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For Teck Metals Ltd.

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Draft Wide Area Remediation Plan for the Environmental Management Area related to Historical Aerial Emissions from Teck Trail Operations

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Signature Page

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Contents

Signature Page **2**

Notice **3**

Definitions and Acronyms **9**

Units of Measure **17**

1. Introduction **18**

1.1 Objective 19

1.2 Scope 19

1.3 WARP Boundaries 20

1.4 Applicable Land Use 23

2. Project History **25**

2.1 Timeline 25

2.2 Supporting Programs 27

2.2.1 Programs Supporting Human Health and the Environment 28

2.2.2 Programs under Regulatory Permits 33

3. Site Investigation Summary **35**

3.1 Soil 36

3.1.1 Soil Assessment Approach and Methodology 36

3.1.2 Soil Assessment Results 40

3.2 Groundwater 48

3.3 Surface Water and Sediment 53

3.4 Data Management System 56

4. Risk Assessment Summary **58**

4.1 Human Health Risk Assessment 58

4.1.1 Summary of Human Health Risk Assessment 58

4.1.2 Summary of 2024 HHRA for Lead 62

4.1.3 Risk-Based Standard for Pb for the EM Area 72

4.2 Ecological Risk Assessment 74

4.2.1 Summary of Ecological Risk Assessments 74

4.2.2 Risk-Based Remediation Targets 86

5. Remedial Options Evaluation **92**

5.1 Remedial Options for Protection of Human Health 92

5.1.1 Residential Land 92

5.1.2 Remediation Prioritization Background 93

Contents (Cont'd)

5.1.3 Remediation Planning and Options 93
5.1.4 Considerations for Urban Parks 97
5.1.5 Considerations for Agricultural Land 97
5.1.6 Property Development Program 97

5.2 Remedial Options for Protection of Ecological Receptors in Wildlands 98
5.2.1 Potential Restoration Options 99
5.2.2 Factors Influencing the Feasibility of Restoration Treatments 104
5.2.3 Pilot Studies to Inform Treatments 106

6. Remediation and Confirmation of Remediation Methodology 108

6.1 Soil Remediation to Protect Human Health 108
6.1.1 Soil Assessment 108
6.1.2 Prioritization of Residential Properties for Remediation 108
6.1.3 Pilot Block Remediation 110
6.1.4 Remediation Planning and Implementation 111
6.1.5 Summary of Remediation Completed 115
6.1.6 Property Development Program 121
6.1.7 Other Soil Management 123

6.2 Ecological Risk Management Plan 123
6.2.1 General Tasks in the ERMP Process and Framework for Prioritizing Areas for Treatment 124
6.2.2 Monitoring Methods and Schedule 129
6.2.3 Offsetting 130
6.2.4 ERMP Components in Progress 131
6.2.5 Summary 131

7. Consultation 132

7.1 Previous Public Consultation Summary 132
7.1.1 Human Health 132
7.1.2 Ecological Risks 134

7.2 WARP Indigenous Engagement Summary 134

7.3 WARP Public Consultation Summary 134

7.4 Ongoing Public Engagement 135

8. Performance Verification 136

8.1 Performance Verification for Protection of Human Health 136
8.1.1 Principal Risk Controls 136
8.1.2 Determining the Applicable Remediation Type 138
8.1.3 Performance Verification Actions 138

Contents (Cont’d)

8.1.4 Data Management and Reporting for Performance Verification 141
8.1.5 Review of Pb Exposure Reduction Progress 141
8.2 Performance Verification for Wildlands Restoration 141

9. Reporting 145

9.1 Annual Reporting 145
9.2 Five-Year Review 146

10. Schedule 149

11. References 150

In Text Figures

Figure 1.3-1: The Environmental Management Area (EM Area) Boundary 22
Figure 1.4-1: Simplified map of land use classifications for the EM Area 24
Figure 2.1-1: Dates major smelter improvements, and health and ecological assessment and mitigation activities began 26
Figure 2.2-1: Environmental programs which contribute to WARP 27
Figure 2.2-2: Components of the Trail Area Health & Environment Program 29
Figure 2.2-3: Process for identifying polygons included in the Ecological Risk Management Plan 33
Figure 3.0-1: Conceptual site model of the Teck smelter and surrounding area 35
Figure 3.1-1: Soil sampling locations and the resulting change in the Area of Interest for the Terrestrial ERA 37
Figure 3.1-2: Summary of soil assessment in residential neighbourhoods of the EM Area 39
Figure 3.1-3: Correlation equation for XRF and laboratory Pb 40
Figure 3.1-4: Concentrations of Pb and Zn (mg/kg) in aerially-deposited particulate matter measured during the passive moss monitoring program, from winter 1998 to fall 1999 (from Goodarzi et al. 2006, Figure 3) 42
Figure 3.1-5: Measured and interpolated arsenic, cadmium, lead and zinc in soil (adapted from SNC-Lavalin, 2018) 43
Figure 3.1-6: Summary of Pb concentrations in surface soil on residential properties 45
Figure 3.1-7: Summary of soil metal concentrations compared to depth of sample in Trail 47
Figure 3.2-1: Concentrations of As and Cd in shallow groundwater bearing zone at and near Trail Operations 51
Figure 3.2-2: Concentrations of Pb and Zn in shallow groundwater bearing zone at and near Trail Operations 52
Figure 3.3-1: The AOI for the Aquatic ERA showing the portion of the Columbia River and its tributaries included in the Study Area. Locations where tributaries enter the Columbia River are shown. 54
Figure 4.1-1: Trend of blood lead (Pb) geomean by area, years 1991 to 2023 (from Interior Health, 2023) 64
Figure 4.1-2: Human health conceptual site model for lead (Pb) from Teck Trail Operations 67

Contents (Cont'd)

In Text Figures (Cont'd)

Figure 4.1-3: Human health conceptual site model – Potential lead (Pb) exposure pathways in the home environment (THEP, 2022) ... 68
Figure 4.1-4: Location of neighbourhoods within the City of Trail ... 70
Figure 4.1-5: Mean annual blood lead (Pb) levels (µg/dL), stack emissions (100s of tonnes Pb) and total suspended particulate (µg/m^3) (1991 to 2023) ... 71
Figure 4.2-1: Polygons with plant community impacts and metal concentrations in soil greater than and less than risk-based concentrations (RBCs) ... 76
Figure 4.2-2: Locations of wetlands assessed in the final wetland ERA ... 79
Figure 5.2-1: Measured and interpolated surficial soil pH across the EM Area ... 101
Figure 6.1-1: Remediation guide used for homeowners receiving residential soil replacement ... 114
Figure 6.1-2: Map of remediated residential and community properties (soil replacement or yard improvement) completed up to the end of 2023 ... 118
Figure 6.1-3: Average soil concentration over time in neighbourhoods receiving soil remediation ... 121
Figure 6.2-1: Major tasks in the overall ERMP process ... 124
Figure 6.2-2: Process for prioritizing areas for restoration ... 125
Figure 6.2-3: Ownership of polygons included in the WARP ... 126
Figure 6.2-4: Percent of WARP polygons containing potentially impacted plant communities ... 127
Figure 9.2-1: Six steps of an Adaptive Management Process (Nyberg, 1999) ... 147
Figure 9.2-2: Adaptive management process for the WARP ... 148
Figure 10.0-1: Proposed schedule of the 5 year WARP cycle ... 149
Figure 3: Example of an 11.6 ha polygon with a 50 m x 50 m sampling grid and 50 target sample locations ... 2
Figure 4: 100 m^2 grid overlay applied to determine sampling plot locations and achieve a sampling intensity of 1 plot/ha in polygons ... 4

In-Text Tables

Table 1.3-1: Concentration limit for each specified substance ... 21
Table 1.4-1: Land use classification in the Environment Management Area ... 23
Table 4.1-1: Summary of Phased HHRA for Other Metals ... 59
Table 4.2-1: Summary of ERA phases, their purposes and conclusions ... 80
Table 5.1-1: Summary of risk management options on residential yards ... 95
Table 5.2-1: Restoration Treatment Options to Address Factors Limiting Plant Community Recovery ... 99
Table 5.2-2: Polygons with baseline sampling completed and pilot treatments initiated ... 106
Table 6.1-1: Steps and accountable parties for remediation of prioritized properties ... 112
Table 6.1-2: Summary of the number of residential properties that received remedial actions by year (2008 to 2023) completed on residential properties ... 116
Table 6.1-3: Summary of remedial actions completed on community properties (parks, daycares, schools) ... 117
Table 6.1-4: Summary of excavation information from residential properties with full soil replacement ... 120
Table 6.1-5: Summary of properties remediated through the property development program ... 122
Table 6.2-1: Potential factors impacting restoration success and adaptive management solutions ... 130
Table 8.1-1: Summary of performance verification activities for protecting human health ... 139
Table 8.2-1: Summary of performance verification activities for protecting plant communities ... 143

Contents (Cont'd)

Tables

1a: Summary of Analytical Results for Surface Soil -Total Metals - Compared to Low Density Residential Land Use (RLHD) Standard

1b: Summary of Analytical Results for Surface Soil -Total Metals - Compared to High Density Residential Land Use Standard

2: Summary of Analytical Results for Surface Soil -Total Metals - Compared to Agricultural Land Use Standard

3: Summary of Analytical Results for Surface Soil -Total Metals - Compared to Commercial Land Use Standard

4: Summary of Analytical Results for Surface Soil -Total Metals - Compared to Industrial Land Use Standard

5: Summary of Analytical Results for Surface Soil -Total Metals - Compared to Urban Parkland Land Use Standard

6: Summary of Analytical Results for Surface Soil -Total Metals - Compared to Reverted Wildlands Land Use Standard

Appendices

A: ENV Response to SNC-Lavalin 2018 Soil Concentration Limits for Establishing the WARP Boundary

B: Summary of LCEMP Remediation Sampling Plan from Machmer et al. (in prep.)

C: AtkinsRéalis Notice to Reader

Definitions and Acronyms

This list includes definitions and acronyms that are commonly used in the Wide Area Remediation Plan and associated programs. As such, they are used in the text of the report and in the associated tables.

	Acronym (if available)	Definition
95% Upper Confidence Limit of the Mean	95% UCLM	A statistical value which, when repeatedly calculated from samples of a population, is equal to or exceeds the true average value 95% of the time
Approval in Principle	AiP	A legal instrument in British Columbia issued when a remediation plan has been reviewed and approved
Arsenic	As	One of four specified substances in the WARP (along with cadmium, lead and zinc)
Aquatic Effects Monitoring Program	AEMP	Activities to evaluate the ecological condition in the Canadian portion of the Columbia River as part of a permit requirement for effluent discharge from Trail Operations; formerly referred to as Aquatic Receiving Environment Monitoring Program
BC Property Identification Number	BC PID	A nine-digit parcel identifier that uniquely identifies a parcel in the BC land title register
Biogeoclimatic Ecosystem Classification	BEC	A system that considers climate, site characteristics, vegetation and soil to identify climax (mature) forest ecosystems
Blood Lead (Pb) Level	BLL	A measure of lead (Pb) in blood in micrograms (µg) per decilitre (dL)
Cadmium	Cd	One of four specified substances in the WARP (along with arsenic, lead and zinc)
Consolidated Mining and Smelting	CM&S	The Trail smelter company name from 1906 to 1966
Contaminant of Concern	COC	A substance present in media at a site at levels that exceed prescribed numerical standards and the applicable land, water, vapour and sediment use, as described in in CSR section 11
Contaminant of Potential Concern	COPC	Any contaminant for which the maximum concentration exceeds the appropriate screening benchmark (e.g., guideline and/or standard) in a risk assessment. In Trail, the COPC included: arsenic (As), cadmium (Cd), lead (Pb), zinc (Zn) and other metals
Community Properties	CP	Properties within the Environmental Management Area that are not child-occupied

	Acronym (if available)	Definition
		(i.e., no children younger than 12 years old reside at or visit the property) or are public properties like parks
Columbia River Integrated Environmental Monitoring Program	CRIEMP	Activities completed by stakeholders from government and industry to assess the ecological health status of the Canadian portion of the Columbia River
Contaminated Sites Regulation	CSR	The regulation under the *Environmental Management Act* that governs contaminated sites and activities such as soil assessment and remediation
Central Tendency Exposure	CT Exposure	An estimate of average or typical exposure
Daycare		A residential or commercial space that provides child-minding services for children younger than 12 years old
Duplicate Personal Identification number	DUP PID	Identifies properties where more than one Trail Area Health & Environment Program (THEP) PID is present in the data set. This occurs when more than one Family Identification Number is associated with a THEP PID (e.g., multi-family dwellings and daycare facilities). These Dup PIDs need to be excluded to obtain an accurate summary of results
Environmental Management Area	EM Area	A term used in the CSR to identify a geographic area comprised of many individual parcels that are contaminated from a known source or sources
EM Area Concentration Limits		The EM Area Concentration Limits are defined for As, Cd, Pb and Zn in surficial soils based on background concentrations, site-specific factors and matrix standards. The concentration limits define the boundary of the EM Area and soil with concentrations above these limits may be a result of deposition of historical aerial emissions from Teck Trail Operations, or other sources. They were approved by ENV.
Environmental Management Act	EMA	The main law governing the management of the environment in British Columbia, to protect human health and the quality of water, land and air in the province
Ecological Risk Assessment	ERA	A process for evaluating the likelihood that adverse effects may occur or are occurring to non-human organisms, as a result of being exposed to chemicals and other stressors

	Acronym (if available)	Definition
Exposure Term	ET	A fraction of the week that the property is used by children (e.g., 5 days/week = 0.71). The ET for a full-time primary residence is 1
Ecological Risk Management Plan	ERMP	The components of the WARP addressing wildlands
Geogenic		Related to natural, geological sources
Ground Cover Evaluation	GCE	A visual assessment tool that collects ground cover information used to prioritize yards for remediation
Ground Cover Improvement		Landscaping or lawn care activities that cover bare soils in the yard with grass or other materials
Geographic Information System	GIS	A tool designed to store, manipulate, analyze, manage and present spatial data
Human Health Risk Assessment	HHRA	A process that evaluates the likelihood that adverse effects may occur in people, as a result of exposure to chemicals
Hazard Index	HI	A ratio calculated to evaluate the potential for non-cancer health hazards to occur from exposure to a contaminant; Estimated as the total exposure estimate (sum of all exposure pathways) divided by the non-cancer toxicity reference value (TRV)
Hazard Quotient	HQ	A ratio calculated to evaluate the potential for non-cancer health hazards to occur from exposure to a contaminant; Estimated as the exposure estimate divided by the non-cancer toxicity reference value (TRV)
Interior Health	IH	A branch of the BC government that provides publicly funded health services to residents of the Southern Interior; Participates on the Trail Area Health & Environment Committee; Is responsible for delivering the Family Health Program within THEP
Intelligence Quotient	IQ	A measure of ability to reason and solve problems
Lead	Pb	One of four specified substances in the WARP (along with arsenic, cadmium and zinc)

	Acronym (if available)	Definition
Level of Refinement	LOR	A phase in the ERA that uses more complex approaches (e.g., modelling and field work) to assess impacts than the previous phase. Each LOR focuses on those plants and animals that the previous LOR suggested were at risk of experiencing impacts
Lower Columbia Ecosystem Management Program	LCEMP	Activities to restore land-based ecosystems impacted by the Trail smelter where metals in soil are not the cause of impacts
Max Lead	Max Lead	A discrete sample with the highest Pb soil concentration within a set of soil samples collected from a given PID
Medical Health Officer	MHO	The provincial employee responsible for carrying out legislated requirements under the Public Health Act and other related Acts and regulations, as well as other community health programs
Mitigation Measure		A tangible conservation action taken to avoid, minimize, restore on-site, or offset environmental impacts
Ministry of Environment and Climate Change Strategy	ENV	Branch of the British Columbia government responsible for managing and protecting land, water, air and living resources Previous acronym was MoE, which may be present in historical documents associated with the WARP
Ministry of Forests	FOR	A branch of the British Columbia government responsible for stewardship of Provincial Crown land and natural resources, and protection of BC’s archaeological and heritage resources
US National Health and Nutrition Examination Survey	NHANES	
Notification of Independent Remediation/Notice of Completion of Independent Remediation	NIR/NCIR	Forms required under the *Environmental Management Act*
Park or Urban Park		Outdoor public spaces such as playgrounds, sport fields and walking trails, which are frequented by children of all ages

	Acronym (if available)	Definition
Primary Play Area		An area in a yard or park frequented by children younger than 12, as indicated by, but not limited to, the presence of outdoor play equipment (e.g., sandboxes, swing set), toys or other children's possessions, observations of play patterns (e.g., worn areas of the lawn) or information provided by parents, residents, care givers or property owners
Prioritization Strategy		Approach for prioritizing child-occupied properties for soil assessment and remediation based on age of the child, quality of ground cover and Pb concentration
Priority Status Group		Priority assignment given to a property based on the prioritization strategy (e.g., P1, P2, P3 or NP)
Property Development Program	PDP	A program to provide soil management to owners and proponents of properties before or during a re-development project is undertaken
Property Identification Number	PID	A unique number assigned in the database that identifies a parcel within the Environmental Management Area
Particulate Matter (< 10 µm in diameter)	PM_{10}	Solid particles in the air that are smaller than 10 µm in diameter
Post-Remediation Pb		Pb concentration from a composite sample of the replaced backfill collected from a PID after remediation activities have been completed
Practicable		Capable of being carried out in action, recognizing a host of considerations or circumstances that must be balanced to determine feasibility
Primary Prevention		An intervention system used to lower the incidence of a risk occurring. For example, seat belts in cars would be considered a primary prevention. In the case of exposure to Pb dust in Trail, primary prevention includes tools (and other supports) to reduce dust in homes, so a child is not exposed to the dust in the first place
Prioritization Screening Concentration (ppm)	PSC	The Pb screening concentration used to classify a property in the prioritization framework; Based on age of the children on the property (e.g., 400 ppm for properties with young children; 2,000 ppm for properties with older children where ground cover is poor)

	Acronym (if available)	Definition
Performance Verification Plan	PVP	Describes the controls necessary to confirm risk-based standards are, and continue to be, met at a site, and details the actions taken to verify these risk controls are implemented and maintained
Reasonably Anticipated Land Use	RALU	A realistic future purpose or function of an area (e.g., residential, commercial, agricultural, wildland)
Remediation		Action to eliminate, limit, correct, counteract, mitigate or remove any contaminant, or the adverse effects of any contaminant on the environment or human health. It includes, but is not limited to: (a) Conducting preliminary site investigations, detailed site investigations, analysis and interpretation, which can include tests, sampling, surveys, data evaluation, risk assessment and environmental impact assessment; (b) Evaluating alternative methods of remediation; (c) Preparing a remediation plan, including a plan for removing soil or soil relocation from the site; (d) Implementing a remediation plan; (e) Monitoring, verifying and confirming whether the remediation complies with the remediation plan, applicable standards and requirements imposed by a director; and (f) Other activities prescribed by the BC Minister of Environment.
Remediation Extent		The extent of the remediation services completed on the property in a given year (partial remediation, full soil replacement, yard improvement)
Remediation Status		Classification of a property based on the latest remediation work completed on the property
Reasonable Maximum Exposure	RM Exposure	An estimate of exposures at the upper end of the exposure distribution (i.e., reasonable worst-case)
Seral Stage		Vegetation in a forested landscape that is at a particular age, due to natural disturbance (e.g., wildfire, insects, disease)

	Acronym (if available)	Definition
Site Series		A subdivision of the BEC biogeoclimatic subzone/variant that describes sites capable of producing the same mature or climax vegetation
Soil Assessment		The process of collecting discrete and composite surface soil samples at a given PID. Results are used to calculate the 95% upper confidence limit of the mean (UCLM) and Max Pb. Areas included in an assessment include general yard, vegetable garden, ornamental gardens, play areas and drip zone
Soil and Groundwater Management Program	SGMP	Activities to address conditions within the Teck Trail Operations Site footprint and groundwater migration off-site, including localized areas of ecological impact in the Columbia River
Soil Management Program	SMP	A program that addresses soil within the Trail EM Area
Sulphur Dioxide	SO_2	A colourless, reactive gas produced during combustion of sulphur-containing fuels and industrial operations involving sulphur-containing materials e.g., metal-smelting facilities
Trail Area Health & Environment Committee	THEC	Provides governance for the THEP and is a partnership between the local community, Teck, Interior Health and the BC Ministry of Environment and Parks
Trail Area Health & Environment Program	THEP	A comprehensive community-led program that has evolved continuously since 1988 to improve the Trail Area environment and promote and protect the health of the community related to smelter operations
THEP Database		A purpose-built database system to store and provide access to information related to PIDs and FIDs that are part of the Community Program Office component of the THEP
Toxicity Reference Value	TRV	In HHRA, the level of a substance prescribed by a health agency that a person can be exposed to without appreciable health effects In ERA, a maximum estimate of exposure to a substance which would not elicit an unacceptable adverse toxicological effect
Total Suspended Particulate	TSP	Airborne dust
Property Type	TYPE	Identifies the type of land parcel (residential, park, commercial)

	Acronym (if available)	Definition
Upper Cap Concentration	UCC	The concentration of a substance which when present in the exposure zone of soil, water, sediment or vapour, could pose a high risk to the environment or human health
Upper Columbia White Sturgeon Recovery Initiative	UCWSRI	A cooperative program that began in 2000 and which includes Canadian and American federal, provincial and state governments and U.S. Tribes with a common goal of recovering white sturgeon populations
United States Centers for Disease Control	US CDC	Part of the U.S. Department of Health and Human Services that works to protect America from health, safety and security threats in the U.S.
United States Environmental Protection Agency	US EPA	Branch of the U.S. government responsible for protecting human health and the environment
Wide Area Remediation Plan	WARP	A remediation plan, as defined in the CSR, for an environmental management area for one or more specific substances which have originated from one or more sources specified in the plan
Waste Discharge Regulation	WDR	The law under the *Environmental Management Act* that defines what industries, activities and operations require authorizations to discharge or release waste to the air, water and land
X-Ray Fluorescence Analyzer	XRF	A specialized piece of equipment used to screen metals in soil, sediment, rock and paint
Yard improvement	YIMP	Services used to improve ground cover on the property
Zinc	Zn	One of four specified substances in the WARP (along with arsenic, cadmium and lead)

Units of Measure

Hectare	ha	A unit of area, equivalent to 2.47 acres or 10,000 square metres
Metres above sea level	m asl	A unit of measure to describe a location's height, elevation, or altitude
Microgram per decilitre	µg/dL	A unit of measure to report Pb concentrations in blood
Milligrams per kilogram	mg/kg	A unit of measure representing concentration typical for soil. Equivalent to parts per million (ppm)

1. Introduction

Since the late 1890s, the Teck Metals Ltd. (Teck) integrated smelting and refining complex has operated in Trail, BC (Teck Trail Operations). Over the course of this operational history metals have been released to the environment from the facility, and people, plants and animals can be exposed to these metals. If exposures to metals are high enough, there is a risk (chance) of health or ecological effects.

Under the *Environmental Management Act* (EMA), the *Contaminated Sites Regulation* (CSR) outlines the requirements for identifying, assessing and managing sites across the province of British Columbia (BC) where concentrations of chemicals, such as metals, exceed regulatory concentrations. The CSR lays out standards for site identification, assessment and remediation, under the administration of the BC Ministry of Environment and Parks (ENV). The CSR enables the use of a "wide area" approach for sites with many parcels of land whose contaminants came from one or more specific sources, as is the case in the area surrounding Teck Trail Operations.

This Wide Area Remediation Plan (WARP) was developed to satisfy the regulatory requirements for managing metals in the environment that result from historical aerial emissions from Teck Trail Operations. The regulatory mechanism for approving and implementing remediation activities outlined in this WARP is an Approval in Principle. Given the geographic area this WARP encompasses, the remediation activities will take place over many years. The WARP will be reviewed and renewed on a five-year cycle to support adaptive management and refinement.

The WARP is comprised of 11 sections, as follows:

- Section 1 outlines the WARP's objective and scope, geographic boundaries and land uses within those boundaries.
- Section 2 presents a brief history of Teck Trail Operations related to aerial emissions, together with previous assessment and risk management activities related to those emissions, including programs that are complementary to those detailed in this WARP.
- Section 3 presents a summary of site investigation studies, including the methods and results from the assessment of soil, groundwater, surface water and sediment.
- Section 4 presents a summary of the human health and ecological risk assessments, including the risk-based remediation targets.
- Section 5 presents the evaluations of remedial options to address human health and ecological risks.
- Section 6 presents a summary of the remediation process and the methods used to confirm that remediation has been successful.
- Section 7 outlines the consultation planned and conducted on this WARP.
- Section 8 presents the performance verification plan.
- Section 9 describes the reporting that will result from the work described in this WARP.
- Section 10 outlines the schedule of activities to occur annually and every 5 years, as a result of this WARP.

Section 11 presents the references cited in the WARP.

In addition to these sections, a series of appendices provides more detail on the components described in the WARP.

1.1 Objective

The overall objective of this WARP is to outline the strategy for and approaches to reducing human health and ecological risks resulting from exposure to metals sourced from historical aerial emissions from Teck Trail Operations. To accomplish the overall objective, this WARP documents the results of site investigation, human health risk assessment (HHRA), ecological risk assessment (ERA) and the remediation and risk management activities completed to date. Ongoing and future remediation and risk management activities are then outlined. The ongoing activities are land-use specific, and they use risk-based prioritized approaches to manage risks.

In addition, this WARP documents the role and importance of community engagement and consultation, ongoing learning through pilot studies and adaptive management, as well as the periodic re-evaluation of this plan to verify that it remains effective in managing risks over time.

1.2 Scope

The scope of this WARP is to present remediation and management strategies and approaches to address risks to human health and the environment that are associated with specific off-site impacts resulting from substances in historical aerial emissions from Teck Trail Operations. This WARP addresses:

- Deposition of historical aerial emissions from Teck Trail Operations (source);
- Arsenic, cadmium, lead and zinc (specified substances);
- The Environmental Management Area (affected geographic area); and
- Soil, groundwater, surface water and sediment (potentially affected media).

The results of HHRA and ERA, summarized in Section 4, support addressing arsenic (As), cadmium (Cd), lead (Pb) and zinc (Zn) as the specified substances addressed in this WARP, even though other metals have also been identified in emissions from Teck Trail Operations. This scope is consistent with the ENV Director approved EM Area Boundary derivation and the associated concentration limits for soil contamination that originated from historical aerial emissions from Teck Trail Operations, issued in 2018 (ENV, 2018).

Teck's Trail Operations site is excluded from this WARP. Contamination within the Teck Trail Operations Site footprint and groundwater migration off-site are both addressed through independent remediation programs.

With respect to human health, the remediation measures outlined in the WARP focus on decreasing Pb exposure by remediating Pb contaminated soil (and the inherent potential for soil to contribute to Pb in airborne dust). There are other important sources of Pb in the Trail EM Area, notably fugitive dust emissions from Teck Trail Operations which is addressed directly through existing regulatory authorizations. To support a holistic approach to Pb exposure reduction aligned with health outcomes, the WARP incorporates a Medical Health Officer's recommendation to guide remediation of Pb, as outlined in Section 4.1.3.

The WARP outlines linkages to other regulatory and voluntary programs that contribute to managing and reducing human exposures and ecological impacts, specifically:

- The Trail Area Health & Environment Program (THEP), which includes key programs that address human health risk management. These programs include:
  - The Air program component (e.g., stack and fugitive emissions regulated under three ENV permits; and dust control in the community);

  - Voluntary primary prevention programs and education for the community (e.g., Healthy Families Healthy Homes, Pb Safe Renovation); and,
  - Blood lead (Pb) monitoring and follow-up programs for families and children.
- The Lower Columbia Ecosystem Management Program (LCEMP), which addresses impacts to plant communities resulting from historical smelter emissions of metals and sulphur dioxide (SO_2). Because methods to address plant community impacts are similar regardless of metal concentrations in soil, LCEMP includes all areas with plant community impacts. However, this WARP specifically addresses only areas with plant community impacts and metal concentrations in soil high enough to potentially be a cause or contributor to those impacts. Impacts to plant communities where metal concentrations in soil are lower may be due to factors such as low soil pH, low soil nutrients or low soil organic matter;
- The Aquatic Effects Monitoring Program (AEMP), an ongoing program that monitors the aquatic health of the Lower Columbia River downstream of Teck Trail Operations and is a permit requirement related to discharging effluent.

Details on these programs and their linkages to this WARP are provided in Section 2.2, Supporting Programs.

1.3 WARP Boundaries

An Environmental Management Area (EM Area)[1] is a geographic area that comprises many individual sites or parcels contaminated by specific substances that are associated with a known source or sources and attributable to one or more responsible parties. The EM Area associated with Teck Trail Operations is delineated based on concentration limits determined for As, Cd, Pb and Zn in surficial soils, attributable to historical emissions from Teck Trail Operations (SNC-Lavalin 2018) and approved by ENV. These limits are included as Appendix A. To determine the concentration limits, the following factors were considered for each substance:

- Background data from ENV Protocol 4 (ENV, 2017[2]) and other supplemental reference data;
- Mandatory site-specific factors in CSR Schedule 3.1; and
- Matrix standards in CSR Schedule 3.1 based on a site-wide median soil pH.

The concentration limits, together with the rationale for selecting them, are summarized in the table below.

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1 An EM Area was previously referred to as wide area site as defined in ENV's Environmental Protection Division Procedure 8 – Definition of Acronyms for Contaminated Sites. November 1, 2017.

2 The method applied in SNC Lavalin 2018 is consistent with Protocol 4, March 2023 update.

Table 1.3-1: Concentration limit for each specified substance

Specified Substance	Most Stringent Standard (mg/kg)	Rationale
Arsenic (As)	19.7	Site-specific data from Goodarzi et al. (2002), using Protocol 4, Option 2a (establishing background based on supplemental reference data)
Cadmium (Cd)	3	Most stringent matrix standard based on a site-wide median soil pH of 7.0 – < 7.5 in the surrounding soils below 1.0 m depth Standard is for the protection of groundwater flow to freshwater aquatic life
Lead (Pb)	120	Most stringent and mandatory matrix standard, and the regional background established by ENV
Zinc (Zn)	450	Most stringent matrix standard for the protection of soil invertebrates and plants.

Once the concentration limits were determined, the EM Area was delineated using soil data, by amalgamating the outer concentration limit of each specified substance, as shown below in Figure 1.3-1. The total EM Area is approximately 25,400 ha. Although it is an area where one or more of the specified substances from historical aerial emissions may be found, not all properties within the EM Area are contaminated sites and/or require risk management actions.

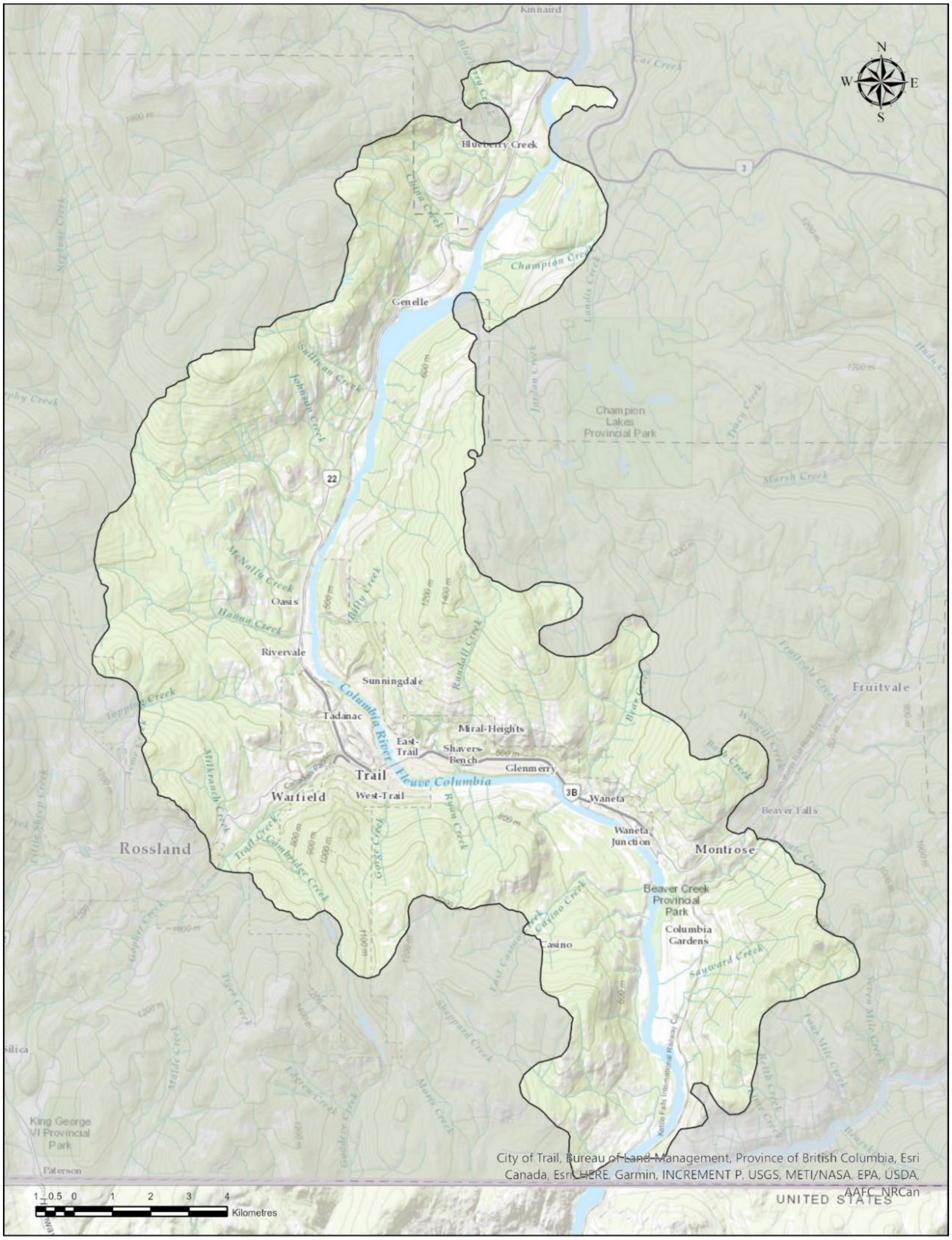

Figure 1.3-1: The Environmental Management Area (EM Area) Boundary

1.4 Applicable Land Use

Within the geographical region of the EM Area, all land use classifications under the CSR are present. The land use classifications, the number of properties for each classification and their approximate land area within the EM Area are provided in Table 1.4-1, below. A simplified map showing the land use classifications in the EM Area is presented in Figure 1.4-1. Data were obtained from the Regional District of Kootenay Boundary and the Regional District of Central Kootenay and are updated periodically. Updates include land use changes, property subdivisions and any other updates provided to the cadastral information system.

Notes about the table below:

- The table includes assumptions for areas that were unclassified in the cadastral information provided;
- All land use classifications are subject to change based on official community plans and bylaws for each jurisdiction;
- Roadways and utility right of ways are classified as Industrial;
- Surface water bodies have been excluded from the area calculations;

The land use descriptions are consistent with definitions in the CSR.

Table 1.4-1: Land use classification in the Environment Management Area

Land Use Classification	Number of Properties	Approximate Area (Ha)	Comments
Residential Land (RL)	6,608	3,000	Low- and high-density residential properties and institutional properties including schools and daycares
Urban Parks (PL)	473	400	Public and private parkland
Agricultural (AL)	150	1,000	Farm properties including barn, crop and range land where the land is used primarily for agricultural production
Commercial (CL)	795	800	Commercial areas of the City of Trail, Warfield and within the RDKB
Industrial (IL)	158	700	Industrial areas excluding Teck Operations lands
Wildlands (WL)	646	9,500 (+ ~ 10,000 ha crown land with no parcels)	Undeveloped private and Crown land

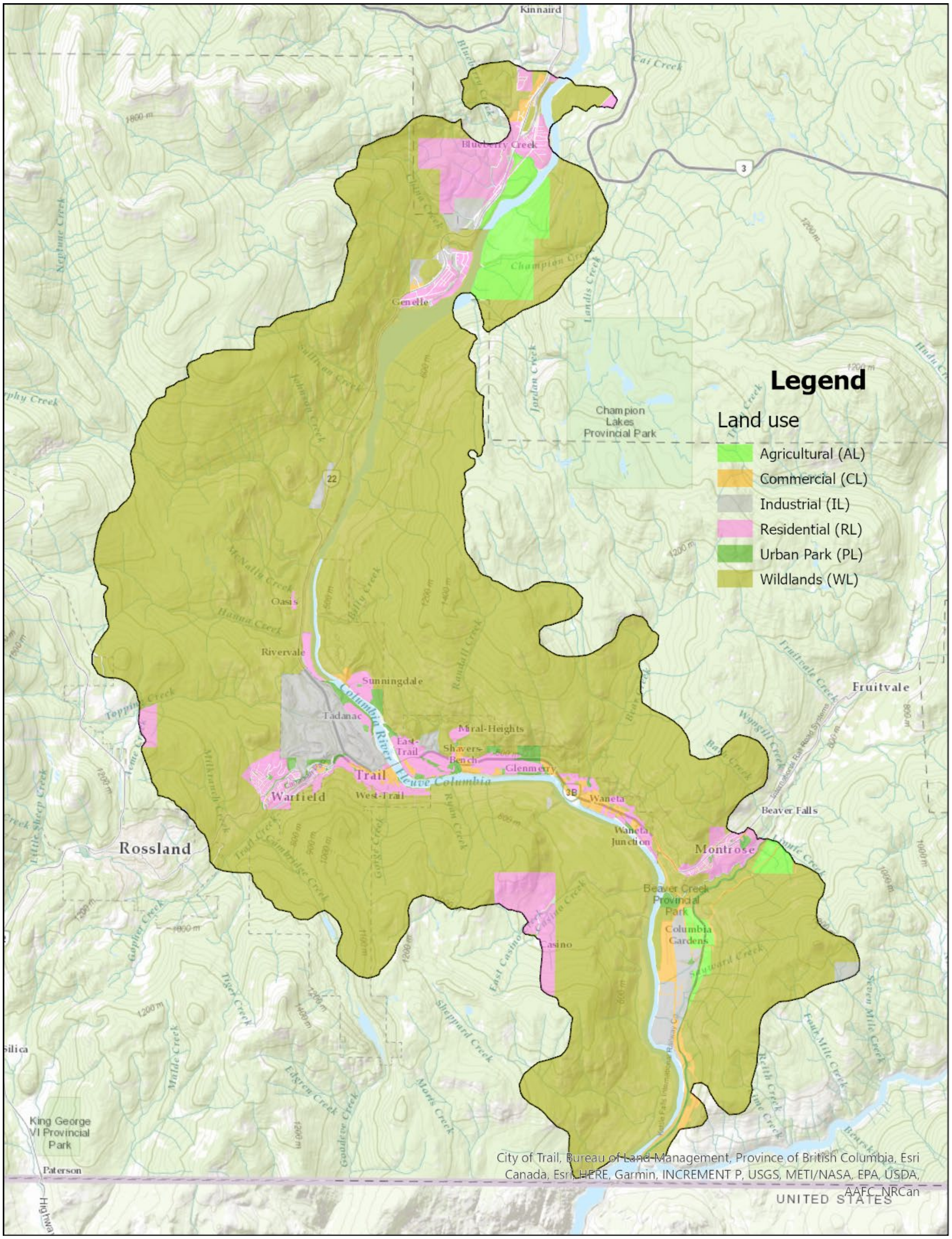

Figure 1.4-1: Simplified map of land use classifications for the EM Area

2. Project History

A brief history of Teck Trail Operations is presented below, together with key upgrades that have resulted in significant improvements in aerial emissions. A history of assessment and risk management activities related to those emissions is also presented, including a brief description of programs that are complementary to those detailed in this WARP.

2.1 Timeline

Teck Trail Operations, one of the largest integrated zinc and lead smelting and refining complexes in the world, is located within the municipal boundaries of the City of Trail. The operation started in 1896 as a small copper-gold smelter treating concentrates from the mines in Rossland and Red Mountain. In 1906, the smelter, along with several of the Rossland mines and a small lead-silver mine in the East Kootenay, joined to form the Consolidated Mining and Smelting Company of Canada Limited (CM&S or Cominco). In 1916, CM&S developed an electrolytic zinc method and began zinc production in Trail. In the 1920s, CM&S expanded and increased the production of Pb and Zn. This brought a need for more workers at the smelter and increased the local population. In the 1930s, CM&S expanded again with the construction of a chemical fertilizer plant and an increase in Zn and Pb production (Trail Historical Society, 2019). In July 2001, Cominco merged with Teck Corporation forming Teck Cominco Limited. The name changed to Teck Metals Ltd. in 2009.

Metallurgical operations have been present in Trail for over a century. As a result, there is a long history of environmental and health monitoring related to metals. In 1977, the Trail Modernization Program was initiated, and since then over $1.7 billion has been invested to improve operational and environmental performance. Stack Pb emissions have been reduced by 99.5% since the installation of the KIVCET[3] Smelter in 1997 and subsequent operations improvements. Later, in 2012, a Fugitive Dust Reduction Program began when it was recognized as the best way to further reduce Pb in airborne dust in the community. A summary of some of the major smelter operational improvements and management actions aimed at reducing emissions is presented in Figure 2.1-1.

In response to concerns raised regarding Pb health risks to children, the Trail Lead Task Force (the Task Force) was formed in 1990. It included representatives from the provincial environment and health agencies, Teck and the community. The Mayor of Trail was the Chair. During the 1990s, the Task Force undertook comprehensive studies to evaluate sources, exposures and the health risks associated with Pb in the Trail area. It began monitoring blood lead (Pb) levels (BLL) in children in 1991. The Task Force concluded its work in 2001 (Hilts et al., 2001) and made the following recommendations:

- Interior Health should continue blood lead (Pb) testing in children aged 6 to 36 months, continue providing counselling and services for families with children who either have or are at risk of elevated BLL, and continue community and pre-school education programs about preventing and reducing exposure to Pb.
- Teck should further reduce facility emissions and increase reporting to the public about plans and progress. It should continue greening around the smelter property and in the community, continue environmental monitoring of air and street dust, continue addressing soil case by case and implement a new program to advise and assist people doing excavation, construction, demolition or renovation.
- The City of Trail should continue to flush and sweep the streets, continue dust control on alleys and other unpaved areas and continue greening of bare public areas.

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[3] This is a Russian acronym for Oxygen Flash Cyclone Electro Thermal Process.

A Trail Area Health & Environment Committee (THEC) should be established to monitor, coordinate and advise on implementing the Task Force's recommendations.

In 2001, the Task Force concluded. The THEC and, eventually, the Trail Area Health & Environment Program (THEP) were created to continue its work.

While human health was the focus of the Task Force, THEC and THEP, there has also been a long history of focus on the environment in the Trail Area. From the start of metallurgical operations at Trail, sulphur dioxide (SO_2) and metals have been emitted into the air, as summarized in Golder (2007a). From 1896 through the 1940s, SO_2 emissions were high enough to impact vegetation cover from south of Castlegar to the U.S. border and to prevent revegetation from occurring near the smelter. Controlling emissions began when high stacks were built in 1925 and 1927, following which three sulphuric acid plants and fertilizer plants were constructed and became fully operational in 1932 (see summaries in Archibold [1974] and Hodson [1971]). Around this time, the company also began controlling the amount of SO_2 that was emitted under certain weather conditions. Emissions declined from the 1940s to the 1990s, and vegetation regrowth began in the 1940s. The most significant decline in SO_2 emissions occurred after the KIVCET smelter was installed in 1997 (Golder, 2007a), following which emissions were thought to be low enough to not restrict sensitive vegetation in the Trail environment from recovering (Enns, 2002). Vegetation recovery has been documented in Hodson (1971), Archibold (1974), Enns (2002) and Golder (2007a), among others. Along with emissions reductions, revegetation activities have been ongoing since 1948. They include applying lime to raise soil pH (Hodson, 1971) and planting grass, shrubs and trees. In 2000, ecological risk assessments were initiated and conducted in a phased manner. Section 4.2 describes the methods, purpose and conclusions of each phase.

Key milestones in smelter improvements, and risk assessment and mitigation activities relevant to this WARP are shown on the timeline in Figure 2.1-1.

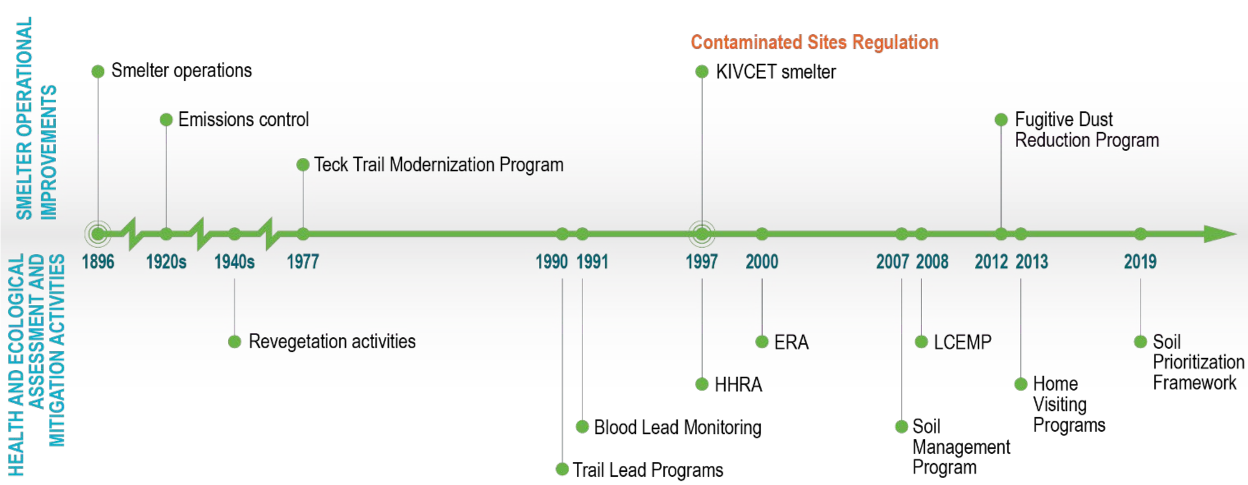

Figure 2.1-1: Dates major smelter improvements, and health and ecological assessment and mitigation activities began

2.2 Supporting Programs

This WARP focusses on Pb, As, Cd, and Zn within the EM Area outside the Teck Trail Operations Site, as described in Section 1.2. Not included in the scope are contemporary environmental discharges associated with Teck Trail Operations and historical contamination on the Teck Trail Operations Site.

In this section, a series of regulatory and non-regulatory frameworks are described, which, while not necessarily components of the WARP, are in place to manage potential influences on human health and the environment associated with historical and contemporary emissions from Teck Trail Operations. The activities and programs described in this section are not directly required under a WARP, but form part of comprehensive programs required to support the Medical Health Officer (MHO) recommendation to reduce children's potential exposure to Pb and address ecological impacts in the EM Area. This section is provided for information purposes only.

The nature of Pb and other metal exposure in the community of Trail and the EM Area is complex. It has therefore led to numerous efforts to reduce metal concentrations in the environment and address impacts beyond those associated with soil. The THEP, LCEMP and AEMP are the result of efforts to create comprehensive programs to improve ecosystems and the health of people in the EM Area. These programs complement the WARP by addressing human and ecological exposures and effects pathways and/or substances not directly addressed by the Contaminated Sites Regulation. Combined, the WARP and these supporting programs form a comprehensive adaptive management approach to continuously reduce exposure to and effects of contaminants in the EM Area. These programs are described in Section 2.2.1.

In addition to these efforts, Teck Trail Operations is solely or partially responsible for several programs that address operational and legacy issues related to current and past emissions to air, land and water. Some of these are independent remediation programs at the smelter site, and others through Environmental Management Act Part 2 (waste discharge authorizations). To drive continuous improvement, Teck Trail Operations has programs in place to improve effluent and air emissions. Programs under regulatory permits are described in Section 2.2.2.

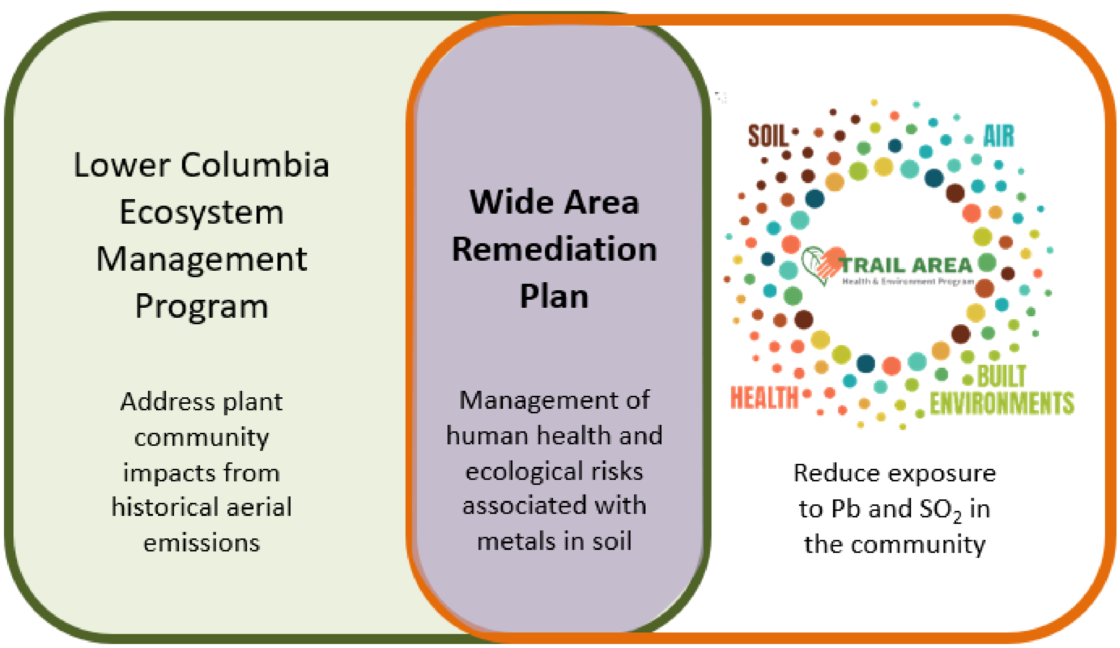

Figure 2.2-1: Environmental programs which contribute to WARP

2.2.1 Programs Supporting Human Health and the Environment

Programs to support the WARP and help address potential impacts to human health and the environment have been ongoing for many decades, and these programs will continue under the WARP. With respect to human health, the comprehensive Trail Area Health & Environment Program will support the MHO recommendation as a holistic approach to further reduce children's exposure to Pb in the community. With respect to plant community impacts, the Lower Columbia Ecosystem Management Program will continue to develop and implement restoration strategies on wildlands in the EM Area to improve wildlife habitat and biodiversity. These programs encompass a comprehensive adaptive management approach to continuously improve outcomes. They are described below, and how they relate to the WARP is shown in Figure 2.2-1.

2.2.1.1 Trail Area Health & Environment Program (THEP)

The THEP supports the community of Trail and surrounding areas to live, work and play in an area that has been influenced by smelter air emissions for more than 125 years.

The THEP has evolved along with the emerging science and understanding of Pb exposures in the Trail area. Since the inception of the program in the 1990s, specialists such as toxicologists, epidemiologists and public health physicians and nurses have collaborated through the program alongside community members and municipal leaders. This collaboration is integral to the success of the program: it has ensured the emerging science around Pb and children's health is integrated into the development and refinement of THEP; and, has ensured that the program meets the needs of the community supporting high participation and acceptance.

The THEP carries out key components of risk reduction in the program areas of Air, Health, Built Environment and Soil, while involving the community through education and by connecting them to the program areas (Figure 2.2-2).

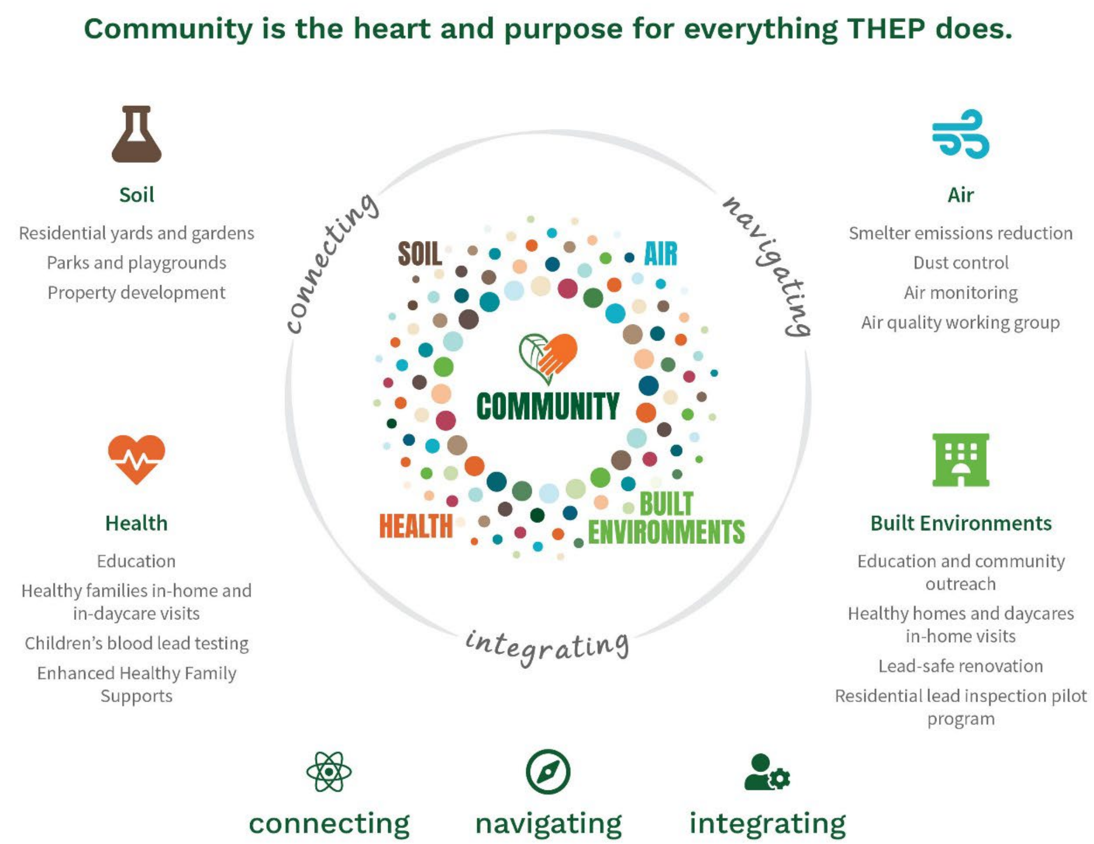

Figure 2.2-2: Components of the Trail Area Health & Environment Program

The Community Program Office located in downtown Trail creates an accessible space for Trail area residents to connect with THEP staff and program offerings. Integral parts of the THEP are clear and transparent communication and connection to the community. Two community newsletters are sent to families in the Trail area each year and radio advertisements promote lead (Pb)-safe lifestyle choices and information about programs. Outreach and communication with the community are ongoing and connect the community with other service providers. The THEP website (thep.ca) provides more information about programs and supports, committee meetings and reports.

2.2.1.1.1 Air

Teck delivers programs for reducing air emissions (fugitive and stack) and monitoring air quality. It also collaborates with the City of Trail on activities to suppress dust in the community. The THEC has an Air Quality Working Group, which is a forum to support collaboration on current and emerging air quality issues.

Teck's comprehensive air monitoring approach incorporates the following:

- Point source emissions from the smelter are monitored by sampling at major sources on the smelter site (e.g., stacks).
- Fugitive emissions at the smelter site are estimated through a comprehensive fugitive emissions inventory every 5 years.

- Ambient air quality in the community is evaluated as follows:
  - **Total airborne dust:** Total suspended particulate and particulate for Pb, As and other airborne metals are collected at two monitoring stations in the Trail area, Butler Park and Birchbank. Readings are taken over 24-hour periods, every 2 days.
  - **Total respirable dust:** Measurements for particles less than 10 µm in diameter (PM10) are taken at four monitoring stations in the Trail area: Butler Park, Birchbank, Warfield and Columbia Gardens. Readings are taken over 24-hour periods, every sixth day.
  - **Settled dust or dustfall:** Settled dust is collected passively in open containers and analyzed monthly for total deposited particulate and metals. Dustfall data are collected at Birchbank, Downtown Trail, Columbia Avenue, Columbia Gardens, Tadanac, Trail Hospital, Glenmerry, Oasis, Stoney Creek, Waneta and Warfield.
  - **Sulphur dioxide (SO_2) gas:** Monitoring occurs at four locations: Butler Park, Birchbank, Haley Park and Columbia Gardens. These stations operate continuously, and real-time data are transmitted back to the process control systems at Teck Trail Operations. If the SO_2 levels begin to climb (such as during a weather inversion), automatic notifications are triggered so that actions can be taken to reduce SO_2 emissions.

The community air monitoring network has evolved over time informed by operational and regulatory changes and supported by data analysis. The comprehensive monitoring approach supports continuous improvement through identification of emissions reduction priorities and evaluation of the effectiveness of emissions control efforts. Results and trends are reported to the THEC, which tracks the progress of air quality improvement initiatives.

A Fugitive Dust Reduction Program was recognized as the best way to further reduce Pb in airborne dust, following the significant reduction in stack emissions achieved through the late 1990s and 2000s. Major investments and operational improvements to reduce fugitive dust started in 2012, including:

- The Smelter Recycle Building, which is almost the size of two Canadian football fields, was constructed in 2016 to enclose the mixing and storage of process feed materials;
- A 10 m high wind fence was installed, reducing dust from areas where feed materials are mixed;
- Wheel washes and truck washes were installed on-site to help reduce materials being tracked onto roads;
- On-site street cleaning was introduced, using street sweepers and water trucks to create a year-round program of roadway sweeping and flushing; and
- Sources of fugitive dust from work activities inside operating plants have been identified and reduced.

To date, the Fugitive Dust Reduction Program has reduced the Pb in airborne dust in the community by 80%.

Teck and the City of Trail collaborate to mitigate dust in the community by implementing dust control measures. These include street sweeping throughout residential neighbourhoods, weekly sweeping and flushing of the downtown core and annual dust suppression of unpaved roads.

2.2.1.1.2 Health

The overall goal of the Health Program is to monitor and reduce health risks from exposure to Pb in the community. This is a key component of supporting the MHO recommendation to further reduce Pb exposure in the community. The Health Program delivers programming directly related to preventing and managing Pb exposure in children (e.g., primary prevention education, voluntary blood lead (Pb) monitoring), along with a holistic approach to promote healthy development in children. Activities within this program include:

- **Healthy Families**: This is a primary prevention, in-home visit that is offered to all families and daycares in THEP Areas 1, 2 and 3[4] with a child 12 months of age or younger. The visits include education, advice and information to minimize Pb exposure. Supports related to the healthy development of the child are provided, with each support promoting a health message related to Pb and healthy development. Educational information includes topics such as nutrition, handwashing, access to public health services for young children and families, and early learning programs. Referrals to other health or social services are provided as needed. Families and daycares are also referred to the Soil and Built Environment Programs (i.e., for soil assessment and/or remediation).
- **Children's Blood Lead (Pb) Testing**: The primary monitoring and evaluation methodology is voluntary blood lead (Pb) testing of children aged 6–36 months in Areas 1, 2 and 3. It is conducted twice a year to monitor progress towards THEC's goal to reduce children's Pb exposure and identify children and families requiring enhanced support. An Interior Health Medical Health Officer (MHO) and epidemiologist review and confirm the results each year.

Enhanced Supports and Services: These provide additional follow up and support for families of children identified with BLLs elevated above the British Columbia Centre for Disease Control (BC CDC) Exposure Investigation Level of 5 µg/dL. Ongoing support is offered to these families throughout the year, including identifying next steps for reducing exposure and retesting BLLs.

2.2.1.1.3 Built Environment Programs

The Built Environment component of the THEP evaluates sources of Pb in the home and other built environments. Dust in the built environment can contain Pb from historical smelter operations and from deteriorating lead (Pb)-based paint. This component of the program works to understand and evaluate Pb sources, and to communicate and support families and property owners to reduce exposure to Pb. It includes three programs.

- **Healthy Homes**: This is a primary prevention program to educate and support residents to promote a safe home environment for young children. In-home visits are offered to expectant families, families with children younger than 36 months of age and new families to the area with children up to approximately 60 months of age. The visit is guided by information and best practices from various agencies including Health Canada, the U.S. HUD, CDC and U.S. EPA. The goal is to help residents identify the best ways to prevent Pb exposure and keep their home healthy and safe.
- **Residential Lead Inspection and Pb-Based Paint Screening**: To better understand Pb exposures within the built environment, residential Pb inspection and indoor and outdoor paint screening have been incorporated as part of the THEP with the goal to better understand the prevalence of non-smelter sources of Pb such as Pb-based paint, water and dust.
- **Lead-Safe Renovation**: This comprehensive program for Pb-safe work practices in residential homes supports homeowners and tenants doing home renovation and construction projects. The program, which is offered for pre-1990 homes in the EM Area, fosters awareness of lead (Pb)-based paint and lead (Pb)-safe home renovation in the broader community. Supports include providing advice and information on Pb dust generated during renovation and construction projects, and supplies are provided free of charge to prevent Pb exposure during renovations.

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[4] THEP Areas refer to groups of neighbourhoods surrounding the smelter. Area 1 includes Casino, Oasis, Warfield and Waneta. Area 2 includes Glenmerry, Shavers Bench and Sunningdale. Area 3 includes East Trail, West Trail, Tadanac and Rivervale.

2.2.1.1.4 Soil Programs

Soil assessment and remediation are covered under the WARP and described in detail in Sections 3, 5 and 6. Although residential properties are a focus of the soil programs, soil assessment and remediation is completed on other properties such as parks, playgrounds, schools and daycares as they are all properties that children frequent. As well, soil programs are available to non-child occupied properties through the block program and commercial and industrial properties as described in Section 3. The WARP will formally regulate the THEP soil management work, outlining a strategy and specific standards for remediation, and approaches that meet the provincial government's legal requirements for contaminated sites management in BC.

2.2.1.2 Lower Columbia Ecosystem Management Program

Historical emissions from Teck Trail Operations impacted plant communities, as mentioned in Section 2.1. The ERA identified where risks to plant communities resulting from smelter emissions could be ruled out, and where plant communities were exhibiting impacts which could be a result of historical smelter emissions. The analysis was facilitated by mapping of plant communities over the ERA Area of Interest (see Section 3.1.1), which is larger than the EM Area. The ERA Area of Interest was divided into more than 2000 smaller areas termed polygons based on biophysical habitat types, to allow assessment of plant communities over a smaller scale. Not all polygons within the ERA Area of Interest, or EM Area, contain plant communities that are impacted from smelter emissions. Also, not all polygons contain metal concentrations in soil that exceed risk-based concentrations protective of plants. However, the EM Area includes polygons with plant communities that are impacted despite metal concentrations in the soil being below risk-based concentrations protective of plants. These areas are thought to be exhibiting ongoing impacts to vegetation as a result of historical SO2 emissions and/or other impacts unrelated to metals in soil such as low soil nutrient levels. Areas with impacted plant communities and soil metal concentrations below risk-based concentrations are not addressed through the WARP. These areas will be addressed voluntarily through the Lower Columbia Ecosystem Management Program (LCEMP) to contribute to Teck's goal of Net Positive Impact. The polygons that are included in the Ecological Risk Management Plan (ERMP) portion of the WARP (see Section 6.2) may be revised over time, based on the results of additional soil sampling and analysis (see Figure 2.2-3), or if risk-based concentrations change in future based on new toxicological information. The risk-based concentrations and methods for the sampling and analysis are documented in the draft report Wildlands Risk-Based Concentrations and Process for Screening Soil Metal Concentrations in LCEMP Polygons (GDWA, 2020).

Discussions on initiating the LCEMP began in 2008. It was envisioned as a collaborative program between Teck, ENV, Ministry of Forests (FOR) and other stakeholders to address terrestrial wildland ecosystems. An LCEMP Steering Committee was formed in 2010 with participants that included ENV, FOR, local Regional Districts (Kootenay Boundary and Central Kootenay), the Kootenay Conservation Program, the Columbia Basin Fish and Wildlife Compensation Program, as well as Teck and its consultants. It was envisioned that the Steering Committee and a Technical Subcommittee would provide technical assistance and recommendations regarding approaches, methods and collaborations, throughout the development, implementation and subsequent performance monitoring phases of the program. Starting in 2024, the LCEMP Steering Committee is proposed to be engaged as the LCEMP Committee, with an updated Terms of Reference and focus (see Section 7). Because the methods and approaches developed to address plant communities are similar regardless of metal concentrations in soil, further details are provided in the ERMP sections of this WARP.

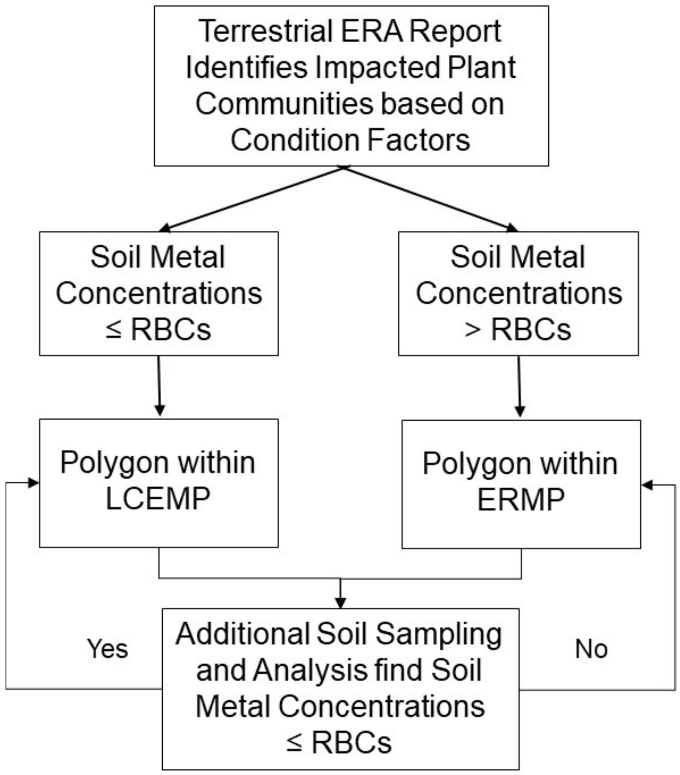

Figure 2.2-3: Process for identifying polygons included in the Ecological Risk Management Plan

2.2.2 Programs under Regulatory Permits

Smelter emissions that are addressed via regulatory permits and associated programs are air emissions and water/effluent discharges.

- **Air emissions:** Teck Trail Operations holds three ENV permits (02690, 02691 and 02692) that regulate air emissions from metallurgical and fertilizer plant facilities. These permits include requirements for continuous monitoring, annual reporting and regulatory limits for point source emissions of the metals addressed in this WARP.
- **Water/Effluent Discharges:** The effluent Teck Trail Operations discharges to the Columbia River is regulated by ENV Permit 02753, which requires an ongoing Aquatic Effects Monitoring Program (AEMP).

The AEMP was developed in consultation with ENV when the Aquatic ERA (Golder, 2010) was completed (see Section 4.2). The Aquatic ERA did not identify wide-scale effects that would require risk management. Its main conclusions were:

- There were no impacts on fish, except for white sturgeon (and impacts on sturgeon were not strongly linked to the smelter);
- There may be localized impacts on the benthic community at two monitoring locations;
- There may be impacts on periphyton within the Initial Dilution Zone and at one other monitoring location; and
- The Aquatic ERA recommended that additional monitoring be completed via the AEMP, because, either there was no strong link between some observed effects and smelter-related metals or there were other possible causes of effects on aquatic species.

Monitoring has been conducted and reported several times since the Aquatic ERA was completed in 2010. The results from AEMP sampling in 2012, 2014, 2016, 2018 and 2021 (Hawes et al., 2014; Hawes & Larratt, 2015; Hawes et al., 2017; Larratt et al., 2019, and Kelly et al., 2023) showed that no adverse responses were detected at the aquatic community-level that would be attributable to the influence of Teck Trail Operations. The AEMP is ongoing.

In addition to the AEMP, Teck supports other regional initiatives by participating in the Columbia River Integrated Environmental Monitoring Program (CRIEMP) and the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI).

3. Site Investigation Summary

The site investigation supports the objective of the WARP, namely, to address metals contamination within the EM Area sourced from historical aerial emissions from Teck Trail Operations (Section 1.2). Specifically, the WARP addresses As, Cd, Pb and Zn, also referred to as the specified substances. The site investigation focussed on metals contamination in surficial soils within the EM Area, and the approach was informed by the mode of contamination (aerial deposition) and the WARP objective of managing risk to both human and ecological receptors.

The contaminant source and migration pathways are reflected in the conceptual site model depicted in Figure 3.0-1. Metal-bearing particulate/dust in aerial emissions from Teck Trail Operations is deposited on exposed surfaces within the EM Area. Deposition is greatest near the smelter in the direction of prevailing winds, which are primarily to the southeast and northwest along the Columbia River Valley. Particulates may settle directly onto exposed soil, vegetation or built structures/pavement overlying the soil. Particulates that settle on built structures or pavement may subsequently be transported to the soil surface by wind or water (rain, snowmelt, irrigation) or human-caused disturbances that resuspend dust (e.g., construction, traffic). Once particulates are in contact with the soil surface, there is limited opportunity for vertical migration into the soil horizon through settlement, mixing (e.g., landscaping, construction, traffic, animal burrowing) and leaching (rain, snowmelt, irrigation). Impacted soil surfaces may also be buried by fill placed over them. Assessment of metal contamination in surface soil to support the WARP is described in Section 3.1.

Potential exists for other environmental media (groundwater, surface water and sediment) to have been affected by historical aerial emissions and, therefore, these media were also assessed. However, the likelihood of lasting impact on these media is inferred to be less than for soil. Sections 3.2 and 3.3 summarize assessment of groundwater, surface water and sediment. Since metals are not volatile or semi-volatile substances, assessment of potential impacts to soil vapour was not required.

Figure 3.0-1: Conceptual site model of the Teck smelter and surrounding area

To support risk assessment, metals concentrations in soil have been assessed across a large part of the Lower Columbia Valley (Section 3.1), and these data have been used to define the EM Area (Section 1.3). The main human health receptor is young children (Section 4) and this has driven the majority of soil investigation work completed on residential properties near the smelter. For ecological risk, plant communities have been the focus.

3.1 Soil

The site investigation approach for soil is described below. It is informed by the mechanism of contamination (aerial deposition), the fate of contaminants in the environment (presence in surface soils) and the most vulnerable receptors (young children and plant communities).

3.1.1 Soil Assessment Approach and Methodology

Soil assessment has focussed on shallow soils for two reasons: the mechanism for impacts to soil is aerial deposition of metals-enriched particulate, and surface soil is a medium with which receptors (young children and plant communities) can routinely come into contact. Soil assessment activities initially took place on residential properties in Trail in the 1990s, to support the Trail Lead Task Force's exposure pathways studies. In the 2000s, sampling was carried out in the surrounding wildlands, agricultural areas and urban areas to inform the ERA. In 2007, a soil assessment program was developed, which standardized assessment methods and then offered soil assessment to residents of Trail, starting in 2008. Soil assessment continues to be offered to residents throughout the EM Area today.

The initial Area of Interest (AOI) for the ERA (Figure 3.3-1) extended along the Columbia River valley, from the International Boundary north to the Brilliant Dam on the Kootenay River and Hugh Keenleyside Dam on the Columbia River. It was approximately defined by the 2,100 m asl contour at the west boundary and the 1,200 m asl contour at the east boundary (i.e., the "height of land" on both sides of the river valley).

In 2001, soil sampling was conducted to refine the AOI and to obtain data for use in the ERA. The strategy for collecting shallow soil samples (0 m to 0.15 m depth) involved systematic, random sampling using a grid sample plan. The sample design used elevation bands and distance rings with a grid overlay. Sampling was reinforced with randomly located sample points within the grid and with the provision that, where variance was high, more detailed sampling would occur. Sample points may have been omitted if they were in an area disturbed by a road, transmission corridor or clear-cut, or if the area was made up of more than 50% bedrock or was located on a slope of 70% or more.

The AOI was redefined by considering the concentrations of metals in soil relative to BC CSR soil standards that were in place at the time. This resulted in an AOI of approximately 40,000 ha, which was about half the original size (Figure 3.3-1). This was documented in the ERA Terrestrial Risk Modelling Level of Refinement (LOR) 3 Report (Intrinsik, 2007), submitted to the ENV for review in 2007.

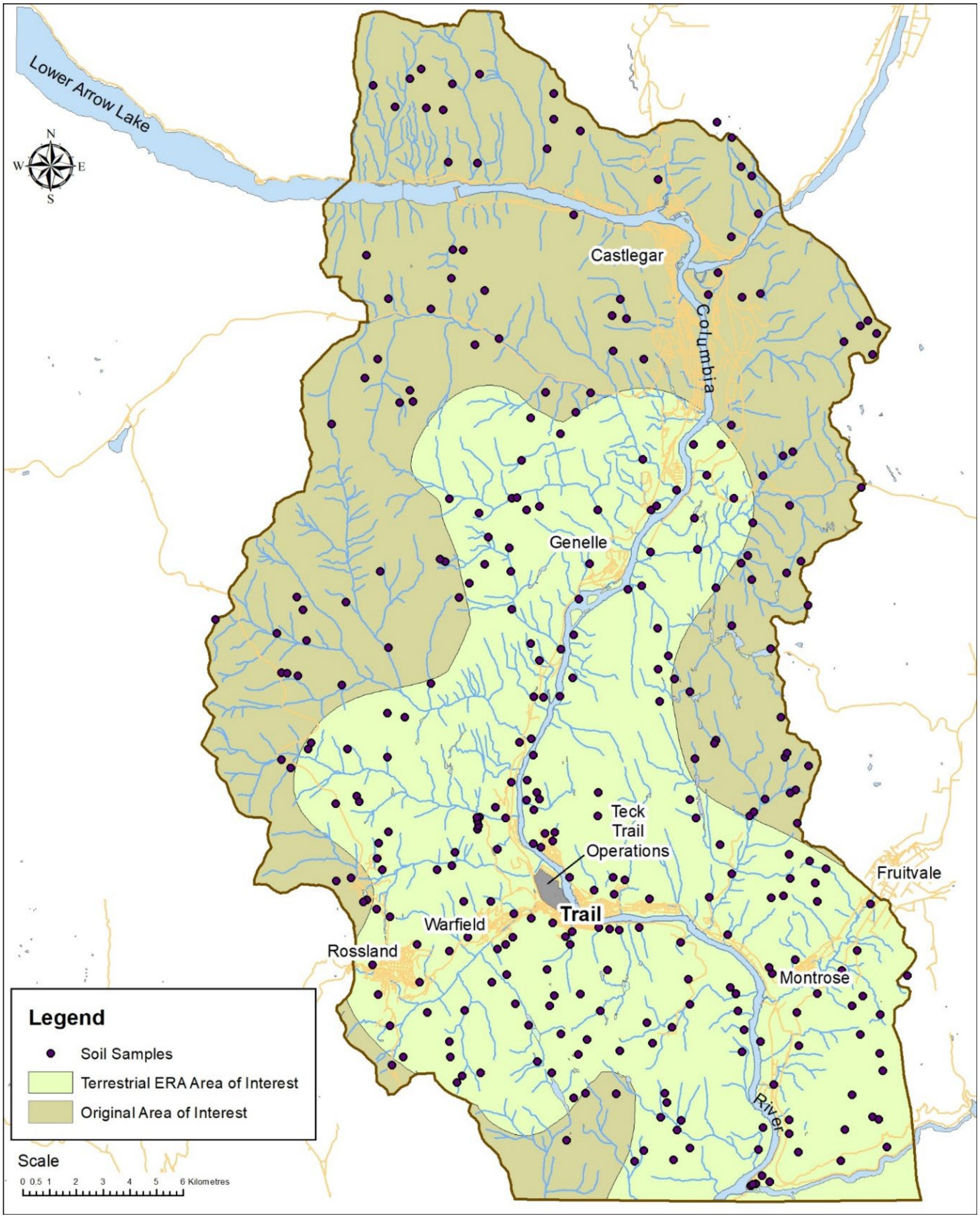

Figure 3.1-1: Soil sampling locations and the resulting change in the Area of Interest for the Terrestrial ERA

A total of 31 potential contaminants of concern were considered in the ERA. They were: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, fluoride, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, phosphorus, potassium, selenium, silver, sodium, strontium, sulphur, thallium, tin, titanium, vanadium and zinc.

In the terrestrial ERA Problem Formulation (Cantox Environmental et al., 2001), maximum concentrations in soil, measured between 1995 and 1999 within the AOI, were screened against regional background. They were then screened against the lowest generic numerical soil standard or the matrix numerical ecological soil standard, regardless of land use designation (see Appendix A, Cantox Environmental et al., 2001). This resulted in 15 contaminants of concern (COCs) being identified for further assessment: antimony, arsenic, barium, boron, cadmium, chromium, copper, fluoride, lead, mercury, selenium, sulphur (due to SO_2), thallium, tin and zinc.

Additional soil sampling was completed in 2001, 2002 and 2004, for the ERA (n=364). Risk analyses that derived the contaminants of potential concern (COPCs) from the COC list were completed in 2003 (LOR2; Cantox Environmental, 2003), 2007 (LOR3; Intrinsik, 2007) and 2011 (Final Terrestrial ERA Report; Intrinsik et al., 2011). Each LOR identified the COPCs and receptors requiring further evaluation. The final list of COPCs that required further evaluation in the ERA was As, Cd, Pb and Zn. The conclusions of the terrestrial ERA reports are summarized in Section 4.2.1.

Since 2008, most surface soil sampling has been completed on residential properties near the smelter, to support the risk management and remedial planning to protect human health, as outlined in Section 6. However, soil sampling is available to all residents within the EM Area and will continue to be offered under the WARP. A total of 2,251 residential properties have been sampled for metals in surface soil, mostly in neighbourhoods close to the smelter, as shown on Figure 3.1-2. Residential sampling involves collecting a minimum of 10, discrete, shallow (0 m to 0.15 m) soil samples on each property assessed. All samples are screened with an XRF analyzer (X-ray fluorescence, and at least two samples from each property are submitted to a laboratory for total metals analysis using the SALM (strong acid leachable metals) analytical method. Sampling on other land-use types (e.g., urban parks, agricultural land) uses the same approach used for residential land, but the sampling density is typically lower for preliminary investigation of larger areas (e.g., greenspaces, pastures).

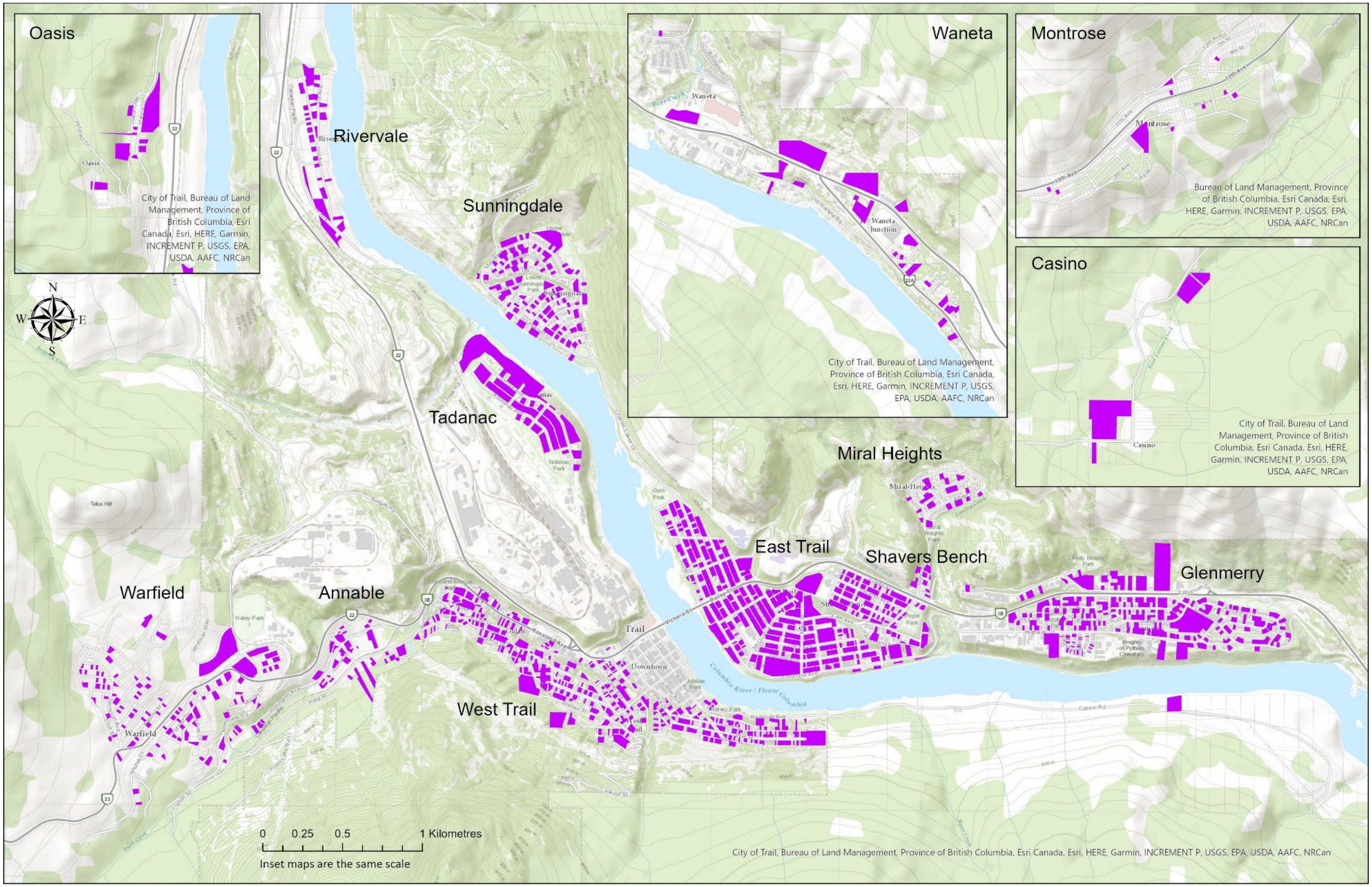

Figure 3.1-2: Summary of soil assessment in residential neighbourhoods of the EM Area

Assessments at commercial and industrial development (or redevelopment) properties, as well as at institutional and large residential developments are addressed through the Property Development Program (PDP). Through this program, Teck provides soil assessment support to property owners and project proponents, to identify soil contaminated by historical aerial emissions from Teck Trail Operations. The scope of assessment activities varies depending on the specific scope and objectives of the project, and it may include surface soil sampling, as well as sampling of excavated materials. Teck's role through the PDP is to identify soils contaminated with metals and to support owners/proponents in managing these materials appropriately during site development works (see Section 5.1.6). Assessing and managing other contamination that may be present at a development property (e.g., due to on-site Schedule 2 activities) are the responsibilities of the property owner and are not addressed under the PDP.

3.1.2 Soil Assessment Results

Soil assessment results for all laboratory analyzed samples within the EM Area are provided in Tables 1 through 6. In these tables, the data are divided into land-use classifications so they can be compared to current CSR standards.

As noted above, for soil assessment related to human health, all samples are screened with an XRF analyzer, and at least two samples per residential property are submitted for laboratory analysis of CSR metals. For the residential data set, a correlation between laboratory and XRF results is completed. The correlation equation for the data set is provided in Figure 3.1-3. The regression equation is updated after XRF calibration and with each new batch of laboratory analyzed data.

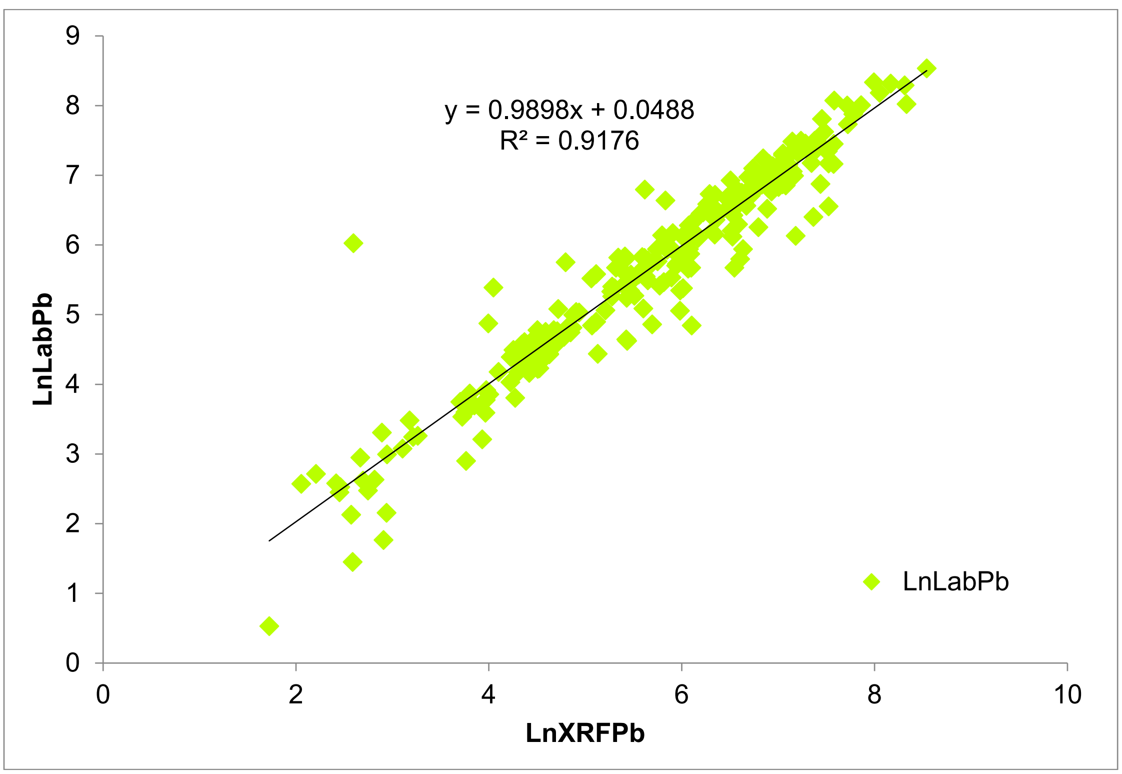

Figure 3.1-3: Correlation equation for XRF and laboratory Pb

The correlated XRF Pb and laboratory Pb data are then used to calculate a 95% UCLM soil Pb concentration for each property. The 95% UCLM for the property is recorded in the THEP database that stores all relevant property information, reported to the property owners and provided in the annual Soil Management Plan (SMP) report tables. Prioritizing properties for remediation is based on the 95% UCLM values and other factors (see Section 6.1).

3.1.2.1 Lateral Delineation in Soil

Lateral delineation of soil contamination arising from aerial emissions from Teck Trail Operations began in the early 2000s. The influence of stack and fugitive dust emissions were evaluated in relation to distance from Teck Trail Operations (Goodarzi et al., 2002). The study used moss bag monitoring stations set up at and near the smelter and extending up to approximately 26 km north and 21 km south of it. The results indicated fugitive dust sources contributed 42% of the total Pb and 45% of the total Zn deposition load within the study area. It also indicated fugitive dust was the major contributor of Pb and Zn deposited within approximately 1 km north and 1.8 km south of the smelter. Deposition was also elevated near the Waneta Reload concentrate/slag storage area (Station “CG” shown on Figure 3.1-4) located 11 km south of the smelter. However, at greater distances from the smelter, the stack emissions became the main source of Pb and Zn deposited. Overall, results showed a significant decrease in deposition of Pb and Zn with increasing distance, in all directions. The study also found that geogenic[5] sources were the major source of metals at stations further from the smelter.

Goodarzi et al. (2006) also showed that aerial deposition of metals was greatest within a short distance from the smelter and that it decreased rapidly with increasing distance from the smelter. The distribution of Cd, Pb and Zn in surface soils around the smelter was similar to their deposition at moss bag monitoring stations. However, this similarity was not observed for other metals, including As, for which soil chemistry, rather than atmospheric deposition, appeared to be the dominant factor. Figure 3.1-4, obtained from Goodarzi et al. (2006) demonstrates the distribution of Pb and Zn in moss monitoring stations across the study area.

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[5] Geogenic (adj): resulting from geological processes.

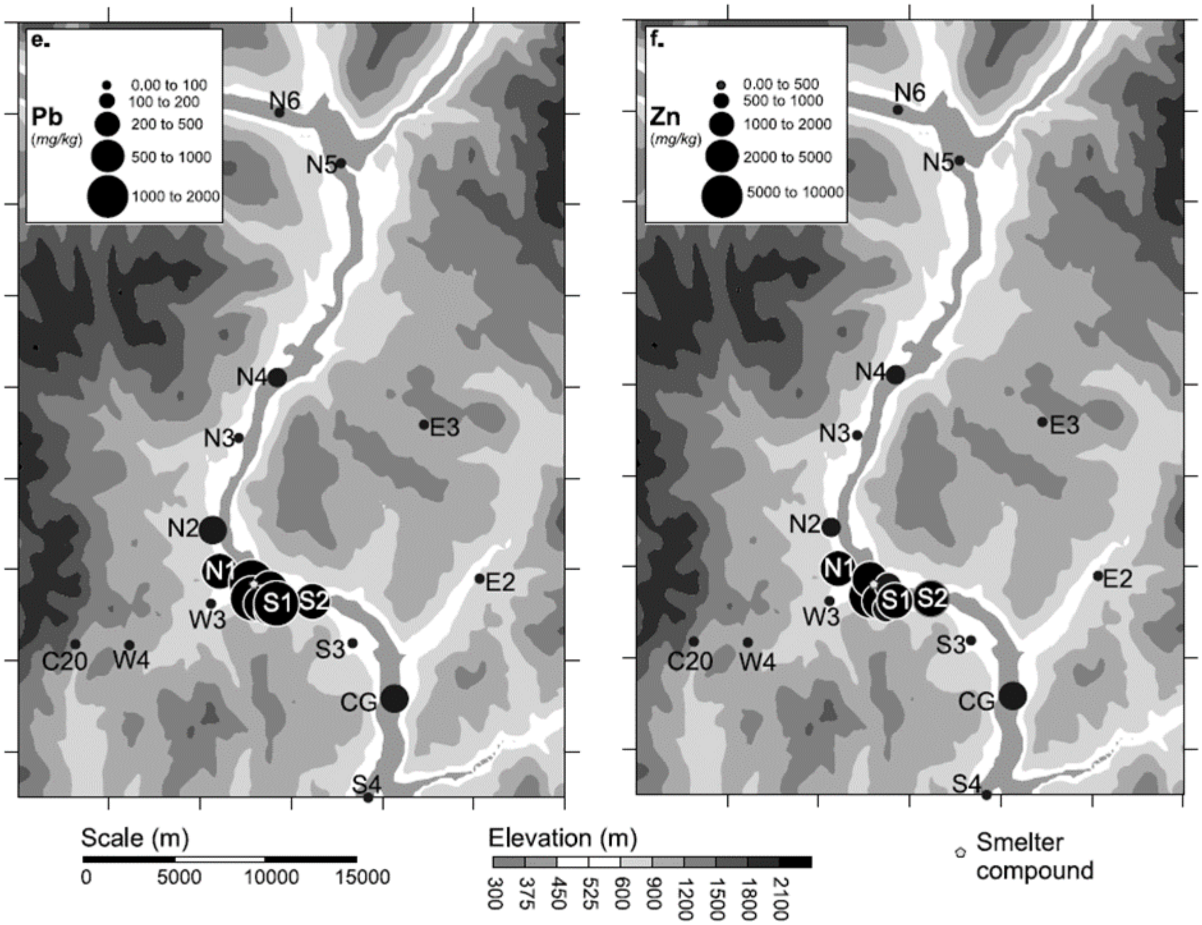

Figure 3.1-4: Concentrations of Pb and Zn (mg/kg) in aerially-deposited particulate matter measured during the passive moss monitoring program, from winter 1998 to fall 1999 (from Goodarzi et al. 2006, Figure 3)

More recently, SNC-Lavalin (2018) showed that the aerial deposition pattern for Pb and Zn observed in Figure 3.1-4 is consistent with the distribution of these metals in soil across the EM Area. Metals concentrations in surface soil samples (0.0 m to 0.15 m depth) collected to support the ERA were compared to the most stringent applicable matrix standards contained in the CSR, using the site-wide median soil pH = 7.0[6] (i.e., Pb = 120 µg/g and Zn = 450 µg/g). The distributions of As, Cd, Pb and Zn in soil are shown in Figure 3.1-5.

[6] A site-wide pH for soil at > 1.0 m depth not affected by natural or anthropogenic point sources was developed to apply the appropriate CSR soil matrix standard for Cd, Pb and Zn (SNC-Lavalin, 2018).

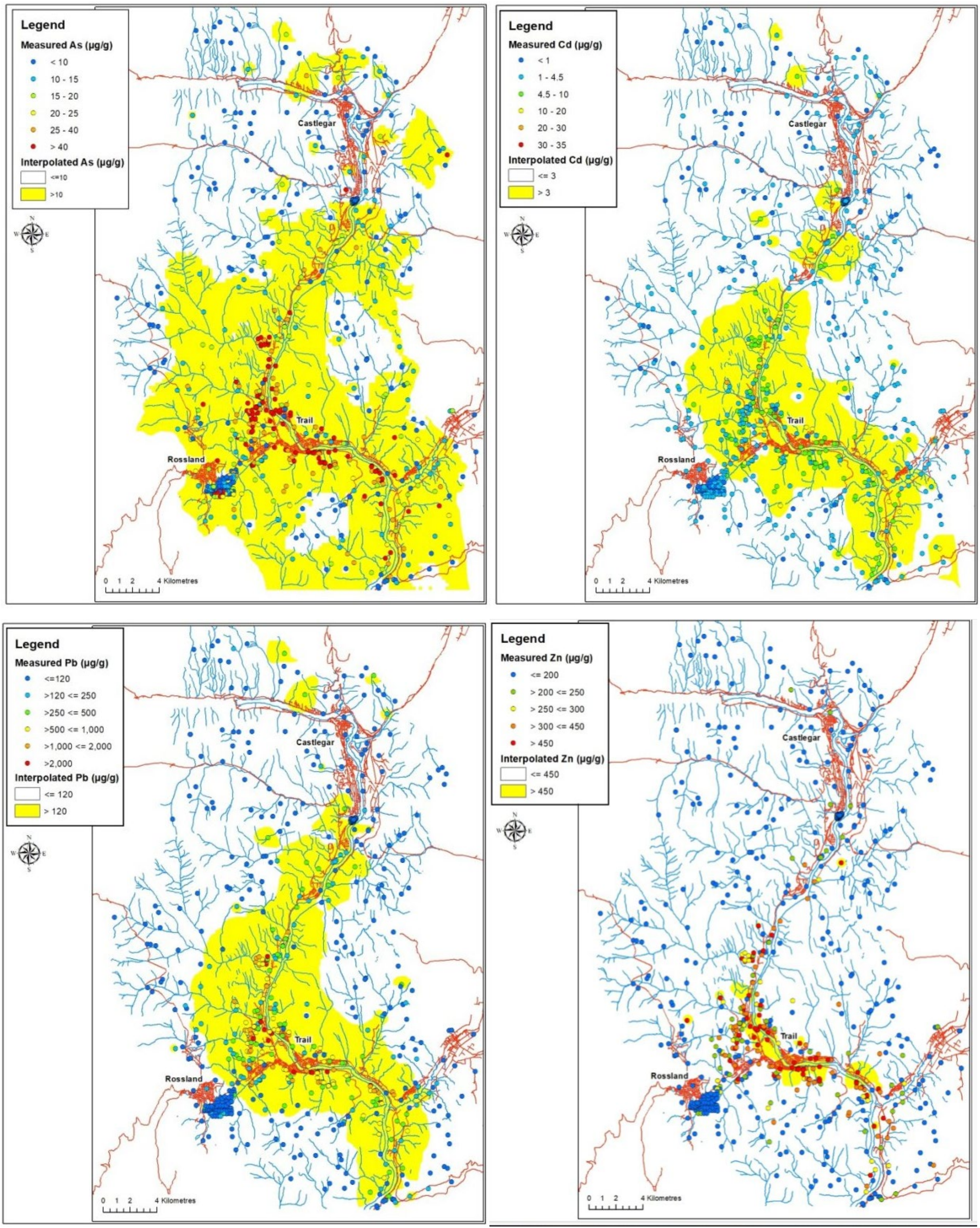

Figure 3.1-5: Measured and interpolated arsenic, cadmium, lead and zinc in soil (adapted from SNC-Lavalin, 2018)

For the purposes of the WARP, the lateral extent of metals contamination in soil associated with historical aerial emissions is defined by the EM Area, as presented in Section 1.3.

The large number of samples taken from residential properties make it possible to observe the lateral distribution of Pb concentrations in surface soil at a finer scale. By the end of 2023, a total of 2,251 residential parcels in the EM Area had been tested. Results of soil samples collected from residential properties presented in Figure 3.1-6 indicate that the concentration of metals is higher in neighbourhoods closer to the smelter.

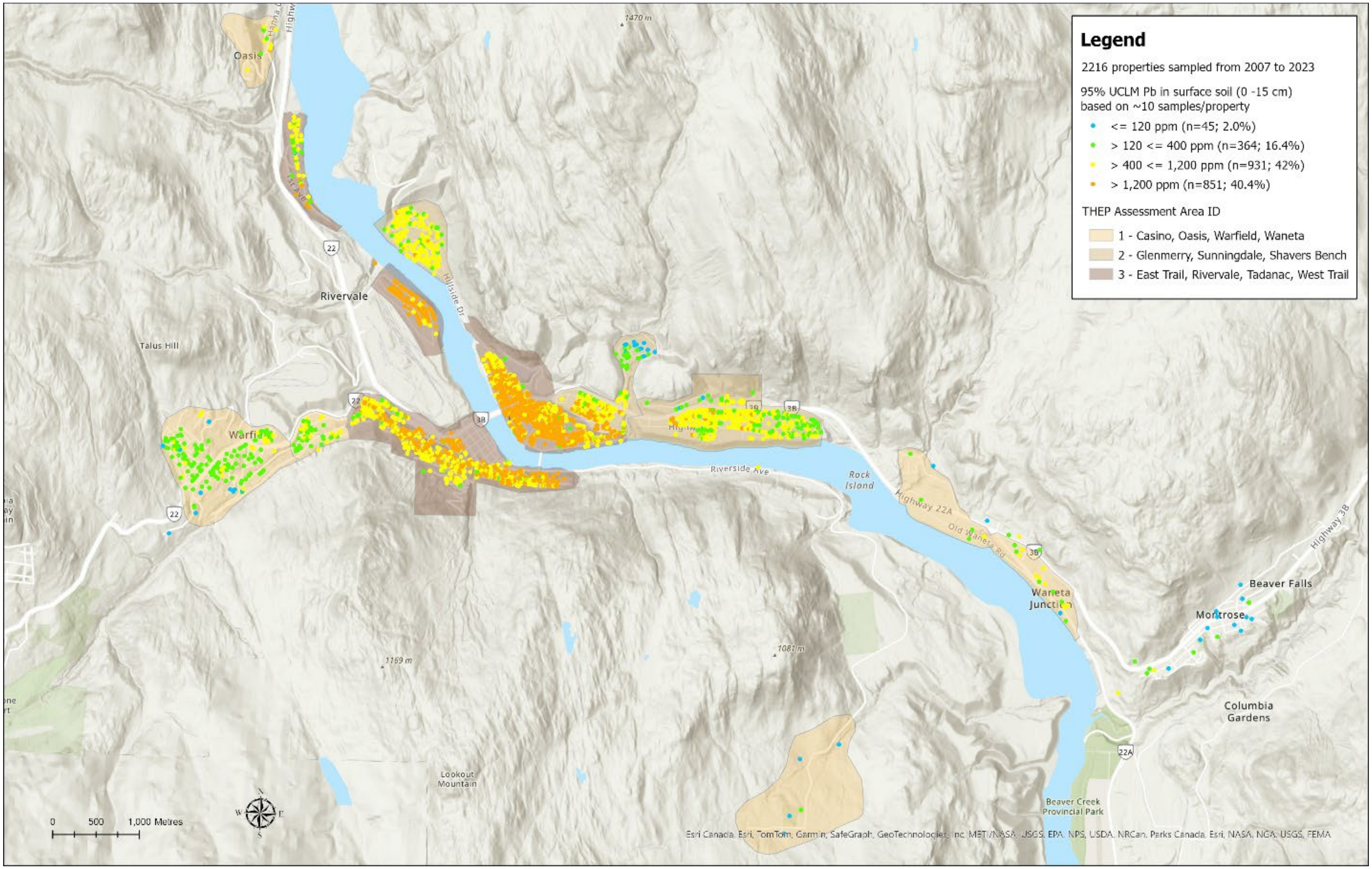

Figure 3.1-6: Summary of Pb concentrations in surface soil on residential properties

3.1.2.2 Vertical Delineation in Soil

Soil concentrations are expected to be highest in surficial soil due to the mode of contamination, namely aerial deposition. Consequently, soil assessment has focussed mainly on understanding conditions in shallow soil. To the extent that elevated metals concentrations may be present at greater depths, the cause may potentially be one or more of the following mechanisms:

- Physical settling or being transported due to vibration, traffic and water infiltration;
- Leaching associated with infiltration of rain, snowmelt or irrigation water applied at surface;
- Mixing of surface and deeper soil due to excavation activities such as animal burrowing, mixing in soil amendments (e.g., for lawns and gardens) or construction activities; and
- Burying of historically impacted soils (e.g., placing fill for construction).

In general, none of these mechanisms is considered to have high potential to cause significant vertical migration of metals contamination (e.g., to depths where groundwater may be present, generally greater than 5 m below ground surface except immediately adjacent to water courses). However, detailed study of the relative importance of these mechanisms or their potential for causing metals to migrate vertically has not been conducted. Studies of this nature are not considered warranted, given that the empirical evidence indicates vertical migration of metals contamination has been relatively limited throughout the EM Area, as discussed below, and that no significant exposure pathways to deep soil or groundwater for the primary receptors (i.e., children and plant communities) were identified. Where elevated metals contamination is encountered at significant depth (i.e., > 1 m), it is typically associated with another source (e.g., contaminated fill) and is not a consequence of historical aerial emissions.

While assessment to confirm the vertical extent of metals contamination has not been conducted at each individual property, strong evidence of vertical delineation is found in areas where extensive soil assessment and remediation have been completed. Graphs for five neighbourhoods and two PDP properties presented in Figure 3.1-7, show the concentrations of As, Cd, Pb and Zn against sample depth. For the neighbourhoods, the values plotted represent the average concentration for each metal measured within a given depth range. For individual PDP properties, the data points represent metal concentrations at individual samples collected at test pit locations. Interpreting the data is complicated by two factors:

- Sampling at greater depth is only carried out when elevated metal concentrations are encountered. Because of this, the proportion of deep samples with elevated metals concentrations is greater than that observed in shallow samples which artificially increases the average concentration values. The figures show this strong positive bias for the deeper samples such that concentrations are not always shown to decline below the minimum EM Area standards for the neighbourhood plots. For the individual PDP properties, metals concentrations are shown to decline below the EM Area standards at depth.
- The aggregation of average concentrations across neighbourhoods combined with the positive bias for deeper samples accounts for fluctuating trend lines on some graphs (i.e., they don't decrease steadily).

Nonetheless, the figures show that the highest soil metals concentrations are consistently found in the upper 0.6 m of soil, and below this depth they decrease, as expected. The figures clearly demonstrate decreasing metals concentrations with depth, trending toward the EM Area concentration limits within the upper 1 m of soil.

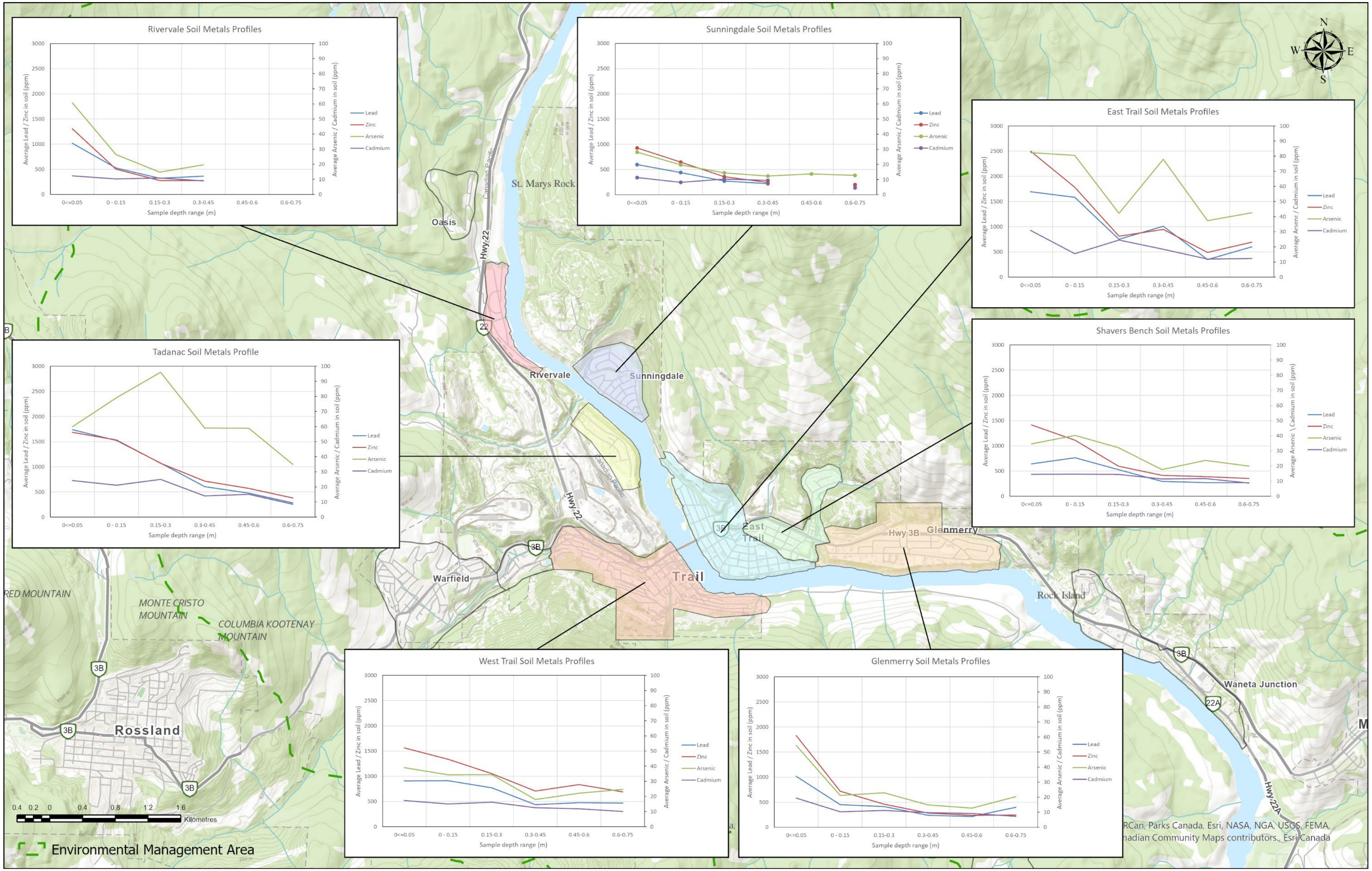

Figure 3.1-7: **Summary of soil metal concentrations compared to depth of sample in Trail**

Overall, the data show that vertical migration of metals contamination in soil associated with historical aerial emissions has been limited and that vertical delineation of contamination has been demonstrated sufficiently to support risk assessment.

3.2 Groundwater

Based on the results of hydrogeological and groundwater quality investigations conducted over three decades, SNC-Lavalin and Golder Associates developed a hydrogeological conceptual site model for the Trail Operations site and surrounding areas (SNC-Lavalin & Golder, 2012). Although the hydrogeological conceptual site model is based on data collected at the smelter and nearby areas of Trail, comparable physical hydrogeological conditions have been demonstrated in other areas (e.g., Waneta Reload) and are expected to be present throughout the EM Area. This conceptual site model describes groundwater occurrence in two main aquifer types: a valley fill aquifer within the buried glacial valley of the Columbia River and upland aquifer(s). The valley fill aquifer is inferred to be continuous through the Columbia River valley upstream and downstream of the smelter. Hydraulic controls on the Columbia River result in the river alternately being a source of recharge to the valley fill aquifer at low river stage or discharge from the aquifer at high river stage. Groundwater flow in the upland aquifer(s) generally occurs within a relatively thin (i.e., less than 10 m) saturated thickness of unconsolidated materials above bedrock. The boundary between the upland and valley fill aquifers occurs where the regional, river-connected water table intersects the bedrock valley walls. Recharge to the upland aquifers is from precipitation and snow melt. Horizontal gradients are primarily controlled by the slope of the underlying bedrock surface in upland areas, and they are generally towards the valley fill aquifer or are locally oriented towards tributaries of the Columbia River. The valley fill and upland aquifers are unconfined. The depth to groundwater is less than 5 m in areas adjacent to water courses, but it can exceed 50 m in both the upland and valley fill aquifers. The valley fill aquifer is influenced by elevation of glaciofluvial benches above the present Columbia River.

The potential influence of soil impacts from historical aerial emissions on groundwater in the EM Area has been evaluated through various studies over the past 20 years. It has been determined to be an inoperable pathway based on the following lines of evidence.

In support of defining the EM Area boundaries, SNC-Lavalin (2018) reviewed previous studies examining metals concentrations in streams and water wells distributed throughout the EM Area. These studies demonstrated that groundwater quality had not been significantly affected by historical aerial emissions from Trail Operations. This conclusion was based on the observed negligible impact to metals concentrations in streams attributable to groundwater flow and the absence of a spatial pattern of metals concentrations in groundwater that would be consistent with the pattern of historical aerial emissions.

Groundwater chemistry from sampling conducted as part of a water well survey for the ERA indicated no spatial pattern of metals concentrations exceeding CSR standards in groundwater (Golder, 2007b), suggesting that historical aerial deposition has not affected groundwater in the area. The study compiled historical chemistry data from 37 water wells in the area and sampled an additional six locations for a total of 43 locations. The wells are situated both inside and outside the EM Area boundary and are generally located in the Columbia River valley, although three wells are in the Rossland Area and four in the Beaver Valley. A summary of groundwater quality from the survey is provided in Tables 1 and 3-1 and Figures 3-1, 3-2 and 3-3 extracted from Golder (2007b) and provided in Attachment 3 of SNC-Lavalin (2018). As shown in the figures, there is no consistent spatial trend in the parameters that exceed the standards, and there are limited exceedances for the four parameters of interest (i.e., As, Cd, Pb, Zn). It is noted that the CSR standards have changed since the report was issued; the increase in the freshwater aquatic life standard for cadmium results in fewer exceedances, and the decrease in the drinking water standard for zinc does not result in additional exceedances.

A further line of evidence to support an absence of impacts to groundwater is surface water quality data collected when groundwater baseflow dominates tributaries in the EM Area. Surface water in tributary creeks to the Columbia River was sampled across the EM Area by Klohn (Klohn, 2004; 2005) during low flow, to estimate quantity and quality of groundwater baseflow contributions to the tributaries. A map of the tributaries sampled extracted from Klohn (2005) is presented as Figures 3.1 and 4.1 in Attachment 3 of SNC-Lavalin (2018). The BC Water Quality Guidelines have changed since those reports were issued and, as such, results from the low flow sampling have been digitized and compared to the current guidelines in Table II-1 in Attachment 3 of SNC-Lavalin (2018). The following conclusions can be made from the rescreened data and interpretations by Klohn:

- In the Klohn, 2005 data set, the drinking water and aquatic screening criteria for As were not exceeded in any creek. The aquatic screening criterion for Pb was exceeded in only one sample (Casino Creek), and the Zn aquatic screening criterion was exceeded in only three samples (once at Lawley Creek and twice at McAlister Creek).
- The spatial distribution and magnitude of Cd, Pb and Zn exceedances in low flow surface water samples (i.e., groundwater baseflow dominated) is not consistent with the spatial distribution and magnitude of soil metals concentrations in the EM Area.
- Klohn (2004) also indicated that, based on detailed surveys of select creeks, groundwater does not appear to be an important pathway for metals entering Johnson, McNally and Bear Creeks, although it may be important for Hanna and Ryan Creeks. These conclusions were based on flow observations in the creeks and the inferred surface flow regime over surficial and bedrock deposits (e.g., creek is a gaining creek over bedrock at or near surface, and it is a losing creek over alluvial terraces). These findings are inconsistent with smelter emissions being a significant source of metals to groundwater-dominated baseflow, given the location of these creeks relative to the smelter (Johnson Creek, 7 km north, McNally Creek, 4.5 km north; Bear Creek, 4 km east; Ryan Creek, 2.5 km southeast and Hanna Creek, 8.5 km north).

The hydrogeological conceptual site model for Trail Operations and proximal surrounding areas (SNC-Lavalin and Golder, 2012) also demonstrates that the pattern of metals contamination in groundwater is not consistent with what would be expected if historical aerial emissions from Teck Trail Operations were a contributing factor. The hydrogeological conceptual site model was prepared to provide context and focus for ongoing remedial planning activities to prevent groundwater contamination discharging to the Columbia River. A co-mingled groundwater plume (historically referred to as the main ammonium sulphate plume) is present at the site, with elevated concentrations of parameters including ammonium, sulphate, fluoride, nitrate and the following metals: antimony, arsenic, cadmium, cobalt, copper, iron, lead, manganese, magnesium, selenium, sodium, thallium, uranium and zinc. The conceptual site model identifies major potential source areas, including historical and current landfills and historical and/or current operations at the Trail Operations facilities. A gravel-rich zone of higher permeability beneath a portion of the site was identified as a key feature that influences groundwater migration, as well as the fate and transport of groundwater contaminants.

Metals concentration data for As, Cd, Pb and Zn in approximately the upper 10 m of the saturated zone (i.e., at or near the water table) are presented in Figure 3.2-1 and Figure 3.2-2 below. Data for As, Cd and Zn represented in the figures are based on data presented in Figures 510392-17, 510392-18, and 510392-19 included in SNC-Lavalin and Golder (2012); which describes that data as representing contemporary concentrations as follows:

- 2010, 2011 wells were sampled by SNC-Lavalin and analyzed between 2012-01 and 2012-05;
- All 2000, 2001, 2002, 2003, 2007, 2009 and -09 series wells were provided by Teck or Golder and analyzed between August and November 2009, except MW2007-5A (analyzed 2009-06-04); MW2007-3B (analyzed 2007-07-11), MW2007-2B (analyzed 2008-12-04), MW2001-2B (analyzed 2005-10-17), MW09 series wells analyzed for metals in June 2010; and
- MW2000-1 sampled by Klohn Crippen (analyzed 2002-05-02).

Data for Pb were not presented in SNC-Lavalin and Golder (2012). To support the current discussion, Figure 3.2-2 presents maximum Pb concentrations in groundwater at wells sampled between 2009 and 2012.

The concentrations of Cd and Zn, and to a lesser extent As and Pb, are generally observed to be elevated at known source areas at Teck Trail Operations and downgradient from them, and also along the high permeability gravel-rich zone. However, concentrations of these metals are not found to be elevated at other areas either within Teck Trail Operations lands or at nearby neighbourhoods (e.g., Tadanac, East Trail) where historical aerial emissions are known to have impacted shallow soil, as discussed previously. The figures further demonstrate that the pattern of elevated concentrations of metals in groundwater does not align with the pattern of shallow soil contamination related to historical aerial emissions within the EM Area.

Given the absence of impacts to groundwater that can be attributed to historical aerial emissions from Teck Trail Operations, groundwater remediation is not addressed within this WARP. The results of ongoing groundwater monitoring programs and studies will be evaluated to verify that this conclusion continues to be valid.

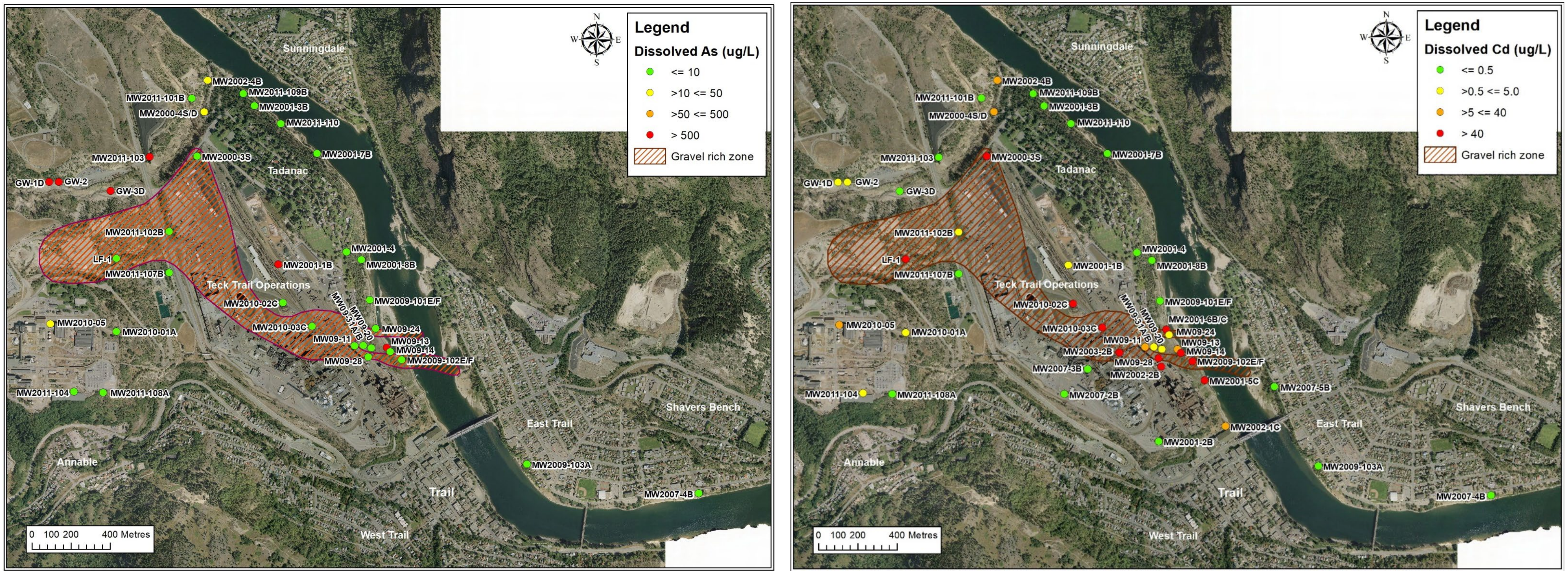

Figure 3.2-1: Concentrations of As and Cd in shallow groundwater bearing zone at and near Trail Operations

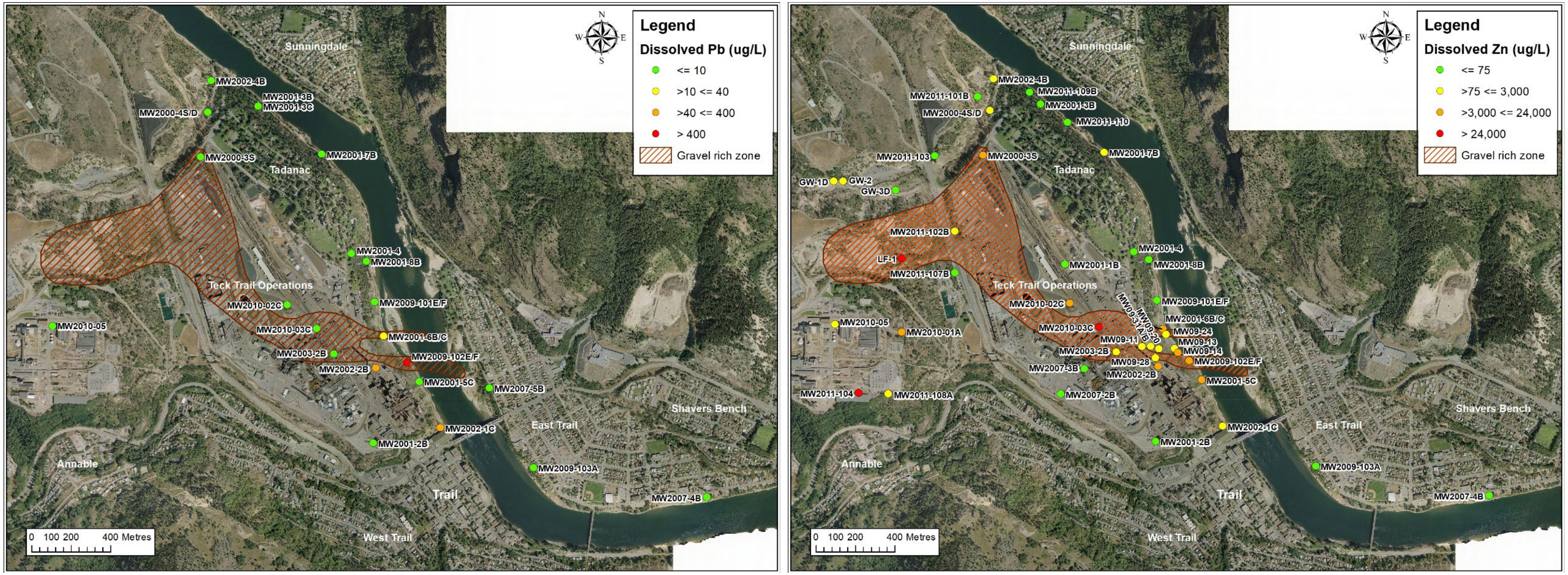

Figure 3.2-2: Concentrations of Pb and Zn in shallow groundwater bearing zone at and near Trail Operations

3.3 Surface Water and Sediment

An aquatic ERA was completed by Golder (2010) to assess impacts to aquatic receptors exposed to COPCs in the Columbia River and its tributaries as a result of the following potential sources to the aquatic environment:

- Atmospheric deposition of COPCs in air emissions directly to the Columbia River;
- Atmospheric deposition of COPCs to the watershed with subsequent surface water transport via tributaries;
- Direct discharge of treated effluent;
- Groundwater transport; and
- Historical discharge of slag.

This is discussed further in Section 4.2.1.

The aquatic Area of Interest for screening water and sediment concentrations (compiled in a Problem Formulation report; Golder, 2003) encompassed the 56 km section of the Columbia River and its tributaries from downstream of the Hugh Keenleyside Dam and Brilliant Dam on the Kootenay River and Waneta Dam on the Pend d'Oreille River, to the International Boundary (Figure 3.3-1). These three dams are physical barriers to fish migration and were therefore considered natural up-stream endpoints for aquatic studies.

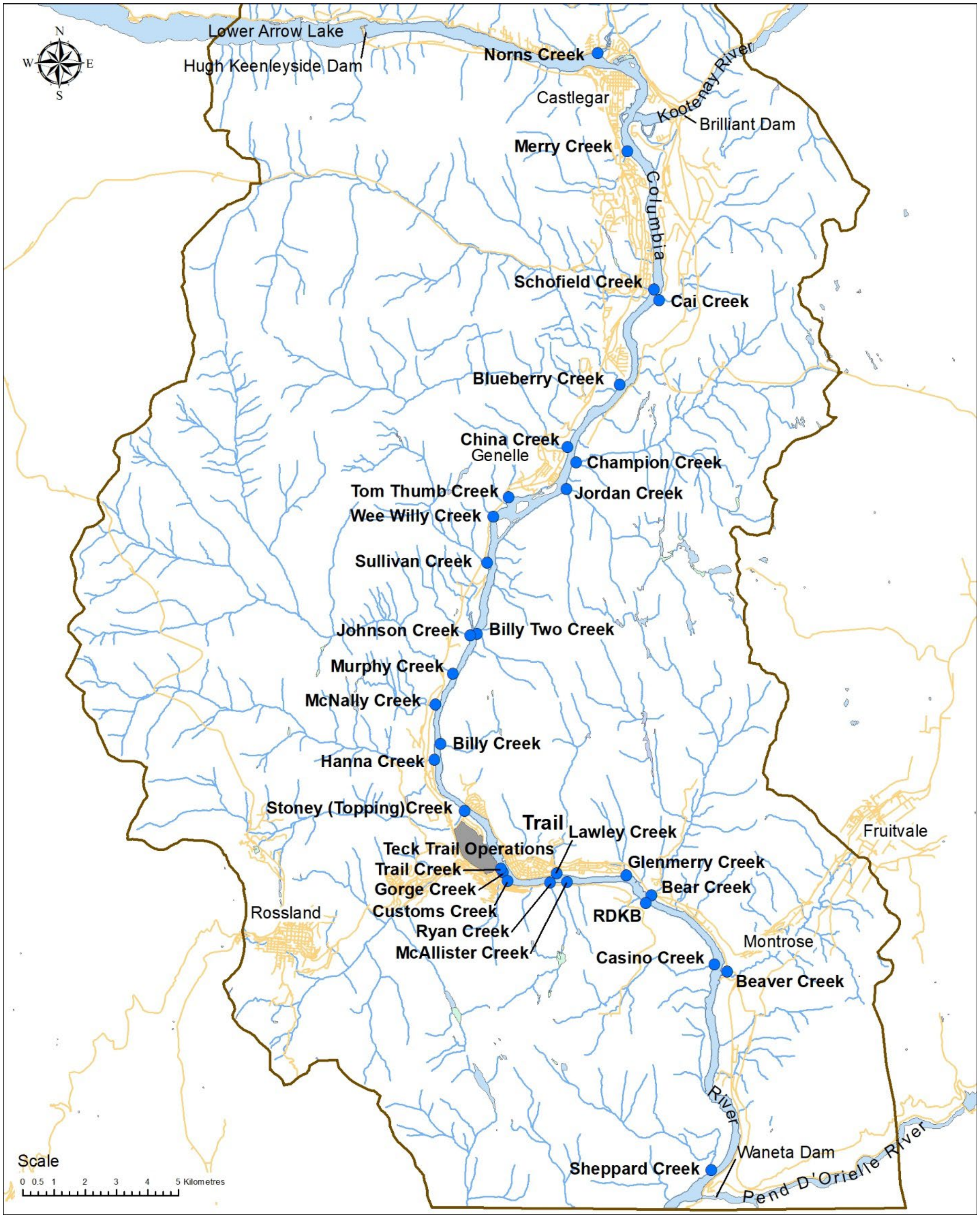

Figure 3.3-1: The AOI for the Aquatic ERA showing the portion of the Columbia River and its tributaries included in the Study Area. Locations where tributaries enter the Columbia River are shown.

To determine water quality, Teck staff collected monthly water samples in 2001 and 2002 from 27 tributary streams in the AOI, as summarized in Golder (2003). ENV also monitored water quality in the Columbia River at five locations (Birchbank, Castlegar Ferry, Donald, Revelstoke, Waneta), variously, between 1979 and 2002. The water samples were analyzed for 22 metals. See Appendix I of Golder (2003) for a summary of the data and comparisons to screening criteria.

The Problem Formulation (Golder, 2003) identified eight COPCs in the Columbia River, and 12 in water of the tributaries (Golder, 2010), based on screening against Lower Columbia River water quality objectives (ENV, 2000). The COPCs included in the final aquatic ERA for surface water of the mainstem of the Columbia River were: arsenic, cadmium, chromium, copper, lead, mercury, thallium and zinc. The COPCs included in the final aquatic ERA for surface water of the tributaries of the Columbia River were: arsenic, cadmium, chromium, cobalt, copper, iron, lead, mercury, selenium, silver, thallium and zinc (Golder, 2010).

Sediment was sampled in the Columbia River mainstem at various locations in 1992 by the Columbia River Integrated Environmental Monitoring Program (CRIEMP), and in 1995 and 1999 by Cominco, as summarized in Golder (2003). ENV also monitored sediment quality in the Columbia River at five locations (Birchbank, Donald, Nicholson, Steamboat Rapids, Waneta), variously, between 1965 and 2002. Also as summarized in Golder (2003), a study of metals in sediment was conducted by the Geological Survey of Canada in 2001. Fifty-six samples were taken from different elevations along 12 creeks in the AOI: Blueberry Creek, China Creek, Champion Creek, Sullivan Creek, Murphy Creek, Hanna Creek, Topping (Stoney) Creek, Trail Creek, Casino Creek, Bear Creek, Ryan Creek and Sheppard Creek. Sediment samples were analyzed for 26 metals. See Appendix II of Golder (2003) for a summary of the data and comparisons to screening criteria.

The Problem Formulation (Golder, 2003) identified nine COPCs in sediment of the mainstem and tributaries, based upon screening against the most conservative of the available sediment quality guidelines (CCME guidelines, the BC guidelines and proposed criteria, and the Lower Columbia River Objectives) (Golder, 2010). In the final aquatic ERA, the COPCs included for sediment of the mainstem and tributaries of the Columbia River were: arsenic, cadmium, chromium, copper, lead, nickel, silver, thallium and zinc (Golder, 2010).

The COPCs identified in surface water and sediment were subsequently addressed in the ERA (see Section 4.2.1).

Several studies have been completed to evaluate the potential link between historical aerial emissions and tributary surface water and sediment. Reyes et al. (2004), evaluated stream sediments in the Trail area to determine possible geogenic and anthropogenic sources of elements. Key findings of this study are summarized below:

- Metals concentrations in sediments in creeks cannot be solely attributed to historical aerial emissions from Teck Trail Operations. Metals enrichment due to geogenic sources (i.e., bedrock weathering) in most catchments and anthropogenic sources other than historical aerial emissions (e.g., landfilling, urban influence) in some catchments was also found to be important.
- Higher metals concentrations were noted in stream sediments closer to the smelter (Trail, Stoney, Sullivan, Bear Creeks). These are possibly due to some input from the smelter, although, as noted, geogenic and other anthropogenic sources have also been identified. Based on evaluation of the 2001 (GSC) sediment data, Reyes et al. (2004) inferred that sediment metal concentrations decrease with distance from the Teck Trail Operations site. However, the evaluated data set includes samples collected both above and below 800 m above sea level (asl). This is not considered representative of potential impacts related to historical aerial emissions, as discussed below.

- Sediment minerology and morphology analysis using Scanning Electron Microscope/Energy Dispersive Spectrometry and X-Ray Diffraction was conducted for Trail, Blueberry, Hanna, Topping, Bear, Shepard, Ryan, China and Murphy Creeks. The analysis identified evidence of emissions related minerals at Lower Trail Creek (calcium phosphate, possibly related to historical fertilizer plant operations) and Ryan Creek (spherical Pb particles, although slag potentially from historical open-air smelting was also observed). The analysis indicated that metals in all creeks were primarily from geogenic sources.

Klohn (2004; 2005), evaluated hydrogeologic/hydrologic conditions for Columbia River tributaries in the Trail Area and reviewed groundwater, surface water, soil and sediment data for the area. Key findings of the studies are summarized below.

- Elevated soil metal concentrations within the study area were generally confined to samples collected below elevation 800 m asl. For most of the tributaries, more than two-thirds of their catchment is above 800 m asl, where anthropogenic sources of metals are largely absent. Flows from these higher elevation catchment areas provide substantial dilution flows for areas below 800 m asl, particularly during freshet.
- The drinking water and aquatic screening criteria for arsenic were not exceeded in surface water samples in any creek. The aquatic screening criterion for Pb was exceeded in only one sample (Casino Creek) and the Zn aquatic screening criterion was exceeded in only three samples (once at Lawley Creek and twice at McAlister Creek). The samples were collected during low flow conditions when groundwater baseflow dominates creek flows, as discussed in Section 2.2. However, as noted above, during higher flow periods (e.g., freshet), the significant dilution flows from higher elevation catchment areas of most creeks would be expected to further reduce metals concentrations.
- In 2004, As, Pb and Zn concentrations in sediment samples (the <2 mm fraction) from China, Jordan, Murphy, Billy and Casino Creeks were generally low. Only two samples (Cd at Billy Creek and Zn and Murphy Creek) exceeded aquatic screening criteria.
- In reviewing the 2001 (GSC) sediment data set specifically for samples collected below 800 m asl, Klohn (2004) did not observe a trend in metals concentrations relative to distance from the smelter (as is observed in soil data). All sediment samples except for Ryan Creek exhibited Cd, Pb and Zn concentrations below screening concentrations. Ryan Creek was noted to be impacted by historical mining. The generally low metal concentrations and the lack of trend relative to proximity to the smelter may be due to continuous flushing of creek water.

3.4 Data Management System

An information management system was developed in 2012, for soil, sediment and surface water data being collected on properties in the EM Area. Historical data were brought into the existing information management system and include the THEP database, as well as various EQuIS, ESRI GIS applications, including ArcGIS Desktop, ArcGIS Pro, Survey 123 and Collector. The THEP database is the primary location for residential data, while EQuIS houses the soil, sediment and surface water data. Both data sets are linked to GIS applications for spatially representing the data.

Soil data include:

1. Soil assessment data: Dates and types of soil assessments, excavation-base, post-remediation, ground cover evaluation (GCE);
2. Soil Analyses: XRF and lab results, sample locations, dates, soil logs, sample depths and duplicates; lab chain of custody and certificates of analysis;

3. Remediation and yard improvement work: Start and end dates, remediation details including remediation depth, area and volume of soil remediated, type of cover material, Notification of Independent Remediation (NIR) / Notification of Completion of Independent Remediation (NCIR)[7] filing dates, Site Risk Classification Report (SRCR) and post--remediation soil concentration; and
4. Documentation: Electronic files consisting of consent forms (e.g., permission to sample soil, permission to remediate, remediation plans), photographs, pre-remediation videos, assessment and remediation report letters to property owners, verification documents and inspection forms.

Blood lead (Pb) level and health-related data are stored by Interior Health because these data are confidential.

Ecological data include:

1. Site identification: Polygon number and label, ownership, zoning;
2. Plant community parameters: Plant community type and area, condition; and
3. Treatment plot data: Baseline condition, treatment details, monitoring schedule and results.

[7] Once the WARP is authorized by ENV via an Approval in Principle, submission of NIR / NCIR will no longer be required.

4. Risk Assessment Summary

Human health and ecological risk assessments have been conducted to assess the potential for metals contamination from the smelter to adversely impact human health and the environment. A summary of the risk assessments conducted is presented in the following sections. The WARP utilizes MHO recommended risk-based standards for Pb under Sections 18 and 18.1 of the BC CSR. A human health risk assessment (HHRA) for Pb was conducted in 2024 (AtkinsRéalis, 2024) to support the development and application of the risk-based standards. Risk-based targets for ecological receptors are also presented.

4.1 Human Health Risk Assessment

The HHRA for metals other than Pb and earlier work related to Pb health risks are summarized in Section 4.1.1. The HHRA for Pb conducted in 2023/2024 (AtkinsRéalis, 2024) is summarized in Section 4.1.2. The risk-based standards for Pb in the EM Area are described in Section 4.1.3.

4.1.1 Summary of Human Health Risk Assessment

The Trail Lead Task Force (the Task Force), formed in 1990, conducted studies to evaluate sources, exposures and the health risks associated with Pb in the Trail area, and it began monitoring BLL in children in 1991, as noted in Section 2.1. Prior to concluding its work in 2001, the Task Force made several recommendations. These included that Interior Health should continue monitoring BLLs and conducting the community education program and that Teck should continue to seek further reductions in facility emissions. When the Task Force concluded, its work continued through the creation of the THEP and the THEC. Also in 2001, Dr. Nelson Ames, the Medical Health Officer for the region, prepared a report evaluating health risks associated with the smelter (Ames, 2001). Dr. Ames concluded that the estimated health risks posed by Pb, As and other smelter-related contaminants in the Trail environment were acceptable in the context of continuous, ongoing improvements and that the priority in the following years should be to further reduce air emissions of Pb and As. He expressed support for the recommendations of the Task Force and recommended that if children's BLLs and calculated risks from arsenic in air did not continue to improve, the remediation plan should be formally reviewed and adjusted as needed, with local and outside experts.

Human health exposures and risks associated with metals from the smelter other than Pb were evaluated using human health risk assessment (HHRA). During the period of 1997 to 2014, a phased HHRA was conducted to evaluate risks from other metals. The HHRA was completed in four phases (Exponent, 1997; 1998; 2000; Integral, 2008). An addendum to the HHRA was prepared (Environ, 2010) to respond to BC ENV comments on the Phase 4 HHRA, and a supplemental evaluation of Cd and thallium in homegrown produce was conducted in 2014 (Environ, 2014). The purpose and conclusions from each phase of the previous HHRA are summarized in Table 4.1-1, with further details provided in Section 3 of the HHRA for Pb (AtkinsRéalis, 2024).

Table 4.1-1: Summary of Phased HHRA for Other Metals

HHRA Phase	Purpose	Conclusions
One. Technical Memorandum: Evaluation of Data for the Risk Assessment Problem Formulation (Appendix A of Exponent, 1997)	Evaluate data from the Trail Lead Program for their quality and appropriateness for use in the Problem Formulation stage of the HHRA to determine if existing data were sufficient to select COPCs.	▪ Soil contaminants for which data quality was acceptable for Problem Formulation were: As, Cd, cobalt, copper, nickel, Zn, vanadium, bismuth, iron, lithium, manganese, and strontium. ▪ Of these, only As and Cd had maximum concentrations in soil exceeding the BC screening criteria. However, bismuth, iron, lithium, manganese, and strontium did not have screening criteria. Note: A comparison of iron, lithium, manganese, and strontium concentrations to current generic soil standards to protect human health (Schedule 3.1, Part 2) shows no concentrations exceeding the standards. There is no standard for bismuth. ▪ Soil contaminants with limited but sufficient data to complete the Problem Formulation were barium, chromium, molybdenum, and beryllium. These four metals had maximum concentrations below the BC screening criteria. However, the lack of speciation data for Cr and the potential negative data bias led to a recommendation for further sampling. ▪ Although the other metals with limited data quality had no screening criteria (aluminum, calcium, magnesium, phosphorus, potassium, sodium, thorium, and titanium), none were recommended for further consideration because they are essential elements and/or have low toxicity.
One. Technical Memorandum: Evaluation of New Data and Determination of Contaminants of Potential Concern (Appendix E of Exponent, 1997)	Evaluate new data (from background, rural and urban locations) collected based on recommendations from the Technical Memorandum: Evaluation of Data for the Risk Assessment Problem Formulation and screen these data to determine COPC for the HHRA.	▪ Maximum concentrations exceed urban or agricultural criteria based on soil ingestion for: antimony, As, Cd, fluoride, Pb, mercury, selenium, silver, thallium, tin, and Zn. However, fluoride was excluded for several reasons, including a screening health risk calculation. Concentrations of Pb in soil exceeded the screening criterion by the greatest amount. ▪ Maximum concentrations of barium, beryllium, chromium, cobalt, copper, molybdenum, nickel, and vanadium did not exceed screening criteria. ▪ Secondary screening was done if sufficient data were available, by comparing the upper 90^{th} percentile to the criterion, the upper 95UCLM to the criterion and ensuring no sample within a dataset had a concentration more than double the criterion. This was done on a neighbourhood basis. Based on this evaluation, silver was eliminated as a COPC. Tadanac had the highest soil concentrations.

Table 4.1-1 (Cont'd): Summary of Phased HHRA for Other Metals

HHRA Phase	Purpose	Conclusions
One. (Exponent, 1997)	Compile available data for metals in soil, dust, vegetables; screen metal concentrations in soil; and recommend data collection.	▪ Eight metals, in addition to Pb, required further evaluation (antimony, As, Cd, mercury, selenium, thallium, tin and Zn).
Two. (Exponent, 1998)	Determine whether imminent (short-term) risks exist to human health.	▪ No imminent threat to human health from metals other than Pb. ▪ Focus should be on continued air monitoring for As, Cd and PM10.
Three. (Exponent, 2000)	Update conclusions of Phase Two by including more recent air data, indoor dust data, home-grown produce data.	▪ No imminent threat to human health from metals other than Pb. ▪ Focus should be on continued air monitoring for As, Cd and PM10.
Four. (Integral, 2008)	Evaluate risks on an area-wide basis (all neighbourhoods combined) as well as on a neighbourhood-specific basis	Area-wide: ▪ Non-cancer health risks were below BC MoE level of concern. ▪ Cancer risks exceed BC MoE acceptable level (1 in 100,000) but were below the U.S. EPA level that requires response action (1 in 10,000). ▪ Neighbourhoods: ▪ Non-cancer health risks were below BC MoE level of concern for agricultural and commercial areas. ▪ Non-cancer health risks (As, thallium) slightly exceeded acceptable levels in residential areas closest to the smelter. A 2002 biomonitoring study (THEC, 2002) suggested risks may be overestimated for thallium (urine concentrations were well below the World Health Organization Level of Concern). ▪ Cancer risks exceed BC MoE acceptable level (1 in 100,000) but were below the U.S. EPA level that requires response action (1 in 10,000). Arsenic concern is related primarily to inhalation, but also to ingestion of soil, dust, and home-grown produce. Overall: ▪ Alternative acceptable cancer risk levels may be considered if recommended by the Medical Health Officer after public consultation. ▪ Since there was strong correlation between lead and other site-related metals, the remediation of lead in soil would address elevated soil concentrations of other metals, in particular arsenic.

Table 4.1-1 (Cont'd): Summary of Phased HHRA for Other Metals

HHRA Phase	Purpose	Conclusions
Addendum. (Environ, 2010)	Respond to BC MoE comments on the Phase Four HHRA.	▪ Several corrections and clarifications were made, none of which substantively changed the results or conclusions of the HHRA.
Evaluation of Trail Homegrown Produce Consumption (Environ, 2014)	Conducted to update exposure and risk estimates for cadmium and thallium exposure from homegrown produce in the Phase 4 HHRA. Recently collected produce data were incorporated to make for a more robust assessment.	▪ Risk calculations showed that consuming Trail garden produce would not cause Cd intakes to exceed recommended levels. ▪ Risk calculations showed that at average consumption rates garden produce would not cause thallium intakes to exceed recommended levels. For leafy vegetables, high consumption rates may result in intakes that exceed recommended levels when the small number of samples with high concentrations is included. ▪ Overall, health risks to Trail consumers of homegrown produce are expected to be low; however, continued monitoring of thallium concentrations in produce may be warranted.

Recommendations based on results of HHRAs for other metals (besides Pb) included:

- Continued air monitoring for As, Cd and particulate matter less than 10 µm diameter (PM_{10}), as well as for Pb.

Risk management measures to address this recommendation included continuing to monitor air quality, continuing to improve air quality in Trail and implementing the Fugitive Dust Reduction Program (FDRP) in 2012.

Given the reduction in emissions and the associated improvement in air quality in the Trail area, the results of the previous HHRAs, specifically As inhalation exposures and associated risks, were reviewed in 2023. Ramboll (2023) conducted a review of air quality data for As collected between 2010 and 2022, revisited inhalation exposure and risk estimates and concluded the following:

- Air concentrations of As have steadily declined over time. As of 2021–2022, they were approaching background levels for the region.
- A review of inhalation toxicity reference values (TRVs) for As identified unit risk factors (URFs) that consider new epidemiological data that addresses limitations present in the original URF established by the U.S. EPA in 1984.
- Using the more recent URFs (Erraguntla et al., 2012; Lewis et al., 2015), cancer risks were estimated to be less than the Health Canada negligible cancer risk level of 1×10^{-5} for all years and locations since 2010.
- Using URFs from the U.S. EPA (1984) and WHO (2000), cancer risks were below 1×10^{-5} at all locations by 2022.
- Based on the above, risks associated with the inhalation of As are less than the Health Canada negligible cancer risk level, which is equivalent to the BC CSR risk-based standard for carcinogens.

4.1.2 Summary of 2024 HHRA for Lead

Given the evolving science related to Pb toxicity and the ongoing biomonitoring program, a detailed CSR HHRA addressing Pb exposures had not been conducted and, therefore, an HHRA for Pb was conducted in 2023/2024 to:

- Assess human health risks associated with exposure to Pb from Teck Trail Operations[8] using standard BC Contaminated Sites Regulation (BC CSR) (BC ENV, 2023a) HHRA methods.
- Review the current risk management strategy and identify any opportunities to further reduce human exposure to Pb from Teck Trail Operations.
- Support a recommendation for risk-based standard for Pb for the EM Area (per Sections 18 and 18.1 of the BC CSR).

8 Objective is to assess risks associated with Pb related to Teck Trail Operations; however, given the age of the community and housing stock, there are non-smelter sources (e.g., Pb in indoor dust from Pb paint) that cannot be partitioned from smelter-related Pb, and, therefore, are inherently included in the evaluation. Further, risk management to reduce overall exposures to Pb from all sources is offered through the integrated nature of the Trail Area Health & Environment Program. Details are provided in this report.

The HHRA for Pb was completed with review and input from the HHRA Working Group[9] and the BC ENV. The HHRA Working Group, which included Pb risk assessment experts, program staff and BC ENV, Interior Health, and BC Ministry of Health representatives, was established to guide the development of the HHRA for Pb, ensure it incorporates the most up-to-date science and is appropriate for the specific Trail-area context. The HHRA Working Group's on-going activities will include evaluation of monitoring data collected from ongoing monitoring activities (including soil, air and blood lead), identification of data gaps, study design and evaluation, review of emerging research and studies from other jurisdictions and supporting updates to ENV regulatory programs. Further discussion of the HHRA Working Group and their continued involvement is provided in Section 8.1.5.

Teck has implemented various programs and operational improvements to continuously reduce exposures to Pb (and other contaminants) sourced from the smelter in the EM Area, resulting in a dramatic reduction in childhood BLL. In the 1992 Pb exposure pathway study involving 241 children living on 176 properties in Trail, the geomean BLL was 10.8 µg/dL (Hilts et al., 1995; 2001), while in 2023 the BLL geomean in children in Trail was 2.1 µg/dL (Interior Health, 2023). Figure 4.1-1 shows the decreasing trend in BLL geomeans by THEP Area over the period of 1991 to 2023.

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9 HHRA Working Group includes representatives from Teck, BC ENV, Interior Health, Ministry of Health, AtkinsRéalis and Ramboll.

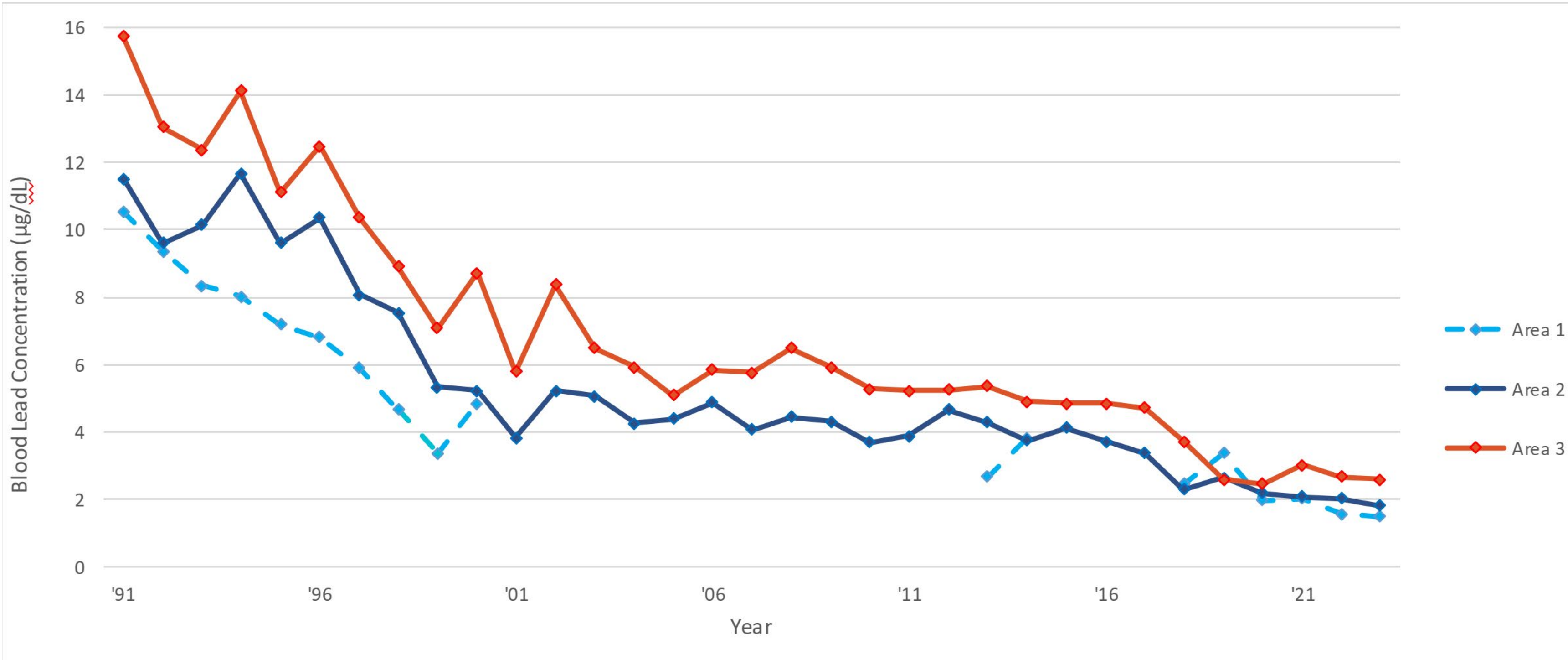


Figure 4.1-1: Trend of blood lead (Pb) geomean by area, years 1991 to 2023 (from Interior Health, 2023)

Lead has been measured in soil across the Trail area at concentrations exceeding the BC CSR standards for various land uses. Therefore, by definition, it is a COC. The Pb concentrations vary between the neighbourhoods in the Trail area, with higher concentrations present in neighbourhoods nearest the smelter. These concentrations are summarized by THEP Area and neighbourhood in Figure 3.1-3. Lead in exterior dust and soil is transported into houses and is therefore present in indoor dust. In indoor dust, Pb can also originate from other sources such as Pb-based paint and cigarette smoke. Finally, based on the continued operation of the Trail smelter, Pb is present in ambient air at low concentrations. Therefore, Pb was retained as a contaminant of potential concern (COPC) in these media.

It is noted that while historical smelter operations have contributed to Pb exposures in Trail, there is the potential for contributions from other sources such as Pb-based paint, historical Pb gasoline emissions and Pb from coal burning and coal ash (Ramboll, 2020), with many of the sources inter-correlated. The THEP has documented Pb paint in homes in Trail. Previous paint screening programs in the Trail area indicate that approximately 50% of the properties tested (interior and exterior testing) have Pb-based paints.

Children are more susceptible to Pb for the key reason that their brains are developing, and they are therefore more susceptible than adults to IQ effects (i.e., for adults, change in systolic blood pressure is the more sensitive endpoint). Within the child age group, young children (younger than 6 years of age) are more susceptible than older children (6 to less than 12 years of age) because (1) young children weigh less, and (2) young children absorb more Pb than older children. The available data suggest that by the time a child reaches approximately six years of age, they absorb Pb at a rate that is similar to an adult (Ziegler et al., 1978; Gulson et al., 1997; Mushak, 2011; Holstege et al., 2020). This is further discussed in Section 6.1.1.

Based on land use around the smelter, and because children are the most sensitive receptors, the residents of the Trail area were identified as the primary receptors of concern for evaluation in the HHRA. Exposures and associated risks to all age groups were evaluated. While there are no reserve lands in the EM Area, Indigenous Peoples in the region were identified as receptors of concern based on the potential for exposure scenarios unique to this receptor group. Interior Health engaged with the Circle of Indigenous Nations (COINS) to obtain information on how Indigenous Peoples in the Trail area are using the land and its resources. Representatives from COINs indicated that traditional plants such as berries, wild rose, cedar, dandelions, nettles and willows may be harvested for consumption or for medicinal purposes (i.e., to make salves, tinctures or teas). COINs did not identify any areas of specific concern regarding where these plants may be harvested from.

Ingesting soil and dust are known to be the dominant Pb exposure pathways for children. Absorbing Pb through skin is negligible compared with uptake through the ingestion and inhalation routes. And uptake via inhalation is significantly lower than via ingestion, particularly for young children who exhibit frequent hand-to-mouth behaviour (ATSDR, 2020).

As Pb from the smelter operations is not generally found in groundwater in the EM Area or the municipal drinking water, exposure to Pb through drinking water was not evaluated further.

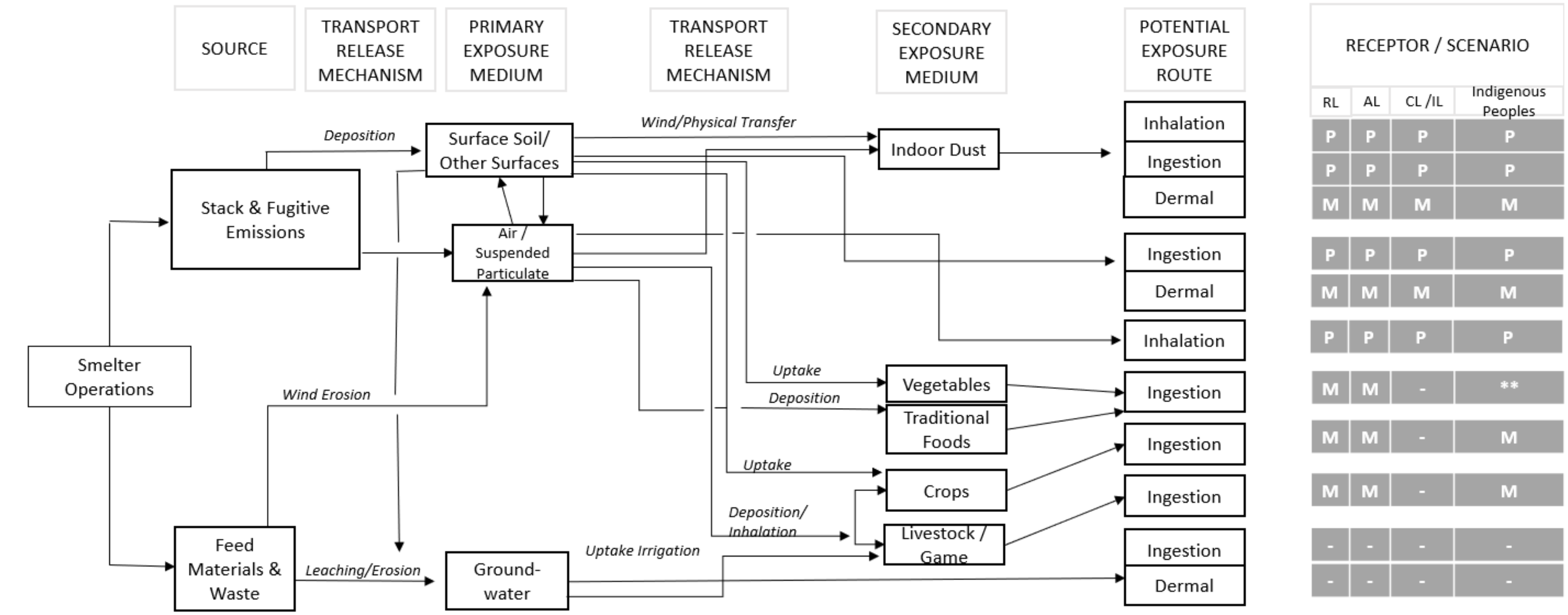
Studies have indicated that Pb in homegrown produce does not translate into higher BLL for children who consume the produce (Brown et al., 2016; Hilts et al., 1995; 2001). Therefore, the consumption of garden produce was not evaluated further in the HHRA. Based on this rationale, Indigenous People's consumption of plants, or use of plants in the EM Area for medicinal purposes, is not expected to result in significant exposures. However, based on the limited available information on potential traditional uses of plants grown in the Trail area, as well as areas that may be used for harvesting, there is uncertainty about the significance of potential exposures to this receptor group. It is recommended that further information be collected from local Indigenous Peoples during consultation scheduled for 2024.

The following Pb exposure pathways were carried forward for evaluation in the HHRA:

- Incidental ingestion of soil and dust deposited on outdoor surfaces;
- Inhalation of soil particulate (i.e., dust generated from soils);
- Incidental ingestion of dust in the home environment;
- Inhalation of dust in the home environment; and
- Inhalation of Pb in ambient air.

Except for soil and outdoor dust ingestion, which are identified as inoperable pathways for the infant age group, each of the above exposure pathways were quantitatively evaluated for all age groups.

A summary of the sources of Pb contamination, the exposure media and the potential Pb exposure pathways is presented in the human health conceptual site model in Figure 4.1-2. All potentially significant exposure pathways identified in the conceptual site model were carried forward for evaluation in the HHRA. Figure 4.1-3, developed by the THEP for educational purposes, provides a pictorial representation of potential Pb exposure pathways within the home.



Legend	
P	Potentially significant pathway; quantitative evaluation
M	Minor pathway; no quantitative evaluation
-	Pathway is not complete
**	Uncertain, more information is required

Figure 4.1-2: Human health conceptual site model for lead (Pb) from Teck Trail Operations

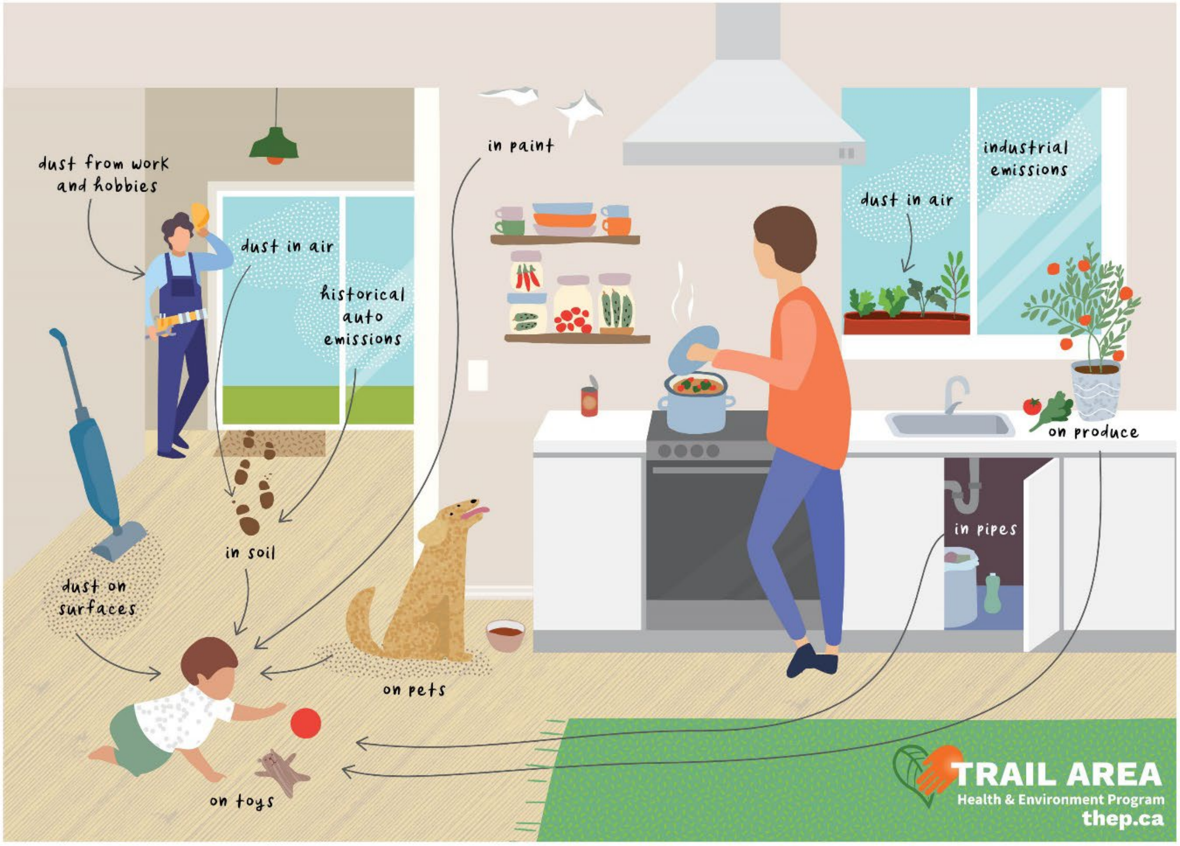


Figure 4.1-3: Human health conceptual site model – Potential lead (Pb) exposure pathways in the home environment (THEP, 2022)

The Pb HHRA used a simplified, probabilistic approach to provide reasonable maximum estimates and central tendency estimates of potential exposures and associated risks. In addition, a Protocol 1 scenario was evaluated to comply with the requirement for deterministic risk assessment included in BC ENV's Protocol 1 (BC ENV, 2023). The reasonable maximum estimates were based on upper-bound soil concentrations and exposure assumptions and represent a worst-case scenario. The central tendency estimates were based on average soil concentrations and exposure assumptions and represent a more typical exposure scenario. The Protocol 1 scenario is moderately less conservative than the reasonable maximum scenario, but as discussed below, is still considered to overpredict risks. The estimated exposures were compared to the Health Canada provisional TRV for Pb for children, and a modified Health Canada TRV for adults (to account for lower Pb absorption in adults). The TRVs represent the level of Pb that people can be exposed to daily without measurable health effects.

The results of the HHRA for Pb indicated the potential for estimates of daily exposures to exceed the Health Canada TRV in the neighbourhoods nearest the smelter for the following receptors and media: infants exposed to indoor dust; young children (ages 6 months to 5 years) and older children (ages 6 to 11 years) exposed to Pb in soil and other outdoor surfaces and indoor dust. When the total exposure estimates are compared to the TRV, a hazard index (HI) is estimated (i.e., estimated total exposure divided by the TRV). The BC CSR risk-based standard is an HI $\leq$ 1.0.

When the results of the HHRA are compared to the blood Pb data that has been collected in Trail for the last 22 years, the reasonable maximum scenario grossly overestimates exposures to Pb, and while the Protocol 1 scenario is moderately less conservative, it too overestimates exposures. Although the central tendency scenario also overpredicts exposure and associated risk, the HIs estimated for this exposure scenario are more reasonable and more accurately reflect potential Pb exposures in the Trail area. On this basis and based on the Health Canada provisional TRV, where central tendency HIs ≤ 1 have been predicted, there is confidence that human health risks are negligible. Where central tendency HIs > 1 have been predicted, further assessment of the potential for health risks has been conducted based on the Interior Health blood lead (Pb) data.

Central tendency scenario HIs less than the BC CSR risk-based standard of ≤ 1.0 have been predicted for all age groups in Montrose, Casino, Columbia Gardens, Warfield and Miral Heights[10]. Central tendency scenario HIs were greater than the BC CSR risk-based standard for children in the neighbourhoods nearest the smelter, including Annable, Oasis, Waneta, Glenmerry, Shavers Bench, Sunningdale, East Trail, Rivervale, Tadanac and West Trail, shown in Figure 4.1-4. Further assessment of the results of the HHRA for these neighbourhoods was conducted using the results of Interior Health's blood lead (Pb) data analysis.

[10] While Miral Heights is located nearer the smelter than select neighbourhoods where HIs > 1 have been predicted, it is geographically separated due to topography, which has likely affected the transport and deposition of aerial emissions in this neighbourhood.

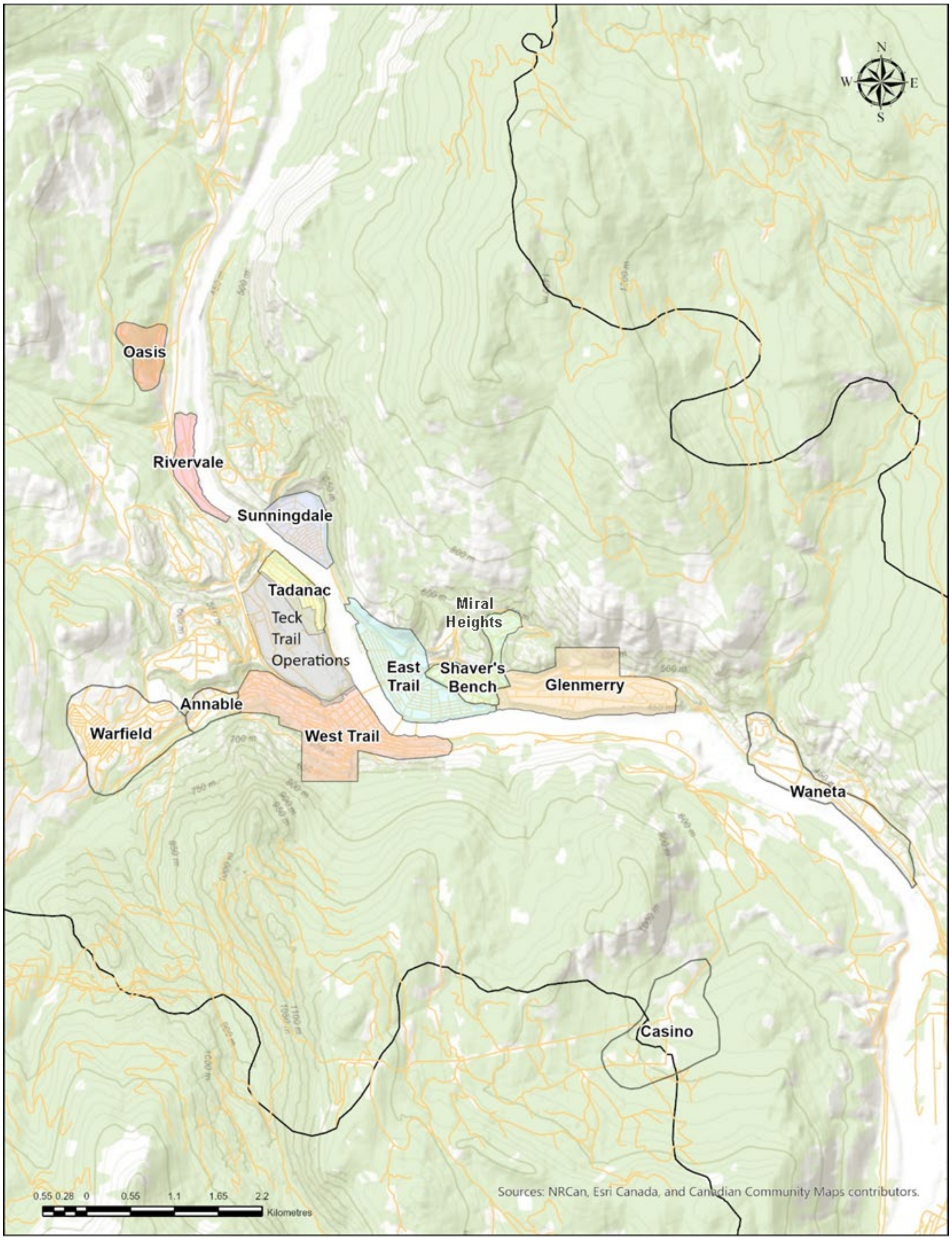


Figure 4.1-4: Location of neighbourhoods within the City of Trail

The reasonable maximum and central tendency scenario HIs predicted by the HHRA were used, along with the basis of the Health Canada TRV for Pb, to predict BLLs for comparing to the BLLs measured in children in the Trail area. As the Protocol 1 scenario HIs fall between the range of estimates provided by the reasonable maximum and the central tendency scenarios, they have not been further considered. Using these predicted BLLs, the following relationships were estimated:

- Reasonable Maximum Scenario: For every 100 mg/kg increase in Pb in soil, there is a 1.6 µg/dL increase in BLL; and

- Central Tendency Scenario: For every 100 mg/kg increase in Pb in soil, there is a 0.5 µg/dL increase in BLL.

The BLLs predicted based on the results of the HHRA exceed measured BLLs. Interior Health's analysis of the blood lead (Pb) data that has been collected in Trail over the last two decades indicated a weak to moderate positive relationship between soil Pb and measured BLL. When the measured BLLs from children in the Trail area were plotted against the soil Pb concentrations at the propert(ies) where the child resides/spends time (N = 997), the line of best fit suggested an estimated increase of 0.10 µg/dL BLL for every 100 mg/kg increase in soil Pb. This estimate is comparable to the literature from other smelter and mining communities. In Broken Hill, Australia, a multivariate regression analysis conducted by Dong et al. (2020) indicated that a soil Pb increase of 100 mg/kg is associated with a 0.12 µg/dL increase in BLL. Using data from the Bunker Hill and a linear regression approach, von Lindern et al. (2003) found that a child's own yard soil to blood lead (Pb) was about 0.6 µg/dL to 1 µg/dL per 1,000 mg/kg Pb in soil (or 0.06 µg/dL to 0.1 µg/dL per 100 mg/kg), with community-wide soil concentrations having a greater effect than a child's own yard.

The HHRA has overpredicted exposures and associated risks to Pb in soil and indoor dust. This is partly due to the HHRA model assuming a linear relationship between soil Pb and BLL. The empirical blood lead (Pb) data from children living in the Trail area (and elsewhere, as indicated in the literature) does not support the assumed linear relationship at the range of soil Pb concentrations in the Trail area. Further, the HHRA model predicted that soil contributes most significantly to overall exposures; while studies indicate that Pb settled from airborne dust is likely the dominant source of elevated BLL in children. This is supported by the air and blood lead (Pb) data from the Trail area. As can be seen in Figure 4.1-5, there is a strong correlation between geomean BLLs in the Trail area and both total suspended particulate Pb concentrations and Pb stack emissions.

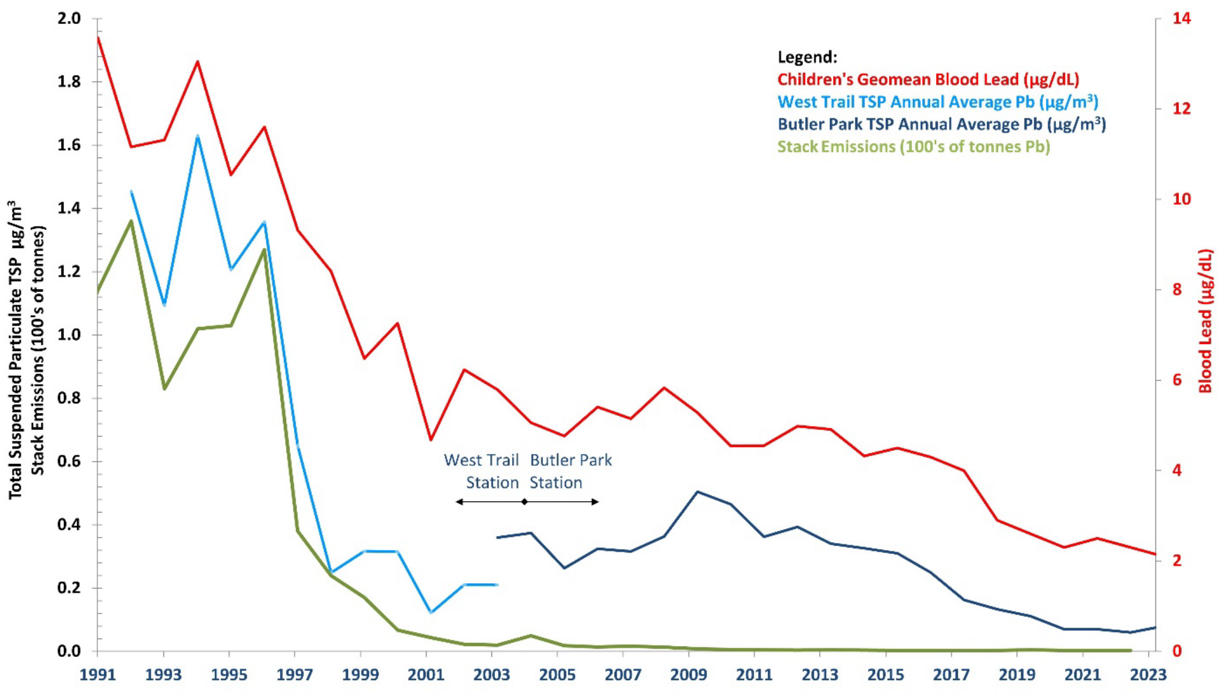


Figure 4.1-5: Mean annual blood lead (Pb) levels (µg/dL), stack emissions (100s of tonnes Pb) and total suspended particulate (µg/m³) (1991 to 2023)

The information presented in this section has been considered in the development of a risk-based standard for Pb for the EM Area to be considered at properties with children present in the neighbourhoods where the HHRA has predicted central tendency scenario HIs > 1.

4.1.3 Risk-Based Standard for Pb for the EM Area

Under Section 18 and 18.1 of the CSR, risk-based standards for Pb for the EM Area have been recommended by an Interior Health Medical Health Officer (MHO). These standards were supported by the results of the HHRA for Pb (AtkinsRéalis, 2024). The MHO's recommendation (Goodison, 2024) includes reducing children's lead (Pb) exposure such that we continue to narrow the gap between blood lead (Pb) levels in children in Trail and those elsewhere in Canada, as well as a risk-based soil standard for lead (Pb). The risk-based standard for soil recommended by the MHO was developed using the results of the HHRA and the Interior Health's Analysis of Variables Influencing Children's Blood Lead Levels in Trail, BC (Interior Health, 2024) and is further discussed below.

When estimating risks, Health Canada (2010; 2024) recommends considering background exposures (including exposures from consumer products, food, air, and water that are not related to the contamination source being assessed). Using this approach, background Pb exposures are summed with Pb exposures from the smelter and compared to the Health Canada TRV for Pb.

The geomean BLL for Canadian children 3 to 5 years of age is 0.5 µg/dL (Health Canada, 2021) and is considered representative of potential background exposures for this age group in the general Canadian population. The blood lead (Pb) monitoring program in the Trail area targets children 6 months to 3 years old because, based on hand-mouth behaviours, this is the age group with the highest potential exposures. There are currently no data for a comparable age-range in the general Canadian population (no age-comparable background dataset), so the Health Canada (2021b) value of 0.5 µg/dL was considered when estimating background BLL for children in Trail.

The Health Canada TRV is derived based on a BLL of 1.2 µg/dL resulting in a 1 IQ point decrement. While it is recognized that Pb is a non-threshold substance and that there is the potential for effects at any level of exposure, Health Canada's recommendation of a TRV for Pb of 0.5 µg/kg bw/day suggests that they do not consider the associated BLL of 1.2 µg/dL and resulting 1 IQ point decrement as an appreciable health effect. Using the background BLL for Canadian children of 0.5 µg/dL, a further 0.7 µg/dL would not result in appreciable health effects. To be health protective and to account for potentially higher background BLLs in the Trail area (see following discussion), only a portion of this 0.7 µg/dL will be apportioned to Pb sourced from the Teck Trail operations.

Several factors not related to the smelter would support an age-comparable background BLL for Trail being higher than the Canadian value. These are:

- Hand to mouth behaviours in the 6- to 36-month age group are greater than in older age groups, which would yield higher potential exposures, and higher background BLLs.
- Sociodemographic factors (e.g., house age) in Trail. Ramboll (2020) indicates that based on information from Statistics Canada (2016), about 63% of occupied private dwellings in Trail were constructed before 1960 and further notes that based on the population history, it is likely that many of the dwellings in Trail were built by 1920. In comparison, the average age of dwellings in Canada is 39.7 years, and in BC is 34.1 years (NRCAN, available at: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=SHCMA&sector=aaa&juris=ca&year=2019&rn=7&page=1&wbdisable=true).
- Higher geogenic Pb in Trail. The 95th percentile geogenic Pb concentration in the Trail area was reported by Goodarzi et al. (2001) to be 37.9 mg/kg. Health Canada (2013, citing Rencz et al. 2006) indicates that in Canada, background Pb concentrations in glacial till (representing unmineralized soil unaffected by anthropogenic activities) were reported to range from 1 to 152 mg/kg, with an arithmetic mean concentration of 9.65 mg/kg and a 90th percentile of 16 mg/kg, based on 7,398 samples collected throughout Canada for the particle size fraction < 63 µm.

From 2003 to 2010, Schoof et al. (2015) examined BLL trends in children ages 1 to 5 in Butte, Montana, and compared them to a reference dataset matched for child age, dates and demographic factors including poverty-to-income ratio[11], house age and race/ethnicity. Geomean BLLs for the Schoof et al. (2015) reference population have been compared to geomean BLLs for the general U.S. population to assess the potential influence of demographic factors on BLL. Geomean BLLs for the reference population were 2.05 µg/dL (2003–2004), 1.80 µg/dL (2005–2006), 1.72 µg/dL (2007–2008) and 1.51 µg/dL (2009–2010). In comparison, geomeans for the general U.S. population, based on National Health and Nutrition Examination Survey (NHANES) survey cycles for children ages 1 to 5, ranged from 1.61 (2003–2006) to 1.33 (2007–2010) (Ruckart et al., 2021). The geomean BLLs for the reference population from Schoof et al. (2015) ranged from 1.1 to 1.3 times those for the general U.S. population. Further, Ruckart et al. (2021) provided weighted geomean BLLs by select sociodemographic factors including income-to-poverty ratios. At an income-to-poverty income ratio < 1.3, the geomean BLLs were approximately 1.2 times the unweighted values (for the 2003–2006 and 2007 to 2010 NHANES survey cycles). Weighting for demographic factors results in an approximate 1.2 times increase in geomean BLLs, as reported by Schoof et al. (2015) and Ruckart et al. (2021). Applying this factor to the geomean BLL for Canadian children of 0.5 µg/dL would add an additional 0.1 µg/dL. To account for the influence of the younger age group represented by the Trail blood lead (Pb) dataset, as well as potential contributions from geogenic sources, an additional 0.2 µg/dL has conservatively been assumed. The resulting 0.3 µg/dL accounts for the potential higher background BLL in the Trail area, and has been subtracted from the 0.7 µg/dL resulting in a remaining 0.4 µg/dL (of the 1.2 µg/dL), as shown below.

- 1.2 µg/dL – 0.5 µg/dL (geomean BLL) – 0.3 µg/dL (potential higher Trail background BLL) = 0.4 µg/dL

As noted, Interior Health estimated a soil Pb to BLL relationship based on the Trail area blood lead (Pb) data of 0.1 µg/dL per 100 mg/kg Pb in soil. As this estimate is substantiated by similar estimates from data in other smelting and mining communities that range from 0.06 µg/dL to 1.2 µg/dL per 100 mg/kg Pb in soil, it has been used to estimate a soil Pb concentration which would maintain Pb exposure within a BLL of 1.2 µg/dL. Using the Interior Health estimated relationship, a soil Pb concentration of 400 mg/kg equates to 0.4 µg/dL. When combined with the Canadian background BLL of 0.5 µg/dL, along with the additional 0.3 µg/dL allocated based on the potential for a higher background BLL in the Trail area, would yield a BLL of 1.2 µg/dL.

Based on the above, a risk-based standard for the EM Area of 400 mg/kg Pb in soil is recommended for properties where young children are present. This risk-based standard for the EM Area is considered within the Prioritization Framework (see Section 6.1). The risk-management principles of this framework should continue to be upheld (see further discussion in Section 6.1), including the following:

- Properties used by children less than 6 years of age at a rate of 2 days per week or more should be the key focus;
- Bare soils pose appreciably greater risk than soils with grass or other coverings; and
- Pb in soils covered by grass do not pose any appreciable risk provided they do not have significant bare areas (lawns cannot have bare areas greater than 9 square feet and the bare areas, no matter the size, cannot be the primary play area of young children).

As noted, the risk-based standard for Pb in the EM Area of a soil Pb concentration of 400 mg/kg is conservatively estimated to contribute approximately 0.4 µg/dL to BLLs.

The BLL declines observed in the Trail area over the last two decades reflect the cumulative effect of the various components of the integrated management approach used in the Trail area to reduce Pb exposures, as well as operational improvements at the smelter and the effectiveness of the biomonitoring program. The integrated management approach, including the biomonitoring program, should continue, with further operational improvements to further reduce Pb in air, where possible.

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[11] Calculated as total family income divided by poverty threshold.

4.2 Ecological Risk Assessment

The ecological risk assessments were conducted in a phased manner, as described in Section 4.2.1. The risk-based remediation targets are detailed in Section 4.2.2.

4.2.1 Summary of Ecological Risk Assessments

In 2000, ecological risk assessments (ERAs) were initiated to determine whether smelter emissions had and were continuing to cause ecological effects. Management goals and objectives were defined early in the ERA process and updated based on information and input from the ERA project team, BC Ministry of the Environment, the Technical Advisory Committee and the Public Advisory Committee (Teck Cominco et al., 2004). These goals and objectives formed the framework for the terrestrial, aquatic and wetland ERAs.

The overall goal guiding the ERAs was to have “no unacceptable residual ecological risk from past or current smelter related emissions.” Residual ecological risk is the risk remaining after natural recovery processes have taken place, or after human intervention such as remediation and restoration. To determine whether the goal was reached, the ERA determined how past, present or future emissions from the smelter have impacted, or might potentially impact, animals (birds, mammals, fish, invertebrates, amphibians), plants, soil, sediment and water in the area. That is, the ERA determined whether the distribution and concentrations of COPCs emitted from the smelter exceeded the CSR standards and whether there was a potential risk to ecological receptors.

The terrestrial, aquatic and wetland ERAs were conducted separately but followed a similar process.

- Step 1: Concentrations of metals in the environment (*e.g.*, in soil, water and sediments) were compared to standards or criteria to identify areas where there was a need to assess risks to animals and plants on land or in water.
- Step 2: The potential for impacts on animals and plants was evaluated by estimating metal uptake for several species based on metal concentrations in soil, water, sediment and food sources. These estimates were then compared with safe values from studies conducted elsewhere (a *bottom-up* approach).
- Step 3: Field studies of the abundance, diversity and condition of animals and plants were conducted to see if any actual impacts could be identified (a *top-down* approach).

Throughout the ERAs, there was input on and review of workplans, study findings and reports. This occurred via public meetings, a Public Advisory Committee and a Technical Advisory Committee which included staff from U.S. EPA, Washington Dept. of Environmental Quality, Western Washington University and ENV. Formal regulatory review was conducted by ENV. This high level of scrutiny throughout the process was done because of the scale and complexity of the ERAs. These multiple reviews and inputs guided the methods used in the ERA.

A summary of the ERA reports, their purposes and their conclusions is presented in Table 4.2-1 and described below.

The ERAs were completed using a phased approach. The phases were called Levels of Refinement (LOR) because each phase used more complex approaches to assess impacts than the previous phase. Each LOR focused on those plants and animals that the previous LOR suggested were at risk of experiencing impacts. When risks were ruled out for plants or animals, no further study was conducted.

The LOR 1 (Problem Formulation) reports (Cantox Environmental et al., 2001; Golder, 2003) used existing information to determine the path forward for the ERAs by:

- Compiling the available data for metals in soil, water and sediment;

- Identifying ecological species to assess in the quantitative ERAs;
- Completing a screening-level risk assessment; and
- Providing recommendations for collecting any additional data.

Subsequent terrestrial ERA reports for LOR 2 and 3 (Cantox Environmental, 2003; Intrinsik, 2007) incorporated more site-specific data and used more advanced modelling techniques to assess exposures and risks. Once the LORs were complete, a Final Terrestrial ERA report was produced (Intrinsik et al., 2011), which incorporated modelling and field data in a weight-of-evidence approach. The science and methods used in the ERA remain as common practice and best practices today. In addition, Section 3.3.6 of the Final Terrestrial ERA Report (Intrinsik et al., 2011) presents a sensitivity analysis, which concludes that any changes in several factors/methods would not alter the recommendations to consider risk management for identified polygons.

Risks to urban plants, agricultural crops, birds and mammals, most Listed Species and most livestock were ruled out. For the Lewis's woodpecker, a blue-listed species (species of special concern), impacts on nesting habitat were considered likely a result of previous SO_2, logging and fire, but direct toxicity from exposure to metals was considered unlikely. Risks could not be ruled out for young horses and plant communities. These are discussed further below.

The Final Terrestrial ERA (Intrinsik et al., 2011) could not rule out risks to young horses from exposure to Pb in soil and forage grass. Because conservative methods were used in the ERA (e.g., comparison of predicted exposures to no-observed-adverse-effect levels [NOAELs]), the report recommended that future opportunities to study exposures to horses should be explored, particularly young horses which are more susceptible to effects from Pb than adult horses. Therefore, in 2022, samples of the same forage grass species were taken from the 10 locations with the highest Pb concentrations measured in forage grass in 2004. The 2022 analysis found significant decreases in concentrations of Pb in the grass samples (30% to 85% reductions), and all concentrations were below the threshold benchmark cited in the literature to protect foals from Pb in diet. In addition, when using this threshold to develop an alternative toxicity reference value (to replace the conservative NOAEL), the estimated risks to horses were acceptable. This study (GDWA, 2023) concluded that risks to horses could be ruled out.

The terrestrial ERA (Intrinsik et al., 2011) concluded that risks to plant communities could be ruled out for 1,598 of the 1,997 polygons in the Area of Interest (Intrinsik et al., 2011). Therefore, under the CSR, no remediation or risk management is required for these polygons. The report also concluded that risks to plant communities could not be ruled out for 465[12] polygons representing up to 7,860 ha of wildland. However, only portions of each polygon contain impacted plant communities. Eleven polygons are on the Teck Trail Operations site. They are, therefore, part of the SGMP and not within the scope of this WARP (see Section 1.2). Of the 454 polygons remaining, only 211 were predicted to have metal concentrations in soil that exceed risk-based concentrations and, therefore, these would be addressed under the WARP in the ERMP. Subsequent soil sampling (up to 2019) and updated interpolation modelling increased the number of polygons included in the WARP to 213 (Figure 4.2-1). The polygons where soil metals concentrations are below risk-based concentrations are not addressed through the WARP and will be evaluated through LCEMP (see Section 2.2.1.2) to work toward Teck's sustainability goal of Net Positive Impact. The polygons included in the ERMP will be reviewed periodically, based on the results of additional soil sampling and revised interpolation modelling. In addition, for both ERMP and LCEMP areas, an updated understanding of plant community condition and soil conditions, when practicable and necessary, will be used when developing treatment prescriptions, to account for conditions that may have changed since the ERA was completed.

[12] Number of polygons according to biophysical habitat map that was updated in 2014 using new provincial BEC mapping standards.

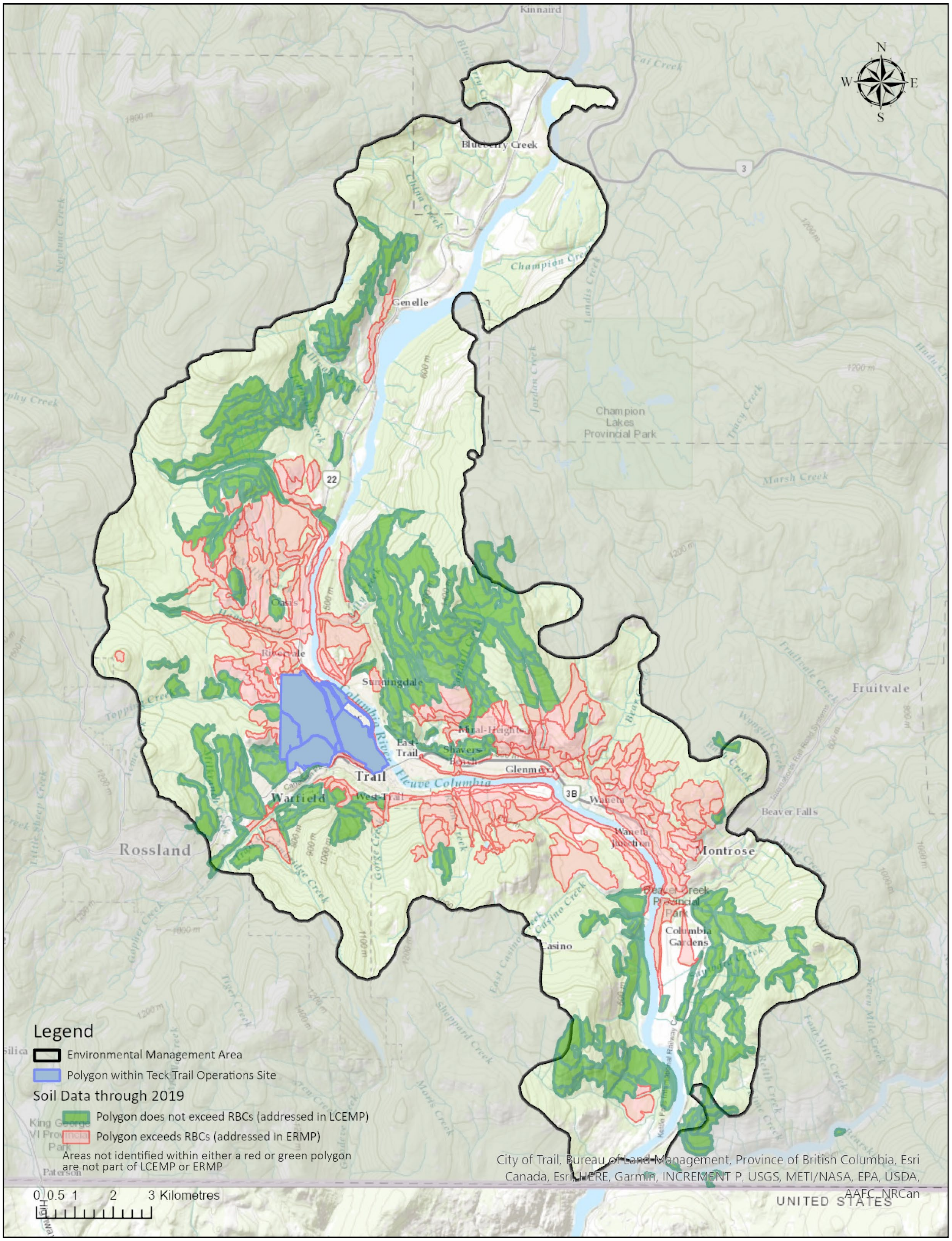

Figure 4.2-1: Polygons with plant community impacts and metal concentrations in soil greater than and less than risk-based concentrations (RBCs)

Aquatic ecological receptor screening was conducted during the Aquatic Problem Formulation (Golder, 2003). Organisms considered were: planktonic organisms (zooplankton and phytoplankton), periphyton, macrophytes, benthic invertebrates, amphibians and fish. As a result of this screening, it was recommended that the aquatic ERA assess risks to the periphyton community, benthic invertebrate community and fish (sport fish and forage fish).

The Aquatic Problem Formulation (Golder, 2003) identified a number of data gaps, which were filled by completion of a large number of aquatic studies (Golder, 2006, 2007c-g) including sediment quality triad assessments, a periphyton community study, fish health study, sequential extraction of sediments, and water quality studies (see Table 4.2-1). These studies were conducted under the direction of a Qualified Person, following a Quality Assurance Project Plan. The study design was reviewed by ENV and by the Technical Advisory Committee and approved by ENV. Analyses were done by a qualified laboratory in accordance with BC standard methods. Sampling programs, interim data reports and analyses were reviewed by ENV. Toxicity testing, field surveys, and data analyses followed protocols that were standard and/or reviewed and agreed to by ENV. Throughout the ERA, an external reviewer and Technical Advisory Committee provided comments to ENV to assist/supplement their review. The Final Aquatic ERA (Golder, 2010) used a weight-of-evidence approach, incorporating multiple types of data (e.g., toxicity testing, field surveys), and considering the magnitude of responses, uncertainties and potential causal links to the smelter. The Aquatic ERA did not identify wide-scale effects that would require risk management. The main Aquatic ERA conclusions were:

- Smelter-related risks were ruled out for water and sediment quality, periphyton, benthic invertebrates, and fish habitat for the tributaries to the Columbia River;
- There were no impacts on fish in the Columbia River, except for white sturgeon, and impacts on sturgeon were not strongly linked to the smelter;
- There may be impacts on the benthic community but only at two sites in the Columbia River (Maglios and Waneta); and
- There may be impacts on periphyton but only at the site within the Initial Dilution Zone, at Stoney Creek (dealt with under a separate risk management program) and at the Korpak site.

The Aquatic ERA recommended that additional monitoring be done, because, either there was no strong link between observed effects and smelter-related metals, or there were other possible causes of effects to aquatic species. This is being addressed by the Aquatic Effects Monitoring Program (AEMP) and the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI). The results from the 2012 to 2021 AEMP sampling (as mentioned in Section 2.2.2), showed that the effects observed potentially due to smelter-related metals observed in the Aquatic ERA on benthic invertebrates and periphyton are no longer seen, or differences are largely driven by habitat structure differences. The Aquatic ERA also recommended that Ryan Creek wetland be evaluated further, due to elevated metal concentrations in fine sediments. Ryan Creek wetland and other wetlands are addressed below.

Teck and ENV agreed that wetlands would be assessed separately because wetlands include both aquatic and terrestrial components, and characterization of wetlands began later during the ERA study than the aquatic and terrestrial ERAs. A preliminary assessment of wetlands began in 2004 and 2005 (Golder & Intrinsik, 2007) with sediment, water and amphibian surveys of five assessment wetlands (including Ryan Creek wetland) and one reference wetland (Figure 4.2-2). Based on the results of that work, additional sampling and analysis were conducted. In 2012, water and sediment samples were collected from these six wetlands and four others (Golder, 2013). In 2014, eight assessment and four reference wetlands (Figure 4.2-2) were surveyed for water and sediment concentrations and for amphibian presence and abundance (Ecoscape, 2015). Statistical analyses of these data were conducted relative to amphibian presence (Ecoscape, 2015; Hausleitner & Thorley, 2016). In 2016, these same 12 wetlands were again sampled for amphibian presence and abundance, and for various amphibian habitat parameters (Machmer et al., 2017). These data were used in a weight-of-evidence risk characterization (Intrinsik, 2018) for amphibians in wetlands. The analysis concluded that amphibian diversity was lower in Thunder Road, Oasis and McNally wetlands, and that these wetlands should be considered when developing the restoration treatments for both the polygon in which they are located and adjacent polygons. Thunder Road wetland is wholly on Teck land. Approximately half of Oasis wetland is on Teck land, with a strip through the middle owned by Fortis (containing a powerline). McNally wetland is located in a polygon which is predominantly Crown land (87%) with a small percentage (13%) of private land.

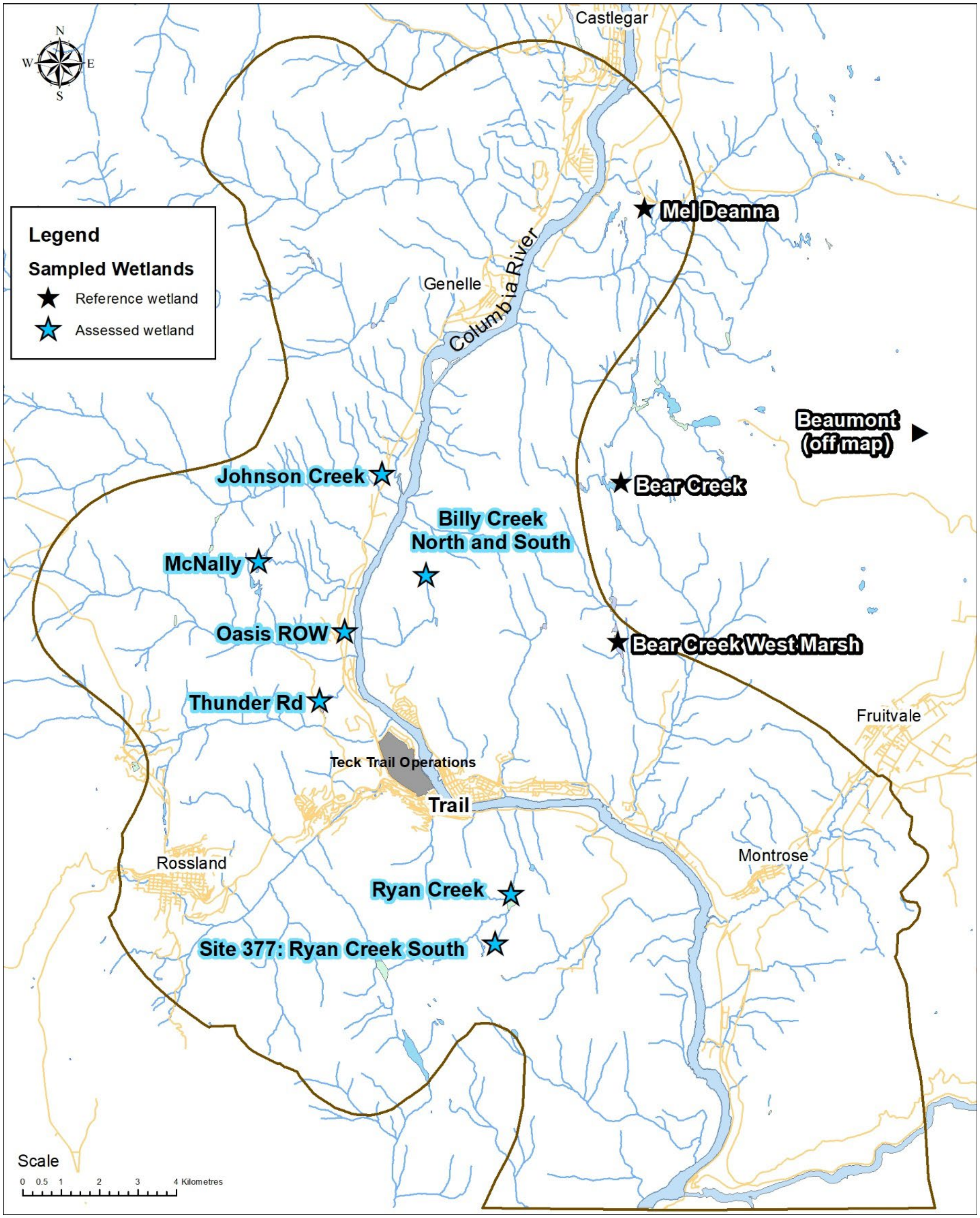

Figure 4.2-2: Locations of wetlands assessed in the final wetland ERA

A summary of the ERA reports, their purposes and their conclusions is presented in Table 4.2-1 below.

Table 4.2-1: **Summary of ERA phases, their purposes and conclusions**

ERA Phase	Purpose	Conclusions
Terrestrial ERA		
One (Cantox Environmental et al., 2001)	To complete a problem formulation, including a review of Trail Operations air emissions and liquid effluents, a description of the environmental setting, a review of the environmental monitoring program, a review of ecotoxicological effects at other smelters and a screening-level ERA.	It identified chemicals and ecological receptors to be evaluated further in the ERA.
Two (LOR2; Cantox Environmental, 2003)	To incorporate updated concentrations of metals in soil, plant tissue, insect tissue, fish tissue, water and sediment, to update toxicity reference values and to incorporate bioavailability.	It revised the list of COPCs and receptors for further analysis. Nine COPCs and 12 wildlife receptors were eliminated in this ERA. The COPCs eliminated were: Sb, Ba, B, Cr, F, Se, S, Tl and Sn. The wildlife receptors eliminated were: belted kingfisher, black bear, domestic chicken, Columbia ground squirrel, domestic cow, coyote, deer mouse, osprey, red-backed vole, red squirrel, red-tailed hawk and white-tailed deer. The following COPCs and receptors were retained for the next ERA phase: ▪ Plants and soil invertebrates ▪ American crow – Cu, Pb, Zn ▪ American robin – Cd, Cu, Pb, inorganic mercury (Hg), Zn ▪ Black-capped chickadee – Cu, Pb, Zn ▪ Mallard – Pb ▪ Dusky shrew – As, Cd, Zn ▪ Horse – Pb ▪ River otter – Pb Threatened and Endangered Species: ▪ Bobolink – As, Cd, Cu, Pb, methylHg, Zn ▪ Canyon wren – As, Cd, Cu, Pb, inorganic and methyl Hg, Zn ▪ Great blue heron – methylHg ▪ Lewis's woodpecker – As, Cd, Cu, Pb, inorganic and methylHg, Zn ▪ Townsend's big-eared bat – As, Cd ▪ White-throated swift – As, Cd, Cu, Pb, inorganic and methylHg, Zn

Table 4.2-1 (Cont'd): **Summary of ERA phases, their purposes and conclusions**

ERA Phase	Purpose	Conclusions
Three (LOR 3; Intrinsik, 2007)	To incorporate updated concentrations of metals in water, sediment, fish, urban and agricultural soil, forage grass in agricultural areas, flying insects and worms. To use the free metabolic rate method and a probabilistic analysis to estimate exposures.	Potential risks to the following receptors from specific COPCs could not be ruled out: ▪ American robin (Cd, Pb); ▪ Bobolink (Cd); ▪ Canyon wren (Cd); ▪ Townsend's big-eared bat (Cd); ▪ White-throated swift (Cd); and ▪ Domestic horse (Pb).
Final Terrestrial ERA Report (Intrinsik et al., 2011)	To use the Sequential Analysis of Lines of Evidence (SALE) Weight-of-Evidence approach to characterize risks.	▪ Risks to the following were ruled out: urban plants, agricultural crops, avian and mammalian wildlife, most Listed Species and most livestock; ▪ Terrestrial plant communities may be at risk in polygons, representing up to 7,860 ha of wildland areas; ▪ Impacts on nesting habitat for Lewis's woodpecker are likely a result of previous SO_2, logging and fire. ▪ Potential risks to young horses could not be ruled out; opportunities to study exposure to young horses should be explored.
Forage Grass Sampling Letter (GDWA, 2023)	To sample forage grass in 2022 and compare to 2004 data to describe risk implications to foals.	▪ In 2022, Pb concentrations in forage were 30% to 85% lower than samples from the same areas in 2004; risks to horses are lower now than those presented in the Final ERA report; ▪ All measured concentrations in forage in 2022 were below the threshold benchmark in the literature for protecting foals from Pb in diet; ▪ When using this threshold to develop an alternative toxicity benchmark, estimated risks to horses are acceptable.

Table 4.2-1 (Cont'd): **Summary of ERA phases, their purposes and conclusions**

ERA Phase	Purpose	Conclusions
Aquatic ERA		
Problem Formulation (Golder, 2003)	To prepare a problem formulation, including a description of the environmental setting, review of the environmental monitoring program and a screening-level ERA.	COPCs and receptors of concern were identified. Studies conducted to address data gaps included: ▪ Relative risk to tributaries from smelter emissions (Golder, 2006); ▪ Sediment quality triad assessment of the effects of the smelter on the Columbia River (Golder, 2007c); ▪ Water quality data summary report (Golder, 2007d); ▪ 2003 periphyton community study (Golder, 2007e); ▪ 2004 fish health study (Golder, 2007f); ▪ Sequential extraction of Columbia River sediments (Golder, 2007g).
Final Aquatic ERA Report (Golder, 2010)	To use the Sequential Analysis of Lines of Evidence (SALE) Weight-of-Evidence approach to characterize risks.	▪ Water and sediment quality, periphyton, benthic invertebrates and fish habitat were evaluated for the tributaries. Smelter-related risks were ruled out; ▪ Sediment in Ryan Creek wetland contained elevated metals, possibly due to its presence down-gradient of an historical trench mining operation; ▪ Risks to mountain whitefish and prickly sculpin were ruled out for the Columbia River; ▪ Risks to periphyton and benthic invertebrates could not be ruled out at selected locations in the Columbia River; ▪ White sturgeon are at risk, but the causal link to the smelter is weak. Impacts are likely due to cumulative effects from multiple stressors.

Table 4.2-1 (Cont'd): Summary of ERA phases, their purposes and conclusions

ERA Phase	Purpose	Conclusions
Amphibians in Wetlands ERA		
Preliminary Investigations (Golder & Intrinsik, 2007)	To do a preliminary characterization of wetlands within the ERA Area of Interest. To evaluate sediment of Ryan Creek wetland based on findings of Aquatic ERA (Golder, 2010).	Sampling conducted in five assessment wetlands and one reference wetland concluded: ▪ Concentrations of metals in water and sediment exceed standards and guidelines; ▪ Concentrations of metals in water are below toxicity threshold values for amphibians, except for zinc at Oasis wetland; ▪ Amphibians in various life stages were observed over seasons and years, providing some indication of sustained populations; ▪ Oasis wetland is affected by water level fluctuations due to culvert maintenance by Ministry of Transportation; ▪ Risks to mallard (representative wildlife species that consumes benthic invertebrates) were minimal.
EcoRA Wetland Survey (Golder, 2013)	To sample wetland chemistry over a greater area, including wetlands from the previous sampling effort, as well as additional wetlands. No amphibian survey was done for this study.	Sampling conducted in six wetlands from previous study plus four additional wetlands concluded: ▪ Concentrations of metals in water and sediment exceed standards and guidelines; ▪ Wetlands at lower elevation (< 800 m) and close to the smelter (within 10 km) have higher metal concentrations; ▪ Concentrations of metals in water are generally below toxicity threshold values for amphibians, except for As, Fe, Pb and Zn, notably at Oasis wetland (south basin). Only the most conservative toxicity values were exceeded and, therefore, risks to amphibians are expected to be low.

Table 4.2-1 (Cont'd): Summary of ERA phases, their purposes and conclusions

ERA Phase	Purpose	Conclusions
Wetland Data Collection and Results (Ecoscape, 2015)	To complete a detailed characterization of water and sediment chemistry, and amphibian presence and abundance.	Sampling conducted in eight assessment wetlands and four reference wetlands concluded: ▪ All assessment and reference wetlands had metal concentrations in water and sediment that exceeded at least one guideline; ▪ Amphibian numbers were higher in assessment wetlands than in reference wetlands; ▪ Elevation (not metal concentration) was the main variable found to influence amphibian abundance; ▪ Reference wetlands differed from assessment wetlands in terms of size, percent shallow open water and percent canopy cover, which may influence comparisons.
Amphibian Occupancy as a Function of Exposure to Contaminants and Habitat (Hausleitner & Thorley, 2016)	To evaluate amphibian species presence (Ecoscape, 2015 data) relative to habitat characteristics, using statistical methods and data from 110 additional reference wetlands in the East and West Kootenay.	▪ Pacific treefrog was detected at all wetlands; ▪ Long-toed salamander presence was influenced positively by elevation and negatively by pH; ▪ Columbia spotted frog occupancy was negatively associated with wetlands identified as assessment wetlands; ▪ No amphibian deformities were observed.
Assessment of Wetland Amphibian Communities (Machmer et al., 2017)	To resample the wetlands sampled in Ecoscape (2015) for amphibian presence and abundance, and to collect additional habitat data; To combine these data with the Ecoscape (2015) data to develop statistical models that may explain amphibian occupancy relative to chemical and habitat variables.	▪ Fewer amphibians were observed in 2016 compared to 2014; ▪ Pacific treefrog was detected at all wetlands in 2016, except Thunder and Oasis, both of which were drying up in 2016; ▪ Long-toed salamander was detected at the same frequency in assessment and reference wetlands; the most significant factor influencing occupancy was canopy cover; ▪ Columbia spotted frog occupancy was positively influenced by the presence of beavers and negatively associated with wetlands identified as assessment wetlands; ▪ Columbia spotted frog occupancy was positively influenced by wetland area; reference wetlands tended to be much larger than assessment wetlands; ▪ No amphibian deformities were observed.

Table 4.2-1 (Cont'd): Summary of ERA phases, their purposes and conclusions

ERA Phase	Purpose	Conclusions
ERA of Amphibians in Wetlands (Intrinsik, 2018)	To apply a weight-of-evidence approach to assess risks to amphibians in wetlands.	▪ Risks associated with smelter emissions were low in Johnson Creek, Ryan Creek, Site 377 and Billy Creek North and South wetlands; no further assessment, or consideration of remediation or restoration is proposed for these wetlands. ▪ Risks associated with smelter emissions were moderate for McNally wetland. There was low potential for toxicity of metals in water and sediment, but only two species of amphibian were observed. This wetland is generally shallow, which may explain the absence of Columbia spotted frog. The wetland is located in a polygon that is predominantly Crown land and that was retained for risk management in the WARP. Thus, it is recommended that the presence of this wetland be considered when developing the restoration treatments for both the polygon in which it is located and adjacent polygons. ▪ Risks associated with smelter emissions also were moderate in Thunder Road and Oasis wetlands. ▪ Thunder Road: Amphibian populations at Thunder Road wetland may be affected because the wetland frequently dries up in summer; however, the influence of Zn in water and various metals in sediment (e.g., As) cannot be ruled out. This wetland is located on Teck land. ▪ Oasis: Amphibian populations at Oasis wetland may be affected by human disturbance (e.g., powerline maintenance, proximity of the highway); however, the influence of As in sediment cannot be ruled out. ▪ Both Thunder Road and Oasis wetlands are located in and/or around polygons that were retained in the WARP. Therefore, it is recommended that the presence of these wetlands be considered when developing the restoration treatments for both the polygons in which they are located and adjacent polygons.

Based on the work summarized above, the ecological impacts that are the focus of this WARP are the terrestrial plant community impacts in 213 polygons, which are addressed in the ERMP. In addition, the presence of nearby wetlands and Listed Species should be considered when developing restoration treatments.

4.2.2 Risk-Based Remediation Targets

In this section, several of the terms used in the discussion of remediation related to wildland plant communities are defined. Thereafter, the risk-based remediation targets for wildland ecosystems are described.

4.2.2.1 Terminology

The general term **remediation,** when applied to reducing risks from contaminants in soil, often refers specifically to soil removal and replacement with clean soil. However, remediation can refer to many other techniques. Therefore, the WARP uses additional terms that are more descriptive of the techniques specifically proposed to reduce risks or impacts to plant communities. These terms, and their definitions, were taken from several sources and are outlined below.

Remediation: The *Environmental Management Act* defines **remediation** as: “action to eliminate, limit, correct, counteract, mitigate or remove any contaminant or the adverse effects on the environment or human health of any contaminant.”

Mitigation: Neither the *Environmental Management Act* nor the CSR (1997; amended 2002) provides a definition of mitigate or mitigation measure. However, the BC Environmental Mitigation Procedures (2014) define **mitigation measure** as “a tangible conservation action taken to avoid, minimize, restore on-site, or offset impacts on environmental values and associated components, resulting from a project or activity.” The Ecological Restoration Guidelines for British Columbia (ENV, no date) define mitigation as “the reduction of environmental harm or impacts. Sometimes mitigation includes the concept of working to offset overall negative impacts by creating habitat or undertaking reclamation in one area to make up for losses in another.” The Environmental Mitigation Procedures (2014) defines **offset** as an action “to counteract, or make up for, an impact on an environmental component that cannot be adequately addressed through other mitigation measures.” Therefore, mitigation includes actions to **restore** and **offset**.

Ecological Restoration: The Environmental Mitigation Procedures (2014) defines “**ecological restoration**” as:

> the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. It is an intentional human activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity, and sustainability. Restoration involves returning the impacted ecosystem to a sustainable ecological trajectory or pathway, determined by the restoration target and reference conditions.

This definition is largely taken from the definition of ecological restoration in the Society for Ecological Restoration “Primer on Ecological Restoration” (SER, 2004). The SER (2004) Primer provides a detailed description of ecological restoration and defines many of the terms associated with restoration (e.g., ecosystem, habitat, reference ecosystem, ecological trajectory).

The definition of ecological restoration in the Ecological Restoration Guidelines (ENV, no date) is taken from the Society for Ecological Restoration (SER, 2004). In addition to defining mitigation and other key terms, the Ecological Restoration Guidelines for British Columbia (ENV, no date) introduce restoration and describe the steps taken to design and implement a restoration project. The Guidelines include a description of the BC Biogeoclimatic Ecosystem Classification (BEC) system, and highlight that BEC can be useful for setting restoration targets and understanding succession.

Summary: The overall goals of the actions described in the ERMP portion of the WARP are to provide suitable growing conditions and promote succession or improved condition of the plant communities. These goals closely align with the definition of ecological restoration, which is mitigation, and is itself encompassed by the broad term “remediation.” Therefore, the term **restoration** will be used throughout the ERMP to describe actions to meet these goals. The term **offset,** also part of mitigation, is used to address plant communities that cannot be adequately restored (see Section 6.2.3).

4.2.2.2 Risk-Based Remediation Targets

The focus of the ERMP portion of the WARP is on restoring plant communities in wildland areas, based on the results of the ERA.

Before planning management actions, the specific goal of the restoration must be defined. While the general goal for wildland plant community restoration is to return impacted polygons to a condition similar to that of comparable, unimpacted reference conditions, the goals may vary according to the desired use of the rights holder or stakeholder, the characteristics of the ecological system and/or a different, reasonably anticipated land use (RALU) of non-Teck land. Therefore, the general goal of returning the site to a forested BEC trajectory (Section 4.2.2.2.1) or non-forested reference condition (Section 4.2.2.2.2) is the primary basis for risk-based remediation targets. Alternate goals based on rights holder or stakeholder goals or based on a different RALU are considered further in Section 4.2.2.2.3.

The condition of plant communities in the EM Area is poorly correlated with metal concentrations in soil. Some areas contain high metals concentrations and exhibit no to limited plant community impacts, while other areas with low metals concentrations do exhibit plant community impacts. The poor correlation is associated with the variable bioavailability of the metals, along with other factors such as soil pH, low nutrient levels and the presence of weeds, which may significantly influence plant communities irrespective of metal concentrations in soil. Because the correlations between metal concentrations in soil and plant community condition indices are poor, both the need for restoration and restoration targets (i.e., measurement of restoration success) will be based on indicators of plant community condition, rather than on metal concentrations in soil. These indicators are based on an understanding of natural disturbance regimes, site conditions, soil moisture and nutrient regimes, and vegetation and successional patterns.

The benchmarks and restoration targets for plant community condition differ depending on whether the ecosystem is forested or non-forested (e.g., brushlands), as described in detail below. Benchmarks for the indicators will be developed based on the natural condition of plant communities outside of the EM Area. The benchmarks will then be compared with data collected from the EM Area to determine the type and magnitude of differences between plant communities inside and outside the EM Area, and hence the type and amount of restoration needed. Once the restoration treatments have been applied, the benchmarks will also be used to evaluate the results to assess how well the ecosystem responded to a treatment. This assessment will determine whether or not ecosystems are on their expected successional trajectory or their condition is acceptable.

4.2.2.2.1 Benchmarks and Restoration Targets for Forested Ecosystems

Identifying Indicators for Benchmark Development

The approaches for identifying and evaluating candidate indicators for plant community condition for climax (mature) or near-climax forests, and development of the benchmarks for these forests, are described in the Quality Hectares Approach document (Machmer & Boulanger, in prep.). It provides a quantitative framework for assessing current vegetation and tracking changes in condition relative to a benchmark. The methodology involves (a) identifying the vegetation community, (b) identifying relevant indicators for that community, (c) establishing appropriate benchmarks (by indicator) and (d) calculating a standardized measure of quality (the quality coefficient) for a site, relative to the community benchmarks. The quality coefficient can be calculated and tracked over time, in response to management actions or disturbance (e.g., fire, disease).

A quantitative approach was used to identify indicators of ecological condition. First, vegetation communities were identified based on an updated biophysical habitat map and legend consistent with the updated BEC-based ecosystem classification used for southeastern BC. The Ministry of Forests (FOR) provided regional BEC data for 798 plots in forested, cottonwood floodplain, brushland, grassland and rock-dominated ecosystems relevant to the EM Area. To develop benchmarks, BEC plot data were ranked and filtered based on plot data quality, disturbance and proximity to the Trail area. Of 798 BEC plots, 692 were selected for benchmark characterization. Adequate sample sizes could not be achieved for all ecosystem units, so 40 site series[13] were grouped by moisture regime to obtain 17 dry, intermediate and moist ecosystem groups with reasonable sample sizes.

Next, a preliminary list was developed of 25 possible indicators to represent vegetation condition. It was then refined, based on (a) rationale for measurement, (b) how indicators are likely to be correlated and (c) which indicators have data available. A suite of 15 BEC-based indicators was identified to be considered further for benchmark development. This involved quantitative evaluation to determine symmetry and variability in the indicator data, followed by curve-fitting to various statistical distribution curves (for two common ecosystem groups). Of these, 10 BEC-based indicators were retained. Two additional structural indicators were retained for use from the preliminary list that lacked corresponding BEC data (coarse woody debris abundance and large tree density). For these two indicators, previous regional data sources were gathered, and benchmarks are being developed, which include additional 2017–2018 data gathered locally.

The 12 indicators proposed for use to evaluate climax or near-climax forest ecosystems are:

- Native tree cover (%);
- Native shrub cover (%);
- Native herb cover (%);
- Native moss/lichen layer cover (%);
- Native tree regeneration cover (%);
- Native species richness (number of species);
- Non-native tree (black locust) cover (%);
- Non-native shrub and herb cover (%);
- Organic matter cover (%);
- Decaying wood cover (%);
- CWD abundance (number/m of transect); and
- Large tree density (number/ha).

Plant communities develop and change over time (i.e., undergo succession) in a predictable way. While the BEC system is based on classification of mature (climax or near-climax) forests, it is natural for a proportion of the landscape to have vegetation that is at an earlier point in succession. Vegetation in a forested landscape that is at a particular age, due to a natural disturbance such as wildfire, insects or diseases is said to be in an earlier seral stage. Therefore, seral plant association descriptors (by indicator and dominant species) for earlier stage plant communities are being developed. Structural stages are used as a framework to identify recognizable stages of seral plant associations (communities) along a successional pathway. The seven structural stages used to illustrate stand development along a successional trajectory (Province of BC, 2010) are:

- Stage 1 - Sparse/Cryptogram;

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[13] A site series is a subdivision of the BEC biogeoclimatic subzone/variant that describes sites capable of producing the same mature or climax vegetation.

- Stage 2 - Herb;
- Stage 3 - Shrub/Herb;
- Stage 4 - Pole/Sapling;
- Stage 5 - Young Forest;
- Stage 6 - Mature Forest; and
- Stage 7 - Old Forest.

For each structural stage and ecosystem unit (BEC subzone/variant/site series), an expected plant association is described based on plant presence/dominance in characteristic vegetation layers.

It is anticipated that plant association descriptors can be identified for each structural stage and BEC unit, to evaluate whether plant communities are on an appropriate trajectory of succession. Therefore, seral benchmarks will be developed to estimate the average percentage cover of indicator/dominant plant species.

Significant field work was completed in 2022 and 2023 to obtain the data needed to develop the seral indicators for forested ecosystems, with a focus on structural stages 3, 4 and 5. Additional field work may be needed to fill data gaps in 2024, with data analysis occurring in 2025 and a report providing proposed seral benchmarks anticipated in 2025/2026. General support for this approach was provided by FOR, both in terms of reviewing the sampling plan and contributing to funding, and it is anticipated that data analysis and reporting will be done collaboratively with FOR.

The locations sampled to obtain the seral data can also serve as permanent reference sites to better understand how ongoing impacts of climate change influence plant successional trajectories through time, for both restored and reference sites. Climate change must be considered because it is a confounding factor influencing plant communities. The sampling locations can be re-visited in future to help identify where challenges related to climate change are associated with treatment failures due to drought, invasive species or other factors.

Using the Benchmarks to Define Remediation Targets

The degree of similarity (e.g., in species composition and percentage cover) between reference sites and sites within the EM Area can be determined using the benchmarks for either mature forests (Machmer & Boulanger, in prep.) or earlier seral stages (in preparation). Where differences are apparent, the benchmarks will help identify how plant associations differ (e.g., what species are missing or are present that shouldn't be, and to what extent). They also provide targets for restoration in terms of species that should be encouraged, added and/or removed at particular structural stages of succession. Targets inform restoration management actions and permit adaptive adjustments to ecosystem development, so they align better with expected natural trajectories.

While the general approach of applying the benchmarks to define restoration targets is scientifically sound, several aspects need to be refined further. Three priority aspects for future discussion are listed below, along with initial recommendations for consideration.

<u>Relative importance and/or interaction of the various indicators in determining the quality coefficient</u>

When calculating the quality coefficient using the identified indicators, the indicators could be given equal weight or, if there is justification, specific indicators may be given more weight. Related indicators (e.g., structure, composition, function) could be combined (averaged) and treated as a single indicator. It is proposed to initially include many relevant, equally weighted indicators, but to evaluate this periodically (e.g., consider eliminating indicators and/or refining indicator weightings) using an adaptive management framework.

A sensitivity analysis can be done to determine how sensitive the results are to including or excluding certain indicators. This is done by removing one or a combination of indicators from the quality coefficient calculation for treatment polygon(s). Such an analysis helps identify which indicators are primarily driving the final quality coefficient scores, and whether this scoring system accurately reflects improvements (or lack thereof) observed during treatments or needs to be adjusted. This will initially be completed using data collected from the restoration trial polygons during the first WARP cycle, and it will inform whether any adjustments to the scoring system are warranted.

The degree of similarity between reference stands and a stand in the EM Area

The degree of similarity between the reference stands and a stand in the EM Area that indicates a successful restoration or acceptable quality remains to be defined. The benchmark condition for a given indicator is not a single value, but rather a curve fitted to the data, which has a central tendency, a variance and a distribution generated by pooling plot data in a given ecosystem unit. The approach for developing benchmarks for mature forested ecosystems, as described in Machmer & Boulanger (in prep.), provides our best estimate for indicator values within a given ecosystem unit. Benchmark distributions reflect several factors: natural variation in the indicator, variation due to sampling, and the influences of succession, natural disturbance and climate change.

Due to natural variability, even comparisons of one reference stand to another would not be expected to result in 100% similarity. Therefore, it will be important to identify a minimum acceptable degree of similarity that indicates successful (acceptable) restoration, based on natural variability and provincial policy. The detailed ERA guidance for BC (SAB, 2008) states: “for most environmental receptors, the goal is not to protect each individual from any toxic effect, but rather to protect enough individuals so that a viable and healthy population and community of organisms can be maintained.” Protocol 1 in BC (ENV, 2023) defines a protection level for reverted wildlands as an EC25 (effects are allowed to up to 25% of organisms). The minimum acceptable degree of similarity of each indicator, or combination of indicators, to their respective benchmark remains to be determined.

The distribution of forest seral stages across the EM Area

The distribution of forest seral stages across the EM Area may be considered when evaluating restoration success. Natural disturbance factors (e.g., fire, insects, disease) vary by ecosystem type and influence seral distribution across the landscape. A study is in progress to understand how the relative distribution of seral stages in the EM Area compares to target or expected natural amounts (in relevant landscape units (LUs) by BEC subzone/variant). A report is being prepared that will compare relative seral stage distributions (by LU-BEC unit) in the EM Area to:

- Seral targets in the Kootenay Boundary Higher Level Plan Order (HLPO; Province of BC, 2002); and
- Expected seral targets based on Range of Natural Variation from the Forest Practices Code Biodiversity Guidebook (Province of BC, 1995).

Additional analyses are required to determine how the results will be applied when prioritizing areas for restoration and determining restoration success.

4.2.2.2.2 Benchmarks and Restoration Targets for Non-Forested Ecosystems

Forest ecosystems comprise most of the wildlands in the EM Area. However, several non-forested ecosystems (e.g., brushlands, grasslands, wetlands, floodplains) are important habitats, and some are or could become provincially listed ecosystems. These ecosystems require different risk-based remediation targets from those developed for forest ecosystems.

For non-forested ecosystems, approaches will be applied including comparing ecosystems in the EM Area to reference ecosystem descriptions provided by the Conservation Data Centre to assess the condition of the ecosystem and the restoration it needs. Tools to assess condition already exist (e.g., condition indices for listed brushland ecosystems), and they could be modified to suit the WARP assessment. This work is still in development.

4.2.2.2.3 Alternate Goals Based on Rights Holder or Stakeholder Goals or a Different RALU

The general goal for wildland plant community restoration is to return impacted polygons to a condition similar to that of unimpacted comparable reference conditions, as mentioned in Section 4.2.2.2. However, the goal may vary according to the desired use of the rights holder or stakeholder, characteristics of the ecological system and/or a different reasonably anticipated land use (RALU) of non-Teck land.

An alternate goal, such as a park, could be considered in an area that may be difficult to restore, has low habitat value and which may allow conservation efforts to focus on more valuable habitat elsewhere. The rationale for a different land use goal would be documented and only be considered if there is a reasonable expectation that such a goal would be successful.

When considering an alternate RALU, any existing management plans for these areas must be understood before restoration plans are developed. Restoration to a BEC trajectory will not be done on lands for which an alternate management plan exists. In these cases, an appropriate approach is either to address the area under other aspects of the WARP (e.g., if the plan is for residential or commercial development), or do restoration to a goal that includes some or many, but not all, of the requirements that apply to restoration along a BEC trajectory (e.g., for timber harvest or ungulate winter range). The landowner, rights holders, stakeholders or the Crown may also want the land left as is.

4.2.2.2.4 Summary of Risk-Based Remediation Targets

Based on the results of the ERA, the focus in the WARP is to restore plant communities in wildland areas. Because of the poor correlations between the concentrations of metals in soil and the condition of plant communities, the need for restoration and the restoration targets to inform restoration success will be based on plant community condition indicators rather than on metal concentrations in soil.

Identifying and evaluating candidate indicators of plant community condition for climax (mature) or near-climax forests and developing the benchmarks for these forests, are described in the Quality Hectares Approach (Machmer & Boulanger, in prep.).

Because it is natural for a proportion of the forested landscape to be in earlier seral stages (e.g., due to wildfire, insects, diseases), seral benchmarks for earlier stage plant communities are being developed. It is anticipated that plant community descriptors can be identified for each earlier stage, to help evaluate whether plant communities are on an appropriate trajectory of succession.

Benchmarks are used to evaluate how close the ecosystem is to the restoration target. By comparing the benchmarks for either mature forests (Machmer & Boulanger, in prep.) or early seral stages (in preparation) to sites within the EM Area, the degree of similarity can be determined (e.g., in species composition and percentage cover). Where differences are apparent, the benchmarks help identify how plant associations differ (what species are missing, or present but should not be, and to what extent). They also help identify what vegetation layers and species should be encouraged, added and/or removed at particular structural stages of succession. Targets inform management actions and permit adaptive adjustments to ecosystem development to align with natural trajectories.

While the science behind developing benchmarks is standard, applying the benchmarks to a large EM Area under the CSR is not. Discussions with ENV and subject matter experts within FOR and WLRS is proposed, to determine how to apply this novel approach within the CSR.

5. Remedial Options Evaluation

The *Environmental Management Act* defines **remediation** as "action to eliminate, limit, correct, counteract, mitigate or remove any contaminant or the adverse effects on the environment or human health of any contaminant." The goal of soil remediation is to minimize the risk of exposure to metals in soil while ensuring remediation is safe, adaptable and sustainable. The strategy for soil remediation is risk-based and is adapted to various land uses across the EM Area. The engineering and administrative controls that have been put in place to provide this risk-based approach are described in the sections below.

5.1 Remedial Options for Protection of Human Health

As noted in Section 1.2, the WARP focuses on decreasing Pb exposure by remediating Pb contaminated soil (and the inherent potential for contaminated soil to contribute to Pb in airborne dust). There are other important sources of Pb in the Trail EM Area, notably fugitive dust emissions from Teck Trail Operations, which are addressed directly through existing regulatory authorizations.

The remedial options to protect human health in the EM Area are risk-based and are described below. For clarity, remediation on residential land is referred to in various documents as "soil management." It includes the remedial strategies outlined in Teck's Soil Management Plan and herein. The terms soil management and remediation are used interchangeably, with remediation mostly used in technical documents (e.g., this WARP) and soil management in public facing documents (e.g., THEP website, homeowner forms, etc.). Remediation to support the protection of human health typically includes:

- Soil assessment: The sampling and analysis of soil at properties to evaluate levels of metals in surficial soils;
- Ground Cover Evaluation: determining the quality, accessibility and type of ground cover on a property that may pose a potential risk of exposure to soil to young children or track-in of soil into the home (e.g. walkways, play areas, parts of the property used by pets, etc.);
- Soil replacement: The excavation, disposal and replacement of soil on all or part of a property; and/or
- Ground cover improvement: The covering, changing, maintenance or improvement of ground cover when soil replacement is not achievable or practical. Ground cover improvement includes lawn care.

5.1.1 Residential Land

The primary goal of soil remediation activities on residential land is to manage risks related to the potential exposure of children to metals in soil, particularly young children who are at the greatest risk of exposure to Pb. The prioritization approach for remediation of residential property changed over time to meet the needs of the community. The objective was to promote participation in soil assessment and remediation programs and address historical impacts efficiently and effectively.

5.1.2 Remediation Prioritization Background

During the 1990s and early 2000s, while smelter emissions were being reduced through operational upgrades, soil remediation actions through the Lead Task Force primarily involved capping and ground cover improvements on properties where children were identified as having elevated BLLs. In 2008, following emission reductions and reductions in Pb in airborne dust in the community, soil was replaced in the first four residential yards and eight vegetable gardens as a remedial action. Until 2019, residential properties were tested and prioritized for soil replacement when the 95% UCLM for Pb exceeded the BC CSR Upper Cap Concentration (UCC) in Protocol 11. In 2008 this was 5,000 ppm Pb. It was lowered to 4,000 ppm Pb in 2014 and 1,200 ppm in 2017. Vegetable gardens were also prioritized for soil replacement when soil Pb exceeded 1,000 ppm (EPA). In addition to soil replacement at properties with soil exceeding UCC, ground cover improvements were carried out on properties with young children, along with other primary prevention programs such as Healthy Homes visits, as described in Section 2.2.

In 2019, following further reductions to Pb in airborne dust through the Fugitive Dust Reduction Program, a risk-based prioritization framework was developed to articulate a scientifically defensible strategy to prioritize remediating properties where the risk of exposure is greatest. The prioritization approach is described in SNC-Lavalin (2019).

Under the WARP, prioritizing properties for remediation is proposed to continue as:

1. Highest-risk properties from the prioritization framework (e.g., properties with children, bare exposed soil and soil Pb over current thresholds developed through the HHRA).
2. Vegetable gardens identified using the prioritization framework.
3. Other community priorities (e.g., properties/blocks where soil Pb concentrations may be higher and contribute to neighbourhood exposure).

Significant progress in addressing the highest priority properties was made between 2019 and 2022, and in 2023 a pilot project to remediate entire blocks was initiated, alongside prioritizing properties where children are present. The initiative prioritizes neighbourhood blocks for remediation where:

1. At least 80% of the block has been tested (soil assessment is offered where data gaps exist);
2. Children are living in the surrounding blocks, with the higher number of children present prioritized first; and
3. Block soil concentrations are highest.

Currently, soil replacement on blocks that are part of this initiative also addresses properties in the EM Area with soil concentrations above UCC. This is a strategic and beneficial way to prioritize properties for soil remediation where soil concentrations are elevated and children are not living. The strategy does not consider ground cover in prioritizing blocks for remediation.

5.1.3 Remediation Planning and Options

In the years leading up to the remediation of the first properties in Trail in 2008, a summary of remedial options was prepared for consideration (Hilts et al., 2001). It weighed the pros and cons of many types of remediation including: phytoremediation, soil removal, on-site burial of contaminated soil, ground cover improvements and numerous other ways to manage the risks of soil exposure. Because residential remediation targeted properties with young children with elevated BLLs, quicker solutions (e.g., soil replacement) were favoured over slower acting approaches (e.g., phytoremediation). The residential soil remediation program, as noted above, was initiated in 2008, and expanded in 2019. The 2019 program substantially increased the pace of residential remediation.

Under the Soil Management Plan, once soil assessment and prioritization are complete, remediation planning and an options evaluation are carried out on each residential property prioritized for remediation. This step considers the site-specific aspects of the property to determine the best soil management approach. The considerations include:

- Access constraints onto and within the property;
- Risks related to property damage such as work around utilities, complex landscape features such as foundation walls and other areas of concern;
- Longevity of the remedial action and long-term maintenance requirements; and
- Future land use, timing and objectives of the property owner.

Once the options are considered and the preferred remedial actions are agreed upon with the property owner, an agreement documenting the remediation plan is developed to outline the recommended remedial actions to be employed on the property. It is signed by the property owner to provide consent. Typical remedial actions are risk based and may include replacing soil, capping and/or improving the ground cover. Given the complexity of the sites and the disruption to residents during soil management on residential properties, the remedial options typically used are those summarized in Table 5.1-1.

Table 5.1-1: Summary of risk management options on residential yards

Soil Management Action	Description	Rationale
Soil Replacement		
Shallow soil excavation	Excavation of soil to 0.3 m below grade.	▪ Generally, excavation removes the soil with the highest concentration of metals to a depth where human exposure is unlikely; ▪ Can be done reasonably quickly on many properties (e.g., less than a week of disruption per property); ▪ Is above the depth of most utilities; ▪ Is above the depth of most footings/foundations so does not impact structures; and ▪ Balances risk management objectives with sustainability objectives, e.g., reduced trucking and equipment related greenhouse gas (GHG) emissions compared to deeper excavation, reduced community disturbance, reduced requirement for replacement topsoil (a limited resource).
Partial Soil Excavation	Excavation on part of the property to a depth of 0.3 m	• Completed when parts of the yard are inaccessible (e.g., around large trees, adjacent vulnerable structures, on or below steep slopes) or where soil Pb concentrations exceed soil management thresholds on only part of the property.
Installation of geotextile	Placement of a permeable landscape fabric at the base of the excavation	▪ Identifies the extent of soil removal for future reference; and ▪ Provides a physical barrier if digging in a yard.
Backfill cap	Replacement of soil, gravel, sand and other materials	▪ Provides a backfill cap with soil concentrations that meet minimum EM Area standards; ▪ Blocks direct exposure to underlying elevated metals concentrations, if present; ▪ Is pre-characterized to verify backfill is acceptable for use in the EM Area[14], and ▪ Homeowners can choose different backfill materials depending on need and how they use their property (e.g., gravel for a driveway, topsoil for lawn).
Landscaping	Replacement of landscape features across the yard	▪ Provides immediate vegetation cover to remediated areas to stabilize shallow soil; ▪ Minimizes disruption; and ▪ Restores yard for property owners.

[14] Acceptable soil would meet Risk Based Remediation Standard for Pb, EM Area Concentration Limits for As, Cd and Zn and BC CSR standards for other metals relative to the applicable land use.

Table 5.1.1 (Cont'd): Summary of risk management options on residential yards

Soil Management Action	Description	Rationale
Covering and Improvements		
Lawn care	Seeding, fertilizing and aerating lawn areas to improve cover	▪ Improves ground cover in lawn areas to minimize exposure to bare soil; ▪ Inexpensive and can be provided quickly with little planning and coordination; ▪ Generally well supported by residents; ▪ Used as an interim approach for properties waiting for soil replacement; and ▪ Used as a long-term approach for areas with limited access and where consent for soil replacement has not been received from the property owner.
Covering with geotextile and landscape materials	Capping or covering area with landscape fabric and landscape features. May include shallow excavation (0 m–0.15 m depth).	▪ Commonly used on properties with difficult access or constraints that limit excavation (e.g., large trees, utilities). As with lawn care, non-invasive treatment such as covering can be used where soil remediation consent has not been obtained from the property owner. ▪ Can be used as an interim or long-term approach depending on the site specific conditions of the property.
Hardscaping	Covering areas with patio stone, asphalt or concrete	• Provides a more permanent cover that is low maintenance and durable, depending on the use.
Limiting Access		
Fencing/ barricades	Placing fencing or barriers to limit access to parts of a yard	▪ Used for areas that cannot be remediated through cover or soil removal and replacement. Areas are fenced to limit access. Requires long term maintenance of the fencing.
Planting vegetation	Installing small shrubs or ground cover to limit access to soil that cannot be removed.	▪ Used for areas that cannot be remediated through cover improvements or soil replacement; planting vegetation can limit people's access to soil; and ▪ Requires vegetation to be maintained long term.

Many of the approaches described in Table 5.1-1 require long term maintenance to verify capping materials (grass, landscape materials, etc.) remain in good condition. Information and guidance are provided to property owners regarding cover maintenance and, in some cases, resources are also provided (e.g., hoses for watering, grass seed, topsoil). Monitoring cover materials is incorporated into the Performance Verification Plan (Section 8). The remediation options are reviewed and adapted annually and case by case. Remediation plans and records are recorded in the THEP database and mapped in the GIS for future reference. This is also the case for urban parks, agricultural, commercial and industrial properties discussed below.

5.1.4 Considerations for Urban Parks

Urban parks include playground spaces and larger greenspaces. Because parks are areas that children frequent, they are prioritized for remediation within the Soil Management Plan (SMP) under the same general methods and prioritization strategy used for residential properties. Within a park, younger children tend to frequent playground structures (swings, sandboxes, play equipment) where they return to play each time they visit. As a result, playground areas can be prioritized separately from greenspaces, which are accessed less frequently, particularly by young children. Remediating urban parks is typically carried out by maintaining ground cover and doing targeted soil replacement in primary play areas.

Prioritization decisions at park areas are informed by soil assessment results and by annual inspection and ground cover evaluation of playground and greenspace areas. Records of annual inspections are maintained in the THEP database, and recommendations about appropriate remedial actions are provided to property owners (e.g., municipalities).

When remediation is prioritized, the remedial actions are typically undertaken collaboratively with the landowner. Potential remedial actions are:

- Providing support for ground cover improvements where necessary (see Table 5.1-1)
- Conducting targeted shallow soil replacement in high-use/primary play areas (see Table 5.1-1); and
- Coordinating and streamlining efforts with landowners during park modifications (e.g., playground replacement, tree removal).

5.1.5 Considerations for Agricultural Land

Like urban parks, agricultural land is divided into categories to evaluate risks and prioritize remedial actions depending on how each area is used and the anticipated receptors. Residential and barnyard areas have higher risk for human exposure to soil metals because they are frequented by residents, including children. Agricultural fields and pastures are considered lower risk for human health exposure because they typically have some form of vegetation ground cover and residents do not access them as often. The remedial approach for agricultural land will be included in the 2024 Annual Report provided to ENV. The remedial options for agricultural land are the same as listed in Table 5.1-1.

5.1.6 Property Development Program

Through the PDP, the risk-based remediation of metals in shallow soil on properties undergoing development or upgrade is a site-specific process based on current and future land-use for the proposed development. This includes commercial, industrial, institutional and large residential development properties. The process for selecting remedial option(s) is driven by redevelopment objectives and/or CSR requirements. A property owner may wish to obtain a CSR regulatory instrument (e.g., to support municipal permitting process or for due diligence purposes).

Remediation at a development property may include:

- Remediating surficial soils contaminated from aerial deposition of smelter-related metals;
- Remediating other historical smelter or non-smelter related contamination such as contaminated fill; and
- Remediating contamination related to non-smelter sources including historical activities/facilities at the property and adjacent lands.

The scope of this WARP includes only remediating metal contamination associated with historical aerial emissions from Teck Trail Operations (i.e., shallow soil). The other types of remediation are addressed case by case, depending on site investigation findings and the responsible party. Property owners are solely responsible for managing non-smelter related contamination at their properties.

Remediation is most typically achieved through a combination of removing contaminated soil and disposing it off-site, or by capping (e.g., under paved surfaces or structures). The remediation method and depth of excavation are determined by the objectives and scope of the development project. Teck's support for development projects includes:

- Assessing soil potentially impacted by smelter related sources,
- Coordinating disposal at approved locations depending on soil quality (i.e., RDKB landfill through the waste soil application process, or a Teck owned landfill under permit).
- Confirming the work is completed and providing a summary report to the property owner and Teck.

5.2 Remedial Options for Protection of Ecological Receptors in Wildlands

The primary goals of restoring wildlands in the EM Area are to support suitable growing conditions (e.g., soil pH, nutrients) and promote succession or improved condition of the plant communities. Achieving these goals fosters a more natural ecosystem that provides a diversity of habitats to support native plant and animal species, including species at risk and regionally significant species and ecosystems.

Removing soil to meet numerical standards across the EM Area is impracticable. It could significantly impact biodiversity and damage the plant communities that are present, and it could be logistically difficult due to access and soil volumes. Replacing soil has the same logistical difficulties, with the added challenge of finding sufficient soil from the same BEC subzone/variant so that seeds and other soil components (e.g., invertebrates, microorganisms) are appropriate to the area. Removing soil is also generally unnecessary for reducing the toxicity of metals in soil to plant communities and/or promoting plant community restoration. The condition of plant communities in the EM Area is poorly correlated with metal concentrations in soil, as noted in Section 4.2.2, due to the variable bioavailability of the metals and factors such as soil pH, low nutrient levels and presence of weeds, which have a significant influence on plant communities irrespective of metal concentrations in soil.

The approach to wildlands restoration is to look at natural restoration processes, determine what is limiting recovery and then design a restoration treatment to address those limiting factors. Potential restoration treatment options for wildlands are described in Section 5.2.1. Conditions may restrict which restoration treatment options are practicable in specific EM Area polygons. The factors to be considered when evaluating potential treatment options are outlined in Section 5.2.2. Pilot treatments that will contribute to developing and understanding restoration options in the EM Area are introduced in Section 5.2.3.

5.2.1 Potential Restoration Options

Potential restoration treatments to address impacts to plant communities within the EM Area include:

- Add lime to the soil to raise pH (to target pH 6);
- Scarify, or make the soil rough and loose, to control erosion and eliminate compaction while creating microsites for pioneering vegetation species;
- Treat weeds (selective pulling, herbicide, bio-control);
- Conduct vegetation brushing (remove aggressive understory plants to allow other native understory vegetation to compete);
- Apply silviculture treatments (prescribed fire, selective tree thinning, pruning, brushing);
- Plant native trees, shrubs and/or herbs;
- Allow natural attenuation/regeneration; and
- Apply access controls and use restrictions, signage and/or public education/awareness initiatives.

Combinations of treatments may be used.

More detail for each of these potential options is provided in Table 5.2-1 and thereafter.

Table 5.2-1: Restoration Treatment Options to Address Factors Limiting Plant Community Recovery

Factor Preventing Recovery	Primary Treatment Option	Additional Treatment Options	Comment
Low soil pH	Liming		Liming increases soil pH to the optimum range for natural ecosystems, and it adds calcium and magnesium to the soil
Elevated metal concentrations in soil	Liming		Liming increases soil pH, which decreases metal bioavailability and toxicity
Soil compaction	Scarification, making soil rough and loose	Access controls and use restrictions, signage and/or public education/awareness initiatives, if compaction is due to trespassing	
Weeds outcompeting native plants	Weed treatment	Access controls and use restrictions, signage, and/or public education/awareness initiatives, if weed introduction is due to trespassing	Weed treatments may include herbicides, mechanical efforts, biological efforts and/or cultural control efforts.

Table 5.2-1 (Cont'd): Restoration Treatment Options to Address Factors Limiting Plant Community Recovery

Factor Preventing Recovery	Primary Treatment Option	Additional Treatment Options	Comment
Plants in poor condition due to decadent growth, disease, competition	Silviculture treatments (prescribed fire, selective tree thinning, pruning, brushing), vegetation brushing		Silviculture treatments are specific to trees; Brushing is used to address competition and may also be conducted on shrubs and herbs.
Unvegetated openings and/or a lack of suitable plant cover, density and distribution	Planting native trees, shrubs and/or herbs	Add fertilizer, organic matter such as woody debris, and/or gel packs for irrigation	Soil conditions must be suitable for plant growth prior to planting.

5.2.1.1 Liming

In many parts of the EM Area, surficial soil (0 cm to 15 cm depth) is less than pH 5 (Figure 5.2-1). A low soil pH may increase bioavailability of some metals, such as Pb and Zn, which may increase plant uptake of metals. The metals may then interfere with various physiological systems within the plant.

Applying lime to raise soil pH is expected to be an important first step in many restoration areas. Determining whether lime is needed and the rate for applying it will be site specific. It will depend on factors such as the local parent material (which influences natural background soil pH) and the buffering capacity of the soil (measured as buffer pH).

To promote vegetation growth, improve nutrient and water uptake from soil and decrease bioavailability of metals (Pb, Zn) in soil, proposed lime application would target pH 6.0. Targeting pH 6.0 allows soil pH to decrease somewhat over time and still remain within the range of natural background levels. In addition, keeping the soil pH below 6.5 is consistent with the recommendation in U.S. EPA (2007) to raise the soil pH no higher than pH 6.5 so that arsenic mobility in soils is not increased significantly.

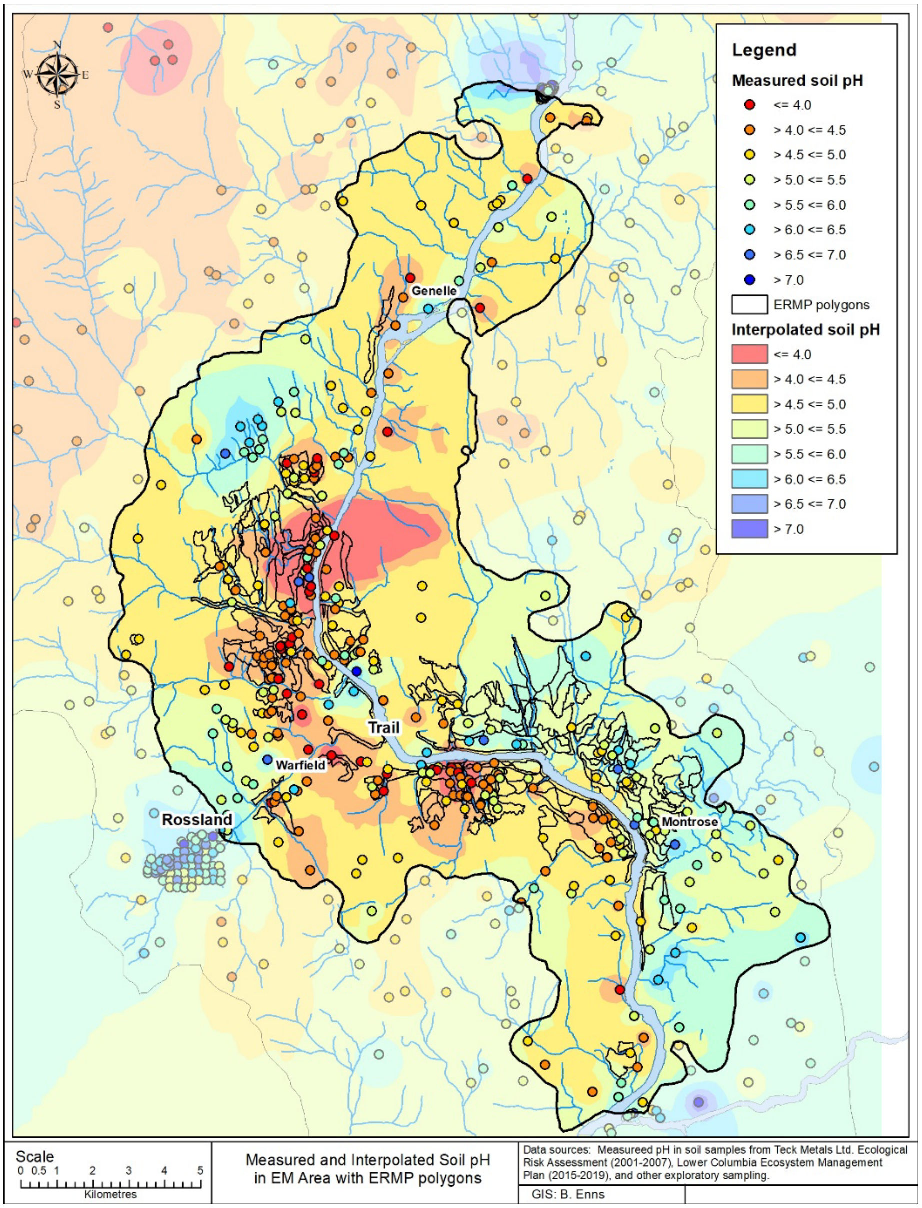


Figure 5.2-1: Measured and interpolated surficial soil pH across the EM Area

Liming will be conducted by applying dolomitic lime onto surface soils. The effectiveness of liming at increasing and maintaining soil pH varies with the size(s) of the lime particles. In the initial pilot treatments the lime selected for use had a range of particle sizes with 70% of the lime passing a 20 mesh sieve and 5% passing a 40 mesh sieve. This should result in a slow release to avoid a spike in pH. Using dolomitic lime also increases calcium and magnesium in the soil. Both are essential plant nutrients and are at “low” or “very low” concentrations in many EM Area soils, relative to levels needed for optimal plant growth, as measured in the soil nutrient analyses conducted during soil sampling in 2015 and 2016.

For applying lime, hand-spreading, mechanical spreading and aerial spreading will be considered. Lime should be applied with caution, especially in mountainous terrain where it can be carried away in run-off and can accumulate at unpredictable concentrations elsewhere (e.g., toe slopes, depressions, benches below steep slopes).

Literature suggests that in some areas liming may be sufficient to promote natural plant community succession, depending on other factors (Hamilton et al., 2016; liming around the smelter in Flin Flon, Manitoba). In other areas, alternate restoration actions may be required, such as removing invasive species or planting native trees and shrubs.

To create favourable conditions for plant growth, lime should be applied the year before any planting and can be applied several years before planting. Therefore, an opportunity exists to do broad-scale liming, rather than focus on small areas. This creates an opportunity for natural revegetation to begin. For example, liming to increase soil pH to favour conifer growth may be evaluated as an approach to address weeds, because coniferous trees generate more year-round shade than deciduous species, and this may help control weed introduction and spread.

5.2.1.2 Scarification / Rough and Loose Treatment

Compaction impacts a minority of polygons (e.g., south towards Fort Shepherd Conservancy and in patches along Casino Road, Hanna Creek Drive), due mainly to old roadbeds, motorized recreation impacts, dirt bike use and/or horse trails. These areas would benefit from being scarified. Not only would it reduce compaction/erosion but it would also promote rough and loose soils with microsites more amenable for planting vegetation and/or for adjacent native vegetation to fill in naturally. The treatment would also serve to discourage use by horses and motor vehicles. It would be confined to relatively flat terrain in readily accessible areas, due to the need for heavy equipment.

5.2.1.3 Weed Treatments

The densities of invasive weeds are high. Contributing to this are the relatively dry local climate and the abundance of open terrain and anthropogenic disturbances, which provide habitat and dispersal routes for invasive plants. In polygons where plant communities have been impacted, invasive species have opportunistically colonized open/disturbed areas, and invasive weed control treatment will be a key component of successfully restoring these sites over time. A number of confirmed species are classified as provincially noxious (e.g., knotweed spp., Canada thistle, hound’s tongue, dalmation toad flax, yellow flag iris) or regionally noxious (e.g., common tansy, hoary alyssum, orange hawkweed, plumeless thistle). Once established, they are difficult to completely eradicate without consistently using herbicides coupled with mechanical, biological and cultural control efforts.

Where herbicide treatments are needed to address weeds, it may be beneficial to plant site-appropriate native species (e.g., poverty oatgrass) to cover the soil quickly and reduce the potential for invasive weeds to fill in exposed soil. The seral classification work (see Section 4.2.2.2.1) will provide guidance on selecting suitable plantings to contain invasive weeds and promote natural succession in treatment polygons. Guidance will include percentage cover estimates for each indicator and dominant species in each vegetation layer during each stage of succession.

5.2.1.4 Understory Vegetation Brushing

Brushing is an activity to control or reduce competition for space, light, moisture and nutrients adjacent to target plants. It may be done by chemical, manual, grazing or mechanical means. Brushing aggressive understory plants such as bracken fern and dogbane may be needed to allow other native and/or planted vegetation to compete for sunlight. In addition, brushing may be considered as an enhancement treatment to rejuvenate decadent shrubs (i.e., shrubs with a high proportion of dead material). Manual brushing to remove the dead and decadent growth may stimulate resprouting, suckering and vigorous new growth in some decadent shrub species (e.g., saskatoon, willow, Douglas maple, red-osier dogwood, choke cherry, mock orange, etc.), thereby enhancing shrub density, health and palatability for wildlife.

5.2.1.5 Silviculture Treatments

Silviculture treatments include prescribed fire, selective tree thinning, pruning and brushing of trees. These treatments are used to reduce competition, improve tree vigor or prevent disease.

In some polygons, vegetation is visibly impacted by diseases and/or insects (e.g., trees infected by white pine blister rust or birch/aspen decline). Such stands may benefit from systematically pruning susceptible and/or unhealthy tree segments (e.g., removing the lower limbs of western white pine trees or the dead and dying tops and limbs of paper birch prone to decline).

5.2.1.6 Planting Native Trees, Shrubs and/or Herbs

In many polygons, impacts were characterized by unvegetated openings and/or a lack of suitable plant cover, density and distribution relative to what would be expected, based on typical soil, moisture and nutrient regime characteristics. Selectively planting target indicator/dominant species may reduce unvegetated openings and increase suitable vegetation cover. The target plant species and appropriate vegetation types will depend on the successional stage of the site (and adjacent sites that may provide seed or propagule sources) and the current soil, moisture and nutrient regime conditions.

Increased densities of shrubs and regenerating conifers in open patches will also help shade out encroaching invasive species and deter people from using motorized vehicles, while providing “anchors” and partial shading for herbaceous cover to develop (Thorburn, 2020).

It may be necessary to add nutrients or organic matter to the soil to make conditions favourable for the plantings. In areas that have experienced soil erosion, soil or woody debris may need to be added. Woody debris contributes to restoration by providing habitat and structure for other organisms (e.g., fungi, invertebrates, vertebrates), together with moisture and nutrients for plants as the wood slowly breaks down (Polster, 2016).

Climate change impacts such as increased growing season temperatures, reduced precipitation and prolonged summer drought are posing extraordinary challenges to vegetation establishment and survival in forestry and ecosystem restoration settings. These impacts are also seen and predicted to be of future concern in the ecosystems of the BC Southern Interior (Holt et al., 2012). Short-term irrigation of newly planted native shrubs and trees may be necessary to promote successful establishment of new plantings.

The most practical and efficient way to irrigate plantings may be to use gel packs that can be planted along with the trees and shrubs. Irrigation using truck-mounted water tanks or backpack sprayers is impractical for much of the EM Area, due to distance from roads and the volume of water that would be needed.

5.2.1.7 Natural Attenuation/Regeneration

There may be areas where a natural successional trajectory is observed. Allowing an area to regenerate without treatment may be considered if the area may not benefit significantly from treatment, or if there is a significant chance that implementing a treatment could have unintended negative consequences (e.g., introduce invasive plants). Similarly, there may be areas that may not be possible or appropriate to remediate (e.g., talus slopes, rock outcrops). The “natural attenuation/regeneration” approach could be the best restoration option for these areas. It may include a monitoring schedule to verify that regeneration is occurring without active treatment.

5.2.1.8 Access Controls and Use Restrictions, Signage or Public Education/Awareness Initiatives

Access controls and use restrictions can be implemented on Teck-owned land. Signage could also be used to encourage people to adhere to restrictions by communicating why access is not permitted (e.g., Ecological Restoration Area). More detailed educational signage explaining the ongoing restoration initiative could also be an option. Signage, if agreed to by the landowner/steward, may be considered for Crown or other lands.

General public education and awareness initiatives may be used to keep the public informed about ongoing efforts to restore an area. These may include newspaper/flyer ads, radio ads, updates to the Teck.com website, newsletters and social media posts, among others.

5.2.2 Factors Influencing the Feasibility of Restoration Treatments

The wildlands within the EM Area represent a large area comprised of diverse ecosystems with varied topography and accessibility. The restoration options described above require different types and amounts of equipment and materials. Therefore, there are several factors to consider when designing a treatment for a particular area, and some of these factors will limit the options available. Factors with potentially limiting criteria for each treatment are being compiled and described in detail in a document "Factors Influencing the Feasibility of Restoration Treatments" (Machmer & Ehman, in prep.). They are summarized below. The Machmer and Ehman document is planned for review and discussion with the LCEMP Committee, to verify the list of factors is comprehensive and appropriate, and that criteria proposed are reasonable and will permit restoration treatment implementation while also ensuring worker safety.

The proposed factors and criteria potentially limiting restoration feasibility from Machmer and Ehman (in prep.) are listed and described below. They are:

- Zoning and minimum treatment unit size thresholds
- Steep or unstable slope limitations
- Inherent terrain limitations
- Access limitations
- Other factors

Zoning and Minimum Treatment Unit Size Thresholds: Zoning may be "incompatible" or "potentially compatible" with restoration treatment. Attempts were made to classify City of Trail and Regional District of Kootenay Boundary zoning categories according to these two classifications. Zoning categories considered incompatible with wildland restoration are: residential, commercial, industrial and institutional. Polygons for which 100% of the zoning is incompatible may be considered under other WARP land use categories and programs. Zoning categories that are or could potentially be compatible with wildlands restoration (at least in portions of a property) include: rural holdings, rural residential, rural resource, agricultural resource, forest resource, parks and recreation, conservation area and rail/trail corridor. The appropriateness of restoration on a parcel of potentially compatible land also depends on factors such as current and future land use, land ownership, landowner interest and the proportion of a property with wildlands (e.g., not used for dwellings, other structures, agriculture, forestry, recreation, etc.). Several minimum sizes of a treatment unit are proposed (i.e., ≥ 4 ha, ≥ 2 ha, and ≥ 1 ha) for the "potentially compatible" areas.

Steep or Unstable Slope Limitations: Steep or unstable slopes have the potential to limit the feasibility or type of restoration treatment. According to the Government of Canada's slope gradient classification, "extremely steep" slopes are those with a slope gradient greater than 30% (Government of Canada 2013). The BC Forest Safety Council (2015) provides guidance to forest workers conducting mechanical treatments with heavy equipment on steep slopes, which are defined as slopes greater than 35%. WorkSafeBC (2011) also provides guidelines for using specialized forestry equipment on steep slopes, ranging from 35%–50%, depending on the equipment. Most steep slope harvesting is conducted on the coast; in dryer forests of the Kootenay region, harvesting is generally not conducted on slopes of 40% or greater (D. MacKillop, pers. comm.), as outlined in a Timber Supply Analysis Discussion Paper (Ministry of Forests, Lands and Natural Resource Operations, 2016).

Based on this information, three slope limitation categories are proposed:

- Maximum gradient of 30% for treatments involving heavy equipment;
- Maximum gradient of 40% for treatments involving ATV access; and
- Maximum gradient of 60% for treatments involving foot access.

The potential for helicopter access, including any related slope limits, needs to be assessed further as program development advances.

Inherent Terrain Limitations: Terrain that is excessively dry, rock-dominated, steep, sandy or consistently wet can limit operability and/or reduce restoration treatment options. Proposed limitation criteria are:

- Rock-dominated site series (Ro [rock outcrop], Rt [talus], or CL [cliff]) on very steep slopes greater than 60%; or
- Wetlands or wet forest forested site series (110, 111, 112, 113) with operability limitations.

In addition, feasibility trials and effectiveness monitoring are proposed for polygons with rock-dominated site series on moderately steep slopes (greater than 30% to less than or equal to 60%), and treatment and effectiveness monitoring is recommended on gentle to moderate slopes (less than 30%).

Access Limitations: Access can limit the ability to implement operational restoration treatments efficiently, depending on the type of treatment and the machinery/equipment involved. Lack of access is often confounded with steep or unstable slopes and/or terrain types that limit road and trail building. The criteria for this factor are proposed as:

- Areas 100 m or further from access roads or trails are lower priority for treatments involving heavy equipment;
- Areas 500 m or further from access roads or trails are lower priority for treatments involving ATV use; and
- For foot access, two options are proposed for consideration. Areas either 1 km or more or 2 km or more from access roads or trails are lower priority for treatments involving foot access.

Other Factors: Other factors that may influence restoration feasibility and/or appropriateness include:

- Aggressive invasive plants (in particular invasive black locust);
- Disclimax polygons (e.g., birch-bracken fern disclimax stands[15]);
- Listed plant or animal species or plant communities (e.g., rare grassland-brushland communities in the ICHxwa, ICHxw and ICHdw1);

[15] A disclimax stand is one that is relatively stable at an early successional stage due to a disturbance, and therefore does not undergo natural forest succession.

- Elevated arsenic concentrations in soil at the base of steep slopes (where the potential for runoff and accumulation of lime would need to be considered); and
- Overall time and effort relative to the benefits of restoration.

An annual review of Listed Species will be done to determine whether there are new Listed Species, or whether some species are no longer listed. Listed Species records in the project database will be updated annually.

5.2.3 Pilot Studies to Inform Treatments

Pilot projects may be needed to demonstrate proof of concept for the restoration treatments listed above. Currently, these are being conducted on Teck lands, where access is less constrained, and any unexpected or unwanted changes can be more easily managed. Pilot studies initiated to date are summarized in Table 5.2-2.

Before initiating the first pilot study, a small-scale plot-level study was initiated in 2017 at Polygon 1566. It provided insight into technical and logistical planning for treatments that might be used for operational scale pilot studies. Each treatment area was 20 x 20 m, with a 5 m buffer zone between treatment areas. It was determined that factors preventing plant community recovery at Polygon 1566 included elevated concentrations of As and Pb (at approximately 1.5 times the ecological risk-based concentration), low soil pH (3.8–4.2), low decomposition of needle litter, soil loss and lack of soil moisture. Therefore, the treatments applied were liming, soil addition and irrigation, alone and in combination. Each treatment method and a control plot were included on a dry site and a moist site (16 plots total). The results of the small-scale plot-level study at Polygon 1566 will be used to inform future treatments. For example, acquiring a sufficient quantity and quality of soil from an appropriate BEC unit would be challenging and, therefore, impractical for large-scale implementation of soil addition treatments.

Table 5.2-2: Polygons with baseline sampling completed and pilot treatments initiated

Polygon #	Geographic Location	Issues Preventing Recovery	Type of Polygon Treatment	Treated	# Plots	BEC Units Represented
1360	North of Fort Shepherd	Control polygon for 1361, 1359 and 791	None	Not applicable	6	ICHxw104
1361	North of Fort Shepherd	Low soil pH (4.5, 4.7), soil compaction from motorized vehicles, bare areas lacking vegetation, elevated soil metals (As, Pb, Zn ~ 2x risk-based concentration)	Rough and loose; add coarse woody debris	Dec. 2017, April 2018	13	ICHxw104
791	North of Fort Shepherd	Low soil pH (4.6-5.2), low soil nutrients, areas lacking vegetation, white pine blister rust, elevated soil metals (As, Pb, Zn ~ 2x risk-based concentration)	Liming, pruning, planting trees (12,000, of which 9,800 had gel packs) and shrubs (1,800) with fertilizer bags added	2020/ 2021 2021 2022	18	ICHxw104

Table 5.2-2 (Cont'd): Polygons with baseline sampling completed and pilot treatments initiated

Polygon #	Geographic Location	Issues Preventing Recovery	Type of Polygon Treatment	Treated	# Plots	BEC Units Represented
1359	North of Fort Shepherd	Low soil pH (4.5, 4.6), low soil nutrients, white pine blister rust, elevated soil metals (As, Pb, Zn ~ 2x risk-based concentration)	Liming, pruning, to compare to 791	2021	14	ICHxw104

The first pilot project was conducted at Polygon 1361 (North of Fort Shepherd area). Polygon 1360 was identified as the control polygon. The BEC unit represented in both polygons was the ICHxw104. In Polygon 1361, there were elevated concentrations of As, Pb and Zn in soil (at approximately 2 times the ecological risk-based concentration). However, the primary issue preventing recovery was identified to be soil compaction from motorized vehicles such as dirt bikes and ATVs. Therefore, the treatment was to make areas within Polygon 1361 rough and loose, to reduce compaction and create microsites for pioneering vegetation species. Then coarse woody debris (CWD) was placed over the excavated areas to add a slow-release nutrient source and discourage motorized vehicle use. The work began in December 2017 and was completed in April 2018. This pilot project highlighted challenges with adding CWD. One significant lesson learned was that the prescription must more clearly define the volume, density, piece size and tree species preferred for CWD treatments, and the source material must be screened to minimize the introduction of invasive species by the treatment.

The second pilot project was conducted at Polygons 791 and 1359 (north of Fort Shepherd area). Polygon 1360 also was deemed an adequate control for these two polygons. The BEC unit represented was also ICHxw104. At Polygons 791 and 1359, the issues preventing plant community recovery were low soil pH, low soil nutrients and white pine blister rust. Both polygons also had elevated concentrations of As, Pb and Zn (at approximately twice the ecological risk-based concentration). However, Polygon 791 had areas lacking vegetation, whereas Polygon 1359 was considered to have sufficient vegetation cover over most areas.

In 2020/2021, liming was done at Polygons 791 and 1359. In both polygons, white pine was pruned to reduce symptoms and likelihood for transmission of blister rust infection and improve overall tree condition. No further treatment was conducted at Polygon 1359. In Polygon 791, trees and shrubs were planted and supplemented with fertilizer bags. The trees were Ponderosa Pine, Western Larch, Aspen, and the shrubs were *Ceanothus velutinous* (snowbrush), *Symphoricarpus albus* (snowberry) *and Mahonia aquifolium* (Oregon grape). Gel packs were planted with 9,800 of the 12,000 trees. This pilot study will provide information on the effectiveness of liming to increase soil pH, decrease signs of metal toxicity in plants (e.g., chlorosis) and create soil conditions favourable for shrub and tree growth in the presence or absence of fill plantings. It will also provide insight into any unexpected consequences of liming (e.g., whether it promotes the growth of weeds or other disturbance-associated species). The use of gel packs as an irrigation method will also be assessed.

These pilot treatments need to be monitored for several years, to evaluate the type and amount of treatment and determine whether changes are needed (adaptive management). Additional pilot treatments will be considered in consultation with the LCEMP Committee. These additional pilot treatments may evaluate other restoration options to address different limiting factors or focus on priority ecosystems such as rare brushlands.

Once there is confidence that a restoration treatment is safe and effective, it can be considered for non-Teck lands.

6. Remediation and Confirmation of Remediation Methodology

A summary of the remediation process and the methods used to confirm remediation has been successful are presented below.

6.1 Soil Remediation to Protect Human Health

While the WARP was under development, Teck has been carrying out soil assessment and remediation under the Annual Soil Management Program (SMP) Workplan (as outlined in ENV, 2018). The goal of soil management activities is to identify and reduce potential impacts of elevated Pb (and other metals) that children may be exposed to in soil. Over time, remediation action levels have changed, but the priority for remediation has remained the same: to address properties where the potential risk of exposure to Pb is the greatest. Properties prioritized to date for soil remediation include:

- Those with young children;
- Those with vegetable gardens;
- Those in neighbourhoods close to the smelter, where metals are typically higher; and
- Other properties where soil disturbance creates risk of exposure, such as where owners are moving or excavating soil.

6.1.1 Soil Assessment

The soil assessment program that was standardized in 2007, will continue to offer soil assessment to residents throughout the EM Area under the WARP. It will utilize the same methods as described in Section 3.1.1 for residential properties. This includes the sampling and analysis of metals across the property and annual ground cover evaluation. Residential properties where young children are living are prioritized for soil assessment as are properties with vegetable gardens and properties in neighbourhoods where soil metal concentrations are likely to be higher. Soil results are evaluated individually (maximum concentration or specific concentrations in bare areas) as well as statistically to review the opportunities to reduce potential exposure to young children and to the community. The assessment and ground cover evaluation prioritizes individual properties as well as informs broader community remediation under the block program outlined in Section 6.1.3.

Commercial and industrial properties are tested under the Property Development Program, as described in Section 6.1.6.

6.1.2 Prioritization of Residential Properties for Remediation

In 2019, a risk-based approach was developed for prioritizing and remediating properties in the EM Area. The objective of the prioritization strategy was to provide a scientifically defensible approach to identify and prioritize properties for which soil remediation is the most important. At the time, the strategy was based on the one developed by United States Department of Housing and Urban Development (U.S. HUD) and was adapted for the context of the EM Area. It has since been reviewed and updated based on the results of the HHRA for Pb.

Based on the results of the HHRA and risk estimates for the central tendency scenario below the CSR risk-based standard for all age groups, including young children, in the neighbourhoods of Montrose, Casino, Columbia Gardens, Warfield and Miral Heights, the probability of adverse health effects is negligible. Therefore, properties in these neighbourhoods will generally not be prioritized for remediation; however, soil assessment is available to confirm soil concentrations and condition of ground cover. An exception to this may exist for properties where young children are present and where the 95% UCLM soil concentration exceeds the risk-based standard for Pb for the EM Area of 400 mg/kg Pb in soil. The neighbourhood boundaries are somewhat arbitrary, with the potential for neighbourhoods to be immediately adjacent one another (e.g., West Trail and Annable/Warfield). Therefore, the neighbourhood approach used in the HHRA may not capture properties at the boundaries of neighbourhoods. The requirement for consideration for prioritization of remediation at such properties should be determined on a property specific basis and following the below outlined principles and criteria of the Prioritization Framework.

The results of the HHRA for the central tendency scenario indicated the potential for risks to exceed the CSR risk-based standard for children (infants, young children and/or older children) in neighbourhoods located nearest the smelter including Annable, Oasis, Waneta, Glenmerry, Shavers Bench, Sunningdale, East Trail, Rivervale, Tadanac and West Trail. These neighbourhoods were therefore identified as areas requiring further assessment based on the results of the Interior Health blood lead (Pb) data analysis. Using the results of this analysis, the risk-based standard for Pb for the EM Area of 400 mg/kg was developed and is applicable to properties in these neighbourhoods where children are present.

To date, the characteristics used to prioritize properties for remediation have been (1) the presence of young children on the property, (2) the presence of bare soils versus soils covered with grass or other materials and (3) soil Pb concentrations (95% UCLM for the property).

Considering these characteristics, prioritization groups were established in 2019 under the Prioritization Framework. The framework and the prioritization groups have been modified based on the results of the HHRA and the risk-based standard for Pb in the EM Area. The risk-management principles of the framework, which have been upheld based on the current science on Pb exposure and toxicity, include the following:

- Properties where young children are present are the key focus; and,
- Bare soils pose greater risk than soils with grass or other forms of good ground cover (e.g., mulch, gravel).

The potential for risks greater than the CSR risk-based standard were also estimated for older children (ages 5 to < 12 years) in some of the same neighbourhoods where the potential for risks were predicted for younger children (< 5 years). With respect to older children, although assumed to ingest soil at the same rate as younger children, older children have higher average body weights than younger children. Health Canada (2024) recommends an average body weight of 16.5 kg for the most sensitive age group children aged 6 months to <5 years whereas they provide a body weight 2 times higher (32.9 kg) for the 5 to <12 years old age group. Additionally, the available data suggests that older children absorb less Pb (i.e., lower oral absorption) than younger children. Citing a variety of studies and their results regarding oral absorption, Mushak (2011) indicate that infants and toddlers consuming diets common to this age band absorb more Pb by ingestion than do older children, and by 5-6 years of age, such children have oral Pb uptake rates comparable to that for adults, about 10% or less (Mushak, 2011).This is further supported by the following:

- Literature dating back to 1970s (e.g., Ziegler et al., 1978) indicates that gastrointestinal (GI) absorption is greatest in infants and young children.
- A Pb isotope study conducted by Gulson et al. (1997) suggests that children ages 6–11 years and their mothers absorb a similar percentage of ingested Pb. This study is referenced by ATSDR (2020).

- Holstege et al. (2020) indicate that Pb absorption is inversely proportional to chronologic age and indicate that in general, approximately 30–50% of Pb ingested by children is absorbed, compared with approximately 10% of that ingested by adults.
- WHO (2023) indicates that young children absorb 4-5 more Pb than adults.

While there is limited available data of Pb absorption differences at ages between young children and adults, the available data supports that absorption decreases with age, with both Gulson et al. (1997) and Mushak (2011) suggesting that by the age of approximately 6 that children's oral absorption rates are comparable to adults. The use of a factor of 2.5 to account for this difference appears supported and conservative as it assumes only a 2.5 times difference, whereas key agencies, including the WHO, indicate a difference of 4-5 times between children and adults.

As a result of applying the body weight factor of 2 and the absorption factor of 2.5 to risk-based standard for Pb for the EM Area of 400 mg/kg for young children, a Prioritization Screening Concentration of 2,000 mg/kg was calculated for older children (i.e., 400 mg/kg x 2 x 2.5 = 2,000 mg/kg). It is noted that based on the available literature, older children in the Prioritization Approach are defined as children aged 6 to 12 years of age. Thus, for the Prioritization Approach, young children are those aged 1 to < 6 years, and older children are those 6 to < 12 years. While these age ranges differ slightly from those evaluated in the HHRA, inclusion of children up to 6 years of age as young children is health protective.

Based on the above, the recommended revised Prioritization Approach is as follows:

Priority 1 (P1): The property has bare, exposed soil; and

- The soil Pb concentration exceeds 400 mg/kg where the children present are younger than 6 years of age (i.e., young children); or
- The soil Pb concentration exceeds 2,000 mg/kg where the children present are 6 years to less than 12 years of age (i.e., older children).

Priority 2 (P2): The property has good ground cover (i.e., soils are covered with grass or other materials); and

- The soil Pb concentration exceeds 400 mg/kg if young children are present; or
- The soil Pb concentration exceeds 2,000 mg/kg if older children are present.

Consistent with the 2019 approach, prioritized properties are intended to include residential properties, daycare centres and parks because they represent the highest potential risk for Pb exposure to children compared to other land use areas. The objective is that top priority properties (i.e., Priority 1 properties) are prioritized for remediation within the calendar year. Based on the results of the HHRA, properties without children are considered to represent negligible risk and were not considered as part of the overall prioritization. However, they are still eligible for soil testing and soil management support where these are needed (e.g., vegetable garden soil replacement, soil disposal, etc.).

6.1.3 Pilot Block Remediation

It is understood that children are exposed to Pb in their environment beyond their immediate yard. Due to the SMP's ongoing progress in addressing properties in the P1 and P2 groups, there is opportunity to further reduce children's potential exposure to metals in soil by reducing neighbourhood levels of soil Pb, particularly where concentrations are comparatively high. Literature to support neighbourhood-wide remediation indicates that for the proportion of Pb exposure related to soil, a child's own yard may contribute 30% and the broader community soil may contribute another 30% (Von Lindern; et al., 2003). Both yard and community-wide soil remediation will reduce in-house Pb-containing dust Pb, which is expected to be the primary Pb exposure pathway for young children. As such, prioritizing remediation of neighbourhood blocks is expected to further reduce average soil Pb levels in child-occupied areas of the community and further reduce children's exposure to Pb in soil.

In 2023, a pilot project was started to remediate blocks where average soil Pb concentrations are high. Under the risk-based block prioritization method, blocks with the most children and the highest soil Pb concentrations are remediated first. Remediating adult-occupied properties within these blocks should also be beneficial for the child-occupied properties because soil with high Pb is removed. This pilot project takes place in addition to the prioritized remediation of P1 and P2 child-occupied properties within the EM Area. Distinguishing reductions to children's BLLs related to block remediation may take many years because concurrent programs are reducing exposure and providing education and primary prevention. The influence of block remediation versus individual yard remediation on children's BLLs may be evaluated in the future once sufficient datasets are collected to permit analyses.

Remediating residential properties involves several steps, and it typically takes months to plan and execute the work, depending on how complex the site is. The remediation process is discussed in the section below.

6.1.4 Remediation Planning and Implementation

The steps to remediate properties to reduce human exposure to Pb in soil is outlined on the THEP website and in brochures and information provided to property owners. Most communication targets the process for residential land; however, the process is essentially the same for all land-use types (https://thep.ca/homeowners-guide-to-soil-remediation/). One exception is remediation supported under the Property Development Program, which is addressed in Section 6.1.5.

6.1.4.1 Participants

The primary participants and their roles in developing and executing the remediation plan are:

- **Teck:** Teck authorizes and funds the SMP and the remediation of residential yards, subject to the property owner's consent. Teck directly contracts the Consultant and the Contractor to carry out the work. For remediation at community owned properties (e.g., parks, schools), the Contractor may be retained by the property owner (government agency) if remediation work is to be coordinated with other scheduled maintenance works;
- **Property Owners:** The Property Owner authorizes and participates in planning and long-term maintenance of the remediation work on their property;
- **Consultants:** The Consultant provides technical oversight and contract management on behalf of Teck. The consultant prioritizes properties based on the prioritization approach and plans, schedules remediation activities and conducts soil sampling and field data collection. The Consultant is the main point of contact for the property owner; and
- **Contractors:** The Contractor conducts the physical work associated with remediation, including excavation, soil management, off-site disposal, backfilling, landscape replacement and other related activities.

6.1.4.2 Remediation Approach and Scope

For each property, the remediation plan is developed primarily to satisfy the objective of reducing exposure of property users (especially young children) to elevated Pb concentrations in soil. Other factors that influence the remediation plan include feasibility issues such as safe access (steep slopes, narrow access), obstructions (large trees, structures, utilities) and scheduling issues, such as when and for how long the property owner will allow access for remediation. Depending on these factors, the remediation approach and scope reflected in the remediation can include:

- **Full soil replacement across all non-hardscaped portions of the property:** This is typically carried out where metals concentrations are elevated throughout the property and major access restrictions are not present.
- **Partial soil replacement:** This is completed when soil in some areas of the property does not require soil replacement, where excavation depth is restricted, such as by large tree roots or utilities, or where a portion of the parcel cannot be safely accessed for soil removal.
- **Yard improvement:** This may include adding or improving grass or mulch cover, may be carried out where poor ground cover is the chief reason for prioritizing a property for remediation or where scheduling of soil replacement work is not convenient or approved by the property owner. Typically, this is a temporary measure to be followed later by full or partial soil replacement, as appropriate.

In some cases, a combination of approaches is applied, such as soil replacement for a vegetable garden with yard improvement for the remainder of the yard. The steps to carry out remediation are summarized in the table below:

Table 6.1-1: Steps and accountable parties for remediation of prioritized properties

Remediation Steps	Accountable Party		
	Property Owner	Consultant	Remediation Contractor
Provide a written offer and obtain signed consent from the property owner to remediate the property	x	x	
Develop a remediation plan with the owner to outline the scope of work, identify areas requiring remediation, gain access to the property and confirm the remediation methods that will be used on the property. Coordinate and schedule the remediation.	x	x	
Gather input from the remediation contractor who will conduct the civil works to confirm the scope of the remediation and the objectives can be met.	x	x	x
Prepare and submit applicable CSR notifications*		x	
Execute the Remediation Plan (steps provided below).			x
Oversee the work and adherence to the Remediation plan. Ensure work is carried out safely and the objectives of the remediation are met. Communicate concerns and discuss changes to the plan.	x	x	
Screen, sample and submit samples to the lab for analysis.		x	
Resolve issues and verify the work is complete.	x	x	x
Prepare and submit applicable CSR completion notifications* (NCIR documentation including updated SRCR if site reclassification is warranted). Record all data, photos, analytical results and property information in the THEP database, and file under the property. Prepare and issue a summary of the work completed to the property owner.		x	

Note: *Submissions (NIR/SRCR) related to the *Environmental Management Act* Independent Remediation process will not be required in future when remediation is carried out under the WARP.

6.1.4.3 Remediation Plan Activities

The activities included in the Remediation Plan depend on the scope of the remediation work.

6.1.4.3.1 Soil Replacement

For full soil replacement, the following activities are typically carried out by the Remediation Contractor and the Consultant:

- Confirm and evaluate backfill sources, materials and equipment/personal to carry out the work. Evaluating backfill sources includes confirming of the quantity and quality of soil, and confirming that metals concentrations are below applicable standards;
- Mobilize equipment and tools to the property and provide property owners and contractors safe access;
- Remove small plants, shrubs and other vegetation, as needed, for remediation and access.
- Strip sod for disposal;
- Excavate soil to the depth outlined in the Remediation Plan (typically 0.3 m in yard areas and 0.6 m in vegetable gardens) and remove from site for disposal;
- Screen soil at the excavation base with an XRF analyzer to determine metals concentrations;
- Collect soil samples at the base of the excavation for laboratory analysis of metals concentrations;
- Install the geotextile fabric to delineate the extent of the excavation;
- Backfill the property with approved backfill material;
- Collect post remediation samples from the replaced soil to update the property's soil quality information in the THEP database;
- Replace landscape features across the property according to the plan (sod, gravel, plants, etc.);
- Continue communicating with the property owner regarding remediation progress and schedule; and
- Provide guidance to the owner for long term maintenance.

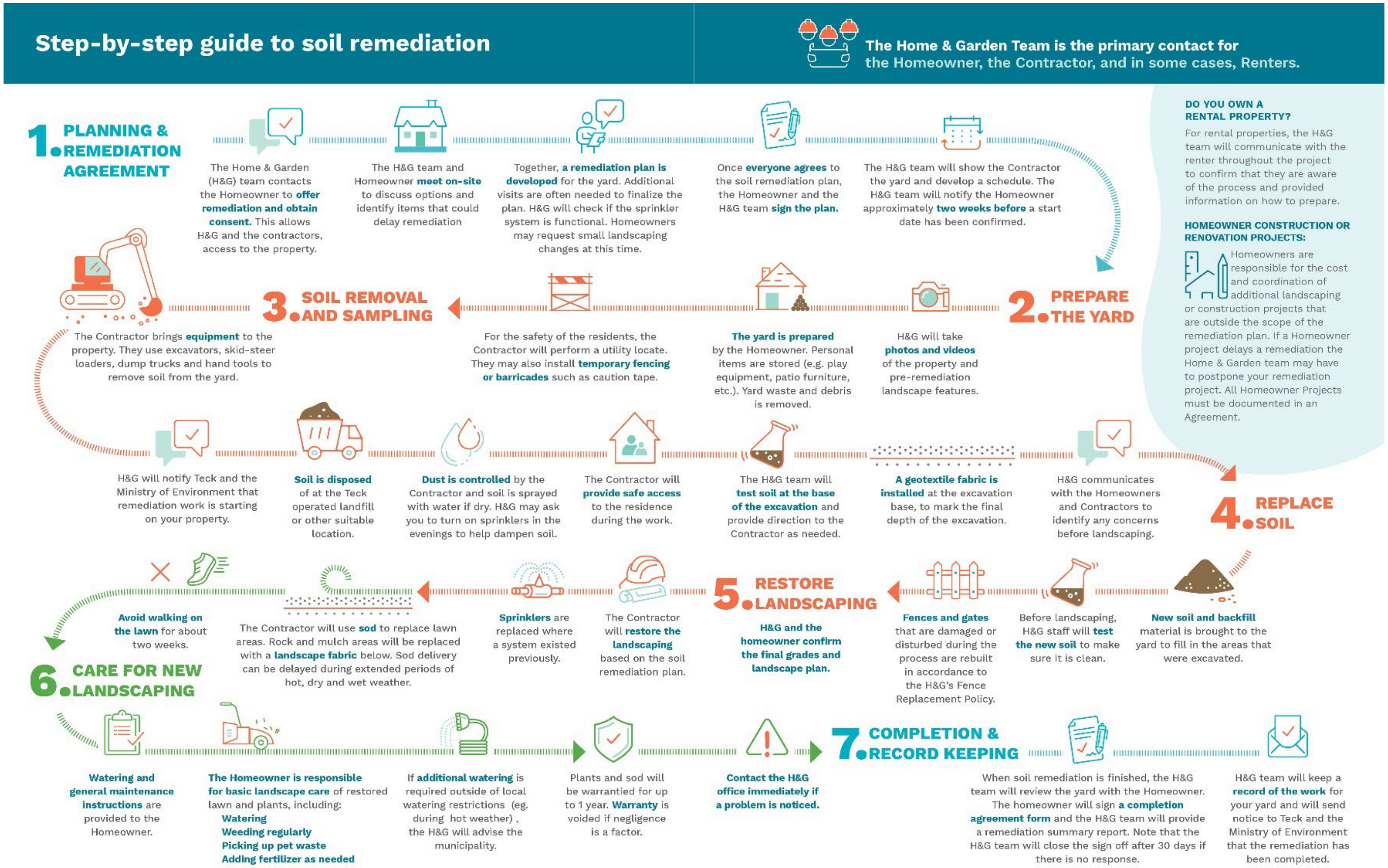


Figure 6.1-1: Remediation guide used for homeowners receiving residential soil replacement

6.1.4.3.2 Yard Improvement

Yard improvement projects follow a similar approach to soil replacement, in terms of planning and executing the work, and they can be implemented when access or permission restrictions exist. Generally, the scope involves limited or no soil removal. Yard improvement projects reduce human exposure to metals in soil by adding or enhancing ground cover elements such as lawn, mulch or hardscape. Property-specific project details are outlined in the Remediation Plan for each property. Communication, soil sampling and analysis, record keeping and reporting are all the same for both types of remediation (soil replacement or yard improvement).

The main differences between yard improvement projects and soil replacement projects are:

- Preparing the remediated area is a done by tilling, removing shallow soil (e.g., less than 0.15 m) and removing vegetation to prepare the area for the new cover materials (lawn, mulch, hardscape);
- Depending on the scope of work, demarcation fabric may not be installed because the depth of excavation (if any) is too shallow. And shallow fabric may impede sod and vegetation growth.

6.1.4.4 Summary

The remediation planning and implementation approaches described above were developed primarily for residential properties, but they are also applied at agricultural properties and community properties such as schools and urban parks. As described previously, community owned properties like schools and parks are comprised of both high use areas such as playgrounds and sandboxes, which can be prioritized for remediation, and lower exposure areas such as playing fields and pathways. For these properties, the landowner is a government agency. To minimize disruption to users, remediation works at these properties are usually planned to coincide with scheduled maintenance or development activities at the property.

Agricultural properties are also comprised of both high use areas such as yards, gardens and barn yards, and areas used less by people such as pastures. Although no agricultural properties have been prioritized for remediation to date (i.e., on the basis of lower soil concentrations in rural areas further from the smelter), remediation planning at agricultural properties would focus on high use areas where people (particularly young children) have higher potential for being exposed.

6.1.5 Summary of Remediation Completed

Properties remediated during the period of 2019 to 2023 were prioritized based on the 2019 Prioritization Approach. Following the completion of the HHRA (AtkinsRéalis, 2024), the Prioritization Approach has been revisited and modified as appropriate, as described in Section 6.1.1.

Each year, the highest priority properties are addressed through the SMP. Other properties may also be selected for remediation. In previous years, this has included properties adjacent to prioritized properties, properties used to access prioritized properties, and neighbourhood blocks. Additional remediation objectives are determined year by year, based on the number of prioritized properties. The number of residential properties where remedial activities were completed each year since 2008, including daycares, schools and other institutional properties, are summarized in Table 6.1-1 and Table 6.1-2 below.

Table 6.1-2: Summary of the number of residential properties that received remedial actions by year (2008 to 2023) completed on residential properties

Year	Lawn Care	Yard Improvement	Partial Soil Replacement*	Full Soil Replacement*	Vegetable Gardens*
Residential					
2008	-	-	-	4	8
2009	-	-	-	-	-
2010	-	-	-	11	-
2011	-	-	1	18	-
2012	-	7	3	13	10
2013	-	22	2	7	9
2014	-	32	-	9	12
2015	-	46	2	6	16
2016	-	57	2	6	8
2017	-	40	1	13	10
2018	-	32	3	21	12
2019	96	11	9	79	25
2020	74	23	9	62	4
2021	54	26	4	59	25
2022	14	21	3	75	12
2023	17	20	1	86	3
TOTAL	**321**	**234**	**39**	**383**	**151**

Notes:

* Soil replacement for vegetable gardens is conducted on all properties that received full or partial soil replacement. The vegetable gardens column in the above table reflects properties where soil replacement occurred solely in the garden, and thus, the total number of vegetable gardens remediated each year can be calculated by the sum of the partial and full soil replacement columns and the vegetable garden column.

Before 2008, full soil replacement was not routinely carried out on residential properties under the Trail Lead Task Force, and while some yard improvement work was completed, it is not included in the above summary.

The total volume of soil replaced on residential properties since 2008 is approximately 40,400 m^3; the total approximate area remediated is 148,000 m^2. A map showing the distribution of properties that have been remediated (full and partial soil replacement and yard improvement) is provided in Figure 6.1-1.

In addition to remediation on residential yards, public and private properties that children frequent are also remediated. A list of daycares, schools and parks where soil remediation has taken place is provided in Table 6.1-2. These properties are also included in Figure 6.1-1.

Table 6.1-3: Summary of remedial actions completed on community properties (parks, daycares, schools)

Property	Year of Work	Soil Volume Removed (m^3)	Remediation Strategy
JL Crowe School	2007–2010	0	N/A - Capped in Place below playing field and new school
Tadanac Tennis Courts	2015	87	Full soil replacement of part of the park area surrounding the tennis courts
Sunningdale Daycare	2020	240	Full soil replacement of daycare property
Sunshine Daycare	2020	77	Full soil replacement of daycare property
Upper Sunningdale Park	2021	26	Improvement of ground cover around park entrance, parking area and washrooms
Butler Park	2021	167	Full soil replacement of boulevard spectator area (part of property) following the removal of large trees.
Birchbank Playground Improvement	2022	45	Improvement of ground cover below play structures
Glenmerry School	2022–Ongoing in stages	2,100	Excavation of soil for new school. Started in 2022 and will be completed by 2024, following demolition of current school.

Notes: Daycares located in residential homes (e.g., licensed dayhomes) are not included in this list and are included in the residential property Table 6.1-1.

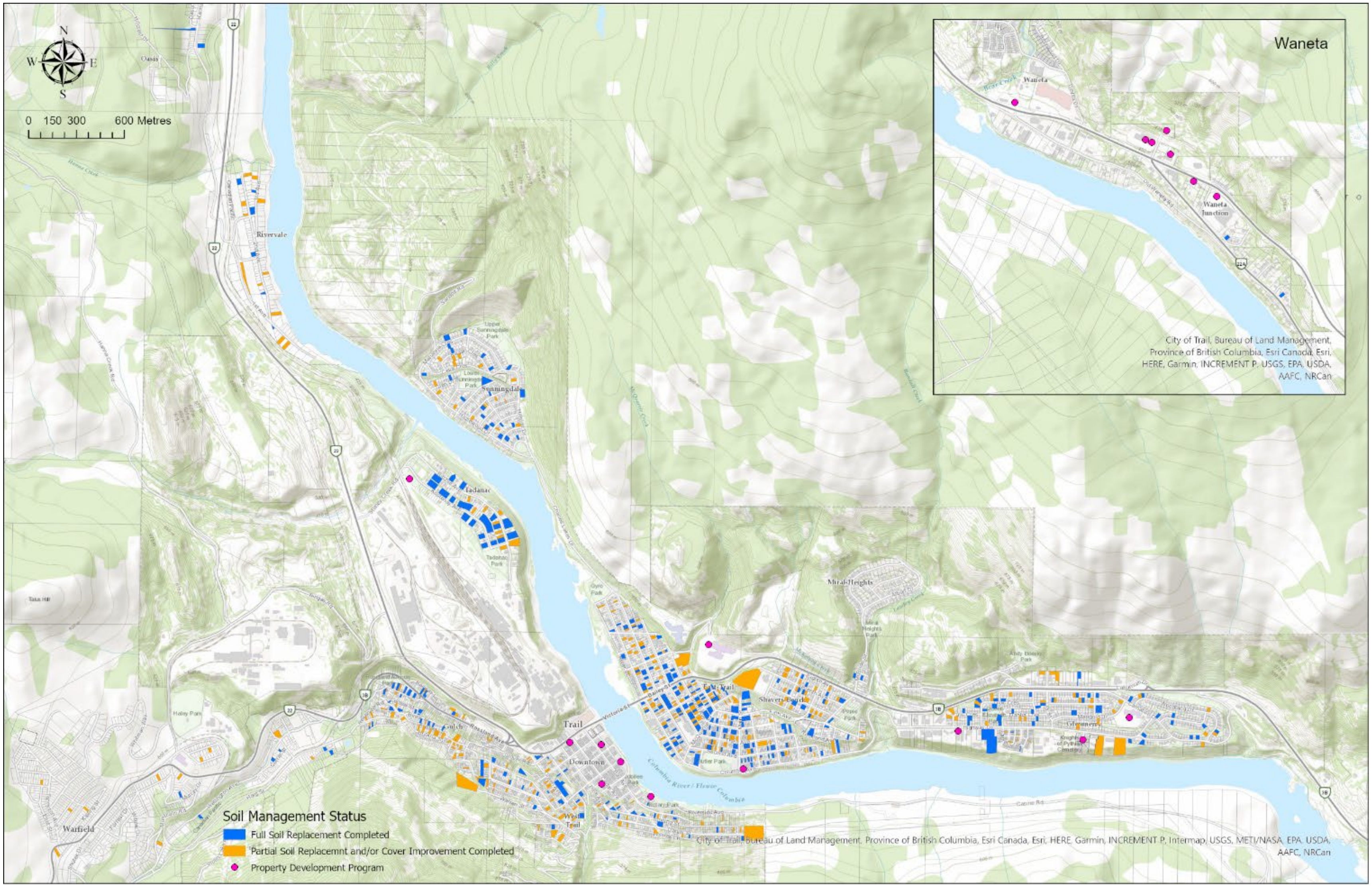


Figure 6.1-2: Map of remediated residential and community properties (soil replacement or yard improvement) completed up to the end of 2023

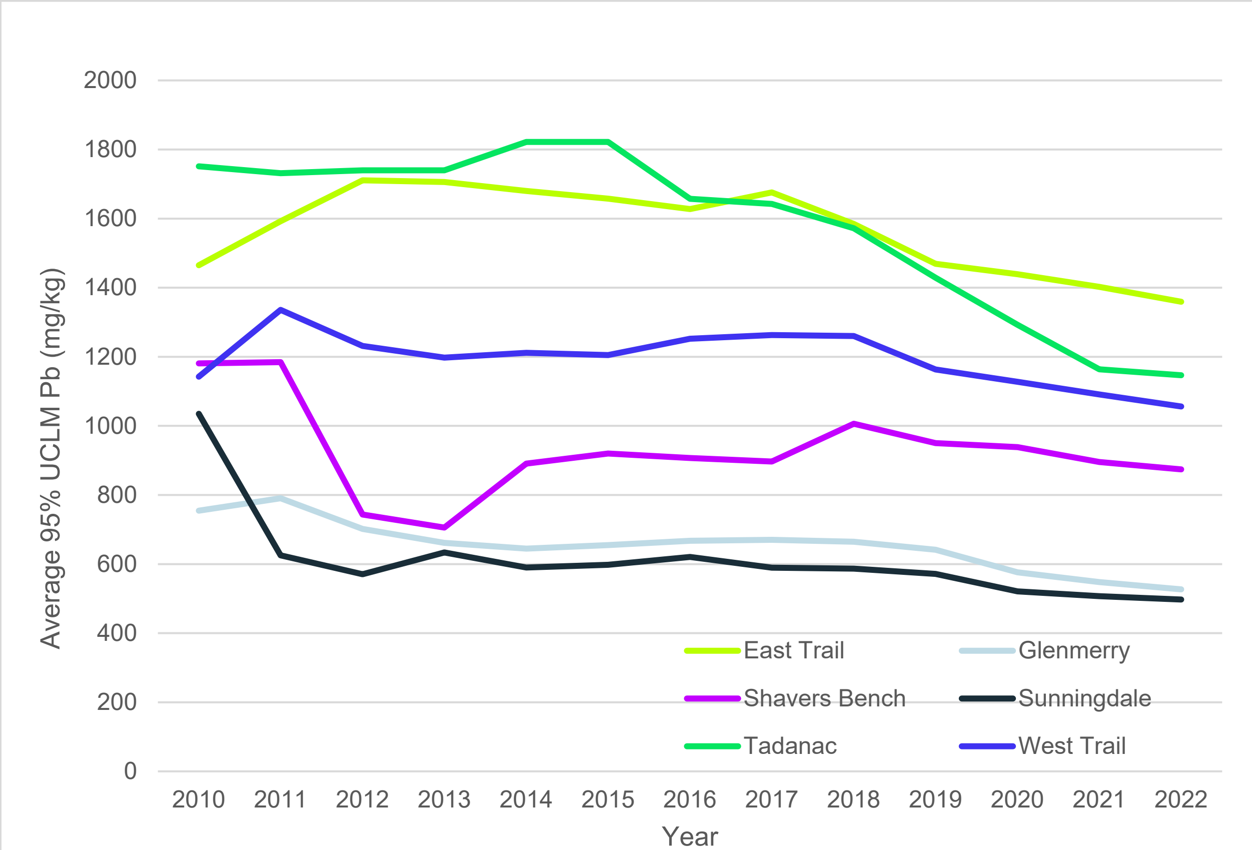
A summary of information showing the impact of remediation in reducing soil Pb concentrations on a neighbourhood scale is provided in Table 6.1-3. For neighbourhoods with limited soil assessment data, neighbourhood averages are not considered reliable. Neighbourhoods with fewer than 10 soil assessment properties are not included in the table. Even in certain neighbourhoods where only a few properties have been remediated, community average soil Pb concentrations are declining, which should support reduced exposure (Von Lindern et al., 2003).

For properties that have been remediated, the excavation depth and soil concentration at the base of excavation can vary depending on property specific constraints such as trees, retaining walls, building foundations, slopes and underground utilities. As well, in neighbourhoods where a relatively small number of properties have been assessed and remediated, the data are expected to be less representative of actual neighbourhood conditions. With more soil assessment and subsequent soil remediation taking place each year, it is expected that the neighbourhood average Pb concentrations will become more accurate and will decline over time, as shown on Figure 6.1-2.

Table 6.1-4: Summary of excavation information from residential properties with full soil replacement

Neighborhood	All Properties		Remediated Properties Only				
	Neighbourhood Average Surface Soil Pb (Pre-Remediation) (mg/kg)	Current* Neighbourhood Average Surface Soil Pb (mg/kg)	Number of Properties Remediated	Neighbourhood Average Surface Soil Pb (Pre-Remediation) (mg/kg)	Average Excavation Depth (m)**	Excavation Base Average Pb (mg/kg)	Neighbourhood Average Surface Soil Pb (Post-Remediation) (mg/kg)***
Annable	421	353	4	734	0.30	486	27.2
East Trail	2,223	1,359	199	2866	0.34	1324	81.0
Glenmerry	643	527	52	790	0.31	403	43.4
Oasis	263	350	3	823	0.30	377	35.7
Rivervale	756	586	8	943	0.29	471	54.1
Shavers Bench	1,035	874	21	1178	0.34	510	44.6
Sunningdale	591	497	24	621	0.29	323	31.8
Tadanac	2,392	1,147	26	3053	0.33	887	54.9
Waneta	408	354	2	774	0.31	443	16.2
Warfield	287	279	3	443	0.29	288	43.6
West Trail	1,240	1,056	70	1270	0.32	652	56.8

Note: Neighbourhoods with no remediated properties have been excluded from the table.
* Current average incorporates concentrations from all properties, both remediated and not remediated.
** Target depth of remediation is 0.30 m but varies depending on individual property constraints and/or soil Pb concentrations.
*** There are multiple sources of soil backfill, and all soil meets the CSR standards.



Note: As the number of properties assessed in each neighbourhood increases, the average neighbourhood soil Pb concentration in each neighbourhood becomes more representative over the time period shown.

Figure 6.1-3: Average soil concentration over time in neighbourhoods receiving soil remediation

6.1.6 Property Development Program

Through the Property Development Program (PDP), Teck has supported owners and proponents of developments at institutional, commercial, industrial and multi-unit residential properties to manage metals contaminated soil to support their development objectives, as described in Section 5.1.6.

A summary of remedial excavation information for properties that have been part of the PDP is provided in Table 6.2-1. The properties remediated are included on Figure 6.1-1. Since 2019, properties remediated as part of the PDP have been included in the annual report.

Table 6.1-5: Summary of properties remediated through the property development program

Proponent	Year of Work	Soil Volume Removed (m^3)	Remediation Strategy
BC Housing / Highland Development Consultants – 1939 Columbia Avenue	2003	880	Excavation and disposal at Teck Landfill
Canadian Tire	2004	32,600	Soil relocation to Duncan Flats (Teck owned property)
Skylark Developments Alberta Inc. (Walmart)	2004	30,000	Excavation and disposal at RDKB McKelvey Creek Landfill
Kootenay Chrysler	2004	8,265	Soil relocation to Duncan Flats (Teck owned property)
J.L. Crowe School	2007-2010	0	N/A — Capped in Place below playing field and new school
AM Ford	2014	720	Soil removal and disposal of topsoil at Teck Landfill.
City of Trail — Dewdney Ave. Parking	2017	0	NA — Capped in Place
Kootenay Savings Credit Union	2017	40	Excavation and disposal at Teck Landfill
Canadian Tire	2021	200	Excavation for expansion of garden centre. Disposal of 50 m^3 to Teck Landfill; 150 m^3 to RDKB McKelvey Creek Landfill
The Bench at Blaylock Development Inc.	2022	5,966	Excavation and disposal at Teck Landfill
Dairy Queen	2022	1,615	Excavation and disposal at Teck Landfill
Ralcomm	2022	30	Excavation and disposal at Teck Landfill
BC Housing – Waneta Group Home	2023	18	Teck Landfill
Glenmerry Bowl	2023	0	N/A - Capped in Place
City of Trail - Groutage Project	2023	148	Teck Landfill
Glenmerry School	2022 - Ongoing in stages	2,100	Disposal at Teck Landfill. Excavation for new school started in 2022 and will be completed in 2024, following demolition of current school.
Salvation Army	2022-2023	18	Excavation and disposal at Teck Landfill

6.1.7 Other Soil Management

In addition to prioritizing properties for remediation, soil management support is available to provide soil characterization and proper handling/disposal within the EM Area. Soil testing is available to all property owners in the EM Area to determine the concentration of metals in surface soil and to help property owners evaluate remediation and/or disposal requirements, if necessary. Residential properties typically enter the soil management process through the THEP. Commercial properties typically enter it through the PDP.

Information about soil testing and soil management is publicized through various outreach activities:

- Information is available at thep.ca and in THEP bi-annual newsletters;
- It is advertised on the digital banner at the City of Trail Arena (along a major roadway);
- Information regarding soil disposal is available on the RDKB website and at the McKelvey Creek landfill through trained landfill supervisors;
- Outreach and support through the lead-safe renovation program are available for owners doing excavation work concurrent with demolition or renovation;
- Ongoing communication and relationship building with municipalities, utility companies and regional districts supports early engagement on development projects and provides soil management guidance and best practices;
- Support is provided to property owners for disposing of waste soil during homeowner-initiated projects, including applying for soil disposal at the RDKB regional landfill when possible; and
- Connection to the BC 1 Call excavation notification system is provided through the City of Trail.

The process for managing soil and ensuring proper disposal is:

- The owner contacts the program office to determine the process. This triggers a review of previous soil results and/or initiates a new site investigation such as stockpile sampling or additional soil sampling;
- The analytical results are reviewed relative to the scope of soil removal and volume/area estimates;
- Soil disposal options are discussed;
- The owner, with support from the CPO, applies for soil disposal at an appropriate location (e.g., RDKB, Teck, soil re-use) and the soil disposal plan is finalized;
- Oversight is provided to verify the excavation is managed properly and soil is disposed of at the approved location(s);
- Confirmatory samples are collected if needed; and
- Records are kept in the THEP database and property owners receive reports.

Typically, this type of soil management is for small volumes of soil (< 5 m^3) generated by a property owner disturbing soil on their own property.

6.2 Ecological Risk Management Plan

The ERMP encompasses all of the approaches and methodologies, previously outlined and described below, related to restoring plant communities in wildland areas. This initial ERMP establishes a general process and framework that will undergo review and refinement as work progresses. Therefore, the ERMP is designed to be inherently flexible and follow an adaptive management approach.

- The approaches to evaluating the condition of plant communities and success of restoration treatments are described in Section 4.2.2;

- The most likely methods that will be used to restore plant communities, and the ongoing pilot studies of some of these restoration treatments are described in Section 5.2;
- The main steps in the ERMP process, and a proposed framework for prioritizing areas for restoration are presented in Section 6.2.1;
- The monitoring methods and schedule are described in Section 6.2.2;
- When no restoration treatment option is considered practicable, or restoration has not been successful or has been only partially successful, offsetting may be proposed, as described in Section 6.2.3; and
- Not all of the components of the ERMP have been finalized; several ongoing tasks are described in Section 6.2.4.

6.2.1 General Tasks in the ERMP Process and Framework for Prioritizing Areas for Treatment

The general ERMP process for prioritizing treatment for a polygon or group of polygons could entail the following major tasks (Figure 6.2-1):

- Complete a feasibility assessment;
- Conduct baseline sampling;
- Develop the prescription;
- Implement a risk management (restoration) treatment;
- Monitor the treatment;
- Perform adaptive management, if needed; and
- Offset, if necessary.

Not every task will be required for every polygon, and the specific scope of each task may vary depending on factors such as similarity to polygons that have been successfully treated. The scope of each task will be reviewed and refined over time as knowledge about each component in the process is gained. Updates will be provided in future versions of the WARP.

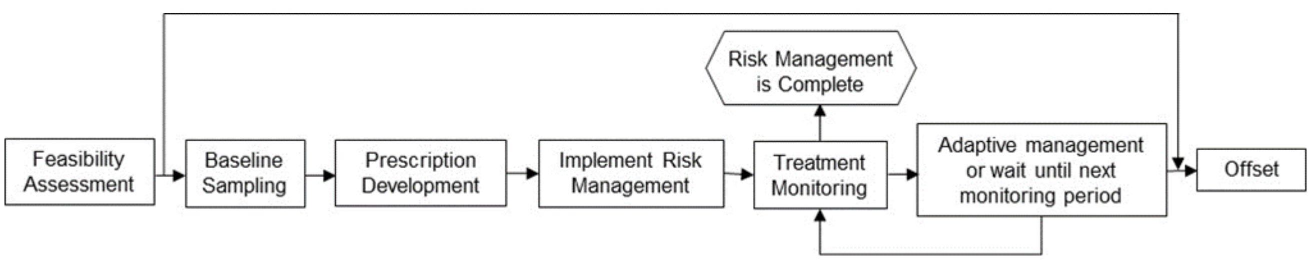


Figure 6.2-1: Major tasks in the overall ERMP process

Prioritizing is necessary because the land area being considered for restoration is too large to conduct baseline assessment and treatment across all polygons over a short time (a few years).

The process to prioritize areas for restoration treatment includes the first three major tasks in the above flowchart:

- Feasibility assessment;
- Baseline sampling; and
- Prescription development.

Each of these three larger tasks includes various steps. These steps and the logic behind the resulting prioritization, which is based on results from these steps, are provided in Figure 6.2-2 and the text below. As illustrated, prioritization plays a role in each of the major tasks.

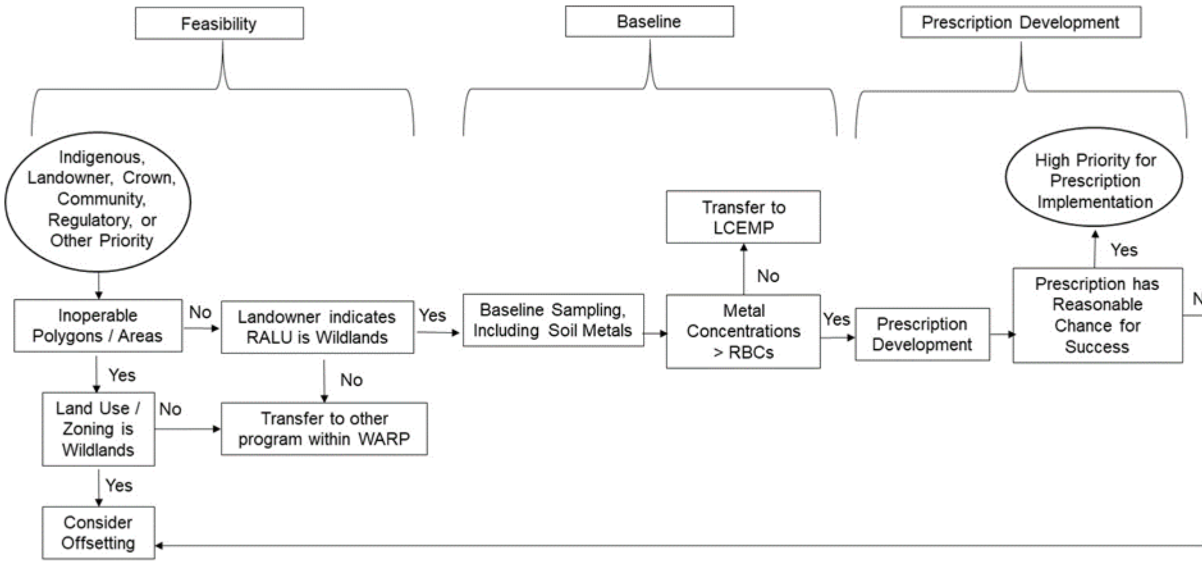


Figure 6.2-2: Process for prioritizing areas for restoration

6.2.1.1 Feasibility Assessment

The process of feasibility assessment will include:

1. Considering priorities and concerns of Indigenous Governments and Organizations.
2. Considering landowner, Crown, community, regulatory or other issues, concerns and priorities.
3. Evaluating whether restoration actions are practicable. It may not be feasible to conduct restoration activities in areas that are inaccessible or where site conditions preclude success (e.g., steep slope, no roads or trails to the area, rock or black locust-dominated sites), if there is no ecological benefit to do so (e.g., due to land use or zoning), and/or other factors. (Factors that influence the feasibility of restoration treatments are detailed in Section 5.2.2.) For these polygons, offset actions may be proposed. Baseline sampling may be conducted for some polygons where restoration is not feasible, as long as it is safe to do so, and if needed for the evaluation of offset needs or other purposes as determined by ENV, Teck or the LCEMP Committee.
4. Considering ownership, with priority given to polygons not owned by Teck, once there is reasonable confidence in treatment approaches to address particular conditions, based on results of pilot studies on Teck-owned land. Ownership will be confirmed when landowners are contacted to determine the reasonably anticipated land use (RALU), or when a polygon is identified for treatment. Ownership as of 2022 is illustrated in Figure 6.2-3, with unsurveyed land parcels identified as “assumed Crown land.”
5. Considering private and Crown landowner RALU and land management requests. The Crown is represented by the Ministry of Forests (FOR) and Ministry of Water, Land and Resource Stewardship (WLRS), which conduct their own land management planning activities. Therefore, FOR/WLRS will be engaged to inform prioritizing restoration activities on Crown land and specify RALU for each polygon or area (e.g., groups of polygons) planned for treatment. In addition, if lands are likely to be developed into an alternative land use (e.g., residential, industrial), then actions related to restoring wildland land use should not be initiated. Rather, other components of the WARP process (e.g., remediation to residential standards, Property Development Program) may be more appropriate for evaluating/remediating the polygon. Private landowners may also opt not to have their lands restored.

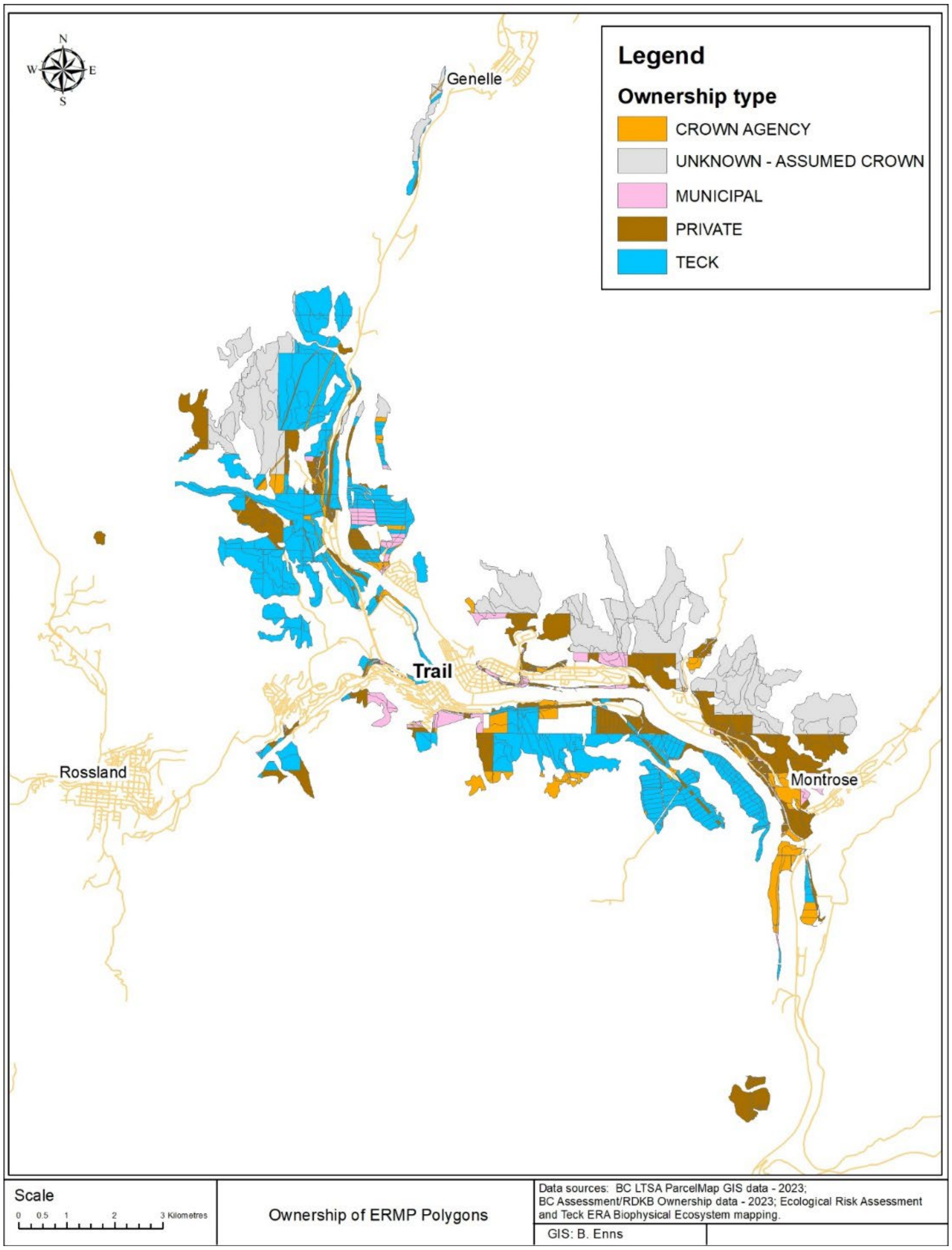


Figure 6.2-3: Ownership of polygons included in the WARP

6.2.1.2 Baseline Sampling

Identifying polygons/areas for baseline sampling will be based on several factors, including:

- Conditions that make an area difficult to treat (e.g., access, slope, adjacent land use, black locust), but which did not eliminate the area in the feasibility assessment;
- Consideration of the potential for archaeological sites and whether further archaeological assessment is required to inform appropriate actions;
- Polygon size, with higher priority given to larger polygons, or several contiguous polygons, because this allows a common treatment to be applied to a large number of hectares. Where a common treatment is possible, LCEMP polygons may be considered together with ERMP polygons;

- Level of impact (with respect to plant community effects), with the percentage of polygon impacted being a surrogate for this measure. This measure could be combined with polygon size to identify larger areas that would benefit the most from treatment. The percentage of polygon potentially impacted, based on data from the ERA, is illustrated in Figure 6.2-4;
- Similarity with respect to plant community, and type and magnitude of impact to a polygon that has already undergone feasibility assessment or successful treatment; and
- Ecosystem benefits, with priority given to plant community condition and ecosystem function, as well as ease of implementing the treatment and the probability of success. This consideration may result in the most impacted polygons not receiving the highest priority, particularly if restoration may require substantial resources over a long time with a relatively low probability of success (e.g., steep slopes with bare rock).

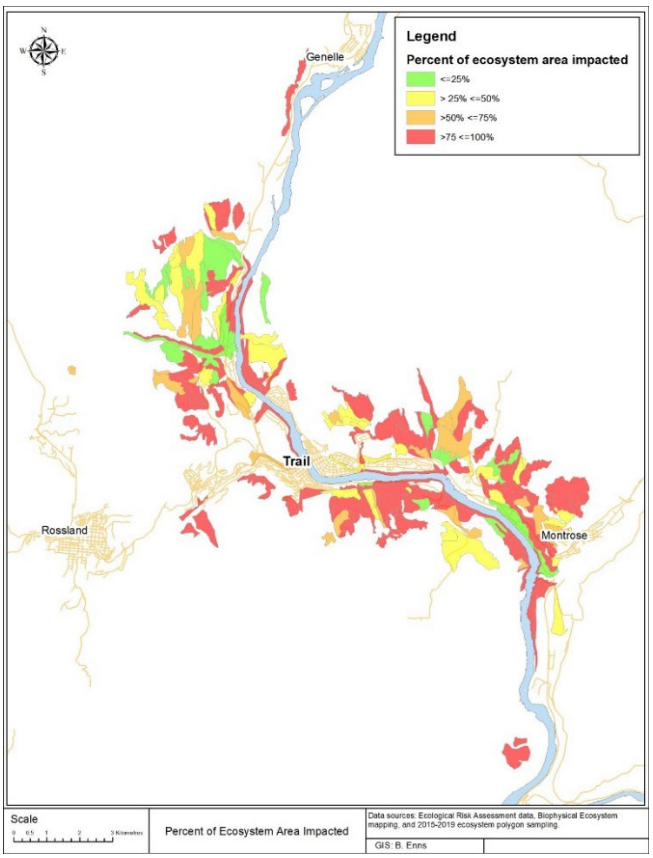


Figure 6.2-4: Percent of WARP polygons containing potentially impacted plant communities

Baseline sampling is conducted for parameters that will be used to determine current conditions. Sampling protocols are compiled in the document “Sampling Protocols Recommended for Planned Remediation Polygons” (Machmer et al., in prep.). This document provides guidance for layout, density and distribution of sample plots; collection of field data including descriptions of the soils, vegetation, Listed Species, stand structure and wildlife use; and collection of soil chemistry data that includes analysis of metals, pH and nutrients. Baseline sampling may be different for other end-condition goals (e.g., timber management) or non-forested ecosystems.

The ERA used a weight-of-evidence approach to assess risks to plant communities, and did not rely solely on metal concentrations in soil. Not every polygon was sampled for metal concentrations in soil; interpolation methods were used to estimate metal concentrations in soil between sampling locations. Therefore, soil samples for metal and nutrient analysis may be taken during the baseline sampling, when practicable and needed for developing restoration treatments (see Machmer et al., in prep., sampling protocols). The purpose is to evaluate whether metal or nutrient levels could impact restoration activities. If a polygon is found to have soil metal concentrations less than risk-based concentrations (either through soil sampling, or updated interpolation modelling incorporating nearby soil sampling), it will be assumed that metal concentrations in soil are unlikely to limit plant communities, and this polygon will be considered for treatment within LCEMP (see Section 2.2.1.2). However, if the area is contiguous with an area requiring treatment under the ERMP, then this area may be included, if it is cost-effective and efficient to do so.

6.2.1.3 Prescription Development

Prescription development includes steps such as:

- Verifying the RALU;
- Reviewing plant community condition indicators that identified the community as impacted;
- Reviewing Listed Species and Listed Ecosystem records;
- Reviewing previous pilot study results to inform treatment;
- Preparing an approach for recommended treatment in a prescription document; and
- Outlining treatment tasks, creating a general schedule for implementation (e.g., what tasks are done at what time of the year, and over how many years) and creating a schedule for monitoring treatment success.

Once the prescription has been developed, it will be discussed with the landowner. No treatment will be initiated until Teck and the landowner agree on the prescription. Treatments will only be proposed and implemented if there is a reasonable chance for success. For areas where treatment is not implemented, offset actions may be proposed. Agreement to the offsetting approach would have to be obtained from the landowner.

Timewise, the goal is to implement prescription treatments within 3 years of baseline assessment, so that baseline conditions remain relevant to the treatment.

At this stage in the process, before the treatment is implemented, a final evaluation should be done of the factors that may influence priorities:

- Ecological: Priority habitat, Species at Risk, landscape context, area, and habitat condition;
- Administrative: Urgency, maintenance and management requirements;
- Rights holder and stakeholder interest;
- Feasibility: Accessibility, probability of success, period of effectiveness, cost and duration of implementation; and
- Biodiversity management and public awareness: Biodiversity values, management of damaging agents (e.g., invasive species), public awareness objectives.

All the above factors are important to consider when prioritizing areas for treatment. The remaining tasks in the ERMP process (Figure 6.2-1) are less critical to prioritization. These include:

- Implementing a risk management (restoration) treatment;
- Monitoring treatment and determining whether restoration targets have been met;
- Performing adaptive management, if needed; and
- Offsetting, if necessary.

A detailed implementation plan may be prepared, if needed, to provide additional operational details that were not included in the prescription document. Teck will oversee the contractors working to implement the prescription and to monitor progress.

Treatment monitoring and offsetting are described in detail below. Adaptive management is discussed in Section 9.2.

6.2.2 Monitoring Methods and Schedule

6.2.2.1 Monitoring Methods

Sampling protocols are compiled in the document "Sampling Protocols Recommended for Planned Remediation Polygons" (Machmer et al., in prep.; see Appendix 4 for sampling details excerpted from this document). The document provides guidance for sample plot layout, density and distribution; collecting field data, including descriptions of the soils, vegetation, Listed Species, stand structure and wildlife use; and collecting soil chemistry data, including for analysis of metals, pH and nutrients.

Vegetation parameters are evaluated to determine whether restoration targets have been met. For mature forests, vegetation parameters are evaluated by calculating quality coefficients. For earlier seral stage forests, they are evaluated by comparing to seral indicators. For non-forested ecosystems, they are evaluated by calculating condition indices (see Section 4.2.2.)

The influence needs to be evaluated of sampling versus natural variation on the individual indicators used to assess vegetation condition. To do so, the confidence limits for each indicator's distribution will be reviewed periodically to inform sampling effort as the ERMP program matures. For example, data collected as part of the restoration trial at Polygon 1361 were reviewed to help determine minimum sample sizes needed to reduce the influence of sampling error.

6.2.2.2 Monitoring Schedule

In the Sampling Protocols document (Machmer et al., in prep.), monitoring was recommended in years 1, 2, 3 and 5 after treatment. Monitoring may also be considered in subsequent years. However, this is a preliminary schedule and the ongoing pilot treatments will inform whether modifications are required. It is a goal of the seral benchmark study to inform the monitoring effort by developing milestones to track change. In addition, as specific parameters become redundant or controlled, they may be dropped from future monitoring.

The frequency and scope of post-treatment monitoring may change over time, as monitoring results for different site types subject to a range of treatments are analyzed and adaptive adjustments are made to reflect initial learnings. The recommended monitoring scope and schedule will be updated in future versions of the WARP.

In general, it is anticipated that monitoring will be done for each restoration treatment area, and results will be reviewed periodically to determine the need for adaptive management (i.e., changes in treatment if results do not meet expectations) or offsetting (see Section 6.2.3). Several examples of possible factors that may influence the success of a restoration treatment, together with potential solutions, are presented in Table 6.2-1.

Table 6.2-1: Potential factors impacting restoration success and adaptive management solutions

Potential Factors that May Arise During Restoration	Potential Solution to the Problem
Too much or too little lime is applied, resulting in soil pH that is too high or too low	Add additional lime if pH too low; monitor if pH too high (pH may change over time)
Humans impair risk management activities (e.g., by using motorized vehicles, mountain bikes, grazing domestic animals)	Community engagement, signage, enforcement
Wildlife impair activities (e.g., browsing by ungulates)	Apply browse protectors or deterrents, or alternate plantings
Insect pests adversely affect plants	Change species of plants used in restoration
Invasive species prevent native or planted vegetation from getting established or growing	Implement weed control measures
Land use changes occur during activities (e.g., wildlands to residential)	Re-evaluate risk management plan with new RALU

6.2.3 Offsetting

Mitigation measures, as noted in Section 4.2.2, include not only restoration actions but also offset projects that provide restoration, enhancement or conservation outcomes to compensate for the difference between the restoration goal and what could be achieved. Offsetting is the last step in the mitigation hierarchy. In broad terms, offsets may be required for:

1. Areas where restoration is not feasible; and
2. Residual impacts in areas where restoration activities have been only partially successful.

There may be situations where offset projects are not needed, for example, when a landowner requests remediation or restoration to an alternate land use. In addition, offsets will not be proposed to account for natural or man-made impacts to ERMP areas beyond the potential impacts caused by the smelter (e.g., forest fire, logging, pests/disease).

Monitoring will be done for each restoration treatment area (see Section 6.2.2), and results will be reviewed periodically to determine the need for adaptive management (i.e., changes in treatment if results do not meet expectations) or offsetting.

Two general approaches to offset projects may be considered:

1. Teck land within the EM Area could be designated for Conservation or other uses;
2. Teck provides resources (funding, in-kind) for conservation, remediation, restoration or other actions on non-Teck-owned land within the EM Area.

Regardless of the approach taken, identifying appropriate offset projects may consider factors such as those related to prioritization, listed previously:

- Ecological: Priority habitat, Species at Risk, landscape context, area, and habitat condition;
- Administrative: Urgency, maintenance and management requirements;
- Rights holder and stakeholder interest;
- Feasibility: Accessibility, probability of success, period of effectiveness, cost and duration of implementation; and
- Biodiversity management and public awareness: Biodiversity values, management of damaging agents (e.g., invasive species), public awareness objectives.

A key factor in identifying a biodiversity offset is to identify an offset site or action that is similar to or has higher ecological value than the area that is impacted, which is termed a “like-for-like or better” offset. Determining like-for-like or better is done by considering ecosystem type, area and condition (e.g., the indicators listed in Section 4.2.2.2.1), as well as presence of Listed Species or their habitat.

Significant portions of the low elevation wildlands in the EM Area are owned by Teck. Teck ownership has limited development in the valley bottom of the lower Columbia valley relative to other southern BC valleys (e.g., Okanagan, Similkameen and upper Columbia). This ownership legacy provides a unique opportunity to preserve the lands and enhance the ecosystems in this area by using these lands as offsets.

Information on each potential offset site would include: site identification, area, ecosystem type and ecological condition. Information on potential offset activities would include: location where activity occurred, site owner, type/scope of activity, financial contribution, area restored and condition. These details would be provided to ENV for their review. It is anticipated that offset projects will be considered case by case, to determine where and when their use is appropriate, and pending agreement to the offset by the Affected Party, Teck and ENV.

6.2.4 ERMP Components in Progress

Several tasks needed to finalize the ERMP approaches and methods are in progress, with some planned to be completed within the first WARP cycle (i.e., within the next 5 years). Tasks and target completion dates include:

1. Complete the analysis of distribution of forest seral stages across the EM Area (2024/2025);
2. Develop benchmarks (e.g., condition indices) for non-forested ecosystem such as brushlands (2024/2025);
3. Develop seral indicators for forested ecosystems: Additional field work in 2024, analysis in 2025, draft for submission in 2025/26;
4. Monitor pilot restoration trials on an ongoing basis;
5. Conduct soil sampling in select polygons without data for soil metal concentrations, soil pH, buffer pH and soil nutrients (2024/2025);
6. Update list of polygons within ERMP versus LCEMP, based on additional soil metal data (2026);
7. Review opportunities for polygon grouping based on ecosystem type, site series and connectivity, to support baseline assessment and treatment (2025);
8. Review data related to lime application and consider larger-scale pilot study for soil pH adjustment; and
9. Engage with Indigenous Governments and Organizations and stakeholders proposed via the LCEMP Committee, to allow further development or completion of specific tasks; see Section 7 for more details.

6.2.5 Summary

Restoring diverse plant communities over a large area requires that many factors be considered. Progress has been made in identifying restoration approaches, their limitations and scientifically defensible methods to assess vegetation condition. However, components of the ERMP are still being developed. Therefore, the ERMP provides a general process and framework, and is designed to be flexible. At the 5-year review of the WARP, the results of the tasks listed above will inform the plan for the renewed WARP and subsequent 5-year period.

7. Consultation

Consultation conducted prior to the WARP is summarized in Section 7.1. Summaries of WARP Indigenous engagement and public consultation are provided in Sections 7.2 and 7.3. Proposed ongoing public engagement is detailed in Section 7.4.

7.1 Previous Public Consultation Summary

Previous public consultation for human health is summarized in Section 7.1.1 and for ecological risks is summarized in Section 7.1.2.

7.1.1 Human Health

Strong relationships supporting a healthy community is a community development and health promotion best practice and has been foundational to the success of public consultation in Trail. Community engagement is the essence of THEP and is fundamental to the success of both THEP and THEC. In the words of one THEC member:

> “The Trail Area Health & Environment Program combines all of the elements necessary to protect and enhance the health and environment of the Trail community. It is unique in that from the initial program developed over 20 years ago it has been led and overseen by the community itself.”

THEC has held three major public consultations since the inception of THEP, first in 2000/2001, then in 2009/2010 and most recently in 2016 and 2019. Details specific to the previous and recent public consultations are provided below. They are also available on the THEP website at http://www.thep.ca/community-consultation/.

7.1.1.1 Previous Public Consultation (2000–2010)

The first public consultation was held in 2000 and led to the creation of the Lead Task Force Report and recommendations to ENV in 2001. The purpose of the consultation was to incorporate the public’s long-term expectations for remedial activities. In addition, international experts were consulted so that the Lead Task Force could benefit from their combined experience and knowledge of remedial efforts. The consultation methods, results and evaluation were summarized in Ferraro et al. (2000).

A second public consultation took place in 2009 and 2010. The objectives of the consultation were threefold: (1) to update the public on health risks from smelter metals, (2) to assess public acceptability of new blood lead (Pb) and air quality goals, as well as the program activities to meet those goals and (3) to obtain input for a long-term plan to be submitted for approval to ENV under the CSR. The consultation methods, results and evaluations were compiled in Circle B Services (2011).

The consultation used various methods to engage the public, including a community newsletter, a website (www.thep.ca), a focus group dinner, meetings with stakeholder groups and on-site consultation materials at the Community Program Office storefront in downtown Trail.

Public input was primarily gathered by means of a survey, available electronically and in print. In total, 210 participants completed the survey. Results showed that the significant majority of respondents supported the proposed blood lead (Pb) and air quality goals, along with maintenance of the key program components; however, many respondents knew little or nothing about THEP before the consultation. The consultation was successful in achieving its quantifiable goals, including number of participants, completion of materials, meetings held, website development and increased awareness and understanding for some people.

The consultation also identified opportunities for adaptive management of THEP, particularly as it relates to community engagement. Over the course of the consultation, several enhancements were incorporated into THEP: the website www.thep.ca was developed; new fact sheets and FAQ materials were created with an emphasis on plain language communication for a wide public audience; a new logo and brand were approved, providing program materials with a consistent, audience-friendly look and feel; and a Community Program Office was established at 1319 Bay Avenue to make program offerings more publicly accessible.

7.1.1.2 Public Consultation (2016)

A third public consultation took place in 2016. The major focus of the 2016 consultation was to gauge community support for new blood lead (Pb) and air quality goals that would set the THEP's course until 2020. A second focus was to gather feedback on how to improve and refine THEP and a third focus was to determine if the community's awareness of the THEP had grown since the 2010 consultation. The consultation methods, results and evaluations were compiled in Vox (2016).

Results of the consultation showed that most respondents supported THEC's goals for the program components, respondents who had used THEP were very satisfied with their experience, and that public awareness of THEP had increased dramatically from 16% in 2010 to 86% in 2016.

7.1.1.3 Soil Management Consultation (2019)

In 2019, the Soil Management Program (SMP) expanded, and a communications and engagement plan was implemented with the following objectives:

- Support the identification of all residential properties that have children under 12 years old and that have the potential to be classified as a priority property for soil management and provide these residents with information about the prioritization framework for residential properties.
- Provide information to residents and the broader community explaining the expanded SMP as the next step in a continual process of improvement for Teck and meeting the requirements of the Contaminated Sites Regulation (CSR).
- Introduce residents and the broader community to the CSR and how it applies to Trail, including Teck's obligation as the responsible party.
- Communicate and anticipate issues related to the new' aspects of soil management, i.e.:
    - The priority-based approach (based on child age, ground cover and soil Pb concentrations)
    - The wider area of focus (the issue of Pb in soil was new to some communities)
    - The increased program activity (more work would be taking place than in previous years)
    - Where residents can learn more information regarding the CSR, the history of the THEP to date and planned next steps.

When the 2019 remediation season was completed, a survey was promoted throughout the community to understand community perceptions of the expanded SMP. There were 108 responses, with 96% of respondents indicating they were supportive or very supportive of the increased soil remediation work. Based on the responses, there were very few concerns regarding noise, traffic and dust related to the soil remediation work. Respondents noted communication efforts related to the SMP favourably.

A second survey was provided to recipients of soil remediation. Of the 50 responses received, 90% of respondents indicated they were satisfied or very satisfied with the remediation work completed on their property. Overall, the community was supportive of the SMP.

7.1.2 Ecological Risks

Public meetings were held regularly during the ERA to present results, document progress and seek input from the general public. Since completing the ERA, communication and consultation have occurred primarily via LCEMP Steering Committee meetings.

7.1.2.1 Consultation During the Ecological Risk Assessment (2000–2007)

Public meetings were held in spring of 2000, 2001, 2002, 2003 and 2004, to provide information and seek feedback from the public on ERA study plans and progress. During the 2002 and 2003 public meetings, written surveys also were used to obtain feedback. Newsletters were distributed to update the public on study progress and plans. They included a tear-off response section that invited comments or questions. The newsletter sent in March 2002 asked readers to reply if they were interested in participating on a Public Advisory Committee (PAC) for the ERA. Again, at the April 2002 public meeting, people were invited to participate on the PAC. The PAC first met in August 2002, and it met several times thereafter to tour some of the study area and provide feedback. A final public meeting was held in May 2007 to present the results of the ERA before the “Final Terrestrial ERA Report - Draft for Discussion” was submitted to ENV (January 2008). Feedback obtained via these various approaches was considered throughout the development of the ERA.

7.1.2.2 Consultation During ERMP and LCEMP Development (2008–2020)

After the draft Final Terrestrial ERA was submitted, consultation focussed primarily on outreach to groups with technical expertise in the areas of land management and stewardship, and wildlife habitat and ecosystems. The primary mechanism for this outreach was the LCEMP Steering Committee, which began meeting in 2008 and focussed on technical aspects required for ecological restoration. Participants included representatives from ENV, FOR, the regional district, Kootenay Conservation Program and the Fish & Wildlife Compensation Program. Meetings were held every year from 2010 to 2019, except 2011.

In 2016, a meeting was held to begin planning for broader public consultation on the ERMP/LCEMP. Representatives from the LCEMP Steering Committee were involved, along with a resident member of the THEC and consultation experts. Further work on the consultation approach was put on hold until the ERMP/WARP was further along in development.

7.2 WARP Indigenous Engagement Summary

This section will detail activities undertaken related to Indigenous Engagement during WARP development.

7.3 WARP Public Consultation Summary

This section will detail the actions undertaken related to Public Consultation on the WARP and the related MHO recommendation.

7.4 Ongoing Public Engagement

Ongoing engagement related to human health risk management is proposed via THEC and THEP. The avenue for engagement includes using the communication strategies currently being used in the community:

- Continued operation of the Community Program Office for ad hoc community and visitor input. This will include tracking questions and comments from the public for program refinement and improvement of clear messaging, FAQs, etc.;
- Public communication through community newsletters, outreach events and social media;
- THEC meetings that are held five times annually, are open to the public and that highlight program components and operational updates as well as provide oversight, direction and guidance, and updates on progress toward goals;
- Surveys to solicit feedback on program components such as soil management and collaborative programs that support WARP objectives; and
- Collaboration and information sharing across program partners.

An ongoing engagement related to the ERMP is proposed via an LCEMP Committee. Timing for meetings, discussions, review of specific topics and other activities will be based on input provided by those participating in the Committee. One of the first tasks for the Committee will be to develop a Terms of Reference for the Group. Participation in the Committee is voluntary, and participants may vary over time. Topics for discussion within the first WARP cycle (next 1-5 years) may include:

- Benchmark indicators of mature and climax forest communities (Quality Hectares approach; Machmer and Boulanger, in prep.);
- Plant association descriptors for earlier structural stages (focus on stages 3, 4, and 5) for forested ecosystems;
- Indicators of plant community condition in non-forested ecosystems (e.g., brushlands);
- How to use indicators for forested and non-forested ecosystems to evaluate restoration success (e.g., weighting of indicators, target degree of similarity between reference stands and treatment stands);
- How to incorporate seral distributions across the EM Area to prioritize treatment areas, and evaluate restoration success;
- Restoration options, to verify the list is comprehensive and reasonable for the EM Area;
- Factors influencing the feasibility of restoration treatments (Machmer & Ehman, in prep.), to verify the list of constraints is comprehensive and reasonable and that the categorization criteria are appropriate';
- Prioritization framework for restoration treatment; and
- Use of offsets.

At the 5-year review of the WARP, the results of the above tasks will inform the plan for the renewed WARP and the subsequent 5-year period (see Section 9.2).

8. Performance Verification

The objectives of the performance verification program (PVP) are to verify the continued protection of human health and ecological communities following the remedial interventions noted in the previous sections. For human health (Section 8.1), the PVP focusses on soil management work completed using the Prioritization Approach outlined in Section 6.1 on properties within the EM Area. For ecological communities (Section 8.2), the PVP focusses on restoring wildlands using a prioritized approach described in Section 6.2.

The PVP herein presents the principal risk controls that are required based on the results of the HHRA and ERA, along with the long-term monitoring and maintenance activities necessary to verify that risk controls are implemented and remain effective, Further, the PVP includes interventions for the continued safe handling of soil in the EM Area as needed. Ongoing supporting programs, as described in Section 2.2, are intended not only to continue but also to support long term monitoring objectives and continual improvements to health and the environment in the EM Area.

8.1 Performance Verification for Protection of Human Health

8.1.1 Principal Risk Controls

The principal risk control required to protect human health is the following:

- Child-occupied properties with soil Pb concentrations greater than the risk-based standard for Pb for the EM Area of 400 mg/kg will be reviewed for remediation prioritization based on the Prioritization Framework (see Section 6.1).

Properties prioritized for remediation will have soil removed and replaced (full or partial replacement) or risk-managed (e.g., lawn care, yard improvement). As a result, a variety of remedial activities can be used on a given property.

Where it is not feasible to remove all soil that exceeds the Prioritization Screening Concentration that applies to a property (see Section 6.1), additional risk controls will be required to protect human health. These additional risk controls are described in the following sections.

8.1.1.1 Engineered Risk Controls

Engineered controls are the physical barriers put in place during remedial excavations. The engineered controls used on residential properties include the following:

1. **Install a geotextile demarcation fabric:** At the base of all soil replacement excavations, a geotextile fabric is placed to delineate the extent of remedial activities visually and physically. Below the demarcation fabric, soil may continue to have metals concentrations above the risk-based standard for Pb for the EM Area and if it is disturbed may require soil management.

2. **Placement of a soil cap:** A cap of clean cover soil is used to backfill remedial excavations after the demarcation fabric is installed. In most cases, this will be to a depth of at least 0.3 m across remediated parts of the yard. In some cases, where soil cannot be removed to a depth of 0.3 m (i.e., around large trees, alongside house foundations or retaining walls), the geotextile and backfill are installed to the extent possible and recorded with administrative controls (described below).
3. **Install landscape cover:** The final part of the cap is landscape cover, which acts as a mechanism to prevent soil erosion and reduce exposure to soil where soil cannot be removed and replaced. After the clean soil cap is installed, landscape cover is placed. It consists of sod for lawn areas, and mulch or landscape rock for ornamental garden beds and/or un-vegetated areas. Mulch and landscape rock are laid over landscape fabric to make maintaining the landscape cover materials easier. Other surface features used in parks and playground areas include rubber matting, wood chips, sand, pea gravel or other materials to meet other objectives (e.g., play surface requirements).
4. **Install hardscape cover:** The cover materials can include hardscaping such as pavement or asphalt on properties (e.g., driveways, parking areas), stone patios and pathways, and similar installations. Typically, no soil investigation and subsequent remediation are completed below hardscape materials; rather, these are addressed when or if the hardscaping is removed from the property. In the interim, hardscaping acts as a permanent cover to prevent access to underlying soils.

8.1.1.2 Administrative Controls

The administrative controls for the PVP include recording property specific information, namely property ownership, soil metal concentrations, remediation activities, the presence or condition of engineered risk controls (e.g., soil cap, ground cover) and reporting to property owners. The property information is retained in the THEP database, as described in Section 2. The administrative controls include communicating with property owners and communicating at the community level and are described as follows:

- Communications with property owners to provide:
  - Property-specific reports that summarize the remediation activities and post-remediation soil assessment results.
  - Remediation record drawings: These are provided as part of the property report. The drawings visually detail the work completed and identify the extent of remedial excavation, the area where demarcation fabric was installed, areas that were not remediated to a minimum depth of 0.3 m and areas where other engineering controls are in place, such as landscape and hard scape installations.
  - A guidance brochure with instructions on how to maintain their newly remediated yard and the engineered risk controls installed during remediation (i.e., cap, cover and demarcation layer).
  - Contact information to report any disturbance to engineered controls and to seek support to restore the engineered controls, if required.
  - Records of interactions with property owners that include questions and comments about activities on their property.
- Community level communications include:
  - Maintaining up-to-date information about the SMP on the website at www.thep.ca.
  - Providing a SMP information brochure and FAQs to homeowners, outlining what to expect before, during and after soil remediation.

- Engaging in ongoing outreach initiatives with the community to maintain and enhance community knowledge about the SMP, including:
  - Operating the Community Program Office where residents and visitors can get information about the SMP (soil assessment, remediation and property status information);
  - Publishing a biannual newsletter that is delivered to every address and includes a targeted mail-out to all residents with young children;
  - Attending community outreach events to connect with the community (e.g., booth at the local farmer's market, teddy bear's picnic, etc.); and
  - Distributing brochures and posters at various locations in the City of Trail such as the hospital maternity ward, City Hall, Regional District Kootenay Boundary office, real estate offices, hardware stores, etc.

8.1.2 Determining the Applicable Remediation Type

As defined by the BC ENV (see Performance Verification Plan webpage at https://www2.gov.bc.ca/gov/PVP) based on the risk controls specified above, properties remediated under the WARP are Type 2 sites. This is based on the principal risk controls required at the properties. As noted on the webpage, Type 2 sites require a PVP. The following sections outline the proposed performance verification activities and, where applicable, contingency plans. The engineered risk controls installed including demarcation fabric, soil cap and landscape/hardscape features require performance verification to verify they remain in place and are thus effective in preventing children from being exposed to Pb in soil. Performance verification includes inspection and monitoring, which on a case-specific basis, may identify maintenance requirements; however, prescriptive routine maintenance is not required.

8.1.3 Performance Verification Actions

The performance verification actions outlined below, are intended to verify the risk controls (engineered or administrative) remain in place and are effective in preventing children from being exposed to Pb in soil at each remediated property.

Table 8.1-1: Summary of performance verification activities for protecting human health

Risk Control	Verification Activity	Details of Verification Activity (Summary of tasks, locations, comparison to which benchmarks, timing, etc.)	Performance Indicator(s)	Management / Contingency Action if Performance Indicators Not Met
Protection of Human Health				
A.	Documentation of Remediation Activities	▪ Maintain Remediation Records in the Database including: ▫ Confirmation sampling of cap materials; ▫ Photo documentation of fabric and cap installation and other engineered controls; ▫ Area and depth or thickness of demarcation layer/cap; ▫ Photo documentation of landscape cover type and condition after soil replacement.	▪ Quality assurance checks of information in database to confirm proper documentation– reported in annual PVP report.	▪ If quality assurance checks find deficiencies, correct deficiencies and identify/address root cause(s).
B.	Property Reporting	▪ Send owner copy of remediation letter report including remediation record drawing and results of post remediation soil sampling; ▪ Verify received through survey as described in C, below.	▪ Remediation letter report sent to owner by January 31 of the year following remediation	▪ If documentation errors are noted, correct and identify root causes; ▪ If survey determines reports not sent to owner or if owner changes, provide new owner a copy of the remediation letter report using the Property Status Report tool in the Database. Also, update new owner contact information.

Table 8.1-1 (Cont'd): Summary of performance verification activities for protecting human health

Risk Control	Verification Activity	Details of Verification Activity (Summary of tasks, locations, comparison to which benchmarks, timing, etc.)	Performance Indicator(s)	Management / Contingency Action if Performance Indicators Not Met
C.	Verification of Receipt of Remediation Report and Property Condition	▪ Verify with property owner that they have received the remediation report and document in THEP database. ▪ Verify the condition of the remediation by: ▫ Inspecting the demarcation layer and/or resampling cap material following any known disturbance such as excavation work, pets digging, etc. (and recorded as above); ▫ Conduct a survey of a portion of remediated properties every 5 years to identify possible changes to the demarcation fabric or other engineered controls at the property; ▫ Add visual ground cover evaluation of a portion of remediated properties to determine changes to landscape / hardscape cover.	▪ Quality assurance checks of information in database to confirm documentation of maintenance activities; ▪ Survey objectives are to contact 10% of remediated or maintained properties with a goal of less than 10% non-compliance.	▪ If survey determines disturbance of cap or demarcation layer occurred without oversight, confirm this information is added to property records; evaluate risk at affected property and develop a site-specific contingency plan to address unacceptable risks; ▪ If an unacceptable number of the surveyed properties are non-compliant (e.g., > 10%), address the non-compliance individually with property owners, and implement additional community-wide outreach.
D.	Document ongoing community level communication	▪ Record interactions with the public through the community office and report annually to the THEC; ▪ Keep website information up to date and relevant; include remediation progress; ▪ Keep brochures stocked at locations in and around Trail.	▪ Interaction metrics that summarize the types of questions coming into the office; ▪ Public input, including questions and gaps identified in the website information; ▪ Public uses brochures stocked at various locations.	▪ Review/supplement community office staffing levels if office's response rate is unsatisfactory ▪ Update/supplement website information to address gaps ▪ Restock brochures as needed

8.1.4 Data Management and Reporting for Performance Verification

Data associated with performance verification activities will be managed via the THEP database or LCEMP database, as outlined in Section 2.

Performance verification activities will be reported annually. The annual performance verification report shall include the following information:

- A summary of inspections, including ground cover evaluations, monitoring and maintenance undertaken during the reporting period;
- Summary of current and cumulative results of the PVP actions undertaken;
- Recommended modifications to the PVP, if any, for consideration and approval of the Director, along with supporting rationale; and
- Supporting documentation (e.g., analytical reports, tables and figures, records of inspection, etc.).

8.1.5 Review of Pb Exposure Reduction Progress

In addition to performance verification activities for monitoring risk controls related to soil at individual properties, progress toward the MHO recommended blood lead value and long-term effectiveness of the integrated measures in place to reduce Pb exposure will be formally reviewed through a working group. As with the HHRA working group that provided input into the approach for the HHRA for Pb (see Section 4.1.2), it will include members from ENV, IH and Teck, and part of their mandate will be ongoing review to inform the adaptive management framework of the WARP with respect to human health. The working group's activities will include evaluation of monitoring data collected from ongoing monitoring activities (including soil, air and blood lead), identification of data gaps, study design and evaluation, review of emerging research and studies from other jurisdictions and supporting updates to ENV regulatory programs. Examples of ongoing studies include blood lead (Pb) monitoring and the Long-Term Soil Study to evaluate the potential for remediated soil to be recontaminated due to ongoing Teck Trail Operations activities, dust re-suspension and/or ancillary activities.

8.2 Performance Verification for Wildlands Restoration

The objective of the PVP for wildlands restoration is to verify that plant communities in wildland areas are protected, according to the RALU, following restoration treatments that were completed using a prioritized approach within the EM Area.

The risk controls and associated verification activities are described in Table 8.2-1. They are:

A. Documenting restoration treatments, including any adaptive management;
B. Appling access controls and use restrictions;
C. Maintaining property data records and communicating with property owners, rights holders and stakeholders;
D. Documenting ongoing community level communication; and
E. Documenting maintenance of conservation covenants.

A. Documenting restoration treatments, including any adaptive management

Restoration activities will be recorded in the LCEMP Database. If monitoring indicates that adaptive management is needed, any changes to the treatment, including additional treatments, will also be documented. The specific areas undergoing treatment will be documented and mapped. If monitoring results in a conclusion that the plant community condition is acceptable, further risk controls are not needed, and monitoring can be discontinued.

B. Applying access controls and use restrictions

The success of restoration treatments in some areas may depend on the public's cooperation in allowing restoration to occur without these areas being disturbed (e.g., by using motorized vehicles or bikes, riding horses or grazing animals).

Access controls and use restrictions can be implemented on Teck-owned land. Signage could also be used to encourage adherence to restrictions by communicating why access is not permitted (e.g., Ecological Restoration Area). There could also be more detailed educational signage explaining the ongoing restoration initiative. Signage, if agreed to by the landowner/steward, may be considered for Crown or other lands. These controls would be checked regularly to verify they are in good condition.

C. Maintaining property data records and communicating with property owners, rights holders and stakeholders

Property specific reports will be provided to the owner (for private lands) or the LCEMP Committee (for Crown or Teck lands) summarizing the restoration activities and post-restoration monitoring results. Questions and comments about the restoration activities will be compiled.

D. Documenting ongoing community level communication

General public education and awareness initiatives may be used to keep the public informed about ongoing efforts to restore an area. These may include newspaper/flyer ads, radio ads, updates to the Teck.com website, newsletters and social media posts, among others. Updates could also be provided to interested stakeholders identified through consultation activities or who otherwise self-identify.

E. Documenting maintenance of conservation Covenants

Records will be kept of any conservation covenants for properties used as offsets for areas that could not be restored to the target condition.

Table 8.2-1: Summary of performance verification activities for protecting plant communities

Risk Control	Verification Activity	Details of Verification Activity	Performance Indicator(s)	Management / Contingency Action if Performance Indicators Not Met
A	Document restoration treatments, including any adaptive management	Maintain information in the LCEMP database including: ▪ Treatment details (e.g., type, source, amount, timing); ▪ Photo documentation of baseline and post-treatment condition; ▪ Details on any adaptive management; ▪ Record/map area and treatment(s).	Quality assurance checks of information in LCEMP database to confirm documentation of information; reported in annual PVP report.	Provide additional support as needed to promote proper documentation.
B	Apply access controls and use restrictions	Annual check conducted on gates, fences and signage. Documentation of annual check and any repair or replacement needed.	Records are updated in the LCEMP database within 6 months; annual check conducted and any needed repairs completed.	Provide additional support as needed to verify checks are done, repairs made and documentation is complete.
C	Maintain Property Data Records and Communicate with Owners, Rights Holders, Stakeholders	Keep rights holder, stakeholder and property owner requests in the LCEMP database. Keep treatment records up to date and complete in the LCEMP database. Send letter summarizing the restoration activities and post-restoration monitoring results to the landowner (for private lands) or LCEMP Committee (for Crown and Teck lands).	Records are updated in the LCEMP database within 6 months of treatment. Restoration letter is sent to owner within one year of treatment or monitoring.	If documentation errors are noted, correct and identify root causes.

Table 8.2-1 (Cont'd): Summary of Performance Verification Activities for Protection of Plant Communities

Risk Control	Verification Activity	Details of Verification Activity	Performance Indicator(s)	Management / Contingency Action if Performance Indicators Not Met
D	Document ongoing community level communication	Record interactions with the public, rights holders and stakeholders through the LCEMP database. Keep website up to date with relevant and new restoration progress information.	Types of questions are summarized as part of annual reporting; Questions and gaps in the website information noted by public, rights holders and stakeholders are documented.	Review/supplement staffing levels if response rate is unsatisfactory; Update/supplement website information to address gaps.
E	Document maintenance of conservation covenants	Record annual verification of an ongoing conservation covenant for properties used as offsets in the LCEMP database.	Records are updated in the LCEMP database within 3 months of verification.	Review/supplement staffing levels if response rate is unsatisfactory.

9. Reporting

Annual reports related to remediation activities will be prepared to document progress, performance verification and lessons learned. They will also recommend future work or changes to program components and will document relevant changes to supporting programs. Separate reports may be prepared for the human health and ecological components, as described below. In addition, the WARP will undergo review every 5 years to determine the need for changes.

9.1 Annual Reporting

An update on WARP activities related to human health will be provided annually, with a focus on soil management activities. It will highlight progress on remediating yards and gardens and enhancing the prioritization framework, if any. The annual update will replace the SMP and Workplan, and it will aim to streamline reporting requirements for properties receiving Soil Management. This annual update will be provided to ENV by April 30 each year. An annotated draft table of contents for the annual report is provided below.

1. Introduction:
   - Describes the scope of the annual report and how it ties into the WARP
2. Annual Workplan:
   - Number of properties proposed for soil assessment and ground cover evaluation
   - Number of properties prioritized for remediation work
   - Number of properties planned for Property Development or Soil Relocation
3. Soil Assessment Progress:
   - Number of residential properties that underwent soil (yard and garden) assessment in the previous year
4. Soil Management Program Progress:
   - Residential properties that underwent:
     - Yard soil replacement
     - Garden soil replacement
     - Yard improvement
   - Total number of properties remediated through the SMP
   - Update on active Property Development Program and/or Soil Relocation projects, tables summarizing soil volumes excavated, neighbourhood average soil concentrations and other relevant information related to soil management
   - Maps summarizing data related to soil assessment and completion of remediation
5. Performance Verification:
   - Performance verification activities, inspections and results
6. Challenges:
   - Description of any challenges that arose
   - Approaches that were tried to resolve the challenges and the level of success
   - Lessons learned

7. Conclusions and Recommendations:
   - Conclusions about the progress made during the year
   - Recommendations for any changes to the remediation program methods and/or prioritization framework
   - The results of the annual Interior Health blood lead (Pb) report will be referenced and interpreted in the context of the MHO's recommendation

An annual ERMP report will be submitted to ENV. Annual reports during the first 5-year cycle will track progress made on the tasks listed in Section 6.2.4 (ERMP Components in Progress) and LCEMP Committee topics such as those listed in Section 7 (Consultation). Draft documents previously submitted to ENV will be revised when these tasks are completed. The revised documents will be submitted to ENV and the LCEMP Committee.

9.2 Five-Year Review

The WARP will be reviewed every 5 years to determine the need for changes. Items considered in the 5-year review may include:

- Current science relative to BLLs, lead toxicology, exposure analysis, plant community restoration;
- Review of BLLs relative to fugitive dust reduction and soil remediation activities;
- Review of the Risk-Based Soil Prioritization Strategy;
- Lessons learned from remediation and restoration activities;
- Changes in the remediation schedule;
- Changes in regulatory policy; and
- Input from the Medical Health Officer.

It is proposed that the start date of the 5-year cycle for updating WARP documents be timed to coincide with the acceptance of the WARP. The WARP Five-Year Review will be submitted to ENV, based on input from ongoing programs (THEP and LCEMP), Trail area specific studies and current science.

The 5-year review will allow for adaptive management to be formally considered. Adaptive management is a systematic process for improving practices by learning from the results of research, monitoring and other information. Adaptive management will allow the WARP to evolve with changing circumstances, results of monitoring and advances in the science of toxicology and restoration, so that actions are taken, when necessary, to meet goals and objectives.

The general six-step process for adaptive management (Nyberg, 1999) is illustrated in Figure 9.2-1. It starts with assessing the problem, then moves to designing a management plan and monitoring program to evaluate the effectiveness of the plan. Thereafter, the plan is implemented and monitored relative to the objectives. The outcomes are then evaluated and the practices are adjusted, if needed. The lessons learned, combined with consideration of the other issues listed above (e.g., current science) should allow the problem to be re-assessed, with new options becoming available for activities (if needed) that allow the WARP objective to strive for continuous improvement (Nyberg, 1999).

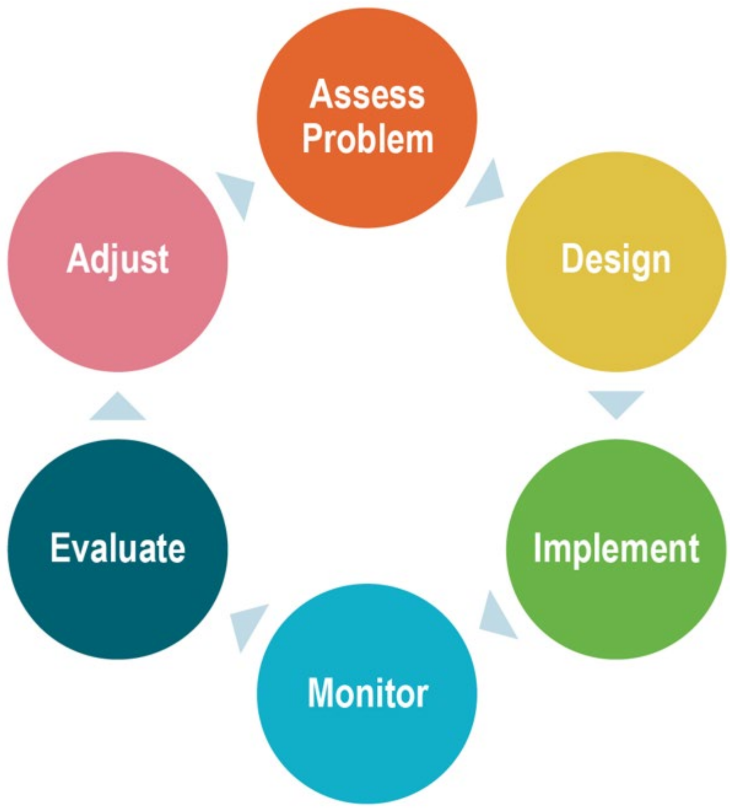


Figure 9.2-1: Six steps of an Adaptive Management Process (Nyberg, 1999)

Soil remediation to address human health risks has been conducted for several years and, therefore, it is already in the adaptive management cycle, with ongoing monitoring, evaluation and adjustment as needed. Research and pilot studies of plant community restoration also have been conducted for several years, although the approaches are less well developed than the approaches to soil remediation for human health, and different approaches may be needed for different ecosystem types. Therefore, the restoration activities are in an earlier stage of the adaptive management process, with more design, monitoring and evaluation needed. At any given time, different areas being remediated and restored will be in different phases of the adaptive management process.

Monitoring data will be evaluated to assess whether the WARP objectives are being met. For human health objectives, this includes:

- Monitoring conducted by Teck (e.g., air quality) and IH (e.g., BLL, Healthy Families program, enhanced support follow-up), will contribute to the evaluation of WARP remediation objectives, as described in Section 2, Supporting Programs;
- Monitoring soil quality, including community average soil Pb concentrations, will contribute to interpreting any changes in community exposures (i.e., BLL in children);
- Remediation approaches and methods will be reviewed to determine whether modifications are needed to reduce exposures. For example, a Long-Term Soil Study has been initiated to evaluate the potential for soil recontamination from ongoing smelter emissions, or re-suspension, which may influence remediation strategies;
- Factors that contributed to developing the human health-based remediation action levels will be reviewed (e.g., toxicity reference value for Pb);
- Communication approaches (e.g., through surveys) will be reviewed to verify they are effective at reaching property owners and the community with the intended messages.

For plant communities, this includes:

- Reviewing soil data (e.g., pH, nutrients) and pilot or other treatment data to determine whether the treatment is contributing to improvements in plant community parameters;
- Reviewing restoration approaches and methods to determine whether modifications to treatments should be implemented;
- Reviewing communication approaches to verify they are effective at reaching property owners and the community with the intended messages.

Through the adaptive management process, data from monitoring, results from pilot studies and other information will be used to assess whether the WARP is meeting its objectives (Figure 9.2-2). Any modifications needed as a result of this assessment will be incorporated into the ongoing implementation of the WARP.

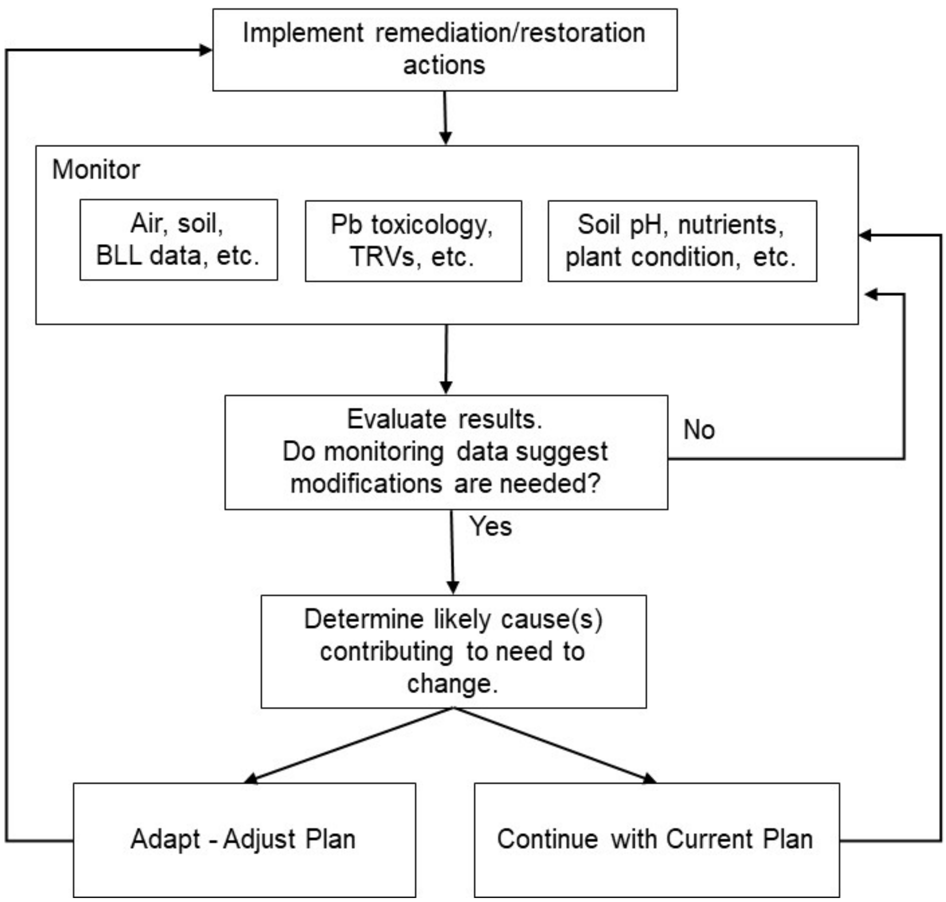


Figure 9.2-2: Adaptive management process for the WARP

10. Schedule

The schedule for implementing remediation and restoration activities is presented here. As mentioned in Section 6, remediation has been conducted for several years to manage human health risks, with ongoing monitoring, evaluation and adjustment as needed. These activities, as described in Section 6.1, will continue. Similarly, the supporting programs (e.g., air quality, BLL monitoring) that contribute to understanding human health risks and risk reduction have been ongoing for many years and are expected to continue. Additional studies will be conducted when necessary (e.g., the Long-Term Soil Study). A key part of ensuring the programs and actions taking place to protect human health will be through the working group described in Sections 4.1.2 and 8.1.5. This group will continue to meet to review emerging science around Pb and human health exposure to Pb in the environment.

Research and pilot studies of plant community restoration have also been conducted for several years, with monitoring ongoing. There is a proposal for an LCEMP Committee to discuss and review various topics contributing toward further developing the restoration priorities and approaches and the methods to evaluate restoration success, as mentioned in Sections 2.2.1.2 and 7. The timing for discussions, reviewing specific topics and conducting other activities will be based on input provided by the Committee; therefore, a schedule cannot yet be presented. It is anticipated that technical documents currently in draft form will be finalized in the next few years, based on input from the LCEMP Committee. Pilot projects are expected to continue for several years, with the possibility of new pilot projects in the next 5 years. In the longer term, the need for pilot projects, their number or type, is unknown. The timing for initiating broader-scale restoration treatments also is currently unknown, although feasibility studies and treatment prescription development may begin before the next WARP cycle. Implementing broader-scale restoration treatments will begin when there is reasonable confidence that the approach is safe and effective for addressing site conditions. Monitoring, adaptive management and evaluation of potential offset projects are expected to continue for many years.

The start date of the 5-year cycle for updating the WARP, as mentioned in Section 9.2, is proposed to coincide with the acceptance of the WARP. Assuming the WARP is accepted in 2024, the first 5-year cycle would be from 2025 to 2029. An example of the anticipated schedule for the 5 year WARP cycle is provided in Figure 10.0-1.

Proposed Schedule for First 5 Year WARP Cycle	2024				2025				2026				2027				2028				2029			
Item	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
WARP Submission and Review																								
Indigenous Engagement on Draft WARP		x	x	x	x																	x		
Public Consultation on Draft WARP[1]					x																		x	
Revisions to WARP with inclusion of Consultation findings					x	x																		x
Anticipated Approval in Principle						x																		
Human Health Objectives																								
Human Health Working Group Meetings[2]			x	x		x		x		x		x		x		x		x		x		x		x
Annual Blood Lead Monitoring Clincs (Feb & Sept)	x		x		x		x		x		x		x		x		x		x		x		x	
Blood Lead Case Conference				x				x				x				x				x				x
Continuation of THEP Supporting Programs[3] and THEC governance	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Soil Management Program		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x
Prioritization, Planning and Annual SMP Report	x				x				x				x				x				x			
Long Term Soil Study Annual Sampling and Data Evaluation				x				x				x				x				x				x
Determine key areas requiring updating in next WARP version																			x	x				
Ecological Objectives																								
LCEMP Committee Meetings[4]			x	x		x	x			x	x			x	x			x	x			x	x	
Update Terms of Reference for LCEMP Committee				x																				
Review and Revise Technical Documents						x	x			x	x			x	x			x	x			x	x	
Monitor Pilot Projects						x	x			x	x			x	x			x	x			x	x	
Conduct infill soil sampling for select polygons without soil data						x	x																	
Annual report								x				x				x				x				x
Determine key areas requiring updating in next WARP version																			x	x				
	2024				2025				2026				2027				2028				2029			

[1] Consultation is proposed for January 2025. Delays in this schedule may push other WARP deliverables

[2] As described in Section 2 of the WARP

[3] Schedule of meetings to be determined by Human Health Working Group

[4] Schedule of meetings and order of document review to be determined by LCEMP Committee

Figure 10.0-1: Proposed schedule of the 5 year WARP cycle

Progress over the next one to two WARP cycles will help to refine efforts beyond the predictable activities presented here. The schedule of activities will be updated in future WARP submissions, as needed.

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TABLES (Provided in separate electronic excel file only)

1a: Summary of Analytical Results for Surface Soil -Total Metals - Compared to Low Density Residential Land Use (RLHD) Standard
1b: Summary of Analytical Results for Surface Soil -Total Metals - Compared to High Density Residential Land Use Standard
2: Summary of Analytical Results for Surface Soil -Total Metals - Compared to Agricultural Land Use Standard
3: Summary of Analytical Results for Surface Soil -Total Metals - Compared to Commercial Land Use Standard
4: Summary of Analytical Results for Surface Soil -Total Metals - Compared to Industrial Land Use Standard
5: Summary of Analytical Results for Surface Soil -Total Metals - Compared to Urban Parkland Land Use Standard
6: Summary of Analytical Results for Surface Soil -Total Metals - Compared to Reverted Wildlands Land Use Standard

APPENDIX A

ENV Response to SNC-Lavalin 2018 Soil Concentration Limits for Establishing the WARP Boundary

BRITISH COLUMBIA

File: 26250-20/3250
SITE: 3250

August 13, 2018

SENT BY EMAIL: Clare.North@teck.com

Clare North, P.Geo.
Superintendent, Environmental Remediation
Teck Metals Ltd.

Dear Ms. North:

Re: Soil Concentration Limits for Establishing the Boundary of the Teck Metals Ltd., Trail Smelter Facility Wide Area Remediation Plan Site

This letter provides my decision on your July 23, 2018 letter requesting director's approval of soil concentration limits to establish a Wide Area Remediation Plan (WARP) Site boundary for widespread soil contamination originating from historical aerial emissions from the Trail Smelter Facility in Trail BC. The application was submitted by SNC Lavalin Inc (SNC) on behalf of Teck Metals Ltd (Teck). The WARP Site boundary established by SNC on the basis of the proposed soil concentration limits is provided in Attachment 1 below.

In reaching my decision I have relied on information provided in the following supporting document:

> *Determination of Concentration Limits for Teck Trail WARP Boundary*, SNC_Lavalin, July 23, 2018

The primary rationale and supporting information presented by SNC in the above document for the proposed lead, zinc, cadmium and arsenic concentration limits in soil is summarized in italics below:

- *In order to apply the appropriate CSR soil matrix standard for lead, zinc and cadmium, the determination of a site-wide pH of soil not affected by natural or anthropogenic point sources is required… Based on the statistics, a site-wide median soil pH of 7.0 is considered to be appropriate site soil pH to use for the selection of soil matrix standards for the groundwater pathway receptors.*

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- *According to Hoy and Dunne 2015, the complex tectonic and magmatic processes that have taken place in the area resulted in a variety of mineral deposits and related numerous past producers and historical mining camps located in the Rossland-Salmo-Nelson map area.*

- *Geological information provided by BC Ministry of Energy and Mines MINFILE database indicates that the following significant mineral ores were/are present in the area: galena (lead sulphide); arsenopyrite (iron arsenide sulphide); chalcopyrite (copper iron sulphide); pyrrhotite (iron sulphide); sphalerite (zinc, iron sulphide); pyrite (iron sulphide); tetrahedrite (copper, iron, silver, zinc); boulangerite (lead-antimony sulphide); stibnite (antimony sulphide); gersdorffite (nickel arsenic sulphide); and stromeyerite (silver-copper sulphide), gold and bismuth, along with associated calcite (calcium carbonate).*

- *Aerial distribution is controlled mainly by the physiography of the region in relation to shape and orientation of the Columbia River Valley (deep valley oriented NNE to SSE) and direction of the prevailing southeasterly winds. The ridges along the valley are physiographical barriers that limit deposition beyond the valley walls. Deposition of the specified substances extended 11.3 km to the NNE (N4) and 14.1 km to the SSE (S4) of the Trail smelter; and 2 km to the east (E1) and 2.8 km to the west (W3).*

- *Drinking water and aquatic screening criteria for As were not exceeded in any creek.*

- *All of the sampling locations that exceeded screening criteria for cadmium, lead and zinc are situated in creeks that are proximal (i.e., within 10 km) to the smelter. Also, these samples were collected from reaches that contain soil with elevated concentrations and are within the 120 µg/g lead limit.*

- *Klohn also indicated that, based on detailed surveys of select creeks, groundwater does not appear to be an important pathway for metals entering Johnson, McNally and Bear Creeks (Klohn, 2004).*

- *Based on this* [groundwater] *information…the groundwater pathway to the creeks does not appear to be significantly affecting creek quality at low flow conditions. Exceedances of BCWQG are not ubiquitous across the wide area, and the spatial pattern is not contiguous, despite decades of historical aerial deposition and a relatively contiguous source at surface. Furthermore, detailed review of some creeks with exceedances suggest that the groundwater pathway is not significant.*

- *A summary of groundwater quality …is provided …As can be seen in the figures, there is no consistent spatial trend in the parameters that exceed, and there are limited exceedances for the four parameters of interest (i.e., As, Cd, Pb, Zn).*

- *Due to the influence of natural sources of arsenic, the approach used in determining a concentration limit for arsenic was to utilize the results of the background study carried out by the Geological Survey of Canada and Teck (Sanei et al., 2007). For the background study, a comprehensive assessment of the area was completed to identify background sites at which 37 soil samples were collected and analyzed. The paper looked at various statistical methods to calculate an upper background threshold, including the 95th percentile which is used in by BC ENV in Protocol 4. The resulting background concentration for arsenic was estimated to be 19.7 µg/g.*

- *The elevated arsenic in the Rossland area is not considered to be sourced from the Teck Trail Operations, but related to geogenic sources associated with extensive mineralization (background conditions) and historical mine workings. There are a few smaller isolated areas outside of the main area which are considered to be the result of localized natural background conditions and not related to smelter operations.*

The concentration limits proposed by SNC for defining the boundary of the Teck, Trail Wide Area Remediation Plan Site and rationale are provided in Table D of the July 23, 2018 report and copied below.

Table D: Proposed Concentration Limit for Each Specified Substance

Specified Substance	Most Stringent Standard (µg/g)	Rationale
Lead (Pb)	120	Most stringent and mandatory matrix standard and established regional background by ENV. Standard is for human health protection for intake of contaminated soil.
Zinc (Zn)	450	Most stringent matrix standard for the protection of soil invertebrates and plants toxicity. Median soil pH in the surrounding the area is 7.0 - < 7.5 below 1 m depth (i.e., the aquatic life pathway is no longer the most stringent).
Cadmium (Cd)	3	Most stringent matrix standard based on a site-wide median soil pH of 7.0 - < 7.5 in the surrounding soils below 1.0 m depth. Standard is for the protection of groundwater flow to freshwater aquatic life.
Arsenic (As)	19.7	Site-specific data from Goodarzi et al., 2002, using Protocol 4, Option 2a (establishing background based on supplemental reference data).

Based on the lines of evidence presented in the July 23, 2018 SNC report referred to above, I accept the proposed concentration limits for defining the boundary of the Teck, Trail WARP Site associated with soil contamination originating from historical emissions from the Teck, Trail Smelter Facility in Trail, B.C. Furthermore, I accept the additional lines of evidence presented by SNC in support of the WARP Site boundary depicted in Attachment 1.

Therefore, I confirm my approval of the concentration limits for lead (120 *ug*/g), zinc (450 *ug*/g), cadmium (3 *ug*/g) and arsenic (19.7 *ug*/g) and of the WARP Site boundary proposed by SNC for defining the boundary of the WARP Site for purposes of Teck Metals Ltd's application for a Wide Area Remediation Plan.

This decision has been reached under Section 47 of the Contaminated Sites Regulation and Section 53 of the *Environmental Management Act*. It pertains to establishing the geographic boundary of a Site acceptable to the director for purposes of considering an application for a Wide Area Remediation Plan. It is not intended to limit the responsibility of Teck for any contamination that may be subsequently identified beyond the WARP Site boundary approved herein and found to have originated from historical emissions from the Teck, Trail Smelter Facility.

This decision is based on the most recent information provided to the Ministry of Environment and Climate Change Strategy (ministry) regarding the above-referenced site. The ministry, however, makes no representation or warranty as to the accuracy or completeness of this information. The ministry expressly reserves the right to change or substitute different requirements where circumstances warrant.

If you have any questions regarding this letter please contact Lavinia Zanini at Lavinia.Zanini@gov.bc.ca or you can contact me at Peggy.Evans@gov.bc.ca.

Sincerely,

Peggy Evans
for Director, *Environmental Management Act*

cc: Lavinia Zanini, Ministry of Environment & Climate Change Strategy
Jennifer Puhallo, Ministry of Environment & Climate Change Strategy
Lucy Hewlett, Ministry of Environment & Climate Change Strategy
Stephan Humphries, SNC-Lavalin Inc.
Patricia Carmichael, SNC-Lavalin Inc.
(sent by email)

Attachment 1. (included)

Attachment 1. Proposed Wide Area Site Boundary

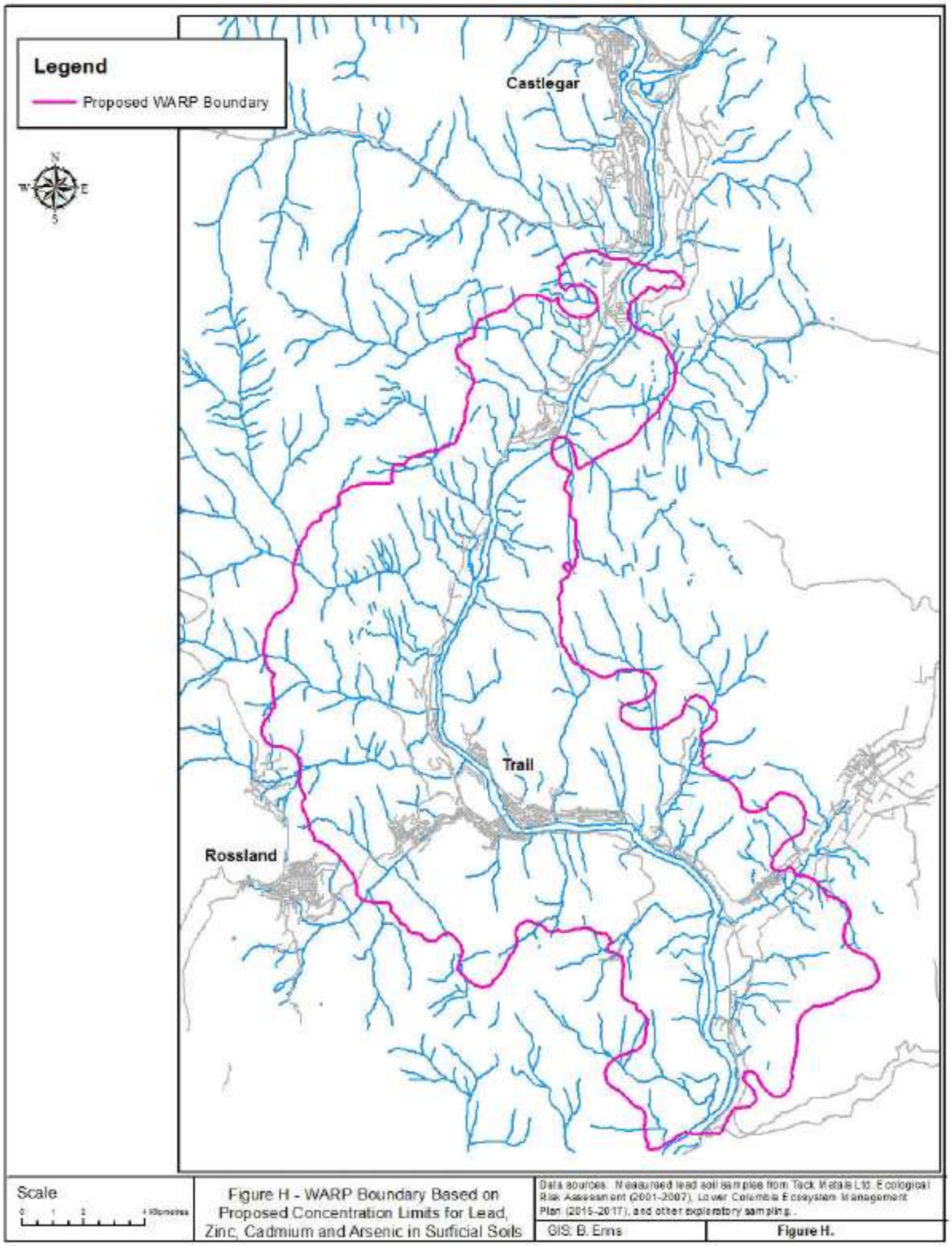

Figure H - WARP Boundary Based on Proposed Concentration Limits for Lead, Zinc, Cadmium and Arsenic in Surficial Soils

APPENDIX B

Summary of LCEMP Remediation Sampling Plan from Machmer et.al. 2018

B-1 Introduction

The material in this appendix is excerpted from Machmer et al. (2018) *Lower Columbia Ecosystem Management Program: Draft Sampling Protocols for Polygons Planned for Remediation*. It includes sampling protocols that may be used in two phases of the LCEMP Remediation/Risk Management process: the *Baseline Sampling* phase, to collect baseline data on soils and vegetation necessary for prescription development, and; the *Treatment Monitoring* phase, to gather data to measure effectiveness of remediation/risk management.

General sampling methods detailed in this document are recommended to (a) characterize ecosystem, site, vegetation, and soil conditions, and (b) provide information on stand structure (i.e., coarse woody debris and large trees) and wildlife use. More in-depth sampling methods are included to address specific variables of interest (e.g., soil pH, metals, and nutrients) which influence the potential for recovery. It is anticipated that all protocols needed to evaluate a polygon can be found in this document. However, once feasibility/pilot studies have been completed, not every sampling protocol described herein may be needed at every polygon. For example, in rock or shrub-dominated polygons, sampling of large trees would not be necessary.

Both the scope and frequency of post-treatment monitoring is expected to change over time, as monitoring results for different site types subject to a range of prescriptions have been analyzed and adaptive adjustments are made to reflect initial learnings. These lessons learnt may allow for more focused sampling of key indicators of vegetation change over time.

B-2 Soil Metals, pH and Nutrients

Prior to beginning any remediation or risk management work in a given polygon, soil sampling and analyses for soil metal concentrations, strong acid leachable metals (SALM), pH, electrical conductivity, and soil nutrients will be conducted, as described below.

B-2.1 Sampling Layout

For each polygon, a 50 metre by 50 metre sampling grid will be created in the GIS to cover the entire polygon. A single target sample location will be placed within each grid cell with the intention of maintaining an inter-sample distance of approximately 50 metres (see Figure 3). Grid cells that cover only a small portion of the polygon may not be allocated a target sample location. The coordinates of these target locations will be loaded into a GPS. Actual sample locations may differ from pre-determined target locations, due to site limitations such as bedrock to surface, lack of soil, or topography. Actual sample locations and other sample data will be recorded using smartphone-based GIS applications (ESRI Survey 123 and Collector) connected to a high resolution (sub-metre) GPS. One discrete sample will be taken from the actual recorded location.

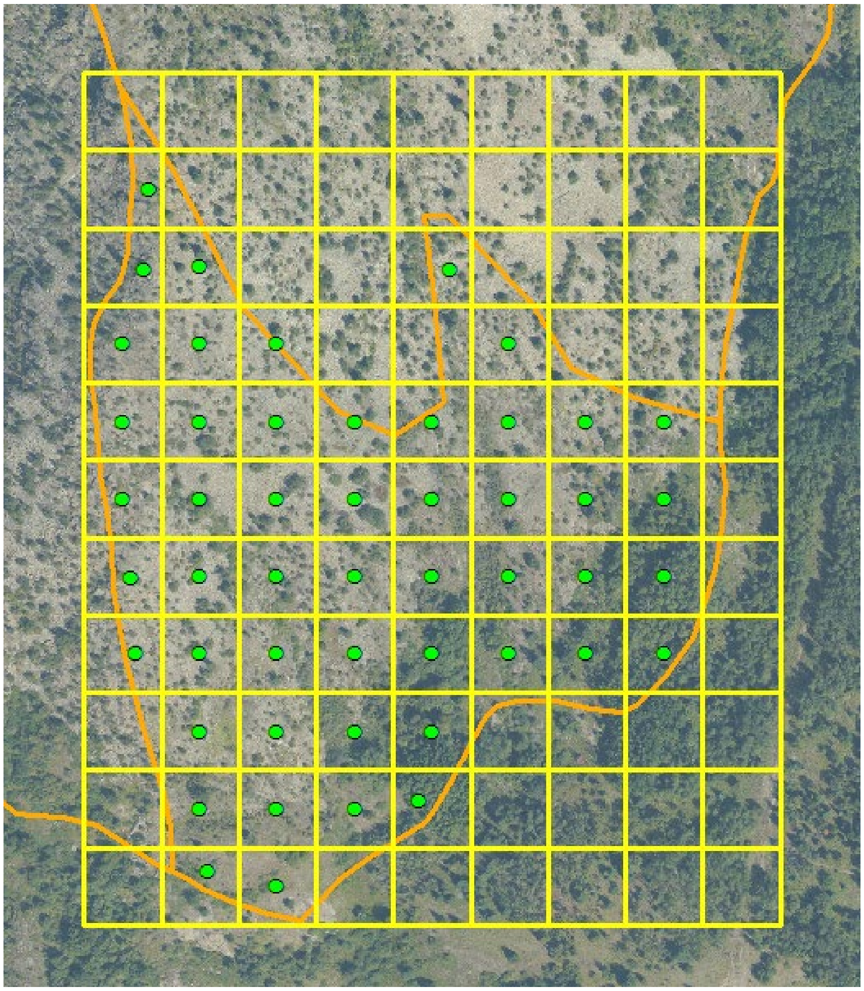

Figure 2: Example of an 11.6 ha polygon with a 50 m x 50 m sampling grid and 50 target sample locations

B-2.2 Sampling and Analysis Methods

Each sample should have at least 250 grams of soil to ensure that there is enough soil to do the desired laboratory analyses. Before collecting the soil at each location, any existing LFH (litter, fibre, humus) layer will be carefully removed, so that the sample consists only of soil. The samples will be collected using a soil auger of a size and design appropriate for collecting the desired amount of soil. Sample depths will be from 0 cm (the surface) to 15 cm below the surface. To avoid cross-contamination of the samples, the auger will be rinsed clean with water, and nitrile gloves worn during sample collection will be changed after each sample is taken.

Each sample will be given a unique sample ID that is recorded in the GIS application and on the corresponding sample bag. Each sample ID will conform to the following sequence: SSyy-LCxxxx-zz-yymmdd, where:

SS = Surface Soil;

yy = two-digit year (assumes year is 2000 plus YY);

LC = Lower Columbia (to avoid confusion with THEP soil samples);

xxxx = four-digit LCEMP polygon ID with leading zeros if needed;

zz = two-digit sample number with leading zero if needed;

mm = two-digit month with leading zero if needed; and

dd = two-digit day of month with leading zero if needed.

For example, sample 3 from polygon 1366 taken on June 8th, 2018, would have a sample ID of "SS18-LC1366-03-180608".

After collection, all samples will be well mixed within the sample bag and then analyzed for metals concentrations using an X-ray Fluorescence (XRF) device. A subset of a least 1/5 (20%) of the samples will be submitted to an accredited soil lab(s) for analysis of pH, soil nutrients and strong acid leachable metals (SALM / EPA 6020A). The samples chosen for lab analysis will have representatives from the range of lead concentrations (as determined by the XRF analysis) for each polygon. Once lab results are available, the relationship between XRF and lab results will be analyzed, documented, and used to determine 'predicted lab values' for the 80% of samples that weren't analyzed by the lab.

To provide guidance on growing conditions, nutrient analyses will be undertaken for a subset of the samples collected based on soil types within the polygon. Analyses will address the following parameters: pH and electrical conductivity; percent sand, silt, clay, total organic matter; total percent nitrogen, carbon to nitrogen ratio; available P, K, Ca, and Mg; cation exchange capacity, and exchangeable Ca, Mg, Na, and K.

The results from pre-treatment soil sampling and analyses will inform the process of designing appropriate treatments for the LCEMP polygons.

B-3 Ecosystem, Site, Vegetation and Soil Conditions

B-3.1 Sampling Layout

Site, vegetation and soil conditions in polygons will be sampled at a density of one plot/ha (with a minimum of three plots nested in each proposed treatment unit of a selected polygon). In GIS, a grid with points spaced 100 m apart will be overlaid on polygons of interest to establish approximate sample plot locations (Figure 4). In the field, a randomly located starting point will be established to locate the first plot centre.

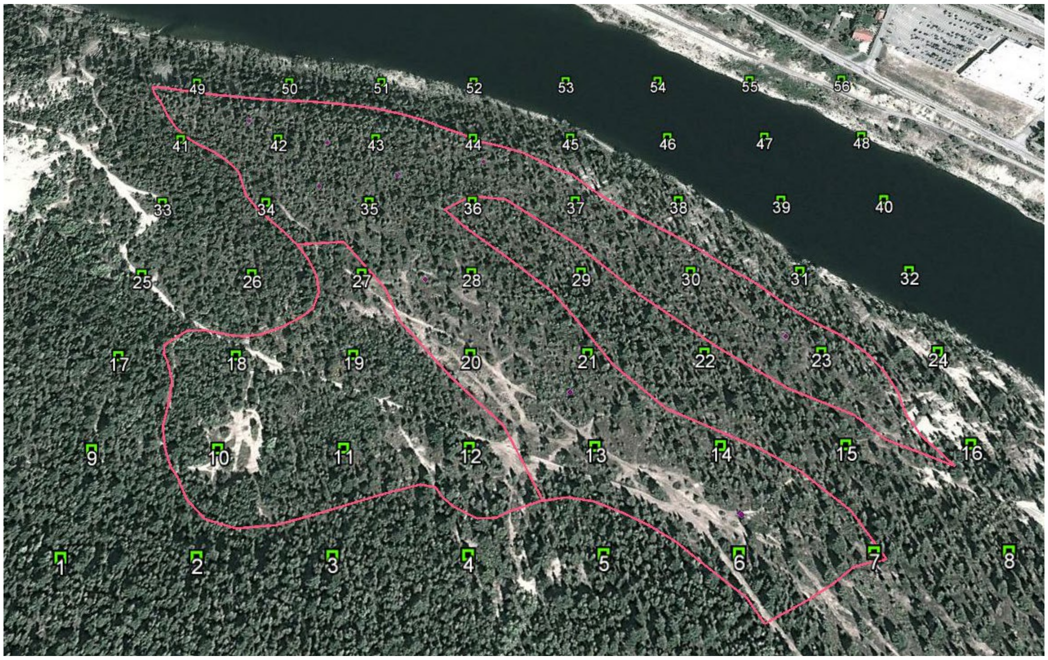

Figure 3: 100 m² grid overlay applied to determine sampling plot locations and achieve a sampling intensity of 1 plot/ha in polygons

Each plot centre will be marked with a spike and washer, and flagging will placed on the spike. If the spike is unstable, a rock will be placed and painted close by. If feasible, the tree closest to the plot centre will be marked with paint, and flagging labelled with the plot number, bearing and distance to the plot centre will be established. UTM coordinates for the plot centres will be recorded.

B-3.2 Field Data Collection

The systematic sampling approach described below will be applied to collect data in plots nested in treatment units of polygons for each outlined component of the ecosystem. In the case of pilot studies, control units will also be established. Controls will be established for pilot studies, and depending on their utility, use of controls may or may not be continued once pilot studies have been completed.

FS882 (1-3) ecosystem field forms (Province of BC 2010) will be used to collect plot data for ecosystem, site, vegetation, and soil parameters. The requisite data forms and an explanation of all data fields can be viewed at the following website: https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/conservation-data-centre/field_manual_describing_terrestrial_ecosystems_2nd.pdf . Required information to be filled in on the forms is indicated below (with an asterix), however, it is recommended that data for the other parameters listed is also collected, although this information may not be required.

B-3.2.1 Site Description

The following general information will be collected to describe the site:

- Date*
- Project ID*
- Field plot number*

- Surveyors*
- General Location*
- Plot UTM coordinates + accuracy*

The following site information will be collected within 11.28 m radius (400 m^2) plots used to compare site features of the degraded ecosystems with benchmark ecosystems:

- Plot Representing*
- Successional Status*
- Structural Stage*
- Elevation*
- Slope %*
- Aspect*
- Meso Slope Position*
- Surface Shape*
- Site Diagram
- Photos (overview photos to show stand and terrain features in the four cardinal directions [N, E, S, W] from the plot centre; close-up photos to show the herb and moss/lichen vegetation and substrate)*
- Site Disturbance*
- Exposure Type*
- Substrate (organic matter, decaying wood, mineral soil, bedrock, rock by %)*
- Notes

B-3.2.2 Vegetation Description

Vegetation layer data will be collected within nested plots. An 11.28 m radius (400 m^2) plot is required to gather data for the tree (>10 m tall) layer and a 5.64 m radius (100 m^2) plot will be used for the shrub, herb and moss/lichen layers. Percent cover data will be collected for each species by vegetation layer, including the A1, A2, A3, B1 and B2 layers for trees. Data on tree regeneration (% cover) will be gathered in the B1 and B2 layers. All native, exotic and invasive species will be included and any unknown species will be collected and labeled for future identification. The following data will be gathered:

- Surveyor(s)*
- Plot Number*
- Complete Species List*
- % Cover by Layer – Tree (A), Shrub (B), Herb (C), Moss/Lichen (D)*
- 7-letter species code and % cover for each species by layer (0.1% minimum cover value, for lower % covers use "+" for trace; use field name to identify any unknown species)*
- Notes

B-3.2.3 Listed Plant Species

For any red- and blue-listed plant species observed in the plots or polygons, locations will be recorded using UTM coordinates and information about the populations will be summarized on the B.C. Conservation Data Centre FIELD SURVEY FORM (PLANTS).

B-3.2.4 Invasive Plant Species

For any nuisance and invasive plant infestations observed in the plots or polygons, locations will be recorded using UTM coordinates and information about the populations will be summarised on IAPP Site & Invasive Plant Survey Record forms.

B-3.2.5 Soil Description

Soil information will be collected to use for comparing degraded sites to reference ecosystems. The soil pit will be dug within the 5.64 m radius plot to ≈60 cm depth, or to a restrictive layer (i.e., bedrock), or into the C layer (the unaltered parent material) if feasible, where digging is more difficult. Information will be collected on the following parameters:

- Surveyor(s)*
- Plot Number*
- Bedrock and Coarse Fragment Lithology
- Terrain Texture, Surficial Material and Surface Expression*
- Soil Classification – Great Group
- Humus Form*
- Rooting Depth*
- Root Restricting Layer – Type, Depth*

B-3.2.6 Ecosystem Classification

The following ecosystem information will be determined and recorded on the Site Description page of the ecosystem field form:

- Soil Moisture Regime (SMR)*
- Soil Nutrient Regime (SNR)*
- Biogeoclimatic Unit* and Site Series*

B-4 Stand Structure and Wildlife

Standardized data on wildlife, large coarse woody debris (CWD) and trees will be gathered at the same plot locations described in Section B-3.1.

B-4.1 Coarse Woody Debris

CWD data will be gathered along 2 x 24 m transects (first azimuth random and second at a 90º angle) established at plot centres. Detailed methods described in Chapter 7 of Field Manual for Describing Terrestrial Ecosystems 2nd Edition (Land Management Handbook 25) will be used to record both the following general and specific CWD information on the FS882 (7) field forms:

General:

- Date*
- Plot Number*
- Surveyor(s)*
- Azimuth for Transects 1 and 2*
- Meter Segments Sampled for 24 m long Transects 1 and 2*

Specific (for all pieces >30 cm diameter):

- Diameter (estimated in cm)*
- Length (estimated in m)*

B-4.2 Large Trees

Tree mensuration data will be gathered on mature (M) trees >12.5 cm dbh and associated wildlife use in 11.28 m radius (400 m^2) plots. The plot size will be extended to 25.23 m radius (2,000 m^2) to record the same data for any additional dominant (D) trees measuring >40 cm dbh only. Methods described in Chapter 6 of Field Manual for Describing Terrestrial Ecosystems 2nd Edition (Land Management Handbook 25) will be used to record the following data on the mensuration FS882 (4) field form:

General:

- Date*
- Surveyor(s)*
- Plot Number*
- Plot Size*

Specific:

- Subplot (M/D)*
- Tree Number*
- Tree Species*
- Diameter (estimated dbh in cm)*
- Crown C (decay class 1-9)*
- Wildlife Use (C – cavity nest; O = open nest; D = denning/resting; F = feeding; M = mark tree; P = perching/roosting)*
- Wildlife Species (wherever possible, ID the user, using 5 letter species code beginning with A = amphibian; B = bird; M = mammal; R = reptile)*

B-4.3 Wildlife Detections and Sign

Methods described in Chapter 6 of Field Manual for Describing Terrestrial Ecosystems 2nd Edition (Land Management Handbook 25) will be used to record any other evidence of wildlife detections (sightings, songs, calls, etc.) or use (i.e., wildlife sign such as trails, tracks, scat, browsing, feeding and nesting) on the FS882 (6) field forms. The same plots established for ecosystem sampling will be used to collect systematic data on wildlife occurrence and use, corresponding to the following fields:

- Species (use standardized 5-letter code beginning with A = amphibian; B = bird; M = mammal; R = reptile)*

- Sex (F = female; M = male; U = unknown)
- Life Stage (E = egg; N = nestling; J = juvenile; S = sub-adult; A = adult; U = undetermined);
- Activity Code (see lists provided)
- Descriptor (S = seen; H = heard; F = fresh sign; Y = sign <1 year; O = old sign)*
- Number (number of animals present or relative abundance of sign scored as H = high; M = moderate; L = low; T = trace)*

Additional opportunistic wildlife detections in the polygon as a whole will be recorded. Wildlife data obtained during tree mensuration will be amalgamated with the additional opportunistic wildlife detections and sign data above to determine activity per plot and total wildlife species richness per plot and polygon.

B-4.4 Listed Wildlife Species

For any red and blue-listed species observed in the plots and/or polygons, locations will be marked and UTM coordinates will be recorded with relevant sighting details (e.g., number of individuals, adult/juvenile, associated habitat use info, etc.). Listed wildlife species data will be entered into Teck's own data management system and will also be submitted annually to the BC CDC and SPI databases.

B-5 Monitoring Timeframe and Frequency

Pre-treatment monitoring will be conducted in all LCEMP polygons to establish a baseline, preferably within a year of treatment implementation. During the early years of LCEMP implementation in pilot studies and priority polygons, monitoring is recommended in years 1, 2, 3 and 5 post-treatment. However, the frequency and scope of post-treatment monitoring is expected to change over time, as monitoring results for different site types subject to a range of prescriptions have been analyzed and adaptive adjustments are made to reflect initial learnings.

B-6 Data Entry and Storage Considerations

Ecosystem, site, vegetation, and soil data collected as outlined in Section B-3.2 and will be entered into a BC standardized VPRO MS Access database file. Stand structure and wildlife data will be entered into an MS Excel database file. These data files will be imported into Teck's data management system under development.

APPENDIX C

AtkinsRéalis Notice to Reader

C-1 AtkinsRéalis Notice to Reader

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Information in this report should not be used as geotechnical data for any purpose unless specifically addressed in the text of this report. Groundwater conditions described in this report refer only to those observed at the location and time of observation noted in the report.

This report must be read as a whole, as sections taken out of context may be misleading. If discrepancies occur between the preliminary (draft) and final version of this report, it is the final version that takes precedence. Nothing in this report is intended to constitute or provide a legal opinion.

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