Elk Valley Water Quality Plan

2019 Implementation Plan Adjustment

Annex E: Methods Used to Develop the 2019 Implementation Plan Adjustment

July 2019

Teck

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ACRONYMS AND ABBREVIATIONS

Acronym or Abbreviation	Description
AWTF	Active water treatment facilities
CMO	Coal Mountain Operations
EVO	Elkview Operations
EVWQP	Elk Valley Water Quality Plan
FRO	Fording River Operations
GHO	Greenhills Operations
IIP	Initial Implementation Plan
IPA	Implementation Plan Adjustment
KNC	Ktunaxa Nation Council
LCO	Line Creek Operations
N	North
RWQM	Regional Water Quality Model
S	South
SRF	Saturated Rock Fill
SPO	Site Performance Objectives
Teck	Teck Coal Limited
u/s	upstream
WLC	West Line Creek

UNITS OF MEASURE

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

1 Introduction

The methods used to develop the 2019 Implementation Plan Adjustment (IPA), based on the mitigation options outlined in Annex C, are described in this document. The 2019 IPA is an adjustment to the Initial Implementation Plan (IIP) included in the Elk Valley Water Quality Plan (EVWQP; Teck 2014). The 2019 IPA outlines Teck's updated mitigation plan to meet the long-term water quality-based Compliance Limits and Site Performance Objectives (SPOs) for nitrate, selenium and sulphate defined in *Environmental Management Act* Permit 107517.

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

- 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 model 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.

Like the IIP, the 2019 IPA is based on the application of biologically-based AWTFs, and clean water diversions where practical to support efficient treatment, to address increasing selenium and nitrate water concentrations within the Elk Valley. Alternative forms of mitigation that Teck continues to investigate and may incorporate into future updates to the 2019 IPA, such as Saturated Rock Fills, are outlined in Annex J.

Methods used to select the clean water diversions incorporated into the 2019 IPA are outlined in Annex D. The expected performance of active water treatment, in terms of effluent concentrations, is outlined in Section 2.3.3 of the main report.

The purpose of this document (Annex E) is to describe the methods used to develop the 2019 IPA in reference to the overall approach outlined in the main report, which consisted of:

- Reviewing and, where appropriate, updating stream prioritization for water treatment.
- Determining mitigation to meet long-term Compliance Limits and SPOs for planned waste rock to 2037 (i.e., for the Planned Development Scenario).
- 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).
- 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).

Stream prioritization for water treatment is discussed below in Section 2. A description of the methods used to identify the hydraulic capacity, nitrate design load removal and phasing of mitigation to meet short, medium and long-term SPOs and Compliance Limits for the Planned and Permitted Development Scenarios are outlined in Section 3.

2 Stream Prioritization

The need for water quality mitigation has been identified at four of Teck's five mining operations in the Elk Valley (Figure 2-1): Fording River Operations (FRO), Greenhills Operations (GHO), Line Creek Operations (LCO) and Elkview Operations (EVO). Coal Mountain Operations (CMO) has not been identified for mitigation in the 2019 IPA, because it does not contribute appreciably to nitrate, selenium or sulphate loading in the Elk Valley. Water quality mitigation focused on other constituents will continue to advance at CMO, if and as appropriate, to address local monitoring results.

Water quality mitigation in the IIP took the form of active water treatment, and six active water treatment facilities (AWTFs) were identified for implementation, two at FRO, two at LCO and one at each of GHO and EVO:

- FRO AWTF North (FRO-N)
- FRO AWTF South (FRO-S)
- GHO AWTF
- West Line Creek (WLC) AWTF
- LCO Dry Creek (LCO DC) AWTF
- EVO AWTF

Each AWTF was modelled in the IIP as collecting and treating mine-influenced water from one or more mine-affected watersheds in its vicinity. Grouping multiple treatment sources or intake streams improved the efficiency of the AWTF by keeping the treatment facility closer to its full hydraulic capacity when flows fluctuate seasonally. With multiple intake streams, sources were prioritized by selenium concentration, which reflected the understanding that selenium concentration was the limiting water quality constituent in the Elk Valley. Each AWTF drew in water sequentially from the source with the highest selenium concentration to the source with the lowest concentration, until either the hydraulic capacity of the AWTF was reached or all available intake sources were treated. If the capacity was reached before all intake sources were treated, the remaining water bypassed the treatment facility and was released into local watercourses.

The same six AWTFs and their associated treatment areas remain the focus for mitigation for the 2019 IPA; however, the source evaluation was repeated, taking into consideration changes to projected conditions based on updated mine plans and the updated RWQM. Potential mine-affected watersheds for each of the six treatment areas were characterized with reference to selenium concentrations, selenium loads and waste rock volume through the 20-year planning window based on Teck's 2016 long-range mine plans as outlined in more detail by operation below.

Sources were prioritized for treatment based on consideration of current and future cumulative waste rock volumes, current and future selenium concentrations and flow volumes. Receiving environment concentrations are driven by load and flow. Load removal is required to meet downstream Compliance Limits and SPOs; however, concentration and flow inform treatability. As a result, consideration was given to both the load carried by potential treatment sources and constituent concentrations contained therein, with a view to maximizing the load reduction/removal across the AWTF while minimizing the volume of treated water. Load reduction across an AWTF is maximized by targeting sources with high selenium concentrations and reasonable flow volumes. Sources with selenium effluent concentrations in a similar range to selenium effluent concentrations were not selected for treatment. This approach was adopted, so that selenium-rich sources were targeted first, thereby providing the best opportunity to influence constituent concentrations on a regional scale.

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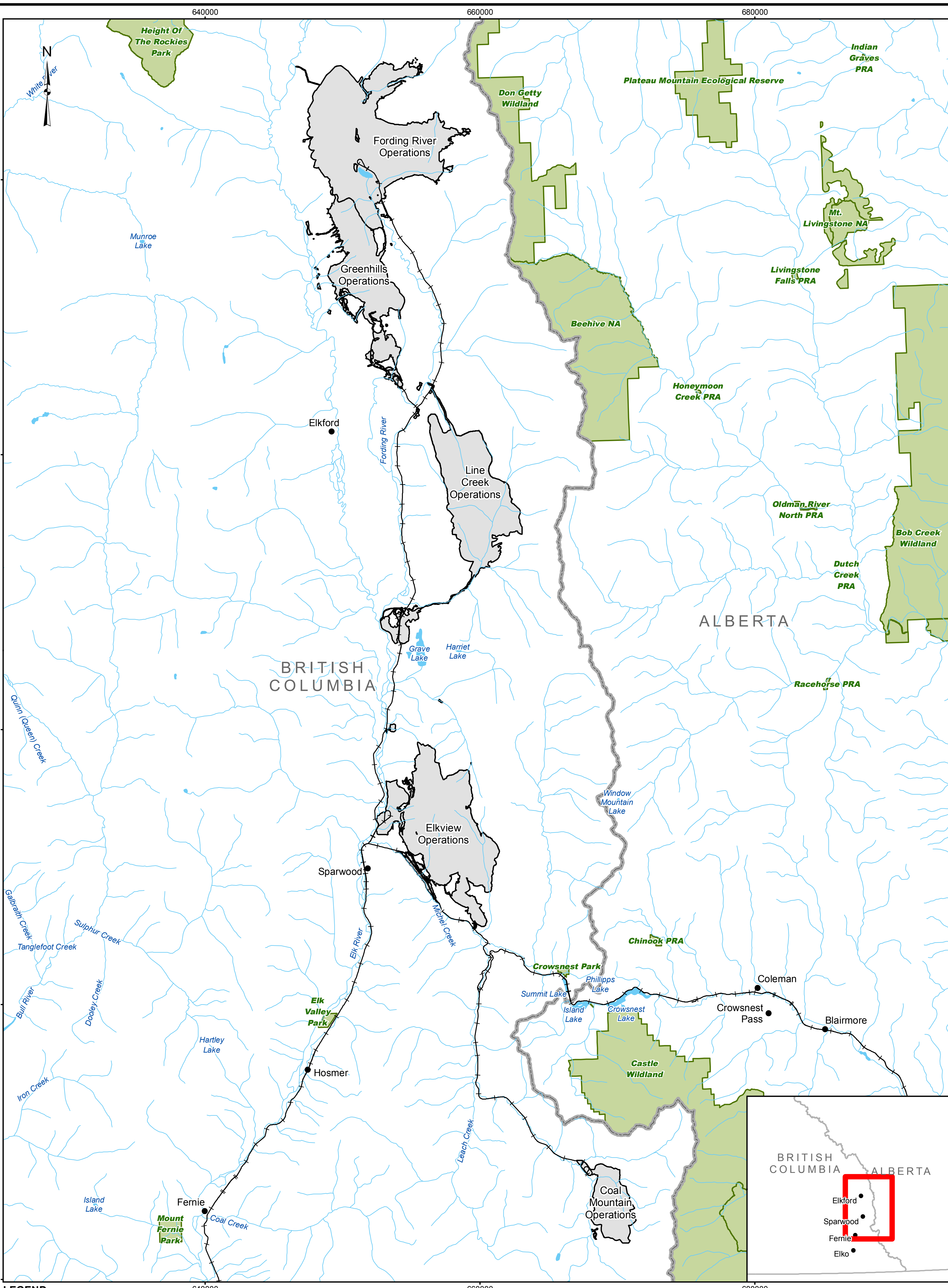

LEGEND

- POPULATED PLACE
- RAILROAD
- WATERCOURSE
- BRITISH COLUMBIA - ALBERTA BORDER
- OPERATIONAL BOUNDARY
- PARK / PROTECTED AREA
- WATERBODY

5 0 5

SCALE 1:270,000 KILOMETRES

REFERENCE

BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED. PARKS AND PROTECTED AREAS OBTAINED FROM IHS MARKIT CANADA LIMITED AND ALBERTA PARKS, GOVERNMENT OF ALBERTA.
PROJECTION: UTM ZONE 11 DATUM: NAD 83

WATER QUALITY PLAN ADJUSTMENT

TITLE

TECK COAL MINING OPERATIONS IN THE ELK VALLEY

Teck

PROJECT		1792554	FILE No.	5000
DESIGN	AS	25 Jul. 2018	SCALE AS SHOWN	REV. 0
GIS	LB	24 Aug. 2018		
CHECK	AS	24 Aug. 2018	**FIGURE: 2-1**	
REVIEW	JPB	24 Aug. 2018		

2.1 Fording River Operations

Mine-affected watersheds at FRO are divided into two areas for mitigation, FRO-N and FRO-S (Figure 2-2). Details for each treatment area are provided below.

2.1.1 Fording River North

The FRO-N treatment area includes the following watersheds that have been affected by historical mining activities at FRO or will be affected by future mining activities according to the Planned Development Scenario (Figure 2-2):

- Clode Creek (i.e., Clode Creek and Eagle 4 Pit sub-watersheds)
- Swift North Spoil Drainage
- Lower Fording 2/Swift Pit
- Henretta North Draining Tributaries (i.e., McSlide Creek, McDonald Creek, McMillan Creek and Moore Creek)
- Henretta Creek
- Lake Mountain Pit

An evaluation of the mine-affected watersheds in the FRO-N treatment area in 2016 (i.e., consistent with the end of the calibration period for the RWQM) and projected future conditions (i.e., 2037, consistent with the end of the 20-year planning period) is presented in Table 2-1. The data summarized in the table include cumulative waste rock volumes and mean monthly average selenium loads and concentrations under average flow conditions in 2016 and 2037.

In 2016, most of the waste rock in the FRO-N treatment area is located in the Clode Creek watershed, which has been disturbed by historical and on-going mining activities at Turnbull and Eagle pits (455 million bank cubic metres [BCM], or 53% of the 2016 total waste rock volume in the FRO-N treatment area; Table 2-1). Consequently, Clode Creek also has the highest selenium load and the second highest in-stream selenium concentration. Historical mining and waste rock placement has also occurred in the Henretta Creek, Swift North Spoil Drainage, Lake Mountain and Lower Fording 2/Swift Pit watersheds; as such, they contribute to selenium load from the FRO-N treatment area. There has been no historical mining or waste rock placement in the Henretta North Draining Tributaries.

Future mining activities in the FRO-N treatment area, based on the 2016 long-range mine plan, include completion of the Turnbull, Eagle, Lake Mountain and Swift pits and placement of associated waste rock. The 2016 long-range mine plan for FRO includes placement of waste rock from the Turnbull and Eagle pits in McSlide Creek, McDonald Creek, McMillan Creek and Moore Creek (i.e., north draining tributaries to Henretta Creek), as backfill in Turnbull Pit and in the Clode Creek watershed. Waste rock from the Swift and Lake Mountain pits would be placed in the Swift North Spoil Drainage, as backfill in the Swift and Lake Mountain pits, as well as in the combined Swift/Cataract watershed (addressed in the FRO-S treatment area).

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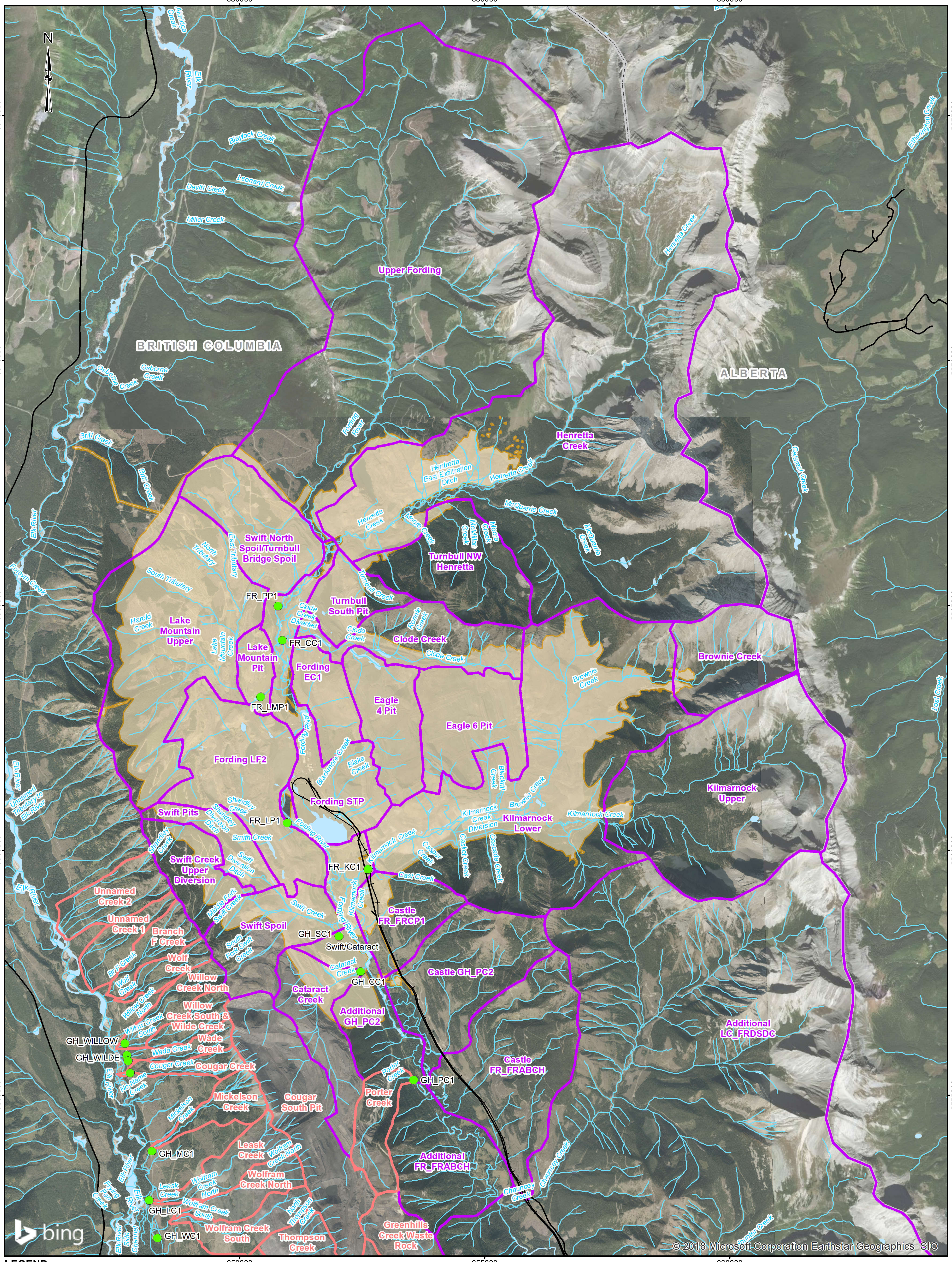

LEGEND

- MONITORING / MODELLING NODE
- CITY/TOWN/COMMUNITY
- ROAD
- CANADIAN PACIFIC RAILWAY
- WATERCOURSE
- WATERBODY
- BRITISH COLUMBIA - ALBERTA PROVINCIAL
- FORDING RIVER OPERATIONS C-3 PERMIT BOUNDARY
- FRO SUB-WATERSHED
- GHO SUB-WATERSHED
- BROWNIE CREEK — SUB-WATERSHED NAME

2 0 2

SCALE 1:75,000 KILOMETRES

REFERENCE

BASE DATA: CANVEC, GEOGRATIS 2017
IMAGERY: LIDAR IMAGERY PROVIDED BY TECK. ADDITIONAL IMAGERY BY MICROSOFT BING © 2017 MICROSOFT CORPORATION AND ITS DATA SUPPLIERS.
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 11N

WATER QUALITY IMPLEMENTATION PLAN

TITLE

MINE-AFFECTED WATERSHEDS CONSIDERED FOR TREATMENT AT FORDING RIVER OPERATIONS

Teck

PROJECT		1792554	FILE No.	5000
DESIGN	AS	26 Jun. 2018	SCALE AS SHOWN	REV. 0
GIS	PS/MP	30 Jun. 2018		
CHECK	AS	24 Aug. 2018	**FIGURE: 2-2**	
REVIEW	JPB	24 Aug. 2018		

Table 2-1 Selection and Prioritization of Mine-affected Watersheds for Fording River Operations North Treatment Area

Mine-affected Watershed	Current (2016)[a]			Future (2037)			Priority Level
	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	
Clode Creek	455	1.1	143	617	3.0	329	1
Swift North Spoil Drainage	65	*0.0037*	*1.1*	1,093	3.1	238	2
Swift Pit[b]	0	*0.086*	*50*	288	0.97	120	3
Lower Fording 2[c]	152	*0.67*	*150*	24	0.11	114	not selected
Henretta Creek[d]	159	1.1	18	295	1.4	34	not selected
Henretta North Draining Tributaries	0	*0.0069*	*1.1*	136	0.44	81	not selected
Lake Mountain Pit[e]	30	0.48	15	-[f]	-[f]	-[f]	not selected
Total	**861**	**3.4**	n/a	**2,316**	**8.6**	n/a	n/a

BCM = bank cubic metres; kg/d = kilograms per day; n/a = not applicable; µg/L = micrograms per litre.

(a) Values in *italics* are modelled data. Modelled data are presented, because observed data were not available.

(b) Mining in Swift Pit is modelled to be completed by the end of 2036 after which the pit is allowed to fill. While Swift Pit is filling, water is pumped from the pit to the FRO-N AWTF to maintain flows in the Fording River.

(c) Mining in the Swift Pit area will result in changes to the watershed boundaries of Lower Fording 2 and Swift Pit. Beginning in 2017, the area of the Lower Fording 2 watershed (and waste rock volume contained therein) decreases in the RWQM as the area of the Swift Pit watershed (and waste rock volume contained therein) increases, because of changes to topography and water management as the Swift Pit area is mined out.

(d) Henretta Creek includes the waste rock volume and load from the Henretta North Draining Tributaries.

(e) Lake Mountain Pit includes waste rock from the Lake Mountain Creek Upper watershed in 2016. In 2018, flow from the Lake Mountain Creek Upper watershed is modelled to be diverted to the Swift North Spoil Drainage.

(f) Mining in Lake Mountain Pit is modelled to be completed by the end of 2023 after which the pit is allowed to fill.

The Swift North Spoil Drainage watershed will contain the largest volume of waste rock (i.e., 1,093 million BCM, or 47% of the 2037 total waste rock volume in the FRO-N treatment area) by the end of 2037, followed by the Clode Creek watershed (617 million BCM, 27%). The Swift North Spoil Drainage and Clode Creek watersheds also have the highest projected selenium loads and in-stream concentrations in 2037, as shown in Table 2-1.

The Swift Pit and Henretta Creek watersheds are projected to have similar waste rock volumes by the end of 2037. The projected selenium loading in Henretta Creek will be higher than that projected for Swift Pit; however, projected concentrations in Henretta Creek are substantially lower due to higher flow rates and are projected to be below target effluent concentrations (i.e., 30 µg/L or 95% removal when influent concentrations are greater than 600 µg/L to December 31, 2025, and 20 µg/L from January 1, 2026 onward). Swift Pit projected concentrations are higher, justifying treatment priority of this source over Henretta Creek. Henretta Creek, or point sources within this catchment, may be considered for treatment if Compliance Limits are not met once treatment is implemented.

Although Lake Mountain Pit is projected to have high in-pit selenium concentrations, mining in Lake Mountain Pit is modelled to be completed by the end of 2023 after which the pit is allowed to fill (i.e., water would no longer be released to the environment). Lake Mountain Pit is modelled to spill outside of the 20-year planning period and is not sent to treatment.

The mine-affected watersheds selected for treatment in the FRO-N water treatment area, in order of priority based on projected selenium concentrations are summarized below and shown in Table 2-1:

- Clode Creek (i.e., Clode Creek and Eagle 4 Pit sub-watersheds)
- Swift North Spoil Drainage
- Swift Pit

These mine-affected watersheds account for 60% of the total waste rock volume in the FRO-N treatment area in 2016 and are expected to account for 86% of the waste rock and 82% of the selenium load in the FRO-N treatment area in 2037. The selected mine-affected watersheds in the FRO-N treatment area for the 2019 IPA are identical to those in the IIP; however, the order of priority has been updated to reflect the projections. The order of priority was Swift North Spoil Drainage, Clode Creek and Swift Pit in the IIP.

2.1.2 Fording River South

The FRO-S treatment area includes the following mine-affected watersheds (Figure 2-2):

- Swift Creek
- Cataract Creek
- Kilmarnock Creek
- Porter Creek

An evaluation of the mine-affected watersheds in the FRO-S treatment area in 2016 (i.e., consistent with the end of the calibration period for the RWQM) and projected future conditions (i.e., 2037, consistent with the end of the 20-year planning period) is presented in Table 2-2. The data summarized in the table include cumulative waste rock volumes and mean monthly average selenium loads and in-stream concentrations for average flow conditions in 2016 and 2037.

Table 2-2 Selection and Prioritization of Mine-affected Watersheds for Fording River Operations South Treatment Area

Mine-affected Watershed	Current (2016)			Future (2037)			Priority Level
	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	
Swift Creek[(a)]	219	2.0	499	1,019	6.9	>900	1
Cataract Creek[(a)]	439	1.9	598				
Kilmarnock Creek	1,294	3.9	150	1,631	8.6	245	2
Porter Creek	81	0.31	69	81	0.30	110	not selected
Total	**2,034**	**8.1**	n/a	**2,732**	**15.8**	n/a	n/a

BCM = bank cubic metres; kg/d = kilograms per day; n/a = not applicable; µg/L = micrograms per litre.

(a) Flow from Cataract Creek is modelled to be diverted to Swift Creek from 2018 onward.

Kilmarnock Creek, Swift Creek and Cataract Creek have been disturbed by historical mining and waste rock placement at FRO. Swift Creek and Cataract Creek also have historical disturbance associated with GHO. Porter Creek has been disturbed by historical mining and waste rock placement at GHO. Currently, waste rock is located primarily in Kilmarnock Creek (1,294 million BCM, or 64% of the 2016 total waste rock volume in the FRO-S treatment area; Table 2-2), Cataract Creek (439 million BCM, 22%), and Swift Creek (219 million BCM, 11%). Consequently, these three watersheds have the highest selenium loads and in-stream concentrations in the FRO-S treatment area, as shown in Table 2-2.

Future mining activities in the FRO-S treatment area, based on the 2016 long-range mine plan, include completion of Eagle and Swift pits and placement of associated waste rock. Mining for the FRO Castle Project is planned to begin towards the end of the 20-year planning window. Future waste rock placement is planned for the combined Swift/Cataract watershed from mining in Swift Pit and for Kilmarnock Creek from mining in Eagle and Castle pits. No additional waste rock placement is planned in Porter Creek.

Kilmarnock Creek would continue to have the largest volume of waste rock (1,631 million BCM, or 60% of the 2037 total waste rock volume in the FRO-S treatment area) by the end of 2037, followed by the combined Swift/Cataract watershed (1,019 million BCM, 37%). Although Kilmarnock Creek would continue to have the highest projected selenium load, the combined Swift/Cataract would have higher in-stream selenium concentrations due to its lower flow.

The mine-affected watersheds selected for water treatment in the FRO-S treatment area, in order of priority based on projected in-stream selenium concentrations are summarized below and shown in Table 2-2:

- Swift and Cataract Creeks
- Kilmarnock Creek

These mine-affected watersheds account for 96% of the total waste rock volume in the FRO-S treatment area in 2016 and are expected to account for 97% of the total waste rock volume and 97% of the selenium load in the FRO-S treatment area in 2037. Porter Creek, which is the only other mine-affected watershed in the FRO-S treatment area, has lower selenium load and in-stream concentration and is not selected for treatment. The selected mine-affected watersheds and treatment priorities in the FRO-S treatment area for the 2019 IPA, considering the updated projections, are identical to those in the IIP.

The selected mine-affected watersheds account for 85% of the total waste rock volume in the FRO-N and FRO-S treatment areas in 2016 and are expected to account for 92% of the total waste rock volume in 2037.

2.2 Greenhills Operations

The GHO treatment area includes the following watersheds that have been affected by historical mining activities at GHO or will be affected by future mining activities according to the current mine plan (Figure 2-3):

- Greenhills Creek
- Thompson Creek
- Wolfram Creek
- Leask Creek
- Mickelson Creek
- Cougar Creek
- Wade Creek
- Wilde Creek
- Willow Creek

An evaluation of the mine-affected watersheds in the GHO treatment area in 2016 (i.e., consistent with the end of the calibration period for the RWQM) and projected future conditions (i.e., 2037, consistent with the end of the 20-year planning period) is presented in Table 2-3. The data summarized in the table include cumulative waste rock volumes and monthly average selenium loads and concentrations under average flow conditions in 2016 and 2037.

Most of the historical waste rock from GHO mining activities has been placed in the West Spoil, which is located in the Leask, Wolfram, and Thompson Creek watersheds (288 million BCM, or 57% of the 2016 total waste rock volume in the GHO treatment area; see Table 2-3); the East Spoil in the Greenhills Creek watershed (135 million BCM; 27%); and spoils in the Swift and Cataract Creek watersheds (addressed as part of the FRO-S treatment area). Waste rock from GHO mining activities has also been placed as backfill in the Cougar South Pit (i.e., Cougar Phases 3 to 6), which is modelled to be dewatered to Michelson Creek from 2015 to 2030. No historical mining or waste rock placement has occurred in the Willow, Wilde, Cougar, or Wade Creek watersheds. Leask, Wolfram, Thompson and Greenhills Creeks have the highest selenium loads and in-stream concentrations in the GHO treatment area, as shown in Table 2-3.

Future mining activities in the GHO treatment area, based on the 2016 long-range mine plan, include on-going mining of the Cougar South pits (Phases 3 to 6), mining of the Cougar North pits (Phases 7 to 11) and placement of associated waste rock. Waste rock is planned to be placed in the West Spoil, as backfill in the Cougar South and Cougar North pits, as well as in the Mickelson, Cougar, Wade, Wilde and Willow Creek watersheds. The West Spoil will continue to contain the largest volume of waste rock in the GHO treatment area (555 million BCM, or 59% of the 2037 total waste rock volume in the GHO treatment area; see Table 2-3). No additional waste rock placement is planned in the East Spoil.

Flows from Leask Creek, Wolfram Creek, and Thompson Creek (i.e., the West Spoil) are assumed to be mixed and collected as a single stream for treatment. The sources selected for water treatment at GHO, in order of priority, are summarized below and shown in Table 2-3:

- Combined flow from Leask Creek, Wolfram Creek, and Thompson Creek
- Greenhills Creek

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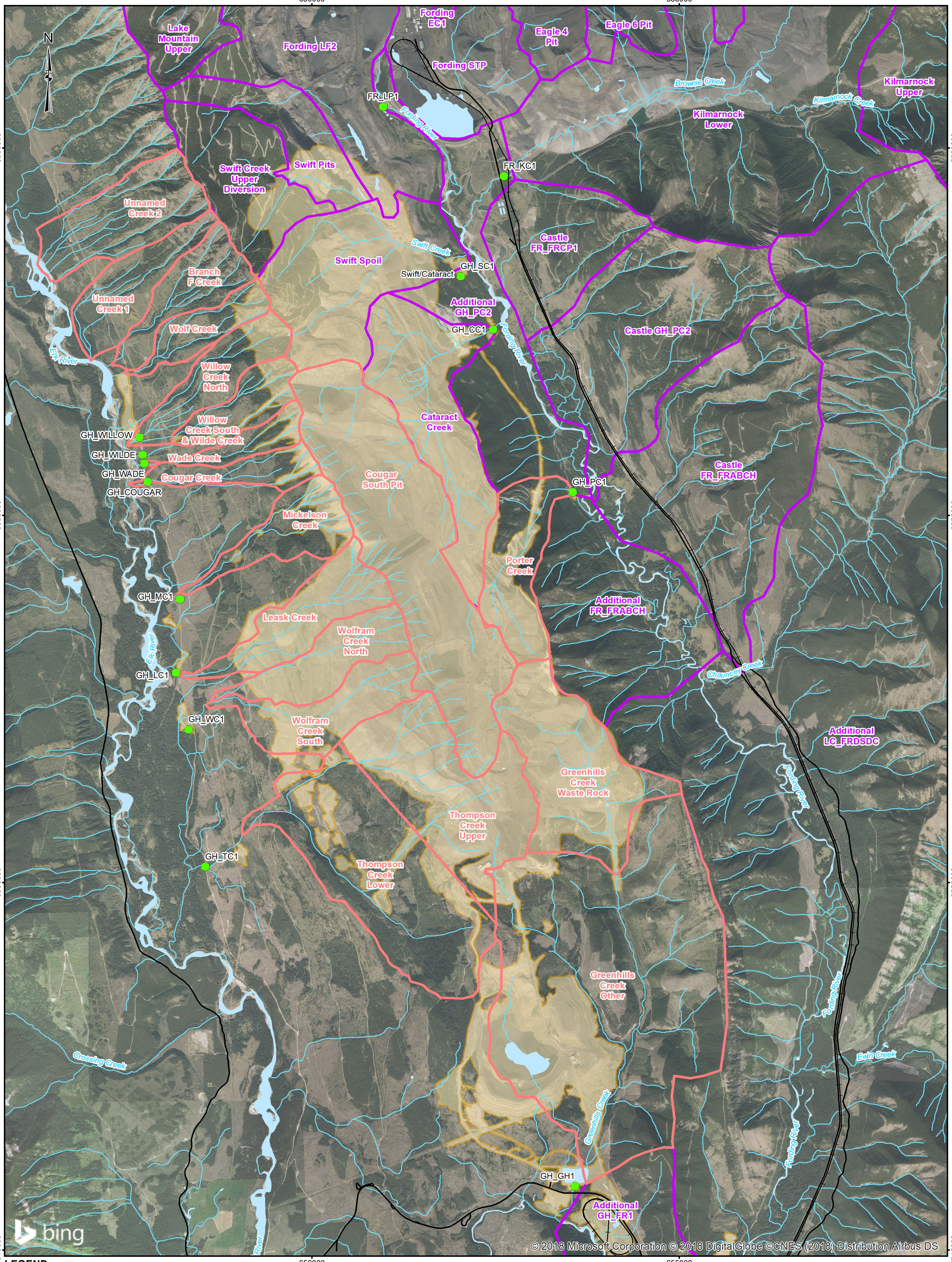

LEGEND

- MONITORING / MODELLING NODE
- CITY/TOWN/COMMUNITY
- ROAD
- CANADIAN PACIFIC RAILWAY
- WATERCOURSE
- WATERBODY
- BRITISH COLUMBIA - ALBERTA PROVINCIAL
- GREENHILLS OPERATIONS C-137 PERMIT BOUNDARY
- GHO SUB-WATERSHED
- FRO SUB-WATERSHED
- WADE CREEK — SUB-WATERSHED NAME

2 0 2

SCALE 1:50,000 KILOMETRES

WATER QUALITY IMPLEMENTATION PLAN

TITLE

MINE-AFFECTED WATERSHEDS CONSIDERED FOR TREATMENT AT GREENHILLS OPERATIONS

Teck

PROJECT		1792554	FILE No.	5000
DESIGN	AS	26 Jun. 2018	SCALE AS SHOWN	REV. 0
GIS	PS/MP	30 Jun. 2018	FIGURE: 2-3	
CHECK	AS	24 Aug. 2018		
REVIEW	JPB	24 Aug. 2018		

REFERENCE

BASE DATA: CANVEC, GEOGRATIS 2017

IMAGERY: LIDAR IMAGERY PROVIDED BY TECK. ADDITIONAL IMAGERY BY MICROSOFT BING © 2017 MICROSOFT CORPORATION AND ITS DATA SUPPLIERS.

PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 11N

Table 2-3 Selection and Prioritization of Mine-affected Watersheds for Greenhills Operations Treatment Area

Mine-affected Watershed	Current (2016)[a]			Future (2037)			Priority Level
	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	
Leask Creek	48	0.21	51	198 (484)[b]	1.3	595	1
Wolfram Creek	123	0.13	50	237	0.71	258	
Thompson Creek	117	0.45	92	122	0.91	157	
Greenhills Creek	135	*1.4*	89	135	2.2	175	2
Mickelson Creek[b]	79	*0.62*	3.2	101	0.65	376	not selected
Willow Creek	0	*<0.01*	2.5	32	0.63	72	not selected
Wilde Creek[d]	0	*<0.01*	-	58	0.42	54	not selected
Cougar Creek	0	*<0.01*	0.48	31	0.20	326	not selected
Wade Creek	0	*<0.01*	1.3	25	0.16	318	not selected
Total	**502**	**2.8**	n/a	**940 (1,424)[e]**	**6.8**	n/a	n/a

BCM = bank cubic metres; kg/d = kilograms per day; n/a = not applicable; µg/L = micrograms per litre.

(a) Values in *italics* are modelled data. Modelled data are presented, because observed data were not available.

(b) Value in parenthesis is the total waste rock volume in the Cougar South Pit. Mining in Cougar South Pit is modelled to be completed by the end of 2030 after which the pit is allowed to fill. In 2037, Cougar South Pit is filling and does not contribute load to the receiving environment.

(c) Mickelson Creek is modelled to receive operational dewatering flows from Cougar South Pit from 2015 to 2030.

(d) Wilde Creek is modelled to receive operational dewatering flows from Cougar North pits (Phases 7 to 11).

(e) Value in parenthesis is the total waste rock volume in the GHO treatment area that is contributing load to the receiving environment plus the total waste rock volume in the Cougar South Pit.

The combined flow from Leask Creek, Wolfram Creek, and Thompson Creek has been selected as the first priority, because these mine-affected watersheds are projected to have high selenium loads and in-stream concentrations in 2037. Together with Greenhills Creek, these mine-affected watersheds account for 84% of the total waste rock volume in the GHO treatment area in 2016 and are projected to account for 74% of the total waste rock volume and 76% of the selenium load in the GHO treatment area in 2037. Other potential sources in the GHO treatment area (i.e., Mickelson, Cougar, Wade, Wilde and Willow creeks) are not selected for treatment, because these mine-affected watersheds have relatively small waste rock volumes and projected selenium loads. While Mickelson Creek, Cougar Creek, and Wade Creek are projected to have among the highest selenium concentrations in 2037, they have relatively low selenium load compared to the selected mine-affected watersheds. The selected mine-affected watersheds and treatment priorities in the GHO treatment area for the 2019 IPA, considering the updated projections, are identical to those in the IIP.

2.3 Line Creek Operations

Mine-affected watersheds at LCO are divided into two areas for mitigation: LCO Phase I (i.e., Line Creek watershed) and LCO Phase II (i.e., LCO Dry Creek watershed; Figure 2-4). Details for each treatment area are provided below.

2.3.1 Line Creek Operations Phase I

The LCO Phase I treatment area includes the following mine-affected watersheds (Figure 2-4):

- West Line Creek
- Mine Services Area West (a sub-watershed of Line Creek upstream of West Line Creek)
- Line Creek upstream of West Line Creek

An evaluation of the mine-affected watersheds in the LCO Phase I treatment area in 2016 (i.e., consistent with the end of the calibration period for the RWQM) and projected future conditions (i.e., 2037, consistent with the end of the 20-year planning period) is presented in Table 2-4. The data summarized in the table include cumulative waste rock volumes and mean monthly average selenium loads and concentrations under average flow conditions in 2016 and 2037.

Historically, waste rock from LCO Phase I mining activities has been placed in Line Creek upstream of West Line Creek (491 million BCM, or 70% of the total waste rock in the LCO Phase I treatment area in 2016) and in West Line Creek (210 million BCM, 30%). Approximately 128 million BCM of waste rock has been placed in the Mine Services Area West watershed, which is a sub-watershed of Line Creek upstream of West Line Creek. Currently, West Line Creek has the highest in-stream concentration in the LCO Phase I treatment area, followed by Mine Services Area West and Line Creek upstream of West Line Creek, as shown in Table 2-4.

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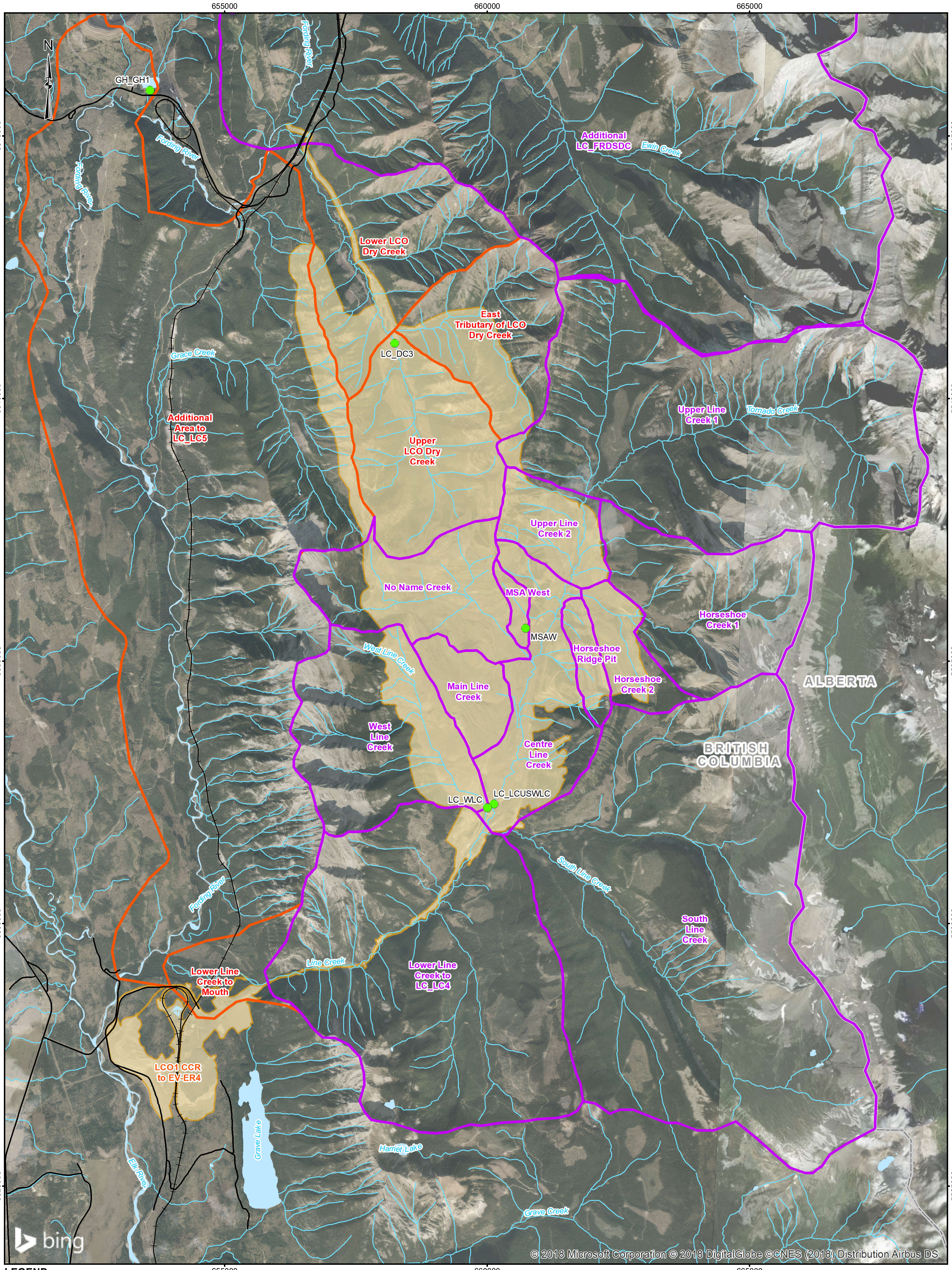

LEGEND

- MONITORING / MODELLING NODE
- CITY/TOWN/COMMUNITY
- ROAD
- CANADIAN PACIFIC RAILWAY
- WATERCOURSE
- WATERBODY
- BRITISH COLUMBIA - ALBERTA PROVINCIAL BOUNDARY
- LINE CREEK OPERATIONS C-129 PERMIT BOUNDARY
- PHASE I SUB-WATERSHED
- PHASE II SUB-WATERSHED
- LINE CREEK — SUB-WATERSHED NAME

2 0 2

SCALE 1:70,000 KILOMETRES

REFERENCE

BASE DATA: CANVEC, GEOGRATIS 2017
IMAGERY: LIDAR IMAGERY PROVIDED BY TECK. ADDITIONAL IMAGERY BY MICROSOFT BING © 2017 MICROSOFT CORPORATION AND ITS DATA SUPPLIERS.
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 11N

WATER QUALITY IMPLEMENTATION PLAN

TITLE

MINE-AFFECTED WATERSHEDS CONSIDERED FOR TREATMENT AT LINE CREEK OPERATIONS

Teck

PROJECT		1792554	FILE No.		5000
DESIGN	AS	26 Jun. 2018	SCALE AS SHOWN	REV.	0
GIS	PS/MP	30 Jun. 2018			
CHECK	AS	24 Aug. 2018	FIGURE: 2-4		
REVIEW	JPB	24 Aug. 2018			

Future mining activities in the LCO Phase I treatment area, based on the 2016 long-range mine plan, include completion of the Mine Service Area Extension (MSAX), North Line Creek Extension (NLX) and Burnt Ridge Extension (BRX) pits, and placement of associated waste rock in existing disturbed areas in Line Creek upstream of West Line Creek. No additional waste rock placement is planned in the West Line Creek watershed. By the end of 2037, Line Creek upstream of West Line Creek would continue to contain the largest volume of waste rock (642 million BCM, or 75%), with approximately 262 million BCM or 41% located in the Mine Services Area West sub-watershed. West Line Creek would have the highest in-stream selenium concentration by the end of 2037, followed by Mine Services Area West and Line Creek upstream of West Line Creek (Table 2-4).

All mine-affected watersheds in the LCO Phase I treatment area are selected for treatment. The mine-affected watersheds selected for water treatment in the LCO Phase I treatment area, in order of priority based on projected in-stream selenium concentrations are summarized below and shown in Table 2-4:

- West Line Creek
- Mine Services Area West
- Line Creek upstream of West Line Creek

The selected mine-affected watersheds and treatment priorities in the LCO Phase I treatment area for the 2019 IPA are the same as those in the IIP, with one exception. In the 2019 IPA, Mine Services Area West, which is a sub-watershed of Line Creek upstream of West Line Creek, is explicitly collected for treatment. In the IIP, Mine Services Area West was collected for treatment as part of Line Creek upstream of West Line Creek.

2.3.2 Line Creek Operations Phase II

The LCO Phase II Project is in the LCO Dry Creek watershed, north of LCO Phase I (Figure 2-4). Mining activities at LCO Phase II recently began and, based on the 2016 long-range mine plan, include completion of the Burnt Ridge North and Mount Michael pits and placement of associated waste rock in upper LCO Dry Creek and as backfill in the Burnt Ridge and Mount Michael pits.

Dry Creek upstream of the East Tributary is the only watershed affected by historical and on-going mining activities; therefore, prioritization of mine-affected watersheds is not required. The cumulative waste rock volume and mean monthly average selenium load and in-stream concentration in Dry Creek upstream of the East Tributary under average flow conditions in 2016 (i.e., consistent with the end of the calibration period for the RWQM) and projected future conditions (i.e., 2037, consistent with the end of the 20-year planning period) are presented in Table 2-5.

Table 2-4 Selection and Prioritization of Mine-affected Watersheds for Line Creek Operations Phase I Treatment Area

Mine-affected Watershed	Current (2016)[a]			Future (2037)			Priority Level
	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	
West Line Creek	210	1.8	430	210	2.2	487	1
Mine Services Area West[b]	128	*1.1*	*114*	262	3.0	207	2
Line Creek u/s of West Line Creek	491	1.9	35	642	7.8	76	3
Total	**701**	**3.7**	n/a	**852**	**10**	n/a	n/a

BCM = bank cubic metres; kg/d = kilograms per day; n/a = not applicable; µg/L = micrograms per litre; u/s = upstream.

(a) Values in italics are modelled data. Modelled data are presented, because observed data were not available.

(b) The Mine Services Area West watershed is a sub-watershed of Line Creek upstream of West Line Creek.

Table 2-5 Mine-affected Watersheds at Line Creek Operations Phase II

Mine-affected Watershed	Current (2016)[a]			Future (2037)			Priority Level
	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	
Dry Creek u/s of the East Tributary	13	*0.015*	2.3	480	3.5	389	1

BCM = bank cubic metres; kg/d = kilograms per day; µg/L = micrograms per litre; u/s = upstream.

(a) Values in italics are modelled data. Modelled data are presented, because observed data were not available.

2.4 Elkview Operations

The EVO treatment area includes the following mine-affected watersheds (Figure 2-5):

- Natal Pit
- Cedar Pit/Baldy Ridge 6 Pit
- Baldy Ridge Pits
- F2 Pit
- Bodie Creek
- Gate Creek
- Erickson Creek
- EVO Dry Creek
- Lower Harmer Creek
- South Pit, Milligan Creek, and Thresher Creek (modelled as a single watershed in the RWQM)
- Goddard Creek
- Balmer Creek
- Six Mile Creek
- Otto Creek

An evaluation of the mine-affected watersheds in the EVO treatment area in 2016 (i.e., consistent with the end of the calibration period for the RWQM) and projected future conditions (i.e., 2037, consistent with the end of the 20-year planning period) is presented in Table 2-6. The data summarized in the table include cumulative waste rock volumes and mean monthly average selenium loads and concentrations for average flow conditions in 2016 and 2037.

Most of the current waste rock in the EVO treatment area is in Erickson Creek (622 million BCM, or 38% of the 2016 total waste rock in the EVO treatment area), EVO Dry Creek (417 million BCM, 25%) and Natal Pit (273 million BCM, or 17%). These watersheds have the highest selenium load and in-stream concentrations in the EVO treatment area, as summarized in Table 2-6.

Future mining activities in the EVO treatment area, based on the 2016 long-range mine plan, include mining of Natal, Baldy Ridge and Adit Ridge pits and placement of associated waste rock. Waste rock will be placed in Erickson Creek, EVO Dry Creek, and South Pit/Milligan/Thresher Creek, and as backfill in the Cedar, Natal and Baldy Ridge pits. By the end of 2037, most of the waste rock will continue to be in Erickson Creek (1,310 million BCM, or 42% of the 2037 total waste rock in the EVO treatment area), EVO Dry Creek (789 million BCM, 25%) and Natal Pit (527 million BCM, 17%). These watersheds are projected to have the highest selenium load and in-stream concentrations in the EVO treatment area, as shown in Table 2-6.

Projected loadings and in-stream concentrations in tributaries at EVO are affected by projected waste rock volumes and management of water in mine pits. In the 2017 RWQM, pit inflows are modelled to be discharged to the receiving environment while each pit is being actively mined (i.e., inflows = outflows). More specifically, mine pit water is modelled as follows:

- During active mining in Natal Pit, up to 0.3 m^3/s of the incoming water flow is sent to Bodie Creek (EV_BC1), with excess flows diverted to Gate Creek (EV_GT1).
- During active mining in Baldy Ridge Pits, incoming water is sent to Aqueduct Creek (EV_AQ1) prior to 2021 and Bodie Creek (EV_BC1) from 2021 to 2037.
- During active mining in Cedar Pit/Baldy Ridge 6 Pit, incoming water is sent to:
    - EVO Dry Creek in 2016
        - April to June - 60% of incoming flow
        - July to October - 10% of incoming flow
    - Natal Pit in 2016
        - April to June - 20% of flow remaining after pumping to EVO Dry Creek
        - July to March 80% of flow remaining after pumping to EVO Dry Creek
    - Goddard Creek in 2016 - remaining flow that is not pumped to EVO Dry Creek or Natal Pit
    - Erickson Creek in 2017
        - April to June - 60% of incoming flow
        - July to October - 10% of incoming flow
    - Process Plant from April 2018 to 2037 - up to a maximum of 2,200 m^3/d
    - Natal Pit from 2017 to 2037
        - April to June - 20% of flow remaining after pumping to Erickson Creek or Process Plant
        - July to March 80% of flow remaining after pumping to Erickson Creek or Process Plant
    - Goddard Creek from January 2017 to December 2037 - remaining flow that is not sent to Natal Pit, Erickson Creek or Process Plant
- Water from F2 Pit is modelled to be sent to Erickson Creek upstream of the potential AWTF intake.

The mine-affected watersheds selected for active water treatment in the EVO treatment area, in order of priority are listed below and shown in Table 2-6:

- Bodie Creek
- Gate Creek
- Erickson Creek

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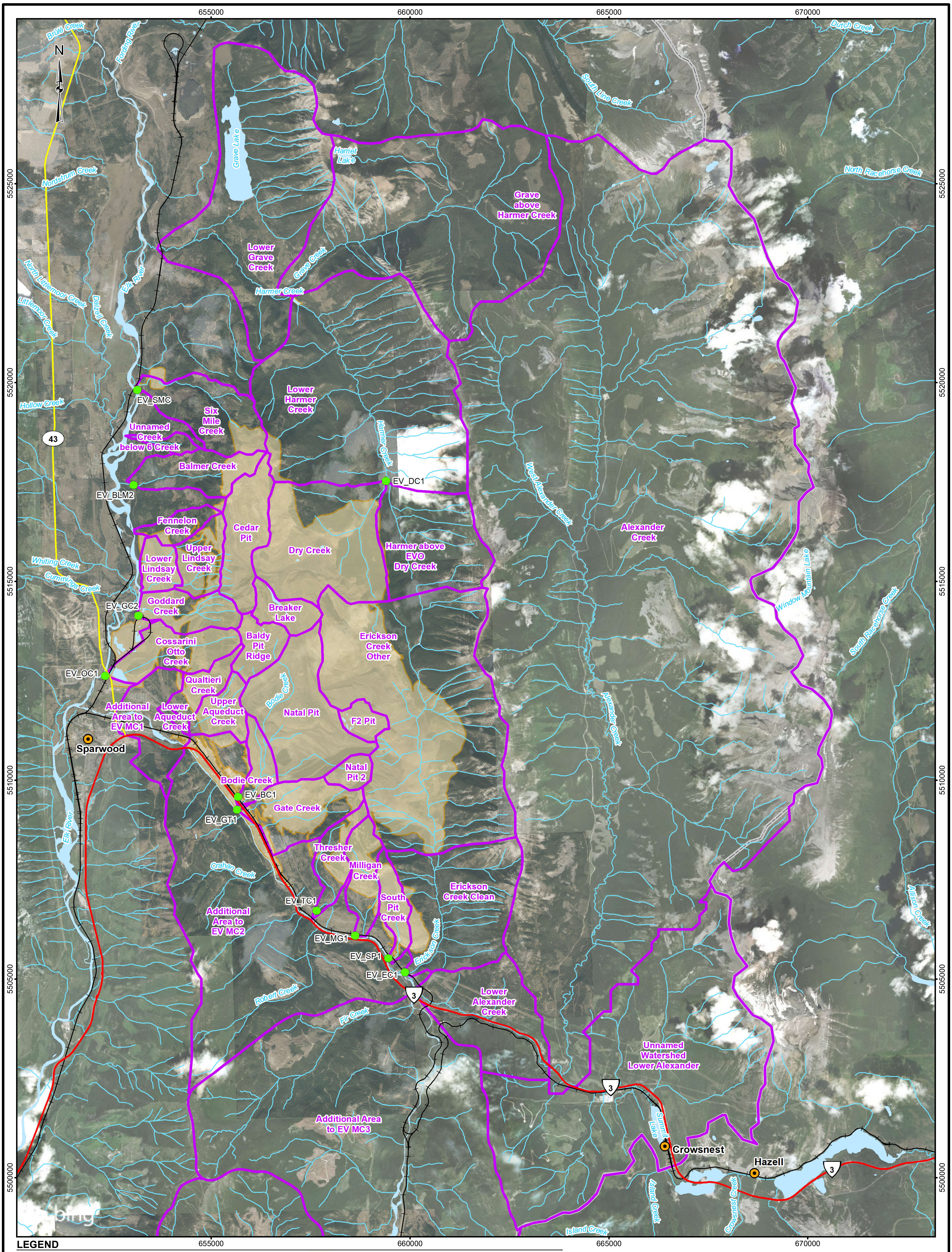


LEGEND

- MONITORING / MODELLING NODE
- CITY/TOWN/COMMUNITY
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- CANADIAN PACIFIC RAILWAY
- WATERCOURSE
- WATERBODY
- BRITISH COLUMBIA - ALBERTA PROVINCIAL BOUNDARY
- ELKVIEW OPERATIONS C-2 PERMIT BOUNDARY
- SUB-WATERSHED
- GRAVE CREEK SUB-WATERSHED NAME

2 0 2

SCALE 1:90,000 KILOMETRES

REFERENCE

BASE DATA: CANVEC, GEOGRATIS 2017
IMAGERY: LIDAR IMAGERY PROVIDED BY TECK. ADDITIONAL IMAGERY BY MICROSOFT BING © 2017 MICROSOFT CORPORATION AND ITS DATA SUPPLIERS.
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 11N

WATER QUALITY IMPLEMENTATION PLAN

TITLE

MINE-AFFECTED WATERSHEDS CONSIDERED FOR TREATMENT AT ELKVIEW OPERATIONS

Teck

PROJECT		1792554	FILE No.	5000
DESIGN	AS	26 Jun. 2018	SCALE AS SHOWN	REV. 0
GIS	PS/MP	30 Jun. 2018		
CHECK	AS	24 Aug. 2018	FIGURE: 2-5	
REVIEW	JPB	24 Aug. 2018		

Table 2-6 Selection and Prioritization of Mine-affected Tributaries for Elkview Operations Treatment Area

Mine-affected Watershed	Current (2016)			Future (2037)			Priority Level
	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	
Pits							
Natal Pit[(a)]	273	0.7	56	527	5.0	433	not selected
Cedar Pit/Baldy Ridge 6 Pit[(b,c)]	27	0.18	39	175	2.6	543	not selected
Baldy Ridge Pits[(c,d)]	0	0.01	10	1.8	0.12	37	not selected
F2 Pit[(c,e)]	18	0.00052	1.1	22	0.16	316	not selected
Tributaries							
Bodie Creek[(a)]	68	0.52	88	68	5.7	369	1
Gate Creek[(a)]	50	0.87	98	18	0.18	232	2
Erickson Creek[(b)]	622	2.0	133	1,310	10	435	3
EVO Dry Creek	417	1.2	144	789	1.5	145	not selected
South Pit[(f)]	20	0.079	169	45	0.2	53	not selected
Milligan Creek[(f)]		0.051	62				
Thresher Creek[(f)]		0.013	9.3				
Goddard Creek	0	0.14	40	0	0.0043	1.5	not selected
Balmer Creek	3.6	0.009	6.6	3.6	0.0082	2.5	not selected
Six Mile Creek	3.6	0.0027	2.1	3.6	0.0098	2.2	not selected
Lower Harmer Creek[(c)]	142	0.35	18	142	0.42	17	not selected
Otto Creek	0	0.0023	0.61	0	0.0033	1.7	not selected

Table 2-6 Selection and Prioritization of Mine-affected Tributaries for Elkview Operations Treatment Area

Mine-affected Watershed	Current (2016)			Future (2037)			Priority Level
	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	Cumulative Waste Rock Volume (million BCM)	Mean Monthly Average Selenium Load (kg/d)	Mean Monthly Average Selenium Concentration (µg/L)	
Aqueduct Creek[c,d]	0	0.00099	7.4	0	0.0036	1.1	not selected
Total	**1,644**	**5.2**	n/a	**3,105**	**19**	n/a	n/a

BCM = bank cubic metres; kg/d = kilograms per day; n/a = not applicable; µg/L = micrograms per litre.

(a) In 2016, water from Natal Pit is modelled to be sent to Bodie Creek and Gate Creek based on historical dewatering rates. In 2037, water from Natal Pit is modelled to be sent to Bodie Creek (up to a maximum of 0.3 m^3/s) and to Gate Creek (remaining flow).

(b) In 2016, water from Cedar Pit/Baldy Ridge 6 Pit is modelled to be sent to EVO Dry Creek (April to June [60% of flow], July to October [10% of flow], November to March [0% of flow]), Natal Pit (flow that is not pumped to EVO Dry Creek; April to June [20% of flow]; July to March [80% of flow]) and to Goddard Creek (remaining flow). In 2037, water from Cedar Pit/Baldy Ridge 6 Pit is modelled to be sent to Natal Pit (April to June [20% of flow]; July to March [80% of flow])), the Process Plant from (up to a maximum of 2,200 m^3/d) and Goddard Creek (remaining flow).

(c) In 2016, modelled concentrations and loads are presented in place of observed measurements.

(d) Water from Baldy Ridge Pits is modelled to be sent to Aqueduct Creek in 2016 and 2037.

(e) Water from F2 Pit is modelled to be sent to Erickson Creek upstream of the AWTF.

(f) In the 2017 RWQM, South Pit, Milligan Creek and Thresher Creek are modelled as a single watershed.

Bodie Creek and Gate Creek are selected for treatment, because they receive operational dewatering flows from Natal Pit. These mine-affected watersheds account for 62% of the total waste rock volume in the EVO treatment area in 2016 and are expected to account for 62% of the waste rock volume and 88% of the selenium load in the EVO treatment area in 2037. EVO Dry Creek, while containing the second largest volume of waste rock, is not selected for treatment. In the 2019 IPA, as well as in the EVWQP, the need for water quality mitigation was assessed at a regional-scale rather than local scale (i.e., focused on controlling constituent concentrations in the Fording River and Elk River). During the development of the EVWQP, an evaluation was completed to determine the regional effect of treating EVO Dry Creek on projected concentrations in the Elk River. This evaluation was completed using a hypothetical AWTF placed in EVO Dry Creek; the AWTF had a hydraulic capacity of 10,000 m^3/d, which was equivalent to projected mean winter flows under average flow conditions. Results of this planning analysis indicated that selenium concentrations in the Elk River downstream of Grave Creek were projected to decrease by less than 1 µg/L over the planning period. Based on these results, the operational challenges associated with constructing and operating an AWTF in Dry Creek (i.e., need for a new road, powerline and other supporting infrastructure) , and results of the integrated effects assessment completed on Management Unit 4 (MU4), treatment at EVO Dry Creek was not included in the IIP. It is not included in the 2019 IPA for the same reasons; in the 2019 IPA Planned Development Scenario , the long-term projected mean monthly average selenium load in EVO Dry Creek (i.e., 1.5 kg/d) is relatively low compared to the long-term projected mean monthly average selenium loads in the Elk River downstream of Michel Creek (i.e., 56 kg/d) and in Erickson Creek (10 kg/d).

Other mine-affected watersheds at EVO have much lower selenium loads and in-stream concentrations and are not selected for treatment. The selected mine-affected watersheds and treatment priorities in the EVO treatment area for the 2019 IPA, considering the updated projections, are identical to those in the IIP.

2.5 Summary

Prioritization of mine-affected watersheds for treatment at FRO, GHO, LCO and EVO has been updated for the 2019 IPA considering the 2016 long-range mine plans and updated model projections. A summary of the mine-affected watersheds selected for treatment is shown in Table 2-7. The mine-affected watersheds selected for treatment account for 75% of the total waste rock volume and 78% of the selenium load in the Elk Valley in 2016 and are expected to account for 75% of the total waste rock volume and 91% of the projected selenium load in the Elk Valley in 2037.

Table 2-7 Summary of Mine-affected Watersheds Selected for Treatment

Treatment Area	Mine-affected Watersheds Selected for Treatment	Current (2016)				Projected (2037)			
		Cumulative Waste Rock Volume		Selenium Load		Cumulative Waste Rock Volume		Selenium Load	
		% of Treatment Area Total	% of Elk Valley Total	% of Treatment Area Total	% of Elk Valley Total	% of Treatment Area Total	% of Elk Valley Total	% of Treatment Area Total	% of Elk Valley Total
FRO-N	1. Clode Creek 2. Swift North Spoil Drainage 3. Swift Pit	60%	8%	35%	5%	86%	17%	82%	11%
FRO-S	1. Swift and Cataract Creeks 2. Kilmarnock Creek	96%	32%	96%	33%	97%	23%	98%	25%
GHO	1. Leask, Wolfram, and Thompson Creeks 2. Greenhills Creek	84%	7%	78%	9%	74%	6%	76%	8%
LCO Phase I	1. West Line Creek 2. Mine Service Area West 3. Line Creek u/s of West Line Creek	100%	11%	100%	16%	100%	7%	100%	16%
LCP Phase II	1. Dry Creek u/s of the East Tributary	100%	0%	100%	0%	100%	4%	100%	6%
EVO	1. Bodie Creek 2. Gate Creek 3. Erickson Creek	64%	17%	65%	15%	67%	18%	88%	26%
Total			75%		78%		75%		91%

EVO = Elkview Operations; FRO-N = Fording River Operations North; FRO-S = Fording River Operations South; GHO = Greenhills Operations; LCO = Line Creek Operations; u/s = upstream; % = percent.

3 Identification of Mitigation

The methods used to develop the 2019 IPA are described in this section, based on the mitigation options outlined in Annex C. Mitigation required to meet the short, medium and long-term SPOs at Order Stations and, to the extent possible, Compliance Limits at Compliance Points for both the Planned Development Scenario and Permitted Development Scenario were identified. The SPOs and Compliance Limits defined in *EMA* Permit 107517 are summarized in Tables 3-1 and 3-2, respectively.

The hydraulic capacity, nitrate design load removal and timing of the mitigation included in the 2019 IPA were estimated using a six-step modelling process:

1. Identifying the total hydraulic capacity and nitrate design load removal required to meet long-term SPOs and Compliance Limits at Order Stations and compliance points under the Planned Development Scenario.
2. Phasing the mitigation over time to meet short- and medium-term SPOs and Compliance Limits at Order Stations and compliance points under the Planned Development Scenario.
3. Applying the mitigation sequence from Step 2 to the Permitted Development Scenario.
4. Adjusting the mitigation, as required, to meet the short-, medium- and long-term SPOs and Compliance Limits at Order Stations and compliance points under the Permitted Development Scenario.
5. Optimizing the mitigation sequence to reduce projected concentrations in excess of limits for the Permitted Development Scenario.
6. Verifying that the mitigation sequence from Step 5 yields projected concentrations that would be at or below the short-, medium- and long-term SPOs and Compliance Limits at Order Stations and compliance points for the Planned Development Scenario.

The process used to estimate the timing, hydraulic capacity and nitrate design load removal of the mitigation included in the 2019 IPA began with the Planned Development Scenario, because mine plans for the Planned Development Scenario were available earlier in the 2019 IPA process than mine plans for the Permitted Development Scenario. Total hydraulic capacity and total nitrate design load removal for each AWTF were identified prior to phasing the mitigation over time to constrain the number of combinations of hydraulic capacities and nitrate design load removals that required evaluation. The clean water diversions identified in Annex D were included in the evaluation (i.e., were accounted for in the RWQM). Each step is discussed in more detail below.

3.1 Step 1 – Identifying Total Hydraulic Capacity and Nitrate Design Load Removal for the Planned Development Scenario

In the 2017 RWQM, AWTF sizing is defined by hydraulic capacity and nitrate design load removal. Hydraulic capacity, expressed in terms of cubic metres per day (m^3/d), refers to the amount of water a facility can treat. With biological AWT, the projected nitrate load entering a facility influences retention time and removal performance; there is a limit to the nitrate load a facility can receive while still achieving the desired level of treatment. This limit is referred to as the nitrate design load removal, expressed in terms of kilograms per day (kg/d), and is the maximum nitrate mass that a facility can accept and still achieve expected removal rates.

Table 3-1 Site Performance Objectives at Order Stations as Established in Permit 107517

Order Station (EMS Number)	Description	Constituent	Monthly Average Site Performance Objectives and Effective Date		
			Short-term	Medium-term	Long-term
GH_FR1 (0200378)	Fording River downstream of Greenhills Creek	Selenium	-	63 µg/L by December 31, 2019	57 µg/L by December 31, 2023
		Nitrate[(a)]	20 mg/L Immediately	14 mg/L by December 31, 2019	11 mg/L by December 31, 2023
		Sulphate	429 mg/L Immediately	-	-
LC_LC5 (0200028)	Fording River downstream of Line Creek	Selenium	-	51 µg/L by December 31, 2019	40 µg/L by December 31, 2023
		Nitrate[(a)]	18 mg/L Immediately	10 mg/L by December 31, 2019	-
		Sulphate	429 mg/L Immediately	-	-
GH_ER1 (0206661)	Elk River upstream of Boivin Creek	Selenium	19 µg/L Immediately	-	-
		Nitrate	3 mg/L Immediately	-	-
		Sulphate	309 mg/L Immediately	-	-
EV_ER4 (0200027)	Elk River upstream of Grave Creek	Selenium	23 µg/L Immediately	-	-
		Nitrate	4 mg/L by December 31, 2019	3.5 mg/L by December 31, 2025	3.0 mg/L by December 31, 2028
		Sulphate	429 mg/L Immediately	-	-
EV_ER1 (0200393)	Elk River downstream of Michel Creek	Selenium	19 µg/L Immediately	-	-
		Nitrate	3 mg/L by December 31, 2019	-	-
		Sulphate	429 mg/L Immediately	-	-
RG_ELKORES (E294312)	Elk River at Elko Reservoir	Selenium	19 µg/L Immediately	-	-
		Nitrate	3 mg/L by December 31, 2019	-	-
		Sulphate	429 mg/L Immediately	-	-
RG_DSELK (E300230)	Koocanusa Reservoir	Selenium	2 µg/L Immediately	-	-
		Nitrate	3 mg/L Immediately	-	-
		Sulphate	429 mg/L Immediately	-	-

mg/L = milligram per litre; µg/L = microgram per litre.

(a) SPOs for nitrate at GH_FR1 as of 2023 and LC_LC5 as of 2019 are hardness dependent based on the following formula: Level 1 benchmark for the Fording River N as mg/L = $10^{1.0003\log 10(\text{hardness})-1.52}$ where hardness is in mg/L of $CaCO_3$. Values in the table above were calculated based on a hardness of 360 mg/L.

Table 3-2 Monthly Average Limits at Compliance Points as Established in Permit 107517

Compliance Point (EMS Number)	Description	Constituent	Monthly Average Limits and Effective Date		
			Short-term	Medium-term	Long-term
FR_FRCP1 (E300071)	FRO Compliance Point	Selenium	130 µg/L Immediately	90 µg/L by December 31, 2019	61 µg/L by December 31, 2023
		Nitrate	27 mg/L Immediately	19 mg/L by December 31, 2019	13 mg/L by December 31, 2023
		Sulphate	580 mg/L Immediately	620 mg/L by December 31, 2019	650 mg/L by December 31, 2023
GH_FR1 (0200378)	GHO Fording River Compliance Point	Selenium	80 µg/L Immediately	63 µg/L by December 31, 2019	57 µg/L by December 31, 2023
		Nitrate	20 mg/L Immediately	14 mg/L by December 31, 2019	11 mg/L by December 31, 2023
		Sulphate	429 mg/L Immediately	-	-
LC_LCDSSLCC (E297110)	LCO Compliance Point	Selenium	80 µg/L Immediately	50 µg/L by December 31, 2015	29 µg/L by December 31, 2033
		Nitrate	14 mg/L Immediately	7 mg/L by December 31, 2015	3 mg/L by December 31, 2033
		Sulphate	429 mg/L Immediately	-	-
GH_ERC (0300090)	GHO Elk River Compliance Point	Selenium	15 µg/L Immediately	-	8 µg/L by December 31, 2027
		Nitrate	3 mg/L Immediately	-	3 mg/L by December 31, 2027
		Sulphate	309 mg/L Immediately	-	-
EV_HC1	EVO Harmer Creek Compliance Point	Selenium	45 µg/L Immediately	57 µg/L by December 31, 2017 (interim)[a]	Requires development[a]
		Nitrate	4 mg/L Immediately	16 mg/L by December 31, 2017	8 mg/L by December 31, 2021
		Sulphate	300 mg/L Immediately	380 mg/L by December 31, 2017	450 mg/L by December 31, 2021
CM_MC2	CMO Compliance Point	Selenium	19 µg/L Immediately	-	-
		Nitrate	5 mg/L Immediately	-	-
		Sulphate	500 mg/L Immediately	-	-
EV_MC2	EVO Michel Creek Compliance Point	Selenium	28 µg/L Immediately	20 µg/L by December 31, 2021	19 µg/L by December 31, 2025
		Nitrate	6 mg/L Immediately	6 mg/L by December 31, 2021	6 mg/L by December 31, 2025
		Sulphate	429 mg/L Immediately	-	-

CMO = Coal Mountain Operations; EVO = Elkview Operations; FRO = Fording River Operations; GHO = Greenhills Operations; LCO = Line Creek Operations; mg/L = milligram per litre; µg/L = microgram per litre.

(a) The Compliance Limits for selenium are determined following the process outlined in Section 2.7.1 of Permit 107517. Establishment of the Compliance Limits requires written approval by the Director.

In the 2017 RWQM, source waters targeted for treatment are directed to each treatment facility sequentially from the source with the highest selenium concentration to the source with the lowest, until the hydraulic capacity is reached, the nitrate design load removal of the treatment facility is reached, or all available sources are treated. If the hydraulic capacity or the nitrate design load removal of the treatment facility is reached before all available sources are treated, then excess water bypasses the treatment facility and continues to be discharged to the receiving environment through the source tributary. Thus, the selenium and nitrate load removed by a given AWTF is dependent, within the 2017 RWQM, on the hydraulic capacity and nitrate design load removal assigned to the facility; hence, the focus in Step 1 on these two attributes.

Step 1 involved the following activities:

- Identifying the hydraulic capacity required to meet long-term limits at the FRO, LCO and EVO Michel Creek compliance points.
- Combining the hydraulic capacities for FRO, LCO and EVO with hydraulic capacities for LCO Dry Creek and GHO as per the IIP (i.e., initial treatment capacity of 7,500 m3/d at both LCO Dry Creek and GHO).
- Adjusting mitigation as required to meet long-term SPOs and Compliance Limits at Order Stations and compliance points.
- Identifying estimated nitrate design load removal.

Most of the waste rock in the Elk Valley resides upstream of the FRO, EVO and LCO compliance points, and those compliance points are also independent of one another (i.e., they are not located upstream or downstream of one another). As a result, initial activities could proceed in parallel, with a focus on identifying the hydraulic capacity required to meet Compliance Limits and SPOs in the upper Fording River, Line Creek and Michel Creek.

The hydraulic capacities and fully effective dates at FRO and EVO were initially set to reflect the design basis for the first phases of the FRO AWTF-S and EVO AWTF (Table 3-3). At LCO, the hydraulic capacity and fully effective date of the first phase of the WLC AWTF were set to reflect current operations (Table 3-3). Hydraulic capacity was then added incrementally, with the 2017 RWQM being run under weekly 1-in-10-year low, average and 1-in-10-year high flow conditions. Model output was processed to generate monthly average concentrations of selenium and nitrate for each flow condition, and maximum monthly average concentrations of selenium and nitrate from all three flow conditions were identified. Maximum monthly average concentrations of selenium and nitrate were compared to long-term Compliance Limits, with the objective of identifying the appropriate hydraulic capacity that resulted in maximum monthly average concentrations at or below the corresponding long-term Compliance Limit (Table 3-4). The timeframe considered was from the date when the corresponding long-term Compliance Limit was effective to the end of the planning period (i.e., 2037).

Once total hydraulic capacity at FRO, EVO and LCO was identified, it was combined with 7,500 m^3/d of capacity at LCO Dry Creek and GHO (Table 3-3). Projected monthly average concentrations of selenium and nitrate at Order Stations and remaining compliance points were compared to long-term SPOs and Compliance Limits, respectively. Hydraulic capacities were then adjusted, as required, to produce maximum monthly average concentrations that met long-term SPOs and Compliance Limits with the smallest amount of total hydraulic capacity. This activity included evaluations of whether hydraulic capacities at LCO Dry Creek and GHO could be adjusted while still meeting downstream Compliance Limits and SPOs, as well as whether hydraulic capacities at FRO, LCO and EVO needed to be increased to meet downstream SPOs.

Nitrate design load removals were estimated following the identification of total hydraulic capacity. The nitrate design load removal at each AWTF was initially set to the maximum monthly average nitrate load of water entering the facility. The 2017 RWQM was run iteratively with total hydraulic capacities remaining unchanged, but with nitrate design load removals decreasing from one model run to the next. The purpose of this exercise was to identify the lowest nitrate design load removal that could be applied to each AWTF without resulting in changes to projected concentrations of selenium and nitrate at Order Stations and Compliance Points (Table 3-5).

Sources targeted for treatment were those outlined in Table 3-3. Assumed effluent concentrations and water availabilities were as per the planning basis for conditions prior to 2025 (Tables 3-6 and 3-7).

Table 3-3 Mitigation in the 2017 Regional Water Quality Model used as a Starting Point for the Development of the 2019 Implementation Plan Adjustment for the Planned Development Scenario

Sources Targeted for Treatment	Treatment Facility	Total Water Volume Treated (m^3/d)	Associated Diversions and Conveyance of Mine-Influenced Water[(a)]	Year Fully Effective in RWQM
LCO West Line and Mine Services Area West	WLC Phase I	7,100	Convey a portion of West Line Creek and a portion of MSAW to AWTF	5,500 m^3/d on February 1, 2016
			Discharge to Line Creek	1,600 m^3/d on December 31, 2019
GHO Swift, Cataract and FRO Kilmarnock	Fording River South Phase I	20,000	Diversion of Upper Kilmarnock Creek Convey Swift and Cataract and the mine-influenced portion of Kilmarnock to the AWTF	December 31, 2021
			Discharge to the Fording River	
EVO Bodie, Gate, Erickson	Elkview Phase I	20,000	Convey mine-influenced water from Bodie, Gate and Erickson to the AWTF	September 30, 2022
			Discharge to Erickson Creek	
FRO Clode, Swift North Spoil, Swift Pit	Fording River North Phase I	TBD	Convey mine-influenced water to the AWTF	December 31, 2023
			Discharge to the Fording River	
LCO Line Creek	WLC Phase II	TBD	Diversion of Upper Line Creek, Horseshoe Creek and No Name Creek Convey mine-influenced water to the AWTF	December 31, 2024
			Discharge to Line Creek	
FRO Kilmarnock	Fording River South Phase II	TBD	Convey Swift and Cataract and the mine-influenced portion of Kilmarnock to the AWTF	December 31, 2025
			Discharge to the Fording River	
EVO Erickson	Elkview Phase II	TBD	Convey mine-influenced water to the AWTF	December 31, 2026
			Discharge to Erickson Creek	
GHO West Spoil and Greenhills Creek	Greenhills	7,500	Convey mine-influenced water to the AWTF	December 31, 2027
			Discharge to Thompson Creek	
LCO Dry Creek	LCO Dry Creek	7,500	Convey mine-influenced water to the AWTF	December 31, 2029
			Discharge to the Dry Creek	

AWTF = Active Water Treatment Facility; EVO = Elkview Operations; FRO = Fording River Operations; GHO = Greenhills Operations; LCO = Line Creek Operations; MSAW = Mine Services Area West; RWQM = Regional Water Quality Model; TBD = to be determined; WLC = West Line Creek; m^3/d = cubic metre per day.

(a) The diversion of Upper Kilmarnock Creek was modelled to be fully effective and operational by December 31, 2020, with a maximum capacity of 10,000 m^3/d. The diversion of Upper Line Creek and Horseshoe Creek was modelled to by fully effective and operational by December 31, 2024, with a maximum capacity of 35,000 m^3/d. The diversion of No Name Creek was modelled to be fully effective and operational by December 31, 2024, with a maximum capacity of 7,000 m^3/d. See Annex D for details on the selection of clean water diversions.

Table 3-4 Example of How Required Hydraulic Capacities were Identified

Model Run Number	Hydraulic Capacity	Nitrate Design Load Removal	Projected Maximum Monthly Selenium Concentration	Long-term Limit
1	20,000	-	64	61
2	25,000	-	62	61
3	30,000	-	60	61
4	35,000	-	59	61
5	40,000	-	59	61

Note: Shading denotes the required hydraulic capacity.

Table 3-5 Example of How Required Nitrate Design Load Removals were Identified

Model Run Number	Hydraulic Capacity	Nitrate Design Load Removal	Projected Maximum Monthly Selenium Concentration	Long-term Limit
1	30,000	-	60	61
2	30,000	1,500	60	61
3	30,000	1,400	60	61
4	30,000	1,300	60	61
5	30,000	1,200	60	61
6	30,000	1,100	61	61
7	30,000	1,000	62	61

Note: Shading denotes the required nitrate design load removal.

Table 3-6 Treated Effluent Concentrations without Consideration of Improvements over Time

Constituent	Effluent Concentration
Selenium	30 µg/L or 95% removal if influent greater than 600 µg/L
Nitrate as N	2 mg/L[(a)]
Sulphate	Addition of 20 mg/L to influent concentration[(b)]

N = nitrogen; µg/L = micrograms per litre; mg/L = milligrams per litre.

(a) Effluent nitrate concentration is 1.0 mg/L at West Line Creek Phase I.

(b) Addition of 20 mg/L of sulphate to treated effluent for West Line Creek Phase I, Fording River South Phase I, Elkview Phase I and Fording River North Phase I. At all other treatment facilities, the effluent sulphate concentration is equal to the influent concentration.

Table 3-7 Water Availabilities and Intake Efficiency without Consideration of Improvements over Time

Treatment Facility	Sources Targeted for Treatment	Water Availability (%)	Intake Efficiency (%)
Fording River North	Clode Creek, Swift North Spoil and Swift Pit	80%	95%
Fording River South	Swift Creek and Cataract Creek	95%	95%
	Kilmarnock Creek	75%	95%
Greenhills	West Spoil (Leask, Wolfram and Thompson Creeks)	95%	95%
	Upper Greenhills Creek	75%	95%
West Line Creek	West Line Creek and Line Creek upstream of West Line Creek	95%	95%
	Mine Services Area West	90%	95%
LCO Dry Creek	Dry Creek	99%	95%
Elkview	Bodie Creek and Gate Creek	95%	95%
	Erickson Creek	90%	95%

LCO = Line Creek Operations; % = percent.

3.2 Step 2 - Phasing Mitigation over Time for the Planned Development Scenario

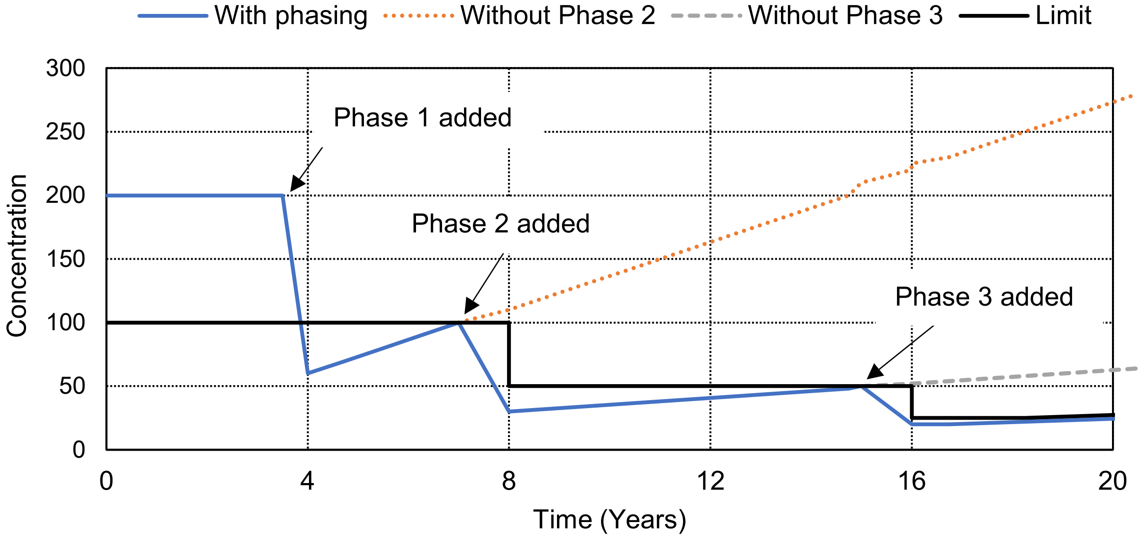
The results of Step 1 provided an estimate of the total hydraulic capacity and nitrate design load removal required to meet long-term Compliance Limits and SPOs. Step 2 involved phasing the total hydraulic capacity over time to meet, to the extent possible, short- and medium-term Compliance Limits, SPOs and the timelines specified in Permit 107517 for meeting the long-term Compliance Limits and SPOs for both selenium and nitrate.

This exercise started with setting the timing for the facilities where schedules are fixed:

- WLC AWTF back in operation at 7,100 m^3/d by the end of December 2019.
- Phase 1 of the FRO AWTF-S set to be fully effective by the end of December 2021.
- Phase 1 of the EVO AWTF set to be fully effective by the end of September 2022.

Subsequent phases and treatment at other locations were then added to the 2017 RWQM in time to maintain instream concentrations at or below SPOs and, to the extent possible, Compliance Limits. This process is illustrated in Figure 3-1.

Figure 3-1 Conceptual Illustration of Process used to Phase Mitigation



Phasing was conducted with a focus on selenium. Priority was placed on meeting short, medium and long-term SPOs, and then meeting short- and medium-term Compliance Limits to the extent possible. Projected nitrate concentrations were compared to Compliance Limits and SPOs after an initial phased configuration had been developed, which resulted in minor modifications.

Step 2 was completed unconstrained by considerations of the time required to design, permit, safely build and commission / ramp up individual treatment facilities and two-year spacing between treatment facilities. Such considerations were incorporated into Step 4.

3.3 Step 3 - Applying Mitigation to the Permitted Development Scenario

In Step 3, the inputs to the 2017 RWQM were modified to reflect changes to site conditions from the Planned Development Scenario to the Permitted Development Scenario. Modifications included changes to waste rock deposition schedules (i.e., moving from existing, permitted and planned projects under the Planned Development Scenario to existing and permitted projects under the Permitted Development Scenario) and an extension to the time period under consideration (see Section 1.3 of the main report).

The time period under consideration was 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, as described in Section 1.3 of the main report. Year 2053 corresponds to a time at which all of the waste rock considered in the Permitted Development Scenario has been deposited and the lag associated with that rock has passed (i.e., all of the waste rock is contributing selenium and sulphate load). The following five mine pits are projected to be at some stage of filling in 2053:

- Swift Pit at FRO
- Cougar Phase 4-6 and Cougar Phase 7-11 at GHO
- Burnt Ridge North 3 at LCO, and

- Natal Pit at EVO.

The filling of these mine pits with water is explicitly included in the 2017 RWQM. These pits are large, and they are modelled using reservoir elements. Each reservoir element has a set volume, and they begin to fill with water once activity in each pit is complete. They then begin to release water to the receiving environment once full. For each mine pit, the 2017 RWQM was run for:

- low, average and high flows prior to the end of mining (i.e., before mine pits begin to fill)
- average flows for all watersheds upstream of the mine pits while the mine pits are filling
- low, average and high flows from the projected decant date onward

Once the modifications were complete, the 2017 RWQM was run under the Permitted Development Scenario using the phased mitigation from Step 2. Monthly average concentrations at Order Stations and compliance points were summarized; time series plots were developed, and the resulting information was reviewed to identify locations and times when projected concentrations of selenium or nitrate were above SPOs or Compliance Limits.

3.4 Step 4 - Altering Mitigation under the Planned Development Scenario

Step 4 involved adding additional mitigation to the phased configuration developed for the Planned Development Scenario in Step 2 and evaluated for the Permitted Development Scenario in Step 3. Mitigation was added to address the following:

- Permitted activities that are modelled to occur after 2037.
- Loading associated with permitted waste rock placed prior to 2037, but that begins to influence the receiving environment after 2037 as a result of lag.
- The time required to design, permit, safely build, commission and ramp up individual treatment facilities and the frequency at which treatment facilities can be implemented. Consistent with the EVWQP and based on experience to date, a frequency of one treatment facility every two years (after the commissioning of Phase I of FRO AWTF-N) was used, as described in Section 4.1.2 of the main report.
- Expected improvements in selenium effluent quality over time (i.e., selenium effluent concentrations moving from 30 μg/L or 95% removal when influent concentrations are greater than 600 μg/L to 20 μg/L by 2025/2026, depending on the facility [Table 3-8]).
- Increased source water availability at FRO after 2033 (Table 3-9).

As in Steps 1 and 2, mitigation was initially added and then altered in an iterative fashion. The 2017 RWQM was run under weekly 1-in-10-year low, average and 1-in-10-year high flow conditions. Model output was processed to generate monthly average concentrations of selenium and nitrate for each flow condition, and maximum monthly average concentrations of selenium and nitrate across all three flow conditions were identified. Maximum monthly average concentrations of selenium and nitrate were initially compared to SPOs, followed by long-term Compliance Limits and then short and medium-term Compliance Limits. Projected maximum monthly average concentrations of selenium and nitrate were screened using an approach similar to that outlined in Step 2, taking into consideration total capacity requirements, sizing of individual treatment phases, the frequency at which projected concentrations were higher than short- or medium-term Compliance Limits and the magnitude of projected exceedances.

Table 3-8 Effluent Selenium Concentration Considering Improvement over Time

Treatment Facility	Effluent Selenium Concentration		
	20 µg/L or 95% removal if influent greater than 400 µg/L	30 µg/L or 95% removal if influent greater than 600 µg/L	20 µg/L
West Line Creek	to December 31, 2024	-	from January 1, 2025 onward
Fording River South	-	to December 31, 2024	from January 1, 2025 onward
Elkview	-	to December 31, 2024	from January 1, 2025 onward
Fording River North	-	to December 31, 2025	from January 1, 2026 onward
Greenhills	-	-	from December 31, 2031 onward
LCO Dry Creek	-	-	from December 31, 2037 onward

LCO = Line Creek Operations; µg/L = micrograms per litre; - = not applicable.

Table 3-9 Water Availabilities and Intake Efficiency Considering Improvement over Time

Treatment Facility	Sources Targeted for Treatment	Water Availability until December 31, 2033	Water Availability from January 1, 2034 onward	Intake Efficiency
Fording River North	Clode Creek, Swift North Spoil and Swift Pit	80%	95%	95%
Fording River South	Swift Creek and Cataract Creek	95%	95%	95%
	Kilmarnock Creek	75%	95%	95%
Greenhills	West Spoil (Leask, Wolfram and Thompson Creeks)	95%		95%
	Upper Greenhills Creek	75%		95%
West Line Creek	West Line Creek and Line Creek upstream of West Line Creek	95%		95%
	Mine Services Area West	90%		95%
LCO Dry Creek	Dry Creek	99%		95%
Elkview	Bodie Creek and Gate Creek	95%		95%
	Erickson Creek	90%		95%

LCO = Line Creek Operations; % = percent.

3.5 Step 5 - Optimizing the Mitigation Sequence

Step 5 was initiated following a review of the results of Step 4 with Communities of Interest (COIs). Concerns were raised about the frequency and duration over which concentrations of selenium and nitrate at the LCO compliance point and selenium at the EVO Michel Creek compliance point were projected to be above Compliance Limits. Step 5 involved altering the timing and sizing of several facilities (i.e., FRO AWTF-S Phase II, EVO AWTF Phase II and WLC AWTF Phase III) to reduce the frequency and duration of projected concentrations above Compliance Limits in Michel Creek and Line Creek.

3.6 Step 6 - Verifying the Mitigation Sequence with the Planned Development Scenario

Step 6 involved applying the mitigation sequence produced in Step 5 back onto the Planned Development Scenario. The purpose of this exercise was to verify that projected concentrations of selenium and nitrate were at or below SPOs and Compliance Limits at a similar frequency to those under the Permitted Development Scenario during the 20-year planning period, which they were (as outlined below in Section 5 of the main report).

4 References

Teck (Teck Coal Limited). 2014. Elk Valley Water Quality Plan. Submitted to the British Columbia Ministry of Environment, July 2014.

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