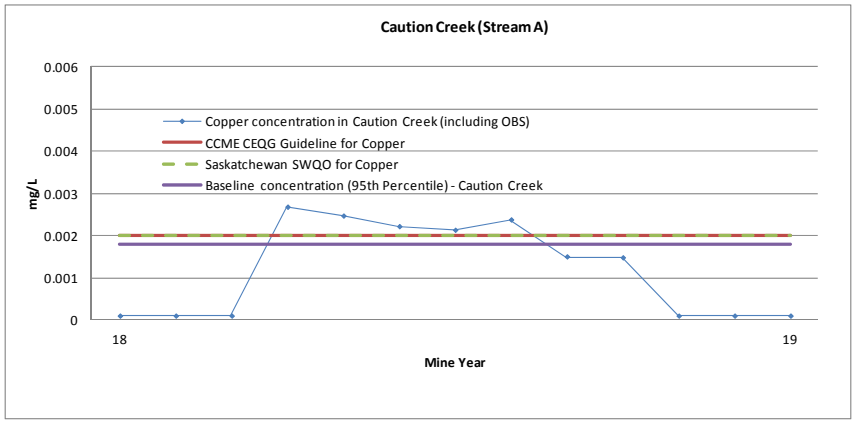


Figure 3-67 Comparison of predicted copper concentrations in a median and wet rainfall scenario in Caution Creek



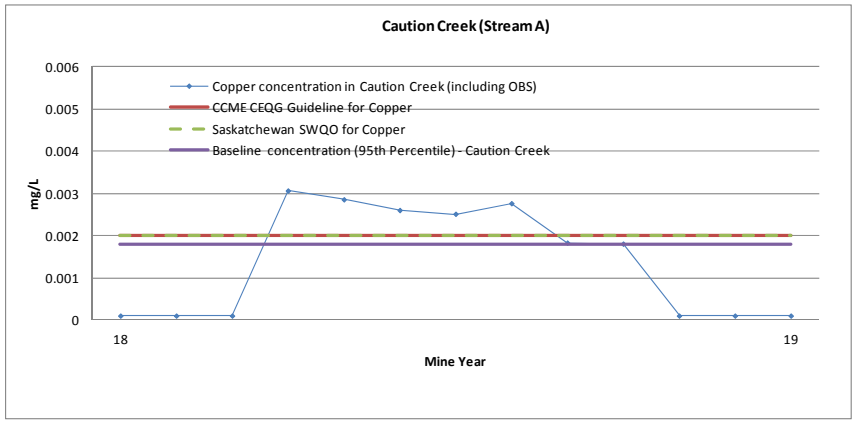
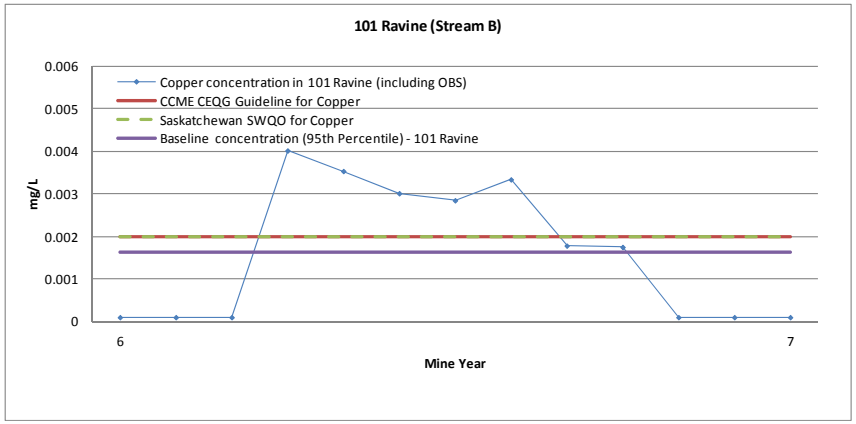


Figure 3-68 Comparison of predicted copper concentrations in a median and dry rainfall scenario in 101 Ravine



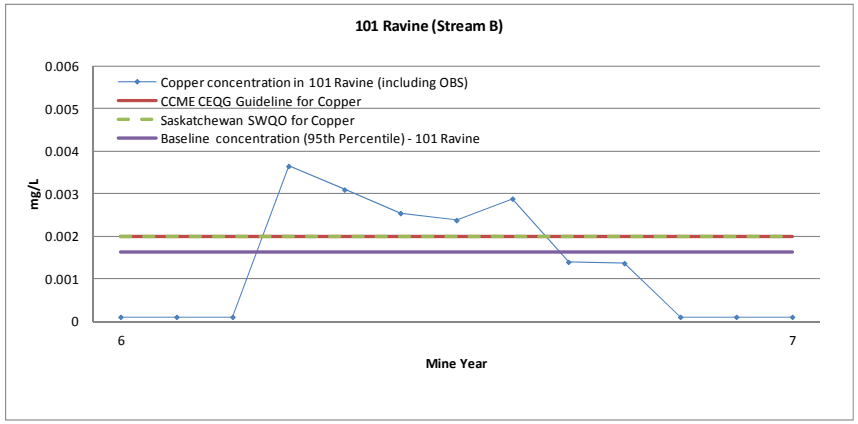
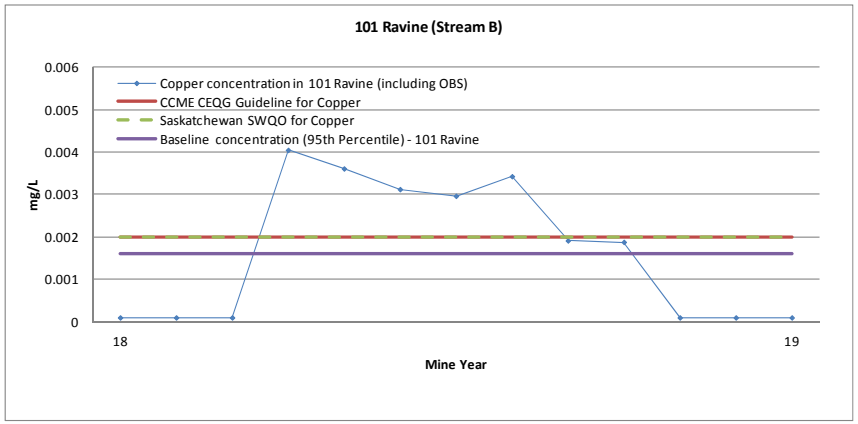


Figure 3-69 Comparison of predicted copper concentrations in a median and wet rainfall scenario in 101 Ravine



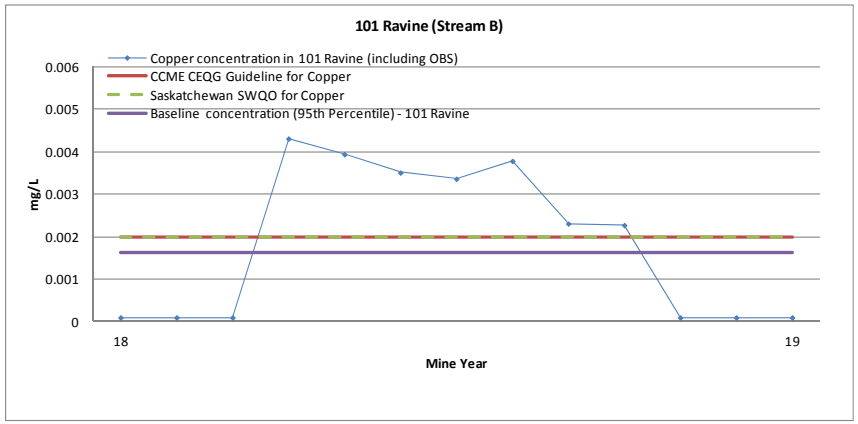
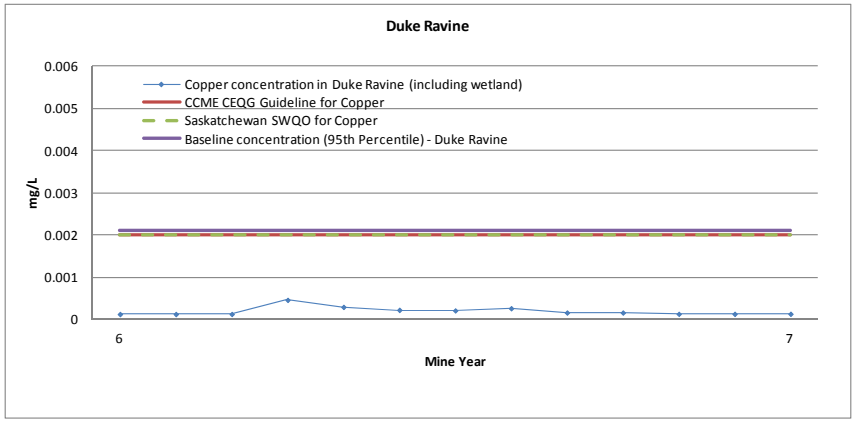


Figure 3-70 Comparison of predicted copper concentrations in a median and dry rainfall scenario in Duke Ravine



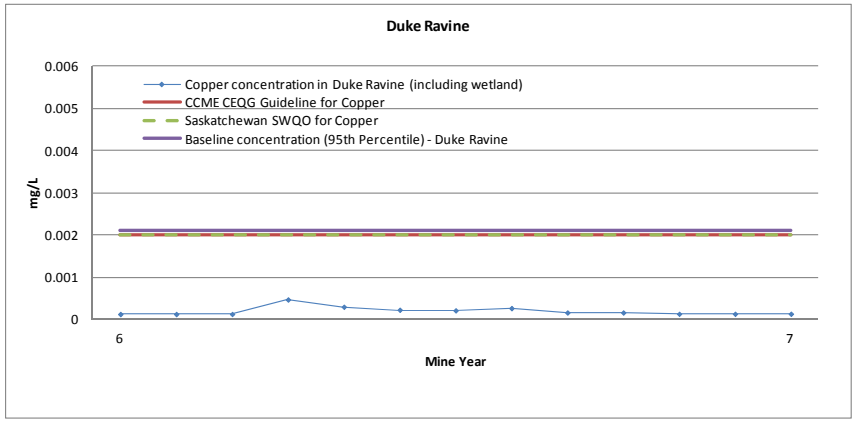
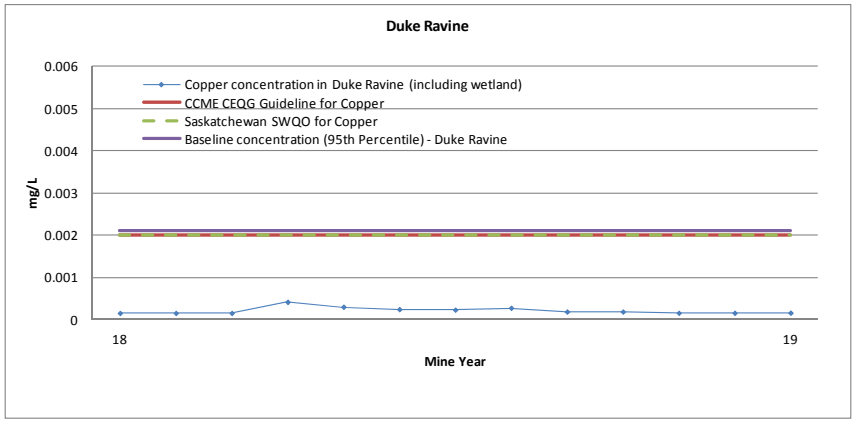


Figure 3-71 Comparison of predicted copper concentrations in a median and wet rainfall scenario in Duke Ravine



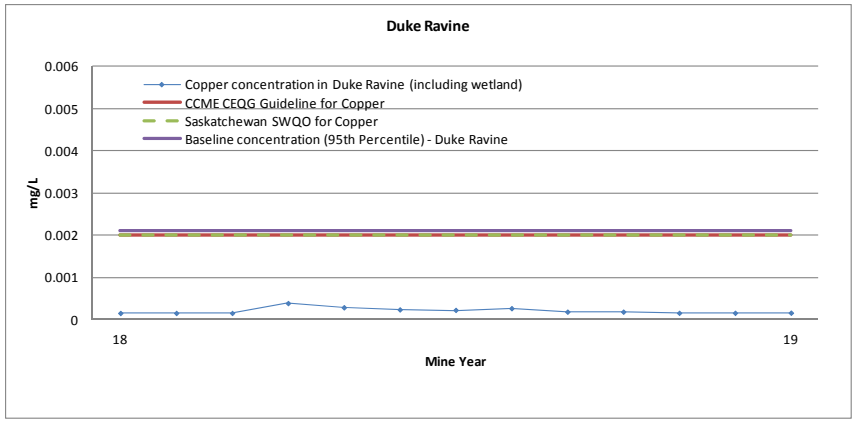
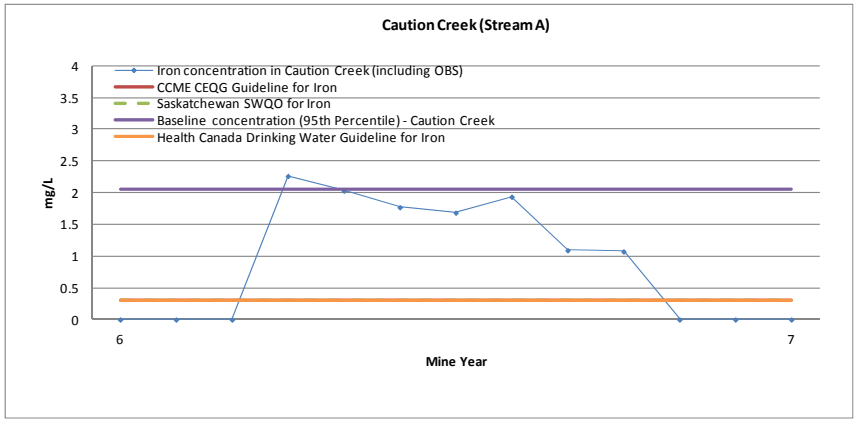


Figure 3-72 Comparison of predicted Iron concentrations in a median and dry rainfall scenario in Caution Creek



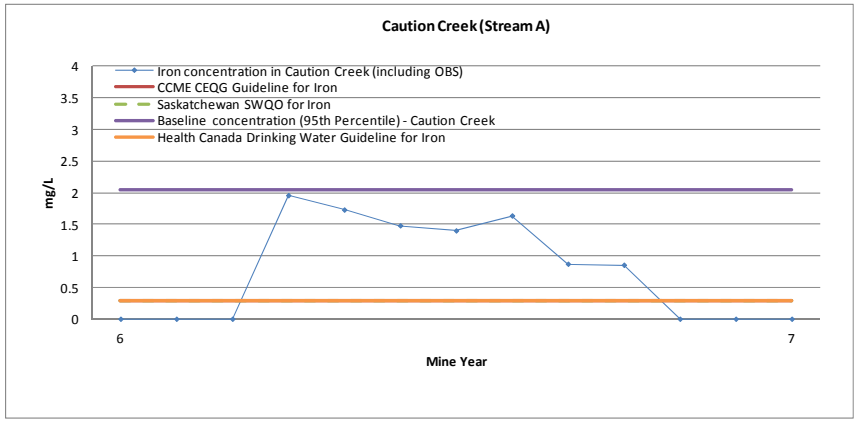
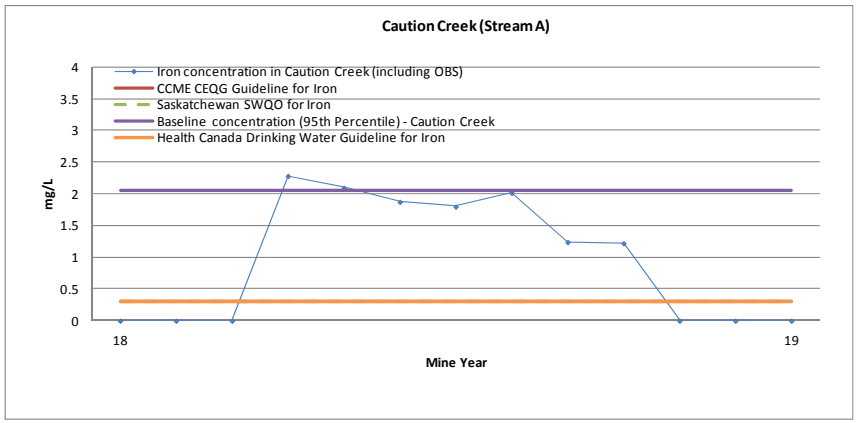


Figure 3-73 Comparison of predicted Iron concentrations in a median and wet rainfall scenario in Caution Creek



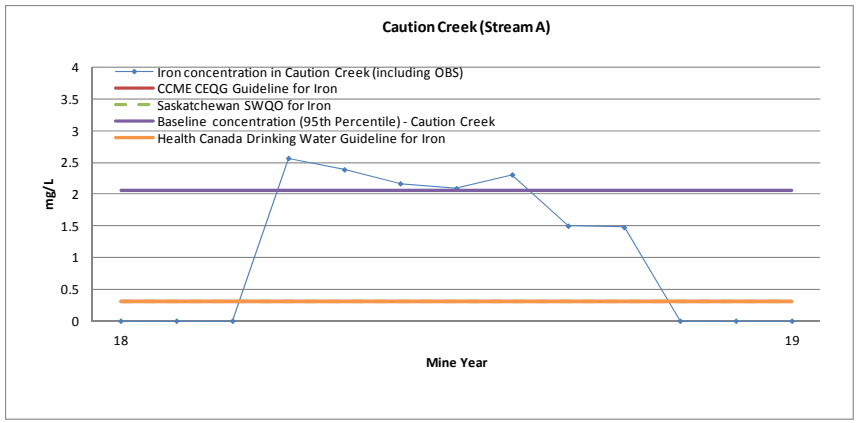
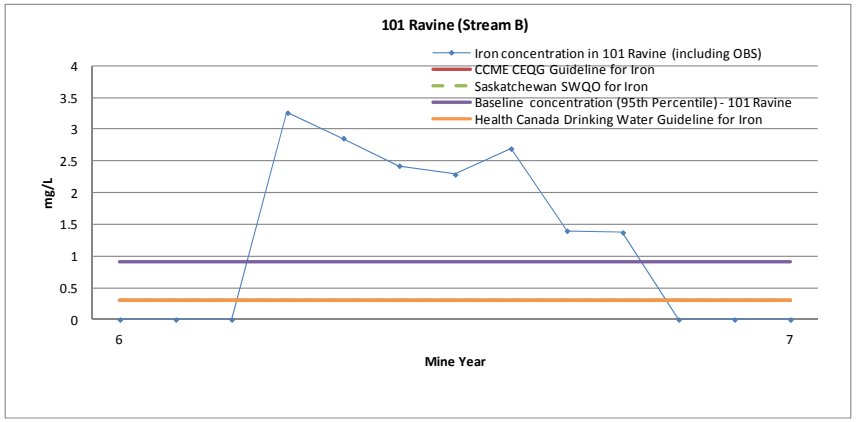


Figure 3-74 Comparison of predicted Iron concentrations in a median and dry rainfall scenario in 101 Ravine



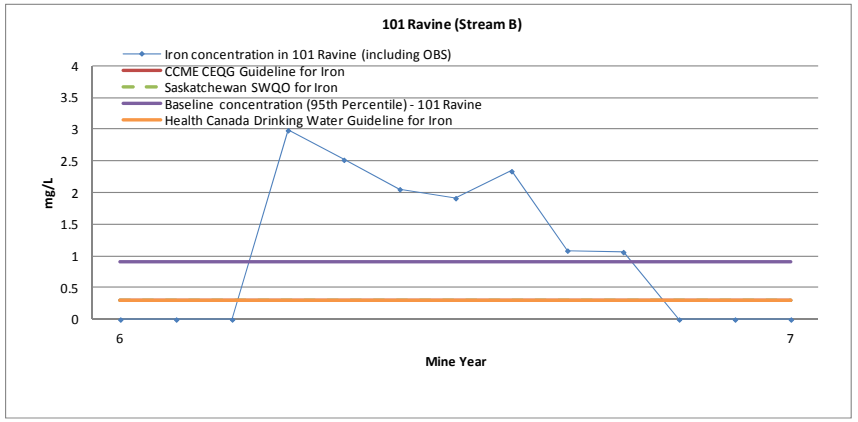
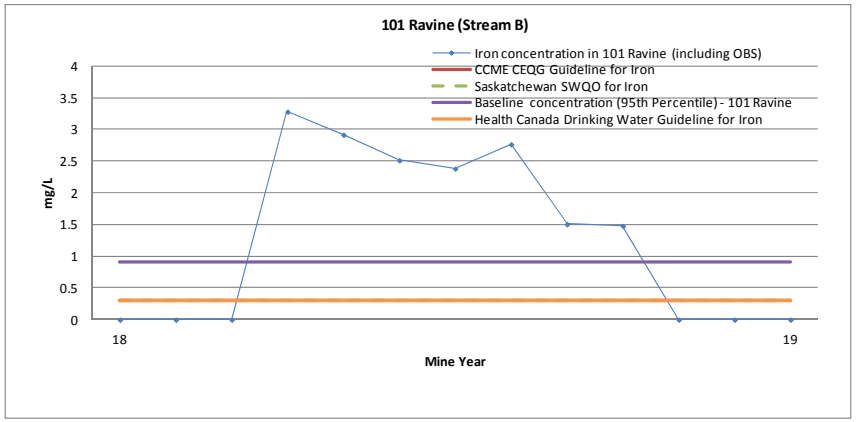


Figure 3-75 Comparison of predicted Iron concentrations in a median and wet rainfall scenario in 101 Ravine



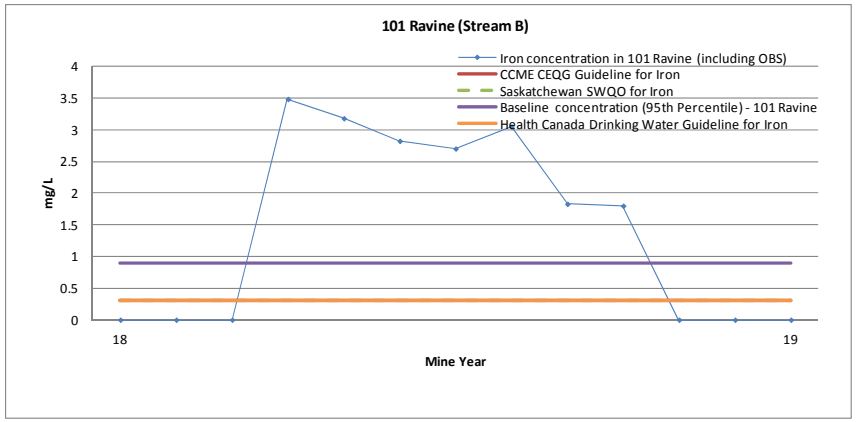
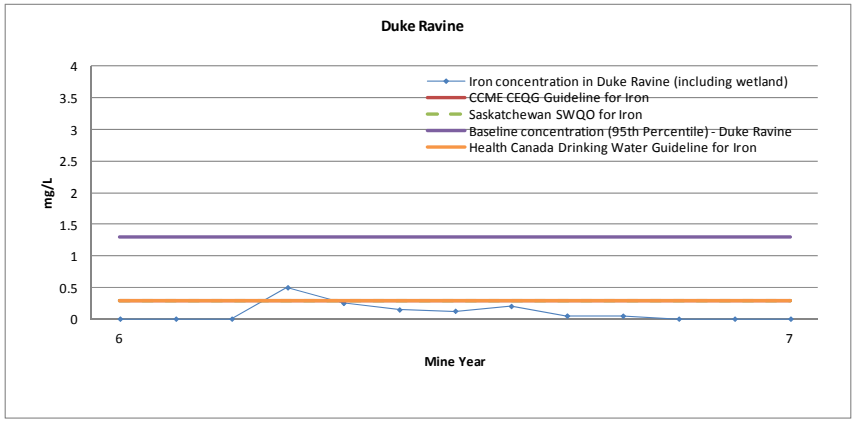


Figure 3-76 Comparison of predicted Iron concentrations in a median and dry rainfall scenario in Duke Ravine



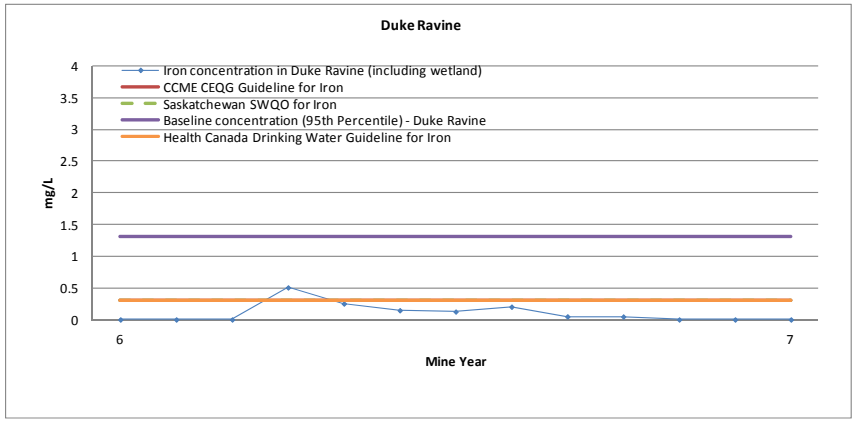
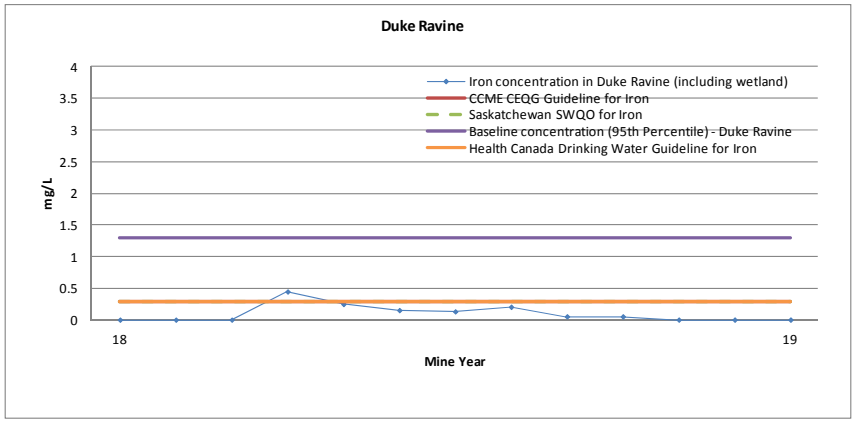


Figure 3-77 Comparison of predicted Iron concentrations in a median and wet rainfall scenario in Duke Ravine



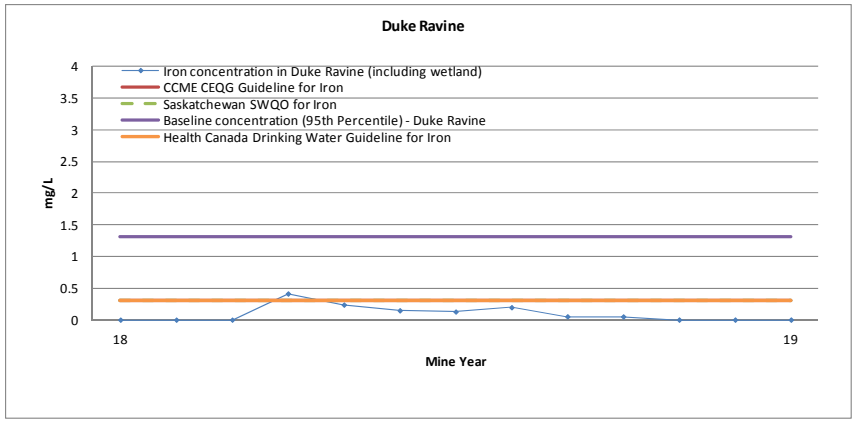
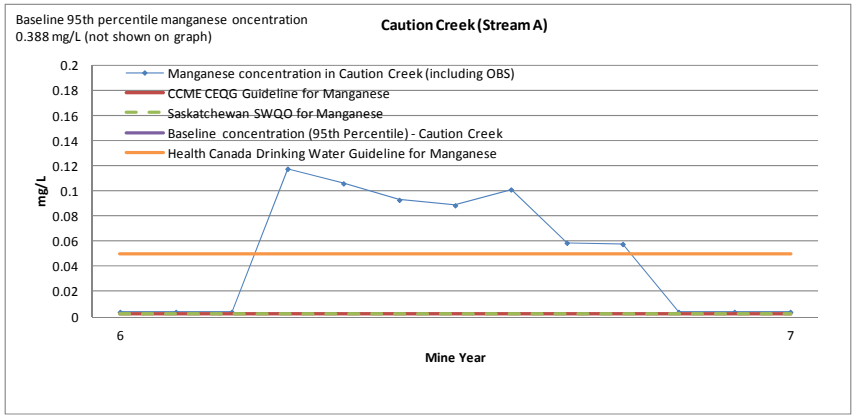


Figure 3-78 Comparison of predicted Manganese concentrations in a median and dry rainfall scenario in Caution Creek



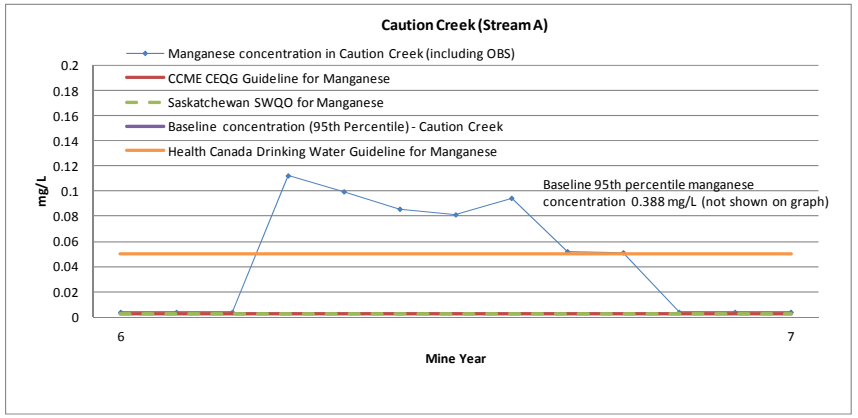
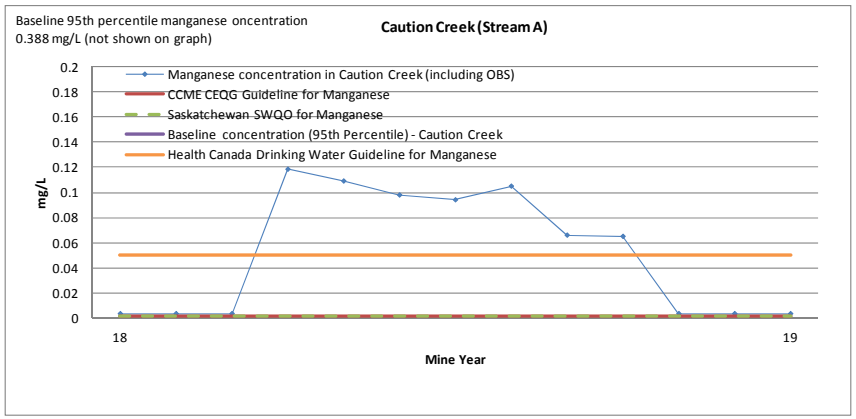


Figure 3-79 Comparison of predicted Manganese concentrations in a median and wet rainfall scenario in Caution Creek



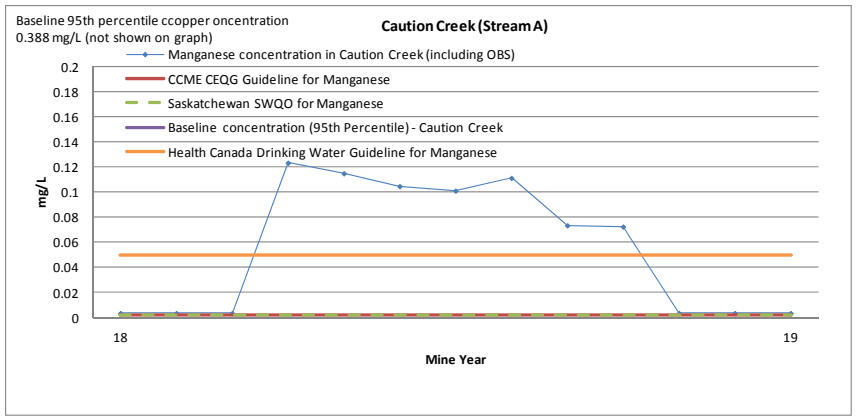
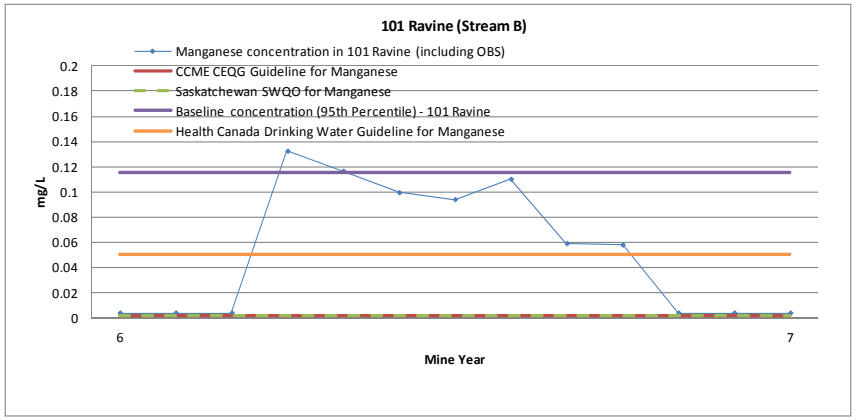


Figure 3-80 Comparison of predicted Manganese concentrations in a median and dry rainfall scenario in 101 Ravine



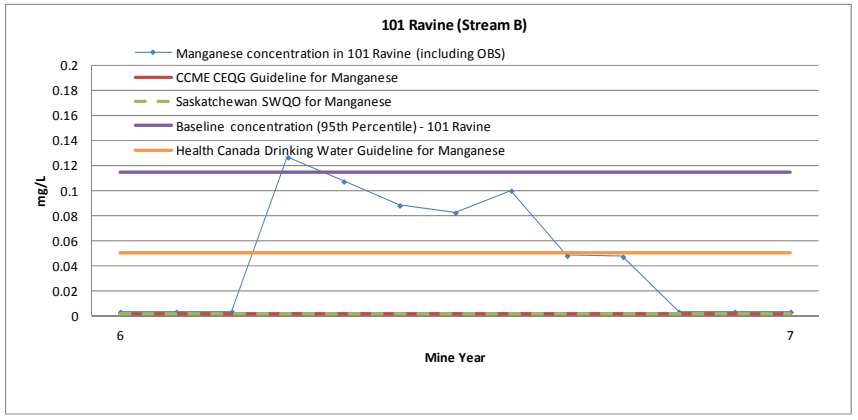
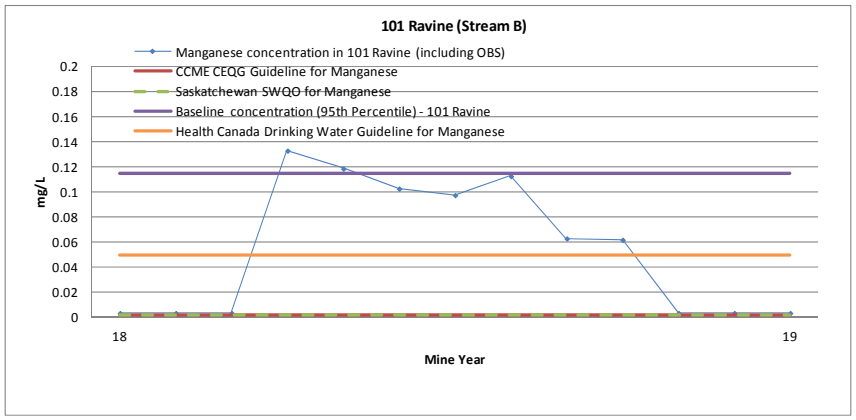


Figure 3-81 Comparison of predicted Manganese concentrations in a median and wet rainfall scenario in 101 Ravine



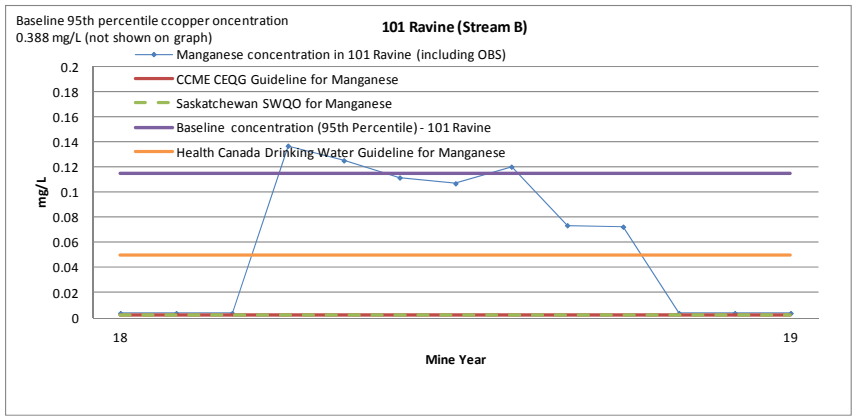
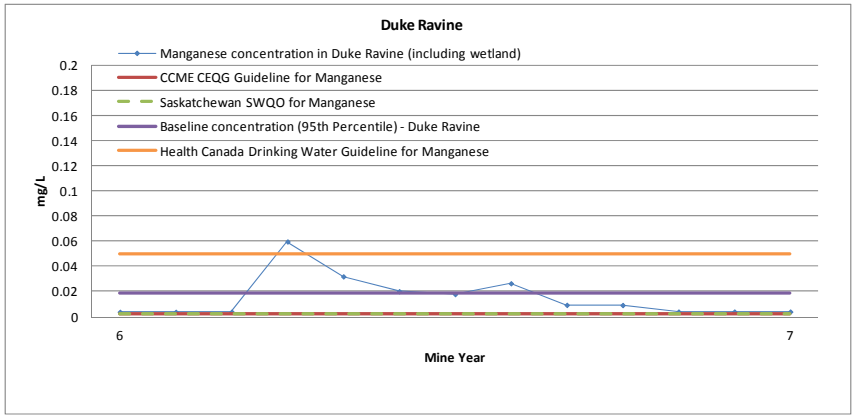


Figure 3-82 Comparison of predicted Manganese concentrations in a median and dry rainfall scenario in Duke Ravine



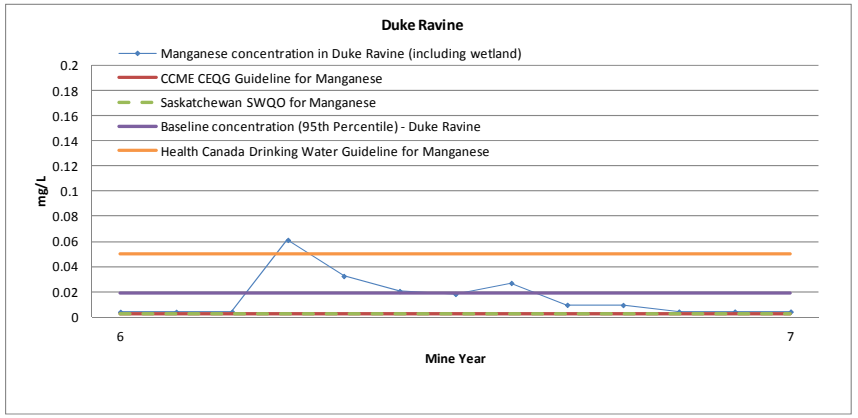
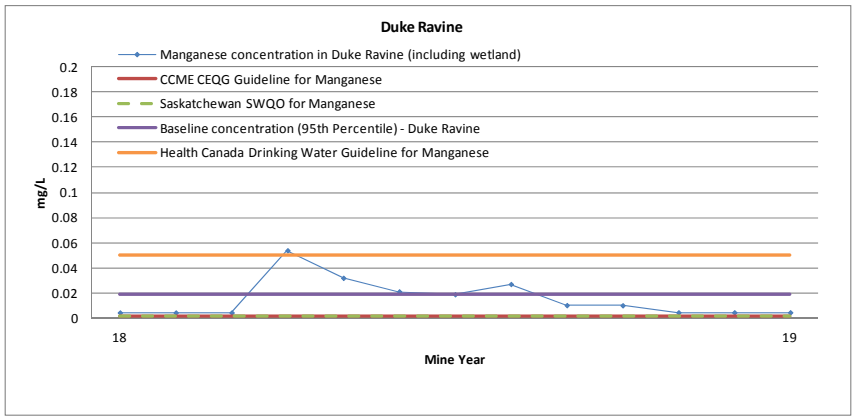


Figure 3-83 Comparison of predicted Manganese concentrations in a median and wet rainfall scenario in Duke Ravine



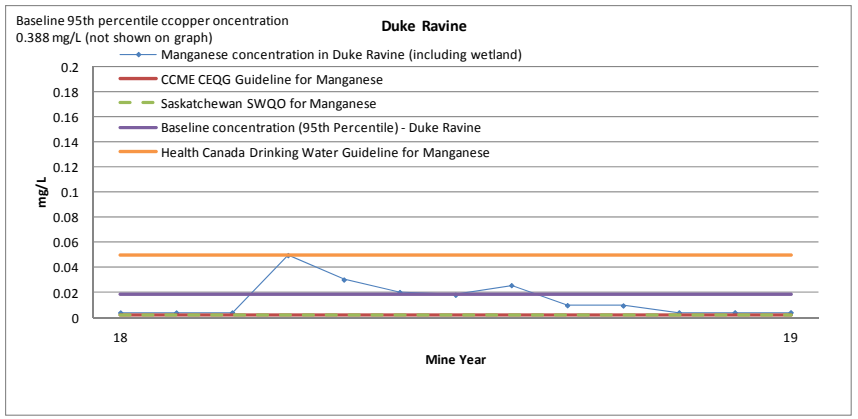
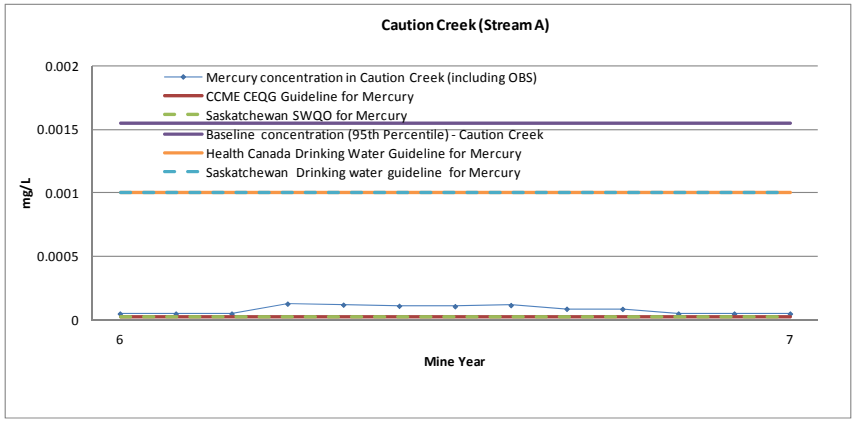


Figure 3-84 Comparison of predicted Mercury concentrations in a median and dry rainfall scenario in Caution Creek



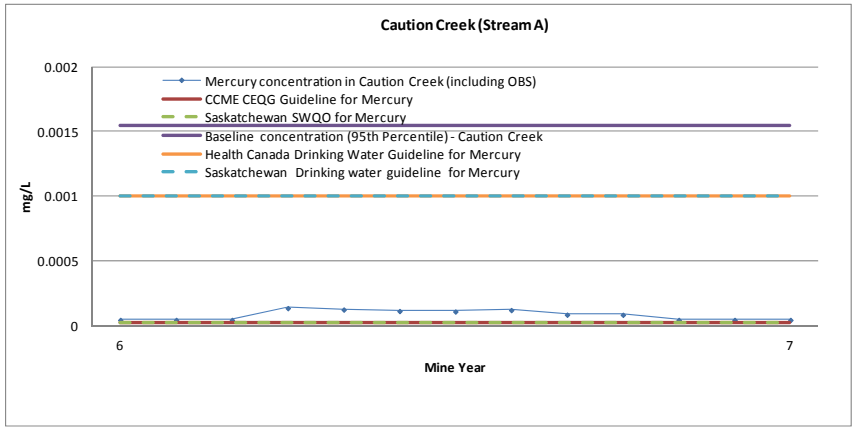
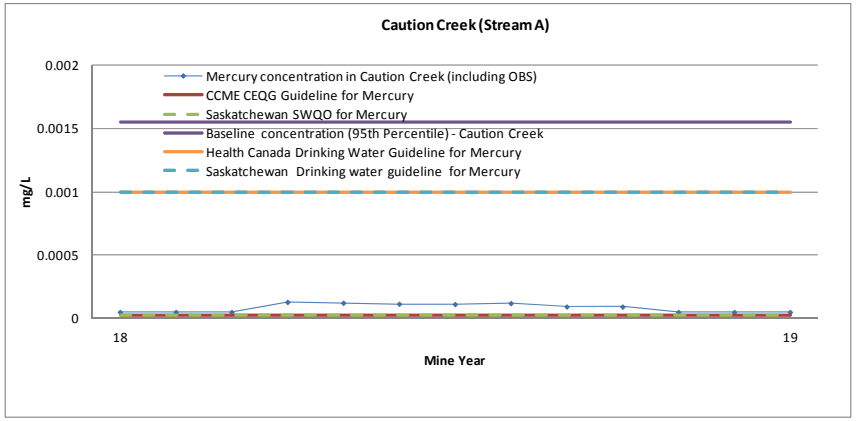


Figure 3-85 Comparison of predicted Mercury concentrations in a median and wet rainfall scenario in Caution Creek



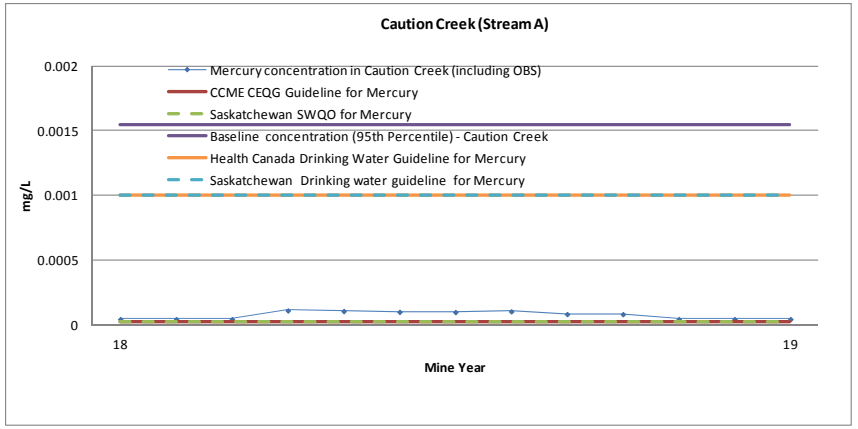
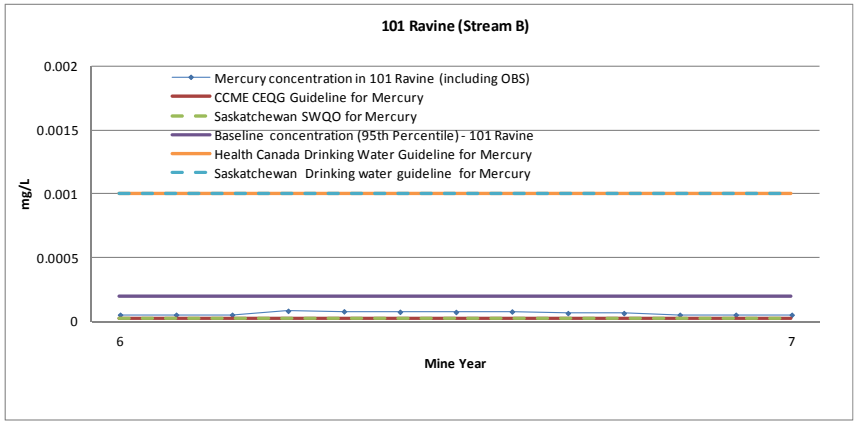


Figure 3-86 Comparison of predicted Mercury concentrations in a median and dry rainfall scenario in 101 Ravine



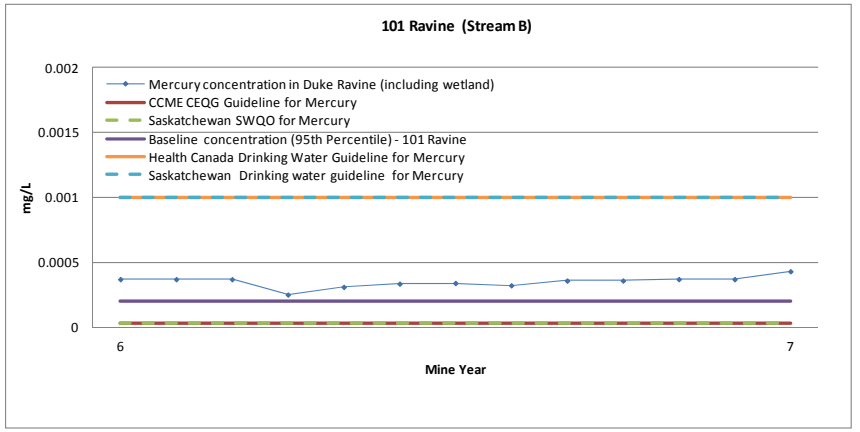
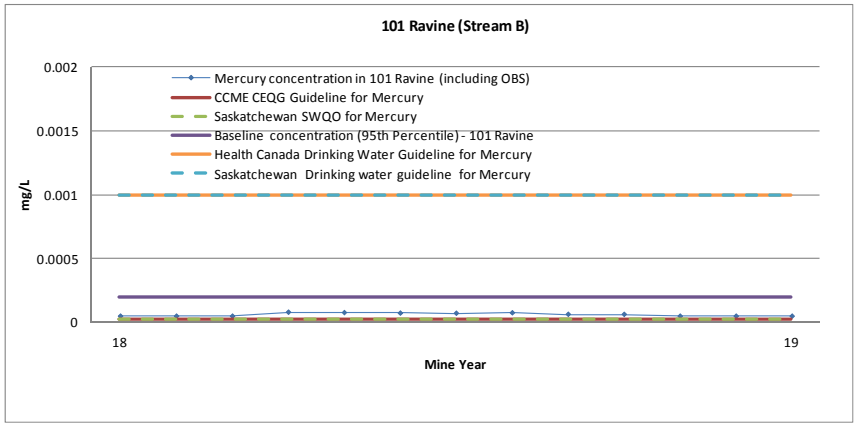


Figure 3-87 Comparison of predicted Mercury concentrations in a median and wet rainfall scenario in 101 Ravine



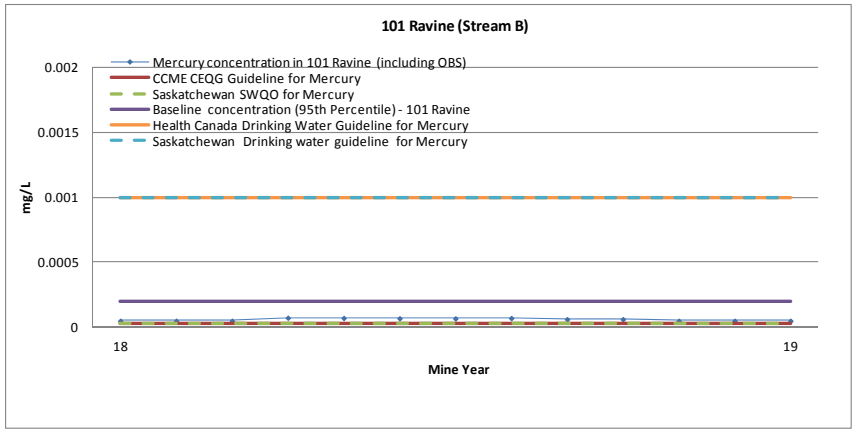
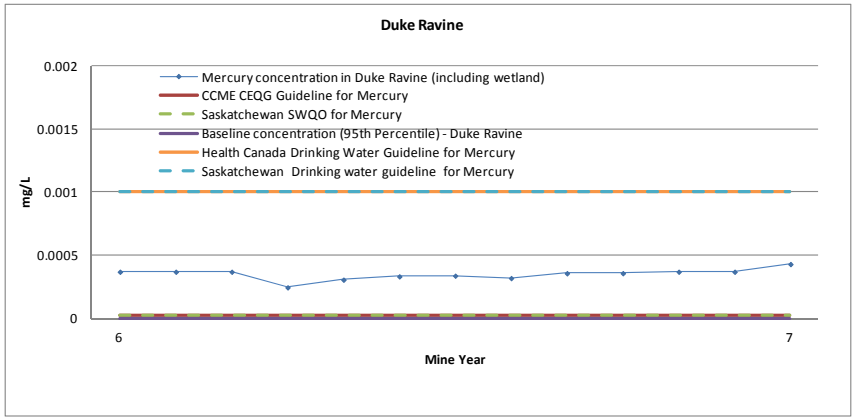


Figure 3-88 Comparison of predicted Mercury concentrations in a median and dry rainfall scenario in Duke Ravine



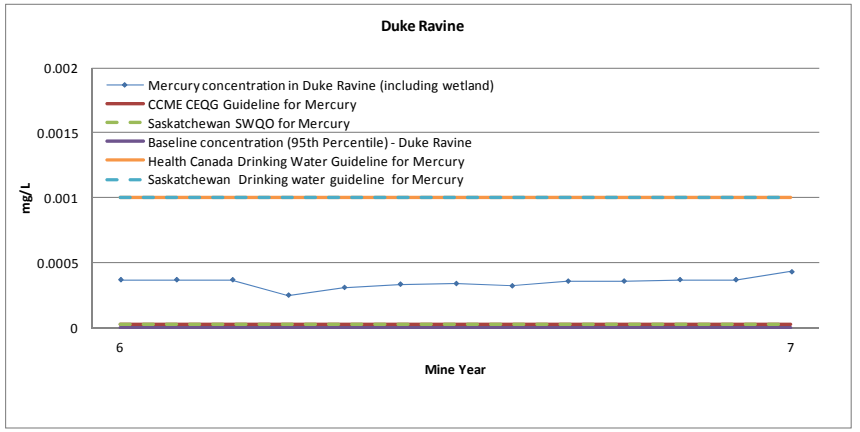
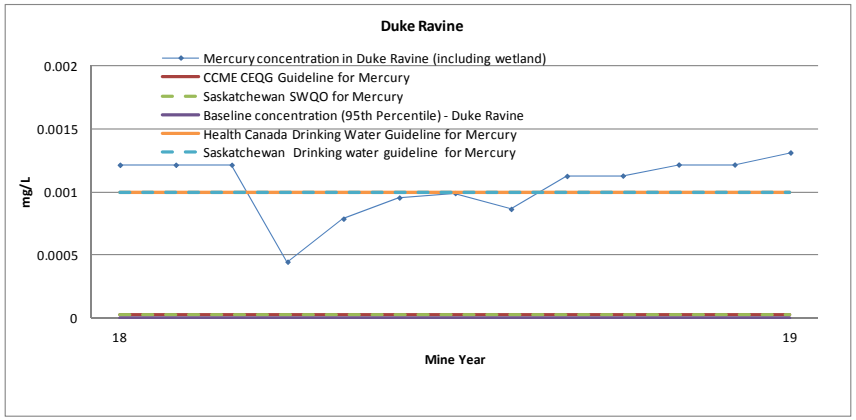


Figure 3-89 Comparison of predicted Mercury concentrations in a median and wet rainfall scenario in Duke Ravine



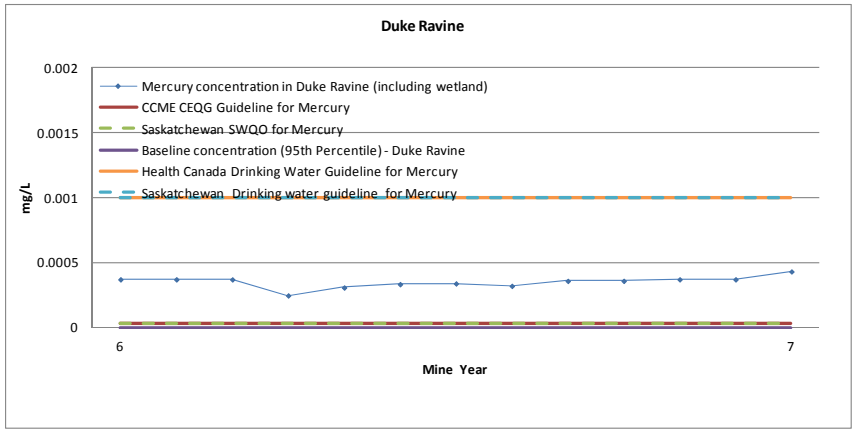
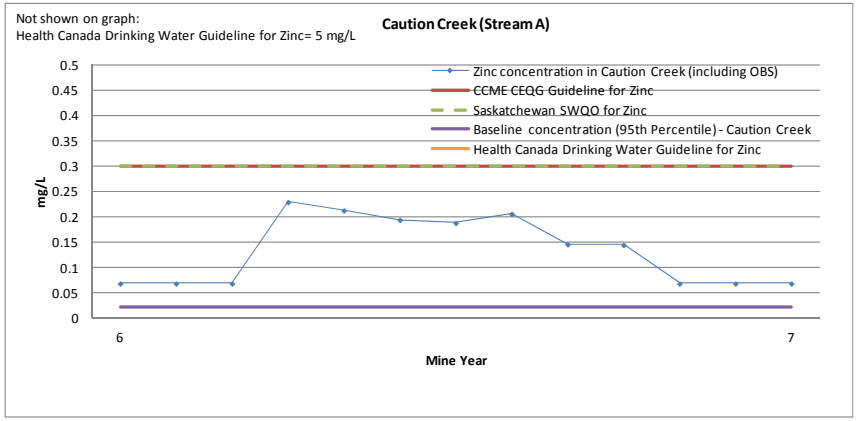


Figure 3-90 Comparison of predicted Zinc concentrations in a median and dry rainfall scenario in Caution Creek



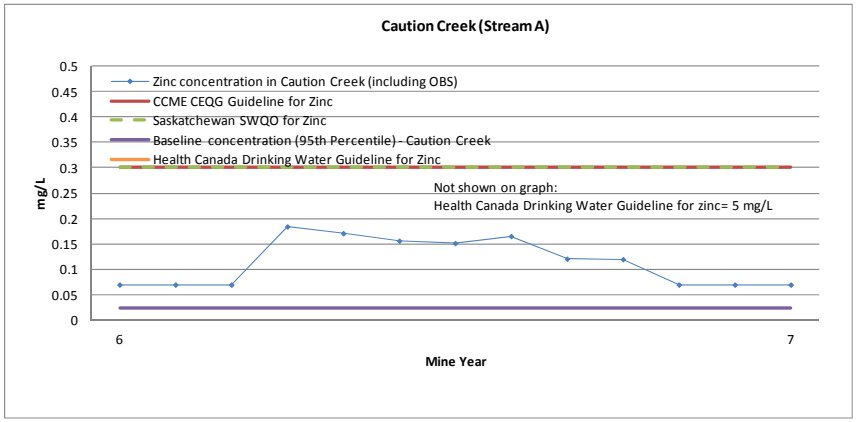
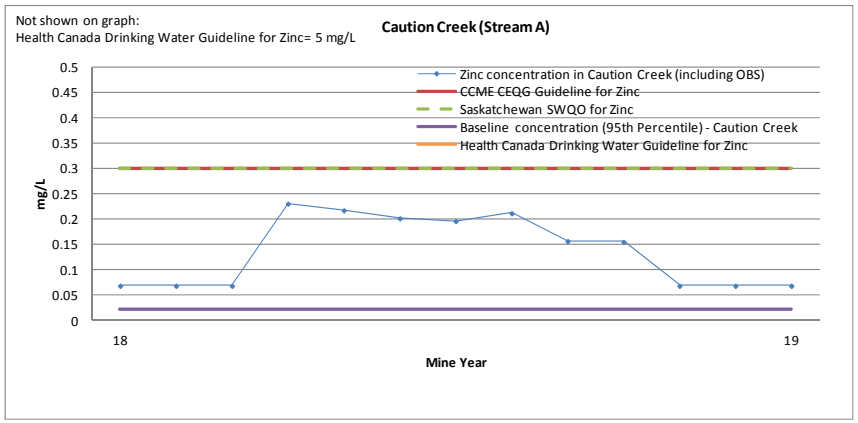


Figure 3-91 Comparison of predicted Zinc concentrations in a median and wet rainfall scenario in Caution Creek



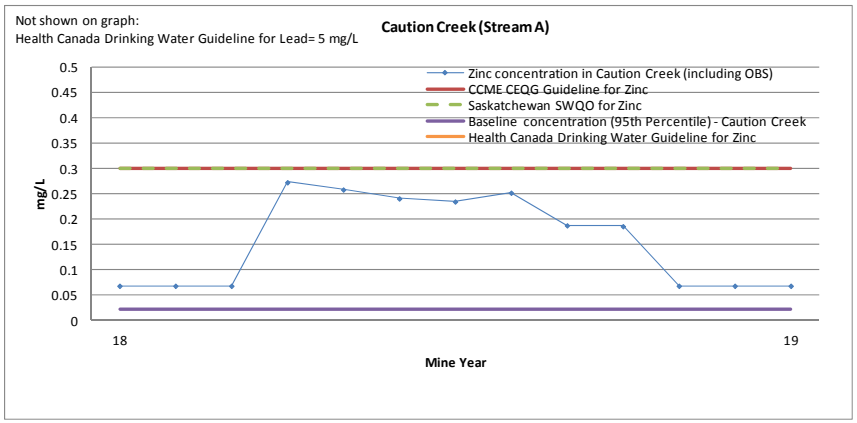
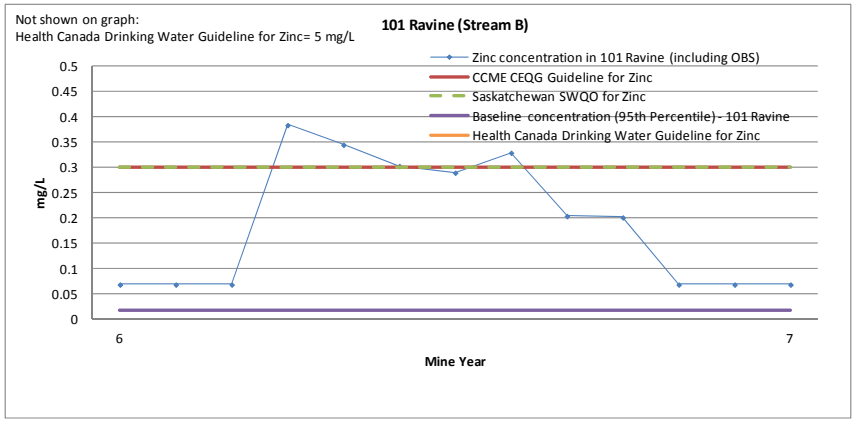


Figure 3-92 Comparison of predicted Zinc concentrations in a median and dry rainfall scenario in 101 Ravine



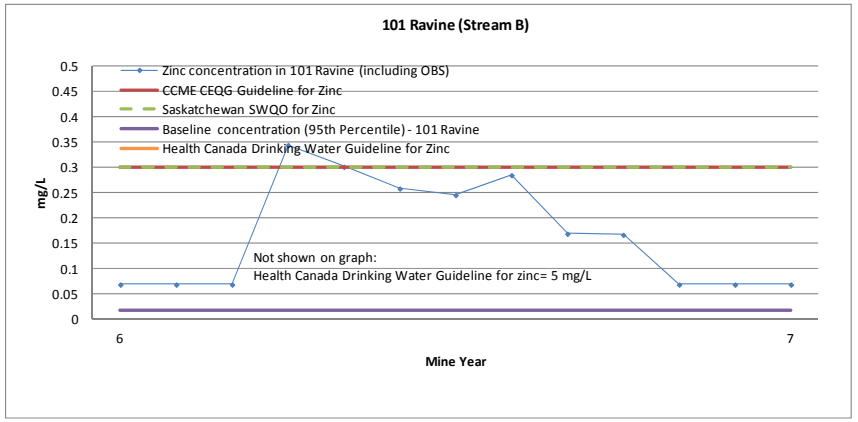
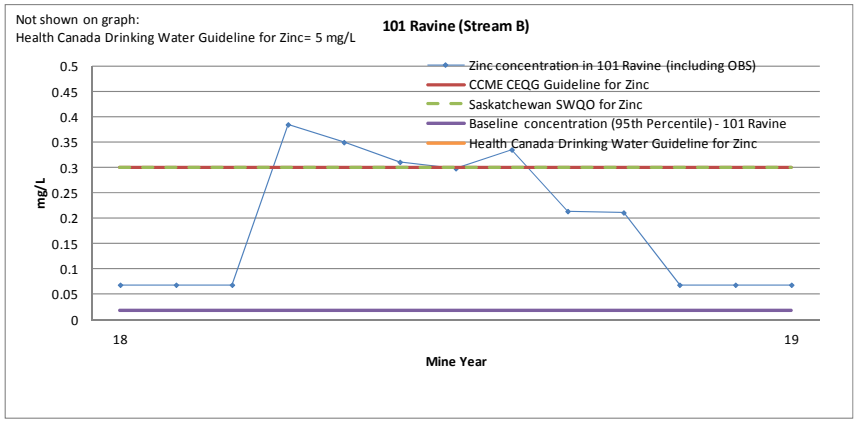


Figure 3-93 Comparison of predicted Zinc concentrations in a median and wet rainfall scenario in 101 Ravine



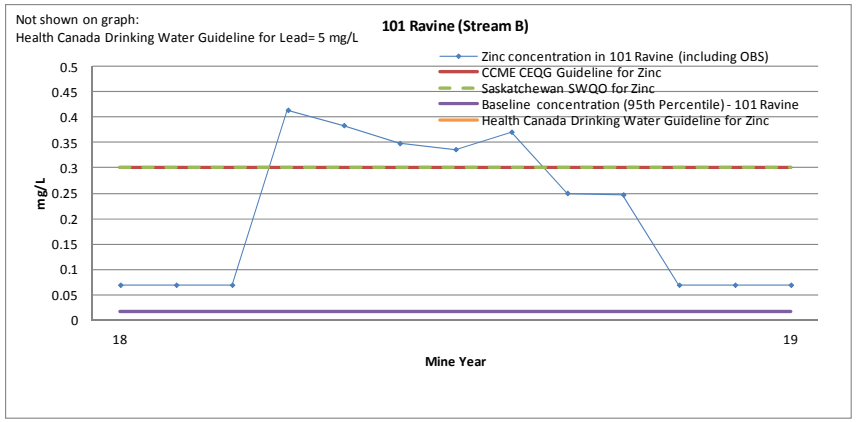
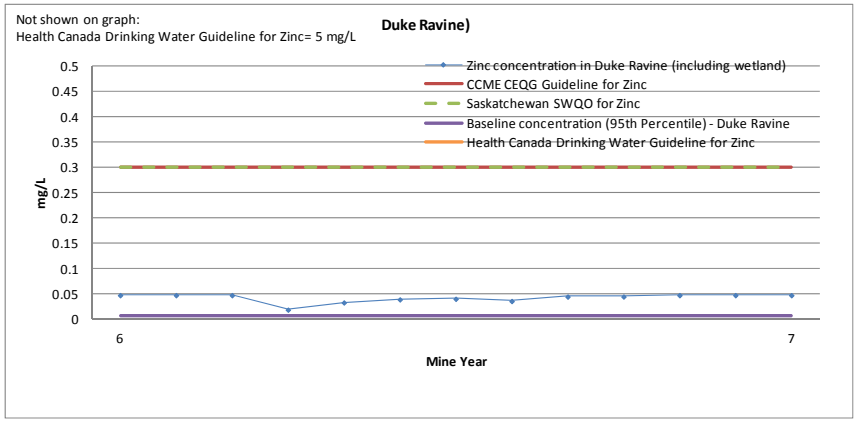


Figure 3-94 Comparison of predicted Zinc concentrations in a median and dry rainfall scenario in Duke Ravine



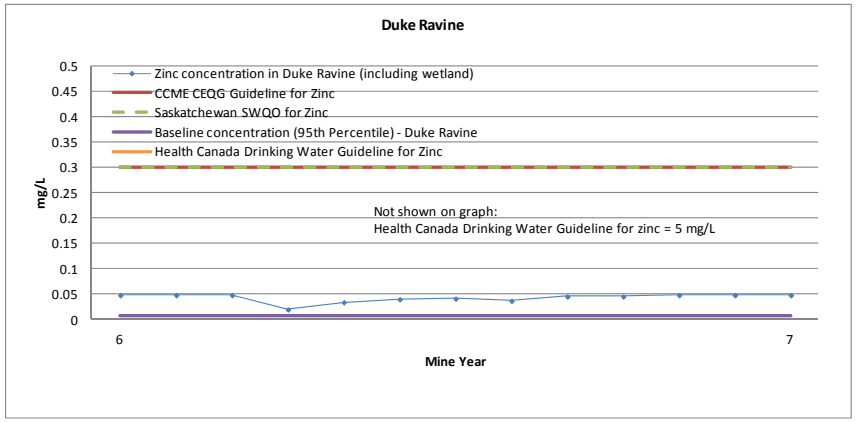
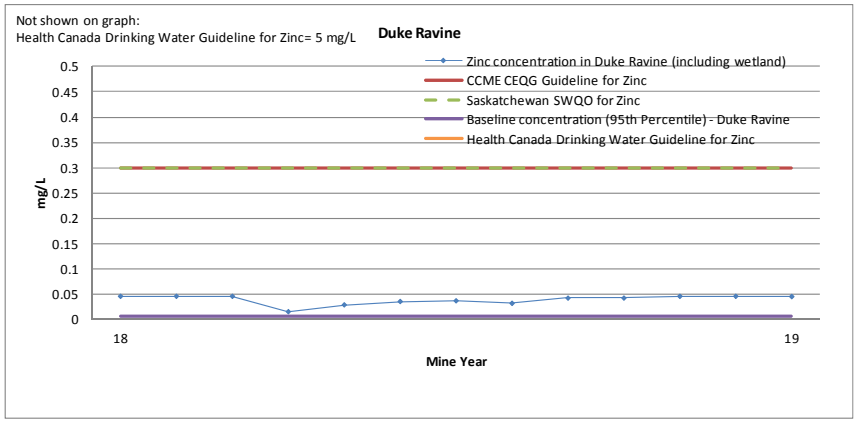
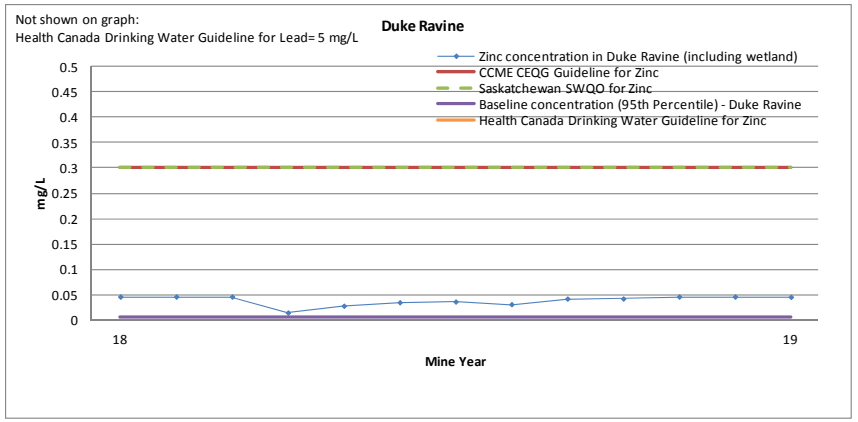


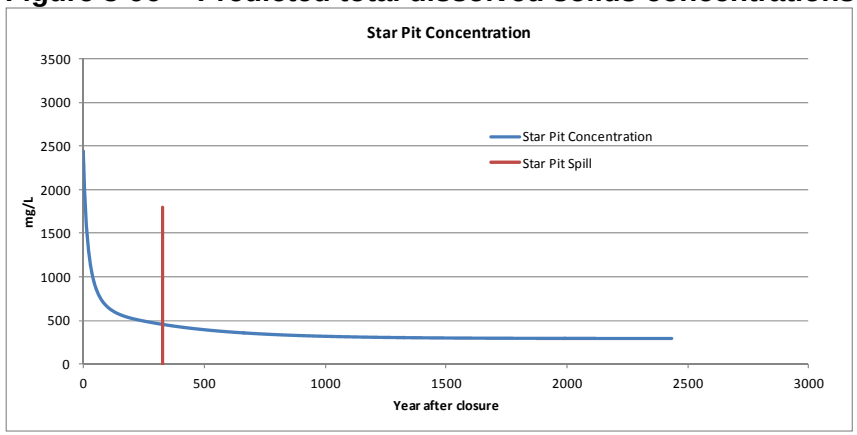
Figure 3-95 Comparison of predicted Zinc concentrations in a median and wet rainfall scenario in Duke Ravine





Annual changes of water quality in Star and Orion pit

Figure 3-96 Predicted total dissolved solids concentrations at closure



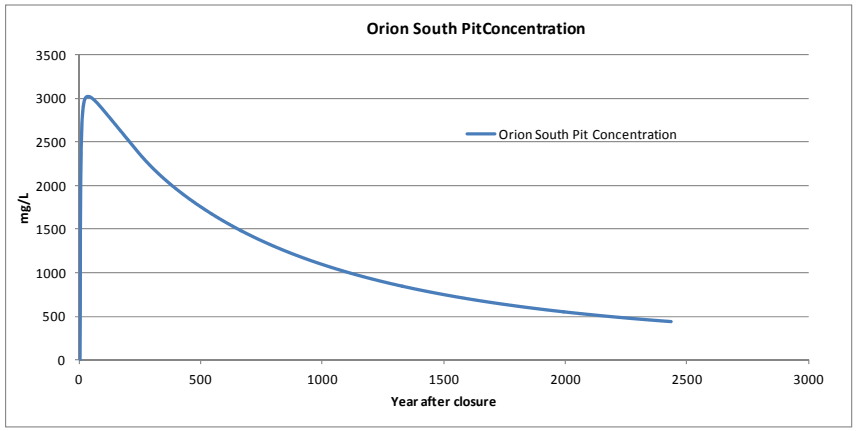
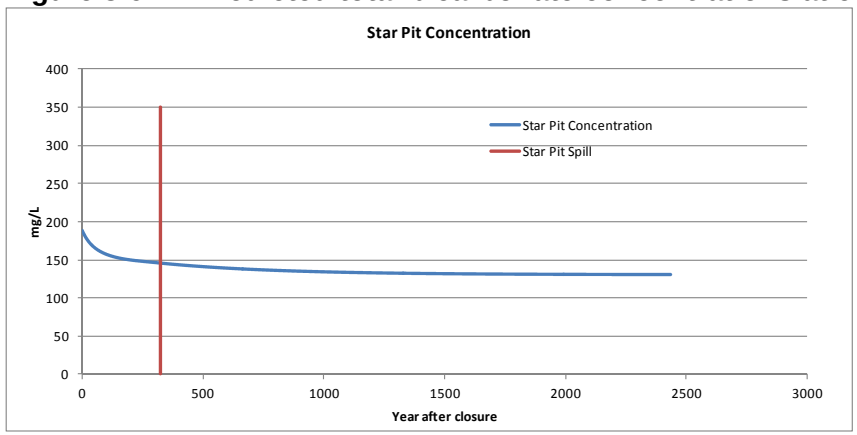


Figure 3-97 Predicted total bicarbonate concentrations at closure



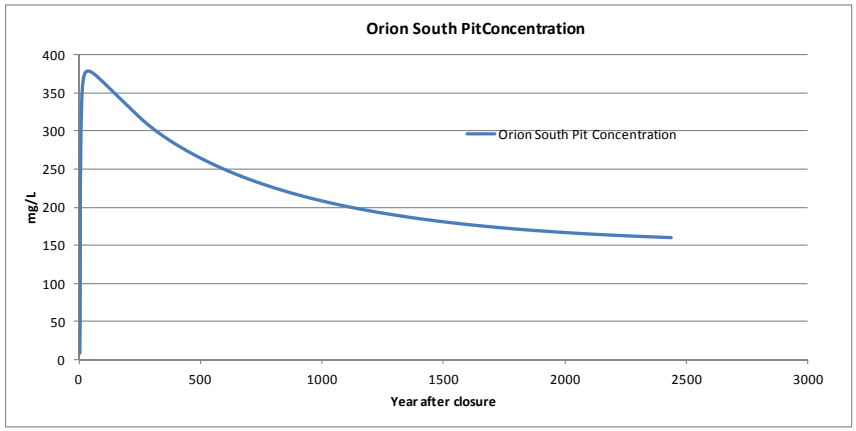
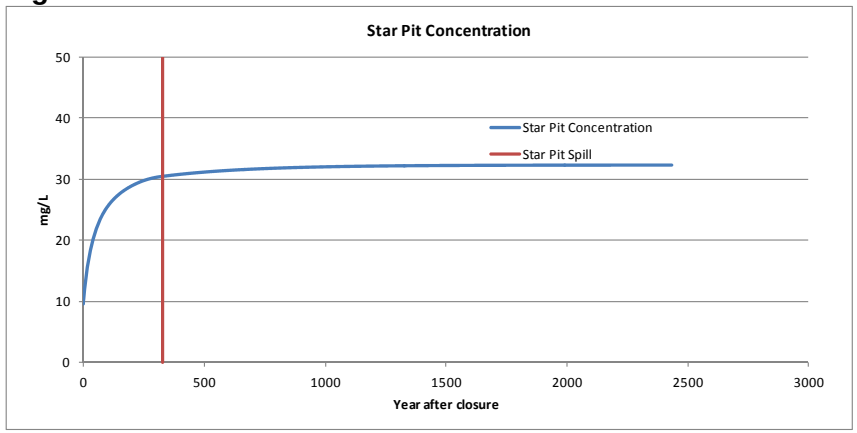


Figure 3-98 Predicted calcium concentrations at closure



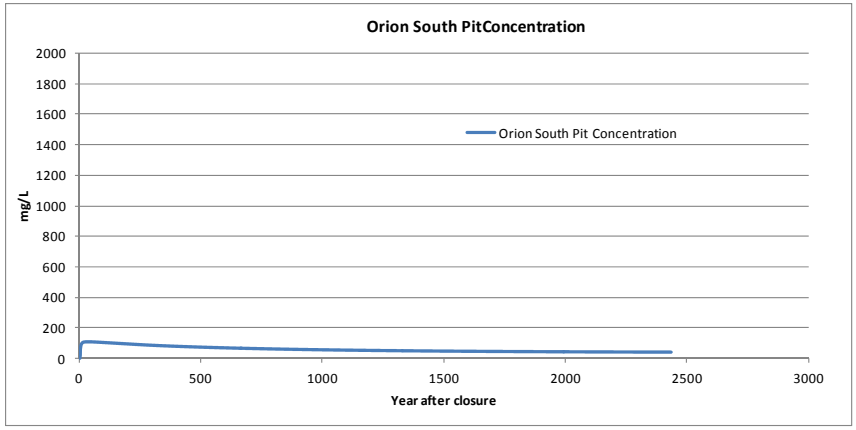
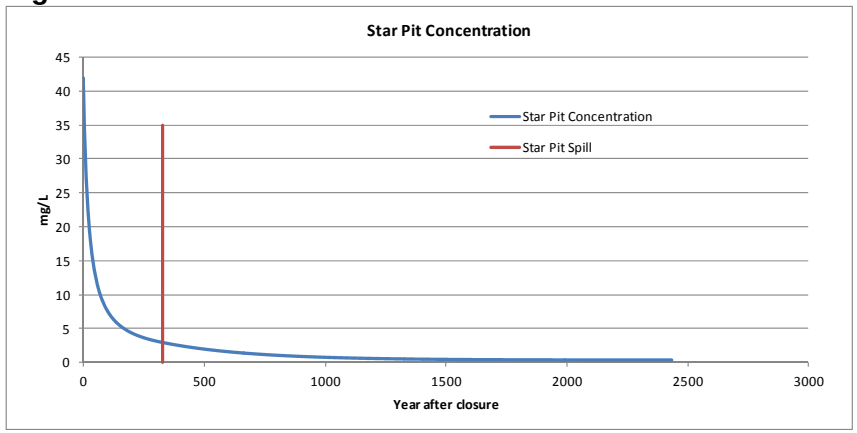


Figure 3-99 Predicted carbonate concentrations at closure



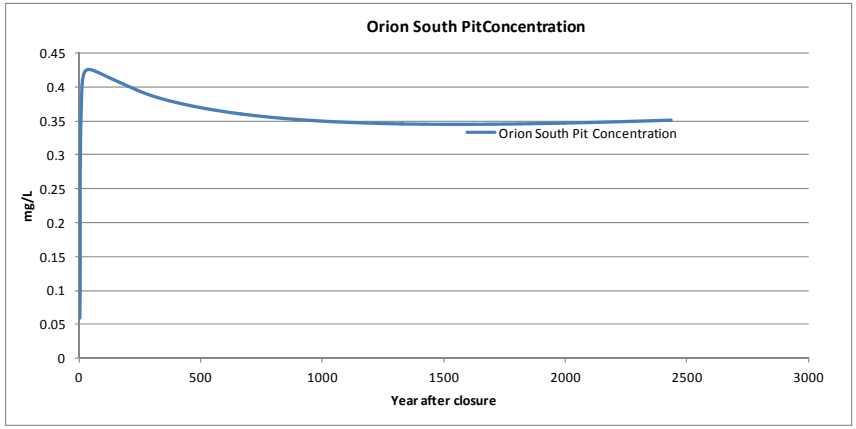
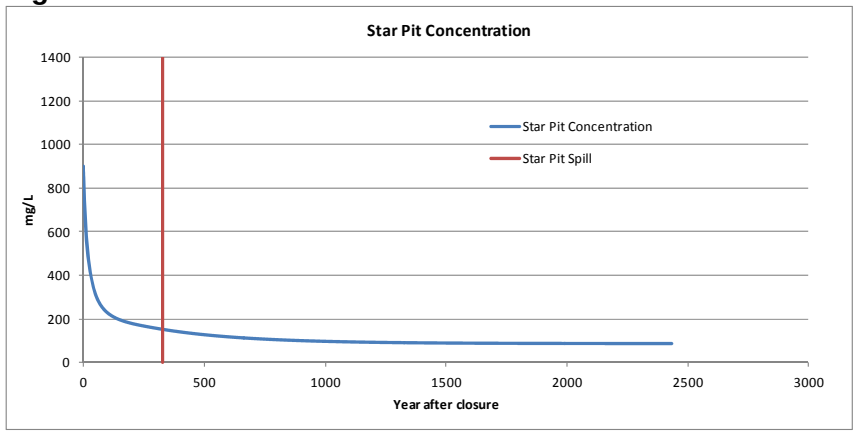


Figure 3-100 Predicted chloride concentrations at closure



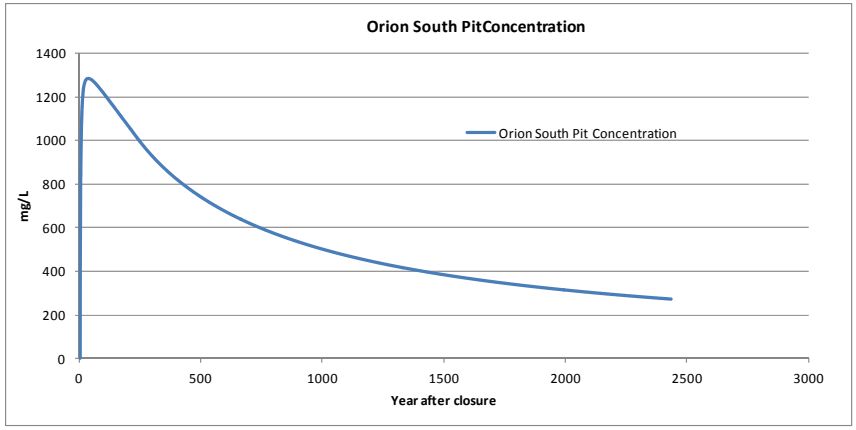
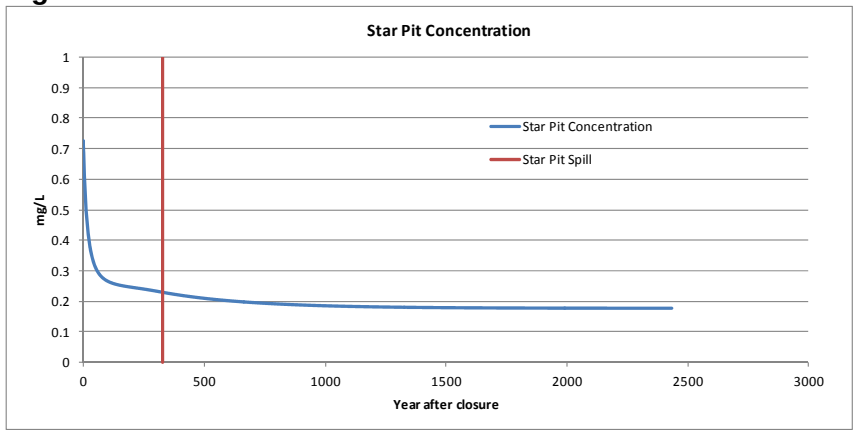


Figure 3-101 Predicted fluoride concentrations at closure



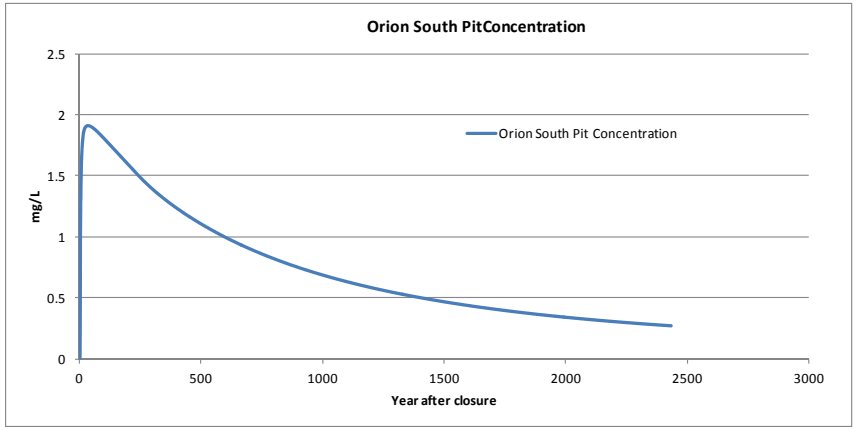
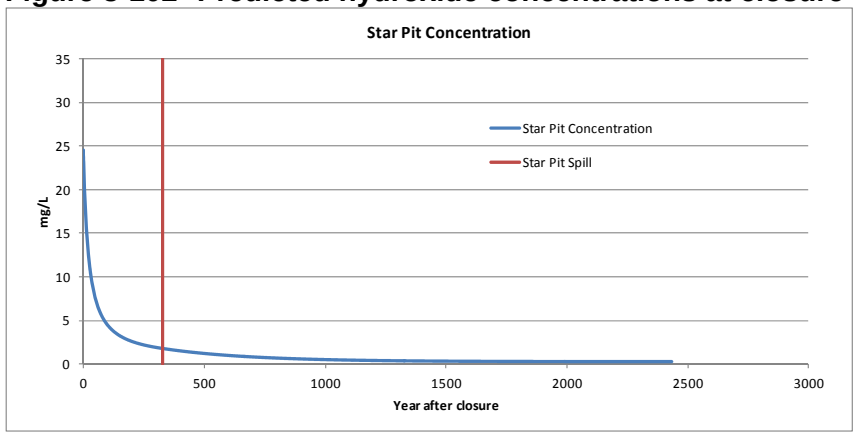


Figure 3-102 Predicted hydroxide concentrations at closure



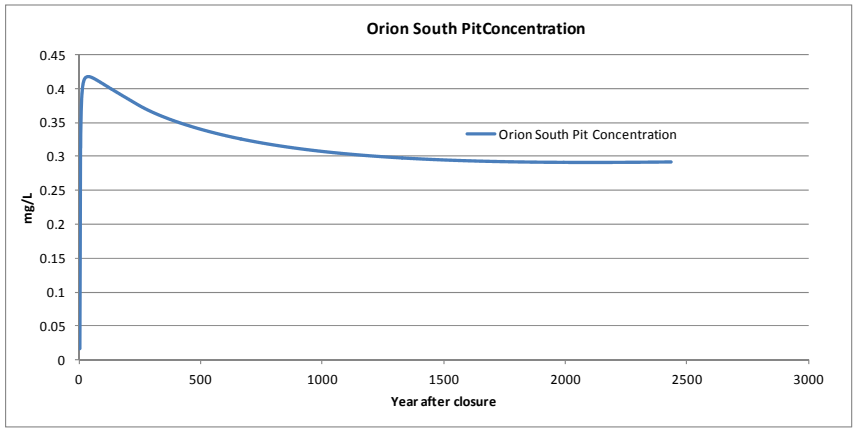
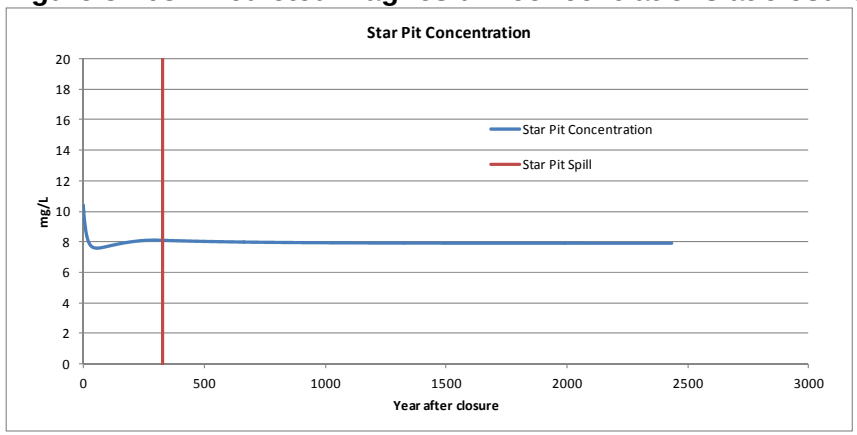


Figure 3-103 Predicted magnesium concentrations at closure



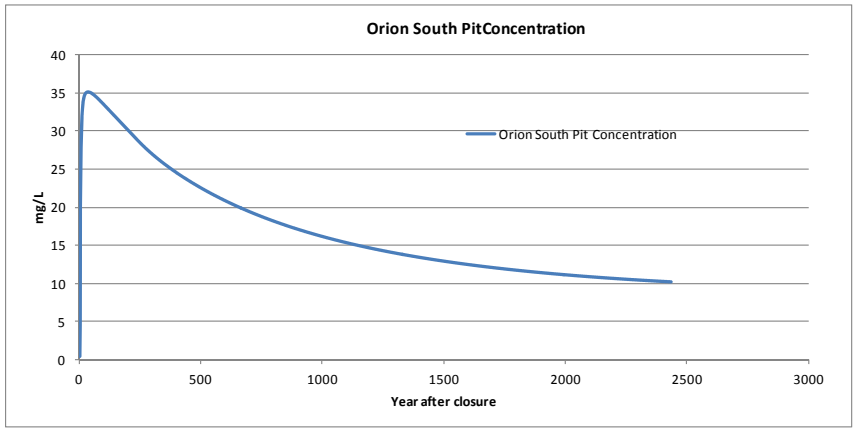
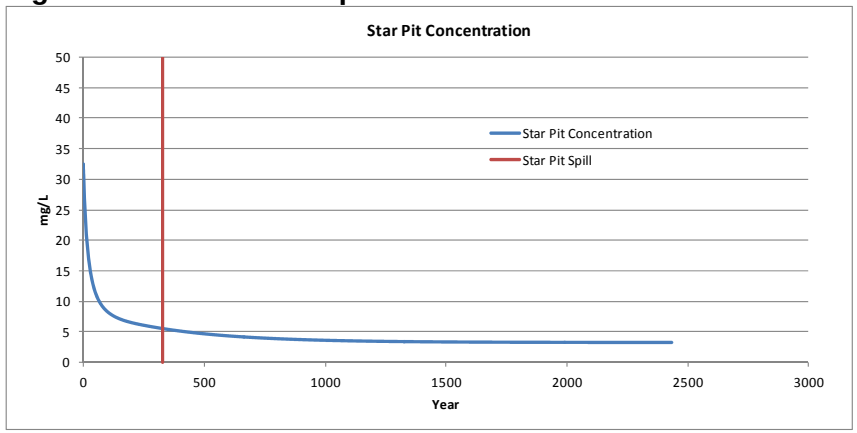


Figure 3-104 Predicted potassium concentrations at closure



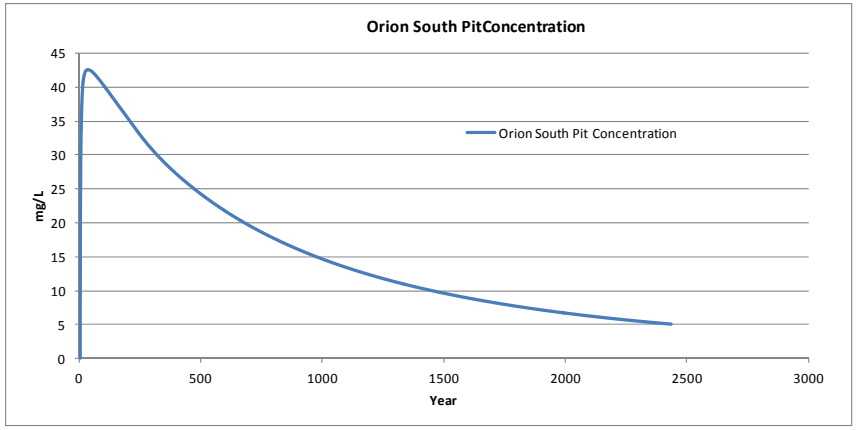
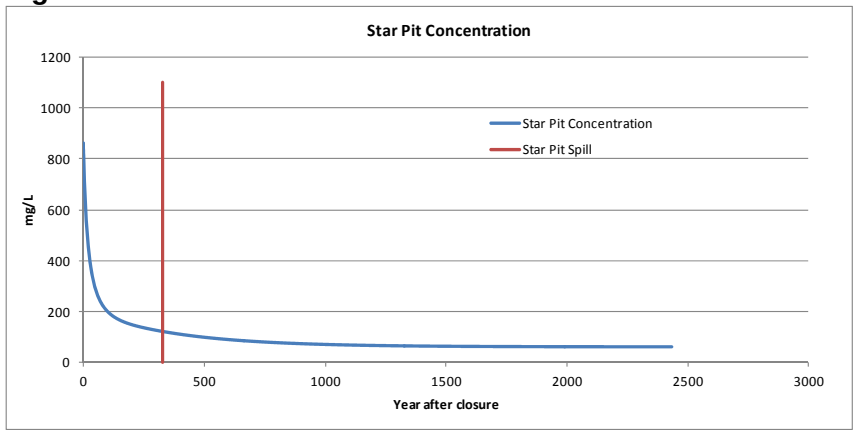


Figure 3-105 Predicted sodium concentrations at closure



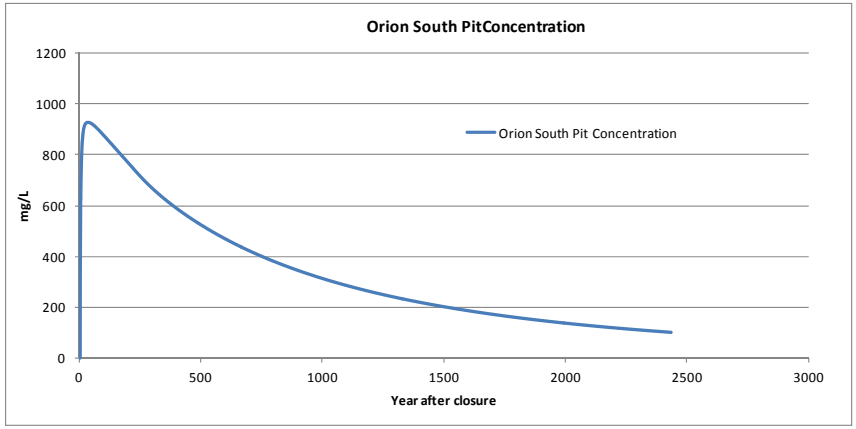
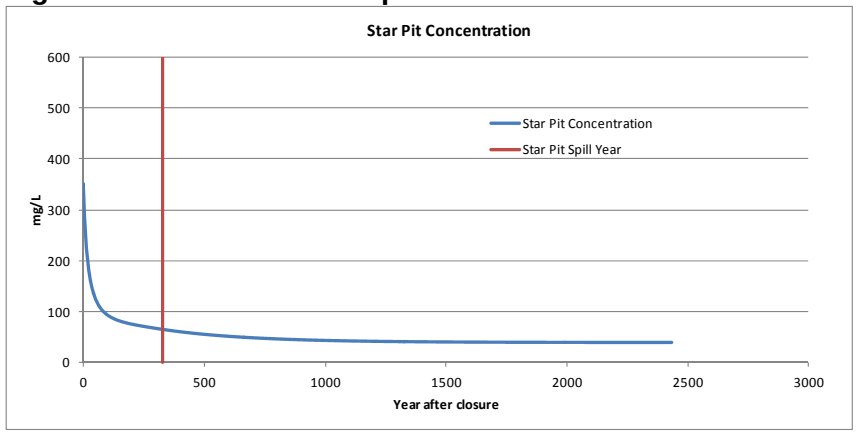


Figure 3-106 Predicted sulphate concentrations at closure



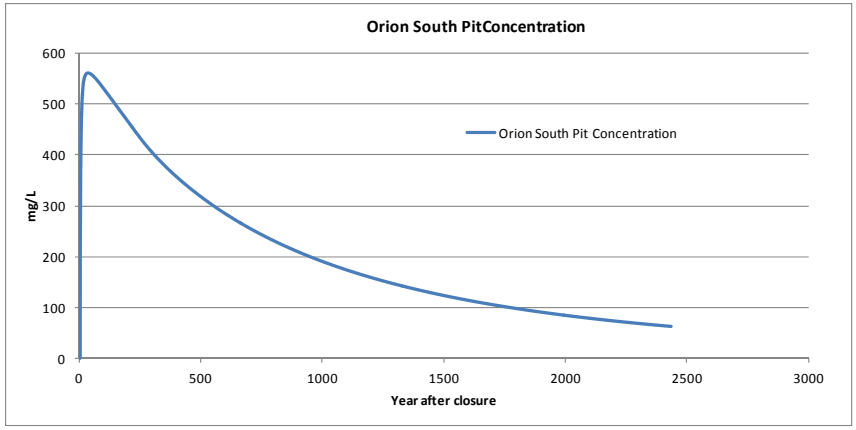
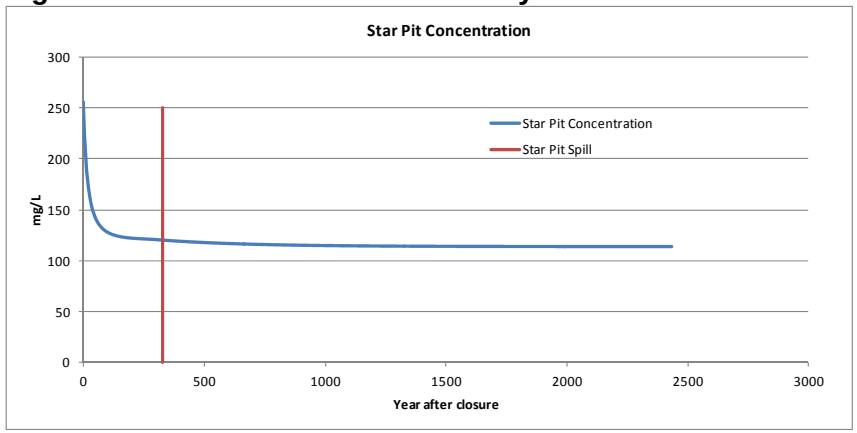


Figure 3-107 Predicted total alkalinity at closure



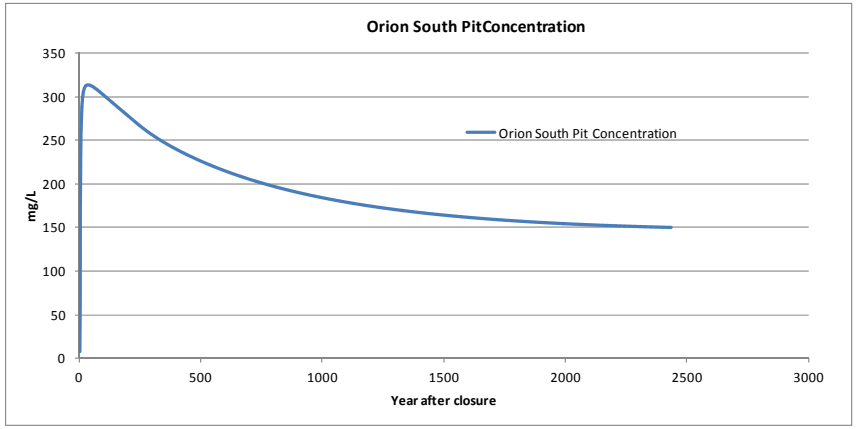
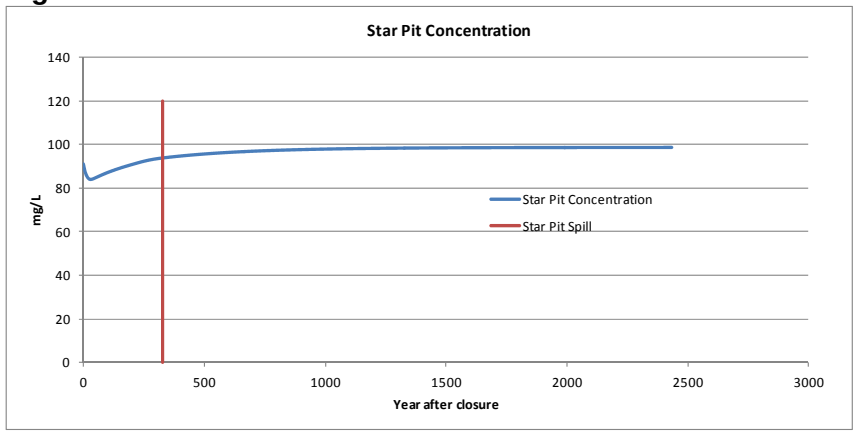


Figure 3-108 Predicted total hardness concentrations at closure



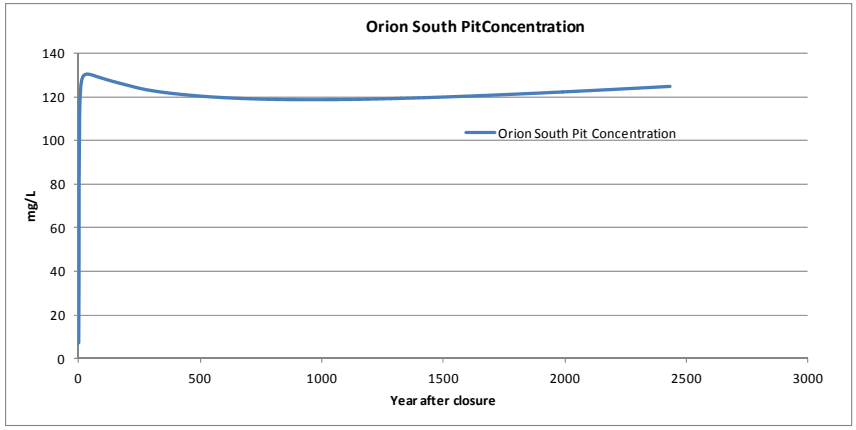
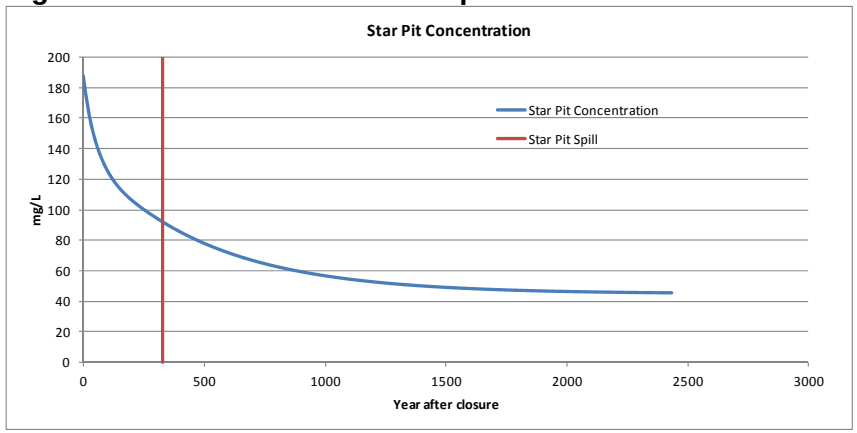


Figure 3-109 Predicted total suspended solids concentrations at closure



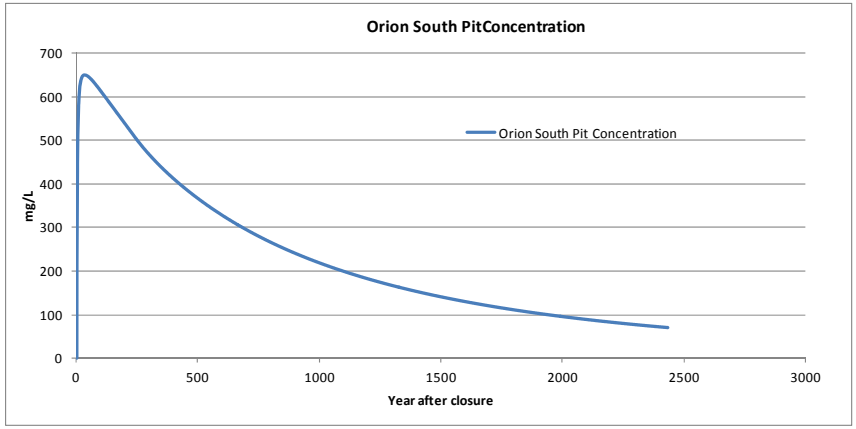
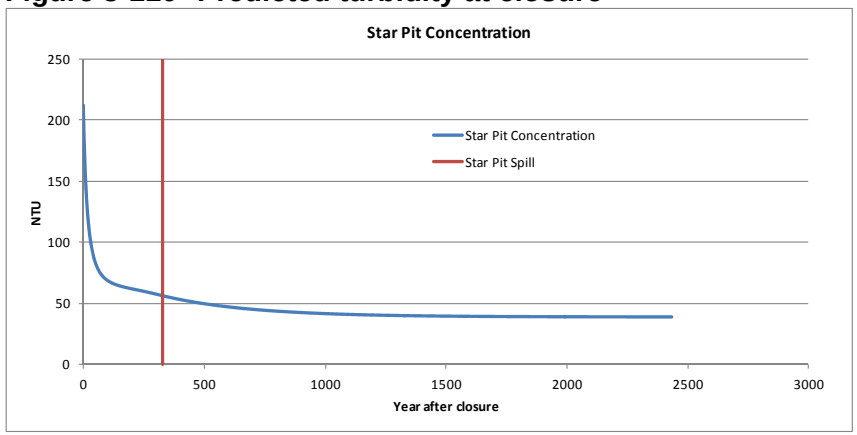


Figure 3-110 Predicted turbidity at closure



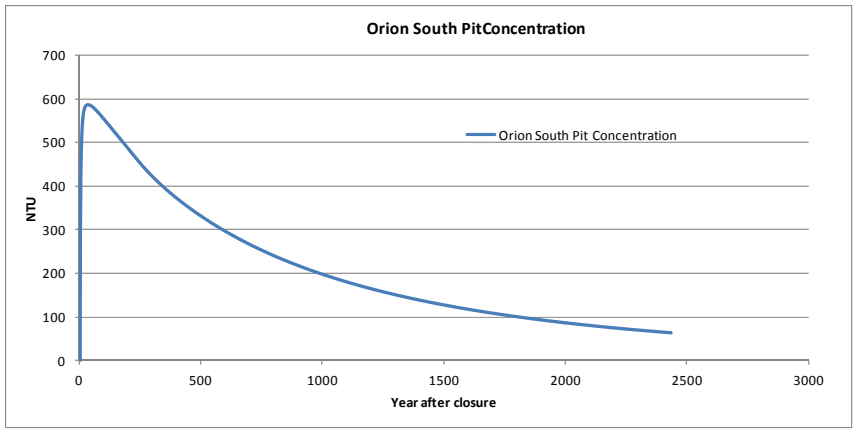
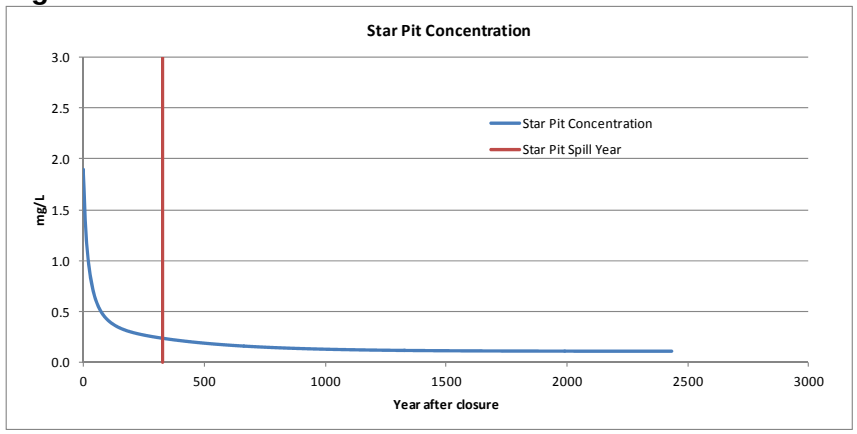


Figure 3-111 Predicted ammonia concentrations at closure



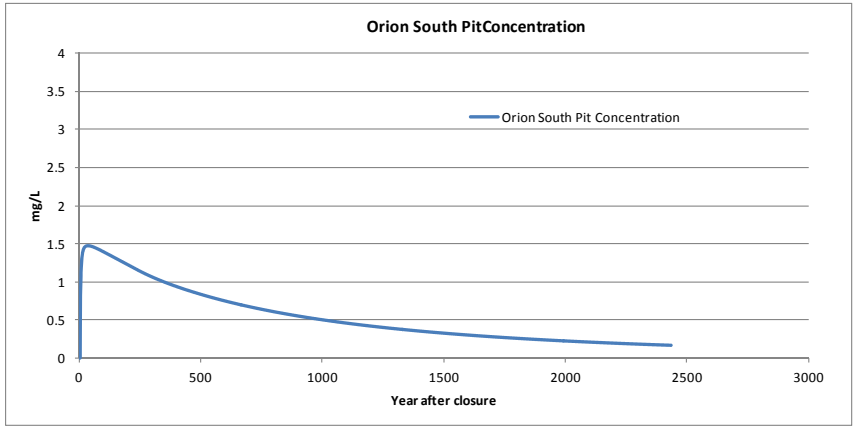
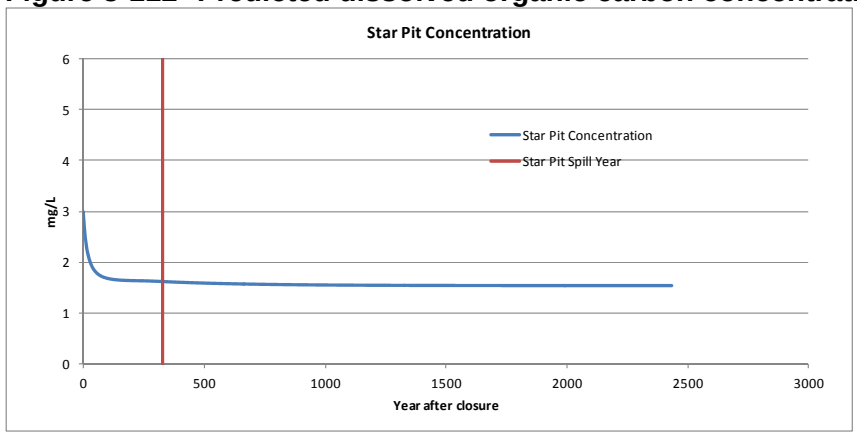


Figure 3-112 Predicted dissolved organic carbon concentrations at closure



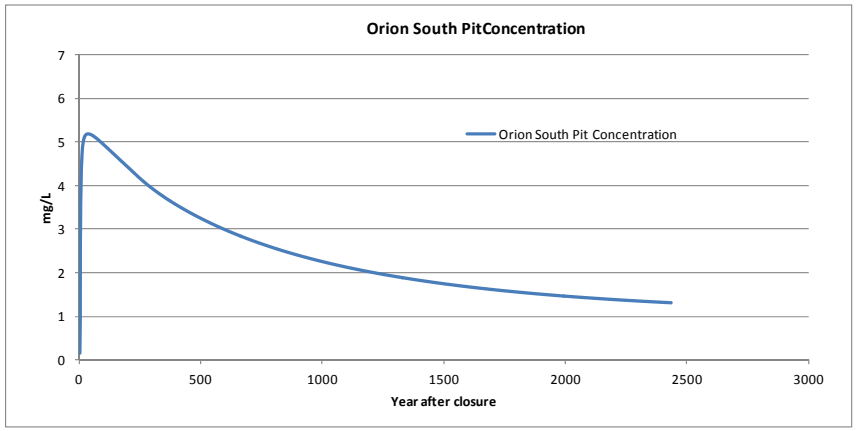
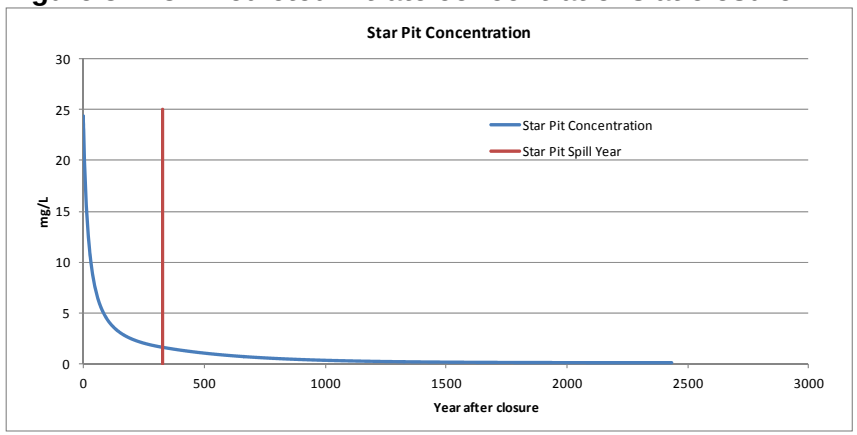


Figure 3-113 Predicted nitrate concentrations at closure



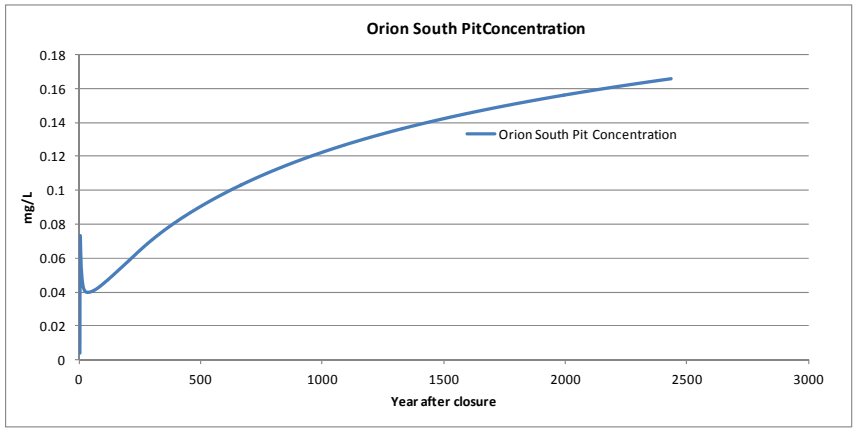
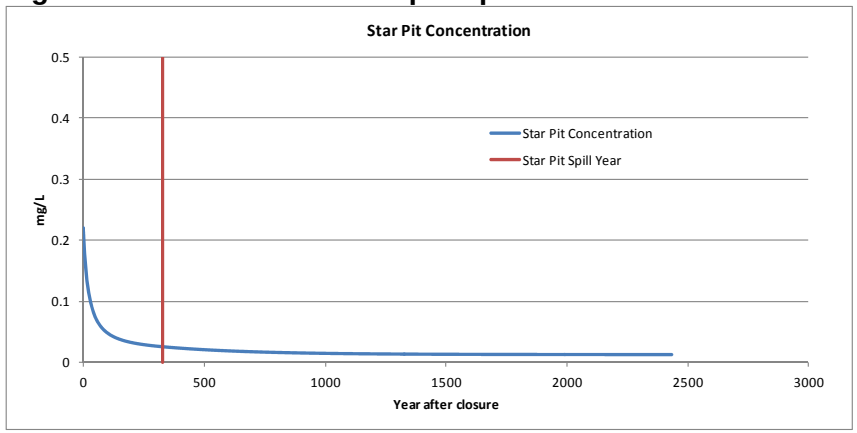


Figure 3-114 Predicted total phosphorus concentrations at closure



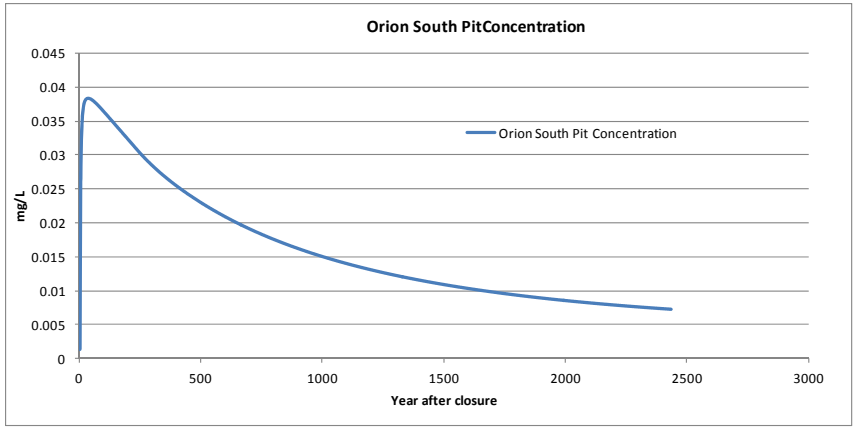
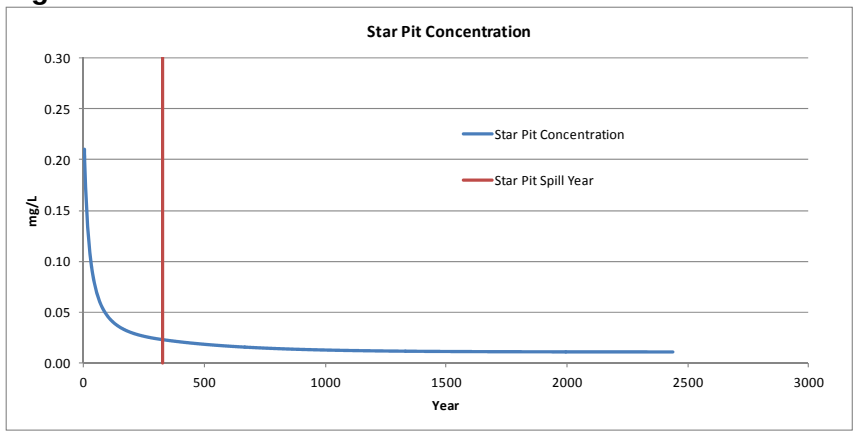


Figure 3-115 Predicted aluminum concentrations at closure



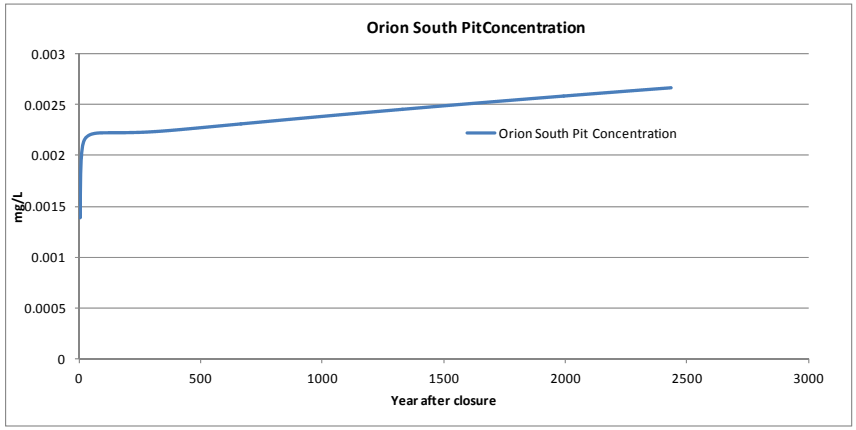
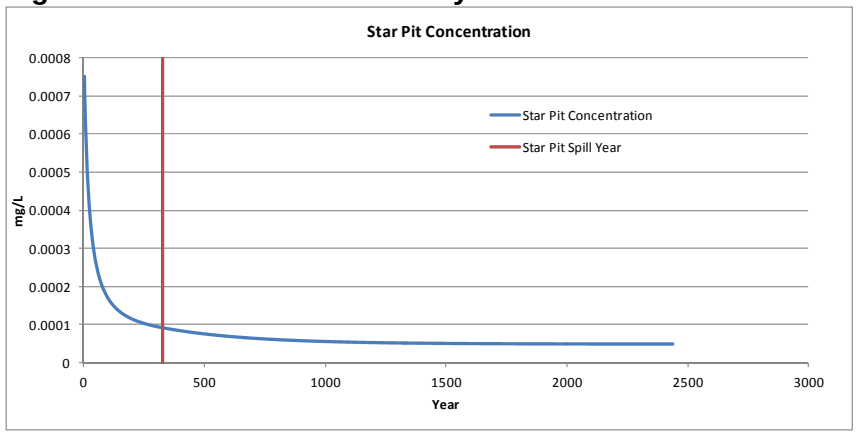


Figure 3-116 Predicted antimony concentrations at closure



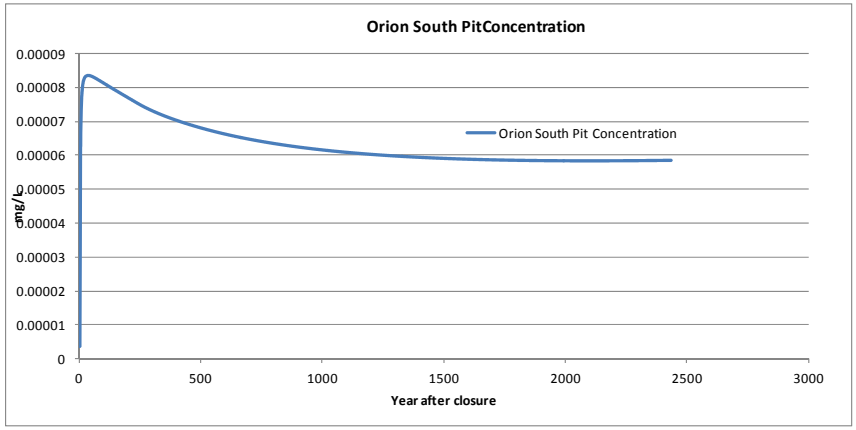
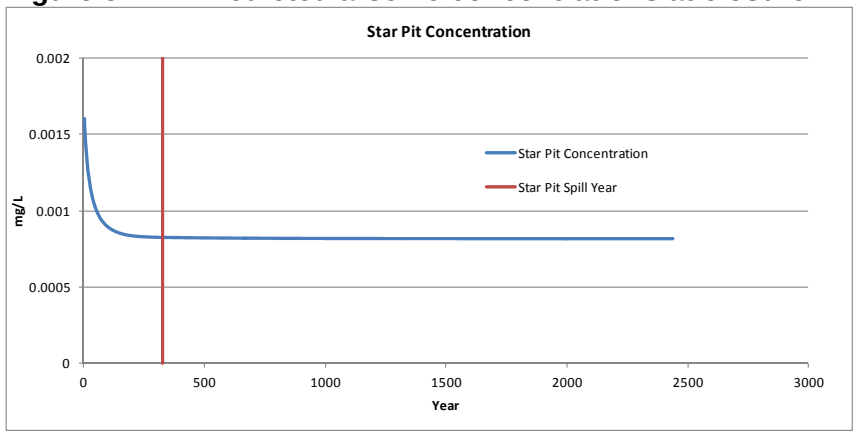


Figure 3-117 Predicted arsenic concentrations at closure



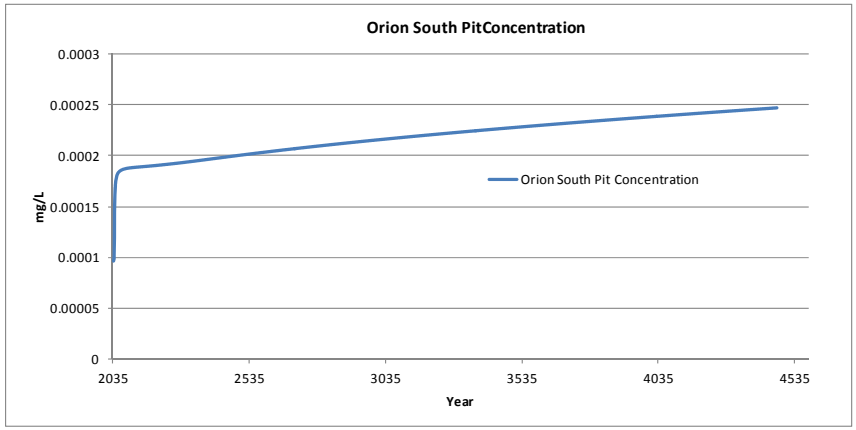
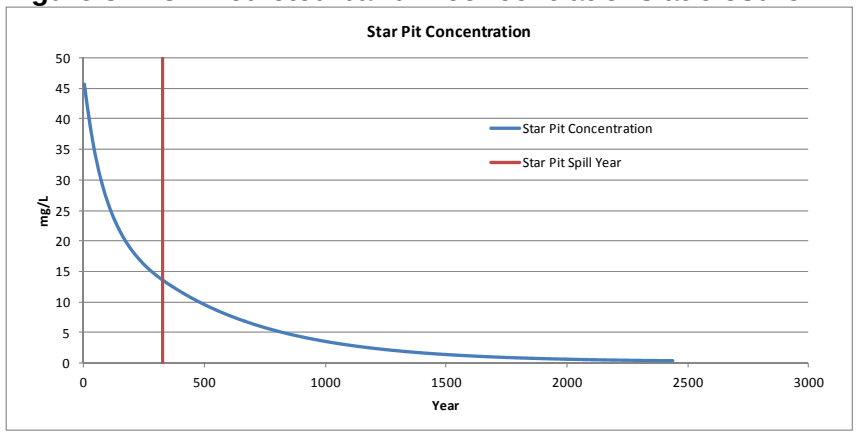


Figure 3-118 Predicted barium concentrations at closure



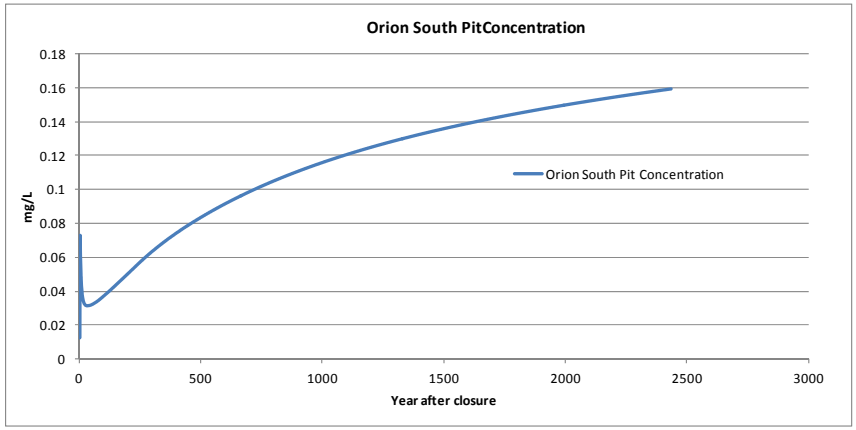
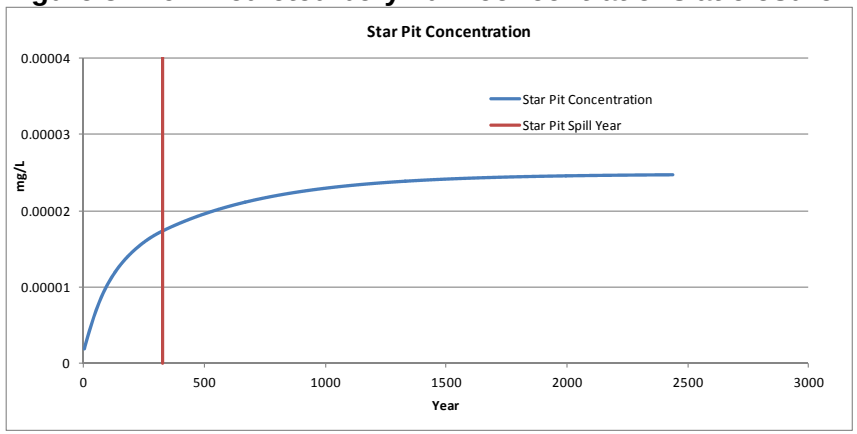


Figure 3-119 Predicted beryllium concentrations at closure



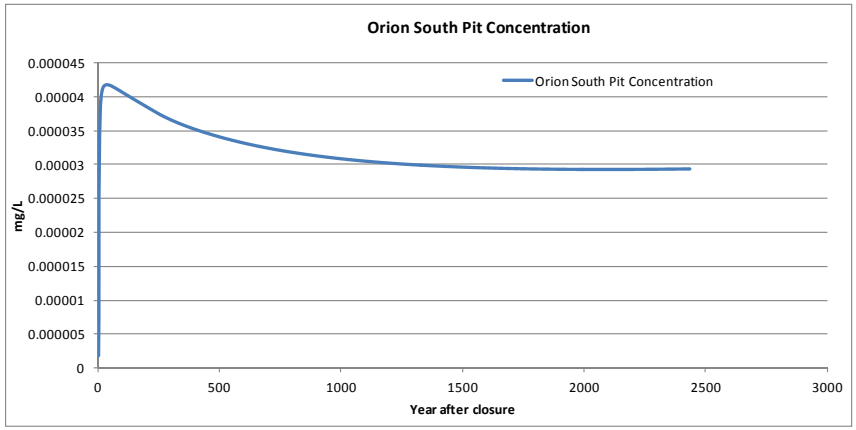
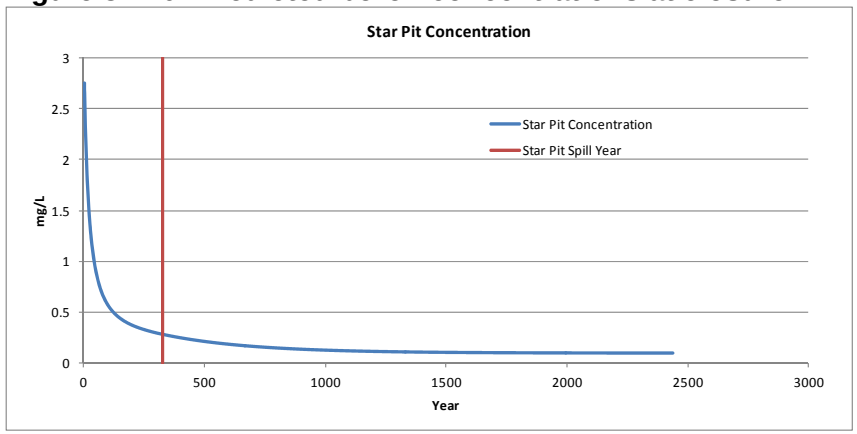


Figure 3-120 Predicted boron concentrations at closure



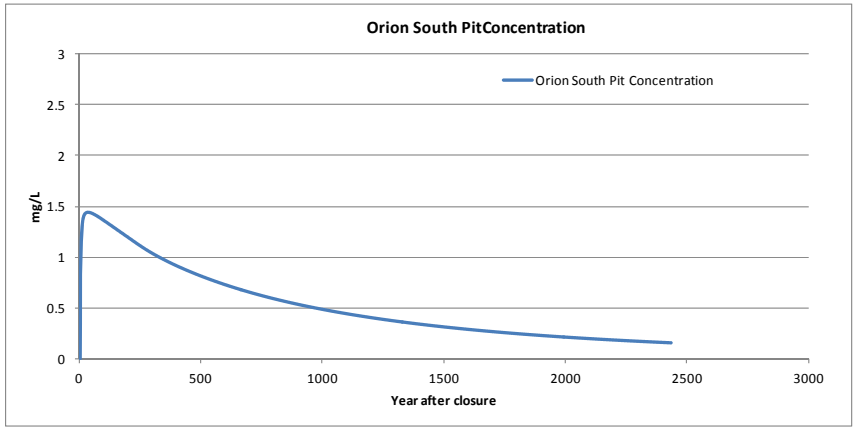
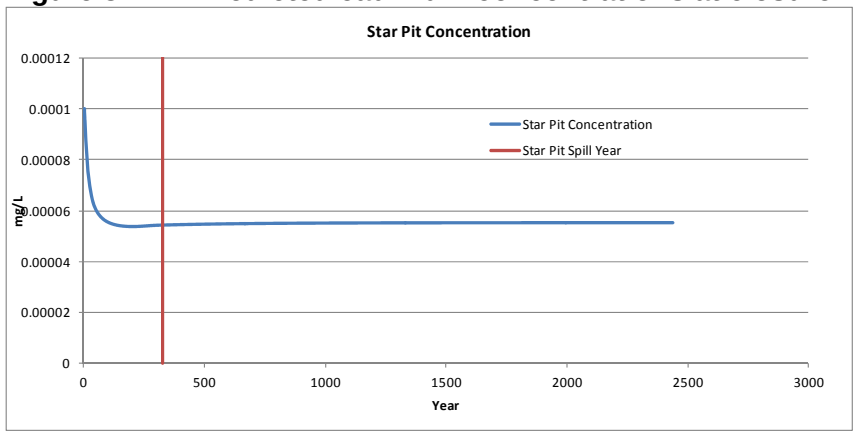


Figure 3-121 Predicted cadmium concentrations at closure



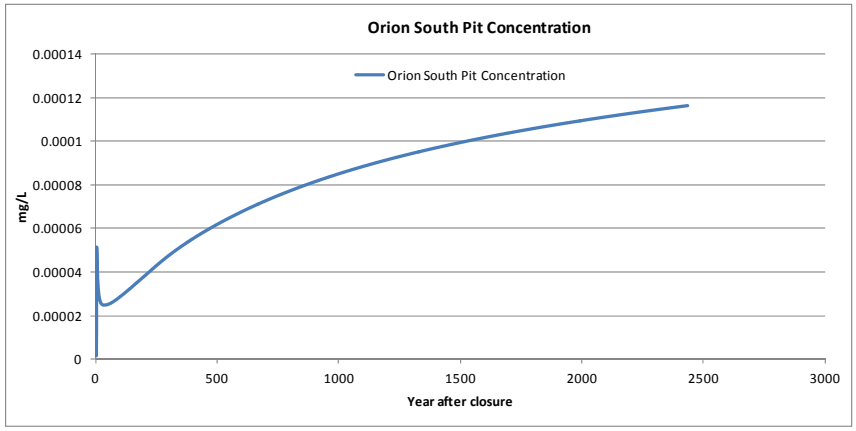
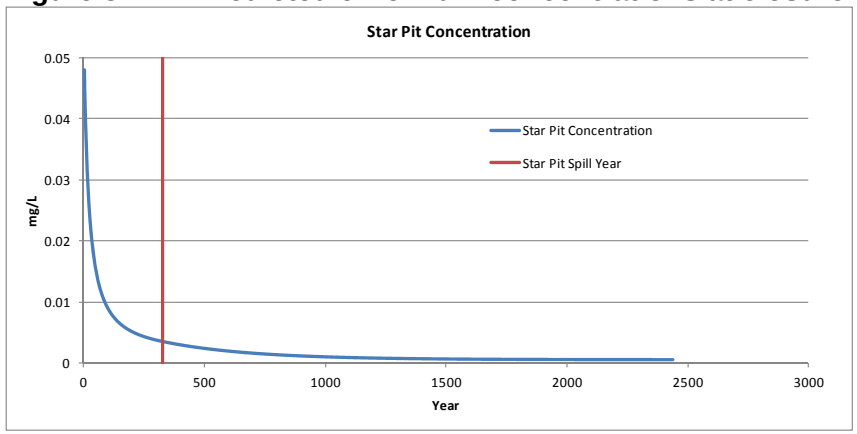


Figure 3-122 Predicted chromium concentrations at closure



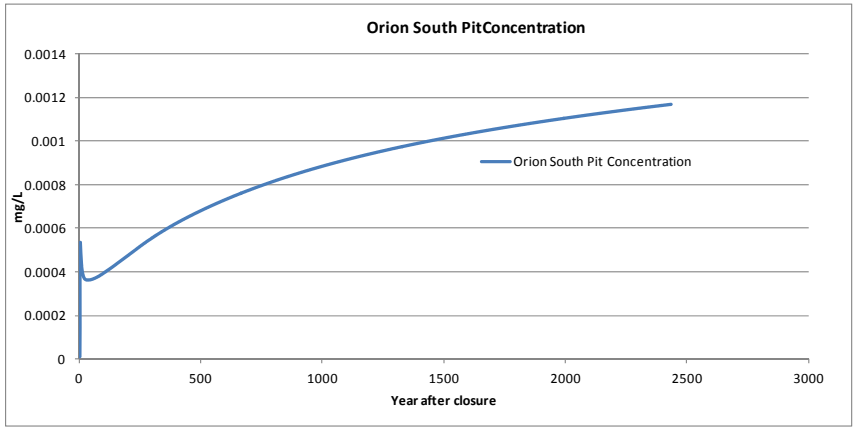
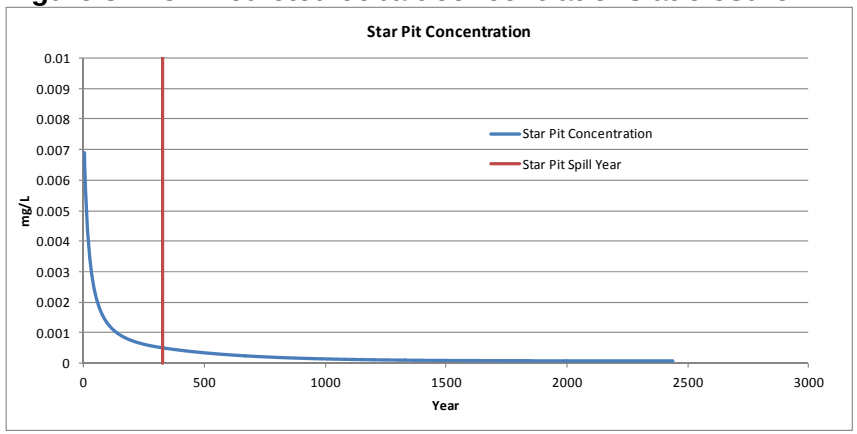


Figure 3-123 Predicted cobalt concentrations at closure



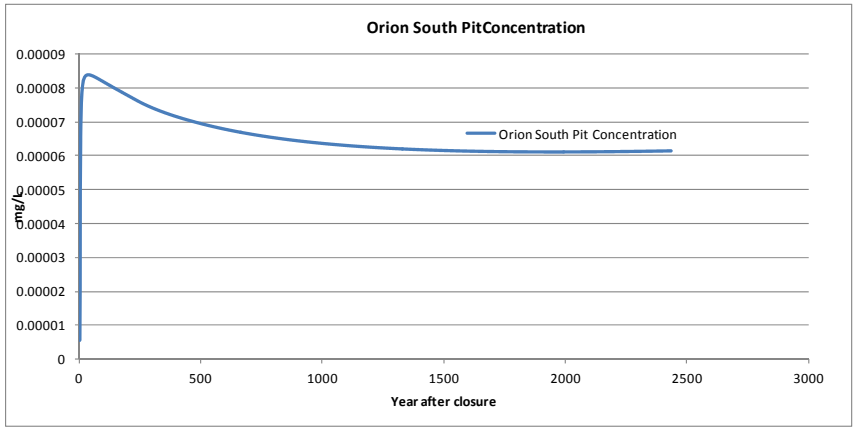
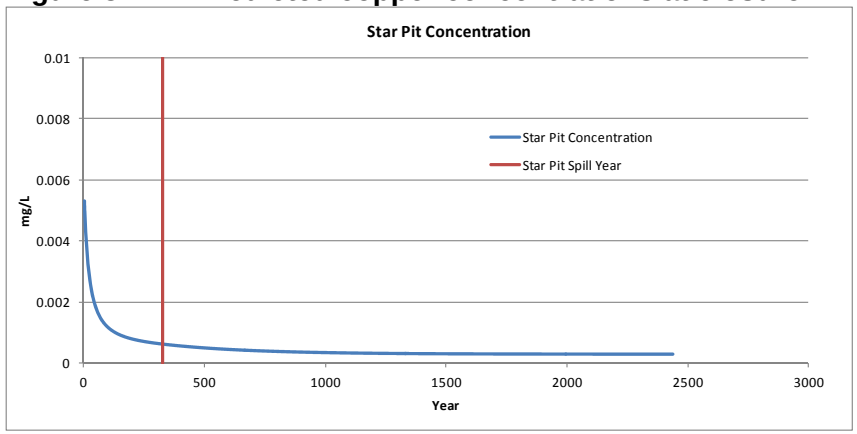


Figure 3-124 Predicted copper concentrations at closure



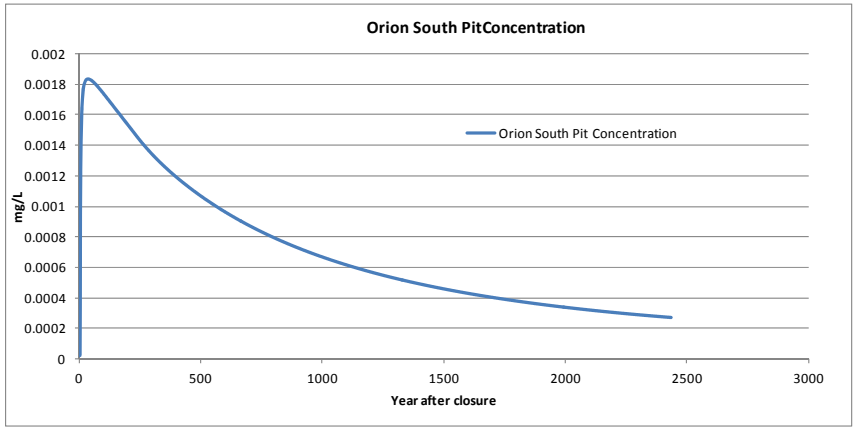
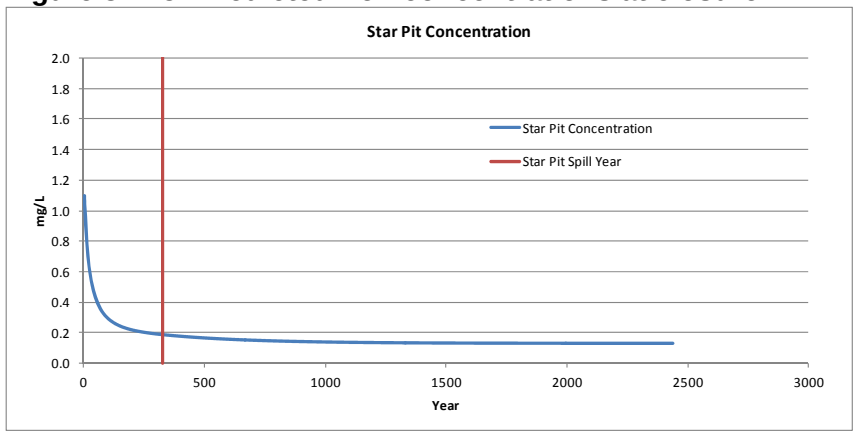


Figure 3-125 Predicted iron concentrations at closure



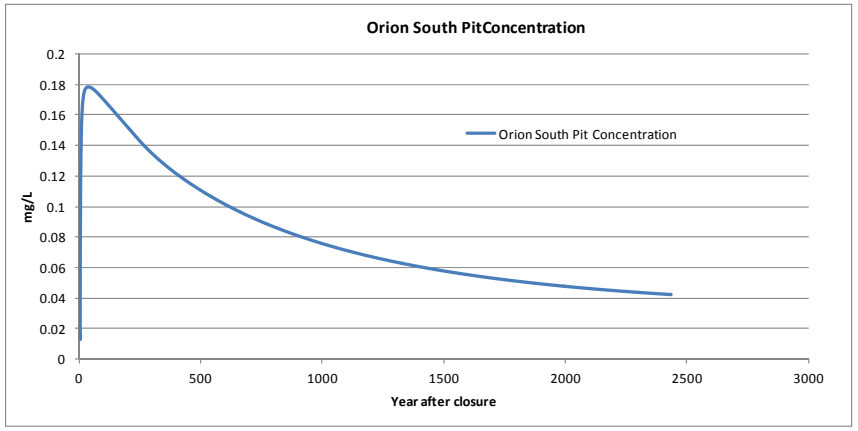
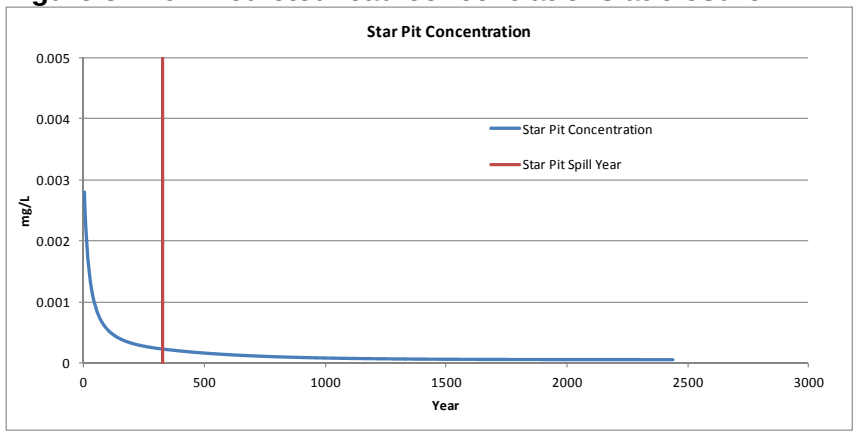


Figure 3-126 Predicted lead concentrations at closure



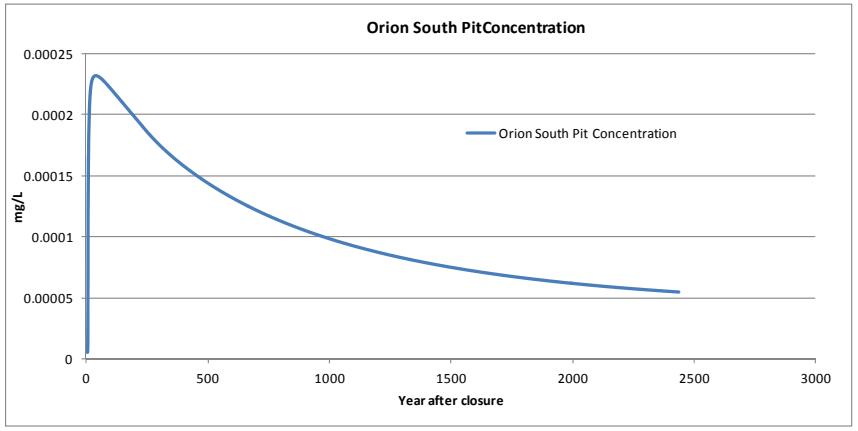
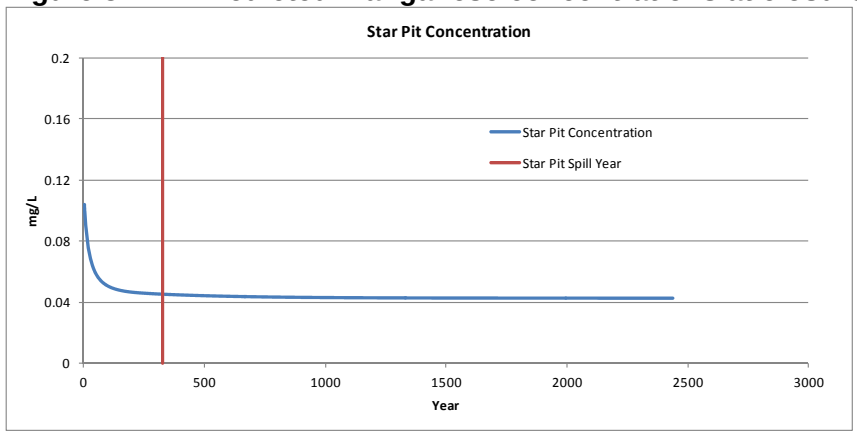


Figure 3-127 Predicted manganese concentrations at closure



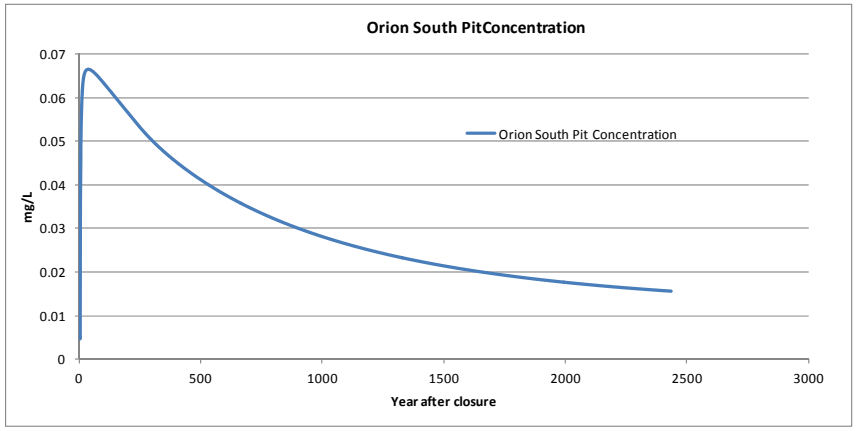
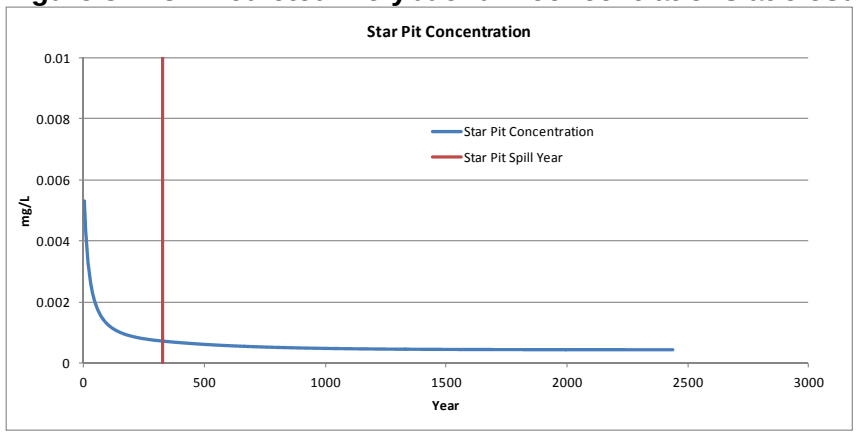


Figure 3-128 Predicted molybdenum concentrations at closure



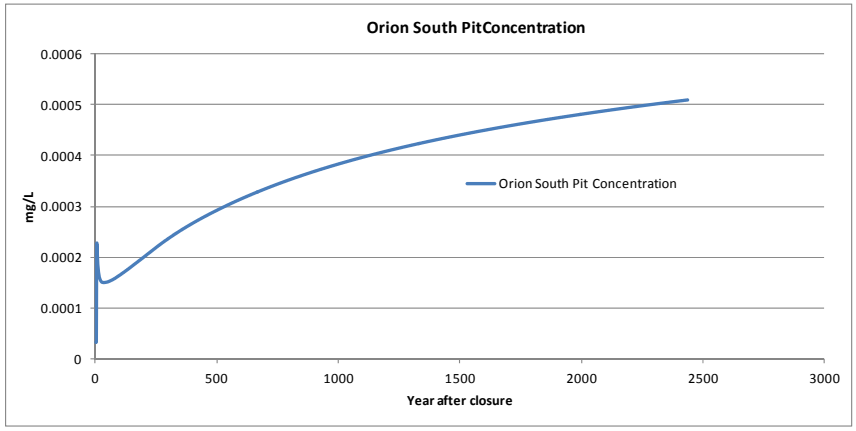
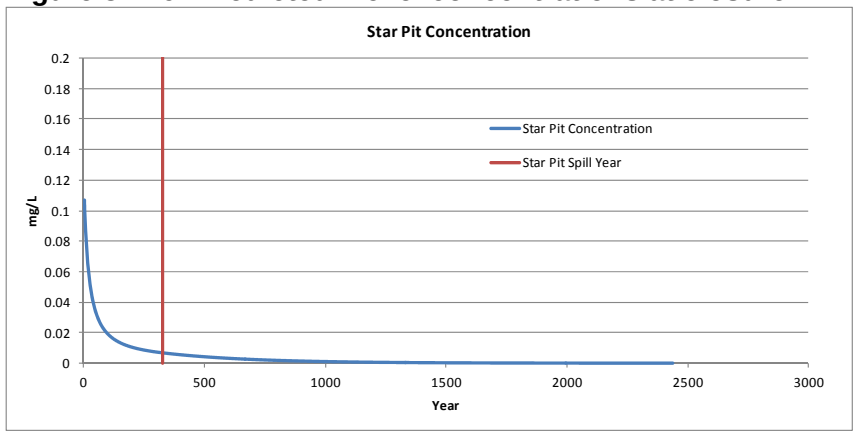


Figure 3-129 Predicted nickel concentrations at closure



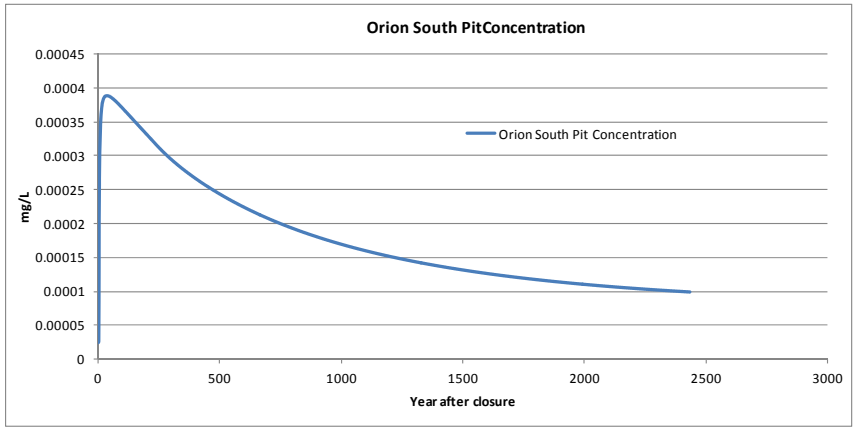
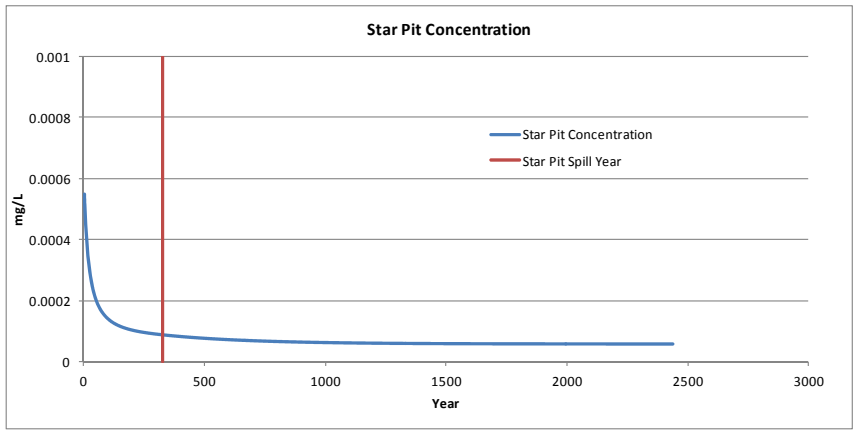


Figure 3-130 Predicted selenium concentrations at closure



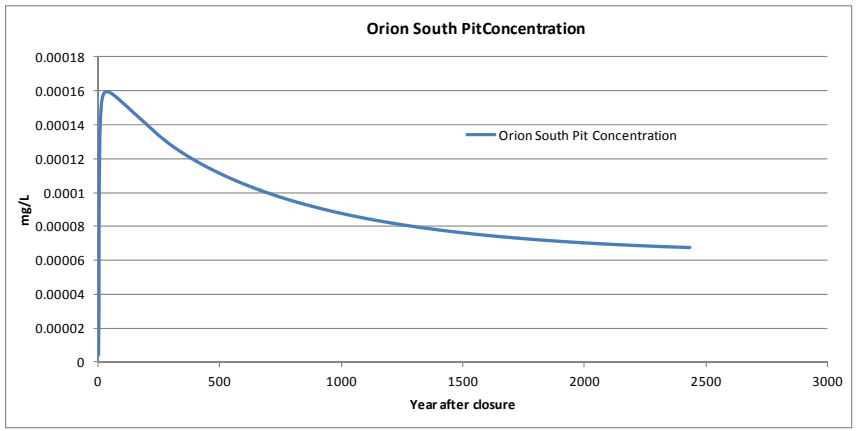
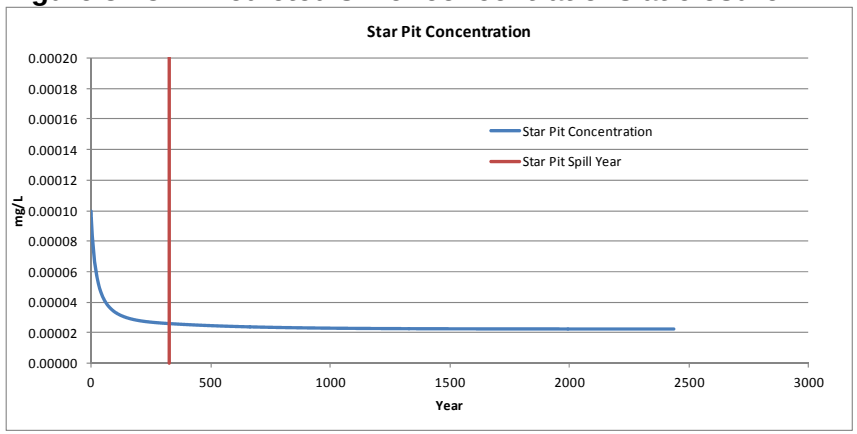


Figure 3-131 Predicted silver concentrations at closure



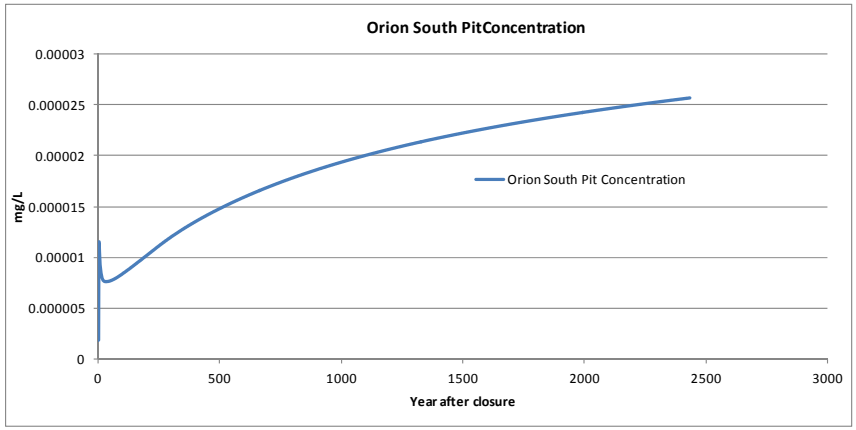
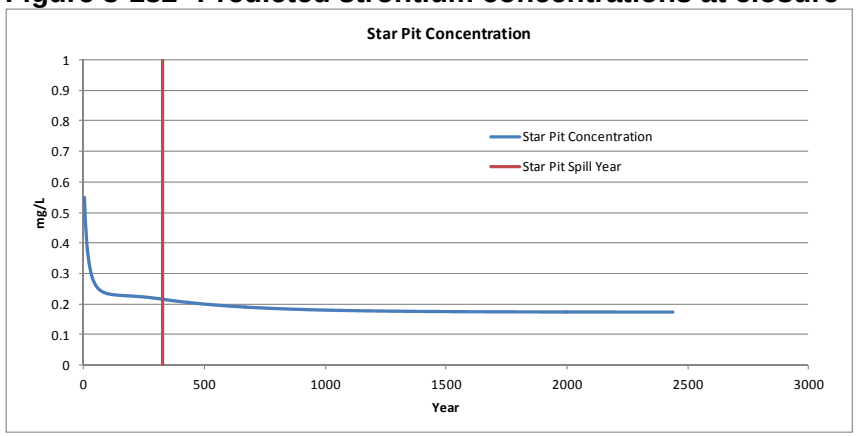


Figure 3-132 Predicted strontium concentrations at closure



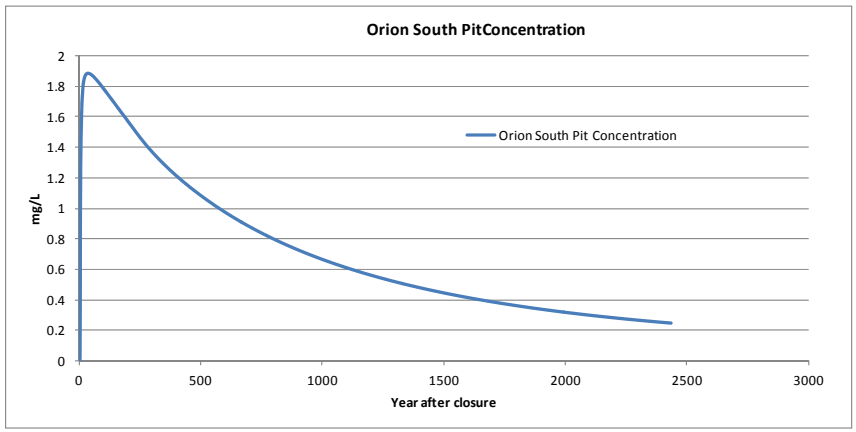
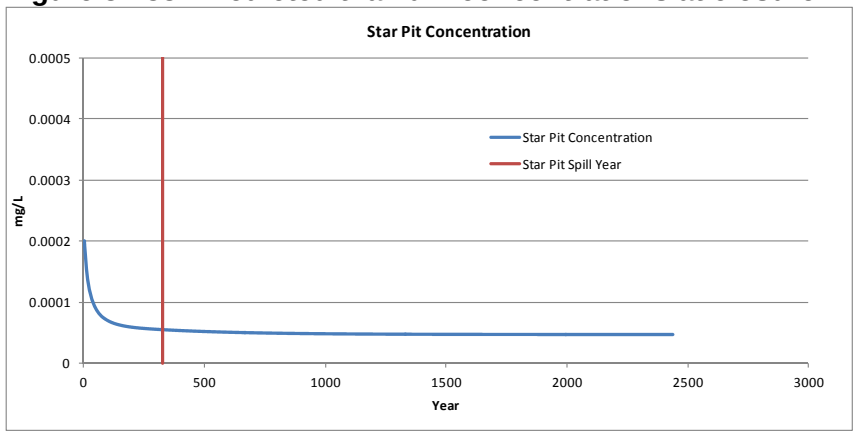


Figure 3-133 Predicted thallium concentrations at closure



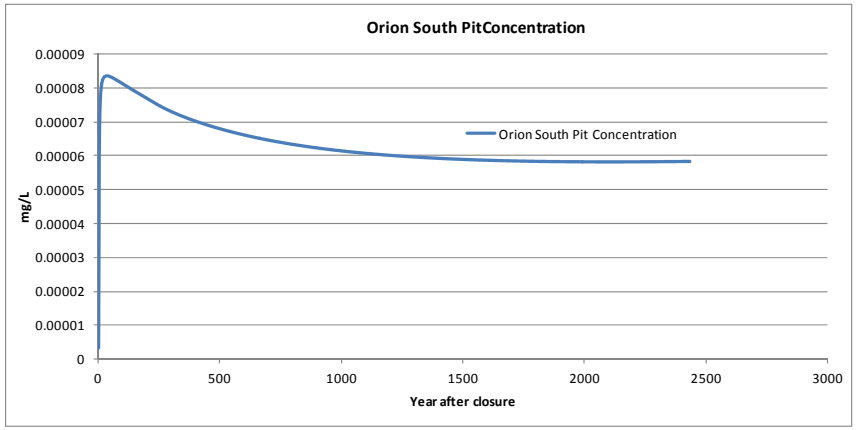
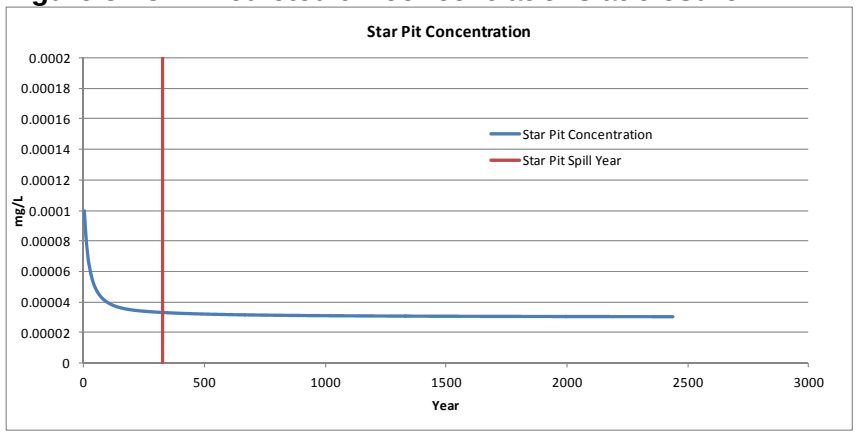


Figure 3-134 Predicted tin concentrations at closure



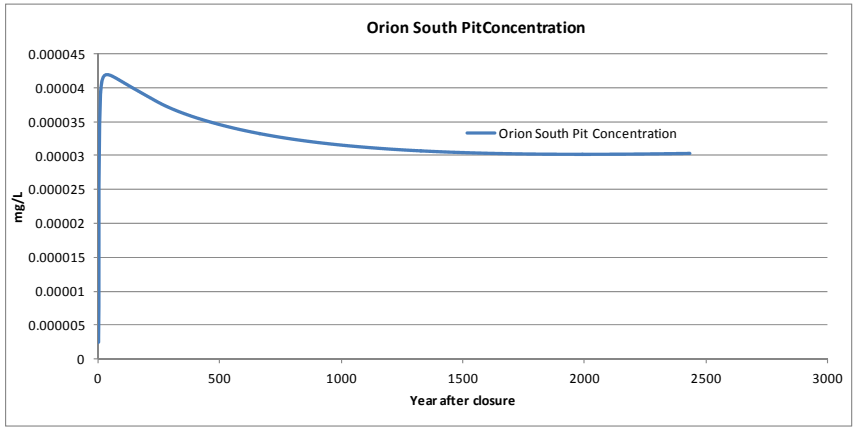
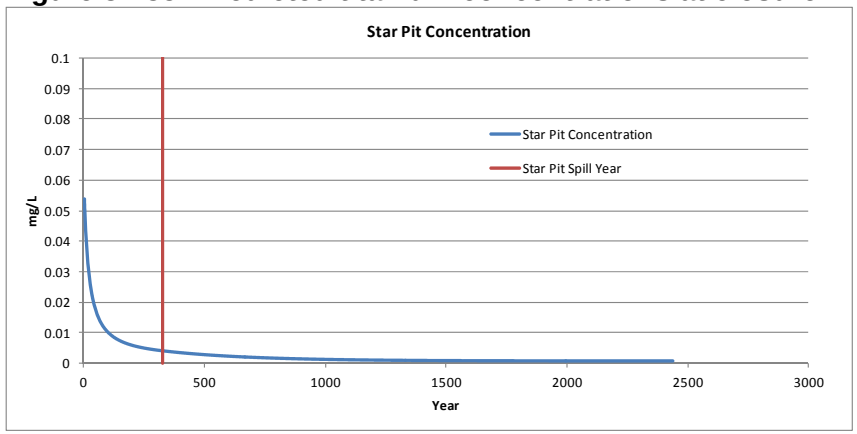


Figure 3-135 Predicted titanium concentrations at closure



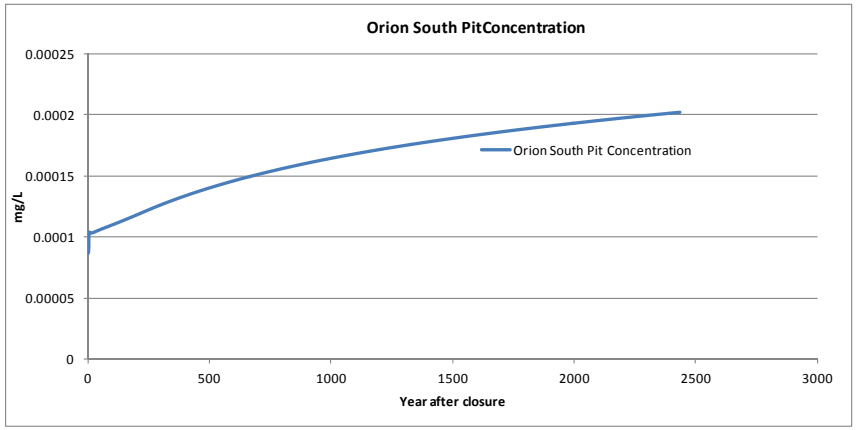
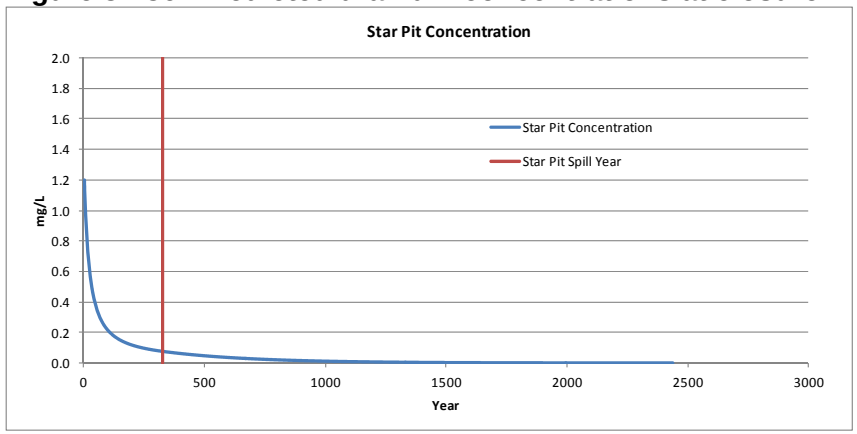


Figure 3-136 Predicted uranium concentrations at closure



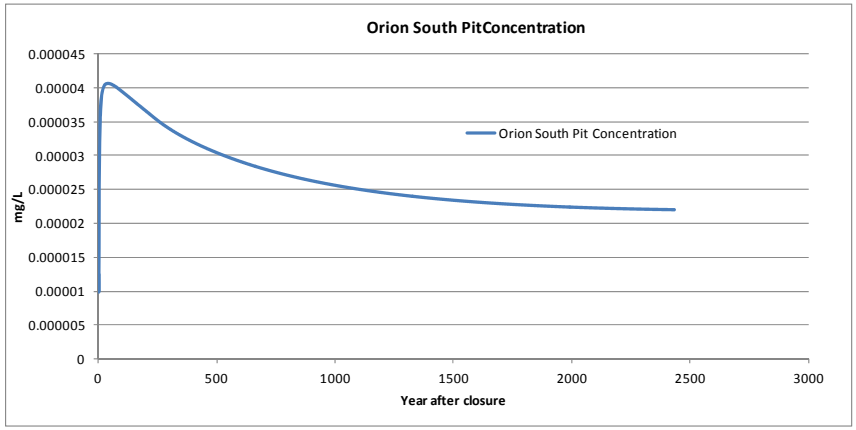
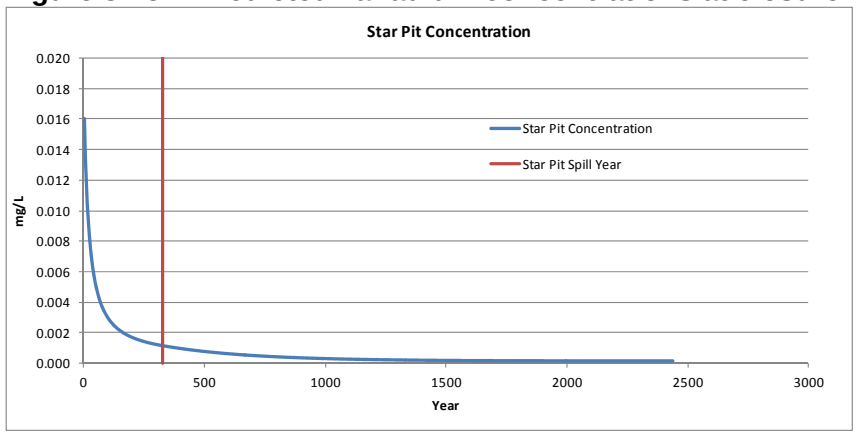


Figure 3-137 Predicted vanadium concentrations at closure



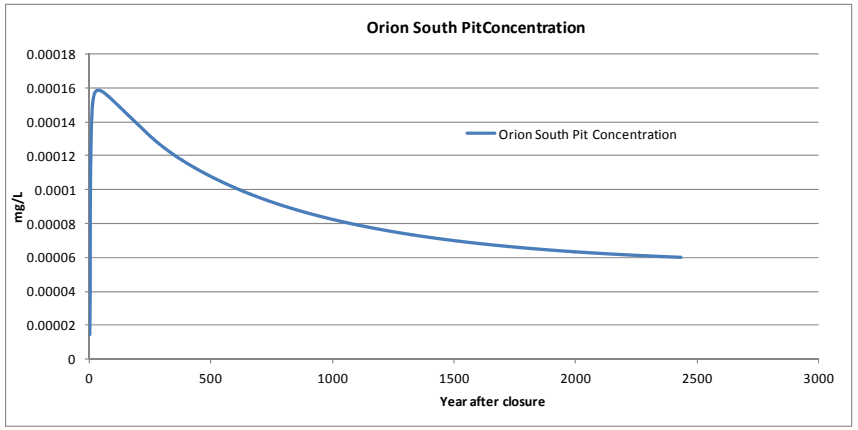


Figure 3-138 Predicted zinc concentrations at closure