

Elk Valley Water Quality Plan

2019 Implementation Plan Adjustment

**Annex F: Projected Concentrations of Nitrate, Selenium and
Sulphate**

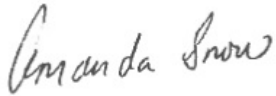
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Teck

This report has been prepared by:

GOLDER ASSOCIATES LTD.



Amanda Snow, MASC
Senior Water Quality Specialist

This report has been reviewed by:



J.P. Bechtold, MASC, PBIOL
Principal, Senior Water Quality Specialist

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ACRONYMS AND ABBREVIATIONS

Acronym or Abbreviation	Description
AWTF	Active water treatment facilities
CMO	Coal Mountain Operations
EVO	Elkview Operations
EVWQP	Elk Valley Water Quality Plan
FRO	Fording River Operations
GHO	Greenhills Operations
IIP	Initial Implementation Plan
IPA	Implementation Plan Adjustment
LCO	Line Creek Operations
RWQM	Regional Water Quality Model
SPO	Site Performance Objectives
Teck	Teck Coal Limited
WLC	West Line Creek

UNITS OF MEASURE

Unit of Measure	Description
µg/L	micrograms per litre
mg/L	milligrams per litre

1 Introduction

The projected concentrations of nitrate, selenium and sulphate at Order Stations and Compliance Points are presented in this document with mitigation based on the 2019 Implementation Plan Adjustment (IPA). The 2019 IPA is an update to the Initial Implementation Plan (IIP) included in the Elk Valley Water Quality Plan (EVWQP, Teck 2014). The 2019 IPA outlines Teck's updated mitigation plan to meet the long-term water quality-based Compliance Limits and Site Performance Objectives (SPOs) for nitrate, selenium and sulphate defined in *Environmental Management Act* Permit 107517.

The 2019 IPA was developed using the 2017 Regional Water Quality Model (RWQM) described in Teck (2017), and updated as outlined in Annex B. It considers two future development scenarios:

- **Planned Development Scenario:** This scenario is representative of the 2016 mine plan for Teck's five Elk Valley Operations and incorporates existing waste rock and water management through 2016 and planned (permitted and unpermitted) development through the end of 2037.
- **Permitted Development Scenario:** This scenario incorporates existing waste rock and water management through 2016, similar to the Planned Development Scenario, but post 2016 includes all permitted development for Teck's five Elk Valley Operations. The model period has been extended beyond 2037 to account for the full effects of loading from the permitted waste rock and from pit spilling (as opposed to the 20 year period for the Planned Development Scenario).

The 2019 IPA was developed based on refinements and additions to both the decisions (i.e., the sources to target for treatment and how quickly treatment could be constructed) and assumptions (i.e., the effluent quality from treatment, release rates, and water availability for treatment) used to set the EVWQP IIP. Refinements and additions resulted from Teck's learning since the EVWQP and constitute the basis on which the IIP was adjusted. The updated understanding was reflected in the water quality modelling completed to support the development of the 2019 IPA and is expected to be adjusted over time. The water related inputs used to inform the 2019 IPA are summarized in Section 2 of the main document and in Annex C.

Like the IIP, the 2019 IPA is based on the application of biologically-based AWTFs, and clean water diversions where practical to support efficient treatment, to address increasing selenium and nitrate water concentrations within the Elk Valley. Alternative forms of mitigation, such as Saturated Rock Fills, that Teck continues to investigate and may incorporate into future updates to the IPA are outlined in Annex J. Methods used to select the clean water diversions incorporated into the 2019 IPA are outlined in Annex D. The expected performance of active water treatment, in terms of effluent concentrations, is outlined in Section 4 of the main report. A summary of the mitigation included in the 2017 RWQM for the 2019 IPA is provided in Table 1-1.

Projected monthly average concentrations of nitrate, selenium, and sulphate at Order Stations and Compliance Points for the Planned Development Scenario and the Permitted Development Scenario are presented in Sections 2 and 3, respectively. Section 4 presents projected monthly average influent concentrations of nitrate, selenium, and sulphate for each active water treatment facility (AWTF) for the Planned Development Scenario and the Permitted Development Scenario. It also includes projected monthly average loads of nitrate and selenium removed by each AWTF for the Planned Development

Scenario and Permitted Development Scenario and a reference to Appendix A, which contains monthly hydrographs showing flows available for treatment.

The projected monthly average concentrations outlined herein were developed based on the assumptions and inputs outlined in Annex E, which included assumptions specific to improvements to effluent selenium concentrations and increased water availability after 2033 in selected tributaries at Fording River Operation (FRO). The sensitivity of the projected selenium concentrations to the assumption for improvements in effluent selenium concentrations over time were assessed by assuming no improvements and the results are provided in Appendix B. Similarly, the sensitivity of the projected selenium and nitrate concentrations to the assumption of increased water availability was assessed by keeping these assumptions static at lower assumed values; these results are provided in Appendix C. Projected monthly average concentrations of nitrate, selenium and sulphate for the Permitted Development Scenario without mitigation are provided in Appendix D.

Table 1-1 Mitigation Included in the 2017 Regional Water Quality Model for the 2019 Implementation Plan Adjustment

Site	Sources Targeted for Treatment	Treatment Facility	Hydraulic Capacity (m ³ /d)	Associated Diversions and Conveyance of Mine-Influenced Water	Fully Effective Date in 2017 RWQM ^(a)
FRO	Swift, Cataract and Kilmarnock creeks	FRO AWTF-S Phase I	20,000	• Diversion of Upper Kilmarnock watershed	December 31, 2021
		FRO AWTF-S Phase II	5,000	• Convey mine-influenced water to treatment	December 31, 2029
		FRO AWTF-S Phase III	20,000	• Discharge to the Fording River	December 31, 2035
	Clode Creek, North Spoil and Swift Pit	FRO AWTF-N Phase I	30,000	• Convey mine-influenced water to treatment	December 31, 2023
		FRO AWTF-N Phase II	20,000	• Discharge to the Fording River	December 31, 2039
LCO	West Line Creek and Line Creek	WLC Phase I	6,000	• Diversion of Upper Line Creek, Horseshoe Creek and No Name Creek	December 31, 2018
		WLC Phase II	1,100		December 31, 2019
		WLC Phase III	12,500	• Convey mine-influenced water to treatment	December 31, 2025
		WLC Phase IV	32,500	• Discharge to Line Creek	December 31, 2033
	LCO Dry Creek	LCO Dry Creek Phase I	2,500	• Convey mine-influenced water to treatment	December 31, 2037
		LCO Dry Creek Phase II	2,500	• Discharge to the Fording River	December 31, 2049
EVO	Bodie, Gate and Erickson creeks	Elkview Phase I	20,000	• Convey mine-influenced water to treatment • Discharge to Erickson Creek	September 30, 2022
		Elkview Phase II	20,000		December 31, 2027
		Elkview Phase III	5,000		December 31, 2043
GHO	Leask, Wolfram, Thompson and Greenhills creeks	Greenhills Phase I	5,000	• Convey mine-influenced water to treatment • Discharge to Thompson Creek	December 31, 2031
		Greenhills Phase II	2,500		Post 2100
Total			204,600		

^(a) In the 2017 RWQM, the fully effective date refers to the date when the treatment facility is build, seeded, commissioned and effective at the hydraulic capacity listed above.

RWQM = Regional Water Quality Model; EVWQP = Elk Valley Water Quality Plan; LCO = Line Creek Operations; GHO = Greenhills Operations; FRO = Fording River Operations; EVO = Elkview Operations; WLC = West Line Creek; AWTF = Active Water Treatment Facility; m³/d = cubic metres per day; kg/d = kilograms per day.







2 Projected Concentrations for the Planned Development Scenario

Monthly average concentrations of nitrate, selenium and sulphate projected to be above SPOs and/or Compliance Limits for the Planned Development Scenario are summarized in Tables 2-1 to 2-3, respectively.

Projected monthly average concentrations of nitrate, selenium and sulphate at Order Stations and compliance points for the Planned Development Scenario are shown in Figures 2-1 to 2-6, respectively. The projections are presented as time series plots. The solid orange, blue and grey lines correspond to the projected monthly concentrations under low, average and high flows for the Planned Development Scenario. The figures include SPOs, Compliance Limits, historical observations (green points) and fully effective dates (vertical lines) for the AWTFS.

The x-axis in Figures 2-1 to 2-6 runs from the start of 2013 to the end of 2037. The calibration period for the RWQM is January 1, 2004 to December 31, 2016. Projected concentrations shown in solid grey prior to 2017; therefore, correspond to the monthly concentrations projected to occur each year under observed flow conditions.

The legend below applies to all time series plots in this section.

-  Projected Monthly Average Concentrations under Low Flows
-  Projected Monthly Average Concentrations under Average Flows
-  Projected Monthly Average Concentrations under High Flows
-  Monthly Average Monitored Concentrations
-  Site Performance Objective
-  Limit

Projected hardness values used to calculate the hardness-dependant SPO for nitrate are presented in Table 2-4. For each year, the hardness-dependant SPO for nitrate is calculated using the minimum hardness value from the month when the maximum nitrate concentration is projected to occur.

Table 2-1 Summary of Projected Monthly Average Nitrate Concentrations above Site Performance Objectives or Compliance Limits between 2019 and 2037 for the Planned Development Scenario

Location		Year	Month	Maximum Projected Concentration (mg/L)	Corresponding Site Performance Objective / Limit (mg/L)	Maximum Magnitude of Exceedance (mg/L)
Order Stations	Fording River downstream of Greenhills Creek (GH_FR1; 0200378) ^(a)	2020 to 2021	January to April	17	14	3
	Elk River upstream of Grave Creek (EV_ER4; 0200027)	2020 to 2021	January to April	5.6	4	1.6
Compliance Points	FRO Compliance Point (FR_FRCP1; E300071)	2019	January to April	32	27	5
		2020 to 2022	October to May	31	19	12
		2024	April	14	13	1
	Fording River above Chauncey Creek (FR_FRABCH)	2019	January to April	29	25	4
		2020 to 2022	December to May, October	28	18	10
		2024	April	13	12	1
	LCO Compliance Point (LC_LCDSSLCC; E297110)	2019 to 2025	October to May	12	7	5

^(a) This location is also the GHO Fording River Compliance Point.

FRO = Fording River Operations; LCO = Line Creek Operations; GHO = Greenhills Operations.

Table 2-2 Summary of Projected Monthly Average Selenium Concentrations above Site Performance Objectives or Limits between 2019 and 2037 for the Planned Development Scenario

Location		Year	Month	Maximum Projected Concentration (µg/L)	Corresponding Site Performance Objective / Limit (µg/L)	Maximum Magnitude of Exceedance (µg/L)
Order Stations	Fording River downstream of Greenhills Creek (GH_FR1; 0200378) ^(a)	2020 to 2021	December to April	78	63	15
	Fording River downstream of Line Creek (LC_LC5; 0200028)	2020 to 2021	January to April	58	51	7
	Elk River upstream of Grave Creek (EV_ER4; 0200027)	2020 to 2021	February	26	23	3
	Koocanusa Reservoir (RG_DSELK; E300230)	2019 to 2022	January to April	2.6	2.0	0.6
Compliance Points	FRO Compliance Point (FR_FRCP1; E300071)	2020 to 2021	October to May, August	127	90	37
	Fording River above Chauncey Creek (FR_FRABCH)	2020 to 2021	October to May	118	85	33
	LCO Compliance Point (LC_LCDSSLCC; E297110)	2019 to 2025	December to May	69	50	19
	GHO Elk River Compliance Point (GH_ERC; E300090)	2028 to 2030	February	9	8	1
	EVO Harmer Creek Compliance Point (EV_HC1; E102682)	2028 to 2030; 2032 to 2037	August to May	76	57	19
	EVO Michel Creek Compliance Point (EV_MC2; E300091)	2021	February	29	28	1
		2022	January to March, August to September	32	20	12
		2027	August	20	19	1

^(a) This location is also the GHO Fording River Compliance Point.

EVO = Elkview Operations; FRO = Fording River Operations; GHO = Greenhills Operations; LCO = Line Creek Operations.

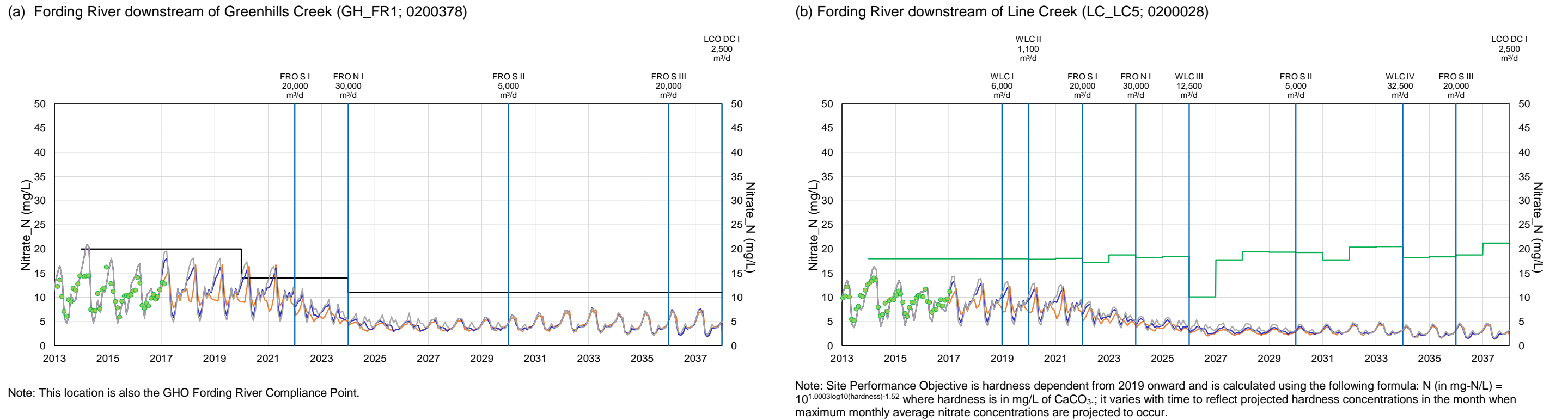
Table 2-3 Summary of Projected Monthly Average Sulphate Concentrations above Site Performance Objectives or Limits between 2019 and 2037 for the Planned Development Scenario

Location		Year	Month	Maximum Projected Concentration (mg/L)	Corresponding Site Performance Objective / Limit (mg/L)	Maximum Magnitude of Exceedance (mg/L)
Order Stations	Fording River downstream of Greenhills Creek (GH_FR1; 0200378) ^(a)	2028 to 2037	January to April	550	429	121
	Fording River downstream of Line Creek (LC_LC5; 0200028)	2034 to 2037	February to March	477	429	48
Compliance Points	FRO Compliance Point (FR_FRCP1; E300071)	2037	February to March	681	650	31
	Fording River above Chauncey Creek (FR_FRABCH)	2037	February to March	632	605	27
	LCO Compliance Point (LC_LCDSSLCC; E297110)	2026 to 2037	February to March	487	429	58

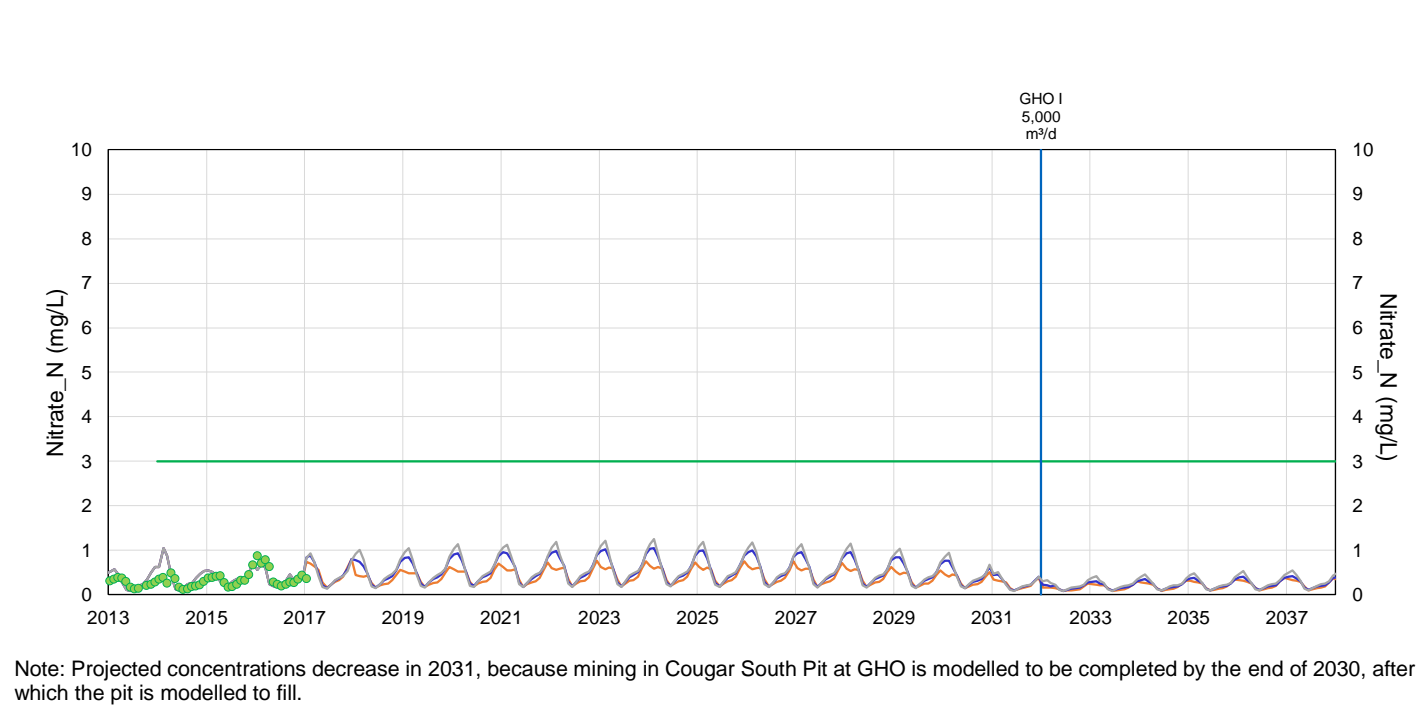
^(a) This location is also the GHO Fording River Compliance Point.

LCO = Line Creek Operations; FRO = Fording River Operations, GHO = Greenhills Operations.

Figure 2-1 Projected Monthly Average Concentrations of Nitrate at Order Stations between 2013 and 2037 for the Planned Development Scenario



(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)



(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)

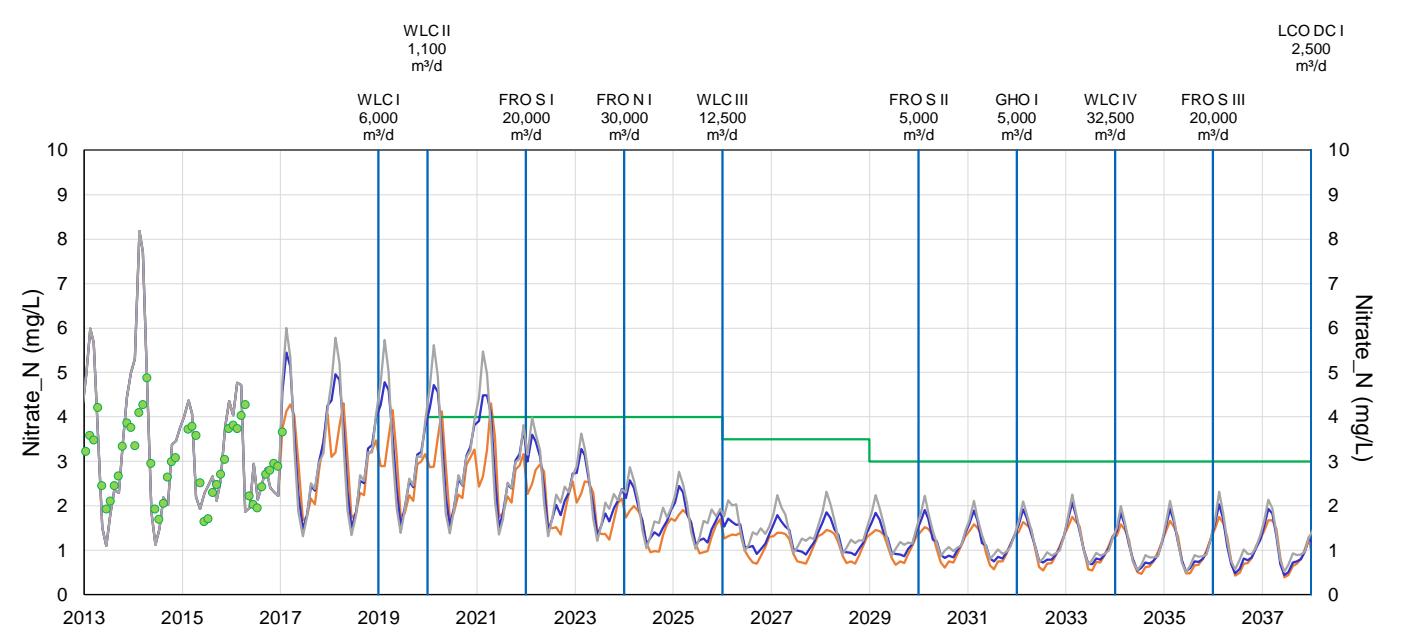
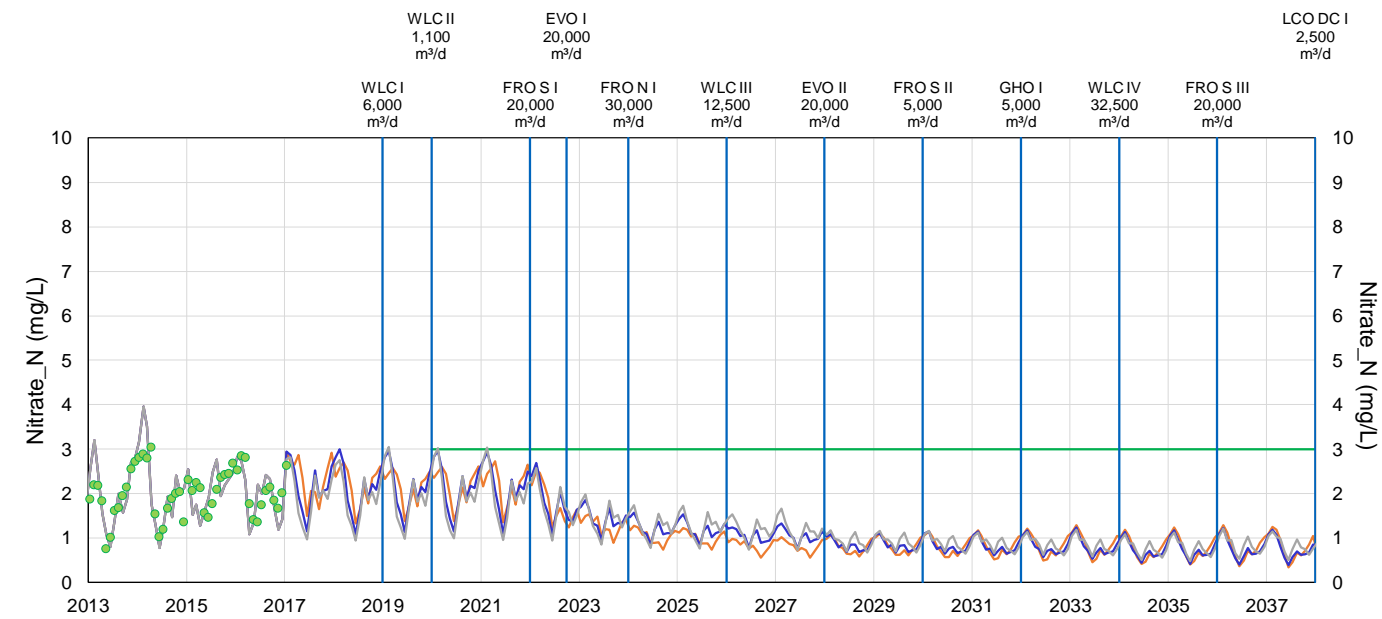
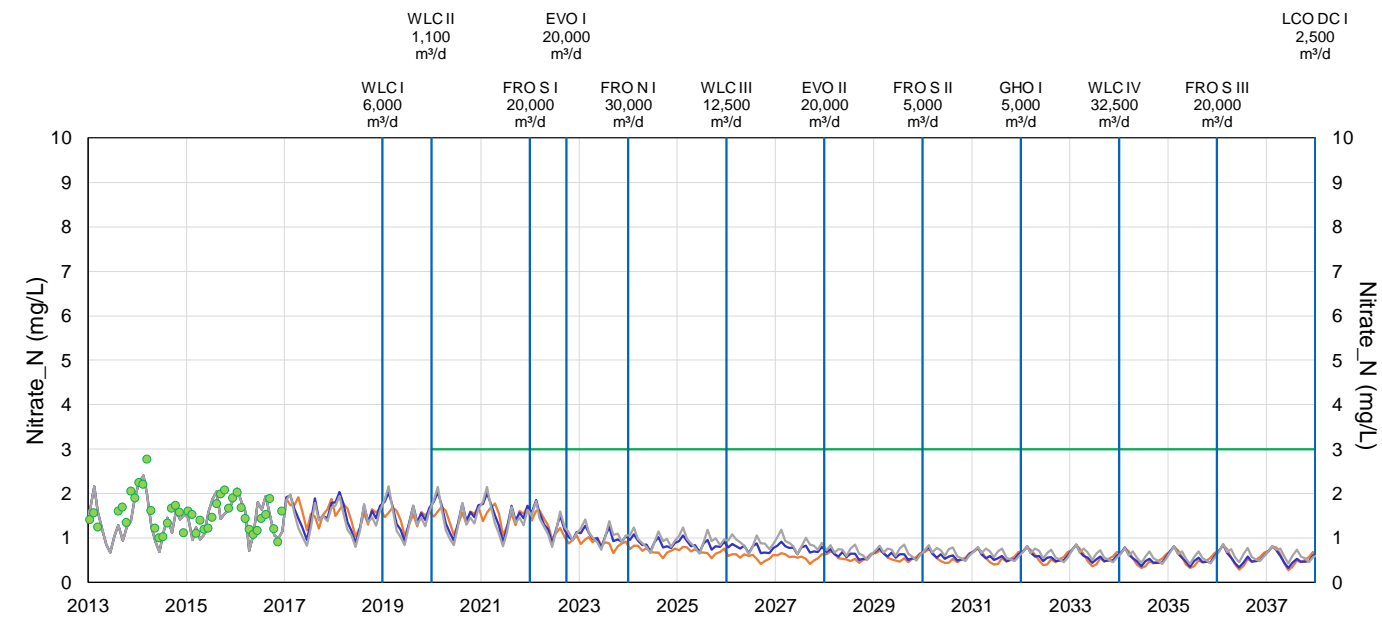


Figure 2-1 Projected Monthly Average Concentrations of Nitrate at Order Stations between 2013 and 2037 for the Planned Development Scenario (Continued)

(e) Elk River downstream of Michel Creek (EV_ER1; 0200393)



(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)

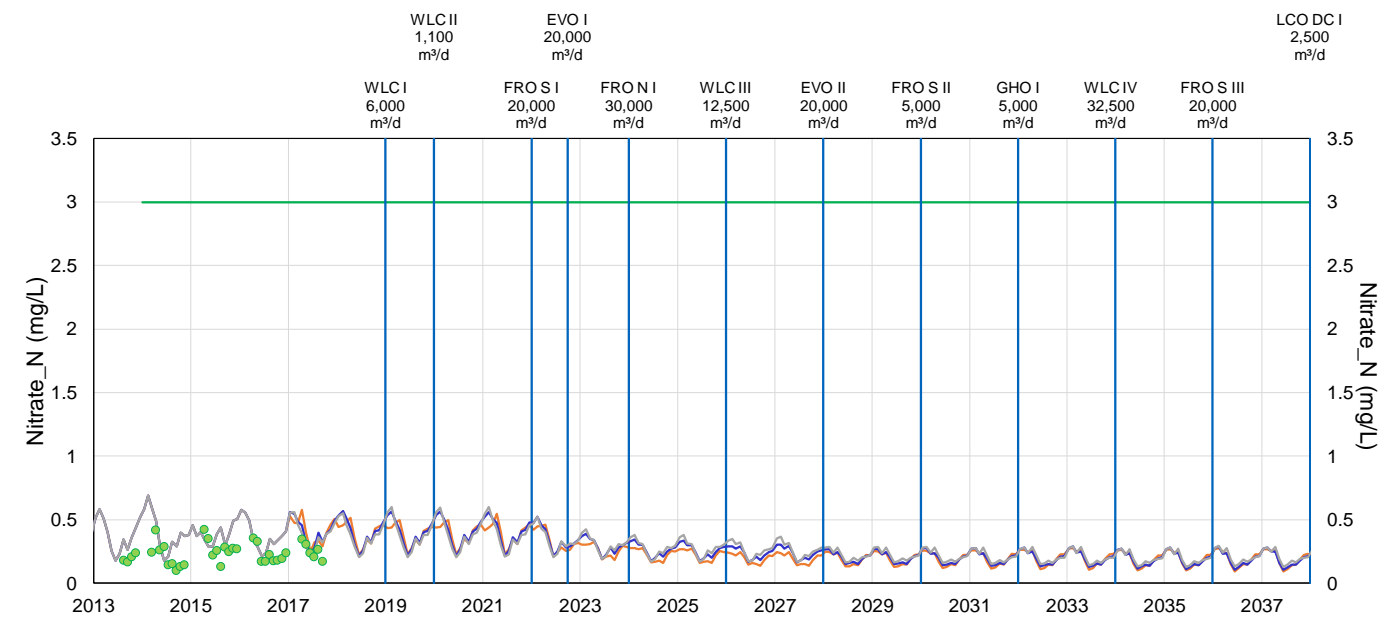
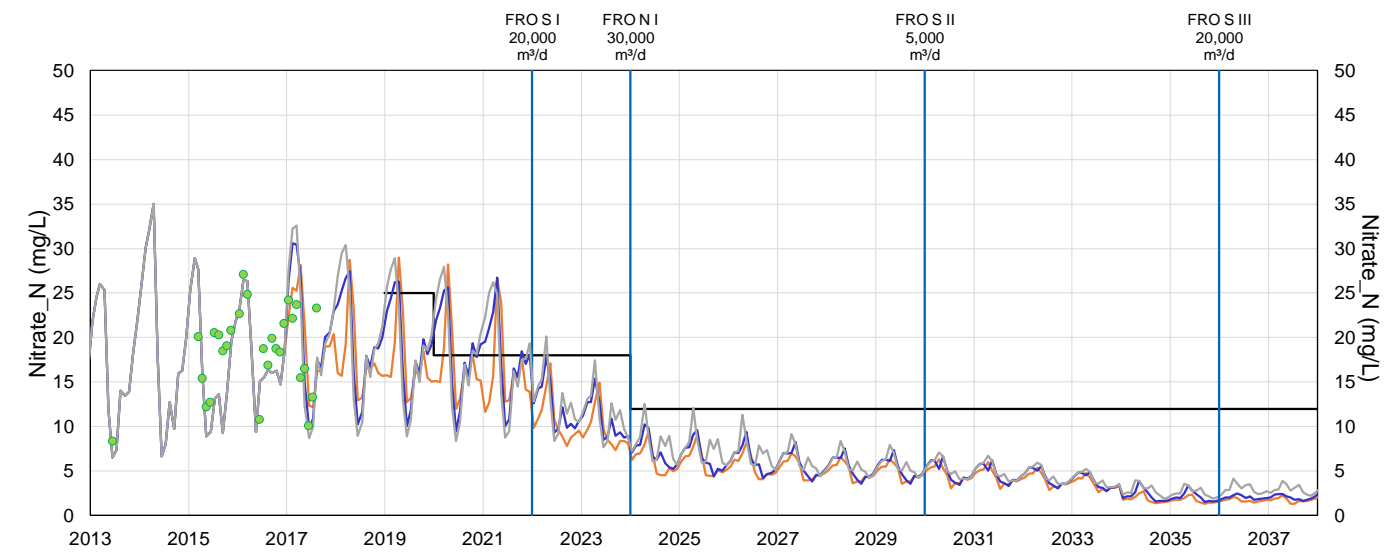
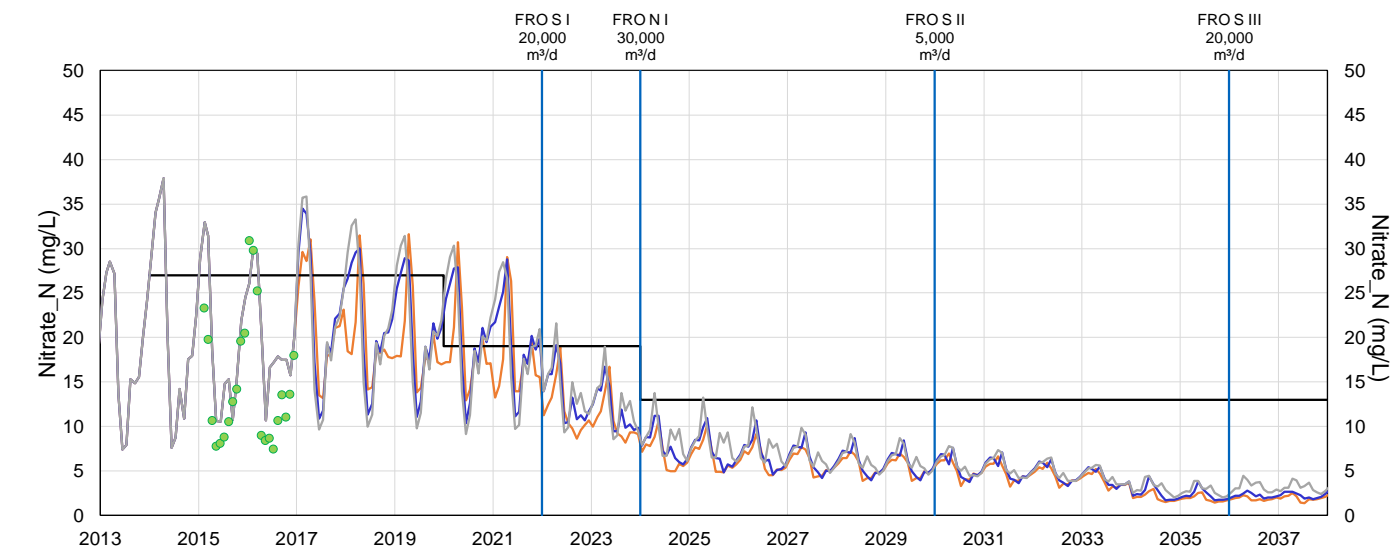


Figure 2-2 Projected Monthly Average Concentrations of Nitrate at Compliance Points between 2013 and 2037 for the Planned Development Scenario

(a) FRO Compliance Point (FR_FRCP1; E300071)

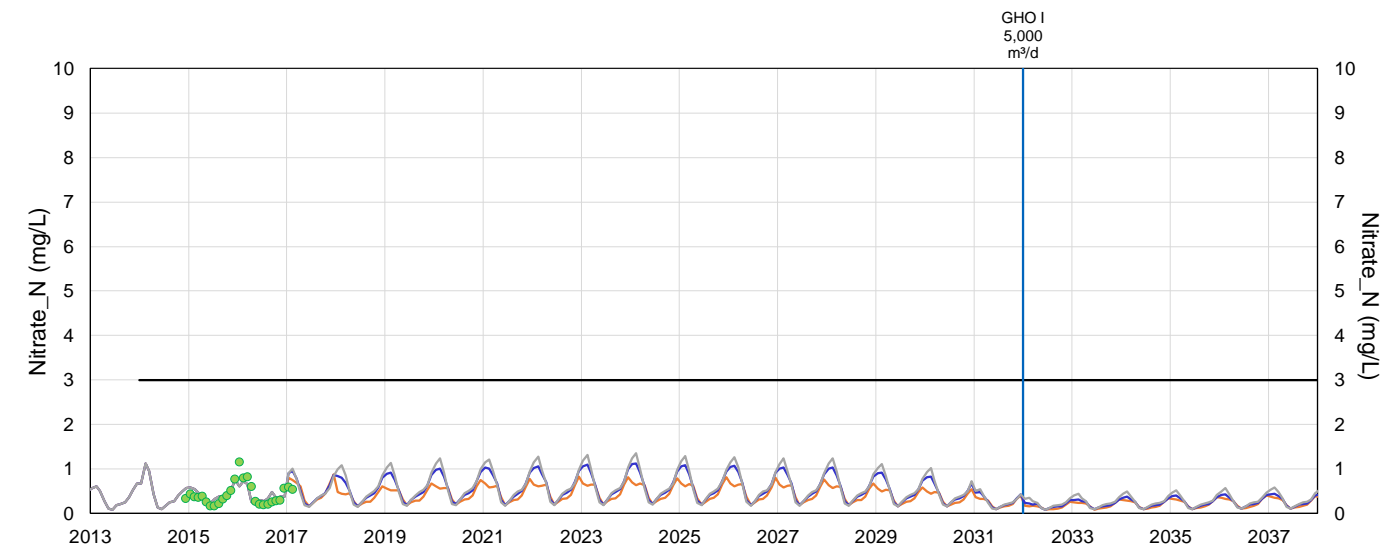
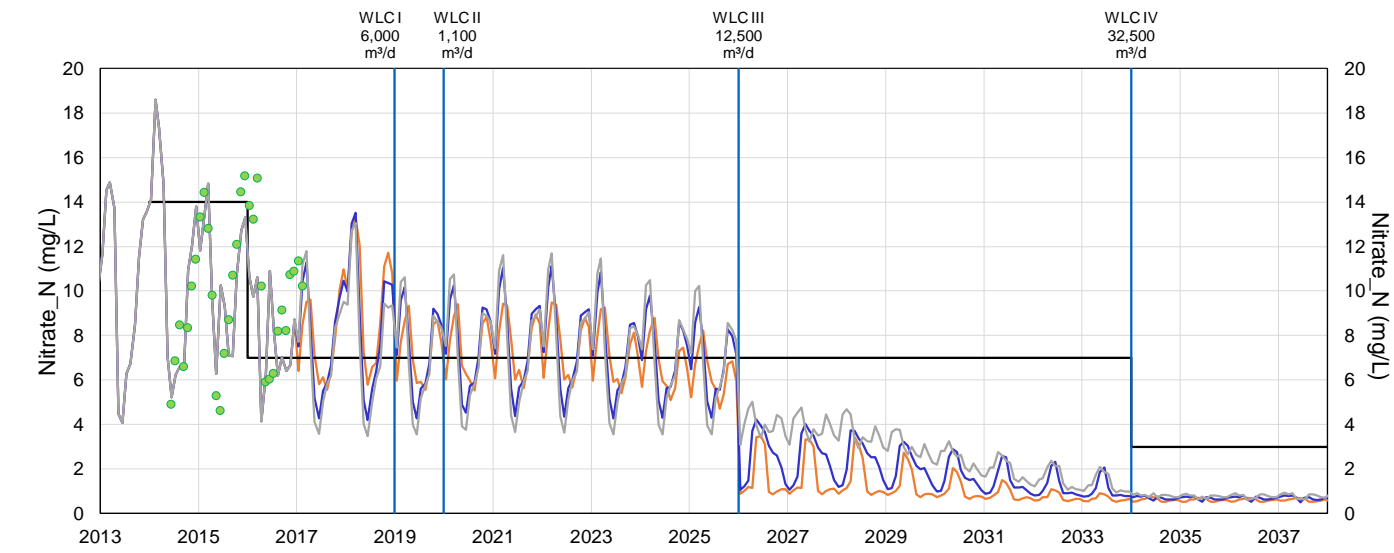
(b) Fording River above Chauncey Creek (FR_FRABCH)



Note: Projected concentrations are presented at Fording River above Chauncey Creek (FR_FRABCH), because it is the location proposed for the new Fording River Operations Compliance Point.

(c) LCO Compliance Point (LC_LCDSSLCC; E297110)

(d) GHO Elk River Compliance Point (GH_ERC; E300090)

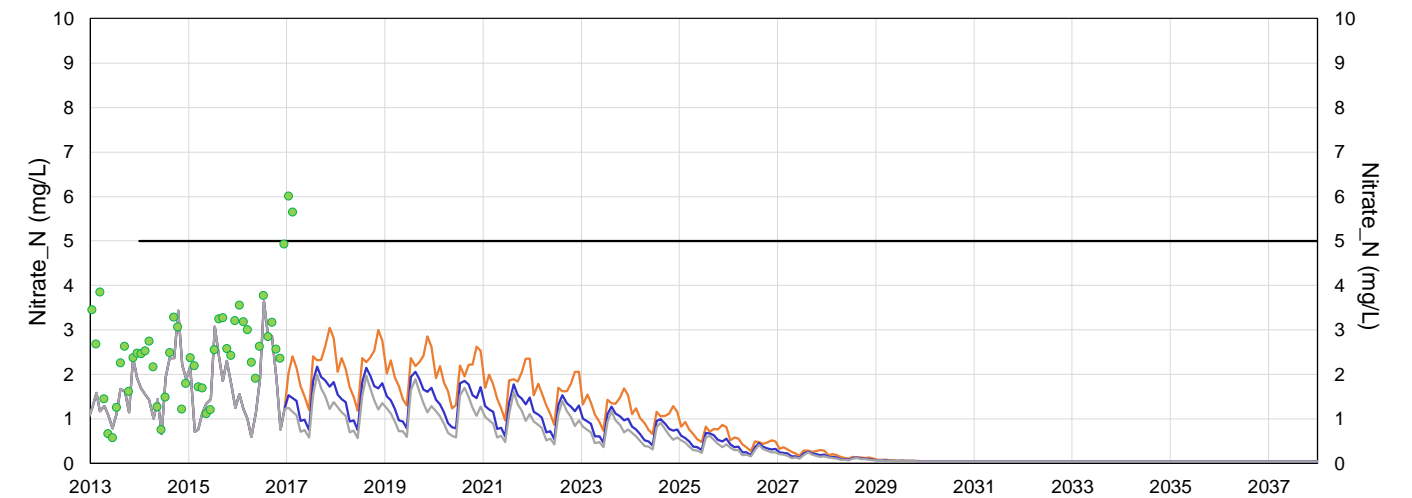
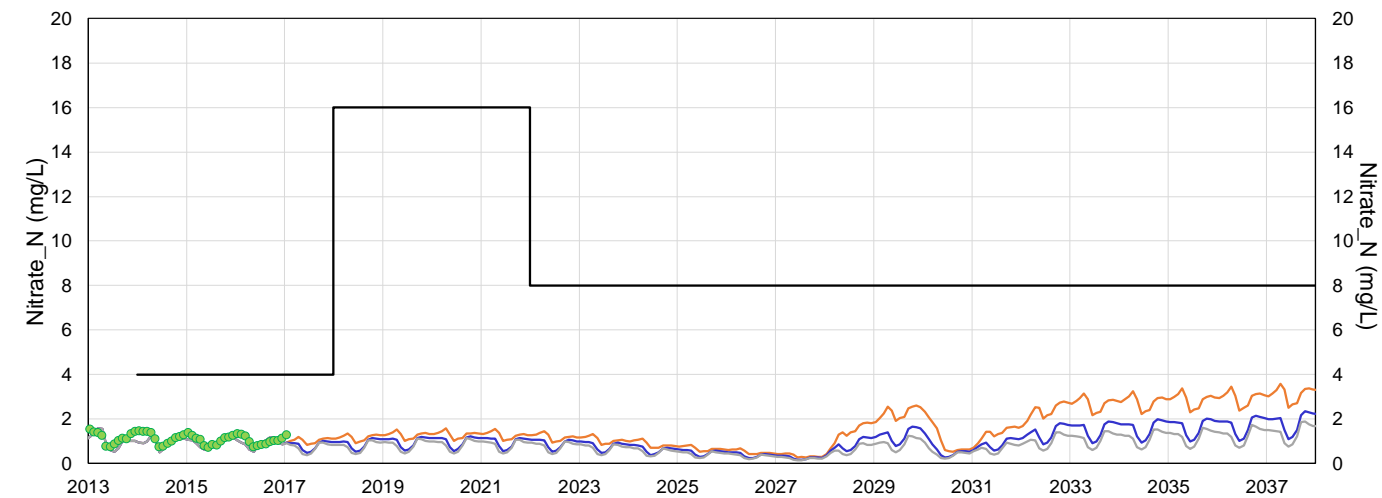


Note: Projected concentrations decrease in 2031, because mining in Cougar South Pit at GHO is modelled to be completed by the end of 2030, after which the pit is modelled to fill.

Figure 2-2 Projected Monthly Average Concentrations of Nitrate at Compliance Points between 2013 and 2037 for the Planned Development Scenario (Continued)

(e) EVO Harmer Compliance Point (EV_HC1; E102682)

(f) CMO Compliance Point (CM_MC2; E258937)



Note: In January 2017, a non-compliance occurred at the CMO Compliance Point, CM_MC2. Pit dewatering activities in January were similar to other months (i.e., pumping rates and concentrations), but creek flows decreased which resulted in an exceedance of the nitrate permit limit. Pumping rates were immediately adjusted to bring nitrate concentrations back within the permit limit.

(g) EVO Michel Creek Compliance Point (EV_MC2; E300091)

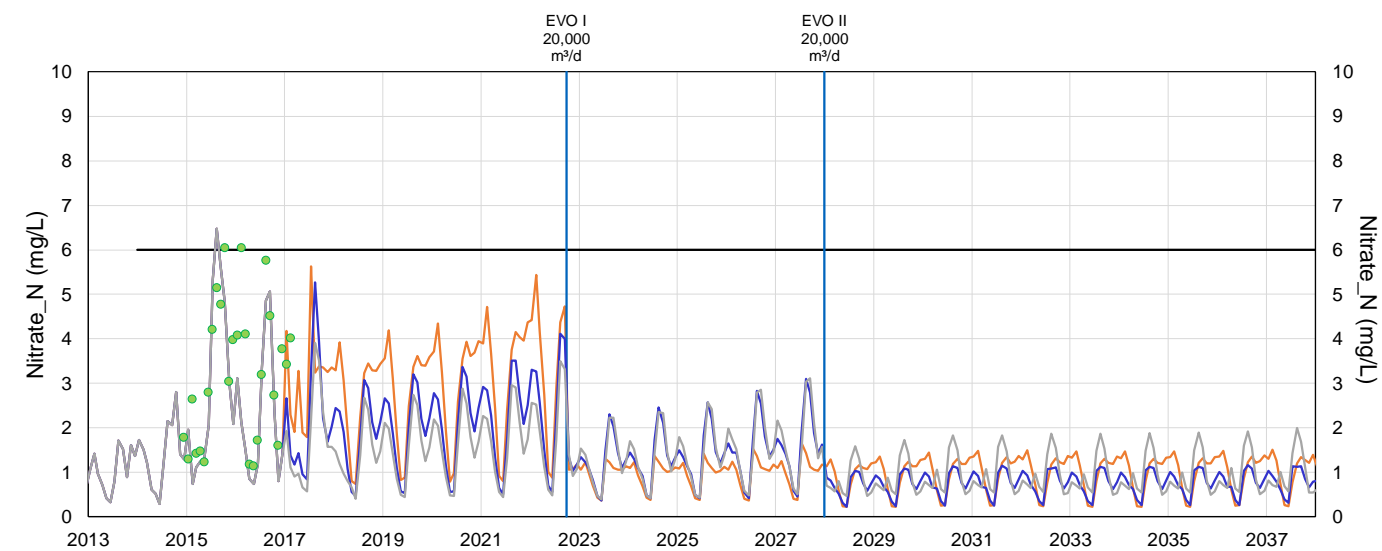
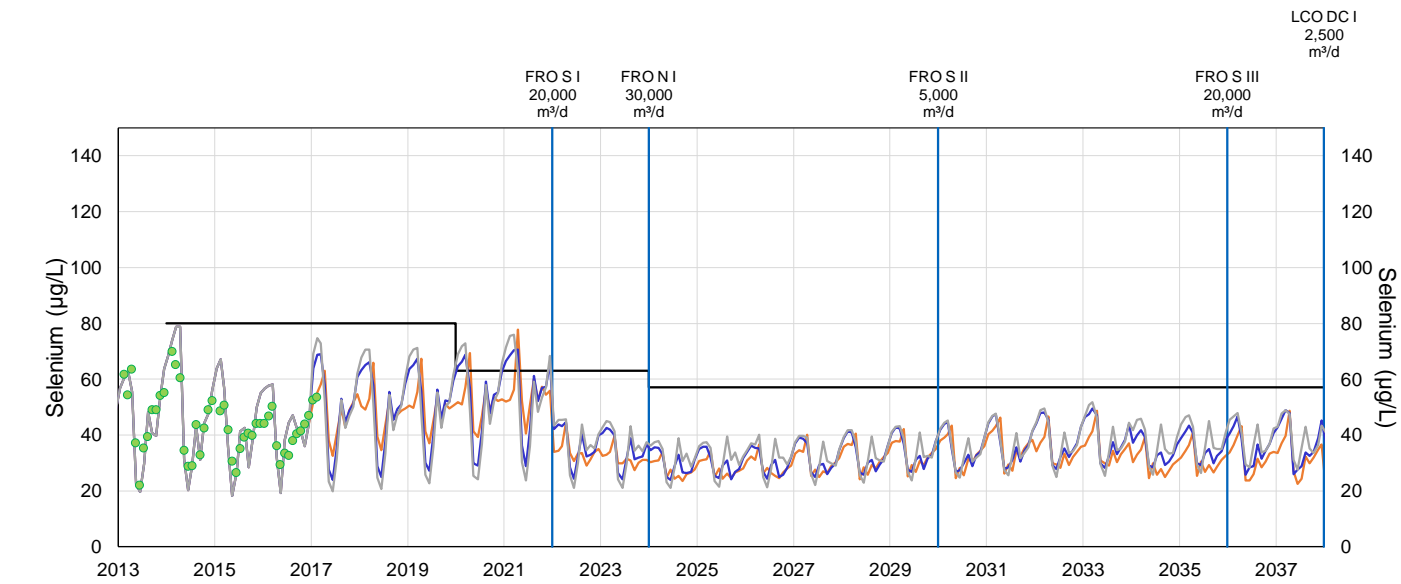


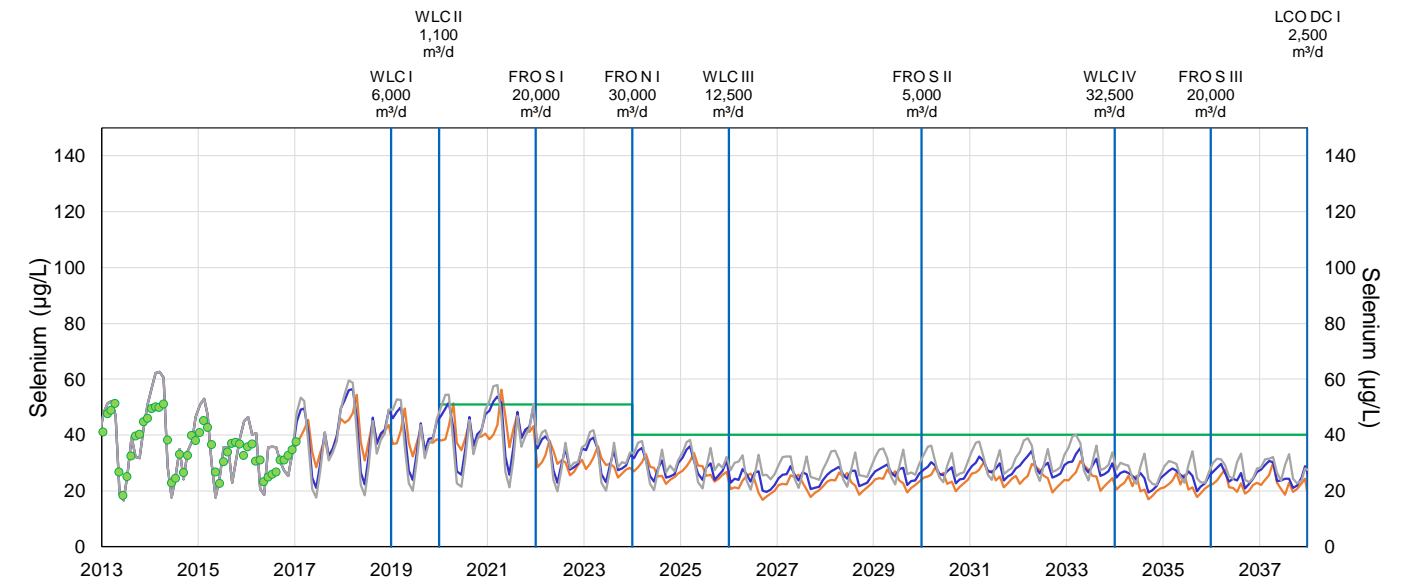
Figure 2-3 Projected Monthly Average Concentrations of Selenium at Order Stations between 2013 and 2037 for the Planned Development Scenario

(a) Fording River downstream of Greenhills Creek (GH_FR1; 0200378)

(b) Fording River downstream of Line Creek (LC_LC5; 0200028)



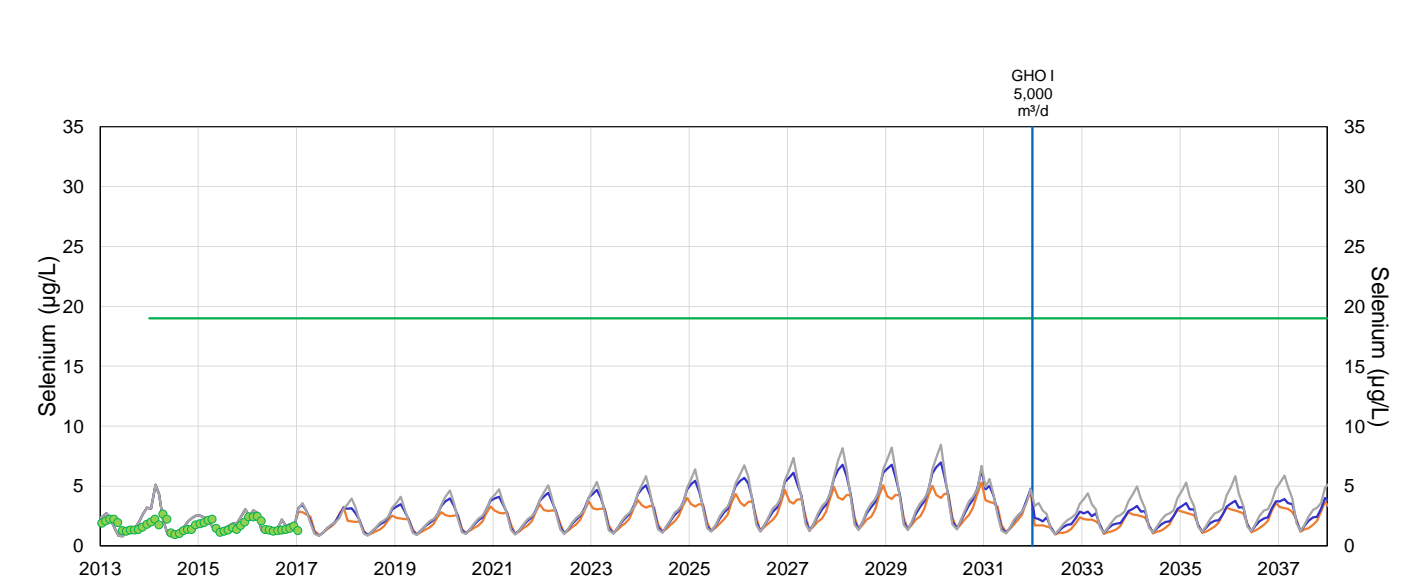
Note: This location is also the GHO Fording River Compliance Point.



Note: Projected concentrations under high flows (gray line) differ from those under low or average flows between 2026 and 2034, because the volume of mine-influenced water bypassing the treatment facilities is notably higher than in either of the other two flow scenarios. The higher rate of bypass results in less load removal and higher downstream concentrations.

(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)

(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)



Note: Projected concentrations decrease in 2031, because mining in Cougar South Pit at GHO is modelled to be completed by the end of 2030, after which the pit is modelled to fill.

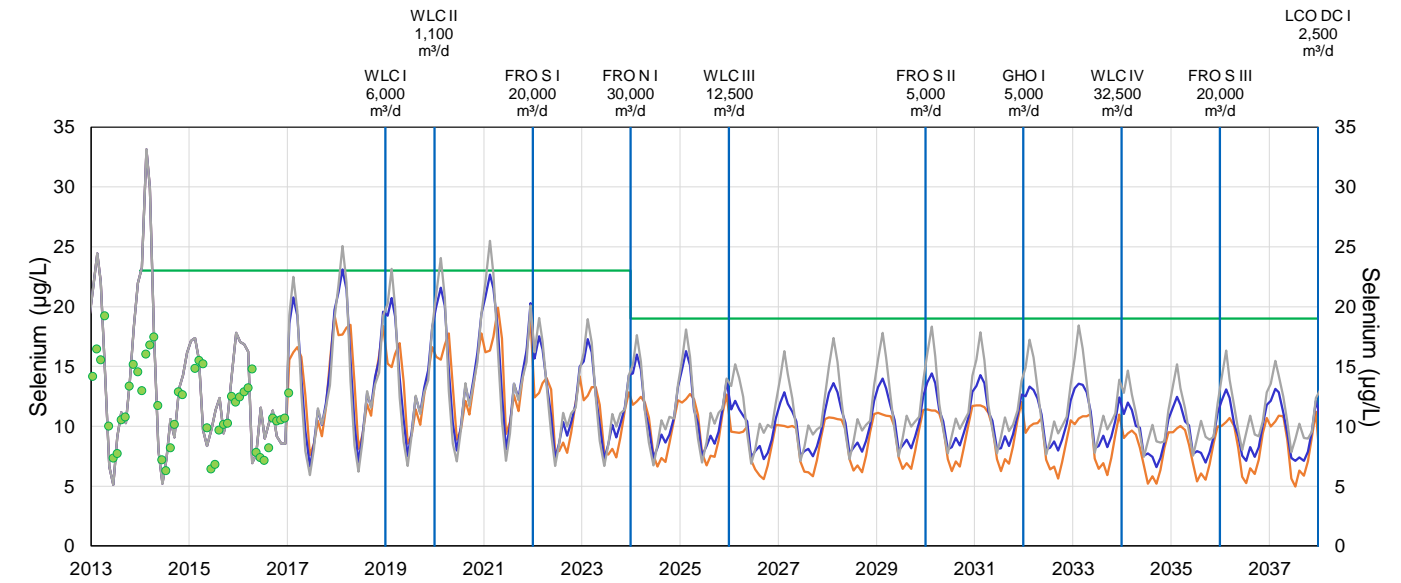
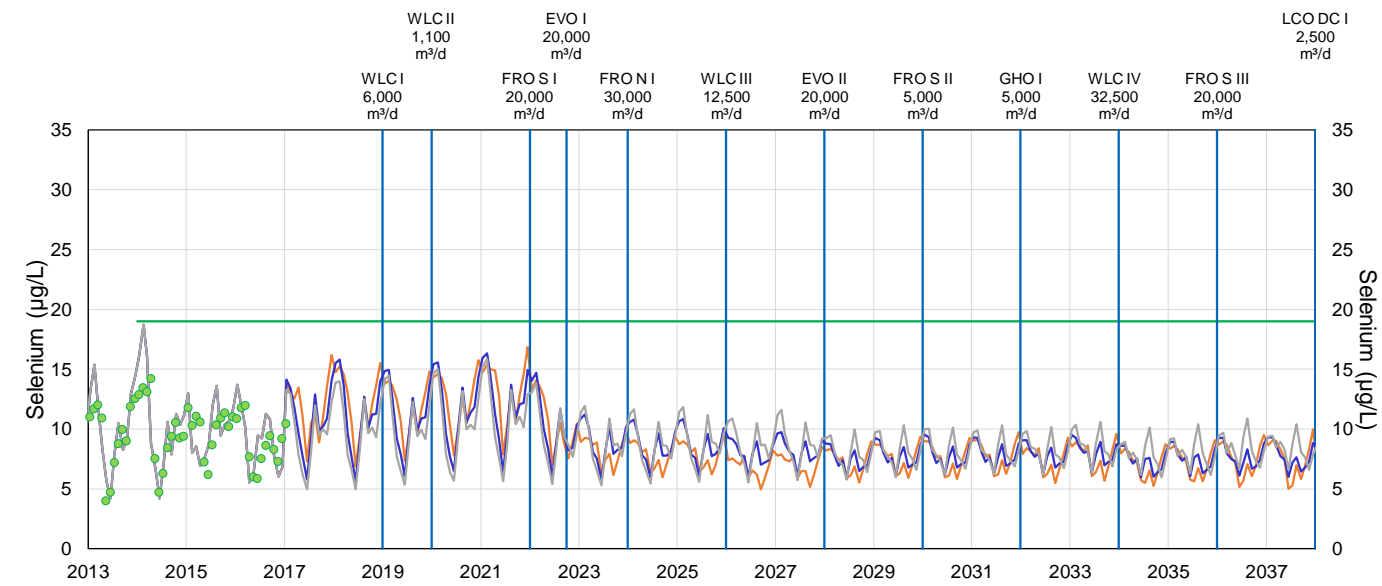
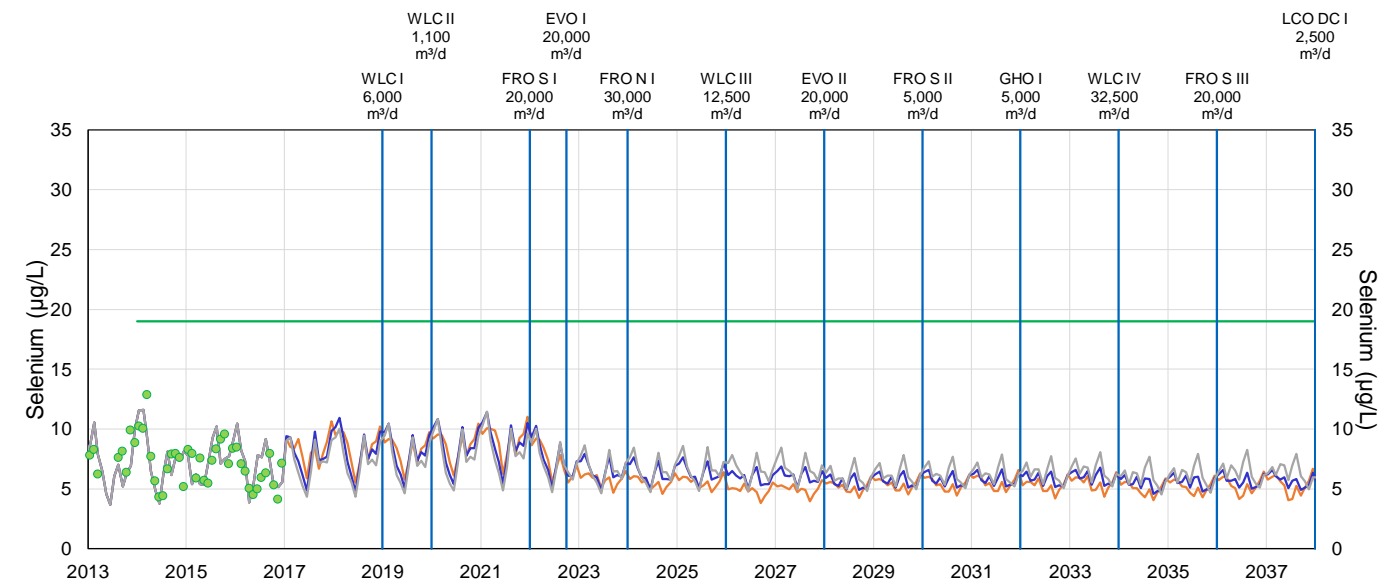


Figure 2-3 Projected Monthly Average Concentrations of Selenium at Order Stations between 2013 and 2037 for the Planned Development Scenario (Continued)

(e) Elk River downstream of Michel Creek (EV_ER1; 0200393)



(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)

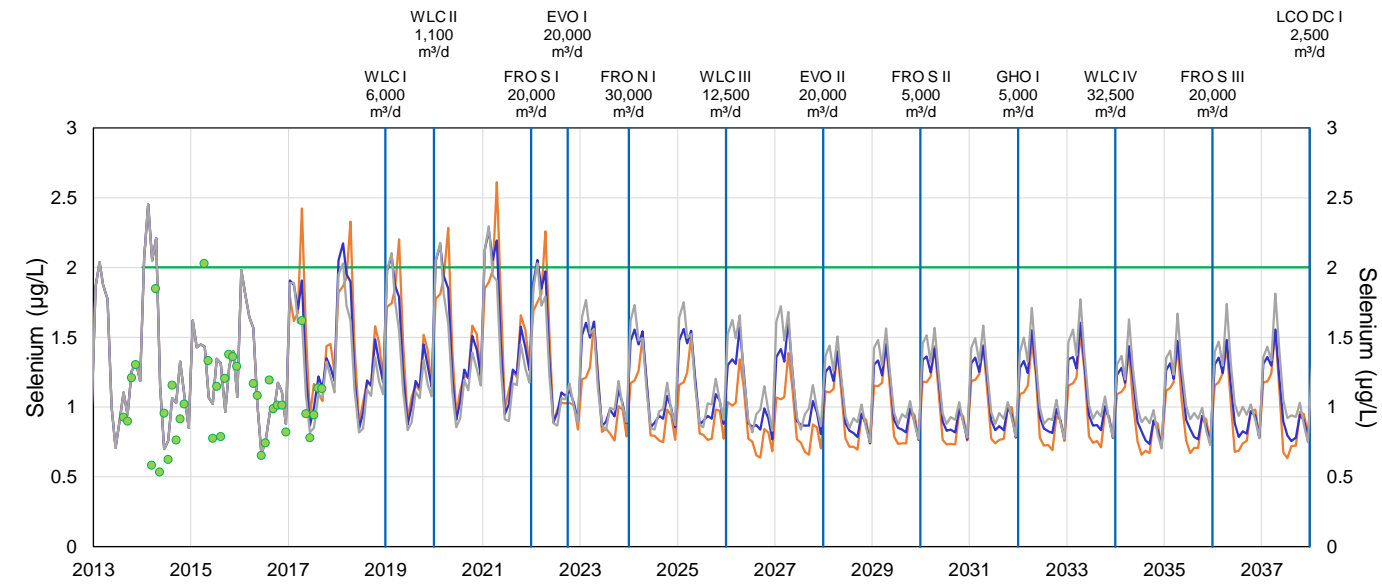
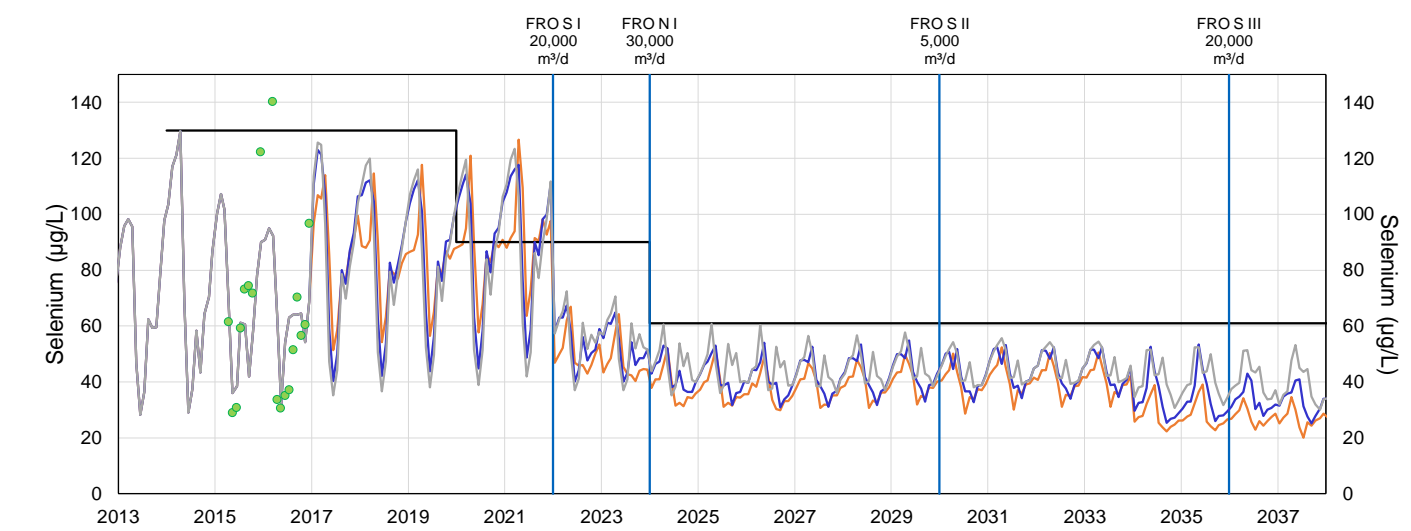
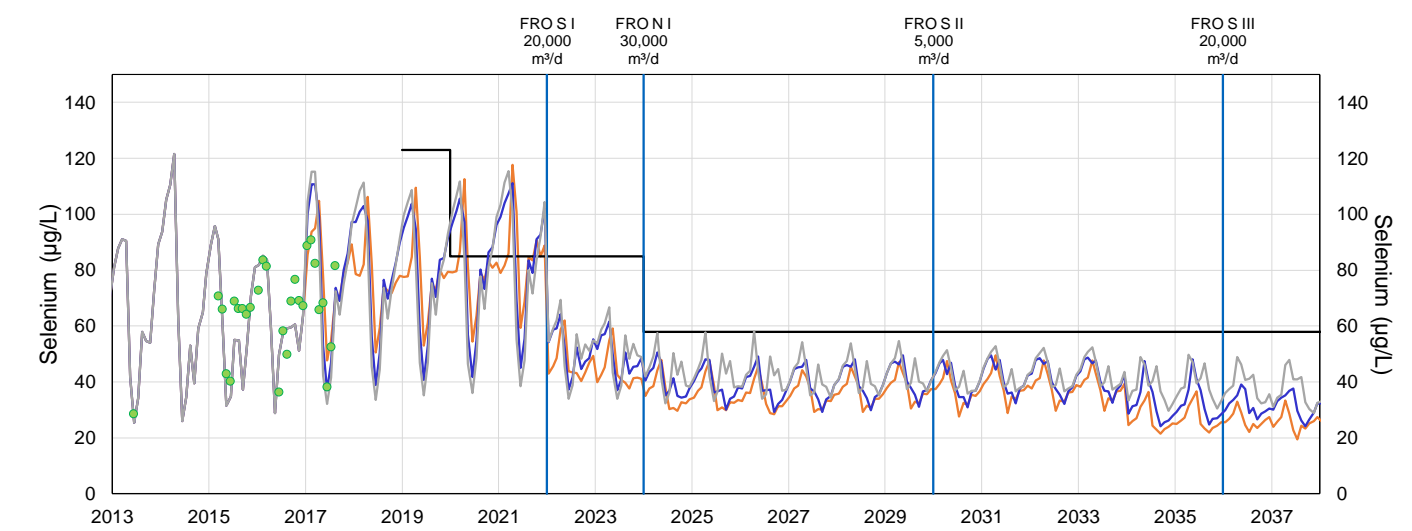


Figure 2-4 Projected Monthly Average Concentrations of Selenium at Compliance Points between 2013 and 2037 for the Planned Development Scenario
(a) FRO Compliance Point (FR_FRCP1; E300071) (b) Fording River above Chauncey Creek (FR_FRABCH)

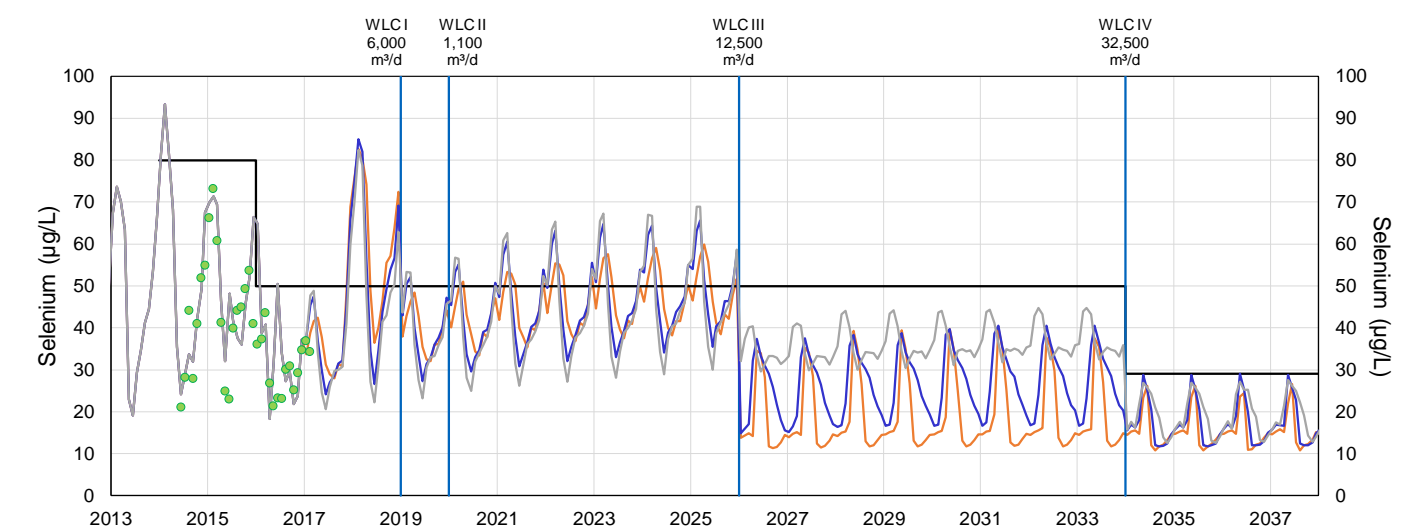


Note: At FR_FRCP1, monitored data are presented from January 2015 to December 2016. Five monitored data points are not presented on the plot, because including them on the plot would required an extension of the y-axis that would not allow the reader to easily compare the model projections to the Compliance Limit. The five monitored data points (i.e., monthly average monitored concentrations) that are not presented on the plot are: 310 µg/L in February 2015, 229 µg/L in March 2015, 164 µg/L in November 2015, 447 µg/L in January 2016 and 316 µg/L in February 2016. Model projections at FR_FRCP1 reflect fully mixed conditions, whereas monitoring data collected during low flow periods reflect primarily the quality of Cataract Creek water; hence, the difference between model projections and monitored concentrations during low flow periods.



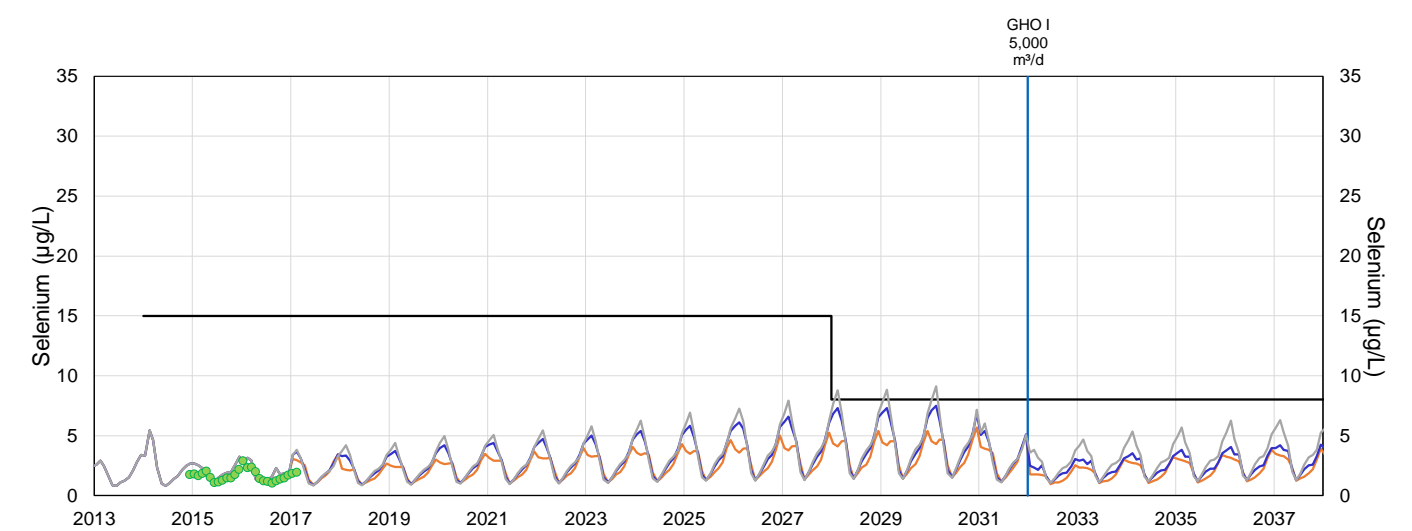
Note: Projected concentrations are presented at Fording River above Chauncey Creek (FR_FRABCH), because it is the location proposed for the new Fording River Operations Compliance Point.

(c) LCO Compliance Point (LC_LCDSSLCC; E297110)



Note: Projected concentrations under high flows (gray line) differ from those under low or average flows between 2026 and 2034, because the volume of mine-influenced water bypassing the WLC AWTF is notably higher than in either of the other two flow scenarios. The higher rate of bypass results in less load removal and higher downstream concentrations.

(d) GHO Elk River Compliance Point (GH_ERC; E300090)

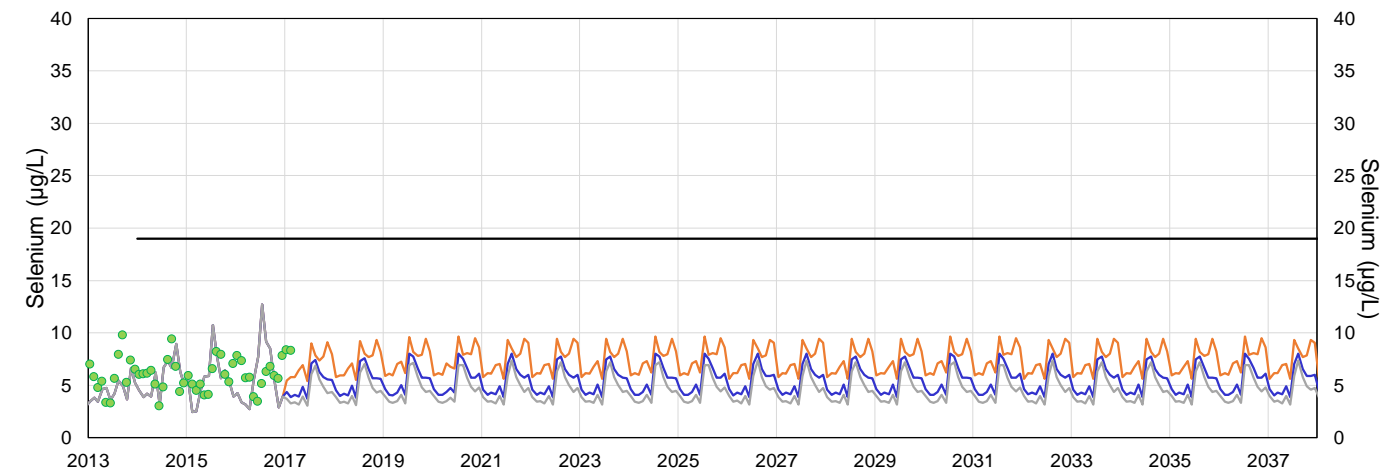
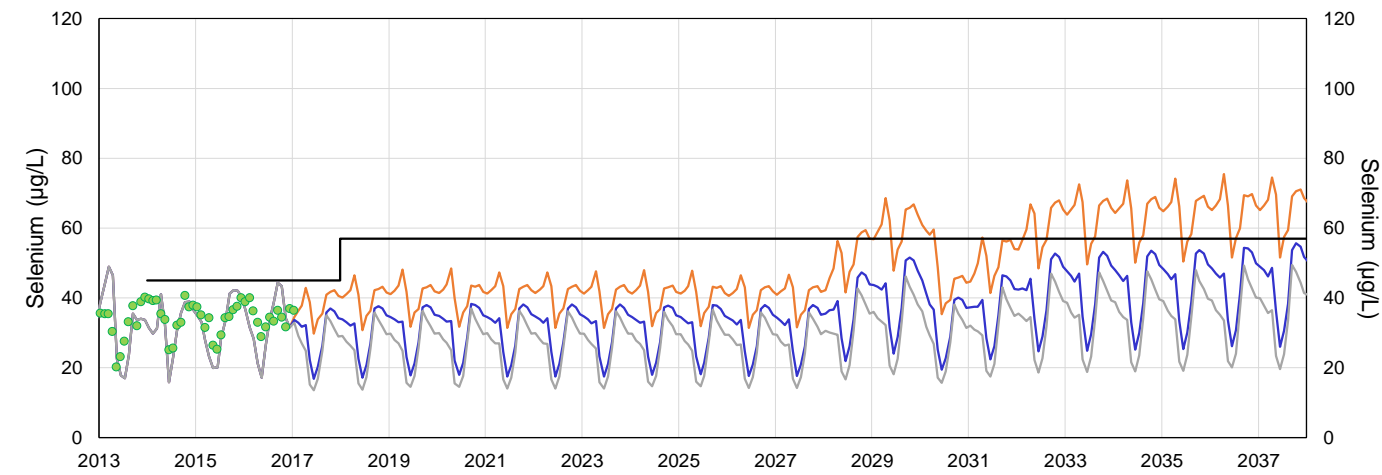


Note: Projected concentrations decrease in 2031, because mining in Cougar South Pit at GHO is modelled to be completed by the end of 2030, after which the pit is modelled to fill.

Figure 2-4 Projected Monthly Average Concentrations of Selenium at Compliance Points between 2013 and 2037 for the Planned Development Scenario (Continued)

(e) EVO Harmer Compliance Point (EV_HC1; E102682)

(f) CMO Compliance Point (CM_MC2; E258937)



(g) EVO Michel Creek Compliance Point (EV_MC2; E300091)

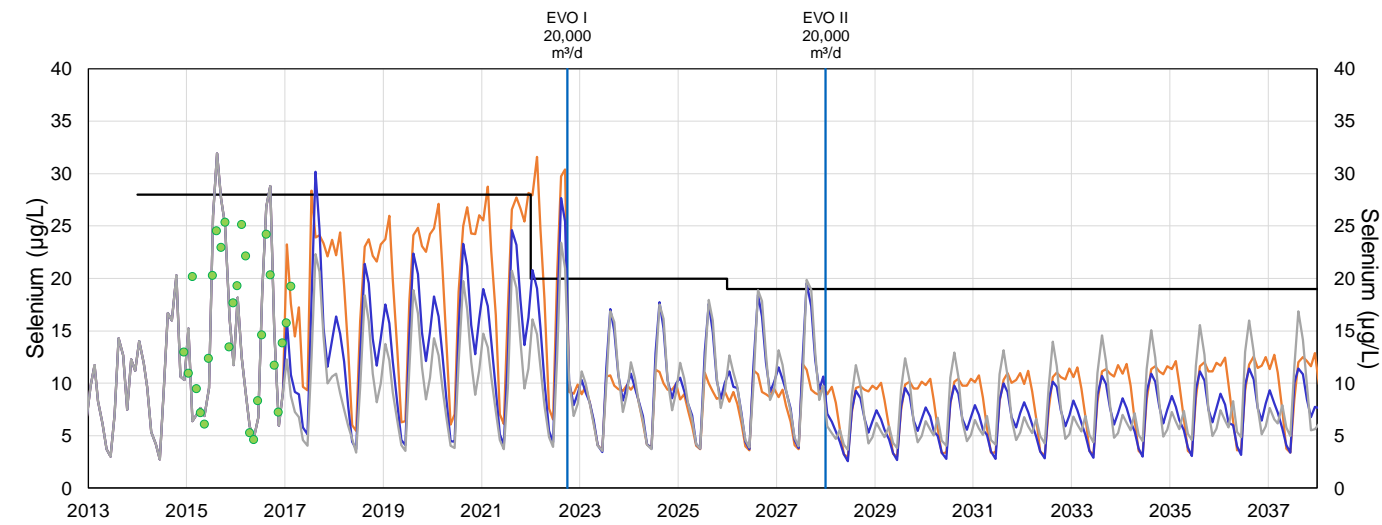
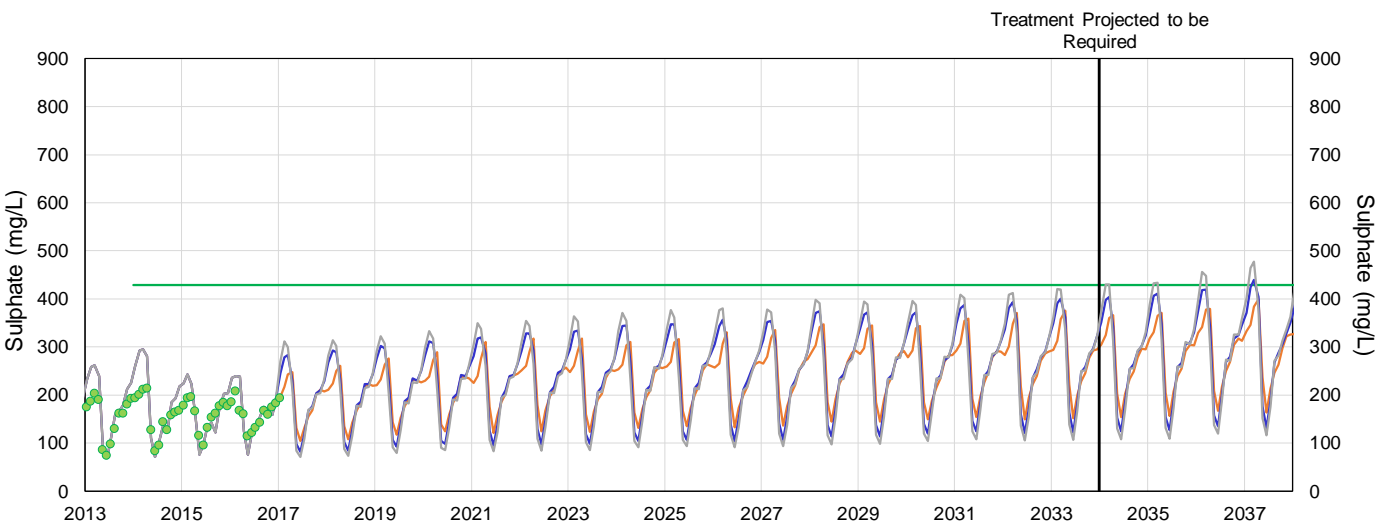
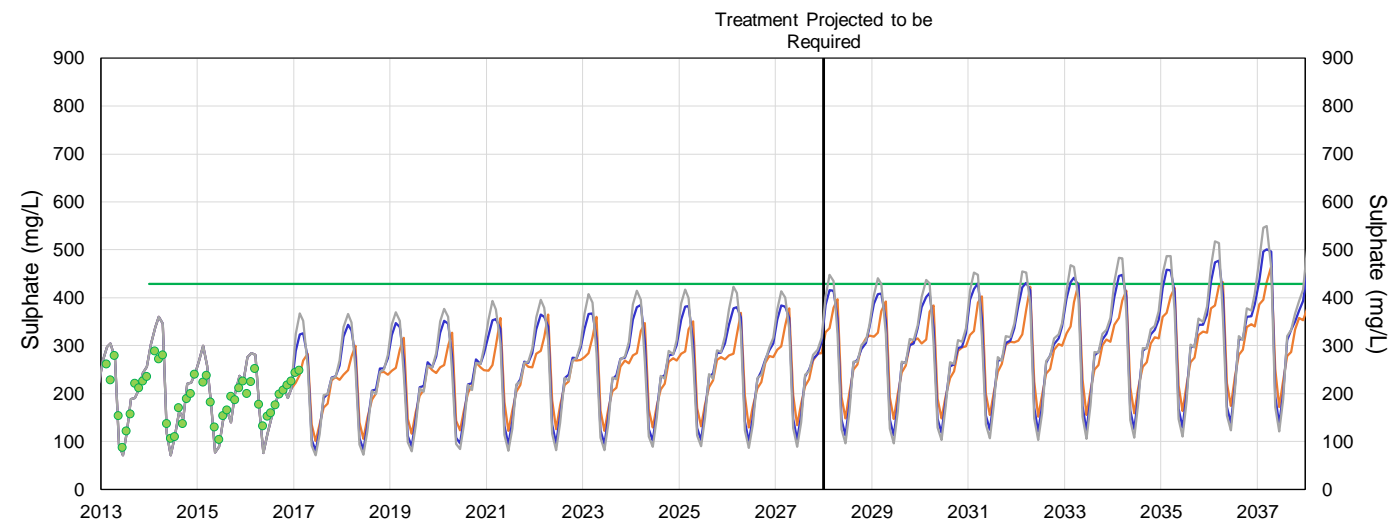
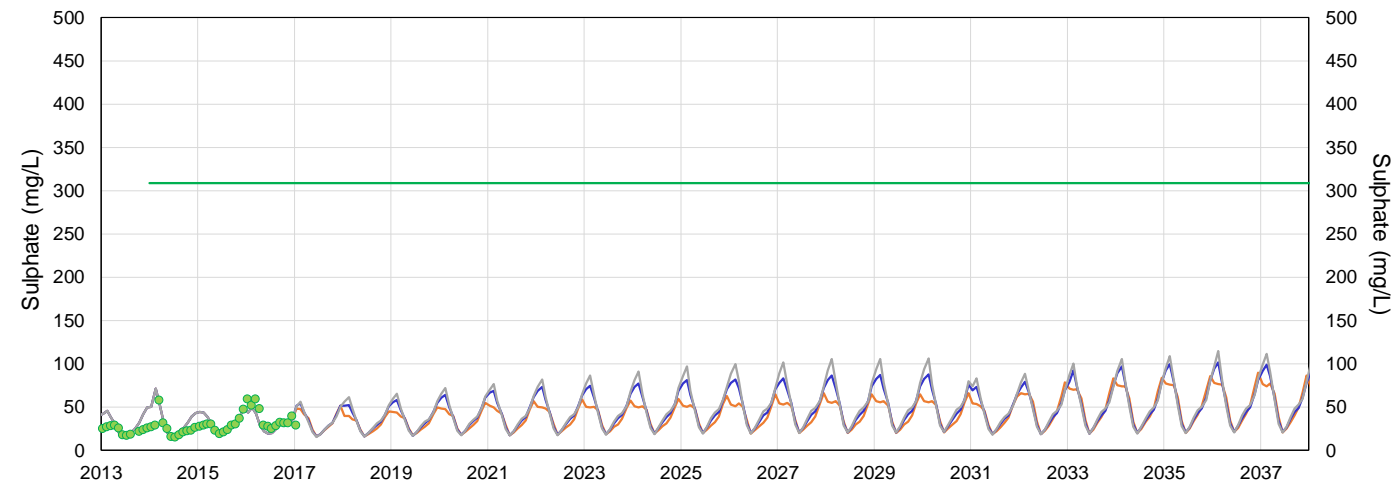


Figure 2-5 Projected Monthly Average Concentrations of Sulphate at Order Stations between 2013 and 2037 for the Planned Development Scenario
(a) Fording River downstream of Greenhills Creek (GH_FR1; 0200378) (b) Fording River downstream of Line Creek (LC_LC5; 0200028)

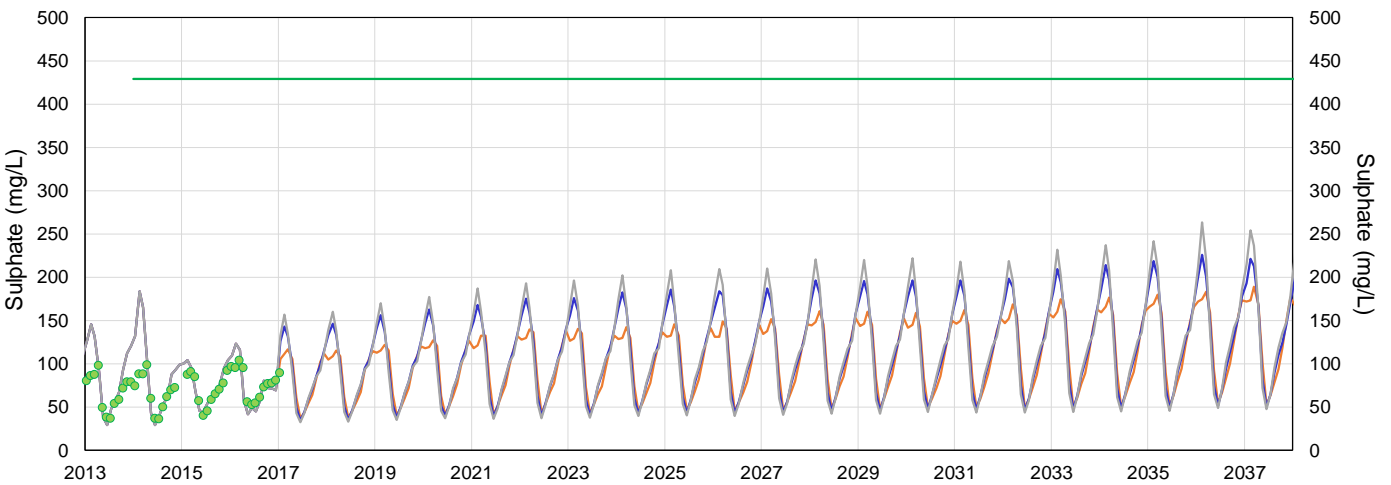


Note: This location is also the GHO Fording River Compliance Point.

(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)

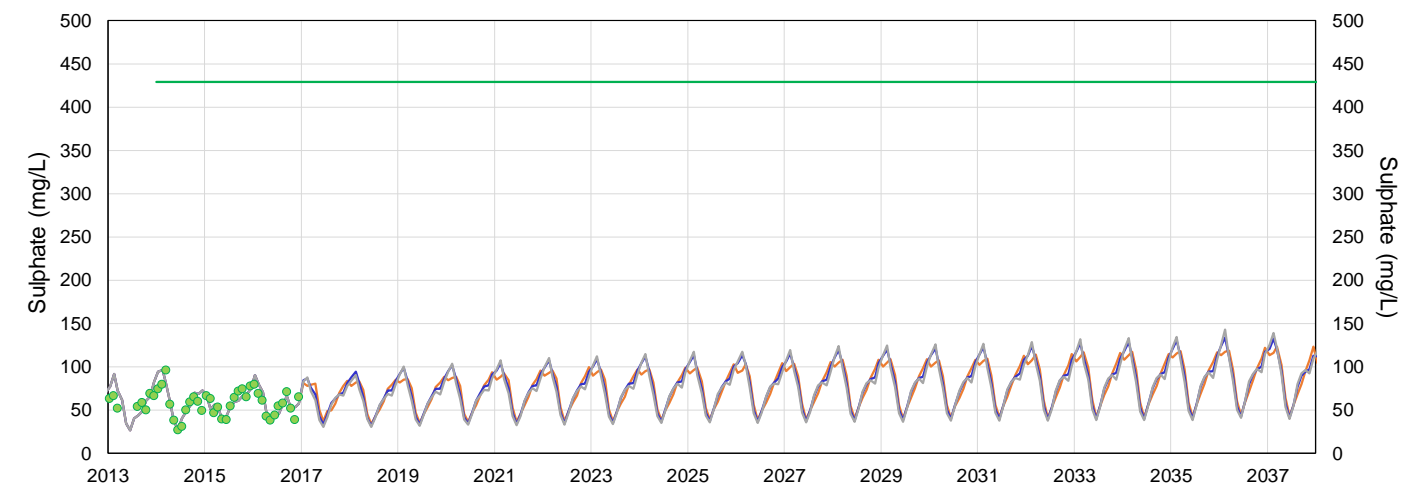
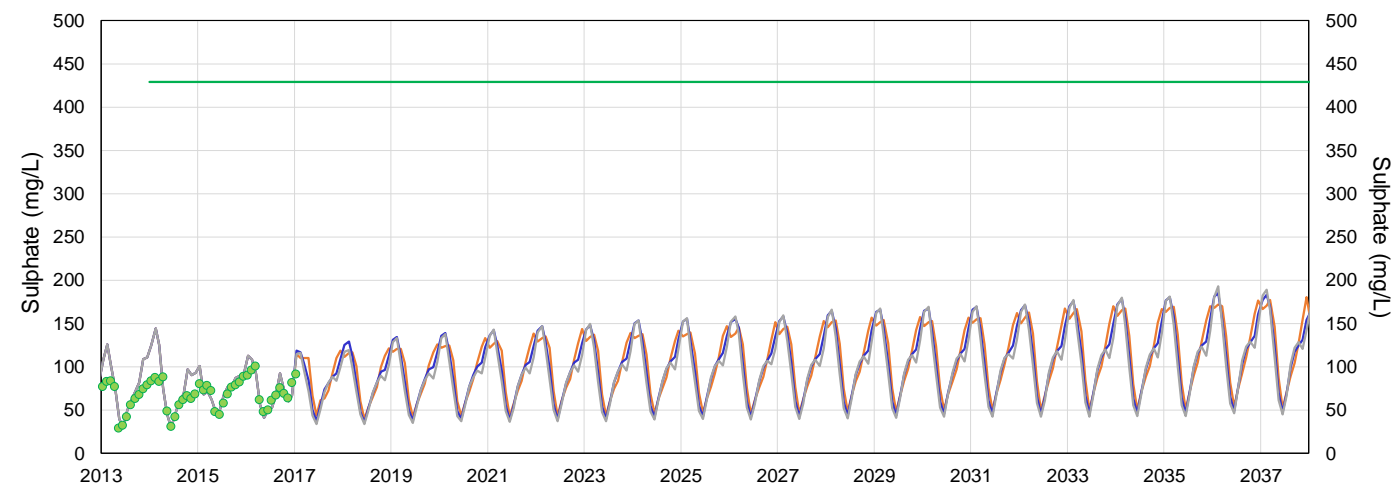


(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)



Note: Projected concentrations decrease in 2031, because mining in Cougar South Pit at GHO is modelled to be completed by the end of 2030, after which the pit is modelled to fill.

Figure 2-5 Projected Monthly Average Concentrations of Sulphate at Order Stations between 2013 and 2037 for the Planned Development Scenario (Continued)
(e) Elk River downstream of Michel Creek (EV_ER1; 0200393) (f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)

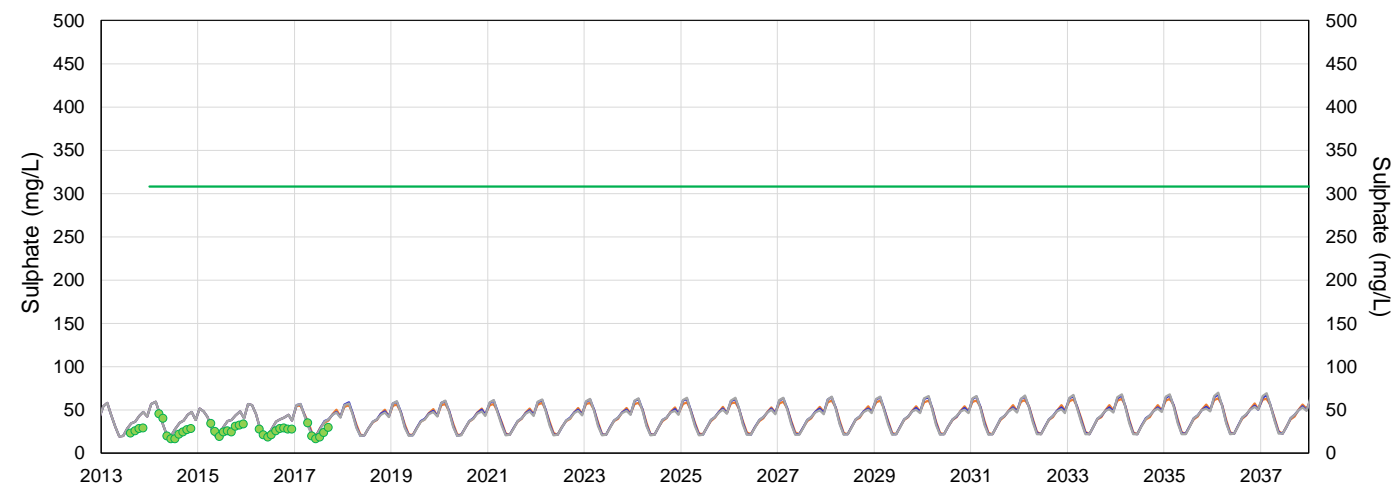
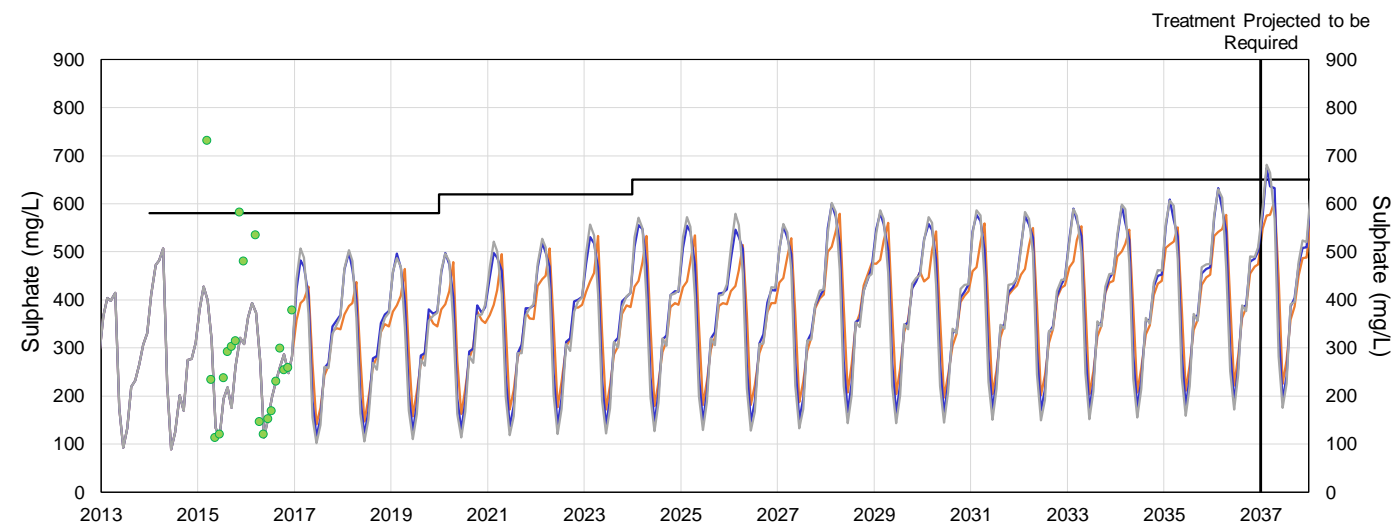
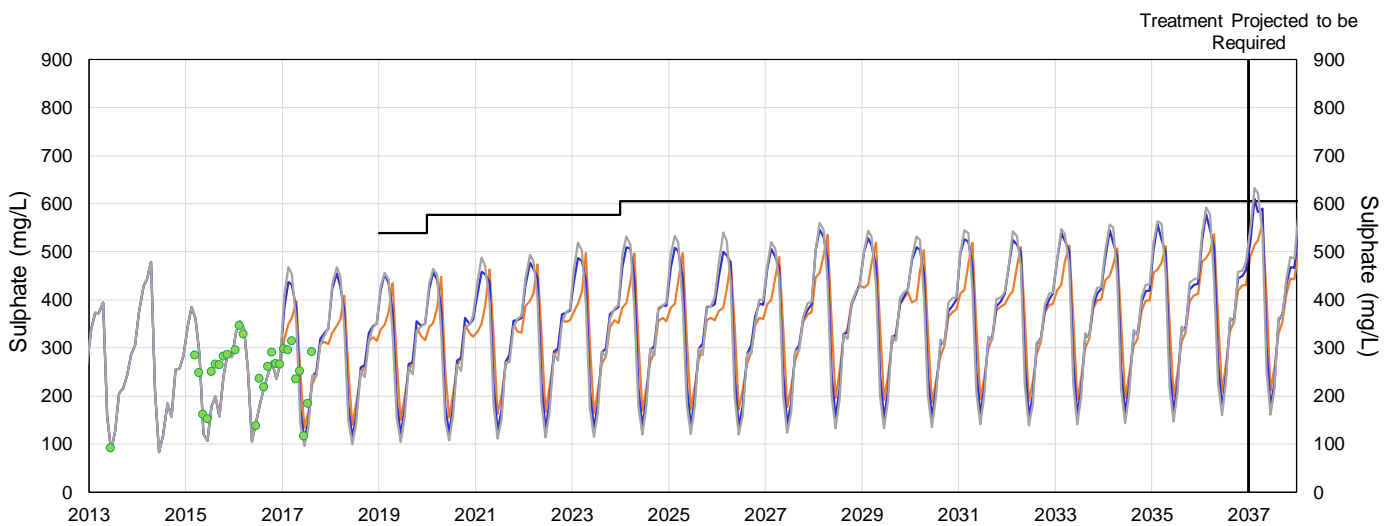


Figure 2-6 Projected Monthly Average Concentrations of Sulphate at Compliance Points between 2013 and 2037 for the Planned Development Scenario
(a) FRO Compliance Point (FR_FRCP1; E300071) (b) Fording River above Chauncey Creek (FR_FRABCH)

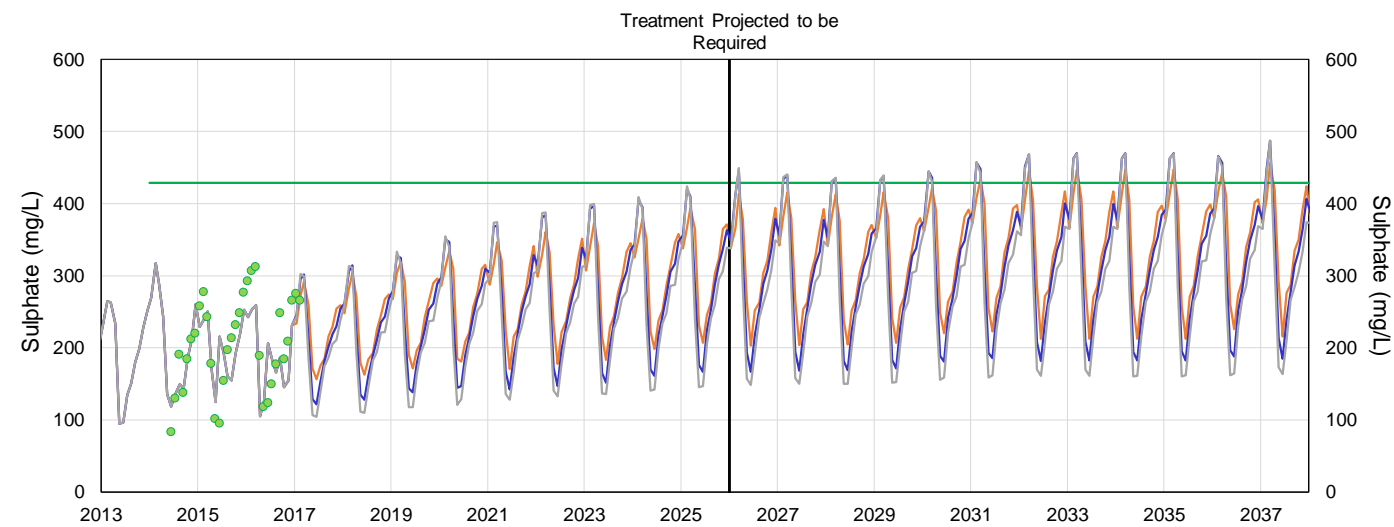


Note: At FR_FRCP1, monitored data are presented from January 2015 to December 2016. Three monitored data points are not presented on the plot, because including them on the plot would required an extension of the y-axis that would not allow the reader to easily compare the model projections to the Compliance Limit. The three monitored data points (i.e., monthly average monitored concentrations) that are not presented on the plot are: 983 mg/L in February 2015, 1,500 mg/L in January 2016 and 1,160 mg/L in February 2016. Model projections at FR_FRCP1 reflect fully mixed conditions, whereas monitoring data collected during low flow periods reflect primarily the quality of Cataract Creek water; hence, the difference between model projections and monitored concentrations during low flow periods.

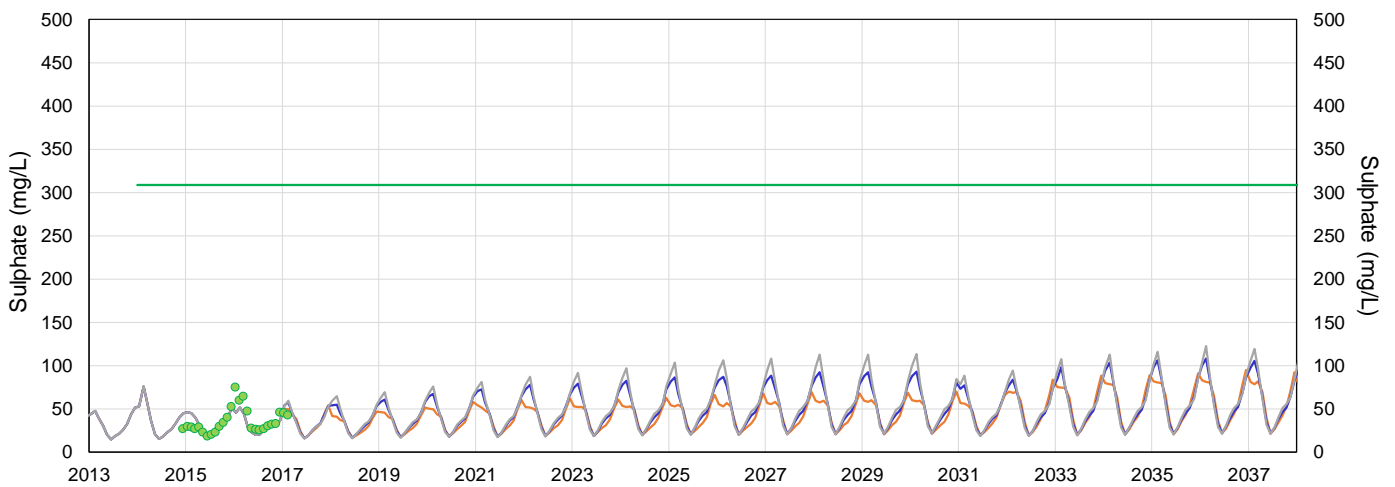


Note: Projected concentrations are presented at Fording River above Chauncey Creek (FR_FRABCH), because it is the location proposed for the new Fording River Operations Compliance Point.

(c) LCO Compliance Point (LC_LCDSSLCC; E297110)



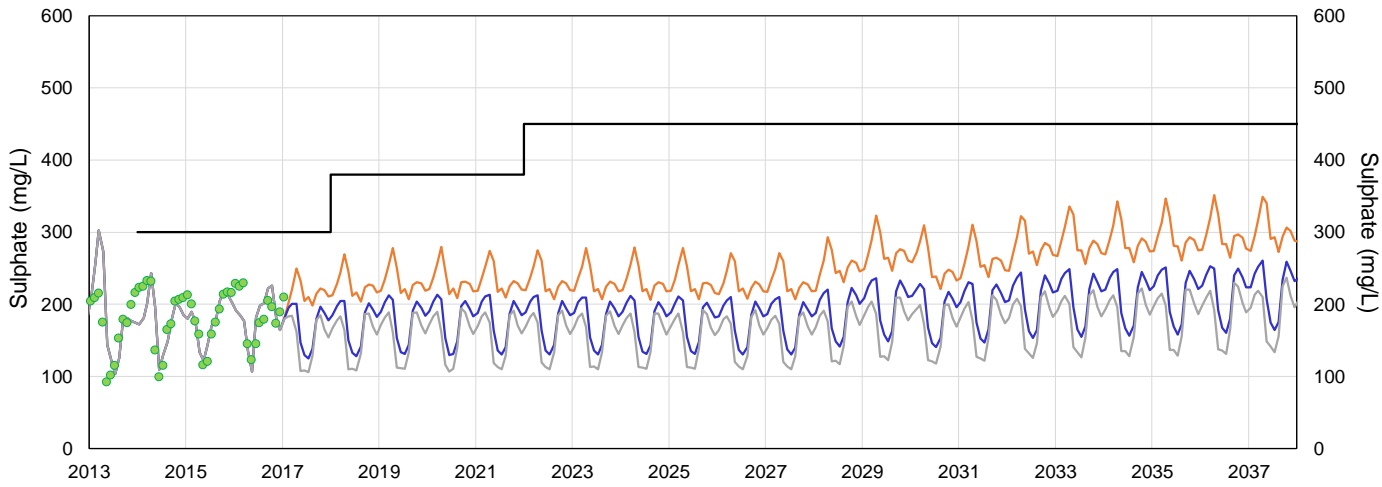
(d) GHO Elk River Compliance Point (GH_ERC; E300090)



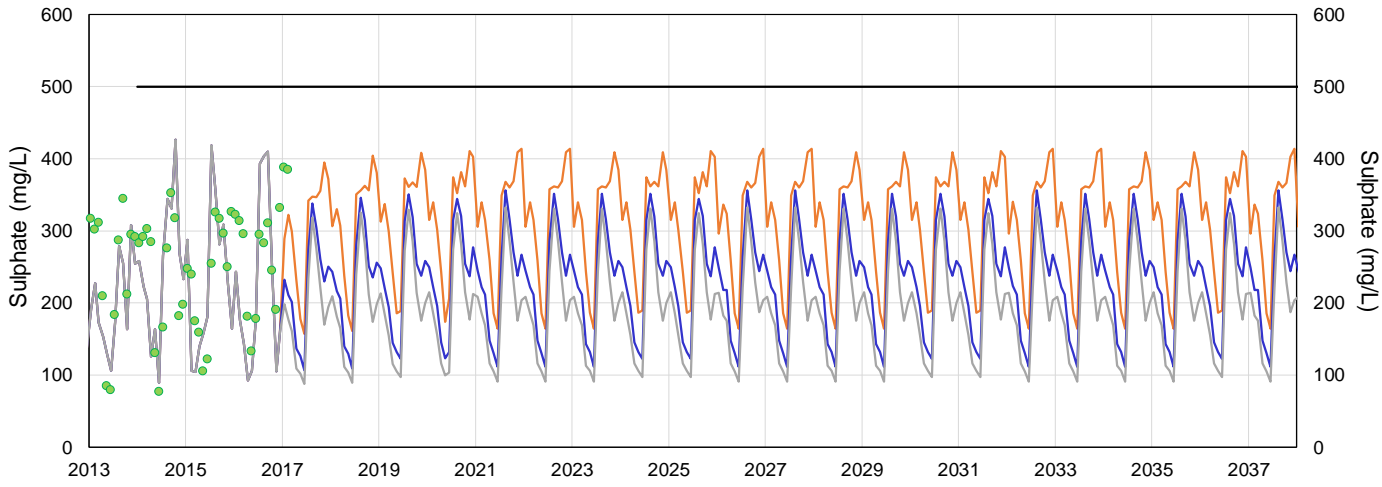
Note: Projected concentrations decrease in 2031, because mining in Cougar South Pit at GHO is modelled to be completed by the end of 2030, after which the pit is modelled to fill.

Figure 2-6 Projected Monthly Average Concentrations of Sulphate at Compliance Points between 2013 and 2037 for the Planned Development Scenario (Continued)

(e) EVO Harmer Compliance Point (EV_HC1; E102682)



(f) CMO Compliance Point (CM_MC2; E258937)



(g) EVO Michel Creek Compliance Point (EV_MC2; E300091)

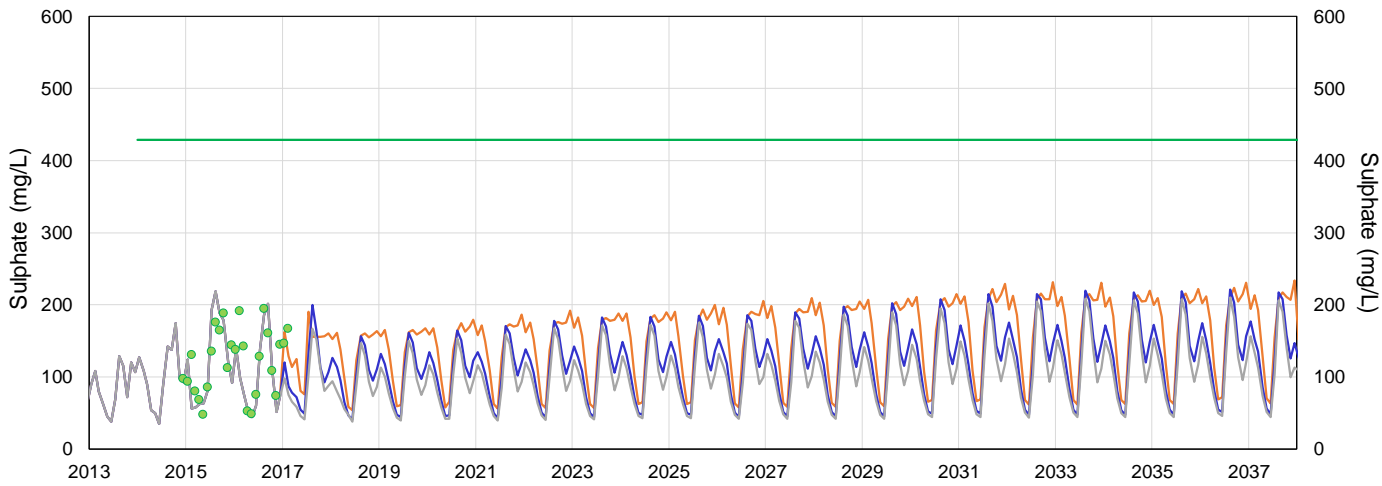


Table 2-4 **Projected Hardness Concentrations used to Calculate the Site Performance Objective for Nitrate in the Fording River downstream of Line Creek (LC_LC5; 0200028) for the Planned Development Scenario**

Year	Hardness (mg/L)
2020	592
2021	597
2022	569
2023	621
2024	604
2025	610
2026	335
2027	586
2028	642
2029	639
2030	638
2031	586
2032	674
2033	678
2034	602
2035	608
2036	620
2037	701

mg/L = milligrams per litre.

3 Projected Concentrations for the Permitted Development Scenario

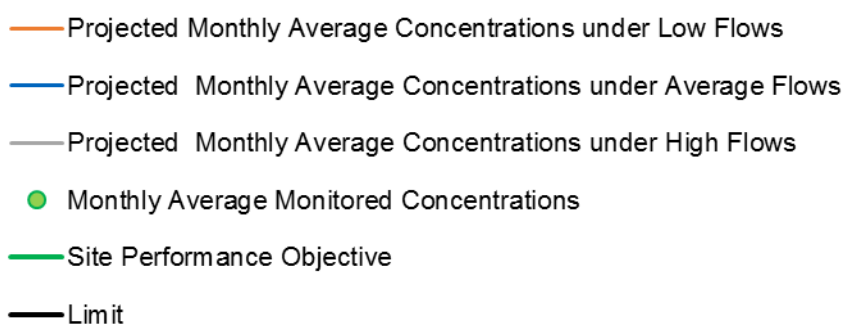
Monthly average concentrations of nitrate, selenium and sulphate projected to be above SPOs and/or Compliance Limits for the Permitted Development Scenario are summarized in Tables 3-1 to 3-3, respectively.

Projected monthly average concentrations of nitrate, selenium and sulphate at Order Stations and Compliance Points for the Permitted Development Scenario are shown in Figures 3-1 to 3-6, respectively. The projections are presented as time series plots. The solid orange, blue and grey lines correspond to the projected monthly average concentrations under low, average and high flows for the Permitted Development Scenario. The figures include SPOs, Compliance Limits, and historical observations (green points). The fully effective dates for the AWTFs have been excluded from these graphs for visual simplicity. The mitigation applied in the Planned Development Scenario is the same as for the Permitted Development Scenario.

The x-axis in Figures 3-1 to 3-6 runs from the start of 2013 to the end of 2130. The calibration period for the RWQM is January 1, 2004 to December 31, 2016. Projected concentrations shown in solid grey prior to 2017; therefore, correspond to the monthly average concentrations projected to occur each year under observed flow conditions. Year 2130 corresponds to a time at which all of the waste rock considered in the Permitted Development Scenario has been deposited and the lag associated with that rock has passed (i.e., all of the waste rock is contributing selenium and nitrate load) and water volumes in all mine pits are either being actively managed or are decanting to the receiving environment.

The 2019 IPA includes active management of water volumes in Swift and Natal pits after 2053 (i.e., water from Swift and Natal pits is pumped year-round to the FRO AWTF-N and EVO AWTFs, respectively, thereby controlling the timing of pit filling and decant), and passive management of other pits (i.e., all other pits are allowed to passively fill and decant over time, without active management of pit water volumes).

The legend below applies to all time series plots in this section.



Projected hardness values used to calculate the hardness-dependant SPO for nitrate in the Fording River are presented in Table 3-4. For each year, the hardness-dependant SPO for nitrate is calculated using the minimum hardness value from the month when the maximum nitrate concentration is projected to occur.

Table 3-1 Summary of Projected Monthly Average Nitrate Concentrations above Site Performance Objectives or Compliance Limits between 2019 and 2053 for the Permitted Development Scenario

Location		Year	Month	Maximum Projected Concentration (mg/L)	Corresponding Site Performance Objective / Limit (mg/L)	Maximum Magnitude of Exceedance (mg/L)
Order Stations	Fording River downstream of Greenhills Creek (GH_FR1; 0200378) ^(a)	2020 to 2021	January to April	17	14	3
	Elk River upstream of Grave Creek (EV_ER4; 0200027)	2020 to 2021	January to April	5.6	4	1.6
Compliance Points	FRO Compliance Point (FR_FRCP1; E300071)	2019	January to April	31	27	4
		2020 to 2022	October to May	30	19	11
	Fording River above Chauncey Creek (FR_FRABCH)	2019	January to April	29	25	4
		2020 to 2022	December to May, October	28	18	10
	LCO Compliance Point (LC_LCDSSLCC; E297110)	2019 to 2025	October to May	12	7	5

^(a) This location is also the GHO Fording River Compliance Point.

FRO = Fording River Operations; GHO = Greenhills Operations; LCO = Line Creek Operations.

Table 3-2 Summary of Projected Monthly Average Selenium Concentrations above Site Performance Objectives or Limits between 2019 and 2053 under the Permitted Development Scenario

Location		Year	Month	Maximum Projected Concentration (µg/L)	Corresponding Site Performance Objective / Limit (µg/L)	Maximum Magnitude of Exceedance (µg/L)
Order Stations	Fording River downstream of Greenhills Creek (GH_FR1; 0200378) ^(a)	2020 to 2021	December to April	73	63	10
	Fording River downstream of Line Creek (LC_LC5; 0200028)	2020 to 2021	February to April	56	51	5
	Elk River upstream of Grave Creek (EV_ER4; 0200027)	2020 to 2021	February	25	23	2
	Koocanusa Reservoir (RG_DSELK; E300230)	2019 to 2022	January, February, April	2.5	2	0.5
Compliance Points	FRO Compliance Point (FR_FRCP1; E300071)	2020 to 2021	October to May	120	90	30
	Fording River above Chauncey Creek (FR_FRABCH)	2020 to 2021	October to May	112	85	27
		2026	April	59	58	1
	LCO Compliance Point (LC_LCDSSLCC; E297110)	2019 to 2025	December to May	69	50	19
	GHO Elk River Compliance Point (GH_ERC; E300090)	2028 to 2029	February	8.6	8	0.6
	EVO Harmer Compliance Point (EV_HC1; E102682)	2029, 2034 to 2053	August to May	76	57	19
		2021	February	29	28	1
		2022	January to March, August to September	31	20	11
	EVO Michel Creek Compliance Point (EV_MC2; E300091)	2027	August	20	19	1

^(a) This location is also the GHO Fording River Compliance Point.

EVO = Elkview Operations; FRO = Fording River Operations; GHO = Greenhills Operations; LCO = Line Creek Operations.

Table 3-3 Summary of Projected Monthly Average Sulphate Concentrations above Site Performance Objectives or Limits between 2019 and 2053 for the Permitted Development Scenario

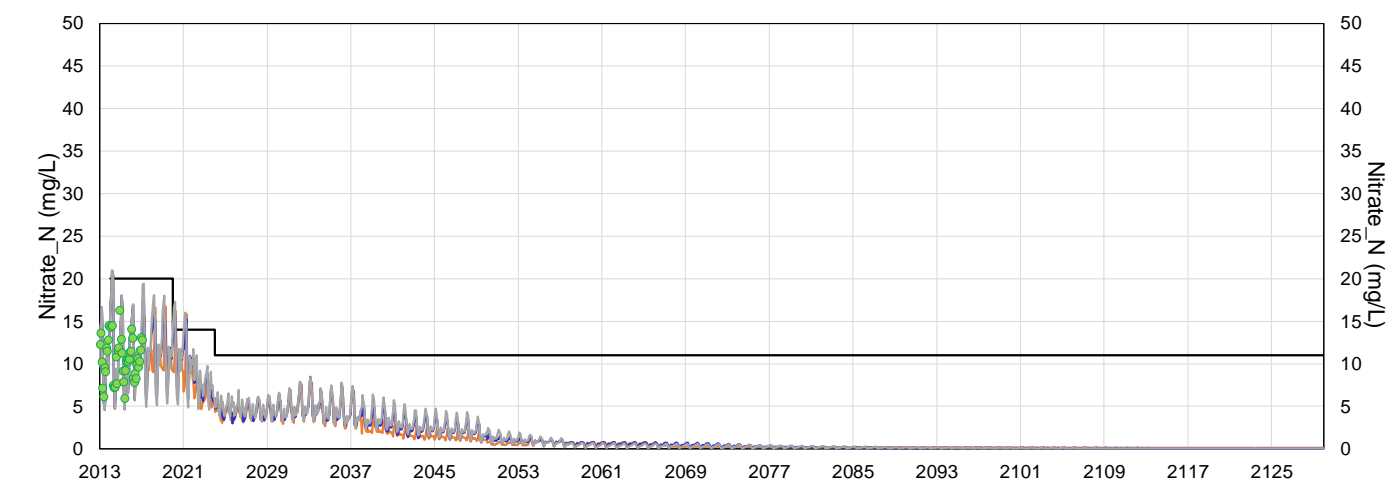
Location		Year	Month	Maximum Projected Concentration (mg/L)	Corresponding Site Performance Objective / Limit (mg/L)	Maximum Magnitude of Exceedance (mg/L)
Order Stations	Fording River downstream of Greenhills Creek (GH_FR1; 0200378) ^(a,b)	2028 to 2053	October to April	687	429	258
	Fording River downstream of Line Creek (LC_LC5; 0200028)	2034 to 2053	January to April	558	429	129
Compliance Points	FRO Compliance Point (FR_FRCP1; E300071)	2038 to 2053	December to April	865	650	215
	Fording River above Chauncey Creek (FR_FRABCH)	2038 to 2053	December to April	805	605	200
	LCO Compliance Point (LC_LCDSSLCC; E297110)	2026 to 2053	February to March	492	429	63
	EVO Harmer Compliance Point (EV_HC1; E102682)	2045 to 2053	April	459	450	9

^(a) This location is also the GHO Fording River Compliance Point.

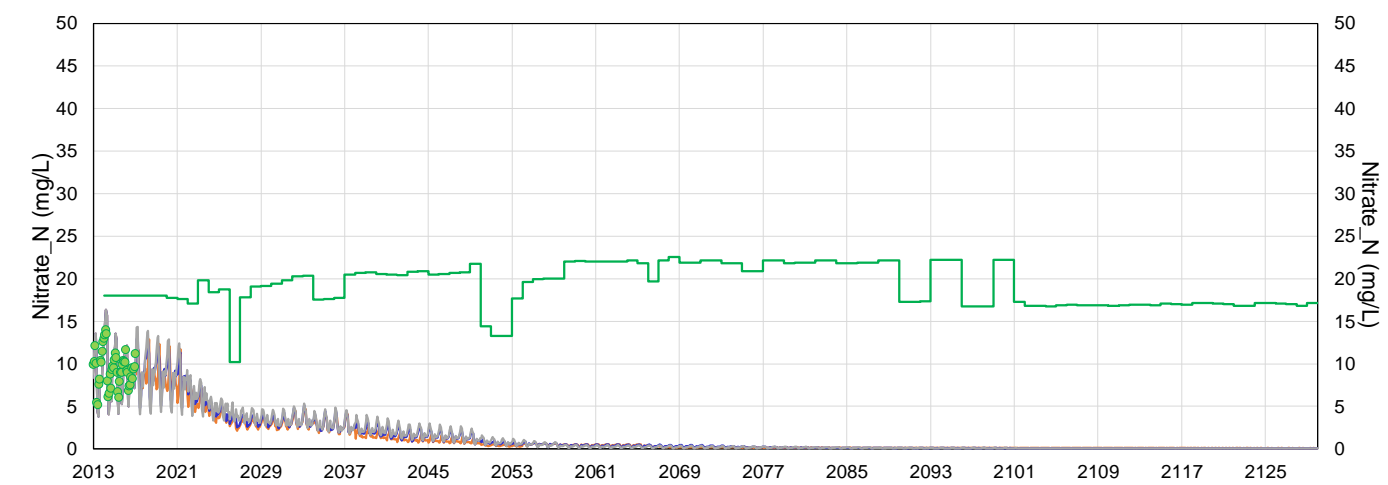
^(b) Although the maximum projected monthly average sulphate concentration in 2023 is above the SPO (i.e., 431 versus 429 mg/L), this result is not included in the table, because it is a model artefact. Loading from rehandled waste rock is being modelled as a one-time pulse not subjected to lag. Loading from rehandled waste rock is expected to be more gradual than has been simulated. Thus, sulphate concentrations in 2023 are not expected to be above the SPO at this location. The 2020 RWQM Update will include improvements to the manner in which loading from rehandled waste rock are modelled.

LCO = Line Creek Operations; FRO = Fording River Operations; GHO = Greenhills Operations.

Figure 3-1 Projected Monthly Average Concentrations of Nitrate at Order Stations between 2013 and 2130 for the Permitted Development Scenario
(a) Fording River downstream of Greenhills Creek (GH_FR1; 0200378) (b) Fording River downstream of Line Creek (LC_LC5; 0200028)

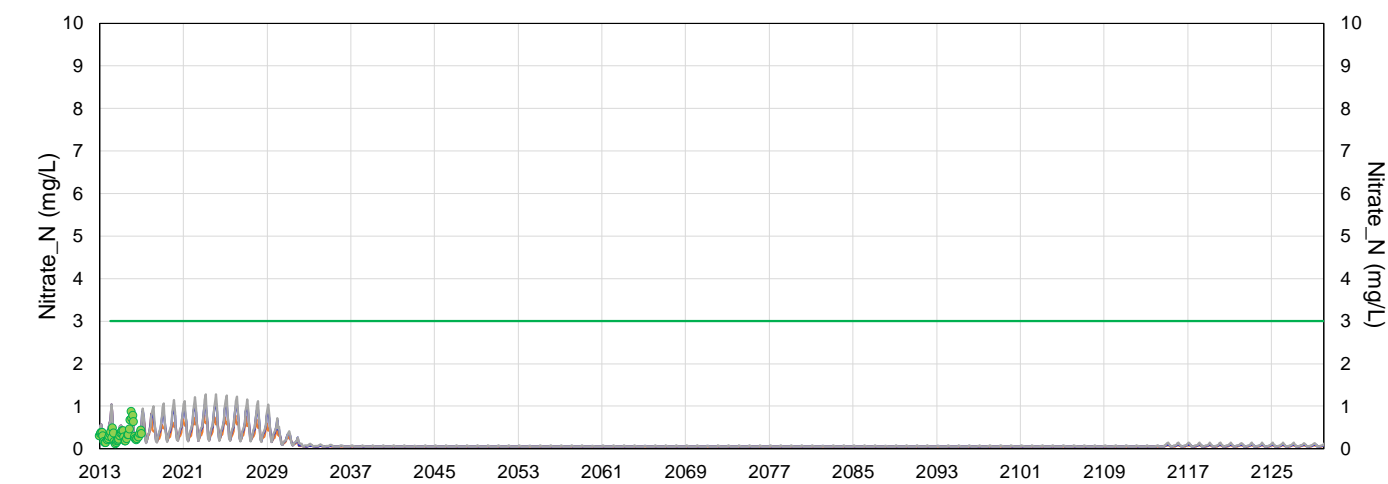


Note: This location is also the GHO Fording River Compliance Point.



Note: Site Performance Objective is hardness dependent from 2019 onward and is calculated using the following formula: $N \text{ (in mg-N/L)} = 10^{1.0003\log_{10}(\text{hardness}) - 1.52}$ where hardness is in mg/L of CaCO_3 ; it varies with time to reflect projected hardness concentrations in the month when maximum monthly average nitrate concentrations are projected to occur.

(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)



(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)

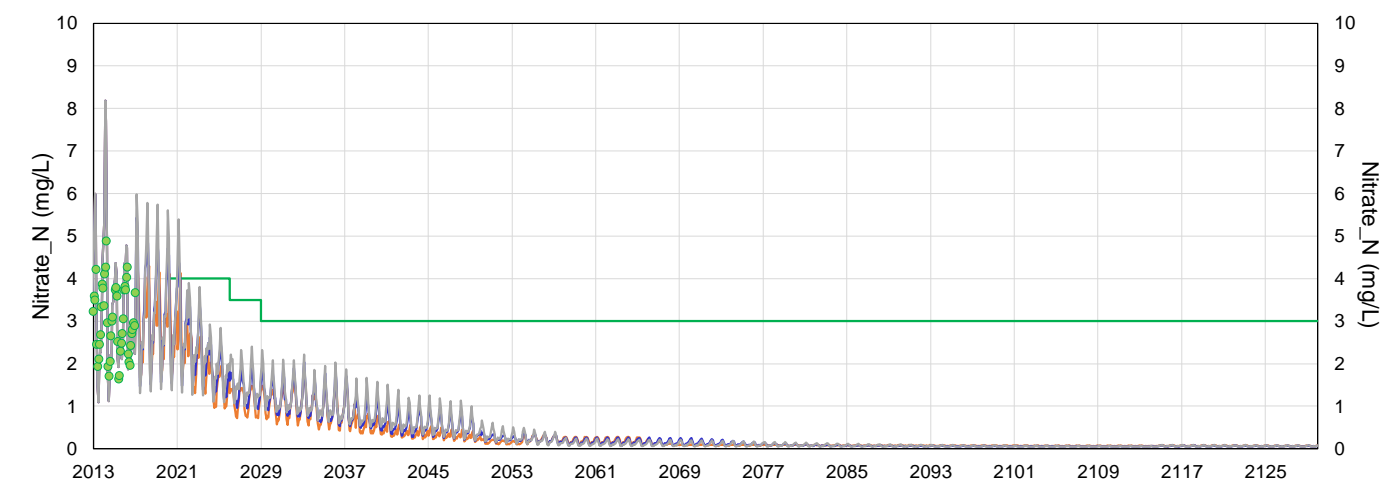
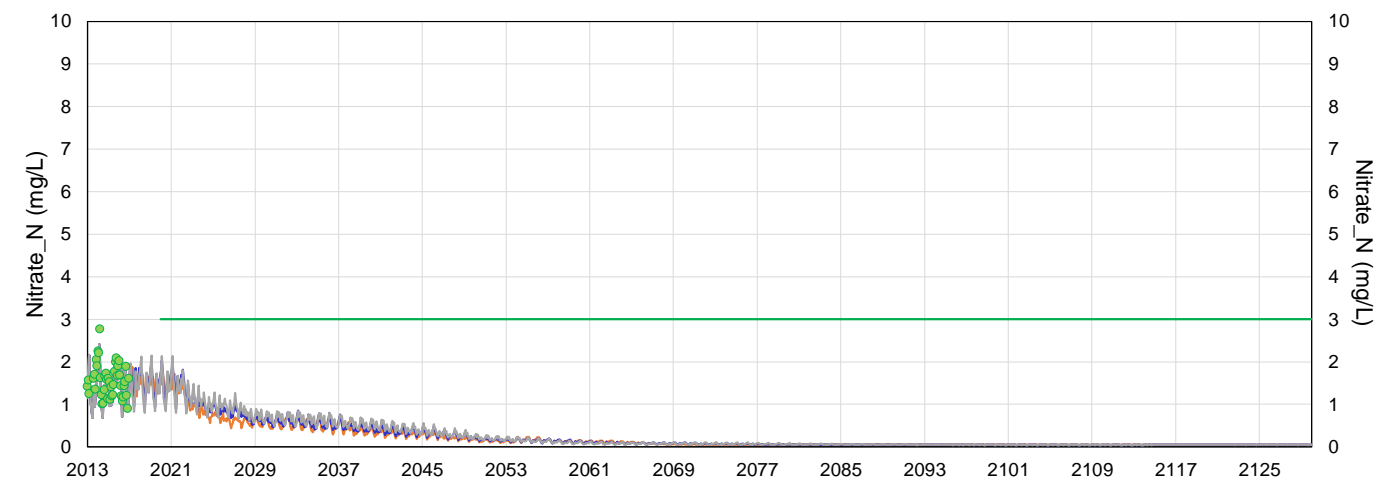
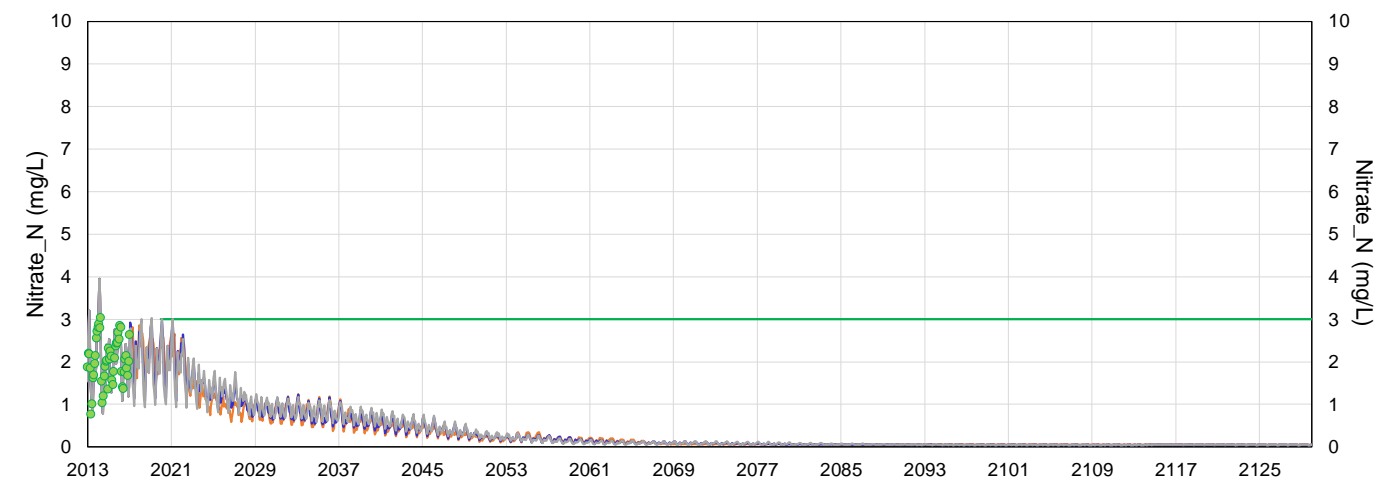


Figure 3-1 Projected Monthly Average Concentrations of Nitrate at Order Stations between 2013 and 2130 for the Permitted Development Scenario (Continued)

(e) Elk River downstream of Michel Creek (EV_ER1; 0200393)

(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)

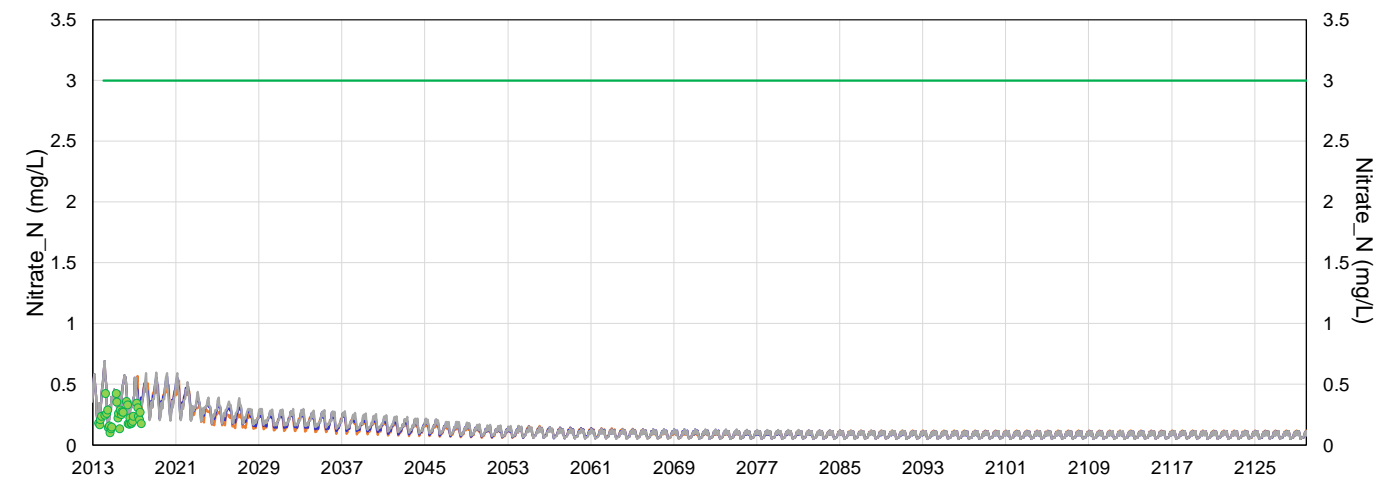
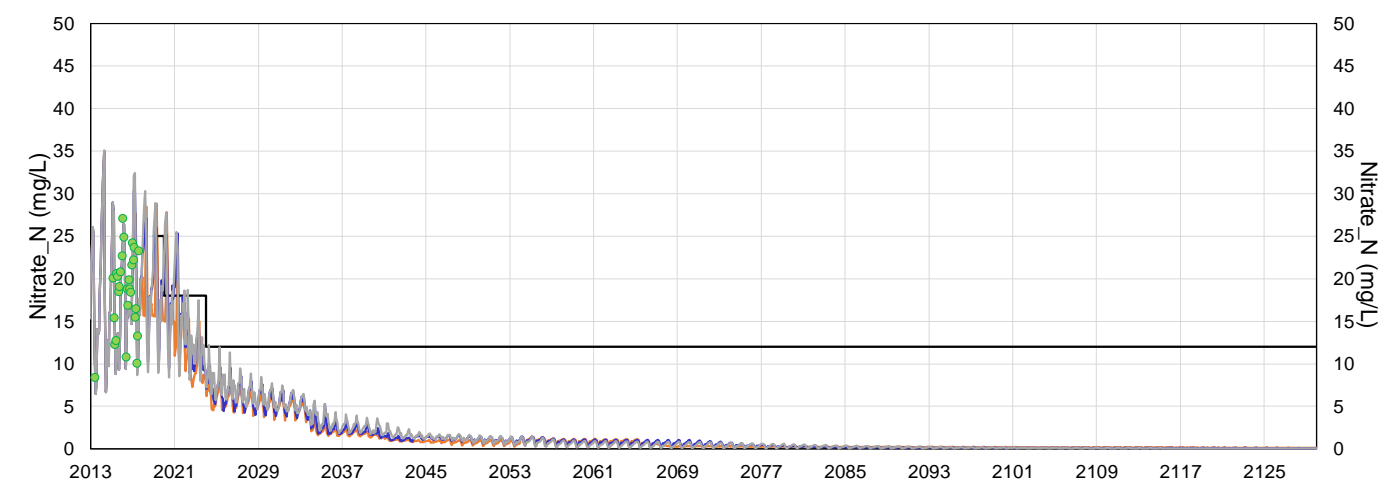
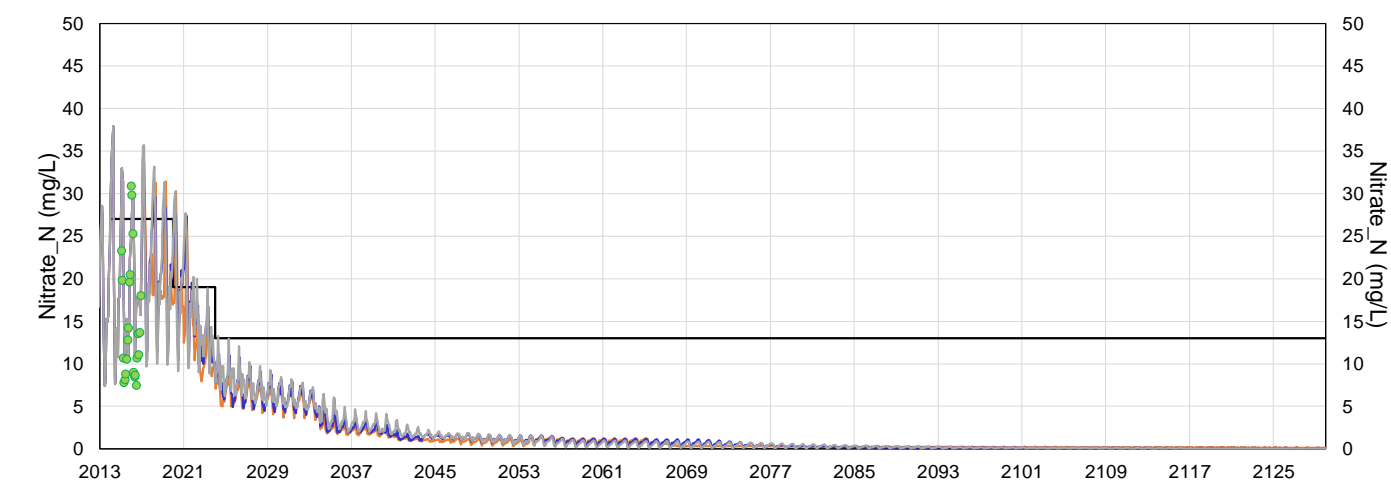
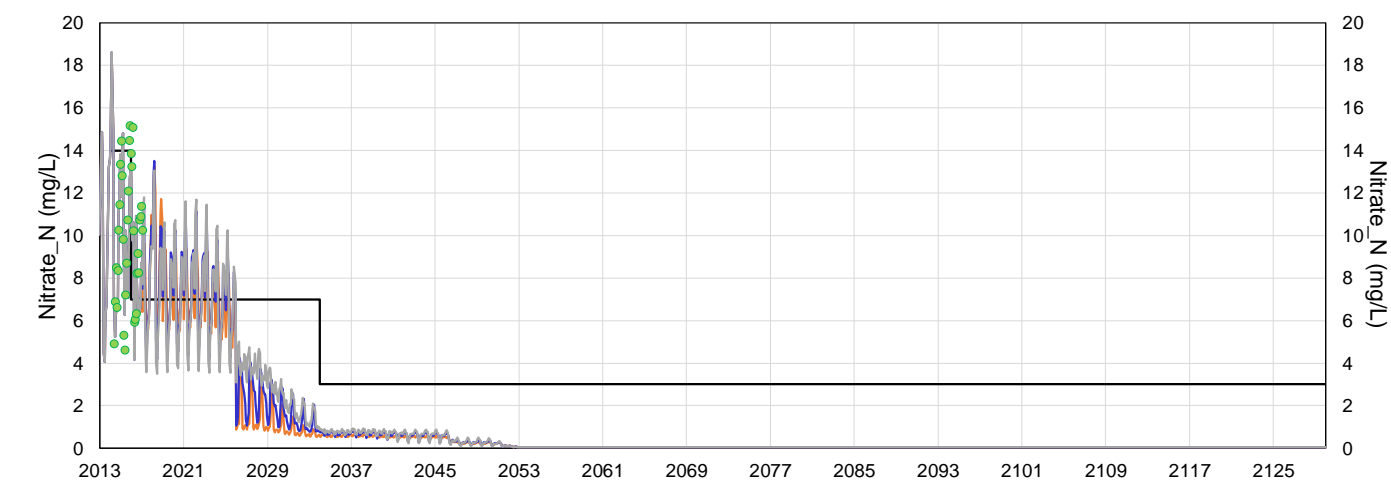


Figure 3-2 Projected Monthly Average Concentrations of Nitrate at Compliance Points between 2013 and 2130 for the Permitted Development Scenario
(a) FRO Compliance Point (FR_FRCP1; E300071) (b) Fording River above Chauncey Creek (FR_FRABCH)



Note: Projected concentrations are presented at Fording River above Chauncey Creek (FR_FRABCH), because it is the location proposed for the new Fording River Operations Compliance Point.

(c) LCO Compliance Point (LC_LCDSSLCC; E297110)



(d) GH0 Elk River Compliance Point (GH_ERC; E300090)

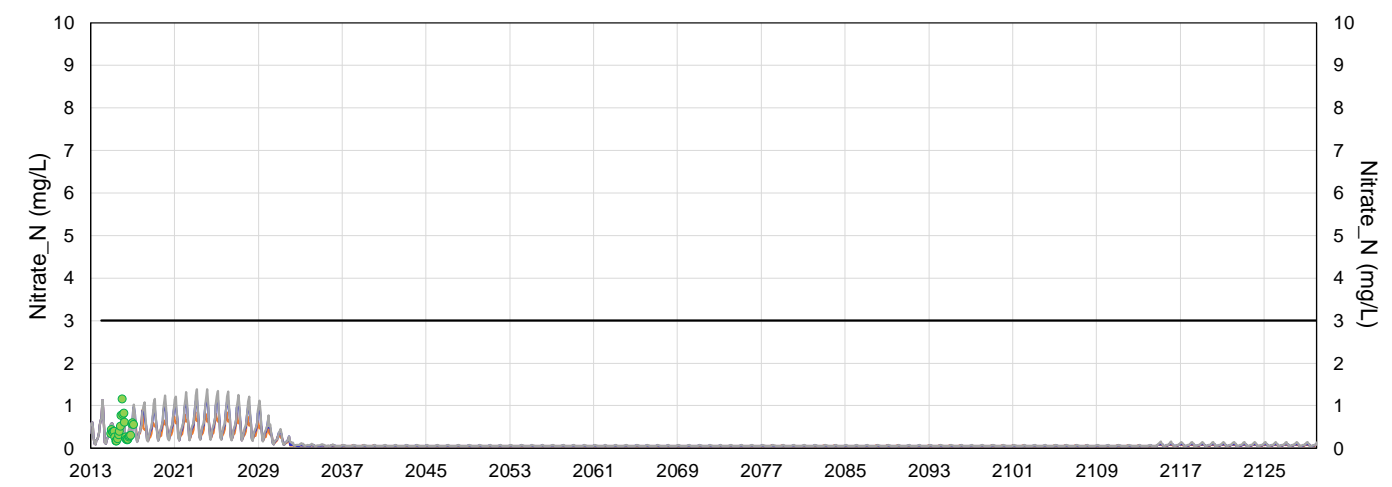
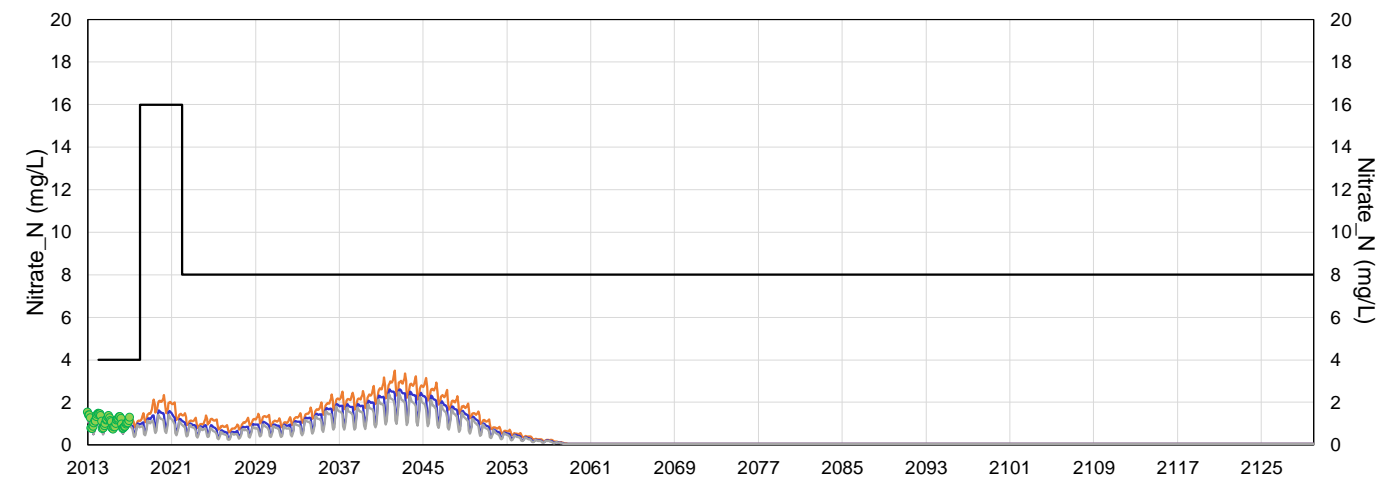
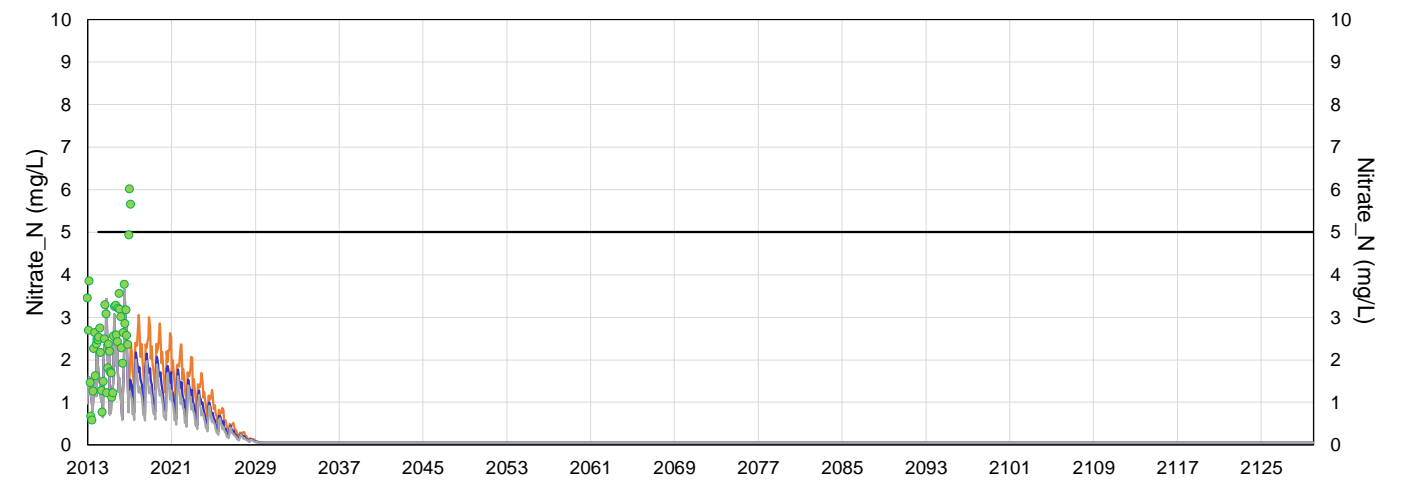


Figure 3-2 Projected Monthly Average Concentrations of Nitrate at Compliance Points between 2013 and 2130 for the Permitted Development Scenario (Continued)

(e) EVO Harmer Compliance Point (EV_HC1; E102682)



(f) CMO Compliance Point (CM_MC2; E258937)



Note: In January 2017, a non-compliance occurred at the CMO Compliance Point, CM_MC2. Pit dewatering activities in January were similar to other months (i.e., pumping rates and concentrations), but creek flows decreased which resulted in an exceedance of the nitrate permit limit. Pumping rates were immediately adjusted to bring nitrate concentrations back within the permit limit.

(g) EVO Michel Creek Compliance Point (EV_MC2; E300091)

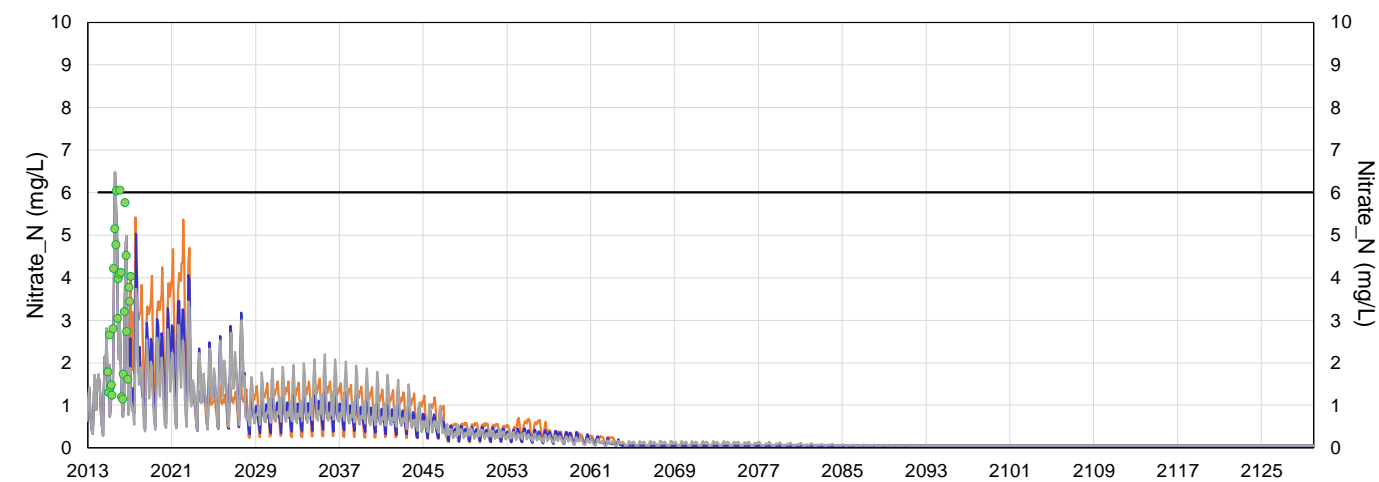
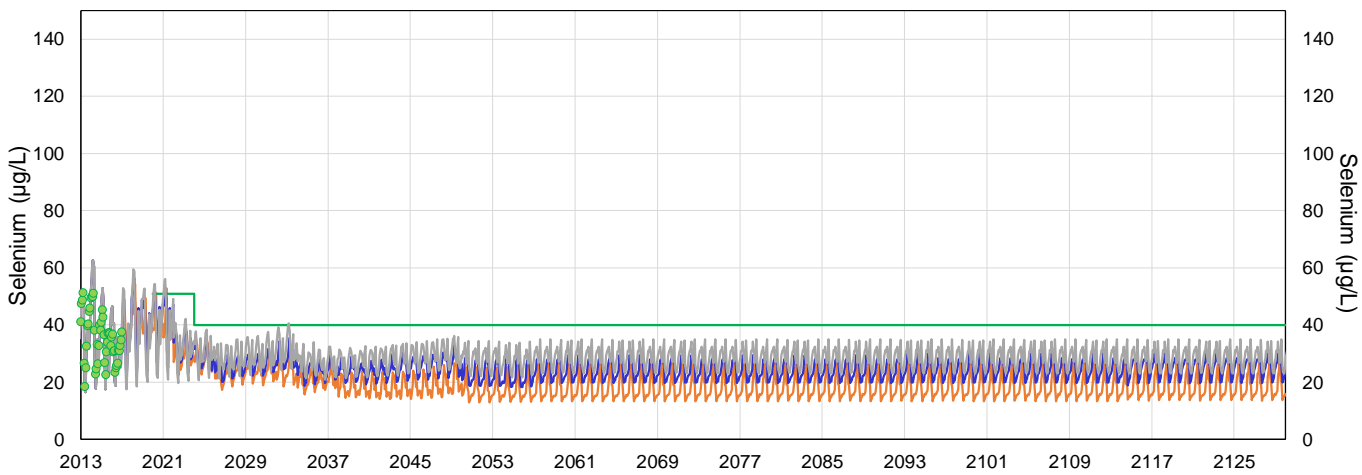
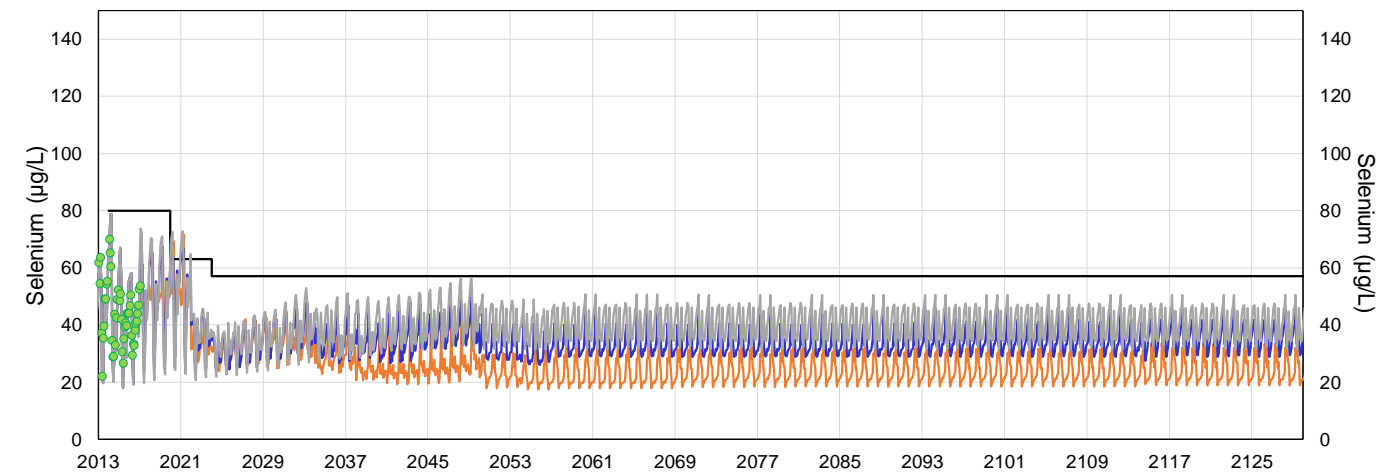


Figure 3-3 Projected Monthly Average Concentrations of Selenium at Order Stations between 2013 and 2130 for the Permitted Development Scenario

(a) Fording River downstream of Greenhills Creek (GH_FR1; 0200378)

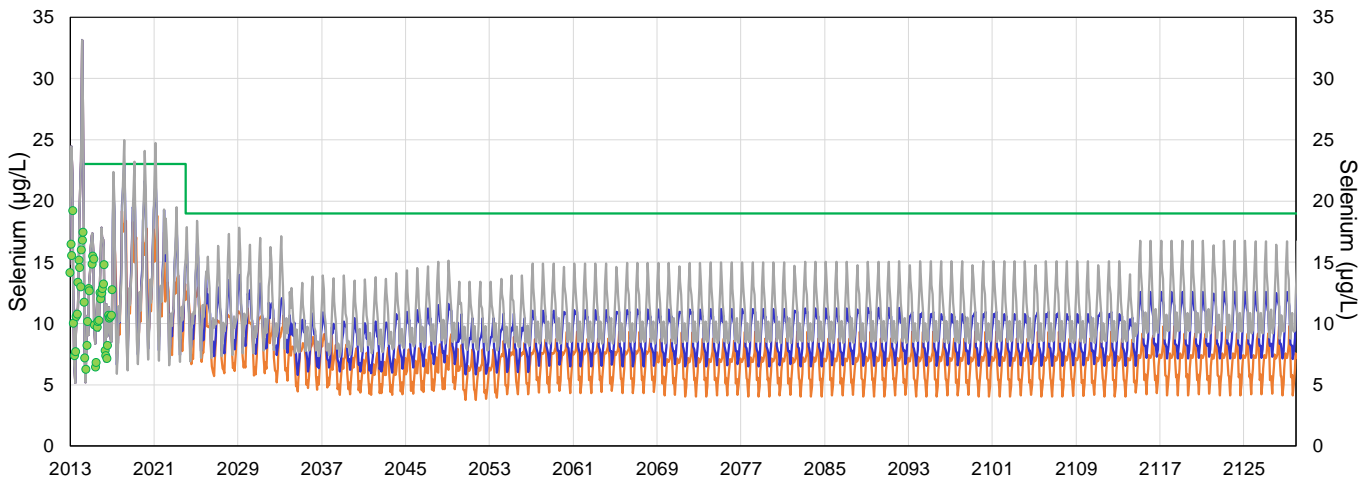
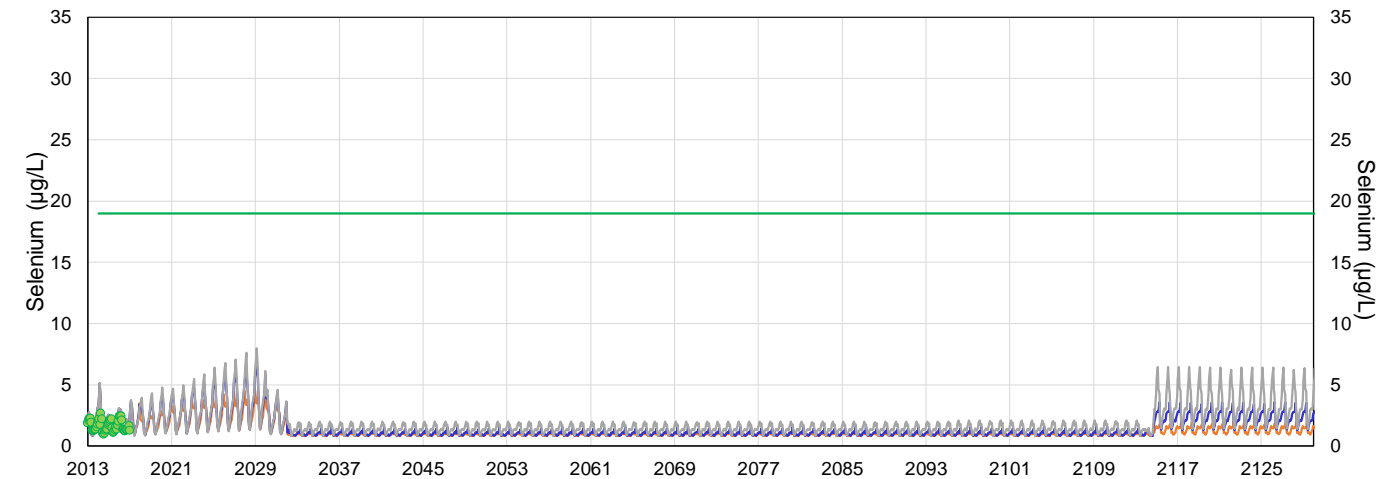
(b) Fording River downstream of Line Creek (LC_LC5; 0200028)



Note: This location is also the GHO Fording River Compliance Point.

(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)

(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)

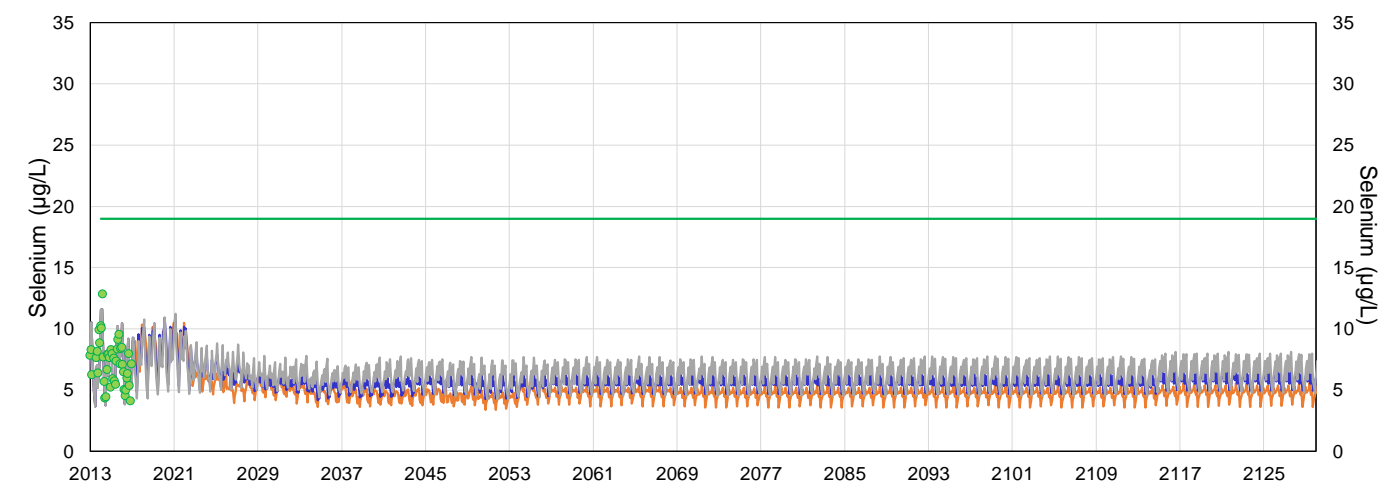
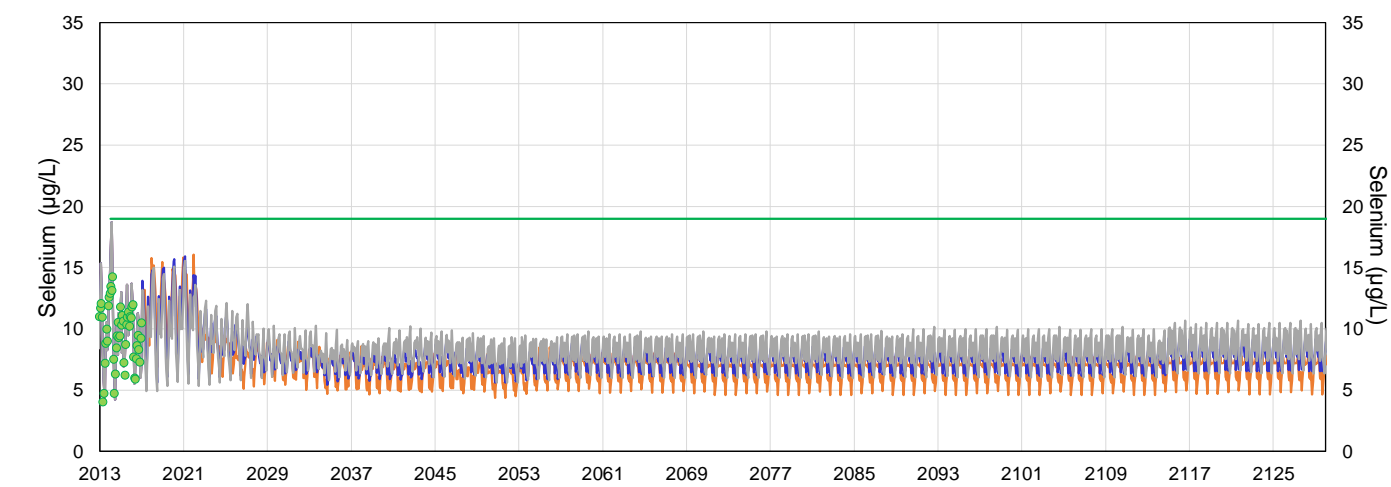


Note: Projected concentrations decrease in 2030, because mining in Cougar South Pit at GHO is modelled to be completed by the end of 2029, after which the pit is modelled to fill. Cougar South Pit is estimated to spill in 2115.

Figure 3-3 Projected Monthly Average Concentrations of Selenium at Order Stations between 2013 and 2130 for the Permitted Development Scenario (Continued)

(e) Elk River downstream of Michel Creek (EV_ER1; 0200393)

(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)

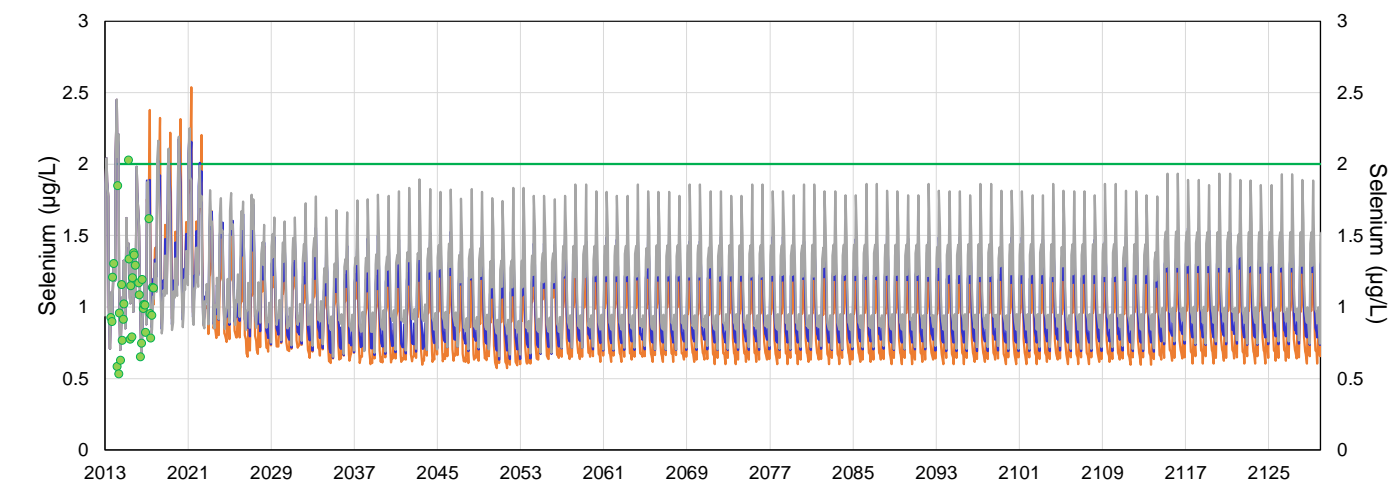
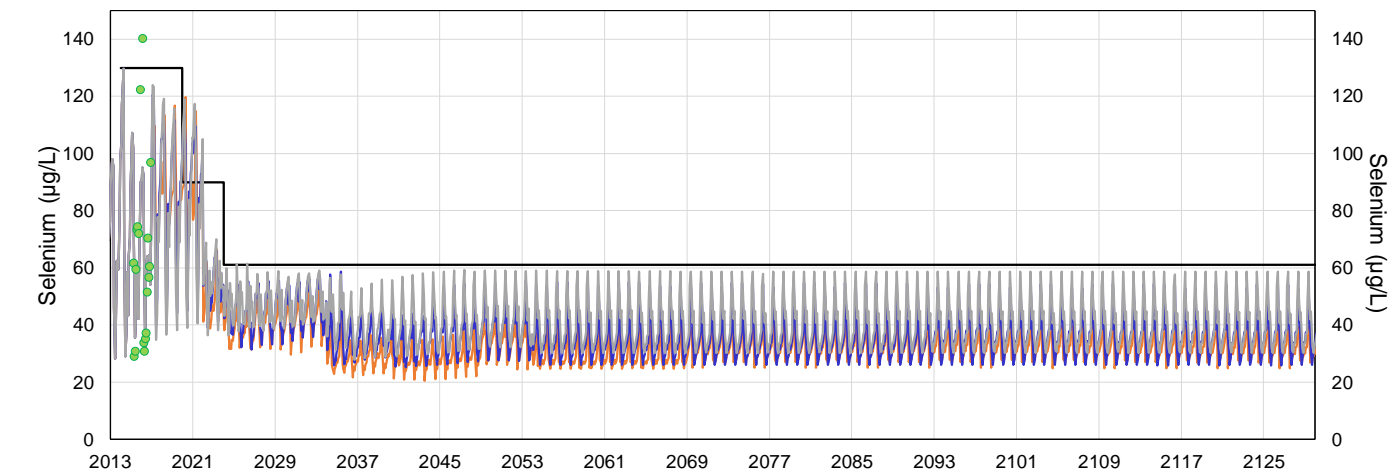
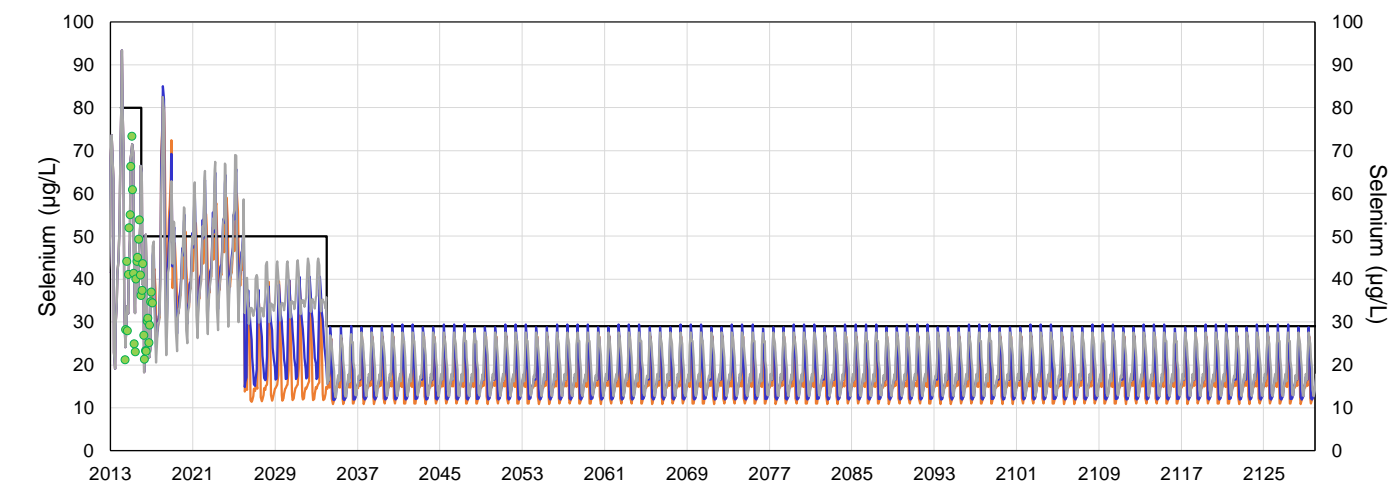


Figure 3-4 Projected Monthly Average Concentrations of Selenium at Compliance Points between 2013 and 2130 for the Permitted Development Scenario
(a) FRO Compliance Point (FR_FRCP1; E300071) (b) Fording River above Chauncey Creek (FR_FRABCH)

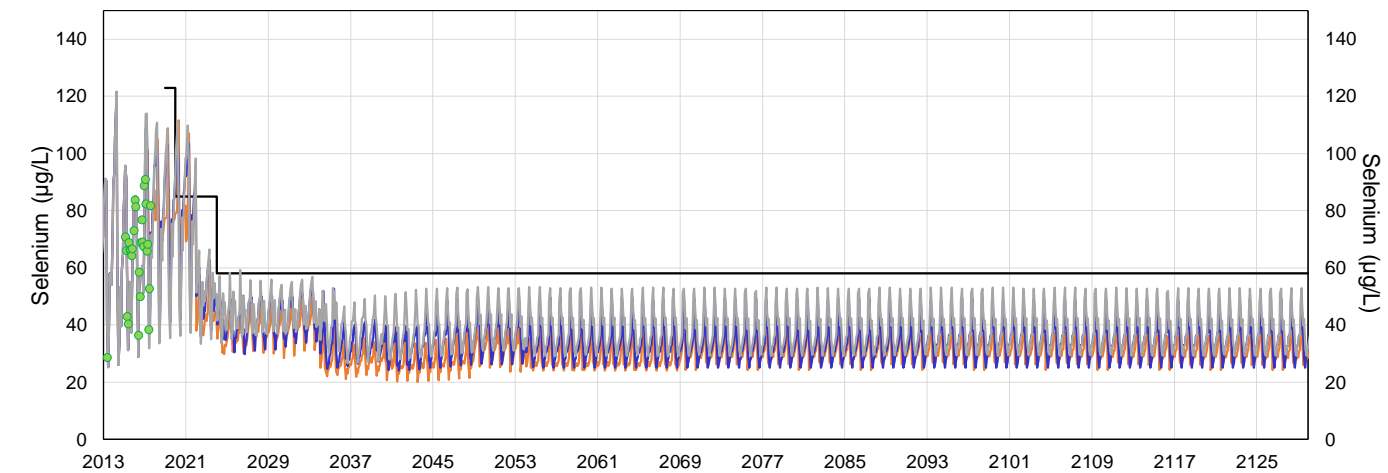


Note: At FR_FRCP1, monitored data are presented from January 2015 to December 2016. Five monitored data points are not presented on the plot, because including them on the plot would required an extension of the y-axis that would not allow the reader to easily compare the model projections to the Compliance Limit. The five monitored data points (i.e., monthly average monitored concentrations) that are not presented on the plot are: 310 µg/L in February 2015, 229 µg/L in March 2015, 164 µg/L in November 2015, 447 µg/L in January 2016 and 316 µg/L in February 2016. Model projections at FR_FRCP1 reflect fully mixed conditions, whereas monitoring data collected during low flow periods reflect primarily the quality of Cataract Creek water; hence, the difference between model projections and monitored concentrations during low flow periods.

(c) LCO Compliance Point (LC_LCDSSLCC; E297110)

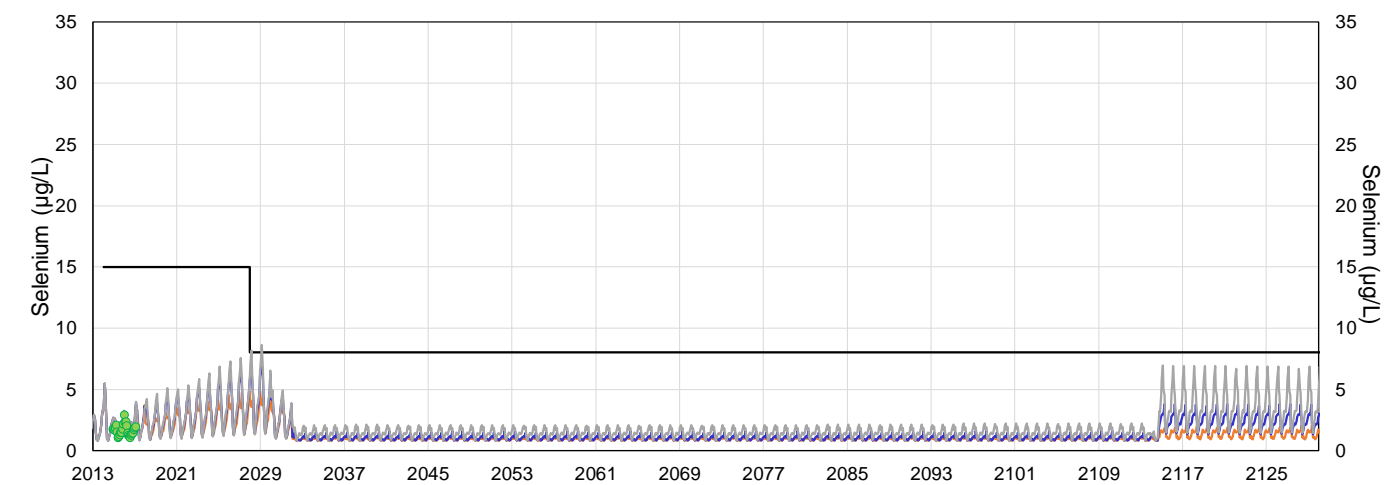


Note: Projected concentrations under high flows (gray line) differ from those under low or average flows between 2026 and 2034, because the volume of mine-influenced water bypassing the WLC AWTF is notably higher than in either of the other two flow scenarios. The higher rate of bypass results in less load removal and higher downstream concentrations.



Note: Projected concentrations are presented at Fording River above Chauncey Creek (FR_FRABCH), because it is the location proposed for the new Fording River Operations Compliance Point.

(d) GHO Elk River Compliance Point (GH_ERC; E300090)

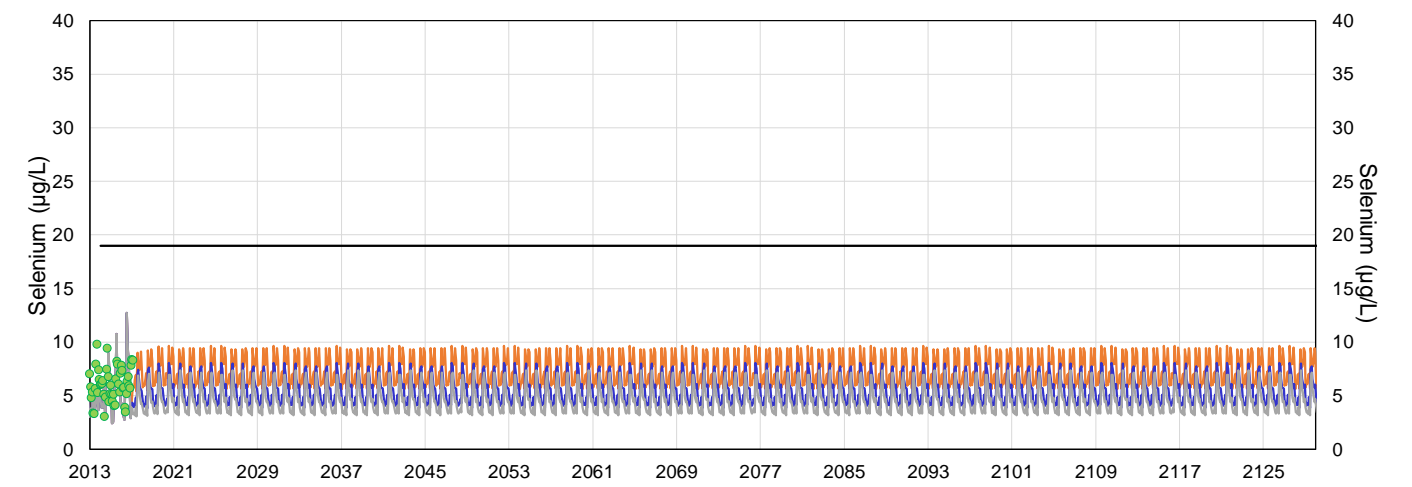
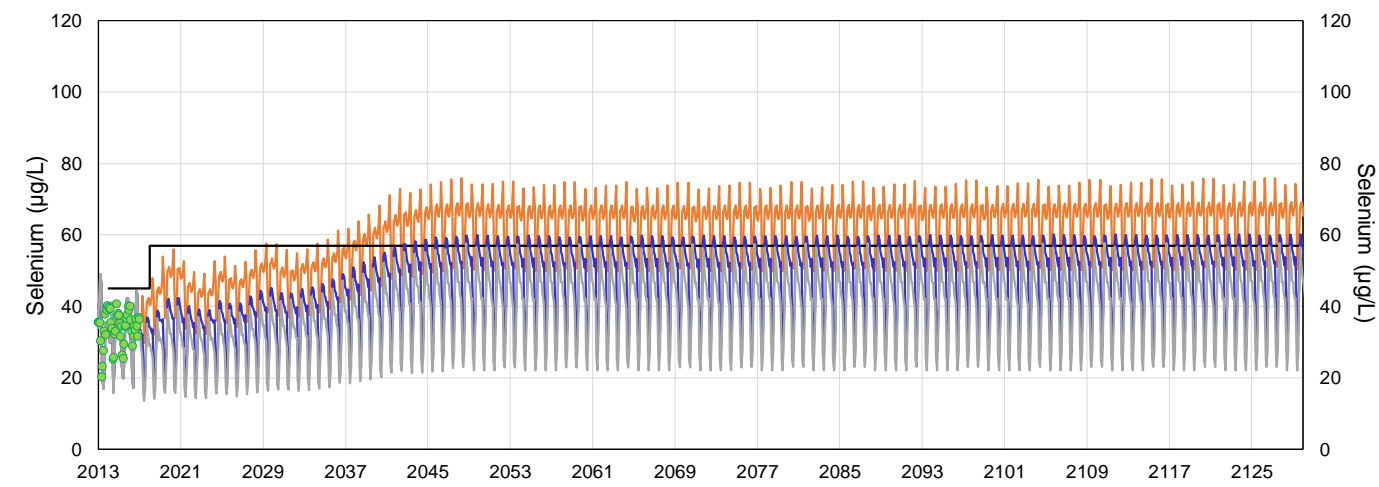


Note: Projected concentrations decrease in 2030, because mining in Cougar South Pit at GHO is modelled to be completed by the end of 2029, after which the pit is modelled to fill. Cougar South Pit is estimated to spill in 2115.

Figure 3-4 Projected Monthly Average Concentrations of Selenium at Compliance Points between 2013 and 2130 for the Permitted Development Scenario (Continued)

(e) EVO Harmer Compliance Point (EV_HC1; E102682)

(f) CMO Compliance Point (CM_MC2; E258937)



(g) EVO Michel Creek Compliance Point (EV_MC2; E300091)

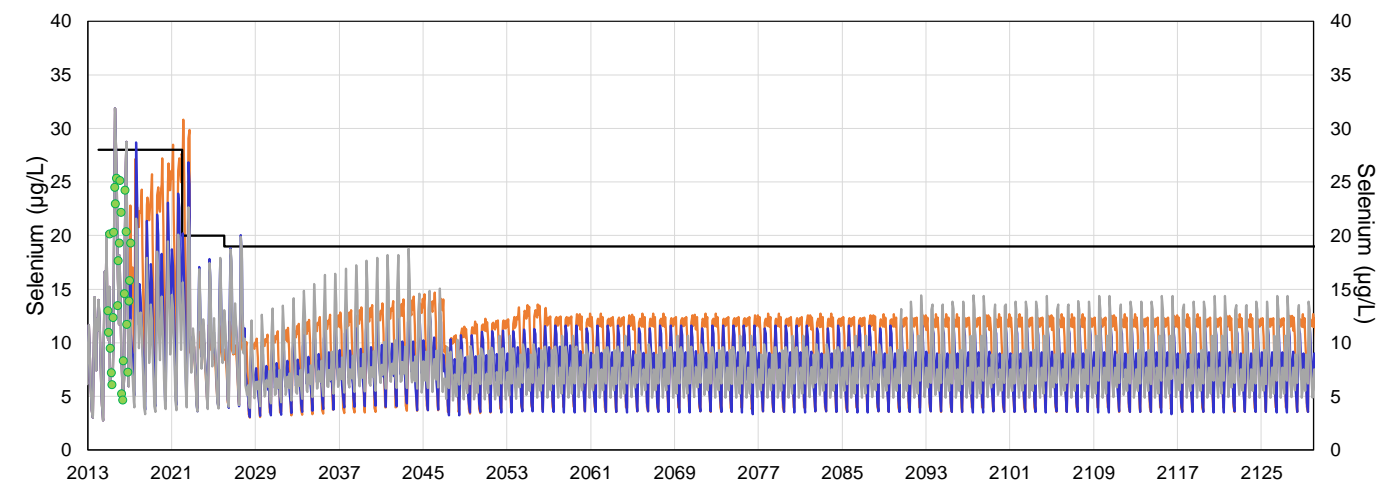
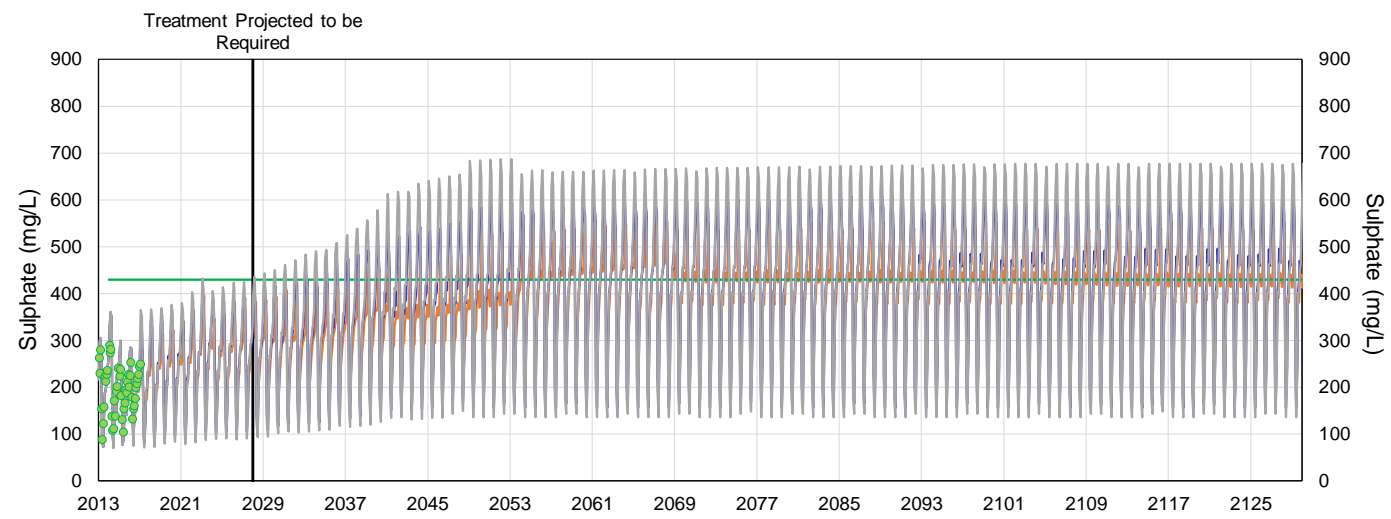
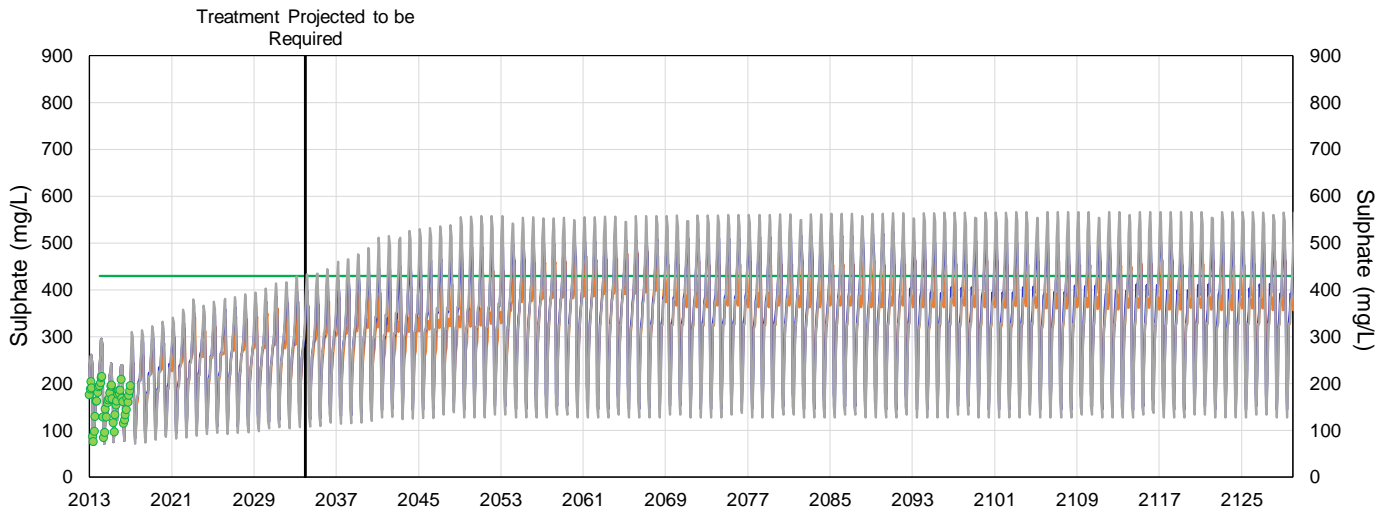


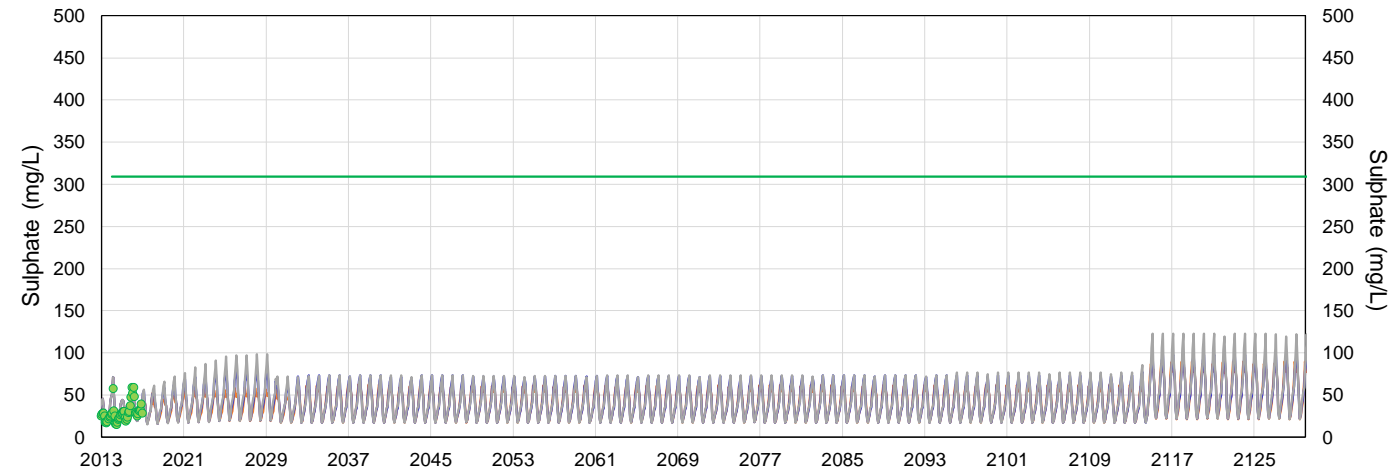
Figure 3-5 Projected Monthly Concentrations of Sulphate at Order Stations between 2013 and 2130 for the Permitted Development Scenario
(a) Fording River downstream of Greenhills Creek (GH_FR1; 0200378) (b) Fording River downstream of Line Creek (LC_LC5; 0200028)



Note: This location is also the GHO Fording River Compliance Point. The maximum monthly average sulphate concentration (431 mg/L) in February 2023 is projected to be above the SPO (429 mg/L) due to a model artefact related to the way in which loading from rehandled waste is described in the RWQM (a one-year pulse not subject to lag). Loading from rehandled waste rock is expected to be more gradual than has been simulated. Thus, sulphate concentrations in 2023 are not expected to be above the SPO at this location.



(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)



Note: Projected concentrations decrease in 2030, because mining in Cougar South Pit at GHO is modelled to be completed by the end of 2029, after which the pit is modelled to fill. Cougar South Pit is estimated to spill in 2115.

(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)

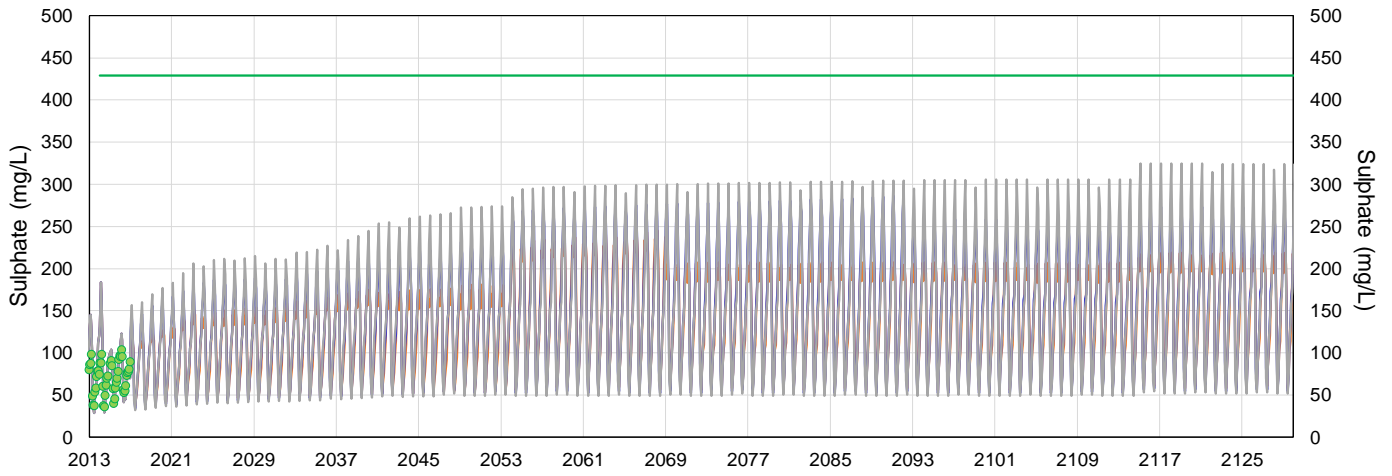
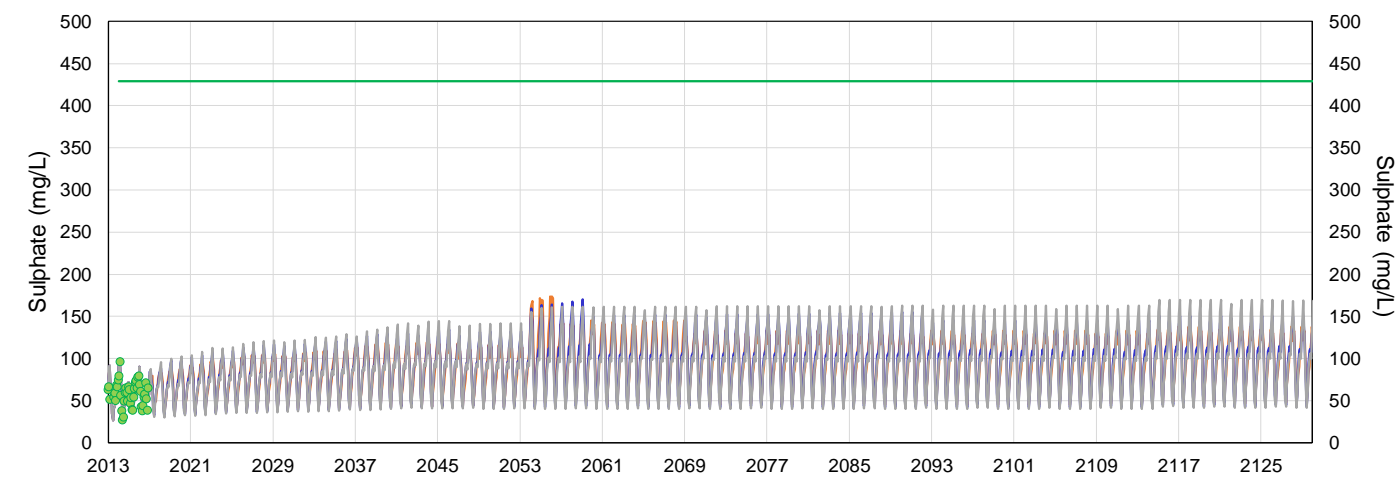
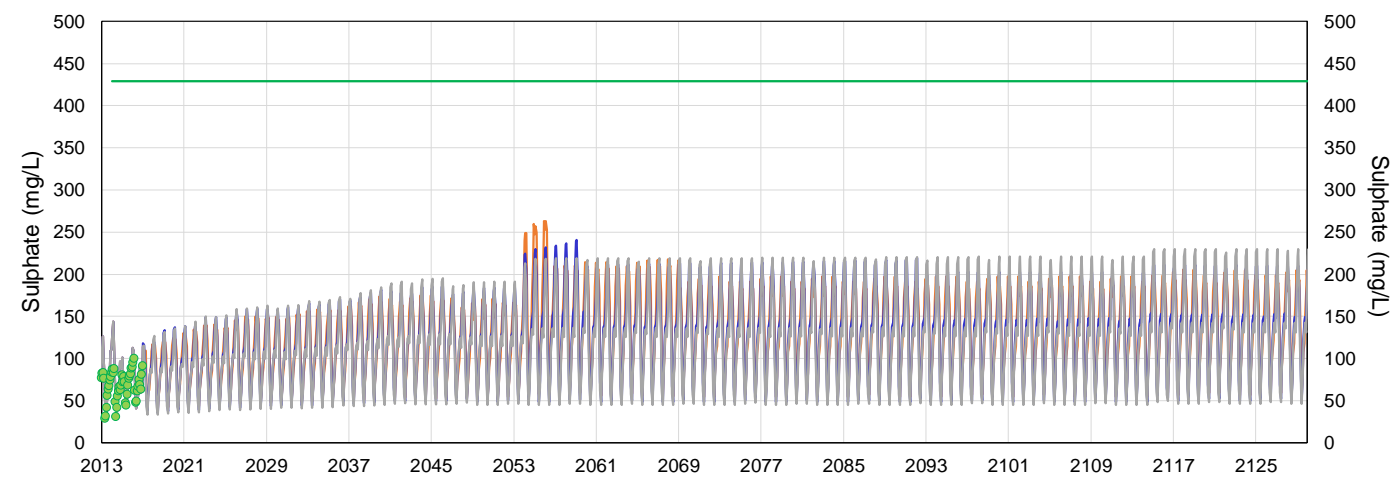


Figure 3-5 Projected Monthly Concentrations of Sulphate at Order Stations between 2013 and 2130 for the Permitted Development Scenario (Continued)
(e) Elk River downstream of Michel Creek (EV_ER1; 0200393) (f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)

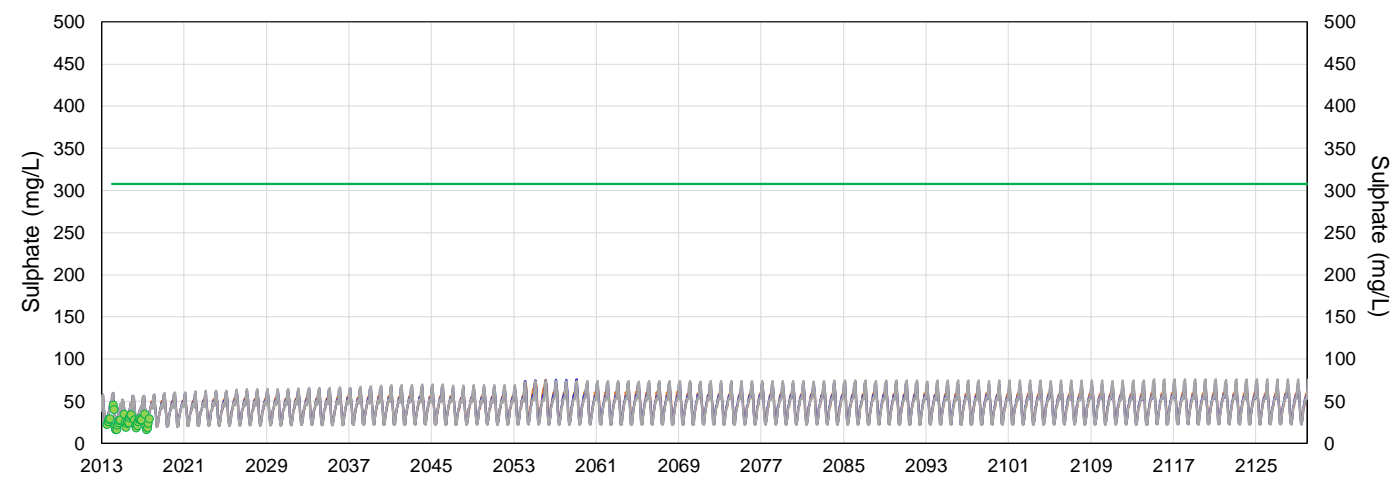
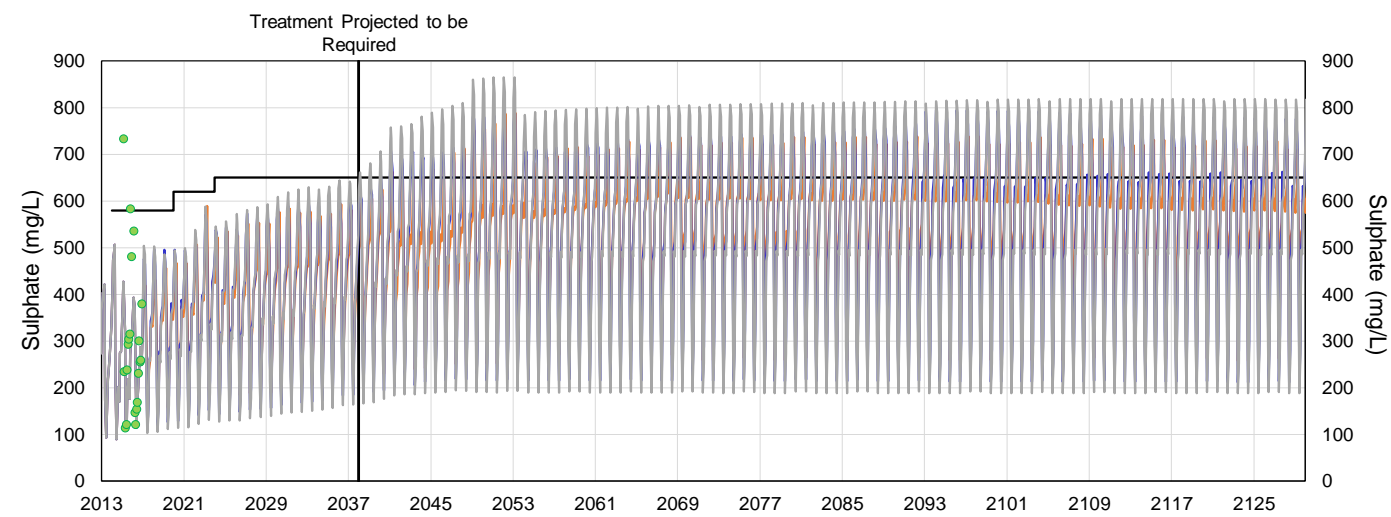
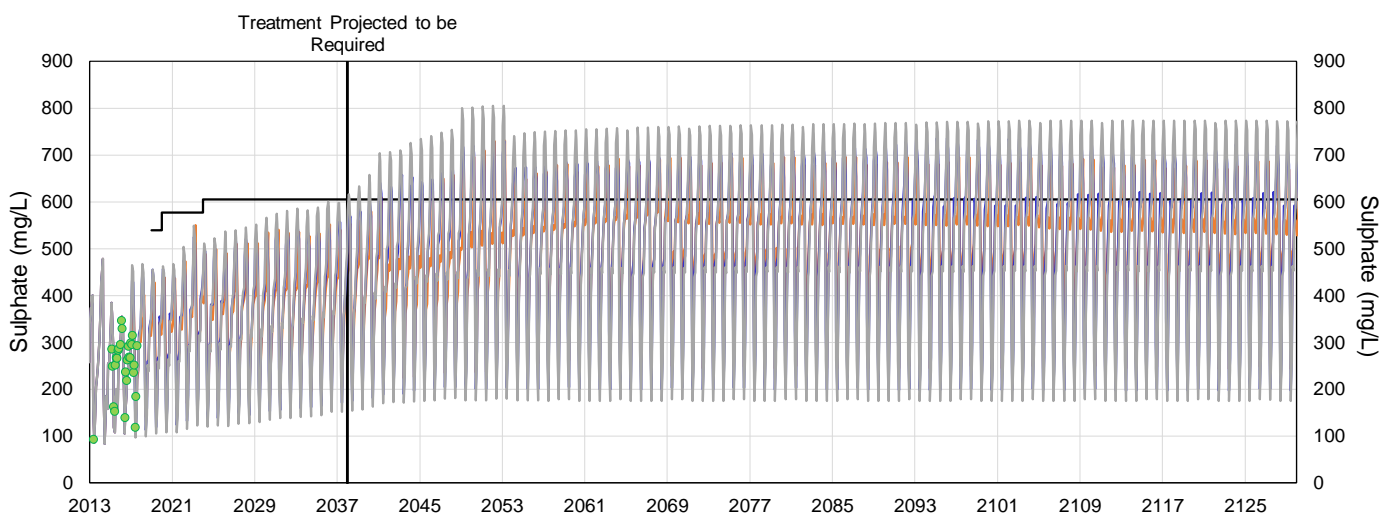


Figure 3-6 Projected Monthly Average Concentrations of Sulphate at Compliance Points between 2013 and 2130 for the Permitted Development Scenario
(a) FRO Compliance Point (FR_FRCP1; E300071) (b) Fording River above Chauncey Creek (FR_FRABCH)

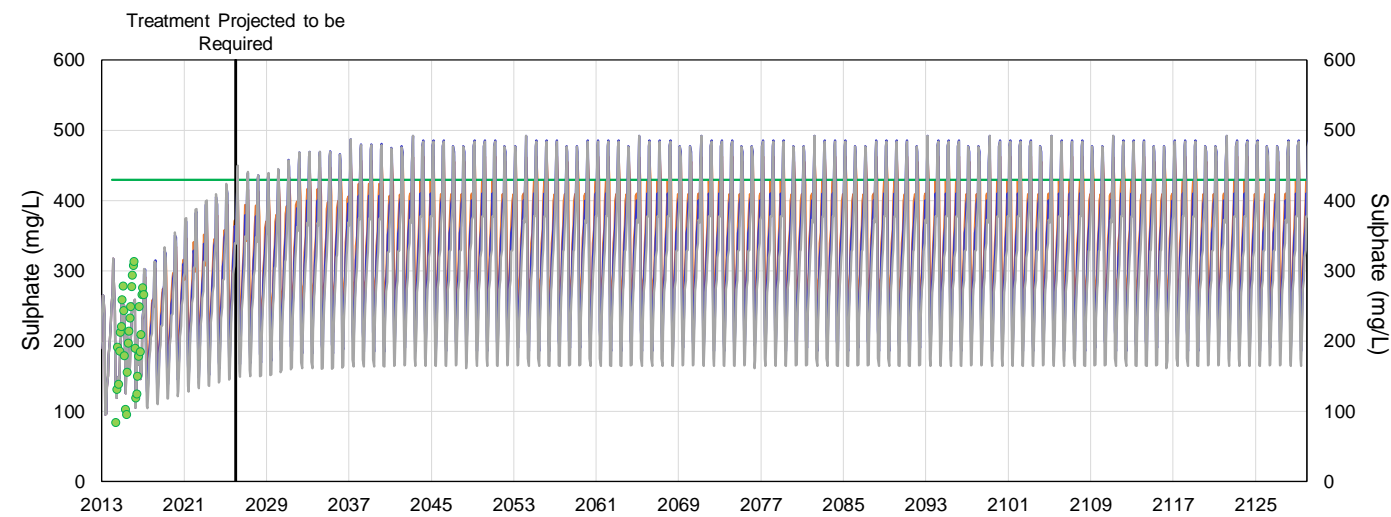


Note: At FR_FRCP1, monitored data are presented from January 2015 to December 2016. Three monitored data points are not presented on the plot, because including them on the plot would required an extension of the y-axis that would not allow the reader to easily compare the model projections to the Compliance Limit. The three monitored data points (i.e., monthly average monitored concentrations) that are not presented on the plot are: 983 mg/L in February 2015, 1,500 mg/L in January 2016 and 1,160 mg/L in February 2016. Model projections at FR_FRCP1 reflect fully mixed conditions, whereas monitoring data collected during low flow periods reflect primarily the quality of Cataract Creek water; hence, the difference between model projections and monitored concentrations during low flow periods.

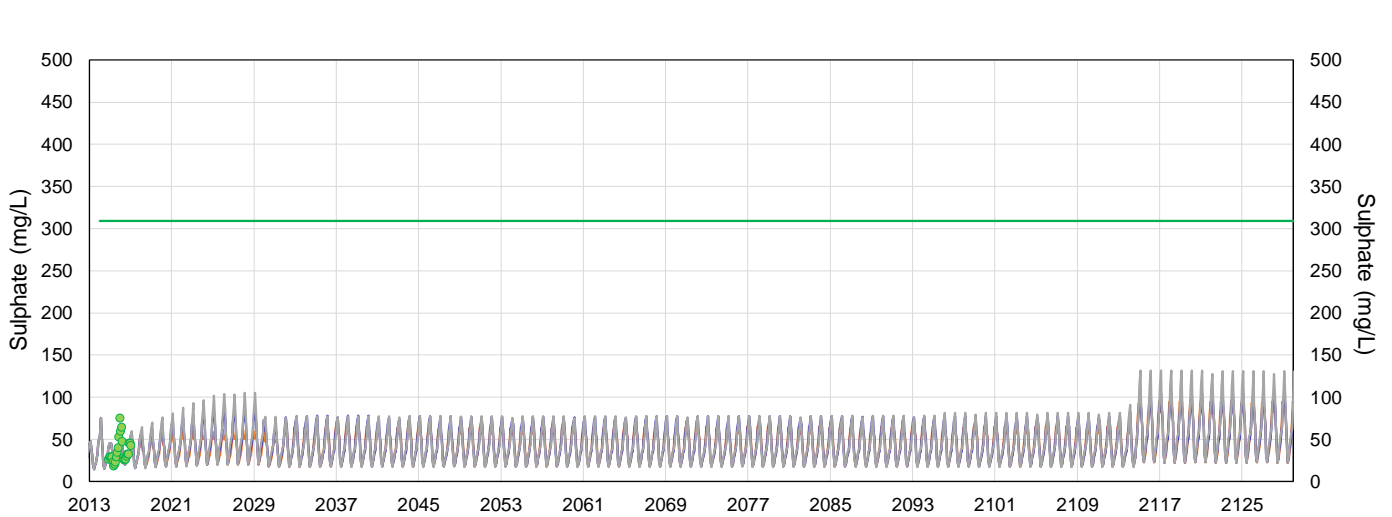


Note: Projected concentrations are presented at Fording River above Chauncey Creek (FR_FRABCH), because it is the location proposed for the new Fording River Operations Compliance Point.

(c) LCO Compliance Point (LC_LCDSSLCC; E297110)



(d) GHO Elk River Compliance Point (GH_ERC; E300090)

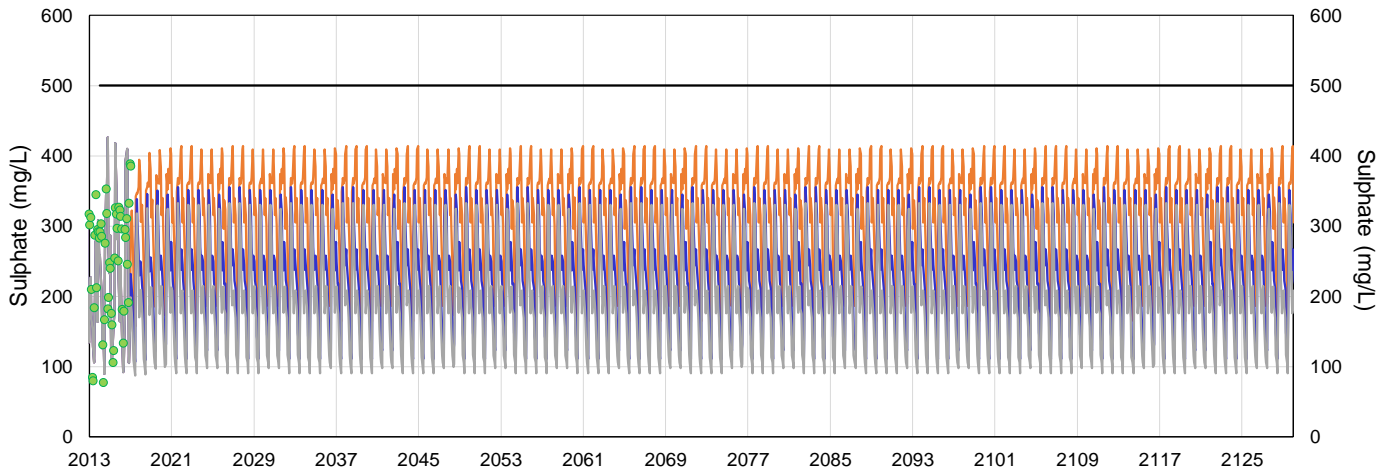
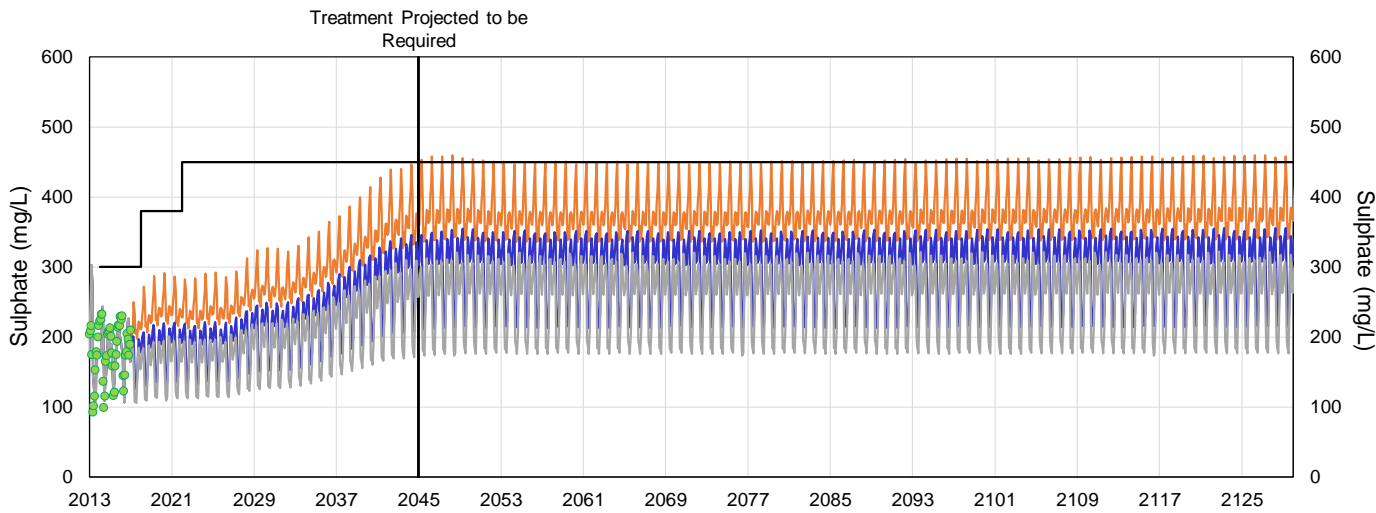


Note: Projected concentrations decrease in 2030, because mining in Cougar South Pit at GHO is modelled to be completed by the end of 2029, after which the pit is modelled to fill. Cougar South Pit is estimated to spill in 2115.

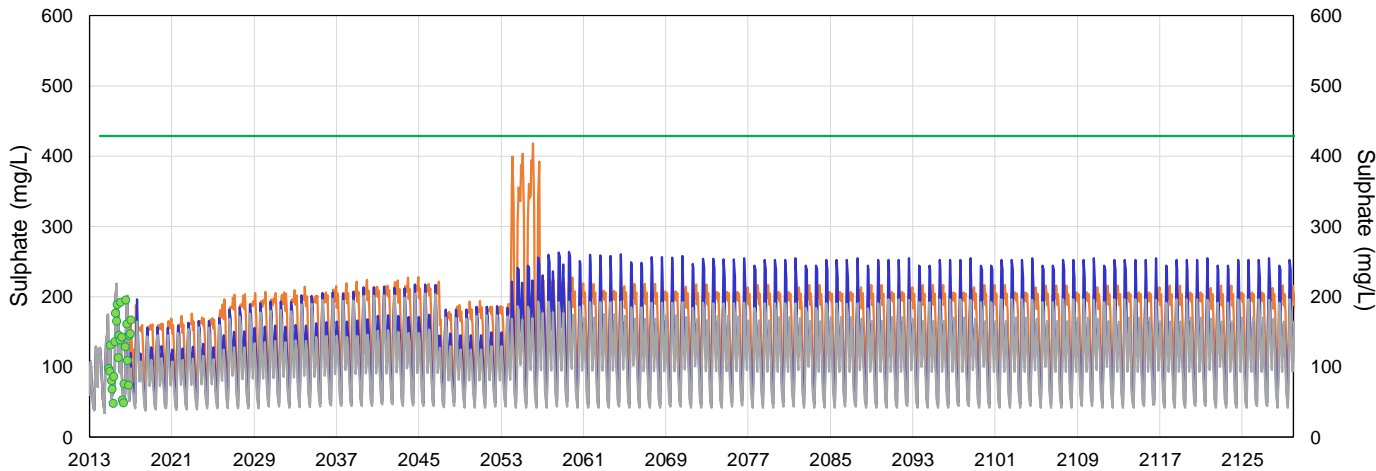
Figure 3-6 Projected Monthly Average Concentrations of Sulphate at Compliance Points between 2013 and 2130 for the Permitted Development Scenario (Continued)

(e) EVO Harmer Compliance Point (EV_HC1; E102682)

(f) CMO Compliance Point (CM_MC2; E258937)



(g) EVO Michel Creek Compliance Point (EV_MC2; E300091)



Note: Mining in Natal Pit is modelled to be completed by the end of 2046. From 2047 to the end of 2053, Natal Pit is modelled to fill. From 2054 onward, water volume in Natal Pit is modelled to be actively managed (i.e., water from the pit is pumped to the EVO AWTF). Projected concentrations in Michel Creek increase from 2054 to 2056 under low flows (orange line), because the water quality in Natal Pit once full is representative of average flow conditions (i.e., the pit was modelled to fill with average flows and corresponding average water quality). Consequently, the water pumped from the pit to the AWTF immediately after filling contains elevated sulphate concentrations relative to those that would otherwise occur under low flow conditions; hence, the projected increase in sulphate concentrations from 2054 to 2056. After 2056, pumping rates are sufficient under low flow conditions to keep the pit empty, which produces the projected decrease in sulphate concentrations.

Table 3-4 **Projected Hardness Concentrations used to Calculate the Site Performance Objective for Nitrate in the Fording River downstream of Line Creek (LC_LC5; 0200028) for the Permitted Development Scenario**

Year	Hardness (mg/L)	Year	Hardness (mg/L)	Year	Hardness (mg/L)	Year	Hardness (mg/L)	Year	Hardness (mg/L)	Year	Hardness (mg/L)
2020	587	2040	679	2060	727	2080	723	2100	733	2120	565
2021	582	2041	676	2061	727	2081	724	2101	572	2121	562
2022	564	2042	675	2062	728	2082	733	2102	555	2122	556
2023	655	2043	687	2063	728	2083	733	2103	555	2123	556
2024	608	2044	689	2064	732	2084	721	2104	553	2124	567
2025	619	2045	678	2065	721	2085	721	2105	559	2125	567
2026	338	2046	679	2066	650	2086	724	2106	559	2126	565
2027	589	2047	683	2067	733	2087	724	2107	557	2127	562
2028	632	2048	685	2068	744	2088	733	2108	558	2128	556
2029	633	2049	718	2069	723	2089	733	2109	557	2129	567
2030	641	2050	477	2070	723	2090	572	2110	556	2130	567
2031	654	2051	439	2071	732	2091	570	2111	557		
2032	670	2052	438	2072	732	2092	574	2112	560		
2033	673	2053	583	2073	720	2093	733	2113	560		
2034	579	2054	647	2074	720	2094	733	2114	559		
2035	581	2055	659	2075	691	2095	734	2115	564		
2036	587	2056	661	2076	691	2096	554	2116	562		
2037	678	2057	662	2077	732	2097	554	2117	560		
2038	683	2058	728	2078	732	2098	553	2118	566		
2039	686	2059	729	2079	721	2099	733	2119	567		

mg/L = milligrams per litre.

4 Projected Influent Concentrations and Load Reductions at the Proposed Active Water Treatment Facilities

Projected monthly average influent concentrations of nitrate, selenium and sulphate for each AWTF for the Planned Development Scenario and the Permitted Development Scenario are shown in Table 4-1. The summary statistics represent the average, minimum, and maximum projected monthly average concentrations from the fully effective dates of the AWTFs to the end of the planning period (i.e., 2037 for the Planned Development Scenario; 2053 for the Permitted Development Scenario). Table 4-1 also includes projected monthly average loads of nitrate and selenium removed by each AWTF for the Planned Development Scenario and Permitted Development Scenario. Monthly hydrographs of the flows available for treatment are provided in Appendix A.

Table 4-1 Projected Influent Concentrations and Load Reductions at the Active Water Treatment Facilities

Treatment Facility	Constituent	Planned Development Scenario ^(a,b)		Permitted Development Scenario ^(a,c)	
		Monthly Average Influent Concentration ^(d)	Monthly Average Load Reduction (kg/d)	Monthly Average Influent Concentration ^(d)	Monthly Average Load Reduction (kg/d)
Fording River South	Nitrate	43 (10 - 87)	542 (205 - 1,310)	29 (0.67 - 86)	400 (<1 - 1,310)
	Selenium	576 (352 - 778)	7.9 (4.2 - 20)	543 (352 - 815)	10 (4.3 - 21)
	Sulphate	1,510 (762 - 2,080)	-	1,380 (789 - 2,070)	-
Fording River North	Nitrate	29 (18 - 57)	672 (283 - 1,640)	24 (3.5 - 63)	540 (66.8 - 1,830)
	Selenium	160 (104 - 251)	3.4 (1.3 - 6.9)	249 (105 - 391)	5.8 (1.5 - 14)
	Sulphate	525 (334 - 798)	-	767 (323 - 1,260)	-
West Line Creek	Nitrate	16 (0.21 - 36)	251 (<1 - 744)	9.6 (0.051 - 36)	156 (<1 - 744)
	Selenium	249 (125 - 352)	3.8 (0.64 - 9.5)	244 (125 - 352)	5.1 (0.64 - 9.6)
	Sulphate	859 (426 - 1,260)	-	895 (426 - 1,280)	-
LCO Dry Creek	Nitrate	-	-	69 (16 - 160)	191 (64.9 - 387)
	Selenium	-	-	577 (254 - 877)	1.8 (0.58 - 4.3)
	Sulphate	-	-	1,660 (1,120 - 1,830)	-
Elkview	Nitrate	49 (31 - 64)	1,330 (582 - 1,740)	42 (9.5 - 69)	1,180 (292 - 1,740)
	Selenium	304 (196 - 429)	8.1 (3.5 - 13)	386 (189 - 542)	11 (3.2 - 20)
	Sulphate	1,080 (845 - 1,250)	-	1,040 (728 - 1,250)	-
Greenhills	Nitrate	19 (13 - 26)	82 (53 - 92)	5.9 (3.3 - 20)	19 (6.4 - 87)
	Selenium	339 (203 - 443)	1.5 (0.91 - 1.9)	311 (194 - 386)	1.5 (0.87 - 1.8)
	Sulphate	1,900 (1,220 - 2,170)	-	1,810 (1,210 - 2,070)	-

(a) Values presented are the projected mean (minimum – maximum) monthly average concentrations/loads under average flow conditions.

(b) Timeframe considered is from the year when the AWTF is fully effective and operational to 2037.

(c) Timeframe considered is from the year when the AWTF is fully effective and operational to 2053.

(d) Influent concentrations for selenium are reported in micrograms per litre. Influent concentrations for nitrate and sulphate are reported in milligrams per litre.

AWTF = active water treatment facility; LCO = Line Creek Operations; kg/d = kilograms per day; < = less than.

5 References

Teck Coal Limited (Teck). 2014. *Elk Valley Water Quality Plan*. Prepared by Teck Coal Limited and submitted to the British Columbia Minister of Environment. July 2014.

Teck. 2017. *2017 Elk Valley Regional Water Quality Model Update Overview Report*. Prepared by Teck Coal Limited and submitted to the British Columbia Minister of Environment. October 31, 2017.

Appendix A – Hydrographs of Water Available for Treatment

July 2019

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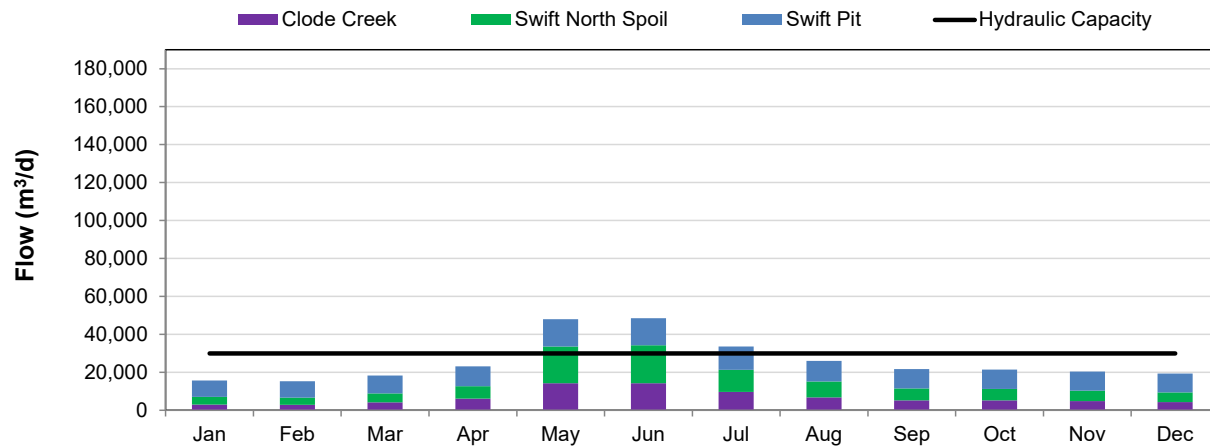
Figure A–1:	Monthly Hydrographs of Flows Available for Treatment at Fording River Operations North Active Water Treatment Facility for the Permitted Development Scenario	1
Figure A–2:	Monthly Hydrographs of Flows Available for Treatment at Fording River Operations South Active Water Treatment Facility for the Permitted Development Scenario.....	2
Figure A–3:	Monthly Hydrographs of Flows Available for Treatment at Greenhills Operations Active Water Treatment Facility for the Permitted Development Scenario	3
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Figure A–5:	Monthly Hydrographs of Flows Available for Treatment at Line Creek Operations Dry Creek Active Water Treatment Facility for the Permitted Development Scenario	5
Figure A–6:	Monthly Hydrographs of Flows Available for Treatment at Elkview Operations Active Water Treatment Facility for the Permitted Development Scenario	6

Monthly hydrographs of the flows available for treatment at each active water treatment facility for the Permitted Development Scenario are shown in Figures A-1 to A-6. The projections are presented as stacked column plots. For reference, the hydrographs are plotted along with the treatment capacities identified for the 2019 Implementation Plan Adjustment (IPA).

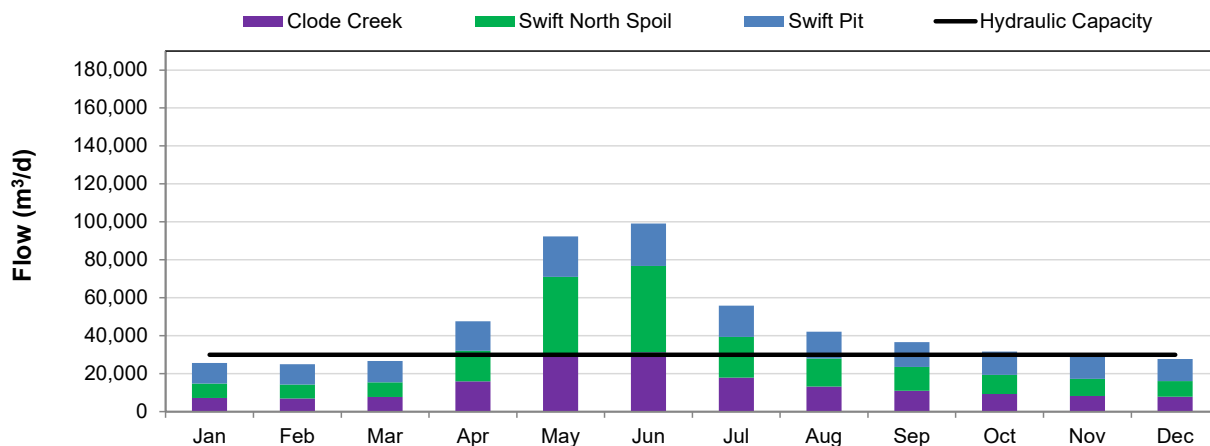
The monthly hydrographs are shown for the first year that each active water treatment facility is fully effective and operational under low, average, and high flows. The hydrographs are based on the assumption that clean-water diversions have been implemented, but do not account for surface water availabilities or intake efficiencies in the water management system.

Figure A-1: Monthly Hydrographs of Flows Available for Treatment at Fording River Operations North Active Water Treatment Facility for the Permitted Development Scenario

(a) Low Flows



(b) Average Flows



(c) High Flows

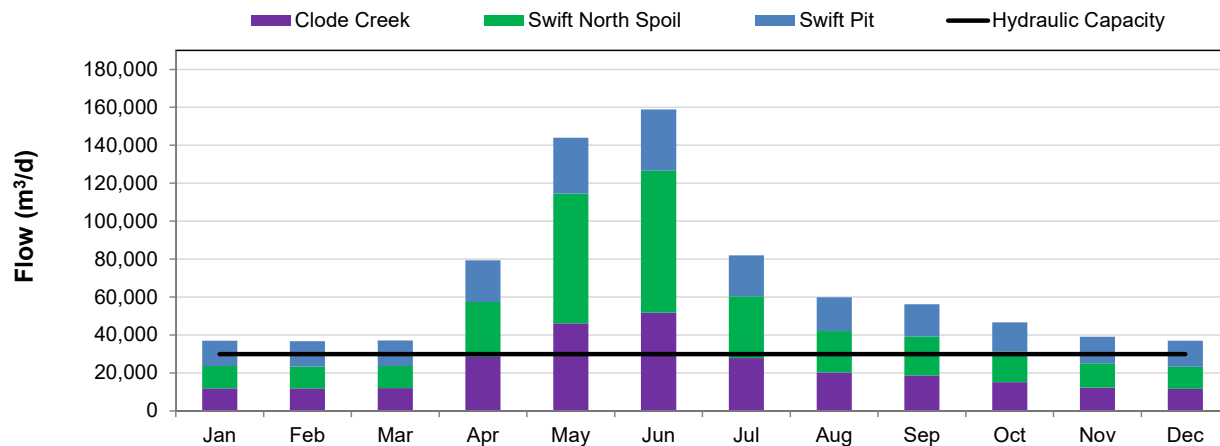
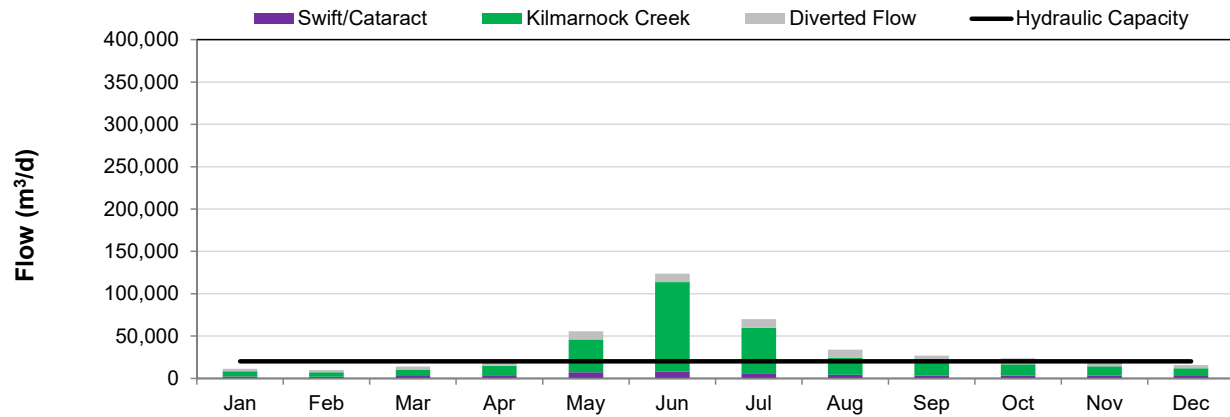
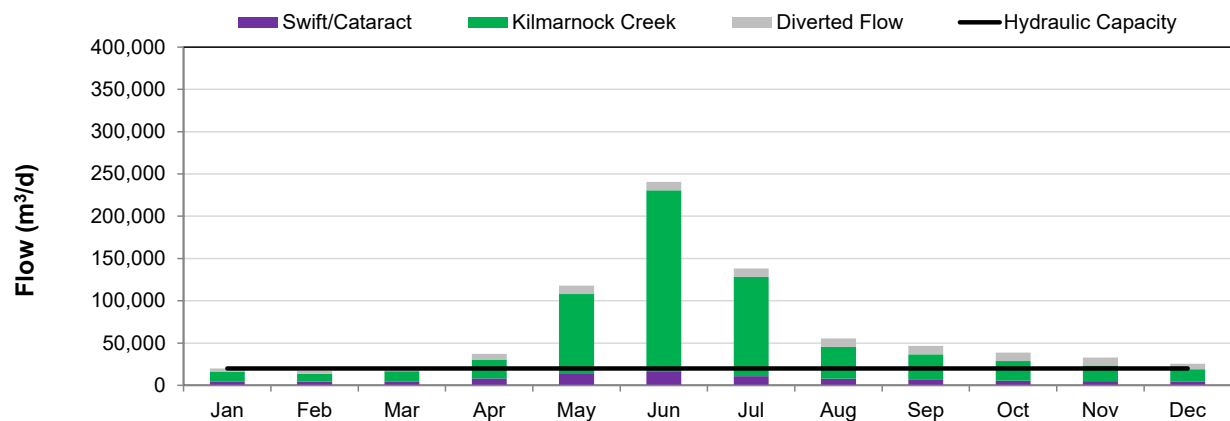


Figure A-2: Monthly Hydrographs of Flows Available for Treatment at Fording River Operations South Active Water Treatment Facility for the Permitted Development Scenario

(a) Low Flows



(b) Average Flows



(c) High Flows

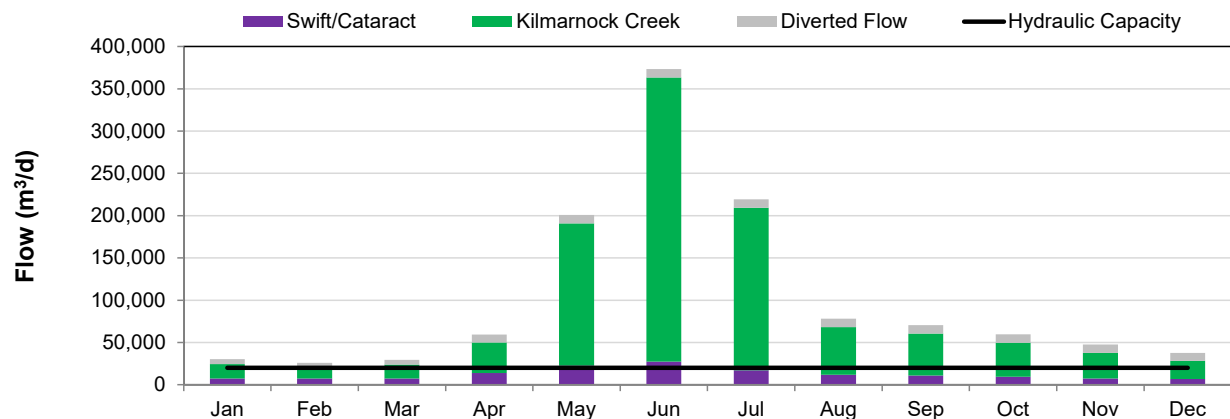
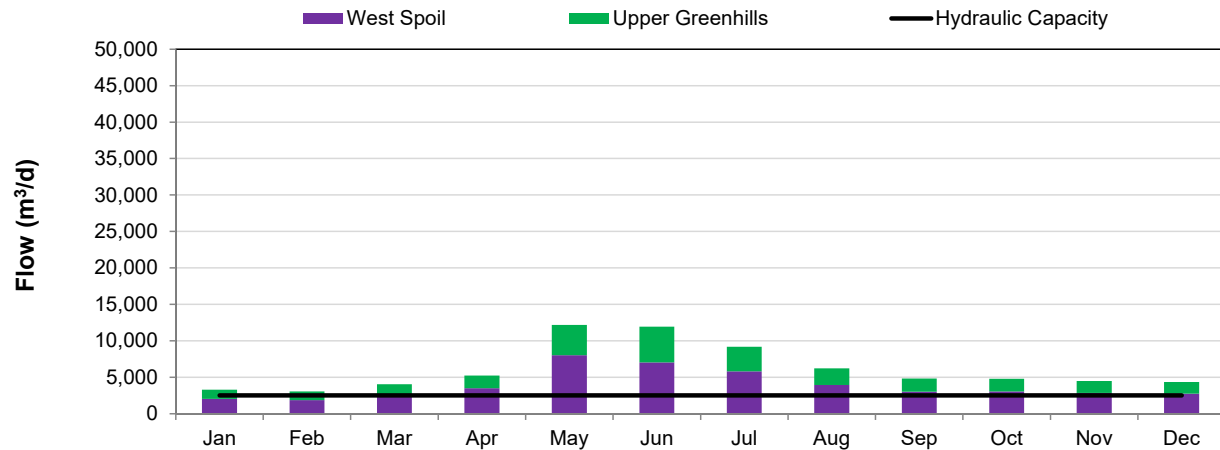
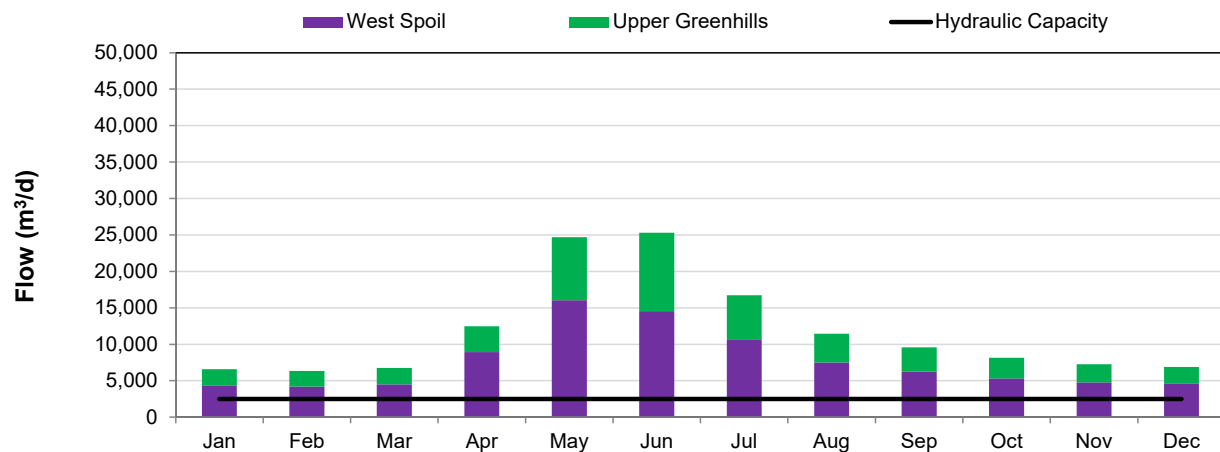


Figure A-3: Monthly Hydrographs of Flows Available for Treatment at Greenhills Operations Active Water Treatment Facility for the Permitted Development Scenario

(a) Low Flows



(b) Average Flows



(c) High Flows

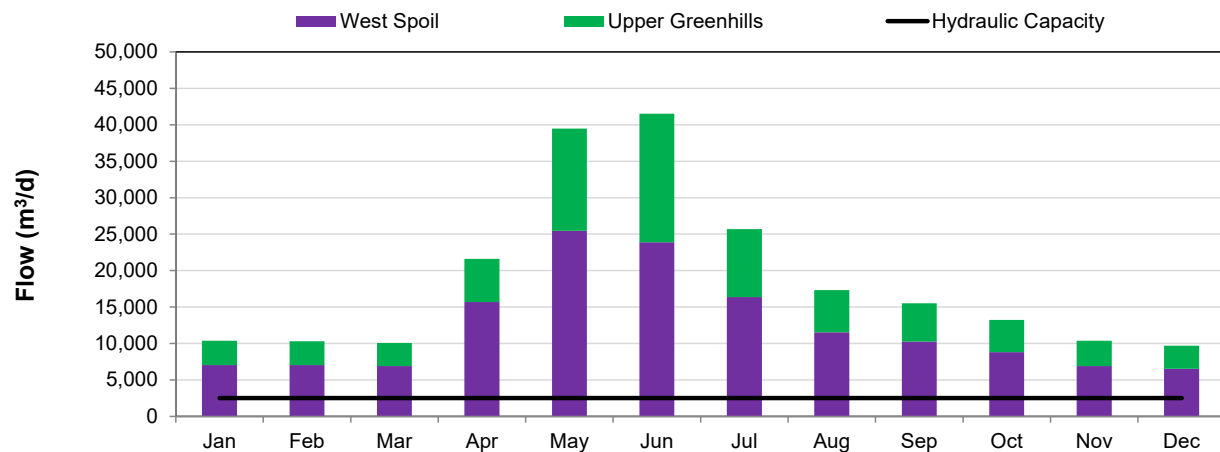
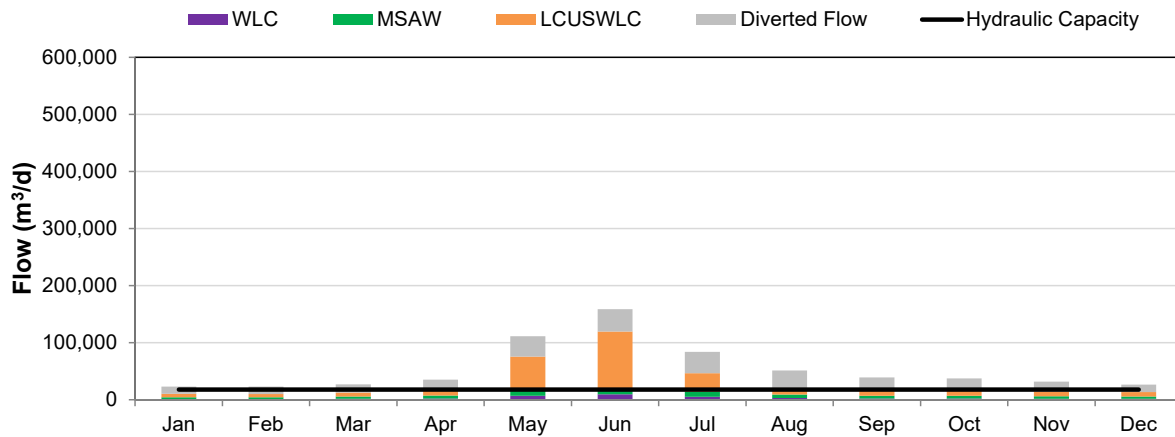
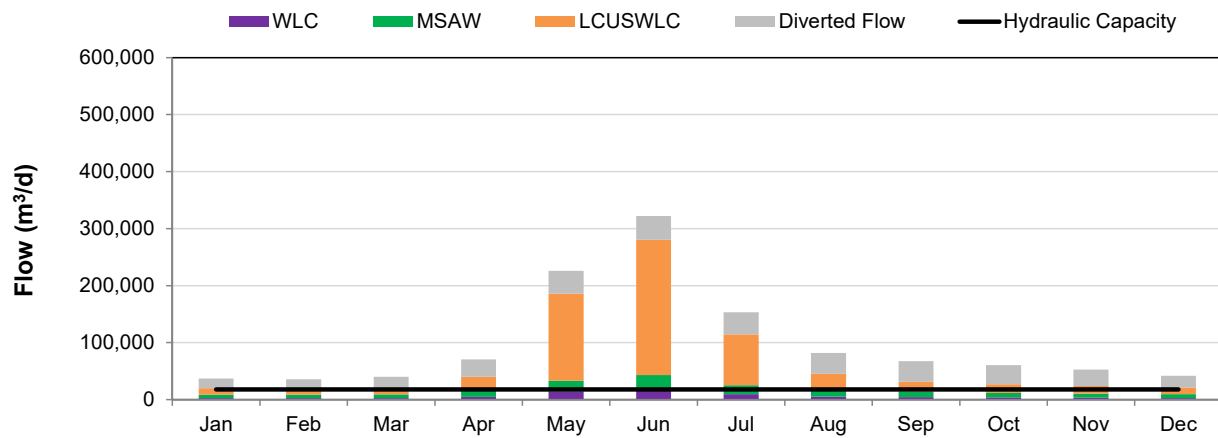


Figure A-4: Monthly Hydrographs of Flows Available for Treatment at Line Creek Operations West Line Creek Active Water Treatment Facility for the Permitted Development Scenario

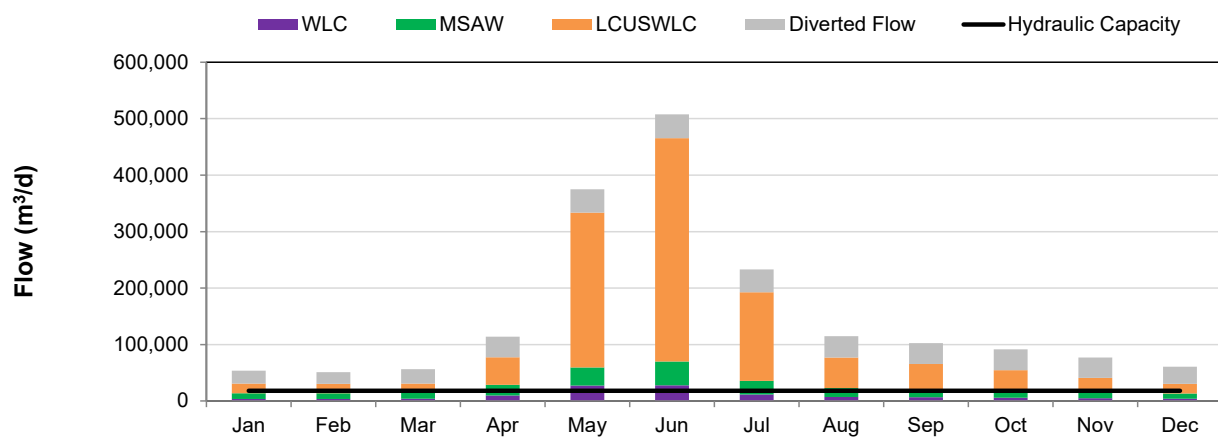
(a) Low Flows



(b) Average Flows



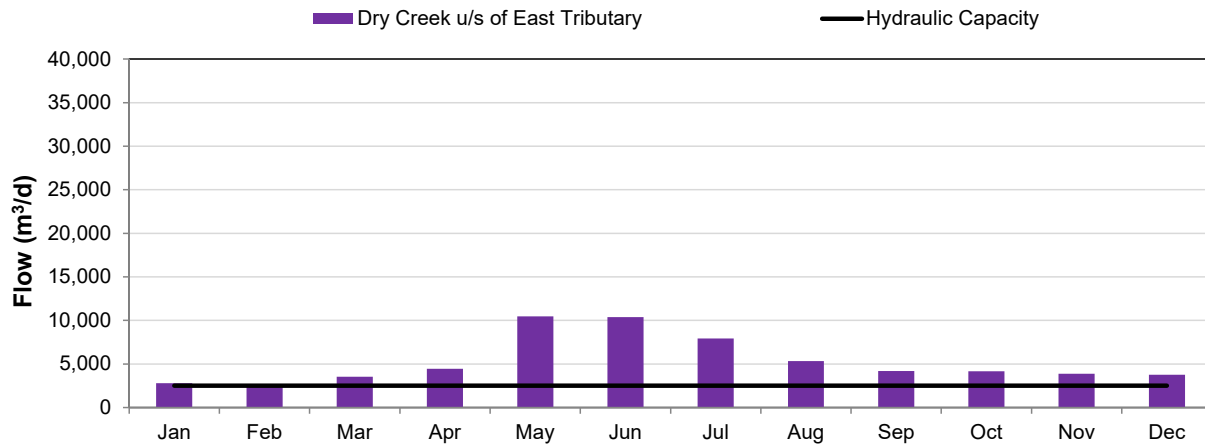
(c) High Flows



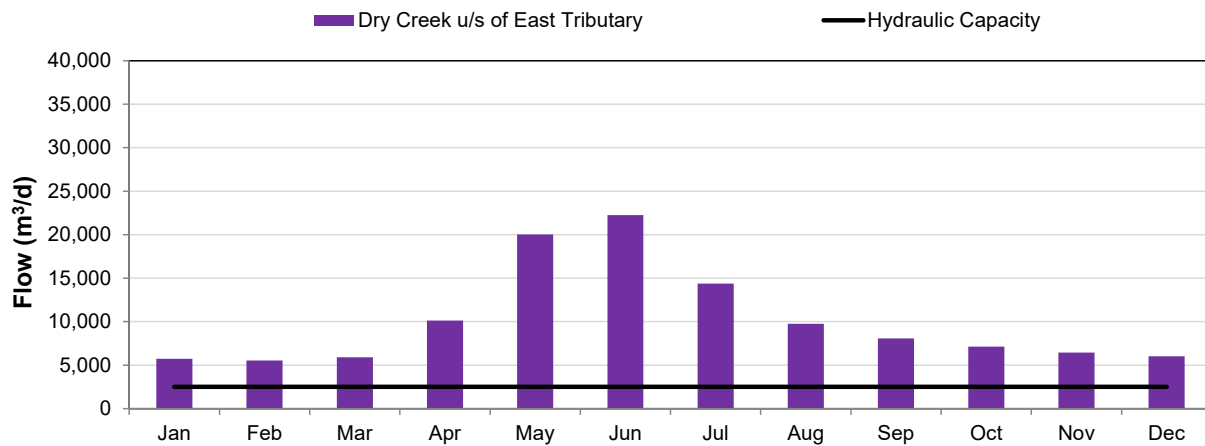
Note: WLC = West Line Creek; MSAW = Mine Services Area West; LCUSWLC = Line Creek upstream of West Line Creek

Figure A-5: Monthly Hydrographs of Flows Available for Treatment at Line Creek Operations Dry Creek Active Water Treatment Facility for the Permitted Development Scenario

(a) Low Flows



(b) Average Flows



(c) High Flows

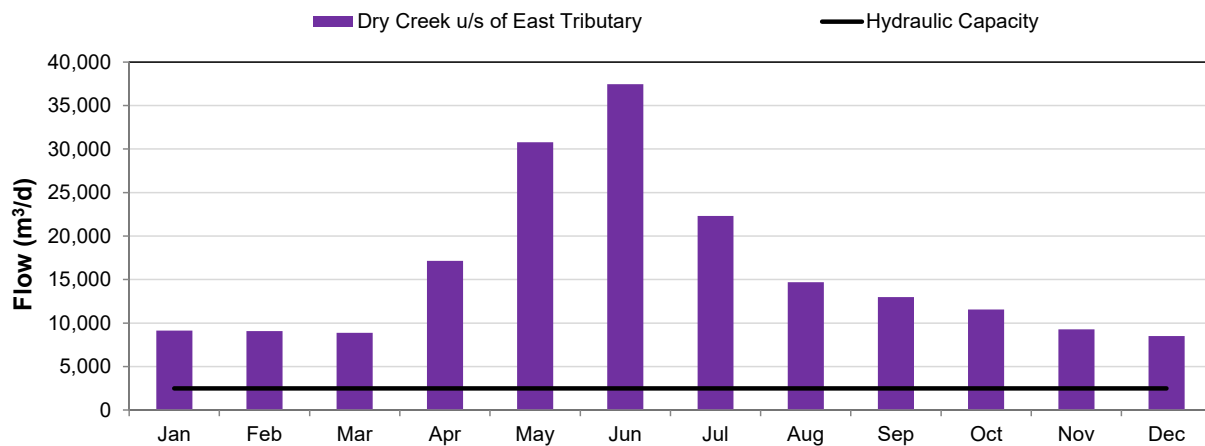
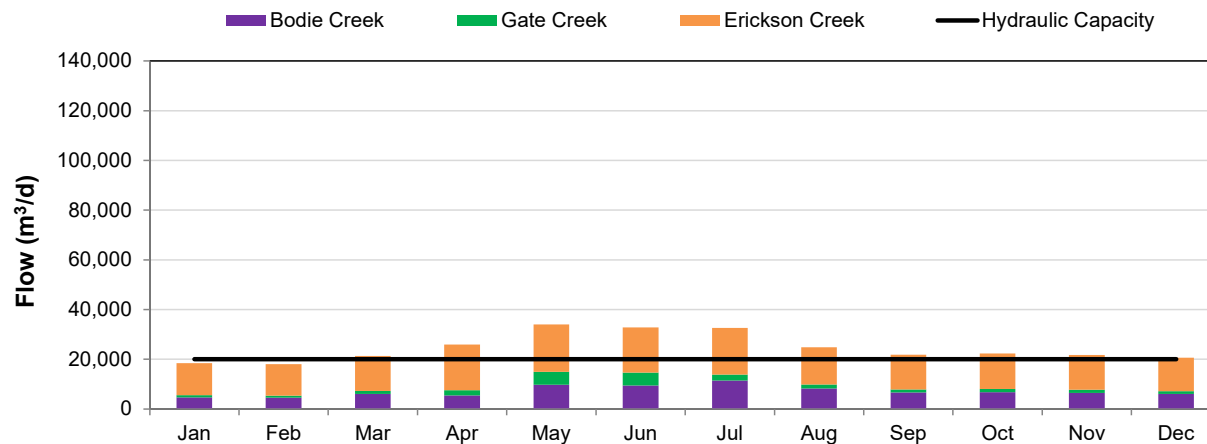
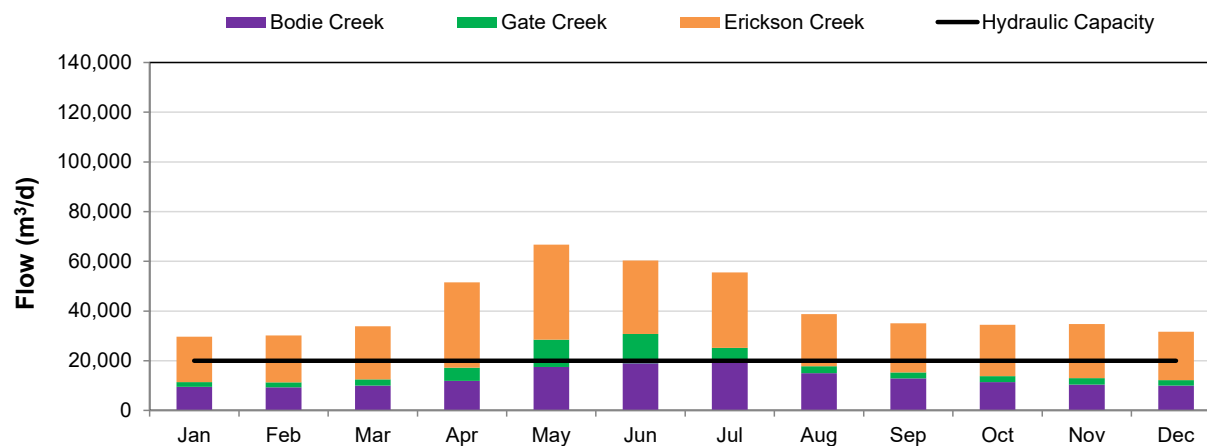


Figure A-6: Monthly Hydrographs of Flows Available for Treatment at Elkview Operations Active Water Treatment Facility for the Permitted Development Scenario

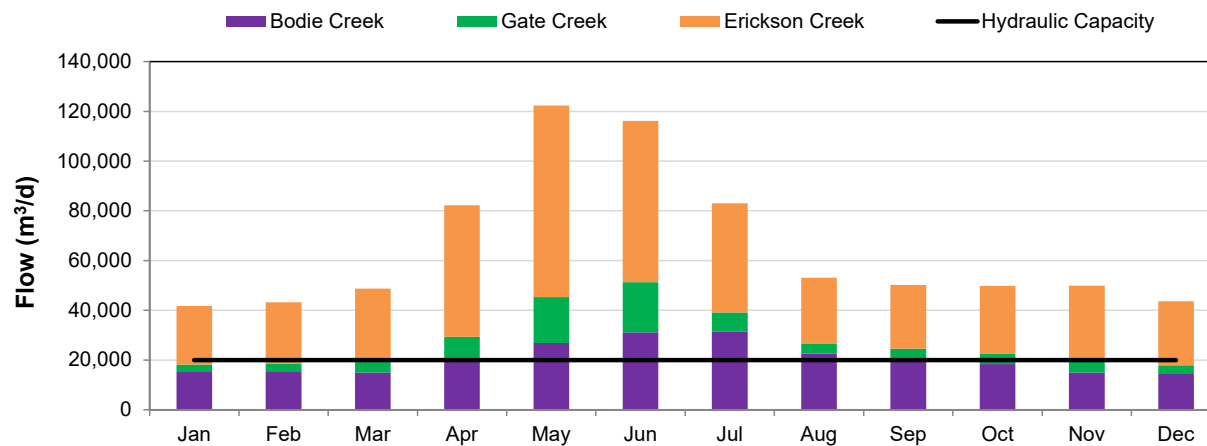
(a) Low Flows



(b) Average Flows



(c) High Flows



Appendix B – Projected Concentrations of Selenium without Ongoing Improvements to Effluent Selenium Concentrations

July 2019

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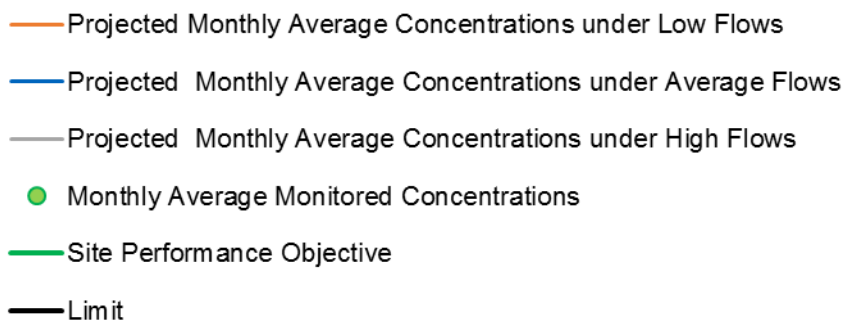
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Figure B-2	Projected Monthly Average Concentrations of Selenium at Compliance Points between 2013 and 2053 for the Permitted Development Scenario without Ongoing Improvements to Effluent Selenium Concentrations	6

Selenium effluent concentrations are expected to decrease over time as Teck gains experience operating biologically-based active water treatment facilities in the Elk Valley. This expectation is reflected in the 2019 IPA by assuming that selenium effluent concentrations decrease over time, as outlined in Annex C and discussed in Section 2 of the main report. The influence of this assumption on projected selenium concentrations is outlined herein. More specifically, monthly average concentrations of selenium projected to be above Site Performance Objective (SPOs) and/or Compliance Limits for the Permitted Development Scenario with and without the assumed improvement in effluent selenium concentrations are summarized in Table B-1.

Projected monthly average concentrations of selenium at Order Stations and compliance points for the Permitted Development Scenario without the assumed improvement in effluent selenium concentrations are shown in Figures B-1 and B-2, respectively. The projections are presented as time series plots. The solid orange, blue and grey lines correspond to the projected monthly concentrations under low, average and high flows. The figures include SPOs, Compliance Limits, historical observations (green points) and fully effective dates (vertical lines) for the AWTFs.

The x-axis in Figures B-1 and B-2 runs from the start of 2013 to the end of 2053. The calibration period for the RWQM is January 1, 2004 to December 31, 2016. Therefore, projected concentrations shown in solid gray prior to 2017 correspond to the monthly average concentrations projected to occur each year under observed flow conditions. Year 2053 corresponds to the time in the model at which all the waste rock considered in the Permitted Development Scenario has been deposited and the lag associated with that rock has passed (i.e., all the waste rock is contributing selenium and sulphate load).

The legend below applies to all time series plots in this appendix.



Projected monthly average selenium concentrations above SPOs are the same with and without the assumed improvement in effluent selenium concentrations, with two exceptions. The two exceptions involve monthly average selenium concentrations that are projected to be above long-term SPOs at the following Order Stations without the assumed improvement in effluent selenium concentrations:

- Fording River downstream of Greenhills Creek (GH_FR1; 0200378) in 2048 and 2049
- Fording River downstream of Line Creek (LC_LC5; 0200028) in 2033

In both cases, differences between projected selenium concentrations and the corresponding SPO are small, 1 to 2 µg/L (Table B-1).

Projected monthly average selenium concentrations above Compliance Limits are the same with and without the assumed improvement in effluent selenium concentrations, with three exceptions. The three exceptions involve monthly average selenium concentrations that are projected to be above Compliance Limits at the following compliance points without the assumed improvement in effluent selenium concentrations:

- FRO Compliance Point (FR_FRCP1; E300071) in 2025, 2026 and 2033
- Fording River above Chauncey (FR_FRABCH) in 2025 and 2033
- EVO Michel Creek Compliance Point (EV_MC2; E300091) in 2043

In all three cases, differences between projected selenium concentrations and the corresponding Compliance Limit are small, 2 to 3 µg/L (Table B-1).

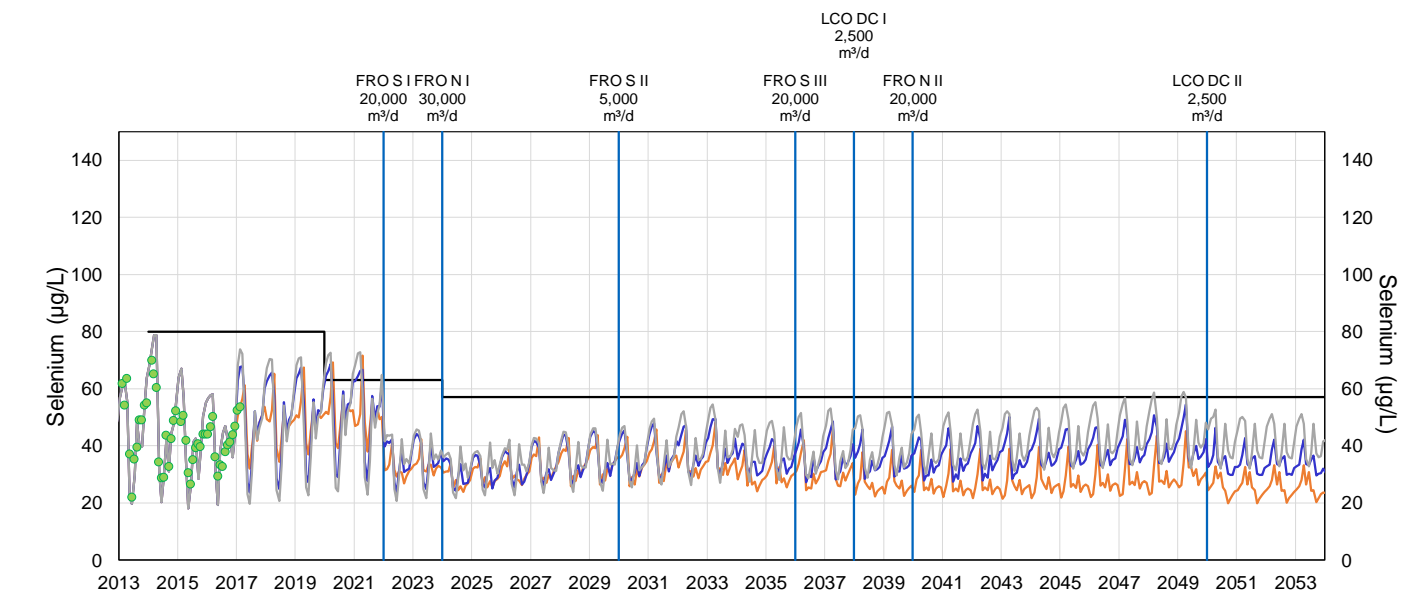
Table B-1 Summary of Projected Monthly Average Selenium Concentrations above Site Performance Objectives or Compliance Limits between 2025 and 2053 for the Permitted Development Scenario with and without Ongoing Improvements to Effluent Selenium Concentrations

Location		Corresponding Site Performance Objective / Limit (µg/L)	With Continuous Improvement in Effluent Selenium Concentrations				Without Continuous Improvement in Effluent Selenium Concentrations			
			Year	Month	Maximum Projected Concentration (µg/L)	Maximum Magnitude of Exceedance (µg/L)	Year	Month	Maximum Projected Concentration (µg/L)	Maximum Magnitude of Exceedance (µg/L)
Order Stations	Fording River downstream of Greenhills Creek (GH_FR1; 0200378) ^(a)	57	-	-	-	-	2048, 2049	March	59	2
	Fording River downstream of Line Creek (LC_LC5; 0200028)	40	-	-	-	-	2033	February, March	41	1
Compliance Points	FRO Compliance Point (FR_FRCP1; E300071)	61	-	-	-	-	2025, 2026, 2033	April	64	3
	Fording River above Chauncey Creek (FR_FRABCH)	58	2026	April	59	1	2025, 2026, 2033	April	61	3
	EVO Michel Creek Compliance Point (EV_MC2; E300091)	19	2027	August	0	1	2027, 2043	August	21	2

(a) This location is also the GHO Fording River Compliance Point.
Bolded values are different from those generated with continuous improvement in effluent selenium concentrations.
Projected monthly average selenium concentrations above Site Performance Objectives (SPOs) or Compliance Limits are presented between 2025 and 2053; 2025 corresponds to the year when ongoing improvements to effluent selenium concentrations were modelled to begin.
EVO = Elkview Operations; FRO = Fording River Operations; GHO = Greenhills Operations; LCO = Line Creek Operations; µg/L = micrograms per litre.

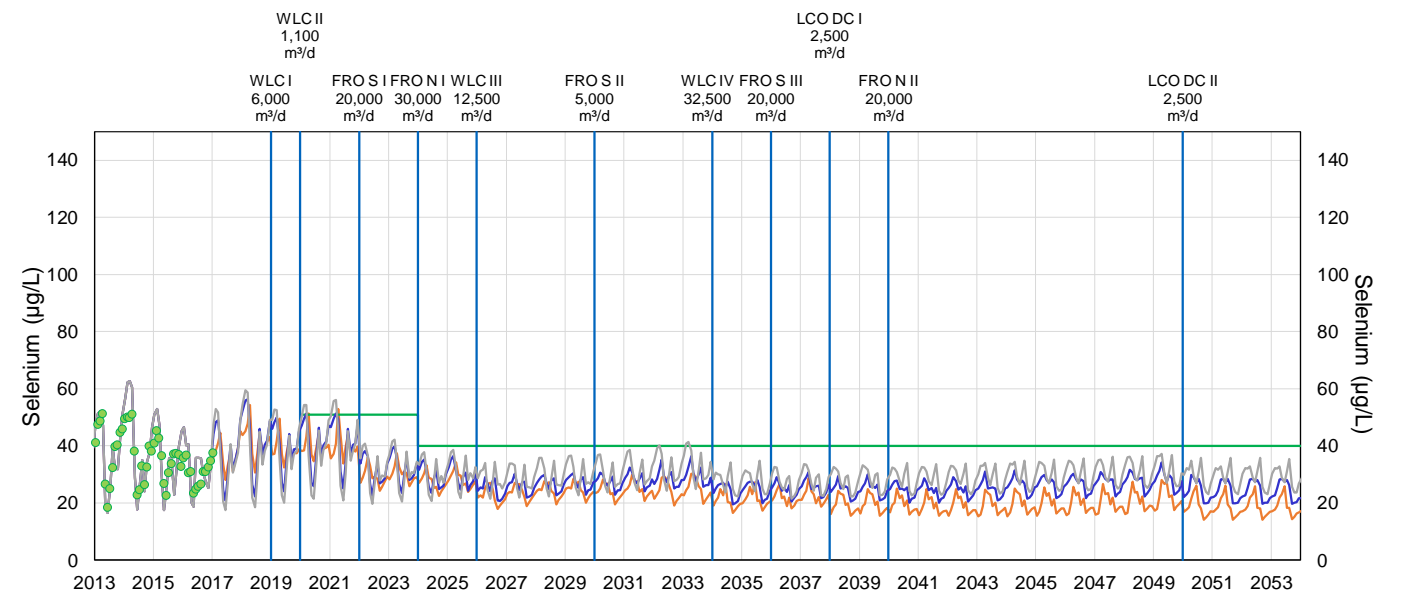
Figure B-1 Projected Monthly Average Concentrations of Selenium at Order Stations between 2013 and 2053 for the Permitted Development Scenario without Ongoing Improvements to Effluent Selenium Concentrations

(a) Fording River downstream of Greenhills Creek (GH_FR1; 0200378)

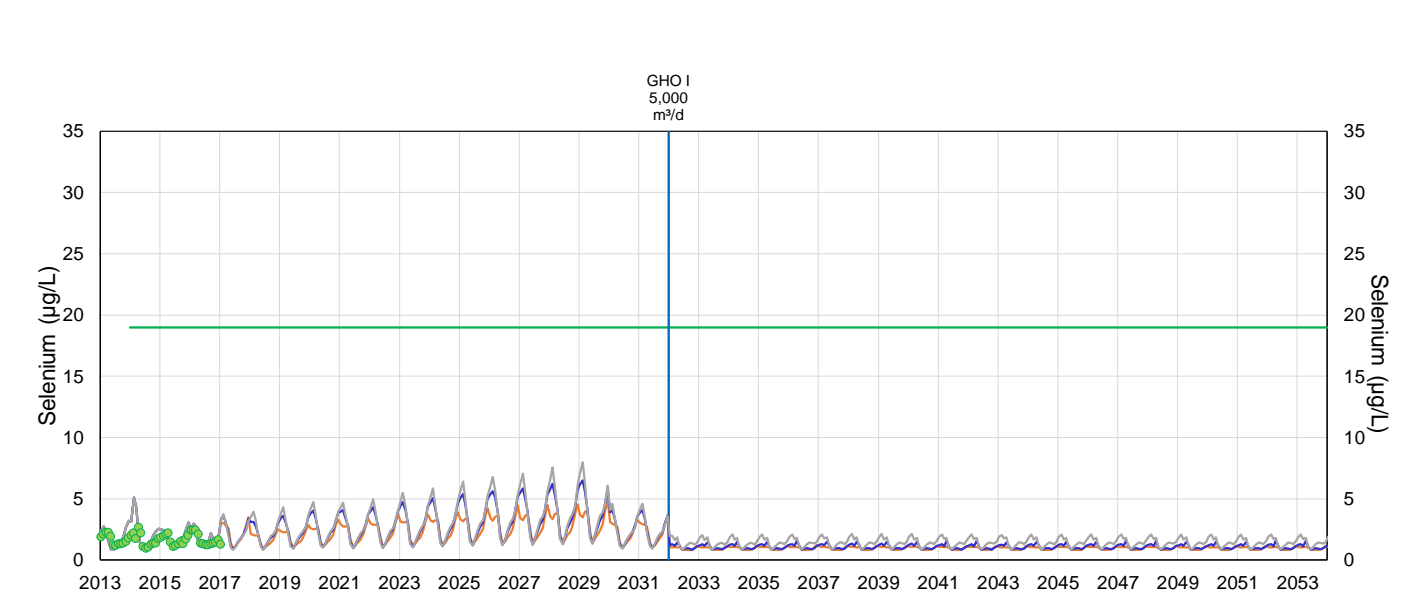


Note: This location is also the GHO Fording River Compliance Point.

(b) Fording River downstream of Line Creek (LC_LC5; 0200028)



(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)



(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)

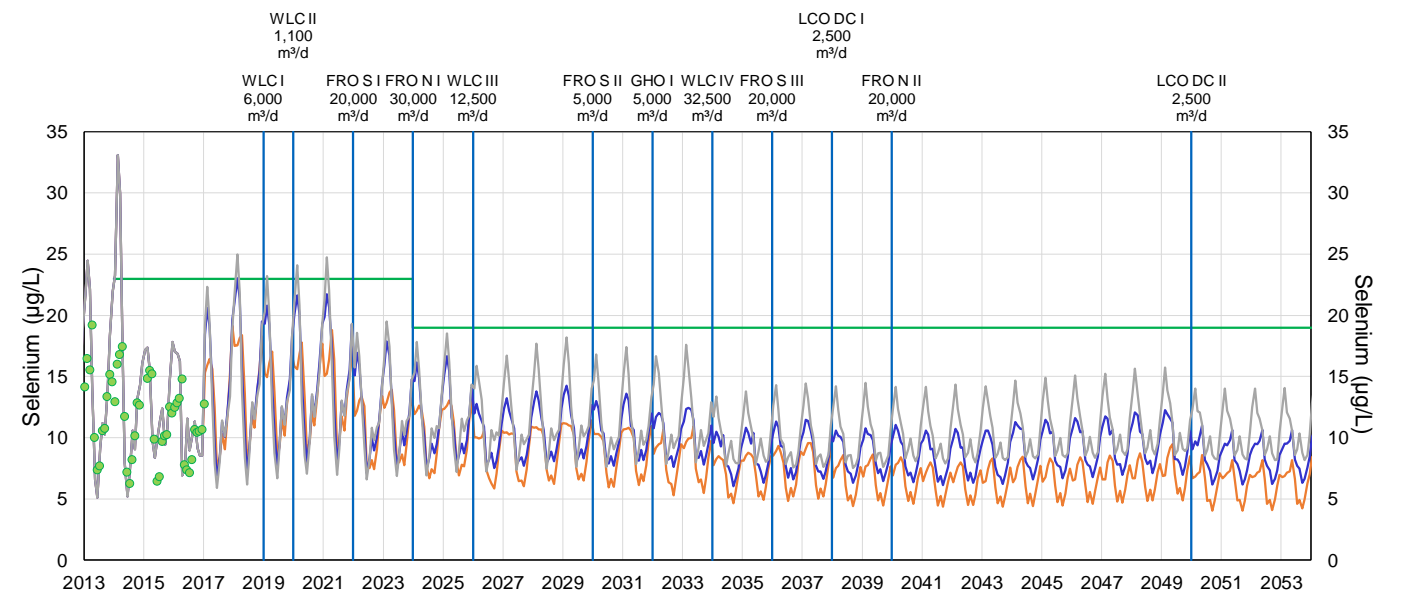
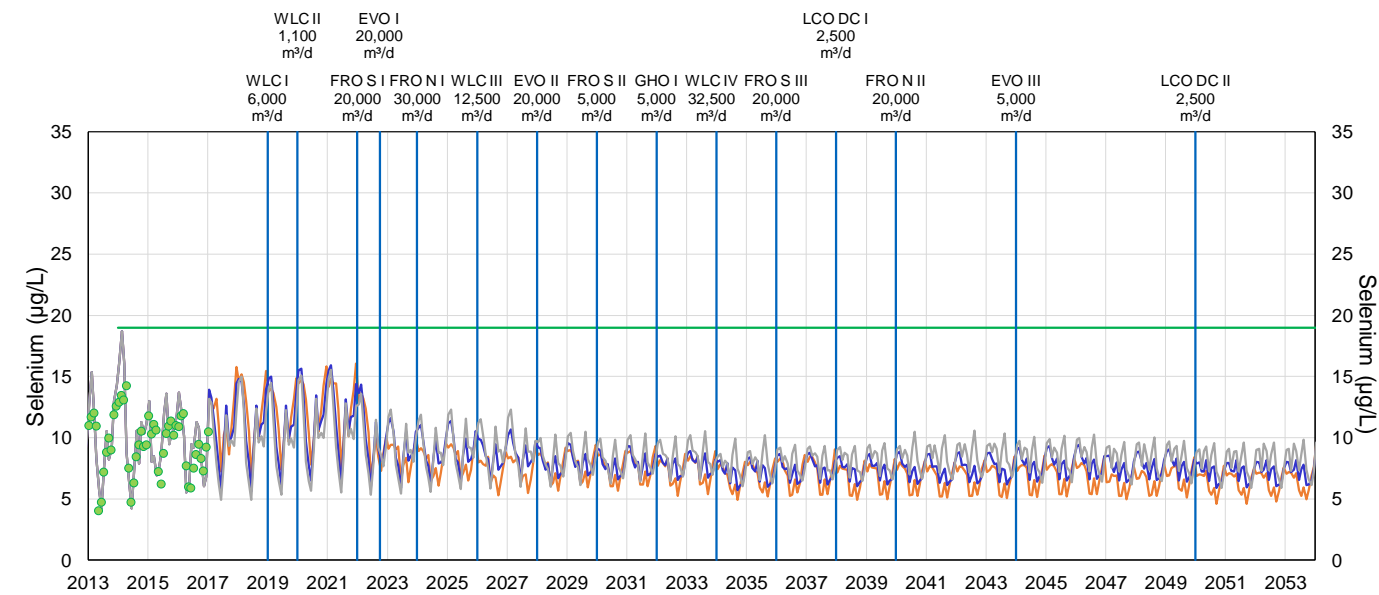
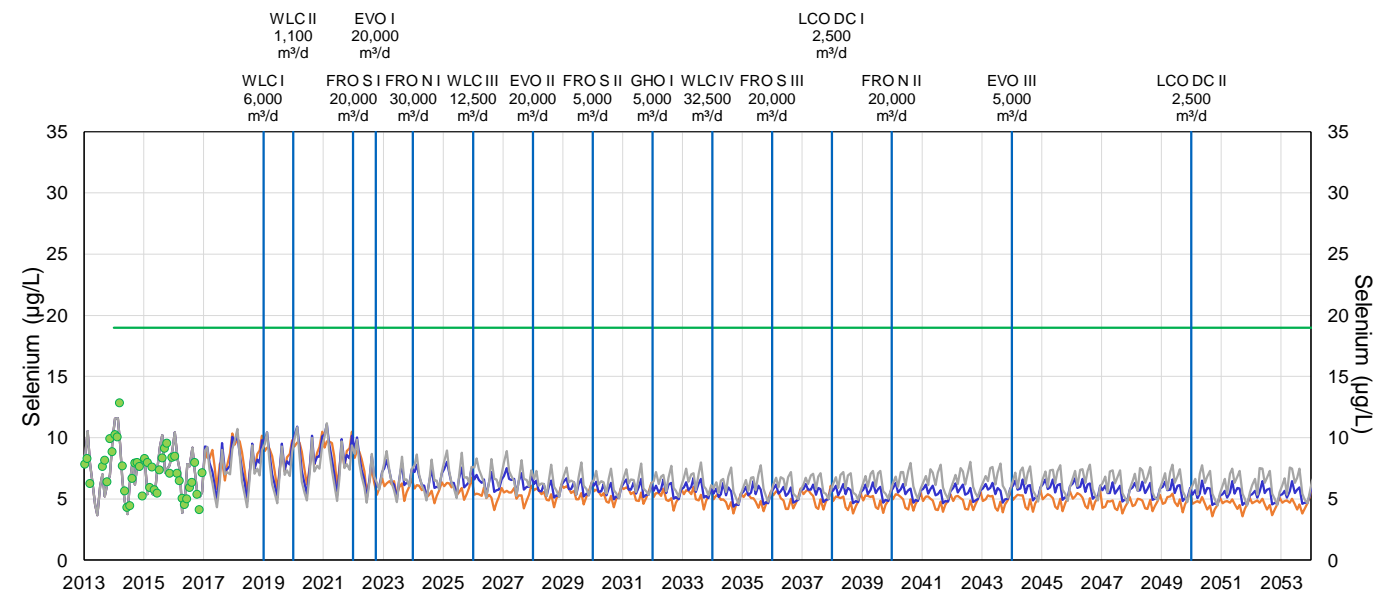


Figure B-1 Projected Monthly Average Concentrations of Selenium at Order Stations between 2013 and 2053 for the Permitted Development Scenario without Ongoing Improvements to Effluent Selenium Concentrations (Continued)

(e) Elk River downstream of Michel Creek (EV_ER1; 0200393)



(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)

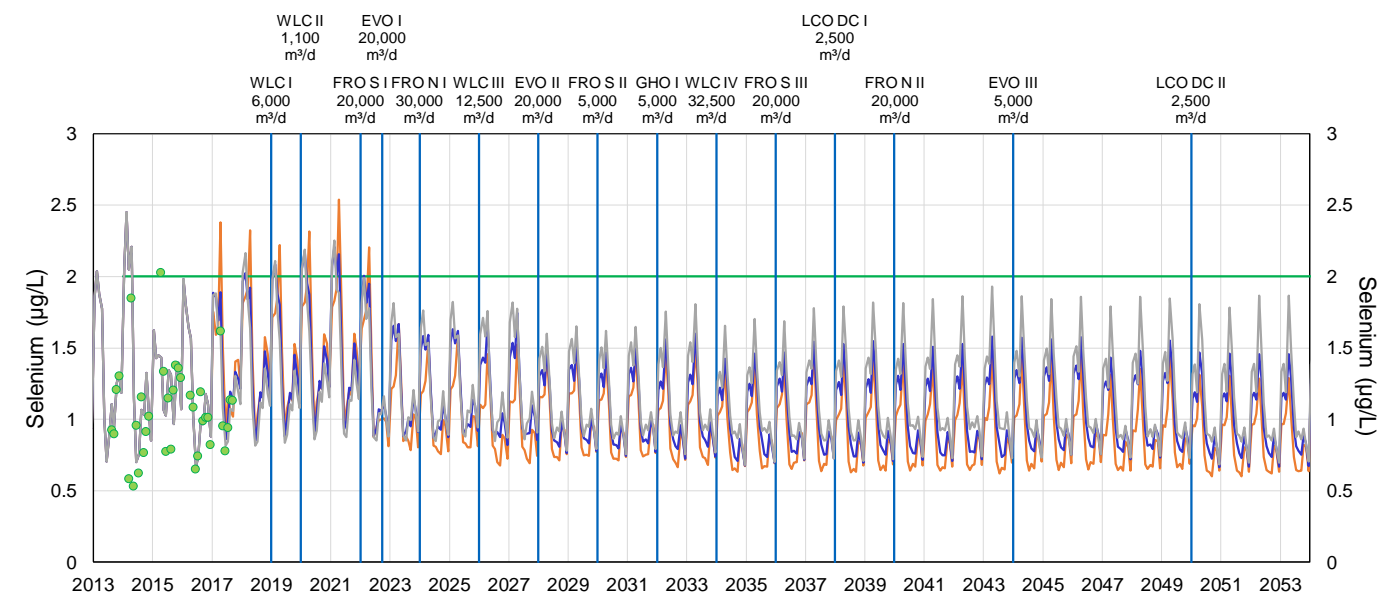
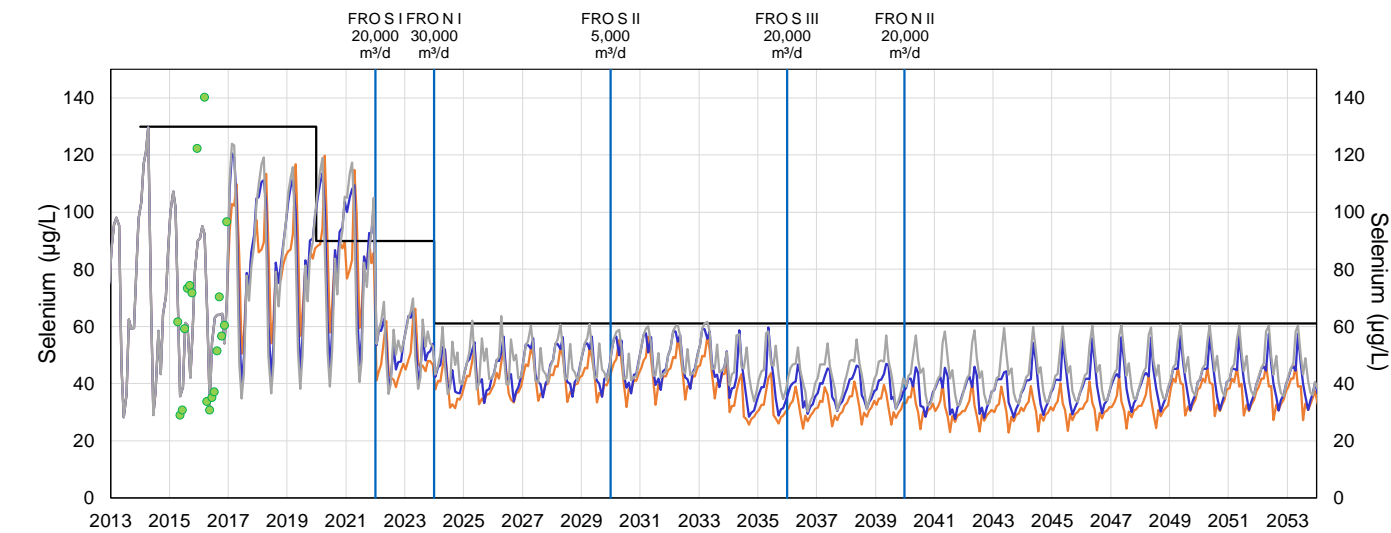


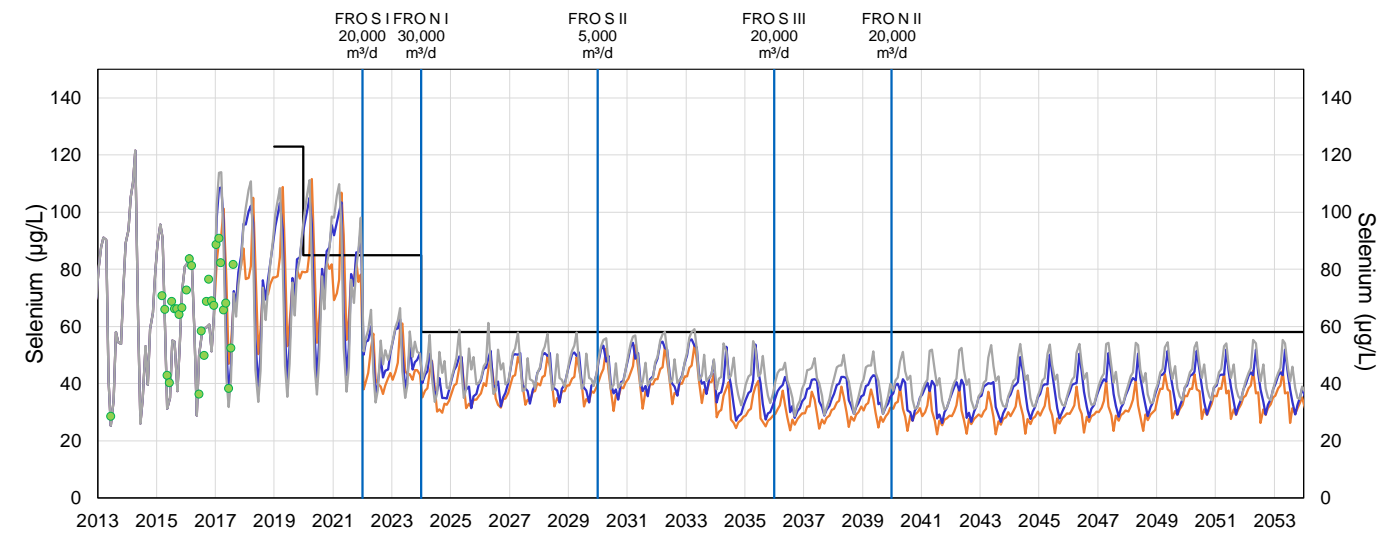
Figure B-2 Projected Monthly Average Concentrations of Selenium at Compliance Points between 2013 and 2053 for the Permitted Development Scenario without Ongoing Improvements to Effluent Selenium Concentrations

(a) FRO Compliance Point (FR_FRCP1; E300071)



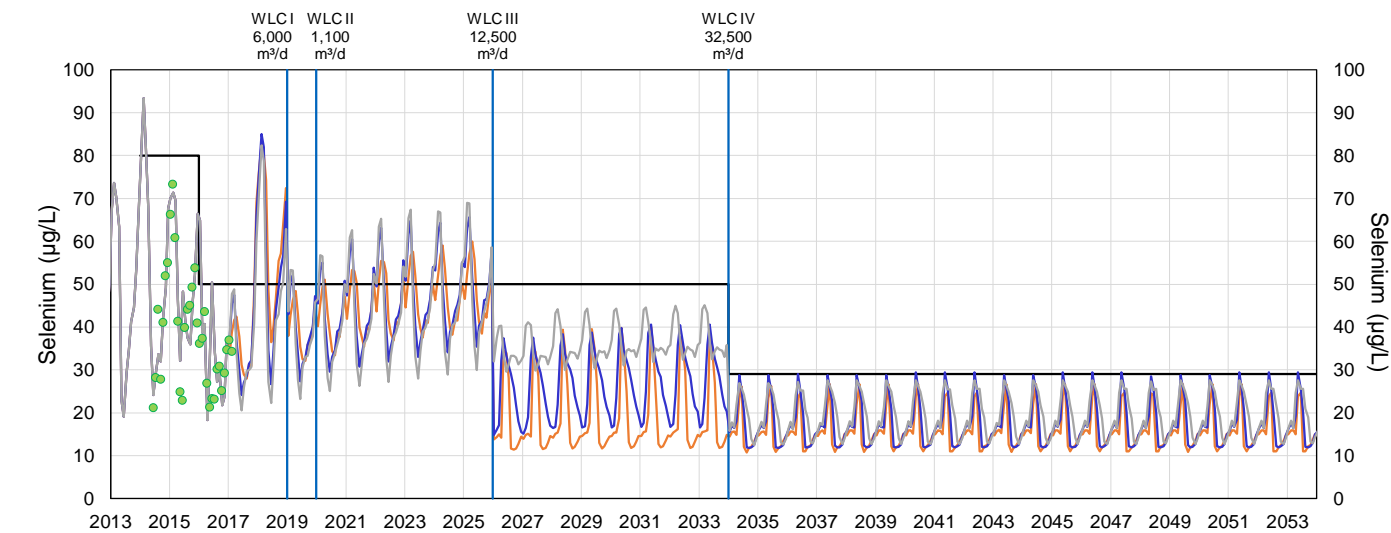
Note: At FR_FRCP1, monitored data are presented from January 2015 to December 2016. Five monitored data points are not presented on the plot, because at certain times of the year (i.e., winter) monitored concentrations at the FRO Compliance Point are not representative of concentrations in the Fording River. The five monitored data points (i.e., monthly average monitored concentrations) that are not presented on the plot are: 310 µg/L in February 2015, 229 µg/L in March 2015, 164 µg/L in November 2015, 447 µg/L in January 2016 and 316 µg/L in February 2016. Model projections at FR_FRCP1 reflect fully mixed conditions, whereas monitoring data collected during low flow periods reflect primarily the quality of Cataract Creek water; hence, the difference between model projections and monitored concentrations during low flow periods.

(b) Fording River above Chauncey Creek (FR_FRABCH)



Note: Projected concentrations are presented at Fording River above Chauncey Creek (FR_FRABCH), because it is the location proposed for the new Fording River Operations Compliance Point.

(c) LCO Compliance Point (LC_LCDSSLCC; E297110)



(d) GHO Elk River Compliance Point (GH_ERC; E300090)

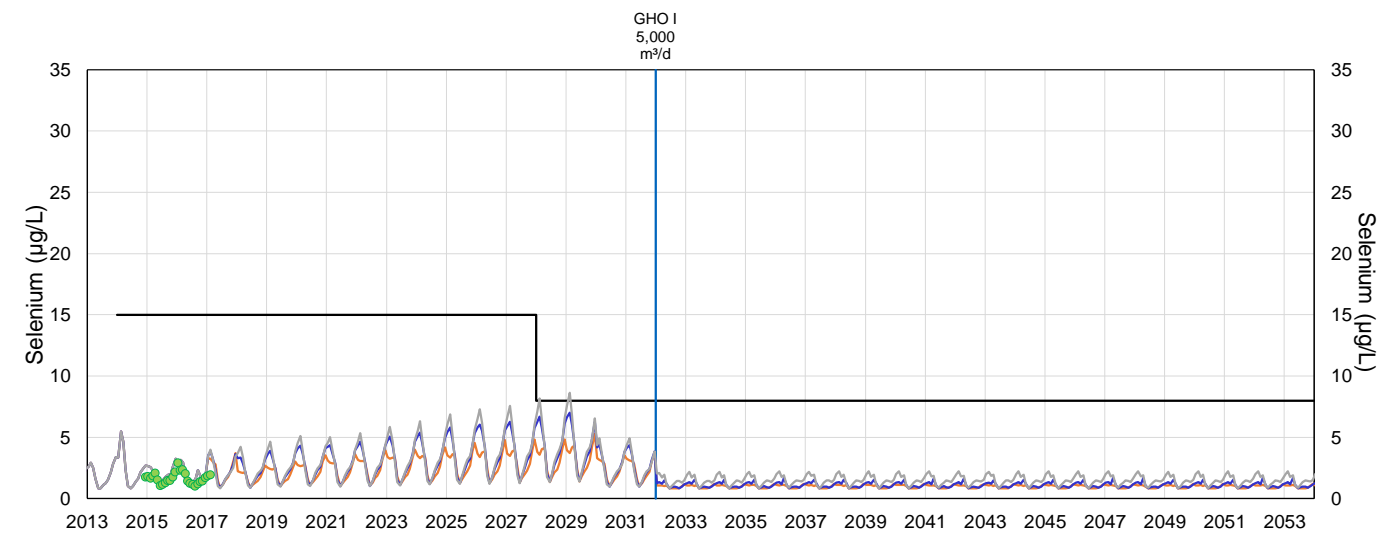
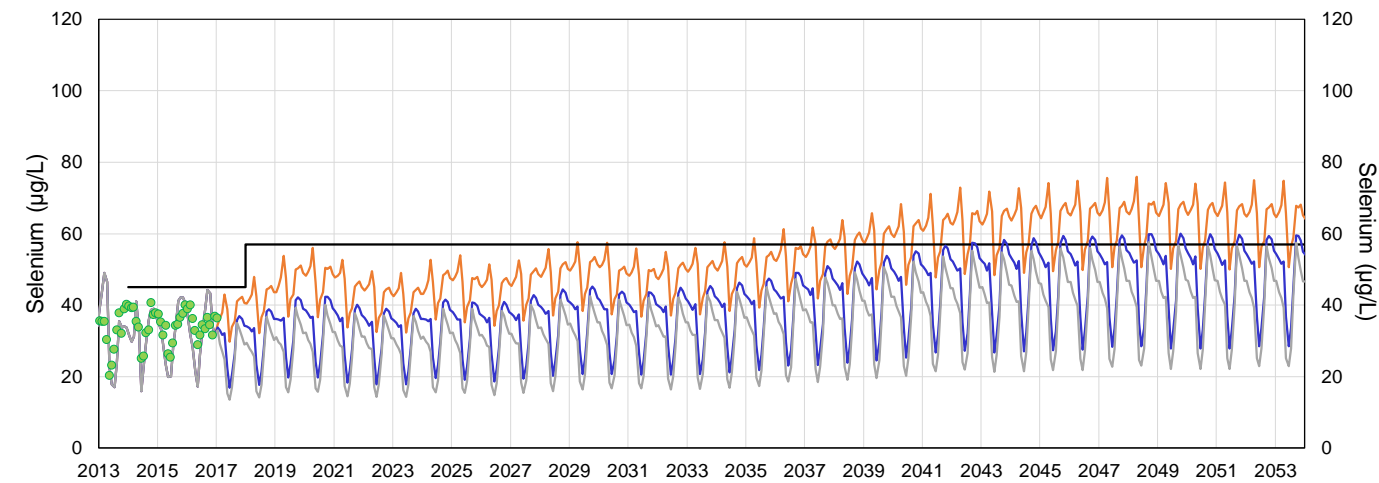
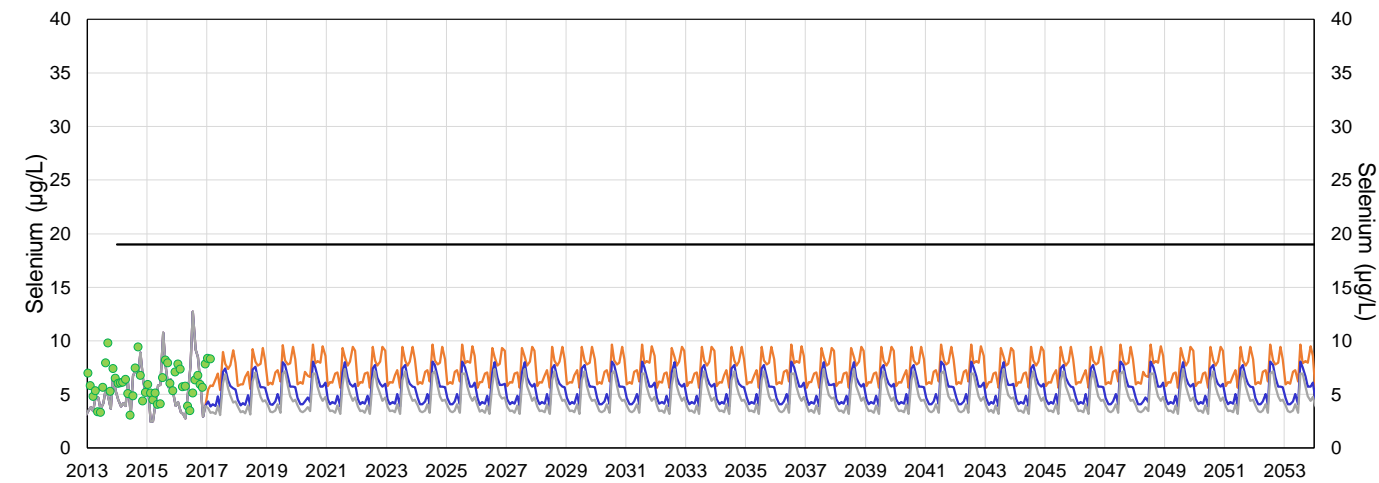


Figure B-2 Projected Monthly Average Concentrations of Selenium at Compliance Points between 2013 and 2053 for the Permitted Development Scenario without Ongoing Improvements to Effluent Selenium Concentrations (Continued)

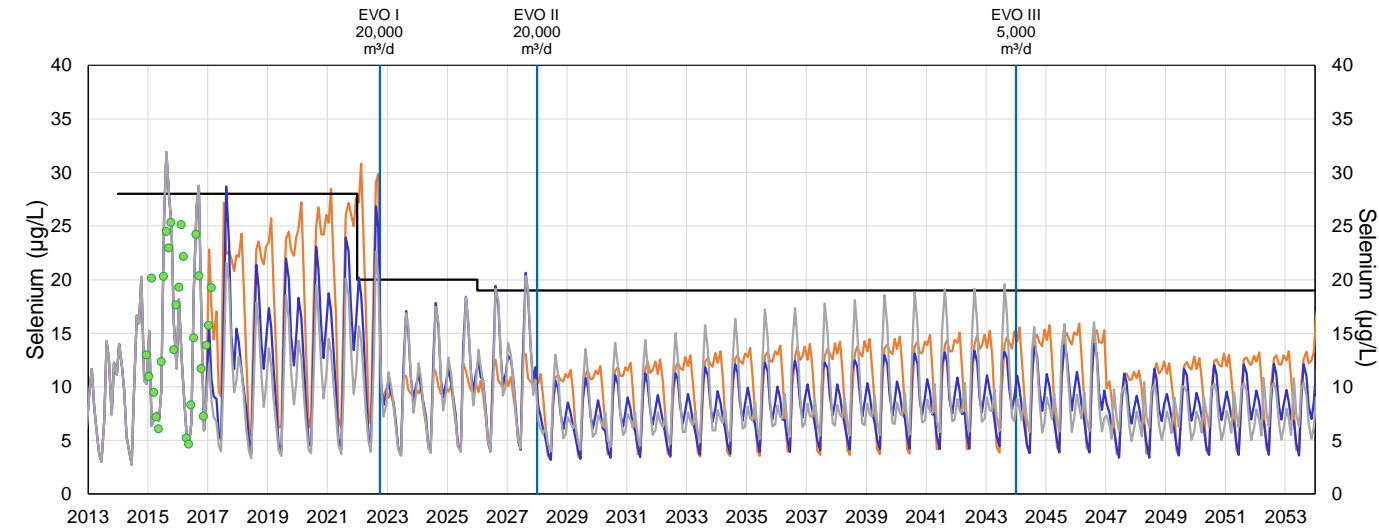
(e) EVO Harmer Compliance Point (EV_HC1; E102682)



(f) CMO Compliance Point (CM_MC2; E258937)



(g) EVO Michel Creek Compliance Point (EV_MC2; E300091)



Appendix C – Projected Concentrations of Nitrate, Selenium and Sulphate without Assumed Improvements to Water Availability

July 2019

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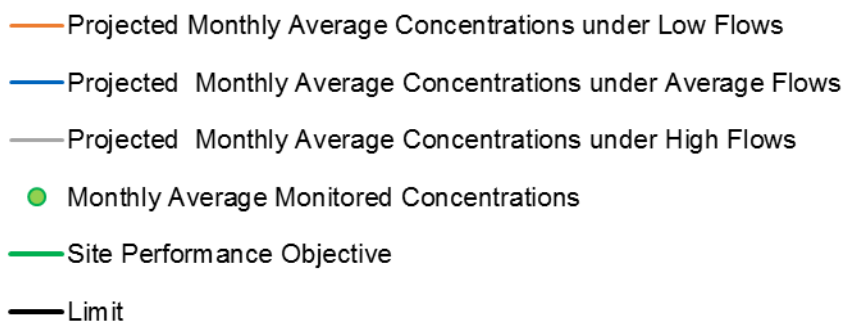
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How improvements to water availability in selected tributaries targeted for treatment at FRO were incorporated into the 2019 IPA are described in Annex E, Table 3-9. Monthly average concentrations of selenium and sulphate projected to be above Site Performance Objective (SPOs) and/or Compliance Limits for the Permitted Development Scenario between 2034 and 2053 with and without assumed improvement in water availability are summarized in Tables C-1 and C-2. Monthly average concentrations of nitrate are projected to be less than SPOs and Compliance Limits for the Permitted Development Scenario between 2034 and 2053 with and without assumed improvement in water availability.

Projected monthly average concentrations of nitrate, selenium and sulphate at Order Stations and compliance points for the Permitted Development Scenario without assumed improvement in water availability are shown in Figures C-1 to C-6, respectively. The projections are presented as time series plots. The solid orange, blue and grey lines correspond to the projected monthly concentrations under low, average and high flows. The figures include SPOs, Compliance Limits, historical observations (green points) and fully effective dates (vertical lines) for the AWTfS.

The x-axis in Figures C-1 to C-6 runs from the start of 2013 to the end of 2053. The calibration period for the RWQM is January 1, 2004 to December 31, 2016. Therefore, projected concentrations shown in solid gray prior to 2017 correspond to the monthly average concentrations projected to occur each year under observed flow conditions. Year 2053 corresponds to the time in the model at which all the waste rock considered in the Permitted Development Scenario has been deposited and the lag associated with that rock has passed (i.e., all the waste rock is contributing selenium and sulphate load).

The legend below applies to all time series plots in this appendix.



Projected monthly average selenium concentrations above SPOs are the same with and without assumed improvements in water availability, with two exceptions. The two exceptions involve monthly average selenium concentrations that are projected to be above long-term SPOs at the following Order Stations without assumed improvement in water availability (Table C-1):

- Fording River downstream of Greenhills Creek (GH_FR1; 0200378) from 2036 to 2053
- Fording River downstream of Line Creek (LC_LC5; 0200028) from 2046 to 2049

Differences between projected selenium concentrations and the corresponding SPO range from 13 µg/L downstream of Greenhills Creek to 2 ug/L downstream of Line Creek (Table C-1).

Projected monthly average selenium concentrations above Compliance Limits are the same with and without assumed improvement in water availability, with two exceptions. The two exceptions involve monthly average selenium concentrations that are projected to be above long-term Compliance Limits at the following compliance points without assumed improvement in water availability (Table C-1):

- FRO Compliance Point (FR_FRCP1; E300071) in 2035 and from 2038 to 2053
- Fording River above Chauncey (FR_FRABCH) in 2035, 2036 and from 2038 to 2053

In both cases, differences between projected selenium concentrations and the corresponding Compliance Limit are in the order of 7 ug/L (Table C-1).

Projected monthly average sulphate concentrations above SPOs and/or Compliance Limits in the Fording River without assumed improvement in water availability are 1 to 2 mg/L less than projected concentrations with assumed improvement in water availability (Table C-2). Projected monthly average sulphate concentrations without assumed improvement in water availability are slightly less than those with assumed improvement in water availability, because the current biological active water treatment process adds 20 mg/L sulphate to influent concentrations and lower rates of water availability result in less water receiving treatment.

Table C-1 Summary of Projected Monthly Average Selenium Concentrations above Site Performance Objectives or Compliance Limits between 2034 and 2053 for the Permitted Development Scenario with and without Assumed Improvement in Water Availability

Location		Corresponding Site Performance Objective / Limit (µg/L)	With Assumed Improvement in Water Availability				Without Assumed Improvement in Water Availability			
			Year	Month	Maximum Projected Concentration (µg/L)	Maximum Magnitude of Exceedance (µg/L)	Year	Month	Maximum Projected Concentration (µg/L)	Maximum Magnitude of Exceedance (µg/L)
Order Stations	Fording River downstream of Greenhills Creek (GH_FR1; 0200378) ^(a)	57	-	-	-	-	2036 to 2053	January to April	70	13
	Fording River downstream of Line Creek (LC_LC5; 0200028)	40	-	-	-	-	2046 to 2049	February to March	42	2
Compliance Points	FRO Compliance Point (FR_FRCP1; E300071)	61	-	-	-	-	2035, 2038 to 2053	February to April	68	7
	Fording River above Chauncey Creek (FR_FRABCH)	58	-	-	-	-	2035, 2036, 2038 to 2053	February to April	65	7

(a) This location is also the GHO Fording River Compliance Point.
Projected monthly average selenium concentrations above Site Performance Objectives (SPOs) or Compliance Limits between 2034 and 2053 are presented; 2034 corresponds to the year when the assumed improvement in water availability was modelled to occur.
EVO = Elkview Operations; FRO = Fording River Operations; GHO = Greenhills Operations; LCO = Line Creek Operations; µg/L = micrograms per litre.

Table C-2 **Summary of Projected Monthly Average Sulphate Concentrations above Site Performance Objectives or Compliance Limits between 2034 and 2053 for the Permitted Development Scenario with and without Assumed Improvement in Water Availability**

Location		Corresponding Site Performance Objective / Limit (mg/L)	With Assumed Improvement in Water Availability				Without Assumed Improvement in Water Availability			
			Year	Month	Maximum Projected Concentration (mg/L)	Maximum Magnitude of Exceedance (mg/L)	Year	Month	Maximum Projected Concentration (mg/L)	Maximum Magnitude of Exceedance (mg/L)
Order Stations	Fording River downstream of Greenhills Creek (GH_FR1; 0200378) ^(a,b)	429	2028 to 2053	October to April	683	254	2034 to 2053	October to April	685	256
	Fording River downstream of Line Creek (LC_LC5; 0200028)	429	2034 to 2053	January to April	556	127	2034 to 2053	January to April	557	128
Compliance Points	FRO Compliance Point (FR_FRCP1; E300071)	650	2038 to 2053	January to April	859	209	2036 to 2053	December to April	862	212
	Fording River above Chauncey Creek (FR_FRABCH)	605	2038 to 2053	January to April	799	194	2036 to 2053	December to April	802	197

(a) This location is also the GHO Fording River Compliance Point.

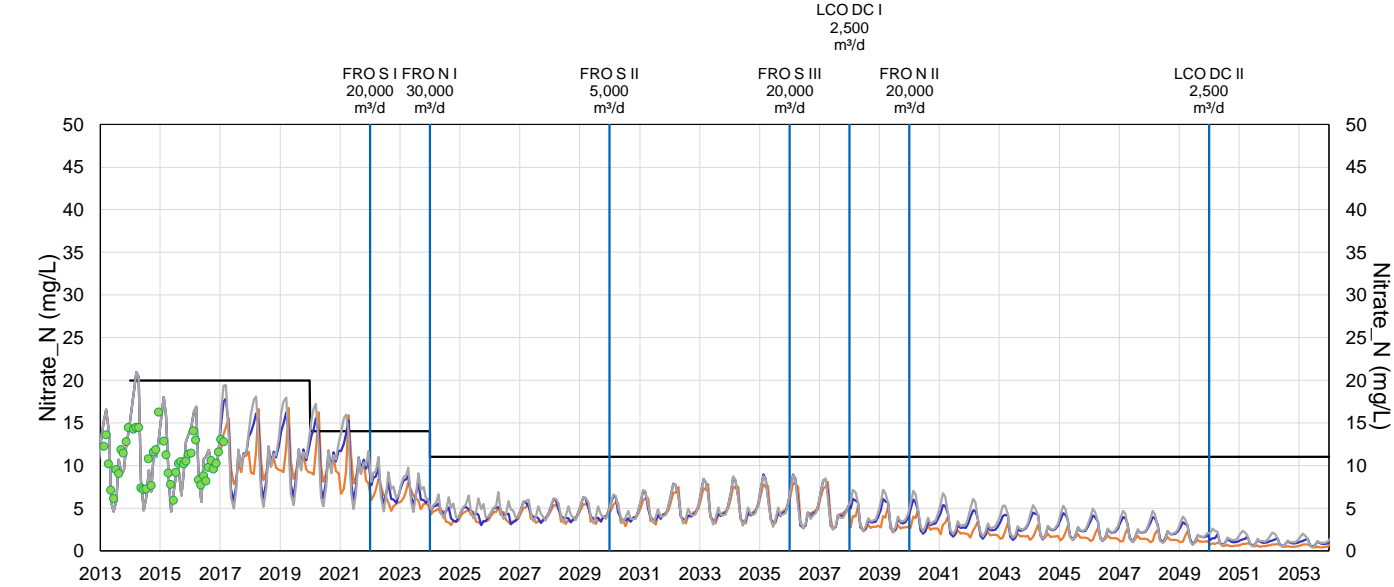
(b) The maximum monthly average sulphate concentration (431 mg/L) in February 2023 is projected to be above the SPO (429 mg/L) due to a model artefact related to the way in which loading from rehandled waste is described in the RWQM (a one-year pulse not subject to lag). Loading from rehandled waste rock is expected to be more gradual than has been simulated. Thus, sulphate concentrations in 2023 are not expected to be above the SPO at this location.

Bolded values are different from those generated with improved water availability.

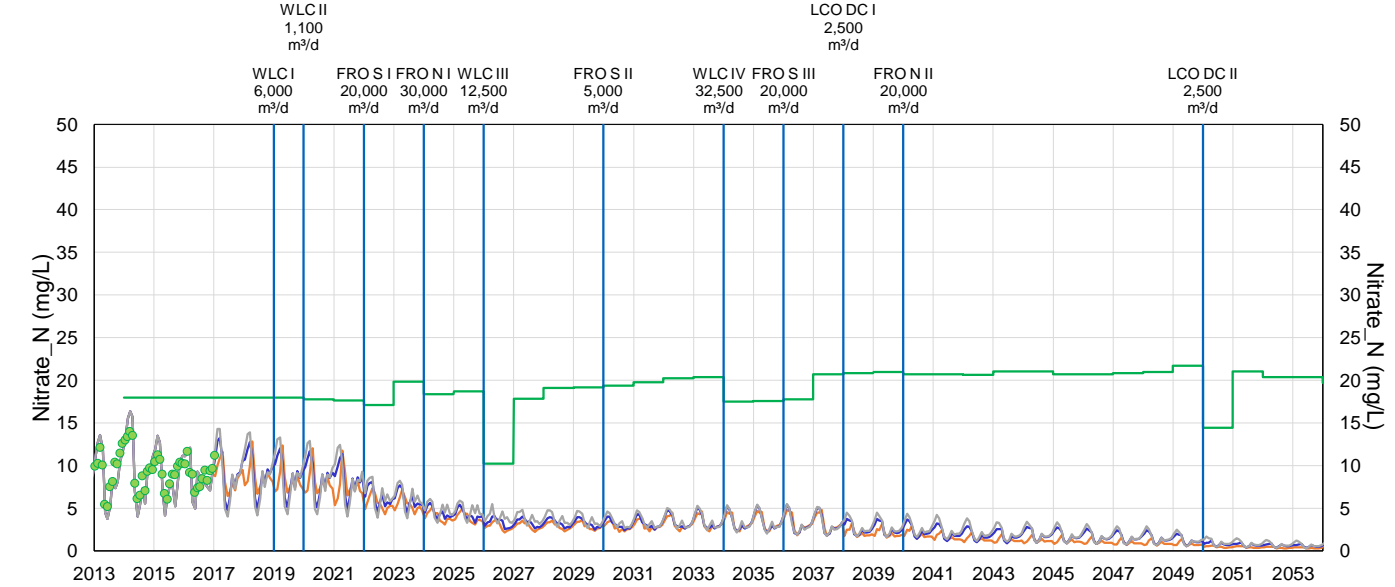
Projected monthly average sulphate concentrations above Site Performance Objectives (SPOs) or Compliance Limits between 2034 and 2053 are presented; 2034 corresponds to the year when the assumed improvement in water availability was modelled to occur.

FRO = Fording River Operations; LCO = Line Creek Operations; mg/L = milligrams per litre.

Figure C-1 Projected Monthly Average Concentrations of Nitrate at Order Stations between 2013 and 2053 for the Permitted Development Scenario without Assumed Improvement in Water Availability
(a) Fording River downstream of Greenhills Creek (GH_FR1; 0200378) (b) Fording River downstream of Line Creek (LC_LC5; 0200028)

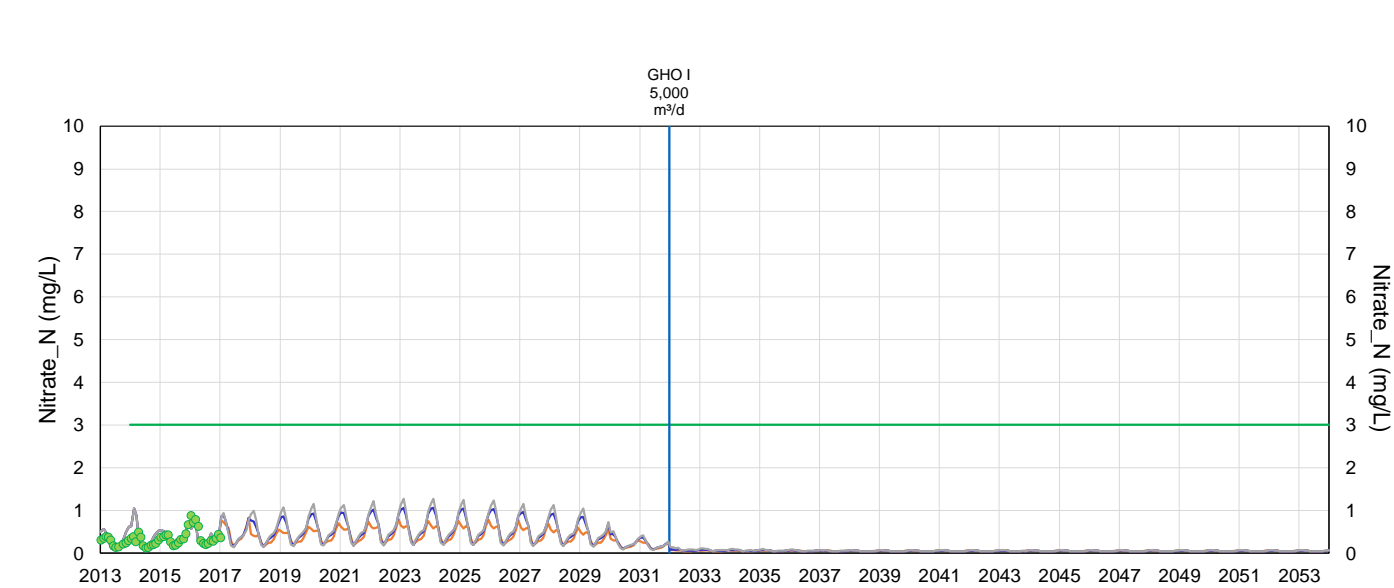


Note: This location is also the GHO Fording River Compliance Point.



Note: Site Performance Objective is hardness dependent from 2019 onward and is calculated using the following formula: $N \text{ (in mg-N/L)} = 10^{1.0003 \log_{10}(\text{hardness}) - 1.52}$ where hardness is in mg/L of CaCO_3 ; it varies with time to reflect projected hardness concentrations in the month when maximum monthly average nitrate concentrations are projected to occur.

(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)



(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)

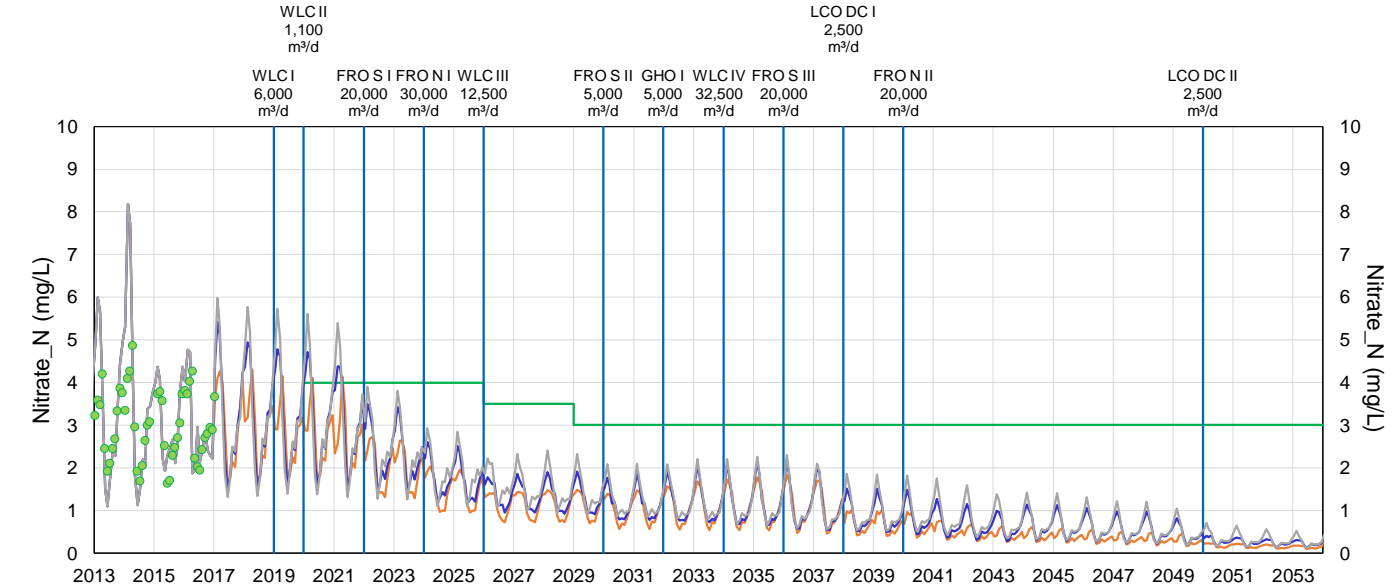
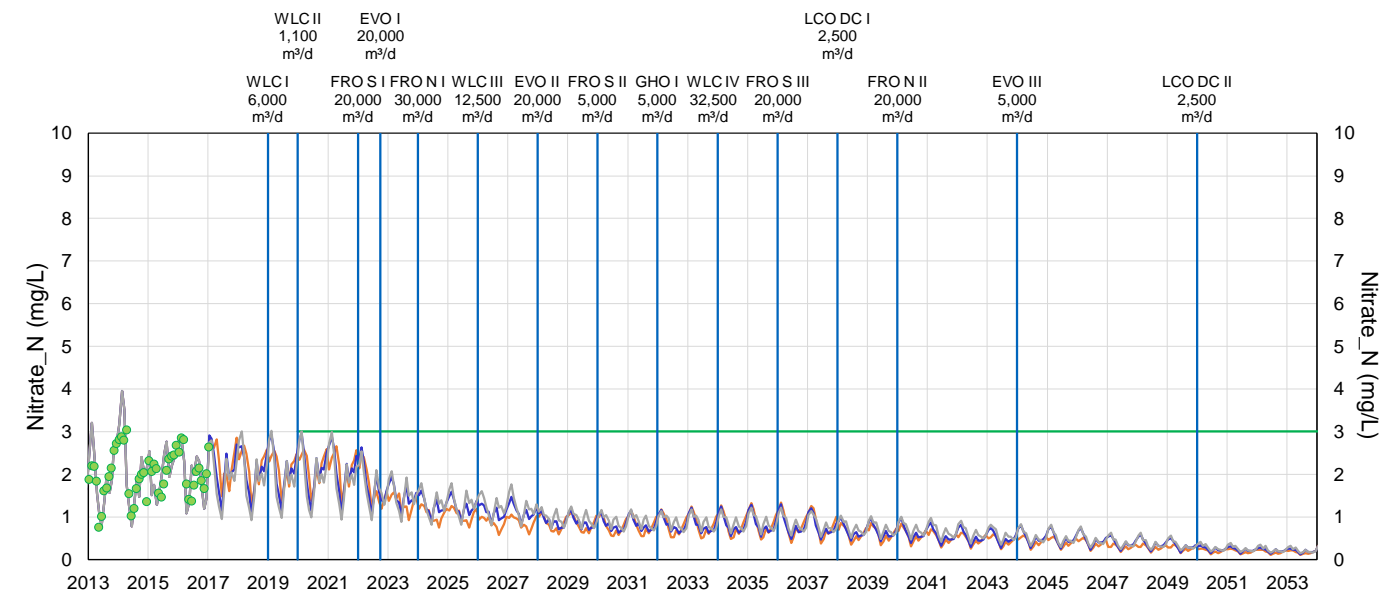
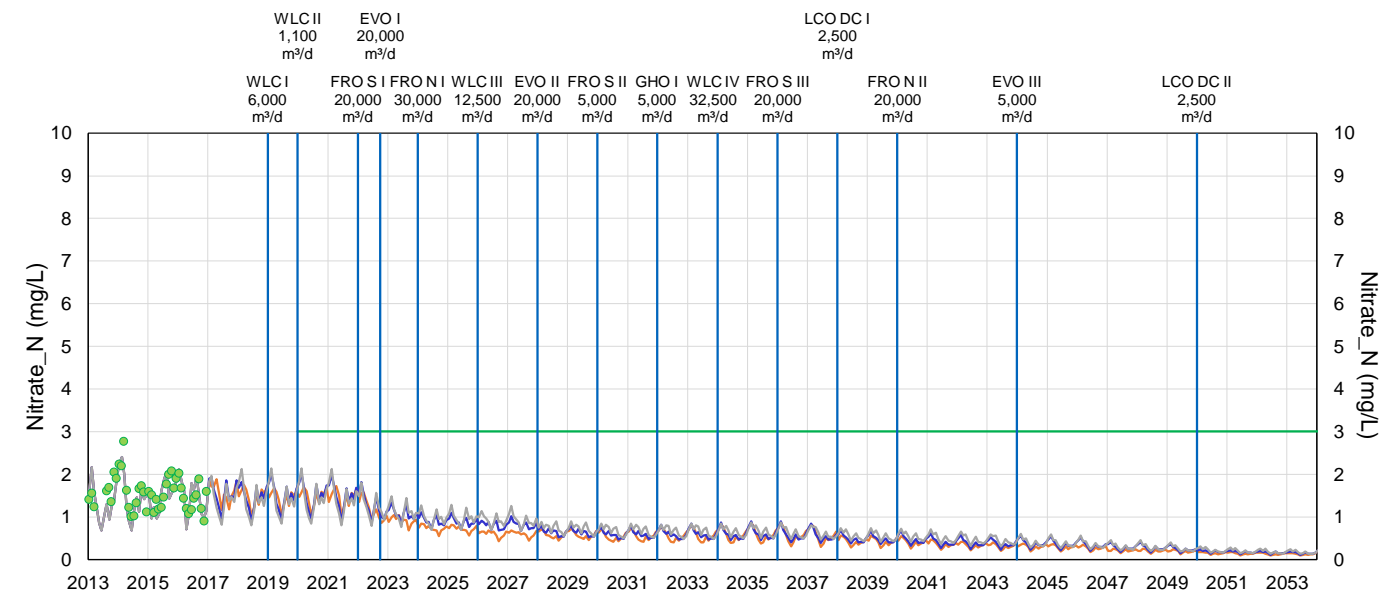


Figure C-1 Projected Monthly Average Concentrations of Nitrate at Order Stations between 2013 and 2053 for the Permitted Development Scenario without Assumed Improvement in Water Availability
(Continued)

(e) Elk River downstream of Michel Creek (EV_ER1; 0200393)



(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)

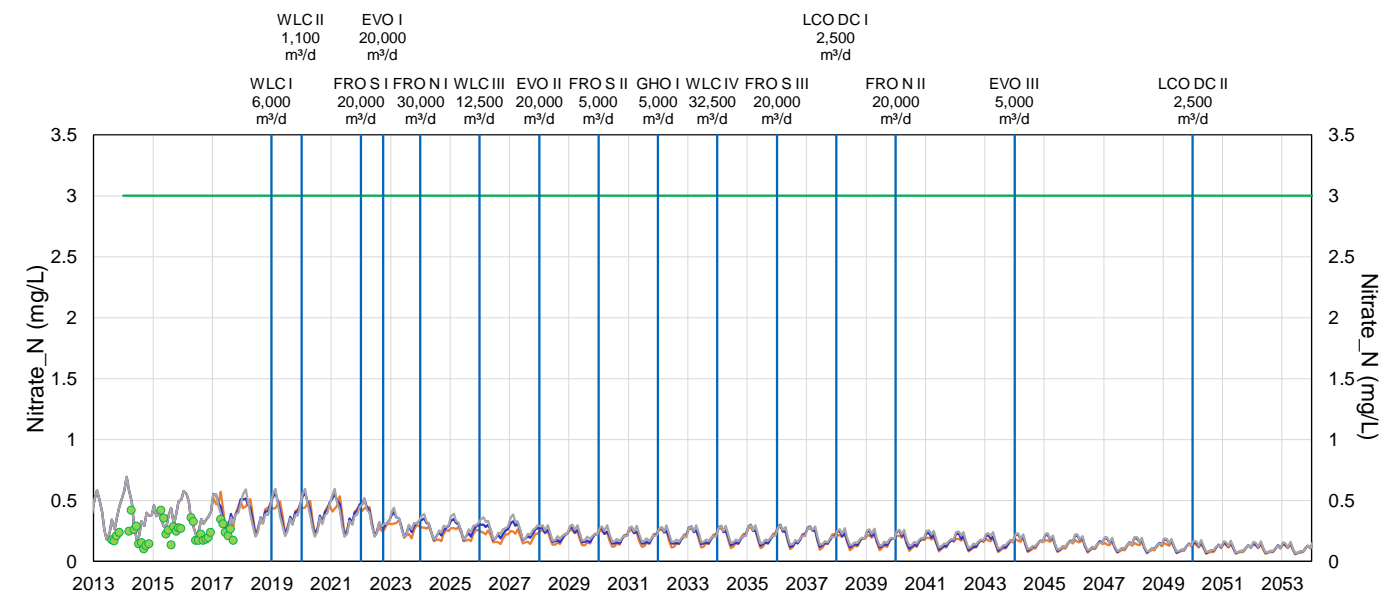
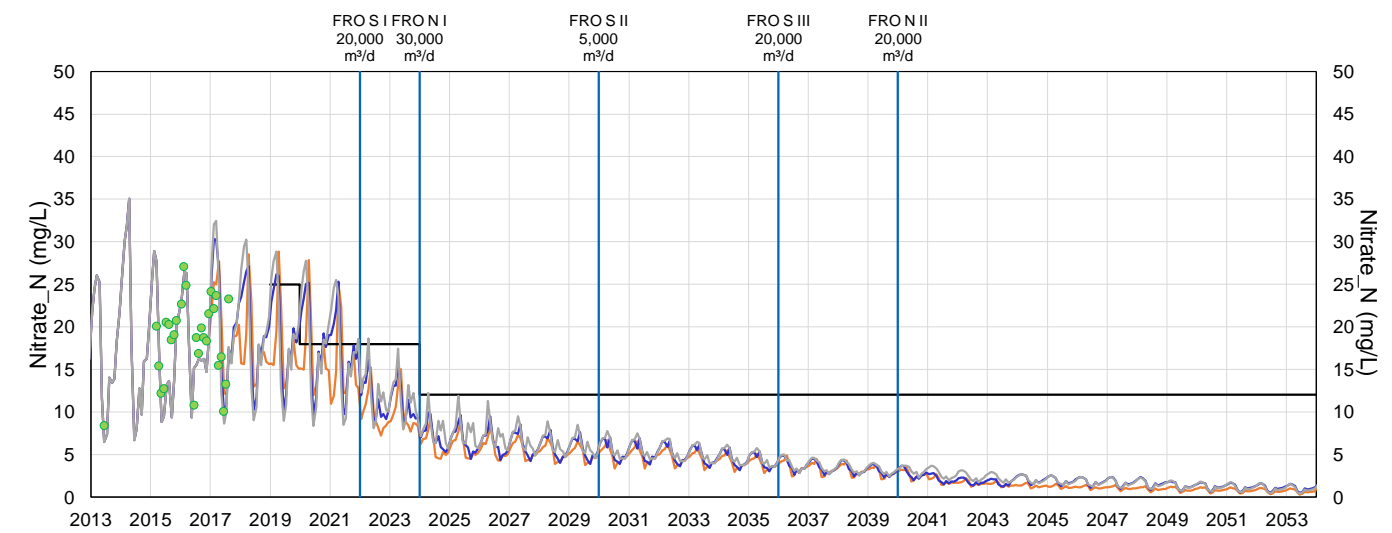
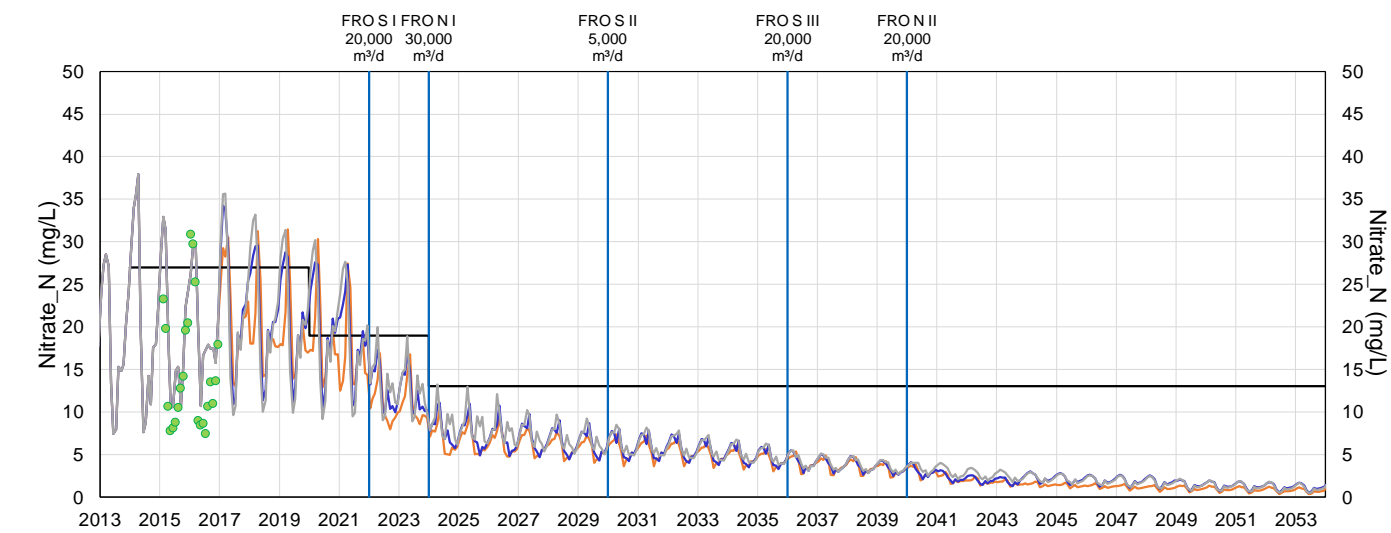
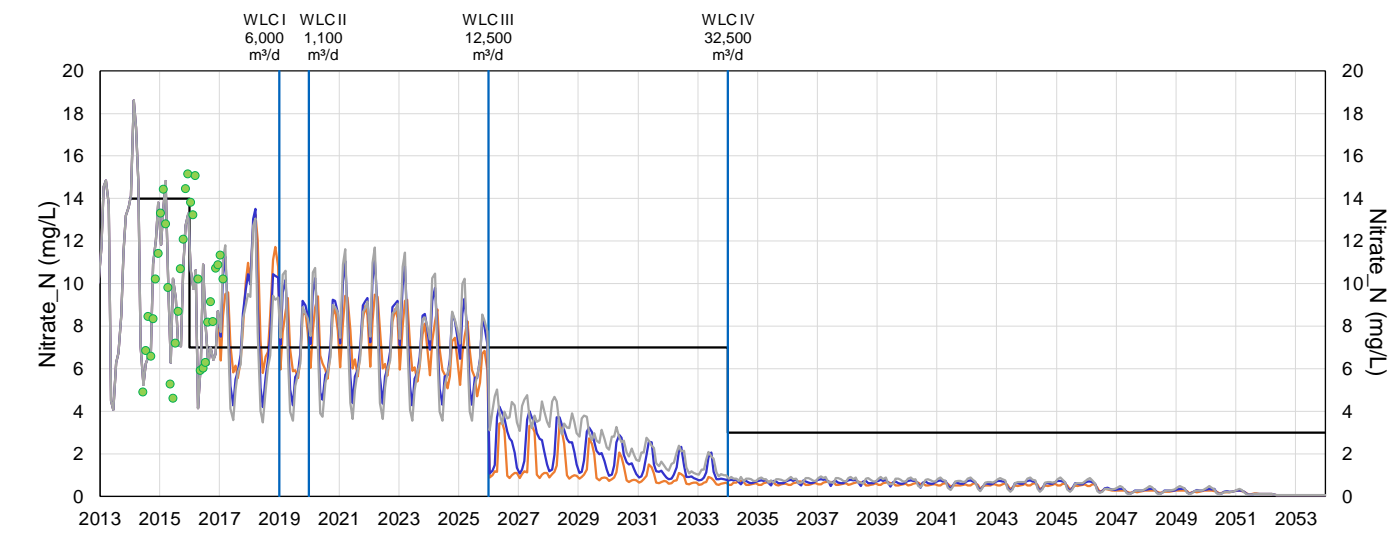


Figure C-2 Projected Monthly Average Concentrations of Nitrate at Compliance Points between 2013 and 2053 for the Permitted Development Scenario without Assumed Improvement in Water Availability
(a) FRO Compliance Point (FR_FRCP1; E300071) (b) Fording River above Chauncey Creek (FR_FRABCH)



Note: Projected concentrations are presented at Fording River above Chauncey Creek (FR_FRABCH), because it is the location proposed for the new Fording River Operations Compliance Point.

(c) LCO Compliance Point (LC_LCDSSLCC; E297110)



(d) GHO Elk River Compliance Point (GH_ERC; E300090)

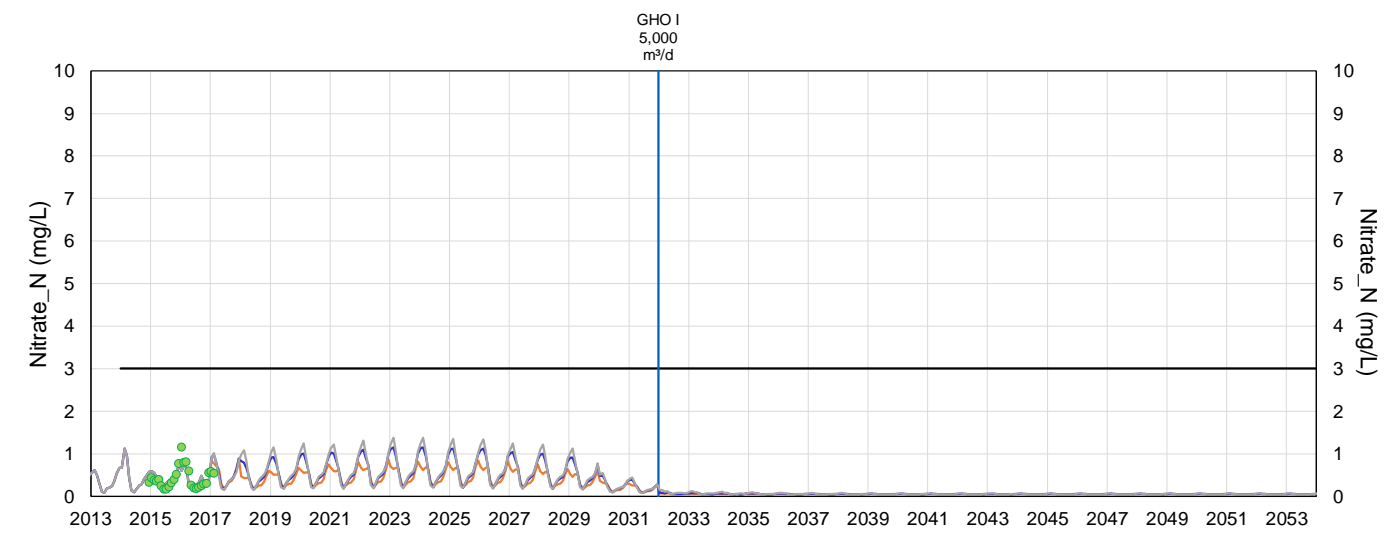
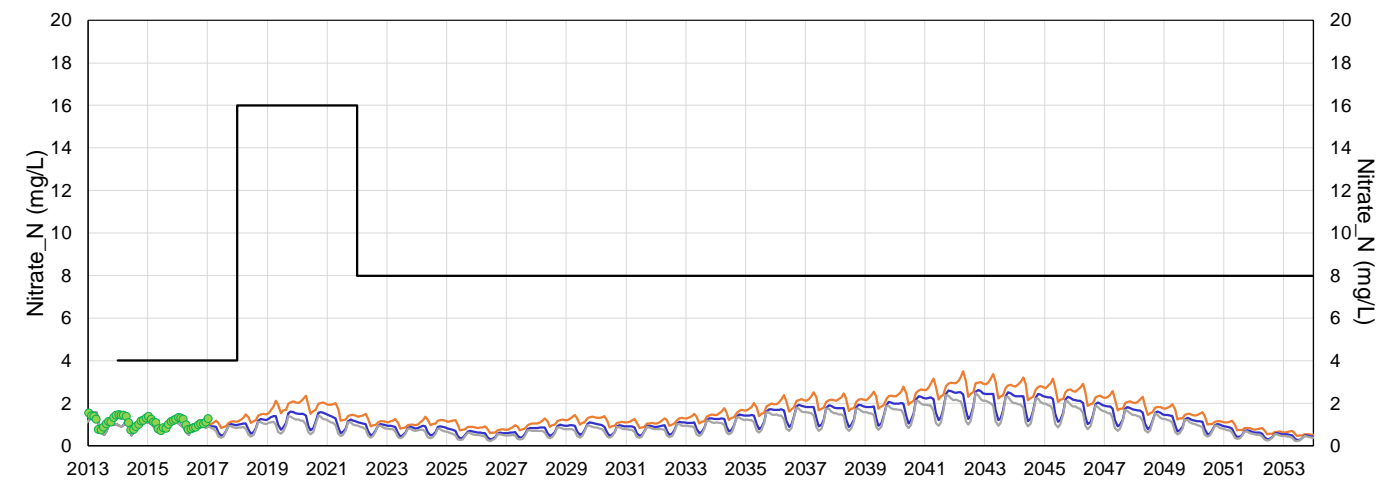
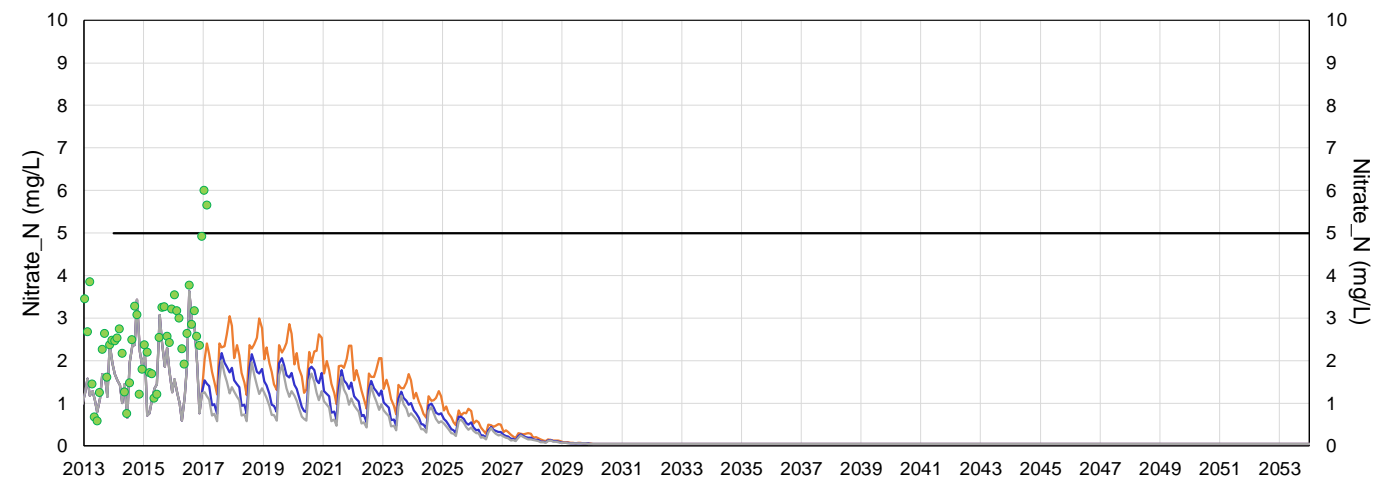


Figure C-2 Projected Monthly Average Concentrations of Nitrate at Compliance Points between 2013 and 2053 for the Permitted Development Scenario without Assumed Improvement in Water Availability (Continued)

(e) EVO Harmer Compliance Point (EV_HC1; E102682)



(f) CMO Compliance Point (CM_MC2; E258937)



(g) EVO Michel Creek Compliance Point (EV_MC2; E300091)

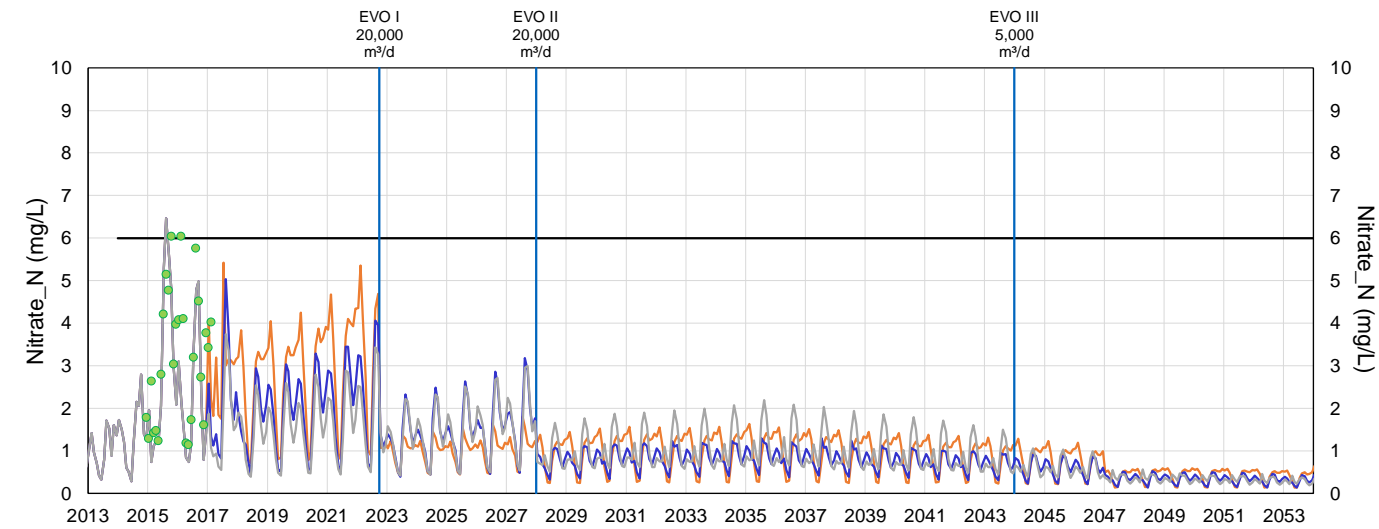
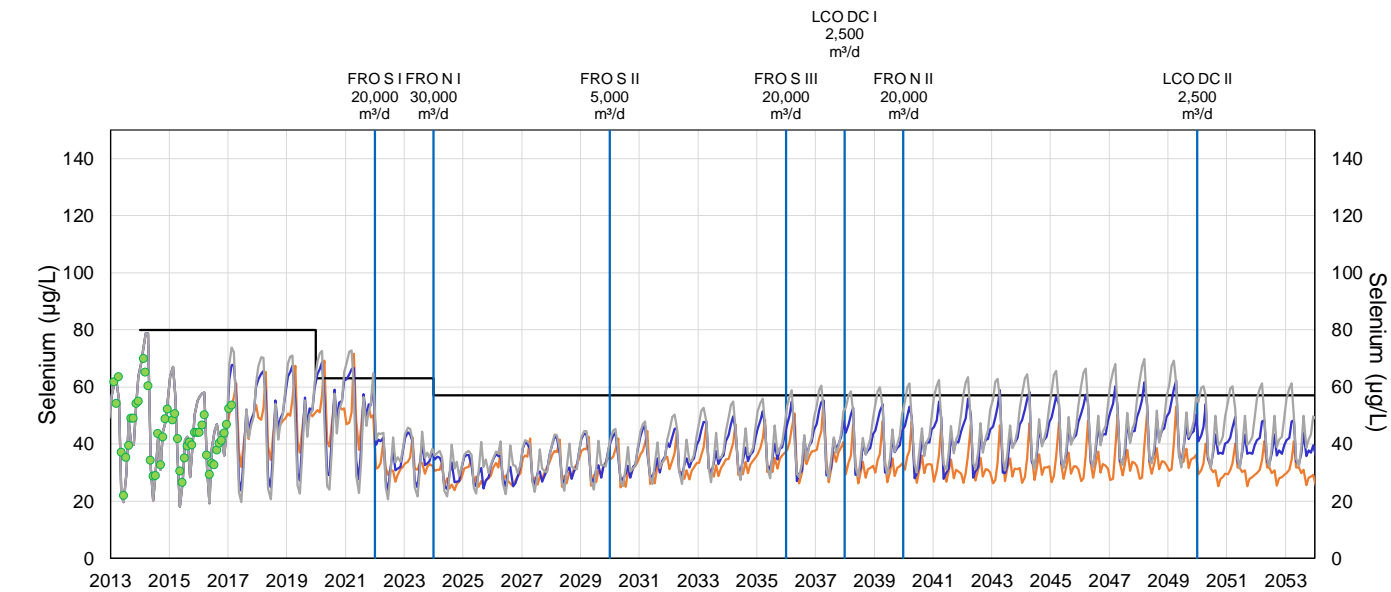
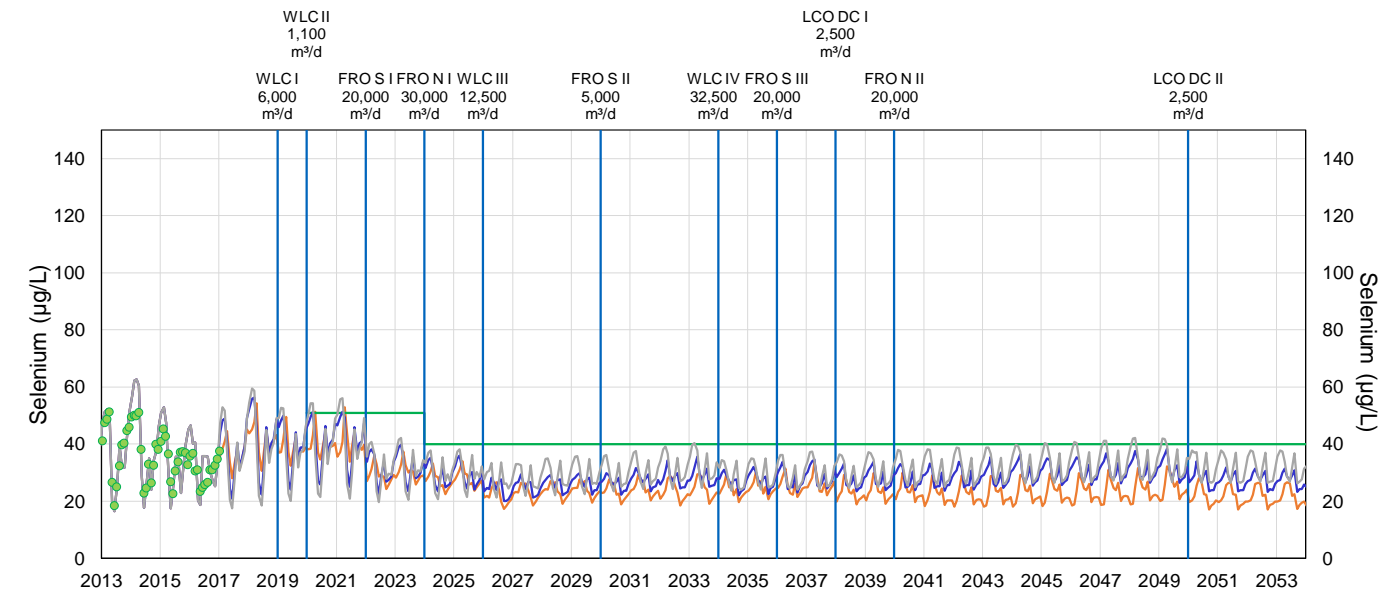


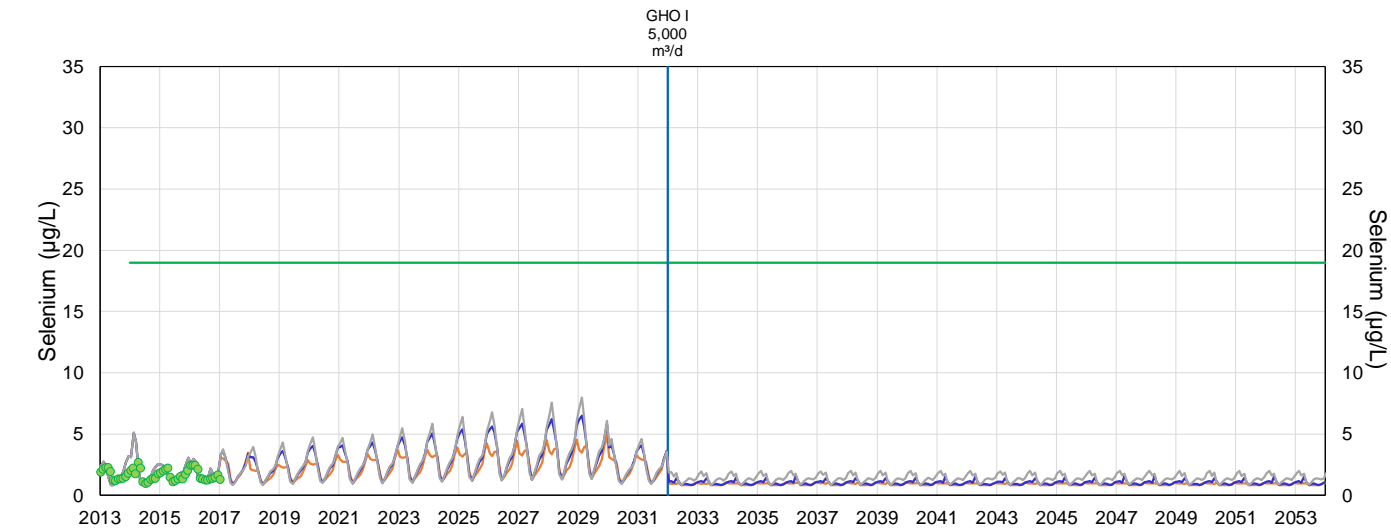
Figure C-3 Projected Monthly Average Concentrations of Selenium at Order Stations between 2013 and 2053 for the Permitted Development Scenario without Assumed Improvement in Water Availability
(a) Fording River downstream of Greenhills Creek (GH_FR1; 0200378) (b) Fording River downstream of Line Creek (LC_LC5; 0200028)



Note: This location is also the GHO Fording River Compliance Point.



(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)



(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)

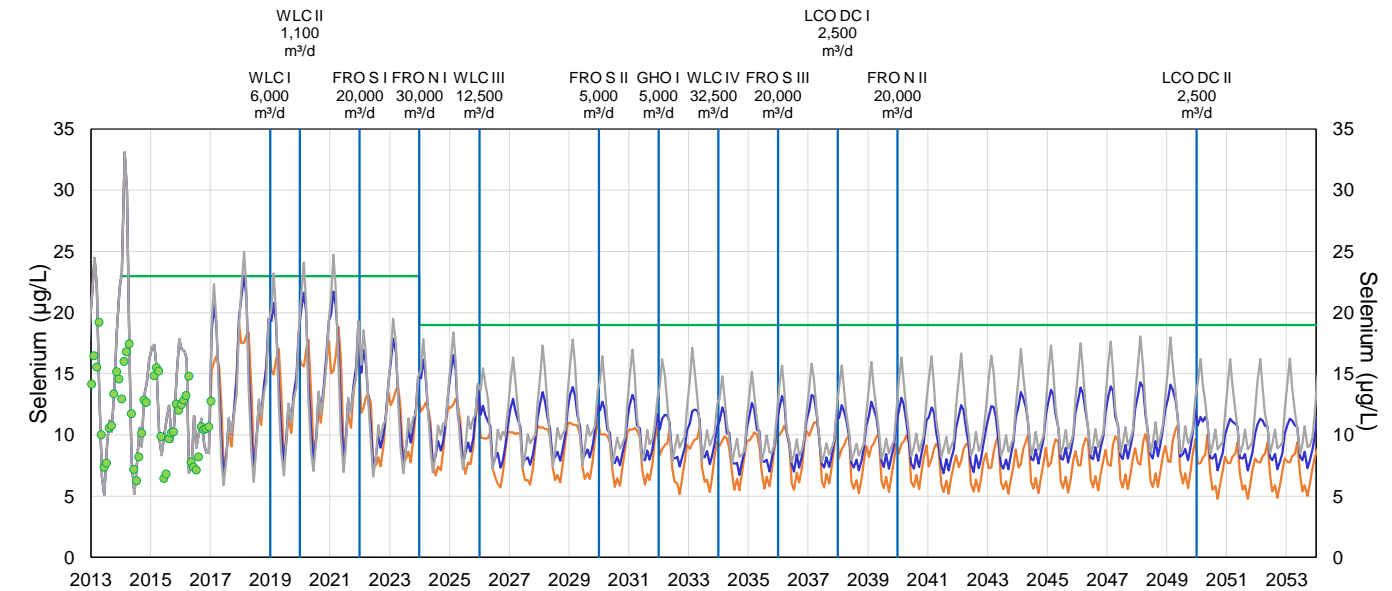
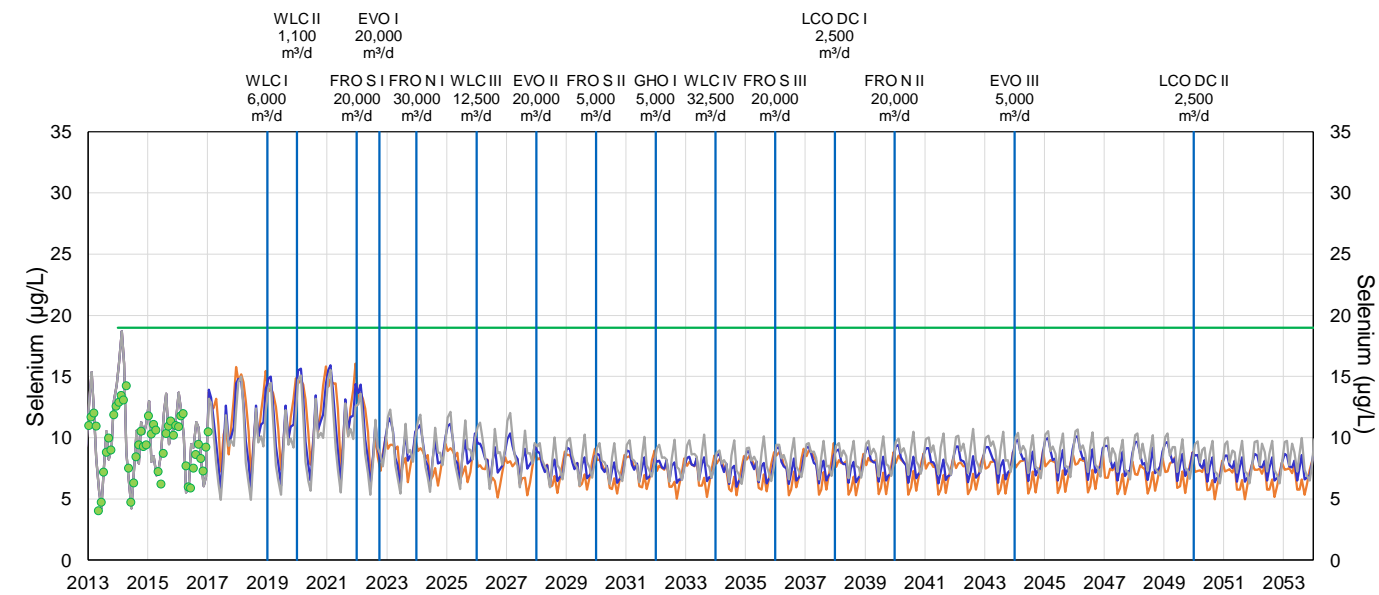
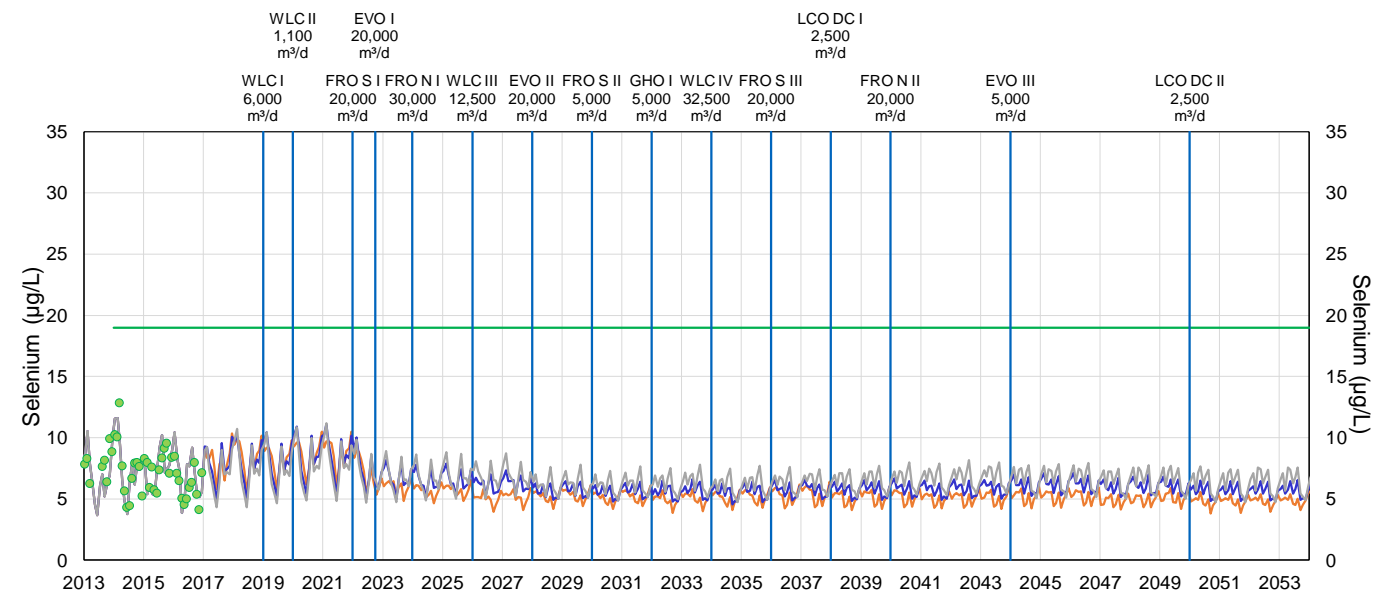


Figure C-3 Projected Monthly Average Concentrations of Selenium at Order Stations between 2013 and 2053 for the Permitted Development Scenario without Assumed Improvement in Water Availability (Continued)

(e) Elk River downstream of Michel Creek (EV_ER1; 0200393)



(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)

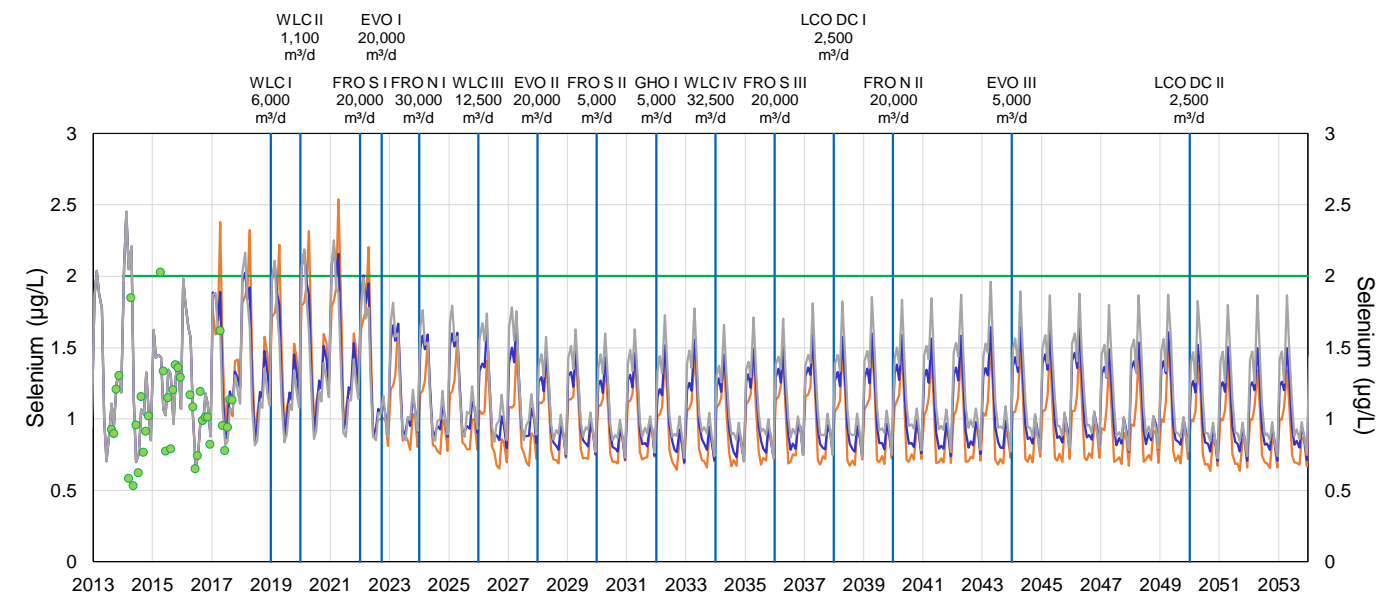
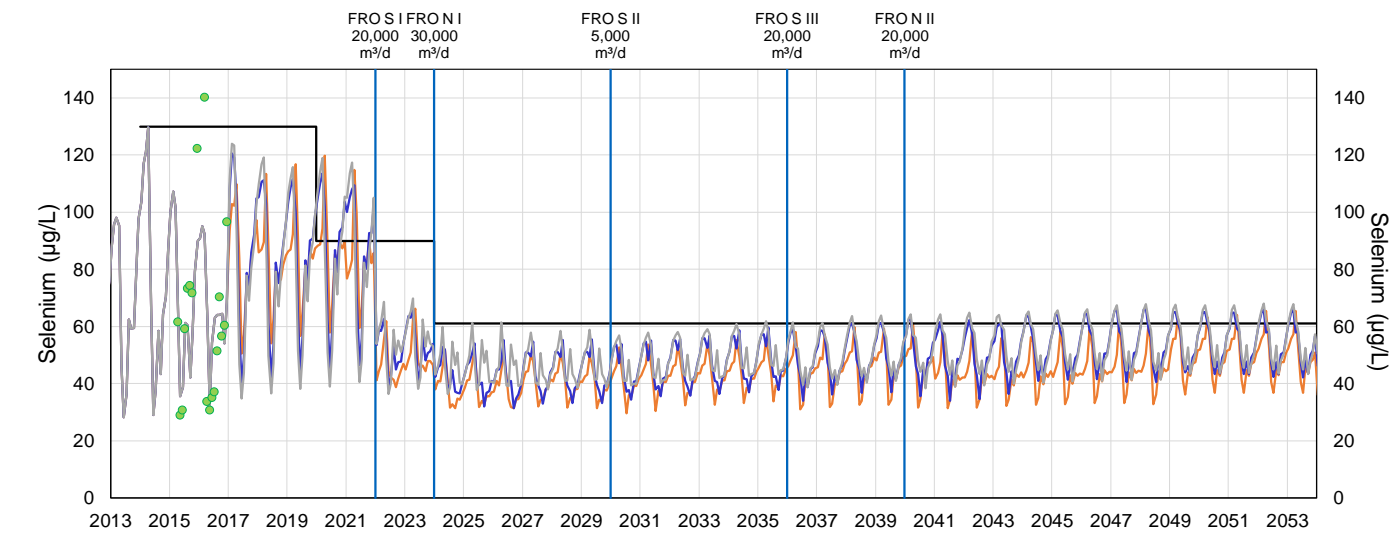


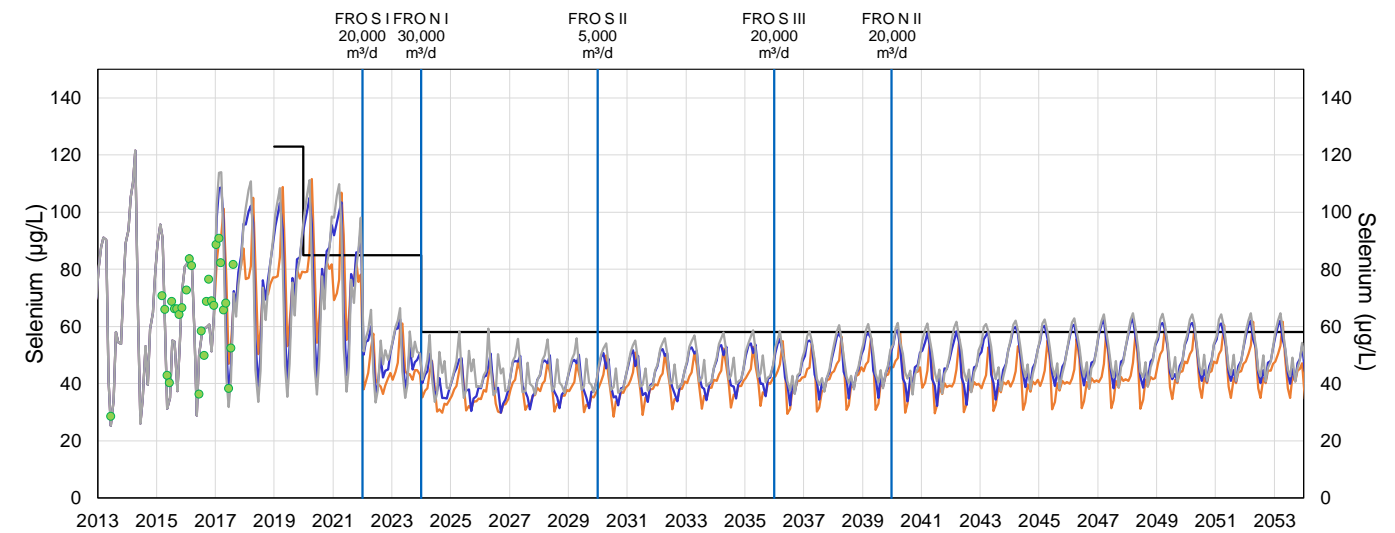
Figure C-4 Projected Monthly Average Concentrations of Selenium at Compliance Points between 2013 and 2053 for the Permitted Development Scenario without Assumed Improvement in Water Availability

(a) FRO Compliance Point (FR_FRCP1; E300071)



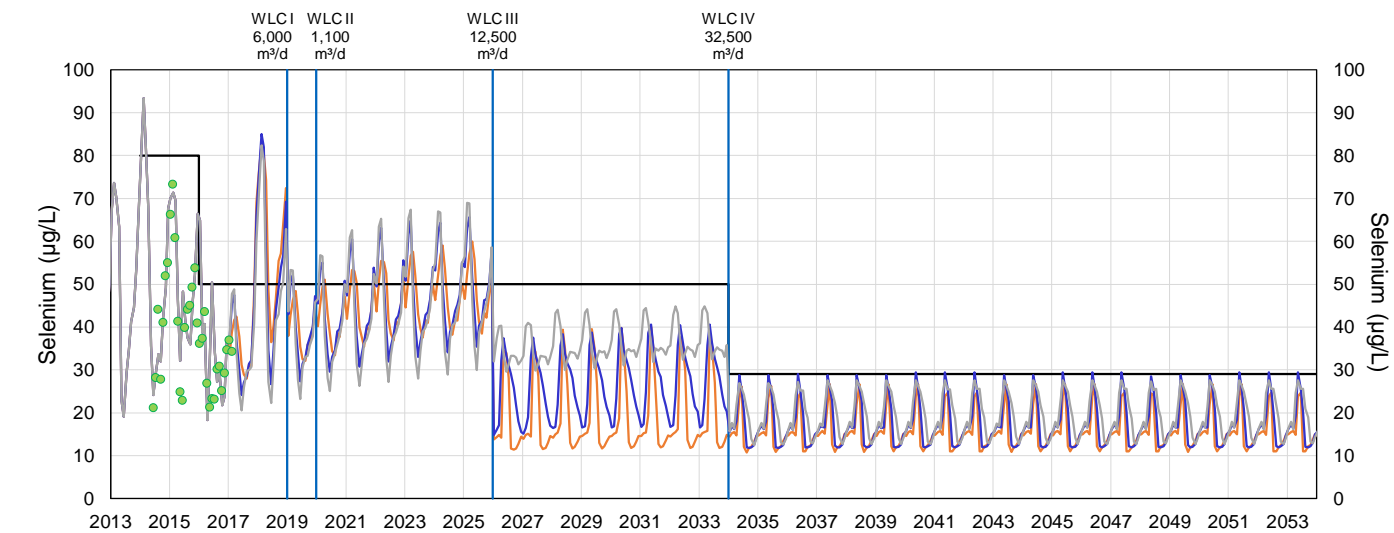
Note: At FR_FRCP1, monitored data are presented from January 2015 to December 2016. Five monitored data points are not presented on the plot, because at certain times of the year (i.e., winter) monitored concentrations at the FRO Compliance Point are not representative of concentrations in the Fording River. The five monitored data points (i.e., monthly average monitored concentrations) that are not presented on the plot are: 310 µg/L in February 2015, 229 µg/L in March 2015, 164 µg/L in November 2015, 447 µg/L in January 2016 and 316 µg/L in February 2016. Model projections at FR_FRCP1 reflect fully mixed conditions, whereas monitoring data collected during low flow periods reflect primarily the quality of Cataract Creek water; hence, the difference between model projections and monitored concentrations during low flow periods.

(b) Fording River above Chauncey Creek (FR_FRABCH)



Note: Projected concentrations are presented at Fording River above Chauncey Creek (FR_FRABCH), because it is the location proposed for the new Fording River Operations Compliance Point.

(c) LCO Compliance Point (LC_LCDSSLCC; E297110)



(d) GHO Elk River Compliance Point (GH_ERC; E300090)

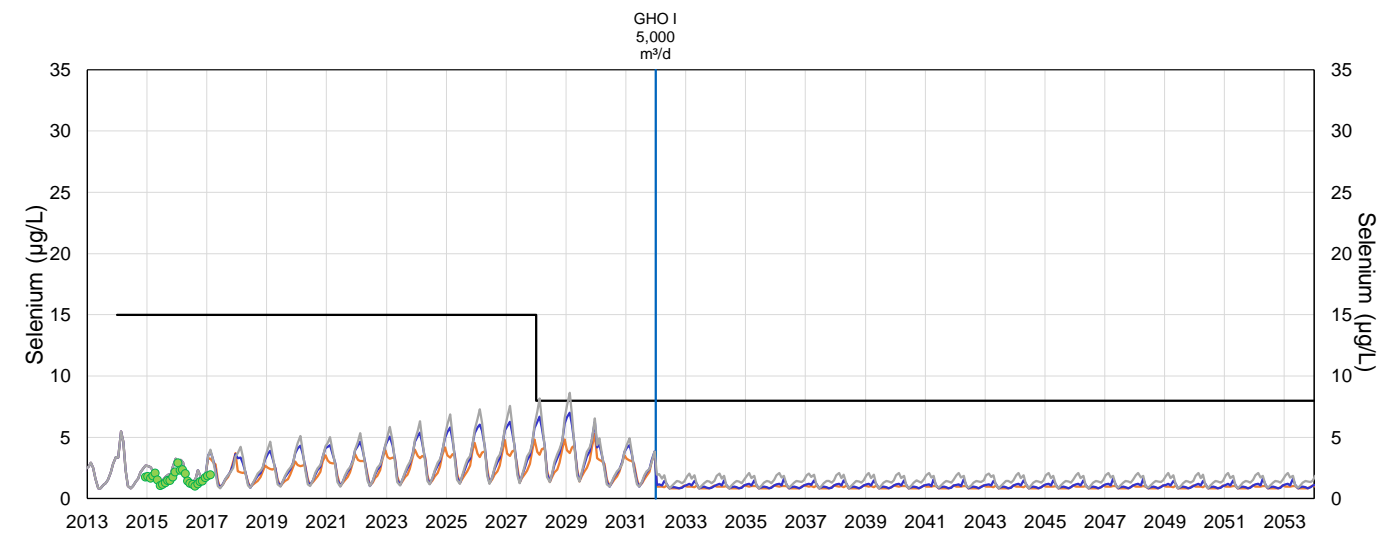
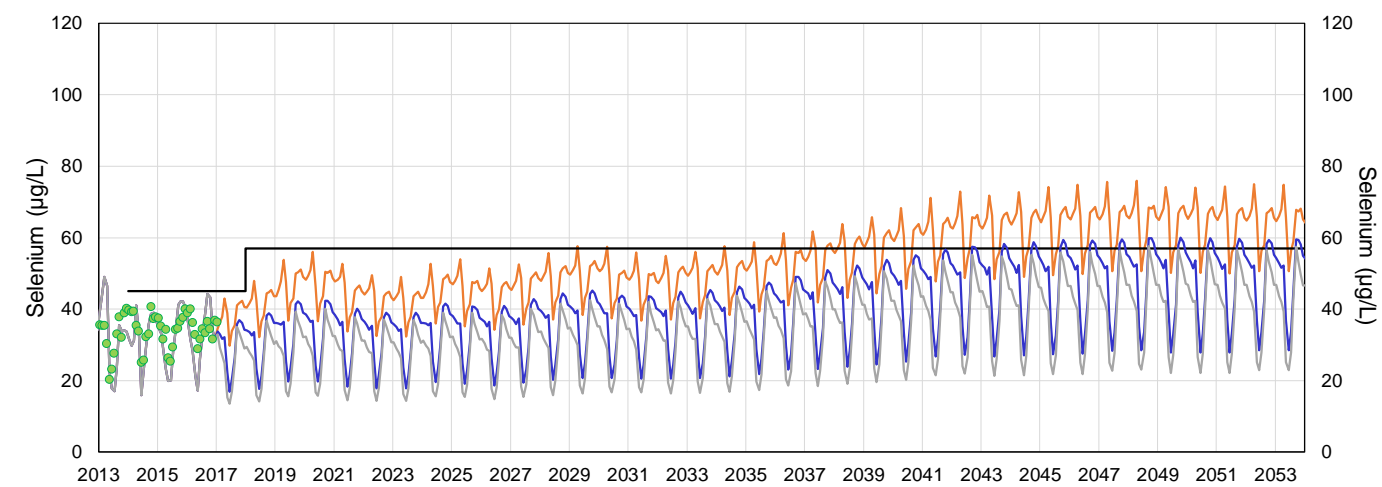
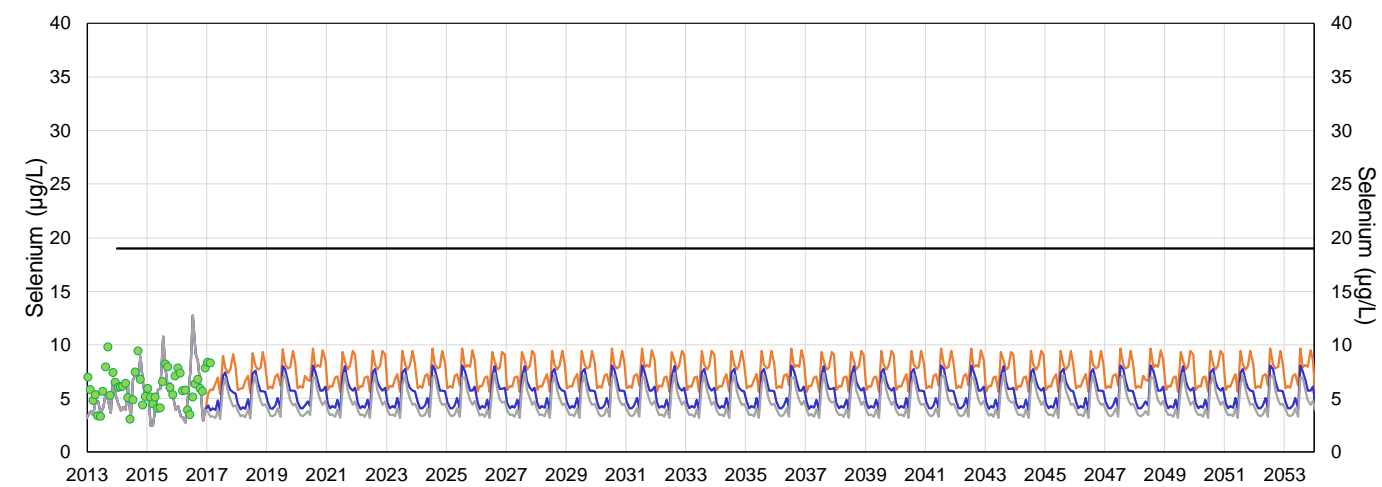


Figure C-4 Projected Monthly Average Concentrations of Selenium at Compliance Points between 2013 and 2053 for the Permitted Development Scenario without Assumed Improvement in Water Availability (Continued)

(e) EVO Harmer Compliance Point (EV_HC1; E102682)



(f) CMO Compliance Point (CM_MC2; E258937)



(g) EVO Michel Creek Compliance Point (EV_MC2; E300091)

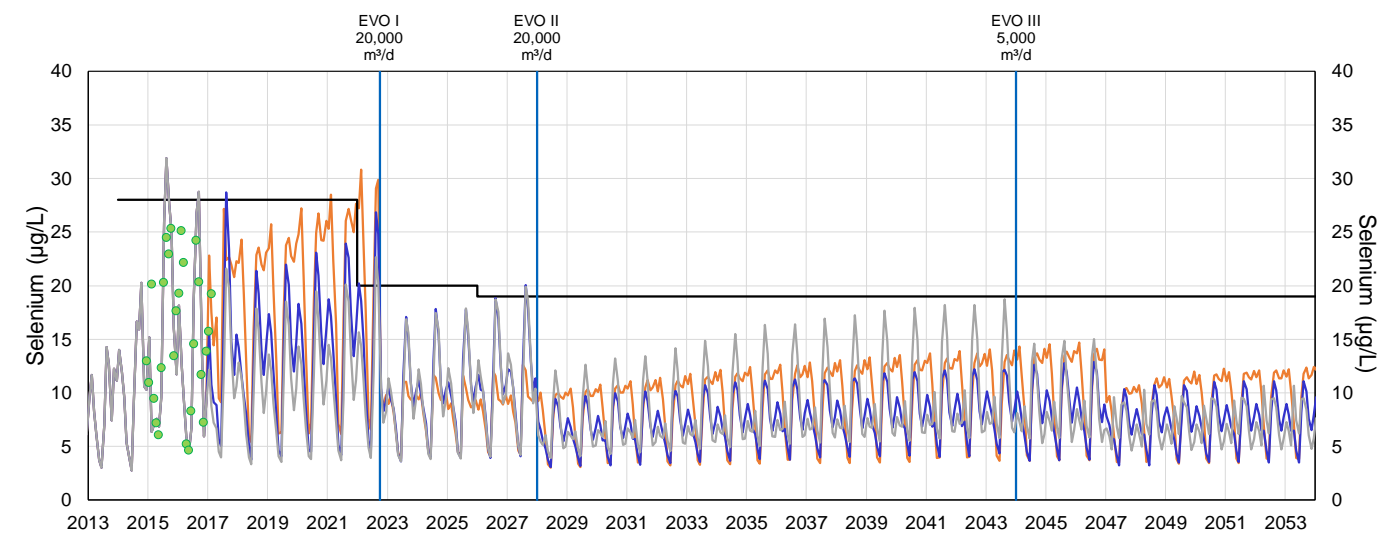
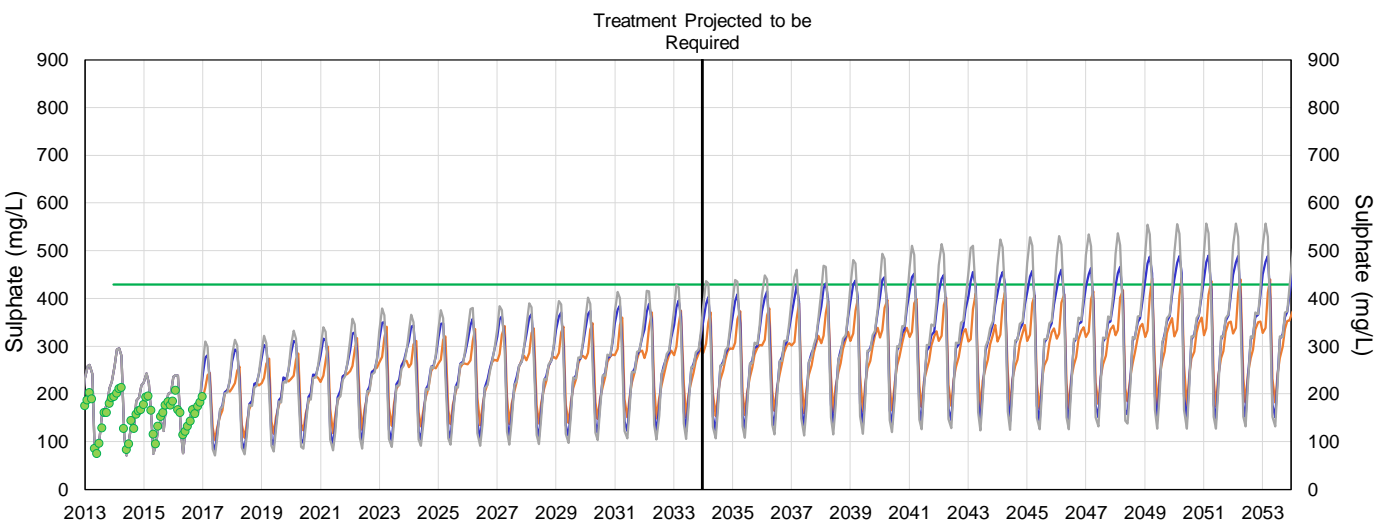
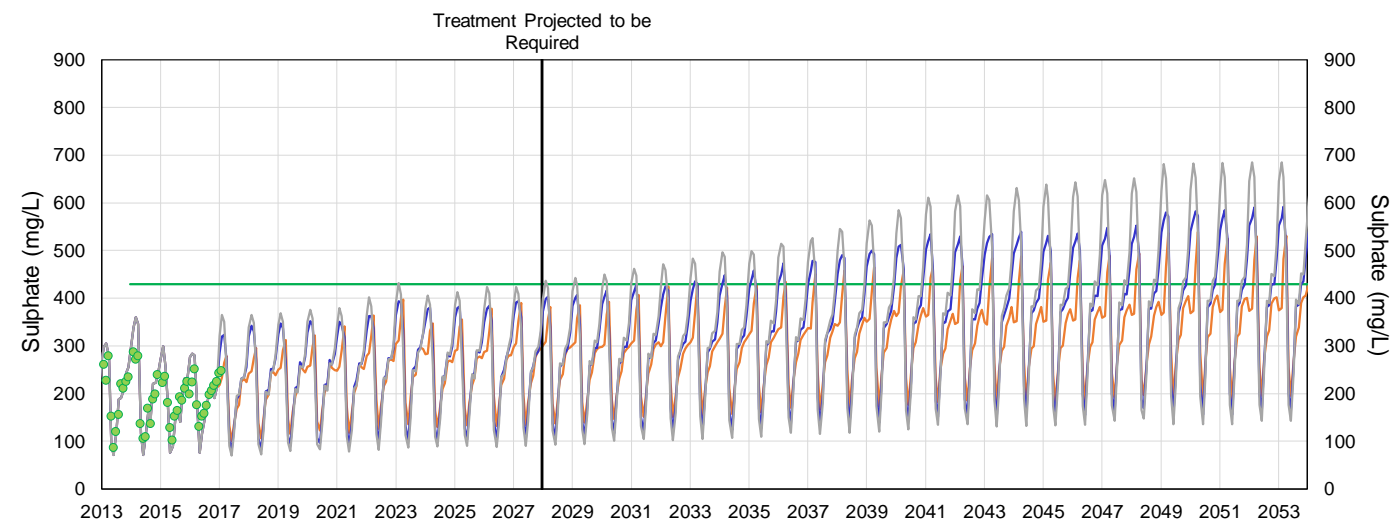
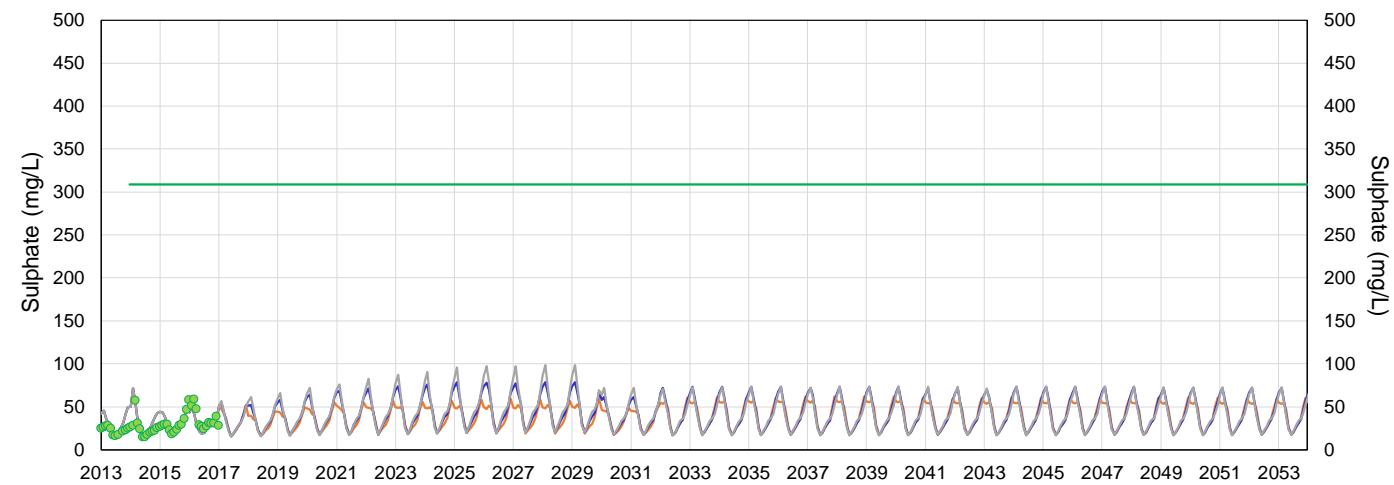


Figure C-5 Projected Monthly Average Concentrations of Sulphate at Order Stations between 2013 and 2053 for the Permitted Development Scenario without Assumed Improvement in Water Availability
(a) Fording River downstream of Greenhills Creek (GH_FR1; 0200378) (b) Fording River downstream of Line Creek (LC_LC5; 0200028)



Note: This location is also the GHO Fording River Compliance Point. The maximum monthly average sulphate concentration (431 mg/L) in February 2023 is projected to be above the SPO (429 mg/L) due to a model artefact related to the way in which loading from rehandled waste is described in the RWQM (a one-year pulse not subject to lag). Loading from rehandled waste rock is expected to be more gradual than has been simulated. Thus, sulphate concentrations in 2023 are not expected to be above the SPO at this location.

(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)



(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)

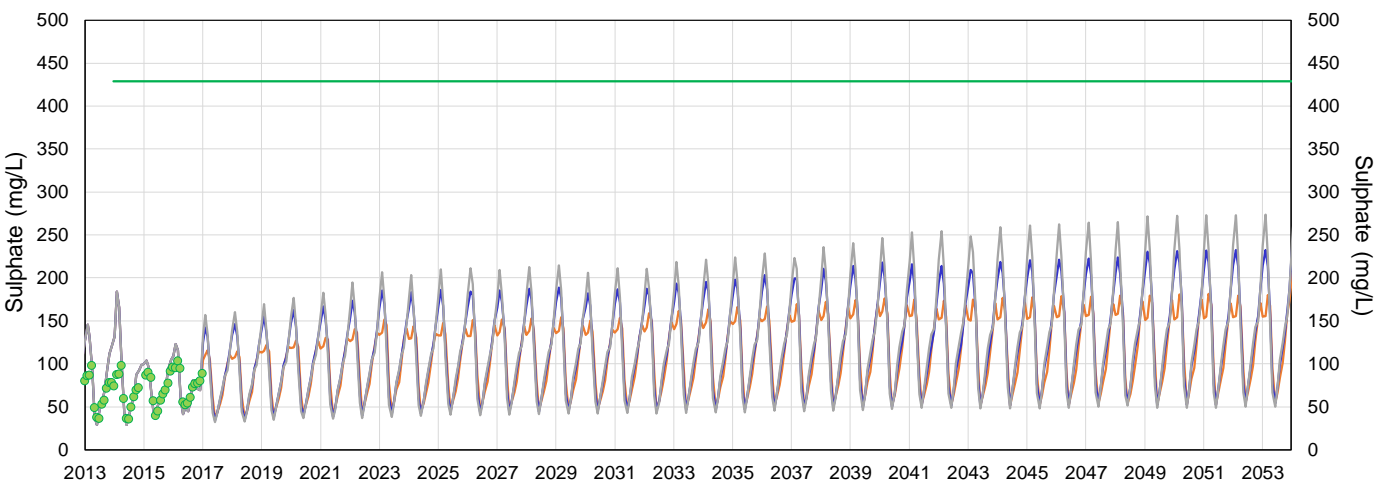
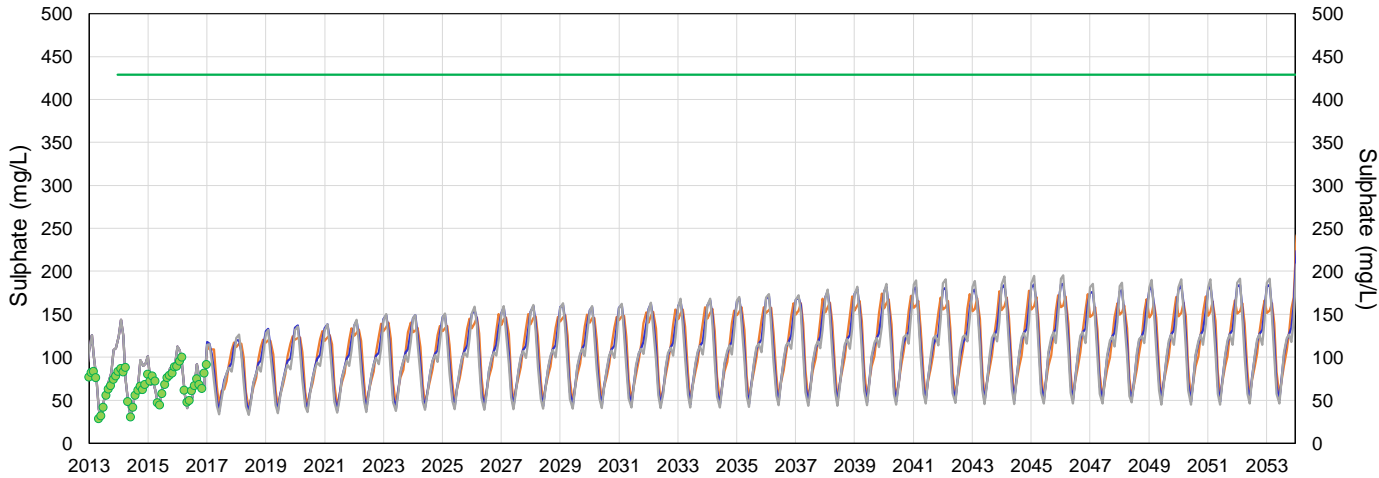
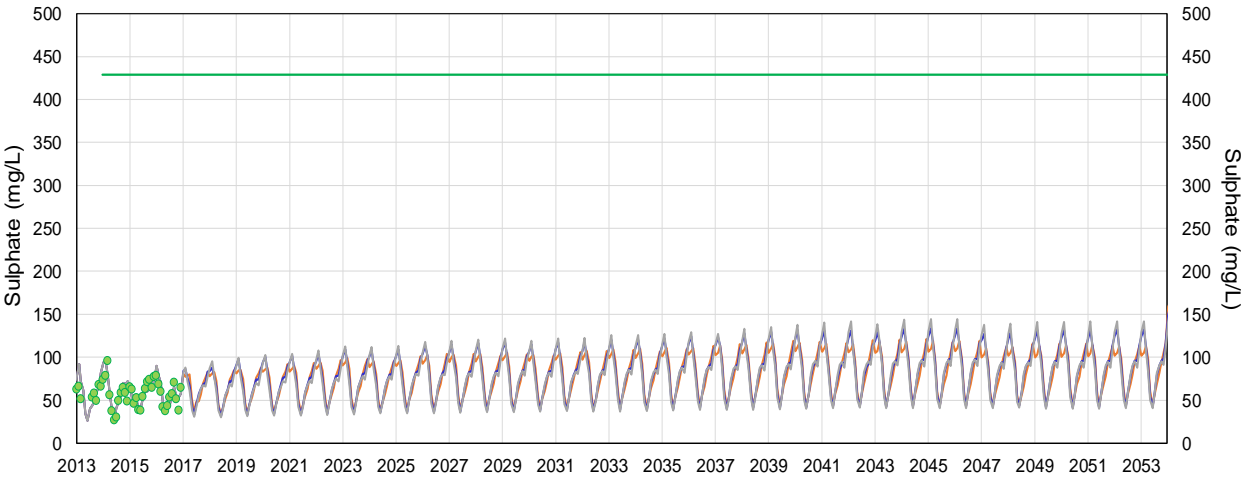


Figure C-5 Projected Monthly Average Concentrations of Sulphate at Order Stations between 2013 and 2053 for the Permitted Development Scenario without Assumed Improvement in Water Availability (Continued)

(e) Elk River downstream of Michel Creek (EV_ER1; 0200393)



(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)

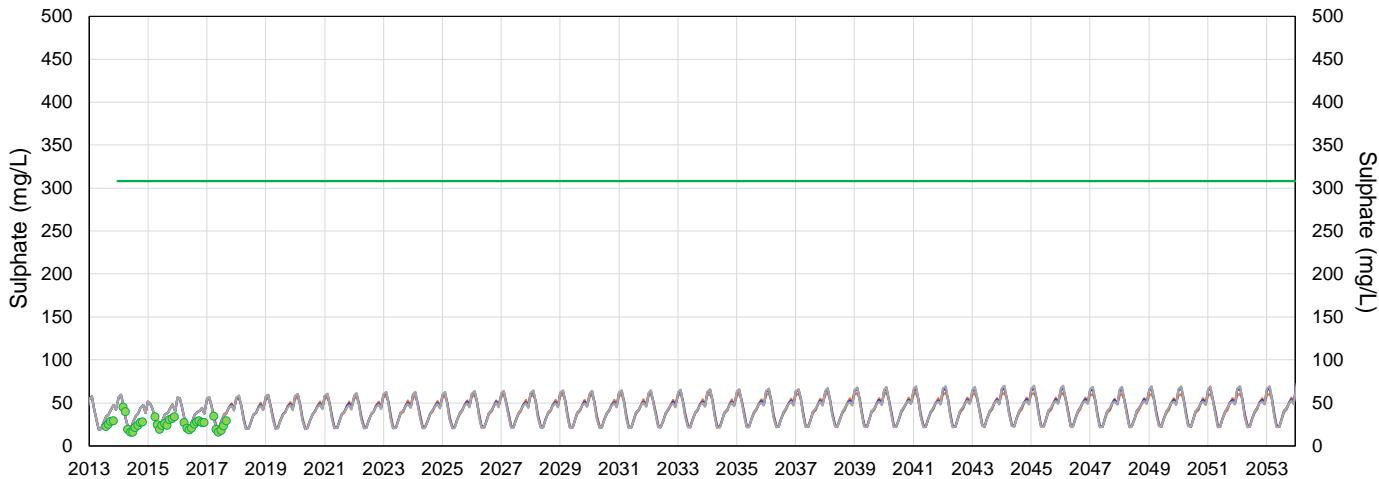
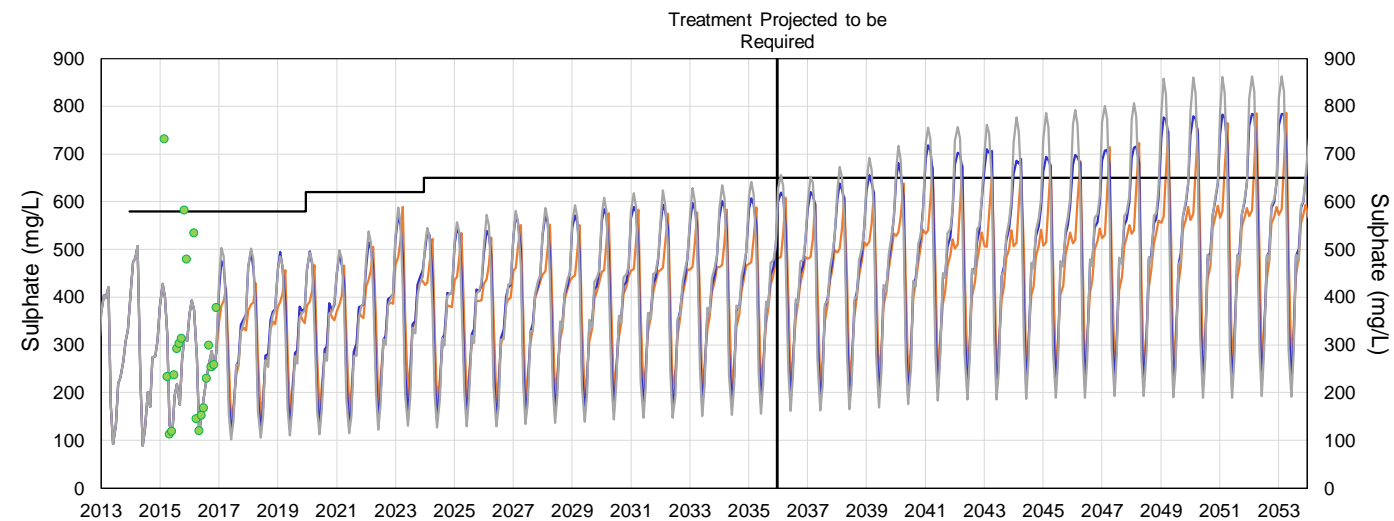


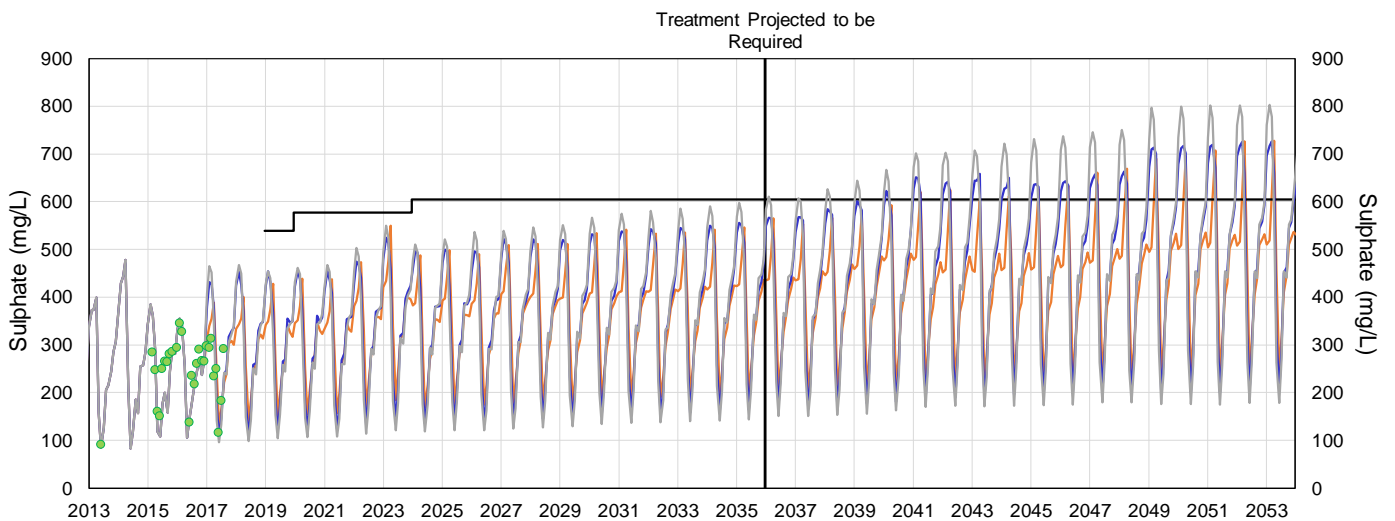
Figure C-6 Projected Monthly Average Concentrations of Sulphate at Compliance Points between 2013 and 2053 for the Permitted Development Scenario without Assumed Improvement in Water Availability

(a) FRO Compliance Point (FR_FRCP1; E300071)



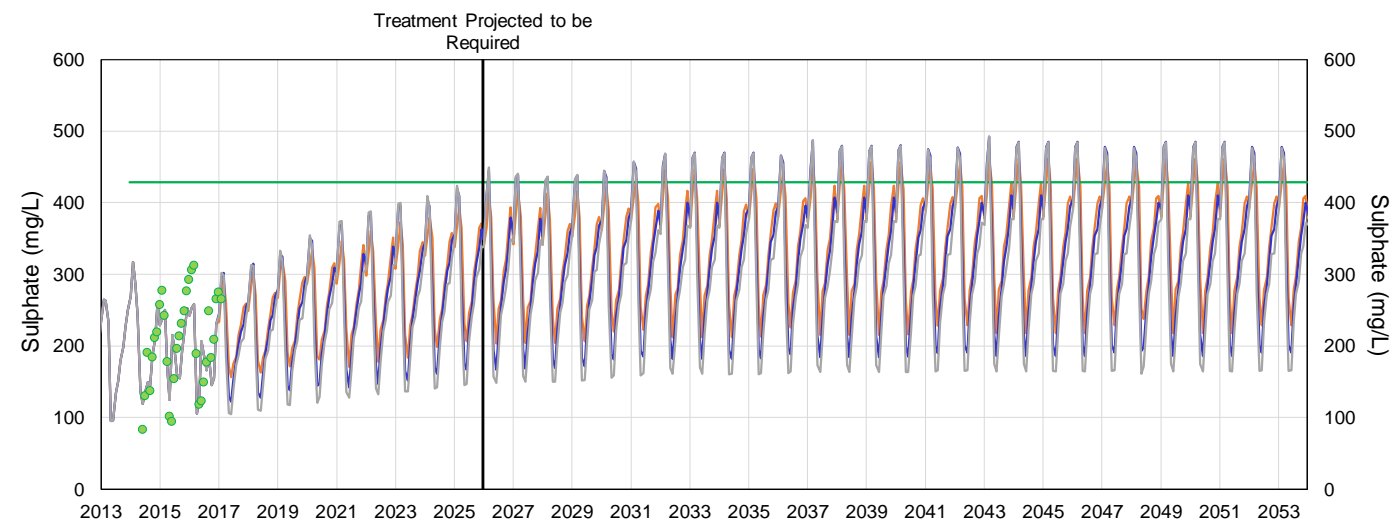
Note: At FR_FRCP1, monitored data are presented from January 2015 to December 2016. Three monitored data points are not presented on the plot, because at certain times of the year (i.e., winter) monitored concentrations at the FRO Compliance Point are not representative of concentrations in the Fording River. The three monitored data points (i.e., monthly average monitored concentrations) that are not presented on the plot are: 983 mg/L in February 2015, 1,500 mg/L in January 2016 and 1,160 mg/L in February 2016. Model projections at FR_FRCP1 reflect fully mixed conditions, whereas monitoring data collected during low flow periods reflect primarily the quality of Cataract Creek water; hence, the difference between model projections and monitored concentrations during low flow periods.

(b) Fording River above Chauncey Creek (FR_FRABCH)



Note: Projected concentrations are presented at Fording River above Chauncey Creek (FR_FRABCH), because it is the location proposed for the new Fording River Operations Compliance Point.

(c) LCO Compliance Point (LC_LCDSSLCC; E297110)



(d) GH0 Elk River Compliance Point (GH_ERC; E300090)

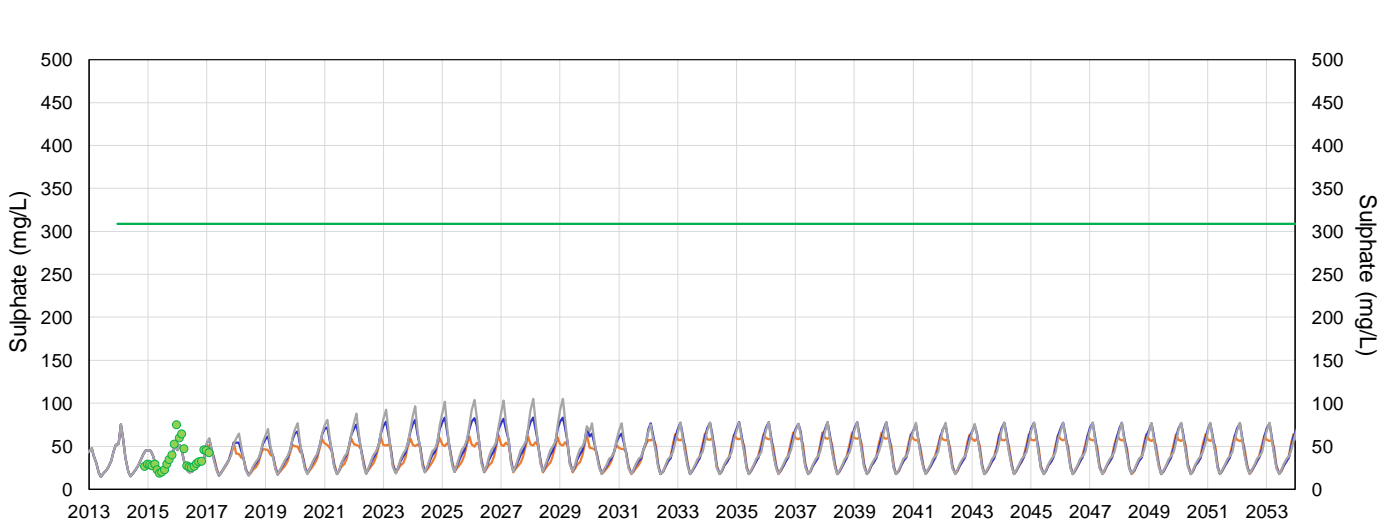
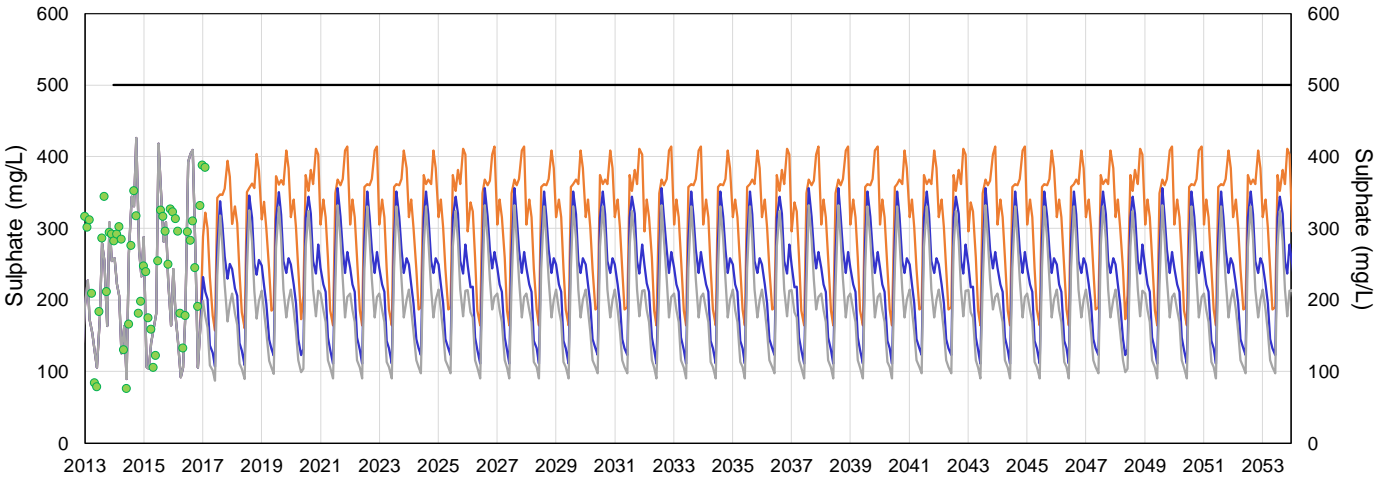
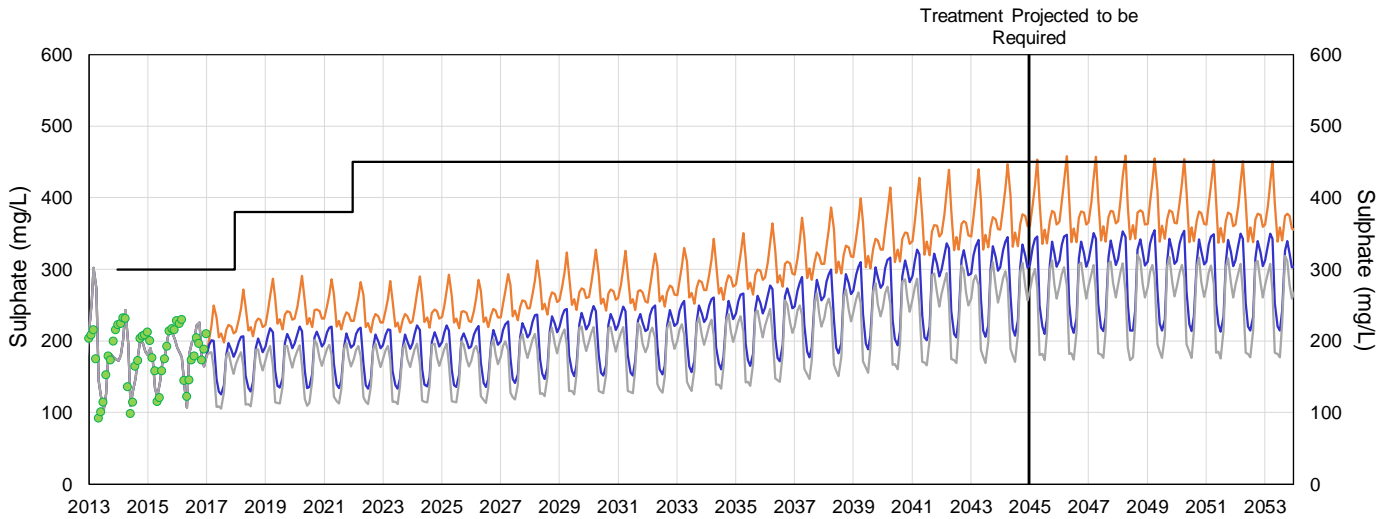
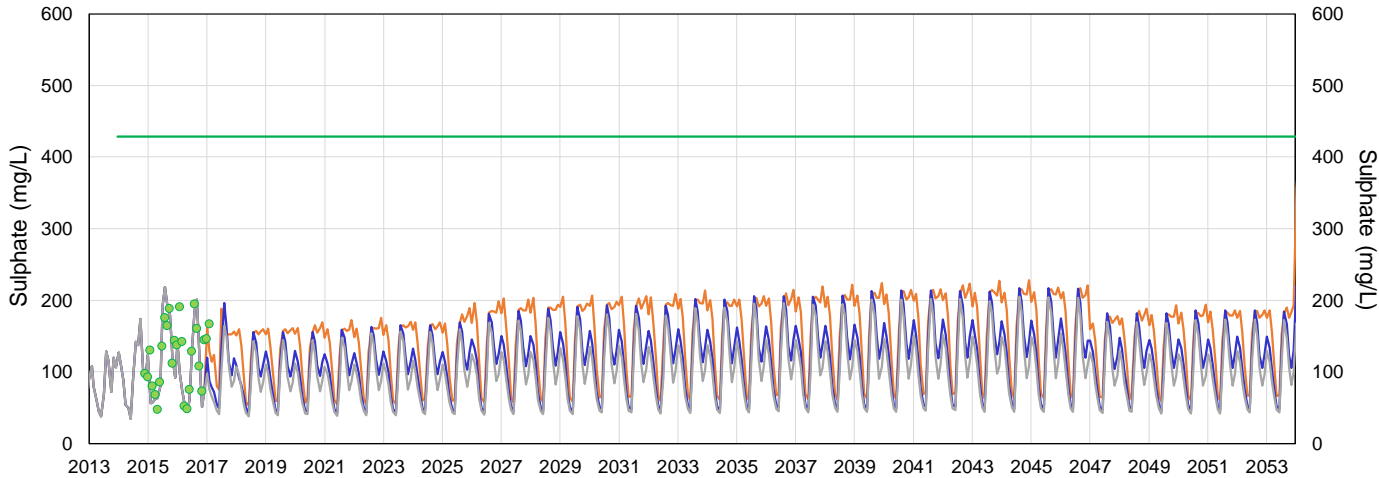


Figure C-6 Projected Monthly Average Concentrations of Sulphate at Compliance Points between 2013 and 2053 for the Permitted Development Scenario without Assumed Improvement in Water Availability (Continued)
(e) EVO Harmer Compliance Point (EV_HC1; E102682) (e) CMO Compliance Point (CM_MC2; E258937)



(f) EVO Michel Creek Compliance Point (EV_MC2; E300091)



Appendix D – Projected Concentrations of Nitrate and Selenium without Mitigation

July 2019

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Projected monthly average concentrations of nitrate and selenium at Order Stations and compliance points for the Permitted Development Scenario with and without the 2019 Implementation Plan Adjustment (IPA) are shown in Figures D-1 to D-4. Comparable figures were not generated for sulphate, because sulphate is not subject to treatment in the 2019 IPA. Thus, the figures shown elsewhere in the 2019 IPA already represent unmitigated projected concentrations.

The projections shown in Figures D-1 to D-4 are presented as time series plots. The solid orange, blue and green lines correspond to the projected monthly concentrations with the 2019 IPA under low, average and high flows. The solid light gray, dashed light gray and dashed dark gray lines correspond to the projected monthly concentrations without active water treatment under low, average and high flows, respectively¹. The figures include Site Performance Objectives (SPOs), Compliance Limits, historical observations (green points) and fully effective dates (vertical lines) for the AWTfs.

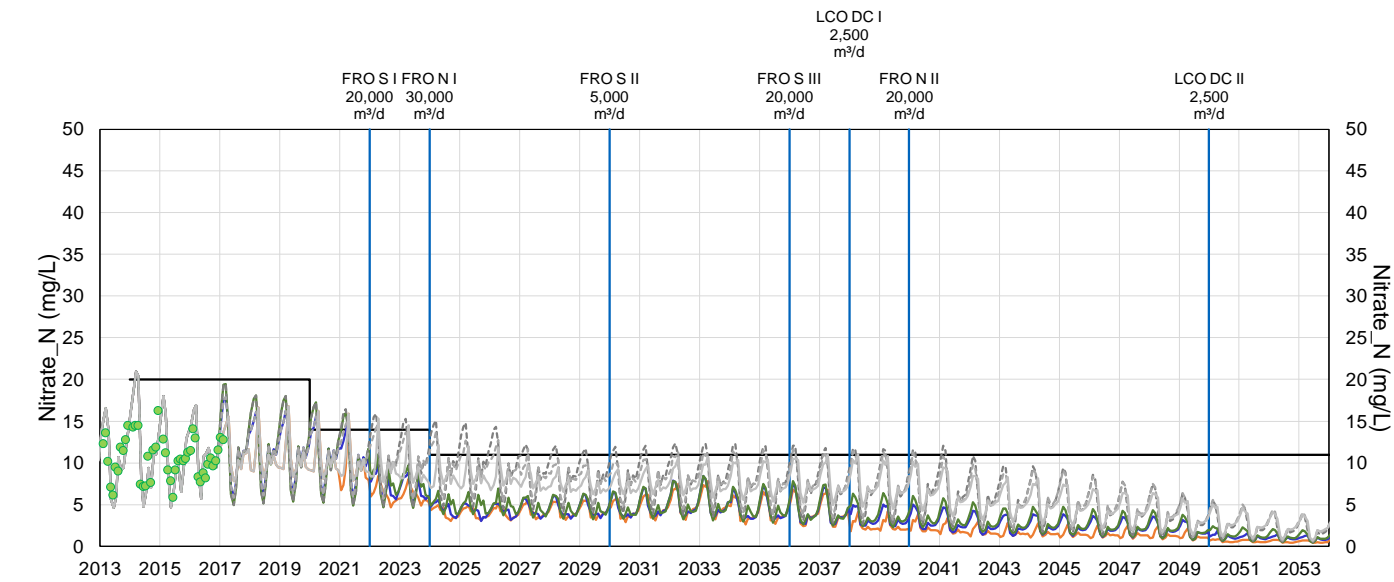
The x-axis in Figures D-1 to D-4 runs from the start of 2013 to the end of 2053. The calibration period for the RWQM is January 1, 2004 to December 31, 2016. Therefore, projected concentrations shown in solid gray prior to 2017 correspond to the monthly average concentrations projected to occur each year under observed flow conditions. Year 2053 corresponds to the time in the model at which all the waste rock considered in the Permitted Development Scenario has been deposited and the lag associated with that rock has passed (i.e., all the waste rock is contributing selenium and sulphate load).

The legend below applies to all time series plots in this appendix.

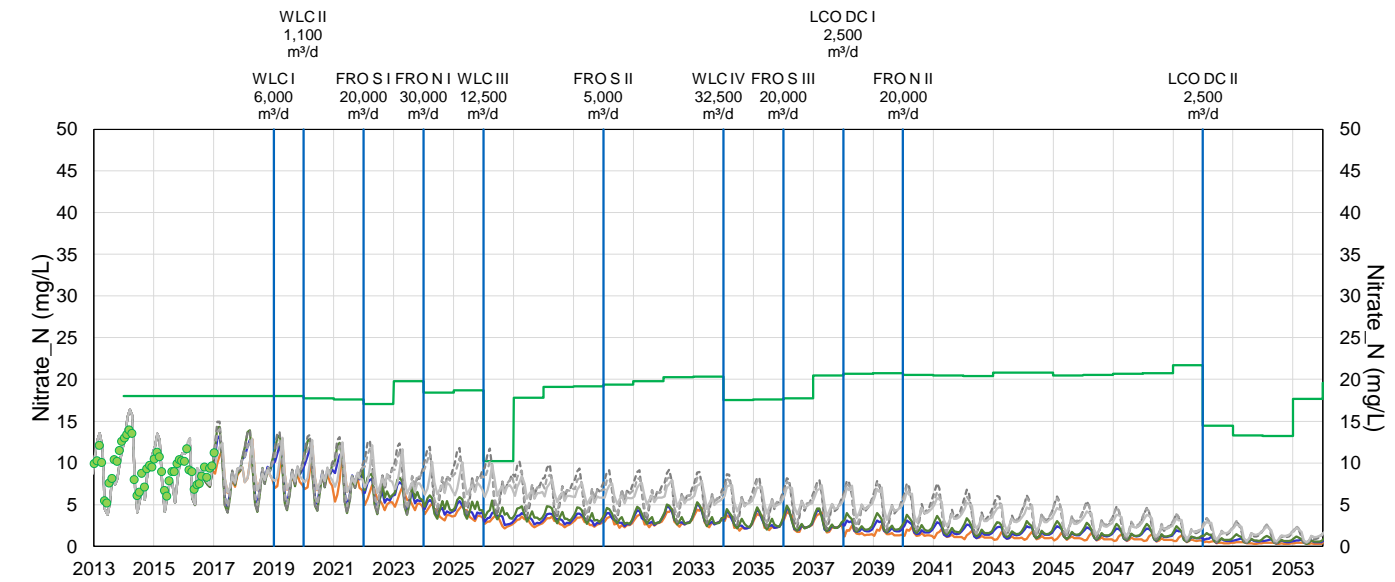
-  Projected Monthly Average Concentrations under Low Flows with the 2019 IPA
-  Projected Monthly Average Concentrations under Average Flows with the 2019 IPA
-  Projected Monthly Average Concentrations under High Flows with the 2019 IPA
-  Projected Monthly Average Concentrations under Low Flows without Active Water Treatment
-  Projected Monthly Average Concentrations under Average Flows without Active Water Treatment
-  Projected Monthly Average Concentrations under High Flows without Active Water Treatment
-  Monthly Average Monitored Concentrations
-  Site Performance Objective
-  Limit

¹ Projected monthly concentrations without active water treatment do not include Phase I of the West Line Creek Active Water Treatment Facility.

Figure D-1 Projected Monthly Average Concentrations of Nitrate at Order Stations between 2013 and 2053 for the Permitted Development Scenario
(a) Fording River downstream of Greenhills Creek (GH_FR1; 0200378) (b) Fording River downstream of Line Creek (LC_LC5; 0200028)

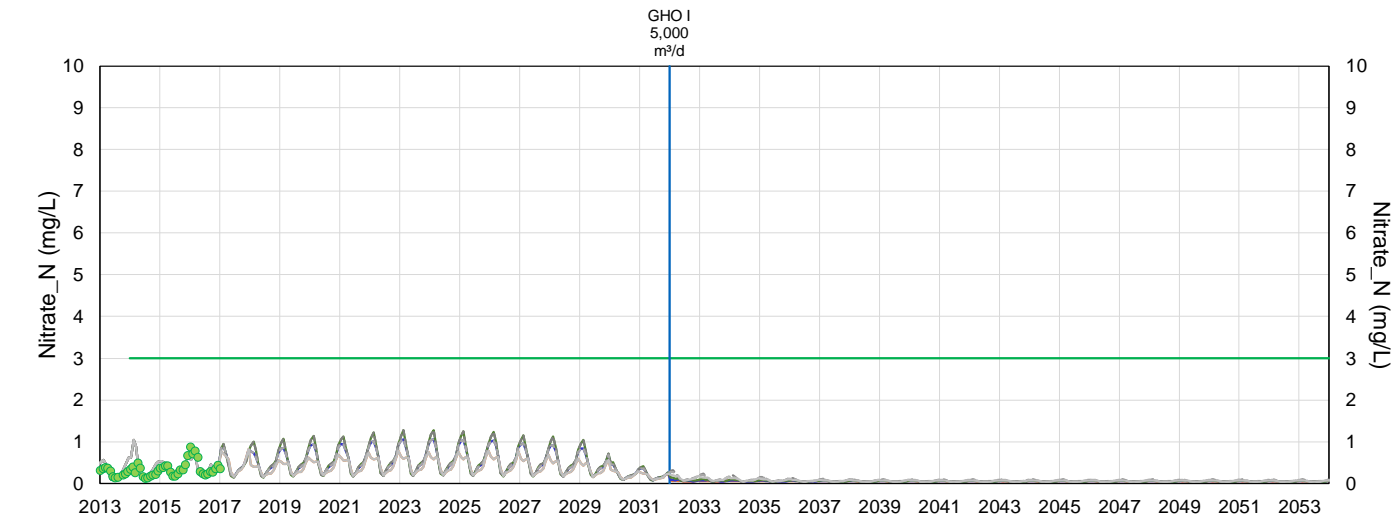


Note: This location is also the GHO Fording River Compliance Point.



Note: Site Performance Objective is hardness dependent from 2019 onward and is calculated using the following formula: $N \text{ (in mg-N/L)} = 10^{1.0003 \log_{10}(\text{hardness}) - 1.52}$ where hardness is in mg/L of CaCO_3 ; it varies with time to reflect projected hardness concentrations in the month when maximum monthly average nitrate concentrations are projected to occur.

(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)



(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)

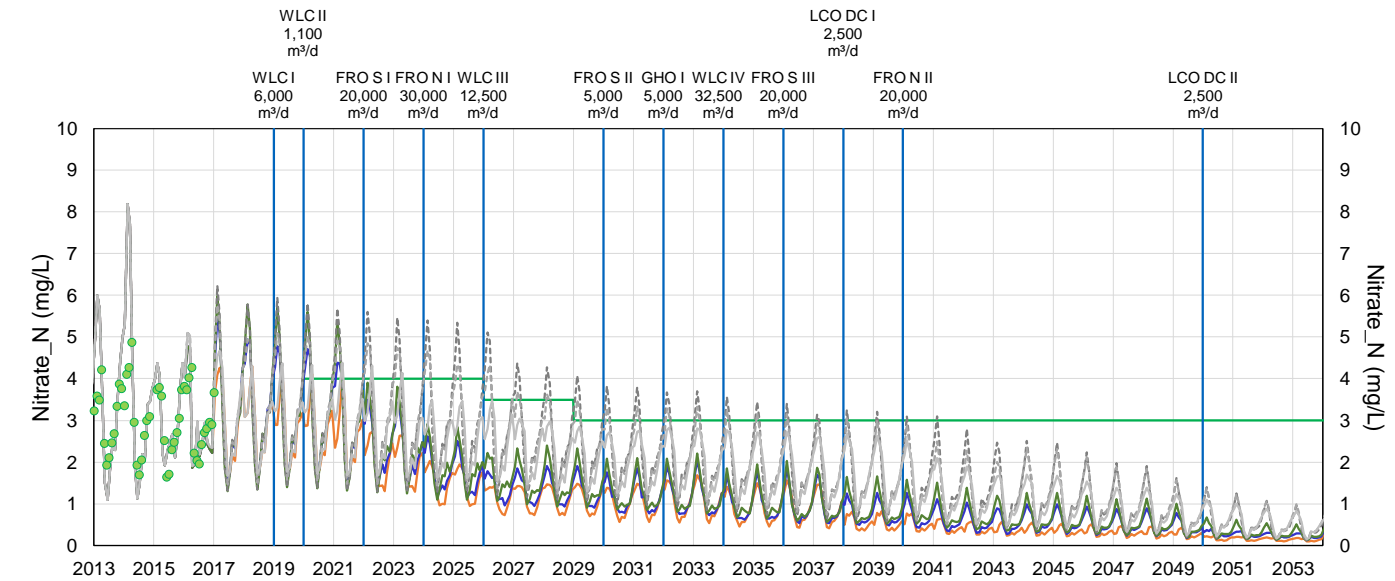
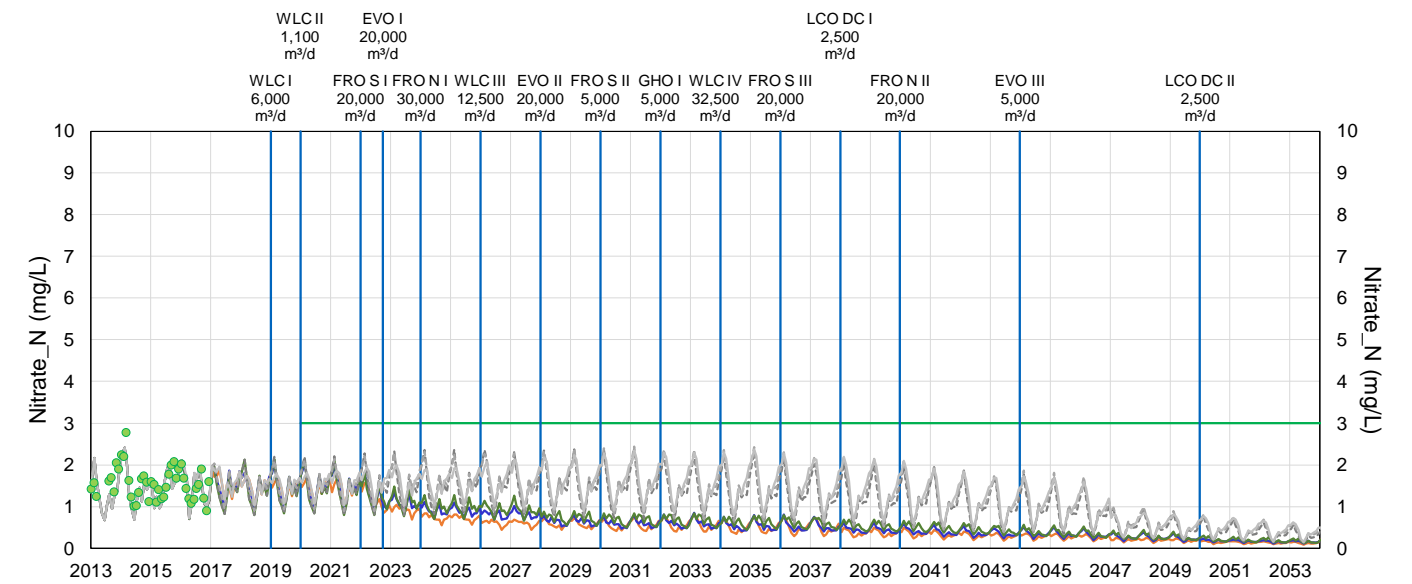
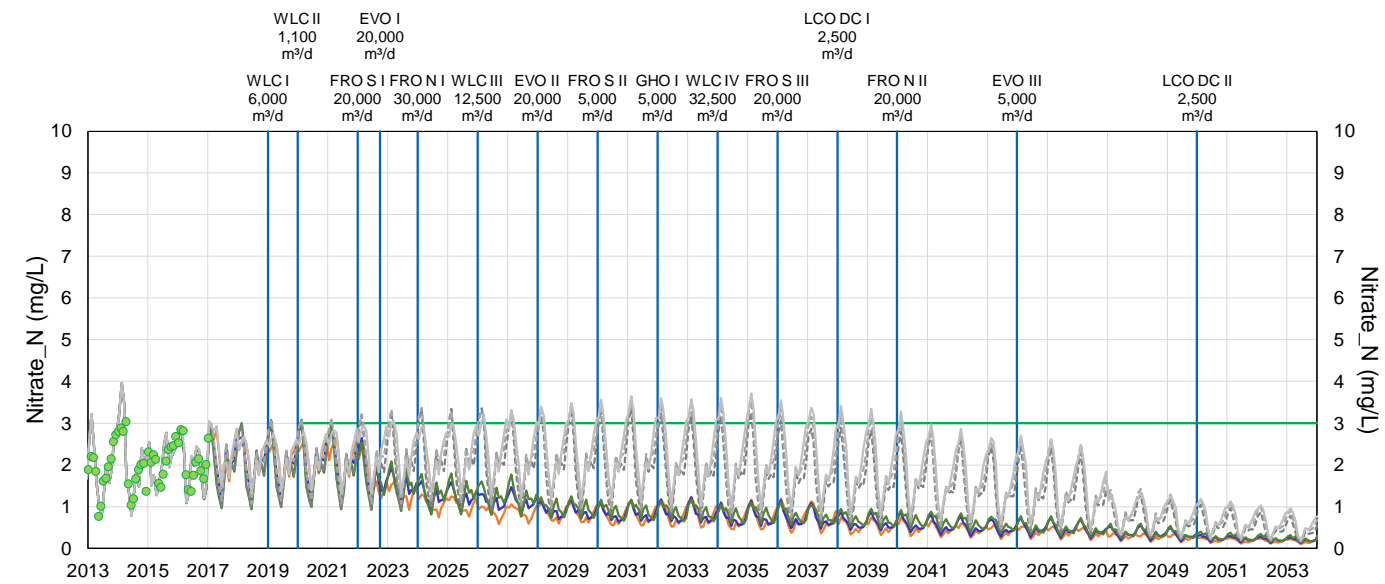


Figure D-1 Projected Monthly Average Concentrations of Nitrate at Order Stations between 2013 and 2053 for the Permitted Development Scenario (Continued)

(e) Elk River downstream of Michel Creek (EV_ER1; 0200393)

(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)

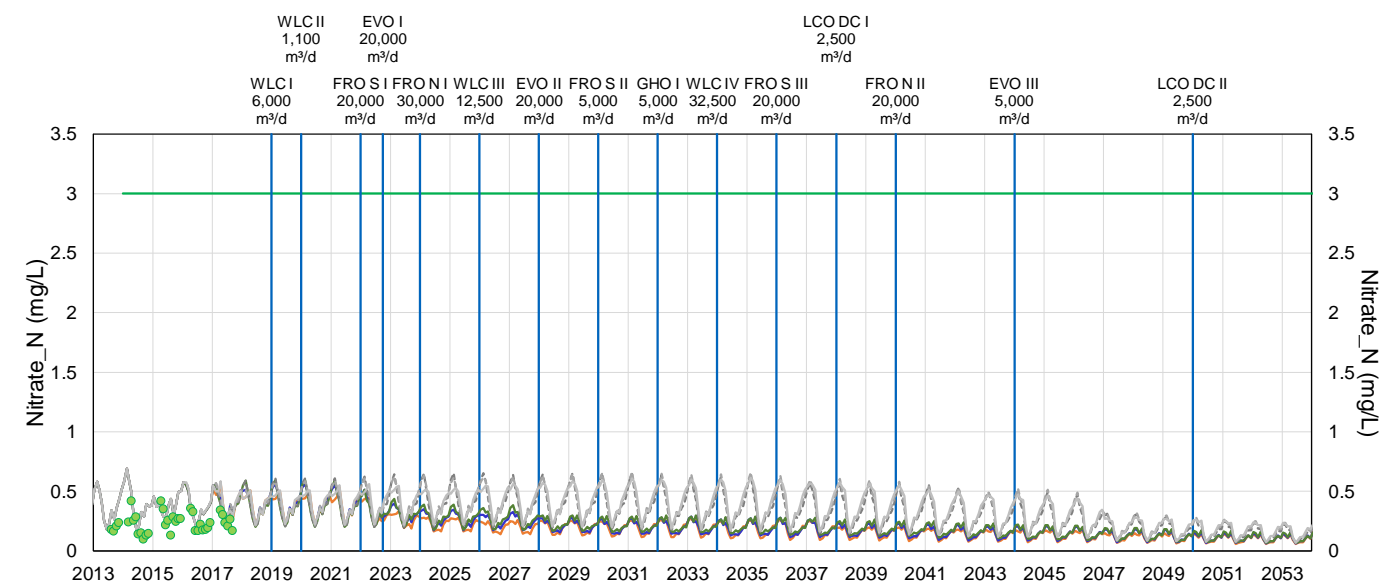
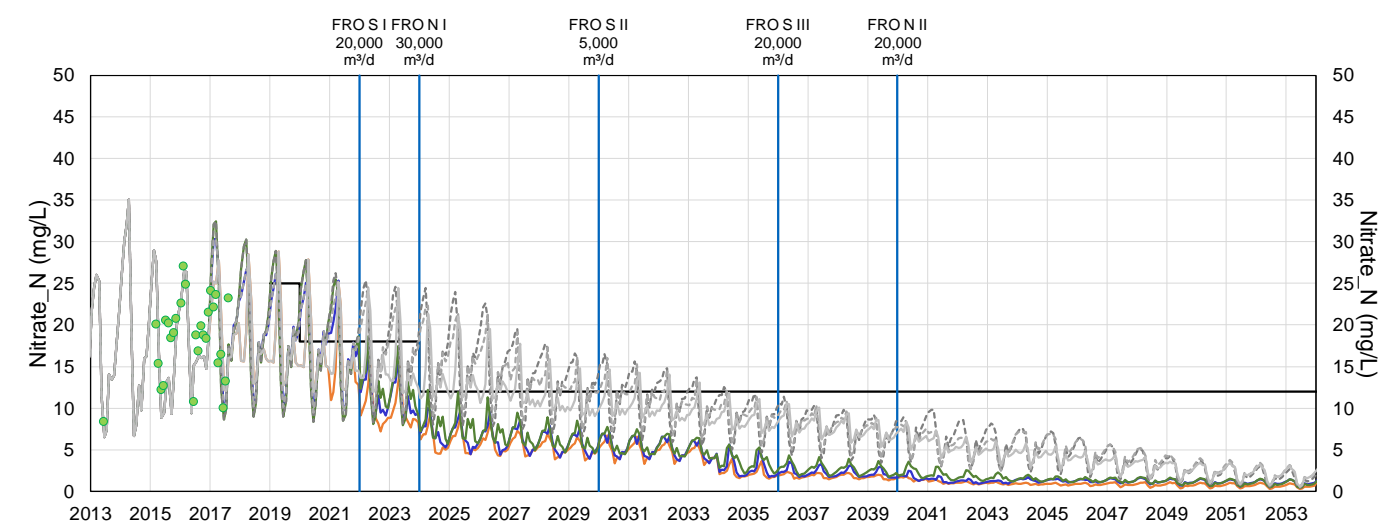
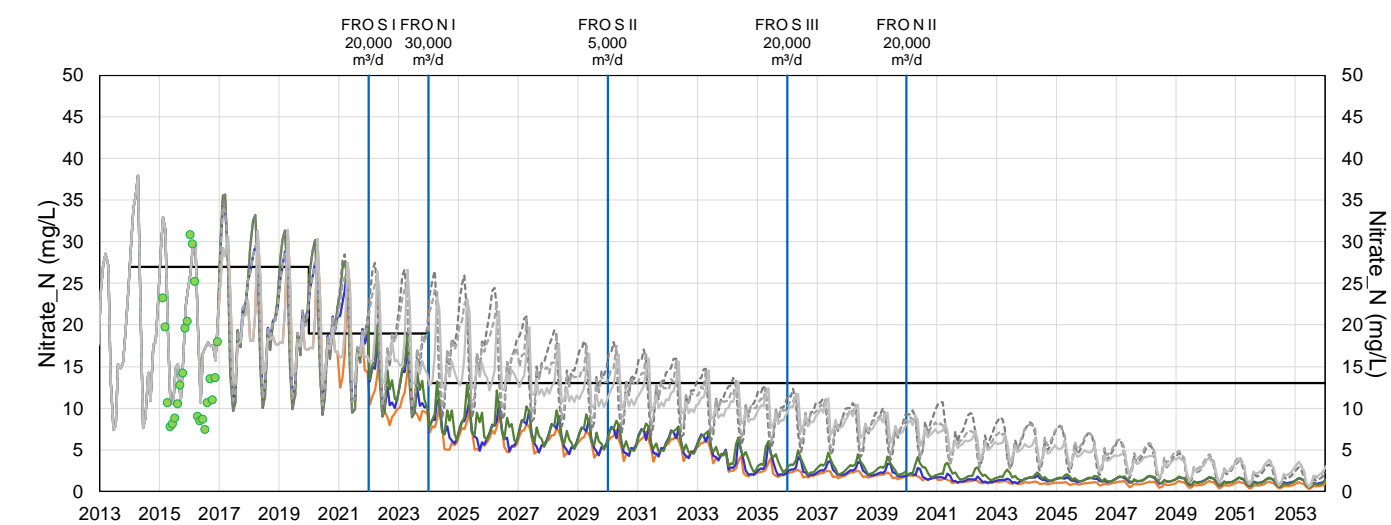
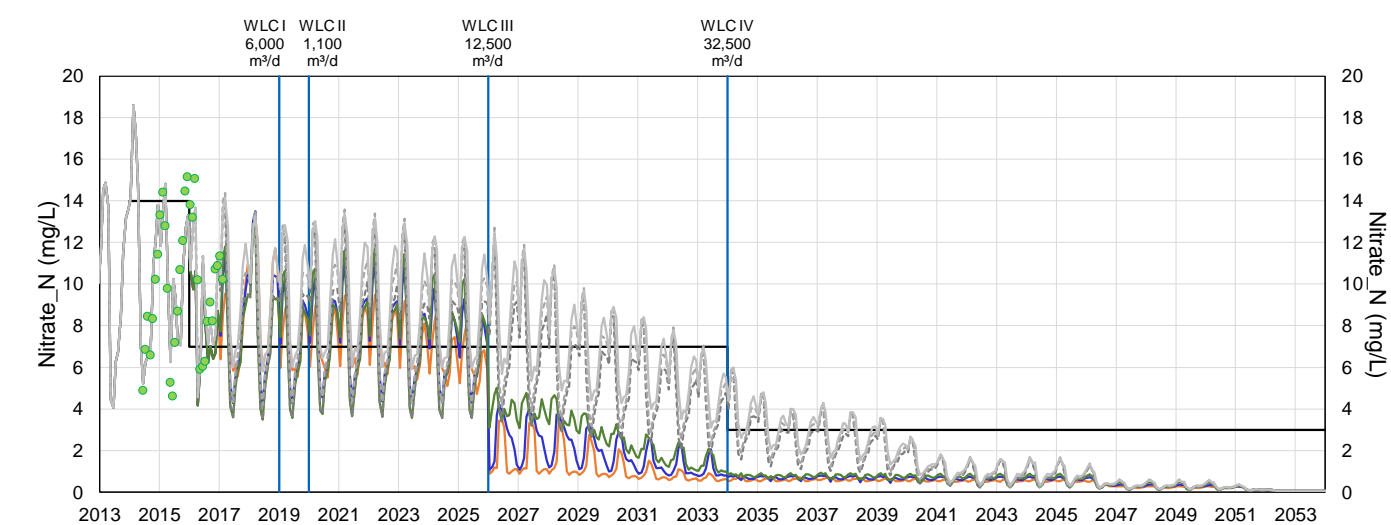


Figure D-2 Projected Monthly Average Concentrations of Nitrate at Compliance Points between 2013 and 2053 for the Permitted Development Scenario
(a) FRO Compliance Point (FR_FRCP1; E300071) (b) Fording River above Chauncey Creek (FR_FRABCH)



Note: Projected concentrations are presented at Fording River above Chauncey Creek (FR_FRABCH), because it is the location proposed for the new Fording River Operations Compliance Point.

(c) LCO Compliance Point (LC_LCDSSLCC; E297110)



(d) GHO Elk River Compliance Point (GH_ERC; E300090)

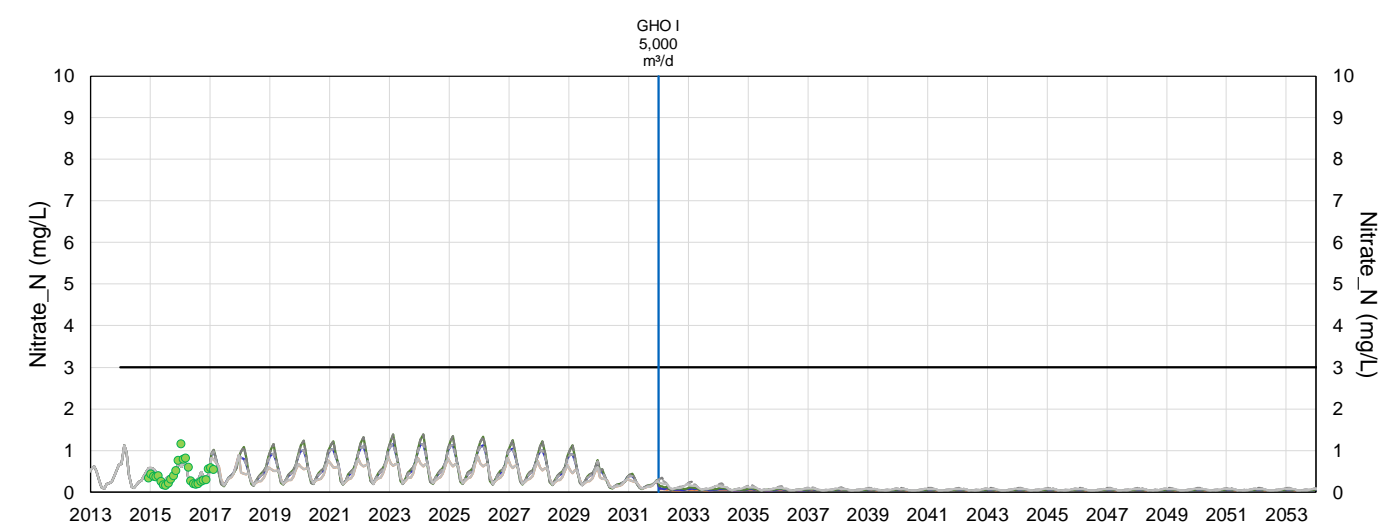
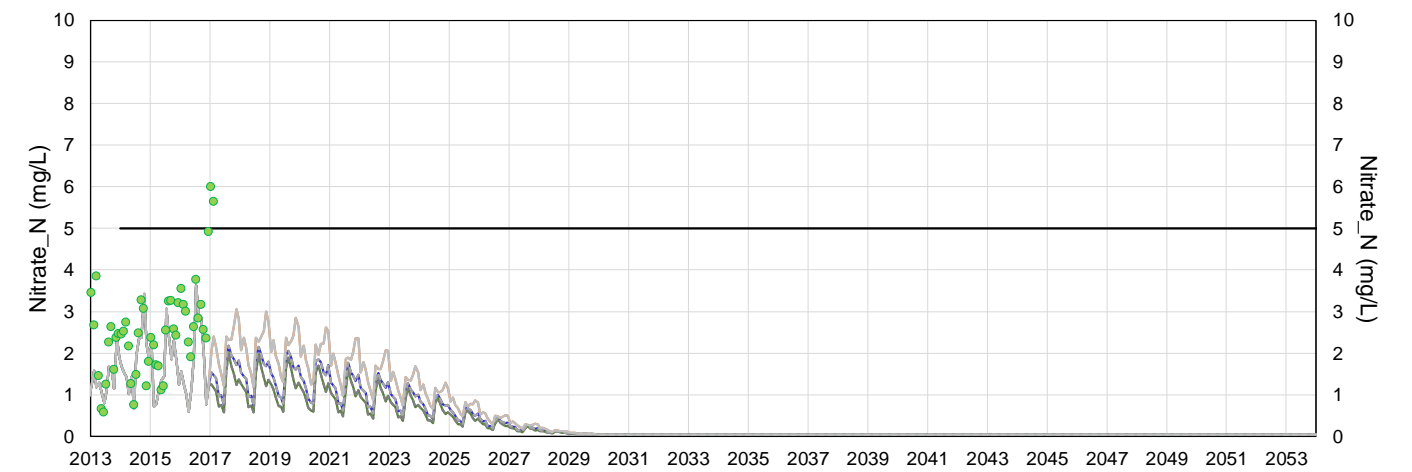
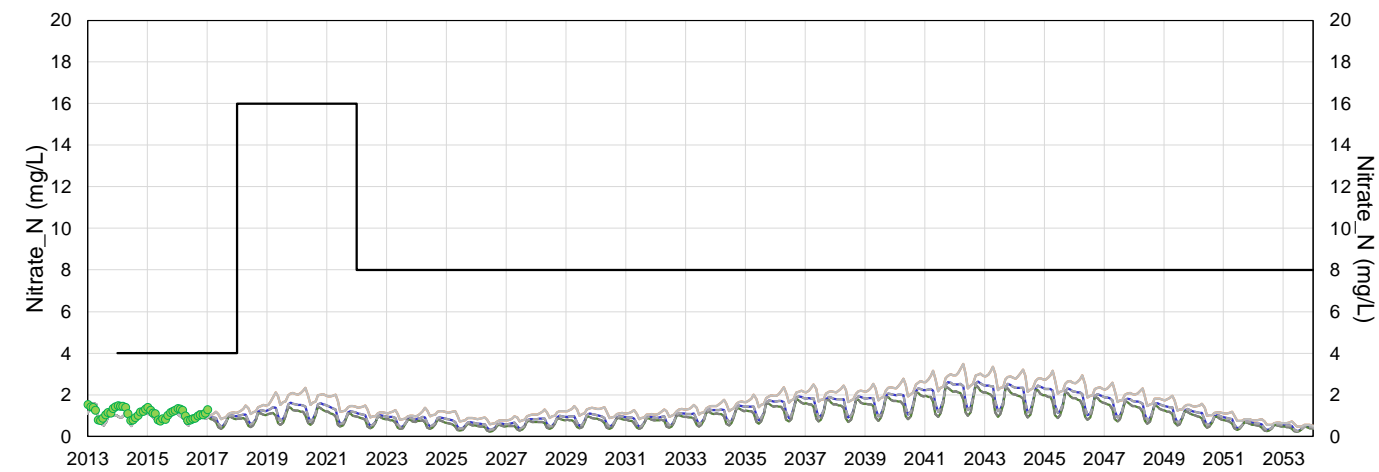


Figure D-2 Projected Monthly Average Concentrations of Nitrate at Compliance Points between 2013 and 2053 for the Permitted Development Scenario (Continued)

(e) EVO Harmer Compliance Point (EV_HC1; E102682)

(f) CMO Compliance Point (CM_MC2; E258937)



(g) EVO Michel Creek Compliance Point (EV_MC2; E300091)

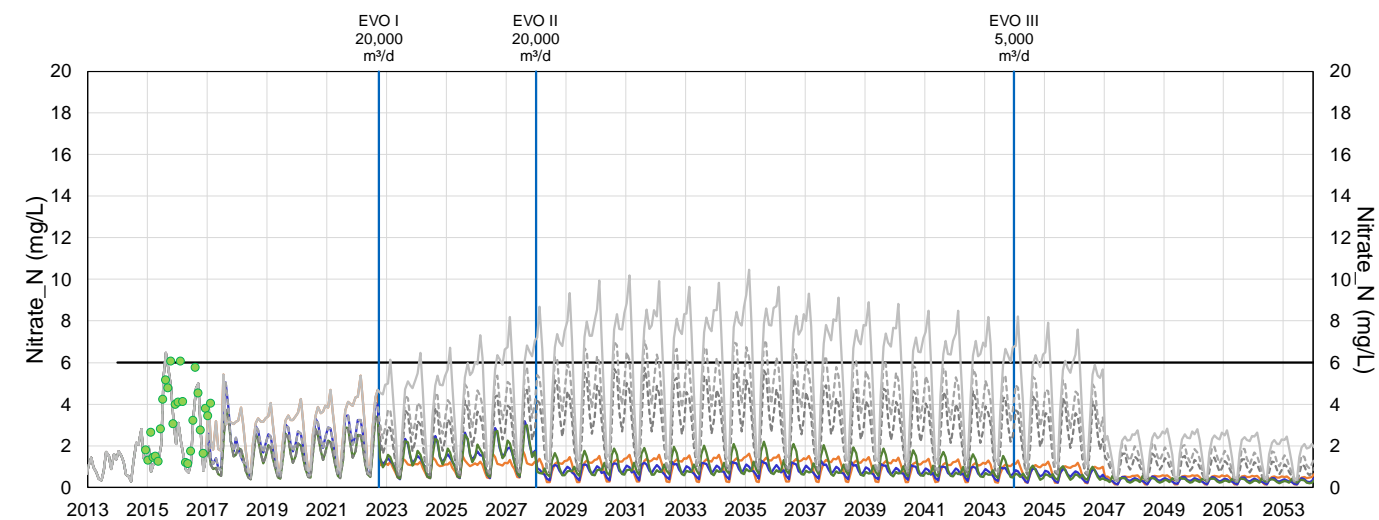
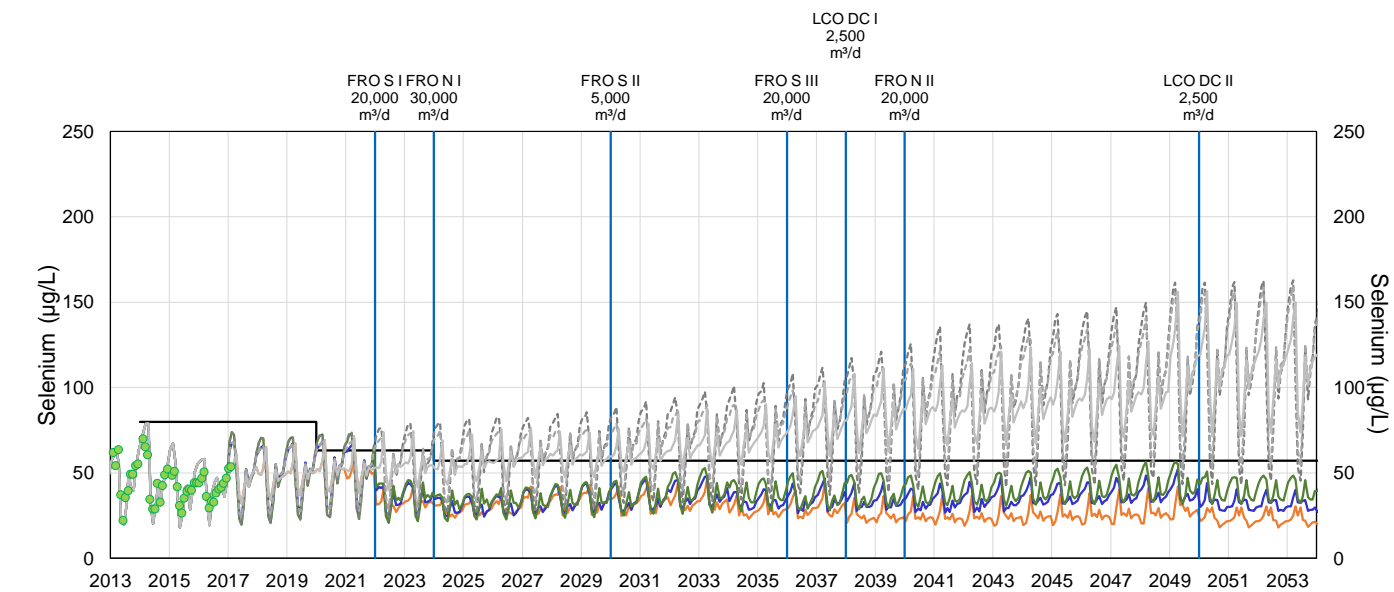


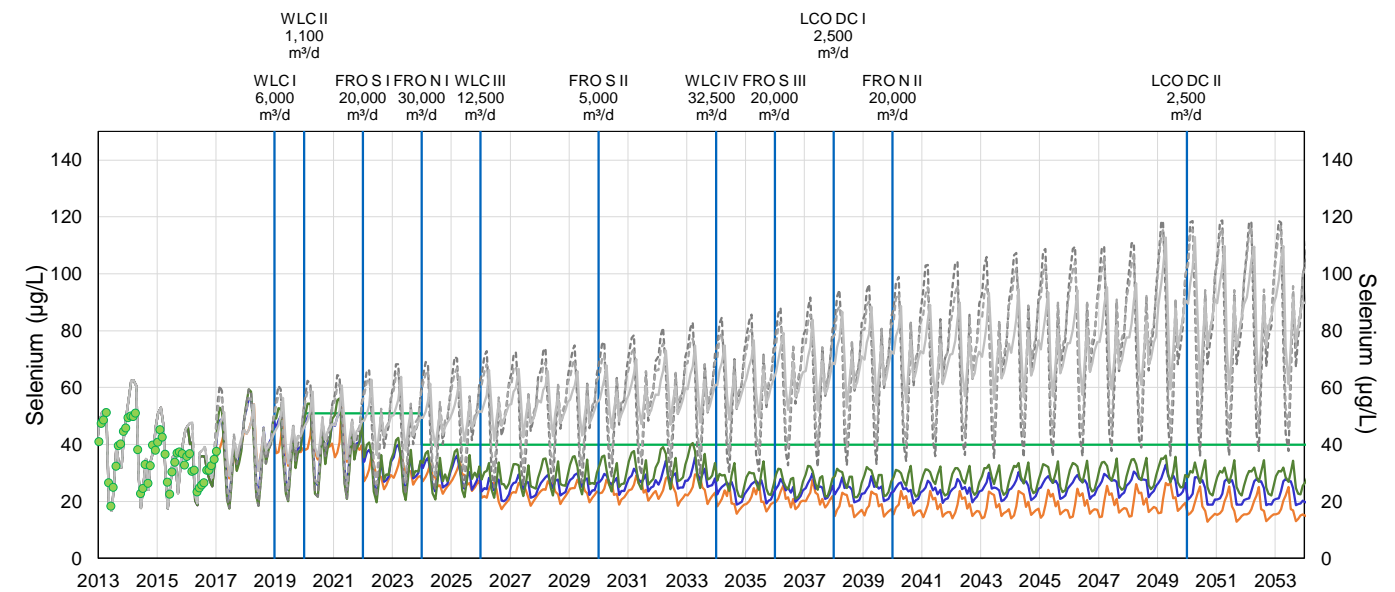
Figure D-3 Projected Monthly Average Concentrations of Selenium at Order Stations between 2013 and 2053 for the Permitted Development Scenario

(a) Fording River downstream of Greenhills Creek (GH_FR1; 0200378)

(b) Fording River downstream of Line Creek (LC_LC5; 0200028)



Note: This location is also the GHO Fording River Compliance Point.



(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)

(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)

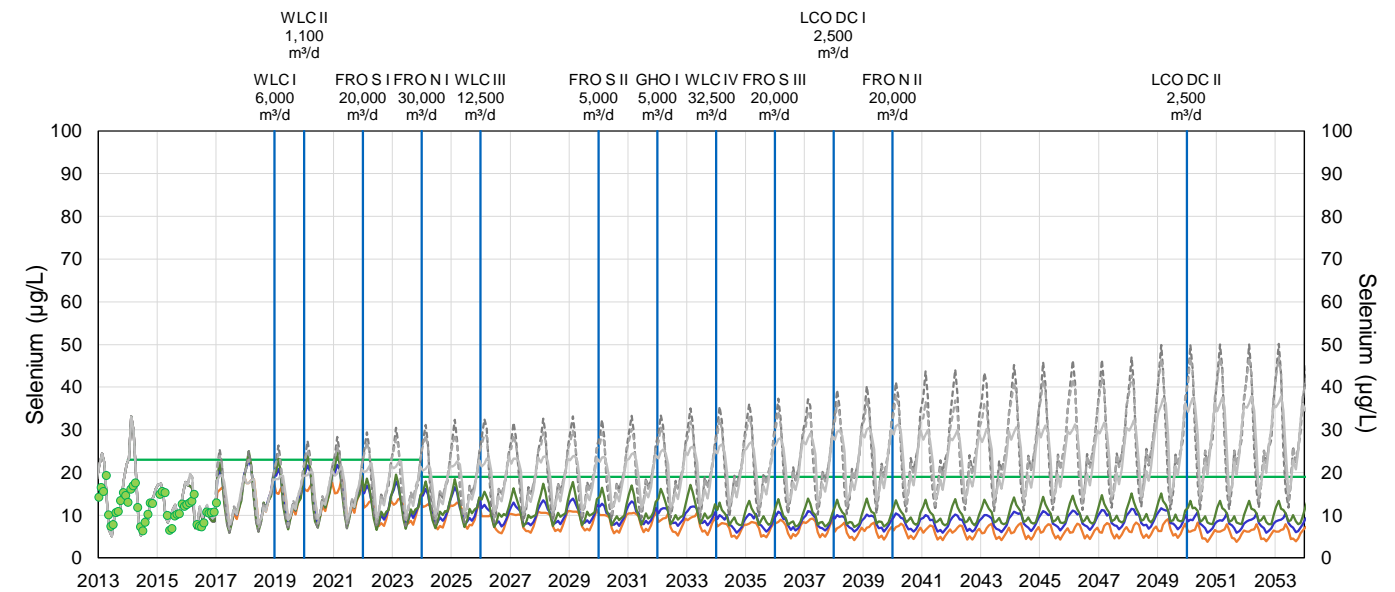
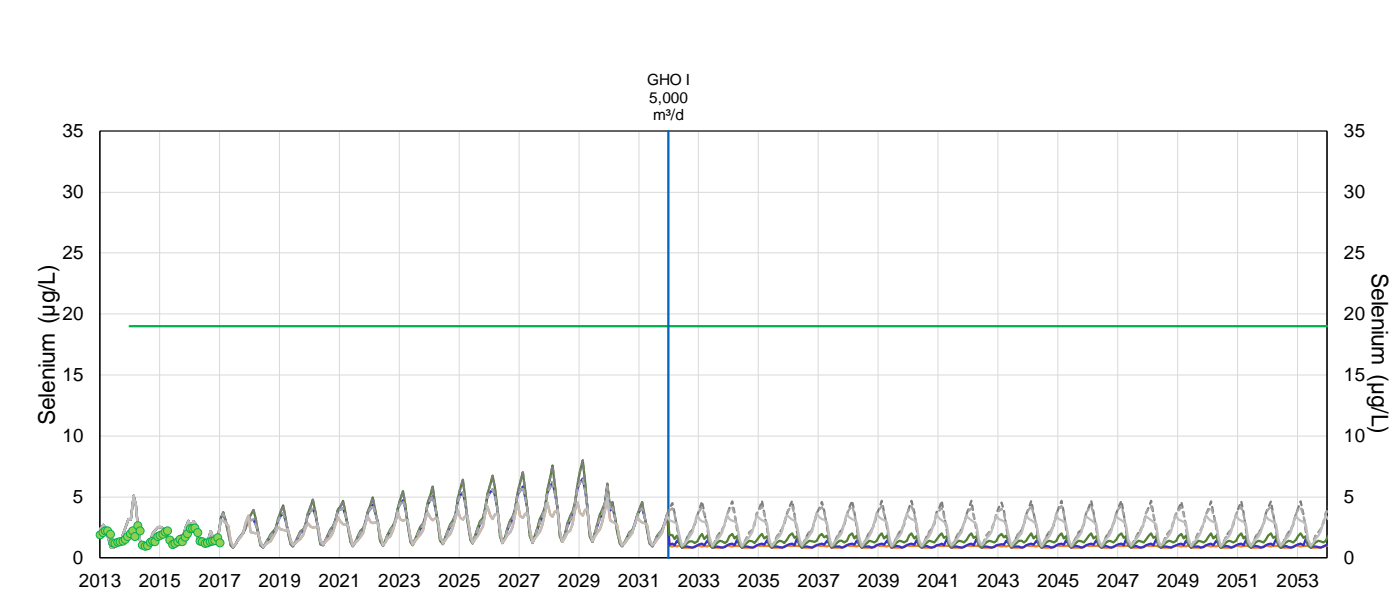
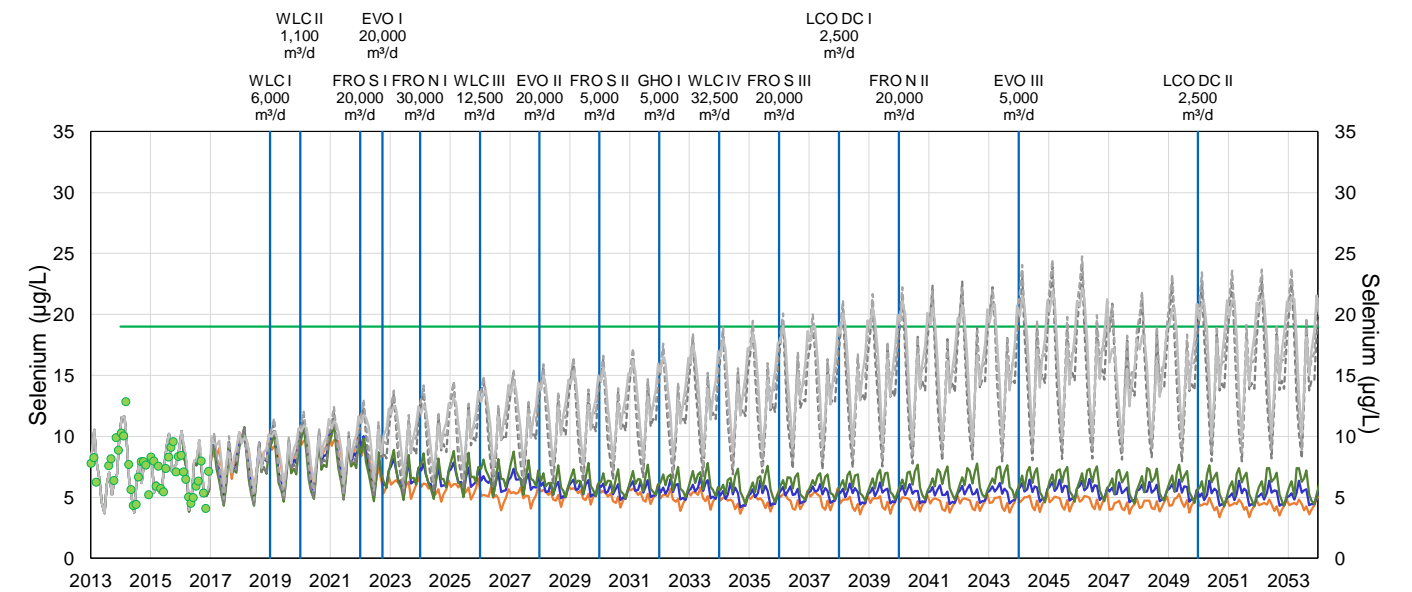
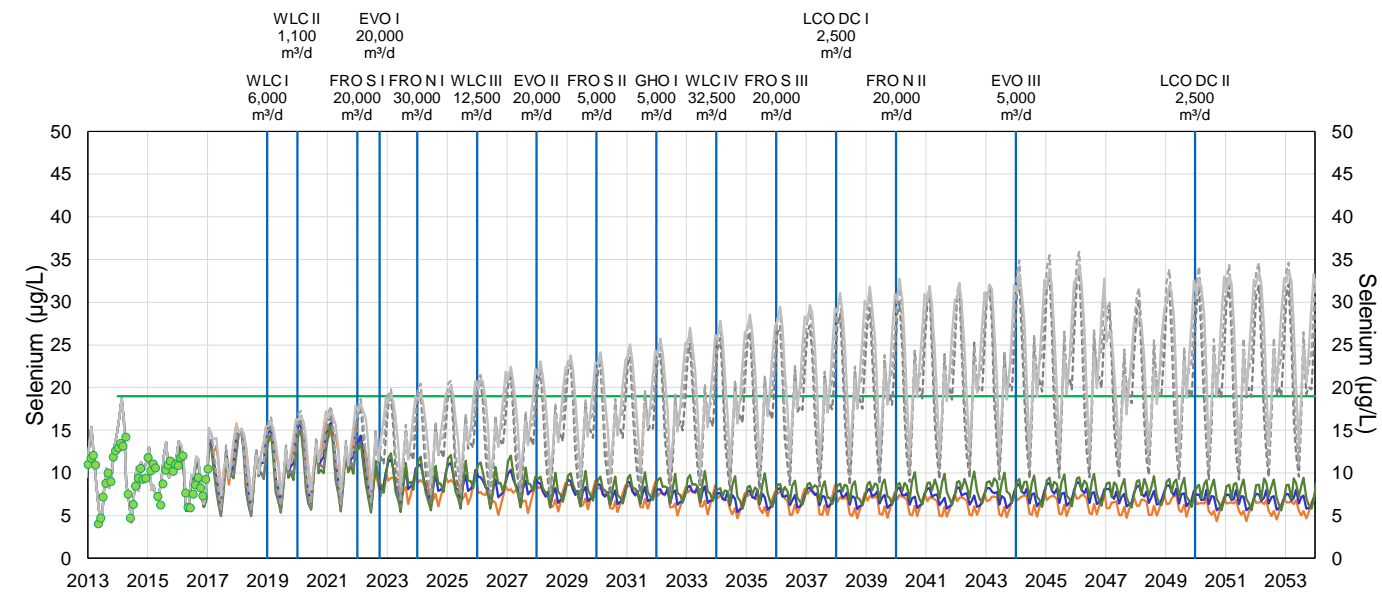


Figure D-3 Projected Monthly Average Concentrations of Selenium at Order Stations between 2013 and 2053 for the Permitted Development Scenario

(e) Elk River downstream of Michel Creek (EV_ER1; 0200393)

(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)

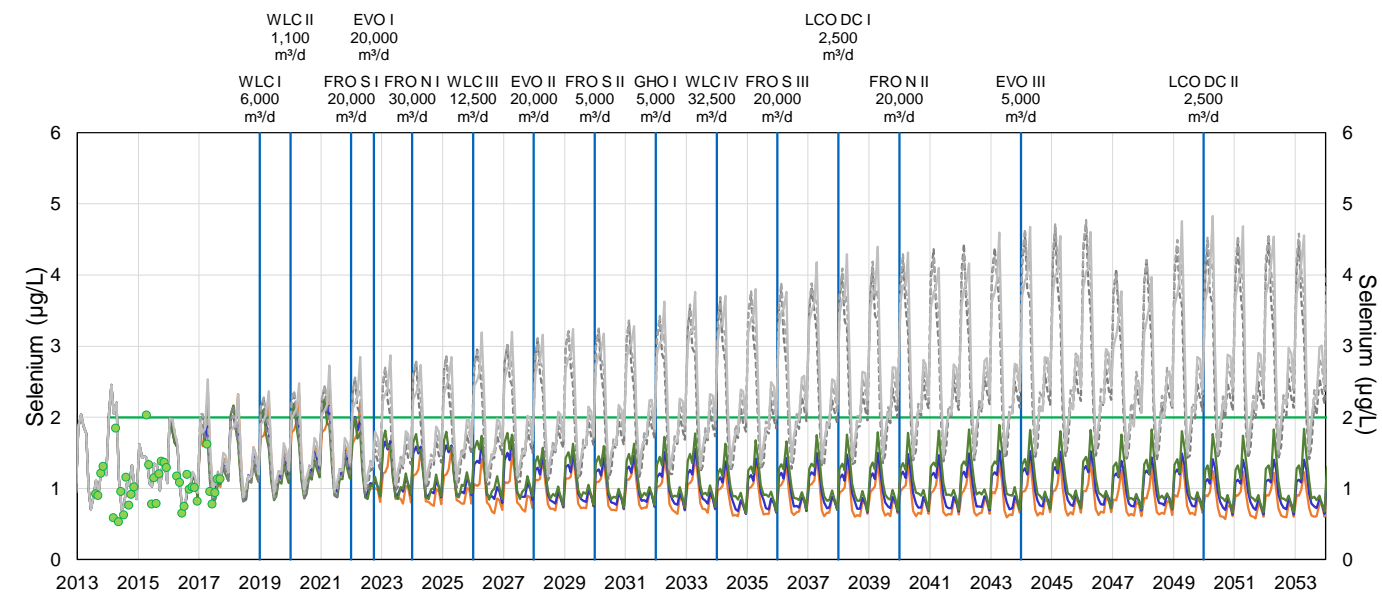
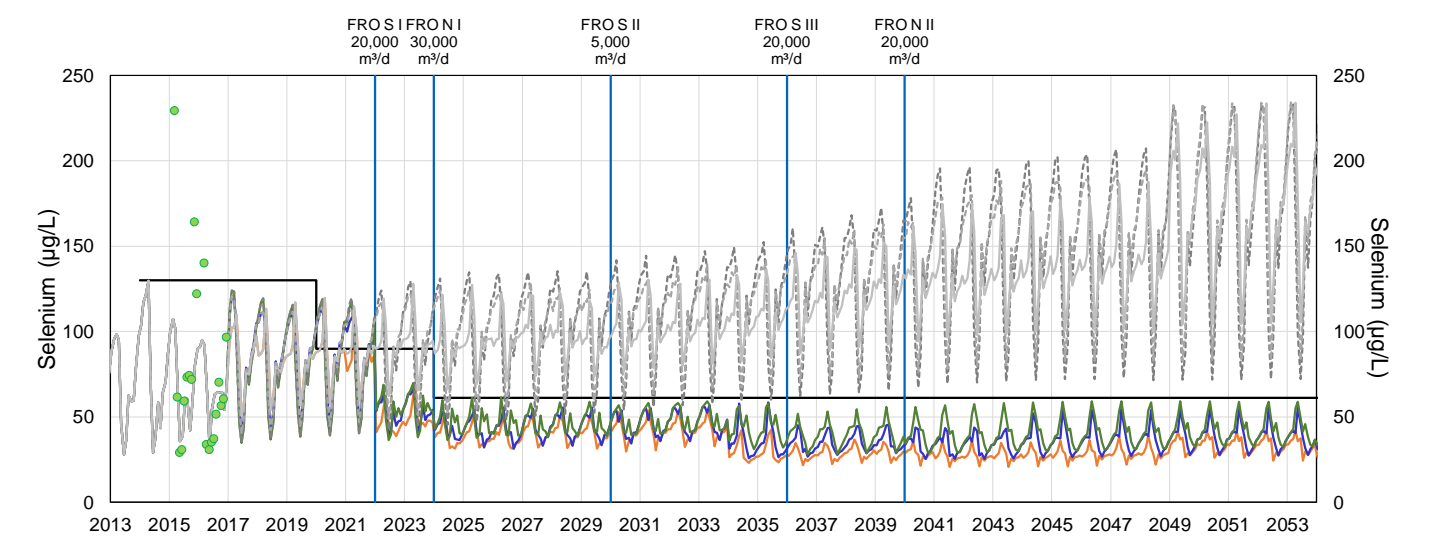
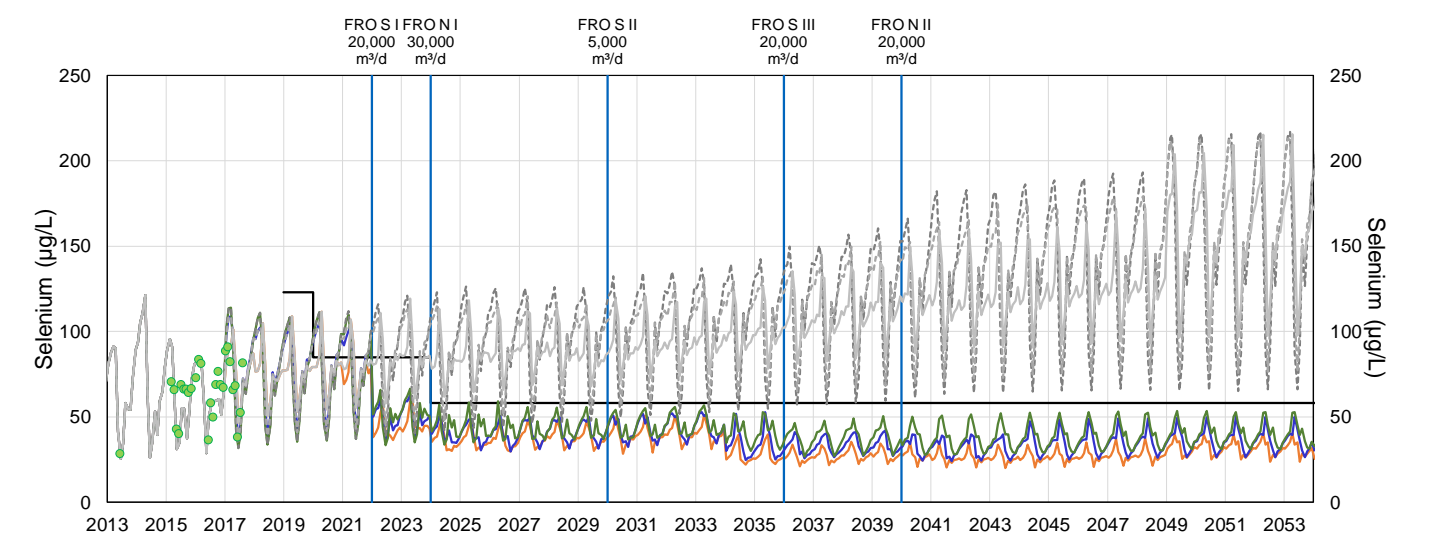


Figure D-4 Projected Monthly Average Concentrations of Selenium at Compliance Points between 2013 and 2053 for the Permitted Development Scenario
(a) FRO Compliance Point (FR_FRCP1; E300071) (b) Fording River above Chauncey Creek (FR_FRABCH)

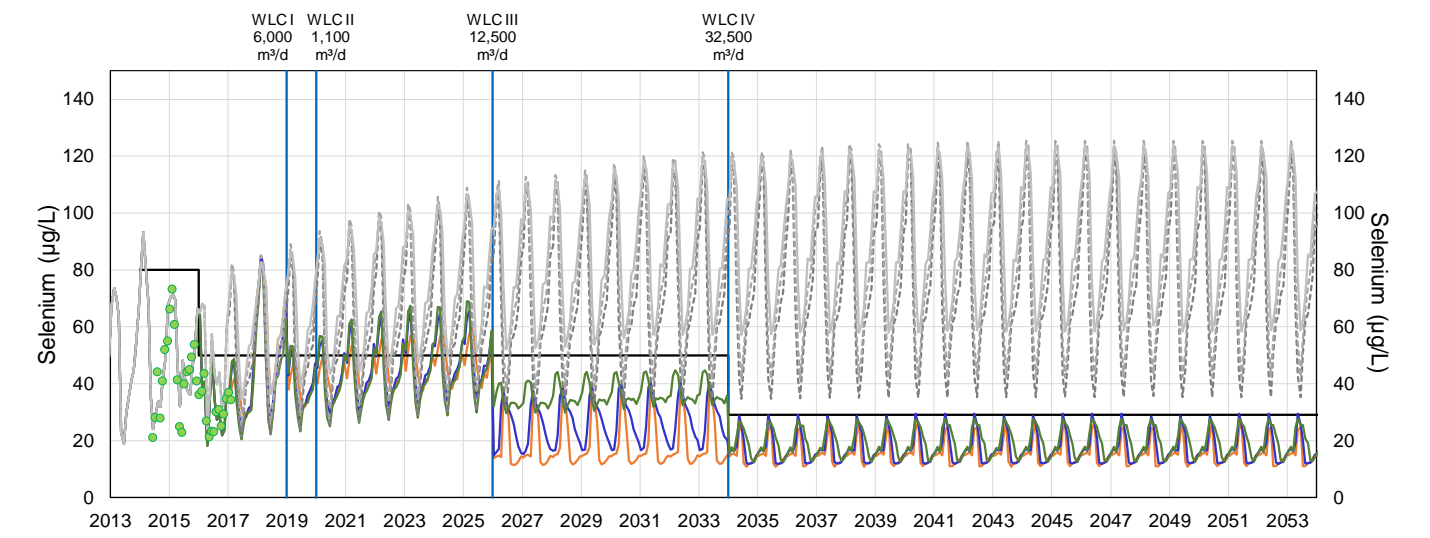


Note: At FR_FRCP1, monitored data are presented from January 2015 to December 2016. Three monitored data points are not presented on the plot, because at certain times of the year (i.e., winter) monitored concentrations at the FRO Compliance Point are not representative of concentrations in the Fording River. The three monitored data points (i.e., monthly average monitored concentrations) that are not presented on the plot are: 310 µg/L in February 2015, 447 µg/L in January 2016 and 316 µg/L in February 2016. Model projections at FR_FRCP1 reflect fully mixed conditions, whereas monitoring data collected during low flow periods reflect primarily the quality of Cataract Creek water; hence, the difference between model projections and monitored concentrations during low flow periods.



Note: Projected concentrations are presented at Fording River above Chauncey Creek (FR_FRABCH), because it is the location proposed for the new Fording River Operations Compliance Point.

(c) LCO Compliance Point (LC_LCDSSLCC; E297110)



(d) GHO Elk River Compliance Point (GH_ERC; E300090)

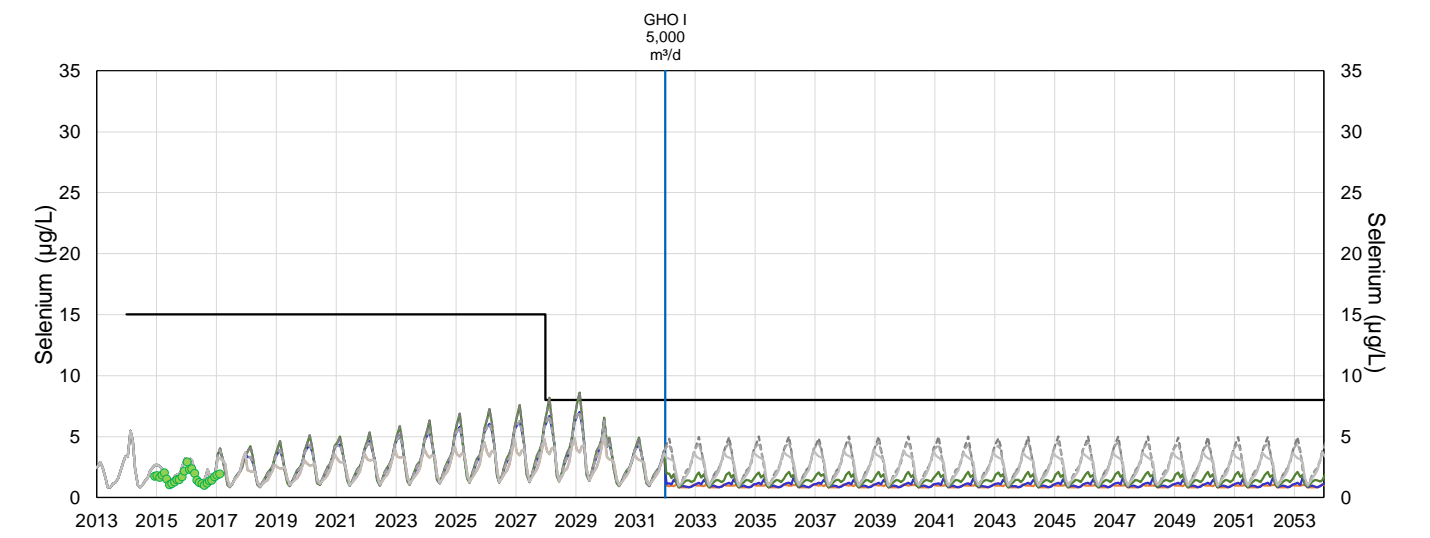
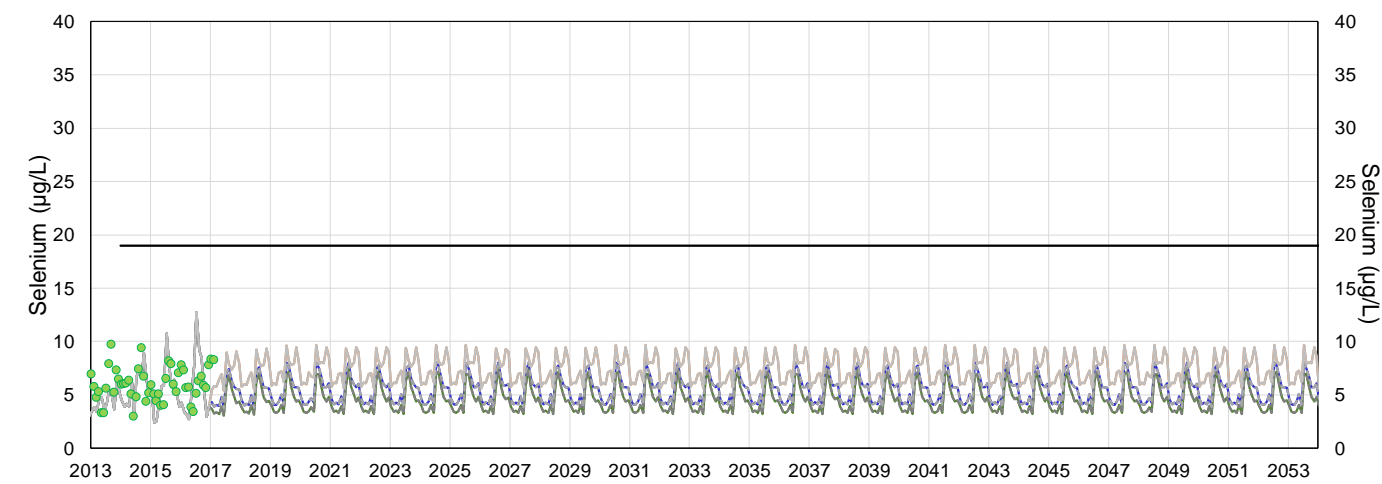
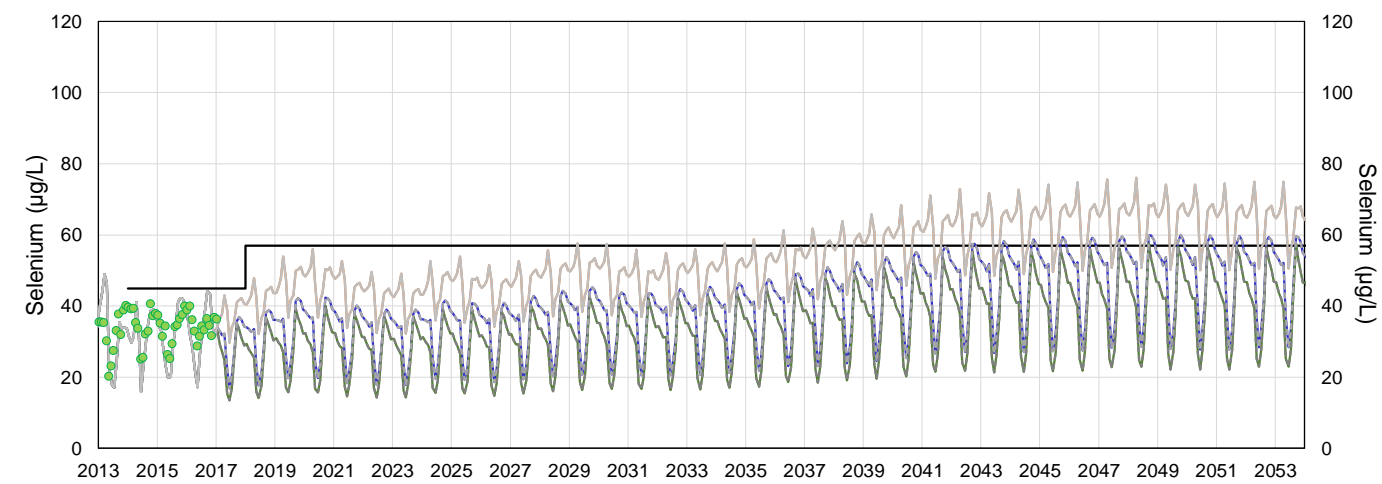


Figure D-4 Projected Monthly Average Concentrations of Selenium at Compliance Points between 2013 and 2053 for the Permitted Development Scenario (Continued)
(e) EVO Harmer Compliance Point (EV_HC1; E102682) (f) CMO Compliance Point (CM_MC2; E258937)



(g) EVO Michel Creek Compliance Point (EV_MC2; E300091)

