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July 31, 2019

Herman Henning
Chief Inspector of Mines
Ministry of Energy, Mines and Petroleum Resources
Province of British Columbia
Victoria, B.C.

Doug Hill
Regional Director Mining Operations (Williams Lake)
Ministry of Environment and Climate Change Strategy
Williams Lake, B.C.

Dear Mr. Henning and Mr. Hill,

Reference: Elk Valley Water Quality Plan 2019 Implementation Plan Adjustment

Teck Coal Limited (Teck) is pleased to submit the 2019 Implementation Plan Adjustment (2019 IPA). The 2019 IPA is a revised implementation plan developed to achieve the Site Performance Objectives (SPOs) and Compliance Limits included in the Elk Valley Water Quality Plan (EVWQP) and Permit 107517. This submission is being made to meet C-permit and Permit 107517 requirements.

As outlined in the original EVWQP, the Initial Implementation Plan was intended to be adjusted over time as uncertainties are resolved through the Adaptive Management Plan and improved ways to manage water quality are identified. Teck expects that this IPA will be further adjusted in the future to take into account future improvements. The primary difference between the Initial Implementation Plan included in the EVWQP and the 2019 IPA are:

- the timing of treatment
- increased total treatment capacity, and
- the period over which treatment was assessed (extended from the 20-year planning window in the EVWQP to mitigate the estimated water quality effects of Teck's permitted development).

The 2019 IPA works towards stabilization and reduction of selenium and nitrate concentrations in the Elk Valley at Order Stations to meet SPOs. The IPA projects that selenium and nitrate concentrations will be at or below SPOs at all seven Order Stations following the commissioning of the Fording River Operations South Active Water Treatment Facility (AWTF) and the implementation of treatment at Elkview Operations. Prior to treatment at these two locations, selenium and nitrate concentrations are predicted to be seasonally (under winter low flow conditions) above SPOs at four of the Order Stations. Teck continues to investigate options, including source control, to address projected near-term water quality concentrations from exceeding limits.

These projected near-term and seasonal exceedances of SPOs were evaluated to confirm that regional protection goals for aquatic health would continue to be met. The updated integrated assessment included in the IPA concluded that the regional protection goals established in the EVWQP would be met both in the near-term (2018 to 2022, prior to commissioning of the Fording River Operations South AWTF and of treatment at Elkview Operations) and in the longer-term.

Teck sought input from the B.C. Ministry of Energy, Mines and Petroleum Resources (EMPR), B.C. Ministry of Environment and Climate Change Strategy (ENV), and representatives of the Ktunaxa Nation Council (KNC) on the 2019 IPA through several meetings and other communications that began in early 2018. The 2019 IPA incorporates feedback through technical review conducted by ENV, EMPR and KNC on August 31, 2018 and February 19, 2019 earlier submissions of the IPA. The 2019 IPA also incorporates outreach with other stakeholders.

During the review process with ENV, EMPR and KNC, divergent views were expressed with respect to the incorporation of alternative treatment technologies such as Saturated Rock Fill (SRF) technology into the IPA at this time. In response to input from the review process, the 2019 IPA contemplates tank-based biological AWTFs and clean water diversions, where practical, to support efficient treatment. However, Teck continues to advance alternative water treatment technologies (including SRFs) and we expect that SRFs and other technologies will replace some tank-based AWTFs in future adjustments to the implementation plan, consistent with the adaptive management approach and the water quality objectives outlined in the EVWQP. Although these alternative technologies are not part of the 2019 IPA they are described in Annex J of the 2019 IPA, including the steps Teck is taking to advance alternative treatment technologies to meet water quality objectives in the EVWQP and applicable permit requirements.

As a result of the success of Phase 1 of the Elkview Operations F2 Pit SRF Full-Scale Trial, Teck is in the process of expanding the treatment capacity of the Elkview Operations F2 SRF. Teck is also advancing work towards alternative treatment at our other operations. Overall this strategy, and the implementation of alternative treatment, has the key benefit of providing an opportunity for earlier project implementation and an anticipated earlier improvement to water quality for selenium and nitrate.

In addition, Teck has also developed and implemented significant improvements to blasting practices as a source control method to reduce nitrate release. The effectiveness of this nitrate source control is not yet quantified and is therefore not yet accounted for in the nitrate concentration projections in the 2019 IPA. Work is underway to quantify the benefits of this nitrate source control with its expected positive impact on water quality. And finally, research and development into additional methods to reduce reliance on active water treatment, including source control, is also underway.

We look forward to your written acknowledgement of the 2019 IPA submission and continuing to work with ENV, EMPR and KNC on next steps towards continuing to improve water quality and as we progress future implementation plan adjustments. If you have questions regarding the 2019 IPA submission please do not hesitate to contact Matthew Gay at 250 425 8088 and email matthew.gay@teck.com or myself at the number below.

Sincerely,

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Attachments:
Attachment A – Elk Valley Water Quality Plan 2019 Implementation Plan Adjustment (July 2019)

Elk Valley Water Quality Plan

2019 Implementation Plan Adjustment

July 31, 2019 (Revision 1.0)

Teck

List of Authors and Contributors

The preparation of this 2019 Implementation Plan Adjustment has been a collaborative effort between Teck staff and technical consultants:

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EXECUTIVE SUMMARY

In April 2013, the British Columbia (B.C.) Minister of Environment issued Ministerial Order No. M113 (Order), which required Teck to prepare an area-based management plan for the Elk River watershed and the Canadian portion of the Koocanusa Reservoir. In this plan, Teck was required to identify the water quality mitigation, for existing plus planned (to end of 2037) waste rock, that is required to stabilize and reduce concentrations of nitrate, selenium, sulphate, and cadmium and the formation of calcite downstream, its five mines.

From 2013 to 2014, Teck developed an area-based management plan, called the Elk Valley Water Quality Plan. Teck had input from the public, First Nations, provincial and federal governments, technical experts, and other Communities of Interest. Teck submitted the Elk Valley Water Quality Plan to the Minister in July 2014 and it was approved in November that same year. The Elk Valley Water Quality Plan, or EVWQP, includes an Initial Implementation Plan (IIP) that outlines the mitigation planned to achieve targets for the concentration of selenium, sulphate, nitrate, and cadmium in surface water at specific locations throughout the Elk Valley and in the Koocanusa Reservoir. These targets, both short-term and long-term, are meant to stabilize and reverse increasing concentrations of the four constituents named in the Order. Active Water Treatment Facilities (AWTFs) and clean water diversions were identified in the EVWQP as mitigation tools to achieve this.

In November 2014, the B.C. Ministry of Environment issued Permit 107517 to Teck under the *Environmental Management Act*. Many of the actions and commitments that Teck made in the EVWQP IIP were incorporated into the permit requirements. To maintain compliance, Teck must meet the requirements in the Permit, including the construction and operation of AWTFs on the timelines specified and achievement of water quality targets.

Compliance Limits and Site Performance Objectives under Permit 107517 are collectively referred to as water quality targets in this document. Compliance Limits are set for compliance points. Compliance points are water monitoring stations that are downstream from each of Teck's mine operations in the Elk Valley. These points are intended to be at the point where all or most of the point and non-point discharges from a mine site or portions of a mine site are expected to report. There are eight compliance points that have limits for selenium, sulphate, nitrate, and cadmium (Figure E-1; the compliance point shown as LC_WTF_OUT is for the West Line Creek AWTF effluent discharge point).

Site Performance Objectives, or SPOs are set for Order Stations. These stations are also water monitoring stations, but these are further downstream from Teck's mining operations. They are intended to reflect fully mixed conditions, taking into account water from all upstream sources. There are seven Order Stations which have SPOs for selenium, sulphate, nitrate, and cadmium. SPOs are based on the targets from the integrated effects assessment completed for the EVWQP, whereas the Compliance Limits listed in Permit 107517 were based on the 2014 Regional Water Quality Model (RWQM) projected water quality conditions under the IIP. The locations of the Order Stations and compliance points are illustrated on Figure E-1.

Mines Act C-Permits require adjustments to the IIP, based on an adaptive management approach, by July 31, 2019 and every three years thereafter. Permit 107517 and Mines Act C-Permits required the RWQM be updated by October 31, 2017.The October 2017 RWQM update showed that the projected concentrations were above limits and SPOs, resulting in the need to update the mitigation plan (IIP).

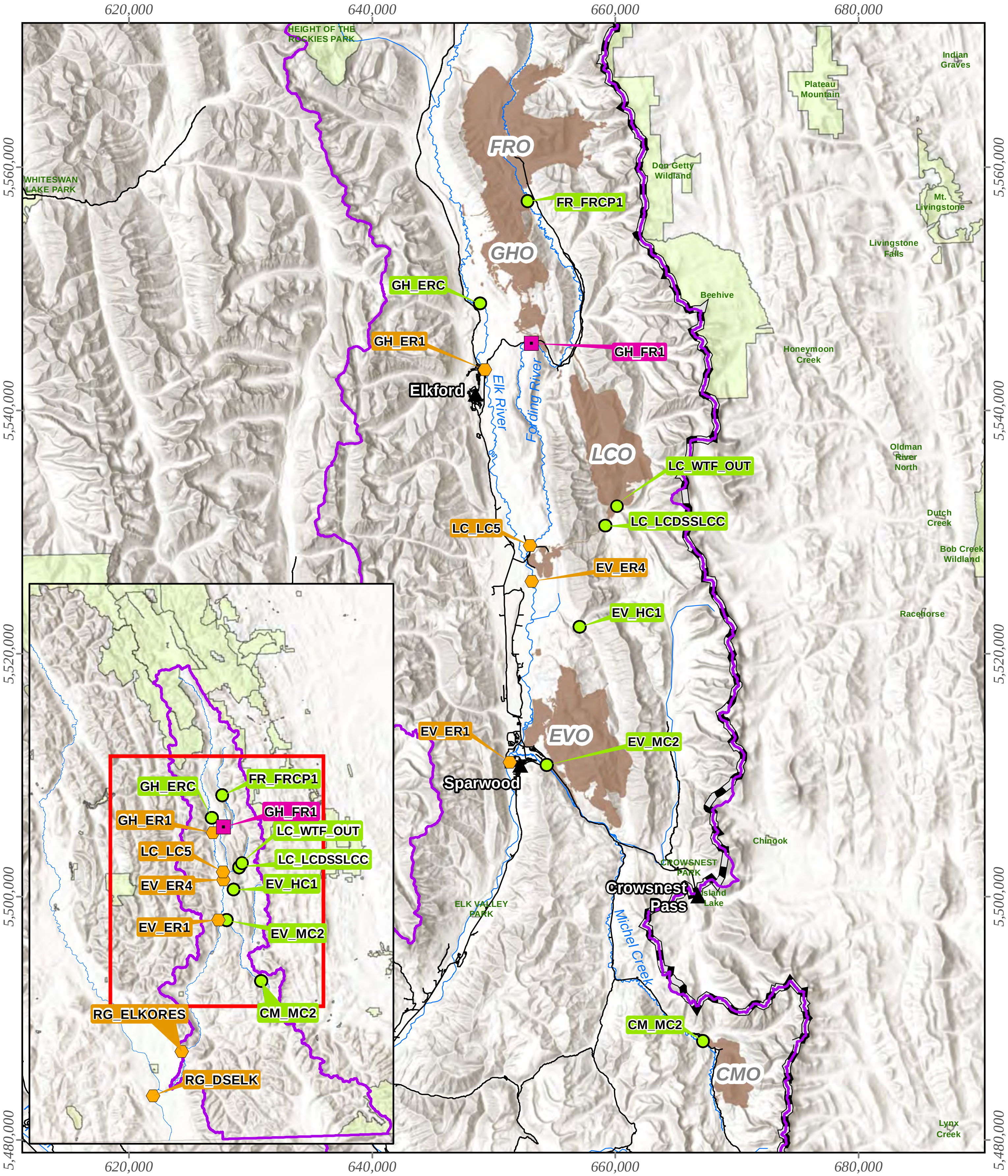

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Figure E-1 Locations of Teck Mining Operations, Order Stations and Compliance Points in the Elk Valley

Order Stations
Compliance Points
Order Stations/Compliance Points
Teck Coal Mine Operations
Communities
Rivers
Roads
Province Boundaries
Protected Areas
Elk River Watershed

N

0 2,500 5,000 10,000 Meters

DATE:	MINE OPERATION:
2/1/2019	ELK VALLEY OPERATIONS
SCALE:	COORDINATE SYSTEM:
1:409,629	NAD 1983 UTM Zone 11N

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Key Adjustments to the IIP Reflected in the 2019 IPA

The 2019 Implementation Plan Adjustment (2019 IPA) is a revised implementation plan developed to achieve the SPOs and Compliance Limits included in the EVWQP and Permit 107517.

Teck completed the 2019 IPA and provided opportunity for the B.C. Ministry of Energy, Mines and Petroleum Resources (EMPR), B.C. Ministry of Environment and Climate Change Strategy (ENV), and representatives of the Ktunaxa Nation Council (KNC) to provide input. Ten review meetings were held with EMPR, ENV and the KNC to review information and gather feedback for integration into the plan. Outreach to other Communities of Interest also occurred.

On August 31, 2018, Teck submitted the 2019 IPA to ENV, EMPR, and KNC for their technical review. On February 19, 2019 Teck submitted a revised version of the 2019 IPA for further review. Teck revised the 2019 IPA to incorporate feedback received through the technical review as well as through further outreach with other Communities of Interest.

The primary differences between the IIP and the 2019 IPA are summarized as follows:

- the timing of treatment;
- increased total treatment capacity; and
- the period over which treatment was assessed (extended from a 20-year planning window to mitigate the estimated water quality effects of Teck's permitted development).

Timing of Water Treatment in the Valley and Locations

The IIP included the construction and operation of six AWTFs by 2032, with a total treatment capacity of 130,000 cubic metres per day (m^3/d). The 2019 IPA, informed by the 2017 RWQM[1], includes the construction of the original six AWTFs included in the IIP plus seven additional facilities and associated water management with a total treatment capacity of 204,600 m^3/d over the extended timeframe (see Table E-1). Clean water diversions included in the 2019 IPA are shown in Table E-2. Mitigation in the 2019 IPA is intended to stabilize and reduce concentrations of nitrate, selenium, and sulphate for Teck's permitted development as well as for planned development over the next 20 years. Removal of cadmium is not currently required to meet long-term water quality limits. The sequence of water treatment is also shown on Figure E-2 for the Koocanusa Reservoir at the Order Station (RG_DSELK). In parallel to executing active water treatment, Teck continues to advance alternative water treatment technologies (including Saturated Rock Fills) which have the potential to replace AWTFs in future adjustments to the implementation plan, consistent with the adaptive management approach and the water quality objectives outlined in the EVWQP.

[1] Following submission of the 2017 RWQM, changes were made to the model based on regulatory feedback, to improve model performance, and to some mining related inputs. These changes are documented in the 2019 IPA.

Table E-1 Treatment Capacity and Timing Comparison between the 2019 Implementation Plan Adjustment and the Initial Implementation Plan

Modelled Active Water Treatment Facility (1)	2019 Implementation Plan Adjustment		Initial Implementation Plan	
	Date Fully Effective (2)	Hydraulic Capacity (m^3/d)	Date Fully Effective (3)	Hydraulic Capacity (m^3/d)
West Line Creek (WLC) Phase I	December 31, 2018	6,000	June 30, 2014	7,500
WLC Phase II	December 31, 2019	1,100	-	-
Fording River Operation (FRO) AWTF-S Phase I	December 31, 2021	20,000	December 31, 2019	20,000
Elkview Operation (EVO) Phase I	September 30, 2022	20,000	December 31, 2021	30,000
FRO-N Phase I	December 31, 2023	30,000	December 31, 2023	15,000
WLC Phase III	December 31, 2025	12,500	-	-
EVO Phase II	December 31, 2027	20,000	December 31, 2025	20,000
FRO-S Phase II	December 31, 2029	5,000	-	-
Greenhills Operation (GHO) Phase I	December 31, 2031	5,000	December 31, 2027	7,500
WLC Phase IV	December 31, 2033	32,500	December 31, 2033	7,500
FRO-S Phase III	December 31, 2035	20,000	-	-
Line Creek Operation (LCO) Dry Creek Phase I	December 31, 2037	2,500	December 31, 2029	7,500
FRO-N Phase II	December 31, 2039	20,000	December 31, 2031	15,000
EVO Phase III	December 31, 2043	5,000	-	-
LCO Dry Creek Phase II	December 31, 2049	2,500	-	-
GHO Phase II	2100+	2,500	-	-
Total Hydraulic Capacity (m^3/d)		**204,600**		**130,000**

(1) Clean water diversions associated with the 2019 IPA include the diversion of Upper Kilmarnock watershed at FRO and diversion of Upper Line Creek, Horseshoe Creek and No Name Creek at LCO.

(2) The fully effective date is the date when the treatment facility has been built, biologically seeded, commissioned and is effective at the hydraulic capacity listed above.

(3) The fully effective dates included for the IIP are based on the assumption that there is a four month commissioning period, followed by an eight month ramp up period from the operational dates listed for the first six AWTFs listed in Permit 107517, and from the end of the calendar year (December 31) for the remaining AWTFs listed in Table 8-19 of the EVWQP.

Table E-2 Clean Water Diversion Capacity and Timing Comparison between the 2019 Implementation Plan Adjustment and the Initial Implementation Plan

Clean-Water Diversion	Associated Active Water Treatment Facility	Initial Implementation Plan		2019 IPA	
		Streams and Volume Diverted	Date Operational	Streams and Volume Diverted	Date Operational
Kilmarnock Creek	FRO AWTF-S	Upper Brownie and Kilmarnock watersheds, estimated at 45,000 m^3/d	December 31, 2018	Upper Kilmarnock Watershed, estimated up to 86,000 m^3/d[a]	December 31, 2020[a]
Erickson Creek	EVO AWTF 1	Upper Erickson Watershed, estimated at 14,000 m^3/d	December 31, 2020	Not included	
South Gate Creek	EVO AWTF 1	South Gate Creek, estimated at 3,500 m^3/d	December 31, 2020	South Gate Creek, estimated at 3,500 m^3/d	In place and operating.
Upper Line Creek, Horseshoe and No Name Creeks	WLC AWTF 2	Upper Line Creek and Horseshoe Creek, estimated at 35,000 m^3/d and No Name Creek, estimated at 7,000 m^3/d	2032	Upper Line Creek and Horseshoe Creek estimated at 35,000 m^3/d. No Name Creek estimated at 7,000 m^3/d. Total of 42,000 m^3/d	December 31, 2025

Notes: a) Kilmarnock Creek Clean Water Diversion Project is ongoing and underway, which includes a more detailed assessment of the sizing and timing of the diversion, and of constructability and operability considerations. This more detailed assessment may result in changes to the sizing, timing or operational approach of the diversion.

Site Performance Objectives and 2019 IPA

The 2019 IPA works towards stabilization and reduction of selenium and nitrate concentrations in the Elk Valley at Order Stations. The Plan projects that selenium and nitrate concentrations will be at or below SPOs at all seven Order Stations following the commissioning of the Fording River Operations South AWTF and the Elkview Operations AWTF (i.e., from 2023 onward). Prior to the commissioning of these AWTFs, selenium and nitrate concentrations are predicted to be seasonally (under winter low flow conditions) above SPOs at the following Order Stations: Fording River downstream of Greenhills Creek (GH_FR1; 0200378), Fording River downstream of Line Creek (LC_LC5; 020028), Elk River upstream of Grave Creek (EV_ER4; 0200027), and the Koocanusa Reservoir (RG_DSELK; E300230).

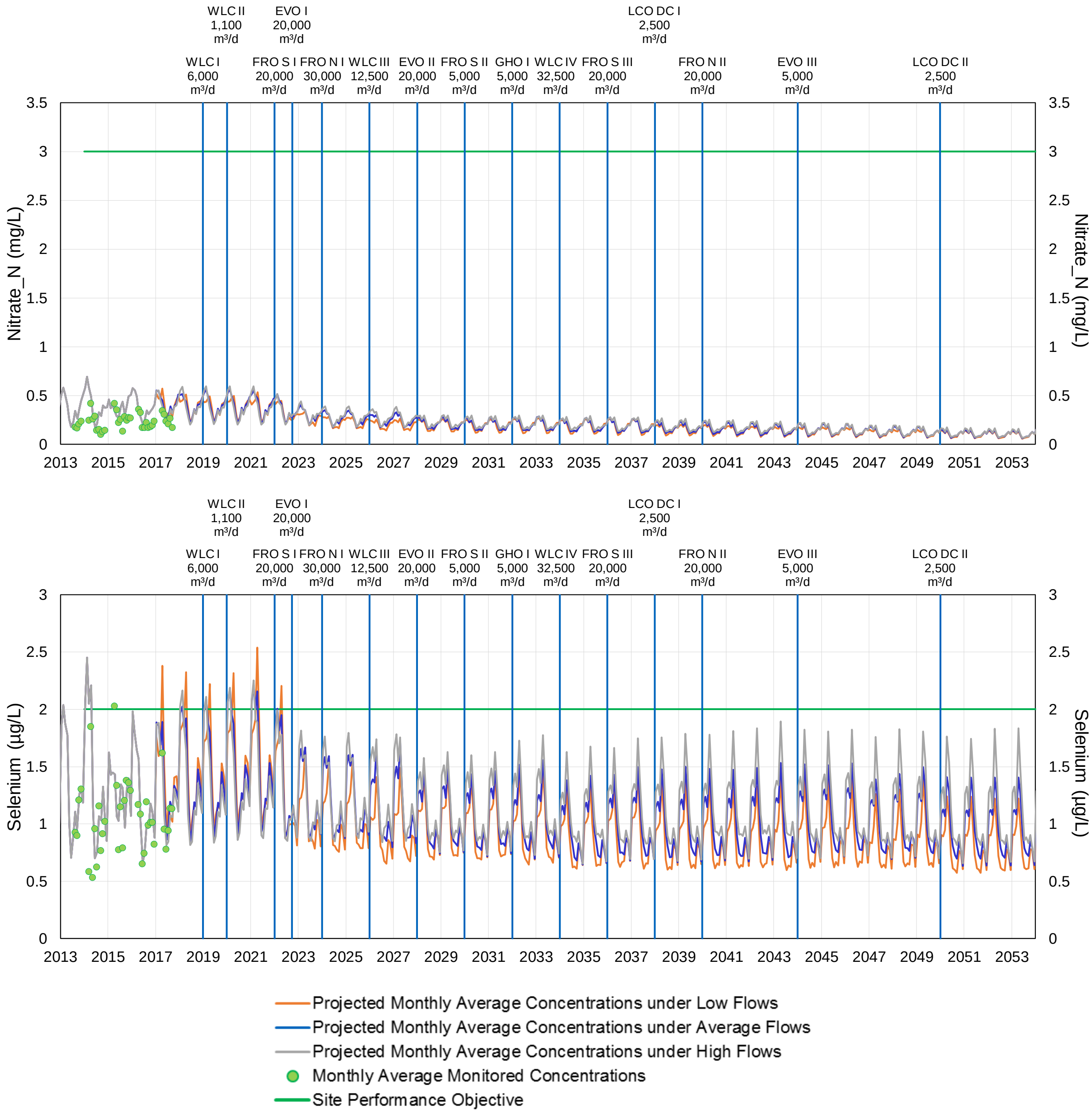
Projected near-term and seasonal exceedances of SPOs for selenium, nitrate, and sulphate were evaluated to confirm that regional protection goals for aquatic health would continue to be met. This analysis followed an updated version of the integrated assessment methodology presented in Annex H of the EVWQP. The analysis concluded that the regional protection goals established in the EVWQP would be met both in the near-term (2018 – 2022, prior to commissioning of the FRO-S and EVO AWTFs) and throughout the planning period (i.e., 2023 to 2037).

Projected selenium concentrations for the Koocanusa Reservoir with the 2019 IPA are shown on Figure E-2. The information on the plot represents monthly average selenium concentrations over time. The solid orange, blue and gray lines correspond to the projected monthly average concentrations under 1-in-10-year low, average and 1-in-10-year high flows, respectively. The green dots represent the monthly average historical concentrations from the monitoring dataset for the RG_DSELK Order Station. The vertical blue lines represent the fully effective dates for the AWTFs in the 2019 IPA (Table E-1).

Teck's current selenium and nitrate treatment technology (biological active water treatment) does not treat sulphate. Based on water quality modelling, sulphate treatment may be required as early as 2026 at

Line Creek Operations. Teck continues to advance and evaluate different sulphate treatment technologies to support the implementation of sulphate treatment by 2026. This includes planning, which is underway, for a sulphate treatment technology pilot program which will be conducted in 2019 and 2020.

Figure E-2 Projected Monthly Average Nitrate and Selenium Concentrations in the Koocanusa Reservoir Order Station RG_DSELK



Research and Development

Teck currently has more than 20 research and development projects underway related to water quality in the Elk Valley, including projects to better control the release of water quality constituents at the source and to develop new water treatment methods. This includes the application and advancement of alternative treatment technologies, nitrate source control, sulphate treatment and calcite management.

Teck will continue to undertake studies to evaluate the effects on the aquatic ecosystem, including studying the ecological relevance of near-term and seasonal nitrate, selenium and sulphate concentrations above SPOs. This will inform future adjustments to the implementation plan.

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ACRONYMS AND ABBREVIATIONS

Acronym or Abbreviation	Description
ANFO	Ammonium Nitrate Fuel Oil
AOP	Advance Oxidation Process
AMP	Adaptive Management Plan
AWT	Active Water Treatment
AWTF	Active Water Treatment Facility
BC	British Columbia
BRE	Baldy Ridge Extension
CAP	Compliance Action Plan
CMO	Coal Mountain Operations
COI	Communities of Interest
CWD	Clean water diversion
EMA	Environmental Management Act
EMC	Environmental Monitoring Committee
EMPR	Ministry of Energy, Mines and Petroleum Resources
ENV	Ministry of Environment and Climate Change Strategy
EVO	Elkview Operations
EVWQP	Elk Valley Water Quality Plan
FBR	Fluidized Bed Reactor
FRO	Fording River Operations
GHO	Greenhills Operations
IIP	Initial Implementation Plan
IPA	Implementation Plan Adjustment
KNC	Ktunaxa Nation Council
LCO	Line Creek Operations
LOM	Life of Mine
MQ	Management Question
N	North
RAEMP	Regional Aquatic Effects Monitoring Program
R&D	Research and Development
RO	Reverse Osmosis
RWQM	Regional Water Quality Model
S	South
SDM	Structured Decision Making Processes
SPO	Site Performance Objectives
SRF	Saturated Rock Fill
Teck	Teck Coal Limited
TMP	Tributary Management Plan
US EPA	United States Environmental Protection Agency
WLC	West Line Creek

UNITS OF MEASURE

Unit of Measure	Description
%	percent
>	greater than
<	less than
BCM	bank cubic metre
m^3	cubic metres
m^3/d	cubic metres per day
mg/L	milligrams per litre
µg/L	micrograms per litre

1 Introduction

1.1 Background and Regulatory Context

Teck Coal Limited (Teck) operates five open-pit steelmaking coal mines in the Elk River watershed in southeastern British Columbia (BC). The individual operations are listed below and shown in Figure 1-1:

- Fording River Operations (FRO)
- Greenhills Operations (GHO)
- Line Creek Operations (LCO)
- Elkview Operations (EVO)
- Coal Mountain Operations (CMO)

The BC Ministry of Environment issued Ministerial Order No. M113 (the Order), under Section 89 of the *Environmental Management Act* (EMA), to Teck in April 2013, which required Teck to develop an Area Based Management Plan called the Elk Valley Water Quality Plan (EVWQP). The EVWQP includes an Initial Implementation Plan (IIP) and a description of the adaptive management process. The adaptive management process outlines a framework to adjust the implementation plan over time in response to new information. In November 2014, the BC Ministry of Environment issued EMA Permit 107517 to Teck, which included a requirement that Teck develop an Adaptive Management Plan (AMP) informed by the process outlined in the EVWQP. This document is the first adjustment of the IIP using the framework of the AMP.

A tool critical to the development of the EVWQP was the 2014 Regional Water Quality Model (RWQM). This tool was developed by Teck to examine how activities at its five coal mines in the Elk River watershed could affect water quality in the Elk River and Fording River, as well as in tributaries located in and around each operation. The 2014 RWQM informed development of the IIP to meet regional water quality requirements (Site Performance Objectives [SPOs] and Compliance Limits) defined in EMA Permit 107517. The locations of the compliance points and Order Stations are shown in Figure 1-1.

The RWQM was updated in 2017, in accordance with EMA Permit 107517 (Section 10.9) and the BC *Mines Act* C-Permit requirements for each operation (Teck 2017). The most noteworthy changes to the 2017 RWQM included new geochemical source terms, updated mine plans and shifts in the timing of implementation of Active Water Treatment Facilities (AWTFs) due to the time required to work through the challenges experienced with the West Line Creek (WLC) AWTF. The updated model projected water quality concentrations above SPOs and Compliance Limits at some locations and timeframes.

In accordance with the AMP, EMA Permit 107517 (Section 11) and the BC *Mines Act* C-Permits, the new projected concentrations triggered a review of the IIP. These permit requirements related to the IIP are provided in Table 1-1.

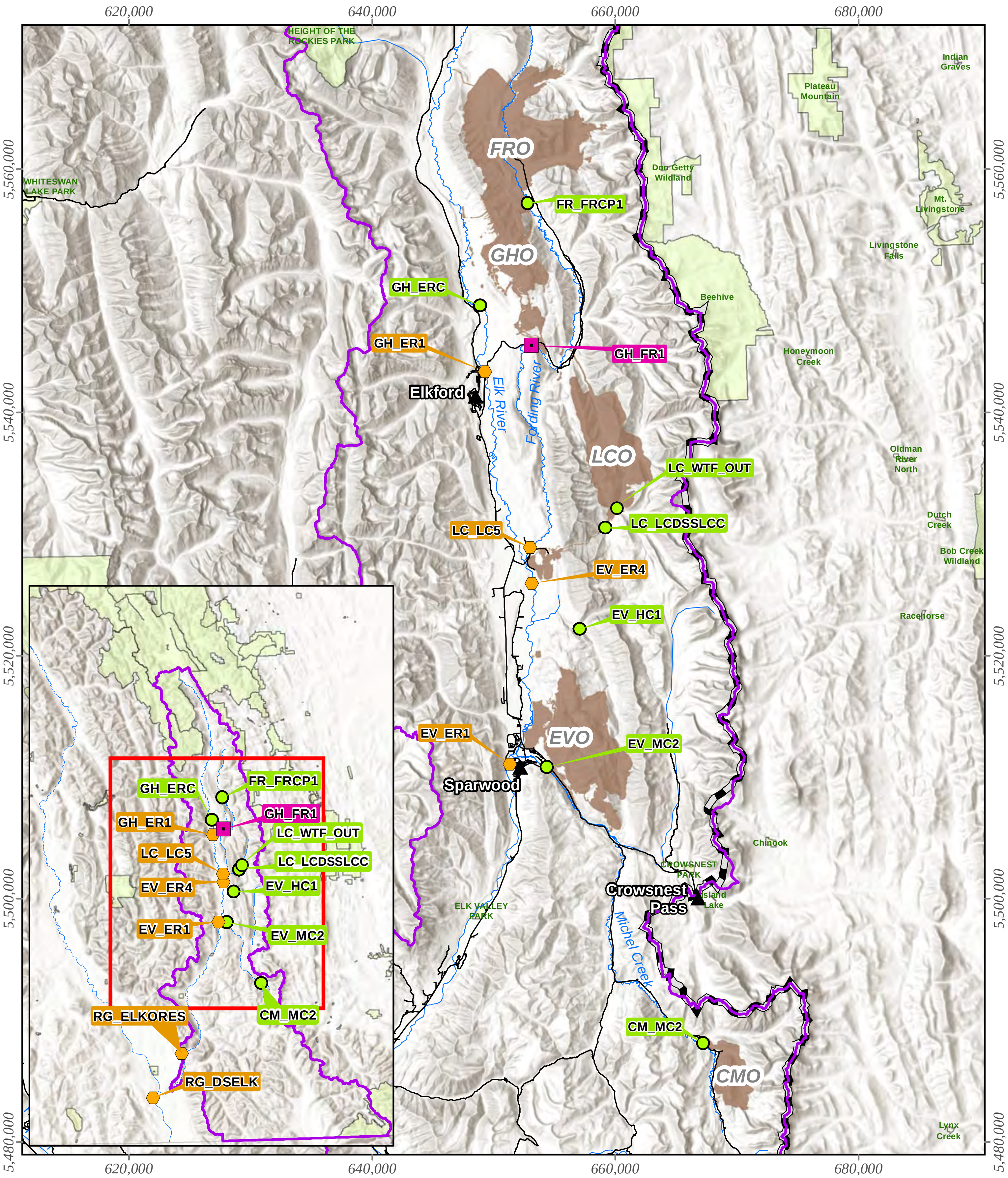

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Figure 1-1 Locations of Teck Mining Operations, Order Stations, and Compliance Points in the Elk Valley

- Order Stations
- Compliance Points
- Order Stations/Compliance Points
- Teck Coal Mine Operations
- Communities
- Rivers
- Roads
- Province Boundaries
- Protected Areas
- Elk River Watershed

N

0 2,500 5,000 10,000 Meters

DATE:	MINE OPERATION:
2/1/2019	ELK VALLEY OPERATIONS
SCALE:	COORDINATE SYSTEM:
1:409,629	NAD 1983 UTM Zone 11N

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Table 1-1 Permit Requirements Related to Implementation Plan

Permit	Requirements	How the Requirement is Addressed
EMA 107517	**Section 11 ADAPTIVE MANAGEMENT PLAN**	
Section 11	Stage 6 - Adjust and Revise the Hypothesis and Management Strategies a. Adjust the ABMP implementation plans and actions as required, including knowledge gained from Section 8.2 - Research and Development. b. Communicate changes to ABMP implementation plans and activities to the Environmental Monitoring Committee. c. Reassesses expected outcomes, potential impacts, and responses to these outcomes for an adjusted plan. Where plan components are related to Human Health, the Permittee shall make reasonable efforts to consult with Interior Health (hbe@interiorhealth.ca). d. Adjust the AMP as required in consultation with the Environmental Monitoring Committee.	a) The ABMP IIP has been adjusted as part of the Adaptive Management cycle. This adjustment of the implementation plan included knowledge gained from the Applied Research and Development Program (e.g. SRFs, and the incorporation of learnings from the R&D program into the source terms for the RWQM update which informs the IPA). b) The changes to the ABMP will be reviewed with the EMC. c) The expected outcomes for water quality are in Annex F, and an assessment of potential impacts is in Annex I. d) The AMP was submitted in December 2018 and will be adjusted in consultation with the EMC through the AMP process.
Section 12	**Section 12 DATA ANALYSIS ACCOUNTABILITY AND TRANSPARENCY** **Section 12.1 FIRST NATIONS REPORTING REQUIREMENT** Unless otherwise agreed to by the Ktunaxa Nation Council (KNC) and the Permittee, the Permittee shall provide the KNC with information related to any material changes to the Initial Implementation Plan, Adaptive Management Plan, the Calcite Management Plan and the Research and Technology Development Plan. In addition, the Permittee shall provide the KNC with all data, information and/or reports generated during the implementation of these plans in accordance with this permit.	The KNC were engaged through the process of updating the IIP and their feedback was considered. The 2019 IPA documentation was provided as part of the submission of this document.
C-Permits [(a)] B1 (c)	Updates to the Initial Implementation Plan i. The Initial Implementation Plan shall be periodically reviewed and revised, based on an adaptive management approach, to meet the objectives and timeframes for water quality, consistent with the Elk Valley Water Quality Plan. ii. The updated Implementation Plan shall include refinements and changes to management targets, mitigation strategies, timelines for implementing mitigation, monitoring plans and research and technology development programs as necessary to meet the objectives and timelines for water quality constituents in the Elk Valley Water Quality Plan. iii. Future iterations of the update Implementation Plan shall specifically evaluate the effectiveness of: - mitigation measures to minimize release of order constituents and reduce reliance on long term active water treatment; and - progressive reclamation and closure activities. iv. The Permittee shall provide an annual report to the Chief Inspector beginning July 31, 2016 that documents adaptive management activities and any proposed changes to the Initial Implementation Plan. v. An update Initial Implementation Plan, informed by all components of the adaptive management cycle, shall be provided to the Chief Inspector on or before July 31, 2019.	i. The IIP was evaluated as part of the 2017 RWQM update based on the adaptive management approach and it was determined that the IIP required an adjustment to meet the objectives of the EVWQP. ii. The 2019 IPA includes details specific to the requirements outlined in (ii). iii. The 2019 IPA includes a detailed discussion of nitrate management, as a measure to reduce the release of nitrate, and of SRFs as a water quality mitigation measure that would minimize release of nitrate and selenium and reduce Teck's reliance on long-term active water treatment. Water quality improvements from progressive reclamation, such as covers, have not been quantified and have therefore not been accounted for in the water quality projections used for the development of the 2019 IPA. Cover systems and the path forward for quantification are discussed Annex J. Closure activities, such as long-term pit water management were included in the 2019 IPA for the Permitted Development Scenario. iv. Not applicable for the 2019 IPA. The AMP Annual Report will be provided as required by permits. v. The 2019 IPA is being submitted to fulfill this requirement.
Letter BRE Water Quality Predictions (16 Dec15)	[Letter detailed that life of mine water quality predictions (based on life of mine waste rock inventory) should be provided for currently approved projects (Base Case) as well as reasonably foreseeable proposed projects for the next twenty years (RFD Case).]	Two development scenarios were carried forward through the development of the 2019 IPA: the Permitted Development Scenario, which meets the requirements for the "currently approved projects" case, and the Planned Development Scenario, which meets requirements of the "reasonably foreseeable proposed projects for the next twenty years" case. These development scenarios are described in Section 1.3 and in Section 2.

(a) Common requirement to the following C-Permits: FRO C-3 Amendment Water Quality and Calcite Mitigation (27Nov14); GHO C-137 Amendment Water Quality and Calcite Mitigation (27Nov14); LCO C-129 Amendment Water Quality and Calcite Mitigation (27Nov14); EVO C-2 Amendment Water Quality and Calcite Mitigation (27Nov14); CMO C-84 Amendment Water Quality and Calcite Mitigation (27Nov14).

AMP = Adaptive Management Plan; EMC = Environmental Monitoring Committee; EVWQP = Elk Valley Water Quality Plan; IIP = Initial Implementation Plan; IPA = Implementation Plan Adjustment; RFD = reasonably foreseeable development; RWQM = Regional Water Quality Model; SPO = Site Performance Objective; SRF = Saturated Rock Fill.

1.2 Purpose and Content of Report

The purpose of this report is to present adjustments to the IIP and to meet the EMA Permit 107517 and BC *Mines Act* C-Permit requirements for documentation of updates to the IIP. The objective of the 2019 IPA is to outline the sources targeted for mitigation and the estimated sequence, timing and sizing of treatment to achieve the objectives of the EVWQP and subsequent SPOs and Compliance Limits for selenium and nitrate as defined in Permit 107517. The 2019 IPA also outlines that sulphate treatment may be required and the steps Teck is taking to further understand and prepare for this. The submission of this report is intended to meet the requirements of the BC *Mines Act* C-Permits specific to the submission of an updated implementation plan, informed by all components of the adaptive management cycle to the Chief Inspector on or before July 31, 2019.

The report is a compilation of the methods used to develop the 2019 IPA, including the mitigation measures and strategy used to inform the 2019 IPA. Continued improvements associated with adaptive management that are integrated into the 2019 IPA or are advancing to support future updates to the implementation plan and the next steps are also included in the report as well as the engagement history and how feedback has been included in the 2019 IPA.

This report documenting the 2019 IPA includes the following:

- An overview of the linkages to other water initiatives such as the LCO Dry Creek and EVO Harmer Creek structured decision making (SDM) processes, the LCO Nitrate Compliance Action Plan (CAP) and the Tributary Management Plan (TMP).
- A summary of the engagement with EMPR, ENV and KNC and other Communities of Interest (COIs).
- A summary of the changes to the 2017 RWQM that were made to support the 2019 IPA.
- A description of the mitigation measures and strategies included in the 2019 IPA.
- The planning basis and model inputs, modelling approach and methods for the 2019 IPA.
- A summary of the planned mitigation and of the water quality projections for selenium, nitrate and sulphate.
- An overview of how elements of the 2019 IPA will be managed under the AMP.
- A summary of the next steps anticipated to be completed prior to, and the forecasted timing of, the next IPA.

Some information provided in this report is a summary of more detailed annex documents appended to this report. The annex documents are as follows:

- Annex A - Summary of Feedback Received
- Annex B - Modifications to the Regional Water Quality Model
- Annex C - Mitigation Inputs to 2017 Regional Water Quality Model
- Annex D - Clean Water Diversion Evaluation

- Annex E - Methods Used to Develop the 2019 Implementation Plan Adjustment
- Annex F - Projected Concentrations of Nitrate, Selenium and Sulphate
- Annex G - Bioaccumulation Analysis in Support of the 2019 Implementation Plan Adjustment
- Annex H - Assessment of Water Availability
- Annex I - Integrated Effects Assessment
- Annex J - Alternative Treatment Mitigation Plan

1.3 Scope

The 2019 IPA is based on the 2017 RWQM. The IIP was adjusted to best meet the SPOs and Compliance Limits set through the EVWQP for selenium, nitrate and sulphate, accounting for the full effects of all permitted development, as well as for the planned development for a 20-year planning window (through 2037). These two development scenarios are summarized as follows, with additional information provided in Section 2:

- Planned Development Scenario: This scenario includes existing, permitted and planned development according to Teck's 2016 long-range mine plan over a 20-year planning window (i.e., 2017 through 2037).
- Permitted Development Scenario: This scenario includes existing waste rock and water management through 2016, and all permitted development. This scenario does not include any future planned development that has not been approved. The modelling period encompasses the full duration of permitted development, plus additional time to account for the full effects of loading from the permitted waste rock and from pit decanting. The purpose of this scenario is to demonstrate how the 2019 IPA will manage the full effects of permitted development and to form the base case for future mining permit applications.

Mitigation measures included in the 2019 IPA are summarized in Section 2.3.1. Like the IIP, the 2019 IPA is based on the application of biologically-based active water treatment (AWT) and diversions (where practical that support efficient treatment) to manage selenium and nitration concentrations in the Elk Valley. The application of these mitigation measures included the assessment of streams targeted for treatment, as well as the location, timing and sizing of mitigation.

In parallel, to executing biologically-based active water treatment (specifically Fluidized Bed Reactor [FBR] based biological AWT at LCO and at FRO), Teck has, and continues to, advance Research and Development (R&D) to identify alternative mitigation measures to reduce reliance on active water treatment. These mitigation measures, and an alternative treatment mitigation plan, is provided in Annex J. Although these alternative mitigation measures are not part of the 2019 IPA, the steps Teck is taking to advance alternative treatment technologies are outlined in Annex J. These technologies will be integrated into future adjustments of the implementation plan as described in the AMP.

Water quality constituents evaluated in the 2019 IPA are nitrate, selenium and sulphate. Sulphate projections were used to inform the potential timing and location of sulphate treatment, should it be required, to support more detailed planning following the 2019 IPA submission.

1.4 Linkage to Other Water Initiatives

Teck is undertaking other water-related initiatives and programs at the regional and operations levels, and through consultation it was requested that Teck provide an overview of how these other water initiatives are linked to the 2019 IPA. The initiatives and programs that are discussed in this section include the EVO Harmer Creek and LCO Dry Creek SDM processes, the LCO Nitrate CAP, the Regional Aquatic Effects Monitoring Program (RAEMP) and the TMP.

The LCO Dry Creek and EVO Harmer Creek SDM processes were underway during the development of the 2019 IPA. The goal for these SDM processes is to define requirements for those tributary systems on the timelines established by those individual SDM processes. The final meeting for the EVO Harmer Creek SDM occurred in November 2018 and the proposed long-term compliance limit for selenium was submitted to regulators on December 22, 2018 (with a statement of support from the KNC). The proposed long-term EVO Harmer Creek Compliance Limit for selenium was approved at 57 µg/L and the Permit 107517 was amended on April 4, 2019. Treatment for EVO Dry Creek is not currently included in the 2019 IPA as the long-term Compliance Limit was not established in time to incorporate into the mitigation plan development; however, the EVO Harmer Creek SDM process may result in relocation of some of the waste rock planned for EVO Dry Creek to other drainages in the short-term. The water quality management plan and associated mitigation options for EVO Dry Creek will be incorporated into a future IPA. The LCO Dry Creek SDM process is evaluating treatment as one of the options to manage water quality in LCO Dry Creek. The outcomes of that process will be incorporated into a future IPA.

The LCO Nitrate CAP was approved by ENV on January 9, 2018. This plan identifies objectives, key performance indicators, and actions that Teck has taken and will take to reduce nitrate concentrations to meet Permit 107517 Compliance Limits at this compliance point. The LCO Nitrate CAP was updated in September 2018 to include scenarios outlining additional treatment options to achieve the nitrate Compliance Limit at the Line Creek Compliance Point, including pros and cons of each treatment option. One of the scenarios presented in the LCO Nitrate CAP update directly references the adjusted size and timing of the second phase of the West Line Creek AWTF as outlined in the 2019 IPA (Section 2.4.1).

The RAEMP provides spatially comprehensive monitoring and assessment of potential mine-related effects on the aquatic environment downstream from Teck's Elk Valley mines. The 2018-2020 RAEMP was designed with input and advice from the Environmental Monitoring Committee (EMC) and is currently being implemented across the watershed. The general objective of the RAEMP is to monitor, assess and interpret indicators of aquatic ecosystem condition related to mine operations, and to inform adaptive management relative to expectations established in approved plans for mine development and in Permit 107517. The approach to spatially integrating monitoring data is being formalized through a data evaluation framework being developed in consultation with the EMC. The results of the RAEMP spatial evaluation will be reviewed for consistency with the integrated assessment methodology used to support the EVWQP and the 2019 IPA. The resulting integrated assessment methodology will be used to inform where management responses are needed (i.e., further investigation, potential mitigation, future IPAs).

The TMP supports the maintenance of a healthy aquatic ecosystem in each management unit and considers the sustainable balancing of environmental, economic, and social costs and benefits. The TMP is intended to incorporate protection and rehabilitation goals for tributaries that will support achieving the area-based objectives of the EVWQP. TMP includes biological prioritization of tributaries for water quality rehabilitation (improvement). Treatment sequence and locations in the 2019 IPA is based primarily on reducing regional loading in order to meet Compliance Limits and SPOs and does not take into consideration the TMP prioritization. Tributary values are considered during the detailed design stage and subsequent permitting phases for the individual AWTFs. Design considerations may include return of treated water to the tributary that it was extracted from, in order to improve local water quality and maintain flows. Future iterations of the IPA will more explicitly consider water quality rehabilitation priorities identified in the TMP.

1.5 Consultation and Engagement

Teck completed the 2019 IPA and provided opportunity for EMPR, ENV and the Ktunaxa Nation Council (KNC) to provide input. Seven review meetings between January and July 2018 were held with these groups to review information and gather feedback for integration into the plan. Two additional review meetings were held between October and December 2018 to review an initial submission of the 2019 IPA (submitted August 31, 2018). Another review meeting was held in May 2019 to review a revised submission of the 2019 IPA (submitted February 19, 2019) in preparation for this final submission of the 2019 IPA. Meeting notes were produced from each meeting and distributed to EMPR, ENV and KNC for review. Where necessary, information and communications were also exchanged between meetings. Table A-1 in Annex A contains the feedback and inputs received from EMPR, ENV, and KNC between January and July 2018 to inform the content of the initial (August 2018) submission of the IPA.

Outreach to the following COIs also occurred:

- BC Environmental Assessment Office
- BC Interior Health Authority
- Environmental Monitoring Committee
- State of Montana Department of Environmental Quality
- United States Environmental Protection Agency (US EPA)
- Environment and Climate Change Canada
- Shuswap Indian Band
- Kootenai Tribe of Idaho
- Confederated Salish and Kootenai Tribes
- Wildsight/Flathead Wild
- Elk River Alliance
- Local governments (District of Sparwood, District of Elkford, City of Fernie, Municipality of Crowsnest Pass, Regional District of East Kootenay Area A)
- Elk Valley mining proponents (Centermount Coal Ltd., Jameson Resources Ltd., North Coal Ltd.)
- Elk Valley residents

The outreach with the above-listed COIs involved informing of the 2019 IPA through meetings, phone calls, or written correspondence, in which the purpose and process for developing the 2019 IPA was conveyed and any questions raised were answered. A summary of the IPA was provided to these COIs in February 2019, which presented the results of the IPA. This summary was posted to Teck's website in March 2019 for general public access. A summary of the engagement with the above noted COIs is contained in Table A-2 of Annex A.

Teck's vison for its relationship with KNC, government, local communities and other COIs is that we seek to build strong relationships and create lasting benefits. As such, Teck will continue to seek input and advice with these groups as we move forward with implementing and achieving the goals of the EVWQP.

1.6 Linkages to the Adaptive Management Plan

As required in Permit 107517 Section 11, Teck has developed an AMP to support implementation of the EVWQP to achieve water quality targets including calcite targets, ensure that human health and the environment are protected, and where necessary, restored, and to facilitate continuous improvement of water quality in the Elk Valley. Following an adaptive management framework, the AMP identifies six Management Questions that will be re-evaluated at regular intervals as part of AMP updates throughout EVWQP implementation. The AMP also identifies key uncertainties that need to be reduced to fill gaps in current understanding and support achievement of the EVWQP objectives.

The information in this report is relevant to three of the six Management Questions (MQs) and several of the key uncertainties identified in the AMP. It describes adjustments needed under MQ 1 ("Will water quality limits and SPOs be met for selenium, nitrate, sulphate and cadmium?") in response to results from the 2017 RWQM, it informs evaluation of MQ 3 ("Are the combinations of methods for controlling selenium, nitrate, sulphate and cadmium included in the implementation plan the most effective for meeting limits and SPOs?"), and also informs evaluation of MQ 6 ("Is water quality being managed to be protective of human health?").

The analyses undertaken as part of the IPA assist in reducing KU 1.2 ("How will uncertainty in the Regional Water Quality Model be evaluated to assess future achievement of limits and SPOs?"), KU 3.1 ("Are there better alternatives to the current active water treatment technologies?"), KU 3.2 ("What is the most feasible and effective method (or combinations of methods) for source control of nitrate release?"), KU 3.3 ("Is clean water diversion a feasible and effective water management strategy to support water quality management?"), KU 3.4 ("What additional flow and groundwater information do we need to support water quality management?"), and KU 3.5 ("Is sulphate treatment required and if so how could we remove sulphate?"). Descriptions on how the analysis undertaken as part of the IPA assist in reducing KUs and how future IPAs will be informed by reducing these KUs is contained in Section 2.5 of this report. The main report for providing details on the reducing KU 1.2 is the 2020 RWQM Update. Similarly, the details of reducing KUs 3.1 through 3.5 will be reported in Teck's Annual R&D reports. Summaries on progress on reducing these key uncertainties, and associated learnings, will be described in Annual AMP Reports.

Please refer to the AMP for more information on the adaptive management framework, Management Questions, key uncertainties, the Response Framework, Continuous Improvement, linkages between the AMP and other EVWQP programs, and AMP reporting.

2 Implementation Plan

2.1 Overview

The process to adjust the 2019 IPA included refinements to both the management based decisions (i.e., the sources to target for treatment and how quickly treatment could be constructed) and data based inputs (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.

Modifications made to the 2017 RWQM since the submission of the *2017 Elk Valley Regional Water Quality Model Update* (Teck 2017) are described in detail in Annex B. These changes were made prior to undertaking the process of updating the mitigation, are based on feedback during the review of the 2017 RWQM and were incorporated into the model to support the development of the 2019 IPA. They are grouped into two categories: changes made to the 2017 RWQM itself, and modifications made to model inputs related to mine site conditions.

Twelve changes were made to the 2017 RWQM in support of the 2019 IPA. These changes were made in response to feedback received from EMPR, ENV and KNC during the review of the 2017 RWQM, as well as to improve model performance. They are summarized as follows:

- Corrected discrepancies between the geochemical source terms reported in the *2017 Elk Valley Regional Water Quality Model Update* (Teck 2017) (6 of the 12 changes).
- Adjusted for bias to reduce model over-projection in Koocanusa Reservoir (3 of the 12 changes).
- Improved ability of the model to replicate observed flow conditions in Erickson Creek.
- Corrected the initial lag times assigned to waste rock in Swift Pit and Lower Fording 2 watersheds at FRO (these watersheds are shown in Figure 2-1 of Annex B).
- Improved flexibility in the modelling of AWTFs.

The modelling methods used to develop the 2019 IPA include the following generalized steps:

- The prioritization of sources identified for water treatment: process and results of review and, where appropriate, updates to the prioritization of sources.
- Determination of the mitigation to meet long-term Compliance Limits and SPOs for planned waste rock to 2037 (i.e., for the Planned Development Scenario, described in Section 2.2).
- Sequencing and phasing mitigation to meet, to the extent possible, short and medium-term Compliance Limits and SPOs for planned waste rock to 2037 (i.e., for the Planned Development Scenario, described in Section 2.2).
- Adjusting the mitigation to meet, to the extent possible, short-, medium- and long-term Compliance Limits and SPOs for permitted waste rock, including the potential identification of mitigation requirements post 2038 (i.e. for the Permitted Development Scenario, described in Section 2.2).

The methods used to develop the 2019 IPA are described in detail in Annex E.

2.2 Development Scenarios

Two development scenarios were assessed in support of the 2019 IPA: a Planned Development Scenario and a Permitted Development Scenario. Site conditions are the water management and mine plan inputs associated with each development scenario for the RWQM used to develop the 2019 IPA. The requirement to carry forward these two development scenarios originated in a letter issued by ENV and EMPR regarding “Water Quality Predictions for the Baldy Ridge Extension (BRE) Project” (MOE and MEM 2015). This letter included a requirement that water quality projections be provided for the full waste rock inventory for currently approved projects (Permitted Development Scenario) as well as reasonably foreseeable proposed projects for the next 20 years (Planned Development Scenario). The approach to meet the intent of this requirement for the 2019 IPA was confirmed through discussion with ENV, EMPR and KNC. The two development scenarios were carried forward for the 2019 IPA so that the plan could mitigate for all permitted development as well as provide the necessary mitigation for planned development within the 20-year planning period.

The Planned Development Scenario is based on the 2016 Life of Mine (LOM) plans. LOM plans fluctuate annually due to, among other things, market conditions, mine design optimizations and new exploration information. The 2016 LOM plans were reviewed against the 2017 LOM plans and, where differences were noted, were adjusted to better match the more current LOM plans. Examples of these adjustments include FRO where the 2016 LOM plan was adjusted to include the updated Turnbull West plans and LCO where the 2016 LOM was adjusted to better match the increased production in the 2017 LOM.

The Planned Development Scenario includes existing waste rock and water management through 2016 with planned (permitted and unpermitted) development through 2037. This is consistent with the 20-year planning period used in the EVWQP. These inputs are similar to the site conditions included in the 2017 RWQM submission (Teck 2017) and any modifications are tracked in the Table 2-1.

The Permitted Development Scenario includes existing waste rock and water management through 2016 and all permitted development for Teck’s Elk Valley operations. This scenario does not include any future planned development that has not been approved. The planning period for this development scenario has been extended beyond 2037 to include placement of all permitted waste rock, with the model timeline extended to account for the full effects of loading from the permitted waste rock and from pit decanting. The purpose of this scenario is to demonstrate how the 2019 IPA will manage the full effects of permitted development, and to form the base case for future mining permit applications.

The planning periods for the two development scenarios are shown in Figure 2-1. A comparison of the cumulative waste rock volumes for the Planned Development Scenario and Permitted Development Scenario is shown in Figure 2-2. The site conditions for the Planned Development Scenario and the Permitted Development Scenario are summarized in Table 2-1.

Figure 2-1 Planning Period Comparison for Planned and Permitted Development Scenarios (Example provided for EV_ER1 Permitted Development Scenario)

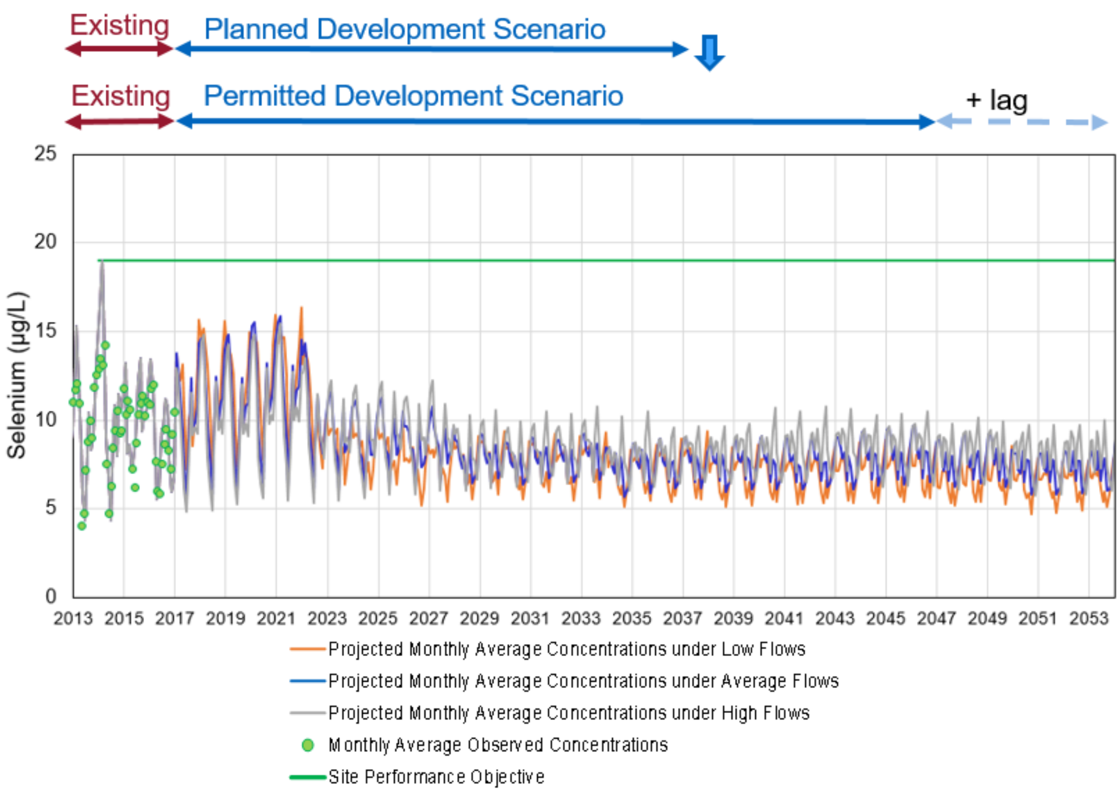


Figure 2-2 Comparison of Cumulative Waste Rock Volumes in the Elk Valley

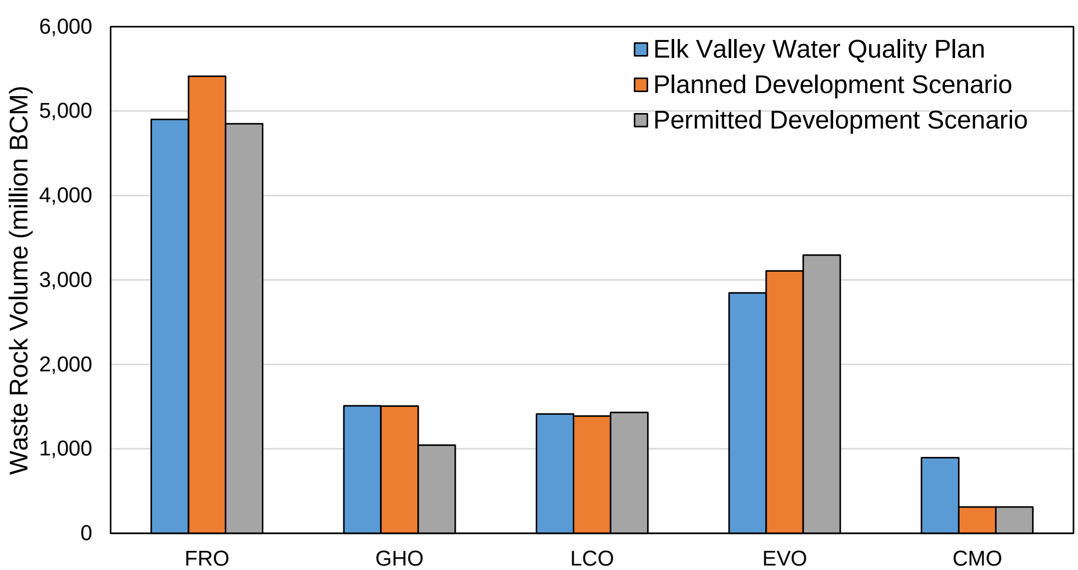


Table 2-1 Changes to Site Conditions among the 2017 Regional Water Quality Model Update, the Planned Development Scenario and the Permitted Development Scenario

Theme	2017 RWQM Update	Planned Development Scenario	Permitted Development Scenario
Planning Window	2017 to 2037	2017 to 2037	2017 to >2100
Mine Areas Included in the RWQM	FRO: Turnbull (South, West, East), Eagle 4, Eagle 6, Lake Mountain, Swift, Castle, Henretta GHO: Cougar South (historical Cougar North, Phases 3, 4, 5, 6) Cougar North (Phases 7 to 11) LCO: Phase I: Horseshoe Ridge, Burnt Ridge South, Mine Services Area West, South; Phase II: Mount Michael 1, 2 and 3 pits, Burnt Ridge North 1, 2 and 3 EVO: Cedar, Baldy Ridge, Natal, F2, Adit Ridge CMO: 6, 14, 34 and 37	FRO: Same as the 2017 RWQM update GHO: Same as the 2017 RWQM update, with revised pumping records for the Cougar Phase 3 Pit in 2015 and inclusion of consumptive water loss at the processing plant LCO: Same as the 2017 RWQM update EVO: Same as the 2017 RWQM update, with the following changes to water management: • revision of flows from the West Fork Tailing Facility (WFTF) to Erickson Creek from 2005 to 2016 • revision of water management at Cedar Pit/Baldy Ridge Pit 6 from 2012 to 2016 • change to future pumping rates from Cedar North [tunnel water] to the WFTF CMO: Same as the 2017 RWQM update	FRO: Turnbull South, Eagle 4, Eagle 6, Lake Mountain, Swift, Henretta Phase III GHO: Same as Planned Scenario, except Cougar North limited to Phase 7 only LCO: Same as the 2017 RWQM update. EVO: Cedar, Baldy Ridge, Natal (excludes Phase 3), F2, Adit Ridge, with water management similar to that of the Planned Scenario (i.e., based on the 2015 BRE Project [Teck 2015] with water management changed to reflect current site plans) CMO: Same as the 2017 RWQM update.

Table 2-1 Changes to Site Conditions among the 2017 Regional Water Quality Model Update, the Planned Development Scenario and the Permitted Development Scenario

Theme	2017 RWQM Update	Planned Development Scenario	Permitted Development Scenario
Waste Rock Volumes	Includes existing, planned and permitted waste rock within the 20-year planning window (2017–2037), as well as residual permitted waste rock beyond 2037. FRO: 5,255 million BCM GHO: 1,512 million BCM LCO: 1,386 million BCM EVO: 3,105 million BCM CMO: 311 million BCM	Includes existing, planned and permitted waste rock within the 20-year planning window (2017–2037). FRO: 5,411 million BCM GHO: 1,505 million BCM LCO: 1,387 million BCM Includes 0.99 million BCM of additional waste rock in Main Line Creek drainage in 2020 as part of the NLX geotechnical amendment. EVO: 3,105 million BCM Includes the reallocation of 50 million BCM of waste rock from the permitted BR2 pit into the Sunshine East Spoil instead of Erickson Spoil (Teck 2018a) CMO: 311 million BCM	Includes existing and permitted waste rock at each operation to the end of mine life FRO: 4,832 million BCM GHO: 1,007 million BCM LCO: 1,431 million BCM EVO: 3,292 million BCM CMO: 311 million BCM
Groundwater Seepage to Pits	Included for: • FRO (for the Swift Project) • GHO (for the CPX Project) • EVO (for Natal pit, Baldy Ridge pits and Cedar pit)	Same as the 2017 RWQM update, with changes at FRO related to modelling completed for the Application Case considered in the Turnbull West Project Application (Teck 2018b)	Same as the 2017 RWQM update, with changes at FRO related to modelling completed for the Base Case considered in the Turnbull West Project Application (Teck 2018b).

BCM = bank cubic metre; CMO = Coal Mountain Operations; CPX = Cougar Pit Extension; EVO = Elkview Operations; EVWQP = Elk Valley Water Quality Plan; FRO = Fording River Operations; GHO = Greenhills Operations; LCO = Line Creek Operations; NLX = North Line Creek Expansion RWQM = Regional Water Quality Model; WFTF = West Fork Tailings Facility.

2.3 Planning Basis

2.3.1 Overview

The 2019 IPA was developed based on refinements and additions to both the management decisions (i.e., the sources to target for treatment and how quickly treatment could be constructed) and inputs (i.e., the effluent quality from treatment, release rates, and water availability for treatment) used to set the EVWQP IIP. These collectively constitute the planning basis on which the IPA was formed. 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 Table 2-2, described in the following sections and in Annex C.

Mitigation measures needed to meet the following three criteria to be included in the RWQM for the 2019 IPA:

- Have quantified effectiveness.
- Are required to meet Compliance Limits and/or SPOs.
- Are permitted (or can be permitted) and can be relied on to be effective.

Biologically-based AWT for nitrate and selenium meets all three criteria and is included as the primary mitigation in the RWQM and the 2019 IPA. Clean water diversions, where practical to support efficient treatment, are also included in the RWQM and the 2019 IPA; however, no influence on load reduction due to a clean water diversion alone has been incorporated (because this has not been proven or quantified).

Nitrate (residuals from blasting activities) source control is a preventative mitigation that Teck continues to implement (more details in Section 2.3.5). However, the effectiveness of nitrate source control is not yet quantified and is therefore not accounted for in the nitrate concentration projections. Work is underway, and described in Section 2.3.5 and Section 3.2, to quantify the benefits of nitrate source control so that nitrate source terms in the RWQM can be refined and its expected positive impact on water quality estimated in future IPAs.

Teck continues to evaluate whether sulphate treatment is required as described in Section 2.3.7 and Section 3.5. Once sulphate treatment requirements and options have been confirmed, an implementation plan for sulphate (if required) will be developed and be incorporated into a future IPA.

Alternative mitigation measures not part of the 2019 IPA are described in Annex J. Although these alternative mitigation measures are not part of the 2019 IPA, an alternative mitigation plan and the steps Teck is taking to advance alternative treatment technologies which will be integrated into future adjustments of the implementation plan; consistent with the AMP are outlined in Annex J.

Table 2-2: 2019 Implementation Plan Adjustment Planning Basis

Input	Planning Basis	Rationale
Water quality SPOs	SPOs at Order Stations as described in Permit 107517 (October 2017)	SPOs at Order Stations were based on the long-term objectives from the EVWQP. They were set based on the effects benchmarks and integrated assessment completed for the EVWQP. No changes to the targets were made as part of this process.
Water quality Compliance Limits	Compliance Limits at compliance points as described in Permit 107517 (October 2017).	Compliance Limits were set based on the 2014 RWQM, and the IIP, which had limited data at some of the compliance points. Resulting modelled concentrations at compliance points will be compared to Compliance Limits, and all efforts made to meet the Compliance Limits.
Water constituents	Selenium, nitrate and sulphate	Removal of cadmium is not currently required to meet long-term water quality targets. No changes were made to the constituents list as part of this process.
Mine plan	Permitted Scenario – 2018 Permitted Mine Plan Planned Scenario – 2016 Mine Plan and 20-year period (to 2037)	KNC and regulatory input that modelled water quality projections are required to full life of mine for permitted development led to the addition of the permitted scenario. The planned scenario signals Teck's intended direction for the mine plan. Mine plans are updated periodically, and these updates will be reflected in future adjustments to implementation plan.
Water quality model projections	2017 RWQM for the IPA	Updated and submitted to EMPR, ENV and KNC in 2017, and regulatory agreement that it be used for the 2019 IPA. See Section 2 (Updates to Regional Water Quality Model and Site Conditions). Updated every three years as per Permit 107517. Next required update 2020.
Flow conditions	All scenarios are run under monthly low, monthly average and monthly high flow conditions	The 2019 IPA is intended to meet the targets under a range of flow conditions. Without treatment, the limiting flow condition is low flows. As more treatment is added to the system, the limiting flow condition becomes high flows.

Table 2-2: 2019 Implementation Plan Adjustment Planning Basis

Input	Planning Basis	Rationale
Geochemical release rates	Catchment-specific average release rates as incorporated in the 2017 RWQM	These reflect current understanding of constituent transport and release.
Mitigation measures – incorporated into the RWQM and projected concentrations	AWT and diversions where practical to support efficient treatment	AWT and diversions are consistent with IIP of the EVWQP. Other mitigation measure will be incorporated into subsequent implementation plan adjustments but are not incorporated into the 2019 IPA. Annex J (Alternative Treatment Mitigation Plan) presents an alternative mitigation plan (based on alternative technologies such as SRFs).
Sources targeted for management and sequence	• Organized by area: • FRO North: Clode Creek, Swift North Spoil Drainage and Swift Pit (Liver Pool Ponds) • FRO South: Swift Creek, Cataract Creek, and Kilmarnock Creek • GHO: Leask Creek, Wolfram Creek, Thompson Creek, and Greenhills Creek • LCO: West Line Creek, Mine Service Area West, and Line Creek upstream of West Line Creek • LCO Dry Creek: LCO Dry Creek upstream of East Tributary • EVO: Bodie Creek, Gate Creek, and Erickson Creek • These will total approximately 75% of the waste rock in the valley in 2037	The sources at each operation were reviewed to ensure that the largest loading sources are targeted. By targeting the largest sources, water quality can be managed regionally most efficiently.
Timing of AWTFs	Post-FRO AWTF-N Phase I (fully effective end of 2023), all future AWTFs spaced two years apart consistent with the EVWQP	AWTFs have a project duration of ~5 years. Two-year spacing allows for an efficient use of resources and sufficient time to advance multiple AWTFs with overlapping delivery schedules. It also provides more of an opportunity to learn from previous AWTFs as opposed to delivering one AWTF per year.
Phasing of AWTFs	Minimum phase size of 5,000 m^3/d, except when total hydraulic capacity was less than 10,000 m^3/d; in those cases (i.e., at GHO and LCO Dry Creek), minimum phase size of 2,500 m^3/d.	Allows for opportunity to learn from previous AWTFs and helps to manage uncertainty with water quality projections and changes to mitigation measures / technologies over time and their impact on future AWTFs.

Table 2-2: 2019 Implementation Plan Adjustment Planning Basis

Input	Planning Basis	Rationale
Clean water diversions	Diversions in Upper Line, No Name, Horseshoe, Kilmarnock and South Gate creeks included.	Diversions in these areas are projected to provide positive benefits for water quality. They should also be technically feasible and practical to operate.
Sizing of clean water diversions	Sized as outlined in Table 2-6	Selected sizing projected to provide a benefit to downstream water quality.
WLC AWTF Phase I effluent quality (to end of 2024) – nitrate and selenium	• Selenium (total): 20 µg/L or 95% removal if influent greater than 400 µg/L • Nitrate: 1 mg/L	To-date WLC AWTF operational data.
WLC AWTF Phase I effluent quality (2025 onwards) – nitrate and selenium	• Selenium (total): 20 µg/L. • Nitrate: 1 mg/L	Represents estimated improvements over time based on to-date WLC AWTF operational data, to-date pilot test work, and focused R&D effort to improve AWTF selenium effluent concentrations.
FRO AWTF-S and EVO AWTF 1 effluent quality (to end of 2024) – nitrate and selenium	• Selenium (total): 30 µg/L or 95% removal if influent greater than 600 µg/L. • Nitrate: 2 mg/L	Based on actual performance of WLC AWTF, same (biological treatment plus AOP) treatment flowsheet, and model projected influent concentrations for both FRO AWTF-S and EVO AWTF 1.
FRO AWTF-S and EVO AWTF 1 effluent quality (2025 onwards) – nitrate and selenium	• Selenium (total): 20 µg/L. • Nitrate: 2 mg/L	Represents estimated improvements over time based on to-date WLC AWTF operational data, to-date pilot test work, and focused R&D effort to improve AWTF selenium effluent concentrations.
FRO AWTF-N effluent quality (to end of 2025) – nitrate and selenium	• Selenium (total): 30 µg/L or 95% removal if influent greater than 600 µg/L. • Nitrate: 2 mg/L	Based on actual performance of WLC AWTF, same (biological treatment plus AOP) treatment flowsheet, and model projected influent concentrations for both FRO AWTF-S and EVO AWTF 1.
FRO AWTF-N effluent quality (2026 onwards) – nitrate and selenium	• Selenium (total): 20 µg/L. • Nitrate: 2 mg/L	Represents estimated improvements over time based on to-date WLC AWTF operational data, to-date pilot test work, and focused R&D effort to improve AWTF selenium effluent concentrations.
All AWTFs (Post-FRO AWTF-N Phase 1) effluent quality from 2025 onwards – nitrate and selenium	• Selenium (total): 20 µg/L. • Nitrate: 2 mg/L	Represents estimated improvements over time based on to-date WLC AWTF operational data, to-date pilot test work, and focused R&D effort to improve AWTF selenium effluent concentrations.

Table 2-2: 2019 Implementation Plan Adjustment Planning Basis

Input	Planning Basis	Rationale
Effluent quality – sulphate	Addition of 20 mg/L to influent concentration	Current biological AWT flowsheet adds an estimated ~20 mg/L through the AOP process as outlined in the WLC AWTF AOP Operational Permit application. Approximately 20 mg/L of sodium sulphite is added to the AOP effluent to quench/remove the ozone to ensure ozone is consumed prior to environmental discharge. The sulphite converts to sulphate once dosed.
WLC AWTF – availability	95%	Based on actual mechanical availability.
AWTF – availability	95% once AWTF reaches 100% capacity. Modelled as 100% as per rationale.	AWTF design capacity will account for ability to make up this unavailability; no modelling impacts (e.g., model at 100% capacity). Reduced AWTF throughput experienced from time to time as a result of recirculation to manage effluent quality and/or for maintenance/repairs. This is not incorporated into the RWQM due to uncertainty of frequency, duration, season timing, etc. Maintenance/repairs will be planned, from an annual timing perspective, in consultation with water modelling/monitoring to minimize potential increases to water quality concentrations. In addition, as operational experience is gained and operational improvements made, the frequency of AWTF reduced capacity will decrease and the ability to make up for reduced capacity during normal operations will increase.

Table 2-2: 2019 Implementation Plan Adjustment Planning Basis

Input	Planning Basis	Rationale
Water availability	Drainage / source specific values summarized below: • FRO Kilmarnock Creek – 75%, 95% (2034 onwards) • FRO Swift and Cataract Creeks – 95% • FRO AWTF-N Intakes Clode Creek, Swift North Spoil Drainage and Swift Pit – 80%, 95% (2034 onwards) • EVO Erickson Creek – 90% • EVO Gate and Bodie Creeks – 95% • LCO Dry Creek – 99% • LCO Line Creek and West Line Creek – 95% • LCO No Name Creek Entering into MSAW – 90% • GHO Upper Greenhills Creek – 75% • GHO Leask and Wolfram Creek – 95%	See Annex H: Assessment of Water Availability.
Collection (intake) efficiency	95%	The percentage of available flow that is captured by the intake. Reflects best engineering judgement of water capture. Site-specific investigations in advance of designing intake structures for water mitigation will be conducted and estimates of water available will be updated.

AMP = Adaptive Management Plan; AOP = advanced oxidation process; AWT = Active Water Treatment; AWTF = Active Water Treatment Facility; EMPR = Ministry of Energy, Mines and Petroleum Resources; ENV = Ministry of Environment and Climate Change Strategy; EVO = Elkview Operations; EVWQP = Elk Valley Water Quality Plan; FRO = Fording River Operations; GHO = Greenhills Operations; IPA = Implementation Plan Adjustment; KNC = Ktunaxa Nation Council; LCO = Line Creek Operations; MQ = Management Question; MSAW = Mine Services Area West; R&D = Research and Development; RWQM = Regional Water Quality Model; SPO = Site Performance Objective; SRF = Saturated Rock Fill; WLC = West Line Creek.

2.3.2 Treatment Timing and Project Duration

Through the EVWQP it was determined that a two-year spacing of AWTFs was necessary to allow for practical, and efficient, use of resources. Two-year spacing allows the design and permitting team to move from one AWTF to the next, and the construction team to do the same, to allow continuity of resources. It allows for procurement of major equipment / long lead items between AWTFs to remain separate; further helping maintain schedules for individual AWTF projects. It provides balance between a practical (and achievable), yet still expedited, rate of implementation of AWTFs allowing for sufficient time to advance multiple AWTFs with overlapping delivery schedules. Two-year spacing also provides more of an opportunity to learn from previous AWTFs, as opposed to one-year spacing. Consistent with the EVWQP, for the 2019 IPA a two-year spacing between AWTFs post FRO AWTF-N was used. This is the most accelerated, yet achievable, timeline for implementing AWTFs.

In the EVWQP, AWTFs were estimated to have a project duration of four years, starting with project kick-off and ending with the start of the commissioning and ramp-up period (e.g. ending with biological seeding of the AWTF). A four year project duration was based on the WLC AWTF project schedule which was approaching completion approximately when the EVWQP was submitted (summer of 2014). The WLC AWTF as-built (actual) project schedule is shown in Figure 2-3.

Teck's updated understanding for the of estimated project duration for the 2019 IPA has increased from four to five years. This is based on experience and lessons learned since the EVWQP including Teck's overall experience with the WLC AWTF and the current schedule for FRO AWTF-S; which is in the detailed design stage with early site works, equipment procurement, and operational permit application preparation underway, and has a forecasted five year project duration. An updated general AWTF project schedule, with estimated activity durations, is shown in Figure 2-4.

Figure 2-3 West Line Creek Active Water Treatment Facility As-built Schedule

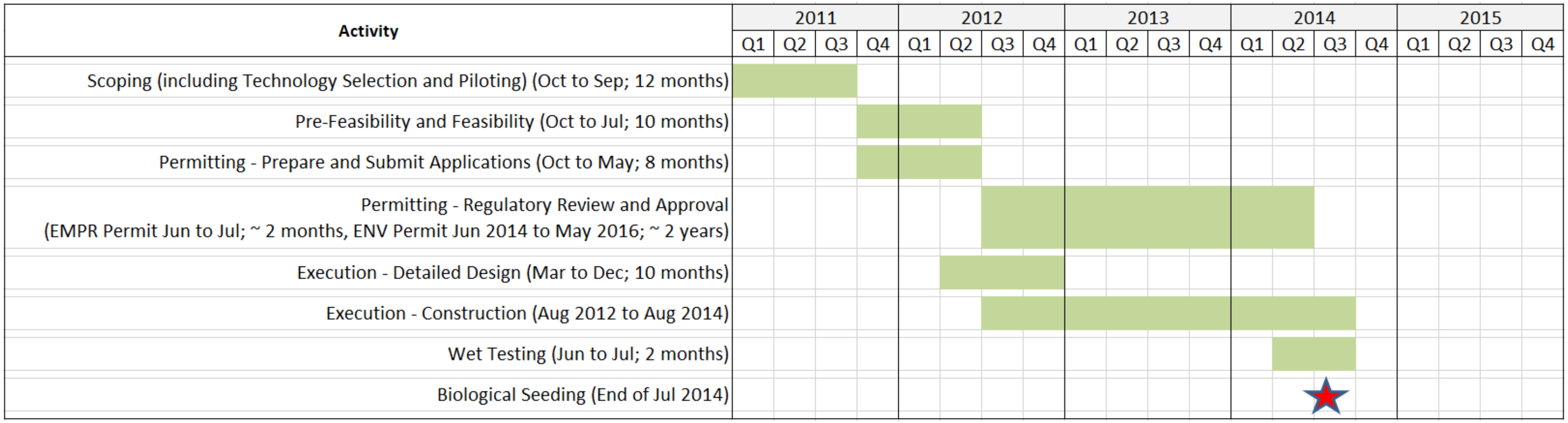
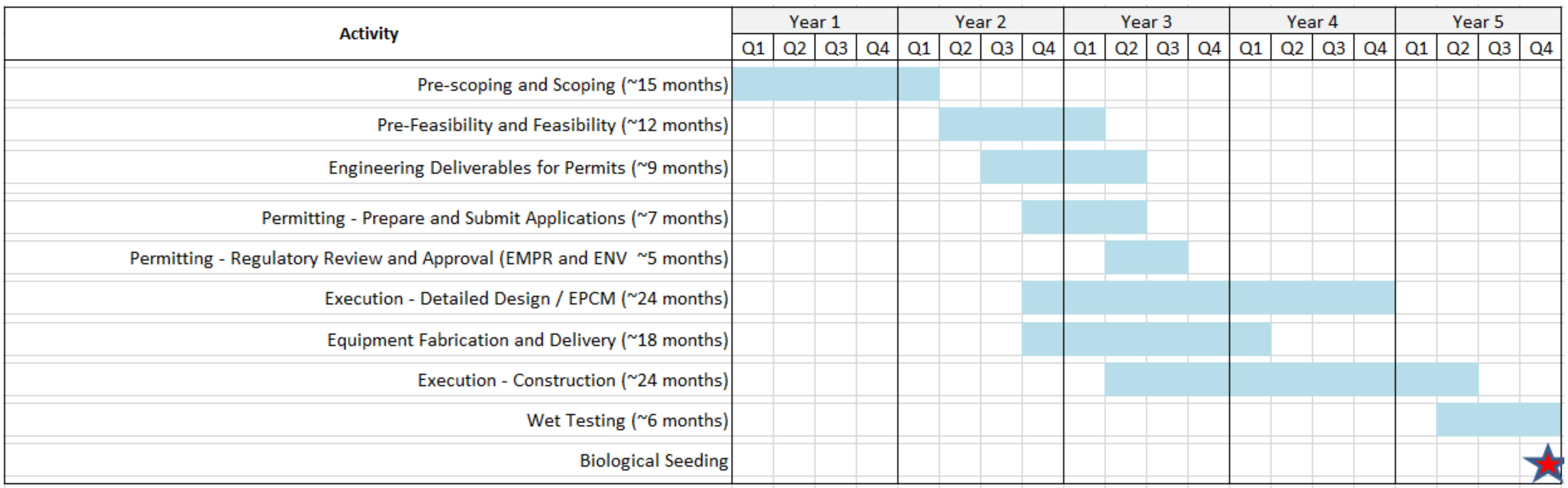


Figure 2-4 Active Water Treatment Schedule (based on FRO AWTF-S) used for the 2019 Implementation Plan Adjustment



2.3.3 Biological Active Water Treatment

2.3.3.1 Overview of Biological Active Water Treatment Process

Biologically-based AWT relies on microorganisms to convert dissolved nitrate and selenium into forms which can be removed from the water. Nitrate is converted into nitrogen gas which is off gassed to atmosphere, and dissolved selenium is converted to solid forms and removed from the water via solid-liquid separation steps. Biologically-based AWT is currently the industry-preferred AWT technology for selenium. The biological AWT process contains the following steps:

a) Pre-treatment, which includes screening at the intake structures, blending of sources in order of priority and heating (via heat exchangers).

b) Biological treatment to convert nitrate to nitrogen gas and to convert selenate and selenite (dissolved forms of selenium) into elemental selenium (particulate form) via a two-stage fluidized bed reactor (FBR) system.

c) Removal of residual organic materials and initial aeration by a moving bed biofilm reactor.

d) High rate settling for the removal of solid forms of selenium from the moving bed biofilm reactor treated water via a ballasted sand clarifier and downstream sand filters.

e) Cooling of treated water via the heat exchangers and then pumped to the advanced oxidation process (AOP) system where reduced forms of selenium are oxidized to selenate.

f) Directing of treated effluent from the AOP system to a buffer pond and then discharged to the receiving environment through an outfall structure.

g) Capturing, conditioning and dewatering of the waste solids prior to transport and disposal at an on-site residuals disposal facility.

The design model for the WLC AWTF which was constructed between mid-2012 and mid-2014 is shown on Figure 2-5. The placement of the AOP at the WLC AWTF is shown on Figure 2-6. The FRO AWTF-S construction site (June 2018) and the design model for this treatment facility (as of July 2018) are shown on Figure 2-7 and Figure 2-8, respectively.

Commissioning, as defined in EMA Permit 107517, is: “bringing the AWTF works into operation, and that subsequent to initiating operation of AWTF works, the commissioning phase includes provision of reasonable timing for undertaking operational refinement or adjustment of works to optimize efficiency and/or effluent quality. In this regard, a maximum of 120 days is considered a reasonable time to commissioning the AWTF.” For the 2019 IPA, biological seeding of an AWTF defines the start of the commissioning and ramp-up period. The commissioning and ramp-up period, or the duration from biological seeding of the bioreactors to operation at full capacity (nitrate and selenium load removal), was set at one year in the 2019 IPA. It includes the 120 days (four months) identified in Permit 107517, after which end of pipe effluent concentrations are expected to be met, plus eight months to ramp-up to 100% capacity (designed water treatment volume and load removal); a total duration of one year, to bring an AWTF from biological seeding to meeting downstream compliance. Based on the re-start of the WLC AWTF it was estimated that at the mid-point of the ramp-up period of each AWTF (i.e., six months after biological seeding) that the AWTF would be operational at 50% capacity. For modelling purposes, however, this mid-point was not captured in the RWQM and represents an opportunity for some treatment capacity to be available prior to the end of the one-year ramp-up period.

Figure 2-5 2012 Design Model of the West Line Creek Active Water Treatment Facility

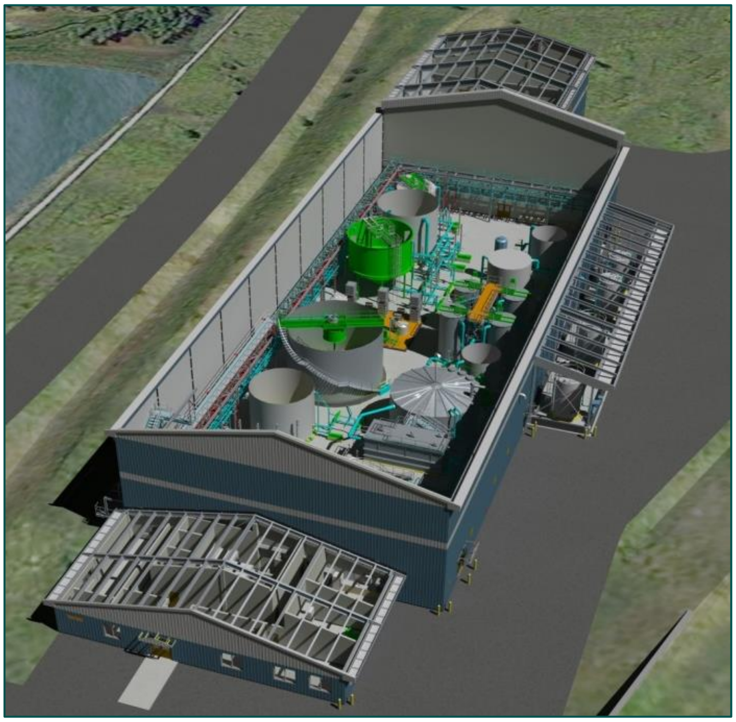
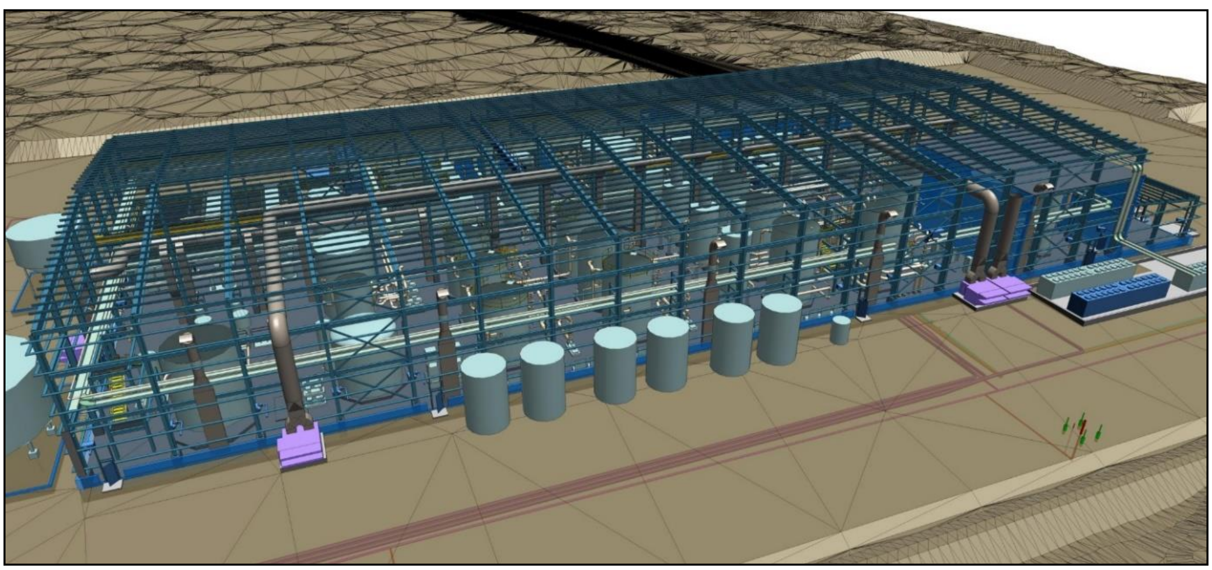


Figure 2-6 Summer 2018 Placement of the Advanced Oxidation Process at the West Line Creek Active Water Treatment Facility

Figure 2-7 Fording River Operation South Active Water Treatment Facility Construction Site (June 2018)

Figure 2-8 Fording River Operation South Active Water Treatment Facility Design Model (July 2018)



2.3.3.2 Effluent Assumptions

2.3.3.2.1 Nitrate

Nitrate effluent concentration assumptions have been refined since the IIP and these refinements are shown in Table 2-3. The reasons for the adjustments are as follows:

- WLC AWTF has consistently achieved less than 0.5 mg/L since August 2018 restart (permit limit = 3 mg/L). Nitrate needs to be removed before selenium; however, small amounts of ammonia are generated in the FBRs and converted to nitrate through treatment informing the adjustment to 1 mg/L for the WLC AWTF.
- FRO AWTF-S and EVO AWTFs expect complete denitrification (same as WLC AWTF), but estimate higher ammonia production as part of the selenium reduction process (as a result of higher influent selenium concentrations for these two AWTF compared to WLC AWTF) informing the adjustment to 2 mg/L for these two AWTFs.
- 2 mg/L for other AWTFs (conservative, consistent with FRO AWTF-S and EVO AWTF).

Effluent nitrate concentrations may be lowered through further analysis/design and operations; this will be reviewed for future IPAs.

Table 2-3 Active Water Treatment Effluent Nitrate Concentrations of the 2019 Implementation Plan Adjustment

Active Water Treatment Facility	Elk Valley Water Quality Plan	2019 Implementation Plan Adjustment
WLC AWTF	0.3 mg/L	1 mg/L
FRO AWTF S		2 mg/L
EVO AWTF 1		
All others		

AWTF = Active Water Treatment Facility; EVO = Elkview Operations; FRO = Fording River Operations; WLC = West Line Creek.

2.3.3.2.2 Selenium

Refinements to selenium effluent concentration input assumptions were undertaken based on learnings from operating WLC AWTF (including with the addition of AOP) and from the design of subsequent AWTFs. These are shown in Table 2-4. What can consistently be achieved, in terms of selenium effluent concentrations, is influenced by a number of factors:

- Influent concentration – The higher the influent concentration the (a) higher the nitrate and selenium load to be removed and the (b) higher the percentage removal required to meet / be below a total selenium effluent concentration of 20µg/L.
- FBR performance – How efficiently and effectively the FBR is reducing nitrate and selenium.
- Solid/Liquids separation – How much selenium reduced to selenite and elemental selenium is removed from the process after it has been reduced into these forms.
- AOP re-dissolution of selenium – How much selenium is re-dissolved through the AOP.
- Additional removal of the non-dissolved forms of selenium (selenite, etc.) via the buffer pond.

The reasons for the adjustments to the effluent selenium concentrations are:

- Higher influent selenium concentrations lead to higher expected effluent concentrations than WLC AWTF for FRO AWTF-S and EVO AWTF.
- FBR performance has demonstrated 95% removal at higher selenium concentrations.
- AOP will increase the dissolved portion of total selenium (i.e. selenate). Since the buffer pond does not remove dissolved selenium the buffer pond no longer provides an additional source of removal.

Table 2-4 Active Water Treatment Effluent Selenium Concentrations of the 2019 Implementation Plan Adjustment

Active Water Treatment Facility	Elk Valley Water Quality Plan	2019 Implementation Plan Adjustment
WLC AWTF Phase I	20 µg/L or 95% removal if influent greater than 400 µg/L	• 20 µg/L or 95% removal if influent greater than 400 µg/L (to end of 2024) • 20 µg/L (2025 onward)
FRO AWTF-S		• 30 µg/L or 95% removal if influent greater than 600 µg/L (to end of 2024) • 20 µg/L (2025 onward)
EVO AWTF		• 30 µg/L or 95% removal if influent greater than 600 µg/L (to end of 2024) • 20 µg/L (2025 onward)
FRO AWTF-N		• 30 µg/L or 95% removal if influent greater than 600 µg/L (to end of 2025) • 20 µg/L (2026 onward)
All others		• 20 µg/L

AWTF = Active Water Treatment Facility; FRO = Fording River Operations; EVO = Elkview Operations; WLC = West Line Creek.

As a result, it is estimated that FRO AWTF S will achieve between 25 µg/L and 30 µg/L when influent selenium is <600 µg/L. EVO AWTF influent water quality is more similar to FRO AWTF-S than WLC AWTF; therefore, Teck expects similar performance for EVO AWTF.

Improvements, of selenium effluent concentrations, over time are estimated (and modeled) based on to-date WLC AWTF operational data, to-date pilot test work, and focused R&D effort to improve AWTF selenium effluent concentrations. To account for these improvements, starting in 2025 an effluent selenium concentration of 20 µg/L is assumed for all AWTFs (already operational and new AWTFs). The only exception is FRO AWTF-N where the 20 µg/L selenium effluent concentration is applied from 2026 onwards. This is because the FRO AWTF-N project is currently underway, with the facility planned to be fully effective at the end of 2023; this allows two years to optimize to achieve the improved selenium effluent concentration of 20 µg/L.

The basis for estimated improvements to selenium effluent concentrations over time is described in the Section 2.3.3.2.2.2 below and in Annex C.

2.3.3.2.2.1 Selenium Bioaccumulation and Speciation

Through the implementation of the EVWQP, Teck's research has demonstrated that biologically-based AWT can change selenium speciation in a way that affects bioaccumulation. Selenium in areas of the Elk Valley not affected by AWT is predominantly (usually >99%) found as the oxyanion selenate (SeO_4, oxidation state +6). Testing of treated water from the WLC AWTF identified that AWTF effluent can contain a higher proportion of selenite (SeO_3, oxidation state +4) and organoselenides (oxidation state +2), which have higher bioavailability than selenate.

The long-term selenium targets included in the EVWQP, and subsequently adopted as SPOs in Permit 107517, were calculated as aqueous total selenium concentrations that, if attained as a monthly average, would result in tissue selenium concentrations in sensitive biota lower than protective tissue-based effects benchmarks. These values were developed based on selenate being the predominant selenium species present in waters in the Elk Valley. Given that biologically-based AWT can change selenium speciation, projected selenium concentrations in the tissues of aquatic species at given aqueous selenium concentrations were re-examined as outlined in Annex G. This analysis was completed using recently developed bioaccumulation models that explicitly account for selenium speciation and the differing rates at which selenium species bioaccumulate.

The conclusions of the analysis are that, when biologically based AWT includes an AOP, changes to selenium speciation are not expected to result in higher bioaccumulation than was considered during the development of the EVWQP. In other words, the inclusion of AOP technology limits the generation of non-selenate species, such that the overall effect of changes to selenium speciation are small, and the long-term SPOs and Compliance Limits in Permit 107517, expressed as total selenium concentrations, remain appropriate for the 2019 IPA.

2.3.3.2.2.2 Ongoing Improvements to Selenium Effluent Concentrations

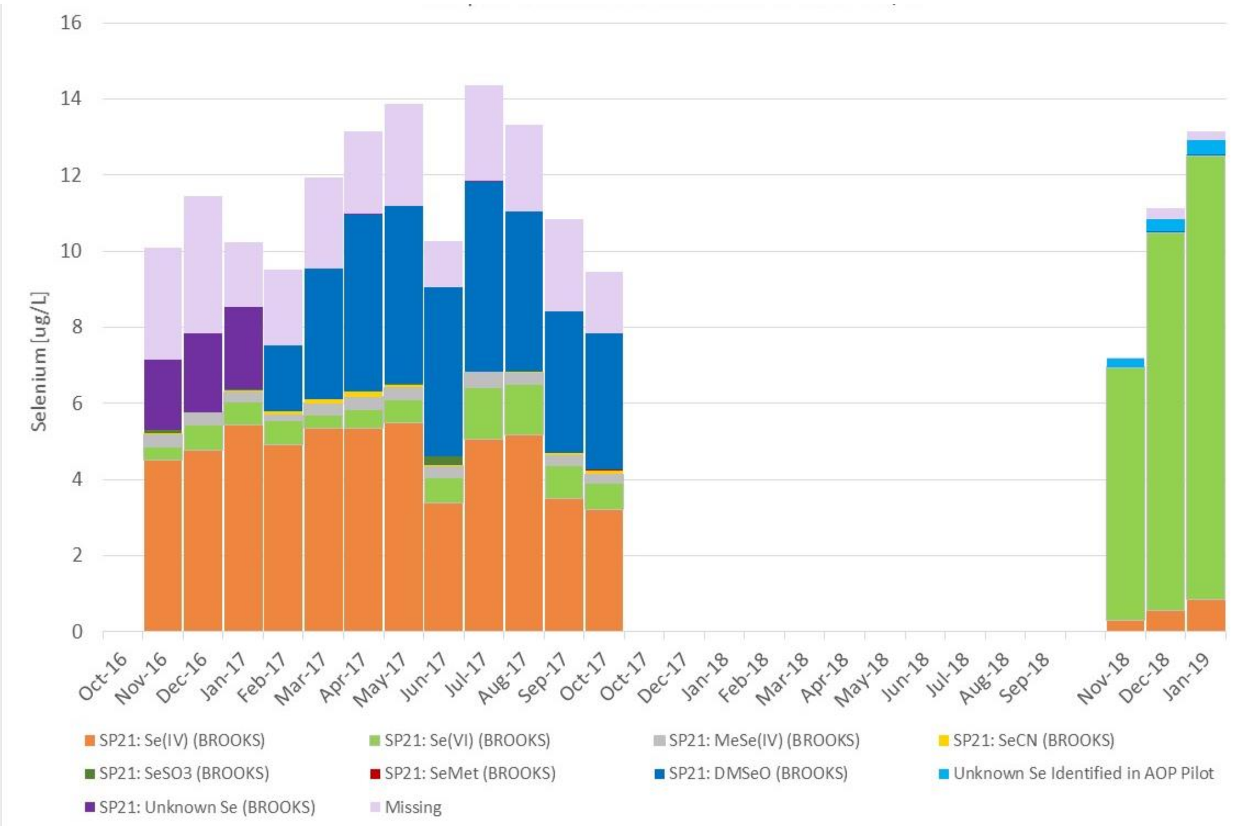
Continuous improvement and the AMP follow similar cycles to achieve incremental improvements that culminate towards achieving a defined goal, which in this case is lowering effluent total selenium concentration for existing and future facilities. These cycles rely on assessing information, designing experiments/improvements, implementation of learnings, monitoring and evaluating results and adjusting operating procedures to integrate learnings. To facilitate and drive this improvement, in 2018 Teck created the Senior Processing role to lead this effort. This role is supported by both the Water Operations and the Water R&D groups.

The following examples illustrate how the continuous improvement cycle has worked to improve WLC AWTF performance since the 2015 restart and the plans going forward.

1) **Selenium Speciation**

- **Assessing information:** In the summer of 2016, a discrepancy between dissolved and total selenium assay results triggered a closer review of selenium speciation. This review raised questions regarding effluent selenium bioavailability. A review of initial receiving environment tissue assays indicated increased local selenium uptake. The next step in the cycle (designing experiment/improvements) was than initiated and the receiving environment monitoring program was increased.
- **Designing experiments/improvements:** Over the fall and winter 2016 and 2017, technologies to either reduce effluent selenium concentrations or convert selenium species were identified and the most promising tested at a bench scale. By spring of 2017, the AOP was identified and a pilot program was completed in 2017. Pilot results showed significant conversion of bioavailable selenium species back to less bioavailable selenate.
- **Implementation of learnings:** In fall 2018, a full-scale AOP installation was completed to convert selenium species in WLC AWTF effluent to selenate.
- **Monitoring and evaluating results:** AOP has operated as designed converting a substantial portion of effluent selenium species to selenate (Figure 2-9). Receiving environment selenium uptake monitoring is in place and ongoing to confirm success.
- **Adjusting operating procedures to integrate learnings:** Selenium conversion efficiency versus AOP operating conditions is being monitored and learnings are being continually integrated into operating procedures and into the designs of future AWTFs.

Figure 2-9 Monthly Average Selenium Speciation in West Line Creek Active Water Treatment Facility Effluent Showing Change in Final Selenium Speciation Due to Installation of the Advance Oxidation Process



Notes:

SP21 = West Line Creek Active Water Treatment Facility effluent discharge compliance point (end-of-pipe)
Orange = Selenite (target selenium species to be converted to selenate through advanced oxidation process)
Green = Selenate (target, less bioavailable, form of selenium)
Blue = Dimethylselenoxide (selenium species to be converted to selenate through advanced oxidation process)
Light Purple = Missing selenium species
Purple = Unknown selenium species

2) Selenite Removal to Reduce Total Selenium (in Effluent)

- **Assessing information:** Triggered by selenium speciation, regular selenium speciation surveys were completed on WLC AWTF effluent (since November 2016). Results showed that selenite was one of the primary selenium species present in WLC AWTF effluent.
- **Designing experiments/improvements:** Processes improvement work to lower the selenite present in the effluent focused on optimizing ferric chloride addition in the Ballasted Sand Clarifier (BSC) because of ferric chlorides' ability to adsorb selenite. AWTF data showed the BSC was effectively removing selenite down to ~2 µg/L, but the subsequent Moving Bed Bioreactor (MBBR) was producing selenite. Bench scale tests were completed through the

winter of 2017 and showed that if ferric chloride was added after the MBBR, and before the sand-filters (in the treatment train) some selenite could be removed.

- **Implementation of learnings:** Based on this, a process change notification was issued and full-scale ferric chloride addition to the sand-filters started in May 2017.
- **Monitoring and evaluating results:** An initial drop in selenite concentrations was observed; however, in July and August of 2017 the selenite leaving the MBBR increased. Ferric addition to the sand-filters helped to mitigate this increase. Further ferric chloride additions could reduce selenite further, however, the solids loading on the sand-filters limited ferric chloride dosing rates at this location.
- **Designing experiments/improvements (round 2):** The increased selenite from the MBBR triggered further bench scale work to either (a) move the BSC to after the MBBR in the treatment process or (b) eliminate the MBBR. Bench scale test results suggested that switching the MBBR and BSC in the treatment process can further reduce selenite. The downside is that selenium in solids carried over to the AOP would oxidise to selenate and increase effluent selenium concentrations. However, an additional benefit of switching the MBBR and BSC would improve BSC solid/liquid separation performance.
- **Implementation of learnings (round 2):** Piping was installed during WLC AWTF downtime, while the AOP was installed, to allow the MBBR to be operated before the BSC.
- **Monitoring and evaluating results (round 2):** Since restart, in fall 2018, WLC AWTF effluent selenite concentrations have remained low to date, although further monitoring is required as the selenite production across the MBBR has not yet achieved steady-state.
- **Adjusting operating procedures to integrate learnings (round 2):** To be determined based on monitoring and evaluating results (round 2) above.

3) Removal of Other Selenium Species to Reduce Total Selenium (in Effluent):

- **Assessing Information:** As shown in Figure 2-9, the three most common non-selenate species in the AWTF effluent prior to AOP were selenite, dimethylselenoxide (initially reported as “unknown”), and a “missing” selenium species. To better identify these species, Teck worked closely with the commercial lab to improve detection limits, speed up turn-around times and identify the unknown selenium species. Finding ways to minimize the formation of these selenium species could result in a lower total selenium in the AWTF effluent.
- **Designing experiments/improvements:** A research program is planned for 2019 to better understand the conditions that lead to the formation of the various selenium species. The first component will consist of a lab program with creek water to understand the impact of carbon source and extent of reduction on selenium speciation. The second component will consist of small-scale parallel FBR trials operated continuously at WLC AWTF to further evaluate the impact of carbon dosing on selenium speciation and will include plant recycle streams in the test feeds, in addition to creek water.

- **Implementation of learnings:** Learnings from the FBR trials will be used to develop operating strategies for both WLC AWTF and Fording River South AWTF (FRO AWTF-S).

The examples above all contribute to improvement in the quality of effluent from the WLC AWTF that will inform future operations and design. In addition to the examples explained above, mean monthly total selenium effluent (and influent) concentrations for the WLC AWTF and average treatment facility throughput are shown in Table 2-5. Mean monthly total selenium effluent concentrations at the WLC AWTF have consistently been below 20µg/L.

Table 2-5 West Line Creek Active Water Treatment Facility Mean Monthly Treatment Throughput and Influent and Effluent Total Selenium Concentrations

Month-Year	Mean AWTF Throughput (m^3/d)	Influent Mean Total Selenium Concentration (µg/L)	Effluent Mean Total Selenium Concentration (µg/L)
Feb-16	6,500	226	9.1
Mar-16	5,300	291	10.9
Apr-16	5,800	305	10.6
May-16	6,100	230	10.5
Jun-16	4,700	252	10.1
Jul-16	5,900	297	13.5
Aug-16	5,400	318	15.0
Sep-16	5,800	298	18.2
Oct-16	5,600	282	10.0
Nov-16	5,300	305	11.9
Dec-16	5,400	298	12.9
Jan-17	5,100	299	12.5
Feb-17	5,400	297	12.6
Mar-17	4,900	339	15.9
Apr-17	5,400	317	17.2
May-17	5,400	360	17.4
Jun-17	5,300	224	13.7
Jul-17	5,400	336	16.1
Aug-17	5,200	389	16.9
Sep-17	5,300	370	11.8
Oct-17	4,000	241	9.5
Oct-18	3,300	297	8.9
Dec-18	4,500	273	11.9
Jan-19	4,800	260	15.5
Feb-19	6,000	260	15.5
Mar-19	5,800	234	15.4
Apr-19	4,700	262	15.5
May-19	5,900	237	17.6
Jun-19	6,500	301	17.5
Jul-19 (forecast)	5,700	220	13.0

The sensitivity of the projected selenium concentrations to improvements in total selenium effluent concentrations over time was assessed in order to quantify the potential risk of not achieving the target selenium effluent concentration of 20 µg/L for all AWTFs (at the time specified or at all). The projected selenium concentrations for the compliance points and Order Stations assuming no improvements to selenium effluent and the comparison to the projections for the 2019 IPA are provided in Appendix B of Annex F.

There are a few projected non-compliances that result if there are no assumed improvements to the effluent selenium concentrations; however, the difference between these maximum projected non-compliances and the SPOs and Compliance Limits is very low (1 µg/L to 3 µg/L) and these projected non-compliances are infrequent. The locations and timing of the projected non-compliances are as follows:

- Order Stations:
  - Fording River downstream of Greenhills Creek (GH_FR1; 0200378) in March of 2048 and 2049
  - Fording River downstream of Line Creek (LC_LC5; 0200028) in February and March 2033
- Compliance points:
  - FRO Compliance Point (FR_FRCP1; E300071) in April of 2025, 2026 and 2033
  - EVO Michel Creek Compliance Point (EV_MC2; E300091) in August and September of 2043

The projected selenium concentrations are not very sensitive to the improvement of selenium effluent concentrations over time as is indicated by the results presented above and the risks associated with not achieving the target concentrations are potential, but infrequent and low magnitude, non-compliances.

2.3.4 Clean Water Diversion

Clean water diversion (CWD) involves the construction of earthen dikes or other physical barriers and/or pipes or other conduits to route clean water from non-mine-impacted areas around mining activities. The IIP includes CWDs in four watersheds: Kilmarnock Creek, Line Creek, Erickson Creek and Gate Creek. The mechanisms by which CWDs may help with water quality management have changed from those understood at the time the EVWQP was prepared. Consequently, an evaluation of potential CWDs was completed to inform which CWDs to include in the 2019 IPA. A summary of how CWDs can assist with water quality management and the results of the CWD evaluation are presented below, with additional details provided in Annex D.

In 2014, CWD was identified in the EVWQP:

- To reduce the volume of water affected by waste rock, thereby reducing the amount of water that needs to be treated.
- To have a larger potential to be effective when it involves the diversion of large, upstream, undisturbed watersheds, such as Upper Line Creek at LCO and Upper Kilmarnock Creek at FRO.

Teck built and operated two gravity-flow CWDs prior to the EVWQP: one at FRO on Kilmarnock Creek and one at GHO on Swift Creek. Lessons learned from these projects suggest that piped clean-water diversions may be the preferred option to reduce the risk of seepage loss and freezing, although this approach will be considered on a case-by-case basis during the design of each CWD project.

It was Teck's understanding during the development of the EVWQP that, by reducing the volume of clean water that comes in contact with mine waste rock, CWDs could help stabilize and reduce selenium and other water quality concentrations in the following two ways:

- By reducing the amount of selenium and other constituents of interest downstream (i.e., when combined with an AWTF with a fixed effluent concentration, more load can be removed from a more concentrated influent stream than one that is more dilute).
- By reducing the estimated cost of mitigation based on the understanding that hydraulic capacity was the primary cost factor in the implementation of AWT.

The current conceptual model for CWDs is that they do not change the mass (load) of selenium and other constituents of interest downstream, as the mass of constituents released is a function of water entering a waste rock pile via precipitation and not dependent on up gradient runoff flowing through the base of a waste rock pile. The run-on (runoff from up-gradient natural catchment areas) is understood to dominantly flow through the coarse rubble zone at the base of the waste rock piles (also referred to as rock drains) and has little interaction with the bulk of the overlying waste rock material.

Teck's understanding of the primary cost factor in active water treatment has changed. During the EVWQP, water treatment facilities were modelled and costs were estimated based on the volume of water requiring treatment (further supporting the inclusion of CWDs in the IIP). Teck's current understanding of biological AWT costs is that treatment costs are largely dependent on the amount of nitrate and selenium removal required (e.g., the required nitrate and selenium load removal), not just the volume of water requiring treatment. Considering the conceptual model for CWDs (that the amount of selenium, nitrate and other water quality constituents released is not impacted by diversion), CWDs have limited cost efficiency benefit to biological AWT, particularly when nitrate concentrations in influent waters are high; nor will they result in water quality improvement without treatment as the total load remains the same.

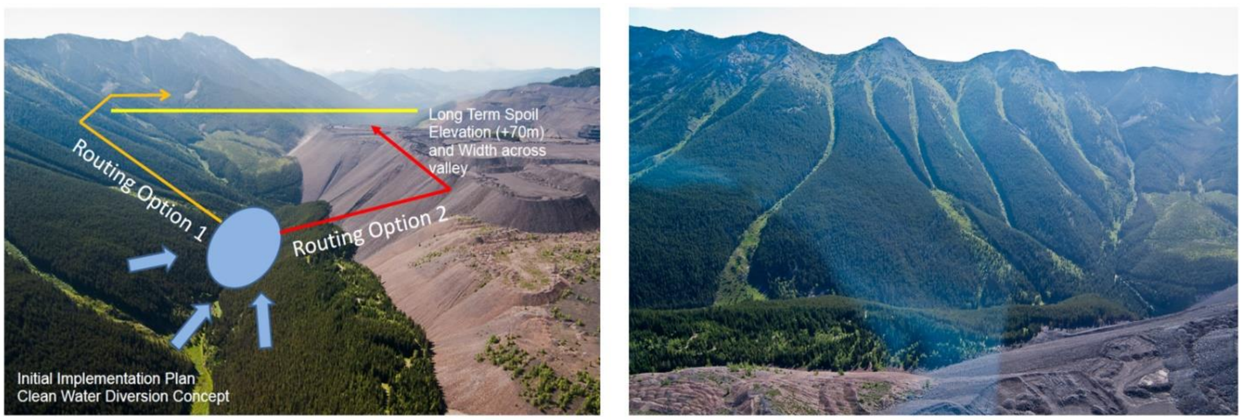
Based on this understanding, an evaluation of potential CWDs was completed to inform which CWDs to include in the 2019 IPA. The evaluation considered technical feasibility, operability and projected benefit to downstream water quality of different CWD configurations. The results of the evaluation are as follows:

- **FRO Kilmarnock Creek CWD**
  - A CWD of at least 10,000 m^3/d in Kilmarnock Creek is technically feasible to build and operate and is projected to result in a benefit to downstream water quality.
  - A smaller sized CWD does not produce the same water quality benefit.
  - Larger sized CWDs may be more technically challenging to build and operate, but are likely feasible to implement. The incremental benefit of larger sized CWDs to downstream water quality is small, becoming more meaningful as nitrate concentrations in mine contact waters decline.

  - At the time the evaluation was conducted, the size of the Kilmarnock Creek Diversion to be included in the 2019 IPA was set to 10,000 m^3/d. The size was subsequently increased, initially to 45,000 m^3/d to be consistent with the EVWQP and then to 86,000 m^3/d. The larger sizing reflects additional water modelling and analysis done as part of the scoping stage of the Kilmarnock Creek CWD Project. The Kilmarnock Creek CWD Project will design, permit and construct the Kilmarnock Creek CWD and has been proceeding in parallel to the 2019 IPA. Work done in support of a larger sized CWD will be described through the Kilmarnock Creek CWD Project (and permit application) later in 2019 and into 2020.
  - A more detailed assessment of the sizing and timing of the Kilmarnock Creek diversion, and of constructability and operability considerations, remains ongoing through the Kilmarnock Creek CWD Project. This more detailed assessment may result in changes to the sizing, timing and/or operational approach of the diversion. Nevertheless, it is expected that a dynamic approach to the operation of the CWD will be used, so that waters travelling through the CWD can be directed to the FRO-S AWTF when necessary to maintain effective operations of the facility.
  - A CWD in Brownie Creek is not being pursued because of challenges related to technical feasibility and operability, as well as the relatively small size of the area under consideration (compared to the combined Kilmarnock-Brownie watershed).
- **LCO Upper Line Creek / Horseshoe and No Name Creek CWDs**
  - Evaluation supports the inclusion of a combined CWD in the order of 20,000 to 42,000 m^3/d that diverts No Name Creek and Upper Line Creek.
  - A combined CWD of this size appears to be technically feasible to build and operate and is projected to result in a benefit to downstream water quality.
  - A smaller sized CWD does not produce the same water quality benefit. Larger sized CWDs may be more technically challenging to build and operate, and their projected incremental benefit to downstream water quality is marginal.
  - A more detailed assessment of constructability and operability, and of the total cost of the combination of different volumes of CWD and planned treatment, is required (post-2019 IPA). This more detailed assessment will be done as part of the AWTF project to which this CWD is linked (e.g., the next phase of the WLC AWTF). Consequently, the configuration of this CWD may change in future IPAs once this assessment is complete.
  - It is expected that a dynamic approach to the operation of the CWD will be used, so that waters travelling through the CWD can be directed to the WLC AWTF when necessary to maintain effective operations of the facility.
- **EVO South Gate Creek CWD**
  - In place as part of EVO site water management and included in the 2019 IPA. The South Gate Creek CWD has been constructed as a collection ditch system and has not been sized/designed to a specific volume per day. The South Gate Creek CWD was designed to capture and divert surface water runoff from an area of non-mining impacted land around down gradient waste rock spoils.

- **EVO Erickson Creek CWD**
    - Not included in the 2019 IPA.
    - Access and operational challenges render this diversion unfavourable. Steep and rugged terrain with high avalanche risk (on the side slope of a mountain) suggests that this diversion would be extremely challenging to construct and in turn operate and maintain. This is shown on Figure 2-10 where the left photograph shows the conceptual routing options evaluated and the right photograph shows the steep and rugged terrain with avalanche chutes along routing option 1. Water quality modelling also indicates that the diversion would have minimal influence on water quality in Michel Creek. For these reasons, this CWD was not included in the 2019 IPA.

Figure 2-10 Erickson Creek Clean Water Diversion Conceptual Routing Options Evaluated



CWDs included in the IIP and in the 2019 IPA are summarized in Table 2-6. They include a diversion of Kilmarnock Creek at FRO, of South Gate Creek at EVO, and of Upper Line Creek, Horseshoe Creek and No Name Creek at LCO.

Table 2-6 Clean Water Diversions Included in the in the 2019 Implementation Plan Adjustment and the Initial Implementation Plan

Clean-Water Diversion	Associated Active Water Treatment Facility	Initial Implementation Plan		2019 IPA	
		Streams and Volume Diverted	Date Operational	Streams and Volume Diverted	Date Operational
Kilmarnock Creek	FRO AWTF-S	Upper Brownie and Kilmarnock watersheds, estimated at 45,000 m^3/d	December 31, 2018	Upper Kilmarnock Watershed, estimated up to 86,000 m^3/d[a]	December 31, 2020[a]
Erickson Creek	EVO AWTF 1	Upper Erickson Watershed, estimated at 14,000 m^3/d	December 31, 2020	Not included	
South Gate Creek	EVO AWTF 1	South Gate Creek, estimated at 3,500 m^3/d	December 31, 2020	South Gate Creek, estimated at 3,500 m^3/d	In place and operating.
Upper Line Creek, Horseshoe and No Name Creeks	WLC AWTF 2	Upper Line Creek and Horseshoe Creek, estimated at 35,000 m^3/d and No Name Creek, estimated at 7,000 m^3/d	2032	Upper Line Creek and Horseshoe Creek estimated at 35,000 m^3/d and No Name Creek estimated at 7,000 m^3/d for a total of 42,000 m^3/d	December 31, 2025

AWTF = Active Water Treatment Facility; EVO = Elkview Operations; EVWQP = Elk Valley Water Quality Plan; FRO = Fording River Operations; IPA = Implementation Plan Adjustment; WLC = West Line Creek.

Notes:

a) The Kilmarnock Creek Clean Water Diversion Project is ongoing and includes a more detailed assessment of the sizing and timing of the diversion, and of constructability and operability considerations. This more detailed assessment may result in changes to the sizing, timing or operational approach of the diversion.

Future evaluations and next steps associated with CWD, focused on answering Key Uncertainty 3.3 of the AMP ("Is clean water diversion an effective water management strategy?") are described in Section 3.3.

2.3.5 Nitrate Source Control

The source of nitrate in the receiving environment is residuals from blasting activities. Controlling this source is a focus area for Teck. Teck asserts that nitrate source control is a proven and effective mitigation measure to reduce nitrate release from waste rock. In 2016, a nitrate management team was established at Teck in the Elk Valley with the primary objective of identifying and implementing best management practices for blasting to reduce nitrate release. Scoping level estimates of losses were made for each type of blasting product and practice used at Teck operations through a combination of literature review, laboratory testing, and field testing. This information was used to identify and prioritize best management practices. The following best management practices, listed in order of estimated nitrate reduction potential, were identified:

1. Eliminating the use of all augured emulsion products: This method of loading blast holes causes blasting product to stick to the sides of the upper section of the hole (Figure 2-11), where it remains undetonated.

2. Lining Ammonium Nitrate Fuel Oil (ANFO) holes: ANFO is not water resistant, and liners prevent products from contacting water in the hole to reduce leaching.
3. Maximizing dewatering of wet holes.
4. Limiting sleep time (i.e., the time explosives are in the borehole before detonation) in areas of moving water: The longer explosives are in the ground in areas of moving water the more likely they are to leach.

Figure 2-11 Augured Emulsion Blasting Product Stuck to the Sides of an Upper Section of a Drill Hole for Blasting

Initial calculations have indicated that these practices have the potential to reduce nitrate loss by >50% compared to 2013 baseline practices. Because of this and the large potential benefits to downstream water quality, these best practices have been implemented and continue to be refined with learnings.

To date, the following has been achieved:

- No augured emulsion products have been loaded since 2016.
- ANFO usage has increased across all five sites from an average of 11.9% in 2015 to an average of 50% in 2018.
- All ANFO holes are now being lined to effectively eliminate leaching.

Future evaluations and next steps associated with nitrate source control, focused on answering Key Uncertainty 3.2 of the AMP ("What is the most feasible and effective method (or combination of methods) for source control of nitrate?") are described in Section 3.2. The result of this work will be the development of inputs to refine the nitrate source terms for the 2020 RWQM update. There are no benefits to nitrate loading from changes to blasting practices assumed in the modelling to support the 2019 IPA.

2.3.6 Water Availability

Water availability refers to the RWQM input values that inform the proportion of total watershed yield that can be captured at each intake location for conveyance to an AWTF. The values assigned to water availability in the RWQM were initially set based on the proportion of total watershed yield that is assumed to be readily available as surface flow; they were increased, if and as necessary, to simulate enhanced capture of mine-influenced water to achieve downstream Compliance Limits and SPOs. Such enhancements would reflect the potential capture of some of the subsurface flow that would otherwise bypass the intake.

Water availability assumptions used in the 2017 RWQM to develop the 2019 IPA are consistent with those in the EVWQP, with the exception of sources at FRO. Water availability assumptions for FRO sources are initially assumed to be the same as defined in the EVWQP, but are increased after 2033 as outlined in Annex H. This increase was required, within the 2017 RWQM, in order for projected maximum monthly average selenium concentrations to be at or below the monthly average Compliance Limit at the FRO Compliance Point. This change prompted an examination of water availability and the likelihood that assumed water capture rates could be achieved through the collection of surface flow in each tributary targeted for treatment; a sensitivity analysis on the degree to which the change in assumed water availability at FRO sources affects downstream projected concentrations of selenium, sulphate and nitrate was also undertaken. The examination of water availability compared to measured surface flow is provided in Annex H; the results of the sensitivity analysis are presented in Appendix C of Annex F.

Results of the examination of water availability indicates that, in general, collection of surface flow should be sufficient to meet the water availability assumptions used in the RWQM in areas where site-specific groundwater evaluations have been done (e.g., LCO Dry Creek, Swift Creek, Cataract Creek). In other areas (e.g., Erickson Creek, Clode Creek), results of the analysis indicate that additional studies and potential design considerations may be required so that the relevant intakes are able to access as much of the total watershed yield as assumed in the RWQM, at least at certain times of the year. Follow-up activities are planned with a particular focus on collecting site-specific information at potential intake locations, as existing flow monitoring locations tend to be located downstream of where potential intakes will be constructed. An overview of planned follow-up activities is outlined in Section 3.4, with additional detail provided in Annex H.

Results of the sensitivity analysis conducted on the assumption of increased water availability at FRO sources indicate that the change in assumed water availability has no effect on the frequency of compliance with nitrate and sulphate Compliance Limits and SPOs. Projected monthly average nitrate and sulphate concentrations above SPOs and/or Compliance Limits are effectively the same with and without assumed increases in water availability, as detailed in Annex F, Appendix C.

Projected monthly average selenium concentrations above SPOs and Compliance Limits are the same with and without assumed increases in water availability, with four exceptions – two exceptions with respect to SPOs, and two exceptions with respect to Compliance limits. The two SPO exceptions involve monthly average selenium concentrations that are projected to be above long-term SPOs at the following Order Stations without assumed increase in water availability:

- 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 µg/L downstream of Line Creek.

The two Compliance Limit exceptions involve monthly average selenium concentrations that are projected to be above long-term Compliance Limits at the following Compliance Points without assumed increase in water availability:

- FRO Compliance Point (FR_FRCP1; E300071) in 2035 and from 2038 to 2053.
- In both cases, differences between projected selenium concentrations and the corresponding Compliance Limit are in the order of 7 µg/L.

These results suggest that projected future concentrations of nitrate, selenium and sulphate have limited sensitivity to the assumed increase in water availability at FRO sources.

2.3.7 Sulphate Treatment

The potential for future sulphate concentrations to be above Compliance Limits and SPOs was identified in the EVWQP and in the 2017 RWQM update. Key Uncertainty 3.5 in the AMP is: “Is sulphate treatment required, and if so how could we remove sulphate?” Teck continues to evaluate this uncertainty through review of the sulphate benchmarks (including monitoring data review and chronic toxicity supporting studies), review of model projections and advancement of sulphate treatment technology development.

Multiple lines of evidence are available that confirm that EVWQP benchmarks for sulphate are adequately protective, and that lower benchmarks would not be needed to attain protection of aquatic life. Sulphate toxicity studies, mixture toxicity studies, and chronic toxicity monitoring indicate that sulphate concentrations at or lower than EVWQP benchmarks do not cause toxicity to sensitive test species, even in the presence of other constituents. Biological monitoring data further confirm that locations at or near EVWQP benchmarks do not exhibit effects that can be attributed to sulphate. Overall, the information available supports the continued use of EVWQP benchmarks as an appropriate basis for evaluating potential effects of sulphate.

Teck initiated R&D for sulphate treatment in 2012 when Teck funded a technical report entitled *Removal, Control and Management of Total Dissolved Solids from Process Effluent Streams in Non-Ferrous*

Metallurgical Industry (Ramachandran 2012). In 2013, a bench scale evaluation of the Paques SULPHATEQ™ process was completed to evaluate ability to treat sulphate, selenate and nitrate. In 2013/2014, the following flowsheets were piloted at FRO for the same constituents:

- Microfiltration combined with nanofiltration
- Microfiltration combined with reverse osmosis (RO)
- Electrodialysis reversal combined with RO

In addition, a high density sludge process was evaluated at a mini-pilot scale. Currently Teck is in the process of evaluating a membrane process at IDE Technologies, a water treatment company, on Eagle Pond water. Planning is currently underway to pilot one or more sulphate treatment technologies in 2019/2020.

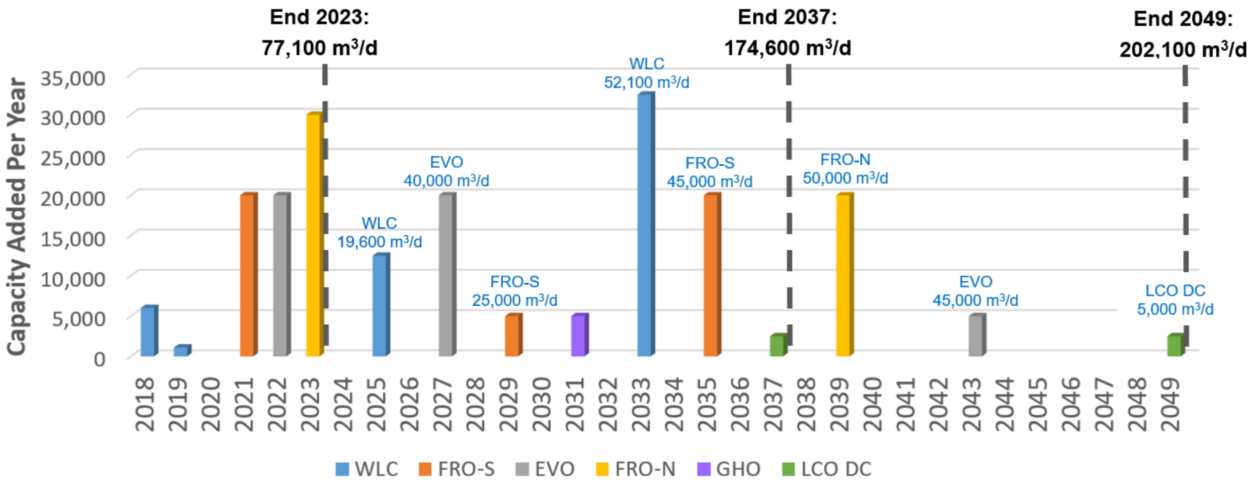
The potential locations and timing where sulphate treatment may be required are identified in the 2019 IPA, but no treatment was accounted for in projected sulphate concentrations provided in Section 2.4.2.2.3. Two parallel paths under the AMP that are proceeding to address Key Uncertainty 3.5 of the AMP ("Is sulphate treatment required and if so how could we remove sulphate?") are described Section 3.5.

2.4 2019 Implementation Plan

2.4.1 Mitigation Plan

The summary of water quality mitigation, in chronological order, for the 2019 IPA is shown in Figure 2-12. The treatment sequence and volumes for the 2019 IPA are shown in Table 2-7 IIP treatment sequence (with updates to the timing of the first three AWTFs [WLC AWTF, FRO AWTF-S and EVO AWTF Phase I]) since the development of the EVWQP, is shown in Table 2-8. The content in Table 2-7 and Table 2-8 is organized by site. A summary of the comparison between the 2019 IPA and the IIP treatment sequence is shown in Table 2-9.

Figure 2-12 Projected Dates When Treatment Included in the 2019 Implementation Plan Adjustment between 2018 and 2050 will be Fully Effective



Notes: Treatment assumed to be fully effective by the end of December in the year indicated (e.g., one year post biological seeding); with the exception of EVO AWTF Phase I, which is assumed fully effective Sept 30, 2022.
Values in blue font are the cumulative treatment capacities.

Table 2-7 2019 Implementation Plan Adjustment

Site	Sources Targeted for Mitigation	Treatment Facility	Hydraulic Capacity (m^3/d)	Associated Diversions and Conveyance of Mine-Influenced Water	Fully Effective Date [(a)]
FRO	Swift, Cataract and Kilmarnock creeks	FRO AWTF-S Phase I	20,000	• Diversion of Upper Kilmarnock watershed • Convey mine-influenced water to treatment • Discharge to the Fording River	December 31, 2021
		FRO AWTF-S Phase II	5,000		December 31, 2029
		FRO AWTF-S Phase III	20,000		December 31, 2035
	Clode Creek, North Spoil and Swift Pit	FRO AWTF-N Phase I	30,000	• Convey mine-influenced water to treatment • Discharge to the Fording River	December 31, 2023
		FRO AWTF-N Phase II	20,000		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 • Convey mine-influenced water to treatment • Discharge to Line Creek	December 31, 2018
		WLC Phase II	1,100		December 31, 2019
		WLC Phase III	12,500		December 31, 2025
		WLC Phase IV	32,500		December 31, 2033
	LCO Dry Creek	LCO Dry Creek Phase I	2,500	• Convey mine-influenced water to treatment • Discharge to the Fording River	December 31, 2037
		LCO Dry Creek Phase II	2,500		December 31, 2049
EVO	Bodie, Gate and Erickson creeks	EVO Phase I	20,000	• Convey mine-influenced water to treatment • Discharge to Erickson Creek	September 30, 2022
		EVO Phase II	20,000		December 31, 2027
		EVO Phase III	5,000		December 31, 2043
GHO	Leask, Wolfram, Thompson and Greenhills creeks	GHO Phase I	5,000	• Convey mine-influenced water to treatment • Discharge to Thompson Creek	December 31, 2031
		GHO Phase II	2,500		Post-2100
Total			**204,600**		

[(a)] In the 2017 RWQM, the fully effective date is the date when the treatment facility has been built, seeded, commissioned and is effective at the hydraulic capacity listed above.

AWTF = Active Water Treatment Facility; EVO = Elkview Operations; EVWQP = Elk Valley Water Quality Plan; FRO = Fording River Operations; GHO = Greenhills Operations; LCO = Line Creek Operations; RWQM = Regional Water Quality Model; WLC = West Line Creek.

Table 2-8 Initial Implementation Plan Developed as Part of the Elk Valley Water Quality Plan (2014)

Site	Sources Targeted for Treatment	Treatment Facility	Hydraulic Capacity (m^3/d)	Associated Diversions	Associated Conveyance of Mine-Influenced Water	Fully Effective Date in EVWQP	Fully Effective Date in 2017 RWQM
FRO	Swift, Cataract and Kilmarnock creeks	Fording River South	20,000	Diversion of Upper Kilmarnock watershed and Upper Brownie watershed	• Convey mine-influenced water to treatment • Discharge to the Fording River	2018	Q4 2021
	Clode Creek, North Spoil and Swift Pit	Fording River North Phase I	15,000	–	• Convey mine-influenced water to treatment • Discharge to the Fording River	2022	Q4 2023
		Fording River North Phase II	15,000	–		2030	Q4 2030
LCO	West Line Creek and Line Creek	WLC Phase I	7,500	–	• Convey mine-influenced water to treatment • Discharge to Line Creek	Q2 2014	5,500 m^3/d in Q1 2018 1,600 m^3/d in Q1 2019
		WLC Phase II	7,500	Diversion of Upper Line Creek		2032	Q4 2033
	LCO Dry Creek	LCO Dry Creek	7,500	–	• Convey mine-influenced water to treatment • Discharge to the Fording River	2028	Q4 2029
EVO	Bodie, Gate and Erickson creeks	EVO Phase I	30,000	Diversion of Upper Erickson watershed and South Gate Creek	• Convey mine-influenced water to treatment • Discharge to Erickson Creek	2020	Q2 2022
		EVO Phase II	20,000			2024	Q4 2025
GHO	Leask, Wolfram, Thompson and Greenhills creeks	GHO	7,500	–	• Convey mine-influenced water to treatment • Discharge to Thompson Creek	2026	Q4 2027
Total			**130,000**				

EVO = Elkview Operations; FRO = Fording River Operations; GHO = Greenhills Operations; LCO = Line Creek Operations; RWQM = Regional Water Quality Model; WLC = West Line Creek.

Table 2-9 Treatment Capacity and Timing Comparison between the 2019 Implementation Plan Adjustment and the Initial Implementation Plan

Modelled Active Water Treatment Facility (1)	2019 Implementation Plan Adjustment		Initial Implementation Plan	
	Date Fully Effective (2)	Hydraulic Capacity (m^3/d)	Date Fully Effective (3)	Hydraulic Capacity (m^3/d)
West Line Creek (WLC) Phase I	December 31, 2018	6,000	June 30, 2014	7,500
WLC Phase II	December 31, 2019	1,100	-	-
Fording River Operation (FRO) AWTF-S Phase I	December 31, 2021	20,000	December 31, 2019	20,000
Elkview Operation (EVO) Phase I	September 30, 2022	20,000	December 31, 2021	30,000
FRO-N Phase I	December 31, 2023	30,000	December 31, 2023	15,000
WLC Phase III	December 31, 2025	12,500	-	-
EVO Phase II	December 31, 2027	20,000	December 31, 2025	20,000
FRO-S Phase II	December 31, 2029	5,000	-	-
Greenhills Operation (GHO) Phase I	December 31, 2031	5,000	December 31, 2027	7,500
WLC Phase IV	December 31, 2033	32,500	December 31, 2033	7,500
FRO-S Phase III	December 31, 2035	20,000	-	-
Line Creek Operation (LCO) Dry Creek Phase I	December 31, 2037	2,500	December 31, 2029	7,500
FRO-N Phase II	December 31, 2039	20,000	December 31, 2031	15,000
EVO Phase III	December 31, 2043	5,000	-	-
LCO Dry Creek Phase II	December 31, 2049	2,500	-	-
GHO Phase II	2100+	2,500	-	-
Total Hydraulic Capacity (m^3/d)		**204,600**		**130,000**

(1) Clean water diversions associated with the 2019 IPA include the diversion of Upper Kilmarnock watershed at FRO and diversion of Upper Line Creek, Horseshoe Creek and No Name Creek at LCO.

(2) The fully effective date is the date when the treatment facility has been built, biologically seeded, commissioned and is effective at the hydraulic capacity listed above.

(3) The fully effective dates included for the IIP are based on the assumption that there is a four month commissioning period, followed by an eight month ramp up period from the operational dates listed for the first six AWTFs listed in Permit 107517, and from the end of the calendar year (December 31) for the remaining AWTFs listed in Table 8-19 of the EVWQP.

The 2019 IPA has a larger total treatment volume than the IIP (e.g., total treatment in the order of 200,000 m^3/d compared to 130,000 m^3/d) and applies to both the Permitted and Planned Development Scenarios. The increase in treatment is for FRO and LCO. This increase resulted primarily from two RWQM refinements and the extension of the planning period from 2034 to 2037, along with the consideration of loading related to existing and permitted waste rock over the long term. The two RWQM refinements are as follows:

- Higher selenium and sulphate loading rates than calculated during the development of the EVWQP and the IIP; higher loading rates resulted from the incorporation of a lag in the release of selenium, sulphate and nitrate from waste rock.
- Slower rates of nitrate loss from waste rock spoils than modelled in the EVWQP.

2.4.2 Projected Water Quality

2.4.2.1 Overview

The mitigation outlined in the 2019 IPA results in the stabilization and reduction of projected selenium and nitrate concentrations at the Order Stations in the Elk Valley. Projected concentrations meet long-term selenium and nitrate Compliance Limits and SPOs at all Compliance Points and Order Stations, respectively. Shifts in the timing to commission FRO AWTF-S and EVO AWTF Phase I, compared to the timing in the IIP, are projected to result in selenium and nitrate concentrations, at some locations, that are seasonally above Compliance Limits and SPOs in the near term (i.e., to the end of 2022), under both the Permitted Development and Planned Development scenarios. Where and when sulphate treatment may be required and a path forward for advancing sulphate treatment technology is also identified in the 2019 IPA. The timelines outlined in Permit 107517 to meet short-, medium- and long-term Compliance Limits and SPOs were developed from the water quality modelling completed in support of the EVWQP (2014). The long-term SPOs for the Order Stations were established based on Level 1 benchmarks for selenium, nitrate and sulphate. The Compliance Limits were established in Permit 107517 based on the 2014 RWQM projected concentrations at compliance points. These projections met the SPOs at the Order Stations and were based on the treatment capacity and timing of Permit 107517. The rationale for how and when the short-, medium- and long-term SPOs and Compliance Limits were adjusted over time in the IIP is as follows:

- The short-term SPOs and Compliance Limits were established based on what was technically and financially achievable, with the timeframes defined by the IIP.
- The medium-term SPOs and Compliance Limits were set to demonstrate progressive reduction in selenium and nitrate water quality concentrations from short- to long-term SPOs and Compliance Limits.
- The timing of the incremental decreases from short-, to medium- and then to long-term SPOs and Compliance Limits were set based on the timing and order of treatment established in the IIP.

The 2014 RWQM outputs reflected Teck's understanding of geochemical release of nitrate, selenium and sulphate from waste rock at the time. Since the EVWQP, the understanding of geochemical release of nitrate, selenium and sulphate from waste rock has advanced to recognize that there is a time delay (lag) between waste rock placement and load release to the receiving environment. This change resulted in higher projected release rates per unit of waste rock for the abovementioned constituents than previously estimated.

Teck's updated understanding of estimated AWTF project duration has increased from four to five years as explained in Section 2.3.2. This is based on experience and lessons learned since the development of the EVWQP, including Teck's overall experience with the WLC AWTF and the current schedule for FRO AWTF-S, which has a forecasted five-year project duration. An accelerated schedule has been included in the 2019 IPA up to and including FRO AWTF-N. This is to make up for shifts in the commissioning dates of the WLC AWTF, FRO AWTF-S and EVO AWTF Phase I that resulted from time required to understand and develop a solution for selenium bioaccumulation and speciation at WLC AWTF and subsequent AWTFs, as described in Section 2.3.3.2.2.1. Consequently, the commissioning of FRO AWTF-N in the 2019 IPA is in line with the timing in Permit 107517. Two-year spacing between consecutive treatment facilities after FRO AWTF-N is intended to allow for sufficient use of resources and to learn from previous AWTFs. This is consistent with the spacing outlined in the EVWQP and is the most accelerated, yet achievable, timeline for implementing AWTFs.

The primary objective of the 2019 IPA was to achieve compliance with all SPOs and Compliance Limits. However, it was recognized that any changes in the inputs to the RWQM and the proposed timing and capacity of treatment had the potential to result in projected non-compliances at some locations. This is because the timing of the changes from short-, to medium- and then long-term SPOs and Compliance Limits were set based on the 2014 RWQM (and its underlying assumptions) and the IIP, and because of the changes to timing of some AWTFs associated with addressing selenium speciation. The secondary objective of the 2019 IPA was to minimize any projected non-compliances of SPOs and Compliance Limits by optimizing the timing and capacity of the treatment, within the bounds of what could be technically achievable.

Shifts in the timing to commission FRO AWTF-S and EVO AWTF Phase I are projected to result in selenium and nitrate concentrations, at some locations, that are seasonally above Compliance Limits and SPOs in the near-term (i.e., to the end of 2022), under both the Permitted Development and Planned Development scenarios. Projected selenium and nitrate concentrations are at or below SPOs at all seven Order Stations under both development scenarios following the commissioning of these two facilities (i.e., from 2023 onward). They are also projected to be at or below Compliance Limits at all seven compliance points under both development scenarios from 2023 onward, with a few exceptions that are outlined in Section 2.4.2.2. A spatially representative overview of projected concentrations compared to SPOs and Compliance Limits is provided in Figure 2-13 and Figure 2-14, respectively, for the Permitted Development Scenario. A summary of the projected nitrate and selenium concentrations above Compliance Limits for the Planned Development and Permitted Development scenarios is provided in Tables 2-10 and 2-11, respectively.

Table 2-10 Summary of Projected Nitrate Concentrations above Site Performance Objectives and Compliance Limits for the Planned and Permitted Development Scenarios

Location		Development Scenario	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]	Planned	2020 to 2021	January to April	17	14	3
		Permitted	2020 to 2021	January to April	17	14	3
	Elk River upstream of Grave Creek (EV_ER4; 0200027)	Planned	2020 to 2021	January to April	5.6	4	1.6
		Permitted	2020 to 2021	January to April	5.6	4	1.6
Compliance Points	FRO Compliance Point (FR_FRCP1; E300071)	Planned	2019	January to April	32	27	5
			2020 to 2022	October to May	31	19	12
			2024	April	14	13	1
		Permitted	2019	January to April	31	27	4
			2020 to 2022	October to May	30	19	11
	LCO Compliance Point (LC_LCDSSLCC; E297110)	Planned	2019 to 2025	October to May	12	7	5
		Permitted	2019 to 2025	October to May	12	7	5

Table 2-11 Summary of Projected Selenium Concentrations above Site Performance Objectives and Compliance Limits for the Planned and Permitted Development Scenarios

Location		Development Scenario	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]	Planned	2020 to 2021	December to April	78	63	15
		Permitted	2020 to 2021	December to April	73	63	10
	Fording River downstream of Line Creek (LC_LC5; 0200028)	Planned	2020 to 2021	January to April	58	51	7
		Permitted	2020 to 2021	February to April	56	51	5
	Elk River upstream of Grave Creek (EV_ER4; 0200027)	Planned	2020 to 2021	February	26	23	3
		Permitted	2020 to 2021	February	25	23	2
	Koocanusa Reservoir (RG_DSELK; E300230	Planned	2019 to 2022	January to April	2.6	2	0.6
		Permitted	2019 to 2022	January, February, April	2.5	2	0.5
Compliance Points	FRO Compliance Point (FR_FRCP1; E300071)	Planned	2020 to 2021	October to May, August	127	90	37
		Permitted	2020 to 2021	October to May	120	90	30

Table 2-11 Summary of Projected Selenium Concentrations above Site Performance Objectives and Compliance Limits for the Planned and Permitted Development Scenarios

Location		Development Scenario	Year	Month	Maximum Projected Concentration (µg/L)	Corresponding Site Performance Objective / Limit (µg/L)	Maximum Magnitude of Exceedance (µg/L)
	LCO Compliance Point (LC_LCDSSLCC; E297110)	Planned	2019 to 2025	December to May	69	50	19
		Permitted	2019 to 2025	December to May	69	50	19
	GHO Elk River Compliance Point (GH_ERC; E300090)	Planned	2028 to 2030	February	9	8	1
		Permitted	2028 to 2029	February	8.6	8	0.6
	EVO Harmer Compliance Point (EV_HC1; E102682)	Planned	2028 to 2030, 2032 to 2037	August to May	76	57	19
		Permitted	2029, 2034 to 2053	August to May	76	57	19
	EVO Michel Creek Compliance Point (EV_MC2; E300091)	Planned	2021	February	29	28	1
			2022	January to March, August to September	32	20	12
			2027	August	20	19	1
		Permitted	2021	February	29	28	1
			2022	January to March, August to September	31	20	11
			2027	August	20	19	1

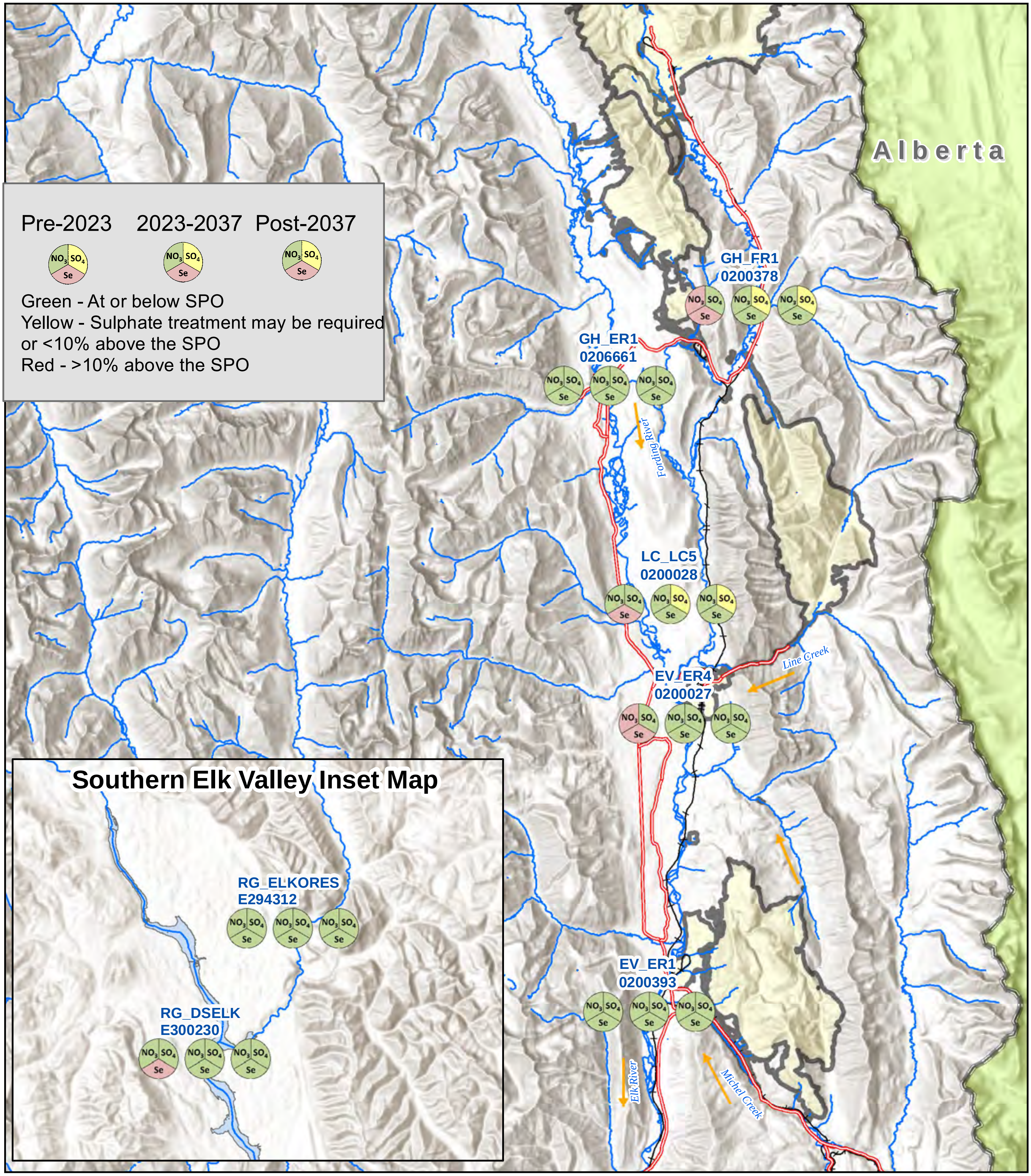


Figure 2-13 Overview of Projected Concentrations Compared to Site Performance Objectives under the Permitted Development Scenario

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Paved Surface
Flow Direction
Permit Boundary
Stream

N

0 1,700 3,400 6,800 Meters

DATE:	MINE OPERATION:
1/29/2019	ELK VALLEY OPERATIONS
SCALE:	COORDINATE SYSTEM:
1:270,000	NAD 1983 UTM Zone 11N

Document Path: \\teckcominco\CGO\Groups\TCGIS\Data\Projects\SeNO3TrendAnalysis\TrendAnalysisSP.mxd

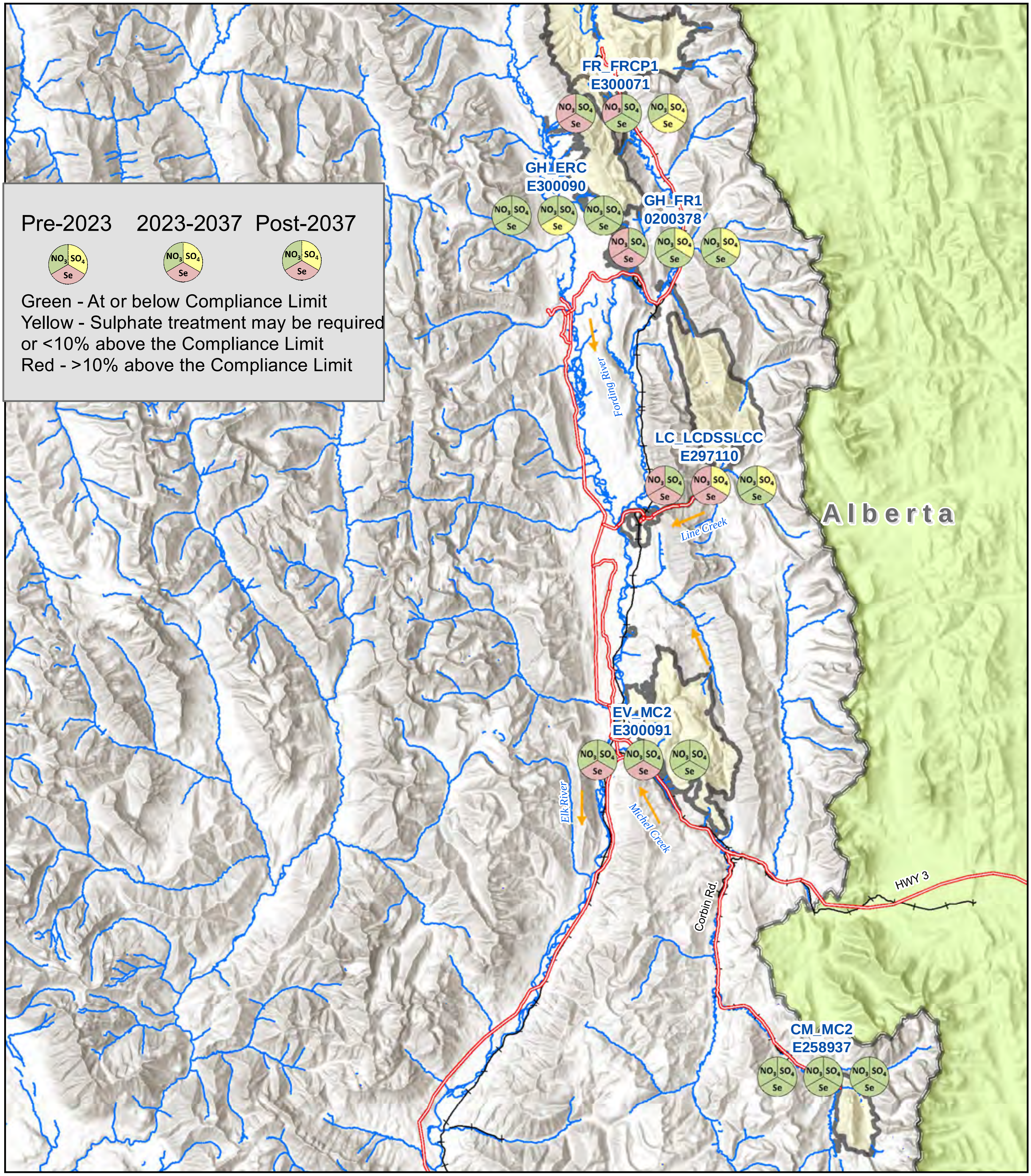

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Figure 2-14 Overview of Projected Concentrations Compared to Compliance Limits under the Permitted Development Scenario

Paved Surface
Flow Direction
Permit Boundary
Stream

N
0 2,375 4,750 9,500 Meters

DATE: 1/29/2019
MINE OPERATION: ELK VALLEY OPERATIONS
SCALE: 1:375,000
COORDINATE SYSTEM: NAD 1983 UTM Zone 11N

Document Path: \\teckcominco\CGO\Groups\TCGIS\Data\Projects\SeNO3TrendAnalysis\TrendAnalysisComplianceFinal.mxd

2.4.2.2 Projected Concentrations

The nitrate, selenium and sulphate projections are presented in this section, with reference to the Permitted Development Scenario. Similar information for the Planned Development Scenario is provided in Annex F. Annex F also includes results for the new proposed location for the Fording River Compliance Point, Fording River above Chauncey (FR_FRABCH), for both development scenarios.

A common figure format is used to display projected nitrate, selenium and sulphate concentrations at Order Stations and compliance points in Sections 2.4.2.2.1 through 2.4.2.2.3. Projected concentrations are shown as monthly average concentrations over time. Historical observations (green points) and fully effective dates (vertical lines) for the AWTFs are included for context. SPOs and Compliance Limits are included for reference. The solid orange, blue and gray lines shown in Figure 2-15 through Figure 2-20 correspond to the projected monthly average concentrations under 1-in-10-year low, average and 1-in-10-year high flows, respectively, with the 2019 IPA.

The x-axis in Figure 2-15 through Figure 2-20 run from the start of 2013 to the end of 2053. The calibration period for the 2017 RWQM is January 1, 2004, to December 31, 2016. Therefore, projected concentrations shown in gray prior to 2017 correspond to monthly average concentrations projected to occur each year under measured flow conditions. Year 2053 corresponds to the time in the model 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 sulphate load). The following five mine pits are projected to be at some stage of filling in 2053:

- Swift Pit at FRO
- Cougar Phases 4 to 6 and Cougar Phases 7 to 11 at GHO
- Burnt Ridge North 3 at LCO
- Natal Pit at EVO

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 the other three pits (i.e., these pits are allowed to passively fill and decant over time, without active management of pit water volumes). Model projections accounting for the decant of these pits, and the influence of the waste rock contained therein, are included in Annex F.

As with any model, input assumptions and projections of future conditions involve uncertainty. Model assumptions are discussed in Teck (2017). Model error and bias are also described therein, with additional details provided in Annex B. Uncertainty in the model projections is taken into account during detailed planning and development of water quality mitigation.

2.4.2.2.1 Nitrate Projections

Order Stations

Monthly average nitrate concentrations are projected to meet short-, medium- and long-term SPOs at the following Order Stations (Figure 2-15):

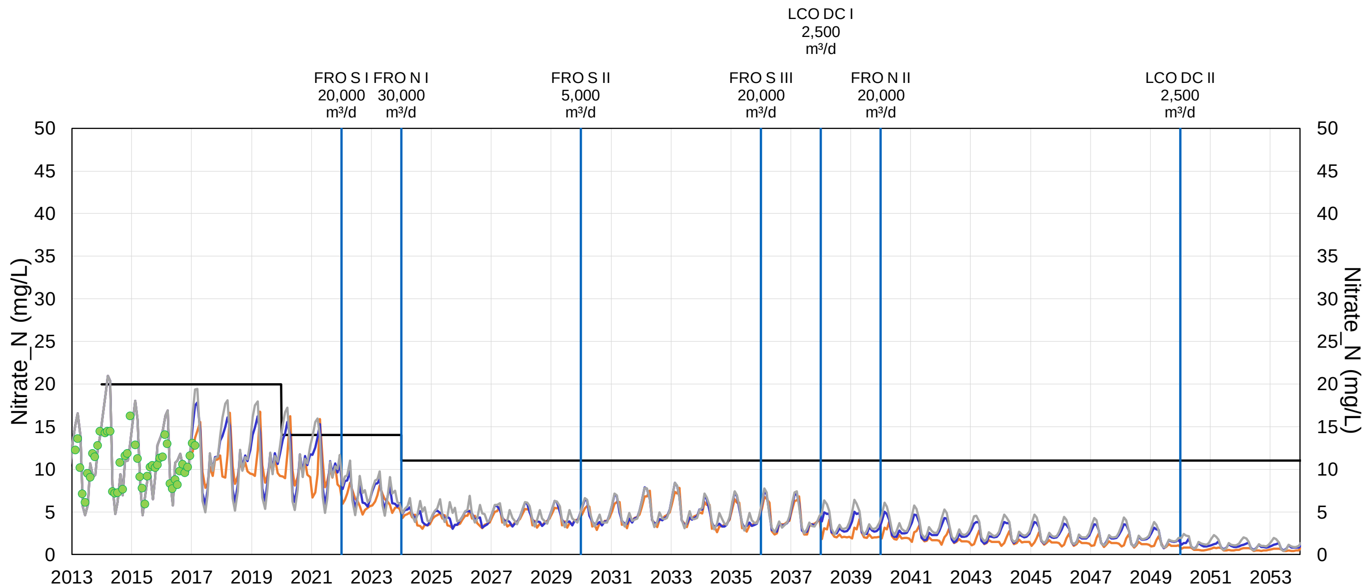
- Fording River downstream of Line Creek (LC_LC5; 0200028)
- Elk River upstream of Boivin Creek (GH_ER1; 020661)
- Elk River downstream of Michel Creek (EV_ER1; 0200393)
- Elk River at Elko Reservoir (RG_ELKORES; E294312)
- Koocanusa Reservoir (RG_DSELK; E300230)

Monthly average nitrate concentrations are also projected to meet medium- and long-term SPOs at the remaining two Order Stations after the commissioning of the first phases of the FRO AWTF-S and EVO AWTFs (i.e., from 2023 onward) (Figure 2-15).

Prior to the commissioning of these two facilities, monthly average nitrate concentrations in the Fording River downstream of Greenhills Creek and in the Elk River upstream of Grave Creek are projected to be higher than SPOs seasonally. This information is summarized in Table 2-10.

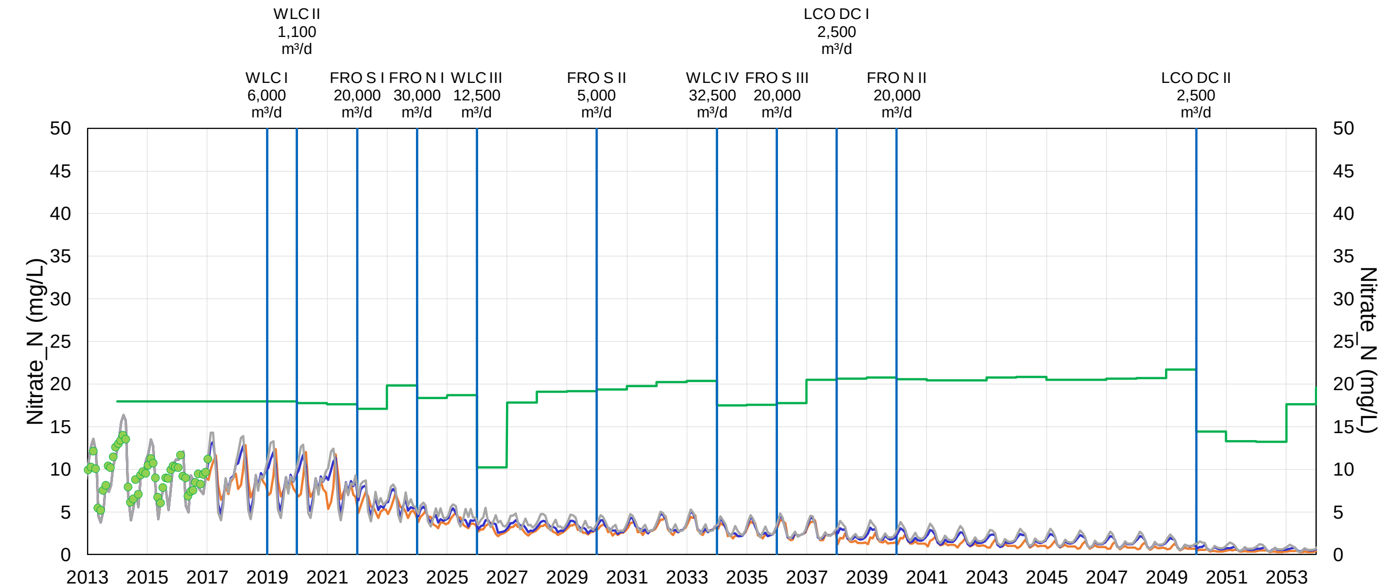
Figure 2-15 Projected Monthly Average Nitrate Concentrations at Order Stations from 2013 to 2053 under the Permitted Development Scenario

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



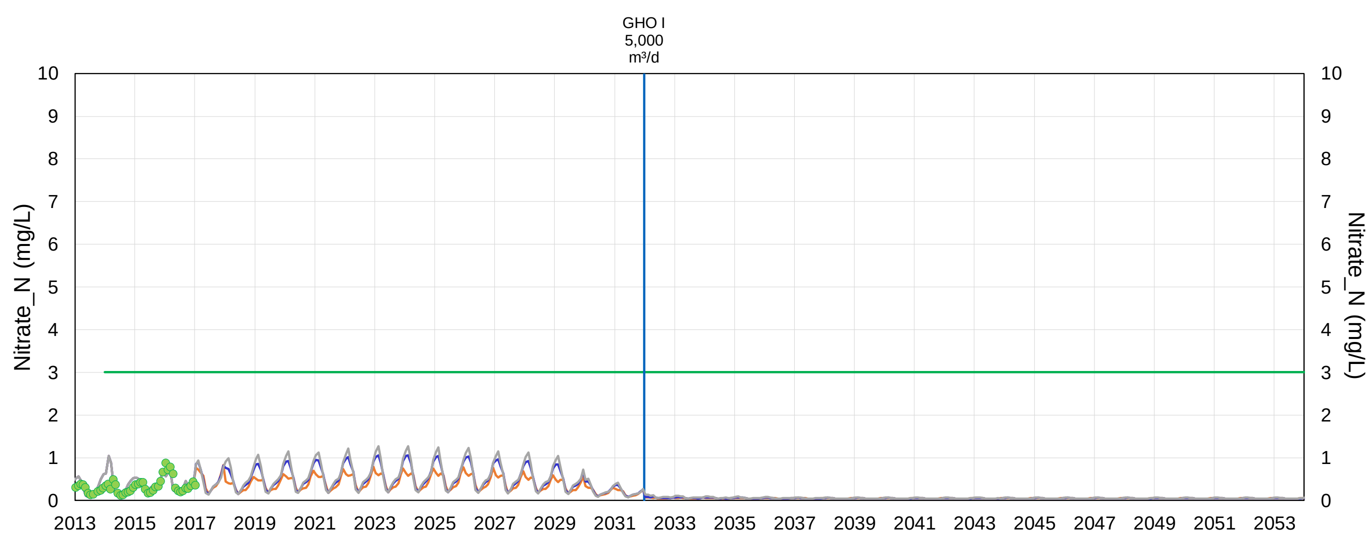
Note: This location is also the GHO Fording River Compliance Point.

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

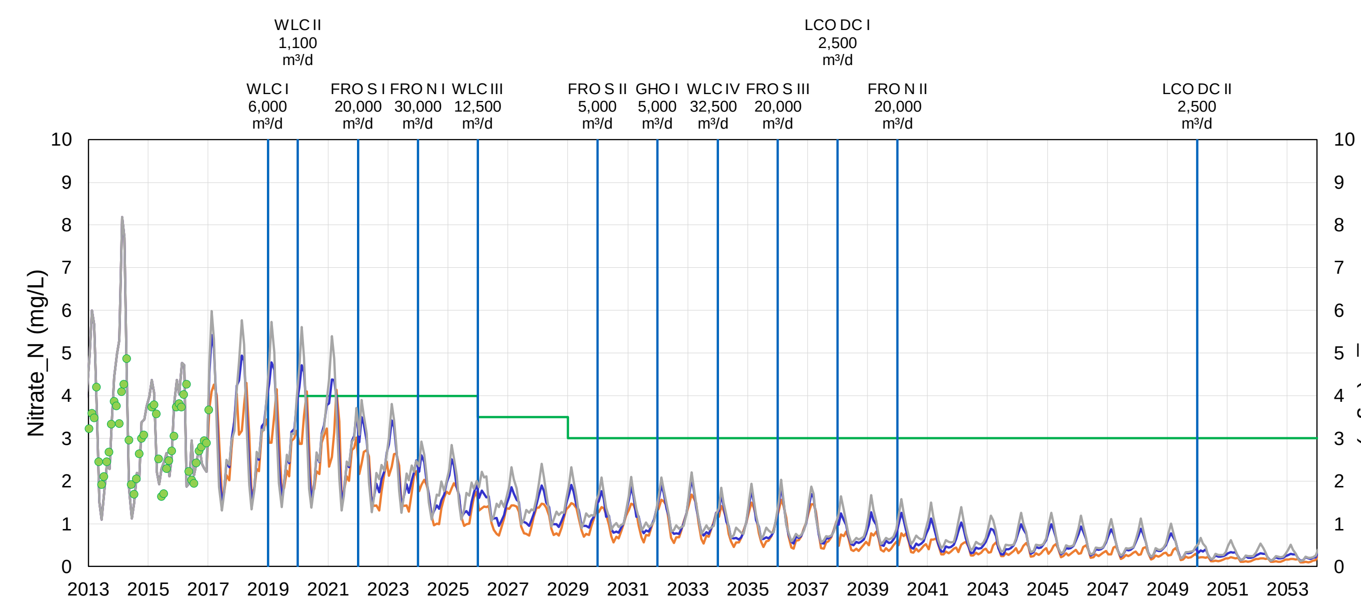


Note: Site Performance Objective is hardness dependent from 2019 onward and is calculated using the following formula: N (in mg-N/L) = $10^{1.0003\log10(\text{hardness})-1.52}$ where hardness is in mg/L of $CaCO_3$.; it varies with time to reflect projected harness concentrations in the month when maximum monthly nitrate concentrations are projected to occur.

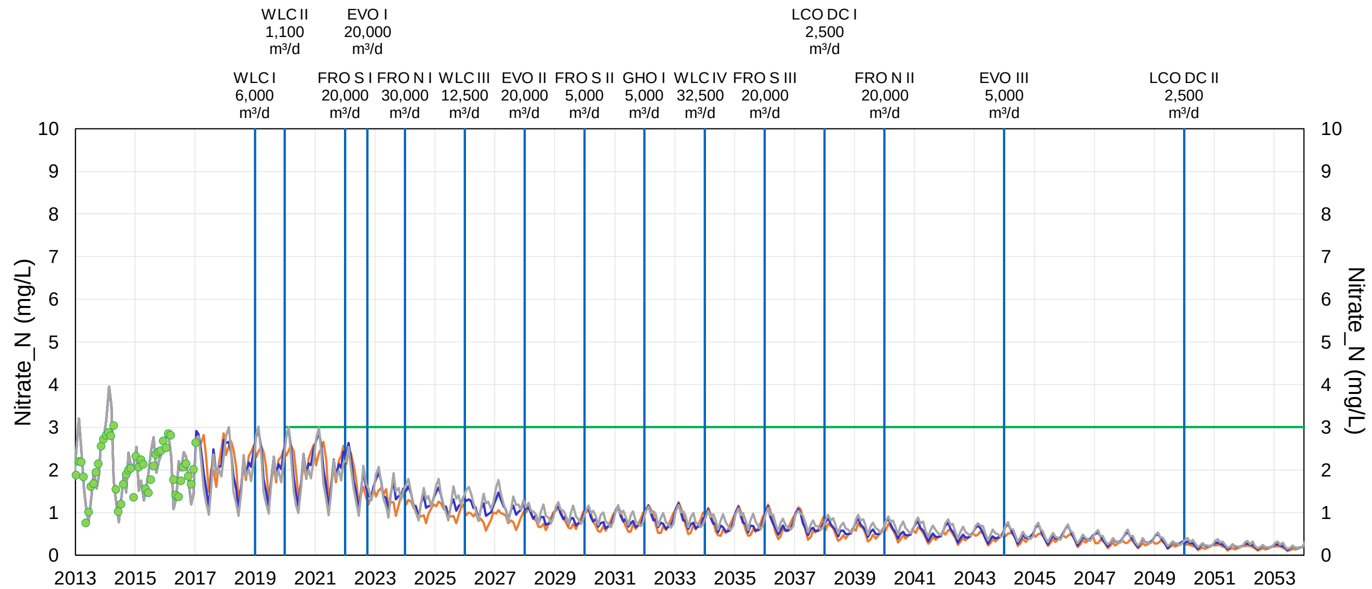
(c) Elk River Upstream of Boivin Creek (GH_ER1; E206661)



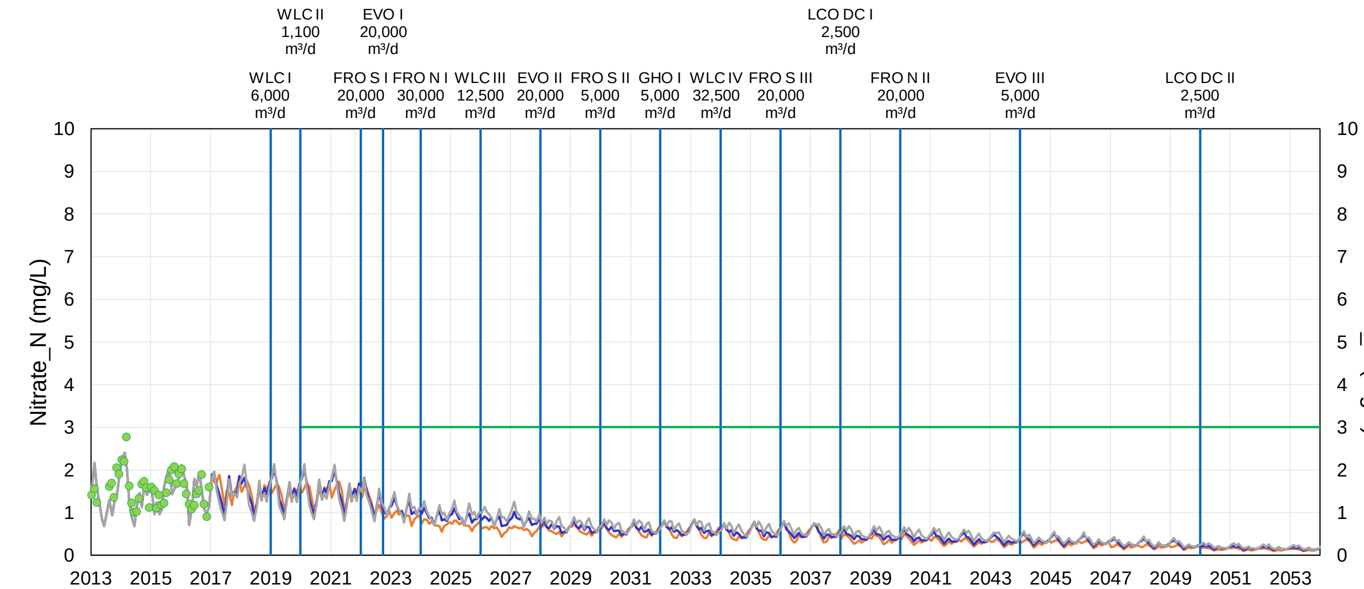
(d) Elk River Upstream of Grave Creek (EV_ER4; 0200027)



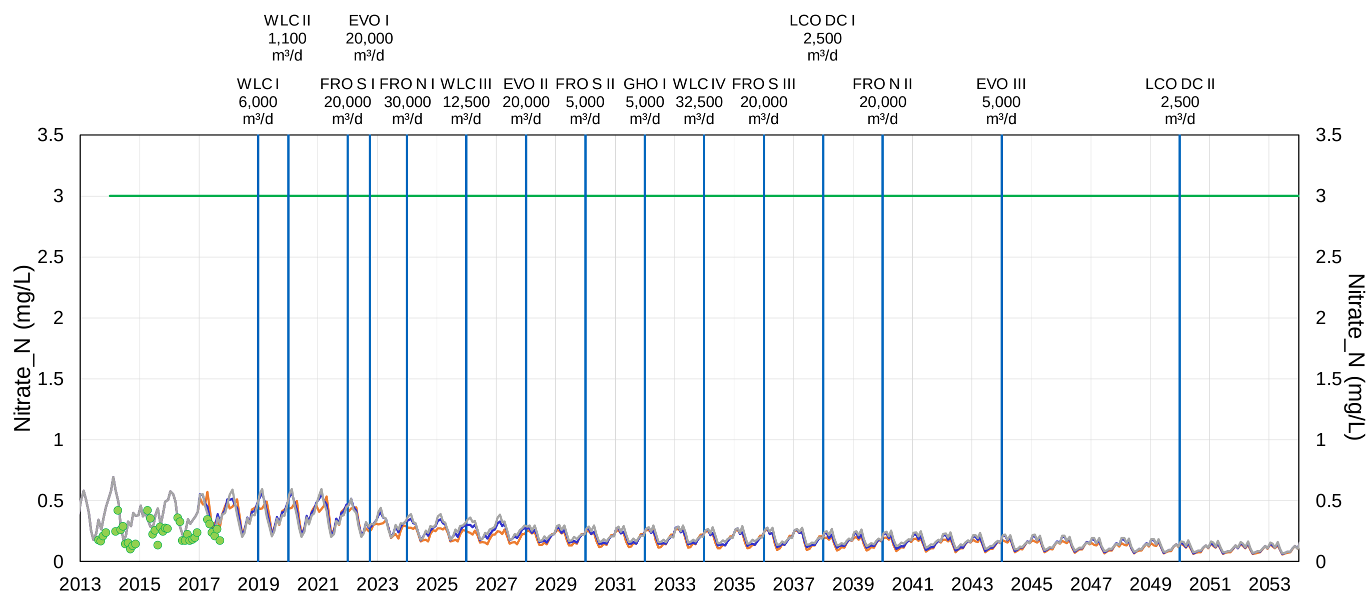
(e) Elk River Downstream of Michel Creek (EV_ER1; 0200393)

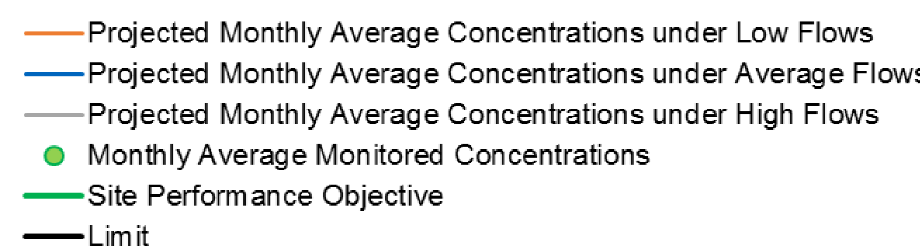


(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)





Compliance Points

Monthly average nitrate concentrations are projected to meet short-, medium- and long-term Compliance Limits at the following compliance points (Figure 2-16):

- GHO Elk River Compliance Point (GH_ERC; E300090)
- CMO Compliance Point (CM_MC2; E258937)
- EVO Harmer Compliance Point (EV_HC1; E102682)
- EVO Michel Creek Compliance Point (EV_MC2; E300091)

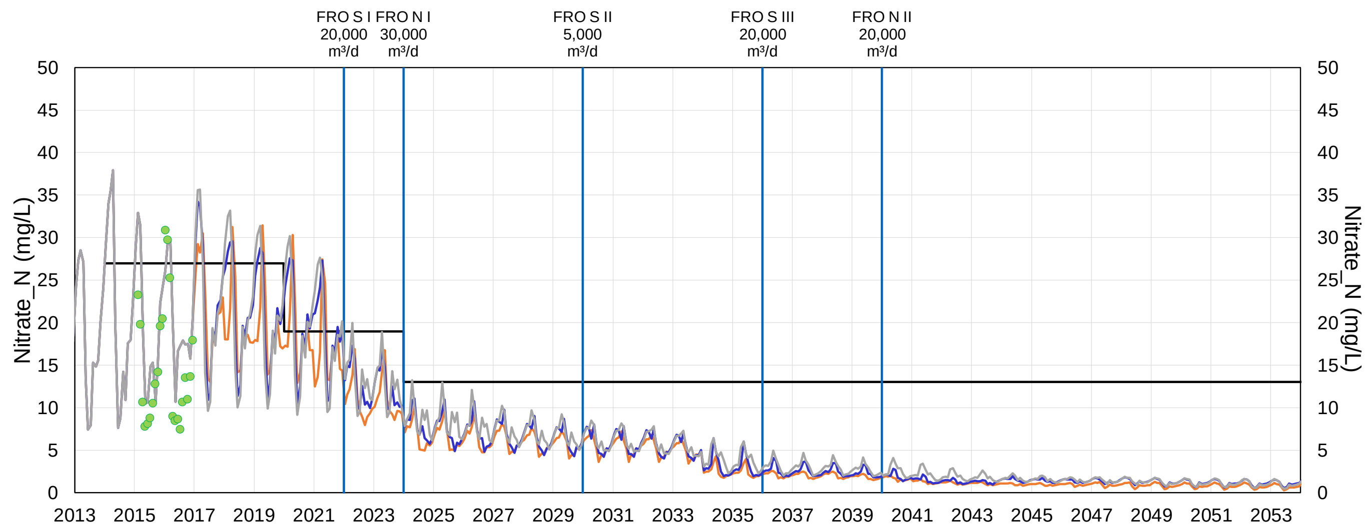
Monthly average nitrate concentrations are also projected to meet Compliance Limits at the remaining compliance points, as follows (Figure 2-16):

- FRO Compliance Point (FR_FRCP1; E300071) – 2023 onwards
- GHO Fording River Compliance Point (GH_FR1; 0200378) – 2022 onwards
- LCO Compliance Point (LC_LCDSSLCC; E297110) – 2026 onwards

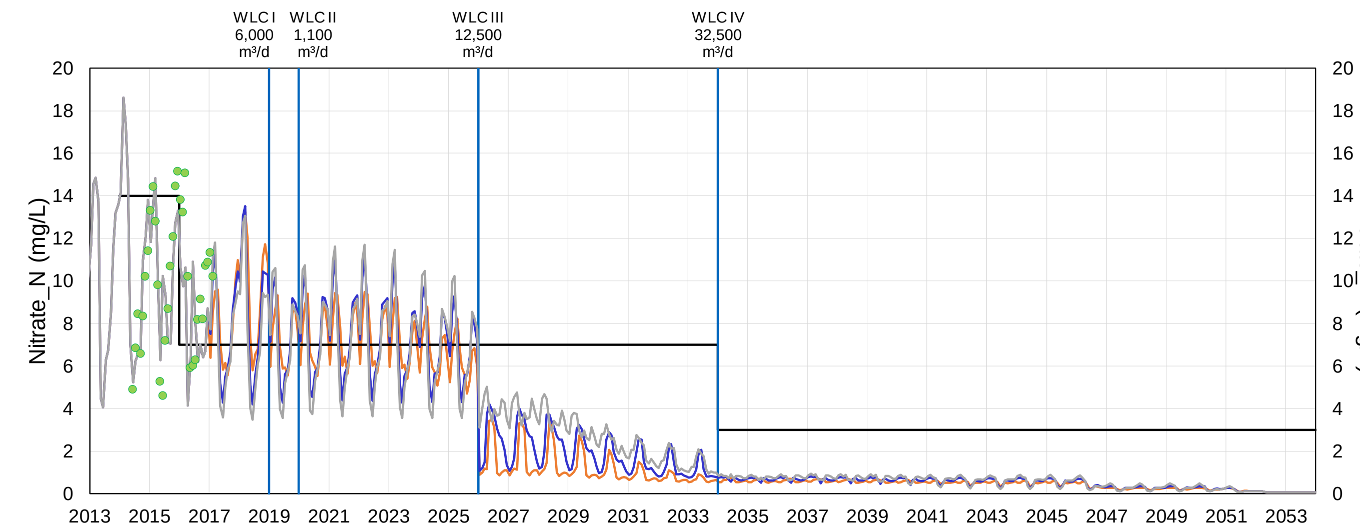
Between 2019 and 2026, monthly average nitrate concentrations at the three aforementioned locations are projected to be higher than Compliance Limits. At all three locations, monthly projected nitrate concentrations are following a downward trend.

Figure 2-16 Projected Monthly Average Nitrate Concentrations at Compliance Points from 2013 to 2053 under the Permitted Development Scenario

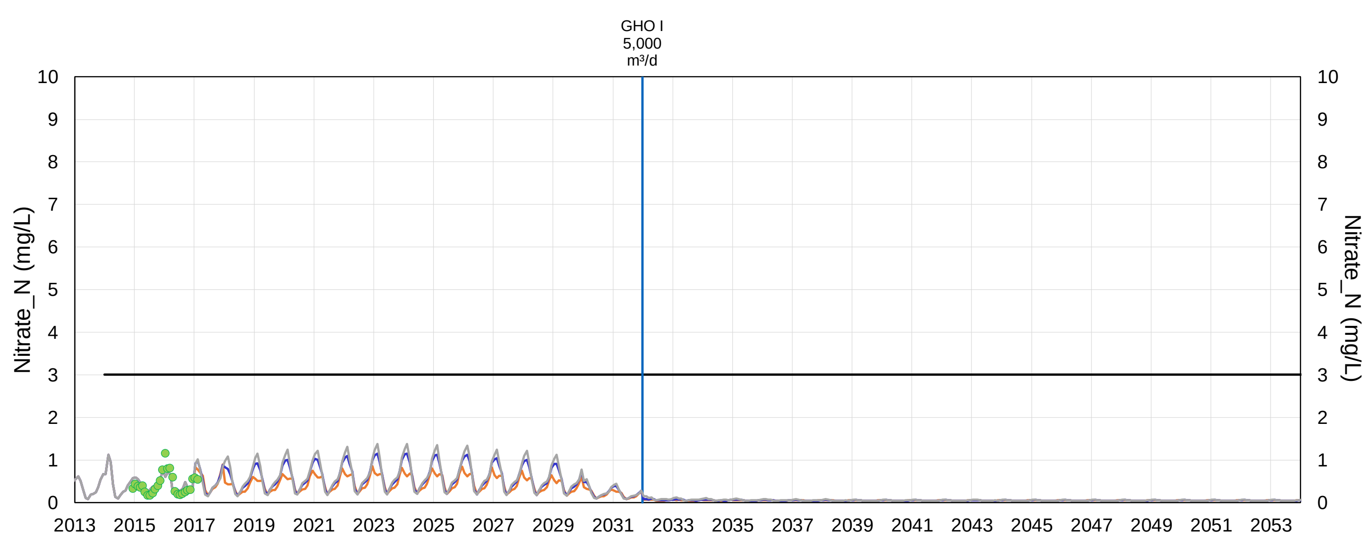
(a) FRO Compliance Point (FR_FRCP1; E300071)



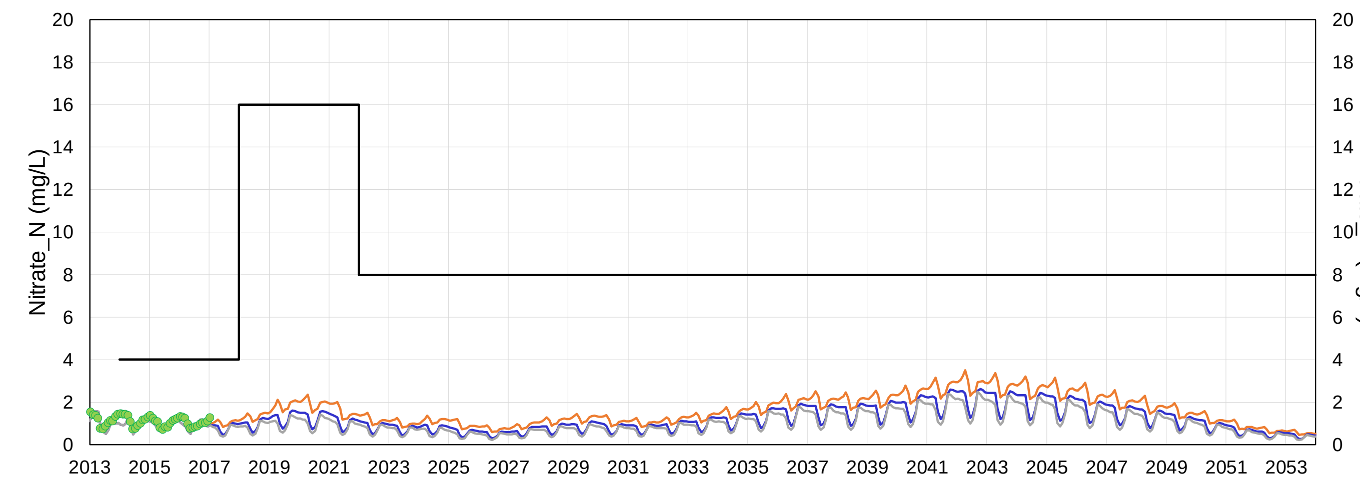
(b) LCO Compliance Point (LC_LCDSSLCC; E297110)



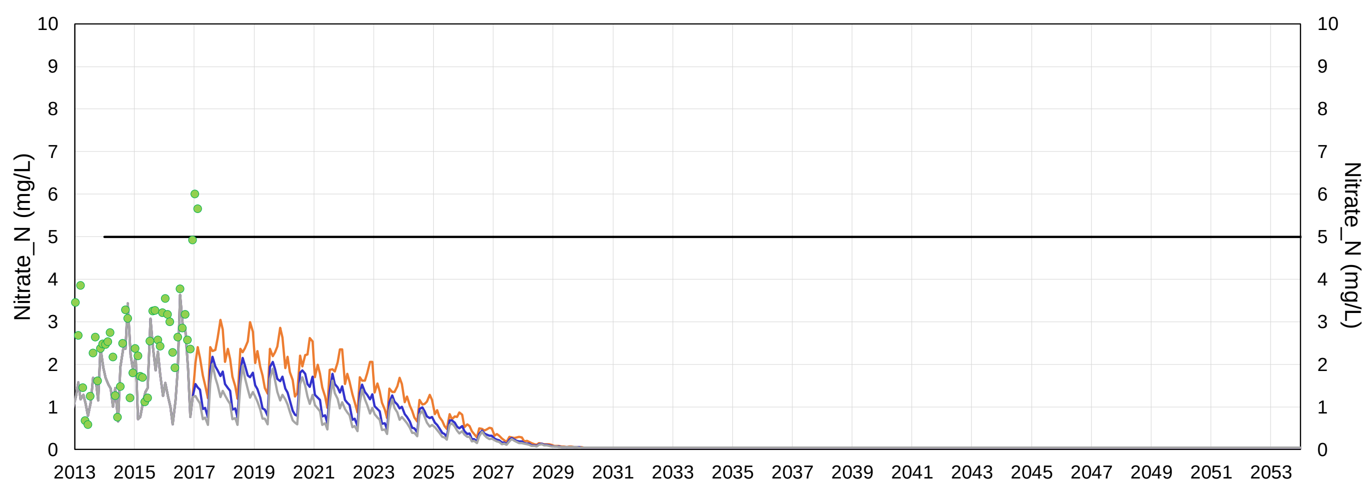
(c) GHO Elk River Compliance Point (GH_ERC; E300090)



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

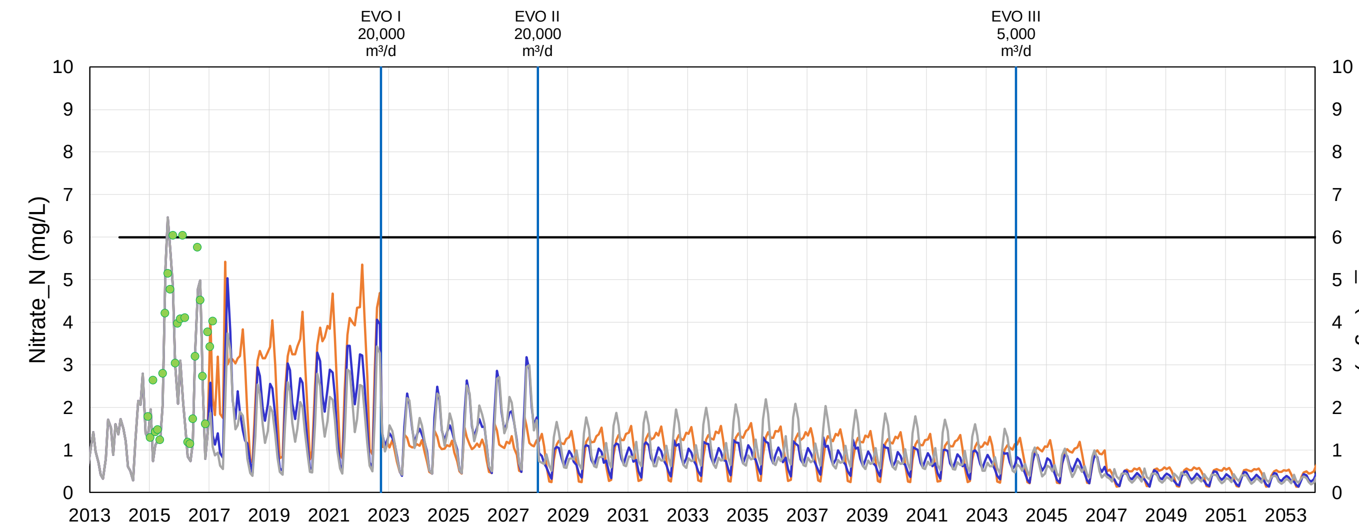


(e) CMO Compliance Point (CM_MC2; E258937)



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 Compliance Limit. Pumping rates were immediately adjusted to bring nitrate concentrations back within the permit Compliance Limit.

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



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

2.4.2.2.2 Selenium Projections

Order Stations

Monthly average selenium concentrations are projected to meet short-, medium- and long-term SPOs at the following Order Stations (Figure 2-17):

- Elk River upstream of Boivin Creek (GH_ER1; E206661)
- Elk River downstream of Michel Creek (EV_ER1; 0200393)
- Elk River at Elko Reservoir (RG_ELKORES; E294312)

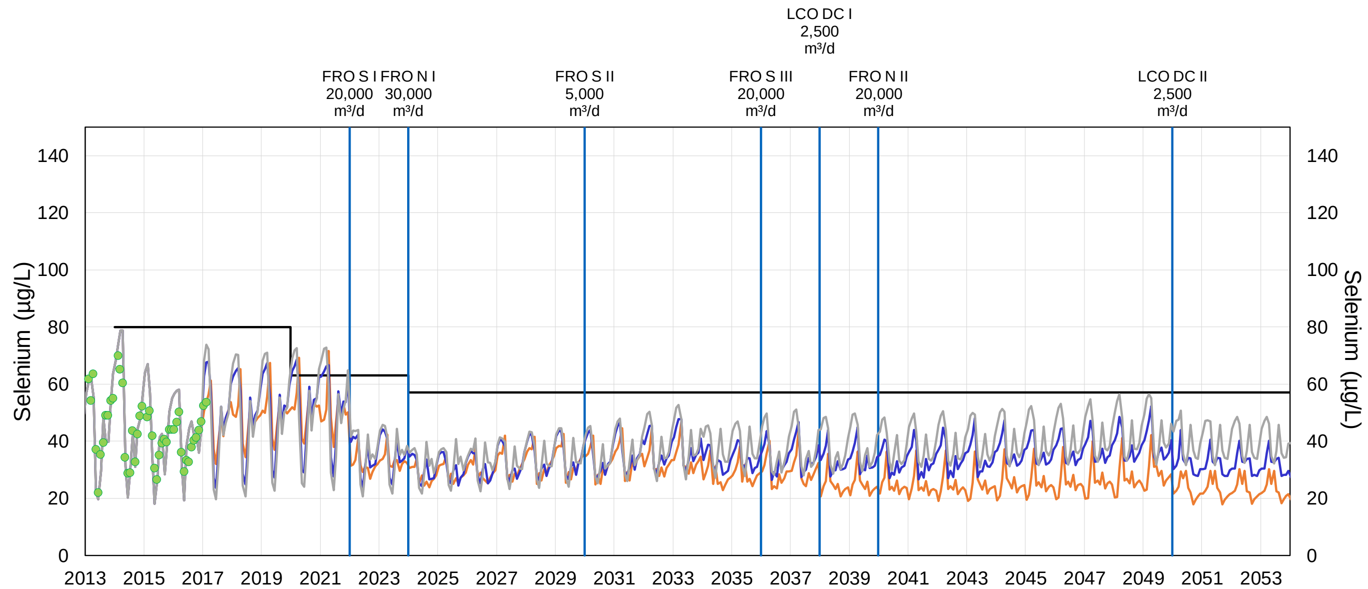
Monthly average selenium concentrations are also projected to meet medium- and long-term SPOs at the remaining Order Stations after the commissioning of the first phases of the FRO AWTF-S and EVO AWTFs (i.e., from 2023 onward) (Figure 2-17):

- Fording River downstream of Greenhills Creek (GH_FR1; 0.00378)
- Fording River downstream of Line Creek (LC_LC5; 0200028)
- Elk River upstream of Grave Creek (EV_ER4; 0200027)
- Koocanusa Reservoir (RG_DSELK; E300230)

Prior to the commissioning of the two AWTFs, monthly average selenium concentrations are projected to be higher than SPOs at the four aforementioned Order Stations. This information is summarized in Table 2-11.

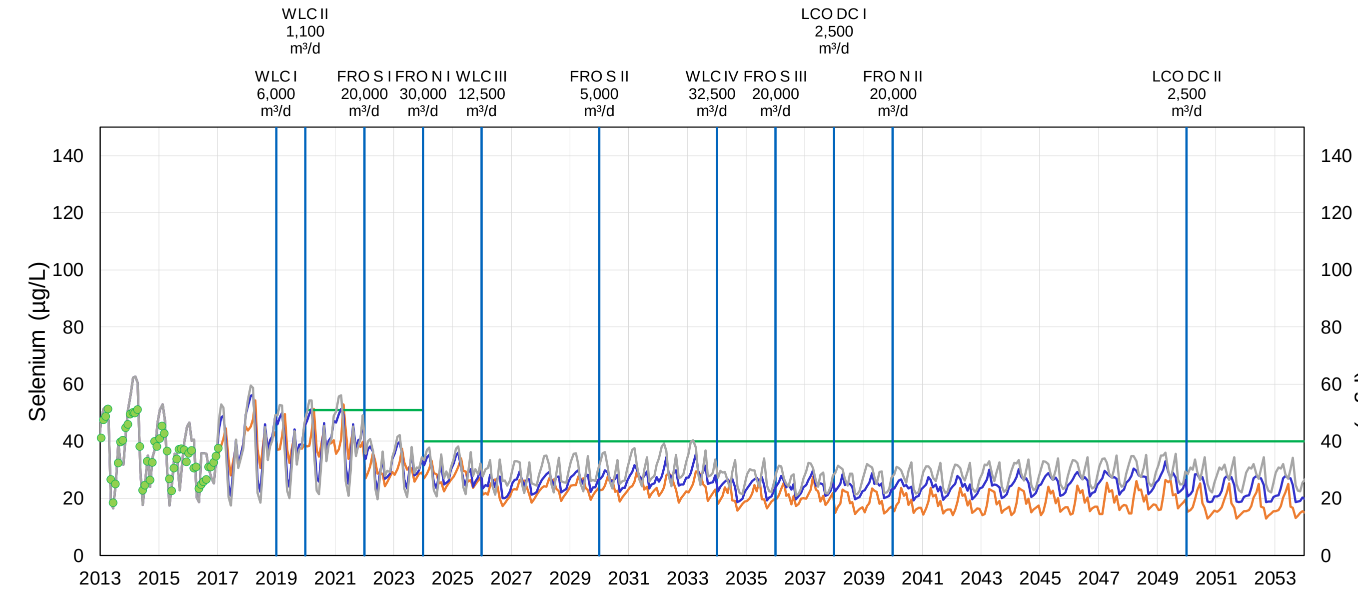
Figure 2-17 Projected Monthly Average Selenium Concentrations at Order Stations from 2013 to 2053 under the Permitted Development Scenario

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

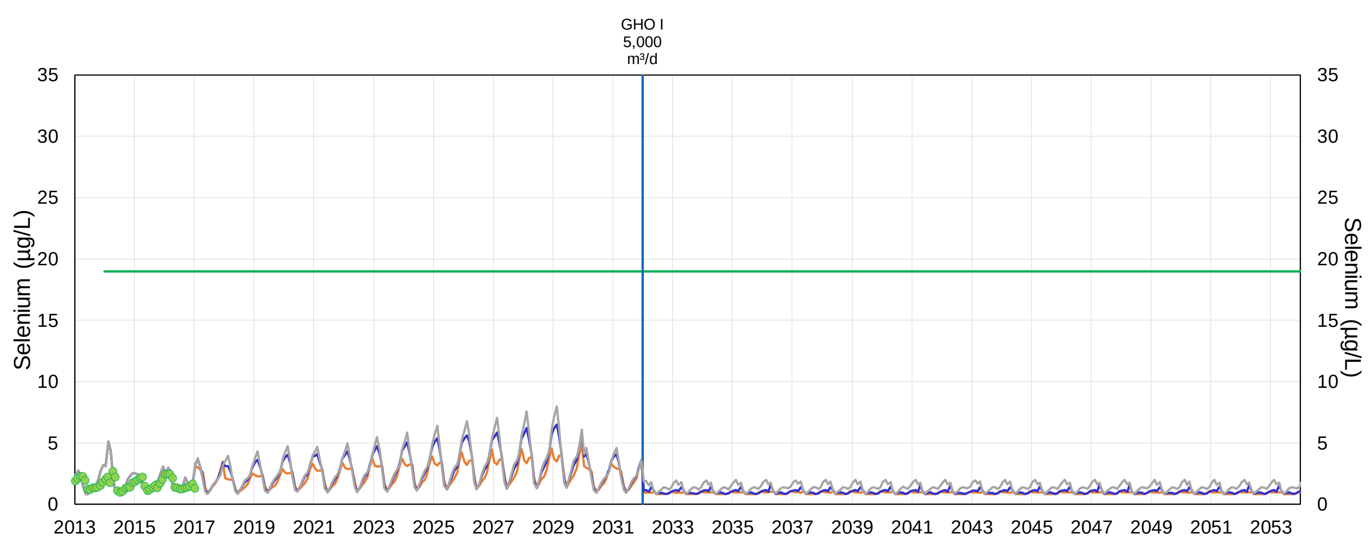


Note: This location is also the GHO Fording River Compliance Point.

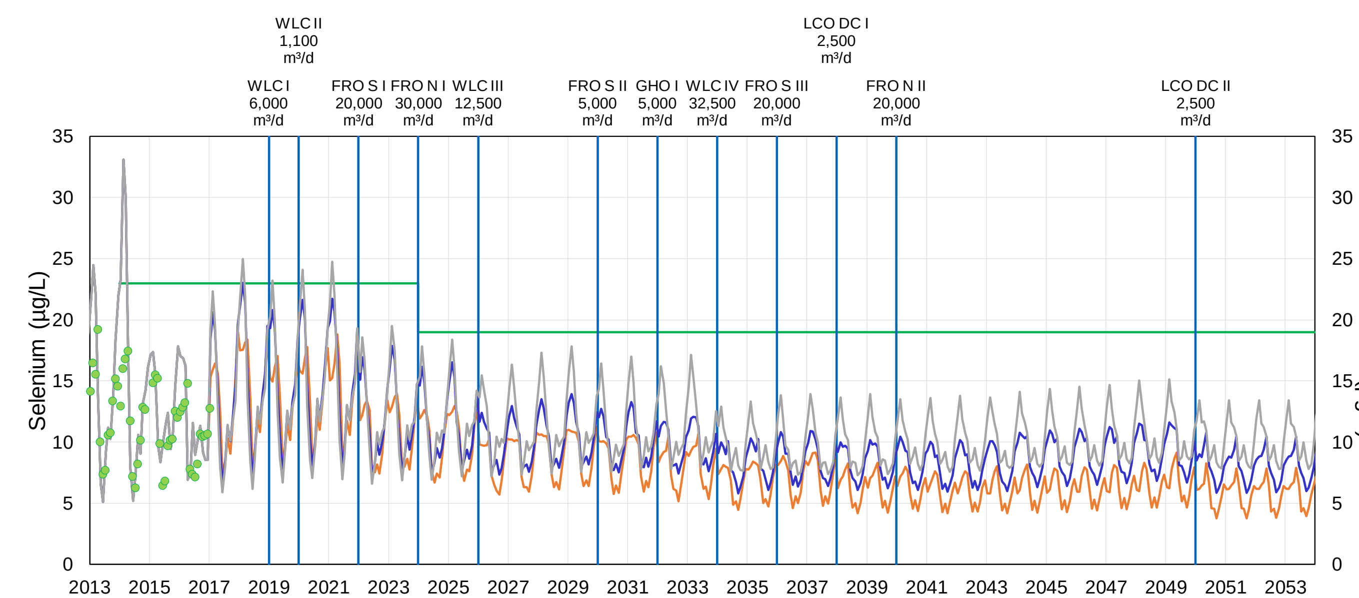
(b) Fording River downstream of Line Creek (LC_LC5; 0200028)



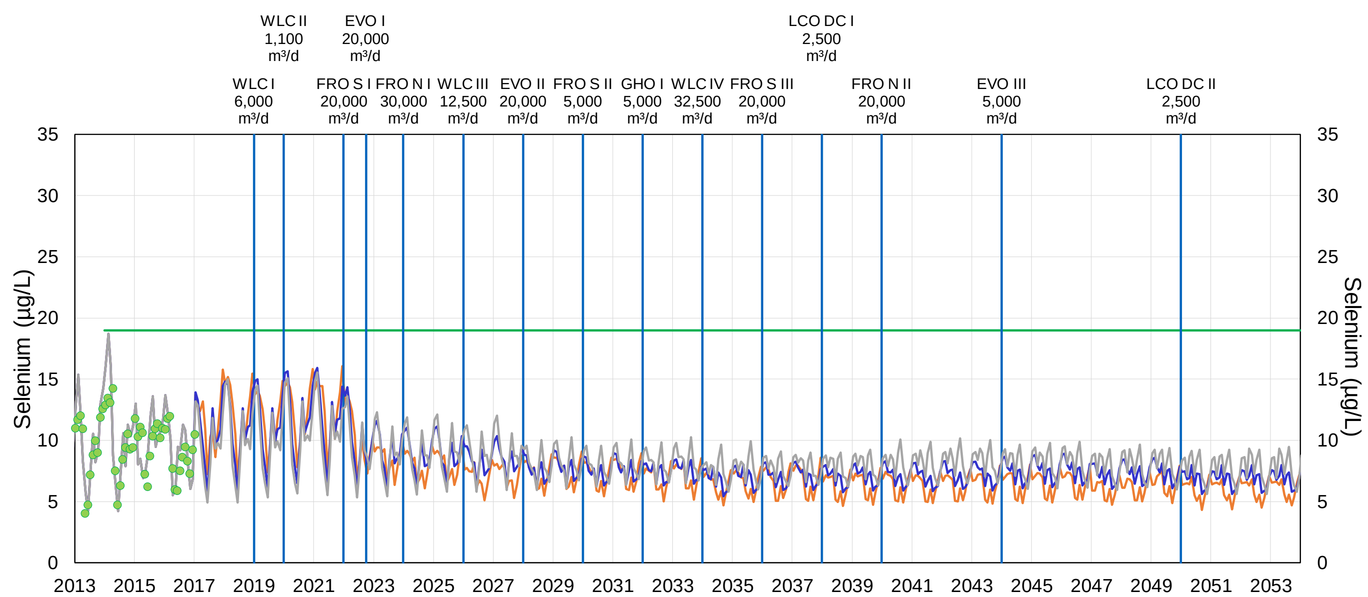
(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)



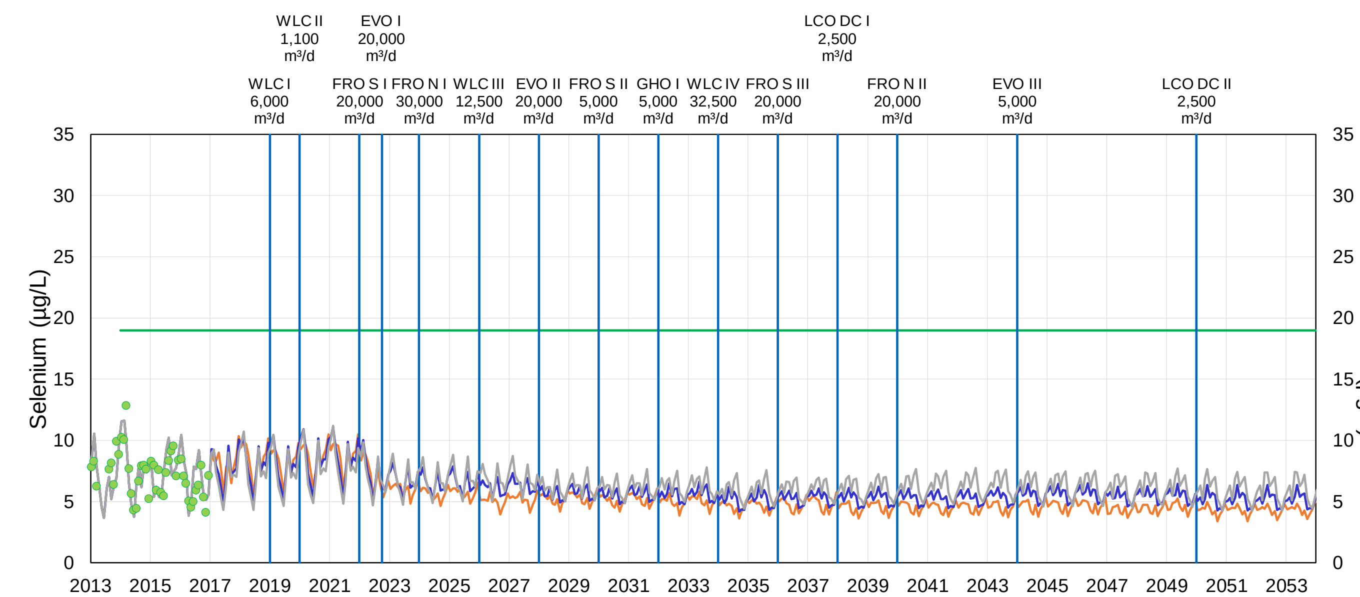
(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)



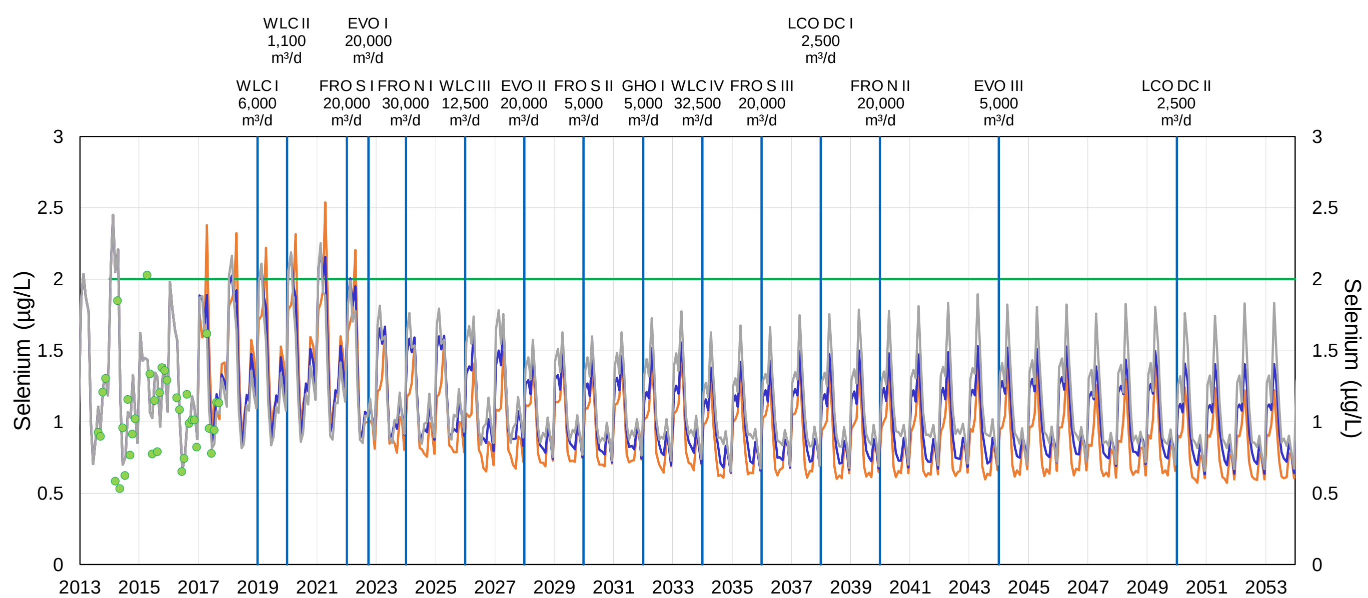
(e) Elk River downstream of Michel Creek (EV_ER1; 0200393)

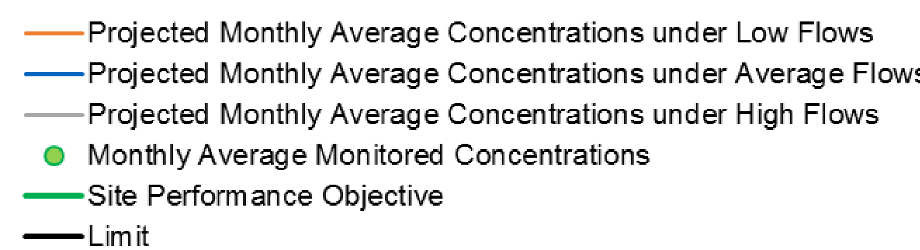


(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)





Compliance Points

Prior to the commissioning of the first phases of the FRO AWTF-S and EVO AWTFs (i.e., prior to 2023), monthly average selenium concentrations are projected to meet Compliance Limits at three compliance points (Figure 2-18):

- GHO Elk River Compliance Point (GH_ERC; E300090)
- EVO Harmer Compliance Point (EV_HC1; E102682)
- CMO Compliance Point (CM_MC2; E258937)

Summary information pertaining to locations where monthly average selenium concentrations are projected to be higher than the corresponding Compliance Limits prior to the commissioning of the first phases of the FRO AWTF-S and EVO AWTFs (i.e., prior to 2023) are summarized in Table 2-11, and are shown in the time-series graphs on Figure 2-18.

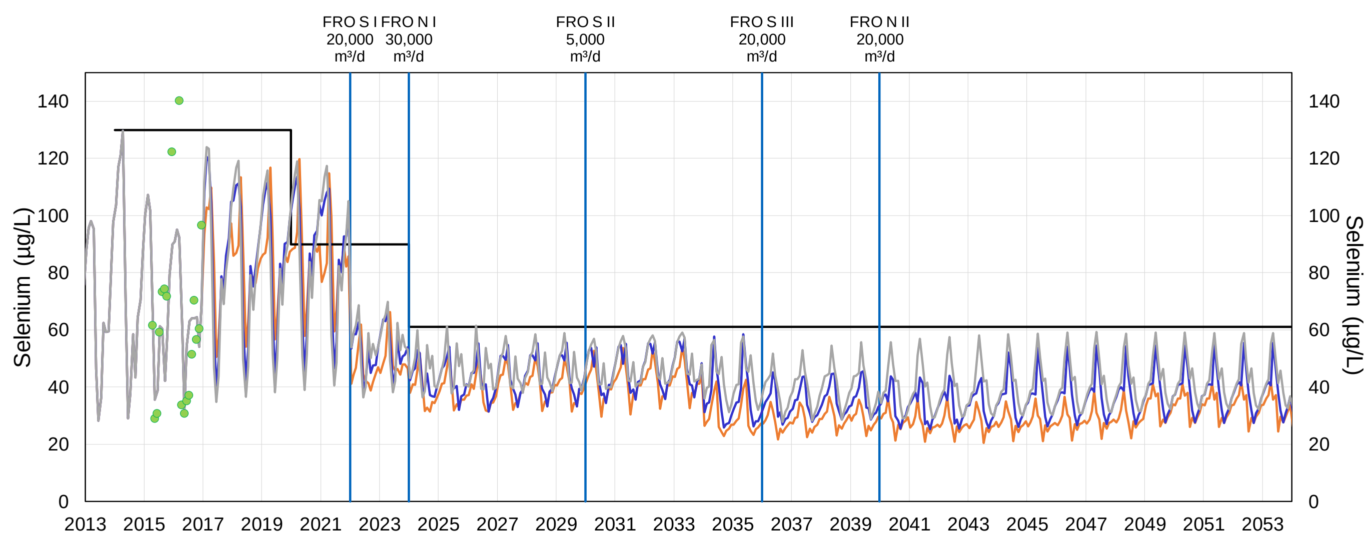
After the commissioning of the first phases of the FRO AWTF-S and EVO AWTFs (i.e., from 2023 onward), monthly average selenium concentrations are projected to meet Compliance Limits at compliance points as follows (Figure 2-18):

- FRO Compliance Point (FR_FRCP1; E300071) – 2022 onward
- GHO Fording River Compliance Point (GH_FR1; 0200378) – 2022 onward
- LCO Compliance Point (LC_LCDSSLCC; E297110) – 2026 onward
- GHO Elk River Compliance Point (GH_ERC; E300090) – 2014 onward, with the exception of one month in 2028 and in 2029
- CMO Compliance Point (CM_MC2; E258937) – 2014 onward
- EVO Michel Creek Compliance Point (EV_MC2; E300091) – 2023 onward, with the exception of one month in 2027

Monthly average selenium concentrations are projected to be seasonally above the Compliance Limit at the EVO Harmer Compliance Point (EV_HC1; E102682) in 2029 and from 2034 to 2053 under the current Permitted Development Scenario. However, mitigation and/or mine plan adjustments have not been incorporated into the 2019 IPA for this location, due to the timing of the EVO Dry Creek SDM process and final decision. The mitigation strategy and mine plan adjustments to address the projected non-compliances for selenium will be proposed through the appropriate permitting approvals process and will be incorporated into future implementation plans.

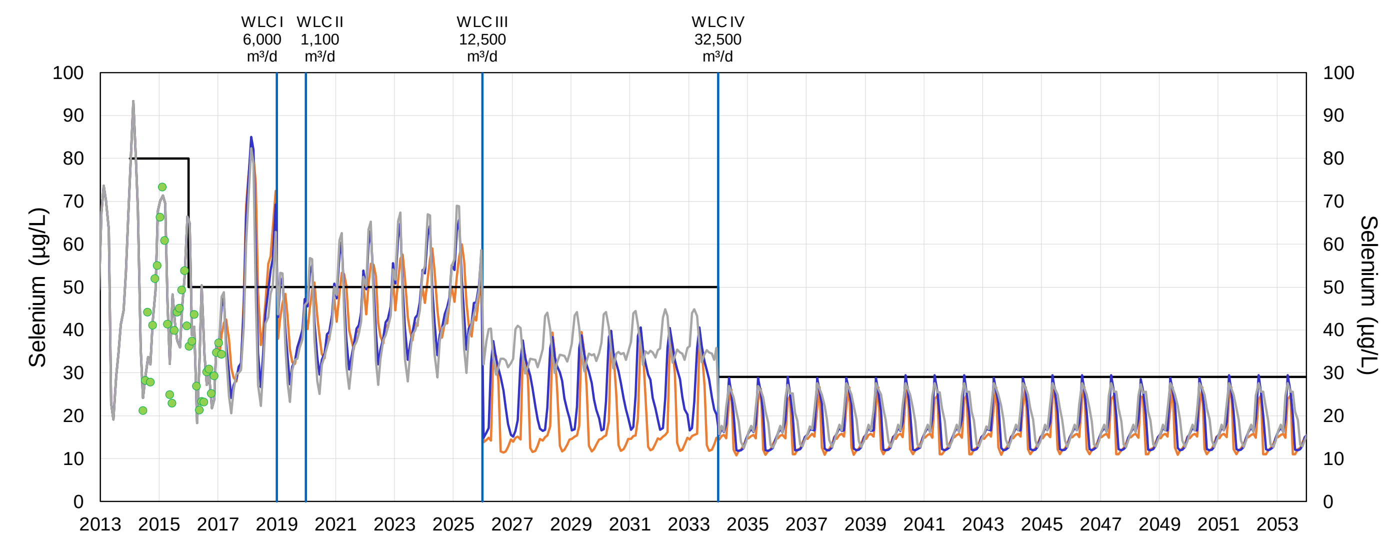
Figure 2-18 Projected Monthly Average Selenium Concentrations at Compliance Points from 2013 to 2053 under the Permitted Development Scenario

(a) FRO Compliance Point (FR_FRCP1; E300071)



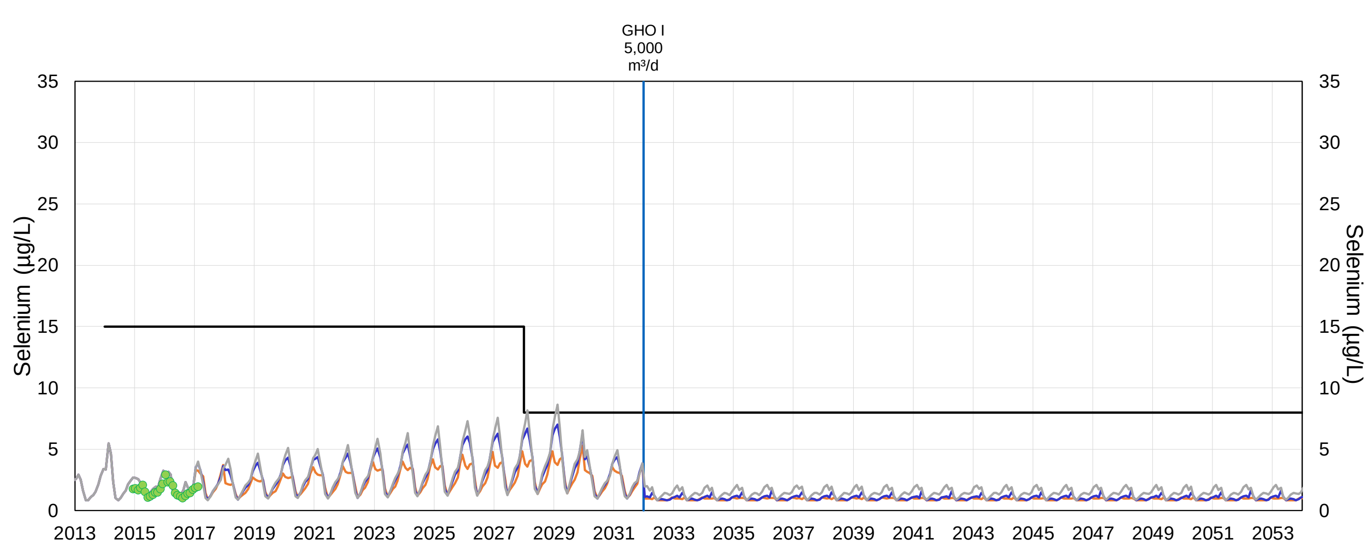
Note: At FR_FRCP1, monitored data are presented from January 2015 to December 2016. Five monitored data points are not presented on the plot, because including them on the plot would required an extension of the y-axis that would not allow the reader to easily compare the model projections to the Compliance 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.

(b) LCO Compliance Point (LC_LCDSSLCC; E297110)

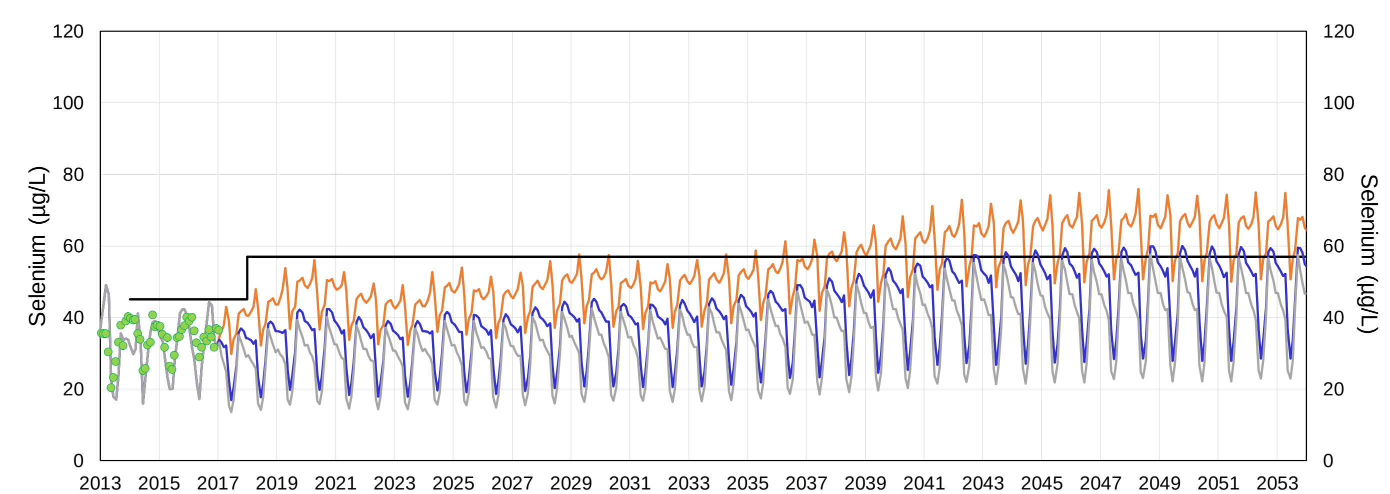


Note: Projected concentrations under high flows (gray line) differ from those under low or average flows between 2026 and 2034, because the volume of mine-influenced water bypassing the WLC AWTF is notably higher than in either of the other two flow scenarios. The higher rate of bypass results in less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

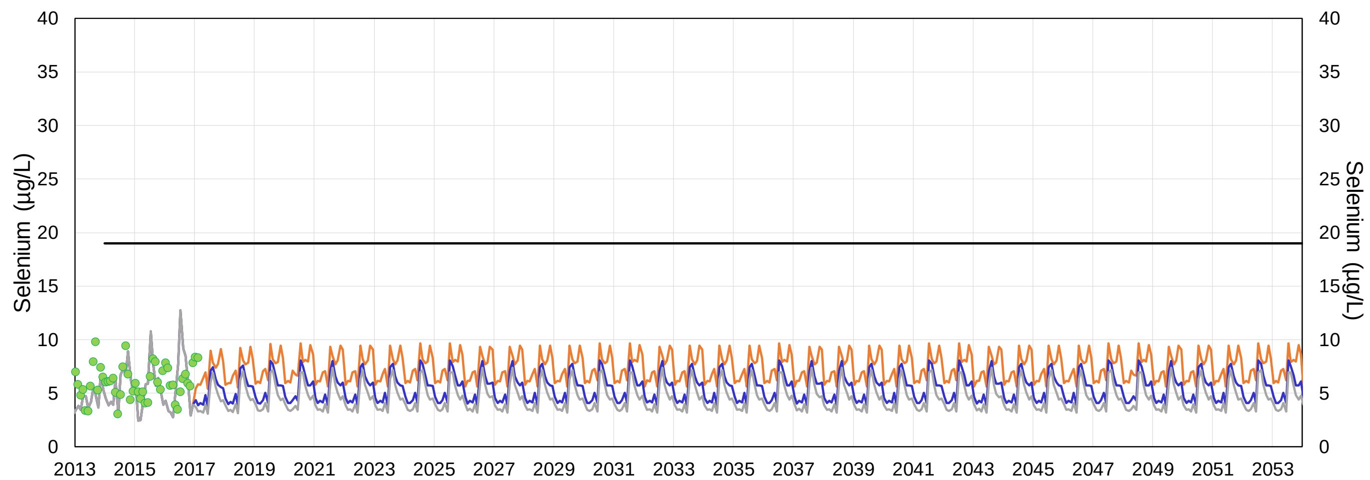
(c) GHO Elk River Compliance Point (GH_ERC; E300090)



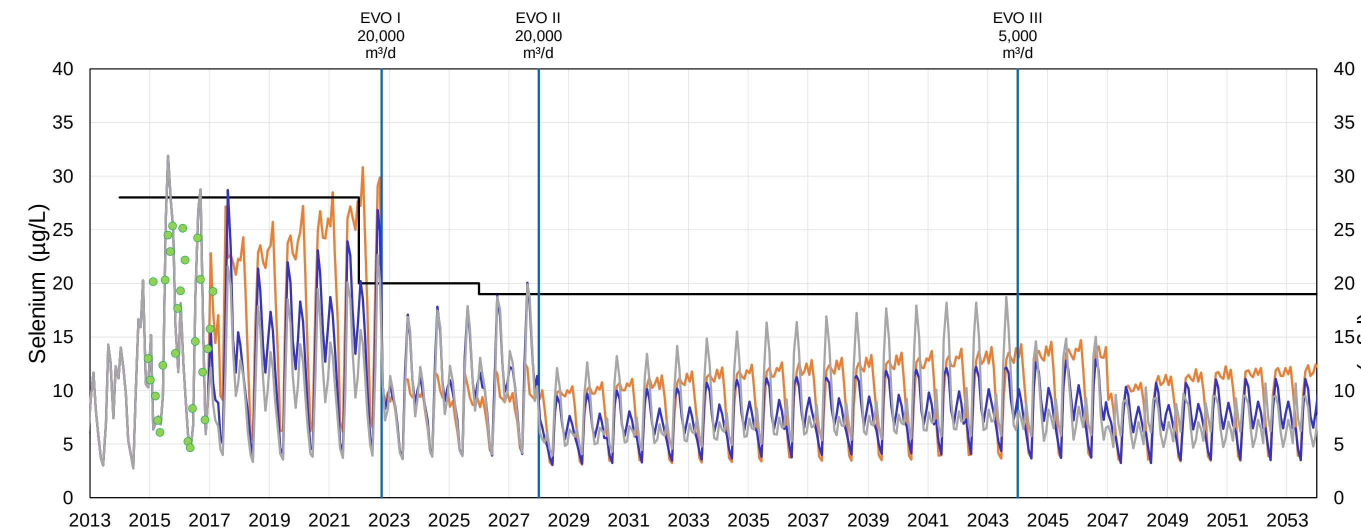
(d) EVO Harmer Compliance Point (EV_HC1; E102682)



(e) CMO Compliance Point (CM_MC2; E258937)



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



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

2.4.2.2.3 Sulphate Projections

Order Stations

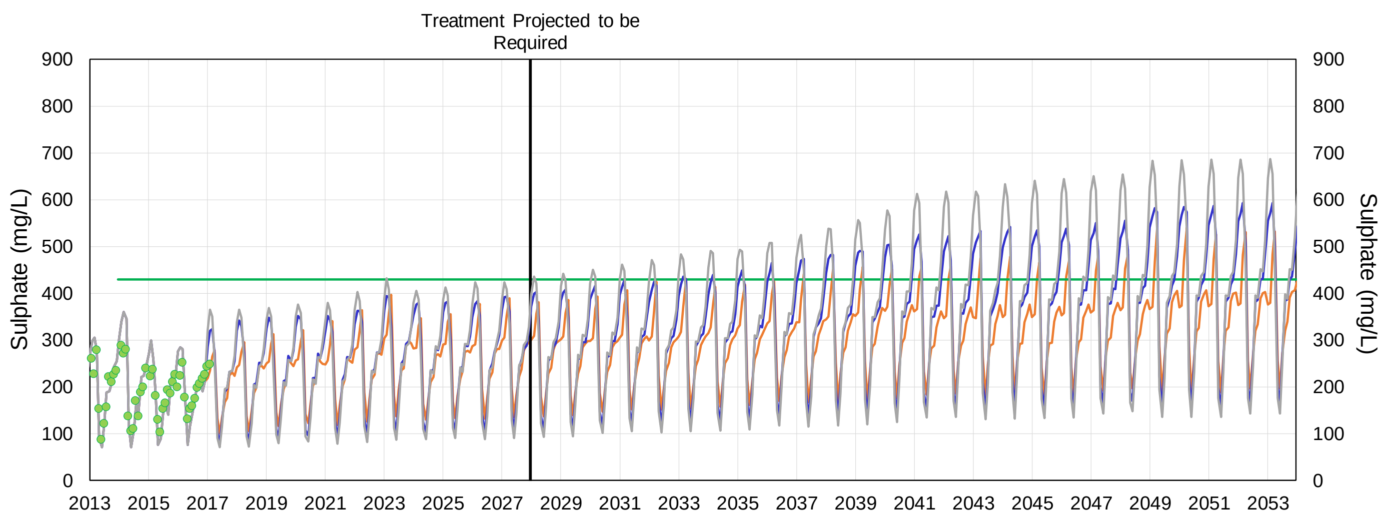
Monthly average sulphate concentrations are projected to meet short-, medium- and long-term SPOs at the following Order Stations (Figure 2-19):

- Elk River upstream of Boivin Creek (GH_ER1; E206661)
- Elk River upstream of Grave Creek (EV_ER4; 0200027)
- Elk River downstream of Michel Creek (EV_ER1; 0200393)
- Elk River at Elko Reservoir (RG_ELKORES; E294312)
- Koocanusa Reservoir (RG_DSELK; E300230)

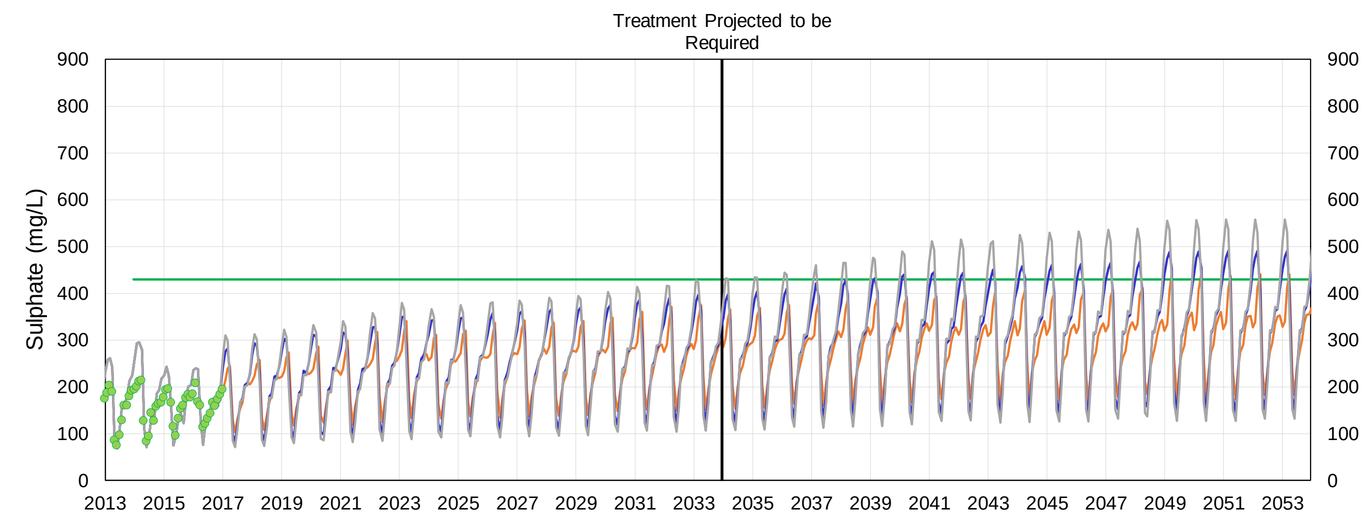
Monthly average sulphate concentrations are also projected to meet SPOs in the Fording River downstream of Greenhills Creek until 2028 and in the Fording River downstream of Line Creek until 2034.

Figure 2-19 Projected Monthly Average Sulphate Concentrations at Order Stations from 2013 to 2053 under the Permitted Development Scenario

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

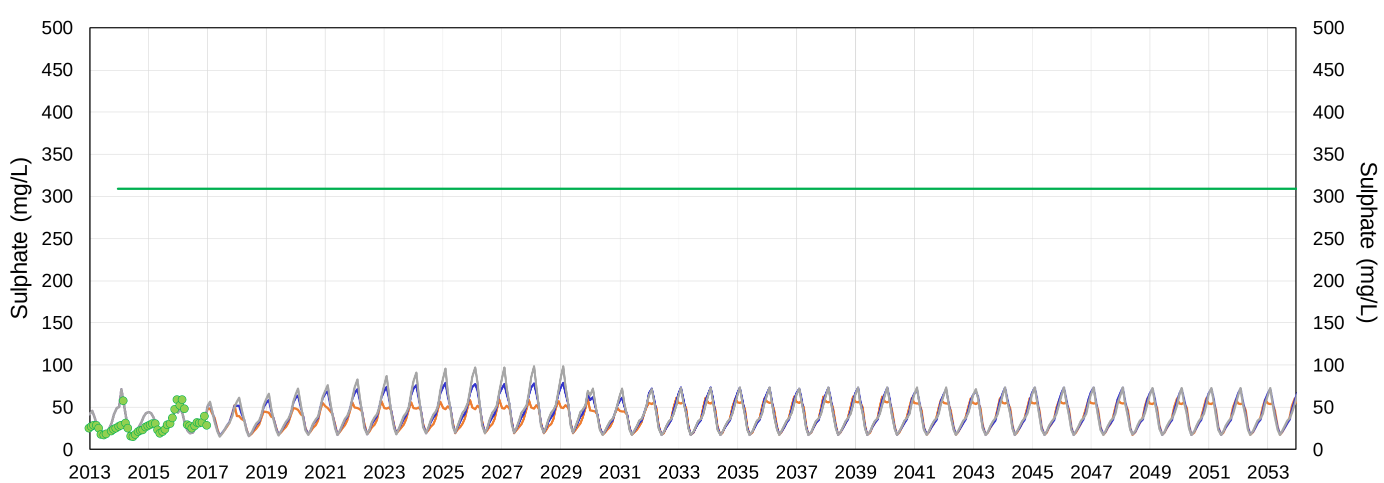


(b) Fording River downstream of Line Creek (LC_LC5; 0200028)

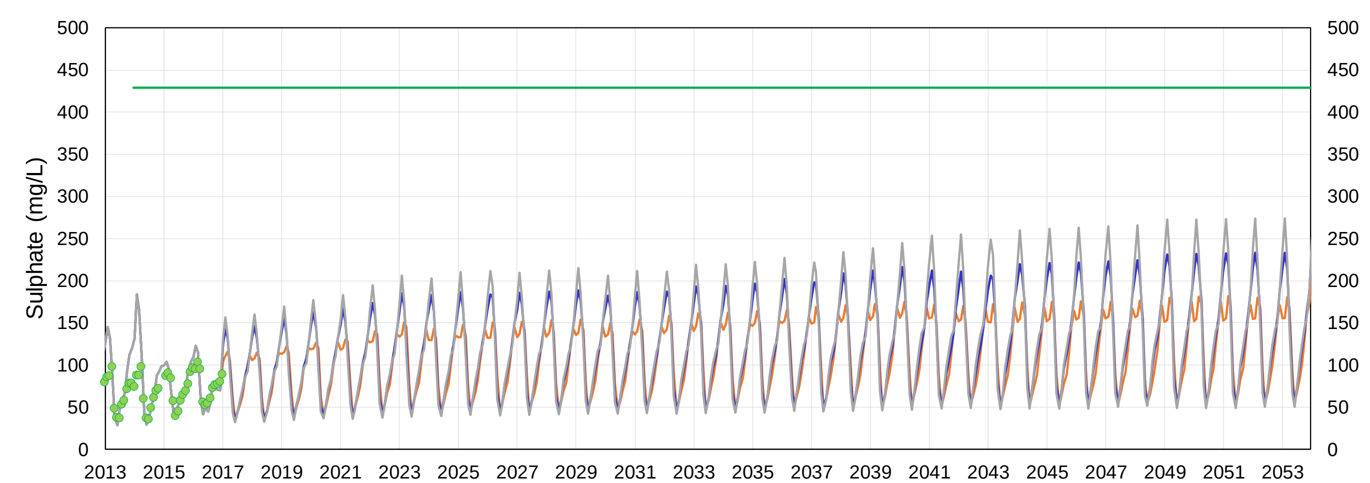


Note: This location is also the GHO Fording River Compliance Point. The maximum monthly average sulphate concentration (431 mg/L) in February 2023 is projected to be above the SPO (429 mg/L) due to a model artefact related to the way in which loading from rehandled waste is described in the RWQM (a one-year 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.

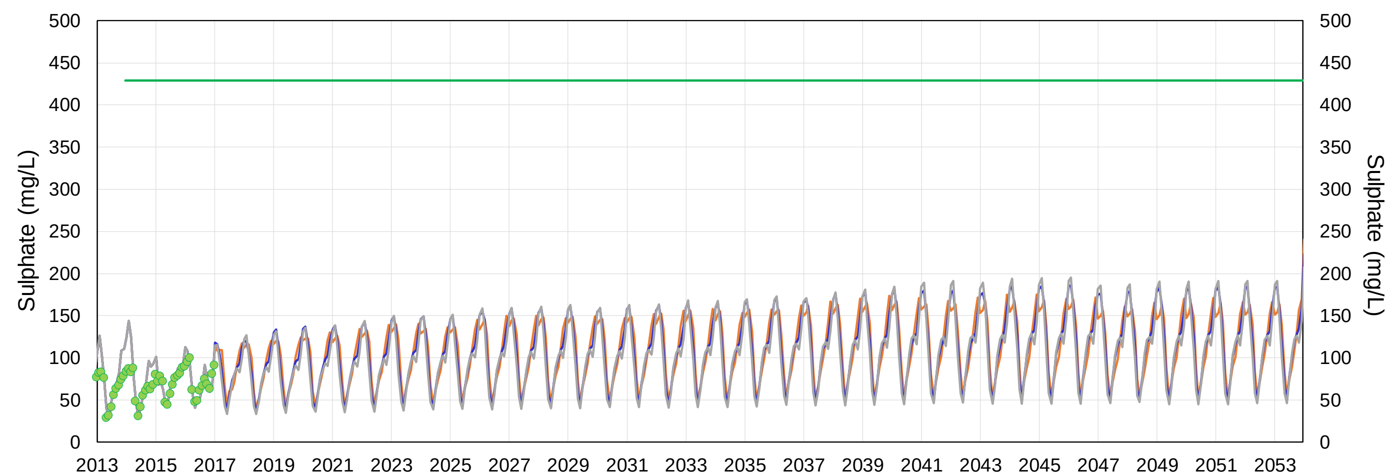
(c) Elk River upstream of Boivin Creek (GH_ER1; E206661)



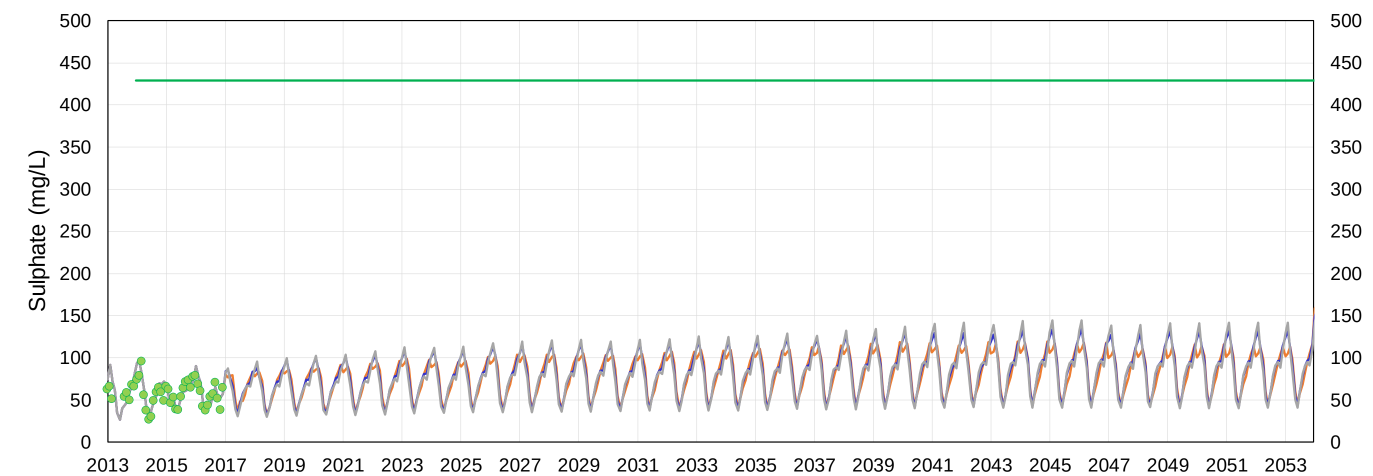
(d) Elk River upstream of Grave Creek (EV_ER4; 0200027)



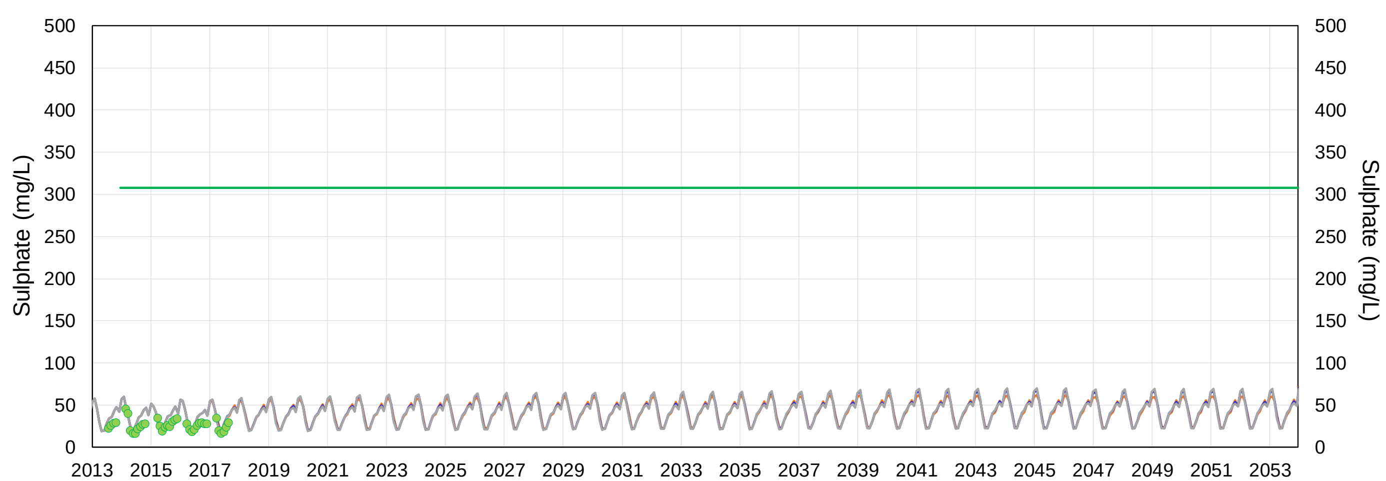
(e) Elk River downstream of Michel Creek (EV_ER1; 0200393)

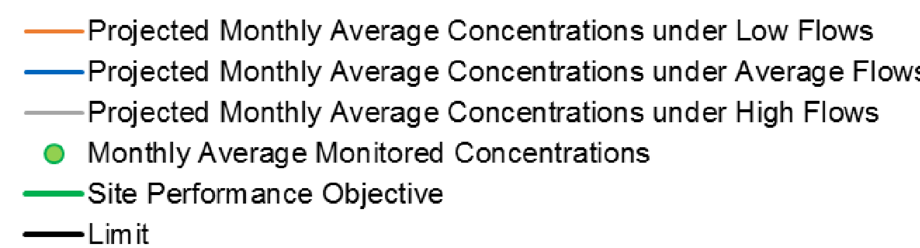


(f) Elk River at Elko Reservoir (RG_ELKORES; E294312)



(g) Koocanusa Reservoir (RG_DSELK; E300230)





Compliance Points

Monthly average sulphate concentrations are projected to meet short-, medium- and long-term Compliance Limits at the following compliance points (Figure 2-20):

- GHO Elk River Compliance Point (GH_ERC; E300090)
- CMO Compliance Point (CM_MC2; E258937)
- EVO Michel Creek Compliance Point (EV_MC2; E300091)

Monthly average sulphate concentrations are also projected to meet Compliance Limits at the remaining compliance points as follows (Figure 2-20):

- FRO Compliance Point (FR_FRCP1; E300071) – until 2038
- GHO Fording River Compliance Point (GH_FR1; 0200378) – until 2028
- LCO Compliance Point (LC_LCDSSLCC; E297110) – until 2026
- EVO Harmer Compliance Point (EV_HC1; E102682) - until 2045

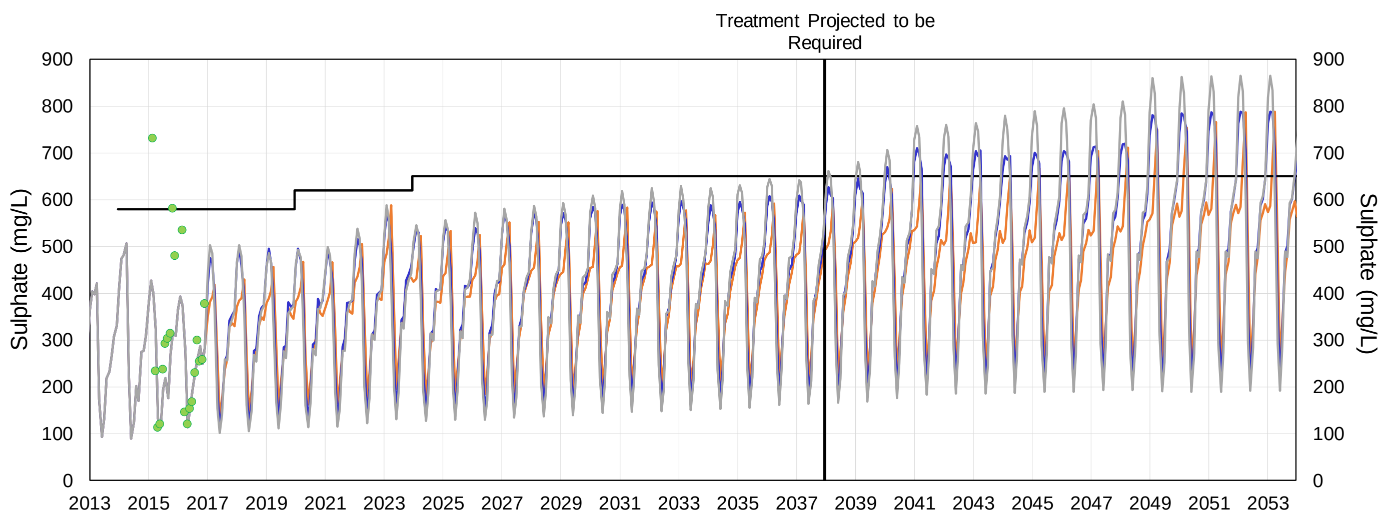
These results, as well as those noted above at the Order Stations, indicate that sulphate treatment may be required at LCO by 2026 and at FRO by 2028.

Monthly average sulphate concentrations are projected to be above the Compliance Limit at the EVO Harmer Compliance Point (EV_HC1;E102682), however, mitigation and/or mine plan adjustments have not been incorporated into the 2019 IPA for this location, due to the timing of the EVO Dry Creek SDM process and final decision (refer to Section 1.4 for more detail). The mitigation strategy and mine plan adjustments to address the projected non-compliances for sulphate will be proposed through the appropriate permitting approvals process and will be incorporated into future implementation plans.

Implementation of sulphate treatment, where (and if) required, is discussed in Section 3.5.

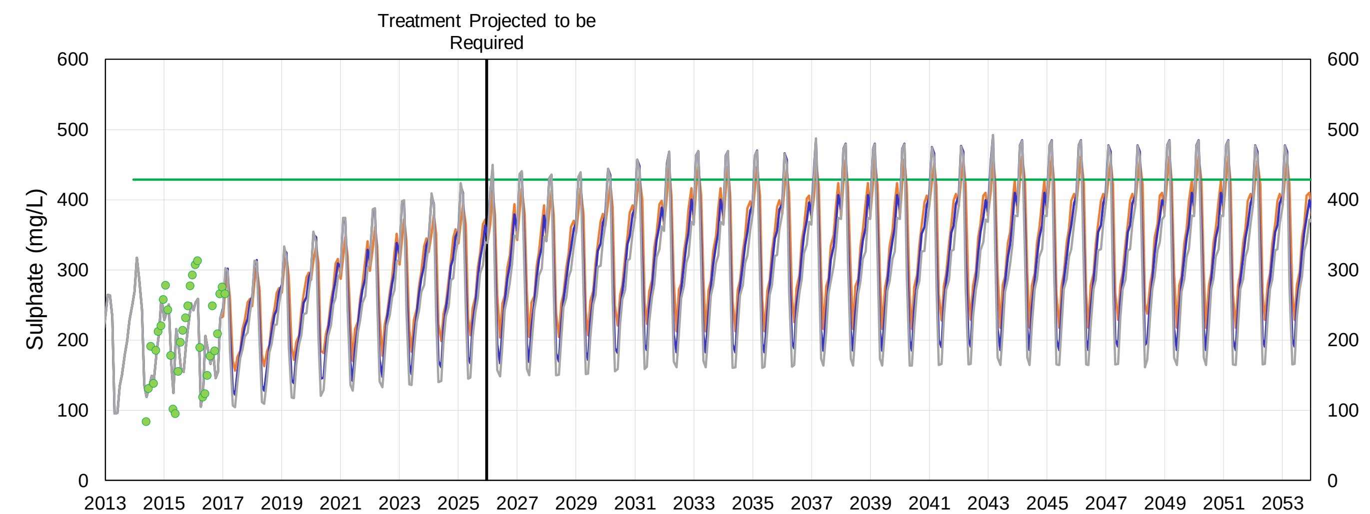
Figure 2-20 Projected Monthly Average Sulphate Concentrations at Compliance Points from 2013 to 2053 under the Permitted Development Scenario

(a) FRO Compliance Point (FR_FRCP1; E300071)

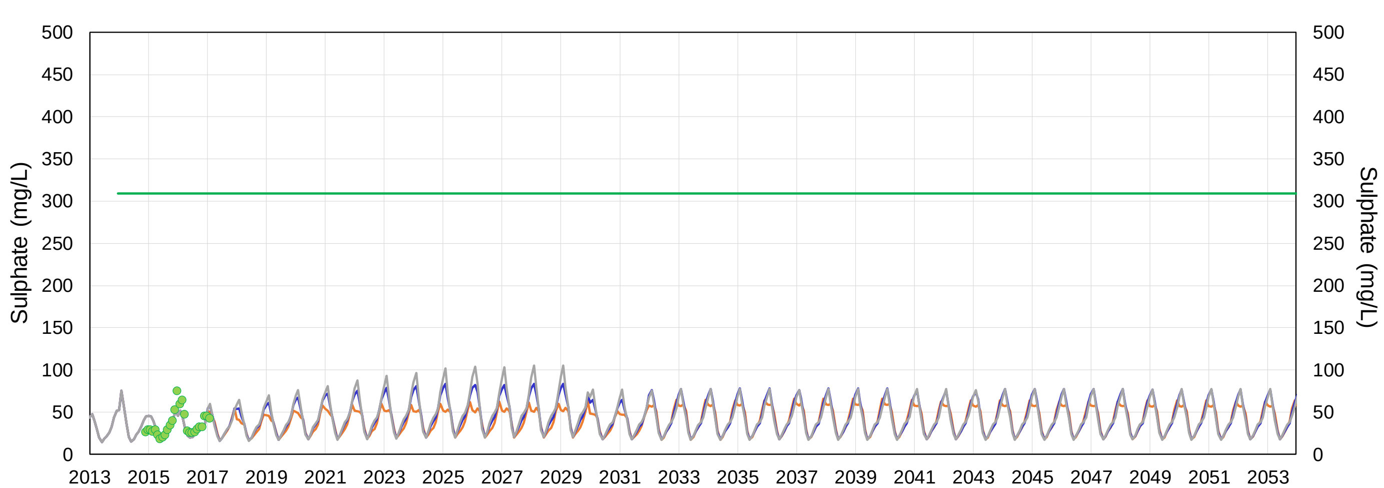


Note: At FR_FRCP1, monitored data are presented from January 2015 to December 2016. Three monitored data points are not presented on the plot, because including them on the plot would required an extension of the y-axis that would not allow the reader to easily compare the model projections to the Compliance 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.

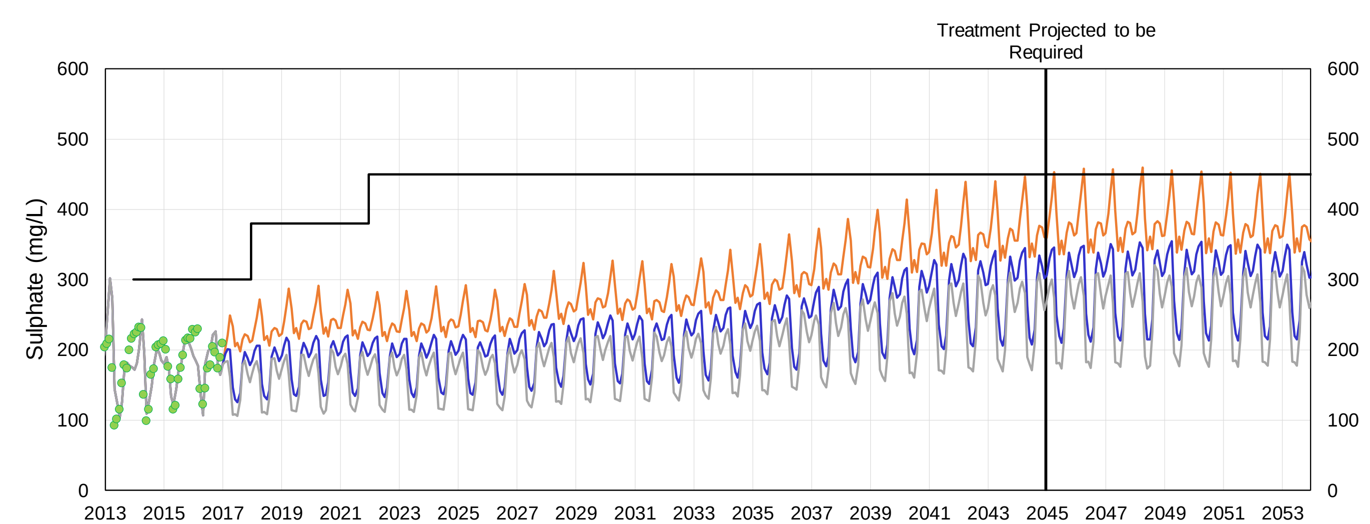
(b) LCO Compliance Point (LC_LCDSSLCC; E297110)



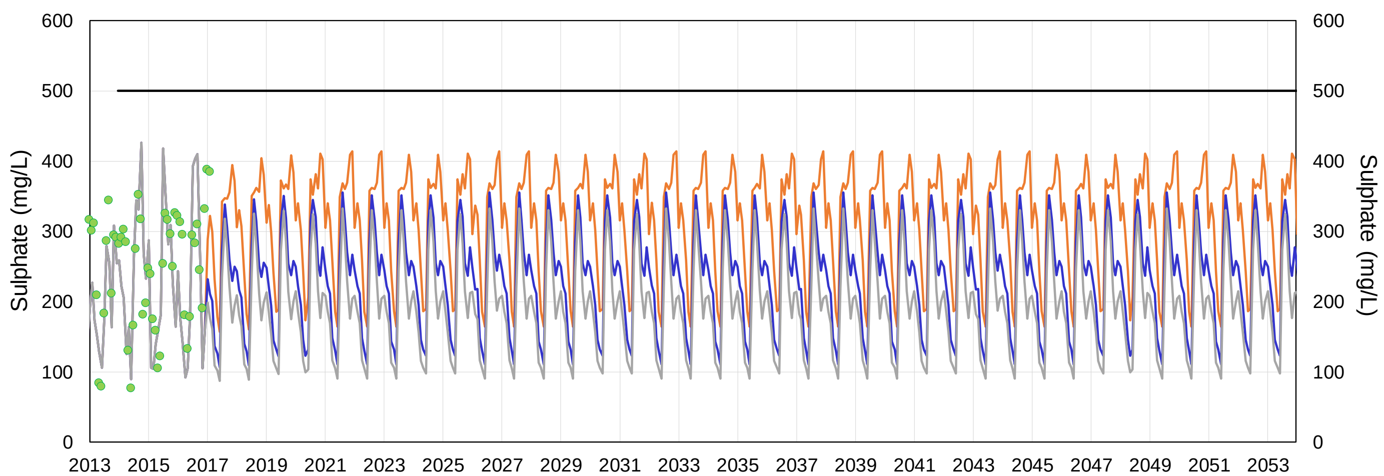
(c) GHO Elk River Compliance Point (GH_ERC; E300090)



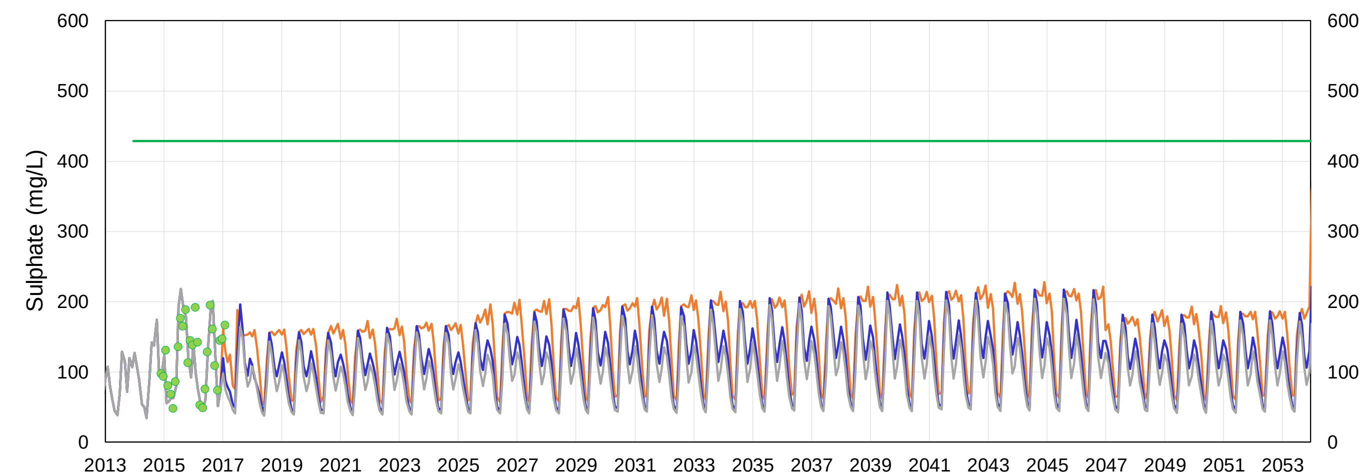
(d) EVO Harmer Compliance Point (EV_HC1; E102682)



(e) CMO Compliance Point (CM_MC2; E258937)



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



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

2.5 Potential Ecological Effects of Projected Water Quality Non-compliances

This section provides an evaluation of potential effects to aquatic health from projected water quality concentrations that are above Compliance Limits or SPOs, and summarizes ongoing work to better predict and evaluate the ecological relevance of these conditions (i.e. peak concentrations, at some locations, above limits from short time periods). This work links into AMP Management Question "Will the aquatic ecosystem be protected by meeting the long-term site performance objectives?", and Teck will expand the scope of the studies conducted to address this question to examine the ecological relevance of near-term and seasonal nitrate, selenium, and sulphate concentrations above Compliance Limits and SPOs.

Nitrate and selenium concentrations that are projected to be above Compliance Limits or SPOs in the Elk or Fording rivers were initially compared to the aquatic effects benchmarks developed as part of the EVWQP (Tables 2-12 and 2-13). Results of the comparison indicate that projected selenium concentrations may be above Level 1 benchmarks for sensitive species, but remain below Level 2 benchmarks. Consequently, while effects to individuals of sensitive species are possible, most species are expected to be unaffected, and no population-level changes are expected for the most sensitive species. No effects are expected to the broader aquatic community.

Similar results were generated for nitrate. Nitrate concentrations that are projected to be above Compliance Limits in Line Creek or SPOs are either:

- below the Level 1 benchmark for sensitive species (in the Fording River downstream of Greenhills Creek and at the LCO Compliance Point), or
- above the Level 1 benchmark but below the Level 2 benchmark for sensitive species (at the Fording River Compliance Point and in the Elk River Upstream of Grave Creek).

Thus, while effects to individuals of sensitive species are possible, most species are expected to be unaffected, and no population-level changes are expected for the most sensitive species. No effects are expected to the broader aquatic community. These results are consistent with those put forth in the FRO Swift and EVO BRE EAC applications, in terms of potential effects related to near-term projections that are above Compliance Limits or SPOs.

In addition to this initial screening assessment, projected near-term and seasonal exceedances of Compliance Limits and SPOs for selenium, nitrate, and sulphate were evaluated to confirm that regional protection goals for aquatic health would continue to be met. This analysis, presented in Annex I, updated the integrated assessment methodology presented in Annex H of the EVWQP and applied that methodology to assess projected conditions throughout each MU. Details of assessment methods and results are presented in Annex I. In brief, the analysis concluded that the regional protection goals established in the EVWQP would be met both in the near- term (2018 – 2022, prior to commissioning of the FRO-S and EVO AWTFs) and throughout the planning period (i.e., 2023 to 2037).

Teck recently commenced work to more fully examine the ecological significance of near-term and seasonal changes in selenium concentrations, such as selenium concentrations periodically exceeding SPOs or Compliance Limits. In July 2018, a working group was assembled consisting of Teck water quality personnel involved in treatment, monitoring and environmental effects, and external experts with expertise in water quality, ecotoxicology, and aquatic effects. The objective of this working group is to develop a kinetic model of selenium bioaccumulation that accounts for time-dependent changes in selenium concentrations rather than assumed steady state conditions. The kinetic model will also explicitly consider how bioaccumulation is affected by selenium speciation.

An improved understanding of the bioaccumulation kinetics (biokinetics) of selenium will help to predict the aquatic effects of changes in selenium concentrations (both magnitude and duration) and selenium speciation. This has relevance to a number of areas including:

- Understanding the significance of periodic and/or seasonal excursions above static Compliance Limits.
- Understanding how effects vary seasonally.
- Understanding how static Compliance Limits relate to aquatic effects.
- Understanding the implications of water treatment facility availability (i.e., short duration shutdowns).
- Understanding the implications of localized changes to selenium speciation related to mining and mitigation activities.

A plan for this work is being developed with EMC input and initial work is expected to commence in Q2 2019. Teck anticipates this work will take approximately two years to complete. Teck also recently commenced work to improve the understanding of Elk River mixing in Koocanusa Reservoir. A simple mixing study using conductivity profiling was completed in 2018 at three different water levels in the reservoir (low, medium and full-pool) at multiple locations. Analysis of the data will inform the need for additional study to support understanding of exposure pathways for potential effects to biota within the reservoir. Information from this work will also be considered in evaluating ecological relevance of near-term and seasonal exceedances of Compliance Limits or SPOs.

In parallel, Teck will further evaluate sulphate Compliance Limits based on appropriate level of protection and learnings to date. Similar work will be done for nitrate to understand the ecological relevance of near-term and seasonal nitrate concentrations above Compliance Limits and SPOs.

How this work will be integrated and used moving forward is outlined in Section 4.

Table 2-12 Summary of Projected Monthly Average Nitrate Concentrations above Site Performance Objectives or Compliance Limits in the Elk River or Fording River

Location	Development Scenario[a]	Year	Month	Maximum Projected Concentration (mg/L)	Corresponding Site Performance Objective / Limit (mg/L)	Maximum Magnitude of Exceedance (mg/L)	Level 1 Benchmark (mg/L)[b]	Level 2 Benchmark (mg/L)[c]
GH_FR1[d]	Planned	2020 to 2021	January to April	17	14	3	20	28
	Permitted	2020 to 2021	January to April	17	14	3	20	27
EV_ER4	Planned	2020 to 2021	January to April	**5.6**	4	1.6	5	8
	Permitted	2020 to 2021	January to April	**5.6**	4	1.6	5	8
FR_FRCP1	Planned	2019	January to April	**32**	27	5	24	34
		2020 to 2022	October to May	**31**	19	12	25	34
		2024	April	14	13	1	16	22
	Permitted	2019	January to April	**31**	27	4	27	37
		2020 to 2022	October to May	**30**	19	11	25	34
LC_LCDSSLCC	Planned	2019 to 2025	October to May	12	7	5	20	28
	Permitted	2019 to 2025	October to May	12	7	5	21	29

[a] Timeframe considered is from 2019 to 2037 for the Planned Development Scenario and from 2019 to 2053 for the Permitted Development Scenario.

[b] Nitrate Level 1 benchmark as mg N/L=$10^{1.0003\log10(\text{hardness})-1.52}$, where hardness is in mg N/L of $CaCO_3$. Level 1 benchmark calculated using the minimum hardness value in the month when the maximum nitrate concentration is projected to occur.

[c] Nitrate Level 2 benchmark as mg N/L= mg N/L=$10^{1.0003\log10(\text{hardness})-1.38}$, where hardness is in mg N/L of $CaCO_3$. Level 2 benchmark calculated using the minimum hardness value in the month when the maximum nitrate concentration is projected to occur.

[d] This location is also the GHO Fording River Compliance Point.

Bold font indicates projected concentration is above the level 1 benchmark.

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

Table 2-13 Summary of Projected Monthly Average Selenium Concentrations above Site Performance Objectives or Compliance Limits in the Elk River or Fording River

Location	Development Scenario[(a)]	Year	Month	Maximum Projected Concentration (µg/L)	Corresponding Site Performance Objective / Limit (µg/L)	Maximum Magnitude of Exceedance (µg/L)	Level 1 Benchmark (µg/L)	Level 2 Benchmark (µg/L)
GH-FR1[(b)]	Planned	2020 to 2021	December to April	**78**	63	15	70	187
	Permitted	2020 to 2021	December to April	**73**	63	10	70	187
LC_LC5	Planned	2020 to 2021	January to April	**58**	51	7	19	74
	Permitted	2020 to 2021	February to April	**56**	51	5	19	74
EV_ER4	Planned	2020 to 2021	February	**26**	23	3	19	74
	Permitted	2020 to 2021	February	**25**	23	2	19	74
FR_FRCP1	Planned	2020 to 2021	October to May, August	**127**	90	37	70	187
	Permitted	2020 to 2021	October to May	**120**	90	30	70	187
LC_LCDSSLCC	Planned	2019 to 2025	December to May	**69**	50	19	19	74
	Permitted	2019 to 2025	December to May	**69**	50	19	19	74
GH_ERC	Planned	2028 to 2030	February	9	8	1	19	74
	Permitted	2028 to 2029	February	8.6	8	0.6	19	74
EV_HC1	Planned	2028 to 2030, 2032 to 2037	August to May	**76**	57	19	70	187
	Permitted	2029, 2034 to 2053	August to May	**76**	57	19	70	187
EV_MC2	Planned	2021	February	**29**	28	1	19	74
		2022	January to March, August to September	**32**	20	12	19	74
		2027	August	**20**	19	1	19	74
	Permitted	2021	February	**29**	28	1	19	74
		2022	January to March, August to September	**31**	20	11	19	74
		2027	August	**20**	19	1	19	74

[(a)] Timeframe considered is from 2019 to 2037 for the Planned Development Scenario and from 2019 to 2053 for the Permitted Development Scenario.

[(b)] This location is also the GHO Fording River Compliance Point.

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

Bold font indicates projected concentration is above the level 1 benchmark.

3 Adaptive Management Plan Key Uncertainty Reduction

Teck's AMP was developed to support implementation of the EVWQP to achieve water quality targets, including calcite targets, ensure that human health and the environment are protected, and where necessary, restored, and to facilitate continuous improvement of water quality in the Elk Valley. Following an adaptive management framework, the AMP identifies six Management Questions that will be re-evaluated at regular intervals as part of AMP updates throughout EVWQP implementation. The AMP also identifies key uncertainties that need to be reduced to fill gaps in current understanding and support achievement of the EVWQP objectives.

The analyses supporting the IPA assist in reducing Key Uncertainty (KU) 1.2 ("How will uncertainty in the Regional Water Quality Model be evaluated to assess future achievement of limits and SPOs?"), KU 3.1 ("Are there better alternatives to the current active water treatment technologies?"), KU 3.2 ("What is the most feasible and effective method (or combinations of methods) for source control of nitrate release?"), KU 3.3 ("Is clean water diversion a feasible and effective water management strategy to support water quality management?"), KU 3.4 ("What additional flow and groundwater information do we need to support water quality management?"), and KU 3.5 ("Is sulphate treatment required and if so how could we remove sulphate?"). Descriptions on how the analysis supporting the IPA assist in reducing KUs and how future IPAs will be informed by reducing these KUs is contained in the following section. The main report for providing details on the reducing KU 1.2 is the 2020 RWQM Update. Similarly, the details of reducing KU 3.1 through KU 3.5 will be reported in Teck's Annual R&D reports. Summaries on progress on reducing these key uncertainties, and associated learnings, will be described in Annual AMP Reports.

Please refer to the AMP (Teck 2018c) for more information on the adaptive management framework, Management Questions, key uncertainties, the Response Framework, Continuous Improvement, linkages between the AMP and other EVWQP programs, and AMP reporting.

3.1 Alternative Mitigations and Plan to Reduce Reliance on Active Water Treatment

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. The AMP Management Question 3 ("Are the combinations of methods for controlling selenium, nitrate, sulphate and cadmium included in the implementation plan the most effective for meeting limits and site performance objectives?" includes Key Uncertainty 3.1 "Are there better alternatives to the current active water treatment technologies?" The objective of reducing this uncertainty is to find the most effective and sustainable treatment, and source control, technologies for long-term water quality management with the goal of reducing long term reliance on active water treatment.

Annex J presents an alternative treatment mitigation plan (based on alternative technologies). It demonstrates what Teck is striving to achieve with its R&D programs. As alternative treatment technologies are sufficiently developed, these technologies will be incorporated for consideration in future IPAs.

Details on the reducing KU 3.1 will be provided in the Annual R&D report. Summaries on KU reduction progress, and associated learnings, will be described in Annual AMP Reports.

3.2 Nitrate Source Control

Key Uncertainty 3.2 of the AMP is "What is the most feasible and effective method (or combination of methods) for source control of nitrate?" Currently, several best practices have been identified that are expected to reduce nitrogen release to the environment, as discussed in Section 2.3.5. Although improvements in water quality have not yet been incorporated into the RWQM (and in the resulting water quality projections included in the 2019 IPA), Teck asserts that that nitrate source control is a proven and effective mitigation measure to reduce nitrate release from waste rock. Nitrate source control thus has the potential to have an impact on downstream water quality as well as the sizing, timing and design of AWTFs.

To date, Teck has implemented the nitrate source control practices described in Section 2.3.5 and will continue to refine practices to work towards further reduction of nitrogen loss from blasting. Currently, ANFO holes can be lined, and there are trials underway to determine if it is possible to line blast holes filled with emulsion. As expected, with the current understanding of a delay between waste rock placement and the appearance of associated nitrate load in the receiving environment, the benefits of nitrate source control have not yet been observed at downstream monitoring stations.

Teck's R&D team has completed sampling of rock immediately after a blast has occurred to quantify nitrate residuals on rock to work towards quantification and future inclusion of these improvements in the RWQM. This sampling program was done on the three product blends that have been used most commonly historically, as well as a new product, not yet used operationally at Teck sites, which is expected to show reduced leaching in wet holes.

Compilation and analysis of information from this field test is currently underway. This study, along with compilation of historical blasting information, will support quantification of the estimated reduction of nitrate loss from improved blasting practices relative to historical practices and will be used to inform refinements to best management practices and further studies to quantify the full range of blasting products, practices and conditions common to Teck's Elk Valley operations. This information will be used to inform nitrate source term refinements for the 2020 RWQM update. Details on the reducing KU 3.2 will be provided in the Annual R&D report. Summaries on KU reduction progress, and associated learnings, will be described in Annual AMP Reports.

3.3 Influence of Clean Water Diversions

Key Uncertainty 3.3 of the AMP is "Is clean water diversion an effective water management strategy?" As summarized in Section 2.3.4, the conceptual model for CWDs is that they do not change the mass (load) of selenium and other constituents of interest downstream. Section 2.3.4 also describes Teck's current understanding of biological AWT costs; that they are largely dependent on the amount of nitrate and selenium removal required (e.g., the required nitrate and selenium load removal), and not just on the volume of water requiring treatment as understood during development of the IIP. Considering the conceptual model for CWDs and Teck's current understanding of AWT costs, CWDs have limited cost efficiency benefit to biological AWT, particularly when nitrate concentrations in influent waters are high; nor will they result in water quality improvement without treatment as the total load remains the same. This updated understanding, as well as Teck's updated understanding of other considerations (site conditions, feasibility, operability, and adaptability), was used to evaluate individual CWDs identified in the EVWQP (Annex D).

Annex D identifies that CWDs will continue to be evaluated (after the 2019 IPA) as follows:

- Through the design, permitting, constructing, commissioning and operating the Kilmarnock Creek diversion and studying its effectiveness and impact on the amount of selenium and other water quality constituents reporting to the un-diverted volume of Kilmarnock Creek.
- By applying the results from the Kilmarnock Creek diversion study (or other applicable research) in evaluating the potential of diversions associated with subsequent AWTFs.

Through more detailed assessments as part of the AWTF project to which a CWD is linked (e.g., for the three planned diversions at LCO with the next phase of the WLC AWTF). These assessments will be used to refine the timing and sizing, as well the construction and operating approach, for each CWD providing a clear linkage with the design basis and permit application of the associated AWTF. Consequently, this detailed assessment may change the configuration of individual CWDs and will be used to inform future adjustments to the implementation plan.

3.4 Water Availability

Key Uncertainty 3.4 of the AMP is “What additional flow and groundwater information do we need to support water quality management”. Water in sources targeted for mitigation travels via two pathways: surface flow and shallow groundwater flow. Teck’s primary design approach for AWTF intakes is to plan for collection of surface water unless groundwater capture is required to meet Compliance Limits and SPOs. Consequently, an examination of the quantity of water available at surface relative to total watershed yield was undertaken in tributaries targeted for treatment, as outlined in Section 2.3.

Results of the examination of water availability indicates that, in general, collection of surface flow should be sufficient to meet the water availability assumptions used in the RWQM in areas where site-specific groundwater evaluations have been done (e.g., LCO Dry Creek, Swift Creek, Cataract Creek). In other areas (e.g., Erickson Creek, Clode Creek), results of the analysis indicate that additional studies and potential design considerations may be required so that the relevant intakes are able to access as much of the total watershed yield as assumed in the RWQM, at least at certain times of the year. Follow-up activities are planned with a particular focus on collecting site-specific information at potential intake locations, as existing flow monitoring locations tend to be located downstream of where potential intakes will be constructed.

The generalized workflow of follow-up activity consists of nine tasks, with the understanding that it will be modified on a site-by-site basis in reflection of data already collected and results of the evaluation outlined herein. Tasks 1 to 6 are typically completed in support of intake siting and design; Tasks 7 and 8 are completed during detailed design and construction, and Task 9 is completed during operations. The tasks are as follows:

1. Additional analysis of available groundwater information, including, as appropriate, use of 3D visualization tools and development of geological cross-sections to characterize and better understand:
    - local hydrogeology beneath waste rock and other source materials;
    - flow paths for mine-affected water between source materials and the receiving environment, including the sources targeted for treatment; and

  - sediment thickness, permeability and potential for groundwater bypass at selected intake locations.

2. Additional water level and flow monitoring near potential intake locations, particularly in areas where intakes may be placed some distance from existing monitoring locations, to better define the proportion of total watershed yield that is flowing at surface at the location of the intake.
3. Flow accretion studies to understand and map gaining and losing reaches to support siting of intake structures in areas of groundwater discharge, where possible.
4. Geophysical surveys to characterize sediment thickness, permeability and support siting of intake structures.
5. Sediment sampling from settling ponds for permeability and particle size analysis to better define exfiltration rates from the ponds.
6. Drilling and installation of groundwater wells and subsequent water quality sampling and monitoring to understand heads, vertical gradients, potential seepage pathways and depth to bedrock to support siting and design of intake structures.
7. Groundwater modelling, where appropriate and warranted, to simulate seepage and quantify potential bypass of selected intake locations under varying flow conditions.
8. Analysis of groundwater monitoring data collected via site-specific and regional programs to validate and refine groundwater models.
9. Monitoring and modelling data used interactively to evaluate intake performance and identify if additional management actions are required.

The status of follow-up activity in each area targeted for treatment is presented in Table 3-1:

Table 3-1 Status of Follow-up Activities on Areas Targeted for Treatment

Areas Targeted for Treatment	Status of Follow-up Activities
FRO North (i.e., Clode Creek, Swift North Spoil and Swift Pit drainages)	• Tasks 1 through 4 are in progress • Tasks 5 and 6 are planned for 2019 • Tasks 7 and 8 will be completed in conjunction with design engineering in 2020 / 2021
FRO South – Swift and Cataract Creeks	• Tasks 1 to 6 are complete • Task 7 and 8 are in progress
FRO South - Kilmarnock Creek	• Tasks 1 to 5 are complete • Task 6 is in progress • Tasks 7 and 8 are planned for 2019
GHO (i.e., Leask, Wolfram, Thompson and Greenhills creeks)	• Scoping study is planned for 2019 and will involve the completion of Tasks 1 to 3, leading to recommendations for Task 4 • Schedule for subsequent tasks will be determined based on the outcome of the scoping study

Table 3-1 Status of Follow-up Activities on Areas Targeted for Treatment

Areas Targeted for Treatment	Status of Follow-up Activities
LCO Dry Creek	• Tasks 1 to 8 are complete • Task 9 is on-going
LCO Line Creek (i.e., West Line Creek, Line Creek and MSAW)	• Intakes for existing facility are in place • Scoping study is planned for 2019, with a focus on understanding what will be required to support further mitigation in this drainage • Scoping study will involve the completion of Tasks 1 to 3, leading to recommendations for Task 4 • Schedule for subsequent tasks will be determined based on the outcome of the scoping study
EVO (i.e., Erickson, Bodie and Gate drainages)	• Tasks 1 to 4 are in progress • Tasks 5 and 6 are planned for 2019 • Tasks 7 and 8 are planned to be completed in conjunction with the design engineering in 2020 / 2021

Notes: EVO = Elkview Operations; FRO = Fording River Operations; GHO = Greenhills Operations; LCO = Line Creek Operations; MSAW = Mine Services Area West.

Potential design considerations that may be considered and evaluated when siting and designing intakes and supporting water management infrastructure include:

- Lining settling ponds where infiltration to ground may be a concern.
- Construction of earth berms with shallow cut-off trenches or upstream liners to increase groundwater capture.
- Installation and operation of shallow groundwater capture wells to reduce groundwater bypass.
- Designing intakes that are appropriate for the physical setting of the site, to achieve the required collection efficiency. For example, pumping from open water surfaces, such as a pit, to enhance capture. In-pit intakes could use a floating pump station, or another practical configuration. Capture rates of greater than 95% can be achieved with such designs, based on prior pit dewatering experience at Teck sites.

A more site-specific discussion of potential design considerations is provided in Annex H.

Should monitoring results indicate that the measures outlined in the 2019 IPA do not produce the projected rates of compliance outlined herein (with respect to the Compliance Limits and SPOs specified in Permit 107517), Teck will evaluate and implement contingency options, as appropriate. Potential contingency options include:

- Relocating intakes within targeted tributaries to more effective locations, if design modifications prove to be insufficient and on-going monitoring identifies more suitable locations.
- Using multiple intakes within a targeted tributary to increase water capture rates (e.g., combining in-pit intakes with those positioned further downstream to optimize capture rates amongst backfilled pits and aboveground spoils).

- Targeting additional sources for treatment, such as:
  - Sources in Henretta Creek at FRO,
  - Mickelson Creek and/or Willow Creek at GHO, and
  - EVO Dry Creek at EVO.

Details on KU 3.4 will be provided in an AMP Technical Memo when the KU is resolved. Summaries on KU reduction progress, and associated learnings, will be described in Annual AMP Reports.

3.5 Sulphate Treatment

Key Uncertainty 3.5 of the AMP is “Is sulphate treatment required and if so how could we remove sulphate?” Sulphate treatment may be required based on modelled water quality projections that are seasonally above current Compliance Limits and SPOs at the Line Creek Compliance Point starting in 2026 and in the Upper Fording River at the FG_FR1 Order Station starting in 2028, as discussed in Section 2.3.7. An update to the first part of this uncertainty (e.g., is sulphate treatment required?) is provided in Section 2.3.7. A summary of to-date R&D for sulphate treatment technology is also provided in Section 2.3.7, addressing the second part of this uncertainty (i.e., how could we remove sulphate?).

Consistent with the two parts of Key Uncertainty 3.5, two parallel paths are proceeding to address this key uncertainty:

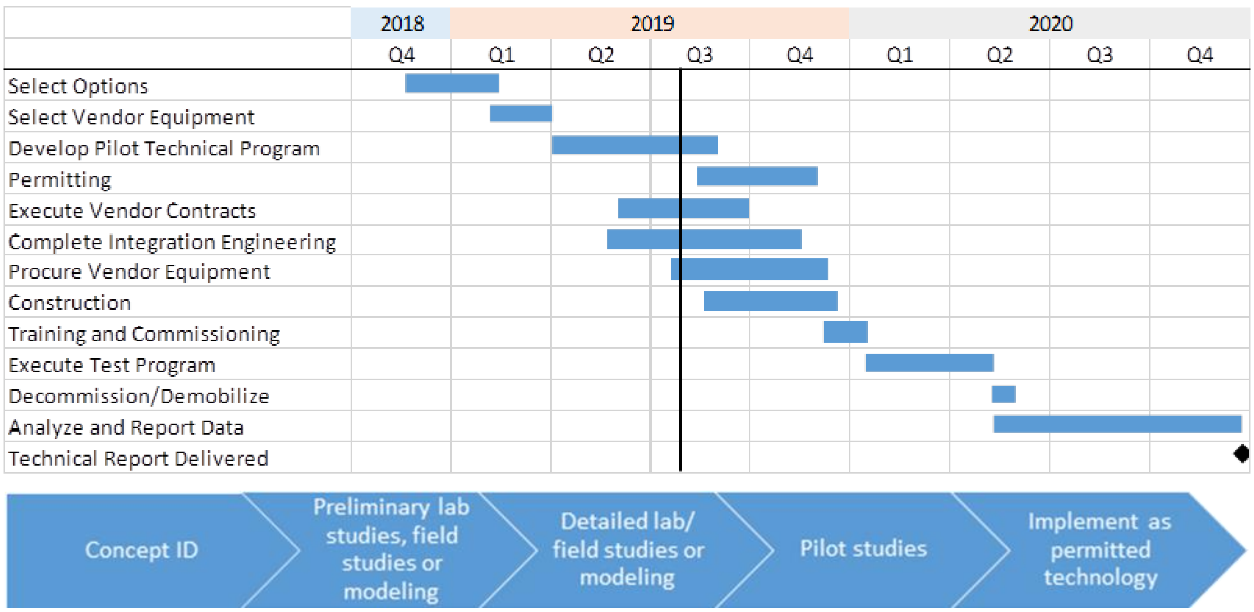
1) **Further evaluation (Stage 5 of the adaptive management cycle) and adjustment (Stage 6 of the adaptive management cycle) to continue to refine our understanding of when and where sulphate treatment is required**: This includes evaluating and potentially adjusting sulphate Compliance Limits at compliance points and Order Stations based on appropriate level of protection and taking into consideration updated learning regarding the potential for sulphate to reduce selenium bioavailability and continuing to evaluate and adjust sulphate water quality projections from the RWQM for the next update in 2020.

   For context, defining the appropriate level of protection for selenium and nitrate was the main focus during the EVWQP. To achieve the schedule for development of the EVWQP (~15-month duration from receipt of the Section 89 Order under the EMA to submission of the EVWQP), extensive and detailed effort was spent on selenium and nitrate. Although the same expertise and review was used to define the appropriate level of protection for sulphate, less effort/time (on a relative comparison basis) was spent on sulphate, supporting further evaluation as described above.

2) **Advancement of sulphate treatment technology development and the selection of a technology (or technologies) that could be used for sulphate treatment in the Elk Valley**: Planning is underway to pilot one or more sulphate treatment technologies in 2019/2020, aimed at selecting a sulphate treatment technology for implementation at full scale. Figure 3-1 below outlines a piloting plan, the outcome of which will be a recommendation on technology to be scaled up. In terms of progress to date, the project team has shortlisted four options from a list of 12 for deeper evaluation. The list of 12 options was developed internally and then cross checked externally to check that no options were overlooked. Options were evaluated based on the following criteria: effluent quality; technology risk; implementation risk and residuals (estimated

volume and characteristics of residuals generated as a bi-product of treatment). The next step will be to identify which of the four options (nanofiltration; electrodialysis reversal; reverse osmosis and barium hydroxide precipitation) should be piloted. In order to support this decision-making process, bench testing, mass balances on both reagents and residues, process flow diagrams and capital and operating cost estimates are being developed. After technology selection, the estimated implementation period (design, permitting, construction and start-up) for full-scale sulphate treatment is expected to be five years (similar to biological AWT for selenium and nitrate) with a six-month to one-year commissioning and ramp-up period. An overlay of piloting, the estimated implementation and ramp-up periods for full-scale treatment should sulphate treatment be required starting in 2026 in Line Creek is shown in Figure 3-1.

Figure 3-1 Sulphate Treatment Technology Piloting Plan



Details on reducing KU 3.5 will be provided in the Annual R&D report. Summaries on KU reduction progress, and associated learnings, will be described in Annual AMP Reports.

3.6 Water Quality Model

The RWQM is used in the AMP to help answer Management Question 1 ("Will limits and SPOs be met for selenium, sulphate, nitrate and cadmium?") and to support evaluations under Management Question 3 ("Are the combinations of methods for controlling selenium, nitrate, sulphate and cadmium included in the implementation plan the most effective for meeting limits and site performance objectives?").

The next RWQM update will be submitted in October 2020, in accordance with EMA Permit 107517 (Section 10.9) and the BC *Mines Act* C-Permit requirements for each operation. The focus of this and each RWQM update is continuing to answer AMP Key Uncertainty 1.2 ("How will uncertainty in the RWQM be evaluated to assess future achievement of limits and SPOs?"). As part of each update of the RWQM, some uncertainties are reduced through study, and new uncertainties identified. The new uncertainties identified in the 2017 RWQM, targeted for the 2020 RWQM update, are as follows:

- Can operational information be used to improve source terms?
- Can the RWQM be improved in specific catchments where mitigation decisions are required and uncertainty is high?
- How may selenium and sulphate release rates change over time?
- What mechanisms are causing the reduction in mass observed between tributaries and at monitoring stations in the main stems?

The uncertainties will be reduced through a combination of compilation and synthesis of information in a new way, design and implementation of supporting studies, and changes in monitoring programs to collect newly identified required information. Model inputs and assumptions will be adjusted based on the learnings from these programs and updated water quality projections will be generated. Details on the reducing KU 1.2 will be provided in the 2020 RWQM Update. Summaries on KU reduction progress, and associated learnings, will be described in Annual AMP Reports.

4 Next Steps and Future Implementation Plan Adjustments

4.1 Introduction

The 2019 IPA was developed to identify the sources targeted for treatment and the estimated sequence, timing and sizing of treatment to achieve the SPOs and Compliance Limits included in the EVWQP and Permit 107517. The potential locations and timing where sulphate treatment may be required is also identified. The removal of cadmium is not currently required to meet the SPOs outlined in Permit 107517. Mitigation in the 2019 IPA is intended to stabilize and reduce concentrations of nitrate and selenium for Teck's permitted development as well as for planned development over the next 20 years. Where and when sulphate treatment may be required and a path forward for advancing sulphate treatment technology is also identified in the 2019 IPA.

Long-term selenium and nitrate Compliance Limits and SPOs are met for all locations. The shift in timing of initial AWTFs (WLC AWTF plus AOP, FRO AWTF-S and EVO AWTF Phase I), coupled with changes to the RWQM, have resulted in projected selenium and nitrate concentrations, at some locations, that are seasonally above Compliance Limits and SPOs in the near-term. In the medium-term (i.e., from 2023 onward), concentrations are projected to be below SPOs but seasonally above Compliance Limits at some locations.

The immediate steps to continue to execute the 2019 IPA to meet the commitments it contains, and the process to adjust the IPA in the future are described in this section.

4.2 Executing the 2019 Implementation Plan Adjustment

The most important items to be advanced to execute the 2019 IPA, and to reduce the likelihood exceeding water quality Compliance Limits and SPOs in the near- and medium-term, are:

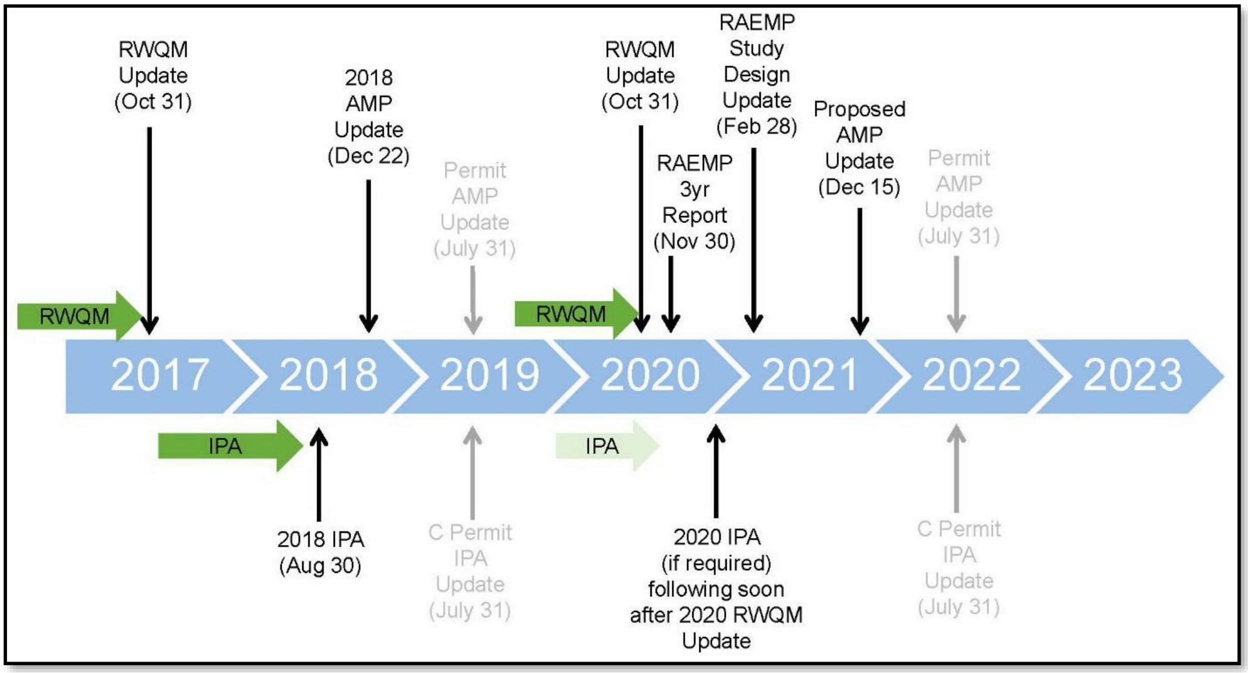
- Implementation of the next AWTFs to meet the 2019 IPA schedule:
  - WLC AWTF: ramp up to 7,500 m^3/day.
  - FRO AWTF-S: fully effective by December 31, 2021.
  - EVO AWTF Phase I: fully effective by September 30, 2022.
- In parallel to executing active water treatment, advancing alternative water treatment technologies (including SRFs) which could replace AWTFs in future adjustments to the implementation plan as outlined in Annex J.
- Continued focus on, and application of, nitrate source control through improved blasting practices.
- Advancing the Kilmarnock Creek CWD and increasing the understanding of CWDs as outlined in Section 3.3 and Annex D.
- Improved understanding of water availability as outlined in Section 2.3.6, Section 3.4, and in Annex H.
- Advancing and evaluating different sulphate treatment technologies to support the implementation of sulphate treatment by 2026. This includes planning, which is underway, for a sulphate treatment technology pilot program which will be conducted in 2019 and 2020 (Section 3.5).

4.3 Future Adjustments of the Implementation Plan

Teck's understanding associated with the management of water quality will evolve and inform subsequent IPAs. In parallel to implementing the mitigation identified in the 2019 IPA ongoing monitoring, supporting studies and research will reduce the key uncertainties identified in Section 3. The rapid advancement of alternative technologies, periodic review of monitoring data, changes to mine plans and updating of planning tools will result in adjustments of the implementation plan. The ongoing application of the six-stage adaptive management cycle will support adjusting the implementation plan to reflect updated understanding and new information. The process to adjust the IPA is a part of AMP.

As described in the AMP, there are three main inputs to the periodic review of the implementation plan: information about alternative technologies from the R&D Program, information from Management Question 1 about whether limits and SPOs are being met or will be met in the future, and information from relevant monitoring (e.g. RAEMP) and management programs. Updates to the RWQM, the AMP, the RAEMP and subsequent IPAs are shown in Figure 4-1. Review of the implementation plan will occur every three years following soon after the RWQM update or more frequently if required to incorporate new information (such as the integration of alternative treatment technologies).

Figure 4-1 Planned Schedule for Updates to the Regional Water Quality Model, the Adaptive Management Plan and the Regional Aquatics Effects Monitoring Program



Water quality projections from the RWQM are evaluated relative to SPOs and Compliance Limits and based on this, the need for an adjustment of the implementation plan is determined. The scope of the AMP update, as described in C-Permits, may include an update to the implementation plan, if required. If additional constituents are identified as requiring regional scale planning to meet the objectives of the EVWQP, they would be brought into the process as identified through the Response Framework in the AMP. In addition, adjustments of the implementation plan are anticipated as alternative technologies are advanced, proven and incorporated in the RWQM in an effort to reduce reliance on AWT.

The review of the implementation plan is an input to the three-year AMP update, unless the results of evaluations that support this Management Question (e.g., RWQM updates and / or preparation and submission of major development permit applications) and/or Management Question 1 indicate that an earlier review is needed.

5 References

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