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CAPITAL POWER CORPORATION

Genesee Cooling Pond Thermal and Water Quality Modelling Study

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REPORT

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1.0 INTRODUCTION

Capital Power Corporation (CPC) currently operates three power generating units (G1 to G3) within the Genesee Generating Station (GGS). The Genesee Cooling Pond (the cooling pond) is currently used as the source and receptor of cooling water for the G1, G2 and G3 units. The water required by the GGS is diverted from the North Saskatchewan River (NSR) and stored in the cooling pond. Water is diverted from the NSR to make up (makeup) for evaporative losses and to improve overall water quality within the cooling pond and improve plant operations at the GGS. The GGS currently diverts water from the NSR under two existing Alberta *Water Act* Licences (File No. 16576, Approvals 00034491-00-00 and 00268020-00-00), which currently allow for a maximum annual diversion of 34.1 Mm^3. Water from the cooling pond is returned directly to the NSR through the blowdown pipeline (the blowdown). Water will be blown down annually to maintain the desired water quality in the cooling pond.

CPC is in the process of evaluating the capacity of the cooling pond to handle two more power generating units (G4 and G5) and the corresponding supplemental cooling required for these units. The proposed units G4 and G5 are based on advanced gas turbine technology with steam turbine generators for waste heat recovery from gas turbine exhaust. Golder Associates Ltd. (Golder) was commissioned by CPC to conduct thermal and water quality modelling to predict water temperature, evaporative losses and concentrations of Total Dissolved Solids (TDS), major ions and Total Dissolved Gases (TDG) in the cooling pond with the addition of G4 and G5. The scope of work also included an assessment of potential effects to fish in the cooling pond and NSR, and an NSR hydrology assessment. Methods, assessment conditions, results and conclusions for the modelling study are presented in the following sections.

2.0 THERMAL MODELLING

During the plant operation, cooling water is discharged from condenser outlet to the cooling pond, and then withdrawn from the pond at the condenser inlet back to the condenser for cooling (Figure 1). Cooling water temperature increases as it goes through the condenser. The increase in temperature between the inlet and outlet of the condenser is referred to as differential temperature.

The flow rate and differential temperature are specific to each condenser unit, and are maintained constant under normal operating conditions. As the cooling pond water temperature varies with seasonal changes, the cooling pond water temperature at the condenser's inlet also varies, resulting in variable outlet temperatures of discharge water, back into the cooling pond. The highest cooling pond water temperature normally occurs in summer. If the cooling pond water temperature at the condenser inlet exceeds 31°C, the performance of the units could be adversely affected. The objective of this thermal modelling is to predict water temperature and evaporation rate in the cooling pond due to the proposed installation of G4 and G5 units at the Genesee Power Plant. Inlet water temperature to the condenser units (G1 to G5) during "worst-case" summer conditions was predicted. Results of the thermal modelling will assess potential thermal effects of the proposed expansion on the cooling pond and the NSR.

The modelling component contained in this study was limited to the modelling and assessment of water temperatures in the cooling pond, and did not include thermal plume modeling in the NSR.

2.1 Method

Completion of the thermal modelling involved the following tasks:

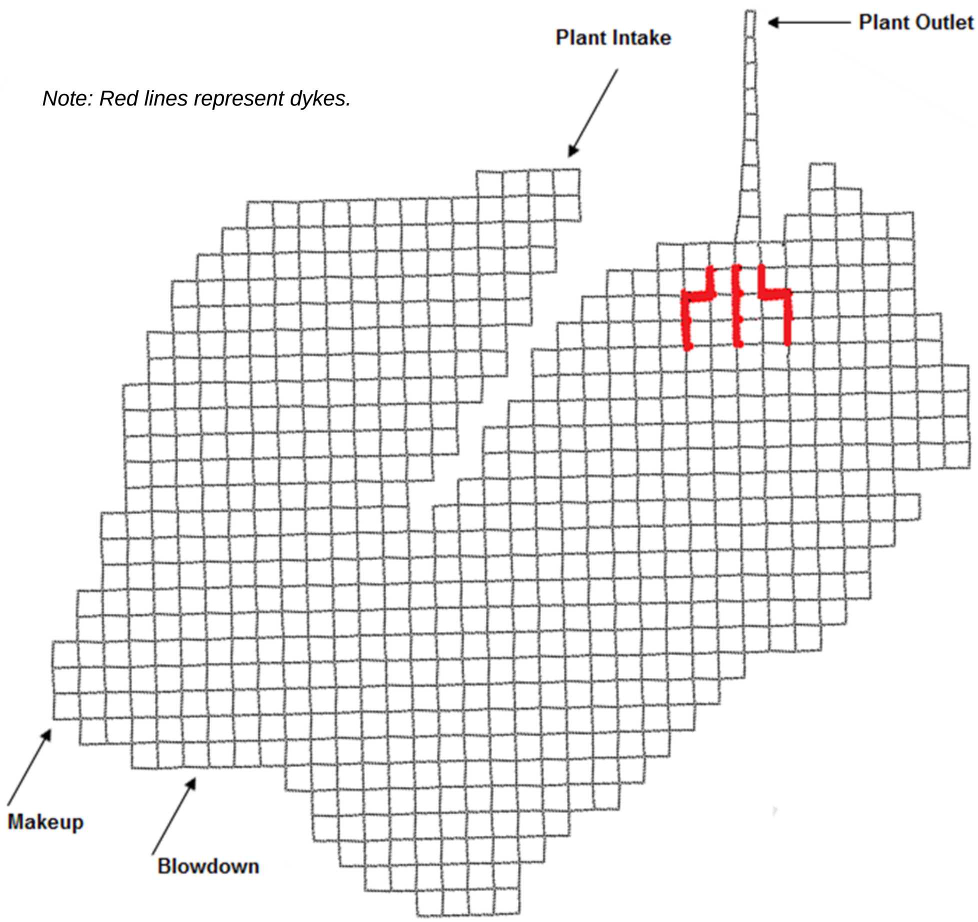
- development of a three dimensional hydrodynamic model to simulate the heat dispersion within the cooling pond;
- gathering and pre-processing of required model input, including bathymetry, meteorological data, flow and water temperature;
- calibration of the model to current conditions; and
- prediction of cooling pond temperature and evaporative losses with the addition of G4 and G5 units, using the calibrated model.

Each of these tasks is outlined in more detail below.

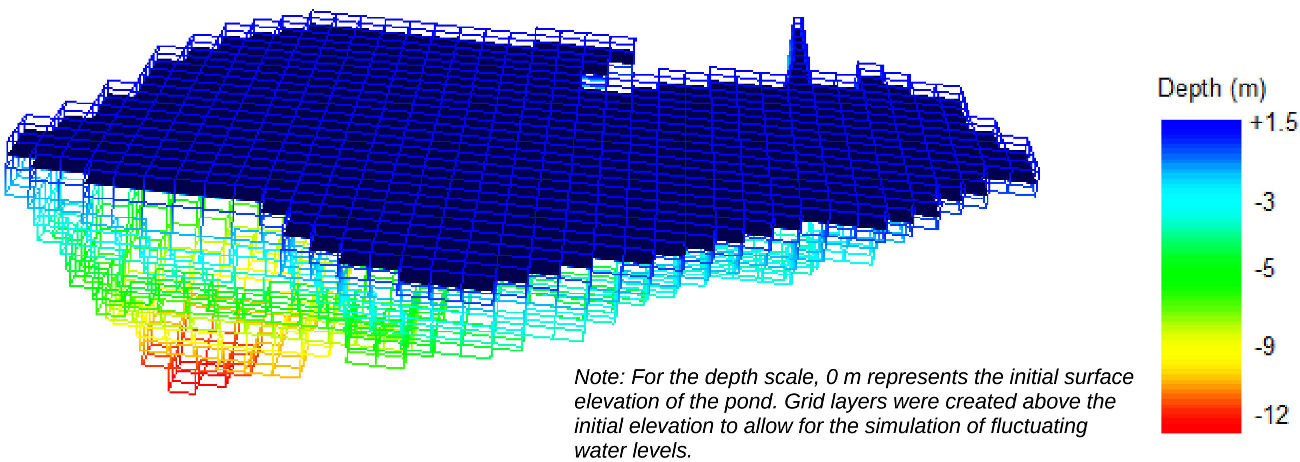
2.1.1 Model Development

2.1.1.1 Model Description

The three-dimensional Generalized Environmental Modelling System for Surface Waters (GEMSS) was used to simulate temperature changes in the cooling pond. The GEMSS modelling package is public domain software distributed by Environmental Resource Management. GEMSS has been extensively used for predicting water temperature in the lakes and is accepted by many U.S. regulatory agencies, including the United States Environmental Protection Agency, the Bureau of Reclamation, the New Jersey Department of Environmental Protection, the Delaware Department of Natural Resources and Environmental Control and the Washington State Department of Ecology. It includes an effective, practical and fully-linked hydrodynamic and water quality module for lakes and reservoirs, and it can simulate vertical, lateral and longitudinal variability in hydrodynamics, temperature and water quality.



(a) Two-dimensional horizontal grid



(b) Three-dimensional grid

Figure 1: Genesee Cooling Pond Model Grid

GEMSS can compute time-varying velocities, water surface elevations and water quality constituent concentrations in ponds, rivers, lakes, reservoirs, estuaries and coastal waterbodies. The model also includes a module to simulate ice-cover in the winter. The computations are done on a horizontal and vertical grid that represents the waterbody bounded by its water surface, shoreline and bottom. The model uses boundary condition formulations for friction, wind shear, turbulence, inflow, outflow, surface heat exchange and water quality kinetics. The HydroDynamic and Transport Module was used in this study for simulating temperature conditions, evaporative losses and ice cover in the cooling pond.

2.1.1.2 Model Setup

The GEMSS modelling software package was configured to reflect the local bathymetric, meteorological and flow conditions of the cooling pond. Figure 1 shows the computational grid developed for this study. The grid has 670 horizontal cells (105 m x 105 m) with 1 m vertical layering (13 layers). Flow velocities and temperatures were simulated at each of the nodes on the grid. Figure 1 shows the grid setup for the cooling pond model. The red lines close to the plant outlet in Figure 1(a) represent barrier dykes in the pond. The three-dimensional grid is shown in Figure 1(b), with colours indicating relative depth.

Hourly and daily water temperatures were simulated for each of the grid nodes, and time series of temperature distributions were output at a number of locations of interest, such as the condenser inlet, condenser outlet and the blowdown location. The model calculates evaporative losses for each cell of the grid at each time step. To calculate total evaporations from the pond evaporative losses from each grid cell were summed.

2.1.2 Model Input Data

Input data required by the GEMSS model included meteorological information, flow rates through the condensers, initial water temperature in the pond, temperatures of the condenser discharge, inflows (rate and temperature) to the pond and water withdrawal rates from the pond. The model simulations were performed for the period of January 1, 2010 to December 31, 2012. The following meteorological data were used in the model:

- hourly solar radiation;
- hourly air temperature;
- hourly dew point temperature;
- hourly wet bulb temperature;
- hourly humidity data;
- hourly wind speed and direction;
- hourly atmospheric pressure; and
- daily precipitation.

All of the above-noted information originated from measurements taken at the cooling pond (CASA 2013), with the exception of the precipitation and atmospheric pressure data. The precipitation and atmospheric pressure data were collected at the Edmonton International Airport (Environment Canada 2013a) which is about 50 km east of the cooling pond.

Following inflow and outflow sources were included in the model:

- condenser cooling water intake and discharge (CPC, pers. comm. 2013a);
- cooling pond makeup (CPC 2009, 2010a, 2011, 2012a and 2013a); and
- cooling pond blowdown (CPC 2009, 2010a, 2011, 2012a and 2013a);

Flows through the G1, G2 and G3 condensers are presented in Table 1 (CPC, pers. comm. 2013a). Data provided by Capital Power (CPC, pers. comm. 2013a,b) show that there were times when one or more condensers were off-line during the simulation period. The flow rate through the offline condenser was set to zero during the times that the condenser was offline, while calibrating the model. For the times that condensers were operating, the observed hourly flow rates were used (CPC, pers. comm. 2013a).

The temperature at the condenser inlet and outlet is plotted in Figure 2 (CPC, pers. comm. 2013c). Using observed time series of inlet and outlet temperature (Figure 2), the differential temperature was calculated and used in the model for the calibration period. Table 1 presents the average differential temperature for condensers G1, G2 and G3.

The observed flow and temperature data were provided for each condenser separately.

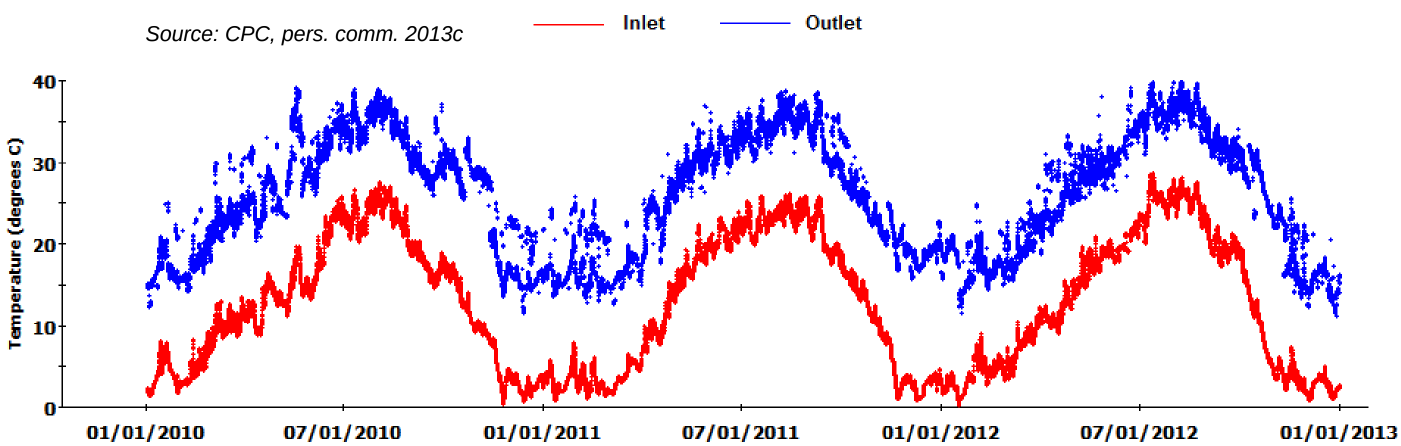


Figure 2: Condenser Inlet and Outlet Water Temperatures Observed During 2010 to 2012

Table 1: Increase in Temperature between the Inlet and Outlet Condensers

Condenser	Range of Condenser Cooling Water Flow Rate (m^3/h)	Range of Average Differential Temperature (°C)
G1	19,440 to 41,400	11 to 23
G2	21,960 to 41,400	11 to 20
G3	50,760 to 63,000	8 to 10

Note: it is assumed there are no losses in the condenser, thus inflow = outflow (CPC, pers. comm. 2013a)

Makeup flows to the cooling pond from the NSR and blowdown flows to the NSR from the pond are presented in Table 2 for the simulation period of January 1, 2010 to December 31, 2012. Temperature data collected at the Alberta Environment's Devon monitoring station (Muricken, pers. comm. 2013) was applied to the NSR makeup water.

Table 2: Genesee Cooling Pond Makeup and Blowdown Flows

	Makeup Flows	Blowdown Flows
Date	**Volume Pumped (m^3)**	**Volume Pumped (m^3)**
Jan-10	1,010,000	0
Feb-10	364,000	0
Mar-10	83,000	0
Apr-10	3,300,000	614,880
May-10	1,200,000	0
Jun-10	145,000	1,530,000
Jul-10	3,270,000	2,060,000
Aug-10	4,171,680	1,869,210
Sep-10	320,000	2,070,000
Oct-10	2,973,960	2,002,320
Nov-10	1,240,000	1,150,000
Dec-10	1,760,000	104,000
Jan-11	597,700	0
Feb-11	0	0
Mar-11	1,425,960	775,000
Apr-11	856,800	857,000
May-11	835,380	0
Jun-11	1,291,320	898,560
Jul-11	517,140	383,000
Aug-11	3,063,060	2,060,000
Sep-11	4,586,940	1,770,000
Oct-11	3,047,760	1,750,000
Nov-11	817,020	374,000
Dec-11	1,400,000	1,100,000
Jan-12	132,000	264,000
Feb-12	688,500	34,000
Mar-12	1,700,000	919,559
Apr-12	544,680	872,200
May-12	3,250,000	1,850,000
Jun-12	416,160	0
Jul-12	887,400	410,572
Aug-12	3,298,680	2,072,476
Sep-12	4,192,200	2,102,112
Oct-12	1,802,340	1,983,902
Nov-12	391,680	0
Dec-12	0	0

Source: (CPC 2009, 2010a, 2011, 2012a and 2013a)

2.1.3 Model Calibration

The model was calibrated using the observed flow and meteorological data for the period of July 1, 2009 to December 31, 2012. An initial ramp-up period of six month (July 2009) was used to allow the model to equilibrate with atmospheric conditions. The remaining period (January 1, 2010 to December 31, 2012) was used to calibrate the model, wherein model predictions were compared to observed data at three locations in the pond, including condenser inlet, condenser outlet and blowdown. The condenser inlet, condenser outlet and blowdown were selected because observed time series of temperature data were available at these locations (Figure 2 and Figure 3). As mentioned in Section 2.1.2, the observed flow and temperature data were provided for each condenser separately. To be able to compare the predicted outlet temperature to the observed outlet temperature (model calibration at the condenser outlet), the flow weighted average temperature was calculated. Because the flow from each condenser enters the pond at the same location, and temperature at the out let of condenser G1 and G2 is different form G3, the flow weighted average of condenser outlet temperatures were calculated to estimate the temperature of the combined flow. The flow weighted average temperature was calculated using flow and temperature data observed at the outlet of G1, G2 and G3. The same method was used to calculate the average observed temperature at the inlet cell for model calibration at the condenser inlet.

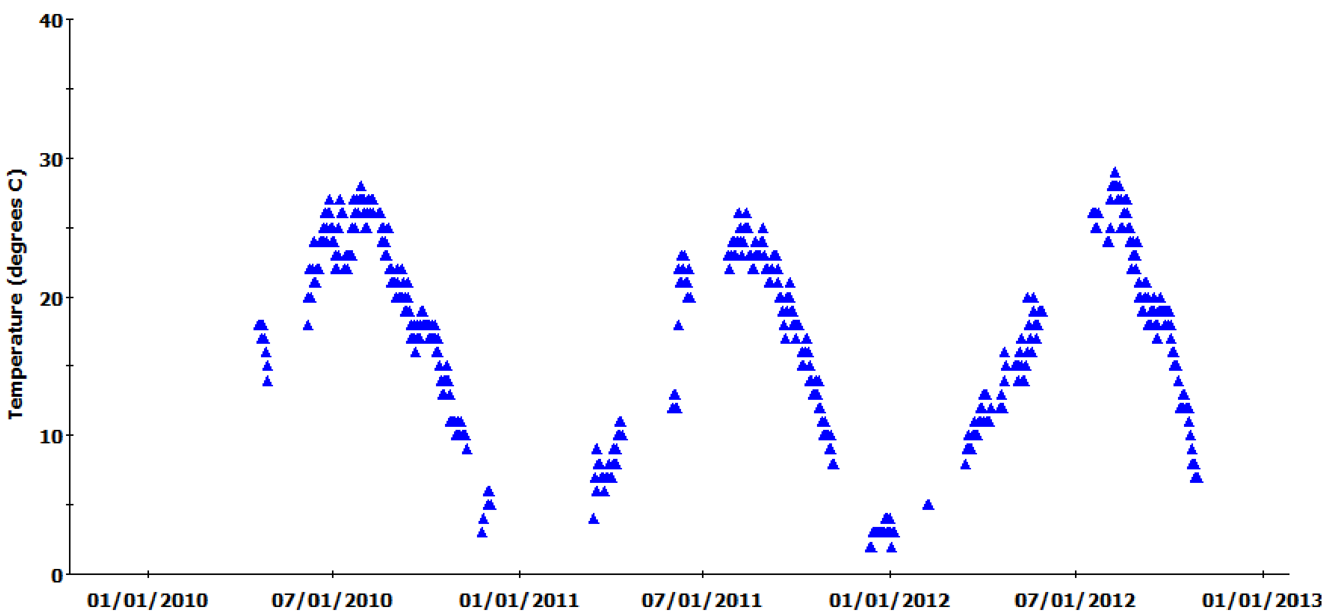


Figure 3: Blowdown Water Temperatures Observed During 2010 to 2012

A qualitative evaluation of model performance was based on a visual comparison of the predicted (modelled) and observed temperatures. Quantitative evaluation was performed using statistical measures including: Average Deviation (AD), Average Absolute Deviation (AAD), and Coefficient of Efficiency (E). The AD (or mean error) is the average value of the temperature difference between the predicted and observed data (James and Burges 1982). This value is an indication of whether the modelled data is generally higher or lower than the observed data. The AAD (also referred to as mean absolute error) is the average value throughout the modelled time series of the magnitude of the temperature difference between the modelled and observed data (Janssen and Heuberger 1995). This value is an indication of the average model error at any given time. Coefficient of efficiency relates the goodness-of-fit of the model to the variance of the measurement data and thus describes the modeling success with respect to the mean of the observations (Nash and Sutcliffe 1970). This value ranges from minus infinity to 1.0, with a value of 1.0 representing a perfect prediction, a value of zero representing a prediction no better than using the mean of measured values. Model calibration parameters were adjusted within a range of reasonable values to minimize the mean absolute error and the absolute error.

The model was also calibrated for the ice cover on the pond using the aerial photos from the wildlife reports (CPC 2010b, 2012b, 2013b). The calibration parameters used for this modelling are presented in Appendix A.

2.1.4 Modelling Scenarios

Once the model was calibrated, following simulations were conducted:

- Base Case (for model calibration), representing present operating conditions (G1, G2 and G3); and
- Application Case, representing Base Case plus the proposed G4 and G5 units.

The conditions under Application Case modelling scenario are summarized in Table 3 (CPC, pers. comm. 2013d).

Table 3: Condenser Flows and Differential Temperature under Application Case Conditions

Condenser	Condenser Cooling Water Flow Rate[a] (m^3/h)	Average Differential Temperature (°C)
G4	30,999	8
G5	30,999	8
Other Equipment	2,315	5

[a]: to be conservative, the summer (extreme) flow rates were applied.

2.1.5 Results

2.1.5.1 Base Case Conditions (Model Calibration)

The cooling pond model was calibrated using the observed temperature data recorded at the inlet and outlet to the condenser and blowdown location. Comparisons of predicted and observed temperatures for the simulation period of January 1, 2010 to December 31, 2012 are illustrated in Figure 4, Figure 5 and Figure 6. In general, simulated temperatures closely follow the pattern of the observed temperatures.

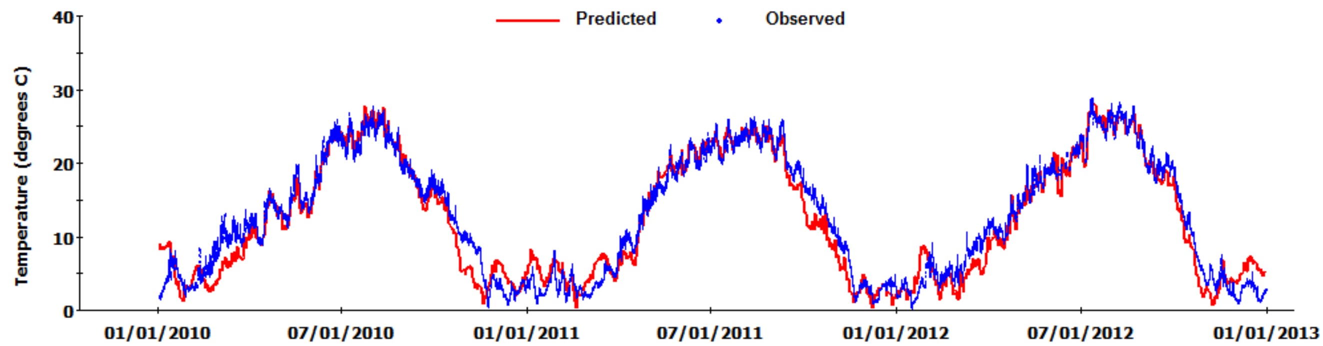


Figure 4: Comparison of Simulated and Observed Water Temperatures at the Condenser Inlet (Base Case)

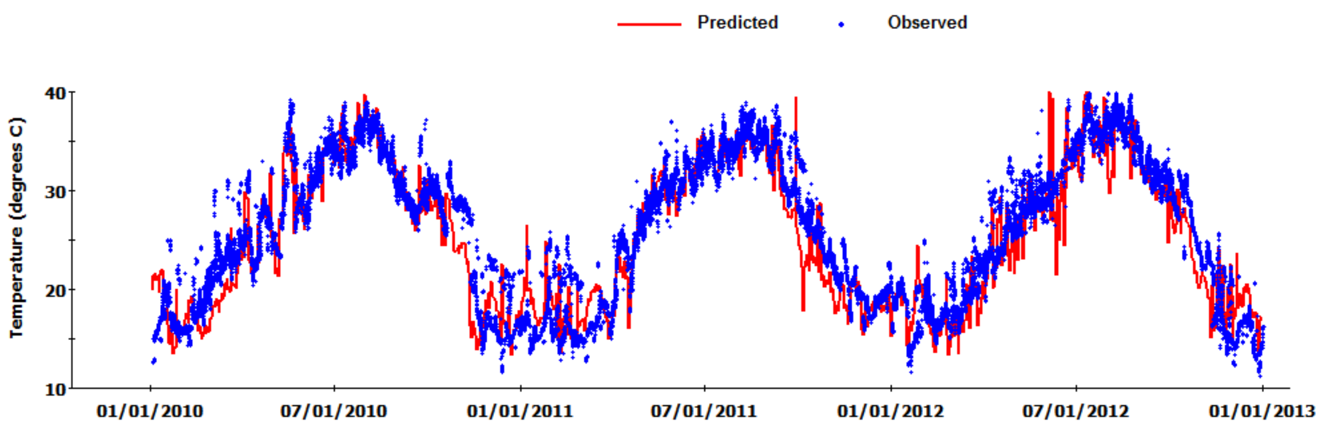


Figure 5: Comparison of Simulated and Observed Water Temperatures at the Condenser Outlet (Base Case)

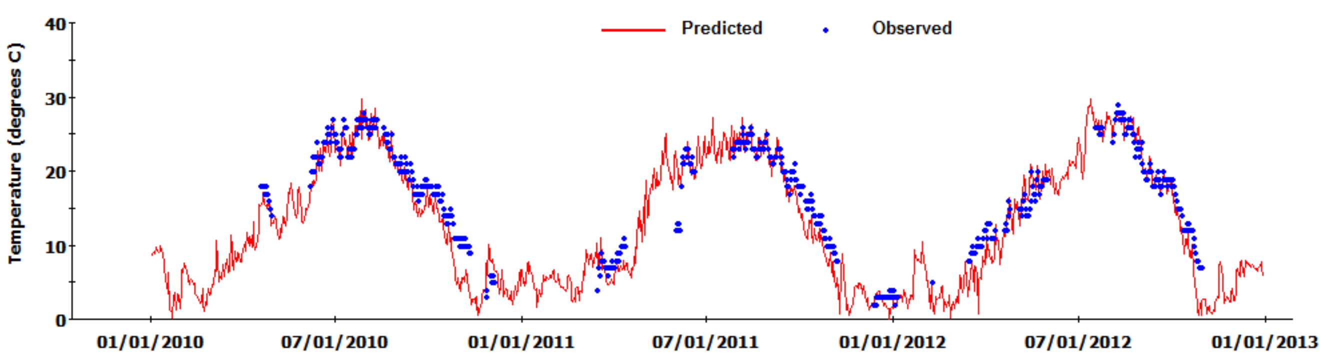


Figure 6: Comparison of Simulated and Observed Water Temperatures at the Blowdown (Base Case)

The calculated statistical parameters to show model performance during calibration are presented in Appendix A. On average, predicted temperatures across the pond were within 1.8°C (at the blowdown), and 1.8°C (at the at the condenser outlet) of observed values (average absolute deviation, Appendix A, Table A-2). The average deviation (mean error) ranged from 0.3°C to 1.1°C. The small positive AD values indicate that the predicted temperatures were slightly lower than the observed temperatures at all three calibration locations (inlet, outlet and blowdown). The coefficient of efficiency was 0.9, indicating a good match between predicted and observed temperatures. The calibration was deemed acceptable as the mean absolute error (or AAD) was less than 5% of the observed temperature variation. Moreover, the coefficient of efficiency, E, was higher than 0.8, indicating a satisfactory performance of the model.

Figure 7 shows a snapshot of simulated surface water temperatures in the cooling pond on July 12, 2012 for the Base Case. Highest temperatures were predicted to occur at the inlet on this date.

As expected, the highest pond water temperature occurs at the condenser outlet. Water temperatures gradually decrease along the southern edge of the pond as water flows toward the blowdown location. By the time the plume reaches the pond blowdown location, its temperature is approximately 12°C lower than at the condenser outlet temperature. Further cooling occurs in the second half of the cooling pond, as water flows from the blowdown location to the condenser inlet channel area. Such spatial variation was consistent as the season changed. On average, temperatures were 16°C higher in the summer than in the winter at the blowdown location and the condenser inlet.

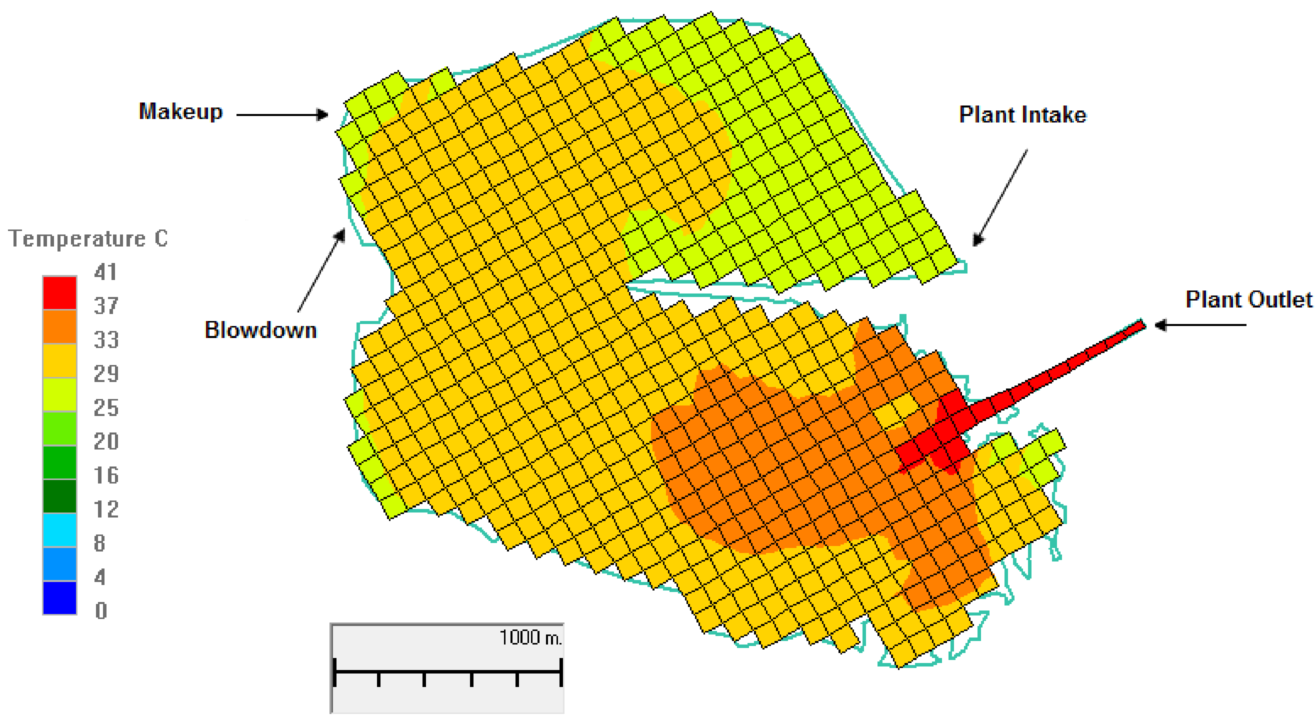


Figure 7: Simulated Distribution of Genesee Cooling Pond Water Temperatures for the Base (Calibration) Case (July 12, 2012)

The calibrated parameters and the final values used for them in the model are presented in Appendix A, Table A-1. Figure A-1 (Appendix A) shows snapshots of simulated ice cover (and thickness) on the cooling pond for three selected dates in winter, when the ice coverage was available from the wildlife reports (CPC 2010b, 2012b, 2013b).

2.1.5.2 Model Simulation and Assessment

Figure 11 shows a snapshot of simulated surface water temperatures in the cooling pond on July 12, 2012 for the Application Case. The spatial patterns are similar to that observed for the Base Case (Figure 7). Water temperatures gradually decrease along the southern edge of the pond as the water flows toward the blowdown location. By the time the plume reaches the pond blowdown location, its temperature is approximately 10°C lower than at the condenser outlet. Similar to the Base Case, temperatures were highest in the summer and cooler in the winter (Figure 8, Figure 9 and Figure 10). On average, temperatures were 17°C higher in the summer than in the winter at the blowdown location and 16°C higher at the condenser inlet.

Predicted changes in cooling pond temperatures from the Base Case to the Application Case are presented in Figure 8, Figure 9 and Figure 10. The maximum simulated temperature (during summer) under the Application Case is predicted to be about 1.8°C higher than the Base Case at the condenser inlet location, and 1.9°C higher at the blowdown location (Table 4).

Table 5 presents predicted evaporation rates under Base Case and Application Case conditions. In the Application Case, evaporative losses from the cooling pond are predicted to increase relative to Base Case due to additional thermal load the pond.

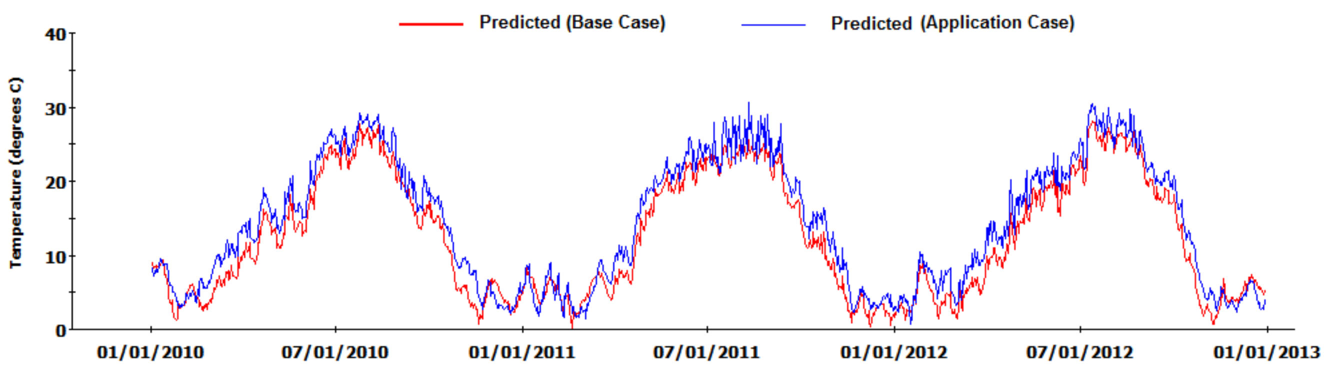


Figure 8: Comparison of Simulated Temperatures at the Condenser Inlet under Base (Calibration) and Application Case Conditions

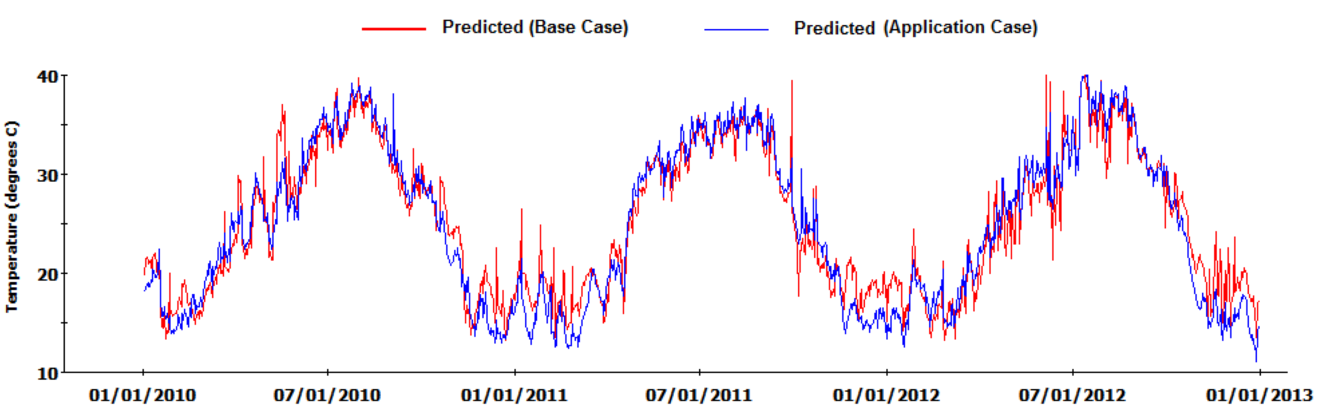


Figure 9: Comparison of Simulated Temperatures at the Condenser Outlet under Base (Calibration) and Application Case Conditions

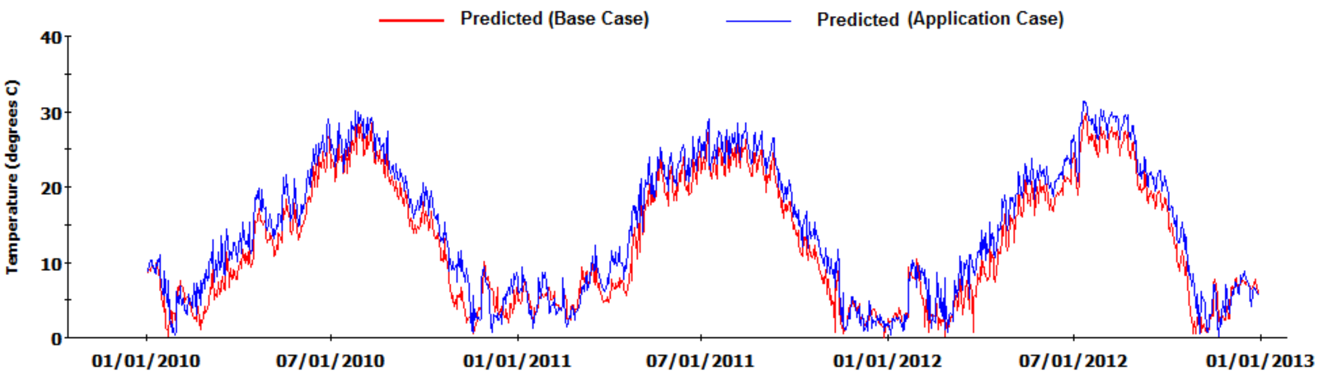


Figure 10: Comparison of Simulated Temperatures at the Blowdown Location under Base (Calibration) and Application Case Conditions

Table 4: Predicted Daily Water Temperatures at the Inlet and Blowdown Locations in the Genesee Cooling Pond, under Base and Application Case Conditions

	Base Case (°C)	Application Case (°C)	Difference (°C)
Temperature at the Condenser Inlet			
Maximum	28.1	30.2	2.1
Average	12.3	14.1	1.8
99th Percentile	26.5	28.5	2.0
Temperature at the Blowdown			
Maximum	29.4	31.5	2.1
Average	12.6	14.5	1.9
99th Percentile	27.4	29.6	2.2

Table 5: Predicted Annual Evaporation Rate at the Genesee Cooling Pond

Simulation Year	Annual Evaporation (Mm^3)		
	Base Case	Application Case	Difference
2010	14.8	18.7	3.9
2011	15.4	19.1	3.7
2012	13.4	17.2	3.8

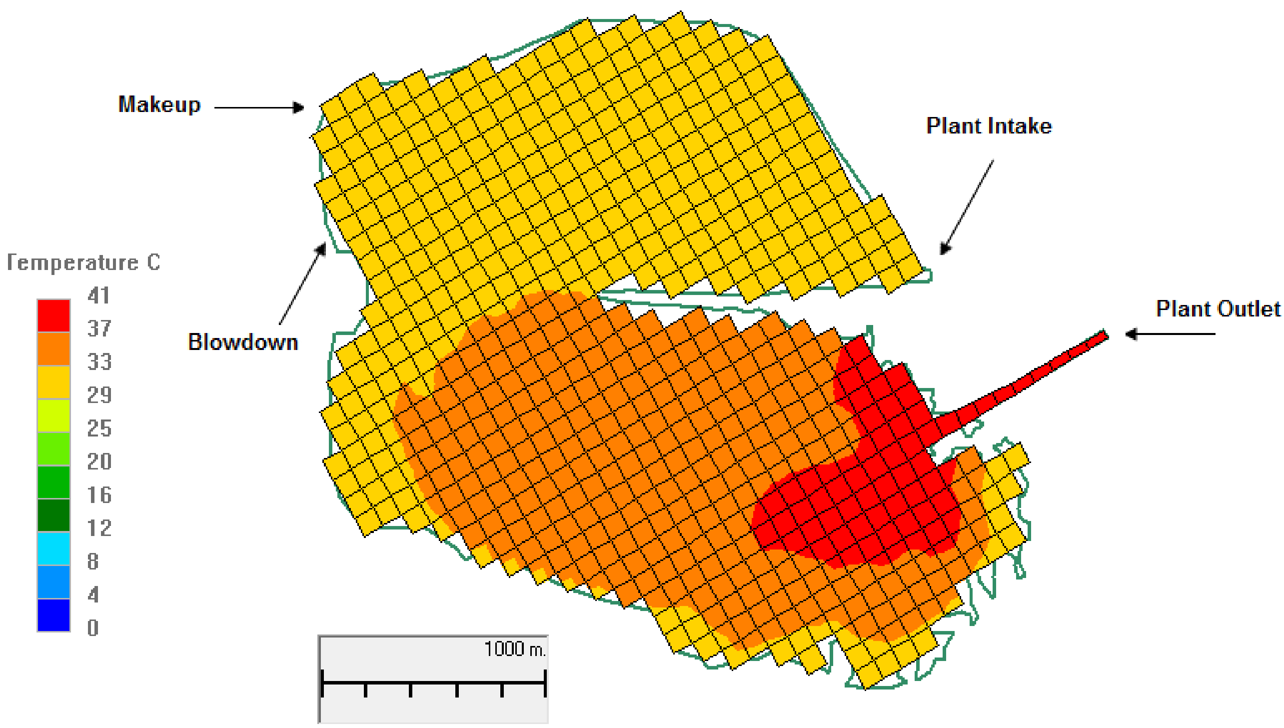


Figure 11: Simulated Distribution of Genesee Cooling Pond Water Temperatures for the Application Case (July 12, 2012)

2.1.6 Conclusions

A GEMSS-based thermal model of the cooling pond was created to simulate temperature changes in the cooling pond resulting from the proposed G4 and G5 units. Changes to the cooling pond temperatures due to the G4 and G5 units are predicted to be less than 2°C on average during the summer relative to the Base Case. Therefore, changes in NSR temperature due to addition of new units are predicted to be small, especially in consideration of the flow in the NSR relative to the blowdown release (i.e., average flows of 194 m^3/s in NSR compared to a maximum flow of 1.19 m^3/s for the blowdown). With the addition of G4 and G5 units, on average evaporative losses from the pond were predicted to increase 26% compared to Base Case.

Predicted temperatures in the cooling pond only apply to the modelled scenarios presented in this report and under the 2010 to 2012 climate conditions. It should be noted that, changes to the climate conditions (i.e., hotter summer) will result in possible changes to water temperatures in the pond beyond the range of temperatures predicted in this report.

3.0 WATER QUALITY MODELLING

As described in Section 1.0, cooling water from the GGS is cycled back to the cooling pond. Also effluents from water treatment plant, drains and blowdowns from steam generators are directed to the cooling pond. Dissolved constituents in all these streams become concentrated in the cooling pond primarily due to evaporation. To control the accumulation and concentration of dissolved constituents in the cooling pond, water is released from the cooling pond (blowdown) and discharged to the NSR. Makeup water from the NSR is then added back to the cooling pond to replace the discharged blowdown water and evaporative losses.

In 2010, Golder developed an Excel-based mass balance model, for the cooling pond, to predict concentrations of TDS and major ions of the water contained in the cooling pond (Golder 2010). The same model was used for this study; however calibration was updated to include the observed data collected since 2010. Evaporative losses predicted by the thermal modelling (Section 2) were input to the mass balance model.

The purpose of the water quality modelling was to:

- recalibrate the Golder (2010) mass balance model using the water quality data collected since 2010;
- predict TDS and various major ion concentrations in the cooling pond with the addition of G4 and G5 units;
- determine the volume of makeup water required to meet TDS operational targets of 250 mg/L and 370 mg/L in the pond; and
- estimate volume of water that needs to be blown down to NSR, based on the updated makeup water volumes.

Predicted cooling pond water quality under the Base and Application Case conditions was analyzed and compared with Surface Water Quality Objectives (WQOs) developed for the NSR (NSWA 2010). The quality of water in the pond was also compared to chronic guidelines for the protection of aquatic health. Concentrations in NSR (in-stream) were also estimated for constituents that are predicted to exceed corresponding guidelines or WQOs. The comparison of model predicted results to the WQOs and guidelines are presented in Section 3.2.

The observed data collected at the pond were also compared to the guidelines and WQOs. Appendix C compares observed data collected at the pond and blowdown location to NSR water quality, guidelines and WQOs developed for the NSR.

3.1 Methods

The Golder (2010) Excel-based mass balance model was used recalibrated and to predict concentrations of TDS and major ions of the water contained in the cooling pond with and without G4 and G5 units. Model setup, calibration and detailed results are described in Appendix B.

Under the Application Case, with the addition of G4 and G5 units, more water and process chemicals will be used in the plant. This also will add more solids into the cooling pond increasing TDS concentrations. A mitigative action to reduce TDS concentrations or maintain existing concentrations is to increase blowdown from the cooling pond. Increasing the blowdown from cooling pond will require additional makeup water diversion from the NSR. Increasing the volume of blowdown and hence makeup water is anticipated to improve overall water quality in the cooling pond for plant operations by reducing TDS, alkalinity, and pH.

The existing generating capacity of the GGS is 1376 MW. Water quality of the cooling pond was predicted based on the existing capacity plus an additional 1050 MW (capacity of G4 and G5 units). Addition of G4 and G5 units will result in additional water consumption due to potential additional evaporative losses. The increased water loss with G4 and G5 units (due to evaporative losses) was predicted using the hydrodynamic thermo model discussed in Section 2.

The volume of additional makeup water required (under the Application Case) to meet TDS targets of 250 mg/L and 370 mg/L in the pond, was predicted using the calibrated model. Based on the calculated makeup water volumes, volumes of blowdown water was calculated. Predicted concentrations of modelled constituents in the NSR were compared to guidelines and WQOs.

3.1.1 Model Scenarios

The CPC's objective is to maintain TDS levels in the cooling pond in the range of 250 to 370 mg/L to improve overall plant operations and improve the water quality of discharge from the cooling pond back to the NSR. The simulations were extended for 20 years. Different volumes of makeup water below (or equal to) the maximum allowable under the current Water Licence (34.1 Mm^3/y) were tried to find out the annual make up water volume which will make water quality in the cooling pond satisfy the operational requirement.

Three scenarios were modeled:

- **Base case:** representing present operating conditions (G1, G2 and G3);
- **Application Case – Scenario 1:** representing Base Case plus the proposed G4 and G5 units, adjusting makeup water volume to keep TDS levels below 370 mg/L in the long term (2020). This scenario has different process chemicals and water loss compared to the Base case; and
- **Application Case - Scenario 2:** similar to Application Case – Scenario 1, except makeup water volume was adjusted keep TDS levels below 250 mg/L in 2020.

3.1.2 In-stream Concentration

The concentrations of modelled constituents in the NSR (in-stream concentrations) were calculated using the approaches discussed in Appendix C and then compared to chronic guidelines for the protection of aquatic health and WQOs. For these calculations, modelled concentrations in 2020 were applied.

3.2 Results and Discussion

Using the calibrated model, long-term simulations were completed to predict TDS and major ion concentrations, makeup water as well as blowdown rates to the NSR, under Base and Application Case conditions. Predicted makeup water and blowdown rates required for each scenario are discussed below. Predicted blowdown water concentrations are the same as predicted concentrations in the cooling pond, because the cooling pond is modelled as a fully mixed system (Appendix B). Predicted blowdown water concentrations and NSR in-stream concentrations are compared to guidelines and WQOs in Table 6 and Table 7.

Base Case: TDS levels in the pond (in 2020) are predicted to be 282 mg/L if the water division rate for makeup water remains the same as current rate (18.5 Mm^3/y). The blowdown rate under the Base Case conditions is approximately 10 Mm^3/y. Concentrations of all parameters are predicted to remain equal to or lower than the 2012 concentrations (Appendix B, Table B-1). In-stream concentrations of all modelled constituents are predicted to remain below corresponding chronic guidelines and WQOs, except for fluoride. Fluoride concentrations in rivers and lakes of Alberta are typically at, or above, the chronic water quality guideline for the protection of aquatic life. Available data indicate a mean fluoride concentration of 0.12 mg/L, with levels ranging from 0.05 to 0.95 mg/L (at 242 sites, number of samples = 10,429) (Government of Canada 1993).

Application Case – Scenario 1: TDS levels in the pond are predicted to remain below 370 mg/L if the water diversion rate for makeup water increases from 18.5 Mm^3/y (average rate from 2008 to 2012; CPC 2009, 2010a, 2011, 2012a and 2013a) to 22 Mm^3/y. The estimated rate of blowdown water for this scenario is about 10 Mm^3/y. Concentrations of all modelled constituents in the cooling pond and the blowdown are predicted to increase relative to the Base Case, but the calculated in-stream concentration will remain close to Base Case levels because of relatively small blowdown flow rate compared to NSR flow rate (Table 6). In-stream concentrations of all modelled constituents are predicted to remain below corresponding chronic guidelines and WQOs, except for fluoride.

Application Case – Scenario 2: Diverting water from NSR at the maximum rate (34.1 Mm^3/y) is predicted to keep TDS levels below 281 mg/L. Concentrations of all constituents in the cooling pond and the blowdown are predicted to decrease relative to the Base Case, except for calcium and barium (Table 6). The estimated rate of blowdown water for this scenario is about 22 Mm^3/y.

Under both scenarios, barium and calcium concentrations in the cooling pond and the blowdown are predicted to increase under Application Case conditions relative to the Base Case, because of higher concentrations of these ions in NSR water relative to the cooling pond. But in reality, the concentrations of barium and calcium in the cooling pond are likely to be lower due to shifting equilibrium as the NSR water is pumped into the cooling pond. Barium is presumed to precipitate in the pond in response to elevated sulphate concentrations from process chemical addition (i.e., sulphuric acid); whereas, calcium is presumed to precipitate due to the reduced solubility of calcite in warmer water (i.e., calcium solids precipitate as calcium-rich makeup water enters the warmer cooling pond) (Appendix D; Golder 2010).

Although the simulations were extended for 20 years, predicted concentrations of chemical constituents within the cooling pond, including TDS (Figure 12), reach steady-state conditions around 2020. Model calibration and detailed results are described in Appendix B. Plots for predicted concentrations of modelled constituents are also presented in Appendix B.

The water quality modelling results (Table 6 and Table 7) show that within the current water licence approval for makeup water rate, the cooling pond water quality can be controlled lower than current level and will not affect NSR water quality with the addition of the G4 and G5 units in the future.

Observed water quality data collected at the cooling pond and blowdown is compared to observed water quality of the NSR, WQOs in the NSR and guidelines in Appendix C.

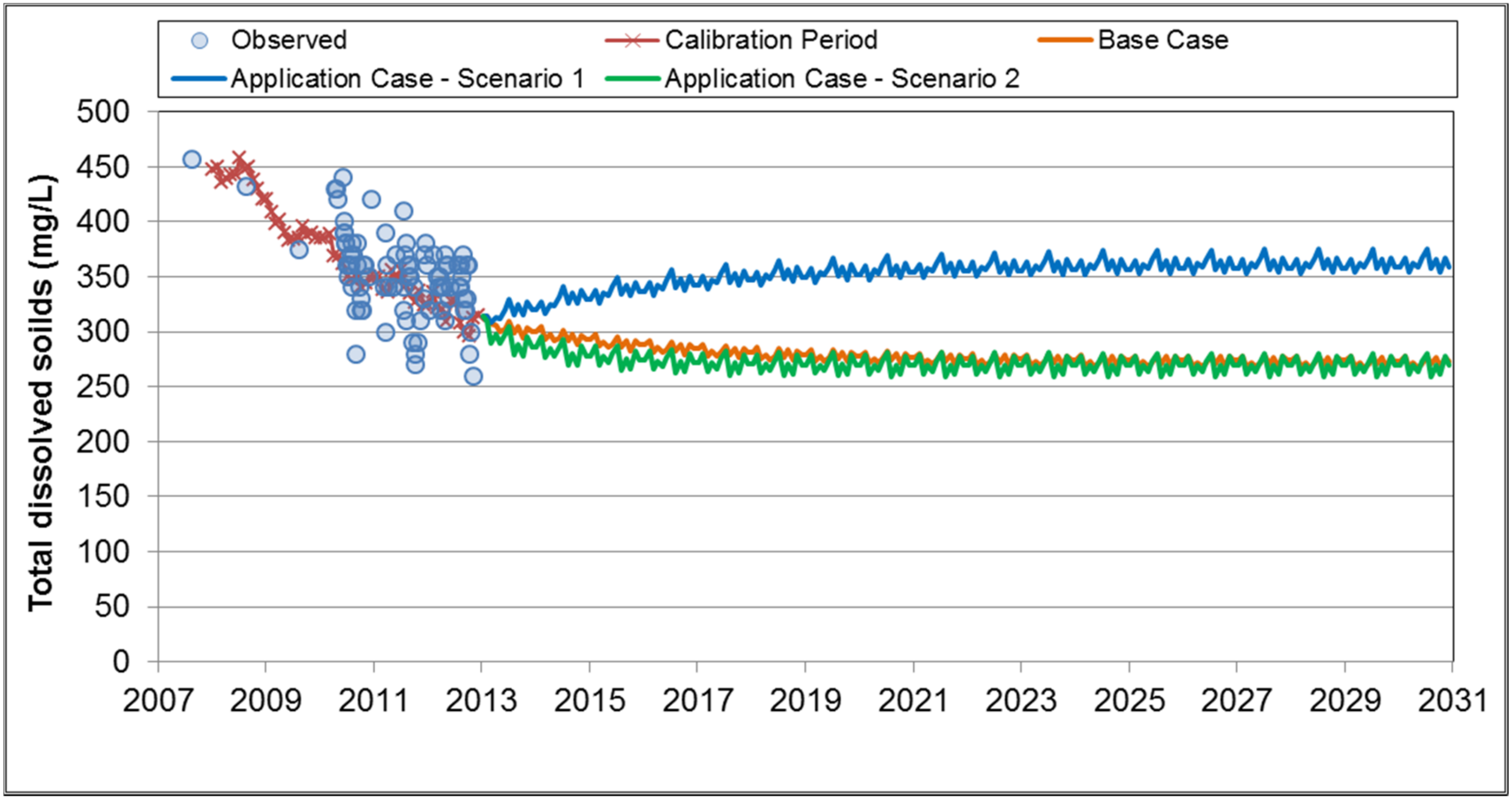


Figure 12: Observed, Calibrated, and Predicted TDS Concentrations in the Genesee Cooling Pond

Table 6: Predicted In-stream Concentrations in the North Saskatchewan River Downstream of the Blowdown Outfall Compared to Water Quality Guidelines

Parameter	Units	Water Quality Guidelines			NSR Upstream of GGS	Predicted GGS Blowdown Concentration			Predicted In-stream Concentration		
		Aquatic Life[a]		Human Health[b]		Base Case	Application Case		Base Case	Application Case	
		Acute	Chronic				Scenario 1	Scenario 2		Scenario 1	Scenario 2
Total Dissolved Solids	mg/L	-	-	-	230	282	369	281	235	245	239
Calcium	mg/L	-	-	-	44	43	58	53	46	46	46
Chloride	mg/L	640	120	-	2	3.3	3.8	2.4	2.2	2.2	2.1
Magnesium	mg/L	-	-	-	14	25	30	21	16	16	16
Barium	mg/L	-	-	1000	0.074	0.11	0.14	0.12	0.081	0.081	0.081
Sodium	mg/L	-	-	-	5	36	42	22	8.9	8.9	7.9
Sulphate	mg/L	-	-	-	42	132	153	95	54	54	51
Fluoride	mg/L	-	0.12	1.5	0.12	0.3	0.35	0.24	**0.15**	**0.15**	**0.14**

(a) Based on the guideline of: CCME (1999).

(b) Based on the guideline of: Health Canada (2008).

" - " symbol indicates no applicable guideline, no applicable objective or no available data.

Table 7: Predicted In-stream Concentrations in the North Saskatchewan River Downstream of the Blowdown Outfall Compared to Relevant Reach-Specific Water Quality Objectives

Parameter	Units	NSR Water Quality Objectives[a]			NSR Upstream of GGS	Predicted GGS Blowdown Concentration			Predicted In-stream Concentration		
		Flow Condition[b]	50th Percentile[c]	95th Percentile[d]		Base Case	Application Case Scenario 1	Application Case Scenario 2	Base Case	Application Case Scenario 1	Application Case Scenario 2
Total Dissolved Solids	mg/L	IC	196	235	230	282	369	281	231	232	231
		OW	186	248							
Calcium	mg/L	IC	46	53	44.3	43	58	53	44	44	44
		OW	42	46							
Chloride	mg/L	IC	0.7	2.6	2	3.3	3.8	2.4	2	2	2
		OW	0.8	2.4							
Magnesium	mg/L	IC	-	-	14.4	25	30	21	15	15	15
		OW	-	-							
Barium	mg/L	IC	-	-	0.0735	0.11	0.14	0.12	0.074	0.074	0.074
		OW	-	-							
Sodium	mg/L	IC	-	-	5	36	42	22	5.4	5.4	5.3
		OW	-	-							
Sulphate	mg/L	IC	45	52	42.2	132	153	95	43	43	43
		OW	38	48							
Fluoride	mg/L	IC	0.12	0.21	0.122	0.3	0.35	0.24	0.12	0.12	0.12
		OW	0.12	0.19							

(a) Based on NSWA (2010) Reach C downstream of the Brazeau River confluence to Devon.

(b) IC = ice covered; OW = open water.

(c) Using the 50th percentile statistic as an objective means at least half of future measurements should be below this value; and there should be no statistically significant, increasing trend detected in the analysis of future, long-term monitoring data.

(d) Using the 95th percentile statistic as an objective means at least 95% of future measurements should be below this value; and there should be no statistically significant increasing trend detected in the analysis of future, long-term monitoring data.

" - " symbol indicates no applicable guideline, no applicable objective or no available data.

4.0 FISH ASSESSMENT

4.1 Genesee Cooling Pond

4.1.1 Waterbody Status under the *Fisheries Act*

Under the federal *Fisheries Act,* Section 35(1) stipulates that "No person shall carry on any work, undertaking or activity that results in the harmful alteration or disruption, or the destruction, of fish[1] habitat" without review and approval by the Minister. The *Act* defines fish habitat as "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes".

An amendment to the *Fisheries Act* was introduced in 2012, which proposed to limit the applicability of Section 35(1) to fish that are "part of a commercial, recreational, or Aboriginal fishery, or to fish that support such a fishery". The Section 35(1) amendment took effect 26 November 2013. Although the cooling pond is not currently open to the public, the cooling pond has been accessible as a recreational fishery as recent as 2001. Some anglers still claim to illegally access the site to angle for walleye and northern pike. Therefore, the present fish assessment has been prepared with consideration of Section 35(1) of the *Fisheries Act* as is currently in force.

4.1.2 Genesee Cooling Pond Biomonitoring Program

The CPC operating approval issued by Alberta Environment for the GGS contains requirements to conduct special monitoring programs[2]. Where these programs overlap, they have been integrated into a Regional Biomonitoring Program (the Biomonitoring Program) which is jointly run by TransAlta Generation Partnership (TransAlta) and CPC. The Biomonitoring Program is designed to monitor the long-term environmental effects, if any, attributable to the operation of the Keephills, Sundance and Wabamun (decommissioned in 2010) Generating Stations, and the GGS.

The Biomonitoring Program focuses on potential exposure pathways[3] to measure impacts on environmental receptors, including fish, using selected indicators of environmental health, such as fish tissue chemistry. The Biomonitoring Program focuses on the measurement and assessment of potential changes in environmental concentrations of several chemicals of potential concern[4] (COPC) associated with aerial and water emissions from generating plants (TransAlta and CPC 2011). The fisheries portion of the biomonitoring program collects northern pike (*Esox lucius*) from the Genesee and Keephills Cooling Ponds, Wabamun Lake, and Wizard Lake. Northern pike and walleye (*Sander vitreus*) have been collected from the North Saskatchewan River (NSR) in the past (i.e., 2004 and 2006), but only walleye were collected in 2010. Lake whitefish (*Coregonus clupeaformis*) are collected in addition to northern pike in Wabamun Lake, with the species representing a lower and a top trophic level fish, respectively, in the lake. Fish collected as part of the Biomonitoring Program undergo an external and internal fish health assessment, including aging, and muscle filets are submitted for tissue chemistry analysis. Baseline fisheries sampling for the Biomonitoring Program was conducted in 2004, prior to the commissioning of the GGS Phase 3 (G3), and results were reported to Alberta Environment in 2005 (TransAlta and EPCOR 2005). Baseline fish programs collected 10 fish per water body per species. Long term

[1] The Fisheries Act defines "fish" as including (a) parts of fish, (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.

[2] Some of the special monitoring programs include the Chemicals of Potential Concern, Mercury Assessment, and North Saskatchewan River Water Quality Programs (among others).

[3] Exposure pathways include aerial emissions (e.g., stack emissions) and water emissions (e.g., cooling pond blowdown discharge).

[4] COPCs chosen for the Biomonitoring Program include arsenic, barium, cadmium, lead, manganese, mercury and selenium. Other COPC are also monitored under separate programs.

monitoring commenced in 2006 (TransAlta and EPCOR 2006). Regular scheduled monitoring occurred again in 2010, at which time fish sample sizes were increased to 35 fish per water body, which allowed better statistical power to detect differences between waterbodies in fish tissue COPC endpoints (TransAlta and CPC 2011). The next phase of the Biomonitoring Program is scheduled to occur in September of 2015.

Fish species collected in the cooling pond during the Biomonitoring Program have been limited to target study species (i.e., northern pike) due to selective fishing methods used during the program (i.e., angling). Baseline data collections, however, indicate the presence of northern pike, walleye, sucker and forage species (e.g., minnows and stickleback) in the cooling pond (EPCOR 2001, Section 4.6).

4.1.3 Water Quality

Changes in water quality in the cooling pond with the addition of G4 and G5 are predicted to be limited largely to TDS, calcium, sodium, magnesium and sulphate under the Application Case - Scenario 1 (year 2020). Concentrations of most parameters are expected to decrease under Application Case – Scenario 2 conditions, with the exception of calcium, which will increase by 10 mg/L in the cooling pond at the blowdown location (Table 6). The predicted increases in concentrations in cooling pond under Application Case – Scenario 1 are as follows (based on Table 6):

- 87 mg/L in TDS;
- 15 mg/L in calcium;
- 5 mg/L in magnesium;
- 6 mg/L in sodium; and
- 21 mg/L in sulphate.

The TDS of a waterbody is essentially an expression of salinity; it is the sum of the concentrations of all common dissolved ions (e.g., sodium, calcium, magnesium, potassium, chloride, sulphate, bicarbonate, and nitrate) in freshwaters (APHA 2005). High concentrations of TDS can be harmful to fish if they are not adapted to these elevated concentrations. The Canadian Council of Ministers of the Environment (CCME) does not have established Water Quality Guidelines (WQGs) for the protection of aquatic life for TDS or chloride.

There are two mechanisms of TDS toxicity to fish: osmotic stress and specific ion toxicity. These two mechanisms are not mutually exclusive. Osmotic stress may occur when a fish is exposed to an increase in TDS, which may cause cellular desiccation due to increased osmotic potential between the organism and the water. Under these circumstances, water flows from the cell (with relatively low solute concentration) to the surrounding environment (an area of relatively high solute concentration). Specific ion toxicity considers the uptake of a particular ion by an organism to concentrations that have adverse effects on normal cellular function. Fish appear to be less sensitive to TDS than other aquatic organisms such as zooplankton, but this is dependent on the life stage tested and the specific ionic composition of the TDS.

TDS effect concentrations reported in the literature range from 250 mg/L up to greater than 10,000 mg/L for various fish species (Dowden and Bennett 1965; Patrick et al. 1968; Grizzle and Mauldin 1995; Stoss et al. 1977; Waller et al. 1996). Stekoll et al. (2003) observed variation in the life history characteristics of 54 Ontario lake trout (*Salvelinus namaycush*) populations with variations in TDS concentrations ranging from 15-180 mg/L. Populations from high-TDS lakes exhibited higher growth rates in early life, lower age at first maturity, and higher natural mortality rates. In another regional example, Alaskan waterbodies may not have TDS exceed 1000 mg/L in receiving water, and permits are required for discharges that result in an increase between 500 and

1000 mg/L (ADEC 2009). In a site-specific TDS guideline permit issued in Alaska to an operating Mine, concentrations of up to 1500 mg/L were permitted during periods when salmonids were not spawning (provided calcium was greater than 50% by weight of the total cations), while during spawning periods, the limit was set at 500 mg/L (ADEC 2009, Brix et al. 2010). Sulphate toxicity to aquatic organisms is expected to occur above 200 mg/L under soft water conditions, and >700mg/L under hard water conditions (based on a species sensitivity distribution, Elphick et al. 2011).

In consideration of these guidelines in natural waterbodies where fish are not isolated in a cooling pond environment and acclimated to Base Case conditions, and given the predicted maximum TDS concentrations in the cooling pond of 369 mg/L, impacts to fish species in the cooling pond due to elevated concentrations of TDS are expected to be minimal. Fish may experience osmotic or ionic stress in areas nearest the discharge location when G4 and G5 initially come online, but fish are expected to acclimate within a short period of time to the new water quality conditions. No toxicity is expected for fish species due to increases in other chemical parameters in the water.

4.1.4 Fish Habitat

4.1.4.1 Thermal Habitat

Water temperatures in the cooling pond are predicted to increase (on average[5]) from <2°C at the condenser inlet and blowdown location, up to a maximum of 2.7°C in near-shore areas in the South Basin as a result of the addition of G4 and G5 (Table 8 and 9). The elevation of water temperatures may affect the survival and reproductive success of fish species currently inhabiting the pond. The effects of increased water temperatures on northern pike (*Esox lucius*) and walleye (*Sander vitreus*) are considered in the following section.

The maximum surface temperature in the cooling pond under Base Case operational conditions was 34.8°C, documented in the south basin in the near shore habitat in mid-summer (July 2012, Table 8). The addition of G4 and G5 under the Application Case is predicted to increase the maximum surface temperature (in the same region of the pond in mid-summer peak temperatures) to 37.3°C.

Table 8: Predicted Average Daily Water Temperatures in the North and South Basins of Genesee Cooling Pond, under Base Case and Application Case Conditions

Temperature in the North Basin (close to the shore)	**Base Case (°C)**	**Application Case (°C)**	**Difference (°C)**
Maximum	30.2	32.2	2.0
Average	13.2	15.4	2.2
99th Percentile	27.8	30.1	2.3
Temperature in the South Basin (close to the shore)			
Maximum	34.8	37.3	2.5
Average	18.7	21.4	2.7
99th Percentile	33.2	35.4	2.2

[5] These predictions were based on average daily water temperature predictions under Base and Application Case scenarios

The literature suggests the optimal thermal habitat for northern pike is approximately 20°C (McPhail 2007), while the upper lethal thermal limit for the species is approximately 29 to 30°C (Casselman 1978 and Ridenhour 1957 in Casselman and Lewis 1996). Walleye have a similar thermal profile, with an optimal thermal range reported from 20-23°C, and an upper thermal limit between 30 to 34°C (Kerr et al 1997; Hasnain et al. 2010; Hokanson 1977). Based on these criteria, there currently exists a limitation in available thermal habitat for adult walleye and northern pike during peak summer temperatures, particularly in shallow areas of the pond (Figure 7). The habitat will be limited further under the proposed addition of G4 and G5 (Figure 11); however, modelled temperature profiles in all regions of the pond are predicted to drop below the upper thermal limits of both species within the first one to two metres from the surface (Figure 13). Although impacts to adult northern pike and walleye due to loss of thermal habitat are predicted as a result of the addition of G4 and G5, these impacts will be mitigated by fish actively selecting cooler waters, as both species migrate to more optimal habitats (e.g., lower temperature waters) during peak temperature periods (Scott and Crossman 1973). For example, the north basin of cooling pond has areas with depth of 10 to 12 m, which will provide refuge during peak temperature periods. The remainder of the pond (i.e., middle of the pond and south basin) is between 3 and 6 m deep. These regions are predicted to continue to provide acceptable thermal habitat that falls within optimal water temperature ranges (i.e., 20 to 23°C) for both walleye and northern pike during the remainder of the year (i.e., during non-peak temperature periods). With the warmer water temperatures, the feeding behaviour of northern pike and the behaviours of their prey may be affected during certain times of the year. Northern pike are an ambush predator and the cooler, deeper water may not contain as much vegetation cover, or prey for consumption.

The increased water temperature in the cooling pond may also impact the spawning, incubation, and rearing of northern pike and walleye. Northern pike are spring spawning species, with spawning initiated in natural systems immediately after ice melts in water temperatures ranging from 4 to 18°C (Scott and Crossman 1973, McPhail 2007). Maximum recruitment occurs at 23 to 24°C in natural waterbodies, and eggs usually hatch in 12 to 14 days (at 20°C), but can hatch in four-to-five days at 17.8 to 20°C (Scott and Crossman 1973, Casselman and Lewis 1996). While adult pike move to deeper, cooler waters at the height of summer temperatures, young remain in shallow spawning areas for several weeks after hatching. Maximum growth of young-of-the-year northern pike in natural waterbodies occurs at 22 to 23°C, whereas maximum recruitment occurs at a temperature that is only slightly higher (23 to 24°C) (Casselman and Lewis 1996). Northern pike have been documented as successfully spawning in the cooling pond, and are believed to spawn in the south basin of the cooling pond in the region where there is abundant macrophyte growth (EPCOR 2001, Section 4.6). Water temperatures are predicted to increase approximately 2.7°C in the south basin of cooling pond with the addition of G4 and G5 during peak summer temperatures (Table 8, Figure 13). If temperature elevations of a similar magnitude occur during spring spawning, northern pike spawning success may be impaired in the cooling pond by reduced egg viability and hatching success. Young that hatch may have an increased incidence of developmental deformities due to the accelerated incubation period. Northern pike young-of-the-year are expected to remain in the shallower water in the south basin during peak summer temperatures and, therefore, will be most likely impacted by the 2.7°C increase in peak summer temperature. Increased rate of development in young-of-the-year fish may occur due to the elevated temperatures, however, concomitant reductions in availability of food items (e.g., benthic invertebrates) may also occur.

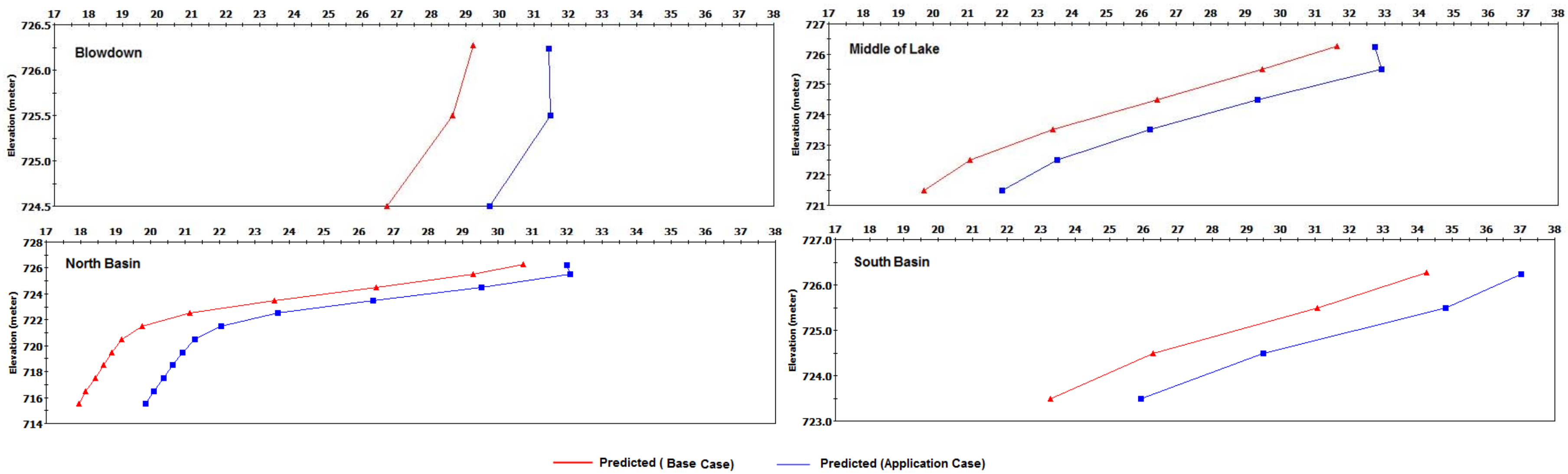


Figure 13: Predicted Temperature profiles in Genesee Cooling Pond under Base and Application Case conditions at the blowdown location, middle of the lake, north basin and south basin on July 12, 2012.

In natural waterbodies, walleye typically spawn in the spring in water temperatures between 4 and 14°C, although spawning behaviours are initiated at lower temperatures (Scott and Crossman 1973, McPhail 2007, Bozek et al. 2011). Walleye prefer spawning in shallow water, usually over rocky shoals, but have been reported to spawn at depths of up to 6.1 m in fluvial habitats (McPhail 2007). Optimal incubation temperatures for walleye eggs are 9 to 15°C, where eggs hatch in 12 to 18 days (Koenst and Smith 1976 in McPhail 2007). Walleye spawning has not been documented in the cooling pond, but it is believed it would occur in the north basin of the cooling pond (EPCOR 2001, Section 4.6). Surface water temperatures are predicted to increase an average of 2.2°C in this area of the cooling pond under the Application Case. Given there has been no evidence supporting successful walleye recruitment in the cooling pond (i.e., presence of juvenile or young-of-the-year fish), it is expected predicted changes in water temperatures in the cooling pond will not alter walleye recruitment from Base Case conditions.

4.1.4.2 Gas Bubble Trauma

Total dissolved gas supersaturation (TDGS) in water can be caused by a variety of natural and anthropogenic phenomena and occurs when the partial pressures of atmospheric gases in solution exceed their respective partial pressures in the atmosphere. At coal-fired power generation facilities, the risk for high TDGS arises when cooling water is heated in the condenser and released to the cooling pond without an opportunity for the gases to dissipate. It is under these conditions that gases may accumulate in the tissues of aquatic organisms (including benthic invertebrates and fish), resulting in gas bubble trauma (GBT). GBT is analogous to the 'bends' experienced by SCUBA divers and can range from mild to fatal depending on the level of TDGS, water depth, temperature of the water, fish species, life cycle stage, and condition of the fish (Mesa et al. 2000). An increase in temperature of 1°C causes an increase in total gas pressure (TGP) of approximately 2%, such that rapid thermal rises of as little as 3 to 5°C can cause GBT (Marking 1987).

Though harmful levels of supersaturation vary with the species of fish involved, the Canadian Council of Ministers of the Environment (CCME) suggests a supersaturation level of 103-110% to be protective of aquatic life, dependent on water depth and partial pressure of dissolved oxygen (CCME 1999). At 1 m depth, most fish can tolerate 120% saturation, with tolerance increasing approximately 10% for each additional metre of depth. Therefore, fish experiencing supersaturated water of 140% require habitat of at least three metres depth to provide a safe refuge from developing GBT. The effects of GBT can be reversible if deeper water is available or if movement to an area with lower TGP is possible (Hans et al. 1999).

Based on predicted changes in temperature (i.e., Application Case), changes in TGP were calculated for the condenser inlet, blowdown, and north and south basins of the cooling pond (Table 9). These changes assumed a 2.5% increase in TGP for each 1°C temperature increase. The greatest increase in TGP (6.8%) was predicted in the south basin, close to shore. Due to the addition of G4 and G5, an additional 0.68 m depth of water will be required, above Base Case TGP-associated depth requirements, to provide safe refuge for fish from this increase in TGP. Based on the maximum TGP recorded in the cooling pond (EPCOR 2001, Section 4.6), the maximum depth required to achieve acceptable TGP for fish in the pond is 2.7 m. Approximately 28% of the pond is less than 3 m deep. However, the north basin of the cooling pond has areas with depths ranging from 10 to 12 m, and the depth within the majority of the remaining pond (i.e., middle of the pond and south basin) is greater than 3 m in depth. As such these deeper areas within the pond are predicted to provide habitat for fish that falls within the TDG protective limit of 100% for fish. It is expected the predicted changes in TGP in the cooling pond will be of short duration and are unlikely to affect the suitability of the pond for maintaining the existing resident fish species and communities.

Table 9: Predicted Changes in Surface Water Temperature and Total Gas Pressure (TGP) and Resulting Fish Habitat Depth Requirements under Base and Application Case (Predicted) Conditions at the Condenser Inlet, Blowdown, North Basin (Near Shore) and South Basin

	Base Case Surface Water Temperature (°C)	Application Case Predicted Surface Water Temperature (°C)	Difference (°C)	Predicted Change in TGP (1) (%)	Additional Depth Necessary (2) (m)	Measured Highest TGP in Pond (3) (%)	Predicted Highest TGP in Pond (%)	Depth Where Predicted TGP is Acceptable for Fish in Pond (4) (m)
Temperature at the Condenser Inlet								
Maximum	28.1	30.2	2.1	5.2	0.52	125.0	130.3	2.53
Average	12.3	14.1	1.8	4.5	0.45	125.0	129.5	2.45
99^{th} Percentile	26.5	28.5	2.0	5.0	0.50	125.0	130.0	2.50
Temperature at Blowdown								
Maximum	29.4	31.5	2.1	5.3	0.53	125.0	130.3	2.53
Average	12.6	14.5	1.9	4.8	0.48	125.0	129.8	2.48
99^{th} Percentile	27.4	29.6	2.2	5.5	0.55	125.0	130.5	2.55
Temperature in the North Basin (close to the shore)								
Maximum	30.2	32.2	2.0	5.0	0.50	125.0	130.0	2.50
Average	13.2	15.4	2.2	5.5	0.55	125.0	130.5	2.55
99^{th} Percentile	27.8	30.1	2.3	5.8	0.58	125.0	130.8	2.58
Temperature in the South Basin (close to the shore)								
Maximum	34.8	37.3	2.5	6.3	0.63	125.0	131.3	2.63
Average	18.7	21.4	2.7	6.8	0.68	125.0	131.8	2.68
99^{th} Percentile	33.0	35.4	2.2	5.5	0.55	125.0	130.5	2.55

(1) Assumes TGP increases 2.5% with each 1°C increase; (2) additional depth necessary to achieve Application Case TGP, and assumes TGP decreases 10% for each 1 m depth; (3) TGP measured in the outlet canal at 0.5 m, assumed highest in pond (EPCOR 2001, Section 4.6); (4) 110% TGP at 0.5m depth, or 120% TGP at 1m depth accepted standard for fish based on CCME (1999) guideline. Depth where predicted TGP is acceptable to fish = ([predicted highest TGP in pond])-110)/10 + 0.5.

4.2 North Saskatchewan River

4.2.1 Water Quality

The following water quality parameters were assessed: total dissolved solids (TDS), calcium, chloride, magnesium, barium, sodium, sulphate, and fluoride. Instream concentrations at the blowdown discharge location on the North Saskatchewan River (NSR) are predicted to be below Base Case conditions under both Application Case Scenarios for all parameters, except TDS (Table 6). The maximum increase in TDS from Base Case concentrations in the NSR is 10 mg/L (under Application Case - Scenario 1). An increase in TDS of only 4 mg/L in the NSR is predicted under Application Case - Scenario 2. No impacts to fish or aquatic life as a result of changes in water quality are expected in the NSR.

4.2.2 Fish Habitat

4.2.2.1 Thermal Habitat

Changes to the water temperature in the NSR (in-stream water temperatures) were estimated using the approach described in Appendix C and are presented in Table 10. Water temperatures in the NSR as a result of the addition of G4 and G5 are not predicted to change during either winter or summer seasons (Table 9); therefore, no impacts to fish or aquatic species as a result of temperature are expected in the NSR.

Table 10: Estimated NSR Water Temperature under Base and Application Case for Extreme Conditions (Winter and Summer)

Parameter	Units	Condition	NSR Temperature at Devon	GGS Blowdown Temperature		Predicted Instream Temperature	
				Base Case	Application Case	Base Case	Application Case
Temperature	°C	Minimum	0	2	2	0.023	0.023
		Maximum	22.2	30	32	22.3	22.3

Note: blowdown rate applied to the Base Case was 0.69 m^3/s (average rate from 2010 to 2012) and the rate applied to the Application Case was 1.19 m^3/s (maximum blowdown capacity)

4.2.2.2 Gas Bubble Trauma

Due to no predicted changes in water temperature in the NSR as a result of the addition of G4 and G5, there are similarly no predicted changes in TGP at the blowdown discharge location in the NSR. No impacts to fish or aquatic species as a result of elevated gas pressures are expected in the NSR.

5.0 NSR HYDROLOGY SUPPORTING ASSESSMENT

The scope of work for the hydrology supporting assessment involved updating the Golder (2010) work including:

- Updating hydrology metrics for the reach, based on data from Water Survey of Canada hydrometric station 05DF001 (North Saskatchewan River at Edmonton);
- Updating a listing of licenced water users between Genesee and Rossdale, and characterizing current NSR water use on that reach of the river;
- Providing comment on the relative magnitude of the incremental water withdrawal, and characterizing effects on NSR water levels; and
- Comparing the effects of the licenced withdrawal with and without blowdown for the Base and Application cases.

5.1 Updated NSR Hydrology

Long-term stream flow data from Station 05DF001 were used to generate statistics to characterize the flow regime of the NSR (Environment Canada 2013b).

The NSR at Station 05DF001, located at the Low Level Bridge in the City of Edmonton, has a gross drainage area of 28,100 km^2 and an effective drainage area of 27,100 km^2. The NSR at Highway 759, at the Environment Canada hydrometric station located upstream of GGS and south of Tomahawk, has a gross drainage area of 22,100 km^2 and an effective drainage area of 22,000 km^2. Despite a difference in drainage areas of 23%, the flow regime is similar in the entire reach from GGS to Station 05DF001. This is due to the vast majority of flow originating in areas of high water yield in the mountains and foothills, the relatively low water yield from the local tributaries, and flow regulation at upstream hydropower facilities.

Flow in the NSR at GGS is regulated at two locations: the Brazeau Dam on the Brazeau River (since 1961) and the Bighorn Dam (since 1972) on the NSR located approximately 330 km upstream of the GGS. These are hydroelectric facilities operated by TransAlta Utilities. The dams are operated to meet peak power demands and cause fluctuations in the NSR flow rate on an hourly to daily scale. Both dams have also caused mean winter flows to increase and have reduced peak flood flows in the NSR (NSWA 2006).

Table 11 provides long-term monthly flow statistics for Station 05DF001 and includes the results of the Alberta Environment (AENV 2005) analysis of naturalized flows for the period 1912 to 2002, naturalized flows for the post-dam period 1973 to 2002, and recorded flows for the post-dam period 1973 to 2011.

As provided in Table 11, the mean flows during the winter months (November through March) are higher in the post-dam period, and mean flows in the adjacent months of October and April are also greater. Mean flows during the open-water months of May through September are currently smaller than if the dams had not been constructed. Annual flows are only slightly affected by the dams.

The AENV (2005) naturalized flow study did not provide daily data that would be required to examine flood peak discharges. Results of analysis of minimum and maximum annual mean daily flows, considering the pre- and post-dam periods are shown in Table 12.

Table 11: Mean Monthly Discharges for Station 05DF001 North Saskatchewan River at Edmonton (1912-2011)

Month	Minimum (m^3/s)			Mean (m^3/s)			Maximum (m^3/s)		
	Naturalized (1912-2002)	Naturalized (1973-2002)	Recorded (1973-2011)	Naturalized (1912-2002)	Naturalized (1973-2002)	Recorded (1973-2011)	Naturalized (1912-2002)	Naturalized (1973-2002)	Recorded (1973-2011)
January	15.7	15.7	82.2	35.9	31.8	112	70.5	69.3	160
February	16.8	16.8	82.2	34.8	33.1	113	65.6	57.0	153
March	14.7	14.7	90.8	46.1	54.9	132	111	111	192
April	67.4	89.7	149	156	160	228	407	407	432
May	102	128	135	290	265	250	1100	429	431
June	240	266	181	547	485	349	1080	1030	857
July	288	322	138	560	552	347	1210	1030	851
August	225	225	127	390	365	220	820	601	479
September	126	126	103	250	227	183	738	371	353
October	49.2	49.2	91.1	135	128	152	293	273	260
November	25.1	25.1	77.5	65.4	57.4	129	130	127	188
December	16.9	16.9	76.0	37.1	30.8	118	83.8	83.8	192
Annual	136	136	140	214	201	194	365	299	292

Table 12: Extreme Flood and Low Flow Discharges for Station 05DF001 North Saskatchewan River at Edmonton (1911-2011)

Return Period (years)	Minimum Mean Daily Discharge (m^3/s)		Maximum Mean Daily Discharge (m^3/s)		Maximum Instantaneous Discharge (m^3/s)	
	Pre-Dam (1911–1960)	Post-Dam (1973–2011)	Pre-Dam (1911–1960)	Post-Dam (1973–2011)	Pre-Dam (1911–1960)	Post-Dam (1973–2011)
2	20.6	69.0	1150	748	1260	848
5	15.1	52.9	1820	1300	1960	1440
10	12.5	43.7	2390	1810	2590	1980
20	10.5	36.6	3050	2430	3350	2650
50	8.37	29.8	4060	3490	4590	3780
100	7.04	26.3	4940	4500	5760	4870
7Q10	15.9	60.2	n/a	n/a	n/a	n/a

To evaluate the effects of changes to river discharge on water levels, a stage-discharge rating curve was used. A stage-discharge rating curve for the NSR at GGS was adapted from that presented in the Genesee Unit 3 Application (EPCOR 2001) and is presented in Figure 14. A stage-discharge rating curve for the NSR at Edmonton was adapted from data available from the Water Survey of Canada and is also presented in Figure 14. These rating curves are assumed to be representative of conditions in the reach of the NSR between GGS and Station 05DF001.

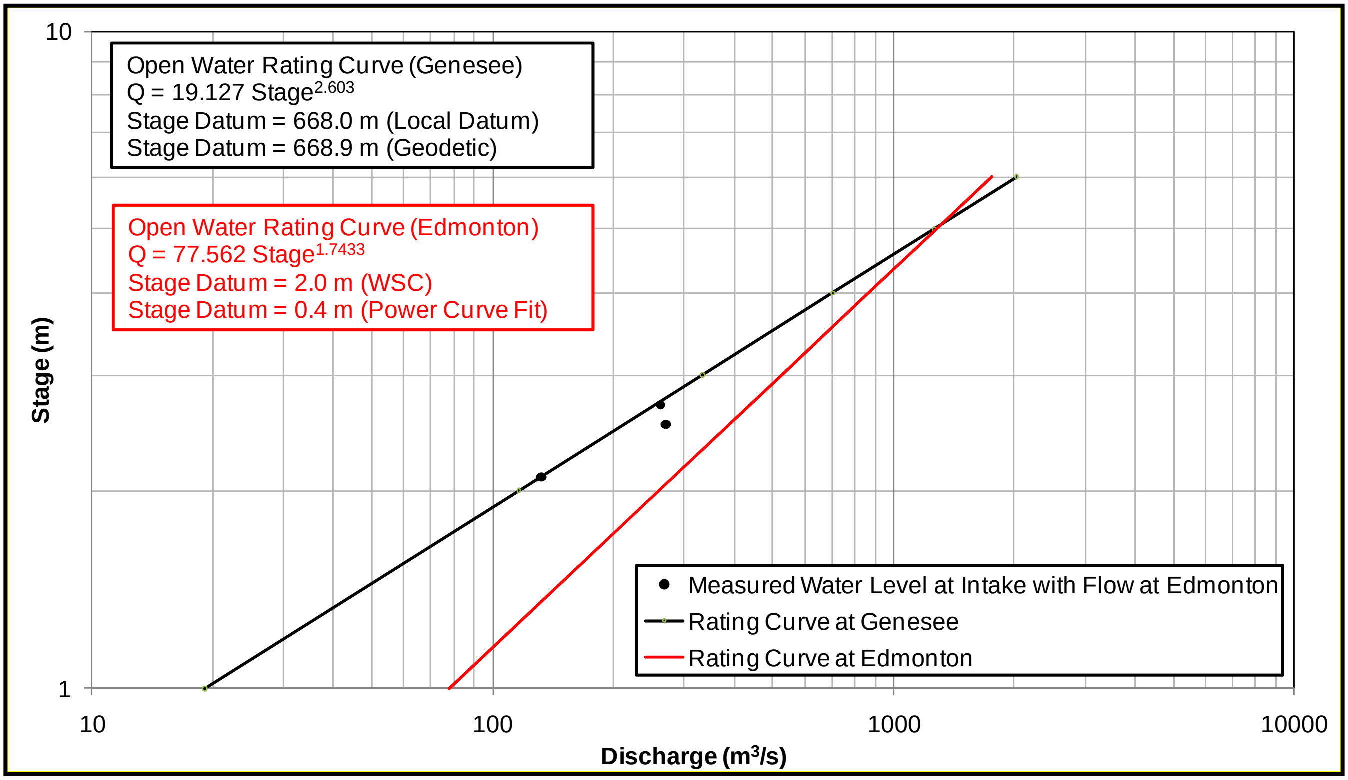


Figure 14: Stage-Discharge Rating Curves for NSR at GGS and Edmonton (Station 05DF001)

5.2 Updated Water Licence Information

A database of water licences on the NSR was received from AENV (2012). The database contained 305 licences for surface water withdrawals from the NSR. Table 13 lists licences for the 9 facilities (comprising a total of 19 licences) with licenced water withdrawals greater than 1 Mm^3/y (annual mean withdrawal rate of 32 L/s) as well as the 14 facilities (comprising a total of 18 licences) with licenced water withdrawals between 0.1 and 1 Mm^3/y (annual mean withdrawal rate of between 3.2 and 32 L/s), between GGS and Station 05DF001. These 23 facilities account for 99.8% of licenced withdrawals and 99.5% of licenced consumptive use, with an additional 32 smaller licences making up the remainder. Some facilities have multiple licences that reflect past expansions or other changes and were added together where appropriate.

Values of consumptive use were calculated as a percentage of 7Q10 (7-day duration low flow with a 1 in 10 year recurrence interval) and mean annual flow (MAF) are based on the post-dam 7Q10 value of 60.2 m^3/s and post-dam MAF of 194 m^3/s.

Information regarding licences upstream of GGS and downstream of Station 05DF001 is provided in Table 14. There are 49 licenced water withdrawals on the NSR upstream of GGS and 219 licenced water withdrawals between Station 05DF001 and the Alberta-Saskatchewan Border. The total licenced withdrawal from these areas is 633.2 Mm^3/y and the total licenced consumptive use is 152.9 Mm^3/y. The total licenced consumptive use is equal to 8.0% of the post-dam 7Q10 and 2.5% of the post-dam mean annual flow.

Table 13: Major Licenced Withdrawals from the North Saskatchewan River between GGS and Station 05DF001

No.	Permit Holder	Approval Name	Industry Activity[a]	Location	Licence Priority Date	Licenced Withdrawal (m^3/y)	Return Flow (m^3/y)	Consumptive Use (m^3/y)	Consumptive Use (% of 7Q10)	Consumptive Use (% of MAF)
1	EPCOR Power Development Corporation	Edmonton/Cooling/ Edmonton Power - F27455	COOLING	SW-32-52-25-W4M	23-Aug-37	53,017,280	37,907,360	15,109,920	0.80%	0.25%
			COOLING	SW-32-52-25-W4M	04-Feb-75	149,382,720	106,808,650	42,574,070	2.24%	0.70%
			COOLING	SW-32-52-25-W4M	07-Jun-54	35,871,600	25,648,200	10,223,400	0.54%	0.17%
2	City of Edmonton	Edmonton/Municipal/ Edmonton City - F00219A	URBAN	SE-9-52-25-W4M	29-Oct-14	23,239,500	16,902,090	6,337,410	0.33%	0.10%
			URBAN	SE-9-52-25-W4M	07-Jun-54	112,562,960	81,867,050	30,695,910	1.62%	0.50%
3	TransAlta Utilities Corporation	Keephills/Cooling/ TransAlta Sundance-F12245-A	COOLING	NE-21-51-3-W5M	19-Nov-73	40,740,740	18,024,691	22,716,049	1.20%	0.37%
			COOLING	NE-21-51-3-W5M	01-Dec-98	14,185,000	9,744,400	4,440,600	0.23%	0.07%
4	TransAlta Utilities Corporation	Keephills/Cooling/ TransAlta Utilities - F17917	COOLING	NE-21-51-3-W5M	23-Aug-79	1,234,000	617,000	617,000	0.03%	0.01%
			COOLING	NE-21-51-3-W5M	02-Dec-76	20,361,000	10,180,500	10,180,500	0.54%	0.17%
			COOLING	NE-21-51-3-W5M	22-Aug-79	21,594,700	10,797,500	10,797,200	0.57%	0.18%
5	Capital Power GP Holdings Inc.	Edmonton Power Inc, Wr, 16576	COOLING	NE-32-50-3-W5M	21-Apr-82	22,128,394	11,064,197	11,064,197	0.58%	0.18%
			COOLING	NE-32-50-3-W5M	03-Jun-10	12,000,000	12,000,000	0	0.00%	0.0%
6	Penn West Energy Trust	Edmonton/Injection/ Acclaim Processing Co Ltd - F09581	INJECTN	NE-9-52-25-W4M	17-Feb-88	883,180	16,040	867,140	0.05%	0.01%
			INJECTN	NE-9-52-25-W4M	11-Feb-80	313,300	0	313,300	0.02%	0.01%
			INJECTN	NE-9-52-25-W4M	13-Sep-56	1,356,830	0	1,356,830	0.07%	0.02%
			INJECTN	NE-9-52-25-W4M	09-May-89	2,269,610	0	2,269,610	0.12%	0.04%
7	Imperial Oil Resources Ltd.	Imperial Oil Resources Ltd, Wr, 12810	INJECTN	SE-23-50-28-W4M	03-Feb-92	3,786,780	345,370	3,441,410	0.18%	0.06%
8	University Of Alberta	Edmonton/Cooling/ University Of Alta, Wr, 11990	COOLING	SE-31-52-24-W4M	23-Apr-79	21,585,910	20,506,610	1,079,300	0.06%	0.02%
			COOLING	SE-31-52-24-W4M	28-Sep-65	21,585,940	20,506,640	1,079,300	0.06%	0.02%

Table 13: Major Licenced Withdrawals from the North Saskatchewan River between GGS and Station 05DF001 *(continued)*

Intake No.	Permit Holder	Approval Name	Industry Activity	Location	Licence Priority Date	Licenced Withdrawal (m^3/y)	Return Flow (m^3/y)	Consumptive Use		
								(m^3/y)	(% of 7Q10)	(% of MAF)
9	Imperial Oil Resources Ltd.	Esso Resources Canada Ltd, Wr, 09220	INJECTN	SW-32-50-26-W4M	07-Oct-53	1,356,830	0	1,356,830	0.07%	0.02%
10	Ravenwood Energy Corp.	Calmar/Injection/Argonauts Group Ltd. - F27496	INJECTN	SE-23-50-28-W4M	20-Feb-96	875,770	0	875,770	0.05%	0.01%
11	Imperial Oil Resources Ltd.	Esso Resources Canada Ltd, WR, 08406	GAS/PTRO	SW-35-50-26-W4M	04-Aug-49	431,720	0	431,720	0.02%	0.01%
12	Ducks Unlimited Canada	Dog Lake, WR, 22733	WTLNDS	SE-28-51-1-W5M	22-May-87	291,100	0	291,100	0.02%	0.00%
13	Town of Devon	Devon/Town/Devon Town - F08355	URBAN	SE-2-51-26-W4M	14-Sep-49	431,720	345,380	86,340	0.00%	0.00%
			URBAN	SE-2-51-26-W4M	29-Jun-84	801,770	641,410	160,360	0.01%	0.00%
14	Capital Power GP Holdings Inc.	Keephills/Cooling/EPCOR Generation - F16576	COOLING	SE-34-50-3-W5M	03-Jul-01	39,000	0	39,000	0.00%	0.00%
			COOLING	SE-34-50-3-W5M	03-Jul-01	108,000	0	108,000	0.01%	0.00%
			COOLING	SE-34-50-3-W5M	03-Jul-01	39,000	0	39,000	0.00%	0.00%
15	Royal Mayfair Golf Club	Mayfair Golf & Country Club, WR, 08565	PRK	NE-36-52-25-W4M	23-Feb-50	123,350	0	123,350	0.01%	0.00%
			PRK	NE-36-52-25-W4M	20-Jul-90	61,670	0	61,670	0.00%	0.00%
16	Windermere Golf & Country Club	Edmonton/Golf Course/Windermere Golf and Country Club	GLFCRS	SW-29-51-25-W4M	11-Dec-03	150,000	0	150,000	0.01%	0.00%

Table 13: Major Licenced Withdrawals from the North Saskatchewan River between GGS and Station 05DF001 *(continued)*

Intake No.	Permit Holder	Approval Name	Industry Activity	Location	Licence Priority Date	Licenced Withdrawal (m^3/y)	Return Flow (m^3/y)	Consumptive Use		
								(m^3/y)	(% of 7Q10)	(% of MAF)
17	Edmonton Country Club	Edmonton Country Club, WR, 08961	CROP	SE-15-52-25-W4M	15-Aug-69	148,020	0	148,020	0.01%	0.00%
18	Imperial Oil Resources Ltd.	Esso Resources Canada Ltd, WR, 09219	INJECTN	NE-27-50-27-W4M	02-Oct-53	135,680	0	135,680	0.01%	0.00%
19	Edmonton Petroleum Golf & Country Club	Edmonton Petroleum Golf & Country Club, WR, 25466	PRK	SW-20-51-25-W4M	03-Jul-91	129,500	0	129,500	0.01%	0.00%
20	Country Club Tour Corp	Edmonton/Golf Course/Country Club Tour Corp - F25149	GLFCRS	NE-29-51-25-W4M	21-Feb-91	122,166	0	122,166	0.01%	0.00%
21	Shearer Properties Ltd.	Shearer Properties Ltd, WR, 11908	GRDN	NE-32-50-26-W4M	21-Jun-65	102,380	0	102,380	0.01%	0.00%
22	Village of Thorsby	THORSBY/VILLAGE /THORSBY VILLAGE - F09192	URBAN	SE-23-50-28-W4M	27-Jun-95	250,550	200,000	50,550	0.00%	0.00%
23	Rabbit Hill Recreation Inc.	Rabbit Hill Recreation Inc, WR, 23710	RCRTN	NE-6-51-25-W4M	02-Jun-89	197,360	172,690	24,670	0.00%	0.00%
28 Smaller Licences (Consumptive Use Less Than 0.1 Mm^3/y)						937,003	0	937,003	0.05%	0.02%
Total Existing and Approved						**564,832,033**	**384,295,778**	**180,536,255**	**9.51%**	**2.95%**

(a) Table excludes Flood Control and Drainage Activities

Table 14: Summary of Licenced Withdrawals for the North Saskatchewan River Upstream of GGS and Downstream of Station 05DF001

Reach of the North Saskatchewan River Main Stem	No. Licences	Total Licenced Withdrawal (m^3/y)	Total Return Flow (m^3/y)	Total Consumptive Use		
				(m^3/y)	(% of 7Q10)	(% of MAF)
Upstream of GGS	95	16,147,716	3,049,170	13,098,546	0.69%	0.21%
Station 05DF001 to Alberta-Saskatchewan Border	219	617,035,061	477,224,338	139,810,723	7.36%	2.29%
Total Existing and Approved		**633,182,777**	**480,273,508**	**152,909,269**	**8.03%**	**2.48%**

The total licenced consumptive water use on the NSR mainstem is equal to approximately 17.5% of the post-dam 7Q10 low flow and 5.4% of the MAF. Actual consumptive use in the NSR basin, which includes NSR tributaries and groundwater supply, was estimated to be approximately 39% of the allocated value in 2005 (AENV 2007a). A summary of water use on the NSR mainstem and at the GGS is provided in Table 15. The proposed diversion would not increase the GGS licenced allocation above the existing value, (0.56% of the NSR MAF), but would increase its consumptive use from 0.18% to 0.24% of the NSR MAF.

Table 15: Summary of Water Use on NSR Mainstem

Quantity	Annual Volume (m^3/y)	Proportion of MAF (%)
NSR Mean Annual Flow (Post-Dam)	6,131,050,729	100.00
Licenced Allocation	1,186,014,810	19.34
Licenced Consumption	333,445,524	5.44
Actual Consumption[a]	130,043,754	2.12
GGS Existing Licenced Allocation[b]	34,128,394	0.56
GGS Existing Licenced Evaporation and Consumption	11,064,197	0.18
GGS Proposed Licenced Allocation	34,128,394	0.56
GGS Proposed Licenced Evaporation and Consumption	14,865,000	0.24

(a) Based on 39% of licenced consumptive use (AENV 2007a).
(b) Includes 12,000,000 m^3/year diversion licence (Approval 000268020-00-00) issued in 2010.

5.3 Updated Effects of Water Withdrawals

5.3.1 Impacts to Flows and Water Levels.

Effects on river discharge and water level at the GGS water intake were determined based on selected flow metrics from the NSR (Table 11 and Table 12), as well as, the stage-discharge rating curves presented in Figure 14. The expected changes in water level during open-water conditions and a 2.2 m^3/s diversion at GGS and Station 05DFD001 for selected representative flows are shown in Table 16. A diversion rate of 2.2 m^3/s was used because water will be diverted at the same rate as recognized in the existing water licence. The proposed increase in consumptive use will result in reduced blowdown volumes to the NSR from the cooling pond. However, the assessment of effects on flow rates and water levels at the GGS, as presented by Golder (2010) remains valid, as that assessment assumed water withdrawal during periods where no blowdown water was being returned to the NSR. That assessment is reproduced in Table 16, with minor adjustments to recognized revised mean annual flow and 7Q10 low flow values.

Table 16: Effects on Flow Rates and Water Levels at GGS and Station 05DF001

Flow			Change in Water Level (m)	
Representative Flow	**Base Case Rate (m^3/s)**	**Project Case Rate (m^3/s)**	**At GGS**	**At Station 05DF001**
2-year flood	739	736.8	0.005	0.006
Mean annual flow	194	191.8	0.011	0.011
7Q10 Low Flow	60.2	58.0	0.022	0.019

Changes in water level due to additional withdrawal were considered in the context of a water level that is variable on a daily basis due to the operation of upstream hydropower facilities. Releases from the TransAlta Bighorn and Brazeau dams produce a diurnal variation in flow that is illustrated in Figure 15. Typical daily variations in flow range from ~0.3 to ~0.8 m.

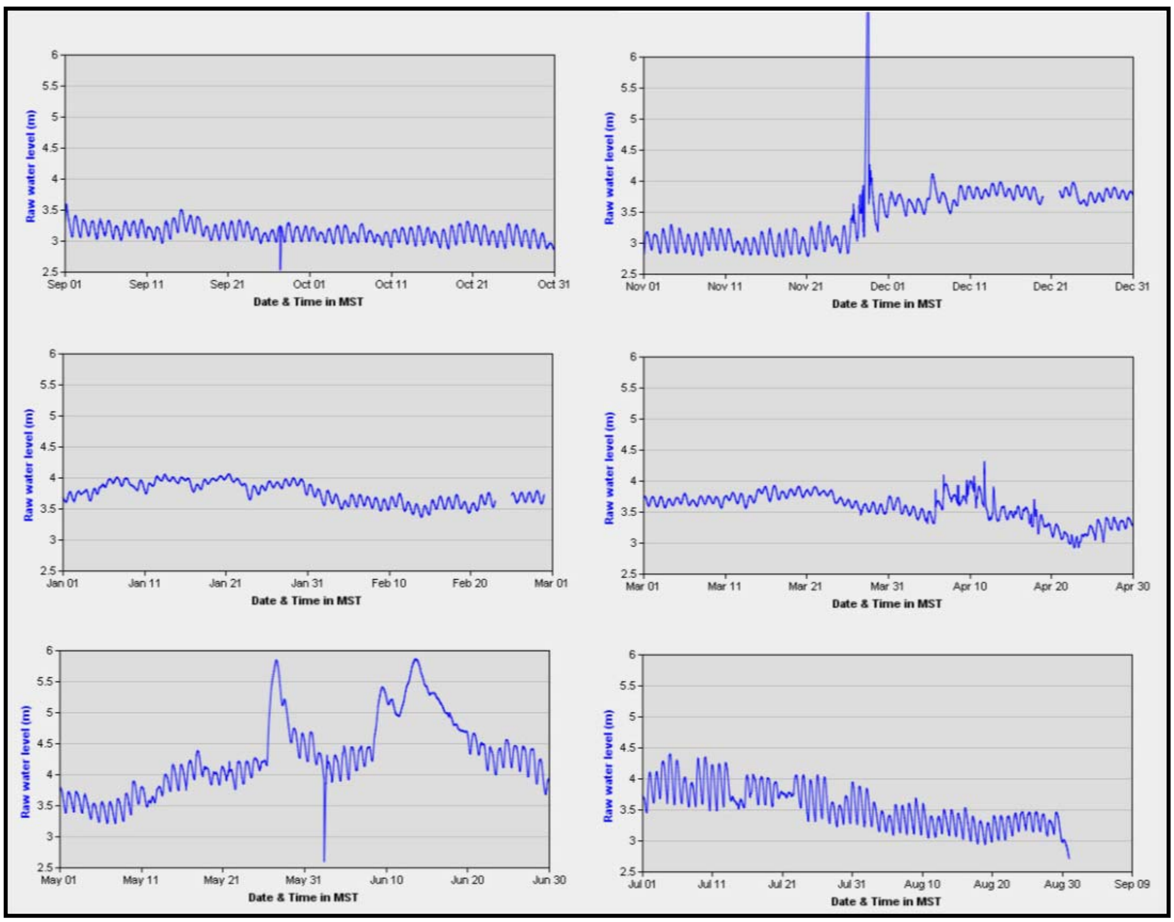


Figure 15: Diurnal Water Level Variation, Station 05DF001, 2007- 2008

The analysis indicates that the effects of the request for additional consumptive use (change from 11.064 Mm^3 to 14.865 Mm^3) for the GGS are the same as estimated for the previous water licence application (Golder 2010) and small relative to the NSR water depth (maximum depth generally greater than one metre at low flow). As the rate of diversion remains unchanged, the predicted impacts to water levels within the NSR are also expected to remain unchanged.

5.3.2 Impacts to Fish

CPC operates the GGS water intake associated with the pumphouse along the NSR under the current Water Licence and an approved "Pumphouse Fish Entrainment Mitigation Proposal" (EPCOR 2004). The fish mitigation proposal was developed to address fisheries concerns associated with the cooling pond identified in the 2001 Environmental Impact Assessment for Unit 3 (EPCOR 2001). The proposal was submitted to AENV on May 21, 2004 and approved by AENV on July 28, 2005.

As previously stated, diversion of the additional surface water from the NSR will not require any changes or modifications to existing infrastructure at the GGS. Specifically, there are no proposed changes to either the river water intake or the river water pumphouse. Moreover, the CPC request to divert additional surface water from the NSR does not require CPC to exceed the maximum diversion rate permissible in its current Water Licence (2.2 m^3/s). Consequently, no change to impacts to fisheries within the NSR (i.e., impingement or entrainment) with respect to CPC's current operation of the water intake, pumphouse, and cooling pond is anticipated.

Notwithstanding the proposed increase in the duration of water diversion from the NSR (i.e., no change in the current water withdrawal rate), CPC can continue to uphold all commitments established to protect fisheries within the previously approved fish mitigation proposal.

5.3.3 Impacts to Other Water Users

As demonstrated in Section 5.3.1, the effects of the proposed diversion on flows and water levels are expected to be negligible. Consequently, no adverse effects on other water users are anticipated due to the additional consumptive use of water from the NSR. This conclusion is consistent with that of AENV (2007b) which states that "The volume of flow in the river downstream of Edmonton is not currently under stress and provides capacity for net withdrawals to support considerable growth."

CPC plans to blow down water to the NSR from the cooling pond as much as possible while withdrawing from the water intake, though to a lesser extent than under Base Case conditions. The river water intake and blowdown outfall are in close proximity; thus, changes to river flows are expected to be small. However, even if return flows were temporarily suspended during pumping operations, the effects are negligible (the water level analysis presented in Section 5.3.1 is based on the worst-case condition of full withdrawal with no discharge).

6.0 CLOSURE

CPC is in the process of evaluating the capacity of the cooling pond to handle two more power generating units (G4 and G5) and the corresponding supplemental cooling required for these units. Golder Associates Ltd. (Golder) was commissioned by CPC to conduct thermal and water quality modelling to predict water temperature, evaporative losses and concentrations of Total Dissolved Solids (TDS), major ions and Total Dissolved Gases (TDG) in the cooling pond with the addition of G4 and G5.

A GEMSS-based thermal model of the cooling pond was created to simulate temperature changes in the cooling pond resulting from the proposed G4 and G5 units. Changes to the cooling pond temperatures due to the G4 and G5 units are predicted to be less than 2°C on average during the summer relative to the Base Case. Therefore, changes in NSR temperature due to addition of new units are predicted to be small, especially in consideration of the flow in the NSR relative to the blowdown release (i.e., average flows of 194 m^3/s in NSR compared to a maximum flow of 1.19 m^3/s for the blowdown). With the addition of G4 and G5 units, on average evaporative losses from the pond were predicted to increase 26% compared to Base Case.

Using the calibrated model, long-term simulations were completed to predict TDS and major ion concentrations, makeup water as well as blowdown rates to the NSR, under Base and Application Case conditions. Under **Application Case – Scenario 1** conditions, TDS levels in the pond are predicted to remain below 370 mg/L if the water diversion rate for makeup water increases from 18.5 Mm^3/y to 22 Mm^3/y. The estimated rate of blowdown water for this scenario is about 10 Mm^3/y. Concentrations of all modelled constituents in the cooling pond and the blowdown are predicted to increase relative to the Base Case, but the calculated in-stream concentration will remain close to Base Case levels because of relatively small blowdown flow rate compared to NSR flow rate. In-stream concentrations of all modelled constituents are predicted to remain below corresponding chronic guidelines and WQOs, except for fluoride.

Under **Application Case – Scenario 2** conditions, diverting water from NSR at the maximum rate (34.1 Mm^3/y) is predicted to keep TDS levels below 281 mg/L. Concentrations of all constituents in the cooling pond and the blowdown are predicted to decrease relative to the Base Case, except for calcium and barium. The estimated rate of blowdown water for this scenario is about 22 Mm^3/y.

Under both scenarios, barium and calcium concentrations in the cooling pond and the blowdown are predicted to increase under Application Case conditions relative to the Base Case, because of higher concentrations of these ions in NSR water relative to the cooling pond. But in reality, the concentrations of barium and calcium in the cooling pond are likely to be lower due to shifting equilibrium as the NSR water is pumped into the cooling pond. Barium is presumed to precipitate in the pond in response to elevated sulphate concentrations from process chemical addition (i.e., sulphuric acid); whereas, calcium is presumed to precipitate due to the reduced solubility of calcite in warmer water (i.e., calcium solids precipitate as calcium-rich makeup water enters the warmer cooling pond).

Although the simulations were extended for 20 years, predicted concentrations of chemical constituents within the cooling pond, including TDS, reach steady-state conditions around 2020. The water quality modelling results show that within the current water licence approved makeup water rate, the cooling pond water quality can be controlled lower than current level and will not affect NSR water quality with the addition of the G4 and G5 units in the future.

The cooling pond and NSR at the blowdown mixing zone boundary were evaluated for effects on fish with regard to water quality, thermal habitat and gas bubble trauma. Impacts due to changes to water quality and thermal habitat are expected to be minimal in the cooling pond and negligible in the NSR. With regard to gas bubble trauma, it is expected the predicted changes in the cooling pond are unlikely to affect the suitability of the pond for maintaining the existing resident fish species and communities, and that no impacts are expected in the NSR.

The additional evaporative water use at the NSR is expected to have no additional effects on water levels beyond those predicted under the existing water licence. The total evaporative and consumptive water use is expected to increase from 0.18% to 0.24% of the mean annual flow of the NSR, but no adverse effects on downstream users are expected.

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APPENDIX A

GEMSS Model Calibration

Table A-1 shows the calibration parameters that were used for the thermal modelling.

Table A-1: Summary of GEMSS Model Parameter Settings

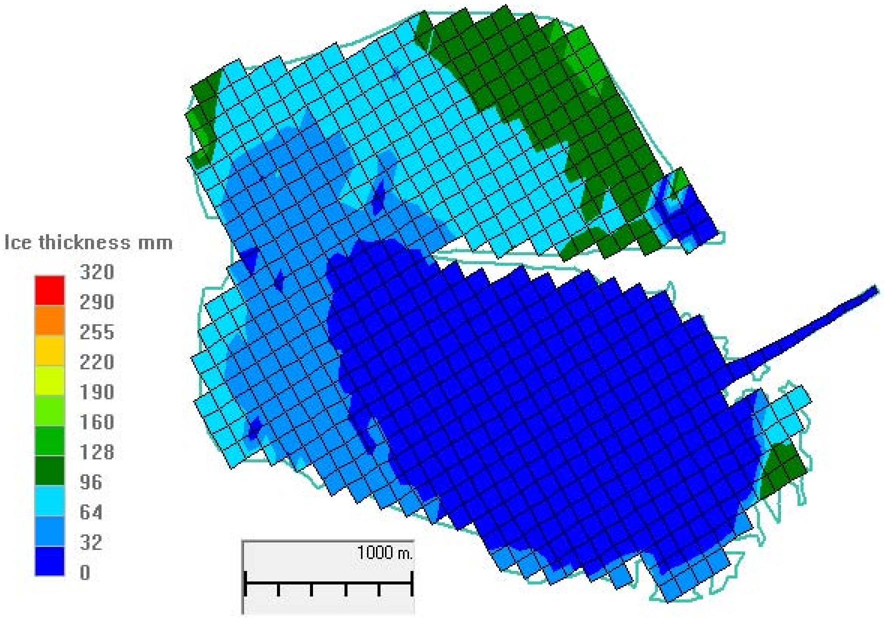
Category	Variable Definition	Genesee Cooling Pond Model
Heat and Light Exchange	Heat Computation Method	Term by Term
	Wind Speed Function	Ryan and Harkeman
	Secchi Depth	1 (m)
	Wind Sheltering Coefficient	0.5
	Vegetative and Topographic Shading Factor	0
Meteorological Scaling Factors	Solar Radiation	1
	Wind Speed	1
	Air Temperature	1
	Evaporation	1.25
Hydrodynamic and Transport	Transport Numerical Scheme	Quickest with Ultimate
	Advection Theta in Z-direction	0.0
	Diffusion Theta in Z-direction	0.0
	Density Function	Gill
	Bottom Friction - Chezy Coefficient	40.0
	Wind Stress Computation Method	Wu
	Vertical Momentum Scheme	0-Equation
	Mixing Length Scheme	Von Karman
	Horizontal Dispersion Scheme	Okubo
	Horizontal Diffusivity Scheme	Prandtl
Ice Module	Model Type	Simplified Formulation
	Coefficient of Water to Ice Heat Exchange	10 (W/m^2)
	Minimum Ice Thickness	2 (mm)
	Ice Limiting Temperature	2 (°C)

m^2 = square metre; °C = degrees Celsius; W = Watts; mm = millimetre; m = meter

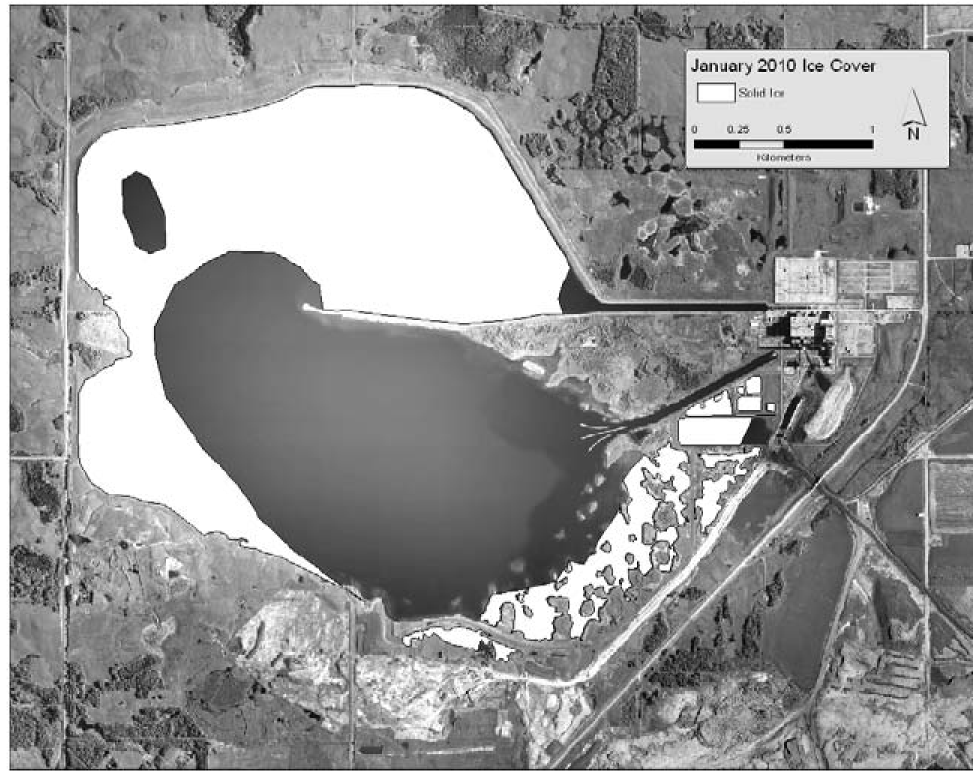
Table A-2: Statistical Comparison of Predicted and Observed Daily Water Temperature (°C)

Statistical Parameter	Inlet	Outlet	Blowdown
Coefficient of Efficiency	0.9	0.9	0.9
Average Absolute Deviation	1.6	1.8	1.8
Average Deviation	0.6	0.3	1.1
n	1096	1096	505

n= number of data points



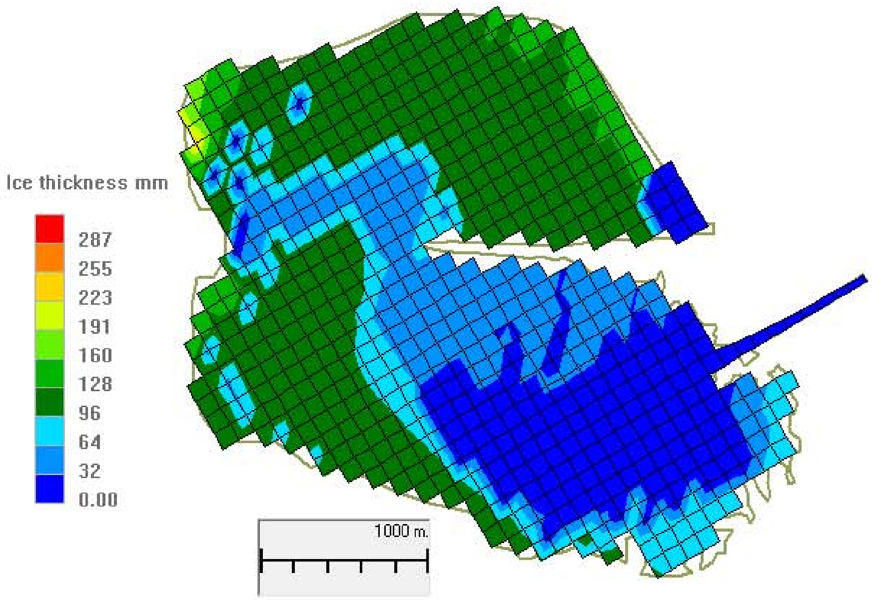
(January 5, 2010)



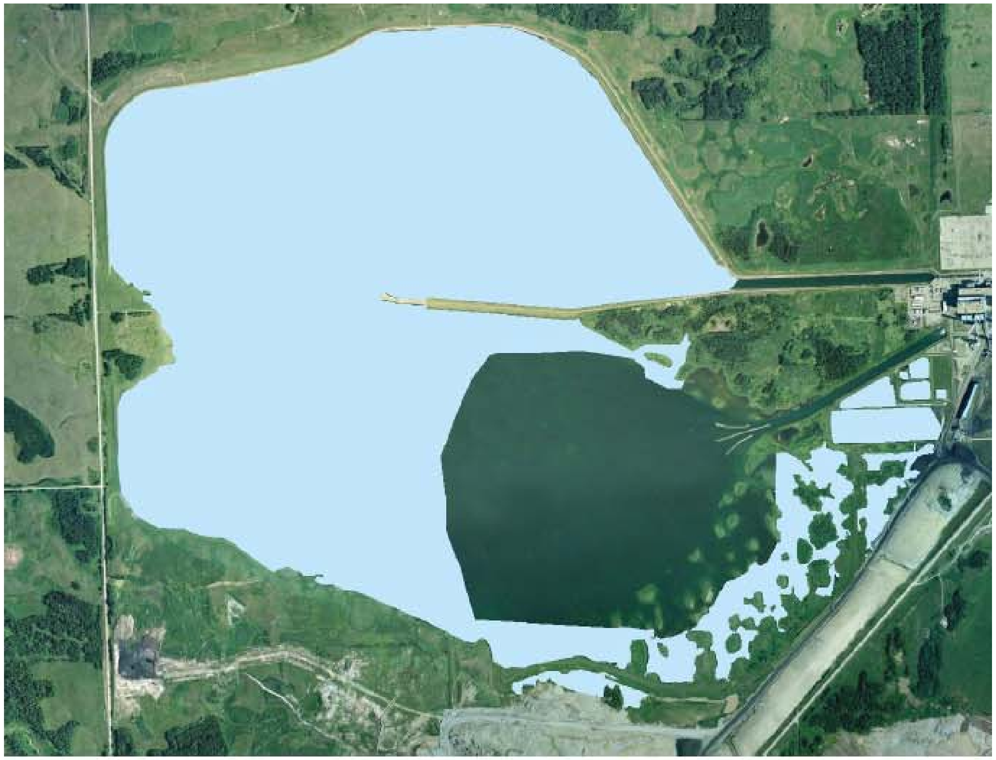
(January 2010)

Figure A-1a: Predicted Ice Coverage and Thickness vs. Observed Ice Coverage on the Genesee Cooling Pond, January 2010.

Note: On the left is simulated extent of ice cover on the pond; on the right is the aerial photograph (white shade on the pond represents ice cover (CPC 2010, 2012, 2013)



(January 19, 2012)



(January 2012)

Figure A-1b: Predicted Ice Coverage and Thickness vs. Observed Ice Coverage on the Genesee Cooling Pond, January 2012.

Note: On the left is simulated extent of ice cover on the pond; on the right is the aerial photograph (white shade on the pond represents ice cover (CPC 2010, 2012, 2013)

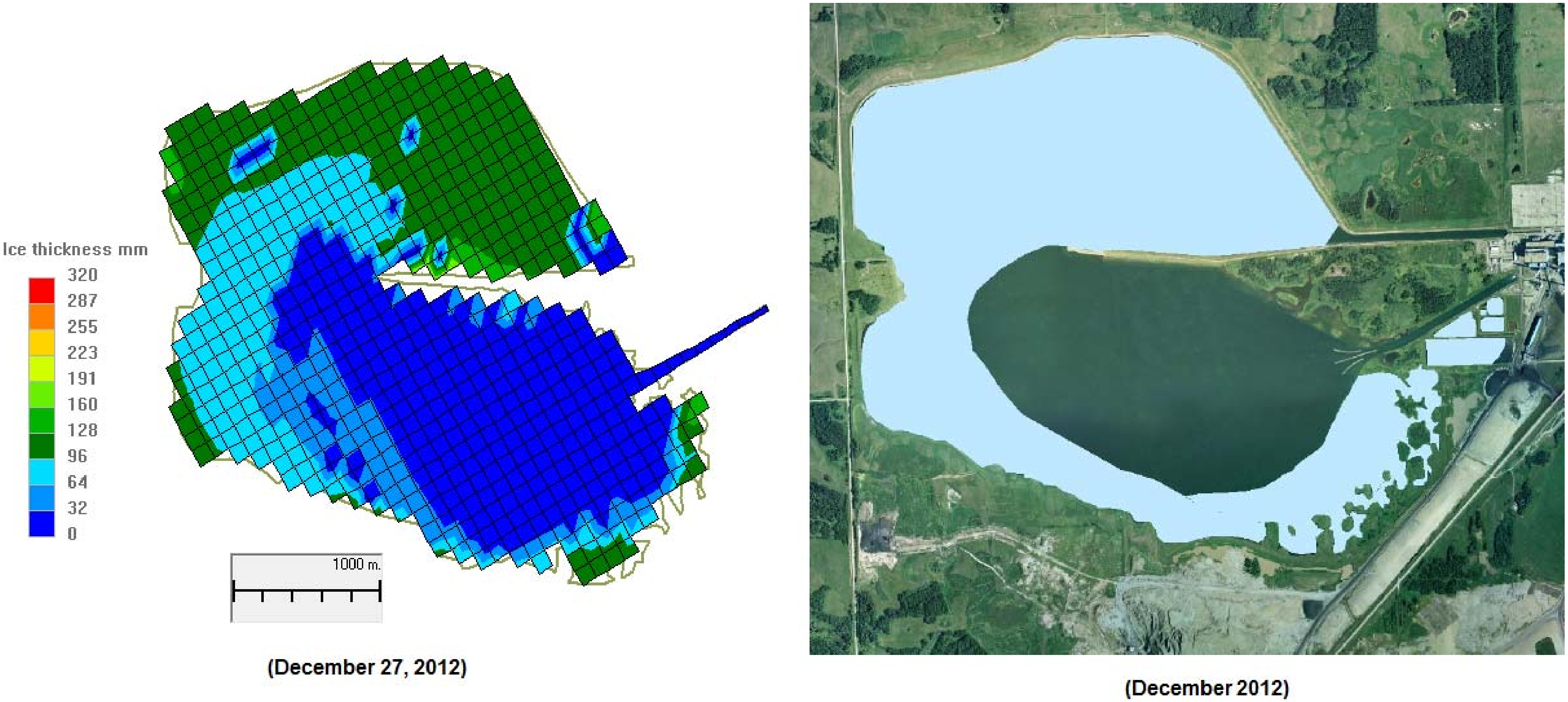


Figure A-1c: Predicted Ice Coverage and Thickness vs. Observed Ice Coverage on the Genesee Cooling Pond, December 2012.

Note: On the left is simulated extent of ice cover on the pond; on the right is the aerial photograph (white shade on the pond represents ice cover (CPC 2010, 2012, 2013)

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APPENDIX B

Water Quality Assessment

WATER AND MASS BALANCE MODELLING

An Excel-based model was developed to predict concentrations of TDS and major ions of the water contained in the cooling pond under various makeup and blowdown rates.

1.0 MODEL SETUP

Concentrations of each constituent in the pond were calculated using Equation 1:

Equation 1 $$C_{pond} = \frac{M_{pond}}{V_{pond}}$$

where,

C_{pond} = concentration of constituent in the pond

M_{pond} = mass of constituent in the pond

V_{pond} = volume of water in the pond

The pond volume and constituent mass were calculated based on Equations 2 and 3 respectively:

Equation 2 $$V_{pond} = V_0 + V_{in} - V_{out}$$

where,

V_0 = initial volume, or volume in the cooling pond from the previous time step

V_{in} = the sum of all inflows

V_{out} = the sum of all outflows

Equation 3 $$M_{pond} = M_0 + M_{in} - M_{out}$$

where,

M_0 = initial mass, or mass in the cooling pond from the previous time step.

M_{in} = the sum of all incoming mass

M_{out} = the sum of all outgoing mass

The water and mass balance equations account for the inflows and outflows depicted in Figure B-1. Inflows included makeup water from the NSR, process chemicals, local runoff, groundwater dewatering and precipitation. Outflows included blowdown water to the NSR, evaporation, process precipitates, and process losses. Each inflow and outflow required the determination of the monthly volume (V), concentration (C), and mass (M) per constituent. A description of each source of water along with the rationale for the calculated or estimated V, C, and M is provided in Table B-1.

The cooling pond was modelled as a fully-mixed system. This level of detail was considered appropriate for determining long-term concentrations in the cooling pond. Although the cooling pond may become thermally stratified at times, it is unlikely to become stratified for durations that would result in long-term accumulation of salts in the hypolimnion (i.e., become meromictic).

The model included parameters that were considered likely to contribute to scaling, based on a geochemical investigation in 2010 (Golder 2010, Appendix D), including the following ions: barium, calcium, chloride, fluoride, magnesium, sodium, and sulphate. TDS, which includes major ions and other dissolved constituents, was also modelled.

Process chemicals and the process precipitates affect the mass balance of the system, but are assumed to have negligible effects on the water balance. The process chemicals were added directly to the cooling pond based on dosage rates described in Table B-1.

2.0 MODEL CALIBRATION

Cooling pond concentrations were calibrated to observed data (Golder 2008, 2009a, 2009b; CPC 2011, 2012, 2013) over 2008 to 2012 using the rates detailed in Table B-1. Initial concentrations in the pond were set by linear interpolation between 2007 and 2008 observed concentrations (Golder 2008, 2009a). The mass of process precipitates, which is the amount of solids that precipitates from the cooling pond, was used as a calibration parameter to match calculated concentrations to observed values.

The rates described in Table B-1 produced an acceptable match between predicted and observed concentrations of magnesium without the need for calibration parameters. It is therefore assumed that magnesium does not contribute to the mineral precipitate in the pond. Calibration is depicted for all eight constituents (Figure B-2 to Figure B-9).In the case of barium, calcium, chloride, sulphate, fluoride, and sodium, a mass of precipitate was assumed as a loss term to produce a calibration for these constituents. As calcium and sulphate were the dominant ions in pond water and makeup water, respectively, it was necessary to apply this calibration parameter to TDS.

The calibrated model provides an approximation of cooling pond conditions, suitable for completion of the present study; however, the model does not explicitly describe the non-linear reactions that lead to precipitation within the cooling pond.

Water balance was checked prior to calibration using inputs and outputs to the pond (Figure B-1). Evaporation losses were estimated using a hydrodynamic thermo model (GEMSS) discussed in Section 2 of the main report. Water quality was then calibrated to observe data (2008 to 2012), collected at the pond and blowdown, by adjusting process precipitates input. Predicted concentrations of calcium and barium did not match the observed data (2008 to 2012) perfectly, thus the model was calibrated to most recent observed data.

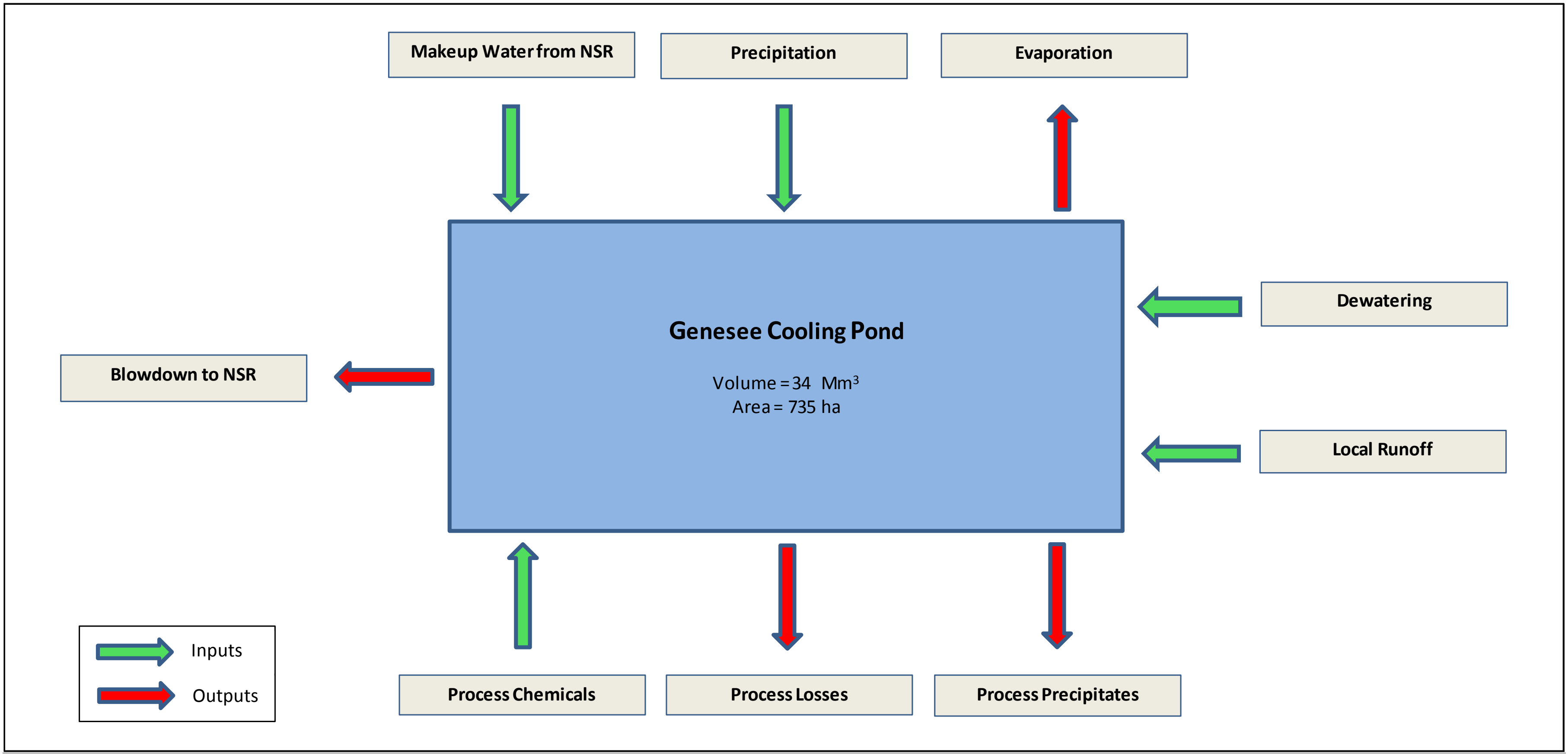

Figure B-1: Genesee Cooling Pond Inputs and Outputs

Table B-1: Description and Source of Data for Inflows and Outflows

Inflow/Outflow	Description	Source of Data		
		Volume	Concentration	Mass
Inflows				
Makeup water	water diverted from NSR to replenish water lost to evaporation and dilute ion concentrations in the pond	initially based on monthly reported volumes from 2008 to 2012 (CPC 2010, CPC 2011, CPC 2012); rates then altered to evaluate different scenarios (see Section 2.2 of the main report)	monthly average concentrations from 1988-2011 (AENV 2012)	volume x concentration
Process Chemicals	chemicals applied to waste streams (effluent settling pond and outlet canal) discharging into the cooling pond (CPC pers. comm. 2013a, Black & Veatch 2013)	set to zero	set to zero	mass of TDS, sodium and sulphate in design dosing rates (EPCOR 2004, CPC pers. comm. 2013, Black & Veatch 2013).
Precipitation	direct precipitation over cooling pond	1990-2012 average monthly precipitation x surface area (Environment Canada 2013).	set to zero	set to zero
Local Runoff	surface runoff from surrounding Genesee Creek catchment and mine drainage	annual volumes (CPC pers. comm. 2013b) of each source divided into monthly volumes based on the monthly precipitations rates	Observed data provided by CPC (CPC pers. comm. 2013b)	volume x concentration
Dewatering	groundwater pumped out during mine operation	annual volumes provided by CPC (CPC pers. comm. 2013c) divided into monthly volumes evenly.	Observed data (CPC pers. comm. 2013c)	volume x concentration
Outflows				
Blowdown	return flow of excess water released to NSR	initially based on monthly reported volumes from 2008 to 2012 (CPC 2010, 2011 and 2012); rates then calculated for each scenario	set equal to cooling pond concentration	volume x concentration
Evaporation	evaporation from cooling pond and generating station (i.e., the water quantity evaporated for cooling duty)	thermal modelling results (Section 2 of the main report)	set to zero	set to zero
Process Precipitates	amount of solids that precipitates in system	set to zero	set to zero	mass of constituent calibrated to observed cooling pond concentrations
Process Losses	water consumed during plant activities (washing, etc.)	Total volume for each scenario divided by 12 months evenly, (Jacobs 2009, Black & Veatch 2013)	set equal to cooling pond concentration	volume x concentration

3.0 RESULTS AND DISCUSSION

Under Base Case conditions (G1, G2 and G3 operational), average volume of makeup water from 2008 to 2012 was applied to the future years (2013 to 2030). Under Application Case conditions (G1, G2, G3, G4 and G5 operational) by applying the current makeup rate (18.5 Mm^3/y) to future years, the 370 mg/L TDS criteria (Application Case – Scenario 1) in 2020 will not be met. Thus, the makeup rate was increased to 22 Mm^3/y to keep maximum predicated TDS concentration in 2020 lower than 370 mg/L. In this scenario, TDS in cooling pond increases after 2013 but will reach steady-state conditions around 2020.

Applying the maximum makeup rate of 34.1 Mm^3/y (existing license) is predicted to keep TDS concentrations close to 281 mg/L in 2020, thus the TDS levels of 250 mg/L (Application Case – Scenario 2) will not be met under the existing license.

Predicted concentrations of modelled constituents along with observed data are presented in Figures B-2 to B-9, for calibration period (2008 - 2012) and 2013 to 2030.

Table B-2 presents predicted concentrations in 2020. Predicted concentrations of chemical constituents within the cooling pond are predicted to reach steady-state conditions within approximately ten years. Certain constituent ions such as sodium and sulphate were predicted to stabilize within approximately five years. Concentration of calcium and barium are predicted to be higher than Base Case levels no matter how much water is diverted from NSR. As discussed in 2010 study (Appendix D, Golder 2010) the lower concentrations of barium and calcium in the pond are likely due to shifting equilibria as the NSR water is pumped into the cooling pond. Barium is presumed to precipitate in the pond in response to elevated sulphate concentrations from process chemical addition (i.e., sulphuric acid); whereas, calcium is presumed to precipitate due to the reduced solubility of calcite in warmer water (i.e., calcium solids precipitate as calcium-rich makeup water enters the warmer cooling pond).

Table B-1: Observed and Predicted Concentrations of Constituents in the GGS Cooling Pond

Constituent	Units	Average Observed Concentrations in 2012 (CPC 2012)	Base Case	Application Case	
			Makeup Rate = 18.5 Mm^3/yr (Existing License)	Makeup Rate = 22 Mm^3/yr (Scenario 1)	Makeup Rate = 34.1 Mm^3/yr (Scenario 2)
Barium	mg/L	0.1	0.11	0.14	0.12
Calcium	mg/L	43	43	58	53
Chloride	mg/L	3.9	3.3	3.8	2.4
Fluoride	mg/L	0.35	0.3	0.35	0.24
Magnesium	mg/L	27	25	30	21
Sodium	mg/L	43	36	42	22
Sulphate	mg/L	131	132	153	95
Total Dissolved Solids	mg/L	337	282	369	281

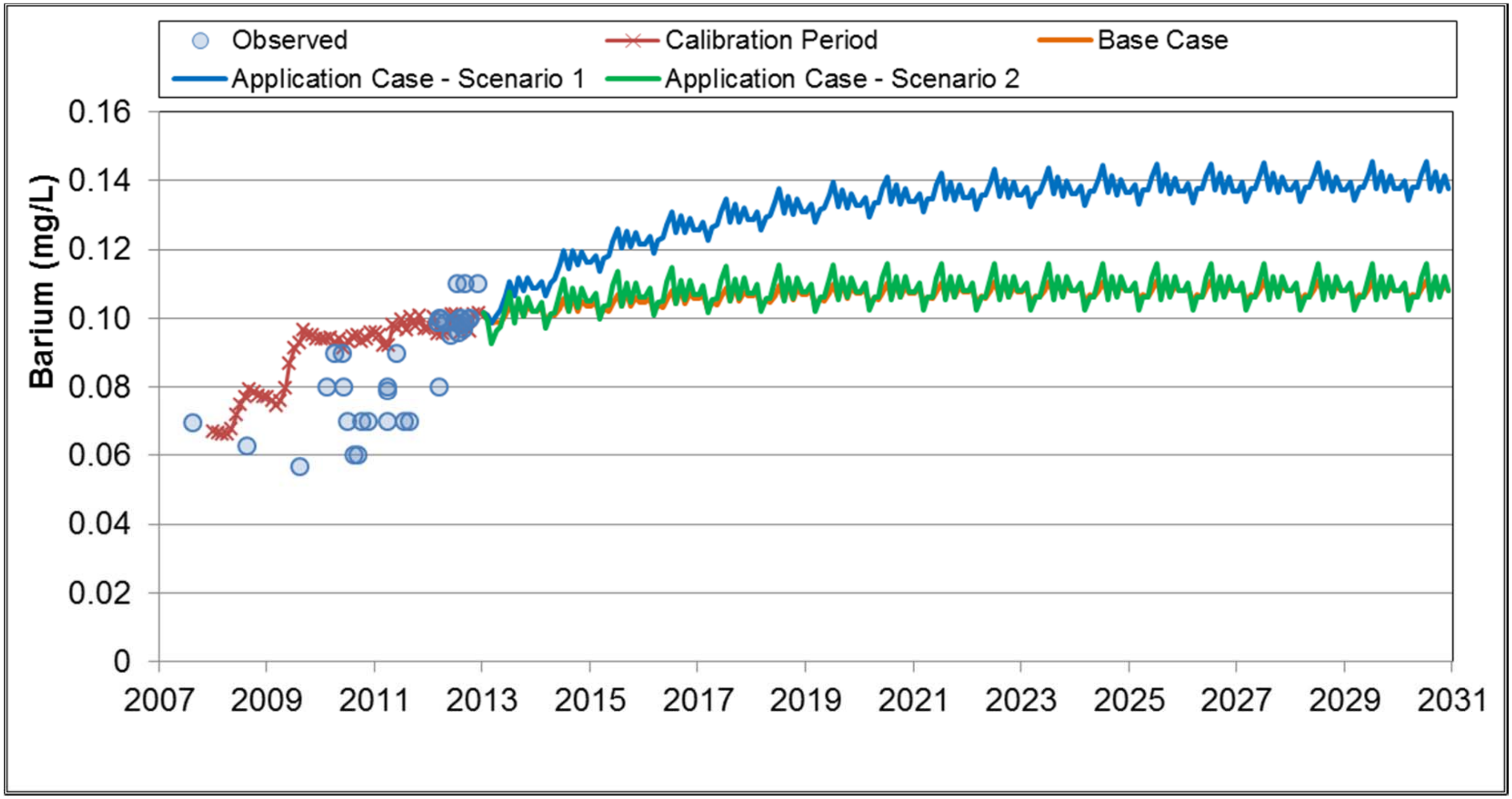

Figure B-2: Observed, Calibrated, and Predicted Concentrations for Barium

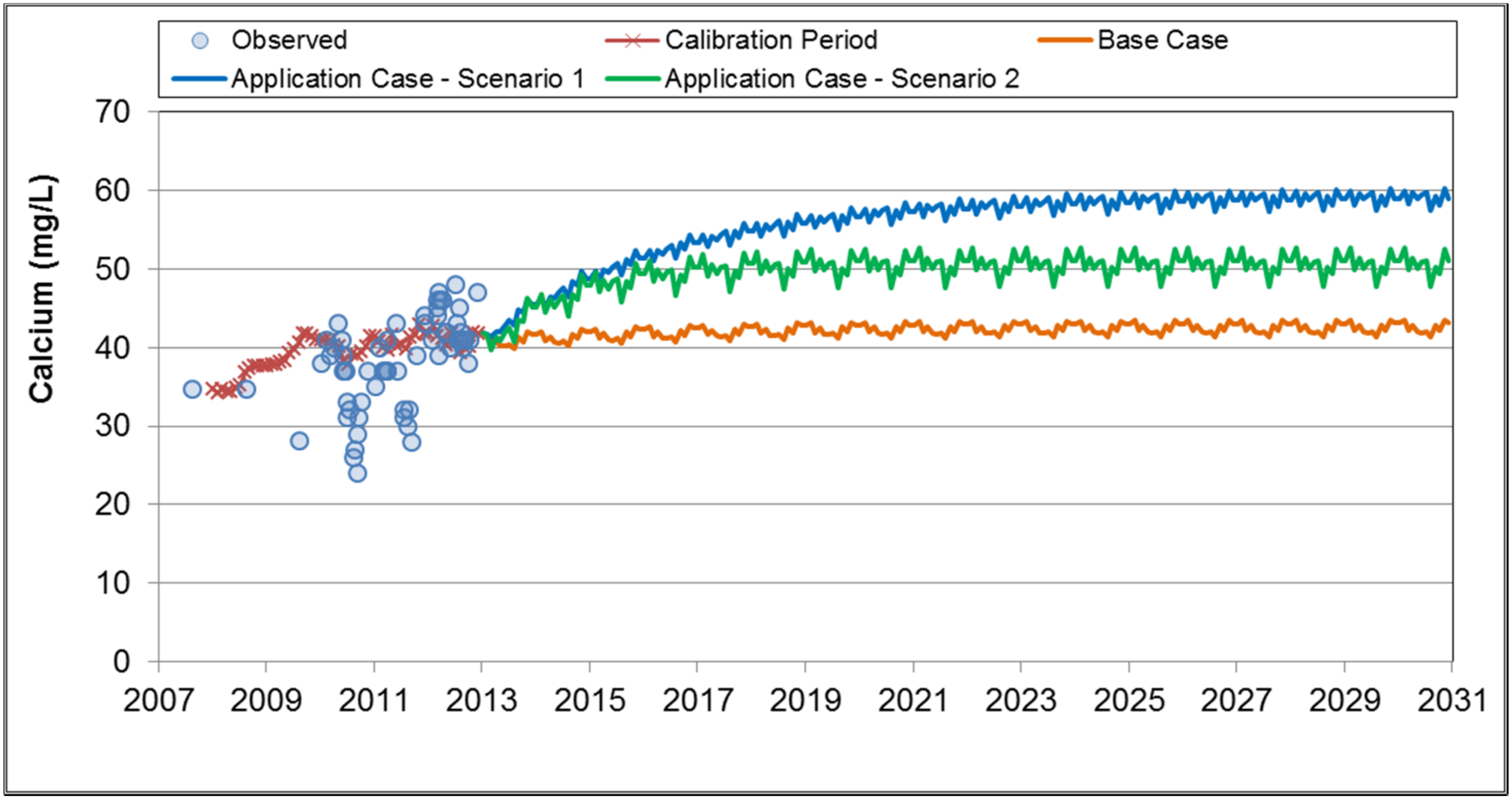

Figure B-3: Observed, Calibrated, and Predicted Concentrations for Calcium

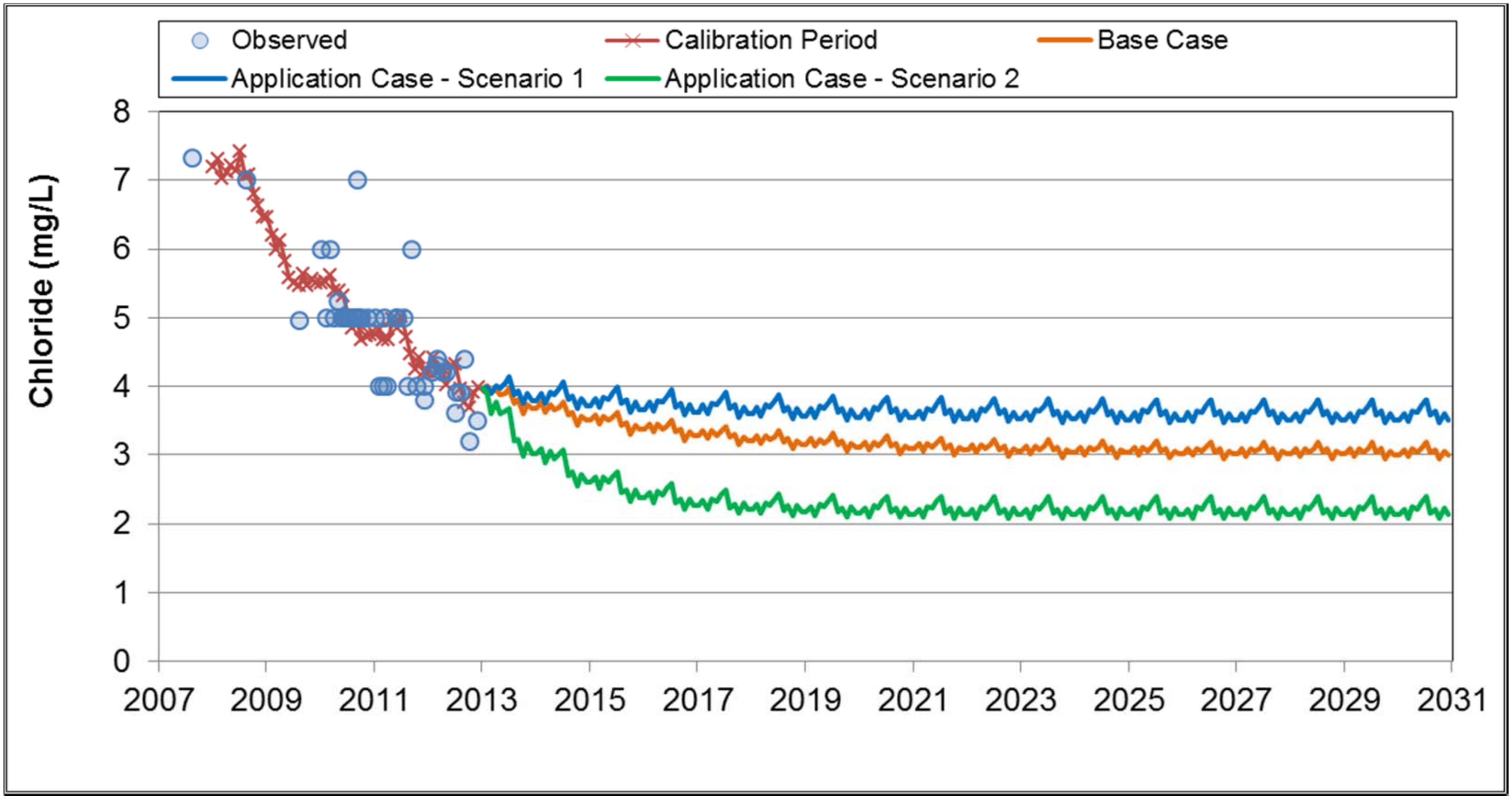

Figure B-4: Observed, Calibrated, and Predicted Concentrations for Chloride

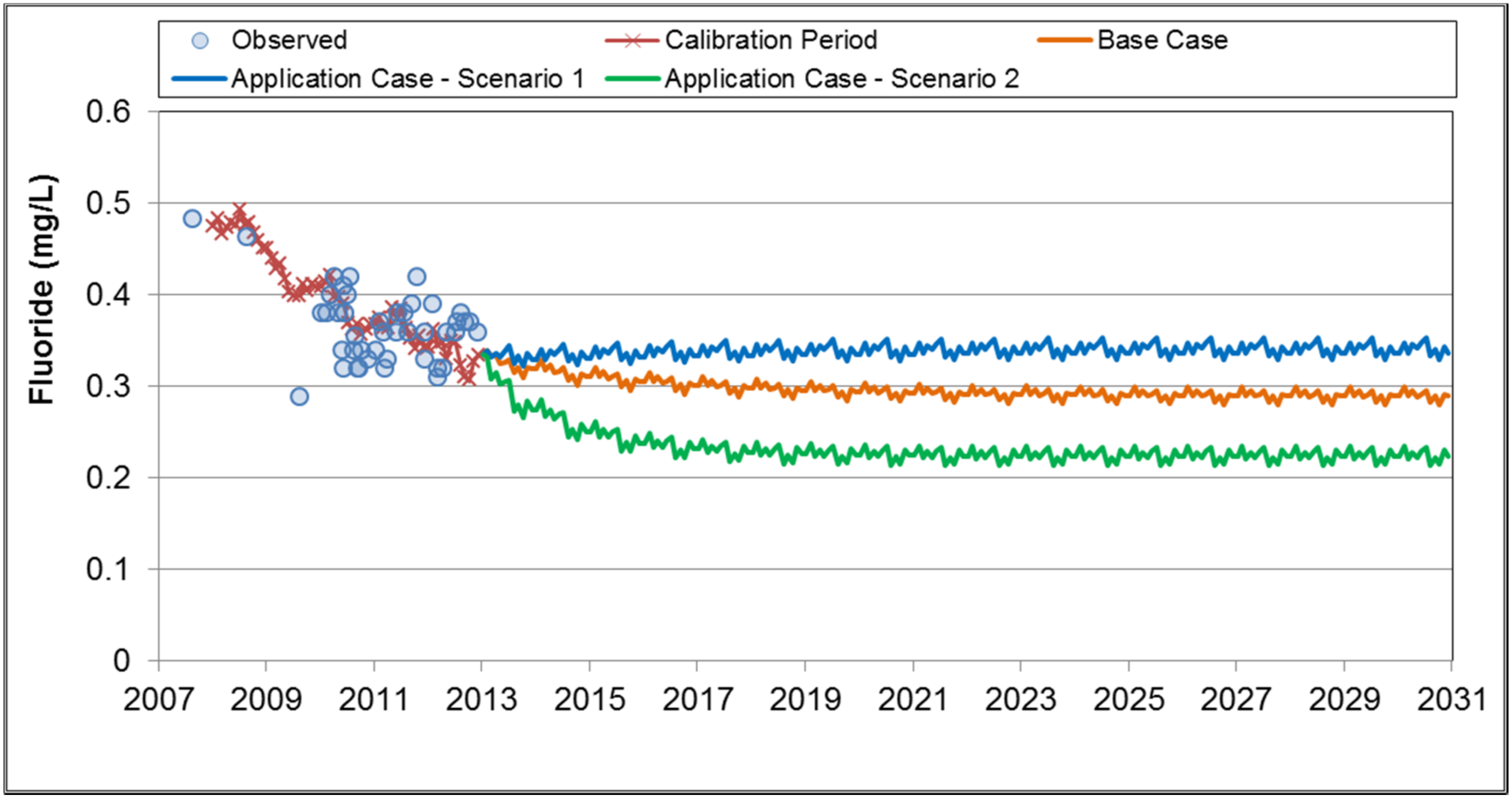

Figure B-5: Observed, Calibrated, and Predicted Concentrations for Fluoride

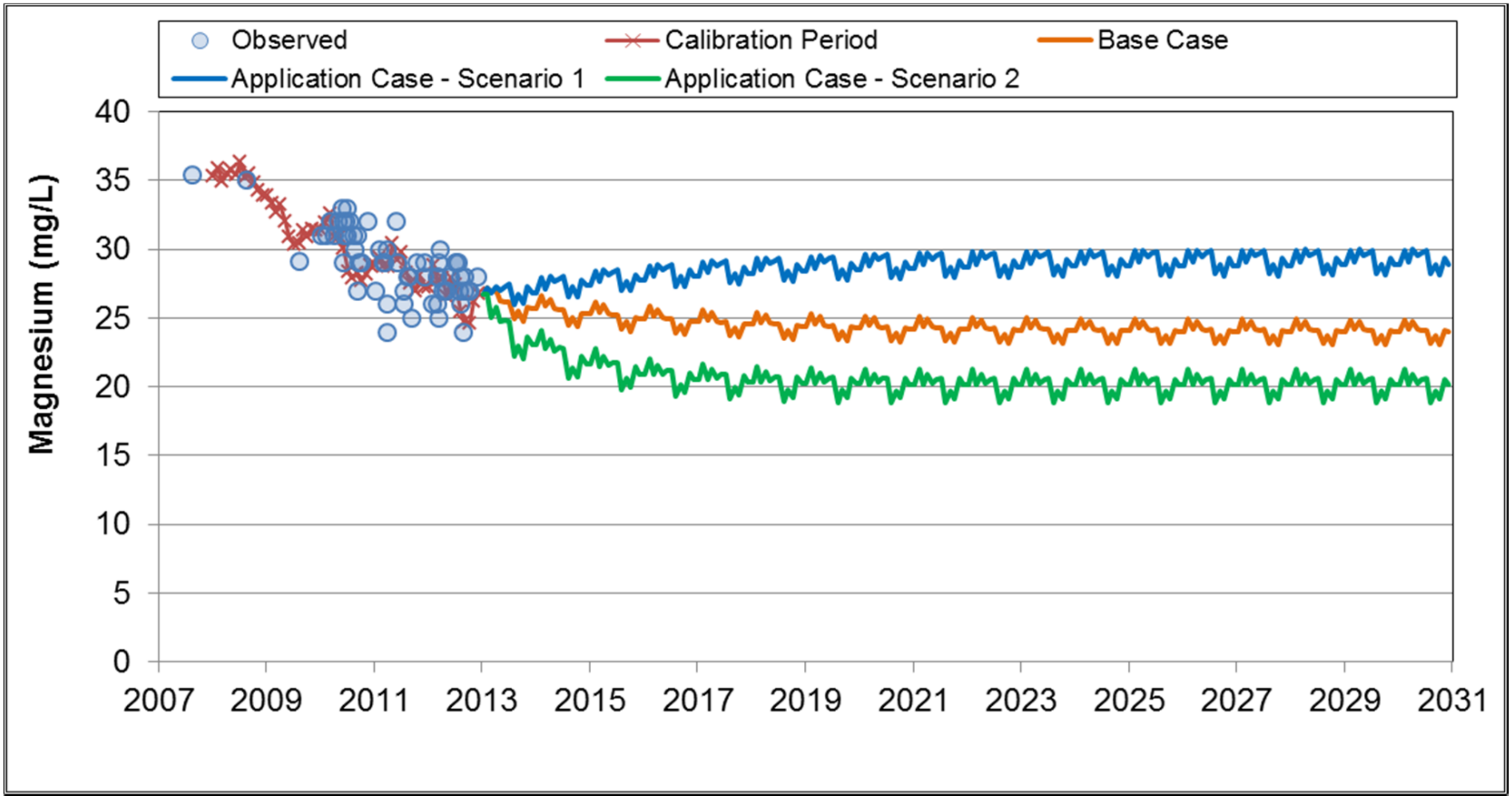

Figure B-6: Observed, Calibrated, and Predicted Concentrations for Magnesium

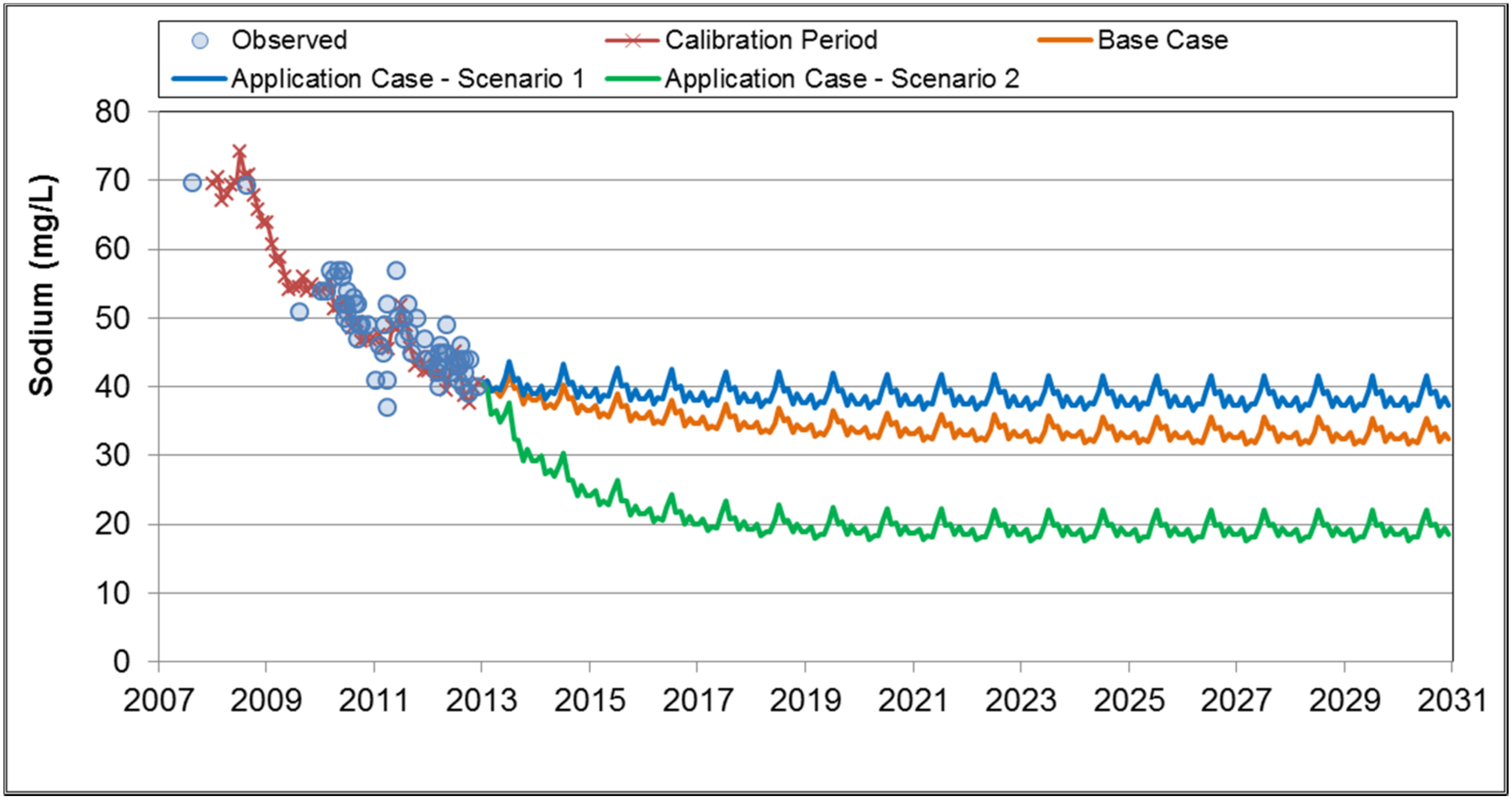

Figure B-7: Observed, Calibrated, and Predicted Concentrations for Sodium

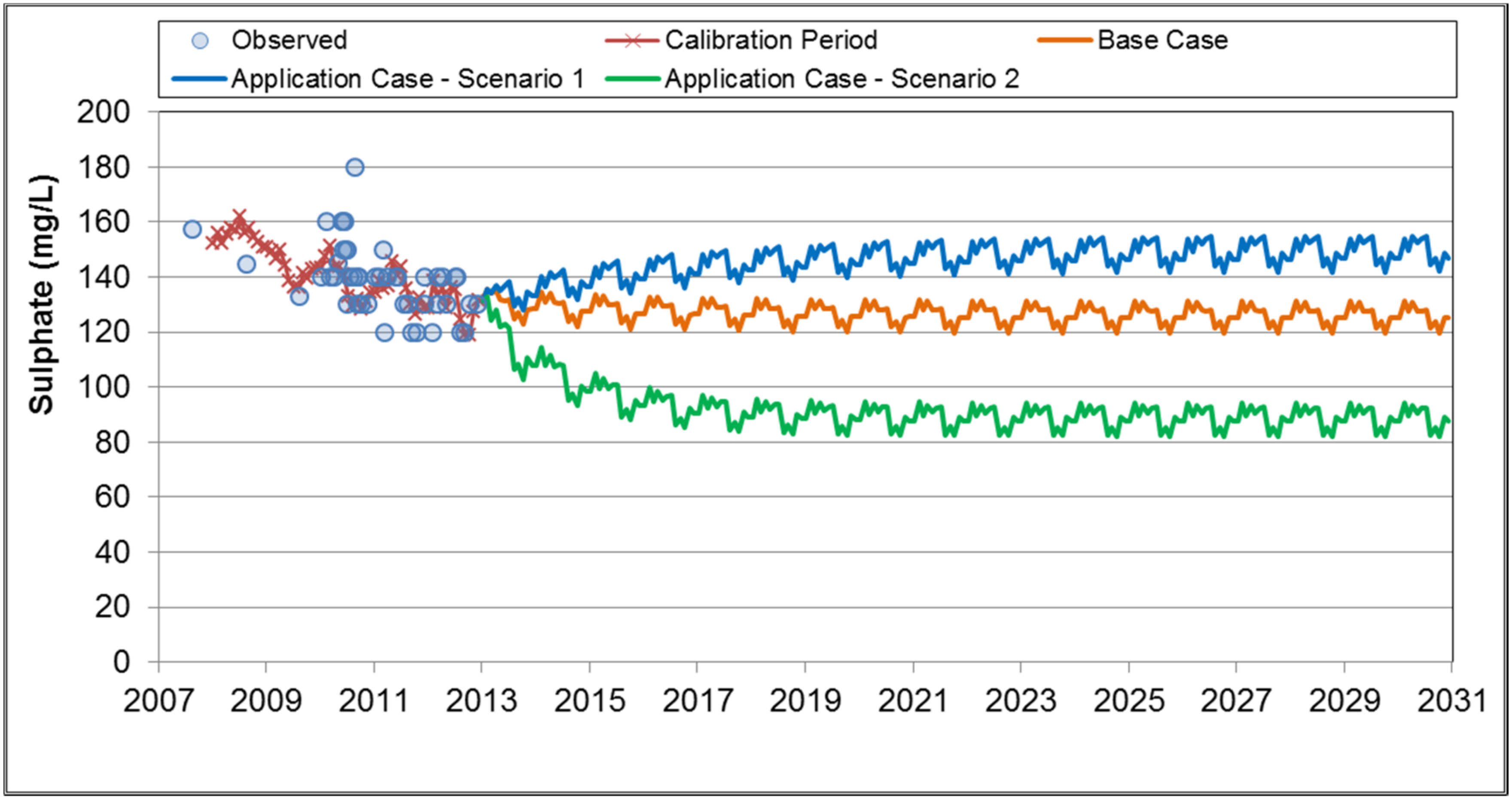

Figure B-8: Observed, Calibrated, and Predicted Concentrations for Sulphate

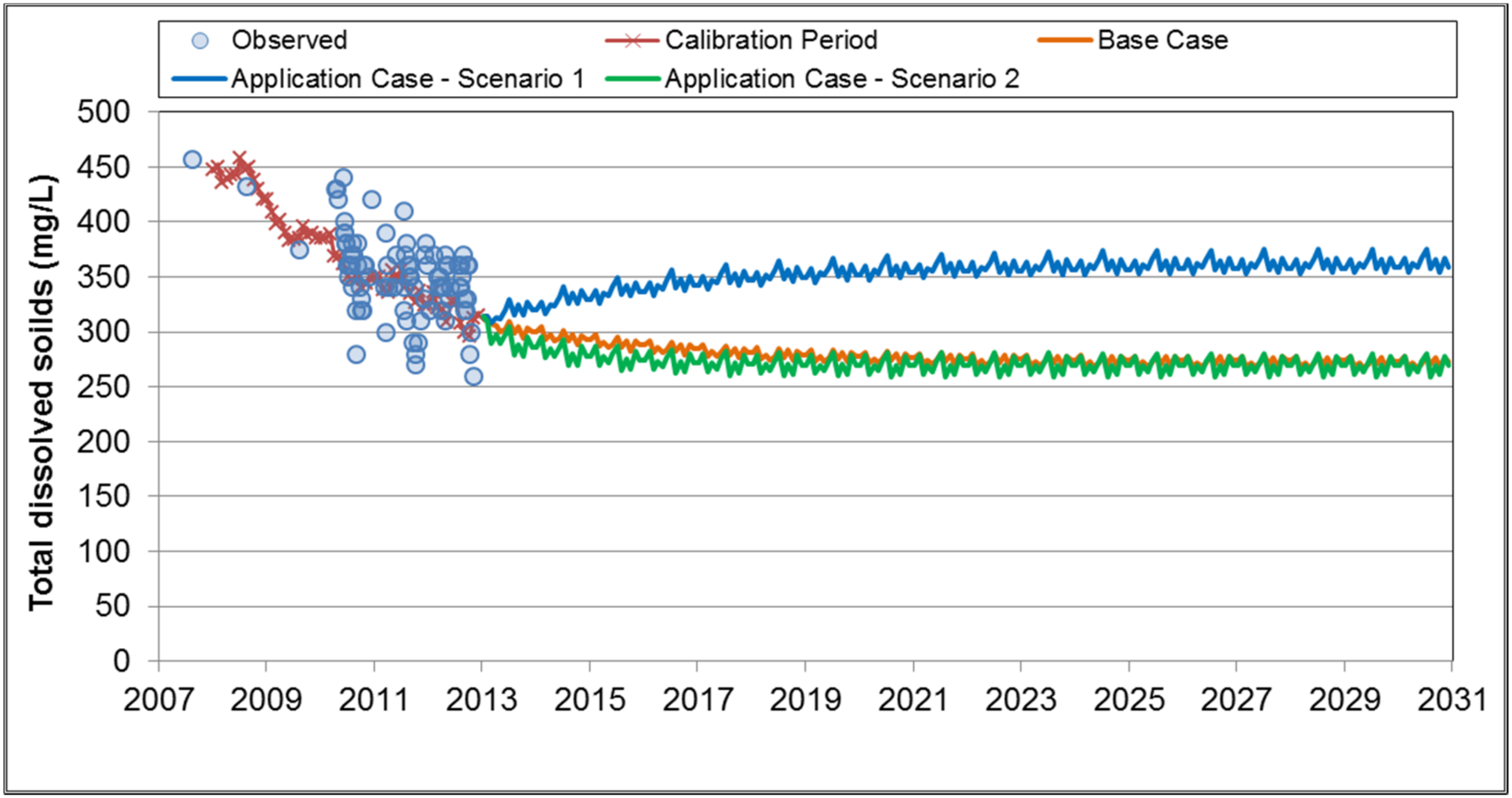

Figure B-9: Observed, Calibrated, and Predicted Concentrations for TDS

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Personal Communications

CPC (Capital Power Corporation) 2013a. Email from Barb Schmidtke to Shadi Dayyani dated October 31, 2013, regarding process chemicals for modelling.

CPC (Capital Power Corporation) 2013b. Email from Barb Schmidtke to Shadi Dayyani dated October 15, 2013, regarding Water Quantity and Quality of Surface Run off from Genesee Mine to Cooling Pond.

CPC (Capital Power Corporation) 2013c. Email from Jeff Sansom to Shadi Dayyani dated October 22, 2013, regarding Water Quantity and Quality of Surface Run off from Genesee Mine to Cooling Pond.

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APPENDIX C

Observed Water Quality of the Genesee Cooling Pond and North Saskatchewan River

Cooling Pond Water Quality and Effect of Blowdown Water on Water Quality in NSR Based on Monitoring Data

In Section 3.2, model predictions for Base and Application Case scenarios were used to calculate the in-stream concentrations. In this section, the observed data collected at the cooling pond is compared to data collected at the NSR and both are compared to chronic guidelines for protection of aquatic life and NSR water quality objectives (WQOs).

Cooling pond water quality data from the Wabamun-Genesee Biomonitoring Program (TransAlta and EPCOR 2007; Golder 2008, 2009a, 2009b, 2011, 2012, 2013) and blowdown water quality data from Capital Power Corporation's (CPC's) Annual Industrial Wastewater and Runoff reports (CPC 2007, 2008, 2009, 2010, 2011, 2012, 2013) were compiled. In Tables C-1 to C-3, summary statistics, including minimum, median and maximum values, were calculated and compared to water quality guidelines for the protection of aquatic life and human health (AENV 1999; CCME 1999; U.S. EPA 2002; Health Canada 2008) and to the proposed surface water quality objectives outlined in NSWA (2010). In the case of the WQOs, the comparisons were completed using the higher 95th percentile objectives, because the maximum observed concentration in cooling pond was used to estimate in-stream concentration.

For those constituents that were above water quality guidelines (with the exception of total nitrogen and total phosphorus), concentrations in the North Saskatchewan River (NSR) were estimated using a "fraction of flow" approach (Table C-4). The affected parameters included pH, fluoride, ammonia, aluminum and chromium, and, consistent with the procedures outlined in AEP (1995), the fraction of flow was set to 10%. The estimated concentrations were then used to determine if in-stream water quality guidelines would be met (Table C-4).

The inputs to this analysis consisted of the maximum constituent concentration observed in the available cooling pond or blowdown water datasets, annual average blowdown flow rates, background water quality in the NSR and river discharge under low flow conditions. The specific values used in the analysis were as follows:

- maximum constituent concentrations listed in Tables C-1 to C-3;
- an annual average blowdown flow (2010 - 2012) of 0.69 m^3/s (CPC 2010, 2011 and 2012);
- maximum allowable blowdown rate of 1.19 m^3/s;
- median constituent levels in the NSR upstream of the Genesee Generating Station, as defined using information from AENV (2012) and Golder (2005, 2008, 2011); and
- 10% of the minimum 7-day, 1 in 10 year flow (7Q10) for the NSR, as listed in Water Act Application Report Section 6.3 (Golder 2010).

A mass balance dilution model was used to calculate the in-stream concentrations of the affected parameters (i.e., pH, fluoride, ammonia, aluminum and chromium). It took the following form:

$$C = \frac{C_e \times Q_e + ff \times C_s \times Q_s}{Q_e + ff \times Q_s}$$

Equation (1)

where: Q_e = blowdown flow rate (m^3/s);
Q_s = flow of receiving river available for mixing (m^3/s);
C_e = constituent concentration in the blowdown (mg/L);
C_s = upstream concentration of constituent (mg/L);
C = resultant in-stream concentration after mixing (mg/L); and
ff = fraction of flow (10%).

For those constituents that were above surface water quality objectives and for total nitrogen and total phosphorus, a similar mass balance dilution model was used to predict in-stream concentrations in the NSR under low flow conditions (Table C-5). For these calculations, it was assumed that all of the receiving river flow (7Q10) was available for mixing (i.e., fraction of flow = 100%).

Observed quality of cooling pond and blowdown water from 2006 to 2012 is summarized in Tables C-1 to C-3. As outlined in Tables C-1 to C-3, Concentrations of fluoride, ammonia, total nitrogen, total phosphorus, aluminum and chromium, as well as pH levels, in the blowdown water or cooling pond can be higher than water quality guidelines for the protection of aquatic life. Aluminum concentrations and pH levels in those waters can also be higher than the relevant human health guidelines. Parameters that can be found at levels in excess of the 95th percentile objective outlined in NSWA (2010) include pH, specific conductance, hardness, TDS, chloride, fluoride, sulphate and ammonia.

In-stream concentrations of chromium under two different pumping rates (existing rate and maximum pumping capacity) were predicted to exceed the chronic water quality guideline for the protection of aquatic life when the maximum observed value of 0.02 mg/L was used. However, this value is approximately ten times higher than all other values in the available dataset. It may, as a result, be an anomalous measurement (e.g., a result of sample contamination or analytical error). When the analysis was performed using the second highest value in the available chromium dataset (i.e., a value of 0.0032 mg/L), in-stream chromium concentrations were predicted to be below water quality guidelines. In-stream concentrations for all other parameters were also predicted to be below relevant water quality guidelines, except for fluoride and aluminum (Table C-4), and in-stream concentrations for all parameters were predicted to be below the relevant surface water quality objectives (Table C-5).

Fluoride concentrations in rivers and lakes of Alberta are typically at or above the chronic water quality guideline for the protection of aquatic life. Available data indicate a mean fluoride concentration of 0.12 mg/L, with levels ranging from 0.05 to 0.95 mg/L (at 242 sites, n = 10,429) (Government of Canada 1993). The clam (*Musculium transversum*) and rainbow trout (*Oncorhynchus mykiss*) are among the freshwater aquatic species most sensitive to the effects of inorganic fluorides. An effects threshold of 0.28 mg/L fluoride was developed for freshwater species (Government of Canada 1993). In-stream concentrations of fluoride under maximum blowdown case were predicted to be below the effects threshold. As such, predicted fluoride concentrations in the NSR are not expected to be inhibitory to aquatic life.

Aluminum toxicity and speciation varies with pH changes in the environment. The aluminum ion, Al^{3+}, is toxic and is normally bound as various Al(OH)n compounds at pH values between 6 and 9. As such, aluminum toxicity is normally observed in low pH environments, where more elemental ion (Al^{3+}) is available. In the NSR upstream of the Genesee Generating Station and in the cooling pond/blowdown water, pH levels are typically greater than 7.5 (AENV 2012; Golder 2005, 2008, 2010); therefore, aluminum toxicity from Al^{3+} is expected to be low.

A chronic effects benchmark for aluminum of 0.15 mg/L was developed to evaluate the impact of predicted changes in water quality to aquatic health. For details on the derivation of chronic effects benchmarks, please refer to Shell (2012). In-stream concentrations of aluminum under different blowdown rate were predicted to be below the chronic effects benchmark. As such, predicted aluminum concentrations in the NSR are not expected to be inhibitory to aquatic life.

Based on the analysis completed, most of the maximum concentrations were observed before 2009 except Total Phosphorus and Sulphate which had maximum value measured in 2010. This means in general the water quality in the cooling pond is getting better with the current makeup water rate. Increasing surface water diversion will result in better water quality in the cooling pond and pond's water will become more like that of the NSR. The predicted changes to water quality in the NSR downstream of the GGS blowdown outfall are expected to be small, with negligible incremental effects to aquatic life or other uses. This conclusion assumes that the maximum observed chromium value of 0.02 mg/L is an anomalous measurement (e.g., a result of sample contamination or analytical error). CPC is committed to on-going monitoring of blowdown water quality to verify this assumption. With the addition of G4 and G5 units, potential water quality change in the cooling pond will be mitigated by increasing division water from the NSR.

Table C-1: Cooling Pond Water Quality

Parameter	Units	Water Quality Guidelines			NSR Water Quality Objectives(d)			Genesee Cooling Pond			
		Aquatic Life		Human Health(c)	Condition(e)	50th Percentile(f)	95th Percentile(g)	Median	Minimum	Maximum	n
		Acute(a)	Chronic(b)								
Conventional Parameters											
pH	pH units	6.5 to 8.5	6.5 to 8.5	6.5 to 9	IC	8	7.6 to 8.5	**8.6**(A,C,NSR)	8.0	**9.1**(A,C,H,NSR)	19
		-	-	-	OW	8.2	7.7 to 8.4				
Specific Conductance	µS/cm	-	-	-	IC	330	375	**601**(NSR)	**566**(NSR)	**997**(NSR)	19
		-	-	-	OW	309	341				
Temperature	°C	-	-	-	-	-(h)	-(h)	**24.2**(NSR)	16	**29.5**(NSR)	19
Dissolved Oxygen	mg/L	5(i)	6.5(j)	-	IC	12.5	11.2	7.8	6.8	11	19
		-	-	-	OW	9.5	12.5				
Hardness	mg/L	-	-	-	IC	170	200	**192**(NSR)	**178**(NSR)	**247**(NSR)	19
		-	-	-	OW	160	176				
Total Alkalinity	mg/L	-	-	-	-	-	-	176	154	214	19
Total Dissolved Solids	mg/L	-	-	-	IC	196	235	**374**(NSR)	**336**(NSR)	**460**(NSR)	19
		-	-	-	OW	186	248				
Total Suspended Solids	mg/L	-	-	-	IC	3	12	< 3	< 3	6.0	19
		-	-	-	OW	12 to 96(k)	139 to 396(k)				
Turbidity	NTU	-	-	-	IC	1.7	6.7	2.1	0.91	31	19
		-	-	-	OW	6.7 to 54(k)	78 to 222(k)				
Major Ions											
Bicarbonate	mg/L	-	-	-	-	-	-	204	164	234	19
Calcium	mg/L	-	-	-	IC	46	53	33	26	41	19
		-	-	-	OW	42	46				
Carbonate	mg/L	-	-	-	-	-	-	8.5	< 5	18	19
Chloride	mg/L	640	120	-(l)	IC	0.7	2.6	**7**(NSR)	**4.1**(NSR)	**8.5**(NSR)	19
		-	-	-	OW	0.8	2.4				

Table C-1: Cooling Pond Water Quality *(continued)*

Parameter	Units	Water Quality Guidelines			NSR Water Quality Objectives[d]			Genesee Cooling Pond			
		Aquatic Life		Human Health[c]	Condition[e]	50^{th} Percentile[f]	95^{th} Percentile[g]	Median	Minimum	Maximum	n
		Acute[a]	Chronic[b]								
Conventional Parameters											
Fluoride	mg/L	-	0.12	1.5	IC	0.12	0.21	**0.36** [C,NSR]	**0.286**[C,NSR]	**0.49**[C,NSR]	19
		-	-	-	OW	0.12	0.19				
Magnesium	mg/L	-	-	-	-	-	-	30	21	37	19
Potassium	mg/L	-	-	-	-	-	-	3.2	2.7	5.0	19
Ion Balance	%	-	-	-	-	-	-				
Silica, reactive	mg/L	-	-	-	-	-	-	1.3	0.45	2.4	19
Sodium	mg/L	-	-	-[l]	-	-	-	51	40	73	19
Sulphate	mg/L	-	-	-[l]	IC	45	52	**135**[NSR]	**114**[NSR]	**164**[NSR]	19
		-	-	-	OW	38	48				
Nutrients											
Nitrate + Nitrite	mg/L	-	-	-	IC	0.078	0.102	< 0.1	< 0.071	< 0.11	19
		-	-	-	OW	0.008	0.098				
Nitrate	mg/L	-	13	10	-	-	-	< 0.1	< 0.05	< 0.11	19
Nitrite	mg/L	-	0.06	-	IC	0.002	0.01	< 0.05	< 0.05	< 0.05	19
		-	-	-	OW	0.002	0.005				
Total Metals											
Aluminum	mg/L	0.75	0.1	0.1	-	-	-	0.014	0.0057	0.044	19
Antimony	mg/L	-	-	0.0055	-	-	-	0.00016	0.00013	0.00019	19
Arsenic	mg/L	0.34	0.005	0.01[m]	-	-	-	0.0023	0.0017	0.0038	19
Barium	mg/L	-	-	1	-	-	-	0.0688	0.0562	0.106	19
Beryllium	mg/L	-	-	0.004	-	-	-	< 0.0002	< 0.0002	< 0.0002	19
Boron	mg/L	29	1.5	5	-	-	-	0.14	0.095	0.2	19
Cadmium[n]	mg/L	0.0041[o]	0.00044[o]	0.005	-	-	-	< 0.00005	< 0.00005	< 0.00005	19

Table C-1: Cooling Pond Water Quality *(continued)*

Parameter	Units	Water Quality Guidelines			NSR Water Quality Objectives[d]			Genesee Cooling Pond			
		Aquatic Life		Human Health[c]	Condition[e]	50th Percentile[f]	95th Percentile[g]	Median	Minimum	Maximum	n
		Acute[a]	Chronic[b]								
Conventional Parameters											
Chromium	mg/L	0.016[p]	0.001[p]	0.05[q]	-	-	-	0.000073	< 0.00006	**0.0032[C]**	19
Cobalt	mg/L	-	-	-	-	-	-	< 0.0001	< 0.0001	0.00013	19
Copper[r]	mg/L	0.026[o]	0.0041[o]	1.3	-	-	-	< 0.0006	< 0.0006	0.012	19
Iron	mg/L	-	0.3	0.3	-	-	-	< 0.05	< 0.03	0.15	16
Lead	mg/L	0.187[o]	0.0073[o]	0.01	-	-	-	< 0.00005	< 0.00005	0.0004	19
Lithium	mg/L	-	-	-	-	-	-	0.016	0.01	0.024	19
Manganese	mg/L	-	-	0.05	-	-	-	0.016	0.009	0.33	19
Mercury[s]	mg/L	0.000013	0.000005	0.001	-	-	-	0.0000008	< 0.0000005	0.000005	19
Molybdenum	mg/L	-	0.073	-	-	-	-	0.004	0.0037	0.0045	19
Nickel	mg/L	0.815[o]	0.091[o]	0.34	-	-	-	0.00089	0.00061	0.0014	19
Selenium	mg/L	-	0.001	0.01	-	-	-	0.00027	0.00014	0.00032	19
Silver	mg/L	0.0125[o]	0.0001	-	-	-	-	< 0.0001	< 0.0001	< 0.0001	19
Strontium	mg/L	-	-	-	-	-	-	0.48	0.45	0.6	19
Thallium	mg/L	-	0.0008	0.00013	-	-	-	< 0.00003	< 0.00003	< 0.00003	19
Titanium	mg/L	-	-	-	-	-	-	0.0013	< 0.0001	0.003	19
Uranium	mg/L	-	-	-	-	-	-	0.00071	0.00058	0.00091	19
Vanadium	mg/L	-	-	-	-	-	-	0.00045	0.00035	0.0007	19
Zinc	mg/L	0.208[o]	0.03	5.1	-	-	-	< 0.0008	< 0.0008	0.0032	19

(a) Based on the more conservative guideline of: AENV (1999) and U.S. EPA (2002), unless otherwise noted.

(b) Based on the more conservative guideline of: AENV (1999), CCME (1999) and U.S. EPA (2002), unless otherwise noted.

(c) Based on the more conservative guideline of: U.S. EPA (2002) using fish consumption rate of 45 g/d (Richardson 1997) and Health Canada (2008), unless otherwise noted.

(d) Based on NSWA (2010) Reach C downstream of the Brazeau River confluence to Devon.

(e) IC = ice covered; OW = open water.

(f) Using the 50th percentile statistic as an objective means at least half of future measurements should be below this value; and there should be no statistically significant, increasing trend detected in the analysis of future, long-term monitoring data.

(g) Using the 95th percentile statistic as an objective means at least 95% of future measurements should be below this value; and there should be no statistically significant increasing trend detected in the analysis of future, long-term monitoring data.

(h) Maintain current frequency of 7-day means between 12°C and 18°C; maximum 24°C,

(i) Instantaneous minimum.

(j) 7-day mean.

(k) Objectives are dependent on flow, as outlined in NSWA (2010).

(l) Health Canada (2008) aesthetic objective guidelines exist for these parameters, but were not used in this study as they do not relate to toxic thresholds; human health guidelines without this superscript are the maximum acceptable concentrations and interim maximum acceptable concentrations.

(m) The Health Canada (2008) drinking water guideline for arsenic was used in place of the lower U.S. EPA (2002) human health guideline for surface waters, because the human health guideline is based on the consumption of oysters, a non-resident species in the North Saskatchewan River.

(n) The U.S. EPA (2002) chronic cadmium guideline was used in place of the lower CCME (1999) chronic guideline, because, as noted by CCME (1999), most ambient waters contain cadmium levels in excess of the recommended CCME chronic cadmium guideline.

(o) Guidelines are hardness dependent; values shown here are based on a median hardness value of 192 mg/L; these guidelines were altered based on site-specific median hardness levels using the methods described in AENV (1999) and U.S. EPA (2002).

(p) Chromium VI guideline.

(q) Chromium III guideline.

(r) U.S. EPA (2002) acute and CCME (1999) chronic guidelines are shown; because Alberta copper guidelines apply to acid extractable values (as opposed to total values).

(s) Alberta draft guidelines for mercury are shown.

(t) A = concentration is higher than the relevant acute aquatic life guideline or beyond the recommended pH or DO concentration range; C = concentration is higher than the relevant chronic aquatic life guideline or beyond the recommended pH or DO concentration range; H = concentration is higher than the relevant human health guideline or beyond the recommended pH range; NSR = concentration is higher than the relevant water quality objective for the North Saskatchewan River.

" - " symbol indicates no applicable guideline, no applicable objective or no available data.

Bolded concentrations are higher than relevant water quality guidelines and/or water quality objectives.

Source: TransAlta and EPCOR (2007); Golder (2008, 2009a, 2009b, 2011, 2012, 2013).

Table C-2: Blowdown Water Quality Based on Available Individual Measurements

Parameter	Units	Water Quality Guidelines			NSR Water Quality Objectives[d]			Genesee Cooling Pond Blowdown			
		Aquatic Life		Human Health[c]	Condition[e]	50th Percentile[f]	95th Percentile[g]	Median	Minimum	Maximum	n
		Acute[a]	Chronic[b]								
Conventional Parameters											
Hardness	mg/L	-	-	-	IC	170	200	**224(NSR)**	**190(NSR)**	**260.5(NSR)**	39
		-	-	-	OW	160	176				
Major Ions											
Bicarbonate	mg/L	-	-	-	-	-	-	230	180	270	18
Calcium	mg/L	-	-	-	IC	46	53	40	27	46	44
		-	-	-	OW	42	46				
Carbonate	mg/L	-	-	-	-	-	-	3.3	< 6	12	18
Chloride	mg/L	640	120	-(h)	IC	0.7	2.6	**5.1(NSR)**	**4.8(NSR)**	**10.5(NSR)**	19
		-	-	-	OW	0.8	2.4				
Fluoride	mg/L	-	-	-	IC	0.12	0.21	-	-	-	-
		-	-	-	OW	0.12	0.19				
Magnesium	mg/L	-	-	-	-	-	-	31	24	37	44
Potassium	mg/L	-	-	-	-	-	-	3.7	2.5	6.1	44
Sodium	mg/L	-	-	-(h)	-	-	-	57	37	90	44
Sulphate	mg/L	-	-	-(h)	IC	45	52	**150(NSR)**	**130(NSR)**	**180(NSR)**	19
Nutrients											
Nitrate	mg/L	-	13	10	-	-	-	< 0.02	< 0.02	0.09	10
Total Metals											
Aluminum	mg/L	0.75	0.1	0.1	-	-	-	0.04	< 0.014	**0.479(C,H)**	44
Arsenic	mg/L	0.34	0.005	0.01(i)	-	-	-	0.0015	< 0.002	0.0032	44
Boron	mg/L	29	1.5	5	-	-	-	0.14	0.09	0.26	44
Cadmium(j)	mg/L	0.0048(k)	0.00049(k)	0.005	-	-	-	< 0.00003	< 0.000005	0.00023	44
Chromium	mg/L	0.016(l)	0.001(l)	0.05(m)	-	-	-	< 0.001	< 0.0005	**0.0025(c)**	40(n)

Table C-2: Blowdown Water Quality Based on Available Individual Measurements *(continued)*

Parameter	Units	Water Quality Guidelines			NSR Water Quality Objectives[d]			Genesee Cooling Pond Blowdown			
		Aquatic Life		Human Health[c]	Condition[e]	50th Percentile[f]	95th Percentile[g]	Median	Minimum	Maximum	n
		Acute[a]	Chronic[b]								
Cobalt	mg/L	-	-	-	-	-	-	< 0.0003	< 0.0001	0.0007	44
Copper[o]	mg/L	0.03[k]	0.0047[k]	1.3	-	-	-	<0.0014	< 0.0002	0.003	42[n]
Iron	mg/L	-	0.3	0.3	-	-	-	< 0.06	< 0.01	0.32	42[n]
Lead	mg/L	0.228[k]	0.0089[k]	0.01	-	-	-	< 0.0002	< 0.0001	0.002	44
Manganese	mg/L	-	-	0.05	-	-	-	0.0065	< 0.004	0.032	44
Molybdenum	mg/L	-	0.073	-	-	-	-	0.005	< 0.006	0.01	44
Nickel	mg/L	0.928[k]	0.103[k]	0.34	-	-	-	0.0013	< 0.0005	0.011	44
Selenium	mg/L	-	0.001	0.01	-	-	-	< 0.0002	< 0.0002	0.0043	42[n]
Silver	mg/L	0.0162[k]	0.0001	-	-	-	-	< 0.0001	< 0.00001	0.00039	44
Thallium	mg/L	-	0.0008	0.00013	-	-	-	< 0.0002	< 0.00005	0.00005	38[n]
Vanadium	mg/L	-	-	-	-	-	-	0.0007	< 0.0005	0.017	44
Zinc	mg/L	0.237[k]	0.03	5.1	-	-	-	< 0.003	< 0.001	0.03	44

(a) Based on the more conservative guideline of: AENV (1999) and U.S. EPA (2002), unless otherwise noted.

(b) Based on the more conservative guideline of: AENV (1999), CCME (1999) and U.S. EPA (2002), unless otherwise noted.

(c) Based on the more conservative guideline of: U.S. EPA (2002) using fish consumption rate of 45 g/d (Richardson 1997) and Health Canada (2008), unless otherwise noted.

(d) Based on NSWA (2010) Reach C downstream of the Brazeau River confluence to Devon.

(e) IC = ice covered; OW = open water.

(f) Using the 50th percentile statistic as an objective means at least half of future measurements should be below this value; and there should be no statistically significant, increasing trend detected in the analysis of future, long-term monitoring data.

(g) Using the 95th percentile statistic as an objective means at least 95% of future measurements should be below this value; and there should be no statistically significant increasing trend detected in the analysis of future, long-term monitoring data.

(h) Health Canada (2008) aesthetic objective guidelines exist for these parameters, but were not used in this study as they do not relate to toxic thresholds; human health guidelines without this superscript are the maximum acceptable concentrations and interim maximum acceptable concentrations.

(i) The Health Canada (2008) drinking water guideline for arsenic was used in place of the lower U.S. EPA (2002) human health guideline for surface waters, because the human health guideline is based on the consumption of oysters, a non-resident species in the North Saskatchewan River.

(j) The U.S. EPA (2002) chronic cadmium guideline was used in place of the lower CCME (1999) chronic guideline, because, as noted by CCME (1999), most ambient waters contain cadmium levels in excess of the recommended CCME chronic cadmium guideline.

(k) Guidelines are hardness dependent; values shown here are based on a median hardness value of 224 mg/L; these guidelines were altered based on site-specific median hardness levels using the methods described in AENV (1999) and U.S. EPA (2002).

(l) Chromium VI guideline.

(m) Chromium III guideline.

(n) For the total metals summary, if the sample concentration was reported as less than the analytical detection limit and the analytical detection limit was higher than the relevant water quality guideline(s), the concentration was not included in the summary statistics.

(o) U.S. EPA (2002) acute and CCME (1999) chronic guidelines are shown; because Alberta copper guidelines apply to acid extractable values (as opposed to total values).

(p) A = concentration is higher than the relevant acute aquatic life guideline or beyond the recommended pH or DO concentration range; C = concentration is higher than the relevant chronic aquatic life guideline or beyond the recommended pH or DO concentration range; H = concentration is higher than the relevant human health guideline or beyond the recommended pH range; NSR = concentration is higher than the relevant water quality objective for the North Saskatchewan River.

" - " symbol indicates no applicable guideline, no applicable objective or no available data.

Bolded concentrations are higher than relevant water quality guidelines and/or water quality objectives.

Source: CPC (2007, 2008, 2009a, 2009b, 2011, 2012).

Table C-3: Blowdown Water Quality based on a Summary of Available Monthly Averages and Monthly Maxiums

Parameter	Units	Water Quality Guidelines			NSR Water Quality Objectives[d]			Genesee Cooling Pond Blowdown							
		Aquatic Life						Monthly Averages				Monthly Maximums			
		Acute[a]	Chronic[b]	Human Health[c]	Condition[e]	50th Percentile[f]	95th Percentile[g]	Median	Minimum	Maximum	n	Median	Minimum	Maximum	n
Conventional Parameters															
Temperature	°C	-	-	-	-	-[h]	-[h]	18.5	3.0	**30.3**[NSR]	44	19.1	3.3	**31.2**[NSR]	44
Hardness	mg/L	-	-	-	IC	170	200	220	190	**261**[NSR]	24	217	190	**265**[NSR]	24
		-	-	-	OW	160	176								
pH	-	6.5 to 8.5	6.5 to 8.5	6.5 to 9	IC	8	7.6 to 8.5	8.5	8.0	**8.9**[A,C,NSR]	45	8.5	8.0	**9.0**[A,C,NSR]	45
		-	-	-	OW	8.2	7.7 to 8.4								
Total Dissolved Solids	mg/L	-	-	-	IC	196	235	**370**[NSR]	**285**[NSR]	**505**[NSR]	44	**380**[NSR]	**300**[NSR]	**627**[NSR]	44
		-	-	-	OW	186	248								
Total Suspended Solids	mg/L	-	-	-	IC	3	12	2.9	< 1	37	44	4.0	1.0	113	44
		-	-	-	OW	12 to 96[i]	139 to 396[i]								
Nutrients								0	0	0	0	0	0	0	0
Ammonia[i]	mg/L	1.76	0.4	-	IC	0.01	0.05	< 0.05	< 0.05	**5.6**[A,NSR]	43	< 0.05	< 0.05	**1.6**[C,NSR]	43
		-	-	-	OW	0.005	0.08								
Total Nitrogen	mg/L	-	1	-	-	-	-	0.68	< 1	**10**[C]	33	0.71	< 1	**19**[C]	33
Total Phosphorus	mg/L	-	0.05	-	IC	0.006	0.024	0.012	< 0.012	**0.87**[C,NSR]	44	0.016	< 0.016	**0.2**[C,NSR]	43
		-	-	-	OW	0.0123 [k]	0.0123 [k]								

(a) Based on the more conservative guideline of: AENV (1999) and U.S. EPA (2002), unless otherwise noted.
(b) Based on the more conservative guideline of: AENV (1999), CCME (1999) and U.S. EPA (2002), unless otherwise noted.

(c) Based on the more conservative guideline of: U.S. EPA (2002) using fish consumption rate of 45 g/d (Richardson 1997) and Health Canada (2008), unless otherwise noted.
(d) Based on NSWA (2010) Reach C downstream of the Brazeau River confluence to Devon.
(e) IC = ice covered; OW = open water.
(f) Using the 50th percentile statistic as an objective means at least half of future measurements should be below this value; and there should be no statistically significant, increasing trend detected in the analysis of future, long-term monitoring data.
(g) Using the 95th percentile statistic as an objective means at least 95% of future measurements should be below this value; and there should be no statistically significant increasing trend detected in the analysis of future, long-term monitoring data.
(h) Maintain current frequency of 7-day means between 12°C and 18°C; maximum 24°C,
(i) Objectives are flow dependent, as outlined in NSWA (2010).
(j) Guidelines are pH (acute and chronic) and temperature (chronic) dependent; ranges shown here correspond to a median pH value of 8.5 and a median temperature values of 18°C ; these guidelines were altered based on site-specific median conditions using the methods described in AENV (1999 with 2011 update) and U.S. EPA (2002).
(k) Objectives were calculated using methods outlined in NSWA (2010) and a median TSS concentration of 3 mg/L.
(m) A = concentration is higher than the relevant acute aquatic life guideline or beyond the recommended pH or DO concentration range; C = concentration is higher than the relevant chronic aquatic life guideline or beyond the recommended pH or DO concentration range; H = concentration is higher than the relevant human health guideline or beyond the recommended pH range; NSR = concentration is higher than the relevant water quality objective for the North Saskatchewan River.

" - " symbol indicates no applicable guideline, no applicable objective or no available data.

Bolded concentrations are higher than relevant water quality guidelines and/or water quality objectives.

Source: CPC (2007, 2008, 2009a, 2009b, 2011, 2012).

Table C-4: Predicted Instream Concentrations in the North Saskatchewan River Downstream of the Blowdown Outfall Compared to Water Quality Guidelines (using Monitoring Data)

Parameter	Units	Water Quality Guidelines			NSR Upstream of GGS	GGS Blowdown Quality	Predicted In-stream Concentrations		
		Aquatic Life		Human Health[c]			Current	Maximum	Percent Change (%)
		Acute[a]	Chronic[b]						
Conventional Parameters									
pH	-	6.5 to 8.5	6.5 to 8.5	6.5 to 9	8.4	9.1	8.5	8.5	<1
Major Ions									
Fluoride	mg/L	-	0.12	1.5	0.12	0.49	**0.16**	**0.18**	16
Nutrients									
Ammonia [d]	mg/L	1.76	0.4	-	0.005	1.6	0.17	0.28	63
Total Nitrogen	mg/L	-	1	-	0.025	19	0.26	0.41	69
Total Phosphorous	mg/L	-	0.05	-	0.0015	0.2	0.004	0.0055	46
Total Metals									
Aluminum	mg/L	0.75	0.1	-	0.086	0.48	**0.13**	**0.15**	21
Chromium - including outlier	mg/L	0.016 [e]	0.001 [e]	-	0.00031	0.02	**0.0023**	**0.0037**	56
Chromium - excluding outlier	mg/L	0.016 [e]	0.001 [e]	-	0.00031	0.0032	0.00061	0.0008	32

[a] Based on the more conservative guideline of: AENV (1999) and U.S. EPA (2002), unless otherwise noted.

[b] Based on the more conservative guideline of: AENV (1999), CCME (1999) and U.S. EPA (2002), unless otherwise noted.

[c] Based on the more conservative guideline of: U.S. EPA (2002) using fish consumption rate of 45 g/d (Richardson 1997) and Health Canada (2008), unless otherwise noted.

[d] Guidelines are pH (acute and chronic) and temperature (chronic) dependent; ranges shown here correspond to a median pH value of 8.5 and a median temperature values of 18.5°C ; these guidelines were altered based on site-specific median conditions using the methods described in AENV (1999 with 2011 update) and U.S. EPA (2002).

[e] Chromium VI guideline.

" - " symbol indicates no applicable guideline, no applicable objective or no available data.

Bolded concentrations are higher than relevant water quality guidelines and/or water quality objectives.

Table C-5: Predicted Instream Concentrations in the North Saskatchewan River Downstream of the Blowdown Outfall Compared to Reach-Specific Water Quality Objectives (using Monitoring Data)

Parameter	Units	NSR Water Quality Objectives[a]			NSR Upstream of GGS	Observed GGS Blowdown Quality	Predicted In-stream Concentrations		
		Condition[b]	50th Percentile[c]	95th Percentile[d]			Current	Maximum	Percent Change (%)
Conventional Parameters									
pH	-	IC	8	7.6 to 8.5	8.4	9.1	8.4	8.4	<1
		OW	8.2	7.7 to 8.4					
Specific Conductance	µS/cm	IC	330	375	310	997	318	324	1.9
		OW	309	341					
Hardness	mg/L	IC	170	200	160.5	265	162	163	<1
		OW	160	176					
Total Dissolved Solids	mg/L	IC	196	235	199	627	204	208	1.8
		OW	186	248					
Major Ions									
Chloride	mg/L	IC	0.7	2.6	0.5	8	0.59	0.65	11.2
		OW	0.8	2.4					
Fluoride	mg/L	IC	0.12	0.21	0.12	0.49	0.12	0.13	2.3
		OW	0.12	0.19					
Sulphate	mg/L	IC	45	52	37.6	180	39	40	3.2
		OW	38	48					
Nutrients									
Ammonia	mg/L	IC	0.01	0.05	0.005	1.6	0.024	0.041	60
		OW	0.005	0.08					
Total Phosphorous	mg/L	IC	0.006	0.024	0.0015	0.2	0.004	0.005	46
		OW	0.0123[e]	0.0123[e]					

(a) Based on NSWA (2010) Reach C downstream of the Brazeau River confluence to Devon.

(b) IC = ice covered; OW = open water.

(c) Using the 50th percentile statistic as an objective means at least half of future measurements should be below this value; and there should be no statistically significant, increasing trend detected in the analysis of future, long-term monitoring data.

(d) Using the 95th percentile statistic as an objective means at least 95% of future measurements should be below this value; and there should be no statistically significant increasing trend detected in the analysis of future, long-term monitoring data.

(e) Objectives were calculated using methods outlined in NSWA (2010) and a median TSS concentration of 3 mg/L.

" - " symbol indicates no applicable guideline, no applicable objective or no available data.

Bolded concentrations are higher than relevant water quality guidelines and/or water quality objectives.

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