AtkinsRéalis

Teck

For the Environmental Management Area Surrounding Teck Trail Operations

Teck Metals Ltd.

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HUMAN HEALTH RISK ASSESSMENT FOR LEAD (Pb) - Draft

Signature Page

Prepared By:

Tara Siemens Kennedy, MET, P.Chem, CSAP
Senior Risk Assessor and Toxicologist/Technical Director – Risk Assessment

Environment Practice
Engineering Services Canada

Andrea McCormick, BSc, P.Ag.
THEP Project Scientist

Environment Practice
Engineering Services Canada

Reviewed By:

Tony Gillett, BASc, P.Eng., CSAP
Director – Tailings, Water & Environment –West

Tailings, Water and Environment
Metals and Minerals North America

Notice to Reader

This document and its contents have been prepared by AtkinsRéalis for the sole benefit of Teck Metals Ltd. to support Teck Metals Ltd. in its submission of a Wide Area Remediation Plan related to contamination on off-site affected properties in the lower Columbia River valley around Trail, BC to the BC Ministry of Environment and Parks. This document is in draft and subject to revision following public consultation. Sections of this draft will be updated prior to any final submission by Teck Metals Ltd. to the BC Ministry of Environment and Parks. AtkinsRéalis assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

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Acknowledgements

AtkinsRéalis and Teck Metals Inc. (Teck) gratefully acknowledge the invaluable contributions of the members of the Human Health Risk Assessment (HHRA) Working Group to this report. The HHRA Working Group included the authors of the report, Pb risk assessment experts and representatives from Teck, the BC Ministry of Environment and Climate Change Strategy (BC ENV), Interior Health, and the BC Ministry of Health. The members of the HHRA Working Group included:

- Dr. Karin Goodison, Medical Health Officer, Interior Health
- Dr. Ray Copes, Consultant to Interior Health
- Leanne Cusack, Public Health Epidemiologist, Epidemiology & Surveillance Unit, Interior Health
- Jenna Le Noble, Surveillance Analyst, Epidemiology & Surveillance Unit, Interior Health
- Anders Erickson, Human Health Risk Assessment Specialist, Health Protection Branch, BC Ministry of Health
- Jasen Nelson, Senior Risk Assessment Officer, BC ENV
- Lavinia Zanini, Senior Contaminated Sites Officer, BC ENV
- Alma Feldpausch, Principal, Health Sciences, Ramboll
- Dr. Rosalind Schoof, Principal, Ramboll
- Clare North, Superintendent, Environmental Remediation, Teck Metals Ltd.
- David Bell, Senior Environmental Specialist, Teck Metals Ltd.

Executive Summary

On behalf of Teck Metals Ltd. (Teck), AtkinsRéalis Canada Inc. (AtkinsRéalis), formerly SNC-Lavalin Inc., has prepared this DRAFT Human Health Risk Assessment (HHRA) for lead (Pb) in the Trail, BC area. This report has been prepared for review by the HHRA Working Group[1], including the BC Ministry of Environment and Parks (BC ENV). The HHRA Working Group, which includes the authors of the report, Pb risk assessment experts and representatives from Teck, the BC ENV, Interior Health, and the BC Ministry of Health, was established to guide the development of the HHRA for Pb and ensure it incorporates the most up-to-date science and is appropriate for the specific Trail area context.

The HHRA was conducted to assess human health risks associated with exposure to Pb from Teck Trail Operations[2] in the Environmental Management Area (EM Area)[3]. A simplified probabilistic approach was used, with three scenarios used to evaluate risks to residents in the EM Area, including a reasonable maximum (RM) scenario or worst-case scenario, a central tendency (CT) scenario which represents an average or more typical exposure scenario, and a Protocol 1 scenario which was included to comply with BC ENV's requirements for deterministic risk assessment. The characterization of residential receptors is protective of other receptor groups, with further information required to understand the Indigenous peoples' traditional use of plants in the EM Area.

The results of the HHRA predicted hazard indices (HIs) for infants exposed to Pb in indoor dust and air, as well as young children and older children exposed Pb in soil and dust on other outdoor surface, indoor dust and air, greater than the CSR risk-based standard of 1.0 in select neighbourhoods in the EM Area.

Given the conservatism in the HHRA model, which assumes a linear Pb exposure to blood Pb level (BLL) dose-response, compounded by the conservatism in the assumptions made, including that people would not wash their hands or take precautions to prevent ingestion or soil and dust, the RM scenario grossly overestimates exposures to Pb, and while the Protocol 1 scenario is moderately less conservative, it too overestimates exposures. These findings were supported by the blood Pb data that has been collected in the Trail area for the last 22 years, with the BLLs predicted by the HHRA for all three scenarios higher than the BLLs measured in the EM Area. While the CT 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.

Given the conservatism in the estimates, where the CT scenario predicted risks were less than the CSR risk-based standard of an HI $\leq$ 1, there is confidence that health risks are negligible. Using this approach, negligible human health risks are predicted for adolescents and adults across all neighbourhoods in the EM Area, as well as for all age groups in Montrose, Casino, Columbia Gardens, Warfield and Miral Heights.

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[1] Pb HHRA Working Group includes representatives from Teck, BC ENV, Interior Health, Ministry of Health, AtkinsRéalis and Ramboll.

[2] 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 thus, 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.

[3] As defined in the ENV letter response on August 13, 2018, to the SNC-Lavalin document entitled: *Determination of Concentration Limits for Teck Trail WARP Boundary,* SNC-Lavalin July 23, 2018.

Based on CT scenario HIs 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, further assessment of the results of the HHRA was conducted, with the results of Interior Health's Analysis of Variables Influencing Children's Blood Lead Levels in Trail, BC (Interior Health, 2024) considered in the derivation of a Trail area specific, risk-based standard. Using the Interior Health estimated soil Pb to BLL relationship (Interior Health, 2024), along with the toxicological basis of the Health Canada TRV for Pb, a Trail area specific, risk-based standard of a soil Pb concentration of 400 mg/kg was developed. Under Sections 18 and 18.1 of the CSR, the Medical Health Officer (MHO) has recommended Trail area specific, risk-based standards for Pb, including the risk-based soil standard for Pb supported by the results of the HHRA. The Trail area specific risk-based soil standard will be used in the existing soil management program prioritization framework, which is described in the Wide Area Remediation Plan for the EM Area (AtkinsRéalis, 2024).

The BLL declines observed in the Trail area over the last two decades likely 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. This is supported by studies conducted in other smelter communities where multifaceted Pb exposure reduction programs, including public health and education programs with home evaluations and support with addressing multiple sources of Pb exposure an important complement to soil remediation activities. Therefore, the integrative and adaptive management strategy used in the Trail area including the biomonitoring program, should continue, with further operational improvements to further reduce Pb in air, where possible.

1. Introduction

On behalf of Teck Metals Ltd. (Teck), AtkinsRéalis, formerly SNC-Lavalin Inc., has prepared this FINAL DRAFT Human Health Risk Assessment (HHRA) for lead (Pb) in the Trail, BC area. This report has been prepared for review by the HHRA Working Group[4], including the BC Ministry of Environment and Parks (BC ENV). The HHRA Working Group, which includes the authors of the report, Pb risk assessment experts and representatives from Teck, the BC ENV, Interior Health, and the BC Ministry of Health, was established to guide the development of the HHRA for Pb and ensure it incorporates the most up-to-date science and is appropriate for the specific Trail area context.

1.1 Objectives

The Pb HHRA is one component of the Wide Area Remediation Plan (WARP) (AtkinsRéalis, 2024) that has been prepared with the objective of managing risks associated with contamination from historical and contemporary aerial emissions from Teck Trail Operations through a risk-based approach. In this context, the objectives of the Pb HHRA are to:

- Assess human health risks associated with exposure to Pb from Teck Trail Operations[5] using standard BC *Contaminated Sites Regulation* (BC CSR) (BC ENV, 2023a) HHRA methods.
- Review the current risk management strategy[6] and identify any opportunities to further reduce human exposure to Pb from Teck Trail Operations.
- Support a recommendation for an alternative risk-based standard for Pb (per Sections 18 and 18.1 of the BC CSR).

1.2 Scope and Approach

A summary of the scope and approach for the Pb HHRA is as follows:

- The Environmental Management Area (EM Area)[7] has been used to establish the HHRA Study Area. The geographic area is presented in **Section 5**, **Figure 5-1**.
- All available environmental quality data (e.g., for soil, groundwater, dust, air) were considered in the HHRA.

[4] Pb HHRA Working Group includes representatives from Teck, BC ENV, Interior Health, Ministry of Health, AtkinsRéalis and Ramboll.

[5] 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 thus, 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.

[6] The HHRA is an important component of the risk management strategy.

[7] As defined in the ENV letter response on August 13, 2018, to the SNC-Lavalin document entitled: *Determination of Concentration Limits for Teck Trail WARP Boundary,* SNC-Lavalin July 23, 2018.

- The HHRA has been conducted using an approach established based on input from the Pb HHRA Working Group and based on BC ENV and Health Canada methods and guidance, including:
  - A CSR HHRA has been conducted using the Health Canada provisional toxicity reference value (TRV) for Pb for toddlers, and a modified Health Canada TRV (to account for lower Pb absorption in adults) for adults (see **Section 7**).
  - Risks higher than the CSR risk-based standards were predicted at some properties that have not been remediated based on the measured soil Pb concentrations and the conservative approach taken in the HHRA, including conservative exposure and toxicokinetic assumptions.
  - Based on 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), under Sections 18 and 18.1 of the CSR, the Medical Health Officer (MHO) has recommended Trail area specific, risk-based standards for Pb. The MHO's recommendation (Goodison, 2024) includes reducing children's Pb exposure such that we continue to narrow the gap between blood Pb levels in children in Trail and those elsewhere in Canada, as well as a risk-based soil standard for Pb supported by the results of the HHRA.
  - Based on the Trail area specific, risk-based soil standard for Pb, the existing risk management programs under the Trail Health and Environment Program (THEP), including the Prioritization Strategy for Soil Remediation (SNC-Lavalin, 2019), were reviewed in the WARP (AtkinsRéalis, 2024).
  - Performance verification measures for risk management of contamination from Teck Trail Operations for the protection of human health have been developed and are included in the WARP (AtkinsRéalis, 2024). The performance verification measures and how they relate to the THEP programs that form the adaptive management framework to reduce overall exposures to Pb in Trail are considered.

1.3 Regulatory Standards

The primary regulation that governs soil assessment and remediation for the EM Area is the BC CSR, which was enacted under the *Environmental Management Act* (EMA) (BC, 2023) on April 1, 1997, and has since been amended several times to account for updates to scientific and policy information.

The CSR outlines requirements for site identification, assessment, and clean-up ("remediation") under the administration of the BC ENV Site Remediation Program.

Under the CSR, a site is contaminated if substances in the environment (soil, water, sediment, vapour) exceed the standards prescribed in the CSR which may be adjusted to account for elevated local background concentrations if applicable. The CSR numerical soil standards are provided based on land use and as the land use in the EM Area is varied, standards for all land uses are applicable. To date, most of the assessment and remediation has been focussed on residential and other child-occupied properties since children are known to be most sensitive to the effects from Pb.

The CSR provides numerical and risk-based standards to determine when remediation is needed and satisfactorily completed. The legislation and regulation provide a framework for two remediation strategies. Contamination may be:

- Removed or reduced so that it no longer remains at a site above applicable numerical standards contained in the regulation (or ENV approved background concentrations); or
- Managed on site to satisfy risk-based standards.

Because of the large geographic area affected by historical aerial emissions, Teck, supported by the THEP, employs a risk-based approach for the purposes of identifying, prioritizing, and remediating residential properties in the EM Area. This Pb HHRA is one component of the WARP (AtkinsRéalis, 2024) for the EM Area which will be submitted to BC ENV in application for an Approval in Principle.

2. Project History and Timeline

Trail is the home of Teck Trail Operations, one of the largest integrated zinc and Pb smelting and refining complexes in the world. F.A. Heinze built the original foundry in 1895 and a railway to Rossland and Red Mountain in 1896 (likely powered by coal-fired steam engines until the mid-twentieth century). In 1906 the smelter, along with several of the Rossland mines and a small Pb-silver mine in the East Kootenay joined together to form the Consolidated Mining and Smelter Company of Canada Limited (CM&S or Cominco). In 1916, CM&S developed an electrolytic zinc method and began zinc production. In the 1920s CM&S expanded and increased the production of Pb and zinc, which brought a need for more workers at the smelter, increasing the local population. In the 1930s CM&S expanded again with the construction of a chemical fertilizer plant and an increase in zinc and Pb production (Trail Historical Society, 2019). In July 2001, Cominco merged with Teck Corporation, thus forming Teck Cominco Limited. The name changed to Teck Metals Ltd. in 2009.

Due to the presence of metallurgical operations in Trail for over a century, there is a long history of environmental and health monitoring related to metals. In 1977, the Trail Modernization Program was announced and since then over $1.7 billion has been invested to improve operational and environmental performance. The largest improvements were realized in the late 1990s through introduction of the KIVCET[8] smelter to improve efficiency and reduce emissions. Overall emissions to air and water have been reduced by over 99%. A summary of some of the major smelter operational improvements and management actions aimed at reducing emissions is presented in **Section 2.1**.

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

- The Interior Health Authority should continue blood Pb testing of children 6 to 36 months of age, continue counseling and services for families with children who have elevated, or risk of elevated BLL, and continue community and pre-school education programs about preventing and reducing exposure to Pb.
- Teck should pursue further reductions in facility emissions with increased reporting to the public on plans and progress, continue greening around the smelter property and in the community, continue environmental monitoring of air and street dust, continue addressing soil on a case-by-case basis, and implement a new program to advise and assist people that are 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.
- A Trail Area Health & Environment Committee (THEC) should be established to monitor, coordinate, and advise on the implementation of the Task Force's recommendations.

[8] KIVCET is a Russian acronym for the oxygen flash cyclone thermal process

Each of these recommendations was implemented. In 2001, the Task Force concluded, and its work continued through the creation of the THEP and the THEC. The THEC is a platform for multi-stakeholder dialogue, collective decision-making, and community engagement with respect to the THEP. **Figure 2-1** provides a summary of the partners that comprise THEC, and an understanding of the focus areas of THEC and the THEP.

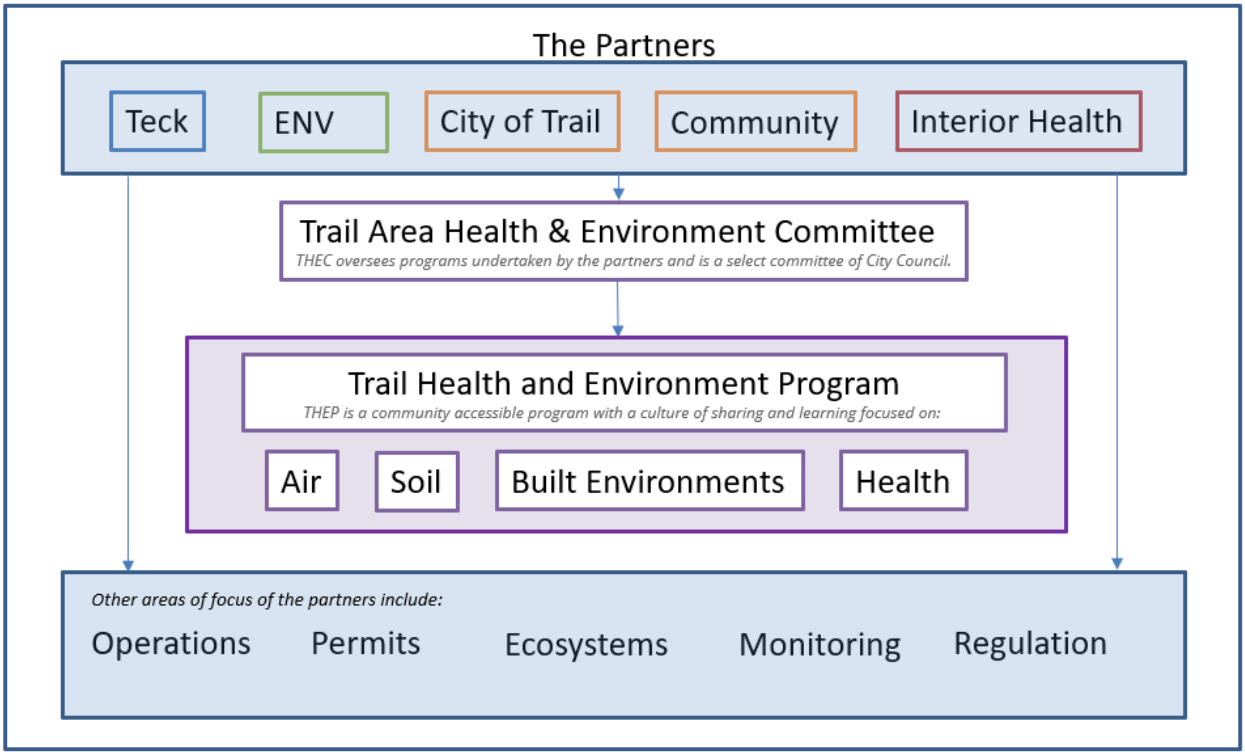

Figure 2-1: Structure and Focus of THEC and THEP

The THEP has evolved along with the emerging science and understanding of Pb exposures in the Trail area. The implementation of public health primary prevention programs (e.g., Family Health, Healthy Families Healthy Homes [HFHH]) targeted at young families have resulted in the lowest children's BLL ever documented in Trail. The comprehensive nature of the THEP includes the education of the community to understand and navigate ways to reduce exposure to Pb. The various programs under the THEP, including *Soil, Air, Health, Built Environment* (e.g., homes, daycares, civic buildings, etc.) and *Community Connection*, have existed for some time (although under various names and numerous sub-programs), as detailed in **Figure 2-2**. The timelines for some of the key programs related to reducing exposures to Pb include the following:

- In 2007 and 2008, Residential Soil Assessment and Remediation programs were formalized. The evolution and status of the Soil Assessment and Remediation program is detailed in **Section 4.1.1**.
- The Fugitive Dust Reduction Program (FDRP) began in 2012 and has achieved ongoing reductions in ambient air Pb through numerous initiatives to reduce dust generated on the smelter site. The FDRP is further described in **Section 2.1**.
- Primary prevention programs to promote health and support for families in Trail were initiated in 2013 through the HFHH Program. HFHH was further expanded to include the communities of Warfield and Annable in 2020. HFHH is described in **Section 2.3**.

Key milestones of the THEP between 1998 and 2022 are shown on the timeline in **Figure 2-2**. Many of the programs continue today and will be discussed throughout this report, with a summary of each of the existing programs presented below under Soil, Air, Health, Built Environment and Community Connection (**Sections 2.1** to **2.5**).

While the focus of the Pb HHRA is exposures and associated risks from Teck Trail Operations, it's not possible to evaluate smelter sources of Pb separately from other sources in the community. Given the age of the community and housing, there are non-smelter sources (e.g., Pb in indoor dust from Pb based paint) that cannot be partitioned from smelter related Pb in all media, and thus, exposures to these non-smelter sources are inherently included in the assessment.

The Pb HHRA and the proposed risk management measures included herein will focus on exposures from current contamination conditions associated with historical and contemporary releases from Teck Trail Operations. The remediation and risk management activities have and continue to play an important role in decreasing Pb exposure in Trail. Further, the integrated and comprehensive nature of the THEP has resulted in a reduction in Pb exposures from all sources, and significant reductions in childhood BLL.

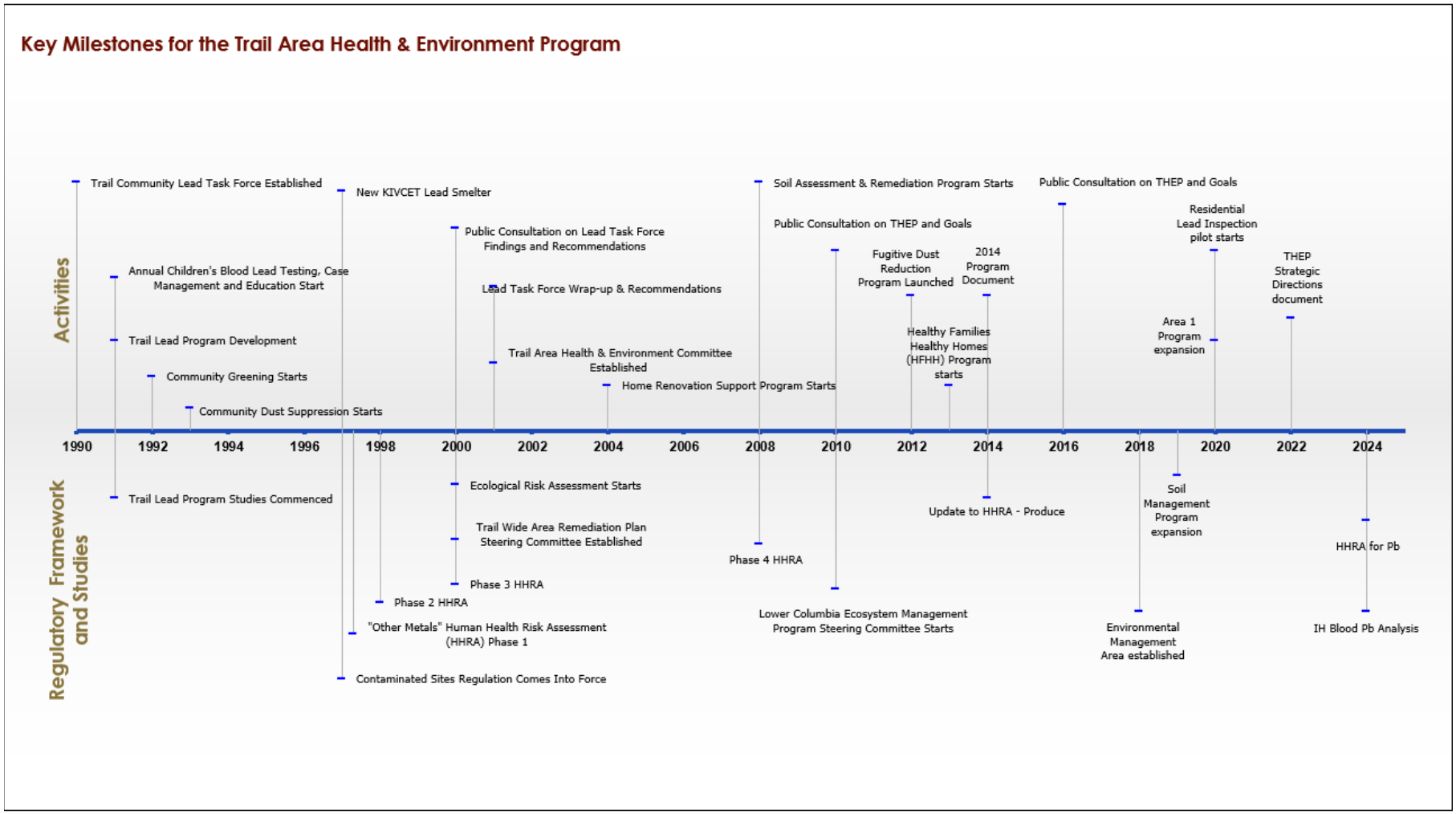

Figure 2-2: Key Milestones for the Trail Area Health and Environment Program (1990 to 2024)

2.1 Soil

Through the 1990s and early 2000s, soil assessment and remediation was completed at select properties by the Task Force. Efforts were focussed on residences where children were at the greatest risk of exposure to Pb in soil. During that time programs were in place to support property owners disposing of soil from their properties or developing land in Trail. The intention was to help limit young child exposure to Pb in soil and ensure proper soil management and disposal of soil impacted by metals. Soil management was not the primary focus of the Task Force as importance was put on reducing Pb in air through source reduction at the smelter. With Pb in air significantly reduced through the 1990s, the THEP began offering soil assessment to residential property owners in 2007. In 2008 THEP commenced a remediation pilot project to provide soil replacement on residential properties. Details of the pilot project and the prioritization of residential properties for soil replacement during the period of 2008 to 2019 are summarized below, along with information of the Soil Management Program (SMP) that was implemented in 2019.

2.1.1 Soil Management Program

In 2018, the EM Area[9] was defined for the Trail area (SNC-Lavalin 2018). The EM Area associated with Teck Trail Operations is based on concentration limits determined for arsenic, cadmium, Pb, and zinc in surficial soils attributable to historical aerial emissions from the Trail smelter. The EM Area boundary is shown in **Section 5**, **Figure 5-1**. In 2019 the SMP was created and to date has been focussed on residential properties within the THEP Areas 1, 2, and 3 (**Figure 5-1**) which include the neighbourhoods nearest the smelter and where the highest soil Pb concentrations have been measured. Commercial and industrial properties, as well as properties undergoing development, are part of the ongoing Property Development Program (PDP) for the EM Area.

2.1.1.1 Soil Assessment and Remediation

A standardized method for residential soil assessment began in 2007 and included yard soil assessment (grassed areas, bare soil and flower gardens) and vegetable garden soil assessment. This program was made available to Trail and Rivervale residents of THEP Areas 1, 2 and 3 on a voluntary basis to prevent and reduce health risks from exposure to metals that may be present in yard and garden soil. With an understanding of the highest potential risks from exposure to Pb, the following properties were prioritized for assessment:

- Expectant families, families[10] with children 36 months or younger, and families with children who have measured BLL above the Family Health case management thresholds;
- Residents requesting vegetable garden soil assessment; and
- Residents of city blocks in areas close to the smelter and where it was suspected that soil metal levels may exceed Remediation Action Levels (see below).

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

[10] Families include extended families, caregivers, and other situations such as daycares where children 36 months of age or younger are present on the property for a significant amount of time.

Remediation Action Levels (RAL) in 2007 corresponded to the Upper Cap Concentrations set out in the BC ENV's (formerly the BC Ministry of Environment) Protocol 11 (BC ENV, 2023c). For residential yards, the RAL in 2007 was 5,000 mg/kg Pb in soil which was lowered in February 2014 to 4,000 mg/kg and to 1,200 mg/kg in 2017 to reflect amendments to the CSR. For vegetable gardens, the RAL was 1,000 mg/kg.

A pilot project for soil replacement began in 2008 and was designed to manage risks related to soil on residential properties where concentrations of smelter metals were above RALs. The program was developed to focus on Pb, which was identified as the main health concern, and specifically for properties with young children and areas with bare soil. Residential yards and vegetable gardens were prioritized for remediation which included: soil replacement, improvement of ground cover and/or capping of bare soil areas.

From 2007 to 2018, residential properties qualified for soil replacement when Pb concentrations exceeded RALs. When Pb concentrations were less than the RALs, but young children were present and poor ground cover was observed, soil risk management in the form of capping and ground cover improvement work was offered.

In 2018, SNC-Lavalin developed an approach to identify the highest risk residential properties for remediation prioritization[11]. The objective of the prioritization strategy was to provide a scientifically defensible approach to identify and prioritize those properties for which remediation is most important, and therefore should occur soonest. The approach was based in part on the United States Department of Housing and Urban Development (US HUD) (2012) methods and focuses on three key attributes of a given property:

- Presence of children in target age groups: <6 years old (i.e., "young children") and 6 to <12 years old ("older children");
- Quality of ground cover (primarily grass but also gravel or mulch cover); and
- Soil Pb concentration.

Further details on the current risk-based prioritization approach are provided in the WARP (AtkinsRéalis, 2024).

In 2019, the regulatory requirement for an annual work plan led to the development of an annual SMP to outline tasks related to managing risks from soil within the EM Area such as outreach, communications, soil assessment, and remediation (i.e., by means of soil replacement or risk management activities), based on the 2018 prioritization approach. While soil assessment and remediation methods continued as they had since 2007 and 2008, respectively, the number of properties offered remediation increased significantly starting in 2019. The goals of the annual SMP are to identify and offer soil testing to all properties with children under 12 years of age, as well as remediate the highest priority properties through remediation measures within approximately 1 year[12] after they are identified.

Commercial, industrial, and agricultural properties within the EM Area are also part of the soil assessment and remediation programs. Typically, commercial and industrial property owners access soil management through the PDP described below in **Section 2.1.2**. A modified approach to soil assessment is used for agricultural properties, as described in **Section 4.1.3**.

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[11] As presented in the SNC-Lavalin report *Prioritization Strategy for Remediation of Lead (Pb) in Residential Soil of Trail, British Columbia*, April 1, 2019.

[12] The timing of remediation can be extended due to circumstances including property access, homeowner needs, season, etc.

As properties are sampled and remediated each year, the annual SMP is updated to address the next highest priority properties, including those newly identified high priority properties not addressed in the previous year, and to monitor conditions at properties where risk management measures are in place.

Further information on the soil assessment approach and results is provided in **Section 4**.

2.1.1.2 Other Soil Management

Soil management within the EM Area also includes support for properties that are not participating in the residential soil assessment and remediation programs. For example, owners moving small amounts of soil or doing landscaping or construction projects on their property often require soil management. At a minimum, soil testing is provided which then facilitates proper soil handling, determines potential re-use options, and ensures proper soil disposal is carried out.

2.1.2 Property Development

The PDP works with property owners, developers, and builders to support the assessment and, if required, risk-based remediation of metal contaminated soil within the EM Area. This program is offered to:

- Manage metal contaminated soils during the development or re-development of properties within the EM Area.
- Prevent unnecessary costs, delay or stigma for proponents of development in the Trail area.
- Support sustainable development by assisting with the investigation and risk-based remediation of metal contaminated soils.
- Facilitate safe excavation, handling, and disposal of excavated metal contaminated soil through testing and risk management.

2.2 Air

As noted, since the 1970s Teck has invested in a modernization program to improve operational and environmental performance at Teck Trail Operations. Emission reductions were identified as the most effective way to reduce children's BLLs and thus, efforts have focussed on this. Operational changes in the 1980s and 1990s significantly reduced stack and fugitive dust emissions (including arsenic, Pb, zinc and sulphur dioxide). Environmental improvements over the past 25 years include the following major investments:

- Stack Emissions Management: Since the replacement of Pb Smelter blast furnaces with the KIVCET Pb furnace in 1997 and subsequent operations improvement, there has been a 99.5% reduction in stack Pb emissions, and a 75% reduction in stack sulphur dioxide (SO_2) emissions. KIVCET has also had a significant carbon emissions benefit.
- FDRP: In recent years, major investments and operational improvements have been made to reduce fugitive dust including: construction of Smelter Recycle Building, close to the size of two Canadian football fields, in 2016 to enclose mixing and storage of process feed materials; installation of a ten-metre high wind fence reducing dusting where feed materials are mixed; installation of wheel washes and truck washes on site to help reduce tracking of materials onto roads; on-site street cleaning via street sweepers and water trucks; a year-round program of roadway sweeping and flushing; and, identification and reduction of fugitive dust sources from work activities inside operating plants.

- In addition, two new acid plants were constructed in 2014 and 2019, resulting in improved operational reliability and environmental performance.

These operational changes have resulted in a 95% reduction in Pb in community air since the 1990s. The decreases in total suspended particulate (TSP) Pb and particulate matter (PM) particles less than 10 µm in diameter (PM_{10}) Pb since 2010 are further discussed in **Section 4.2**.

2.2.1 Air Quality Program

The goal of the Air Quality Program is continuous improvement in air quality, which included achieving and surpassing the 2018 THEP targets for Pb and arsenic levels in community air. The 2018 THEP targets included:

- An objective for Pb based on the 30-day Ontario Ambient Air Quality Criterion (OMOE, 2007) of 0.2 µg/m^3 for Pb and its compounds. This value was the most current and stringent guideline in Canada when the objective was set, and remains the criterion in Ontario (OMOE, 2012).
- An objective for arsenic based on the annual average Alberta Ambient Air Quality Objective (Alberta, 2005) of 0.01 µg/m^3 (0.0033 ppb). This value was the most current and stringent guideline in Canada when the objective was set.

By the 2000s, stack emissions had been reduced to very low levels, and while ambient air Pb and BLLs had initially tracked the stack emissions declines (related to KIVCET and subsequent improvements) they then plateaued. During this time, the Geological Survey of Canada identified fugitive emissions as a contributor to Pb. The THEC and Teck identified the influence of fugitive emissions as the reason for the plateau in BLLs and in 2012, and Teck initiated the FDRP.

The Air Quality Program includes four main approaches:

- Implementing technology to reduce emissions;
- Finding and reducing fugitive emissions of dust from sources other than stack emissions;
- Optimizing performance of emissions control equipment; and
- Suppressing dust in the community.

Teck monitors emissions from the smelter through sampling at major point sources (e.g., stacks), and monitors air quality in the community through the following:

- Measures of total airborne dust (TSP), as well as particulate Pb, arsenic and other metals in the air are taken at two testing locations in the Trail area: Butler Park and Birchbank. Readings are taken over 24-hour periods, twice a day.
- Total respirable dust (PM_{10}) measurements are taken at four testing locations in the Trail area: Butler Park, Birchbank, Warfield, and Columbia Gardens. Readings are taken over 24-hour periods, every 6th day.
- Settled dust or dustfall measurements are taken at Birchbank, Downtown Trail, Columbia Avenue, Columbia Gardens, Tadanac, Trail Hospital, Glenmerry, Oasis, Stoney Creek, Waneta and Warfield. These are continuous samples analyzed monthly for total deposited particulate and metals.
- Sulphur dioxide (SO_2) gas is monitored at four locations throughout the valley at Birchbank, Butler Park, Columbia Gardens and Warfield. These stations operate continuously, with real-time data transmitted back to Teck Trail Operations' process control systems. If the SO_2 levels begin to climb (such as during a weather inversion), the plants are automatically notified so that actions can be taken to reduce SO_2 emissions.

- In 2010, Teck added a real-time metals analyzer for ambient dust at Butler Park. A second real-time monitor was installed at Duncan Flats in 2013. These analyzers are linked back to operations. This allows operations to directly and immediately respond to any unexpected increase in ambient metals concentrations.
- This information is collected and analyzed by Teck's environment staff, with results for Pb, arsenic and SO_2 reported to the BC ENV and the THEC. Regular monitoring helps identify significant emissions sources, track the effectiveness of emissions and dust control efforts, and track progress on air quality objectives.

Further, Teck and the City of Trail collaborate on mitigation of dust in the community by performing additional dust control measures on an ongoing basis consistent with the Task Force recommendations. This includes street flushing and sweepings to control dust throughout the year in Trail and Rivervale and application of dust suppressant to unpaved alleys each June.

2.3 Health

Interior Health has supported Pb monitoring, education, and prevention programs in the Trail area since the early 1990s. The overall goal of the Health Program is to reduce health risks from exposure to Pb and smelter metals in the community. More recently, the Health Program also looks at other impacts from the smelter including SO_2.

The Health Program not only looks at Pb exposure to children but also at the broader context of promoting children's healthy development and engaging the community in human health issues through the core services of voluntary blood Pb testing and education. Specific goals are:

- To prevent young children's and pregnant women's exposure to Pb.
- To inform the community, and particularly expectant families and families with young children, about potential health risks from exposure to Pb and other smelter metals.
- To engage the community, and particularly expectant families and families with young children, in addressing potential health risks.
- To help enhance the health and well-being of young children in the Trail area.

The Health Program uses a collaborative, relationship building approach wherever possible to encourage:

- Client (family) engagement, empowerment, and informed decision-making to promote children's healthy development and prevent Pb exposure.
- Parent/caregiver and community early childhood development service provider participation in the direction and governance of the THEP, and provision of advice on planning, program delivery, and continuous quality improvement.
- Collaborative education, engagement projects and activities with health, social service, and early learning providers.
- Seamless service provision to expectant families and families with young children by Interior Health Community Integrated Health Services, Promotion and Prevention.
- The work of multi-sectoral networks aimed at improving early childhood development outcomes in the Trail area, such as participation in The Greater Trail Early Years Table and the Family Action Network.

The Health Program is delivered by Interior Health Community Integrated Health Services, Promotion and Prevention. An Interior Health Public Health Registered Nurse (RN) delivers the program out of the Kiro Wellness Centre in Trail supported by management, a MHO, an epidemiologist, and Interior Health program supports such as communications, clerical, and laboratory services.

The Health Program includes the following components:

- Community Outreach: Family and Caregiver Education and Engagement, with education and engagement including presentations, distribution of information, educational events, handwashing displays, etc.
- Primary Prevention: Healthy Families Home Visits are offered to all families in Areas 1, 2 and 3 with a child 12 months of age or younger. The visits include education, advice, and provision of information to prevent Pb exposure, and referral to the Soil and Built Environment Program (i.e., for soil assessment and/or remediation). Educational information on topics including nutrition, handwashing, access to public health services for young children and families, early learning programs and effective measures to keep dust levels low in the home and yard. Referrals to other health or social services are also provided as needed. This program is described further in **Section 2.4.1**, below.
- Secondary Prevention: Voluntary blood Pb testing of children aged 6 - 36 months in Areas 1, 2 and 3 is the primary monitoring and evaluation methodology conducted twice a year to monitor progress in reaching THEC's goal to reduce children's Pb exposure and identify children and families requiring case management. An Interior Health MHO and epidemiologist reviews and confirms the results each year. The blood Pb testing clinics are also an opportunity for education and relationship building; Community Program Office (CPO) staff participates in the clinics as well as, on occasion, other public health and early learning professionals. The main clinic is the annual Fall Blood Pb Testing Clinic. It takes place over three weeks in September/October, after maximum summer exposure conditions. Parents of older children up to age 5 years living anywhere in Trail area may request testing and are welcome to attend. Children up to age 5 years who are new to the community or living in homes undergoing renovations or with recent renovations in the Trail area are encouraged to attend. A smaller clinic is held over 2 days in February for young babies that were not 6 months of age the previous Fall, and as follow-up for any children with elevated BLL results from the Fall clinic of the previous year.
- Case Management: Enhanced Support is offered to the families of children with BLLs elevated above the British Columbia Centre for Disease Control (BC CDC) Exposure Investigation Level of 5 µg/dL (or 0.24 µmol/L). Two in-home visits are offered, one by an Interior Health Public Health RN and one by the CPO Team to identify the most probable pathways by which the children may be exposed to Pb and determine the most appropriate support and follow-up actions. The Public Health RN visit includes a home visual review and assessment of possible sources of Pb exposure, as well as discussing the next steps for exposure reduction and retesting of BLLs. Ongoing support is offered to these families throughout the year on a case-by-case basis.

2.4 Built Environments

The built environments program looks at sources of Pb within home and other indoor environments. This includes many non-smelter sources of Pb such as paint and water that have the potential to be in homes, daycares and other places children visit. Dust in the built environment can contain Pb from historical smelter operations, as well as from deteriorating Pb-based paint. The built environment program looks at understanding and evaluating Pb sources, as well as communicating and supporting families and property owners to reduce exposure to Pb.

2.4.1 Healthy Homes

As introduced in the Health section above, the Healthy Homes component includes education, supports and actions to ensure a safe home environment for young children. Healthy Home visits are offered to expectant families, all families with children less than 36 months and new families to the area up to approximately 60 months of age. Education and information are available to everyone. The Health Homes program uses a holistic approach to home health and safety and is guided by information and best practices from various agencies including Health Canada, the US HUD, CDC, and US EPA. CPO staff meet with a family at their home to help them identify the best opportunities to prevent Pb exposure and keep their home healthy and safe. Visits are typically scheduled for a time when soil assessment results are available for the family's yard and include a visual review of the home and yard, a review of the soil assessment results (where available), education, information, and advice on home health and safety, as well as documentation and demonstration of exposure prevention strategies.

Educational topics include preventing health risks from Pb exposure, reducing dust in the home and yard, strategies for yard and garden improvement to prevent exposure, referrals to the Lead Safe Renovation Program and other home health topics, as appropriate. Visits end with a discussion of the family's top three opportunities to make a difference in reducing exposure to Pb. These opportunities are noted on the Healthy Families Healthy Homes poster that is left with the family.

Families may be offered a Dust Buster Kit, a Greening Your Garden Kit, a covered sandbox, a vacuum cleaner, yard remediation and/or home renovation supplies to support family actions to prevent Pb exposure.

A key part of education around Pb in built environments is the exposure pathways diagram as shown in **Section 5.4**, **Figure 5-4**.

2.4.2 Residential Lead Inspection and Pb-Based Paint Screening

To better support our understanding of Pb exposures within the built environment, starting in 2020, a residential lead inspection (RLI) pilot project has been carried out at select homes in the Trail area. The RLI includes an evaluation of indoor dust, water, paint, and soil, if not already tested through the residential soil assessment. The goal of the RLI is to educate families about various sources of Pb in the home and highlight the best opportunities to limit Pb exposure to their children (e.g., management of deteriorating paint, regular clean up of dust in entranceways, etc.).

Starting in 2023, indoor and outdoor paint screening is offered to participants of Health Program (including expectant families, families with children less than 36 months and new families to the area with children up to 60 months of age) and the outdoor paint screening will be offered to participants of the Soil Assessment and Remediation programs. The goal is to better understand the prevalence of Pb-based paint in the Trail area as due to the age of housing, and based on the available literature on Pb exposures, Pb-based paint has the potential to contribute significantly to Pb exposures in the Trail area.

2.4.3 Lead Safe Renovation

The Lead Safe Renovation (LSR) Program is another program that helps to achieve the goal of reducing overall exposures to Pb from built environments. The LSR Program was initiated in 2000 in response to the recommendations from the Task Force (Hilts et al., 2001) and has evolved overtime into a comprehensive program for Pb-safe work practices. Supports are provided to homeowners and tenants doing home renovation and construction projects in Trail and Rivervale. In areas outside Trail and Rivervale, including the communities of Fruitvale, Rossland and Genelle, these supports are available for homeowners and tenants renovating homes built prior to 1976 (after which time manufacturers were regulated to phase out Pb in paint). This is done to foster Pb paint awareness and Pb-safe home renovation in the broader community. Supports include advice and information on Pb dust generated during renovation and construction projects, and supplies provided free of charge (including HEPA-filtered shop vacuum loans) to prevent Pb exposure during renovations.

2.5 Community Connection

The THEP Office opened in 2008, and later became the official CPO in 2010. The CPO is located conveniently in downtown Trail. The location and existence of the CPO creates an accessible space for Trail area residents to connect with THEP staff and offerings. At the CPO, regular office hours are available for residents to come in to ask questions, sign up, or receive program supports and other general inquires. Project and field staff for the THEP work out of this office year-round.

Outreach and communication with the community is ongoing. There is a website (www.thep) that is kept up-to-date with information about programs and supports as well as committee meetings and reports. There are two community newsletters sent to families in the Trail area each year as well as radio advertisements promoting Pb-safe lifestyle choices, as well as information on programs. CPO staff attend outreach events throughout the year such as having a booth at the local farmers market and attending the local Teddy Bear's picnic for outreach to young children. Clear and transparent communication and connection to the community is an integral part of the THEP.

In addition, as part of the Family Health Program, the following is conducted:

- Community Collaboration to Enhance Early Childhood Development involves the Public Health RN participating in a variety of collaborative strategies to improve children's healthy development. These community collaborations occur throughout Greater Trail and surrounding rural areas.
- Community Outreach and Communications includes the Public Health RN prioritizing communication and collaboration between Interior Health and other sectors of the community, including responding to requests for presentations and participating in collaborations to achieve goals. The Family Health Program is emphasized in all of the THEP main communications strategies, including the community newsletter, website, radio ads, brochures, displays, events, and media releases.

3. Previous HHRAs

Following the Task Force studies and risk assessment of Pb in the 1990s (Hilts et al., 2001), and while biomonitoring was underway to monitor exposures to Pb in the Trail Area, during the period of 1997 to 2014, phased HHRAs were undertaken to evaluate risks associated with other metals from the smelter. The HHRAs were 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 cadmium and thallium in homegrown produce was conducted in 2014 (Environ, 2014).

The results of the HHRAs are summarized below. Recommendations based on results of HHRAs for other metals (besides Pb) included:

- Continued air monitoring for arsenic, cadmium, and particulate matter less than 10 µm diameter (PM_{10}), as well as Pb.
- Risk management measures to address this recommendation included continued air quality monitoring, ongoing improvements to air quality in Trail and the implementation of FDRP in 2012. Since there is strong correlation between Pb and other site-related metals, reductions in fugitive dust emissions, and remediation of Pb in soil reduce exposures not only to Pb but also to other metals, in particular arsenic.
- Given the reduction in emissions and the associated improvement in air quality in the Trail area, the results of the previous HHRAs, specifically arsenic inhalation exposures and associated risks, were reviewed in 2023. Ramboll (2023) conducted a review of air quality data for arsenic collected between 2010 and 2022, and revisited inhalation exposure and risk estimates. Ramboll (2023) concluded the following:
  - Air concentrations of arsenic have steadily declined over time and approach background levels for the region as of 2021-2022.
  - A review of inhalation TRVs for arsenic identified unit risk factors (URFs) that consider new epidemiological data that addresses limitations present in the original URF established by the US EPA in 1984.
  - Using the more recent URFs (Erraguntla et al., 2012 and Lewis et al., 2015) cancer risks were estimated to be less than the Health Canada negligible cancer risk level of 1 x 10^{-5} (which is equivalent to the BC CSR risk-based standard) for all years and locations since 2010.
  - Using URFs from the US EPA (1984) and WHO (2000), cancer risks are below 1 x 10^{-5} at all locations by 2022.

3.1 Phase 1: Problem Formulation

Phase 1 of the HHRA was conducted in 1997 (Exponent, 1997). The report was intended to review the work previously completed and make recommendations to the Task Force based on the findings of the review. The report made recommendations for additional data collection and addresses strategic elements (toxicity, HHRA methodologies and input parameters) for consideration in future HHRA.

The report includes the development of a HHRA Problem Formulation and includes discussion on potential inputs and sources of data for the completion of a HHRA. A review was conducted for previous documents that included land use maps, pathway screening analysis, conceptual site model development and contaminant of potential concern (COPC) screening. Human populations that were believed to have

the potential for exposure to metals in soils were determined to include residential populations in the City of Trail neighbourhoods, workers employed in commercial areas of East or West Trail, and farm workers in the outlying agricultural areas in the wider EM Area. The document screened available data and refined the COPC list to include antimony, arsenic, cadmium, mercury, selenium, thallium, tin, and zinc. These eight metals were identified as those requiring evaluation in the HHRA. It was noted that five of the metals (mercury, selenium, thallium, tin, and zinc) were exceeding human health-based criteria at select location(s) and that there may be a potential that only arsenic, cadmium and antimony would be retained as COPCs in future HHRA work.

3.2 Phase 2: Screening-Level Deterministic Risk Calculations

Phase 2 of the HHRA was conducted in 1998 (Exponent, 1998). This phase presents screening-level deterministic risk calculations for non-Pb parameters which evaluated exposures for residential and commercial scenarios via incidental ingestion of soil and dust and inhalation of ambient air. This phase also evaluated exposures via ingestion of soil and inhalation of particulates for an agricultural scenario.

As a part of Phase 2, *in vitro* bio accessibility testing was conducted for cadmium and arsenic in soils to determine estimates of relative bioavailability. In vitro testing indicated that the relative bioavailability of arsenic was 55% and cadmium was 33%[13]. Screening was completed on newly collected data for non-Pb parameters which resulted in COPC refinement to arsenic, cadmium, and antimony. The results of this phase indicated that the consumption of homegrown produce could not be ruled out as a significant contributor to exposure for these metals and recommended the collection of site-specific data. Soil and home-dust data was evaluated; however, a clear regression relationship could not be established for indoor and outdoor concentrations for the metals measured (antimony, arsenic, and cadmium) which was hypothesized to be due to the lack of data from metal sources other than soil.

The findings of the risk assessment indicated that all non-carcinogenic exposures were less than a hazard index (HI) of 1 with carcinogenic risk estimates for arsenic ranging above and below 1×10^{-5} and up to 3×10^{-4}. The carcinogenic risks were driven by arsenic inhalation exposures (9×10^{-7} to 2×10^{-4}). Inhalation exposures were primarily found to be due to the emissions from the active smelter rather than resuspension of contaminated soil by wind. The KIVCET smelter was installed one year prior to the assessment, and thus, it was recommended that emissions be monitored over time, and that the risk estimates be revisited.

The overall findings of the HHRA indicated that there was no imminent (short-term) threat to human health in Trail area from the non-Pb metals based on the results of the HHRA. The potential for adverse health effects from long term residence in Trail was concluded to be limited. Although risks related to arsenic were in excess of the CSR risk-based standard, it was noted that consideration should be given to the uncertainty in the prediction of cancer risks from arsenic in soil and the relatively low exposure levels observed in Trail compared to studies of populations exposed to higher arsenic levels in drinking water.

As indicated above, it was recommended that ongoing work be focussed on continued air monitoring for arsenic and cadmium.

[13] Health Canada no longer recommends the use of in-vitro bioaccessibility testing for cadmium. The results of the Phase 2 HHRA (Exponent, 1998) were reviewed to confirm that the results would not change when 100% absorption (vs. 33%) is assumed. With this change, the results remain below the BC CSR risk-based standards.

3.3 Phase 3: Revised Screening-Level Deterministic Risk Calculation

The Phase 3 HHRA, Exponent (2000), built on the findings of Phase 2 with refinement of risk estimates using newly collected site-specific data on the levels of arsenic and cadmium in produce grown in the area, COPC levels in indoor house dust and updated air concentrations for arsenic and cadmium.

The methodology used was consistent with that of Phase 2. The assessment included soil data collected from between 1989 to 1997, air data collected following the initiation of the KIVCET smelter, and garden produce collected between 1998 and 1999 from a total of 13 neighbourhoods and 14 local retailers. The HHRA assessed potential ingestion of soil, dust and homegrown produce and inhalation of airborne particulates.

Produce and house dust data were incorporated to refine the Phase 2 results. The risk assessment results indicated excess risks from arsenic; however, points of uncertainty associated with the estimation of these risks were documented based on contribution from background soil conditions, the likely overestimation of ingestion of homegrown produce (estimated to be 7%) of total produce ingestion and the conservatism used in the derivation of the carcinogenic TRVs. Risks from air emissions decreased compared to the Phase 2 assessment with the findings being attributed to the KIVCET smelter and it was expected that risks would continue to decrease as further operational measures to reduce emissions were implemented.

Based on the above, contribution of inhalation and ingestion risks to arsenic and cadmium were expected to be lower than predicted in the Phase 3 HHRA and it was recommended that emissions continue to be monitored (specifically for arsenic, cadmium, and Pb) with measurement of the PM_{10} fraction.

3.4 Phase 4: Additional Data Collection and Probabilistic Risk Calculations

Phase 4 of the HHRA was completed by Integral Consulting Inc. in 2008 (Integral, 2008). This phase included addressing data gaps identified by ENV comments from Phases 1 through 3, the consideration of the findings of the 2002 Trail urinary thallium survey and reporting risk estimates on a site wide basis to support a site wide remedial approach, in addition to reporting risk estimates for neighbourhoods that were anticipated to have the highest exposures (East Trail, Rivervale, Tadanac, Waneta, and West Trail).

This phase of the HHRA assessed four scenarios, a residential scenario, a commercial and agricultural scenario, recreational all terrain vehicle (ATV)/bike scenario and a fish consumption scenario. Where applicable, risk pathways evaluated included ingestion of indoor dust, ingestion of soil, ingestion of outdoor dust, and ingestion of country foods. Risk estimates from these pathways were summed for an overall risk estimate. For the inhalation pathway, risks from ambient air inhalation were determined separately with risk estimates added to ingestion risks for neighbourhoods containing an air monitoring station. Fish consumption risks and risks from recreational uses (ATV/biking) were assessed separately from other pathways. The recreational scenario assessed exposures from beach sand and sediment, air, dust, and surface soil present in an area of known off-road recreation along the Columbia River.

Under the residential scenario, non-carcinogenic risks for thallium (via soil, dust, and homegrown produce) for a child receptor exceeded a HI of 1.0 (East Trail, Rivervale, Tadanac and West Trail neighbourhoods) while arsenic exposures (combined child plus adult receptor) exceeded a HI of 1.0 for the Tadanac neighbourhood. For carcinogenic exposures, both neighbourhood and site wide risk

estimates (95th percentile) exceeded 1 in 100,000 (the CSR risk-based standard). Risks were driven by arsenic exposures. It was noted by Integral that none of the 95th percentile risk estimates exceeded 1 in 10,000, the risk level that corresponded to the US EPA response action at the time[14].

Non-carcinogenic risks were below target risk levels for the commercial and agricultural exposure scenarios (antimony and cadmium exposures). Carcinogenic risks were limited to the inhalation route as carcinogenic COPCs were limited to those that are carcinogenic via the inhalation route of exposure. Risks in excess of 1 in 100,000 were predicted (based on the 95th percentile risk estimates) at all three air monitoring stations assessed. Risks for the commercial and agricultural scenario were below those predicted for the residential scenario.

Risks for off-road vehicle uses (ATV/bike user) due to soil exposures were found to be acceptable (below a HI of one) with no carcinogenic COPCs identified for this scenario.

Fish consumption risks in excess of an HQ of 1 were identified for mercury (based on the 95th percentile of risk estimates) and for cadmium, with risks being driven by a single suspect cadmium concentration. Non-carcinogenic risks were below an HQ of 1 for arsenic, selenium, thallium, and vanadium. While carcinogenic risks were considered acceptable (below 1 in 100,000) for average consumption of local fish, exceedances were predicted for mountain whitefish and rainbow trout. Integral noted conservatism in the estimation of the consumption patterns assumed in the assessment.

Concentrations of metals in fish tissues were further characterized as part of the Aquatic Effects Monitoring Program (AEMP). The results reported in the 2021 AEMP (Kelly et al., 2023) indicated that concentrations of most metals in large-bodied fish tissues had declined since 2000 and were below human health consumption guidelines, including for mercury. It is noted that while there is no human health consumption guideline for cadmium in fish, the 2021 cadmium tissue results from large-bodied fish were all below the Lower Columbia Tissue Residue Objective for wildlife (0.9 mg Cd/kg wet weight) and were lower than those measured in 2000.

3.5 Evaluation of Trail Homegrown Produce Consumption

In 2014, Environ conducted pathway specific risk assessment for potential risks associated with cadmium and thallium in homegrown garden produce in Trail (Environ, 2014). The objective of the evaluation was to update the produce ingestion risk estimates from Phase 4 for cadmium and thallium based on refined consumption rates for a variety of produce types and re-evaluate the contribution of the produce consumption pathway to overall risk estimates for each of these parameters. Risks were compared from remediated and un-remediated gardens as a part of the evaluation.

The findings of the report indicated that risks for ingestion and overall exposures using the refined produce ingestion findings were below the CSR risk-based standards; however, when the smoking of cigarettes was considered, cadmium risks exceeded targets. Recommendations of the report included continuing to remediate soil in gardens with Pb concentrations above 1,000 mg/kg and cadmium concentrations above 30 mg/kg through the THEP. Environ noted that concentrations (including those of cadmium and thallium) are expected to reduce over time with measures from the Trail Operations FDRP.

[14] Health Canada (2021) defines a 1 x 10^{-5} (or 1 in 100,000) cancer risks as negligible risk.

4. Soil Assessment Approach and Soil, Dust and Air Results

The soil assessment approach is summarized in **Section 4.1**, with the soil Pb results discussed in **Section 4.2.1**. In addition, the results of a 2016 Dust Study, as well as dustfall data collected in Trail over the last 20 years are presented in **Section 4.2.2**, with the results of air monitoring presented in **Section 4.2.3**

4.1 Soil Assessment Approach

The soil assessment approach for each land use is briefly described in the subsections below. In the case of City boulevards (i.e., grassy areas adjacent roadways and sidewalks), they are classified and managed according to the land use of the adjacent parcel (e.g., boulevards adjacent residential properties are assessed using the approach for residential lands).

Soil assessment has been conducted to characterize worst-case Pb concentrations within the EM Area, and thus has generally focussed on surface soil, and specifically the top 15 cm of the soil profile. Rationale for this focus includes the following:

- Historical and contemporary aerial and fugitive dust emissions from the smelter are the source of the Pb contamination. As Pb enters soil at surface, shallower soils have higher concentrations of contamination than deeper soils. As Pb is typically immobilized by the organic component of soil, Pb deposited from the air is generally retained in the upper 2-5 cm of undisturbed soil (CDC, 1992). Further, because soil development from annual organic matter input is a slow process, shallow soils are expected to reflect inputs from these aerial sources.
- The available soil data indicates that in undisturbed soils, higher Pb concentrations are present in the most surficial soils.
    - A 1990 study (Hilts et al., 2001) demonstrated that Pb concentrations were highest in the top 2 cm of soil.
    - In 2015, SNC-Lavalin conducted a soil profile analysis that demonstrated that the highest concentrations of Pb were in the top 15 cm of soil, relative to deeper fractions (15 cm - 30 cm, 50-65 cm, 85 cm to 1 m). The results of the soil profile analysis for Pb are presented in **Figure 4-1**.

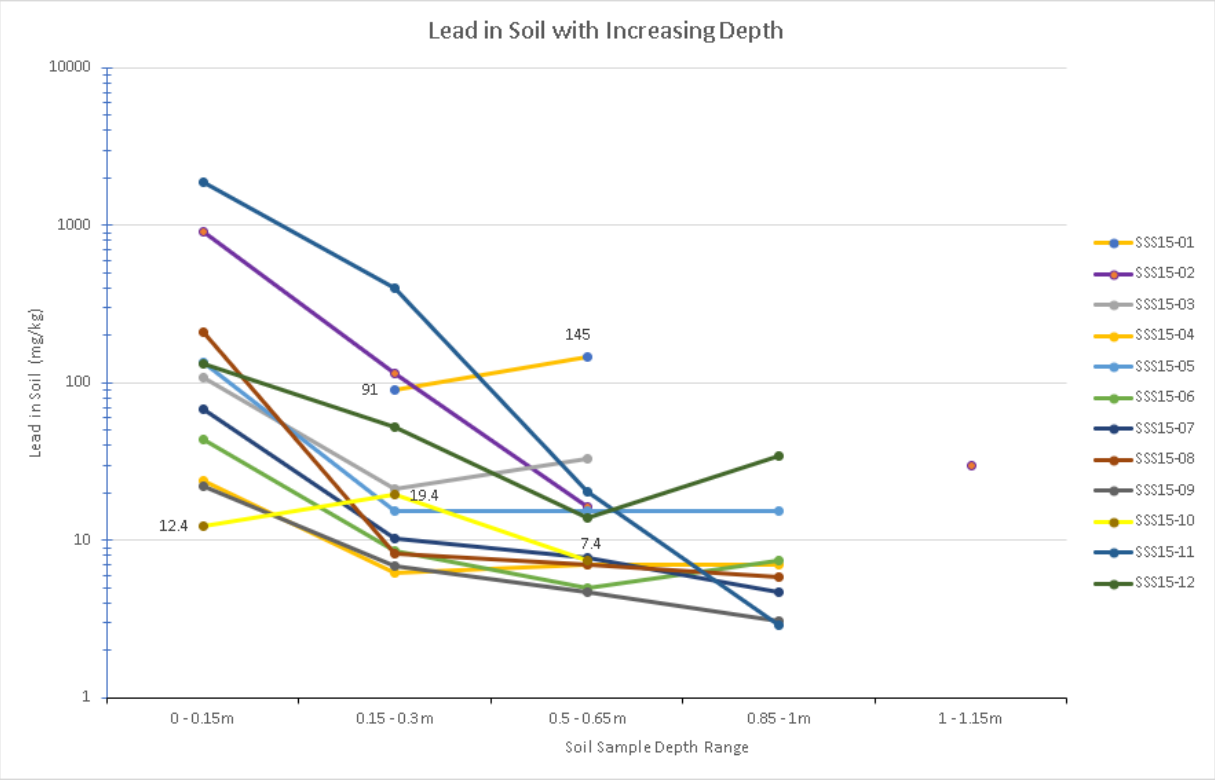


Figure 4-1: 2015 Soil Profile Analysis for Pb

It is widely accepted that human exposures to undisturbed soils is limited to surficial soils. US EPA (2014) indicates that human exposure is typically to the top couple of inches (assumed to be 2-3 inches, or approximately 5-8 cm), and indicates that when metals are a concern that soil samples for use in human health risk assessment exposure assessment should be collected from the top 3-4 inches (or approximately 8 cm - 10 cm). While there is the potential for exposure to deeper soils during activities that disturb soils (e.g., yard maintenance and gardening, construction), children are less likely to undertake these activities and given the community outreach and education programs offered in Trail, it is anticipated that homeowners undertaking these activities will contact the THEP Office.

4.1.1 Residential Land

As noted, the soil assessment approach for residential properties focusses on surface soil (i.e., top 15 cm), which is the most accessible to residents. The soil assessment methods were formalized in 2007 and 2008 based on a review of the literature and programs developed elsewhere to assess Pb contamination and to reduce Pb exposures. At that time, programs were put in place to offer soil testing to residents on a voluntary basis (e.g., not only to properties with young children identified through the blood Pb clinics). In 2019, the SMP was developed with the goal to identify properties where Pb exposures represented the highest risk. The 2019 SMP methods for the assessment of residential and daycare properties include:

- Yard sample collection targeting soil in the top 15 cm across the yard and key areas that pose potential exposure risks to residents (e.g., play areas, gardens, bare soil areas, etc.);
- Flower and vegetable garden composite sample collection;
- Ground Cover Evaluation (GCE) to assess exposure risk; and

- Calculation of property 95% upper confidence limit of the mean Pb concentrations (95% UCLM) and maximum Pb concentrations (Max Pb).

Vertical delineation is not addressed on individual residential properties during initial soil assessment to determine soil remediation priority. The depth of metals present on the property is assessed and remediated during subsequent work phases on the property (e.g., soil replacement) and has been investigated on a neighbourhood scale, not at each individual property.

4.1.2 Urban Parks

The procedures for the soil assessment of parks, greenspaces, and playgrounds follows the same general approach for sampling on residential yards with some modifications:

- Wider spacing in park and greenspace areas to account for the large area;
- Focussed sampling of playgrounds and areas where young children would be likely to return day after day (e.g., sandboxes, picnic tables, play equipment); and
- Includes GCE of all areas of the park and summarizes groundcover into two categories, greenspace, and primary play areas.

4.1.3 Agricultural Land

A modified soil assessment approach has been developed for large agricultural properties. It includes a combination of the methods used on residential land and urban parks. To summarize, the approach:

- Divides the property into areas of primary interest based on exposure risk (gardens, residences, barns, play areas, etc.) and secondary areas (crops, fields, woodland, etc.);
- Areas of primary interest follow the procedures as residential sampling; and
- Secondary areas follow the procedures for park and greenspace sampling.

4.1.4 Commercial and Industrial Lands

The approach to assess soil Pb (and other metals) on commercial properties is typically through the PDP. The PDP follows the CSR process where the assessment and remediation of commercial and industrial properties is triggered by soil disturbance, re-development, or change in use, which provides an opportunity for risk--based remediation. Each development is unique and site-specific risk-based soil assessment and remediation plans are created based on future land use. Management of non-smelter related contaminants, if present, is the responsibility of the property owner / project proponent.

4.2 Assessment Results

Soil assessments have been conducted since 2007, with a focus on residential properties and daycares, as well as parks, school yards and playgrounds. As on the January 2024, 2,251 properties have been assessed; Of those properties, (an estimated) 780 properties have received soil removal and/or risk management. All Priority 1 (P1) properties identified up to 2024 through the Prioritization Approach have had soil removed and/or have received risk management (e.g., ground cover improvement). A summary of these properties is included in **Table 5**, with details on the number of properties that received remediation or risk management each year since 2019 included below in **Table 4-1**. The number of properties that received GCEs each year are also included. GCEs are required to help identify highest priority properties for remediation and to confirm risk management measures remain in place, where applicable.

Table 4-1: Summary of SMP Activities by Year

Year	Remediation and Risk Management Activities
2019	▪ GCEs were completed at 517 residential properties and 40 Parks. ▪ Remediation or risk management work was completed on 204 properties in 2019, including: ▫ 84 properties received full-yard soil replacement (25 properties included vegetable garden remediation). ▫ 7 properties received partial soil replacement. ▫ 6 vegetable garden remediations were completed. ▫ 96 properties received lawn care to improve and maintain good ground cover. ▫ 11 properties received other ground cover improvements.
2020	▪ GCEs were completed at 332 residential properties. 172 of these were follow-ups from 2019 evaluation. ▪ Remediation or risk management work was completed on 150 properties in 2020 including: ▫ 66 properties received full-yard soil replacement (64 P1). ▫ 5 P1 properties received partial yard remediation. ▫ 5 properties had vegetable garden remediation completed. - another 14 vegetable gardens were remediated with the full yard. ▫ 73 properties received lawn care to improve and maintain good ground cover. - 22 of these properties received lawn care in the spring prior to full remediation later in the year. ▫ 23 properties received other types of ground cover improvement.
2021	▪ GCEs were completed at 375 residential properties. 168 of these were follow-up from previous evaluation. ▪ Remediation or risk management work was completed on 138 properties in 2021 including: ▫ 61 properties received full-yard soil replacement (54 P1). ▫ 5 properties received partial yard remediation. ▫ 4 properties had vegetable garden remediation completed. - Another 21 vegetable gardens were remediated with the full or partial yard. ▫ 54 properties received lawn care to improve and maintain good ground cover: - 12 of these properties received lawn care in the spring prior to full remediation later in the year. ▫ 26 properties received other types of ground cover improvement.
2022	▪ GCE were completed at 259 residential properties. 98 of these were follow-up to evaluate current ground cover at yards assessed in previous years. ▪ Remediation or risk management work was completed on 112 properties in 2022 including: ▫ 76 properties received full-yard soil replacement (54 P1). ▫ 4 properties received partial yard remediation. ▫ 2 properties had vegetable garden remediation completed. - Another 10 vegetable gardens were remediated with the full or partial yard. ▫ 9 properties received lawn care to improve and maintain good ground cover. - Some of these properties received lawn care as follow-up from full-yard remediation in 2021. ▫ 21 properties received other types of ground cover improvement.
2023	▪ GCEs were completed at 203 residential properties. 71 of these were follow-up to evaluate current ground cover at yards assessed in previous years. ▪ Remediation or risk management work was completed on 120 properties in 2023 including: ▫ 86 properties received full-yard soil replacement (29 Priority 1). ▫ 1 property received partial yard remediation. ▫ 3 properties had vegetable garden only remediations completed. - Another 21 vegetable gardens were remediated with the full or partial yard. ▫ 16 properties received only lawn care to improve and maintain good ground cover. ▫ 14 properties received other types of ground cover improvement.

As of January 2024, a total of 2,251 parcels within the EM Area have had their soil tested, with a total of 483 properties having had full soil replacement completed and over 300 properties have been risk-managed through yard improvement strategies (e.g., lawn care and ground cover improvements, etc.).

Soil assessment results from residential properties and daycares, parks and school yards are summarized in **Section 4.2.1** and are presented in tables and drawings. The tables referred to herein are included as an excel file. They compile soil summary data for residential properties and other properties used frequently by children collected between 2007 and 2023. A compilation of drawings is provided to visually present the distribution of properties sampled and the 95% upper confidence limit of the mean Pb concentrations (95 UCLM) in surface soil (i.e., top 15 cm) across neighbourhoods in the Trail area.

While soil assessment has focussed on residential properties, the existing dataset allows for a comprehensive understanding of the distribution of Pb concentrations in surface soils across neighbourhoods and the overall EM Area, and thus, provides a good understanding of Pb concentrations on properties of all land uses (e.g., agricultural [AL], commercial [CL] and industrial [IL]).

The available dust and air data are also included in **Sections 4.2.2** and **4.2.3**. Groundwater data has not been included as previous studies have demonstrated that where groundwater impacts are found in the EM Area, there is no spatial trend consistent with soil impacts from historical aerial emissions. Groundwater continues to be monitored by Teck in areas of potential environmental concern.

4.2.1 Soil

4.2.1.1 Residential Land and Urban Parks

The soil assessment and remediation data collected to date is summarized in **Tables 1** to **6**, which are included as an excel file. These tables include the following information:

- Property information (neighbourhood, child occupancy, etc.);
- Soil assessment results and Pb concentrations;
- Results of the most recent GCE;
- Priority Status for the property;
- Remediation work completed on the property;
- Outstanding actions to be carried out on the property; and
- Dates/year work was completed.

Using the filters in **Table 1**, the user can obtain different summaries of up-to-date data. For example, filtering by the SA (Soil Assessment) Date or Rem (Remediation) Date by the year of interest will provide a list of all properties that received soil assessment or remediation services in the specified year. By further filtering by neighbourhood, one can then obtain a list of all properties within a given neighbourhood that received soil management program services. **Tables 2** to **4** include summaries of the 2023 work including family and child-occupied property information, soil assessment and ground cover evaluation, and remediation activities, respectively. **Table 5** summarizes the priorities for 2024 remediation planning and **Table 6** presents the P2 properties, some of which will be considered for remediation in 2024.

- Map Book 1 presents information from **Table 1** (all assessed properties) with the most up-to-date yard 95% UCLM soil Pb concentrations calculated using 10 or more discrete surface soil samples collected from the top 15 cm during soil assessment. Hatched properties indicate that the yard has been remediated and, in those cases, the soil Pb concentration of the backfill is shown on the drawings to show surface soil concentrations currently present on the property.
- Map Book 2 presents the properties that have received soil replacement and displays the associated 95% UCLM soil Pb concentration from the excavation base, below the geotextile demarcation fabric. The backfill materials and landscape features are placed above the demarcation fabric following excavation. Soil results collected from the newly placed backfill are presented in **Table 4** by filtering for “Year” and “Post Rem Pb”.

Table 4-2 presents summary statistics for the soil assessment results collected to 2023 for residential properties, daycares, parks and school yards, based on THEP Areas (see **Figure 5-1**), as well as the Trail area neighbourhoods.

Table 4-2: Summary Statistics for Surface Soil Pb in Residential/Urban Park Areas by Neighbourhood

THEP Assessment Area	Neighbourhood	Total # of properties	N* (# of samples)	95% UCLM Pb (mg/kg)	90th Percentile Pb (mg/kg)	Mean Pb (mg/kg)	SD (mg/kg)	Max Pb (mg/kg)	Min Pb (mg/kg)	Median Pb (mg/kg)
0	Birchbank	1	20	415.6	576.4	296.8	239.2	965	55	247
0	Blueberry Creek	1	11	583.2	714	469.1	208.8	762	196	502
0	Genelle	2	20	198.9	285.4	157.5	107.2	452	13	136
0	Montrose	12	179	93.6	156.6	84.4	96.3	825	6	59
1	Annable	42	502	347.4	543.7	308.3	200.7	2420	1.4	275.5
1	Casino	5	53	367.6	517.8	169.9	330.2	1700	8.4	50.8
1	Columbia Gardens	3	38	397.8	320.5	212.4	262.2	1480	10	141.5
1	Oasis	12	139	422.4	735.2	383.8	281.5	2130	15	330
1	Waneta	28	353	281.5	538	260.2	250.5	2050	0.3	194
1	Warfield	145	1825	222.8	382.6	205.5	170.4	2020	0.05	164
2	Glenmerry	304	3722	487.3	887.9	461.2	364.9	3390	0.3	365
2	Miral Heights	26	326	120.2	214	106.9	88.12	745	3.8	85.8
2	Shavers Bench	147	1790	803.1	1453.2	747	543.7	4200	0.4	634
2	Sunningdale	136	1988	458.7	763.6	431.7	275.5	3400	0.3	395
3	East Trail	655	7511	1644	3291	1575	1376	24652	0.09	1220
3	Rivervale	42	545	610.4	1148.2	550.2	687.4	9920	2.1	363
3	Tadanac	64	1087	1754	3257.2	1535	1660	19500	0.3	1164
3	West Trail	469	5185	934.6	1637.4	897	622.3	6330	0.2	784

Note:

N*	number of discrete surface soil samples collected from the top 15 cm during soil assessment across all properties investigated in the neighbourhood
95% UCLM	95 percent upper confidence limit of the mean soil Pb concentration
mg/kg	milligrams per kilogram, or parts per million (ppm)
SD	standard deviation

As noted, the number of properties samples in select neighbourhoods, and specifically Blueberry Creek (N=1), Birchbank (N=1) and Genelle (N=2), were limited. Given the distance of these areas from the smelter, it is anticipated that soil Pb concentrations at the neighbourhood level would be lower than those in neighbourhoods proximate the smelter. Despite this, based on the limited data set and the results to date that suggest the potential for elevated Pb concentrations, specifically in Blueberry Creek, further sampling is recommended.

4.2.1.2 Other Land Uses

As discussed, the current Pb soil dataset for residential properties provides a comprehensive understanding of the distribution of Pb surface soil concentrations across all land uses.

4.2.2 Dust

A summary of the results of a dust study conducted in 2016 and compared to the results of a study conducted in the 1990s, as well as mean, annual dustfall loadings measured in Trail since 2003, are presented in the following sections.

4.2.2.1 Dust Studies

A dust study was conducted in 2016 to re-assess dust levels in Trail after the operation of the KIVCET smelter for 18 years, and 4 years following the initiation of the FDRP. The study included the collection of dust samples from 63 homes in the Trail area (including East Trail, Rivervale, Tadanac, West Trail, Glenmerry, Shaver's Bench and Sunningdale). The locations of the homes sampled are presented on

. Dust samples were collected from a dust mat placed at the main entrance to the home, a dustfall jar in one of the primary living spaces and a dustfall jar in the yard of the home. The samples were collected over a 4-week period. Participants were instructed not to vacuum or shake out the mats or disturb the dust jars during this period. The results of the study, including for indoor and outdoor dustfall (IDF and ODF), are summarized in **Table 4-3** to **Table 4-5**. **Table 4-6** compares the 2016 results to dust data collected in the 1990s from 35 homes in Trail (i.e., the Sentinel homes). The data were collected from the Sentinel homes during the period of 1994-1996, prior to the new KIVCET smelter, and from 1997-1998, after the KIVCET smelter was operational.

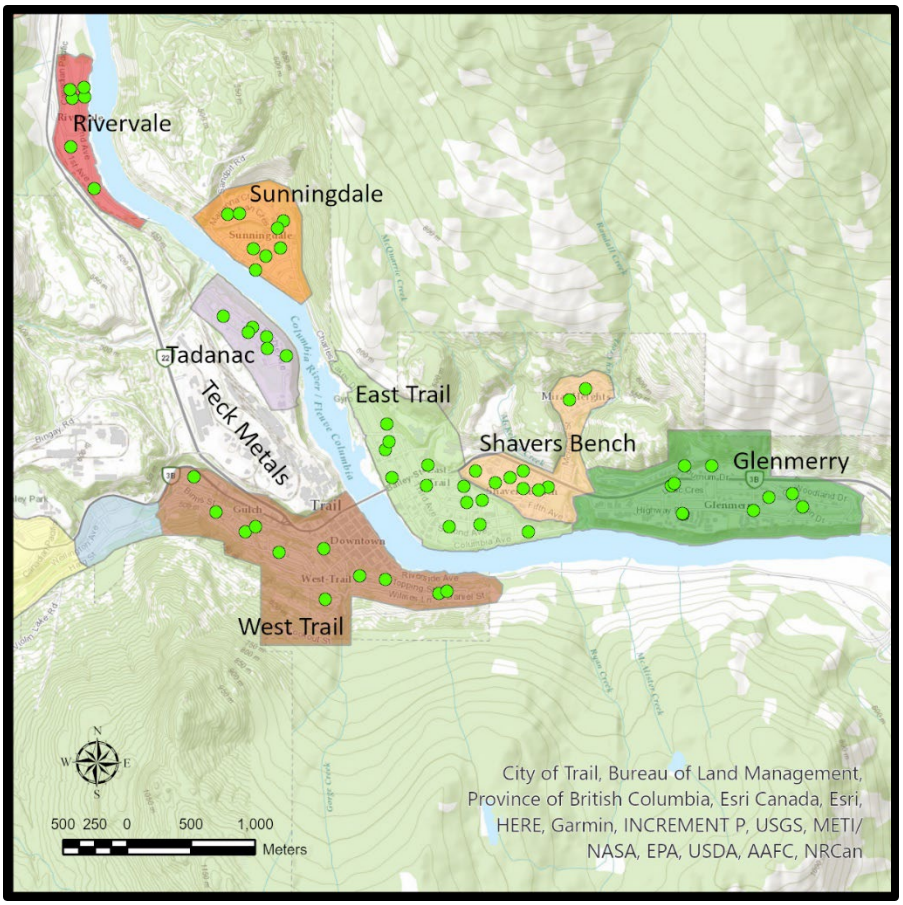


Figure 4-2: 2016 Dust Study Sampling Locations

Table 4-3: 2016 Dust Study Summary Findings for Dust Mats

	Total Mat Dust Weight (mg)	Mat Dust Loading Rate (mg/dm^2/day)	Concentration of Pb in Mat Dust (mg/kg)	Mat Pb Loading Rate (mg Pb/dm^2/day)	Total Mat Pb Weight (mg)
N	62				
Min	910	1.3	39	0.00007	0.0542
Max	105,890	139.38	2,500	0.0445	35.03
Mean ± SEM	6623 ± 1803	8.48 ± 2.36	502 ± 60	0.0042 ± 0.0010	3.293 ± 0.778
Median	3,260	4.2	340	0.0018	1.545
Geometric Mean	3241[a]	4.17[a]	361	0.0019	1.362
Marginal Distribution	Lognormal p>0.15	Lognormal p=0.1287	Lognormal p>0.15	Lognormal p>0.15	Lognormal p>0.15

Notes:

SEM	standard error of the mean
mg	milligrams
mg/dm^2/day	milligrams per square decimeter per day
mg/kg	milligrams per kilogram or parts per million (ppm)
mg Pb/dm^2/day	milligrams Pb per square decimeter per day

[a] excludes 3 outliers

Table 4-4: 2016 Dust Study Summary Findings for Indoor Dustfall

	IDF Total Dust Weight (mg)	IDF Loading Rate ($mg/dm^2/day$)	Concentration of Pb in IDF Dust (mg/kg)	IDF Pb Loading Rate ($mg\ Pb/dm^2/day$)
N	63			
Min	5	0.29	47	0.000014
Max	82.7	2.9	2,665	0.01
Mean ± SEM	16.8 ± 1.3	0.73 ± 0.05	448 ± 49	0.0005
Median	14.8	0.68	414	0.0003
Geometric Mean	16.78	0.642	340	0.0002
Marginal Distribution	Normal[a] p=0.2079	Normal[a] p=0.7086	Normal[b] p=0.1058	Bi-modal

Notes:

IDF	Indoor dustfall
SEM	standard error of the mean
mg	milligrams
$mg/dm^2/day$	milligrams per square decimeter per day
mg/kg	milligrams per kilogram or parts per million (ppm)
$mg\ Pb/dm^2/day$	milligrams Pb per square decimeter per day

[a] excludes 3 outliers
[b] excludes 2 outliers

Table 4-5: 2016 Dust Study Summary Findings for Outdoor Dustfall

	ODF Total Dust Weight (mg)	ODF Loading Rate ($mg/dm^2/day$)	Concentration of Pb in ODF Dust (mg/kg)	ODF Pb Loading Rate ($mg\ Pb/dm^2/day$)
N	60[a]			
Min	2.3	0.15	37	0.000049
Max	192	8.4	21,304	0.007
Mean	33.2 ± 3.7	1.47 ± 0.15	2,566 ± 373	0.003 ± 0.0002
Median	25.2	1.2	2,107	0.003
Geometric Mean	22.8	1.08	1,744	0.002
Marginal Distribution	Normal[b] p = 0.4436	None	None	None

Notes:

ODF	Outdoor dustfall
mg	milligrams
$mg/dm^2/day$	milligrams per square decimeter per day
mg/kg	milligrams per kilogram or parts per million (ppm)
$mg\ Pb/dm^2/day$	milligrams Pb per square decimeter per day

[a] 3 of the original jars were not recovered as 2 jars were missing and 1 jar was filled with nuts
[b] excludes 8 outliers

It is noted that the mean ODF rate is approximately two times the mean IDF rate, with the mean Pb concentration in outdoor dust and the ODF Pb loading rate (which is dependent on the total amount of dust collected, and the concentration of Pb in the dust) approximately six times the Pb concentration and loading rate in indoor dust. It is also noted that the ODF results are biased high by a ODF dust sample with a maximum concentration of Pb in dust of 21,304 mg/kg. The second highest Pb concentration in ODF dust is 6,604 mg/kg. While the source of the high Pb concentration at this location is unknown, the maximum concentration was measured at a home where the dustfall jar was attached to a pole used for the home's clothesline. While the pole itself was not tested for Pb based paints, the exterior paint on the house (which was the same colour as the pole) tested positive for Pb based paint. The home is located approximately 1 km from Butler Park, just south of Gyro Park in the East Trail North. This area typically has lower soil and dust concentrations than some of the other areas such as East Trail South and Tadanac and thus, it is likely that other sources, in addition to the smelter, contributed to the measured Pb concentration.

Table 4-6: Comparison of 2016 Dust Study Data to 1990s Dust Data for Sentinel Homes

Data Set	Mat Dust Load	Mat [Pb]	Mat Pb Load	IDF Dust Load	IDF [Pb]	IDF Pb Load	ODF Dust Load	ODF [Pb]	ODF Pb Load
	mg/dm^2/day	mg/kg	mg/dm^2/day	mg/dm^2/day	mg/kg	mg/dm^2/day	mg/dm^2/day	mg/kg	mg/dm^2/day
Sentinel Homes 94-96 Pre-KIVCET	4.88	753	0.00368	--	1,230	0.0005	--	21,235	0.1667
Sentinel Homes 97/98 Post-KIVCET	--	--	--	--	693	0.0002	--	11,528	0.093
2016 Dust study data	4.75	361	0.00175	0.6740	341	0.0002	1.211	1,745	0.0022

Notes:

[Pb]	Pb concentration
IDF	Indoor dustfall
ODF	Outdoor dustfall
mg/dm^2/day	milligrams per square decimeter per day
mg/kg	milligrams per kilogram or parts per million (ppm)
--	data not available

As presented in **Table 4-6**, a comparison to data from before the KIVCET smelter upgrade indicates Pb concentrations in front entrances in 2016 were approximately half of what they were in the 1990s. The mat Pb loading per day had also decreased by approximately 50%. For indoor dust, the dust loading was approximately the same, but the Pb concentration was again reduced by approximately half. The outdoor dust loading was significantly lower, and dust Pb concentration was an order of magnitude less than it was in the 1990s. As shown in the table, notable differences were observed following the implementation of the KIVCET smelter, with further reductions observed in the 2016 study considered attributable to further operational improvements and the implementation of the FDRP in 2012.

A review of the soil Pb concentrations at the properties, compared to the Pb concentrations in indoor dust indicated that there is no correlation (i.e., insignificant regression) as demonstrated in **Figure 4-3**; however, as presented in **Figure 4-4**, a comparison of soil Pb concentration to Pb concentrations measured in front door mats indicated a correlation.

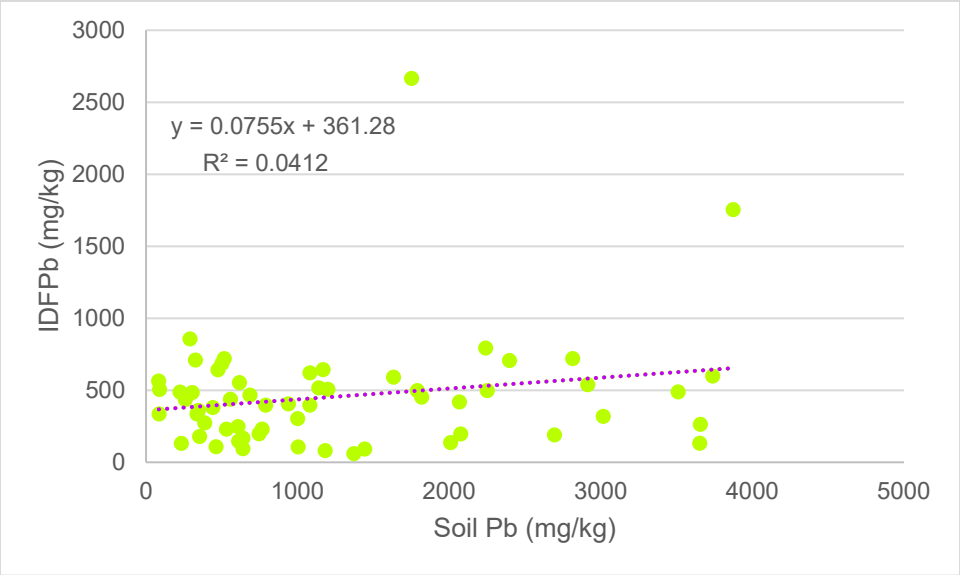


Figure 4-3: Indoor Dust Pb Concentrations Compared to Soil Pb Concentrations

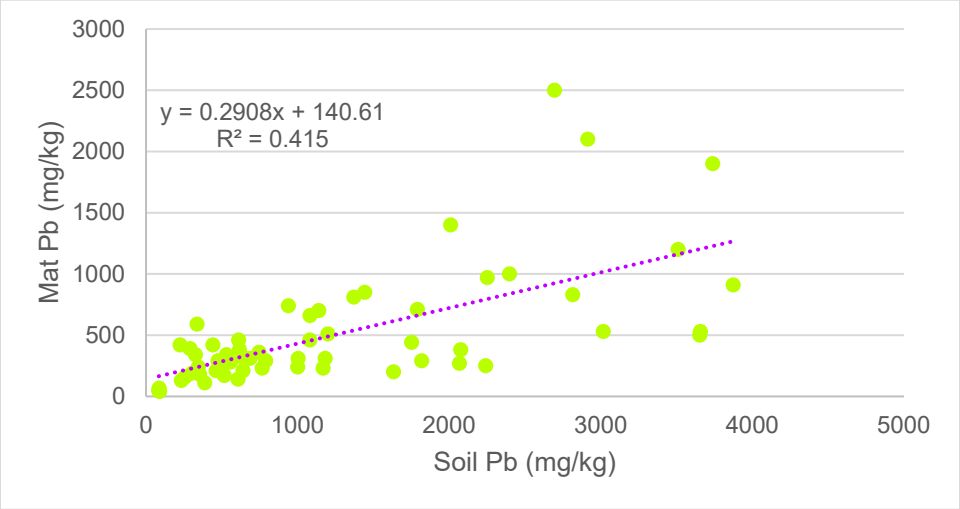


Figure 4-4: Dust Mat Pb Concentrations Compared to Soil Pb Concentrations

Comparative statistics were used to analyze the data from the 2016 dust study to assess factors that may contribute to indoor dust loading and indoor dust Pb concentrations. The findings are summarized as follows:

1. Comparison of the Pb loading rates from outdoor dustfall jars (ODF) to indoor dustfall jars (IDF) and entrance mats using analysis of variance (ANOVA) indicated that when controlling for the significant effect of the area from which samples were collected, the difference between mean ODF Pb loading rates and mean entrance mat Pb loading rates was not statistically significant, but both of these are higher than mean IDF Pb loading rates ($p<0.0001$). It is noted that loading rates depend directly on the total amount of dust collected, and the concentration of Pb in the dust.
2. Using ANOVA and controlling for the significant effect of the area from which samples were collected, the mean Pb concentration is higher in ODF dust than in dust from either the entrance mat or IDF ($p<0.0001$). The difference between mean entrance mat and IDF dust Pb concentrations was not statistically significant.
3. To support the above, a regression analysis indicated that yard soil Pb concentration is a statistically significant predictor of the Pb concentration in the entrance mat dust, but that it is likely not the only factor ($r^2 = 0.58$, $p<0.0001$). As assessed yard soil Pb concentration increases, so did Pb concentration in entrance mat dust. The yard soil concentration was not a statistically significant predictor of the Pb concentration in IDF jar dust. Also, comparing IDF, entrance mat and yard Pb concentrations indicated that the indoor Pb concentrations on both mats and IDFs were lower than yard concentrations ($p<0.0001$).
4. The data from the study provided no statistically significant evidence that indoor Pb concentrations are affected by percent ground cover of soil or yard condition.
5. Neighborhood Pb soil concentrations were estimated using the average 95% UCLM for Pb concentrations measured within a 250 metre or 500 metre radius of each individual property that participated in the study. These measures were correlated with the 95% UCLM for the individual yards ($r = 0.81$ and 0.78 respectively) and with one another ($r = 0.98$), so it is not surprising that they had a similar statistically significant effect on Pb concentration and loading on entrance mats ($r2=0.48$, $p<0.0001$, and $r2=0.47$, $p<0.0001$ respectively). The Pb concentrations of mat dust increase as the neighborhood Pb concentrations increase (as measured by these two variables). Pb concentrations in IDF dust appear to be independent of these neighborhood concentration measures. They do not have a statistically significant regression relationship with IDF Pb loading or concentrations.
6. To determine if the age of the home and the paint condition had an affect on indoor dust Pb concentrations, mean Pb concentration of mat dust collected using was compared using ANOVA. The oldest homes in the study had a significantly greater mean Pb concentration than the pre-1976 homes, which in turn had significantly higher mean Pb concentration than the newest homes ($p<0.0001$). Analysis of Pb loading on the dust mat showed only that the oldest homes had significantly greater mean Pb loading on the mat than newer homes. There were no significant differences between mean Pb loading on the mat between older and pre-1976 homes or pre-1976 homes and newer homes. Neither Pb concentration nor Pb loading in the IDF showed statistically significant differences among the means for the three different house age categories.

7. When all data were included, a comparison of mean dust loading on the entrance mat between households with pets versus households without pets, showed a slightly higher dust loading rate, but it was not a statistically significant difference from those households without pets. Both mean Pb concentration in mat dust (p=0.031) and mean Pb loading on entrance mats (p= 0.015) were significantly higher for households with pets than for households without pets. Upon closer examination of the data, it was found that the three properties with the lowest Pb concentration in mat dust in the study (all <70 ppm) all happened to have no pets. These properties may have had an undue influence on this analysis, and when these data were removed, the same analysis returned no statistically significant difference in mean Pb loading or mean Pb concentration due to the presence or absence of pets.
8. There is no evidence from this study that the number of people living in each house is a factor determining the Pb concentration, Pb loading, total weight or total loading of entrance mat dust. The presence of children in the household was also not a statistically significant factor for Pb concentration, Pb loading, total weight or total loading of entrance mat dust.
9. Analyses comparing mean total mat dust weight, mean total mat dust loading, mean mat Pb, and mean mat loading were performed for 3 occupation related variables (DirtWork, DustJob, TeckEmp). There were no statistically significant differences in any of the four dependent variables tested between households with 1 or more people working in a ‘dirty’ job versus not working in a dirty job. There were no statistically significant differences in three of the four dependent variables tested between households with 1 or more people working in dusty jobs (DustJob) versus working in non-dusty jobs. There was a statistically significant greater mean Pb concentration in mat dust in households with 1 or more people working in a ‘dusty’ job versus households were nobody worked in a dusty job (p=0.036). There were no statistically significant differences in any of the four dependent variables tested between households with 1 or more people working at Teck versus not working at Teck. There were no statistically significant differences in any of the four dependent variables tested between households with ‘Pb hobbies’ versus those without.

The lack of relationship between soil Pb and indoor dustfall Pb is inferred to be in part attributable to contributions of Pb in indoor dust from indoor sources. As noted, the oldest homes in the study had a significantly greater mean Pb concentration in IDF dust than the pre-1976 homes, which in turn had significantly higher mean Pb concentration than the newest homes. Given the age of the housing stock in the City of Trail and the associated prevalence of Pb-based paints, it is likely that Pb-based paints are contributing to Pb concentrations in indoor dust. This is consistent with the HHRAs conducted for other metals (Exponent, 1997 and 1998) which evaluated paired soil and house dust data collected from 60 homes around Trail. No clear relationship could be discerned between indoor and outdoor concentrations of metals, which was considered attributable to uncharacterized indoor sources of metals.

As noted, the dust mat Pb concentrations were correlated with the soil Pb concentrations, as depicted in **Figure 4-4**. The estimated regression coefficient of 0.2908 is consistent with that recommended by Tu et al. (2020). Tu et al. (2020) reviewed residential yard soil and indoor dust datasets from eight communities near historical mining, smelting and refining operations to quantify soil track-in. Using this data, they estimated a soil-to-dust transfer coefficient for Pb without internal sources (e.g., Pb-based paints) of 0.3-0.4. The data from the 2016 Dust Study further support a soil-to-dust transfer coefficient in this range and will be further discussed in **Section 6.1.2**.

Of note, approximately half (32 of 63) of the properties that participated in the 2016 dust study had received some form of soil remediation (i.e., vegetable garden soil replacement, improvement in ground cover in bare areas and/or partial or full soil replacement) prior to the deployment of the dust mats and dustfall jars in August 2016. Of the 32 properties:

- 9 had received soil replacement (top 15 cm only) in their vegetable gardens only;
- 18 had received soil replacement (top 15 cm only) and ground cover improvement, 3 of which also received lawn care;
- 3 properties had received partial soil replacement to 30 cm, one of which also had ground cover improvements; and
- 2 properties had received full remediation to 30 cm, one had a vegetable garden, and one did not.

4.2.2.2 Dustfall Monitoring

Dustfall measurements are taken at Birchbank, Downtown Trail, Columbia Avenue, Columbia Gardens, Tadanac, Trail Hospital, Glenmerry, Oasis, Stoney Creek, Waneta, and Warfield; the locations of the monitoring stations are identified on **Figure 4-5** and discussed in **Table 4-7**. The dustfall measurements are continuous samples analyzed monthly for total deposited particulate and metals. **Table 4-8** and **Figure 4-5** present the mean dustfall loadings from 2003 to 2022 at each of the monitoring locations.

Figure 4-5: Teck Community Air Monitoring Stations

Table 4-7: Air Monitoring Station Locations and Parameters Monitored

Monitoring Station	Direction	Approx. Distance from Smelter Fenceline (m)	Latitude	Longitude	Dustfall	PM_{10}	TSP	Location Notes	Nearby Public Facilities / Sensitive Receptors
Columbia Avenue	East	400	49 5 57	117 42 17	Y	N	N	West edge of East Trail – residential area	Daycares
Downtown	South	400	49 5 43	117 42 30	Y	N	N	Downtown - Mixed-use commercial/residential area	Arena, Businesses, Restaurants
Glenmerry	East-southeast	2875	49 5 51	117 40 10	Y	N	N	West edge of Glenmerry – residential area	Glenmerry Elementary School
Tadanac	Northeast	30	49 6 38	117 43 22	Y	N	N	West edge of Tadanac – residential area	Park, playground
Trail Hospital	East-northeast	750	49 6 11	117 42 5	Y	N	N	East edge of East Trail - Higher elevation	Hospital, High School
Birchbank	North	7300	49 10 45	117 43 44	Y	Y	Y	Parkland / golf course	Golf Course and Park
Oasis	North	2800	49 7 59	117 44 45	Y	N	N	South edge of Oasis - rural residential area	--
Stoney Creek	Northwest	300	49 6 36	117 43 56	Y	N	N	Located in Teck laydown area	--
Warfield	West	1700	49 5 43	117 44 48	Y	Y	N	East edge of Warfield residential area	Elementary School, Outdoor Pool, Park
Warfield - Haley Park	West	1450	49 5 50	117 44 37	Y	Y	N	East edge of Warfield residential area - in a park	Elementary School, Outdoor Pool, Park
Columbia Gardens	Southeast	9500	49 2 42	117 36 26	Y	Y	N	Near an industrial area "Metal Tech Alley"	--
Trimac (Waneta)	Southeast	10500	49 2 2	117 36 22	Y	N	N	Near Teck Waneta re-load facility and industrial area	--
Sunningdale	Northeast	600	49 7 1	117 43 28	Y	N	N	East edge of Sunningdale residential area	Daycare, park
Butler Park	Southeast	950	49 5 46	117 41 52	Y (since2019)	Y	Y	East Trail residential area	Playing fields, Aquatic Centre

Notes:
PM_{10} particulate matter of 10 microns or less
TSP total suspended particulate

Table 4-8: Mean Annual Dustfall Loading (mg/dm^2/day) (2003-2023)

Year	Columbia Ave	Downtown	Glenmerry	Tadanac	Trail Hospital	Birchbank	Oasis	Stoney Creek	Warfield
2003	0.010	0.006	0.005	0.014	0.007	0.001	0.002	0.007	0.002
2004	0.022	0.007	0.007	0.020	0.006	0.002	0.004	0.010	0.002
2005	0.021	0.006	0.006	0.017	0.005	0.003	0.002	0.006	0.001
2006	0.021	0.007	0.006	0.025	0.005	0.001	0.002	0.007	0.001
2007	0.019	0.006	0.005	0.028	0.005	0.001	0.003	0.009	0.001
2008	0.022	0.006	0.005	0.040	0.004	0.001	0.003	0.009	0.002
2009	0.019	0.008	0.007	0.034	0.006	0.000	0.003	0.009	0.001
2010	0.015	0.007	0.006	0.026	0.005	0.000	0.002	0.007	0.001
2011	0.012	0.006	0.006	0.045	0.007	0.001	0.003	0.010	0.001
2012	0.008	0.006	0.005	0.032	0.006	0.002	0.002	0.008	0.001
2013	0.011	0.006	0.006	0.025	0.006	0.001	0.003	0.011	0.001
2014	0.012	0.007	0.005	0.022	0.007	0.001	0.002	0.008	0.001
2015	0.010	0.006	0.004	0.018	0.006	0.001	0.002	0.007	0.001
2016	0.011	0.005	0.004	0.012	0.005	0.001	0.001	0.006	0.001
2017	0.007	0.004	0.004	0.010	0.004	0.001	0.002	0.004	0.001
2018	0.006	0.005	0.002	0.007	0.002	0.001	0.001	0.003	0.000
2019	0.004	0.004	0.002	0.006	0.002	0.001	0.001	0.003	0.001
2020	0.004	0.004	0.001	0.005	0.002	0.001	0.001	0.004	0.001
2021	0.005	0.004	0.002	0.005	0.002	0.001	0.001	0.003	0.000
2022	0.004	0.004	0.002	0.004	0.002	0.000	0.001	0.003	0.000
2023	0.006	0.006	0.001	0.004	0.002	0.000	0.001	0.003	0.001

Notes:
mg/dm^2/day milligrams per square decimetre per day

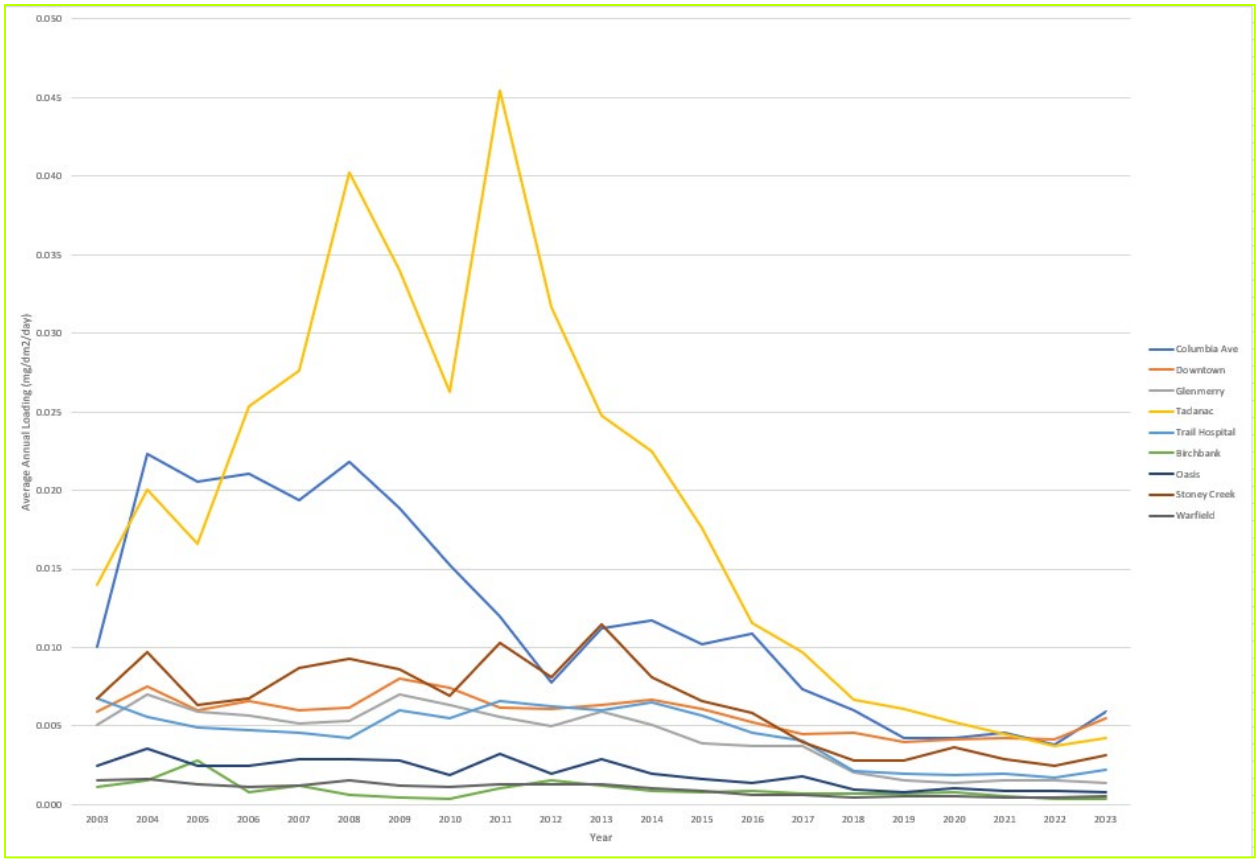


Figure 4-6: Mean Annual Dustfall Loading (mg/dm^2/day) (2003 – 2023)

As presented in **Table 4-8** and in **Figure 4-6**, a declining trend in dustfall levels has been observed since the initiation of the Fugitive Dust Reduction Program. As presented, dustfall loadings have generally continued to decrease since the completion of the 2016 dust study, with the minor fluctuations seen in 2022-2023 influenced by an extended maintenance turnaround and the work to return to stable operations post-turnaround.

4.2.3 Air

Total suspended particulate (TSP) Pb and respirable dust (PM_{10}) Pb data were reviewed and are summarized in **Section 4.2.3.1** and **4.2.3.2**, respectively. The monitoring stations where TSP and PM_{10} are monitored are presented in **Figure 4-4** and in **Table 4-7**.

The TSP Pb data includes all of particle sizes, including particulate >10 µm, or particles that are too large to penetrate beyond the larynx into the thoracic region of the respiratory tract, as well as smaller particles, such as PM_{10} and $PM_{2.5}$.

The PM_{10} Pb data represents the respirable dust Pb concentrations, or the fraction that has the potential to be inhaled and deposited in the lungs. Larger particles primarily deposit in the upper bronchial tubes and are transferred upwards and subsequently ingested. As there are no inhalation TRVs for Pb, the TSP data will be used in the HHRA to estimate exposures associated with inhalation of Pb in air, accounting for both inhaled and ingested fractions.

4.2.3.1 Total Suspended Particulate Pb Concentrations

TSP is measured bi-daily, over 24-hour periods, at two stations, including a station located approximately 1 km southeast of the smelter, and another at Birchbank located approximately 8.5 km north of the smelter. **Table 4-9** and **Figure 4-7** present the mean, annual TSP Pb concentrations from 2010 to 2023 at Butler Park and Birchbank.

Table 4-9: Mean Annual TSP Pb Concentrations (µg/m³) (2010-2023)

Year	Butler Park	Birchbank
2010	0.464	0.143
2011	0.360	0.260
2012	0.392	0.134
2013	0.346	0.171
2014	0.325	0.123
2015	0.305	0.102
2016	0.250	0.095
2017	0.163	0.074
2018	0.133	0.056
2019	0.111	0.051
2020	0.070	0.044
2021	0.068	0.037
2022	0.057	0.033
2023	0.079	0.045

Notes:
TSP total suspended particulate
µg/m³ micrograms per cubic metre

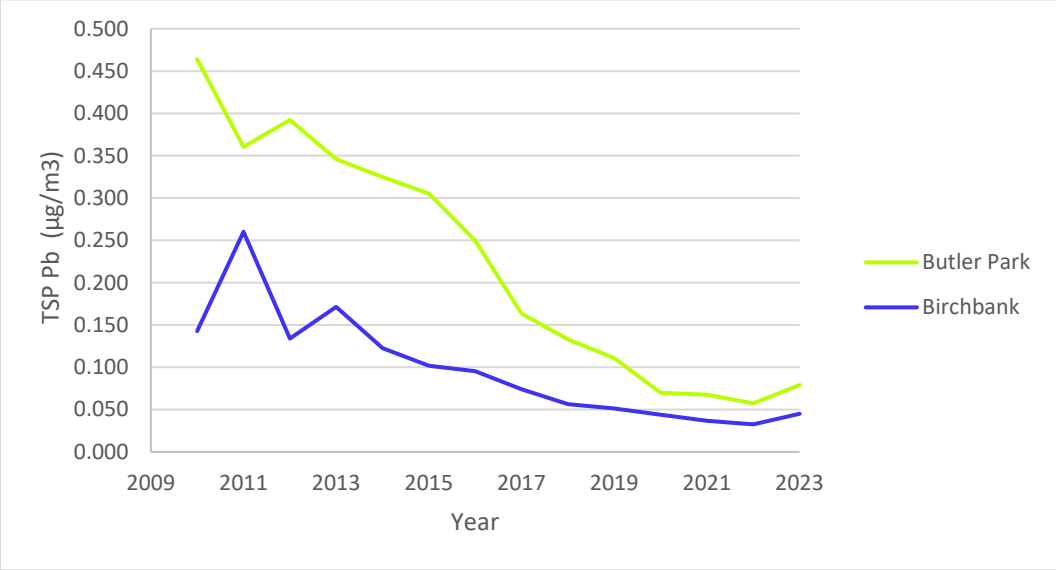


Figure 4-7: Mean Annual TSP Pb Concentrations Measured at Butler Park and Birchbank (2010 – 2023)

The mean, annual TSP Pb concentrations in 2022 at the two stations were 0.057 µg/m^3 and 0.033 µg/m^3 respectively and are approximately an order of magnitude lower than they were prior to the implementation of the FDRP in 2012. There was a slight increase in concentrations in 2023 due to an extended maintenance turnaround and the work to return to stable operations post-turnaround. Based on the data from these two monitoring stations, a declining trend in TSP Pb concentrations in community air has been observed since the initiation of the Fugitive Dust Reduction Program. Further, concentrations below the US EPA National Ambient Air Quality Standard (NAAQS) of 0.15 µg/m^3 for a 3-month rolling average since 2020. It is noted that the US EPA NAAQS is used as there are no Canadian air quality guidelines for Pb, except for Ontario's, which is less stringent than the US EPA NAAQS.

4.2.3.2 Respirable Dust Pb

Respirable dust Pb (PM_{10} Pb) data collected from four stations in Trail (Butler Park, Birchbank, Warfield and Columbia Gardens) were reviewed. The PM_{10} readings are taken over a 24-hour period every 6th day. The mean, annual PM_{10} Pb concentrations at each of the stations from 2010 to 2023 are presented below in **Table 4-10** and **Figure 4-8**.

Table 4-10: Mean, Annual PM_{10} Pb Concentrations (µg/m^3) (2010-2023)

Year	Butler Park	Birchbank	Warfield	Haley Park**	Columbia Gardens
2010	0.175	0.103	0.046	--	0.104
2011	0.111	0.118	0.074	--	0.089
2012	0.159	0.077	0.057	--	0.069
2013	0.138	0.104	0.181	--	0.059
2014	0.162	0.057	0.049	--	0.070
2015	0.155	0.060	0.049	--	0.081
2016	0.107	0.042	0.036	--	0.055
2017	0.090	0.045	0.034	--	0.069
2018	0.070	0.034	0.024	--	0.058
2019	0.065	0.038	0.039	--	0.050
2020	0.040	0.033	0.032	--	0.030
2021	0.038	0.024	0.022	--	0.034
2022	0.031	0.023	0.020	--	0.033
2023	0.037	0.033	0.031*	0.042	0.028

Notes:
PM_{10} particulate matter of 10 microns or less
µg/m^3 micrograms per cubic meter
** Replacement station for Warfield, which was decommissioned in November 2023; operated for all of 2023.
* Data collected from January to October. Station decommissioned in November 2023 and replaced by Haley Park station.

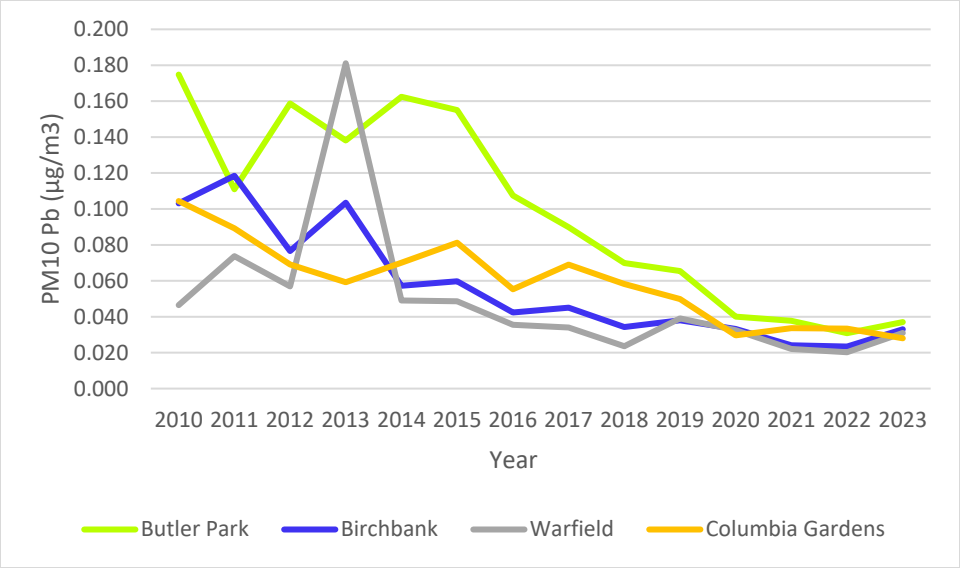


Figure 4-8: Mean Annual PM_{10} Pb Concentrations Measured at Butler Park, Birchbank, Warfield and Columbia Gardens (2010 – 2023)

The mean, annual PM_{10} Pb concentrations in 2023 across the five monitoring stations range from 0.028 µg/m^3 and 0.042 µg/m^3. As with TSP, a steady decrease in PM_{10} Pb concentrations has been observed overtime, with the largest improvements observed in the late 1990s, with the introduction of the KIVCET smelter. It is noted that in 2013 at Warfield and Birchbank monitoring locations, the mean annual PM_{10} Pb concentrations were biased high by a single event in February due to an open vent at the KIVCET smelter and as with TSP, the minor fluctuations seen in 2022-2023 were influenced by an extended maintenance turnaround and the work to return to stable operations post-turnaround.

5. Problem Formulation

5.1 Setting

Trail was incorporated as a city in 1901, is in the Kootenay Region of BC and is a small, urban centre with a population of approximately 7,900 (Statistics Canada 2021). The City of Trail has an area of 34.78 km^2 and is located on both banks of the Columbia River within a relatively narrow valley between the Monashee Mountains to the west and the Selkirk Mountains to the east. Trail is situated on the traditional territory of the Sinixt, Ktunaxa, Secwepemc, and Syilx peoples.

Trail's history and growth occurred alongside the operating smelter, where the city centre spanned out from the smelter. This continues to be reflected in the present-day layout of commercial and residential properties within the city. Many of the first neighbourhoods were developed within walking distance of the smelter. The neighbourhoods found in Trail include Tadanac, East Trail, West Trail, Anable, Sunningdale, Glenmerry, Shavers Bench, Waneta, and Miral Heights, with these areas shown on **Figure 5-1**. Communities surrounding the City of Trail that are also part of the EM Area including Warfield, Rivervale, Oasis, Casino, and Columbia Gardens, as well as rural properties located in the Regional District Kootenay Boundary (RDKB) and Regional District Central Kootenay (RDCK).

Trail is a hub in the West Kootenay region and has many public facilities and community spaces. The Trail Memorial Centre and the Trail and District Public Library are in the downtown, commercial district. Parks, recreational facilities, and green spaces are present throughout the community, including Gyro Park, Jubilee Park, and Butler Park, to name a few. Two Secondary Schools and two Elementary Schools are in Trail and another Elementary School is present in Warfield. The Kootenay Boundary Regional Hospital is found in East Trail. Trail and the surrounding area are popular for outdoor recreational activities including biking, hiking, skiing, golfing, and fishing.

Teck's Trail Operations is the largest employer in Trail, providing 1,400 jobs. Due to the presence of metallurgical operations in Trail for over a century, there is a long history of environmental and health monitoring related to metals. Since the early 1990s, health and environmental monitoring, education and support programs have been available to residents in Trail and the surrounding area through the Task Force, followed by the THEP. In 2018, the EM Area associated with Teck Trail Operations was established based on concentration limits determined for arsenic, cadmium, Pb and zinc in surficial soils attributable to historical Trail smelter emissions. The EM Area boundary is shown below on **Figure 5-1**. Program efforts to date have been focussed within the THEP Areas 1, 2 and 3, which are show on the figure below. The THEP Areas were defined in the Trail Lead Study (Hertzman et al., 1990) prior to the establishment of the EM Area; THEP Area 1 extends outside of the EM Area near the community of Casino, BC.

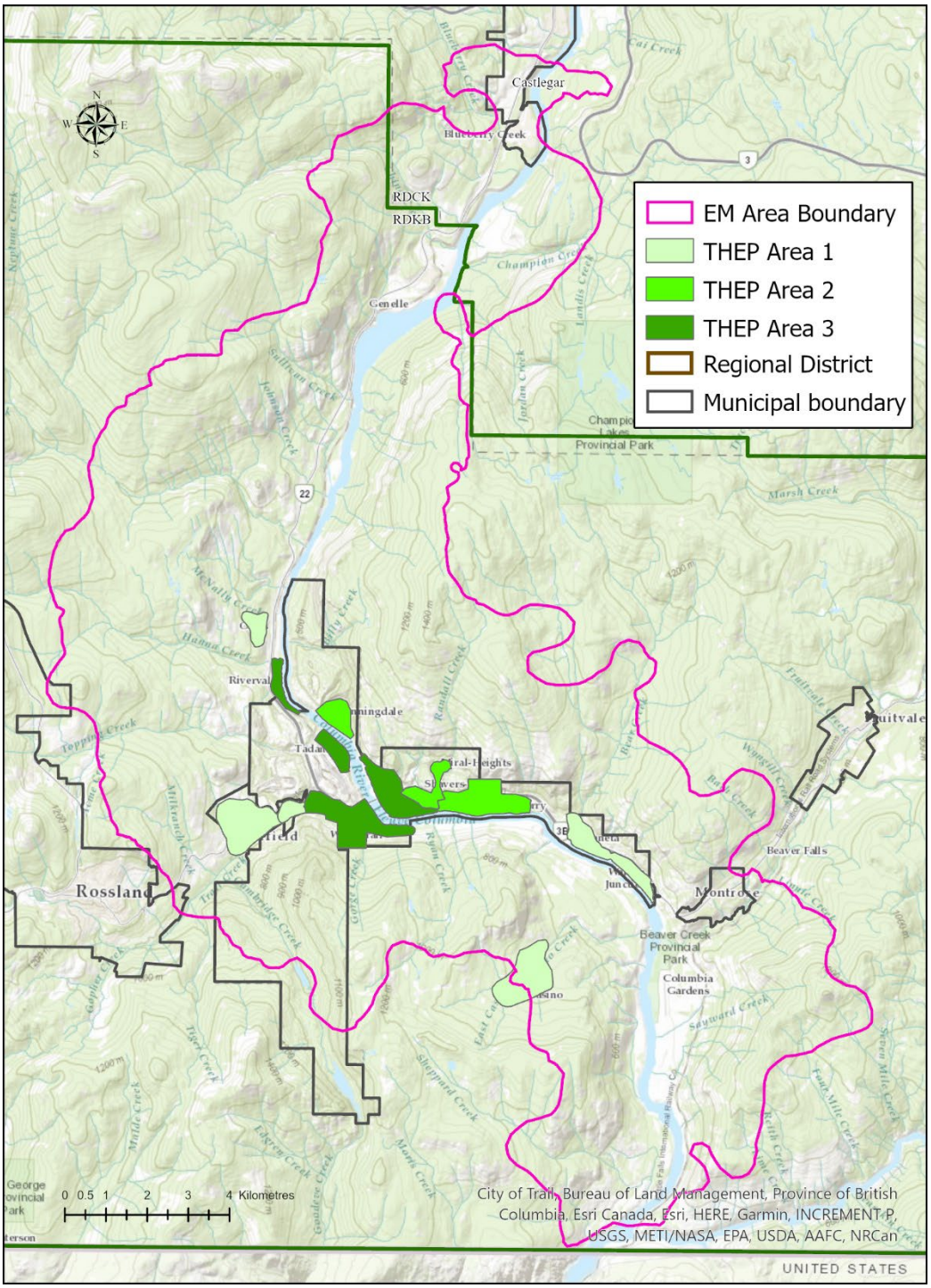


Figure 5-1: The Trail Environmental Management Area Boundary and THEP Areas

5.1.1 Climate

Climate information for the Trail area was obtained from the Government of Canada Ministry of Environment and Natural Resources Climate Normals database available at https://climate.weather.gc.ca/climate_normals/index_e.html. Data was obtained for the Warfield weather station, located approximately 3 km east of Teck Trail Operations at a slightly higher elevation of about 600 m asl, compared to Trail, which is at approximately 400 to 500 m asl. According to the referenced source, average daily temperatures in the area over the last two decades (1991 to 2020) range from -1.7 degrees Celsius in December and January to 21.2 degrees in July. The area receives approximately 785 mm of precipitation annually, with reported snow depths at the end of November, December, January and February 9, 28, 37 and 31 cm. Canada's weather stats for Trail, available at https://trail.weatherstats.ca/charts/count_snow_on_ground-yearly.html reports that over the last six years, Trail has had over 100 days of snow cover (i.e., a minimum of 14.3 weeks of snow cover).

5.2 COPC Screening

Previous HHRAs (Exponent, 1997, 1998, 2000; Integral, 2008) have addressed other metals associated with the smelter operations, with the HHRA conducted by Hilts et al. (2001) assessing exposures and risks associated with Pb. Given the evolving science related to Pb toxicity, as well as the ongoing biomonitoring program, further Pb HHRA has not been conducted and thus, Pb is the contaminant of potential concern (COPC) of focus in this HHRA.

Pb was identified as a concern, specifically for young children, in Trail as early as the mid-1970s, when higher BLL were measured in children living in Trail, compared to a neighbouring community. Concerns were increased when a 1989 study found that approximately 39% of the children tested were above the US EPA's 'level of no concern' of 15 µg/L (Hilts et al., 2001), which prompted the formation of the Task Force in 1990. Since 1990, the Task Force, which became the THEC in 2001, has studied children's Pb exposure and developed actions based on the best and latest science, including the evolving science around Pb toxicity. Exposures to Pb in the children in the community have been measured through biomonitoring since 1991.

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 a 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 the areas of Trail nearest the smelter is 2.1 µg/dL (Interior Health, 2023). **Figure 5-2** shows the decreasing trend in BLL geomeans by THEP Area (see **Figure 5-1**) over the period of 1991 to 2023.

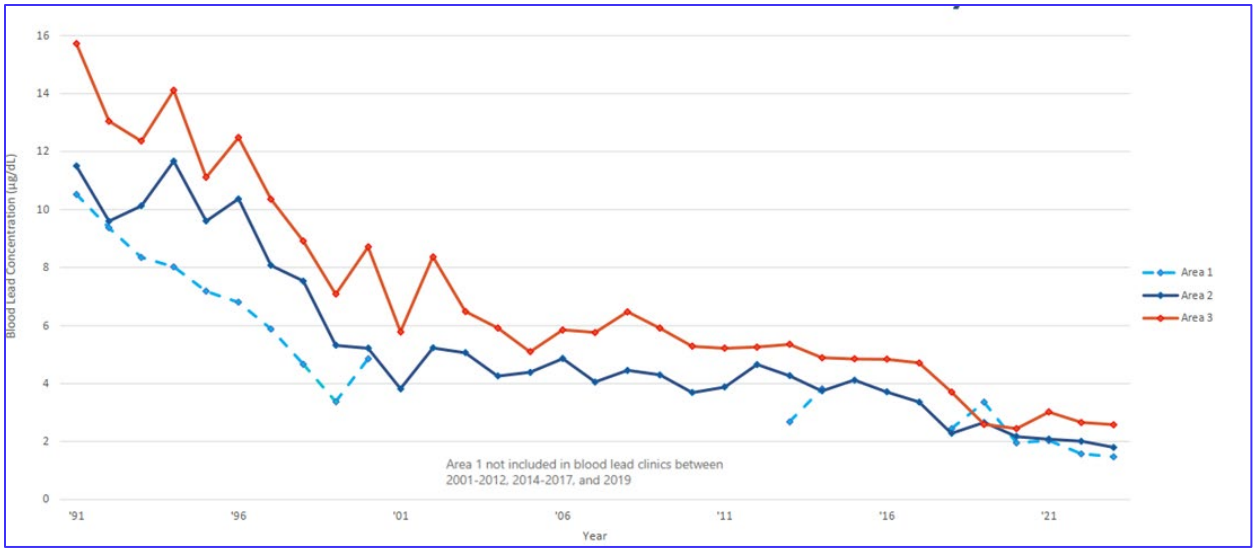


Figure 5-2: Trend of Blood Pb Geomean by Area, Years 1991 to 2023 (From Interior Health, 2023)

Pb has been measured in soil across the Trail area at concentrations exceeding the BC CSR standards for various land uses (AL, RL, CL and IL), and thus, by definition, is a contaminant. The Pb concentrations are variable between the neighbourhoods in the Trail area, with higher concentrations present in neighbourhoods nearest the smelter, The Pb concentrations are summarized by THEP Area and neighbourhood in **Table 4-2**. Pb in exterior dust and soil is transported into houses and thus is present in indoor dust. Pb in indoor dust can also be sourced from other sources, such as Pb paint and cigarette smoke. Finally, based on the continued operation of the Trail smelter, Pb is also present in ambient air at low concentrations. Pb has therefore been retained as a 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 paint, historical Pb gasoline emissions and Pb from coal burning and coal ash (Ramboll, 2020), with many of the sources inter-correlated. Pb paint has been documented in homes in the Trail area by the THEP. Routine standardized paint screening (SPS) began in 2023 as part of the Healthy Homes visits and for properties receiving soil assessment and remediation. The SPS is being conducted to establish a dataset on the prevalence of Pb-based paint in the Trail area. To date, 82 properties have had the exterior of their homes tested, with Pb-based paint identified at 43 of the properties. Previous paint screening programs have indicated similar results, with approximately 50% of the properties tested (interior and exterior testing) having Pb-based paints. It is known that older home age and prevalence of Pb-based paints is associated with higher geomean BLLs (Schoof et al., 2015, Rabito et al., 2007, Etchevers et al., 2015), with increased prevalence of Pb paint in older houses, particularly those built before 1940. Older houses are also more likely to have deteriorated Pb paint surfaces. In addition, exterior Pb paint contributes to soil Pb concentrations, and thus to BLLs (Schoof et al., 2015).

5.3 Receptor Screening

It is widely accepted that children are more susceptible to Pb than older age groups (WHO, 2011; EFSA, 2013). As compared to older age groups, children are more susceptible to Pb for key reason that Pb toxicity affects their developing nervous system and brain, which can be measured as IQ effects, and thus they are 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 (less than 6 years of age) are more susceptible than older children (6 to less than 12 years of age) for key reasons that include: 1) although recent studies indicate they consume similar amounts of soil, young children weigh less; and 2) young children absorb more Pb than older children. The available data suggests that by the time a child reaches approximately six years of age, that they absorb Pb at a rate that is similar to an adult (Ziegler et al., 1978; Gulson et al., 1997; Mushak et al., 2011; Holstege et al., 2020).

Based on land use around the smelter, and as children are the most sensitive receptors, the residents of the Trail area are identified as the primary receptors of concern. Exposures and associated risks to all age groups will be evaluated.

There are parks and green spaces located within the Trail area. While children may be present at these locations, the HHRA predicts that Pb exposures are lower than those for the residential receptors, due to lower frequency and duration of exposures and similar Pb concentrations in Pb impacted media. Characterization of exposures and associated risks to residential receptors is therefore protective of park users.

There is the potential for agricultural workers and industrial workers whose work involves contact with soil to be more highly exposed to soil than other adult workers. On this basis, agricultural and industrial workers are retained as a receptor of concern in the HHRA and will be evaluated if risks in excess of the CSR risk-based standard are estimated for adolescent or adult residents (who are assumed to be exposed 24 hours a day, seven days a week, with Health Canada recommending the same soil ingestion rate across all groups). Commercial workers will also be evaluated separately where unacceptable risks to adolescent or adult residents are identified.

While there are no reserve lands in the EM Area, Indigenous peoples in the region are identified as receptors of concern based on the potential for exposure scenarios unique to Indigenous peoples.

5.4 Exposure Pathway Analysis

The literature indicates that while other exposure sources/pathways may be important for other age groups, in areas where Pb contaminated soils are present, soil and dust ingestion are the dominant exposure pathways for children 1 to 5 years old with elevated BLLs (ATSDR, 2020; Lanphear, 1997). While in some areas drinking water and diet may be significant contributors to exposure, these sources are not expected to be key contributors to exposure in the Trail area (see below discussion). Absorption of Pb through skin is negligible compared with uptake through ingestion and inhalation routes, with uptake via inhalation significantly lower than through ingestion of dust and soil, particularly for young children who exhibit frequent hand-to-mouth behaviour (ATSDR, 2020).

As detailed above, as stack and fugitive dust emissions have declined, community ambient air Pb concentrations have declined and thus, contributions from inhalation exposures will have decreased overtime. While this pathway will be carried forward for evaluation, contributions to overall exposures are expected to be low.

The following two pathways are not carried forward for evaluation: 1) soil leaching to groundwater used for drinking water or other domestic purposes; and 2) consumption of garden produce grown in impacted soils. The rationale for excluding these pathways is presented below. In the case of soil leaching to groundwater used for drinking water, previous studies have demonstrated that where groundwater impacts are found in the EM Area, there is no spatial trend consistent with soil impacts from historical aerial emissions. Groundwater continues to be monitored by Teck in areas of potential environmental concern. Domestic water in Trail is supplied via the municipal water distribution system. This includes the Bear Creek Well, which supplies domestic water to Upper and Lower Shavers Bench, Miral Heights, Glenmerry and Waneta. The Bear Creek well is completed at a depth of 42.5 m below ground surface and is noted by the City of Trail (2021) not to be influenced by contamination. Sampling conducted in 2021 (City of Trail, 2021) determined no Pb was present in the water source or the distribution system itself; however, it is noted that there is the potential for Pb solder and piping to be present in individual homes. Given that 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 is not further evaluated.

Studies have indicated that Pb in homegrown produce does not translate into higher BLL for children that consume the produce (Brown et al., 2016; Hilts et al., 1995 and 2001). The following lines of evidence were considered in the determination of the potential for homegrown garden produce to contribute significantly to overall Pb exposures in Trail:

- The exposure pathway studies conducted in the 1990s (Hilts et al., 1995 and 2001) indicated no difference in BLL in children who reportedly consumed homegrown produce and those who did not (Hilts et al., 1995 and 2001).
- This finding is consistent with other studies that evaluated Pb exposures in mining and smelter communities, including in East Helena, Leadville, Midvale, Butte, and Silver Valley (Lewis & Clark County Health. Dept. et. al., 1983; Colorado Dept. of Health. et. al., 1989; Univ. of Cincinnati, 1990; Butte-Silver Bow Health. Dept. & Univ. of Cincinnati, 1992; Panhandle Dist. Health. Dept., 1986), as well as more recent studies that evaluate Pb exposures (Schoof et al., 2015; Brown et al., 2016).
- It is well documented that Pb absorption is lower in the presence of food (EFSA, 2013; Brown et al., 2016; ATSDR, 2020), with absorption of Pb with a meal varying from 3% to 21% (average of ~ 8%) (EFSA, 2013).
- As noted, the 1992 exposure pathway study identified that only approximately 2% of overall Pb exposure was from diet (total diet, of which a small fraction would be comprised of homegrown produce).
- Garden soil testing continues to be offered to home produce gardeners through THEP, with under the current prioritization program, all gardens greater than 400 mg/kg offered soil removal, or where areas may not be accessible for remediation, risk management (e.g., raised garden boxes with clean soil). Therefore, garden soils on these properties in excess of the prioritization target of 400 mg/kg have been replaced and/or are no longer used for gardening.

Based on the above lines of evidence, the consumption of garden produce was not further evaluated in this HHRA. As presented in **Section 9**, background BLLs, which would include contributions from diet, have been considered in the derivation of the Trail area specific, risk-based standard. Further, it is understood that biomonitoring, which provides a measure of Pb exposure from all sources, will continue in the community with an overall goal of continuous reduction in childhood Pb exposure to narrow the gap between BLLs of children in Trail compared to similar aged children in the rest of Canada.

To help identify exposure pathways that may be unique to Indigenous peoples living in the Trail area, 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). No areas of specific concern where these plants may be harvested from were identified by COINs. Based on the above presented rationale for home grown produce, the consumption of traditional plants, either the plant itself, or medicines made from plants, is not expected to contribute significantly to exposures for Indigenous peoples. Additionally, given the limited dermal absorption of Pb, application of salves made from traditional plants are not expected to result in significant exposure; however, this assumption may need to be revisited if information becomes available that suggests that salves may enhance the absorption of Pb. 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 in the significance of potential exposures to this receptor group. Further information is recommended to be collected from local Indigenous peoples during consultation scheduled for 2025.

In summary, the following Pb exposure pathways were carried forward for evaluation in the HHRA:

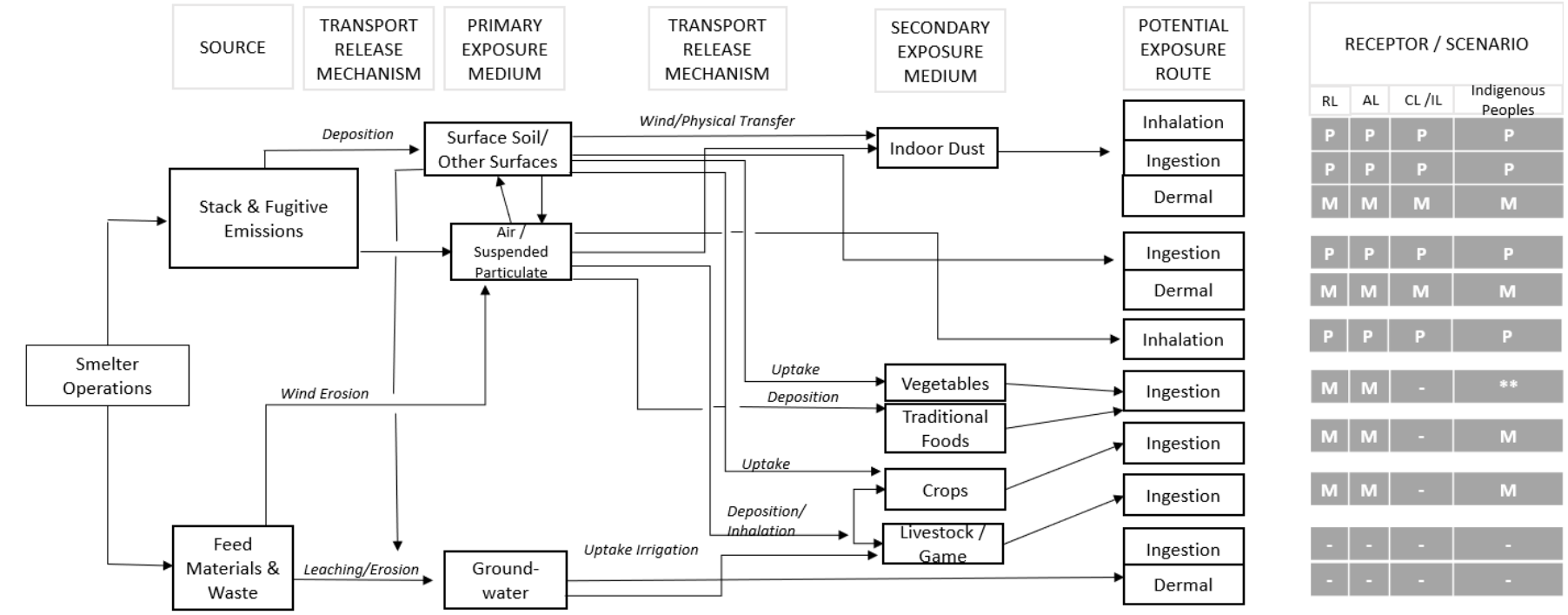
- Incidental ingestion of soil and outdoor dust (i.e., dust deposited on outdoor surfaces);
- Inhalation of soil particulate (i.e., dust generated from soils);
- Incidental ingestion of dust in-home environment;
- Inhalation of dust in the home environment; and
- Inhalation of Pb in ambient air (as TSP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

Except for soil and outdoor dust ingestion which are identified as inoperable pathways for the infant age group and thus, will not be evaluated for infants, each of the above exposure pathways will be quantitatively evaluated for all age groups.

5.5 Conceptual Site Model

A preliminary conceptual site model has been developed based on the Problem Formulation and is presented as **Figure 5-3**. The potentially significant exposure pathways identified in the Conceptual Site Model (CSM) will be carried forward for quantitative evaluation in the future HHRA.

Figure 5-4 provides a pictorial representation of potential Pb exposure pathways within the home and was developed by the THEP for educational purposes.



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

Figure 5-3: Human Health Conceptual Site Model for Pb from the Teck Trail Smelter

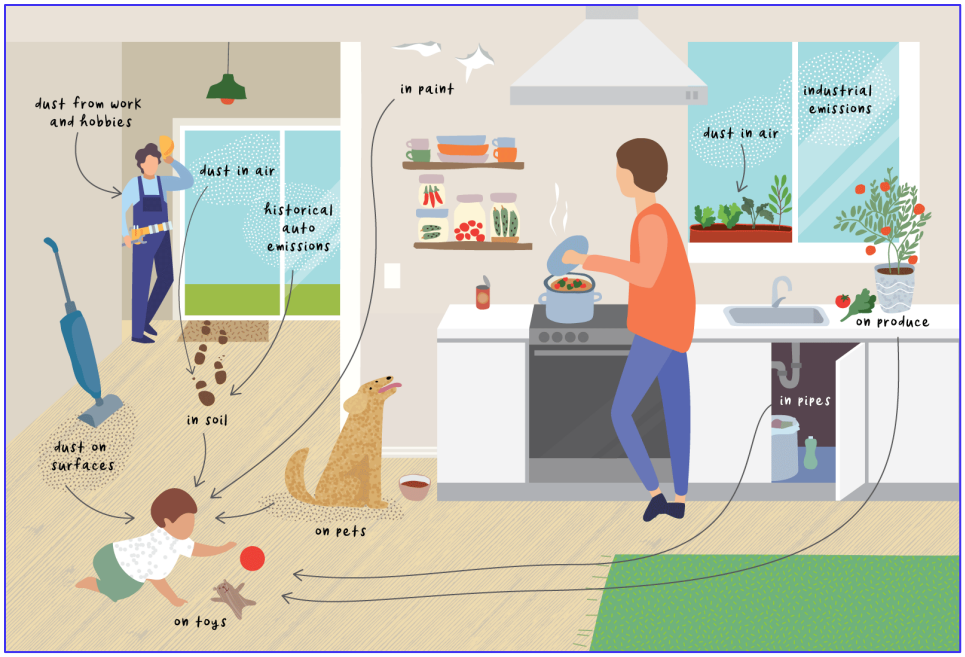


Figure 5-4: Human Health Conceptual Site Model – Potential Pb Exposure Pathways in the Home Environment (THEP, 2022)

6. Exposure Assessment

The exposure point concentrations (EPCs), receptor characteristics, bioavailability estimates, and exposure equations used to estimate exposures via the operable exposure pathways carried forward for evaluation in the HHRA are presented in the following sections.

The Pb HHRA uses a simplified, probabilistic approach to provide both reasonable maximum (RM) estimates, and central tendency (CT) estimates of potential exposures and associated risks (see **Section 8** for Risk Characterization) at the neighbourhood level. This approach includes the use of both RM and CT EPCs and select RM and CT receptor characteristics, as described below. In addition, a third scenario, referred to throughout the remainder of the report at the Protocol 1 scenario, has been included based on the requirements for deterministic risk assessment included in BC ENV's Protocol 1 (BC ENV, 2023b).

The exposure (and risk) estimates are provided in **Appendix A, Tables I-1 to I-60** and are representative of pre-remediation or risk management conditions at properties across the various neighbourhoods in the Trail area. As discussed in earlier sections, while the focus of the SMP has been residential properties and community areas (e.g., parks and school grounds), the dataset provides a comprehensive understanding of surface soil concentrations across neighbourhoods, including agricultural, commercial, and industrial properties. On this basis and based on the rationale presented in **Section 5.4**, characterization of exposures and risks to residential receptors is protective of other receptor groups. Where risks that exceed the CSR risk-based standard are estimated for adolescent and adult residential receptors, characterization of exposures and risks to other receptor groups will be conducted.

6.1 Exposure Point Concentrations

The EPCs, or the estimated concentrations of Pb in the exposure media (i.e., soil, indoor dust, and air) that people in the Trail area have the potential to be exposed to, are summarized as follows.

6.1.1 Soil

A range of soil Pb concentrations measured across the RL and PL properties in the various neighbourhoods in the Trail area were used as soil EPCs. In the estimation of the RM and Protocol 1 scenario exposure estimates, the higher of the 95% UCLM and 90th percentile soil Pb concentration for each neighbourhood was selected as the EPC. In the estimation of the CT scenario estimates, the arithmetic mean neighbourhood soil Pb concentration was selected as the EPC. Summary statistics for all neighbourhoods are presented in **Table 4-2**.

Due to the limited number of properties sampled in Birchbank, Blueberry Creek and Genelle (as noted in **Section 4.2**), and the neighbourhood approach used in the HHRA, these neighbourhoods were not carried forward for evaluation in the HHRA but have been identified as areas where additional sampling should be conducted in the WARP (AtkinsRéalis, 2024).

The mean and 95% UCLM Pb concentrations for each neighbourhood were calculated using US EPA's Statistical Software ProUCL Version 5.1, while the 90th percentile Pb concentrations were calculated in Microsoft Excel. The ProUCL outputs are provided in **Appendix B**. The soil EPCs for each neighbourhood are provided in **Table 6-1**, below.

Table 6-1: Soil Pb EPCs by Neighbourhood

THEP Assessment Area	Neighbourhood	RM and Protocol 1 Scenarios EPC (mg/kg)	CT Scenario EPC (mg/kg)
0	Montrose	156.6	84.4
1	Annable	543.7	308.3
1	Casino	517.8	169.9
1	Columbia Gardens	397.8	212.4
1	Oasis	735.2	383.8
1	Waneta	538	260.2
1	Warfield	382.6	205.5
2	Glenmerry	887.9	461.2
2	Miral Heights	214	106.9
2	Shavers Bench	1453.2	747
2	Sunningdale	763.6	431.7
3	East Trail	3291	1575
3	Rivervale	1148.2	550.2
3	Tadanac	3257.2	1535
3	West Trail	1637.4	897

Notes:
mg/kg milligram per kilogram, or parts per million (ppm)
RM Reasonable Maximum scenario
Protocol 1 Protocol 1 scenario
CT Central Tendency scenario
EPC Exposure point concentration

6.1.2 Dust

As discussed in **Section 4**, the indoor dust Pb concentrations measured in the 2016 Dust Study were not correlated with the soil Pb concentrations from the yards of the properties that participated in the study. As noted, participants in the study were instructed not to disturb the dust mats and jars used in the study, and thus, the lack of correlation is unlikely to be solely attributable to variability in cleaning practices in the homes. The lack of correlation is considered in part attributable to indoor sources of Pb, with contributions to indoor dust Pb from Pb-based paints, along with other potential indoor sources (e.g., smoking). Therefore, dust concentrations modelled from Pb soil concentrations are considered more representative of exposures associated with the smelter. This approach remains conservative as the soil Pb concentrations used to estimate the indoor dust concentrations include potential contributions from other exterior sources, including exterior Pb-based paints, the previous use of leaded fuels, etc.

Modelled concentrations were estimated based on the RM/Protocol 1 and CT scenario soil EPCs and soil-to-dust transfer coefficients for Pb from Tu et al. (2020). As noted, Tu et al. (2020) estimated a soil-to-dust transfer coefficient for Pb without internal sources based on data from eight communities near historical mining, smelting and refining operations. They estimated a soil-to-dust transfer coefficient of 0.3-0.4, which is supported by the dust mat data from the 2016 Dust Study, which estimated a coefficient of 0.291. A soil-to-dust transfer coefficient of 0.3 was used in the estimation of the CT scenario exposure estimates, while 0.4 was used in the estimation of the RM/Protocol 1 scenario exposure estimates.

Table 6-2 presents the indoor dust Pb EPCs by neighbourhood, including both a RM/Protocol 1 scenario EPC based on the RM soil EPC (i.e., higher of the 95% UCLM and 90th percentile soil Pb concentration for each neighbourhood), and a CT EPC based on the CT soil EPC (i.e., arithmetic mean soil Pb concentration for each neighbourhood).

Table 6-2: Modelled Indoor Dust Pb EPCs by Neighbourhood

THEP Assessment Area	Neighbour-hood	Soil RM and Protocol 1 Scenarios EPC (mg/kg)	Indoor Dust RM and Protocol 1 Scenarios EPC[a] (mg/kg)	Soil CT Scenario EPC (mg/kg)	Indoor Dust CT Scenario EPC[b] (mg/kg)
0	Montrose	156.6	62.6	84.4	25.3
1	Annable	543.7	217.5	308.3	92.5
1	Casino	517.8	207.1	169.9	51
1	Columbia Gardens	397.8	159.1	212.4	63.7
1	Oasis	735.2	294.1	383.8	115.1
1	Waneta	538	215.2	260.2	78.1
1	Warfield	382.6	153	205.5	61.7
2	Glenmerry	887.9	355.2	461.2	138.4
2	Miral Heights	214	85.6	106.9	32.1
2	Shavers Bench	1453.2	581.3	747	224.1
2	Sunningdale	763.6	305.4	431.7	129.5
3	East Trail	3291	1316.4	1575	472.5
3	Rivervale	1148.2	459.3	550.2	165.1
3	Tadanac	3257.2	1302.9	1535	460.5
3	West Trail	1637.4	655	897	269.1

Notes:

[a] Estimated as Soil RM/Protocol 1 scenario EPC * 0.4 (soil to indoor dust partition coefficient from Tu et al., 2020)

[b] Estimated as Soil CT scenario EPC * 0.3 (soil to indoor dust partition coefficient from Tu et al., 2020)

mg/kg milligram per kilogram, or parts per million (ppm)
RM Reasonable Maximum scenario
Protocol 1 Protocol 1 scenario
CT Central Tendency scenario
EPC Exposure point concentration

6.1.3 Air

As summarized in **Section 4.2.3.1**, TSP is measured every second day, over 24-hour periods, at Butler Park in East Trail, located approximately 1 km southeast of the smelter, and at Birchbank located approximately 8.5 km north of the smelter. TSP Pb concentrations have steadily declined over the last decade since the implementation of the FDRP, with the minor fluctuations observed in 2022-2023 influenced by an extended maintenance turnaround and the work to return to stable operations post-turnaround. To be health protective, the average annual TSP concentration measured at Butler Park (the station nearest the smelter and with the higher concentrations of the two stations) over the last five years (2019 to 2023) of 0.077 µg/m^3 has been used as the air EPC for to estimate exposures for all three scenarios.

6.2 Receptor Characteristics

Health Canada (2018 [for indoor dust] and 2024) receptor characteristics have been used in the estimation of exposures to Pb in soil, indoor dust, and air, with additional sources referenced as required. A summary of the receptor characteristics used to estimate exposures are summarized in the following sections.

6.2.1 Age Groups

Exposures have been estimated for all age groups, including:

- Infants (ages 0 to less than 6 months);
- Young children (ages 6 months to less than 5 years);
- Older children (ages 5 years to less than 12 years);
- Adolescents (ages 12 years for less than 19 years); and
- Adults (19 years and older).

6.2.2 Body Weight (BW)

Health Canada (2024) was used as the key source of information for body weight. Consistent with BC ENV and the Canadian Council for Ministers of the Environment (CCME) (2006) practice in the development of soil quality standards/guidelines, average body weights provided in Health Canada (2024), and adopted from Richardson (1997), have been used to estimate CT scenario exposures. These average body weights have also been used to estimate the Protocol 1 scenario estimates as recommended in Protocol 1 (BC ENV, 2023b). The source data used by Health Canada to estimate the average body weights was reviewed. Richardson (1997) presents a summary of the recommendations as the arithmetic mean body weights with standard deviation. To estimate the RM exposures, the lower end of the range (calculated as the standard deviation subtracted from the arithmetic mean) was used. The body weights used in the RM and CT estimates are summarized in **Table 6-3**.

Table 6-3: Body Weights

Receptor Group	Body Weight (kg)	
	RM* Scenario	Protocol 1 and CT Scenarios
Infant children (ages 0 to less than 6 months)	5.3	8.2
Young children (ages 6 months to less than 5 years)	12	16.5
Older children (ages 5 years to less than 12 years)	24	32.9
Adolescents (ages 12 years for less than 19 years)	46.2	59.7
Adults (19 years and older)	56.2	70.7

Note:
RM* Scenario Reasonable Maximum; calculated based on data from Richardson, 1997 by subtracting the standard deviation from the arithmetic mean.
CT and Protocol 1 Scenarios Central Tendency; mean body weights provided by Health Canada, 2024.

6.2.3 Soil Ingestion Rate (SIR)

Upper bound soil ingestion rates used to estimate RM exposures for the various age groups were obtained to from Health Canada (2024). The Health Canada (2024) soil ingestion rate of 80 mg/day for young children (age 6 months to less than 5 years) was also used for older children as both Wilson et al. (2013) and US EPA (2017) have concluded that older children (5 to less than 12 years) incidentally ingest approximately the same amount of soil as young children. For adolescents and adults, the Health Canada (2024) soil ingestion rate of 20 mg/day was selected to estimate RM exposures both age groups. Incidental soil ingestion was not identified as an operable exposure pathway for infants and thus, no soil ingestion rate was identified for this age group. It is noted that exposures to indoor dust (via ingestion and inhalation) been estimated for infants, using the exposure rates presented in the following section.

The Health Canada (2024) upper-bound soil ingestion rates were also used to estimate Protocol 1 scenario exposures for the various age groups; however, the Health Canada (2024) soil ingestion rate of 20 mg/day for older children was used for this age group.

Mean soil ingestion rates were reviewed from Stanek et al. (2012), Wilson et al. (2013) and US EPA (2017). Stanek et al. (2012) and Wilson et al. (2013) estimated arithmetic mean soil ingestion rates for a young child in the range of 20 mg/day to 30 mg/day, while the US EPA (2017) estimated a rate of up to 40 mg/day. A mean rate of 30 mg/day was used to estimate CT exposures for both young and older children (5 to 11 years).

Both Wilson et al. (2013) and US EPA (2017) have concluded that soil ingestion rates are markedly reduced for adolescents and adults as compared to young and older children and estimated an arithmetic mean soil ingestion rate in the range of 5 mg/day to 10 mg/day. A soil ingestion rate of 7.5 mg/d was selected as the arithmetic mean rate to estimate CT exposures for adolescents and adults.

The soil ingestion rates used in the HHRA in the estimation of the RM and CT exposures are summarized in **Table 6-4**.

Table 6-4: Soil Ingestion Rates

Receptor Group	Soil Ingestion Rate (mg/d)		
	RM Scenario Rate	CT Scenario Rate	Protocol 1 Scenario
Infant children (ages 0 to less than 6 months)	-	-	-
Young children (ages 6 months to less than 5 years)	80	30	80
Older children (ages 5 years to less than 12 years)	80	30	20
Adolescents (ages 12 years for less than 19 years)	20	7.5	20
Adults (19 years and older)	20	7.5	20

Note:

-	no operable soil exposure pathways were identified for infants, and therefore metric is not provided
RM	Reasonable Maximum scenario
Protocol 1	Protocol 1 scenario
CT	Central Tendency scenario

6.2.4 Dust Ingestion and Inhalation Rates

Health Canada (2018) provides recommended dust ingestion rates and references several studies where additional information on dust ingestion can be found. The Health Canada (2018) rates were selected to estimate the CT and Protocol 1 scenario exposures, while Wilson et al. (2013) was reviewed to identify upper bound dust ingestion rates to estimate RM exposures.

Table 6-5 summarizes the indoor dust ingestion rates used to estimate the RM, CT and Protocol 1 scenario exposures.

Table 6-5: Indoor Dust Ingestion Rates

Receptor Group	Dust Ingestion Rate (mg/d)	
	RM Rate	CT and Protocol 1 Scenario Rate
Infant children (ages 0 to less than 6 months)*	38	38
Young children (ages 6 months to less than 5 years)	54	41
Older children (ages 5 years to less than 12 years)	41	31
Adolescents (ages 12 years for less than 19 years)	2.8	2.2
Adults (19 years and older)	3.3	2.5

Notes:

*	in the absence of a CT rate for infants, the RM rate for infants has been used
RM	Reasonable Maximum scenario
Protocol 1	Protocol 1 scenario
CT	Central Tendency scenario

Given the uncertainty in estimating exposure via dust inhalation versus ingestion, health agencies often recommend using a single rate (g/day) to estimate exposures via both pathways. To ensure that upper bound exposures are considered, a literature review was conducted to identify dust specific inhalation rates. Dust inhalation rates were obtained from Oomen at al. (2008). Inhaled house dust, as estimated from particles in air (mg/m^3) is generally assumed to be 7.6 m^3/d for children and 19.9 m^3/d for adults. When assuming a constant concentration of suspended particles in air of 100 µg/m^3, the amount of inhaled suspended particles is 0.8 mg/d and 2.0 mg/d for adults and children, respectively. These values were adopted for the estimation of exposures via the inhalation of indoor dust and were used to estimate exposures for all three scenarios. For infants, young children and older children, a value of 2.0 mg/d was assumed, while for adolescents and adults a dust inhalation rate of 0.8 mg/d was assumed.

In comparison and to demonstrate the conservatism in the use of the above dust ingestion rates based on a concentration of suspended particles in air of 100 µg/m^3, concentrations of suspended particles in air (i.e., suspended dust) are typically observed to range from 13 µg/m^{3}and 35 µg/m^3 inside homes, with higher concentrations found directly around persons (i.e., personal cloud) and a value of 60 µg/m^3 considered representative for moderately crowded places such as residences (Oomen and Lijzen., 2004).

Table 6-6 summarizes the indoor dust inhalation rates used to estimate exposures.

Table 6-6: Dust Inhalation Rates

Receptor Group	Dust Inhalation Rate All Scenarios (mg/d)
Infant children (ages 0 to less than 6 months)	2.0
Young children (ages 6 months to less than 5 years)	2.0
Older children (ages 5 years to less than 12 years)	2.0
Adolescents (ages 12 years for less than 19 years)	0.8
Adults (19 years and older)	0.8

6.2.5 Air Inhalation Rates

Health Canada (2024) recommended inhalation rates have been used for all age groups to estimate exposures for each of the exposure scenarios, including:

- Infants: 2.2 m^3/d;
- Younger children: 8.3 m^3/d;
- Older children: 14.5 m^3/d;
- Adolescents: 15.6 m^3/d; and
- Adults: 16.6 m^3 /d.

6.2.6 Time Spent Indoors and Outdoors

In accordance with Health Canada (2024) guidance, residential receptors were assumed to be present at home 24 hours per day, 7 days per week for 52 weeks per year. Based on the climate data for the region, snow cover is present for approximately 13 weeks of the year and thus exposures to soils would not occur during this period. However, to not underestimate exposures and associated risks, it has been assumed that residential receptors have the potential to be exposed year round. Additionally, it was assumed that outdoor air exposures to TSP Pb would occur for up to 8 hours per day, in addition to the assumed 24-hour exposure time for inhalation of Pb in indoor dust. Although these values exceed 24 hours in a day, this was assumed due to the potential for days with no outdoor time.

6.3 Bioavailability Assessment

Bioavailability factors considered for Pb for the oral and inhalation exposures are detailed below.

6.3.1 Oral Bioaccessibility

When soil containing Pb is ingested, Health Canada (2010 and 2021a) indicate that the *in vitro* bioaccessibility (IVBA) assay coupled with the US EPA (2007) regression equation can be used to estimate the relative absorption factor across the gastrointestinal tract. Royal Roads University (2017) completed the physiological-based extraction test (PBET) on 24 soil samples collected from Trail, BC. These data indicated an IVBA of 90.9% as the 95% upper confidence limit of the mean (UCLM).

Based on the above IVBA result, the relative oral bioaccessibility of Pb in soils from Trail, BC can be estimated using the following US EPA (2007) equation:

$$AF_G = 0.878 \times IVBA - 2.8$$

where:

AF_G = relative oral bioavailability of Pb via soil ingestion route (as %)

IVBA = *in vitro* bioaccessibility assay result (as %)

Substituting the site-specific IVBA result of 90.9% into the equation above, the relative oral bioavailability in the 24 soil samples was estimated to be 77.0%.

An additional three soil samples from Trail, BC were included in the BC Environmental Laboratory Technical Advisory Committee's (BCELTAC) Round Robin Study titled In Vitro Bioaccessibilty Round Robin II Testing for Lead and Arsenic in Soil Samples (BCELTAC, 2022). PBET was run on the three samples by four BC laboratories, with each reporting three replicate analyses per sample. These data indicated an IVBA of 95.2% as the 95% UCLM of the dataset (3 samples x 3 replicates x 4 labs = 36 results). Substituting the site-specific IVBA result of 95.2% into the equation above, the relative oral bioavailability of Pb in the 3 additional soil samples was estimated to be 80.8%, which is alignment with the estimate for the 24 initial samples.

The average of the 95% UCLMs for the two datasets of 78.9% (rounded to 79%) was used in the estimation of oral exposures to Pb in this HHRA.

6.3.2 Inhalation Absorption

As per Health Canada (2010, 2024) guidance, 100% absorption was assumed in the estimation of inhalation exposures.

6.4 Exposure Intake Equations

Health Canada (2018 and 2024) exposure intake equations have been used to estimate exposures to Pb via each of the operable exposure pathways identified. The equations are provided below.

6.4.1 Direct Contact with Soil and Dust

6.4.1.1 Incidental Ingestion

Incidental soil and dust ingestion exposures were estimated according to the following Health Canada (2024) equation:

$$EIG = \frac{C \times IG \times RAF_{ORAL} \times D_2 \times D_3}{BW}$$

Where:

EIG	=	exposure from the ingestion pathway (µg/kg body weight[bw]/day)
C	=	chemical concentration (µg/g) in soil or indoor dust
IG	=	ingestion rate of person (g/day)

RAF_{ORAL} = relative absorption factor from gastrointestinal tract (unitless, 0.79 or 79% used)

D_2 = days per week exposed/7 days (unitless)

D_3 = weeks per year exposed/52 weeks (unitless)

BW = body weight of person (kg)

6.4.1.2 Inhalation of Soil Particulate

There is the potential for inhalation of soil particulate or dust originating from surface soils. The inhalation of soil particulate was evaluated through the calculation of a dose (µg/kg bw/d) due to the absence of an inhalation specific TRV for Pb.

As per Health Canada guidance (2024), an airborne particulate matter concentration of respirable particulate matter (i.e., PM_{10}) of 0.76 µg/m^3 was assumed.

Soil particulate inhalation exposure was estimated as per the following equation (Health Canada, 2024):

$$EIS = \frac{C_s \times P_{air} \times IR_A \times RAF_{INH} \times D_1 \times D_2 \times D_3}{BW}$$

Where:

EIS = exposure from the inhalation pathway for soil (µg/kg bw/d)

C_S = soil chemical concentration (µg/g)

P_{Air} = particulate concentration in air (g/m^3)

IR_A = air intake rate (m^3/day)

RAF_{INH} = relative absorption factor by inhalation (unitless, 1.0 or 100% assumed)

D_1 = hours per day exposed/24 hours (unitless)

D_2 = days per week exposed/7 days (unitless)

D_3 = weeks per year exposed/52 weeks (unitless)

BW = body weight (kg)

6.4.2 Inhalation of Outdoor Air

Exposure to Pb in outdoor air (as TSP Pb) was estimated using the following Health Canada (2024) equation. Like the estimation of exposures to soil particulate, exposures were estimated as a dose in the absence of an inhalation TRV for Pb.

$$EIA = \frac{C_{air} \times IR_A \times RAF_{INH} \times D_1 \times D_2 \times D_3}{BW}$$

Where:

EIA = exposure from the inhalation TSP Pb (µg/m^3)

C_{air} = outdoor air concentration (µg/m^3)

IR_A = inhalation rate (m^3/day)

RAF_{INH} = relative absorption factor by inhalation (unitless, 1.0 or 100% assumed)

D_1 = hours per day exposed/24 hours (unitless)

D_2 = days per week exposed/7 days (unitless)

D_3 = weeks per year exposed/52 weeks (unitless)

BW = body weight (kg)

6.4.2.1 Inhalation of Indoor Dust

Dust inhalation exposure was estimated as per the following equation, which was modified from Health Canada (2024):

$$EID = \frac{C_{dust} \times IG \times RAF_{INH} \times D_2 \times D_3}{BW}$$

Where:

EID = exposure from the indoor dust inhalation pathway (µg/kg bw/day)

C_{dust} = chemical concentration (µg/g) in indoor dust

IDR = indoor dust inhalation rate (g/day)

RAF_{INH} = relative absorption factor by inhalation (unitless, 1.0 or 100% assumed)

D_2 = days per week exposed/7 days (unitless)

D_3 = weeks per year exposed/52 weeks (unitless)

BW = body weight of person (kg)

7. Toxicity Reference Values for Pb

BC ENV requires that the Health Canada recommended provisional TRV for Pb of 0.5 µg/kg bw/day be used to estimate risks to children.

The basis of the Health Canada provisional TRV is a benchmark dose (lower confidence limit) for a 1% incremental risk ($BMDL_{01}$) from European Food Safety Authority (EFSA, 2013), which is based on an estimated blood Pb level of 1.2 µg/dL for a 1 point IQ decrement in children. Similarly, the World Health Organization (WHO)/Food and Agriculture Organization (FAO) (2011) estimated a blood Pb level of 2 µg/dL for a 1 point IQ decrement in children. The pooled analysis of Lanphear et al. (2005) involving more than 1,300 children was selected as the basis of the EFSA (2013) and WHO (2011) analyses. Although EFSA (2013) arrived at conclusions that suggested Pb was approximately twice as potent as WHO (2011) when expressed as blood levels (i.e., for a 1 IQ point decrement, WHO concluded a blood Pb level of 2 µg/dL versus the EFSA estimate of 1.2 µg/dL), the key difference was that EFSA was based on a 95% lower confidence limit approach while WHO (2011) concluded that a central estimate provided reasonable protection. Despite their differences in selecting BLLs, WHO (2011) and EFSA (2013) provided very similar potency estimates when expressed as intake rates associated with a 1 IQ point decrement: WHO (2011) concluded that 0.6 µg/kg bw/d while EFSA (2013) concluded that 0.5 µg/kg bw/d (primarily due to reliance of different toxicokinetic relationships).

The Health Canada TRV was adopted from EFSA (2013) and has been recommended across all age groups; however, it is widely accepted that the critical effect of Pb in children (IQ decrement) and adults (systolic blood pressure) differ. Although not documented, it is understood that Health Canada's application of the 0.5 µg/kg bw/day TRV across all age groups is to protect women of childbearing age, and potential fetal exposure.

Wilson and Richardson (2013) developed risk specific doses (RSDs) for toddlers and adults of 0.6 µg/kg bw/d and 1.3 µg/kg bw/d, respectively, based on WHO (2011). The recommended TRVs were used by BC ENV in the derivation of the numerical soil standards for Pb and the TRVs are included in BC ENV's Protocol 28 (BC ENV, 2024). Wilson and Richardson (2013) considered women of childbearing age and the potential for fetal exposure. Based on lower Pb oral absorption for adults (40% of the rate of children) and assuming a fetal cord: maternal BLL concentration ratio of 1.0, an RSD for women of childbearing age (for 1 IQ point decrement) was estimated to be 1.5 µg/kg bw/day. Wilson and Richardson (2013) indicated that the fetal (umbilical cord) to maternal blood Pb concentration ratio is approximately 0.9 (with reference to ATSDR, 2007), with a range of approximately 0.7 to 0.9.

- Using this approach, along with the Health Canada provisional TRV of 0.5 µg/kg bw/day, a TRV for an adult is calculated as:
    - 0.5 µg/kg bw/day ÷ 0.4 = 1.25 (rounded to 1.3) µg/kg bw/day

The calculated TRV of 1.3 µg/kg bw/day is equivalent to the RSD developed by Wilson and Richardson (2013) based on a 1 mmHg increase in systolic blood pressure. Therefore, a TRV for Pb of 1.3 µg/kg bw/day for adults is protective of both blood pressure effects and effects to the fetus for women who are pregnant or who could potentially become pregnant.

In summary, the following Pb TRVs will be used in the HHRA:

- Adults and adolescents (> 12 years of age to 19 years of age), including women of childbearing age: 1.3 µg/kg bw/day; and
- Infants, toddlers and children (≤ 11 years of age): 0.5 µg/kg bw/day.

8. Risk Characterization

Risks for receptors of concern were estimated based on a comparison of RM, CT and Protocol 1 scenario exposure estimates (from **Section 6**, Exposure Assessment) to TRVs (from **Section 7**, Toxicity Assessment). As presented in **Section 7**, the TRV for children ≤ 11 years of age is expressed as a risk specific dose (µg/kg body weight/day) based on an estimated blood Pb level of 1.2 µg/dL for a 1 point IQ decrement in children. The TRV for adolescents (> 12 years of age) and adults is the TRV for children adjusted based on lower Pb oral absorption for adults (40% of the rate of children) and assuming a fetal cord: maternal BLL concentration ratio of 1.0. The adjusted TRV of 1.3 µg/kg bw/day is equivalent to the equivalent to the RSD developed by Wilson and Richardson (2013) based on a 1 mmHg increase in systolic blood pressure.

Risks associated with oral and inhalation exposures were estimated as hazard quotients (HQ) values according to the following formula:

$$HQ = \frac{\text{Estimated Exposure (µg/kg bw/day)}}{\text{Risk Specific Dose (µg/kg bw/day)}}$$

A Hazard Index (HI) (the sum of the HQs for all routes of exposure) was estimated for exposure to Pb as the sum of the individual HQ for all applicable exposure pathways as follows:

$$HI = HQ_{INGsoil} + HQ_{INHsoil\ dust} + HQ_{INGindoor\ dust} + HQ_{INHindoor\ dust} + HQ_{INHair}$$

Where:

HI = hazard index

HQ = hazard quotient

INGsoil = ingestion of soil

INHsoil dust = inhalation of soil dust/soil particulate

INGindoor dust = ingestion of indoor dust

INHindoor dust = inhalation of indoor dust

INHair = inhalation of air (as TSP Pb)

According to the BC CSR, total HIs were interpreted according to the following:

- ≤ 1 = no unacceptable human health risks
- > 1 = potential unacceptable risks which may require detailed analysis that considers the uncertainty in the risk estimates and/or risk management

In all cases, however, interpretation of HI values requires careful consideration of all uncertainties in the risk assessment before final conclusions can be made.

Given the compounded conservatism in the HHRA model, including the assumption of a linear soil Pb to BLL dose-response relationship, the HHRA model overpredicts exposures and associated risks. Given this, the estimated HIs are health protective, and where HIs ≤ 1 have been predicted for the CT scenario, there is confidence that there are no unacceptable human health risks. Where HQs > 1 have been predicted for this scenario, further consideration of the uncertainties in the risk estimates is required. The uncertainties in the HHRA are discussed in **Section 10**, along with the implications of those uncertainties on the results of the HHRA.

8.1 Risk Estimates for Residents

As discussed, residential receptors were identified as the primary receptors of concern in the HHRA. While young children (ages 6 months to 5 years) were identified as the most sensitive age group, exposures and associated risks to all age groups were quantified. The characterization of risks to residential receptors in the Trail area is protective of other receptor groups including agricultural and industrial workers. While further information is required to understand Indigenous peoples' traditional use of plants in the EM Area, the characterization of exposures via the other media evaluated in the HHRA (i.e., soil, air, indoor and outdoor dust) for the residential receptors is protective of those potentially experienced by Indigenous peoples.

A summary of the HIs estimated for the residential receptor exposed to Pb in soil, air and indoor and outdoor dust in the Trail area is presented in **Table 8-1** and in **Appendix A,** with **Tables I-1** to **I-40** presenting the results for the RM and CT scenarios, and **Tables 1-41** to **I-60** presenting the results from the Protocol 1 scenario**.** The HQs are presented by THEP Assessment Area (i.e., 0. 1, 2 and 3), further broken down by neighbourhood. The HIs are presented for the RM, CT and Protocol 1 scenarios and for all age groups. Worked calculations for exposure and risk estimates are included in **Appendix C**.

Table 8-1: Hazard Indices for Residential Receptors

THEP Assessment Area	Neighbourhood	Infant			Young Child			Older Child			Adolescent			Adult		
		RM	CT	P1	RM	CT	P1	RM	CT	P1	RM	CT	P1	RM	CT	P1
0	Montrose	0.8	0.2	0.5	**2.2**	0.4	**1.2**	**1.1**	0.2	0.3	0.06	0.02	0.05	0.2	0.02	0.1
1	Annable	**2.7**	0.8	**1.7**	**7.5**	**1.3**	**4.1**	**3.6**	0.7	0.8	0.2	0.04	0.1	0.1	0.04	0.1
1	Casino	**2.6**	0.4	**1.7**	**7.1**	0.8	**3.9**	**3.4**	0.4	0.8	0.2	0.03	0.1	0.1	0.03	0.1
1	Columbia Gardens	**1.9**	0.5	**1.3**	**5.3**	1.0	**3.0**	**2.6**	0.5	0.6	0.1	0.03	0.1	0.1	0.03	0.1
1	Oasis	**3.6**	0.9	**2.3**	**10.0**	**1.7**	**5.5**	**4.8**	0.8	**1.1**	0.2	0.05	0.2	0.2	0.04	0.1
1	Waneta	**2.7**	0.6	**1.7**	**7.4**	**1.2**	**4.1**	**3.5**	0.6	0.8	0.2	0.04	0.1	0.1	0.03	0.1
1	Warfield	**1.9**	0.5	**1.2**	**5.3**	0.9	**2.9**	**2.5**	0.5	0.6	0.1	0.03	0.1	0.1	0.03	0.1
2	Glenmerry	**4.4**	**1.1**	**2.8**	**12.1**	**2.0**	**6.7**	**5.8**	1.0	**1.3**	0.3	0.06	0.2	0.2	0.05	0.2
2	Miral Heights	**1.1**	0.3	0.7	**3.0**	0.5	**1.7**	**1.5**	0.3	0.4	0.1	0.02	0.1	0.1	0.02	0.1
2	Shavers Bench	**7.1**	**1.8**	**4.6**	**19.7**	**3.2**	**10.9**	**9.4**	**1.5**	**2.1**	0.4	0.08	0.3	0.4	0.07	0.3
2	Sunningdale	**3.8**	**1.1**	**2.4**	**10.4**	**1.9**	**5.7**	**5.0**	0.8	**1.1**	0.2	0.05	0.2	0.2	0.05	0.2
3	East Trail	**15.4**	**3.6**	**9.9**	**44.6**	**6.6**	**24.5**	**21.2**	**3.1**	**4.6**	1.0	0.2	0.7	0.8	0.1	0.6
3	Rivervale	**5.4**	**1.2**	**3.5**	**15.6**	**2.3**	**8.6**	**7.5**	**1.1**	**1.6**	0.3	0.1	0.3	0.3	0.1	0.2
3	Tadanac	**15.3**	**3.5**	**9.8**	**44.1**	**6.4**	**24.2**	**21.0**	**3.0**	**4.5**	0.9	0.1	0.7	0.8	0.1	0.6
3	West Trail	**7.7**	**2.0**	**5.0**	**22.2**	**3.8**	**12.2**	**10.6**	**1.8**	**2.3**	0.5	0.1	0.4	0.4	0.1	0.3

Notes:
RM Reasonable Maximum Scenario
CT Central Tendency Scenario
P1 Protocol 1 Scenario
Bold RM or CT Scenario HI greater than 1.0, the CSR risk-based standard
Underline CT Scenario HI greater than 1.0, the CSR risk-based standard
Double underline Protocol 1 Scenario HI greater than 1.0, the CSR risk-based standard

As presented, the HHRA predicted HIs for infants exposed to Pb in indoor dust and air, as well as young children and older children exposed Pb in soil and dust on other outdoor surface, indoor dust and air, were greater than the CSR risk-based standard of 1.0 in select neighbourhoods across assessment areas 1, 2 and 3. Higher HIs were predicted for the RM scenario and for neighbourhoods nearest the smelter, with maximum HIs predicted for East Trail and Tadanac. No HIs > 1 were predicted for adolescents and adults across all neighbourhoods and scenarios. As noted, the characterization of residential receptors is protective of other receptor groups, with further information required to understand the Indigenous peoples' traditional use of plants in the EM Area.

As described in earlier sections of this report, the RM scenario represents a worst-case scenario, while the CT scenario represents an average or more typical exposure scenario. The Protocol 1 scenario was included to comply with BC ENV's Protocol 1 (BC ENV, 2023b) requirements for deterministic risk assessment.

Given the conservatism in the HHRA model, which assumes a linear Pb exposure to BLL dose-response, compounded by the conservatism in the assumptions made, including that people would not wash their hands or take precautions to prevent ingestion or soil and dust, the RM scenario grossly overestimates exposures to Pb, and while the Protocol 1 scenario is moderately less conservative, it too overestimates exposures. As discussed in the following sections, this is supported by the blood Pb data that has been collected in the Trail area for the last 22 years. As noted in **Section 8.2**, BLLs predicted by the HHRA for the RM scenario are as high as 53 µg/dL for East Trail, with the BLLs predicted for select neighbourhoods higher than those that have ever been measured in the community, including in the 1990s when geomean BLLs were approximately five times what they are today. The BLLs predicted for the Protocol 1 scenario were also in some cases higher than those that have been measured, with levels as high as 29 µg/dL for East Trail and Tadanac. While the CT 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. For example, the BLL predicted by the HHRA for the CT scenario for East Trail is 7.8 µg/dL, which is still higher than the measured BLLs, but more reasonable than the RM and Protocol 1 scenario BLLs of 53 µg/dL and 29 µg/dL, respectively.

Based on the above discussion and the Health Canada provisional TRV, where CT HIs $\leq$ 1 have been predicted, there is confidence that human health risks are negligible. Where CT 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 HQs less than the BC CSR risk-based standard of $\leq$ 1.0 have been predicted for all age groups in Montrose, Casino, Columbia Gardens, Warfield and Miral Heights[15]. Central tendency scenario HQs 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. Further assessment of the results of the HHRA for these neighbourhoods was conducted using the results of Interior Health's Analysis of Variables Influencing Children's Blood Lead Levels in Trail BC (Interior Health, 2024) (see **Sections 8.3** and **8.4**).

[15] While Miral Heights is located nearer the smelter than select neighbourhoods where HQs > 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.

8.2 Blood Pb Levels Predicted Based on the HHRA

The range of HIs predicted by the HHRA, as represented by the RM and CT scenarios, were used, along with the basis of the Health Canada TRV for Pb, to predict BLLs. The Health Canada TRV of 0.5 µg/kg bw/day is based on a 1 IQ point decrement associated with a 1.2 µg/dL BLL; in other words, an exposure dose of 0.5 µg/kg bw/day has the potential to result in a 1.2 µg/dL BLL, which has been associated with a 1 IQ point decrement. Using this relationship, a HI of 1 (i.e., dose of 0.5 µg/kg bw/day / TRV of 0.5 µg/kg bw/day) equates to a 1.2 µg/dL BLL. Therefore, to predict BLLs from the HIs estimated in the HHRA, the HIs were multiplied by a factor of 1.2. A summary of the BLLs predicted for young children based on the results of the HHRA is presented in **Table 8-2**.

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. As the HHRA predicted BLLs were estimated based on exposures from Teck Trail Operations (i.e., from air, soil and dust), the background BLL of 0.5 µg/dL has been added to the predicted BLLs to estimate total BLL (including from background exposures). The RM and CT BLLs, with the addition of background BLL, are also presented in **Table 8-2**.

Table 8-2: Blood Pb Levels Predicted for Young Children Based on the HIs from the HHRA – RM and CT Scenarios

THEP Assessment Area	Neighbourhood	RM HI	RM BLL* (µg/dL)	RM BLL + BG BLL of 0.5 (µg/dL)	CT HI	CT BLL*	CT BLL + BG BLL of 0.5 (µg/dL)
0	Montrose	2.2	2.6	3.1	0.4	0.5	1.0
1	Annable	7.5	9.0	9.5	1.3	1.6	2.1
1	Casino	7.1	8.5	9.0	0.8	1.0	1.5
1	Columbia Gardens	5.3	6.4	6.9	1.0	1.2	1.7
1	Oasis	10.0	12.0	12.5	1.7	2.0	2.5
1	Waneta	7.4	8.9	9.4	1.2	1.4	1.9
1	Warfield	5.3	6.4	6.9	0.9	1.1	1.6
2	Glenmerry	12.1	14.5	15.0	2.0	2.4	2.9
2	Miral Heights	3.0	3.6	4.1	0.5	0.6	1.1
2	Shavers Bench	19.7	23.6	24.1	3.2	3.8	4.3
2	Sunningdale	10.4	12.5	13.0	1.9	2.3	2.8
3	East Trail	44.6	53.5	54.0	6.6	7.9	8.4
3	Rivervale	15.6	18.7	19.2	2.3	2.8	3.3
3	Tadanac	44.1	52.9	53.4	6.4	7.7	8.2
3	West Trail	22.2	26.6	27.1	3.8	4.6	5.1

Notes:
RM Reasonable Maximum Scenario
CT Central Tendency Scenario
HI Hazard Index
BLL Blood Pb Level predicted based on the HQ
* BLL estimated by HQ * 1.2 (based on the following: HC TRV of 0.5 µg/kg bw/day = 1 IQ decrement = 1.2 µg/dL BLL)

The following figures present the predicted BLLs, with the addition of background BLL, based on the results of the HHRA plotted against soil Pb concentrations. **Figure 8-1** presents the predicted BLLs for a young child for the RM scenario, and **Figure 8-2** presents the BLLs for a young child for the CT scenario.

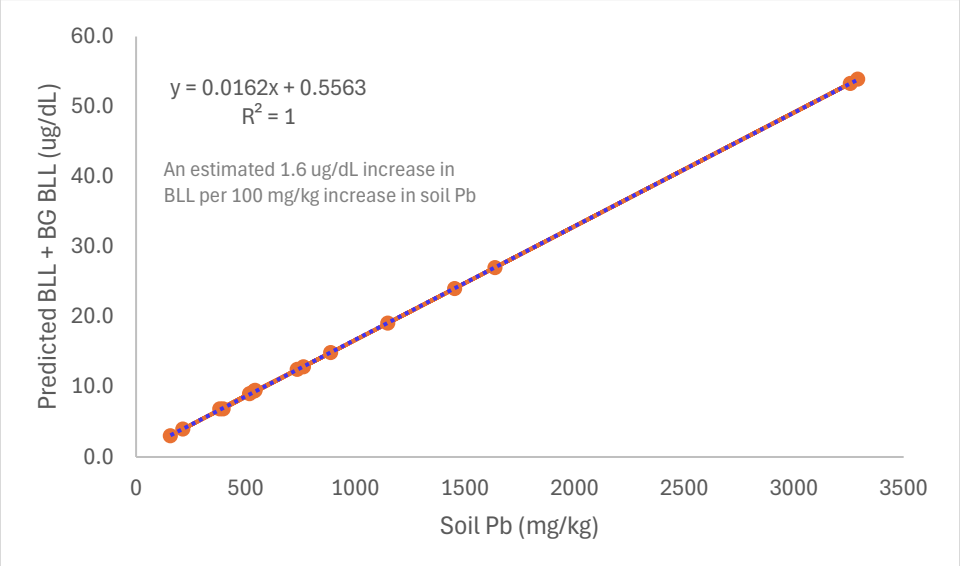


Figure 8-1: BLLs Predicted Based on the Results of the HHRA vs. Soil Pb Concentrations – Young Child, Reasonable Maximum Scenario

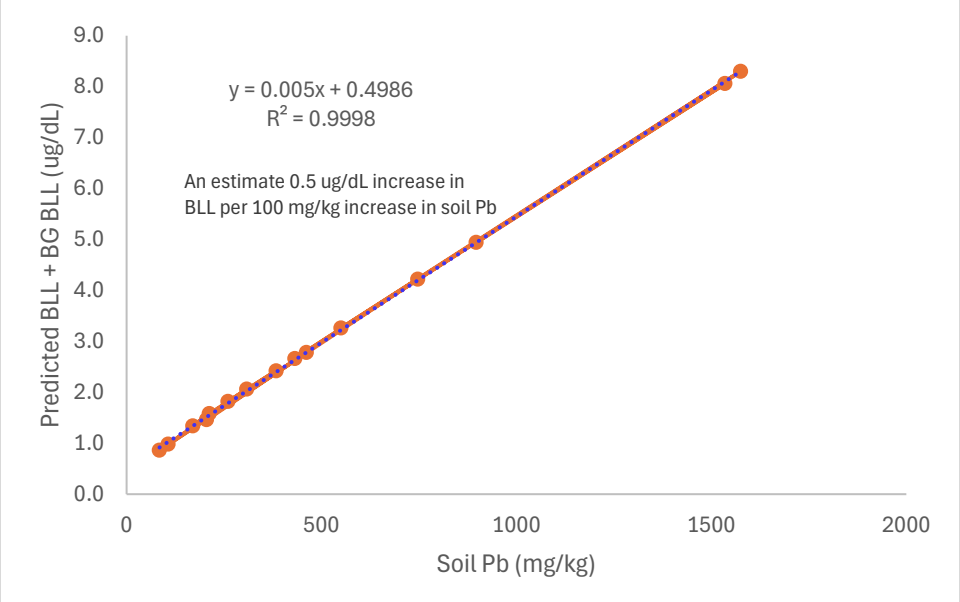


Figure 8-2: BLLs Predicted Based on the Results of the HHRA vs. Soil Pb Concentrations – Young Child, Central Tendency Scenario

As presented in **Table 8-2** and in **Figure 8-1** and **Figure 8-2**, BLLs predicted based on the results of the HHRA (including background BLL) for the RM are as high as 53.9 µg/dL at a soil Pb concentration of 3,291 mg/kg, the soil exposure point concentration for the RM estimates for East Trail. The BLLs predicted based on the HHRA for the CT scenario include a predicted BLL of 8.3 µg/dL at a Pb soil concentration of 1,575 mg/kg, the mean soil Pb concentration in East Trail, which was used as the soil exposure point concentration for the CT estimates.

Based on the data presented in **Figure 8-1** and **Figure 8-2**, the following was predicted:

- RM Scenario: for every 100 mg/kg increase in Pb in soil, there is a 1.6 µg/dL increase in BLL; and
- CT Scenario: for every 100 mg/kg increase in Pb in soil, there is a 0.5 µg/dL increase in BLL.

These relationships are further discussed in **Section 8.3** and are compared to the soil Pb to BLL relationship estimated based on the measured BLLs in the EM Area.

8.3 Analysis of Variables Influencing Children's Blood Lead Levels in Trail BC

Interior Health conducted an analysis of the blood Pb data collected from the Trail area during the period of 2007 to 2023 to explore the relationship between soil Pb concentrations, other environmental Pb data and household level variables on child BLLs in the Trail area (Interior Health, 2024). The work was conducted with the objective to answer the following primary questions, with additional factors such as household income and home age also considered:

1. What is the association between soil Pb concentrations and child BLLs?
2. What is the association between pre- and post-remediation soil Pb concentrations and pre- and post-remediation child BLLs?
3. What is the impact Pb in air (as TSP) on child BLLs in East Trail and Shavers Bench, near the smelter where TSP concentrations are measured?

The methods used in the analyses are detailed in the Interior Health report summarizing the results (Interior Health, 2024). Briefly, the analyses involved matching each blood Pb sample collected from children ages 6 to 36 months from the Trail area during the period of 2007 to 2023 (maximum of 3 samples per child) with the THEP family ID to determine soil Pb concentrations, and other factors considered in the analyses. Soil exposures for children with blood Pb data were calculated as the percentage of time spent at a property (for children that spend time at more than one property) multiplied by the soil Pb 95% UCLM, which was then summed over each child's family IDs. A total of 1,233 unique blood Pb samples with associated soil data were considered; of those samples, 997 were taken before soil remediation.

The results of the analysis indicated the following, with additional details provided in Interior Health (2024):

- A weak to moderate linear relationship between soil Pb concentrations child BLLs, conservatively estimated (i.e., based on a univariate analysis) as a 0.1 µg/dL increase in BLL for every100 mg/kg increase in Pb in soil.
- A moderate linear relationship between TSP Pb concentrations and child BLLs.
- A weak to moderate linear relationship between median household income and child BLLs.
- A weak to moderate linear relationship between house age and child BLLs.

- A moderate to strong relationship between someone in the household working in a Pb based industry and child BLLs.
- Inconclusive results regarding the impact of soil remediation on child BLLs.

8.4 Reconciling the Results of the HHRA with Measured BLLs

As demonstrated in **Sections 8.2** and **8.3**, the BLLs predicted based on the results of the HHRA tend to exceed measured BLLs. This discrepancy is due, at least in part, to the HHRA model which assumes a linear relationship between soil Pb and BLL; however, the empirical blood Pb data in the Trail area (and elsewhere as indicated in the literature) does not support this at the range of soil Pb concentrations in the Trail area.

This linear relationship is not supported by the measured blood Pb data at the range of soil Pb concentrations in the Trail area. As discussed in **Section 8.2**, using the results of the HHRA and the basis of the Health Canada TRV for Pb (i.e., 0.5 µg/kg bw/day = 1 IQ decrement = 1.2 µg/dL BLL) the following is predicted:

- RM Scenario: for every 100 mg/kg increase in Pb in soil, there is a 1.6 µg/dL increase in BLL.
- CT Scenario: for every 100 mg/kg increase in Pb in soil, there is a 0.5 µg/dL increase in BLL.

As noted, Interior Health's univariate analysis of the blood Pb data that has been collected in Trail for over the last two decades indicated a weak-moderate positive relationship between soil Pb and measured BLL (Interior Health, 2024). It is noted that the univariate analysis does not consider exposures to Pb in non-soil sources, and thus, overpredicts the relationship between soil Pb and BLL. When the measured BLLs were plotted against the soil Pb concentrations at the propert(ies) where the child resides/spends time (N = 997), the line of best fit suggests the following:

- Interior Health (2024): for every 100 mg/kg increase in Pb in soil, there is a 0.1 µg/dL increase in BLL.

Figure 8-3 presents the predicted BLLs for a young child based for the CT and RM scenarios from the HHRA and the measured BLLs (analysis conducted by Interior Health and presented in Interior Health, 2024) plotted against soil Pb concentrations.

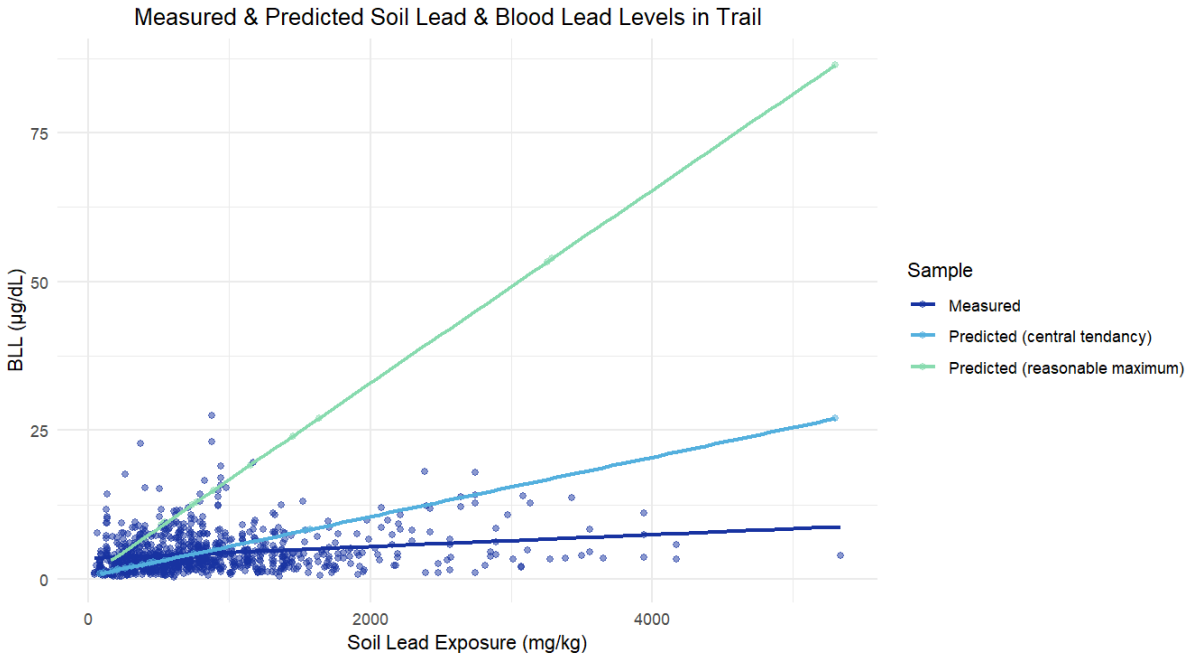


Figure 8-3: BLLs Predicted Based on the Results of the HHRA (Young Child, RM and CT Scenarios) and Measured BLLs vs. Soil Pb Concentrations

As presented in the above figure, the HHRA underpredicts BLLs at soil concentrations of approximately 100 mg/kg for the RM scenario, and at approximately 800 mg/kg for the CT scenario. This underprediction suggests that other sources of Pb, or exposures via media not evaluated in the HHRA, are influencing measured BLLs. Despite the conservatism in the HHRA model and assumptions and the overprediction of exposures from soil and dust, below these soil concentrations the BLLs are underpredicted, emphasizing the importance of other sources of Pb in the Trail area. This is further supported by the results of Interior Health's analysis (Interior Health, 2024), which demonstrated that Pb in TSP, household income, home age and having a person in the home working in a Pb based industry are equally or more strongly correlated with child BLLs as soil Pb.

Studies conducted in other smelter and mining communities have predicted a similar soil Pb to BLL relationship. Dong et al. (2020) evaluated the relationship between soil Pb and BLL using an individual house level model in Broken Hill, the oldest silver-zinc-Pb mining community in Australia. A multivariate regression analysis including demographic parameters was used, with the BLL measured for children in a home each year over 25 years regressed against the mean soil Pb of the same home. The results indicated that a soil Pb increase of 100 mg/kg is associated with a 0.12 µg/dL increase in BLL.

von Lindern et al. (2003) used data from the Bunker Hill Superfund Site in Idaho, which includes an abandoned Pb/zinc mining and smelting complex, as well as waste deposits. The von Lindern et al. (2003) linear regression approach used data from after the smelter closed in 1981. The results indicated that a soil Pb concentration of 1,000 mg/kg was associated with a mean BLL of near 4 µg/dL (von Lindern et al., 2003). von Lindern et al. (2003) also found that the specific contribution of a child's own yard soil to blood Pb was about 0.6 µg/dL to 1 µg/dL per 1,000 mg/kg, with community-wide soil concentrations having a greater effect (1.5 µg/dL to 2.5 µg/dL per 1,000 mg/kg). It is noted that based on the finding of von Lindern et al. (2003) and other studies (Sheldrake and Stifelman, 2003; Laidlaw et al., 2014; von Lindern et al., 2016; Lyle et al., 2021) that indicate the potential for community-wide soil Pb to contribute more than individual yards to exposure to Pb in soil and dust, THEP has included parks and other community spaces in the SMP, and in 2023 implemented the block program whereby entire blocks with 95% UCLM Pb soil concentrations greater than 1,200 mg/kg are remediated.

Studies indicate that soil Pb to BLL is a nonlinear relationship and that Pb absorption may be a capacity-limited process (ATSDR, 2020; Mielke et al., 2007; Mielke et al., 2011, Gulson and Taylor, 2017). Mielke et al (2007) observed that below a soil Pb concentration of 100 mg/kg there is a steep BLL exposure response in children, while above 300 mg/kg the BLL exposure response is gradual, resulting is a curvilinear relationship. This nonlinear relationship cannot be accounted for using the available information and standard CSR risk assessment methods, and thus, the resulting exposure and risk estimates are overpredicted.

8.5 Contributions to Overall Exposure

The results of the HHRA suggest that Pb in soil is the primary contributor to estimated exposure (as well as associated risks and BLLs) for children in the Trail area. The following schematic presents the estimated contribution from the various exposure pathways to overall Pb exposure, with contributions from soil and outdoor dust, indoor dust, and TSP in current emissions to exposure based on the results of the HHRA.

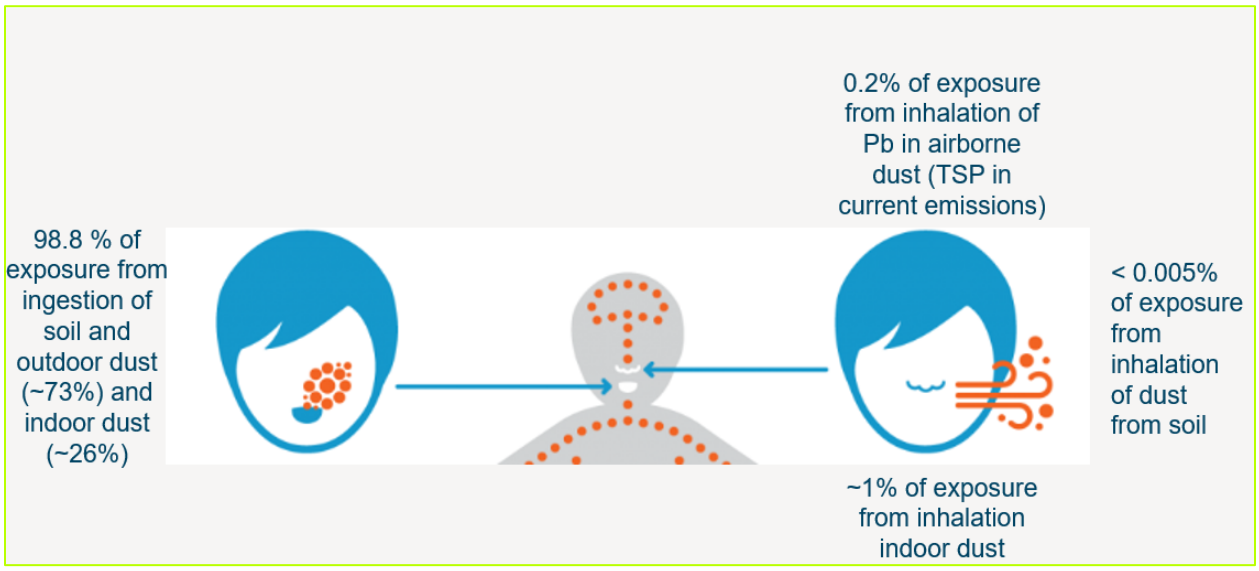


Figure 8-4: Estimated contribution of inhalation (indoor dust, dust from soil and TSP in current emissions) and ingestion (soil and outdoor dust, indoor dust) to overall exposure, based on the results of the HHRA

As presented, the results of the HHRA indicate that ingestion of soil (including outdoor dust) contributes most significantly to overall exposure, with ~73% of the overall exposure coming from this pathway. The ingestion of indoor dust is the second highest contributor, at ~26% of the overall exposure. The inhalation of indoor dust, airborne dust from current emissions (as TSP) and dust generated from soil contribute the remaining ~1.2%.

This finding is inconsistent with studies of exposures in mining and smelting communities. In the last two decades, studies conducted in the USA, Australia, and Canada, including in Trail, have found that atmospheric Pb dust is likely the dominant source of elevated BLL in children (Hilts, 2003; Gulson et al., 2013). Closures of a Pb-zinc smelter in Boolaroo, Australia, a Pb smelter in Noyelles-Godault, France, and the metallurgical complex in Flin Flon, Manitoba, all resulted in decreased children's BLLs after the closures, with no change in soil concentrations (i.e., no remediation) (Dalton and Bates, 2005; Declercq et al., 2006; Intrinsik, 2019).

Consistent with the literature, the 2003 Trail study (Hilts, 2003) and more recent air and blood Pb data collected in the Trail area indicate that decreasing Pb in air emissions results in a concurrent decrease in mean BLLs. When the new smelter technology (i.e., KIVCET) was implemented in 1997, a dramatic decrease in mean BLLs was observed, with mean levels decreasing from 11.5 µg/dL in 1996 to 5.9 µg/dL in 1999 (Hilts, 2003) with no change in soil Pb concentrations. In the summer of 2001, smelting and refining operations in Trail were shut down for three months, and the average BLL decreased to 4.7 µg/dL. This finding is also supported by Interior Health's Analysis of Variables Influencing Children's Blood Lead Levels in Trail, BC , which indicated that Pb in TSP was more strongly correlated with BLLs than Pb in soil (Interior Health, 2024). Further, BLLs have continued to decrease overtime, including following the implementation of the FDRP in 2012, to the 2023 BLL geomean of 2.1 µg/dL for areas in Trail nearest the smelter. As presented in **Figure 8-5**, a strong correlation is observed between geomean BLLs in the Trail area and TSP Pb concentrations.

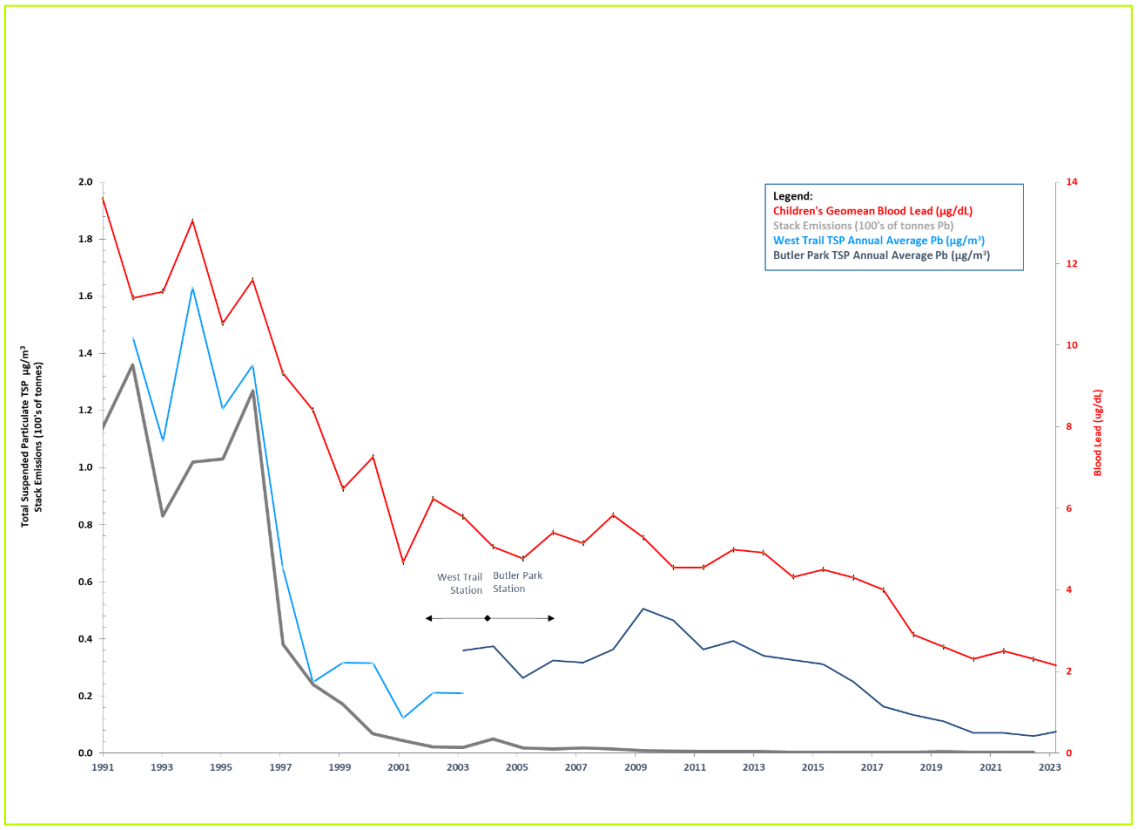


Figure 8-5: Mean Annual BLLs (µg/dL), Stack Emissions (100s of tonnes Pb) and TSP (µg/m^3) (1991 to 2023)

As observed in **Figure 8-5**, the decreases in geomean BLLs observed over the last two decades are closely aligned with decreases in TSP Pb. With the initiation of the SMP in 2019, most of the young child occupied properties with Pb soil concentrations > 400 mg/kg have been remediated, but prior to 2019 most residential properties in the Trail area had not been remediated. Despite this, a steady decline in BLLs has been observed as Pb in TSP decreased.

There is limited evidence available that soil remediation efforts alone reduce BLLs (Schoof et al., 2015; Dobrescu et al., 2022). Where there has been no significant ongoing source of Pb, studies (Aschengrau et al., 1994; Weitzman et al., 1993) have shown that there may be a modest reduction in BLLs after soil remediation, but that no benefit was found when dust was the main exposure pathway (e.g. homes with persistently elevated dust Pb loadings). A 2009 detailed evaluation (meta-analysis) conducted to determine the effectiveness of soil remediation alone in reducing BLL was inconclusive due to insufficient evidence (Yeoh et al., 2009). Dobrescu et al. (2022) also conducted a comprehensive review of previous studies to evaluate the effectiveness of soil remediation to prevent or reduce Pb exposure. Their review identified five studies (four in the US and one in Canada) that met their criteria (i.e., primary risk management of replacement of the upper layer of the soil column with clean soil, with the measured outcomes of BLL in children aged 6 months up to 12 years, dust Pb levels and soil Pb levels). Only one of the studies (Gagne, 1994) identified was conducted in an active smelter community, and the results of that study were inconclusive due to concomitant Pb reduction programs, including a ban of leaded fuel during the study and a reduction in smelter emissions, that were not controlled for. Based on the remaining four studies, Dobrescu et al. (2022) concluded that soil remediation appears to reduce BLL in children when used as a single intervention; however, the studies reviewed implemented soil replacement at soil Pb concentrations > 500 mg/kg (Lanphear et al., 2003), with the largest study replacing soils > 1,000 mg/kg (von Lindern et al., 2003) (N=1425). The authors also concluded that the incremental benefit of soil remediation is limited when other interventions are also implemented.

9. Trail Area Specific, Risk-Based Standard for Pb

As presented in **Section 8**, The HHRA has overpredicted exposures and associated risks from Pb in soil and indoor dust due to:

- The HHRA model assumes a linear relationship between soil Pb and BLL; however, the empirical blood Pb data in the Trail area (and elsewhere as indicated in the literature) does not support this at the range of soil Pb concentrations in the Trail area.
- The HHRA model predicted that soil contributes most significantly to overall exposures, however, studies indicate that Pb settled from airborne dust is likely the dominant source of elevated BLL in children.

Given this overprediction, the estimated HIs are health protective, with the HIs for the CT scenario more representative of potential Pb exposures in the Trail area. As discussed in the HHRA, exposures and risks were overpredicted for all scenarios; however, the CT scenario provides more realistic estimates. On this basis and based on the Health Canada provisional TRV, as CT HIs $\leq$ 1 have been predicted for all groups in Montrose, Casino, Columbia Gardens, Warfield and Miral Heights, the probability of adverse health risks is considered negligible. While uncertainty exists in this conclusion, the uncertainty is reduced by the comparison of the HHRA results with measured BLLs.

Where CT HQs > 1 have been predicted, further consideration of the uncertainties, including further assessment of the predicted risks based on the results of Interior Health's Analysis of Variables Influencing Children's Blood Lead Levels in Trail, BC (Interior Health, 2024), has been conducted. The results Interior Health (2024) have been considered in the derivation of a Trail area specific, risk-based standard to be applied to the EM Area.

The results of Interior Health (2024) suggest that soil Pb contributes approximately 0.1 µg/dL BLL per 100 mg/kg Pb in soil, 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. von Lindern et al. (2003) used data from the Bunker Hill and a linear regression approach and found that a child's own yard soil to blood 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.

Health Canada (2010, 2024) recommends the consideration of background exposures (including exposures from consumer products, food, air, and water that are not related to the contamination source that is being assessed) in the estimation of risks. While this approach is not required by BC ENV for risk assessments conducted under the CSR, it has been considered here. 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 Pb monitoring program in the Trail area targets children 6 months to 3 years old as 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 (2021) value of 0.5 µg/dL has been considered.

As discussed, 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.

There are several non-smelter related factors with the potential to result in the background BLL for Trail being higher than the Canadian value, including:

- 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 mg/kg 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.

Schoof et al. (2015) examined BLL trends in children ages 1 to 5 in Butte, Montana from 2003 to 2010 as compared to a reference dataset matched for child age, dates and demographic factors including poverty-to-income ratio[16], house age and race/ethnicity. Geomean BLLs for the reference population have been compared to geomean BLLs for the general US 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 US population based on 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 US population. Further, Ruckart et al. (2021) provided weighted geomean BLLs by select sociodemographic factors including income-to-poverty ratios. At an income-to-poverty 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).

As reported by Schoof et al. (2015) and Ruckart et al. (2021) weighting for demographic factors results in an approximate 1.2 times increase in geomean BLLs. Applying this factor to the geomean BLL for Canadian children of 0.5 µg/dL would result in a value of 0.6 µg/dL. To account for the influence of the younger age group represented by the Trail blood 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 has been subtracted from the 0.7 µg/dL, resulting in a remaining 0.4 µg/dL (of the 1.2 µg/dL).

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

As noted, Interior Health (2024) estimated a soil Pb to BLL relationship based on the Trail area blood 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 0.12 µg/dL per 100 mg/kg Pb in soil, it has been used to estimate a soil Pb concentration contribution which would maintain Pb exposure within a BLL of 1.2 µg/dL. Using the Interior Health estimated relationship (from Interior Health, 2024), 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 Trail area specific, risk-based standard of 400 mg/kg Pb in soil is recommended to protect children at residential properties in the EM Area. As noted, this soil Pb concentration 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.

10. Uncertainty Analysis

Uncertainty is inherent the risk assessment process. To be health protective yet provide a range of potential exposures, the HHRA has been conducted to assess both a RM scenario and a CT scenario, as well as a Protocol 1 scenario to comply with BC ENV requirements for deterministic risk assessment. To estimate RM exposures, a series of conservative assumptions intended to reflect reasonable worst-case conditions were used; some of these assumptions were more conservative than those recommended by Health Canada (2024), including the use of lower body weights and a higher soil ingestion rate for older children. These conservative, worst-case assumptions were compounded by the HHRA model assumed linear dose response relationship between Pb exposures and BLLs. As a result, the risks estimated for the RM scenario were grossly overestimated, as evidenced by the BLLs predicted by the HHRA compared to the measured BLLs in the Trail area. As discussed, while the CT scenario also overpredicted exposures and risks from soil and dust, the CT exposure and risk estimates reflect more realistic potential exposures and risks in the Trail area. As such, the CT risk estimates were retained to identify neighbourhoods in the Trail area where the results of the HHRA required further analysis and are the focus on the below discussion.

As noted throughout this report, the HHRA model and assumptions have overpredicted exposures to Pb in soil and dust, as well as associated health risks. This has been confirmed through comparison of the HHRA predicted BLLs to the BLLs measured in the Trail area over the last two decades. As presented in **Section 8**, the highest BLLs for the RM scenario are higher than those ever measured in Trail, including in the 1990s. Further, while the HHRA predicted BLLs for the CT scenario were considered more reasonable, the soil Pb to BLL relationship predicted by the HHRA for this scenario was five times the soil Pb to BLL relationship determined by the empirical data (Interior Health, 2024). The overall uncertainty in the HHRA is high but confirmed by the measured BLLs to be conservative and health protective (i.e., predictions are biased high / overestimates).

As noted in **Section 8.3**, at soil concentrations less than approximately 100 mg/kg for the RM scenario, and 800 mg/kg for the CT scenario, the BLLs predicted by the HHRA are lower than those measured in the Trail area. This suggests that other sources of Pb, or exposures via media not evaluated in the HHRA, are influencing BLLs. Despite the conservatism in the HHRA model and the overprediction of exposures from soil and dust, below these soil concentrations the BLLs are underpredicted, emphasizing the importance of other sources of Pb in the Trail area. This is further supported by the results of Interior Health (2024), which demonstrated that Pb in TSP, household income, home age and having a person in the home working in a Pb based industry are equally or more strongly correlated with child BLLs as soil Pb. This is also confirmed by the TSP Pb to blood Pb relationship demonstrated by air and blood Pb data collected in the Trail area, as depicted on **Figure 8-5**. It is noted that the TSP data has been collected from two stations located within the EM Area. These locations were selected based on a review of available data and were approved by the BC ENV. As TSP concentrations in the EM area are variable, and as data is only available from two fixed locations, there is uncertainty in the levels of TSP throughout the EM area and whether the concentrations used in the HHRA are representative. The HHRA used data from the station nearest the smelter to estimate exposures and associated risks, thus, there is some certainty that this approach is protective.

The importance of the measured blood Pb data to the HHRA conclusions must be emphasized. The HHRA has been completed per guidance and protocols required by the BC ENV, and as one component of the WARP (AtkinsRéalis, 2024). The HHRA model is inherently conservative, and while it is one tool that can be used to assess exposures and health risks, with some consideration of site-specific conditions (e.g., bioaccessibility estimates), the blood Pb data provides a true measure of exposure and related health risks that inherently incorporates all site specific conditions, as well as the behaviour of individuals and their influence on BLLs that cannot be accounted for using the HHRA model.

Typically, the uncertainty analysis of an HHRA identifies areas of uncertainty and their influence on the results of the HHRA to estimate the degree of confidence that can be placed in the risk estimates. As the empirical blood Pb data collected in the Trail area since the 1990s confirms that the HHRA has overpredicted risks associated with exposures to soil and dust, there is a high degree of confidence that the risk estimates from the HHRA are biased high and are therefore health protective. The below discussion is therefore focused on the identified data gap related to Indigenous peoples in the EM area, the uncertainty in the Pb TRV and in the derivation of the Trail area specific, risk-based standard for Pb, as well as the reliance on Interior Health's Analysis of Variable Influencing Children's Blood Lead Levels in Trail BC (Interior Health, 2024).

10.1 Data Gap

The primary data gap identified during the completion of the HHRA is uncertainty related to how Indigenous peoples in the Trail area are using plants for traditional purposes. As discussed in **Section 5.4**, Interior Health engaged with 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). No areas of specific concern where these plants may be harvested from were identified by COINs. Based on rationale presented in **Section 5.4** for home grown produce, the consumption of traditional plants, either the plant itself, or medicines made from plants, is not expected to contribute significantly to exposures for Indigenous peoples. Additionally, given the limited dermal absorption of Pb, application of salves made from traditional plants is not expected to result in significant exposure; however, this pathway and the potential for salves to increase dermal absorption of Pb requires further consideration.

Despite the above, 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 in the significance of potential exposures to this receptor group. Further information is recommended to be collected from local Indigenous peoples during consultation scheduled for 2025.

10.2 Toxicity Reference Values for Pb

The TRVs used for Pb in the HHRA are a primary source of uncertainty. The Health Canada provisional TRV for Pb of 0.5 µg/kg bw/day was used in the HHRA to quantify risks to children (up to 11 years old). This provisional TRV was recommended by Health Canada in 2021 (Health Canada, 2021a) and is based on the EFSA (2013) BMDL01, which is based on an estimated blood Pb level of 1.2 µg/dL for a 1 point IQ decrement in children. Similarly, the WHO FAO (2011) estimated a blood Pb level of 2 µg/dL for a 1 point IQ decrement in children. The relationships determined by EFSA (2013) and WHO (2011) were based on Lanphear et al. (2005) involving more than 1,300 children. While the EFSA (2013) estimated BLL of 1.2 µg/dL for 1IQ point is almost half of the 2 µg/dL estimated by WHO (2011), the key difference was that EFSA was based on a 95% lower confidence limit approach while WHO (2011) concluded that a central estimate provided reasonable protection. Despite their differences the RSDs of 0.5 µg/kg bw/day and 0.6 µg/kg bw/day provided by EFSA (2013) and WHO (2011), respectively, are similar. Given this, and that the lower of the two values has been used in the current assessment, there is confidence that the TRV used for children in the assessment is health protective and based on the best available science.

While WHO (2011) and EFSA (2013) are specific to Pb in food, Health Canada's adoption of the TRV and recommended use at contaminated sites indicates that the agency has identified a 1 IQ decrement as an appropriate target in HHRAs for contaminated sites. While the threshold below which Pb is no longer associated with adverse neurodevelopmental effects has not been identified, in an IQ test, 1 IQ point is within the margin or error of 5 IQ points, is not measurable and is not reproducible (Whitaker, 2010).

Health Canada has recommended the provisional TRV of 0.5 µg/kg bw/day for all age groups; however, it is widely accepted that the critical effect in adults is increase in systolic blood pressure. Although not documented, it is understood that Health Canada's application of the 0.5 µg/kg bw/day TRV across all age groups is to protect women of childbearing age, and potential fetal exposure.

Wilson and Richardson (2013) developed RSDs for toddlers and adults of 0.6 µg/kg bw/d and 1.3 µg/kg bw/d, respectively, based on WHO (2011). Wilson and Richardson (2013) considered women of childbearing age and the potential for fetal exposure. Based on lower Pb oral absorption for adults (40% of the rate of children) and assuming a fetal cord:maternal BLL concentration ratio of 1.0, an RSD for women of childbearing age (for 1 IQ point decrement) was estimated to be 1.5 µg/kg bw/day. Using this approach, along with the Health Canada provisional TRV of 0.5 µg/kg bw/day, a TRV for an adult of 1.3 µg/kg bw/day was calculated for use in the HHRA. The HHRA Working Group reviewed this TRV and supported the use of 1.3 µg/kg bw/day in the HHRA for the characterization of risks to adolescents and adults. The calculated TRV of 1.3 µg/kg bw/day is equivalent to the RSD developed by Wilson and Richardson (2013) based on a 1 mmHg increase in systolic blood pressure. Therefore, a TRV for Pb of 1.3 µg/kg bw/day for adults is protective of both blood pressure effects and effects to the fetus for women who are pregnant or who could potentially become pregnant. On this basis, there is confidence that the TRV used for adolescents and adults in the HHRA is health protective and is most appropriate for use based on the currently available science.

10.3 Trail Area Specific, Risk-Based Standard

As discussed in **Section 9**, the Trail area specific, risk-based standard for Pb was developed based on the three primary factors, including:

- The Interior Health (Interior Health, 2024) estimated soil Pb to blood Pb relationship of 0.1 µg/dL BLL per 100 mg/kg Pb in soil.
- The Health Canada TRV that is based on a 1.2 µg/dL resulting in a 1 IQ point decrement.
- The Health Canada (2021b) geomean BLL for Canadian children of 0.5 µg/dL, with consideration of a potentially higher background BLL in the Trail area.

The uncertainty in the Health Canada TRV is discussed in **Section 10.1**. The uncertainty the remaining two these factors is discussed in the following sections.

10.3.1 Interior Health Soil Pb to Blood Pb Relationship

The results of Interior Health's Analysis of Variables Influencing Children's Blood Lead Levels in Trail, BC (Interior Health, 2024) on the relationship between soil Pb and blood Pb estimated that soil Pb contributes approximately 0.1 µg/dL BLL per 100 mg/kg Pb in soil. This relationship was estimated based on a univariate analysis, which examined the effect of a single variable (soil Pb) on blood Pb. Other components of Interior Health (2024) demonstrated that other variables, including household income, Pb in TSP, house age and someone in the home working in a Pb based industry, are equally as well correlated, if not more so, to BLLs. The results of the univariate analysis do not consider the influence of these other variables, and thus, overpredicts the soil Pb to blood Pb relationship.

Further, as discussed in **Section 9**, the estimated soil Pb to BLL relationship from Interior Health (2024) is comparable to those reported in the literature for other smelter and mining communities, which range from 0.06 µg/dL to 0.12 µg/dL BLL per 100 mg/kg Pb in soil (Dong et al., 2020; von Lindern et al., 2003).

Based on the above, it is considered unlikely that the soil Pb to blood Pb relationship has been underestimated. Therefore, the use of this relationship to support the development of the Trail area specific, risk-based standard is considered conservative and protective of human health.

10.3.2 Background BLL

The geomean BLL for Canadian children 3 to 5 years of 0.5 µg/dL (Health Canada, 2021b) was considered in the development of the Trail area specific, risk-based standard. The blood Pb monitoring program in the Trail area targets children 6 months to 3 years old as based on hand-mouth behaviours, this is the age group with the highest potential exposures. There is currently no age-comparable background dataset for the Canadian population.

As noted, non-smelter related factors with the potential to result in the background BLL for the Trail area being higher than the Canadian geomean include increased hand-mouth behaviours in the 6 - 36 month age group, sociodemographic factors, including house age, and geogenic Pb in the Trail area.

Other studies (Schoof et al., 2015; Ruckart et al., 2021) indicate that weighting for demographic factors results in an approximate 1.2 times increase in geomean BLLs compared to overall population geomeans. Consideration of this factor and the geomean BLL for Canadian children of 0.5 µg/dL would result in a value of 0.6 µg/dL. To account for the influence of the younger age group represented by the Trail blood Pb dataset, as well as potential contributions from geogenic sources, an additional 0.2 µg/dL has conservatively been assumed, with an estimated Trail area background BLL of 0.8 µg/dL.

While there is uncertainty in the potential influence of child age, sociodemographic factors and geogenic Pb on BLL, studies indicate that home age (i.e., a sociodemographic factor) is an important predictor of BLL (Schoof et al., 2015, Rabito et al., 2007, Etchevers et al., 2015) due to the increased prevalence of Pb paint in older houses. The BC government (HealthLink BC, 2024) indicates that Pb based paint is the most common source of Pb exposure. Given this, and the data from other studies that support a 1.2 times increase in geomean BLL (or a 0.1 µg/dL increase above the Canadian geomean BLL), the allocation of a 0.1 µg/dL increase in background BLL for age differences and potential geogenic sources is considered reasonable and protective. On this basis, it is unlikely that the potential higher background geomean BLL in the Trail area has been underestimated and thus use of the background concentration in the development of the Trail area specific, risk-based standard for Pb is considered to be conservative and health protective.

11. Conclusions and Recommendations

This HHRA was completed using Health Canada and BC ENV guidance, and with input from the HHRA Working Group, to ensure the most up-to-date science on Pb toxicity was incorporated, and that the assessment is appropriate for the specific Trail area context.

The comparison of the HHRA predicted BLLs to the BLLs measured in the Trail area over the last two decades confirms that the HHRA has overpredicted exposures and associated risks. Given the conservatism in the estimates, where the CT scenario predicted risks were less than the CSR risk-based standard of an HI $\leq$ 1, there is confidence that health risks are negligible. Using this approach, negligible human health risks are predicted for adolescents and adults across all neighbourhoods in the EM Area, as well as for all age groups in Montrose, Casino, Columbia Gardens, Warfield and Miral Heights.

Based on CT scenario HIs 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, further assessment of the results of the HHRA was conducted, with the results of Interior Health's Analysis of Variables Influencing Children's Blood Lead Levels in Trail, BC (Interior Health, 2024) considered in the derivation of a Trail area specific, risk-based standard. Using the Interior Health estimated soil Pb to BLL relationship (Interior Health, 2024), along with the toxicological basis of the Health Canada TRV for Pb, a Trail area specific, risk-based standard of a soil Pb concentration of 400 mg/kg was developed. Under Sections 18 and 18.1 of the CSR, the Medical Health Officer has recommended Trail area specific, risk-based standards for Pb, including the risk-based soil standard for Pb supported by the results of the HHRA. The Trail area specific risk-based soil standard will be used in the existing soil management program prioritization framework, which is described in the Wide Area Remediation Plan for the EM Area (AtkinsRéalis, 2024).

The BLL declines observed in the Trail area over the last two decades likely 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. This is supported by studies conducted in other smelter communities where multifaceted Pb exposure reduction programs, including public health and education programs (Dobrescu et al., 2022; Lyle et al., 2021; Schoof et al., 2015; Boreland et al., 2008), with home evaluations and support with addressing multiple sources of Pb exposure an important complement to soil remediation activities (Schoof et al., 2015). Therefore, the integrative and adaptive management strategy used in the Trail area including the biomonitoring program, should continue, with further operational improvements to further reduce Pb in air, where possible.

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TABLES

(Provided in Separate Excel File)

1: Soil Management Program Property Status 2007 to 2022
2: 2022 Family and Property Status Update
3: 2022 Summary of Soil Assessment and Ground Cover Evaluation
4: 2022 Summary of Soil Remediation Activities
5: 2023 Prioritization and Remediation Planning of P1 Properties
6: 2023 Secondary Prioritization of P2 Properties

DRAWINGS

(Provided in Separate File)

- Map Book 1 – THEP Surface Soil Status
- Map Book 2 – THEP Excavation Base Soil Status
- Map Book 3 – THEP Remediation Priority Status

APPENDIX A

Risk Estimates for Central Tendency (CT), Reasonable Maximum (RM) and Protocol 1 Scenarios (Tables I-1 to I-60)

TABLE I-1. Reasonable Maximum Risk Estimates for a Residential Adult in Assessment Area 0

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Montrose	0.077	628	251.2	0.14	3.6E-05	0.009	2.8E-03	1.3E-02	0.2	0.24

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-2. Central Tendancy Risk Estimates for a Residential Adult in Assessment Area 0

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Montrose	0.057	84.4	25.3	0.01	3.9E-06	0.001	2.2E-04	1.0E-02	0.02	0.02

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-3. Reasonable Maximum Risk Estimates for a Residential Young Child in Assessment Area 0

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Montrose	0.077	156.6	62.6	1.65	5.5E-05	0.445	2.1E-02	1.1E-01	**2.2**	2.7

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-4. Central Tendancy Risk Estimates for a Residential Young Child in Assessment Area 0

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Montrose	0.077	84.4	25.3	0.24	2.2E-05	0.099	6.1E-03	7.7E-02	0.4	0.5

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-5. Reasonable Maximum Risk Estimates for a Residential Older Child Receptor in Assessment Area 0

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Montrose	0.077	156.6	62.6	0.82	4.8E-05	0.169	1.0E-02	9.3E-02	1.1	1.32

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-6. Central Tendancy Risk Estimates for a Residential Older Child in Assessment Area 0

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Montrose	0.077	84.4	25.3	0.12	1.9E-05	0.038	3.1E-03	6.8E-02	0.2	0.28

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-7. Reasonable Maximum Risk Estimates for a Residential Adolescent in Assessment Area 0

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Montrose	0.077	156.6	62.6	0.04	1.0E-05	0.002	8.3E-04	2.0E-02	0.06	0.08

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-8. Central Tendancy Risk Estimates for a Residential Adolescent in Assessment Area 0

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Montrose	0.077	84.4	25.3	0.01	4.3E-06	0.001	2.6E-04	1.5E-02	0.02	0.03

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-9. Reasonable Maximum Risk Estimates for a Residential Infant in Assessment Area 0

	Air Concentration (Annual Mean TSP) µg/m^3	Indoor Dust Concentration µg/g	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood							
Montrose	0.077	62.6	0.709	4.7E-02	6.4E-02	0.8	0.98

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-10. Central Tendancy Risk Estimates for a Residential Infant in Assessment Area 0

	Air Concentration (Annual Mean TSP) µg/m^3	Indoor Dust Concentration µg/g	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood							
Montrose	0.077	25.3	0.185	1.2E-02	4.1E-02	0.2	0.29

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-11. Reasonable Maximum Risk Estimates for a Residential Adult in Assessment Area 1

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Annable	0.077	543.7	217.5	0.12	3.1E-05	0.008	2.4E-03	1.7E-02	0.1	0.17
Casino	0.077	517.8	207.1	0.11	3.0E-05	0.007	2.3E-03	1.7E-02	0.1	0.17
Columbia Gardens	0.077	387.8	155.1	0.08	2.2E-05	0.006	1.7E-03	1.7E-02	0.1	0.13
Oasis	0.077	735.2	294.1	0.16	4.2E-05	0.010	3.2E-03	1.7E-02	0.2	0.23
Waneta	0.077	538	215.2	0.12	3.1E-05	0.008	2.4E-03	1.7E-02	0.1	0.17
Warfield	0.077	382.6	153.0	0.08	2.2E-05	0.005	1.7E-03	1.7E-02	0.1	0.13

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-12. Central Tendancy Risk Estimates for a Residential Adult in Assessment Area 1

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Annable	0.077	308.3	92.5	0.02	1.4E-05	0.002	8.1E-04	1.4E-02	0.04	0.04
Casino	0.077	169.9	51.0	0.01	7.8E-06	0.001	4.4E-04	1.4E-02	0.03	0.03
Columbia Gardens	0.077	212.4	63.7	0.01	9.7E-06	0.001	5.5E-04	1.4E-02	0.03	0.04
Oasis	0.077	383.8	115.1	0.02	1.8E-05	0.002	1.0E-03	1.4E-02	0.04	0.05
Waneta	0.077	260.2	78.1	0.02	1.2E-05	0.002	6.8E-04	1.4E-02	0.03	0.04
Warfield	0.077	205.5	61.7	0.01	9.4E-06	0.001	5.4E-04	1.4E-02	0.03	0.03

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I -13. Reasonable Maximum Risk Estimates for a Residential Young Child in Assessment Area 1

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Annable	0.077	543.7	217.5	5.73	1.9E-04	1.546	7.2E-02	1.1E-01	**7.5**	8.9
Casino	0.077	517.8	207.1	5.45	1.8E-04	1.473	6.9E-02	1.1E-01	**7.1**	8.5
Columbia Gardens	0.077	387.8	155.1	4.08	1.4E-04	1.103	5.2E-02	1.1E-01	**5.3**	6.4
Oasis	0.077	735.2	294.1	7.74	2.6E-04	2.091	9.8E-02	1.1E-01	**10.0**	12.0
Waneta	0.077	538	215.2	5.67	1.9E-04	1.530	7.2E-02	1.1E-01	**7.4**	8.9
Warfield	0.077	382.6	153.0	4.03	1.3E-04	1.088	5.1E-02	1.1E-01	**5.3**	6.3

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-14. Central Tendancy Risk Estimates for a Residential Young Child in Assessment Area 1

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Annable	0.077	308.3	92.5	0.89	7.9E-05	0.363	2.2E-02	7.7E-02	**1.3**	1.6
Casino	0.077	169.9	51.0	0.49	4.3E-05	0.200	1.2E-02	7.7E-02	0.8	0.9
Columbia Gardens	0.077	212.4	63.7	0.61	5.4E-05	0.250	1.5E-02	7.7E-02	1.0	1.1
Oasis	0.077	383.8	115.1	1.10	9.8E-05	0.452	2.8E-02	7.7E-02	**1.7**	2.0
Waneta	0.077	260.2	78.1	0.75	6.6E-05	0.306	1.9E-02	7.7E-02	**1.2**	1.4
Warfield	0.077	205.5	61.7	0.59	5.2E-05	0.242	1.5E-02	7.7E-02	0.9	1.1

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-15. Reasonable Maximum Risk Estimates for a Residential Older Child in Assessment Area 1

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Annable	0.077	543.7	217.48	2.86	1.7E-04	0.587	3.6E-02	9.3E-02	**3.6**	4.30
Casino	0.077	517.8	207.12	2.73	1.6E-04	0.559	3.5E-02	9.3E-02	**3.4**	4.10
Columbia Gardens	0.077	387.8	155.12	2.04	1.2E-04	0.419	2.6E-02	9.3E-02	**2.6**	3.10
Oasis	0.077	735.2	294.08	3.87	2.3E-04	0.794	4.9E-02	9.3E-02	**4.8**	5.77
Waneta	0.077	538	215.2	2.83	1.6E-04	0.581	3.6E-02	9.3E-02	**3.5**	4.25
Warfield	0.077	382.6	153.04	2.02	1.2E-04	0.413	2.6E-02	9.3E-02	**2.5**	3.06

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-16. Central Tendancy Risk Estimates for a Residential Older Child in Assessment Area 1

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Annable	0.077	308.3	92.49	0.44	6.9E-05	0.138	1.1E-02	6.8E-02	0.7	0.79
Casino	0.077	169.9	50.97	0.24	3.8E-05	0.076	6.2E-03	6.8E-02	0.4	0.47
Columbia Gardens	0.077	212.4	63.72	0.31	4.7E-05	0.095	7.7E-03	6.8E-02	0.5	0.57
Oasis	0.077	383.8	115.14	0.55	8.6E-05	0.171	1.4E-02	6.8E-02	0.8	0.97
Waneta	0.077	260.2	78.06	0.37	5.8E-05	0.116	9.5E-03	6.8E-02	0.6	0.68
Warfield	0.077	205.5	61.65	0.30	4.6E-05	0.092	7.5E-03	6.8E-02	0.5	0.56

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-17. Reasonable Maximum Risk Estimates for a Residential Adolescent in Assessment Area 1

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Annable	0.077	543.7	217.5	0.14	3.6E-05	0.008	2.9E-03	2.0E-02	0.2	0.21
Casino	0.077	517.8	207.1	0.14	3.4E-05	0.008	2.8E-03	2.0E-02	0.2	0.20
Columbia Gardens	0.077	387.8	155.1	0.10	2.6E-05	0.006	2.1E-03	2.0E-02	0.1	0.16
Oasis	0.077	735.2	294.1	0.19	4.8E-05	0.011	3.9E-03	2.0E-02	0.2	0.27
Waneta	0.077	538	215.2	0.14	3.5E-05	0.008	2.9E-03	2.0E-02	0.2	0.21
Warfield	0.077	382.6	153.0	0.10	2.5E-05	0.006	2.0E-03	2.0E-02	0.1	0.15

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE 18. Central Tendancy Risk Estimates for a Residential Adolescent in Assessment Area 1

	Air Concentration (Annual Mean TSP) µg/m3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Annable	0.077	308.3	92.5	0.02	1.6E-05	0.002	9.5E-04	1.5E-02	0.04	0.05
Casino	0.077	169.9	51.0	0.01	8.7E-06	0.001	5.3E-04	1.5E-02	0.03	0.04
Columbia Gardens	0.077	212.4	63.7	0.02	1.1E-05	0.001	6.6E-04	1.5E-02	0.03	0.04
Oasis	0.077	383.8	115.1	0.03	2.0E-05	0.003	1.2E-03	1.5E-02	0.05	0.06
Waneta	0.077	260.2	78.1	0.02	1.3E-05	0.002	8.0E-04	1.5E-02	0.04	0.05
Warfield	0.077	205.5	61.7	0.02	1.0E-05	0.001	6.4E-04	1.5E-02	0.03	0.04

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-19. Reasonable Maximum Risk Estimates for a Residential Infant in Assessment Area 1

	Air Concentration (Annual Mean TSP) µg/m^3	Indoor Dust Concentration µg/g	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood							
Annable	0.077	217.5	2.464	1.6E-01	6.4E-02	**2.7**	3.2
Casino	0.077	207.1	2.346	1.6E-01	6.4E-02	**2.6**	3.1
Columbia Gardens	0.077	155.1	1.757	1.2E-01	6.4E-02	**1.9**	2.3
Oasis	0.077	294.1	3.331	2.2E-01	6.4E-02	**3.6**	4.3
Waneta	0.077	215.2	2.438	1.6E-01	6.4E-02	**2.7**	3.2
Warfield	0.077	153.0	1.734	1.2E-01	6.4E-02	**1.9**	2.3

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-20. Central Tendancy Risk Estimates for a Residential Infant in Assessment Area 1

	Air Concentration (Annual Mean TSP) µg/m^3	Indoor Dust Concentration µg/g	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood							
Annable	0.057	92.5	0.677	4.5E-02	3.1E-02	0.8	0.90
Casino	0.057	51.0	0.373	2.5E-02	3.1E-02	0.4	0.51
Columbia Gardens	0.057	63.7	0.467	3.1E-02	3.1E-02	0.5	0.63
Oasis	0.057	115.1	0.843	5.6E-02	3.1E-02	0.9	1.12
Waneta	0.057	78.1	0.572	3.8E-02	3.1E-02	0.6	0.77
Warfield	0.057	61.7	0.451	3.0E-02	3.1E-02	0.5	0.61

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-21. Reasonable Maximum Risk Estimates for a Residential Adult in Assessment Area 2

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Glenmerry	0.077	887.9	355.2	0.19	5.1E-05	0.013	3.9E-03	1.7E-02	0.2	0.3
Miral Heights	0.077	214	85.6	0.05	1.2E-05	0.003	9.4E-04	1.7E-02	0.1	0.1
Shavers Bench	0.077	1453.2	581.3	0.31	8.4E-05	0.021	6.4E-03	1.7E-02	0.4	0.4
Sunningdale	0.077	763.6	305.4	0.17	4.4E-05	0.011	3.3E-03	1.7E-02	0.2	0.2

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE 22. Central Tendancy Risk Estimates for a Residential Adult in Assessment Area 2

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Glenmerry	0.077	461.2	138.4	0.03	2.1E-05	0.003	1.2E-03	1.4E-02	0.05	0.06
Miral Heights	0.077	106.9	32.1	0.01	4.9E-06	0.001	2.8E-04	1.4E-02	0.02	0.03
Shavers Bench	0.077	747	224.1	0.05	3.4E-05	0.005	2.0E-03	1.4E-02	0.07	0.08
Sunningdale	0.077	431.7	129.5	0.03	2.0E-05	0.003	1.1E-03	1.4E-02	0.05	0.05

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-23. Reasonable Maximum Risk Estimates for a Residential Young Child in Assessment Area 2

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Glenmerry	0.077	887.9	355.2	9.35	3.1E-04	2.525	1.2E-01	1.1E-01	**12.1**	14.5
Miral Heights	0.077	214	85.6	2.25	7.5E-05	0.609	2.9E-02	1.1E-01	**3.0**	3.6
Shavers Bench	0.077	1453.2	581.3	15.31	5.1E-04	4.133	1.9E-01	1.1E-01	**19.7**	23.7
Sunningdale	0.077	763.6	305.4	8.04	2.7E-04	2.172	1.0E-01	1.1E-01	**10.4**	12.5

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-24. Central Tendancy Risk Estimates for a Residential Young Child in Assessment Area 2

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Glenmerry	0.077	461.2	138.4	1.32	1.2E-04	0.543	3.4E-02	7.7E-02	**2.0**	2.4
Miral Heights	0.077	106.9	32.1	0.31	2.7E-05	0.126	7.8E-03	7.7E-02	0.5	0.6
Shavers Bench	0.077	747	224.1	2.15	1.9E-04	0.880	5.4E-02	7.7E-02	**3.2**	3.8
Sunningdale	0.077	431.7	129.5	1.24	1.1E-04	0.508	3.1E-02	7.7E-02	**1.9**	2.2

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-25. Reasonable Maximum Risk Estimates for a Residential Older Child in Assessment Area 2

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Glenmerry	0.077	887.9	355.2	4.68	2.7E-04	0.959	5.9E-02	9.3E-02	**5.8**	6.94
Miral Heights	0.077	214	85.6	1.13	6.6E-05	0.231	1.4E-02	9.3E-02	**1.5**	1.76
Shavers Bench	0.077	1453.2	581.3	7.65	4.4E-04	1.569	9.7E-02	9.3E-02	**9.4**	11.30
Sunningdale	0.077	763.6	305.4	4.02	2.3E-04	0.824	5.1E-02	9.3E-02	**5.0**	5.99

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-26. Central Tendancy Risk Estimates for a Residential Older Child in Assessment Area 2

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Glenmerry	0.077	461.2	138.4	0.66	1.0E-04	0.206	1.7E-02	6.8E-02	1.0	1.1
Miral Heights	0.077	106.9	32.1	0.15	2.4E-05	0.048	3.9E-03	6.8E-02	0.3	0.3
Shavers Bench	0.077	747	224.1	1.08	1.7E-04	0.334	2.7E-02	6.8E-02	**1.5**	1.8
Sunningdale	0.077	431.7	129.5	0.62	9.6E-05	0.193	1.6E-02	6.8E-02	0.9	1.1

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-27. Reasonable Maximum Risk Estimates for a Residential Adolescent in Assessment Area 2

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Glenmerry	0.077	887.9	355.2	0.23	5.8E-05	0.013	0.00	0.02	0.3	0.3
Miral Heights	0.077	214	85.6	0.06	1.4E-05	0.003	0.00	0.02	0.1	0.1
Shavers Bench	0.077	1453.2	581.3	0.38	9.6E-05	0.021	0.01	0.02	0.4	0.5
Sunningdale	0.077	763.6	305.4	0.20	5.0E-05	0.011	0.00	0.02	0.2	0.3

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-28. Central Tendancy Risk Estimates for a Residential Adolescent in Assessment Area 2

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Glenmerry	0.077	461.2	138.4	0.04	2.3E-05	0.003	1.4E-03	0.02	0.06	0.07
Miral Heights	0.077	106.9	32.1	0.01	5.4E-06	0.001	3.3E-04	0.02	0.02	0.03
Shavers Bench	0.077	747	224.1	0.06	3.8E-05	0.005	2.3E-03	0.02	0.08	0.10
Sunningdale	0.077	431.7	129.5	0.03	2.2E-05	0.003	1.3E-03	0.02	0.05	0.06

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-29. Reasonable Maximum Risk Estimates for a Residential Infant in Assessment Area 2

	Air Concentration (Annual Mean TSP) µg/m^3	Indoor Dust Concentration µg/g	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood							
Glenmerry	0.077	355.2	4.0	2.7E-01	6.4E-02	**4.4**	5.2
Miral Heights	0.077	85.6	1.0	6.5E-02	6.4E-02	**1.1**	1.3
Shavers Bench	0.077	581.3	6.6	4.4E-01	6.4E-02	**7.1**	8.5
Sunningdale	0.077	305.4	3.5	2.3E-01	6.4E-02	**3.8**	4.5

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-30. Central Tendancy Risk Estimates for a Residential Infant in Assessment Area 2

	Air Concentration (Annual Mean TSP) µg/m^3	Indoor Dust Concentration µg/g	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood							
Glenmerry	0.077	138.4	1.0	6.7E-02	4.1E-02	**1.1**	1.3
Miral Heights	0.077	32.1	0.2	1.6E-02	4.1E-02	0.3	0.4
Shavers Bench	0.077	224.1	1.6	1.1E-01	4.1E-02	**1.8**	2.1
Sunningdale	0.077	129.5	0.9	6.3E-02	4.1E-02	**1.1**	1.3

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-31. Reasonable Maximum Risk Estimates for a Residential Adult in Assessment Area 3

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
East Trail	0.077	3291	1316.4	0.71	1.9E-04	0.047	1.4E-02	1.7E-02	0.8	0.9
Rivervale	0.077	1148.2	459.3	0.25	6.6E-05	0.016	5.0E-03	1.7E-02	0.3	0.3
Tadanac	0.077	3257.2	1302.9	0.70	1.9E-04	0.046	1.4E-02	1.7E-02	0.8	0.9
West Trail	0.077	1637.4	655.0	0.35	9.4E-05	0.023	7.2E-03	1.7E-02	0.4	0.5

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-32. Central Tendancy Risk Estimates for a Residential Adult in Assessment Area 3

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
East Trail	0.077	1575	472.5	0.10	7.2E-05	0.010	4.1E-03	1.4E-02	0.1	0.2
Rivervale	0.077	550.2	165.1	0.04	2.5E-05	0.004	1.4E-03	1.4E-02	0.1	0.07
Tadanac	0.077	1535	460.5	0.10	7.0E-05	0.010	4.0E-03	1.4E-02	0.1	0.2
West Trail	0.077	897	269.1	0.06	4.1E-05	0.006	2.3E-03	1.4E-02	0.1	0.1

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-33. Reasonable Maximum Risk Estimates for a Residential Young Child in Assessment Area 3

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
East Trail	0.077	3291	1316.4	34.67	1.2E-03	9.360	4.4E-01	1.1E-01	**44.6**	53.5
Rivervale	0.077	1148.2	459.3	12.09	4.0E-04	3.265	1.5E-01	1.1E-01	**15.6**	18.7
Tadanac	0.077	3257.2	1302.9	34.31	1.1E-03	9.263	4.3E-01	1.1E-01	**44.1**	52.9
West Trail	0.077	1637.4	655.0	17.25	5.7E-04	4.657	2.2E-01	1.1E-01	**22.2**	26.7

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-34. Central Tendancy Risk Estimates for a Residential Young Child in Assessment Area 3

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
East Trail	0.077	1575	472.5	4.5	4.0E-04	1.9	1.1E-01	7.7E-02	**6.6**	7.9
Rivervale	0.077	550.2	165.1	1.6	1.4E-04	0.6	4.0E-02	7.7E-02	**2.3**	2.8
Tadanac	0.077	1535	460.5	4.4	3.9E-04	1.8	1.1E-01	7.7E-02	**6.4**	7.7
West Trail	0.077	897	269.1	2.6	2.3E-04	1.1	6.5E-02	7.7E-02	**3.8**	4.5

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-35. Reasonable Maximum Risk Estimates for a Residential Older Child in Assessment Area 3

	Air Concentration (Mean Annual TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
East Trail	0.077	3291	1316.4	17.3	1.0E-03	3.6	2.2E-01	9.3E-02	**21.2**	25.4
Rivervale	0.077	1148.2	459.3	6.0	3.5E-04	1.2	7.7E-02	9.3E-02	**7.5**	8.9
Tadanac	0.077	3257.2	1302.9	17.2	1.0E-03	3.5	2.2E-01	9.3E-02	**21.0**	25.2
West Trail	0.077	1637.4	655.0	8.6	5.0E-04	1.8	1.1E-01	9.3E-02	**10.6**	12.7

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-36. Central Tendancy Risk Estimates for a Residential Older Child in Assessment Area 3

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
East Trail	0.077	1575	472.5	2.3	3.5E-04	0.7	5.7E-02	6.8E-02	**3.1**	3.7
Rivervale	0.077	550.2	165.1	0.8	1.2E-04	0.2	2.0E-02	6.8E-02	**1.1**	1.4
Tadanac	0.077	1535	460.5	2.2	3.4E-04	0.7	5.6E-02	6.8E-02	**3.0**	3.6
West Trail	0.077	897	269.1	1.3	2.0E-04	0.4	3.3E-02	6.8E-02	**1.8**	2.2

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-37. Reasonable Maximum Risk Estimates for a Residential Adolescent in Assessment Area 3

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
East Trail	0.077	3291	1316.4	0.9	2.2E-04	0.05	1.8E-02	2.0E-02	1.0	1.1
Rivervale	0.077	1148.2	459.3	0.3	7.6E-05	0.02	6.1E-03	2.0E-02	0.3	0.4
Tadanac	0.077	3257.2	1302.9	0.9	2.1E-04	0.05	1.7E-02	2.0E-02	0.9	1.1
West Trail	0.077	1637.4	655.0	0.4	1.1E-04	0.02	8.7E-03	2.0E-02	0.5	0.6

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-38. Central Tendancy Risk Estimates for a Residential Adolescent in Assessment Area 2

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
East Trail	0.077	1575	472.5	0.12	8.0E-05	0.011	4.9E-03	1.5E-02	0.2	0.2
Rivervale	0.077	550.2	165.1	0.04	2.8E-05	0.004	1.7E-03	1.5E-02	0.1	0.1
Tadanac	0.077	1535	460.5	0.12	7.8E-05	0.010	4.7E-03	1.5E-02	0.1	0.2
West Trail	0.077	897	269.1	0.07	4.6E-05	0.006	2.8E-03	1.5E-02	0.1	0.1

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-39. Reasonable Maximum Risk Estimates for a Residential Infant in Assessment Area 3

	Air Concentration (Annual Mean TSP) µg/m^3	Indoor Dust Concentration µg/g	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood							
East Trail	0.077	1316.4	14.9	4.0E-01	6.4E-02	**15.4**	18.4
Rivervale	0.077	459.3	5.2	1.4E-01	6.4E-02	**5.4**	6.5
Tadanac	0.077	1302.9	14.8	3.9E-01	6.4E-02	**15.2**	18.3
West Trail	0.077	655.0	7.4	2.0E-01	6.4E-02	**7.7**	9.2

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-40. Central Tendancy Risk Estimates for a Residential Infant in Assessment Area 3

	Air Concentration (Annual Mean TSP) µg/m^3	Indoor Dust Concentration µg/g	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood							
East Trail	0.077	472.5	3.5	9.2E-02	4.1E-02	**3.6**	4.3
Rivervale	0.077	165.1	1.2	3.2E-02	4.1E-02	**1.2**	1.5
Tadanac	0.077	460.5	3.4	9.0E-02	4.1E-02	**3.5**	4.2
West Trail	0.077	269.1	2.0	5.3E-02	4.1E-02	**2.0**	2.4

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-41. Risk Estimates for a Residential Adult in Assessment Area 0 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Montrose	0.077	628	251.2	0.11	2.9E-05	0.005	2.2E-03	1.0E-02	0.1	0.2

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-42. Risk Estimates for a Residential Young Child in Assessment Area 0 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Montrose	0.077	156.6	62.6	0.90	3.0E-05	0.246	1.5E-02	7.7E-02	**1.2**	1.5

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-43. Risk Estimates for a Residential Older Child Receptor in Assessment Area 0 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Montrose	0.077	156.6	62.6	0.11	2.6E-05	0.093	7.6E-03	6.8E-02	0.3	0.34

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-44. Risk Estimates for a Residential Adolescent in Assessment Area 0 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Montrose	0.077	156.6	62.6	0.03	8.0E-06	0.001	6.5E-04	1.5E-02	0.05	0.06

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-45. Risk Estimates for a Residential Infant in Assessment Area 0 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Indoor Dust Concentration µg/g	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood							
Montrose	0.077	62.6	0.458	3.1E-02	4.1E-02	0.5	0.64

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-46. Risk Estimates for a Residential Adult in Assessment Area 1 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Annable	0.077	543.7	217.5	0.09	2.5E-05	0.005	1.9E-03	1.4E-02	0.1	0.14
Casino	0.077	517.8	207.1	0.09	2.4E-05	0.004	1.8E-03	1.4E-02	0.1	0.13
Columbia Gardens	0.077	387.8	155.1	0.07	1.8E-05	0.003	1.4E-03	1.4E-02	0.1	0.10
Oasis	0.077	735.2	294.1	0.13	3.4E-05	0.006	2.6E-03	1.4E-02	0.1	0.18
Waneta	0.077	538	215.2	0.09	2.5E-05	0.005	1.9E-03	1.4E-02	0.1	0.14
Warfield	0.077	382.6	153.0	0.07	1.8E-05	0.003	1.3E-03	1.4E-02	0.1	0.10

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-47. Risk Estimates for a Residential Young Child in Assessment Area 1 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Annable	0.077	543.7	217.5	3.12	1.0E-04	0.854	5.3E-02	7.7E-02	**4.1**	4.9
Casino	0.077	517.8	207.1	2.97	9.9E-05	0.813	5.0E-02	7.7E-02	**3.9**	4.7
Columbia Gardens	0.077	387.8	155.1	2.23	7.4E-05	0.609	3.8E-02	7.7E-02	**3.0**	3.5
Oasis	0.077	735.2	294.1	4.22	1.4E-04	1.155	7.1E-02	7.7E-02	**5.5**	6.6
Waneta	0.077	538	215.2	3.09	1.0E-04	0.845	5.2E-02	7.7E-02	**4.1**	4.9
Warfield	0.077	382.6	153.0	2.20	7.3E-05	0.601	3.7E-02	7.7E-02	**2.9**	3.5

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-48. Risk Estimates for a Residential Older Child in Assessment Area 1 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Annable	0.077	543.7	217.48	0.39	9.1E-05	0.324	2.6E-02	6.8E-02	0.8	0.97
Casino	0.077	517.8	207.12	0.37	8.7E-05	0.308	2.5E-02	6.8E-02	0.8	0.93
Columbia Gardens	0.077	387.8	155.12	0.28	6.5E-05	0.231	1.9E-02	6.8E-02	0.6	0.72
Oasis	0.077	735.2	294.08	0.53	1.2E-04	0.438	3.6E-02	6.8E-02	**1.1**	1.29
Waneta	0.077	538	215.2	0.39	9.0E-05	0.320	2.6E-02	6.8E-02	0.8	0.96
Warfield	0.077	382.6	153.04	0.28	6.4E-05	0.228	1.9E-02	6.8E-02	0.6	0.71

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-49. Risk Estimates for a Residential Adolescent in Assessment Area 1 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Annable	0.077	543.7	217.5	0.11	2.8E-05	0.005	2.2E-03	1.5E-02	0.1	0.16
Casino	0.077	517.8	207.1	0.11	2.6E-05	0.005	2.1E-03	1.5E-02	0.1	0.15
Columbia Gardens	0.077	387.8	155.1	0.08	2.0E-05	0.003	1.6E-03	1.5E-02	0.1	0.12
Oasis	0.077	735.2	294.1	0.15	3.7E-05	0.007	3.0E-03	1.5E-02	0.2	0.21
Waneta	0.077	538	215.2	0.11	2.7E-05	0.005	2.2E-03	1.5E-02	0.1	0.16
Warfield	0.077	382.6	153.0	0.08	1.9E-05	0.003	1.6E-03	1.5E-02	0.1	0.12

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-50. Risk Estimates for a Residential Infant in Assessment Area 1 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Indoor Dust Concentration µg/g	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood							
Annable	0.077	217.5	1.592	1.1E-01	4.1E-02	**1.7**	2.09
Casino	0.077	207.1	1.517	1.0E-01	4.1E-02	**1.7**	1.99
Columbia Gardens	0.077	155.1	1.136	7.6E-02	4.1E-02	**1.3**	1.50
Oasis	0.077	294.1	2.153	1.4E-01	4.1E-02	**2.3**	2.81
Waneta	0.077	215.2	1.576	1.0E-01	4.1E-02	**1.7**	2.07
Warfield	0.077	153.0	1.121	7.5E-02	4.1E-02	**1.2**	1.48

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-51. Risk Estimates for a Residential Adult in Assessment Area 2 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Glenmerry	0.077	887.9	355.2	0.15	4.1E-05	0.008	3.1E-03	1.4E-02	0.2	0.21
Miral Heights	0.077	214	85.6	0.04	9.8E-06	0.002	7.5E-04	1.4E-02	0.1	0.06
Shavers Bench	0.077	1453.2	581.3	0.25	6.6E-05	0.012	5.1E-03	1.4E-02	0.3	0.34
Sunningdale	0.077	763.6	305.4	0.13	3.5E-05	0.007	2.7E-03	1.4E-02	0.2	0.19

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-52. Risk Estimates for a Residential Young Child in Assessment Area 2 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Glenmerry	0.077	887.9	355.2	5.10	1.7E-04	1.394	8.6E-02	7.7E-02	**6.7**	8.0
Miral Heights	0.077	214	85.6	1.23	4.1E-05	0.336	2.1E-02	7.7E-02	**1.7**	2.0
Shavers Bench	0.077	1453.2	581.3	8.35	2.8E-04	2.282	1.4E-01	7.7E-02	**10.9**	13.0
Sunningdale	0.077	763.6	305.4	4.39	1.5E-04	1.199	7.4E-02	7.7E-02	**5.7**	6.9

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-53. Risk Estimates for a Residential Older Child in Assessment Area 2 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Glenmerry	0.077	887.9	355.2	0.64	1.5E-04	0.529	4.3E-02	6.8E-02	**1.3**	1.54
Miral Heights	0.077	214	85.6	0.15	3.6E-05	0.127	1.0E-02	6.8E-02	0.4	0.43
Shavers Bench	0.077	1453.2	581.3	1.05	2.4E-04	0.865	7.1E-02	6.8E-02	**2.1**	2.46
Sunningdale	0.077	763.6	305.4	0.55	1.3E-04	0.455	3.7E-02	6.8E-02	**1.1**	1.33

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-54. Risk Estimates for a Residential Adolescent in Assessment Area 2 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
Glenmerry	0.077	887.9	355.2	0.18	4.6E-05	0.010	0.00	0.02	0.2	0.25
Miral Heights	0.077	214	85.6	0.04	1.1E-05	0.002	0.00	0.02	0.1	0.08
Shavers Bench	0.077	1453.2	581.3	0.30	7.5E-05	0.017	0.01	0.02	0.3	0.40
Sunningdale	0.077	763.6	305.4	0.16	3.9E-05	0.009	0.00	0.02	0.2	0.22

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-55. Risk Estimates for a Residential Infant in Assessment Area 2 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Indoor Dust Concentration µg/g	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood							
Glenmerry	0.077	355.2	2.6	1.7E-01	4.1E-02	**2.8**	3.4
Miral Heights	0.077	85.6	0.6	4.2E-02	4.1E-02	0.7	0.9
Shavers Bench	0.077	581.3	4.3	2.8E-01	4.1E-02	**4.6**	5.5
Sunningdale	0.077	305.4	2.2	1.5E-01	4.1E-02	**2.4**	2.9

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-56. Risk Estimates for a Residential Adult in Assessment Area 3 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
East Trail	0.077	3291	1316.4	0.57	1.5E-04	0.028	1.1E-02	1.4E-02	0.6	0.74
Rivervale	0.077	1148.2	459.3	0.20	5.3E-05	0.010	4.0E-03	1.4E-02	0.2	0.27
Tadanac	0.077	3257.2	1302.9	0.56	1.5E-04	0.028	1.1E-02	1.4E-02	0.6	0.74
West Trail	0.077	1637.4	655.0	0.28	7.5E-05	0.014	5.7E-03	1.4E-02	0.3	0.38

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-57. Risk Estimates for a Residential Young Child in Assessment Area 3 - Protocol 1 Scenario

	Oral/Dermal TRV	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
	ug/kg/d										
Neighbourhood											
East Trail	0.5	0.077	3291	1316.4	18.91	6.3E-04	5.168	3.2E-01	7.7E-02	**24.5**	29.4
Rivervale	0.5	0.077	1148.2	459.3	6.60	2.2E-04	1.803	1.1E-01	7.7E-02	**8.6**	10.3
Tadanac	0.5	0.077	3257.2	1302.9	18.71	6.2E-04	5.115	3.2E-01	7.7E-02	**24.2**	29.1
West Trail	0.5	0.077	1637.4	655.0	9.41	3.1E-04	2.571	1.6E-01	7.7E-02	**12.2**	14.7

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-58. Risk Estimates for a Residential Older Child in Assessment Area 3 - Protocol 1 Scenario

	Air Concentration (Mean Annual TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
East Trail	0.077	3291	1316.4	2.4	5.5E-04	2.0	1.6E-01	6.8E-02	**4.6**	5.5
Rivervale	0.077	1148.2	459.3	0.8	1.9E-04	0.7	5.6E-02	6.8E-02	**1.6**	2.0
Tadanac	0.077	3257.2	1302.9	2.3	5.5E-04	1.9	1.6E-01	6.8E-02	**4.5**	5.4
West Trail	0.077	1637.4	655.0	1.2	2.7E-04	1.0	8.0E-02	6.8E-02	**2.3**	2.8

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-59. Risk Estimates for a Residential Adolescent in Assessment Area 3 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Soil Concentration µg/g	Indoor Dust Concentration µg/g	HQ Soil Ingestion	HQ Soil Particulate Inhalation	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood										
East Trail	0.077	3291	1316.4	0.7	1.7E-04	0.03	1.4E-02	1.5E-02	0.7	0.9
Rivervale	0.077	1148.2	459.3	0.2	5.8E-05	0.01	4.7E-03	1.5E-02	0.3	0.3
Tadanac	0.077	3257.2	1302.9	0.7	1.7E-04	0.03	1.3E-02	1.5E-02	0.7	0.9
West Trail	0.077	1637.4	655.0	0.3	8.3E-05	0.01	6.8E-03	1.5E-02	0.4	0.4

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

TABLE I-60. Risk Estimates for a Residential Infant in Assessment Area 3 - Protocol 1 Scenario

	Air Concentration (Annual Mean TSP) µg/m^3	Indoor Dust Concentration µg/g	HQ Indoor Dust Ingestion	HQ Indoor Dust Inhalation	HQ Air Inhalation	HQ All Routes	Predicted Blood Pb (ug/dL) (based on HQ)
Neighbourhood							
East Trail	0.077	1316.4	9.6	2.6E-01	4.1E-02	**9.9**	11.9
Rivervale	0.077	459.3	3.4	9.0E-02	4.1E-02	**3.5**	4.2
Tadanac	0.077	1302.9	9.5	2.5E-01	4.1E-02	**9.8**	11.8
West Trail	0.077	655.0	4.8	1.3E-01	4.1E-02	**5.0**	6.0

HQ = Hazard Quotient

UCLM = Upper Confidence Limit of the Mean

Bold HQ > 1

APPENDIX B

ProUCL Outputs

	A	B	C	D	E	F	G	H	I	J	K	L
1	**UCL Statistics for Uncensored Full Data Sets**											
2												
3	User Selected Options											
4	Date/Time of Computation	ProUCL 5.12023-11-23 11:54:14 AM										
5	From File	PredictedAndActualLabLeadBySampleByNhood_ForProUCL_20231123.xls										
6	Full Precision	OFF										
7	Confidence Coefficient	95%										
8	Number of Bootstrap Operations	2000										
9												
10												
11	**Annable**											
12												
13	**General Statistics**											
14	Total Number of Observations	502			Number of Distinct Observations	329						
15					Number of Missing Observations	0						
16	Minimum	1.4			Mean	308.3						
17	Maximum	2420			Median	275.5						
18	SD	200.7			Std. Error of Mean	8.956						
19	Coefficient of Variation	0.651			Skewness	3.089						
20												
21	**Normal GOF Test**											
22	Shapiro Wilk Test Statistic	0.853			**Shapiro Wilk GOF Test**							
23	5% Shapiro Wilk P Value	0			Data Not Normal at 5% Significance Level							
24	Lilliefors Test Statistic	0.0986			**Lilliefors GOF Test**							
25	5% Lilliefors Critical Value	0.0399			Data Not Normal at 5% Significance Level							
26	**Data Not Normal at 5% Significance Level**											
27												
28	**Assuming Normal Distribution**											
29	**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**							
30	95% Student's-t UCL	323.1			95% Adjusted-CLT UCL (Chen-1995)	324.4						
31					95% Modified-t UCL (Johnson-1978)	323.3						
32												
33	**Gamma GOF Test**											
34	A-D Test Statistic	2.667			**Anderson-Darling Gamma GOF Test**							
35	5% A-D Critical Value	0.765			Data Not Gamma Distributed at 5% Significance Level							
36	K-S Test Statistic	0.0603			**Kolmogorov-Smirnov Gamma GOF Test**							
37	5% K-S Critical Value	0.0408			Data Not Gamma Distributed at 5% Significance Level							
38	**Data Not Gamma Distributed at 5% Significance Level**											
39												
40	**Gamma Statistics**											
41	k hat (MLE)	2.435			k star (bias corrected MLE)	2.422						
42	Theta hat (MLE)	126.6			Theta star (bias corrected MLE)	127.3						
43	nu hat (MLE)	2445			nu star (bias corrected)	2431						
44	MLE Mean (bias corrected)	308.3			MLE Sd (bias corrected)	198.1						
45					Approximate Chi Square Value (0.05)	2318						
46	Adjusted Level of Significance	0.0495			Adjusted Chi Square Value	2317						
47												
48	**Assuming Gamma Distribution**											
49	95% Approximate Gamma UCL (use when n>=50))	323.4			95% Adjusted Gamma UCL (use when n<50)	323.5						
50												
51	**Lognormal GOF Test**											
52	Shapiro Wilk Test Statistic	0.879			**Shapiro Wilk Lognormal GOF Test**							
53	5% Shapiro Wilk P Value	0			Data Not Lognormal at 5% Significance Level							
54	Lilliefors Test Statistic	0.11			**Lilliefors Lognormal GOF Test**							
55	5% Lilliefors Critical Value	0.0399			Data Not Lognormal at 5% Significance Level							
56	**Data Not Lognormal at 5% Significance Level**											
57												
58	**Lognormal Statistics**											
59	Minimum of Logged Data	0.336			Mean of logged Data	5.512						
60	Maximum of Logged Data	7.792			SD of logged Data	0.776						
61												
62	**Assuming Lognormal Distribution**											
63	95% H-UCL	358.1			90% Chebyshev (MVUE) UCL	374						
64	95% Chebyshev (MVUE) UCL	391.9			97.5% Chebyshev (MVUE) UCL	416.8						
65	99% Chebyshev (MVUE) UCL	465.6										
66												
67	**Nonparametric Distribution Free UCL Statistics**											
68	**Data do not follow a Discernible Distribution (0.05)**											
69												
70	**Nonparametric Distribution Free UCLs**											
71	95% CLT UCL	323.1			95% Jackknife UCL	323.1						
72	95% Standard Bootstrap UCL	323			95% Bootstrap-t UCL	325.3						
73	95% Hall's Bootstrap UCL	324.7			95% Percentile Bootstrap UCL	324.1						
74	95% BCA Bootstrap UCL	324.2										
75	90% Chebyshev(Mean, Sd) UCL	335.2			95% Chebyshev(Mean, Sd) UCL	347.4						
76	97.5% Chebyshev(Mean, Sd) UCL	364.3			99% Chebyshev(Mean, Sd) UCL	397.4						
77												
78	**Suggested UCL to Use**											
79	95% Chebyshev (Mean, Sd) UCL	347.4										
80												
81	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
82	Recommendations are based upon data size, data distribution, and skewness.											
83	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
84	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											

	A	B	C	D	E	F	G	H	I	J	K	L
85												
86												
87	**Casino**											
88												
89	**General Statistics**											
90					Total Number of Observations	53			Number of Distinct Observations		48	
91									Number of Missing Observations		0	
92					Minimum	8.42			Mean		169.9	
93					Maximum	1700			Median		50.8	
94					SD	330.2			Std. Error of Mean		45.36	
95					Coefficient of Variation	1.944			Skewness		3.239	
96												
97	**Normal GOF Test**											
98					Shapiro Wilk Test Statistic	0.504		**Shapiro Wilk GOF Test**				
99					5% Shapiro Wilk P Value	0		Data Not Normal at 5% Significance Level				
100					Lilliefors Test Statistic	0.373		**Lilliefors GOF Test**				
101					5% Lilliefors Critical Value	0.121		Data Not Normal at 5% Significance Level				
102	**Data Not Normal at 5% Significance Level**											
103												
104	**Assuming Normal Distribution**											
105					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
106					95% Student's-t UCL	245.8			95% Adjusted-CLT UCL (Chen-1995)		266	
107									95% Modified-t UCL (Johnson-1978)		249.2	
108												
109	**Gamma GOF Test**											
110					A-D Test Statistic	4.848		**Anderson-Darling Gamma GOF Test**				
111					5% A-D Critical Value	0.801		Data Not Gamma Distributed at 5% Significance Level				
112					K-S Test Statistic	0.244		**Kolmogorov-Smirnov Gamma GOF Test**				
113					5% K-S Critical Value	0.128		Data Not Gamma Distributed at 5% Significance Level				
114	**Data Not Gamma Distributed at 5% Significance Level**											
115												
116	**Gamma Statistics**											
117					k hat (MLE)	0.658			k star (bias corrected MLE)		0.633	
118					Theta hat (MLE)	258.3			Theta star (bias corrected MLE)		268.3	
119					nu hat (MLE)	69.72			nu star (bias corrected)		67.1	
120					MLE Mean (bias corrected)	169.9			MLE Sd (bias corrected)		213.5	
121									Approximate Chi Square Value (0.05)		49.25	
122					Adjusted Level of Significance	0.0455			Adjusted Chi Square Value		48.82	
123												
124	**Assuming Gamma Distribution**											
125					95% Approximate Gamma UCL (use when n>=50))	231.4			95% Adjusted Gamma UCL (use when n<50)		233.5	
126												
127	**Lognormal GOF Test**											
128					Shapiro Wilk Test Statistic	0.909		**Shapiro Wilk Lognormal GOF Test**				
129					5% Shapiro Wilk P Value	4.1288E-4		Data Not Lognormal at 5% Significance Level				
130					Lilliefors Test Statistic	0.139		**Lilliefors Lognormal GOF Test**				
131					5% Lilliefors Critical Value	0.121		Data Not Lognormal at 5% Significance Level				
132	**Data Not Lognormal at 5% Significance Level**											
133												
134	**Lognormal Statistics**											
135					Minimum of Logged Data	2.131			Mean of logged Data		4.208	
136					Maximum of Logged Data	7.438			SD of logged Data		1.196	
137												
138	**Assuming Lognormal Distribution**											
139					95% H-UCL	210.1			90% Chebyshev (MVUE) UCL		216.4	
140					95% Chebyshev (MVUE) UCL	253.5			97.5% Chebyshev (MVUE) UCL		305.1	
141					99% Chebyshev (MVUE) UCL	406.3						
142												
143	**Nonparametric Distribution Free UCL Statistics**											
144	**Data do not follow a Discernible Distribution (0.05)**											
145												
146	**Nonparametric Distribution Free UCLs**											
147					95% CLT UCL	244.5			95% Jackknife UCL		245.8	
148					95% Standard Bootstrap UCL	247.4			95% Bootstrap-t UCL		302.7	
149					95% Hall's Bootstrap UCL	270.5			95% Percentile Bootstrap UCL		249.3	
150					95% BCA Bootstrap UCL	275.5						
151					90% Chebyshev(Mean, Sd) UCL	305.9			95% Chebyshev(Mean, Sd) UCL		367.6	
152					97.5% Chebyshev(Mean, Sd) UCL	453.1			99% Chebyshev(Mean, Sd) UCL		621.2	
153												
154	**Suggested UCL to Use**											
155					95% Chebyshev (Mean, Sd) UCL	367.6						
156												
157	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
158	Recommendations are based upon data size, data distribution, and skewness.											
159	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
160	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
161												
162												

163	**Columbia Gardens**											
164												
165	**General Statistics**											
166						Total Number of Observations	38			Number of Distinct Observations	36	
167										Number of Missing Observations	0	
168						Minimum	10			Mean	212.4	
169						Maximum	1480			Median	141.5	
170						SD	262.2			Std. Error of Mean	42.54	
171						Coefficient of Variation	1.235			Skewness	3.695	
172												
173	**Normal GOF Test**											
174						Shapiro Wilk Test Statistic	0.568			**Shapiro Wilk GOF Test**		
175						5% Shapiro Wilk Critical Value	0.938			Data Not Normal at 5% Significance Level		
176						Lilliefors Test Statistic	0.268			**Lilliefors GOF Test**		
177						5% Lilliefors Critical Value	0.142			Data Not Normal at 5% Significance Level		
178	**Data Not Normal at 5% Significance Level**											
179												
180	**Assuming Normal Distribution**											
181						**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**		
182						95% Student's-t UCL	284.2			95% Adjusted-CLT UCL (Chen-1995)	309.6	
183										95% Modified-t UCL (Johnson-1978)	288.4	
184												
185	**Gamma GOF Test**											
186						A-D Test Statistic	1.73			**Anderson-Darling Gamma GOF Test**		
187						5% A-D Critical Value	0.769			Data Not Gamma Distributed at 5% Significance Level		
188						K-S Test Statistic	0.168			**Kolmogorov-Smirnov Gamma GOF Test**		
189						5% K-S Critical Value	0.146			Data Not Gamma Distributed at 5% Significance Level		
190	**Data Not Gamma Distributed at 5% Significance Level**											
191												
192	**Gamma Statistics**											
193						k hat (MLE)	1.374			k star (bias corrected MLE)	1.283	
194						Theta hat (MLE)	154.5			Theta star (bias corrected MLE)	165.5	
195						nu hat (MLE)	104.5			nu star (bias corrected)	97.54	
196						MLE Mean (bias corrected)	212.4			MLE Sd (bias corrected)	187.5	
197										Approximate Chi Square Value (0.05)	75.76	
198						Adjusted Level of Significance	0.0434			Adjusted Chi Square Value	74.96	
199												
200	**Assuming Gamma Distribution**											
201						95% Approximate Gamma UCL (use when n>=50))	273.5			95% Adjusted Gamma UCL (use when n<50)	276.4	
202												
203	**Lognormal GOF Test**											
204						Shapiro Wilk Test Statistic	0.928			**Shapiro Wilk Lognormal GOF Test**		
205						5% Shapiro Wilk Critical Value	0.938			Data Not Lognormal at 5% Significance Level		
206						Lilliefors Test Statistic	0.182			**Lilliefors Lognormal GOF Test**		
207						5% Lilliefors Critical Value	0.142			Data Not Lognormal at 5% Significance Level		
208	**Data Not Lognormal at 5% Significance Level**											
209												
210	**Lognormal Statistics**											
211						Minimum of Logged Data	2.303			Mean of logged Data	4.952	
212						Maximum of Logged Data	7.3			SD of logged Data	0.908	
213												
214	**Assuming Lognormal Distribution**											
215						95% H-UCL	300.8			90% Chebyshev (MVUE) UCL	316.4	
216						95% Chebyshev (MVUE) UCL	364.4			97.5% Chebyshev (MVUE) UCL	430.9	
217						99% Chebyshev (MVUE) UCL	561.7					
218												
219	**Nonparametric Distribution Free UCL Statistics**											
220	**Data do not follow a Discernible Distribution (0.05)**											
221												
222	**Nonparametric Distribution Free UCLs**											
223						95% CLT UCL	282.4			95% Jackknife UCL	284.2	
224						95% Standard Bootstrap UCL	279.3			95% Bootstrap-t UCL	369.3	
225						95% Hall's Bootstrap UCL	594.9			95% Percentile Bootstrap UCL	288.3	
226						95% BCA Bootstrap UCL	308.7					
227						90% Chebyshev(Mean, Sd) UCL	340			95% Chebyshev(Mean, Sd) UCL	397.8	
228						97.5% Chebyshev(Mean, Sd) UCL	478			99% Chebyshev(Mean, Sd) UCL	635.6	
229												
230	**Suggested UCL to Use**											
231						95% Chebyshev (Mean, Sd) UCL	397.8					
232												
233	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
234	Recommendations are based upon data size, data distribution, and skewness.											
235	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
236	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
237												

East Trail

General Statistics

Total Number of Observations	7511	Number of Distinct Observations	3157
		Number of Missing Observations	0
Minimum	0.092	Mean	1575
Maximum	24652	Median	1220
SD	1376	Std. Error of Mean	15.87
Coefficient of Variation	0.873	Skewness	2.814

Normal GOF Test

Lilliefors Test Statistic	0.127	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.0103	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	1601	95% Adjusted-CLT UCL (Chen-1995)	1602
		95% Modified-t UCL (Johnson-1978)	1601

Gamma GOF Test

A-D Test Statistic	23.42	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.778	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0451	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.0186	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.308	k star (bias corrected MLE)	1.308
Theta hat (MLE)	1204	Theta star (bias corrected MLE)	1205
nu hat (MLE)	19649	nu star (bias corrected)	19642
MLE Mean (bias corrected)	1575	MLE Sd (bias corrected)	1378
		Approximate Chi Square Value (0.05)	19318
Adjusted Level of Significance	0.05	Adjusted Chi Square Value	19317

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1602	95% Adjusted Gamma UCL (use when n<50)	1602

Lognormal GOF Test

Lilliefors Test Statistic	0.11	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.0103	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	-2.386	Mean of logged Data	6.934
Maximum of Logged Data	10.11	SD of logged Data	1.205

Assuming Lognormal Distribution

95% H-UCL	N/A	90% Chebyshev (MVUE) UCL	2237
95% Chebyshev (MVUE) UCL	2289	97.5% Chebyshev (MVUE) UCL	2363
99% Chebyshev (MVUE) UCL	2506		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	1601	95% Jackknife UCL	1601
95% Standard Bootstrap UCL	1602	95% Bootstrap-t UCL	1602
95% Hall's Bootstrap UCL	1602	95% Percentile Bootstrap UCL	1603
95% BCA Bootstrap UCL	1602		
90% Chebyshev(Mean, Sd) UCL	1623	95% Chebyshev(Mean, Sd) UCL	1644
97.5% Chebyshev(Mean, Sd) UCL	1674	99% Chebyshev(Mean, Sd) UCL	1733

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	1644		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Glenmerry

General Statistics

Total Number of Observations	3722	Number of Distinct Observations	1113
		Number of Missing Observations	0
Minimum	0.34	Mean	461.2
Maximum	3390	Median	365
SD	364.9	Std. Error of Mean	5.98
Coefficient of Variation	0.791	Skewness	2.451

Normal GOF Test

Lilliefors Test Statistic	0.124	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.0147	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	471.1	95% Adjusted-CLT UCL (Chen-1995)	471.3
		95% Modified-t UCL (Johnson-1978)	471.1

Gamma GOF Test

A-D Test Statistic	7.469	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.768	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0285	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.0184	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.906	k star (bias corrected MLE)	1.904
Theta hat (MLE)	242	Theta star (bias corrected MLE)	242.2
nu hat (MLE)	14185	nu star (bias corrected)	14175
MLE Mean (bias corrected)	461.2	MLE Sd (bias corrected)	334.2
		Approximate Chi Square Value (0.05)	13899
Adjusted Level of Significance	0.0499	Adjusted Chi Square Value	13899

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	470.4	95% Adjusted Gamma UCL (use when n<50)	470.4

Lognormal GOF Test

Lilliefors Test Statistic	0.0573	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.0147	Data Not Lognormal at 5% Significance Level

Data Not Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	-1.079	Mean of logged Data	5.849
Maximum of Logged Data	8.129	SD of logged Data	0.834

Assuming Lognormal Distribution

95% H-UCL	N/A	90% Chebyshev (MVUE) UCL	514.5
95% Chebyshev (MVUE) UCL	525.1	97.5% Chebyshev (MVUE) UCL	539.7
99% Chebyshev (MVUE) UCL	568.6		

Nonparametric Distribution Free UCL Statistics

Data do not follow a Discernible Distribution (0.05)

Nonparametric Distribution Free UCLs

95% CLT UCL	471.1	95% Jackknife UCL	471.1
95% Standard Bootstrap UCL	470.9	95% Bootstrap-t UCL	471.8
95% Hall's Bootstrap UCL	471.6	95% Percentile Bootstrap UCL	471.3
95% BCA Bootstrap UCL	471.3		
90% Chebyshev(Mean, Sd) UCL	479.2	95% Chebyshev(Mean, Sd) UCL	487.3
97.5% Chebyshev(Mean, Sd) UCL	498.6	99% Chebyshev(Mean, Sd) UCL	520.7

Suggested UCL to Use

95% Chebyshev (Mean, Sd) UCL	487.3		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

382												
383	**Miral Hts**											
384												
385	**General Statistics**											
386						Total Number of Observations	326			Number of Distinct Observations	195	
387										Number of Missing Observations	0	
388						Minimum	3.84			Mean	106.9	
389						Maximum	745			Median	85.8	
390						SD	88.12			Std. Error of Mean	4.881	
391						Coefficient of Variation	0.824			Skewness	2.475	
392												
393	**Normal GOF Test**											
394						Shapiro Wilk Test Statistic	0.809			**Shapiro Wilk GOF Test**		
395						5% Shapiro Wilk P Value	0			Data Not Normal at 5% Significance Level		
396						Lilliefors Test Statistic	0.166			**Lilliefors GOF Test**		
397						5% Lilliefors Critical Value	0.0495			Data Not Normal at 5% Significance Level		
398	**Data Not Normal at 5% Significance Level**											
399												
400	**Assuming Normal Distribution**											
401						**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**		
402						95% Student's-t UCL	114.9			95% Adjusted-CLT UCL (Chen-1995)	115.6	
403										95% Modified-t UCL (Johnson-1978)	115	
404												
405	**Gamma GOF Test**											
406						A-D Test Statistic	1.37			**Anderson-Darling Gamma GOF Test**		
407						5% A-D Critical Value	0.768			Data Not Gamma Distributed at 5% Significance Level		
408						K-S Test Statistic	0.0705			**Kolmogorov-Smirnov Gamma GOF Test**		
409						5% K-S Critical Value	0.051			Data Not Gamma Distributed at 5% Significance Level		
410	**Data Not Gamma Distributed at 5% Significance Level**											
411												
412	**Gamma Statistics**											
413						k hat (MLE)	1.845			k star (bias corrected MLE)	1.83	
414						Theta hat (MLE)	57.95			Theta star (bias corrected MLE)	58.42	
415						nu hat (MLE)	1203			nu star (bias corrected)	1193	
416						MLE Mean (bias corrected)	106.9			MLE Sd (bias corrected)	79.02	
417										Approximate Chi Square Value (0.05)	1114	
418						Adjusted Level of Significance	0.0493			Adjusted Chi Square Value	1113	
419												
420	**Assuming Gamma Distribution**											
421						95% Approximate Gamma UCL (use when n>=50))	114.5			95% Adjusted Gamma UCL (use when n<50)	114.5	
422												
423	**Lognormal GOF Test**											
424						Shapiro Wilk Test Statistic	0.979			**Shapiro Wilk Lognormal GOF Test**		
425						5% Shapiro Wilk P Value	0.123			Data appear Lognormal at 5% Significance Level		
426						Lilliefors Test Statistic	0.0984			**Lilliefors Lognormal GOF Test**		
427						5% Lilliefors Critical Value	0.0495			Data Not Lognormal at 5% Significance Level		
428	**Data appear Approximate Lognormal at 5% Significance Level**											
429												
430	**Lognormal Statistics**											
431						Minimum of Logged Data	1.345			Mean of logged Data	4.377	
432						Maximum of Logged Data	6.613			SD of logged Data	0.805	
433												
434	**Assuming Lognormal Distribution**											
435						95% H-UCL	120.2			90% Chebyshev (MVUE) UCL	126.7	
436						95% Chebyshev (MVUE) UCL	134.4			97.5% Chebyshev (MVUE) UCL	145	
437						99% Chebyshev (MVUE) UCL	165.8					
438												
439	**Nonparametric Distribution Free UCL Statistics**											
440	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
441												
442	**Nonparametric Distribution Free UCLs**											
443						95% CLT UCL	114.9			95% Jackknife UCL	114.9	
444						95% Standard Bootstrap UCL	115.2			95% Bootstrap-t UCL	115.8	
445						95% Hall's Bootstrap UCL	116.1			95% Percentile Bootstrap UCL	115	
446						95% BCA Bootstrap UCL	115.2					
447						90% Chebyshev(Mean, Sd) UCL	121.5			95% Chebyshev(Mean, Sd) UCL	128.2	
448						97.5% Chebyshev(Mean, Sd) UCL	137.4			99% Chebyshev(Mean, Sd) UCL	155.4	
449												
450	**Suggested UCL to Use**											
451						95% H-UCL	120.2					
452												
453	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
454	Recommendations are based upon data size, data distribution, and skewness.											
455	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
456	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
457												
458	**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**											
459	**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**											
460	**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**											
461	**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**											
462												

463											
464	**Montrose**										
465											
466	**General Statistics**										
467				Total Number of Observations	179			Number of Distinct Observations	125		
468								Number of Missing Observations	0		
469				Minimum	6			Mean	84.39		
470				Maximum	825			Median	59		
471				SD	96.3			Std. Error of Mean	7.198		
472				Coefficient of Variation	1.141			Skewness	4.624		
473											
474	**Normal GOF Test**										
475				Shapiro Wilk Test Statistic	0.604			**Shapiro Wilk GOF Test**			
476				5% Shapiro Wilk P Value	0			Data Not Normal at 5% Significance Level			
477				Lilliefors Test Statistic	0.215			**Lilliefors GOF Test**			
478				5% Lilliefors Critical Value	0.0666			Data Not Normal at 5% Significance Level			
479	**Data Not Normal at 5% Significance Level**										
480											
481	**Assuming Normal Distribution**										
482				**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
483				95% Student's-t UCL	96.29			95% Adjusted-CLT UCL (Chen-1995)	98.89		
484								95% Modified-t UCL (Johnson-1978)	96.71		
485											
486	**Gamma GOF Test**										
487				A-D Test Statistic	2.161			**Anderson-Darling Gamma GOF Test**			
488				5% A-D Critical Value	0.77			Data Not Gamma Distributed at 5% Significance Level			
489				K-S Test Statistic	0.0871			**Kolmogorov-Smirnov Gamma GOF Test**			
490				5% K-S Critical Value	0.0703			Data Not Gamma Distributed at 5% Significance Level			
491	**Data Not Gamma Distributed at 5% Significance Level**										
492											
493	**Gamma Statistics**										
494				k hat (MLE)	1.562			k star (bias corrected MLE)	1.54		
495				Theta hat (MLE)	54.02			Theta star (bias corrected MLE)	54.81		
496				nu hat (MLE)	559.3			nu star (bias corrected)	551.2		
497				MLE Mean (bias corrected)	84.39			MLE Sd (bias corrected)	68.01		
498								Approximate Chi Square Value (0.05)	497.8		
499				Adjusted Level of Significance	0.0487			Adjusted Chi Square Value	497.4		
500											
501	**Assuming Gamma Distribution**										
502				95% Approximate Gamma UCL (use when n>=50))	93.45			95% Adjusted Gamma UCL (use when n<50)	93.53		
503											
504	**Lognormal GOF Test**										
505				Shapiro Wilk Test Statistic	0.988			**Shapiro Wilk Lognormal GOF Test**			
506				5% Shapiro Wilk P Value	0.868			Data appear Lognormal at 5% Significance Level			
507				Lilliefors Test Statistic	0.0448			**Lilliefors Lognormal GOF Test**			
508				5% Lilliefors Critical Value	0.0666			Data appear Lognormal at 5% Significance Level			
509	**Data appear Lognormal at 5% Significance Level**										
510											
511	**Lognormal Statistics**										
512				Minimum of Logged Data	1.792			Mean of logged Data	4.082		
513				Maximum of Logged Data	6.715			SD of logged Data	0.817		
514											
515	**Assuming Lognormal Distribution**										
516				95% H-UCL	93.64			90% Chebyshev (MVUE) UCL	99.87		
517				95% Chebyshev (MVUE) UCL	107.7			97.5% Chebyshev (MVUE) UCL	118.6		
518				99% Chebyshev (MVUE) UCL	140						
519											
520	**Nonparametric Distribution Free UCL Statistics**										
521	**Data appear to follow a Discernible Distribution at 5% Significance Level**										
522											
523	**Nonparametric Distribution Free UCLs**										
524				95% CLT UCL	96.23			95% Jackknife UCL	96.29		
525				95% Standard Bootstrap UCL	96.38			95% Bootstrap-t UCL	101		
526				95% Hall's Bootstrap UCL	104.3			95% Percentile Bootstrap UCL	96.94		
527				95% BCA Bootstrap UCL	98.36						
528				90% Chebyshev(Mean, Sd) UCL	106			95% Chebyshev(Mean, Sd) UCL	115.8		
529				97.5% Chebyshev(Mean, Sd) UCL	129.3			99% Chebyshev(Mean, Sd) UCL	156		
530											
531	**Suggested UCL to Use**										
532				95% H-UCL	93.64						
533											
534	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.										
535	Recommendations are based upon data size, data distribution, and skewness.										
536	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).										
537	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.										
538											
539	**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**										
540	**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**										
541	**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**										
542	**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**										
543											

544												
545	**Oasis**											
546												
547	**General Statistics**											
548					Total Number of Observations	139			Number of Distinct Observations	129		
549									Number of Missing Observations	0		
550					Minimum	15			Mean	383.8		
551					Maximum	2130			Median	330		
552					SD	281.5			Std. Error of Mean	23.87		
553					Coefficient of Variation	0.733			Skewness	2.582		
554												
555	**Normal GOF Test**											
556					Shapiro Wilk Test Statistic	0.813			**Shapiro Wilk GOF Test**			
557					5% Shapiro Wilk P Value	0			Data Not Normal at 5% Significance Level			
558					Lilliefors Test Statistic	0.168			**Lilliefors GOF Test**			
559					5% Lilliefors Critical Value	0.0755			Data Not Normal at 5% Significance Level			
560	**Data Not Normal at 5% Significance Level**											
561												
562	**Assuming Normal Distribution**											
563					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
564					95% Student's-t UCL	423.3			95% Adjusted-CLT UCL (Chen-1995)	428.7		
565									95% Modified-t UCL (Johnson-1978)	424.2		
566												
567	**Gamma GOF Test**											
568					A-D Test Statistic	0.941			**Anderson-Darling Gamma GOF Test**			
569					5% A-D Critical Value	0.764			Data Not Gamma Distributed at 5% Significance Level			
570					K-S Test Statistic	0.0789			**Kolmogorov-Smirnov Gamma GOF Test**			
571					5% K-S Critical Value	0.0803			Detected data appear Gamma Distributed at 5% Significance Level			
572	**Detected data follow Appr. Gamma Distribution at 5% Significance Level**											
573												
574	**Gamma Statistics**											
575					k hat (MLE)	2.28			k star (bias corrected MLE)	2.236		
576					Theta hat (MLE)	168.3			Theta star (bias corrected MLE)	171.7		
577					nu hat (MLE)	633.9			nu star (bias corrected)	621.5		
578					MLE Mean (bias corrected)	383.8			MLE Sd (bias corrected)	256.7		
579									Approximate Chi Square Value (0.05)	564.7		
580					Adjusted Level of Significance	0.0483			Adjusted Chi Square Value	564.1		
581												
582	**Assuming Gamma Distribution**											
583					95% Approximate Gamma UCL (use when n>=50)	422.4			95% Adjusted Gamma UCL (use when n<50)	422.8		
584												
585	**Lognormal GOF Test**											
586					Shapiro Wilk Test Statistic	0.953			**Shapiro Wilk Lognormal GOF Test**			
587					5% Shapiro Wilk P Value	5.2246E-4			Data Not Lognormal at 5% Significance Level			
588					Lilliefors Test Statistic	0.0865			**Lilliefors Lognormal GOF Test**			
589					5% Lilliefors Critical Value	0.0755			Data Not Lognormal at 5% Significance Level			
590	**Data Not Lognormal at 5% Significance Level**											
591												
592	**Lognormal Statistics**											
593					Minimum of Logged Data	2.708			Mean of logged Data	5.715		
594					Maximum of Logged Data	7.664			SD of logged Data	0.74		
595												
596	**Assuming Lognormal Distribution**											
597					95% H-UCL	452			90% Chebyshev (MVUE) UCL	481.8		
598					95% Chebyshev (MVUE) UCL	519.8			97.5% Chebyshev (MVUE) UCL	572.5		
599					99% Chebyshev (MVUE) UCL	676.1						
600												
601	**Nonparametric Distribution Free UCL Statistics**											
602	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
603												
604	**Nonparametric Distribution Free UCLs**											
605					95% CLT UCL	423.1			95% Jackknife UCL	423.3		
606					95% Standard Bootstrap UCL	423.5			95% Bootstrap-t UCL	433		
607					95% Hall's Bootstrap UCL	431.4			95% Percentile Bootstrap UCL	425.1		
608					95% BCA Bootstrap UCL	428.7						
609					90% Chebyshev(Mean, Sd) UCL	455.4			95% Chebyshev(Mean, Sd) UCL	487.9		
610					97.5% Chebyshev(Mean, Sd) UCL	532.9			99% Chebyshev(Mean, Sd) UCL	621.4		
611												
612	**Suggested UCL to Use**											
613					95% Approximate Gamma UCL	422.4						
614												
615	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
616	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
617												
618	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
619	Recommendations are based upon data size, data distribution, and skewness.											
620	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
621	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
622												

623											
624	**Rivervale**										
625											
626	**General Statistics**										
627				Total Number of Observations	545			Number of Distinct Observations	422		
628								Number of Missing Observations	0		
629				Minimum	2.1			Mean	550.2		
630				Maximum	9920			Median	363		
631				SD	687.4			Std. Error of Mean	29.44		
632				Coefficient of Variation	1.249			Skewness	6.23		
633											
634	**Normal GOF Test**										
635				Shapiro Wilk Test Statistic	0.605		**Shapiro Wilk GOF Test**				
636				5% Shapiro Wilk P Value	0		Data Not Normal at 5% Significance Level				
637				Lilliefors Test Statistic	0.219		**Lilliefors GOF Test**				
638				5% Lilliefors Critical Value	0.0383		Data Not Normal at 5% Significance Level				
639	**Data Not Normal at 5% Significance Level**										
640											
641	**Assuming Normal Distribution**										
642				**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
643				95% Student's-t UCL	598.7			95% Adjusted-CLT UCL (Chen-1995)	607		
644								95% Modified-t UCL (Johnson-1978)	600		
645											
646	**Gamma GOF Test**										
647				A-D Test Statistic	5.223		**Anderson-Darling Gamma GOF Test**				
648				5% A-D Critical Value	0.778		Data Not Gamma Distributed at 5% Significance Level				
649				K-S Test Statistic	0.0764		**Kolmogorov-Smirnov Gamma GOF Test**				
650				5% K-S Critical Value	0.0403		Data Not Gamma Distributed at 5% Significance Level				
651	**Data Not Gamma Distributed at 5% Significance Level**										
652											
653	**Gamma Statistics**										
654				k hat (MLE)	1.279			k star (bias corrected MLE)	1.273		
655				Theta hat (MLE)	430.2			Theta star (bias corrected MLE)	432.2		
656				nu hat (MLE)	1394			nu star (bias corrected)	1388		
657				MLE Mean (bias corrected)	550.2			MLE Sd (bias corrected)	487.6		
658								Approximate Chi Square Value (0.05)	1302		
659				Adjusted Level of Significance	0.0496			Adjusted Chi Square Value	1302		
660											
661	**Assuming Gamma Distribution**										
662				95% Approximate Gamma UCL (use when n>=50))	586.3			95% Adjusted Gamma UCL (use when n<50)	586.4		
663											
664	**Lognormal GOF Test**										
665				Shapiro Wilk Test Statistic	0.992		**Shapiro Wilk Lognormal GOF Test**				
666				5% Shapiro Wilk P Value	0.99		Data appear Lognormal at 5% Significance Level				
667				Lilliefors Test Statistic	0.0396		**Lilliefors Lognormal GOF Test**				
668				5% Lilliefors Critical Value	0.0383		Data Not Lognormal at 5% Significance Level				
669	**Data appear Approximate Lognormal at 5% Significance Level**										
670											
671	**Lognormal Statistics**										
672				Minimum of Logged Data	0.742			Mean of logged Data	5.871		
673				Maximum of Logged Data	9.202			SD of logged Data	0.957		
674											
675	**Assuming Lognormal Distribution**										
676				95% H-UCL	610.4			90% Chebyshev (MVUE) UCL	642.6		
677				95% Chebyshev (MVUE) UCL	680.1			97.5% Chebyshev (MVUE) UCL	732.2		
678				99% Chebyshev (MVUE) UCL	834.5						
679											
680	**Nonparametric Distribution Free UCL Statistics**										
681	**Data appear to follow a Discernible Distribution at 5% Significance Level**										
682											
683	**Nonparametric Distribution Free UCLs**										
684				95% CLT UCL	598.6			95% Jackknife UCL	598.7		
685				95% Standard Bootstrap UCL	598.3			95% Bootstrap-t UCL	610.7		
686				95% Hall's Bootstrap UCL	617.3			95% Percentile Bootstrap UCL	601.6		
687				95% BCA Bootstrap UCL	606.7						
688				90% Chebyshev(Mean, Sd) UCL	638.5			95% Chebyshev(Mean, Sd) UCL	678.5		
689				97.5% Chebyshev(Mean, Sd) UCL	734.1			99% Chebyshev(Mean, Sd) UCL	843.2		
690											
691	**Suggested UCL to Use**										
692				95% H-UCL	610.4						
693											
694	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.										
695	Recommendations are based upon data size, data distribution, and skewness.										
696	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).										
697	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.										
698											
699	**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**										
700	**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**										
701	**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**										
702	**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**										
703											

704											
705	**Shavers Bench**										
706											
707	**General Statistics**										
708					Total Number of Observations	1790			Number of Distinct Observations	1093	
709									Number of Missing Observations	0	
710					Minimum	0.41			Mean	747	
711					Maximum	4200			Median	634	
712					SD	543.7			Std. Error of Mean	12.85	
713					Coefficient of Variation	0.728			Skewness	1.458	
714											
715	**Normal GOF Test**										
716					Shapiro Wilk Test Statistic	0.895	**Shapiro Wilk GOF Test**				
717					5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level				
718					Lilliefors Test Statistic	0.0935	**Lilliefors GOF Test**				
719					5% Lilliefors Critical Value	0.0211	Data Not Normal at 5% Significance Level				
720	**Data Not Normal at 5% Significance Level**										
721											
722	**Assuming Normal Distribution**										
723					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**		
724					95% Student's-t UCL	768.2			95% Adjusted-CLT UCL (Chen-1995)	768.7	
725									95% Modified-t UCL (Johnson-1978)	768.3	
726											
727	**Gamma GOF Test**										
728					A-D Test Statistic	4.941	**Anderson-Darling Gamma GOF Test**				
729					5% A-D Critical Value	0.771	Data Not Gamma Distributed at 5% Significance Level				
730					K-S Test Statistic	0.0345	**Kolmogorov-Smirnov Gamma GOF Test**				
731					5% K-S Critical Value	0.0235	Data Not Gamma Distributed at 5% Significance Level				
732	**Data Not Gamma Distributed at 5% Significance Level**										
733											
734	**Gamma Statistics**										
735					k hat (MLE)	1.611			k star (bias corrected MLE)	1.609	
736					Theta hat (MLE)	463.7			Theta star (bias corrected MLE)	464.4	
737					nu hat (MLE)	5767			nu star (bias corrected)	5759	
738					MLE Mean (bias corrected)	747			MLE Sd (bias corrected)	589	
739									Approximate Chi Square Value (0.05)	5583	
740					Adjusted Level of Significance	0.0499			Adjusted Chi Square Value	5583	
741											
742	**Assuming Gamma Distribution**										
743					95% Approximate Gamma UCL (use when n>=50))	770.5			95% Adjusted Gamma UCL (use when n<50)	770.5	
744											
745	**Lognormal GOF Test**										
746					Shapiro Wilk Test Statistic	0.824	**Shapiro Wilk Lognormal GOF Test**				
747					5% Shapiro Wilk P Value	0	Data Not Lognormal at 5% Significance Level				
748					Lilliefors Test Statistic	0.0987	**Lilliefors Lognormal GOF Test**				
749					5% Lilliefors Critical Value	0.0211	Data Not Lognormal at 5% Significance Level				
750	**Data Not Lognormal at 5% Significance Level**										
751											
752	**Lognormal Statistics**										
753					Minimum of Logged Data	-0.892			Mean of logged Data	6.275	
754					Maximum of Logged Data	8.343			SD of logged Data	1.051	
755											
756	**Assuming Lognormal Distribution**										
757					95% H-UCL	N/A			90% Chebyshev (MVUE) UCL	1008	
758					95% Chebyshev (MVUE) UCL	1046			97.5% Chebyshev (MVUE) UCL	1100	
759					99% Chebyshev (MVUE) UCL	1206					
760											
761	**Nonparametric Distribution Free UCL Statistics**										
762	**Data do not follow a Discernible Distribution (0.05)**										
763											
764	**Nonparametric Distribution Free UCLs**										
765					95% CLT UCL	768.2			95% Jackknife UCL	768.2	
766					95% Standard Bootstrap UCL	768.5			95% Bootstrap-t UCL	768.4	
767					95% Hall's Bootstrap UCL	768.2			95% Percentile Bootstrap UCL	768	
768					95% BCA Bootstrap UCL	767.5					
769					90% Chebyshev(Mean, Sd) UCL	785.6			95% Chebyshev(Mean, Sd) UCL	803.1	
770					97.5% Chebyshev(Mean, Sd) UCL	827.3			99% Chebyshev(Mean, Sd) UCL	874.9	
771											
772	**Suggested UCL to Use**										
773					95% Chebyshev (Mean, Sd) UCL	803.1					
774											
775	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.										
776	Recommendations are based upon data size, data distribution, and skewness.										
777	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).										
778	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.										
779											

Sunningdale											
General Statistics											
Total Number of Observations					1988	Number of Distinct Observations					770
						Number of Missing Observations					0
Minimum					0.27	Mean					431.7
Maximum					3400	Median					395
SD					275.5	Std. Error of Mean					6.179
Coefficient of Variation					0.638	Skewness					2.366
Normal GOF Test											
Shapiro Wilk Test Statistic					0.867	**Shapiro Wilk GOF Test**					
5% Shapiro Wilk P Value					0	Data Not Normal at 5% Significance Level					
Lilliefors Test Statistic					0.11	**Lilliefors GOF Test**					
5% Lilliefors Critical Value					0.0201	Data Not Normal at 5% Significance Level					
Data Not Normal at 5% Significance Level											
Assuming Normal Distribution											
95% Normal UCL						**95% UCLs (Adjusted for Skewness)**					
95% Student's-t UCL					441.9	95% Adjusted-CLT UCL (Chen-1995)					442.2
						95% Modified-t UCL (Johnson-1978)					442
Gamma GOF Test											
A-D Test Statistic					7.86	**Anderson-Darling Gamma GOF Test**					
5% A-D Critical Value					0.764	Data Not Gamma Distributed at 5% Significance Level					
K-S Test Statistic					0.0466	**Kolmogorov-Smirnov Gamma GOF Test**					
5% K-S Critical Value					0.022	Data Not Gamma Distributed at 5% Significance Level					
Data Not Gamma Distributed at 5% Significance Level											
Gamma Statistics											
k hat (MLE)					2.485	k star (bias corrected MLE)					2.481
Theta hat (MLE)					173.8	Theta star (bias corrected MLE)					174
nu hat (MLE)					9878	nu star (bias corrected)					9865
MLE Mean (bias corrected)					431.7	MLE Sd (bias corrected)					274.1
						Approximate Chi Square Value (0.05)					9635
Adjusted Level of Significance					0.0499	Adjusted Chi Square Value					9635
Assuming Gamma Distribution											
95% Approximate Gamma UCL (use when n>=50))					442	95% Adjusted Gamma UCL (use when n<50)					442
Lognormal GOF Test											
Shapiro Wilk Test Statistic					0.885	**Shapiro Wilk Lognormal GOF Test**					
5% Shapiro Wilk P Value					0	Data Not Lognormal at 5% Significance Level					
Lilliefors Test Statistic					0.0931	**Lilliefors Lognormal GOF Test**					
5% Lilliefors Critical Value					0.0201	Data Not Lognormal at 5% Significance Level					
Data Not Lognormal at 5% Significance Level											
Lognormal Statistics											
Minimum of Logged Data					-1.309	Mean of logged Data					5.853
Maximum of Logged Data					8.132	SD of logged Data					0.76
Assuming Lognormal Distribution											
95% H-UCL					N/A	90% Chebyshev (MVUE) UCL					491.9
95% Chebyshev (MVUE) UCL					504.1	97.5% Chebyshev (MVUE) UCL					521
99% Chebyshev (MVUE) UCL					554.3						
Nonparametric Distribution Free UCL Statistics											
Data do not follow a Discernible Distribution (0.05)											
Nonparametric Distribution Free UCLs											
95% CLT UCL					441.9	95% Jackknife UCL					441.9
95% Standard Bootstrap UCL					441.8	95% Bootstrap-t UCL					442.4
95% Hall's Bootstrap UCL					442.6	95% Percentile Bootstrap UCL					442.1
95% BCA Bootstrap UCL					442.8						
90% Chebyshev(Mean, Sd) UCL					450.3	95% Chebyshev(Mean, Sd) UCL					458.7
97.5% Chebyshev(Mean, Sd) UCL					470.3	99% Chebyshev(Mean, Sd) UCL					493.2
Suggested UCL to Use											
95% Chebyshev (Mean, Sd) UCL					458.7						
Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
Recommendations are based upon data size, data distribution, and skewness.											
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											

856												
857	**Tadanac**											
858												
859	**General Statistics**											
860						Total Number of Observations	1087			Number of Distinct Observations	856	
861										Number of Missing Observations	0	
862						Minimum	0.34			Mean	1535	
863						Maximum	19500			Median	1164	
864						SD	1660			Std. Error of Mean	50.36	
865						Coefficient of Variation	1.082			Skewness	4.255	
866												
867	**Normal GOF Test**											
868						Shapiro Wilk Test Statistic	0.716			**Shapiro Wilk GOF Test**		
869						5% Shapiro Wilk P Value	0			Data Not Normal at 5% Significance Level		
870						Lilliefors Test Statistic	0.178			**Lilliefors GOF Test**		
871						5% Lilliefors Critical Value	0.0271			Data Not Normal at 5% Significance Level		
872	**Data Not Normal at 5% Significance Level**											
873												
874	**Assuming Normal Distribution**											
875						**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**		
876						95% Student's-t UCL	1618			95% Adjusted-CLT UCL (Chen-1995)	1624	
877										95% Modified-t UCL (Johnson-1978)	1619	
878												
879	**Gamma GOF Test**											
880						A-D Test Statistic	8.751			**Anderson-Darling Gamma GOF Test**		
881						5% A-D Critical Value	0.79			Data Not Gamma Distributed at 5% Significance Level		
882						K-S Test Statistic	0.0663			**Kolmogorov-Smirnov Gamma GOF Test**		
883						5% K-S Critical Value	0.029			Data Not Gamma Distributed at 5% Significance Level		
884	**Data Not Gamma Distributed at 5% Significance Level**											
885												
886	**Gamma Statistics**											
887						k hat (MLE)	0.89			k star (bias corrected MLE)	0.888	
888						Theta hat (MLE)	1724			Theta star (bias corrected MLE)	1728	
889						nu hat (MLE)	1935			nu star (bias corrected)	1931	
890						MLE Mean (bias corrected)	1535			MLE Sd (bias corrected)	1628	
891										Approximate Chi Square Value (0.05)	1830	
892						Adjusted Level of Significance	0.0498			Adjusted Chi Square Value	1830	
893												
894	**Assuming Gamma Distribution**											
895						95% Approximate Gamma UCL (use when n>=50))	1619			95% Adjusted Gamma UCL (use when n<50)	1620	
896												
897	**Lognormal GOF Test**											
898						Shapiro Wilk Test Statistic	0.849			**Shapiro Wilk Lognormal GOF Test**		
899						5% Shapiro Wilk P Value	0			Data Not Lognormal at 5% Significance Level		
900						Lilliefors Test Statistic	0.145			**Lilliefors Lognormal GOF Test**		
901						5% Lilliefors Critical Value	0.0271			Data Not Lognormal at 5% Significance Level		
902	**Data Not Lognormal at 5% Significance Level**											
903												
904	**Lognormal Statistics**											
905						Minimum of Logged Data	-1.079			Mean of logged Data	6.678	
906						Maximum of Logged Data	9.878			SD of logged Data	1.529	
907												
908	**Assuming Lognormal Distribution**											
909						95% H-UCL	N/A			90% Chebyshev (MVUE) UCL	3071	
910						95% Chebyshev (MVUE) UCL	3306			97.5% Chebyshev (MVUE) UCL	3633	
911						99% Chebyshev (MVUE) UCL	4275					
912												
913	**Nonparametric Distribution Free UCL Statistics**											
914	**Data do not follow a Discernible Distribution (0.05)**											
915												
916	**Nonparametric Distribution Free UCLs**											
917						95% CLT UCL	1618			95% Jackknife UCL	1618	
918						95% Standard Bootstrap UCL	1616			95% Bootstrap-t UCL	1626	
919						95% Hall's Bootstrap UCL	1631			95% Percentile Bootstrap UCL	1621	
920						95% BCA Bootstrap UCL	1622					
921						90% Chebyshev(Mean, Sd) UCL	1686			95% Chebyshev(Mean, Sd) UCL	1754	
922						97.5% Chebyshev(Mean, Sd) UCL	1849			99% Chebyshev(Mean, Sd) UCL	2036	
923												
924	**Suggested UCL to Use**											
925						95% Chebyshev (Mean, Sd) UCL	1754					
926												
927	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
928	Recommendations are based upon data size, data distribution, and skewness.											
929	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
930	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
931												

932												
933	**Waneta**											
934												
935	**General Statistics**											
936						Total Number of Observations	353			Number of Distinct Observations	261	
937										Number of Missing Observations	0	
938						Minimum	0.26			Mean	260.2	
939						Maximum	2050			Median	194	
940						SD	250.5			Std. Error of Mean	13.34	
941						Coefficient of Variation	0.963			Skewness	2.716	
942												
943	**Normal GOF Test**											
944						Shapiro Wilk Test Statistic	0.778	**Shapiro Wilk GOF Test**				
945						5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level				
946						Lilliefors Test Statistic	0.153	**Lilliefors GOF Test**				
947						5% Lilliefors Critical Value	0.0475	Data Not Normal at 5% Significance Level				
948	**Data Not Normal at 5% Significance Level**											
949												
950	**Assuming Normal Distribution**											
951	**95% Normal UCL**							**95% UCLs (Adjusted for Skewness)**				
952						95% Student's-t UCL	282.2			95% Adjusted-CLT UCL (Chen-1995)	284.2	
953										95% Modified-t UCL (Johnson-1978)	282.5	
954												
955	**Gamma GOF Test**											
956						A-D Test Statistic	0.61	**Anderson-Darling Gamma GOF Test**				
957						5% A-D Critical Value	0.777	Detected data appear Gamma Distributed at 5% Significance Level				
958						K-S Test Statistic	0.0293	**Kolmogorov-Smirnov Gamma GOF Test**				
959						5% K-S Critical Value	0.0495	Detected data appear Gamma Distributed at 5% Significance Level				
960	**Detected data appear Gamma Distributed at 5% Significance Level**											
961												
962	**Gamma Statistics**											
963						k hat (MLE)	1.304			k star (bias corrected MLE)	1.295	
964						Theta hat (MLE)	199.6			Theta star (bias corrected MLE)	201	
965						nu hat (MLE)	920.6			nu star (bias corrected)	914.1	
966						MLE Mean (bias corrected)	260.2			MLE Sd (bias corrected)	228.7	
967										Approximate Chi Square Value (0.05)	845	
968						Adjusted Level of Significance	0.0493			Adjusted Chi Square Value	844.7	
969												
970	**Assuming Gamma Distribution**											
971						95% Approximate Gamma UCL (use when n>=50)	281.5			95% Adjusted Gamma UCL (use when n<50)	281.6	
972												
973	**Lognormal GOF Test**											
974						Shapiro Wilk Test Statistic	0.935	**Shapiro Wilk Lognormal GOF Test**				
975						5% Shapiro Wilk P Value	0	Data Not Lognormal at 5% Significance Level				
976						Lilliefors Test Statistic	0.0639	**Lilliefors Lognormal GOF Test**				
977						5% Lilliefors Critical Value	0.0475	Data Not Lognormal at 5% Significance Level				
978	**Data Not Lognormal at 5% Significance Level**											
979												
980	**Lognormal Statistics**											
981						Minimum of Logged Data	-1.347			Mean of logged Data	5.131	
982						Maximum of Logged Data	7.626			SD of logged Data	1.064	
983												
984	**Assuming Lognormal Distribution**											
985						95% H-UCL	337.2			90% Chebyshev (MVUE) UCL	360	
986						95% Chebyshev (MVUE) UCL	388.4			97.5% Chebyshev (MVUE) UCL	427.9	
987						99% Chebyshev (MVUE) UCL	505.4					
988												
989	**Nonparametric Distribution Free UCL Statistics**											
990	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
991												
992	**Nonparametric Distribution Free UCLs**											
993						95% CLT UCL	282.2			95% Jackknife UCL	282.2	
994						95% Standard Bootstrap UCL	282.4			95% Bootstrap-t UCL	284.3	
995						95% Hall's Bootstrap UCL	284.9			95% Percentile Bootstrap UCL	282.9	
996						95% BCA Bootstrap UCL	284.4					
997						90% Chebyshev(Mean, Sd) UCL	300.2			95% Chebyshev(Mean, Sd) UCL	318.4	
998						97.5% Chebyshev(Mean, Sd) UCL	343.5			99% Chebyshev(Mean, Sd) UCL	392.9	
999												
1000	**Suggested UCL to Use**											
1001						95% Approximate Gamma UCL	281.5					
1002												
1003	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1004	Recommendations are based upon data size, data distribution, and skewness.											
1005	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1006	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1007												

1008												
1009	**Warfield**											
1010												
1011	**General Statistics**											
1012						Total Number of Observations	1825			Number of Distinct Observations	554	
1013										Number of Missing Observations	0	
1014						Minimum	0.051			Mean	205.5	
1015						Maximum	2020			Median	164	
1016						SD	170.4			Std. Error of Mean	3.988	
1017						Coefficient of Variation	0.829			Skewness	3.255	
1018												
1019	**Normal GOF Test**											
1020						Shapiro Wilk Test Statistic	0.75			**Shapiro Wilk GOF Test**		
1021						5% Shapiro Wilk P Value	0			Data Not Normal at 5% Significance Level		
1022						Lilliefors Test Statistic	0.151			**Lilliefors GOF Test**		
1023						5% Lilliefors Critical Value	0.0209			Data Not Normal at 5% Significance Level		
1024	**Data Not Normal at 5% Significance Level**											
1025												
1026	**Assuming Normal Distribution**											
1027						**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**		
1028						95% Student's-t UCL	212			95% Adjusted-CLT UCL (Chen-1995)	212.3	
1029										95% Modified-t UCL (Johnson-1978)	212.1	
1030												
1031	**Gamma GOF Test**											
1032						A-D Test Statistic	9.204			**Anderson-Darling Gamma GOF Test**		
1033						5% A-D Critical Value	0.767			Data Not Gamma Distributed at 5% Significance Level		
1034						K-S Test Statistic	0.0561			**Kolmogorov-Smirnov Gamma GOF Test**		
1035						5% K-S Critical Value	0.0232			Data Not Gamma Distributed at 5% Significance Level		
1036	**Data Not Gamma Distributed at 5% Significance Level**											
1037												
1038	**Gamma Statistics**											
1039						k hat (MLE)	2.026			k star (bias corrected MLE)	2.023	
1040						Theta hat (MLE)	101.4			Theta star (bias corrected MLE)	101.5	
1041						nu hat (MLE)	7396			nu star (bias corrected)	7386	
1042						MLE Mean (bias corrected)	205.5			MLE Sd (bias corrected)	144.4	
1043										Approximate Chi Square Value (0.05)	7187	
1044						Adjusted Level of Significance	0.0499			Adjusted Chi Square Value	7187	
1045												
1046	**Assuming Gamma Distribution**											
1047						95% Approximate Gamma UCL (use when n>=50))	211.1			95% Adjusted Gamma UCL (use when n<50)	211.1	
1048												
1049	**Lognormal GOF Test**											
1050						Shapiro Wilk Test Statistic	0.958			**Shapiro Wilk Lognormal GOF Test**		
1051						5% Shapiro Wilk P Value	0			Data Not Lognormal at 5% Significance Level		
1052						Lilliefors Test Statistic	0.0472			**Lilliefors Lognormal GOF Test**		
1053						5% Lilliefors Critical Value	0.0209			Data Not Lognormal at 5% Significance Level		
1054	**Data Not Lognormal at 5% Significance Level**											
1055												
1056	**Lognormal Statistics**											
1057						Minimum of Logged Data	-2.976			Mean of logged Data	5.059	
1058						Maximum of Logged Data	7.611			SD of logged Data	0.778	
1059												
1060	**Assuming Lognormal Distribution**											
1061						95% H-UCL	N/A			90% Chebyshev (MVUE) UCL	226.2	
1062						95% Chebyshev (MVUE) UCL	232.2			97.5% Chebyshev (MVUE) UCL	240.5	
1063						99% Chebyshev (MVUE) UCL	256.9					
1064												
1065	**Nonparametric Distribution Free UCL Statistics**											
1066	**Data do not follow a Discernible Distribution (0.05)**											
1067												
1068	**Nonparametric Distribution Free UCLs**											
1069						95% CLT UCL	212			95% Jackknife UCL	212	
1070						95% Standard Bootstrap UCL	212			95% Bootstrap-t UCL	212.2	
1071						95% Hall's Bootstrap UCL	212.1			95% Percentile Bootstrap UCL	212.4	
1072						95% BCA Bootstrap UCL	211.9					
1073						90% Chebyshev(Mean, Sd) UCL	217.4			95% Chebyshev(Mean, Sd) UCL	222.8	
1074						97.5% Chebyshev(Mean, Sd) UCL	230.4			99% Chebyshev(Mean, Sd) UCL	245.1	
1075												
1076	**Suggested UCL to Use**											
1077						95% Chebyshev (Mean, Sd) UCL	222.8					
1078												
1079	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1080	Recommendations are based upon data size, data distribution, and skewness.											
1081	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1082	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1083												

West Trail				
General Statistics				
Total Number of Observations	5185		Number of Distinct Observations	1833
			Number of Missing Observations	0
Minimum	0.17		Mean	897
Maximum	6330		Median	784
SD	622.3		Std. Error of Mean	8.643
Coefficient of Variation	0.694		Skewness	1.827
Normal GOF Test				
Lilliefors Test Statistic	0.0879	**Lilliefors GOF Test**		
5% Lilliefors Critical Value	0.0124	Data Not Normal at 5% Significance Level		
Data Not Normal at 5% Significance Level				
Assuming Normal Distribution				
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**		
95% Student's-t UCL	911.2		95% Adjusted-CLT UCL (Chen-1995)	911.4
			95% Modified-t UCL (Johnson-1978)	911.2
Gamma GOF Test				
A-D Test Statistic	33.84	**Anderson-Darling Gamma GOF Test**		
5% A-D Critical Value	0.769	Data Not Gamma Distributed at 5% Significance Level		
K-S Test Statistic	0.0594	**Kolmogorov-Smirnov Gamma GOF Test**		
5% K-S Critical Value	0.0185	Data Not Gamma Distributed at 5% Significance Level		
Data Not Gamma Distributed at 5% Significance Level				
Gamma Statistics				
k hat (MLE)	1.789		k star (bias corrected MLE)	1.788
Theta hat (MLE)	501.4		Theta star (bias corrected MLE)	501.7
nu hat (MLE)	18549		nu star (bias corrected)	18540
MLE Mean (bias corrected)	897		MLE Sd (bias corrected)	670.8
			Approximate Chi Square Value (0.05)	18224
Adjusted Level of Significance	0.05		Adjusted Chi Square Value	18224
Assuming Gamma Distribution				
95% Approximate Gamma UCL (use when n>=50))	912.5		95% Adjusted Gamma UCL (use when n<50)	912.5
Lognormal GOF Test				
Lilliefors Test Statistic	0.125	**Lilliefors Lognormal GOF Test**		
5% Lilliefors Critical Value	0.0124	Data Not Lognormal at 5% Significance Level		
Data Not Lognormal at 5% Significance Level				
Lognormal Statistics				
Minimum of Logged Data	-1.772		Mean of logged Data	6.494
Maximum of Logged Data	8.753		SD of logged Data	1.01
Assuming Lognormal Distribution				
95% H-UCL	N/A		90% Chebyshev (MVUE) UCL	1158
95% Chebyshev (MVUE) UCL	1184		97.5% Chebyshev (MVUE) UCL	1220
99% Chebyshev (MVUE) UCL	1290			
Nonparametric Distribution Free UCL Statistics				
Data do not follow a Discernible Distribution (0.05)				
Nonparametric Distribution Free UCLs				
95% CLT UCL	911.2		95% Jackknife UCL	911.2
95% Standard Bootstrap UCL	911.4		95% Bootstrap-t UCL	911
95% Hall's Bootstrap UCL	911.3		95% Percentile Bootstrap UCL	911.2
95% BCA Bootstrap UCL	911.9			
90% Chebyshev(Mean, Sd) UCL	922.9		95% Chebyshev(Mean, Sd) UCL	934.6
97.5% Chebyshev(Mean, Sd) UCL	950.9		99% Chebyshev(Mean, Sd) UCL	983
Suggested UCL to Use				
95% Chebyshev (Mean, Sd) UCL	934.6			

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

APPENDIX C

Worked Calculations

Appendix C. Human Health Risk Assessment

C.1 Example Risk Calculations and Results

This appendix provides information to support the Human Health Risk Assessment (HHRA) results presented in this document.

C.2 Worked Examples of Risk Calculations

The following worked examples provide the risk estimation for exposure to lead (Pb) through direct contact with soil and dust via ingestion and inhalation pathways. The examples show calculations for non-carcinogenic exposures associated risks for toddlers exposed to Pb. The central tendency exposure point concentration for Glenmerry (461.2 µg/g), along with the central tendency receptor characteristics (see report text) have been used.

The following were used as exposure point concentrations:

- Mean soil Pb concentration measured in Glenmerry = 461.2 µg/g.
- Indoor dust Pb concentration for Glenmerry (estimated as soil EPC * 0.3 (soil to indoor dust partition coefficient from Tu et al., 2020) = 138.4 µg/g
- Maximum annual mean total suspended particulate (TSP) outdoor ambient air concentration of Pb in the Study Area = 0.057 µg/m^3

As detailed in Section 7.0 of the report, the Health Canada (2021a) recommended provisional oral toxicological reference value (TRV) for Pb of 0.5 µg/kg body weight[bw]/day was used for a toddler in this HHRA.

The following presents worked calculations for each of the operable exposure pathways evaluated in this HHRA.

C.3 Estimation of Risks from Incidental Ingestion of Soil

Incidental soil ingestion exposures to Pb were estimated according to the following Health Canada (2021a) equation:

$$EIG = \frac{C_S \times IG_S \times RAF_{ORAL} \times D_2 \times D_3}{BW}$$

Where:

EIG = exposure from the ingestion pathway (µg/kg bw/day)

C_s = soil Pb concentration (461.2 µg/g)

IG_S = soil ingestion rate (0.03 g/day; toddler)

RAF_{ORAL} = relative absorption factor from gastrointestinal tract (0.79; unitless, chemical-specific; RRU, 2017 and BCELTAC, 2022)

D_2 = days per week exposed 7/7 days (1; unitless)

D_3 = weeks per year exposed 52/52 weeks (1; unitless)

BW = body weight of person (16.5 kg; toddler)

Non-Carcinogenic Exposures (Toddler)

$$EIG_{toddler} = \frac{461.2\ \mu g/g \times 0.03\ g/day \times 0.79 \times 7\ days/7days \times 52\ weeks/52\ weeks}{16.5\ kg}$$

$$= 0.66\ \mu g/kg\ BW/day$$

Exposure to Pb through the soil ingestion pathway for a toddler resident receptor in the Glenmerry neighbourhood was estimated to be 0.66 µg/kg bw/day. Soil ingestion risk was then estimated as a HQ according to the following equation:

$$HQ = \frac{EIG_{toddler}\ (0.66\ \mu g/kg\ \text{bw}/day)}{\text{TRV}\ (0.5\ \mu g/kg\ \text{bw}/day)}$$

A HQ of 1.3 was estimated for a toddler resident receptor in the Glenmerry neighbourhood exposed to Pb via incidental soil ingestion.

C.4 Estimation of Risks from Incidental Ingestion of Indoor Dust

Incidental indoor dust ingestion exposures to Pb were estimated according to the following Health Canada (2021a) equation:

$$EIG = \frac{C_D \times IG_D \times RAF_{ORAL} \times D_2 \times D_3}{BW}$$

Where:

EIG = exposure from the ingestion pathway (µg/kg bw/day)

C_D = indoor dust Pb concentration (138.4 µg/g)

IG_D = indoor dust ingestion rate (0.041 g/day; toddler)

RAF_{ORAL} = relative absorption factor from gastrointestinal tract (0.79; unitless, chemical-specific; RRU, 2017 and BCELTAC, 2022)

D_2 = days per week exposed 7/7 days (1; unitless)

D_3 = weeks per year exposed 52/52 weeks (1; unitless)

BW = body weight of person (16.5 kg; toddler)

Non-Carcinogenic Exposures (Toddler)

$$EIG_{toddler} = \frac{138.4\ \mu g/g \times 0.041\ g/day \times 0.79 \times 7\ days/7days \times 52\ weeks/52\ weeks}{16.5\ kg}$$

$$= 0.27\ \mu g/kg\ bw/day$$

Exposure to Pb through the indoor dust ingestion pathway for a toddler resident receptor in the Glennmerry neighbourhood was estimated to be 0.27 µg/kg bw/day. Indoor dust ingestion risk was then estimated as a HQ according to the following equation:

$$HQ = \frac{EIG_{toddler}\ (0.27\ \mu g/kg\ \text{bw}/day)}{\text{TRV}\ (0.5\ \mu g/kg\ \text{bw}/day)}$$

A HQ of 0.54 was estimated for a toddler resident receptor in the Glennmerry neighbourhood exposed to Pb via incidental ingestion of indoor dust.

C.5 Estimation of Risks from Inhalation of Soil Particulate Matter

Human receptors at grade may inhale soil particulate matter originating from surface soils and dust. The inhalation of soil particulate and dust was evaluated through the calculation of a dose (µg/kg bw/d) due to the absence of an inhalation-specific TRV for lead (Pb). As per Health Canada guidance (2021a), an inhalable soil particulate matter concentration of 0.76 µg/m^3 was assumed for all exposure scenarios.

Pb exposure via inhalation of soil particulate matter concentration was estimated as per the following equation (Health Canada, 2021a):

$$EID = \frac{C_s \times P_{air} \times IR \times RAF_{INH} \times D_1 \times D_2 \times D_3}{BW}$$

Where:

EID = exposure from the inhalation pathway for soil (µg/kg bw/day)

C_S = soil chemical concentration (461.2 µg/g)

P_{Air} = particulate matter concentration in air (7.6x10^{-7} g/m^3)

IR = inhalation rate (8.3 m^3/day; toddler)

RAF_{INH} = relative absorption factor by inhalation (1; unitless, chemical-specific)

D_1 = hours per day exposed 8/24 hours (0.33; unitless)

D_2 = days per week exposed 7/7 days (1; unitless)

D_3 = weeks per year exposed 52/52 weeks (1; unitless)

BW = body weight (16.5 kg; toddler)

Non-Carcinogenic Exposures (Toddler)

$$EID_{toddler} = \frac{461.2\ \mu g/g \times 7.6 \times 10^{-7}\ g/m^3 \times 8.3\ m^3/day \times 1.0 \times 8\ hr/24\ hr \times 7\ days/7\ days \times 52\ weeks/52\ weeks}{16.5\ kg}$$

$$= 5.9 \times 10^{-5}\ \mu g/kg\ bw/day$$

Exposure to Pb via the inhalation of soil particulate pathway was estimated as a dose for the toddler resident receptor in the Glennmerry neighbhourhood at 5.9 x 10^{-5} µg/kg bw/day. Soil particulate matter inhalation risk was then estimated as a HQ according to the following equation:

$$HQ = \frac{EID_{toddler}\ (5.9 \times 10^{-5}\ \mu g/kg\ bw/day)}{TRV\ (0.5\ \mu g/kg\ bw/day)}$$

A HQ of 1.2 x 10^{-4} was estimated for the toddler resident receptor in the Glennmerry neighbourhood exposed to the Pb in soil via inhalation of soil particulate matter.

C.6 Estimation of Risks from Inhalation of Indoor Dust

Residential toddler receptors may also inhale indoor dust. The inhalation of dust was evaluated through the calculation of a dose (µg/kg bw/d) due to the absence of an inhalation-specific TRV for Pb.

Dust inhalation exposure was estimated as per the following equation, which was modified from Health Canada (2021a):

$$EID = \frac{C_D \times IR_D \times RAF_{INH} \times D_1 \times D_2 \times D_3}{BW}$$

Where:

EID = exposure from the dust inhalation pathway (µg/kg bw/day)

C_D = dust chemical concentration (138.4 µg/g)

IR_D = dust inhalation rate (0.002 g/day; toddler)

RAF_{INH} = relative absorption factor by inhalation (1; unitless, chemical-specific)

D_1 = hours per day exposed 24/24 hours (1; unitless)

D_2 = days per week exposed 7/7 days (1; unitless)

D_3 = weeks per year exposed 52/52 weeks (1; unitless)

BW = body weight (16.5 kg; toddler)

Non-Carcinogenic Exposures (Toddler)

$$EID_{toddler} = \frac{138.4\ \mu g/g \times 2.0 \times 10^{-3}\ g/day \times 1.0 \times 24\ hr/24\ hr \times 7\ days/7\ days \times 52\ weeks/52\ weeks}{16.5\ kg}$$

$$= 1.7 \times 10^{-2}\ \mu g/kg\ bw/day$$

Exposure to Pb via the inhalation of dust pathway was estimated as a dose for the toddler resident receptor in the Glennmerry neighbourhood at 1.7 x 10^{-2} µg/kg bw/day. Dust inhalation risk was then estimated as a HQ according to the following equation:

$$HQ = \frac{EID_{toddler}\ (1.7\ \times 10^{-2}\ \mu g/kg\ bw/day)}{Reference\ Dose\ (0.5\ \mu g/kg\ bw/day)}$$

A HQ of 0.034 was estimated for the toddler resident receptor in the Glennmerry neighbhourhood exposed to the Pb via inhalation of indoor dust.

C.7 Estimation of Risks from Inhalation of Outdoor Ambient Air

Human receptors at grade may also be exposed to Pb via inhalation of outdoor ambient air. Exposure to concentrations of Pb in outdoor air was estimated using the following Health Canada (2021a) equation:

$$EIV_{air} = \frac{C_{air} \times IR_A \times RAF_{INH} \times D_1 \times D_2 \times D_3 \times D_4}{BW}$$

Where:

EIV_{AIR} = exposure from the inhalation of lead (Pb) in outdoor air (µg/m^3)

C_{AIR} = outdoor air Pb concentration (0.057 µg/m^3)

IR_A = inhalation rate (8.3 m^3/day)

RAF_{INH} = relative absorption factor by inhalation (1; unitless, chemical-specific)

D_1 = hours per day exposed 24/24 hours (1; unitless)

D_2 = days per week exposed 7/7 days (1; unitless)

D_3 = weeks per year exposed 52/52 weeks (1; unitless)

BW = body weight (16.5 kg; toddler)

Non-Carcinogenic Exposures

$$EIVair = \frac{0.077\ ug/m3 \times 8.3\ m3/day \times 1.0 \times 24\ hr/24\ hr \times 7\ days/7\ days \times 52\ weeks/52\ weeks}{16.5\ kg}$$

$$= 3.9 \times 10^{-2}\ \mu g/kg\ bw/day$$

Exposure to Pb via the inhalation of outdoor ambient air pathway was estimated as a dose for the toddler resident receptor in the Glennmerry neighbourhood at 2.9 x 10^{-2} µg/kg bw/day. Inhalation risk from outdoor airborne Pb exposure was then estimated as a HQ according to the following equation:

$$HQ = \frac{EID_{toddler}\ (3.9\ \times 10^{-2}\ \mu g/kg\ bw/day)}{Reference\ Dose\ (0.5\ \mu g/kg\ bw/day)}$$

A HQ of 7.7 x 10^{-2} was estimated for the toddler resident receptor in the Glennmerry neighbourhood exposed to the maximum concentration of Pb via inhalation of outdoor ambient air.

C.8 Estimation of Risks from the Assessed Exposure Pathways

The total non-carcinogenic risk (i.e., the sum of the HQs) for a toddler residential exposed to lead (Pb) via the studied exposure pathways is presented below as the Hazard Index (HI):

HQ for ingestion of soil	= 1.3
HQ for ingestion of dust	= 0.54
HQ for inhalation of soil particulate	= 1.2 x 10^{-4}
HQ for inhalation of indoor dust	= 0.03
HQ for inhalation of outdoor air	= 7.7 x 10^{-2}
Total HI for all pathways	**= 2.0**

The central tendency total HI for a toddler receptor exposed to Pb in the Glennmerry neighbourhood via all studied exposure pathways is **2.0**.

AtkinsRéalis

AtkinsRéalis Canada Inc.

1300 - 3777 Kingsway Burnaby, BC
V5H 3Z7 Canada
604.662.3555

atkinsrealis.com