Exponent™

Human Health Risk Assessment for Trail, British Columbia

Phase 2: Screening-Level Deterministic Risk Calculations

Prepared for

Trail Lead Program
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EXECUTIVE SUMMARY

This report describes the human health risk assessment (HHRA) efforts conducted to date by Exponent on behalf of the Trail Lead Program as part of the Phase 2 human health risk assessment, and presents screening-level deterministic risk calculations for non-lead constituents. As part of the Phase 2 risk assessment efforts, Exponent has conducted several analyses, results of which have been provided to the Trail Lead Program as technical memoranda. These analyses are summarized below, prior to a description of the scope and findings of the risk assessment.

Determining an absorbed-dose reference dose (RfD) for cadmium. The standard toxicity benchmark value for cadmium (i.e., the dose below which toxic effects are not anticipated) is based on kidney concentrations that accumulate from a lifetime of exposure. These concentrations reflect lifetime exposure to cadmium from all sources, including background exposures (which are often ignored in risk assessments). However, because cadmium intake from food and cigarette smoke can be significant relative to soil exposure pathways, determination of a cadmium concentration that can exist in soil without producing adverse effects on human populations must account for these other common exposure pathways. Therefore, Exponent assessed background exposure to cadmium to derive an adjusted RfD for use in risk evaluations for Trail.

Evaluating background exposure to arsenic. Because arsenic occurs naturally in the environment and is present in most foods, arsenic exposure is a typical part of everyday life. Therefore, Exponent used information from the literature and BCE databases to develop a summary of background arsenic intake from various sources for people living in southeastern British Columbia. This information provides a basis for evaluating the magnitude of arsenic exposures from soil relative to other sources.

Screening plant concentrations of arsenic and cadmium. Because arsenic and cadmium in soil can be taken up into plants, human consumption of homegrown produce grown in soils containing these metals constitutes a potentially significant exposure pathway. In this task, screening calculations were performed to determine whether potential exposures to these metals from homegrown produce are significant relative to exposures from soil ingestion, which is typically considered to be the primary pathway of exposure to chemicals in soil. The calculations conducted in this assessment indicate that, for arsenic, potential exposures via ingestion of homegrown produce range from 4- to 17-fold below potential exposures via soil ingestion. The opposite is the case for cadmium, for which calculations indicate that exposure to cadmium from ingestion of homegrown produce might exceed exposures from soil ingestion by a factor of greater than three.

These findings indicate that consumption of homegrown produce cannot be ruled out as a significant contributor to metals exposure. Therefore, these results supported the decision to collect site-specific data on concentrations of COPCs in homegrown and store-bought produce. The empirical data from Trail can then be used to assess potential risks to human populations in the area.

Relative bioavailability of arsenic and cadmium in Trail soils. Arsenic and cadmium can occur in soils as different physical or mineralogic species, with varying solubilities. Bioavailability typically decreases with decreasing solubility in different forms of a chemical. Exponent tested soil samples from Trail to determine the bioavailability of arsenic and cadmium as they occur in the soil, relative to the bioavailability of more soluble forms of these elements. This study assessed the oral bioavailability of arsenic and cadmium in Trail soils using data from a physiologically based extraction test (*in vitro* test) that simulates the processes controlling dissolution of chemicals in the human gastrointestinal tract. The *in vitro* testing indicated that a conservative estimate of relative bioavailability of arsenic and cadmium from site soils is 55 percent and 33 percent, respectively.

Refining the COPC list based on new data from Tadanac. In the Phase 1 risk assessment, Exponent staff used the available data to determine contaminants of potential concern (COPCs) for the site, and determined that antimony, arsenic, cadmium, mercury, selenium, thallium, tin, and zinc could be of potential health concern at some locations. Subsequent analysis conducted as part of the Phase 2 risk assessment effort has refined this list, and concluded that (non-lead) COPCs for the site can be limited to arsenic, cadmium, and antimony.

Evaluating paired soil and house-dust data. In the Phase 1 assessment, Exponent recommended collection of paired soil and house-dust samples from 60 homes around Trail, to determine the relation between concentrations of arsenic, cadmium, and antimony in soil and in house dust. Paired samples from a subset of 20 of these homes were collected by the TLP in the spring of 1998. Exponent evaluated these data to determine whether any clear relation could be discerned between indoor and outdoor concentrations of these metals. No clear regression relation could be determined for indoor and outdoor concentrations of any of the metals measured, likely because of uncharacterized indoor metals sources and outdoor metals sources other than soil (e.g., direct contribution from outdoor air to indoor dust).

RISK ASSESSMENT SCOPE

As part of the Phase 1 evaluation conducted by Exponent (then PTI), the available data from the Trail site were reviewed, and the TLP was advised regarding the findings. The Phase 1 report concluded that the screening of concentration data against conservative, health-based screening criteria indicated that all but five neighborhoods were screened out from further analysis in the Phase 2 risk assessment. The neighborhoods included in the Phase 2 evaluation are East Trail, Rivervale, Tadanac, Waneta, and West Trail.

The risk assessment presented in this document follows the conventional four-step risk assessment methodology recommended by regulatory agencies: data evaluation (and identification of COPCs), exposure assessment, toxicity assessment, and combining information from the exposure assessment and toxicity assessment to characterize potential risks. Both an assessment of potential carcinogenic risk and a characterization of potential risks from exposure to noncarcinogenic compounds are included in this assessment, using standard toxicity values recommended by BCE or the U.S. EPA. In addition to the standard characterization of risk, an additional evaluation of cadmium is provided, wherein exposures are estimated based on an absorbed dose (versus an administered dose as is done more conventionally). This was done to allow for a more rigorous evaluation of cadmium, as well as to assess integrated ingestion and inhalation exposures to this COPC.

DATA EVALUATION

All data used in this risk evaluation were provided to Exponent by the Trail Lead Program (TLP). The potential for exposure to COPCs in soil was assessed based on data collected in 1989, 1991, 1996, 1997, and 1998. All data of good quality were used for this evaluation. Data were aggregated by neighborhood, and then by land use. Exposure-point concentrations for COPCs in soil were estimated by calculating the 95 percent upper confidence limit of the arithmetic mean (UCLM) concentration for each COPC in each exposure unit. Insufficient data were available to make a separate determination (either directly, or based on a relation to soil concentrations) of exposure-point concentrations for COPCs in indoor house dust. Therefore, it was assumed in this evaluation that dust concentrations in each exposure unit are the same as the soil concentrations. This assumption likely results in an overestimate of actual risks, and may be refined in subsequent risk assessment efforts for Trail, as allowed by new data. Exposure-point concentrations for air were determined for each neighborhood based on either available daily monitoring data, or quarterly monitoring reports. Only air concentration data collected from July 1997 through July 1998, the period after the new smelter was introduced and the old smelter closed down at the Cominco facility, were used in this assessment, because they are believed to best represent current and future conditions at the site. UCLM air concentrations were determined for each neighborhood, and used in risk calculations.

EXPOSURE EVALUATION

Exponent defined the human populations believed to have potential for exposure to metals in Trail soils during the Phase 1 risk assessment efforts. These were determined to include exposures incurred by residential populations in the neighborhoods, by workers employed in commercial areas of East or West Trail, and by agricultural workers in the outlying agricultural areas around Trail. These potentially exposed populations were included in this risk evaluation.

Calculations of exposure to metals from environmental media were conducted using standard exposure and risk assessment approaches. Assumptions regarding exposure parameters were selected for the site based on site-specific information, guidance from

BCE, guidance from U.S. EPA, or professional judgement. The selection of exposure values focused on generating final estimates of Reasonable Maximum Exposures (RMEs) for each exposure pathway.

TOXICITY ASSESSMENT

The objective of a toxicity assessment is to identify the adverse health effects that a chemical causes, and how the appearance of these adverse effects depends on dose. Toxicity values (i.e., the cancer slope factors, reference doses, and reference concentrations) were obtained mostly from BCE, and an inhalation toxicity criterion for antimony from the U.S. EPA was incorporated. Second, risks from exposure to cadmium were also assessed using an alternative cadmium toxicity value.

RISK CHARACTERIZATION

Characterizing risks for Trail involved taking all the information regarding exposures to site-related compounds, and combining estimates of exposure with information regarding toxicity, to yield estimates of risks. For noncarcinogenic chemicals, risk estimates are expressed as Hazard Indices (HIs). If an HI value is below unity (i.e., HI <1), then it can be reasonably assumed that the exposure will not be associated with toxicity. For carcinogenic chemicals, risk estimates are calculated by multiplying the average lifetime daily dose by the carcinogenic slope factor (CSF), expressed in $(mg/kg\text{-}d)^{-1}$. This yields a unitless estimate of risk, and should be interpreted as the probability of increased incidence of cancer in a lifetime.

Summaries of the risk characterization results are presented in Tables ES-1, ES-2, and ES-3. Table ES-4 summarizes sources of uncertainty in the calculations. As can be seen in these tables, calculated HI values are uniformly below the value of 1 for every COPC, under every exposure scenario, indicating that there is little likelihood of adverse noncancer health effects from exposure to COPCs in Trail.

This risk evaluation also assessed noncancer risks from exposure to cadmium based on an absorbed dose. This method was used to allow for incorporation of background exposures to cadmium, and also for assessment of potential noncancer risks from exposure to cadmium associated with both the inhalation and ingestion exposure pathways. This evaluation, based on absorbed doses of cadmium, indicates that all calculated HI values are below 1, for both smokers and nonsmokers.

Calculated cancer risks from exposure to all chemicals and routes of exposure under the residential exposure scenario range from 2×10^{-4} to 3×10^{-4}. Without exception, the cancer risk estimates are dominated by risks from inhalation exposures to arsenic. Generally, the cancer risks associated with ingestion exposures to arsenic (i.e., from soil and dust) are also well below the estimates associated with inhalation exposures. The exceptions are for Rivervale and Tadanac, where calculated carcinogenic risks associated with residential ingestion exposures to arsenic approach 1×10^{-4}.

For exposures under the commercial scenario, estimated cancer risks for all chemicals and routes of exposure range from 8×10^{-5} to 1×10^{-4}. As with residential exposures, these risks are dominated by inhalation exposures to arsenic.

For exposures under the agricultural exposure scenario, total cancer risks from all chemicals and routes of exposure are 1×10^{-4} for a family living in the agricultural area, and 1×10^{-5} for field activities. These values can be added to estimate the total cancer risk that an individual might incur if they both live and work in an agricultural area. In this case, the total cancer risk for an individual living in an agricultural area and working on a farm is 1×10^{-4}.

CONCLUSIONS

Risks from Inhalation Exposures

The calculated carcinogenic risks from estimated inhalation exposure fall in the range of 9×10^{-7} to 2×10^{-4}. In interpreting these cancer risk estimates, it is important to note that, because of the means by which the carcinogenic slope factor is derived and exposures are estimated, these values represent upper-bound estimates of cancer risk, and actual cancer risk may be as low as zero.

It appears that inhalation exposures are due primarily to current emissions from the active smelter, rather than re-suspension of contaminated soil particles by wind. The new Cominco smelter has now been on line for more than a year, and the air data used in this assessment were collected during that time. It is likely that optimization of the new smelter operations will further reduce air concentrations of COPCs (and associated risks). For this reason, it will be important to track these concentrations over time. In addition, the brief analysis of air data that was conducted as part of this risk assessment raised some issues regarding the available database. For example, the fact that concentrations (expressed as $\mu g/m^3$) of PM_{10} did not display a clear distinction from concentrations of TSP is surprising. Expressed on a $\mu g/m^3$ basis, PM_{10} concentrations should be consistently lower than TSP concentrations. That this was not evident in the available data suggests that further data evaluation may be warranted.

Risks from Incidental Soil Ingestion Exposure

As described above, and discussed in depth in the Phase 1 risk assessment report (PTI 1997), background exposures to cadmium, and the fact that chronic cadmium toxicity is related to a lifetime of cadmium accumulation in the kidney, can be important considerations in evaluating environmental exposures to cadmium. When cadmium risks were evaluated by comparing the RfD to a lifetime average dose, the resulting hazard indices were all 0.01 or less. Although exposures due to cadmium in homegrown produce were not included in this evaluation, these low hazard indices indicate that cadmium doses from plants would need to be 100 times greater than the predicted doses from soil before any health risks would occur. Because homegrown produce is unlikely to contribute doses more than 10 times the soil doses, no risks of adverse health effects are anticipated from the produce pathway.

To ensure that risks from cadmium exposure in Trail were not underestimated, cadmium risks were also evaluated on the basis of an absorbed dose. These calculations confirmed that total exposures in Trail (from background, ingestion, and inhalation) are indeed below the threshold believed to result in toxic effects. The highest hazard index calculated by this method was 0.2—for smokers.

Risks associated with exposure to antimony were also predicted to be negligible. It should be noted that the toxicity data available to support the antimony oral toxicity value are of very poor quality, and were based on studies of a pharmaceutical preparation designed to enhance solubility and bioavailability of the compound. Due to the poor study quality, U.S. EPA applied a very large uncertainty factor in deriving the RfD. Considering this large uncertainty factor and the low hazard indices calculated for antimony exposures in Trail, we conclude that no further evaluation of antimony is required.

The hazard index values for assessing the noncancer risks from exposure to arsenic are below 1 for every scenario and neighborhood evaluated. The highest HI value associated with exposure to arsenic, 0.3, results from childhood exposures to soil under a residential setting. This low HI value indicates a low likelihood of experiencing noncancer toxicity from exposure to arsenic.

Estimated carcinogenic risks from ingestion routes of exposure to COPCs in soil range from 1×10^{-5} to 9×10^{-5}. All of this risk is attributable to incidental ingestion exposures to arsenic, because arsenic is the only COPC believed to be carcinogenic following oral exposure. Consistently, these values are below the corresponding risks from inhalation. In attempting to determine whether these risk estimates indicate a significant health concern, it is important to consider these estimated exposures and risks within an appropriate context.

As described above, because inorganic arsenic is present naturally in soil, food, water, and air, all people are exposed to some level of arsenic each day. Consequently, it is appropriate to compare estimates of the amount of arsenic ingested in soil and dust in Trail with these background exposures. Calculations summarized in this report provide the perspective that, on average, incremental exposures to arsenic from soil and dust in Trail will increase total exposures to about 30 percent more than background exposures alone.

In addition to the point that exposures to arsenic from soil in Trail are small relative to background exposures, the carcinogenic slope factor (CSF, with which risk estimates are derived from calculated exposure) for arsenic likely overestimates risks from oral exposures to arsenic. This likely overestimate of risk suggests that, although calculated risks for ingestion exposures to arsenic from soil approach the 10^{-4} range (i.e., the highest calculated cancer risk from ingestion was 9×10^{-5}), actual risks are likely to be much lower. Because the appropriateness of the CSF used to generate risk estimates for ingestion exposures to arsenic has recently been called into question, this value is currently under review by the U.S. EPA. It would be appropriate to re-evaluate the calculated ingestion risks for Trail if a new CSF becomes available.

Overall Health Risk Summary

Taken together, the findings of this evaluation indicate that there is no imminent (short-term) threat to human health in Trail from metals other than lead. Further, the potential for adverse health effects from long-term residence in Trail is very limited. The main focus of ongoing study should be to continue air monitoring for arsenic and cadmium. Specifically, PM_{10} should be measured, and detection limits should be low enough to support any future risk evaluations. No adverse health effects are anticipated from exposure to cadmium and antimony in soil.

Predicted cancer risks from exposure to arsenic in soil in Trail are within a range of risks considered to be acceptable by some regulatory agencies (i.e., a range of 1×10^{-6} to 1×10^{-4}). A determination of whether the predicted risks are acceptable to the community of Trail should include consideration of the uncertainties associated with predicting cancer risks from arsenic in soil at the relatively low exposure levels observed in Trail, on the basis of studies of populations exposed to very high arsenic levels in drinking water. In addition, the comparison of exposures to arsenic in Trail soils versus natural exposures to inorganic arsenic in the diet and drinking water should be presented.

Phase 3 of the risk assessment, to be completed later this year, will involve refinement of the risk estimates using new site-specific data on the levels of arsenic and cadmium in locally grown produce, COPC levels in indoor house dust, and updated data on arsenic and cadmium levels in Trail air.

TABLE ES-1. SUMMARY OF NONCANCER HAZARD INDICIES

Neighbourhood/Pathway		Antimony	Arsenic	Cadmium
Residential scenarios				
East Trail				
Adult	Ingestion	7E-03	6E-03	9E-03 [a]
Child	Ingestion	1E-01	1E-01	NA
Adult & child	Inhalation	--	--	--
Rivervale				
Adult	Ingestion	9E-03	1E-02	3E-03 [a]
Child	Ingestion	2E-01	3E-01	NA
Adult & child	Inhalation	--	--	--
Tadanac				
Adult	Ingestion	5E-03	7E-03	8E-03 [a]
Child	Ingestion	1E-01	2E-01	NA
Adult & child	Inhalation	1E-01	--	--
Waneta				
Adult	Ingestion	2E-03	2E-03	1E-03 [a]
Child	Ingestion	4E-02	4E-02	NA
Adult & child	Inhalation	3E-02	--	--
West Trail				
Adult	Ingestion	2E-03	4E-03	7E-03 [a]
Child	Ingestion	5E-02	9E-02	NA
Adult & child	Inhalation	9E-02	--	--
Commercial scenarios				
East Trail				
Adult	Ingestion	2E-03	5E-03	1E-02 [a]
Child	Ingestion	5E-02	1E-01	NA
Adult & child	Inhalation	--	--	--
West Trail/Downtown				
Adult	Ingestion	7E-04	1E-03	3E-03 [a]
Child	Ingestion	2E-02	3E-02	NA
Adult & child	Inhalation	1E-01	--	--
Agricultural scenario				
Waneta (farm family)				
Adult	Ingestion	3E-03	5E-03	3E-03 [a]
Child	Ingestion	7E-02	1E-01	NA
Adult & child	Inhalation	4E-02	--	--
Waneta (field activities)				
Adult	Ingestion	3E-03	5E-03	1E-03
Adult	Inhalation	4E-02	--	--

NA – not applicable

-- – insufficient information to complete calculation

[a] Cadmium hazard index applies to entire lifetime.

Note: Scientific notation examples

$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$

$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$

$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE ES-2. SUMMARY OF CANCER RISK ESTIMATES

Neighbourhood/Pathway	Antimony	Arsenic	Cadmium	All Chemicals
Residential scenarios				
East Trail				
Ingestion	--	5E-05	--	5E-05
Inhalation	--	1E-04	3E-05	1E-04
Total carcinogenic risk	--	2E-04	3E-05	2E-04
Rivervale				
Ingestion	--	9E-05	--	9E-05
Inhalation	--	2E-04	2E-05	2E-04
Total carcinogenic risk	--	2E-04	2E-05	3E-04
Tadanac				
Ingestion	--	6E-05	--	6E-05
Inhalation	--	1E-04	3E-05	2E-04
Total carcinogenic risk	--	2E-04	3E-05	2E-04
Waneta				
Ingestion	--	2E-05	--	2E-05
Inhalation	--	9E-05	4E-05	1E-04
Total carcinogenic risk	--	1E-04	4E-05	2E-04
West Trail				
Ingestion	--	3E-05	--	3E-05
Inhalation	--	2E-04	2E-05	2E-04
Total carcinogenic risk	--	2E-04	2E-05	2E-04
Commercial scenarios				
East Trail				
Ingestion	--	4E-05	--	4E-05
Inhalation	--	5E-05	1E-05	6E-05
Total carcinogenic risk	--	9E-05	1E-05	1E-04
West Trail/Downtown				
Ingestion	--	1E-05	--	1E-05
Inhalation	--	6E-05	1E-05	7E-05
Total carcinogenic risk	--	7E-05	1E-05	8E-05
Agricultural scenario				
Waneta (farm family)				
Ingestion	--	4E-05	--	4E-05
Inhalation	--	5E-05	4E-06	6E-05
Total carcinogenic risk	--	9E-05	4E-06	1E-04
Waneta (field activities)				
Ingestion	--	1E-05	--	1E-05
Inhalation	--	8E-07	6E-08	9E-07
Total carcinogenic risk	--	1E-05	6E-08	1E-05

-- – insufficient information to complete calculation

Note: Scientific notation examples

$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$

$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$

$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE ES-3. SUMMARY OF NONCANCER HAZARD INDICIES, CADMIUM EXPOSURES—ABSORBED DOSE

Neighbourhood	Cadmium Hazard Index[a] Non-Smokers	Smokers
Residential scenarios		
East Trail	6E-02	1E-01
Rivervale	4E-02	9E-02
Tadanac	6E-02	1E-01
Waneta	8E-02	2E-01
West Trail	4E-02	8E-02
Commercial scenarios		
East Trail	3E-02	6E-02
West Trail/Downtown	2E-02	5E-02
Agricultural scenario		
Waneta (farm family)	8E-02	2E-01
Waneta (field activities)	2E-03	3E-03

[a] Hazard index is calculated using an absorbed dose RfD, which applies to the total amount of cadmium absorbed from both ingestion and inhalation.

Note: Scientific notation examples:
$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$
$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$
$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE ES-4. SUMMARY OF KEY SOURCES OF UNCERTAINTY

Parameter	Source of Uncertainty	Probable Effect on Risk Estimate: Estimated Magnitude	Probable Effect on Risk Estimate: Direction	Options for Reducing Uncertainty
Outdoor air concentration	Incomplete PM_{10} data (used TSP data)	Unknown	Overestimation	Collect additional PM_{10} data
Outdoor air concentration	Many results less than detection limit—used one-half detection limit	Unknown	Unknown	Use more sensitive detection limits in collection of new data
Indoor air concentration	No indoor air data—assumed equal to outdoor	1.5x	Overestimation	Collect indoor air samples
Indoor dust concentration	No reliable indoor dust data—assumed equal to outdoor soil concentration	Unknown	Overestimation	Indoor dust samples were collected by TLP in Aug/Sept '98.
Antimony concentrations in soil	Few observations for some neighborhoods —predicted based on arsenic concentration data	0.93x–2.0x (based on E. and W. Trail)	Unknown	Collect additional data on antimony in soil
Exposure via consumption of local produce	No reliable data on concentrations of COPCs in local produce—pathway not evaluated	1.25x for arsenic, 4x for cadmium	Underestimation	Samples of local produce were collected by TLP in Aug/Sept '98
Exposure Assumptions (see Tables 4-9)	Variability in human physiology and behavior	Unknown	Overestimation	Bound impact on final exposure and risk estimates with stochastic analysis
Oral RfD for antimony	Extrapolation required in derivation of RfD from animal studies	Up to 1000x (10x for animal to human; 10x for human variability; 10x for LOAEL to NOEL)	Overestimation	Technical reanalysis of toxicology data, or close tracking for updates to regulatory values
Inhalation RfC for antimony	Extrapolation required in derivation of RfC from animal studies	Up to 300x (3x for animal to human; 10x for human variability; 10x for data inadequacies)	Overestimation	Technical reanalysis of toxicology data, or close tracking for updates to regulatory values
Oral RfD for arsenic	Technical basis for derivation unknown	Unknown	Likely overestimation	Technical reanalysis of toxicology data, or close tracking for updates to regulatory values

TABLE ES-4. (cont.)

Parameter	Source of Uncertainty	Probable Effect on Risk Estimate: Estimated Magnitude	Probable Effect on Risk Estimate: Direction	Options for Reducing Uncertainty
Oral RfD for cadmium	Assumptions regarding accumulation in the kidney, and sources of exposure	Up to 8x	Overestimation	Technical reanalysis of toxicology data, or close tracking for updates to regulatory values
CSF for arsenic	Extrapolation from high exposure to low exposure • Whether threshold exists • Whether doses are estimated correctly in study that forms the basis for the CSF • Applicability of study population to Canadian populations	Calculated risks represent an upper-bound estimate. Actual risks may be as low as zero.	Overestimation	Technical reanalysis of toxicology data, or close tracking for updates to regulatory values
CSF for cadmium	Extrapolation from high exposure to low exposure	Calculated risks represent an upper-bound estimate. Actual risks may be as low as zero.	Overestimate	Technical reanalysis of toxicology data, or close tracking for updates to regulatory values

INTRODUCTION

This report describes the human health risk assessment (HHRA) efforts conducted to date by Exponent on behalf of the Trail Lead Program as part of the Phase 2 human health risk assessment, and presents screening-level deterministic risk calculations for non-lead constituents. As part of the Phase 2 risk assessment efforts, Exponent has conducted several analyses, results of which have been provided to the Trail Lead Program as technical memoranda. These analyses are summarized below, prior to a description of the scope of the risk assessment.

DETERMINING AN ABSORBED-DOSE REFERENCE DOSE (RfD) FOR CADMIUM

The standard toxicity benchmark value for cadmium (i.e., the dose below which toxic effects are not anticipated) is based on kidney concentrations that accumulate from a lifetime of exposure. These concentrations reflect lifetime exposure to cadmium from all sources, including background exposures (which are often ignored in risk assessments). However, because cadmium intake from food and cigarette smoke can be significant relative to soil exposure pathways, determination of a cadmium concentration that can exist in soil without producing adverse effects on human populations must account for these other common exposure pathways. Therefore, Exponent assessed background exposure to cadmium to derive an adjusted RfD for use in risk evaluations for Trail. The approach used considered background exposures from food, drinking water, air, and smoking.

The results of this evaluation are that an appropriate adjusted RfD for cadmium in Trail is 0.02 μg/kg-d for nonsmokers, and 0.01 μg/kg-d for smokers. It is important to note that these values are expressed as *absorbed* doses of cadmium (i.e., the amount of cadmium that is absorbed into systemic circulation). This is in contrast to other RfD values for cadmium (e.g., from the British Columbia Ministry of the Environment [BCE], the World Health Organization [WHO], or U.S. Environmental Protection Agency [U.S. EPA]), which are expressed as an *administered* dose (i.e., the amount of cadmium ingested from soil, food, water, or air). Because the cadmium RfDs (including RfDs based on either administered or absorbed dose) are based on the cumulative effects of a lifetime of exposure, they should not be used to assess childhood exposures directly. Instead, child and adult exposures should be combined, and a lifetime average dose used in assessing risk.

EVALUATING BACKGROUND EXPOSURE TO ARSENIC

Because arsenic occurs naturally in the environment and is present in most foods, arsenic exposure is a typical part of everyday life. Therefore, Exponent used information from the literature and BCE databases to develop a summary of background arsenic intake from various sources for people living in southeastern British Columbia. This information provides a basis of comparison for evaluating the magnitude of arsenic exposures from soil relative to other sources. This investigation indicated that mean background exposures to inorganic arsenic for the community of Trail are an estimated 4.0–4.6 μg/day for young children, 8.7–8.9 μg/day for adult nonsmokers, and 10.5–10.7 μg/day for adult smokers. These values represent estimated average daily doses of inorganic arsenic that are absorbed into the body from air, food, drinking water, background soil, and cigarette smoke.

SCREENING PLANT CONCENTRATIONS OF ARSENIC AND CADMIUM

Because arsenic and cadmium in soil can be taken up into plants, human consumption of homegrown produce grown in soils containing these metals may constitute a potentially significant exposure pathway. In this task, screening calculations were performed to determine whether potential exposures to these metals from homegrown produce are significant relative to exposures from soil ingestion, which is typically considered to be the primary pathway of exposure to chemicals in soil. The calculations conducted in this assessment indicate that, for arsenic, potential exposures via ingestion of homegrown produce range from 4- to 17-fold below potential exposures via soil ingestion. The opposite is the case for cadmium, for which calculations indicate that exposure to cadmium from ingestion of homegrown produce might exceed exposures from soil ingestion by a factor of greater than three.

Although these findings indicate that consumption of homegrown produce cannot be ruled out as a significant contributor to metals exposure, there is a high degree of uncertainty regarding the specific application of these findings to Trail. Therefore, these results supported the decision to collect site-specific data on cadmium concentrations in homegrown and store-bought produce. The empirical data from Trail can then be used to assess potential risks to human populations in the area.

DETERMINING THE RELATIVE BIOAVAILABILITY OF ARSENIC AND CADMIUM IN TRAIL SOILS

Exponent tested soil samples from Trail to determine the bioavailability of arsenic and cadmium as they occur in the soil, relative to the bioavailability of more soluble forms of these elements. This study assessed the oral bioavailability of arsenic and cadmium in Trail soils using data from a physiologically based extraction test (*in vitro* test) that simulates the processes controlling dissolution of chemicals in the human gastrointestinal tract. The *in vitro* testing indicated that, on average, arsenic in the Trail soil samples had a relative bioavailability of 50 percent. This value is similar to the *in vitro* estimate of 49 percent relative arsenic bioavailability for soil from Anaconda, Montana. When tested in monkeys, the Anaconda soil yielded a relative bioavailability estimate of 20 percent, suggesting that the *in vitro* estimate is very conservative.

For cadmium, the relative bioaccessibility estimates averaged 61 percent for residential areas, with a value of 41 percent for the sample from the Cominco property boundary. These values are much lower than the *in vitro* estimates of 70–73 percent relative bioavailability for soils from Bartlesville, Oklahoma. When tested in rats, the Bartlesville, Oklahoma sample yielded a relative cadmium bioavailability estimate of 33 percent.

Overall, conclusions from this evaluation were that appropriate, conservative estimates of relative bioavailability for arsenic and cadmium in Trail soils are 55 percent and 33 percent, respectively.

REFINING THE COPC LIST BASED ON NEW DATA FROM TADANAC

In the Phase 1 risk assessment, Exponent staff used the available data to determine contaminants of potential concern (COPCs) for the site. Comparison of the metals concentrations from the available data with soil screening criteria indicated that the concentrations of antimony, arsenic, cadmium, mercury, selenium, thallium, tin, and zinc could be of potential health concern at some locations. However, mapping of the concentration data demonstrated that the only area where concentrations of these metals exceeded soil screening criteria was along the boundary of the Cominco Metals site. Therefore, Exponent recommended that new soil samples be collected from transects in Tadanac to establish whether the elevated concentrations of these metals are widespread, or are constrained to the property boundary.

To answer this question, the Trail Lead Program (TLP) collected soil samples in transects near the boundary of the Cominco Metals facility, and samples from East and West Trail. Exponent evaluated data from the new soil samples to determine which metals need to be considered COPCs for the site. The new data indicated that soil concentrations of mercury, selenium, thallium, and tin exceed soil screening levels only in the area along the Cominco property boundary, and that the concentrations of these metals elsewhere in Tadanac or other Trail neighborhoods do not exceed the soil screening criteria. Therefore, it was concluded that (non-lead) COPCs for the site can be limited to arsenic, cadmium, and antimony.

SCREENING AVAILABLE AIR DATA AGAINST HEALTH-BASED CRITERIA

Prior efforts by Exponent, based on evaluation of metals concentrations in Trail soils, had identified arsenic, antimony, and cadmium as the COPCs for the non-lead risk assessment. However, before other metals could be conclusively eliminated from consideration as COPCs for Trail, all potential exposure pathways of concern needed to be evaluated. Therefore, Exponent compiled air data from quarterly monitoring reports for Trail, and compared the concentrations of metals in these samples to health-based screening criteria, to determine whether the concentrations of metals in air around Trail present a potential health risk.

Using air data from the period during which the new smelter has been operational at the Cominco facility, this screening indicated that concentrations of arsenic, cadmium, and lead exceeded the screening criteria, and therefore merit further evaluation for potential impacts on the health of area residents. No additional metals were added to the list of COPCs based on the evaluation of air data for Trail.

EVALUATING PAIRED SOIL AND HOUSE-DUST DATA

In the Phase 1 assessment, Exponent recommended collection of paired soil and house-dust samples from 60 homes around Trail, to determine the relation between concentrations of arsenic, cadmium, and antimony in soil and in house dust. Paired samples from a subset of 20 of these homes were collected by the TLP in the spring of 1998. Exponent evaluated these data to determine whether any clear relation could be discerned between indoor and outdoor concentrations of these metals. No clear regression relation could be determined for indoor and outdoor concentrations of any of the metals measured, likely because too few data were available, or because of uncharacterized indoor sources of metals or outdoor sources other than soil (e.g., direct contribution from outside air to interior dust).

RISK ASSESSMENT SCOPE

As part of the Phase 1 evaluation conducted by Exponent (then PTI), the available data from the Trail site were reviewed, and the TLP was advised regarding the findings. The Phase 1 effort consisted of compiling available data, reviewing the quality of the available data, providing recommendations for collection of new data, and screening concentration data against soil screening criteria from BCE (PTI 1997).

The Phase 1 report concluded that the screening of concentration data against conservative, health-based screening criteria indicated that three neighborhoods in the Trail vicinity (Casino, Miral Heights, and Montrose) had no exceedances of any health-based criteria. Five neighborhoods (Glenmerry, Oasis, Shavers Bench, Sunningdale, and Upper Warfield) exceeded only agricultural criteria, and there are no identified areas of agricultural land use in those neighborhoods. For Lower Warfield, exceedances (of criteria for antimony in soils) were noted at only two locations. These exceedances occurred within the boundary of the Cominco Metals facility, and therefore are not representative of residential soils in the neighborhood. Therefore, all but five neighborhoods were screened out from further analysis in the Phase 2 risk assessment. The neighborhoods included in the Phase 2 evaluation are East Trail, Rivervale, Tadanac, Waneta, and West Trail. These are the neighborhoods that are closer to the Cominco facility, except for Waneta, which though remote from the facility, exceeded agricultural screening criteria for antimony and cadmium, and residential screening criteria for antimony.

The risk assessment presented in this document follows the conventional four-step risk assessment methodology recommended by regulatory agencies: data evaluation (and identification of COPCs), exposure assessment, toxicity assessment, and combining information from the exposure assessment and toxicity assessment to characterize potential risks. Both an assessment of potential carcinogenic risk and a characterization of potential risks from exposure to noncarcinogenic compounds are included in this assessment, using standard toxicity values recommended by BCE or the U.S. EPA. In addition to the standard characterization of risk, an additional evaluation of cadmium is provided, wherein exposures are estimated based on an absorbed dose (versus an administered dose as is done more conventionally). This was done to allow for a more rigorous evaluation of cadmium, as well as to assess integrated ingestion and inhalation exposures to this COPC. More details of this analysis are provided below.

The sections that follow present all components of the risk evaluation. First, the data available for conducting the evaluation are discussed, along with the methods that were used to select the COPCs. This section discussed data by medium (i.e., separately for soil, house-dust, and air), and also describes limitations associated with the data sets and the derivation of the concentrations used for estimating exposures. The section on data is followed by information regarding the exposure evaluation, including selection of potentially exposed populations, exposure calculations, and information regarding the specific values put into the exposure calculations. Then a discussion of the toxicity information for the metals of concern in Trail is presented. This section includes a discussion of the specific values used, the source of each value, and some technical issues associated with the toxicity values. The exposure and toxicity information is then combined into a risk characterization. This section provides an estimate of the predicted carcinogenic and noncarcinogenic risks, separated out by neighborhood, and by media. Finally, conclusions are presented regarding the findings of this evaluation.

CONTAMINANTS OF POTENTIAL CONCERN

For the neighborhoods where data indicated that soils concentrations exceeded screening criteria, the Phase 1 evaluation identified eight metals (in addition to lead) as potentially requiring further evaluation in the Phase 2 risk assessment. These metals included antimony, arsenic, cadmium, mercury, selenium, thallium, tin, and zinc. As described in the Introduction, screening of new soil data indicates that the elevated soil concentrations of mercury, selenium, thallium, tin, and zinc are limited to locations immediately along the property boundary of the Cominco Metals facility, and do not represent widespread concentrations above screening criteria. Therefore, soil data indicate that COPCs for the site are antimony, arsenic, and cadmium.

In addition, screening of air concentration data from several monitoring stations around Trail against health-based screening criteria indicated that—with the possible exceptions of arsenic, cadmium, and lead—air concentrations of metals are below concentrations that might be anticipated to result in any adverse health effects (Technical Memorandum 2.2). Based on the Phase 2 evaluations of new soil data from Tadanac, East Trail, and West Trail, and the screening of air monitoring data, COPCs included in this risk evaluation have been limited to antimony, arsenic, and cadmium.

DATA EVALUATION

All data used in this risk evaluation were provided to Exponent by Steve Hilts of the Trail Lead Program (TLP).

Below is a discussion, organized by environmental medium, of the available data, the methods used to compile the data for use in the HHRA, the limitations of the available data, and the calculation of the exposure-point concentration, which are summarized in Table 1.

SOIL AND DUST

For the three COPCs, soil concentration data were available from samples collected in 1989, 1991, 1996, 1997, and 1998. Sampling locations covered a broad range of areas, including neighborhoods in proximity to the Cominco Metals facility, as well as areas upstream and downstream from the facility. A full description of the available data is presented in the Phase 1 Technical Memorandum, included as Appendix E of the final Phase 1 report, and in Technical Memorandum 2.2.

All data of good quality were used for this evaluation. All non-detect results were provided to Exponent as one-half the detection limit, and no distinction was made between detect and non-detect results, thereby precluding exclusion of some COPCs based on frequency of detection. It should be noted that use of one-half the detection limit for non-detect data is consistent with U.S. regulatory policy (U.S. EPA 1989). However, it is not consistent with the approach used by BCE in prior evaluations of Trail (BCE 1995), where non-detects (for dust data) were omitted from the data set.

Before any other calculations were performed, results were averaged over time at each sampling location, defined by a unique set of x-y coordinates. These pre-averaged results are presented in Table A-1 (Appendix A). Data from sample locations identified as "background" were not used, and the four samples taken along the Cominco fence line in November 1997 also were not used, because Phase 2 analyses (presented in Technical Memorandum 2.2) indicated that these concentrations are confined to the area near the Cominco property boundary, and are not representative of soil concentrations in neighborhoods.. Any sample locations that were identified by the name of a park were grouped with the neighborhood in which the park was located (e.g., samples from Andy Bileski Park were grouped with Glenmerry).

For the purposes of this risk evaluation, the soils data were first aggregated by neighborhood, then by land use. The sample locations labeled as "Parks/Rec" were grouped into the "residential" land use category; those labeled "institutional" were grouped into the "commercial" category. As part of the Phase 1 effort, maps depicting these land uses were provided to the TLP. Areas categorized as "industrial" were not evaluated in this risk assessment, because they were limited to areas within the Cominco Metals facility. Evaluation of that property is outside the scope of this assessment. Summary statistics were calculated for each area, and are presented in Table 2.

Estimation of Antimony Concentrations

Because fewer soil samples were analyzed for antimony than for arsenic and cadmium, there were two areas for which no antimony data were available—the residential area in Rivervale, and the commercial area within West Trail. To evaluate the potential risks associated with exposure to antimony in soil for these two areas, the relation between arsenic and antimony concentrations was analyzed statistically, and it was determined that antimony concentrations could be predicted using arsenic concentrations. For 20 soil sampling locations, both antimony and arsenic concentration data were available, and a regression relation was established between them. Because the concentration data were distributed lognormally, the data were log transformed for this evaluation. Using all 20 soil samples, the regression correlation coefficient (R^2 value) was 0.89. However, this evaluation indicated that one data pair qualified as an outlier. Therefore, the outlier was eliminated and the regression re-run. Without the outlier, the adjusted R^2 value increased to 0.93. This regression indicated that the maximum-likelihood estimate for antimony concentrations is predicted by the equation:

$$Sb = 0.509 \times As^{1.075} \times 1.041$$

For areas where empirical antimony concentration data for soil were available, these empirical data were used in determining potential human exposures to antimony. However, for the two areas for which no antimony data were available, antimony concentrations were predicted using the equation above. Although uncertainty is introduced by using such a predictive approach, indications are that for this relation (i.e., using arsenic concentrations to predict antimony concentrations), and the range of concentrations in which most of the observations fall (i.e., arsenic concentrations below 100 ppm), the predictive ability is fairly good, with an associated error in the range of under 15 percent. This means that the predicted antimony concentration is probably within 15 percent, plus or minus, of what is truly expected in that location. The statistical analysis used in this determination is provided in Appendix B—Statistics.

SOIL EXPOSURE-POINT CONCENTRATION

The exposure-point concentration (EPC) should represent an upper bound of the average exposure that will occur over time at a given exposure location The 95 percent upper confidence limit on the mean (UCLM) is recommended by the EPA as the most appropriate statistic (U.S. EPA 1992) and has been used in risk assessments by BCE (BCE 1995).

The first step in calculating a UCLM is to determine whether the data set is distributed normally or lognormally, and at this site, the soil data were determined to be distributed lognormally. In some instances—for example, small data sets or sites with extreme variability in chemical concentrations—the calculated UCLM for a data set will exceed the maximum detected concentration. Additionally, if the data set has fewer than three values, it is not possible to calculate a UCLM. In such instances, it is recommended that the maximum concentration be used as the exposure-point concentration (U.S. EPA 1992c). The calculated UCLMs for each area are presented in Table 2, and the value chosen for the exposure-point concentration (i.e., the UCLM or the maximum detected concentration) is highlighted.

DUST DATA

As described in the introduction, information about house-dust concentrations, or the relation between house dust and soil concentrations, is not adequate to determine a separate exposure-point concentration for house dust. Calculations in this evaluation assume that house-dust concentrations are equal to surrounding soil concentrations, an assumption that is likely conservative (i.e., indoor concentrations of metals from environmental sources would be expected to be lower than outdoor concentrations). It is hoped that future sampling efforts will address this data gap.

AIR DATA

All available air data from the Trail vicinity were compiled and evaluated for use in this risk evaluation. Because a new smelter came on line in March 1997, and the old smelter closed down in May 1997, it was determined that only air data collected after that time would be appropriate for use in evaluating potential health risks. Therefore, only the data from July 1, 1997 to the present were used.

Two sources of air monitoring data were available. First, air concentration data were available for samples collected from six sampling stations on a nearly daily basis between January 1, 1997 and July 22, 1998 (sampling frequency: mostly daily, or every 6 days, with a few gaps of 12 or 18 days). Because of the high frequency of sampling associated with these data, they were used preferentially. However, results from quarterly monitoring reports were also used if they provided data for locations not included in the aforementioned data set. All the air concentration data used in this evaluation are presented in Tables A-2 and A-3 (Appendix A).

For all calculations involving non-detects, one-half the detection limit was used. The data were segregated by neighborhood. Because PM_{10} concentrations best represent the concentration to which a person would be exposed, PM_{10} data were used if available. If no PM_{10} data were available for a particular sampling station, data on total suspended particulates (TSP) were used.

PM_{10} data were available from three sampling stations—East Trail, Oasis, and West Trail. Summary statistics were calculated for each area, and are presented in Table 3. Two of the five neighborhoods of interest did not have air sampling stations within their boundaries, so data from the sampling station determined to be most representative of the exposure were used. Specifically, data from the Oasis station were used for Rivervale, and data from the downtown station were used for Tadanac. Results were available from a sampling station labeled "Waneta," but this station is located near the Waneta Dam, which is not within the boundaries of the Waneta neighborhood. It was determined that air concentration data from Columbia Gardens would be more representative of the inhalation exposure for people living in Waneta. The data for the Columbia Gardens station are from a quarterly monitoring report.

AIR EXPOSURE-POINT CONCENTRATION

Exposure-point concentrations for COPCs in air were determined by calculating the UCLM concentration for each location. The UCLMs were calculated and used as described above in the soil section. The calculated UCLMs for each area are presented in Table 3, and the value chosen for use as the exposure-point concentration (i.e., the UCLM or maximum detected value) is highlighted.

AIR DATA LIMITATIONS

There are several limitations to the air concentration data that could potentially affect the risk characterizations. No antimony concentrations were available for two locations—East Trail and Oasis (surrogate for Rivervale)—so the potential risks from antimony inhalation exposure could not be calculated for these areas. Also, PM_{10} data were available for only three locations. Exponent evaluated data for locations where paired PM_{10} and TSP concentration data were available, to determine whether a clear relation between PM_{10} and TSP could be established and used to "correct" TSP data to be more representative of PM_{10} concentrations. This evaluation indicated that no clear relation could be determined, that concentrations of COPCs in PM_{10} and TSP fractions appeared to be similar, and that, in some instances, PM_{10} concentrations exceeded TSP concentrations, which is surprising because data were expressed on a mg/m^3 basis.

For the purposes of these calculations, concentrations of COPCs in indoor air have been set equal to outdoor concentrations, which may produce a slight overestimate of actual risks. Paired data for bedroom air and outdoor air concentrations of lead in Trail indicate that indoor concentrations of lead in air range from 13 to 66 percent of the outdoor concentrations, with indoor concentrations being less than 60 percent of outdoor air concentrations for all but one data pair. Because indoor sources of lead are significant, it is likely that the indoor concentrations of the non-lead COPCs at the site are, at most, 60 percent of the outdoor values. Assuming that individuals spend approximately 80 percent of their time indoors, the assumption that indoor air concentrations are equal to outdoor air concentrations may overestimate risks from inhalation exposures by a factor of approximately 1.5.

EXPOSURE EVALUATION

Exponent defined the human populations believed to have potential for exposure to metals in Trail soils during the Phase 1 risk assessment efforts. These exposures were determined to include those by residential populations in the neighborhoods, by workers employed in commercial areas of East or West Trail (or by workers' children in these areas), and by agricultural workers and their families in the outlying agricultural areas around Trail. These potentially exposed populations are included in this risk evaluation. During the Phase 1 effort, conceptual site models were created that identify the mechanisms of exposure for each of these populations. The models are included in this report as Figures 1, 2, and 3.

Calculation of exposure to metals from environmental media were conducted using standard exposure and risk assessment approaches. The generic equation for calculating chemical intake is:

$$I = C \times \frac{CR\ x\ EFD}{BW} \times \frac{1}{AT}$$

where:

I	= intake (mg/kg-d)
C	= chemical concentration in the environmental media
CR	= human contact rate with the environmental media
EFD	= exposure frequency and duration
BW	= the average body weight over the exposure period
AT	= averaging time.

Specific equations designed to evaluate exposures for the populations and pathways determined appropriate for this assessment are presented in Tables 4–9, along with the assumptions regarding exposure parameters. These site-specific calculations are somewhat more complicated than the generic calculation presented above, because they take additional considerations into account, including apportioning exposure to soil or dust, evaluating childhood exposures separately from adult exposures, and incorporating information regarding relative bioavailability.

Tables 4–9 provide the exposure assumptions that have been compiled for use in the risk evaluation for Trail. These tables provide exposure assumptions for residential, commercial, and agricultural exposure scenarios. The hierarchy used in selecting specific values was 1) site-specific information, 2) guidance from BCE, 3) guidance from U.S. EPA, and 4) professional judgement. The selection of exposure values focused on generating final estimates of Reasonable Maximum Exposures (RMEs) for each exposure pathway. Under this RME approach, some intake variables are not set at their individual

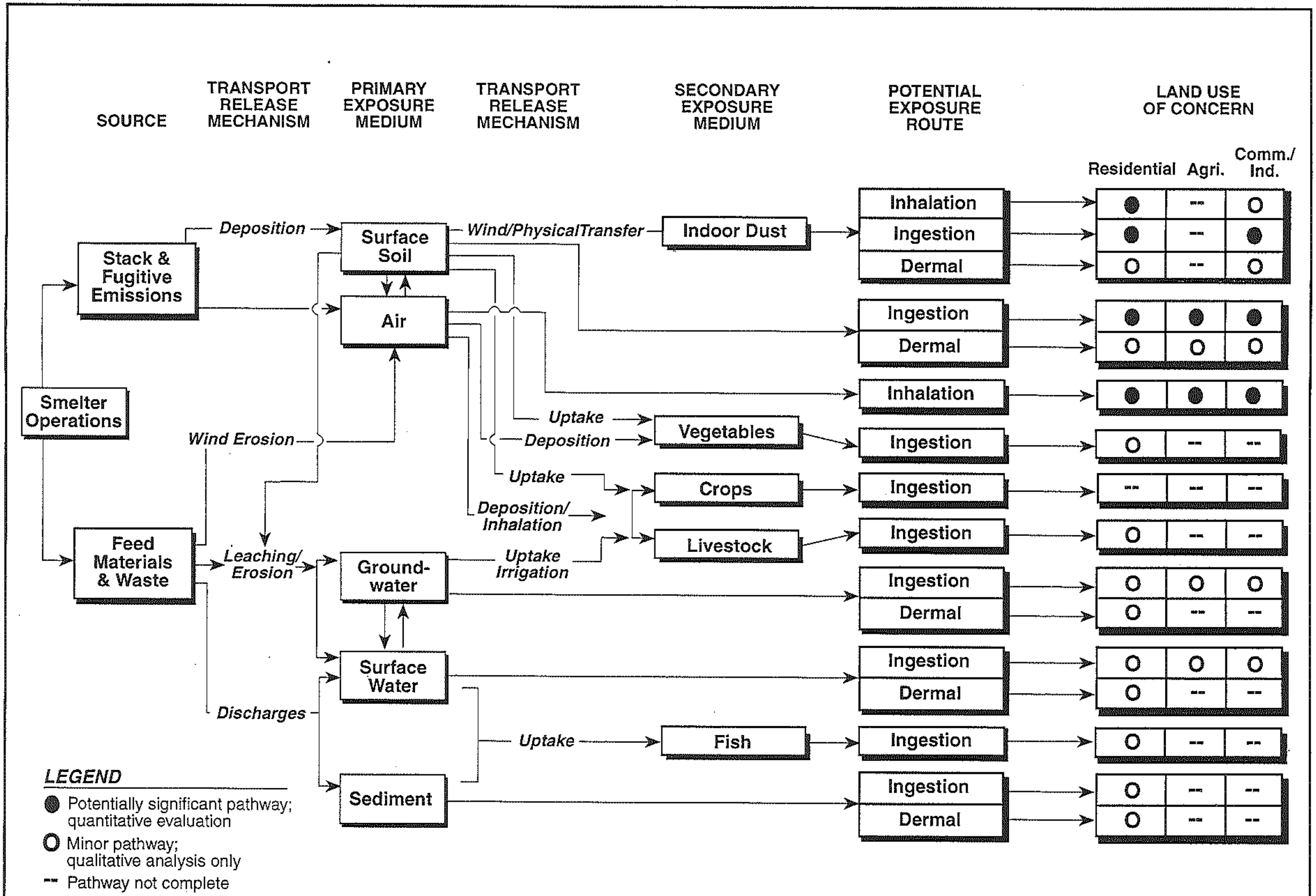

Figure 1. Antimony: conceptual site model for Trail, British Columbia.

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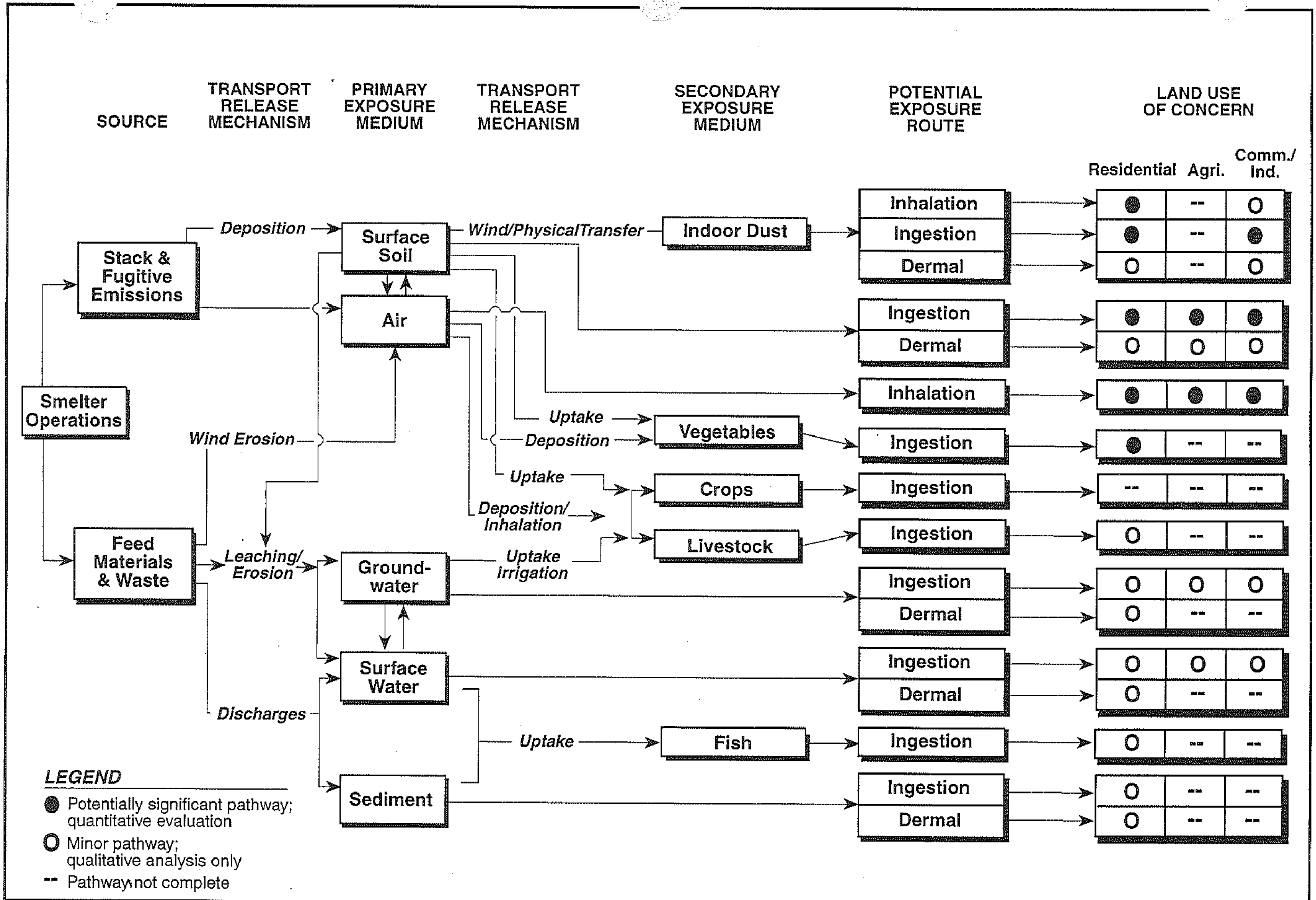

Figure 2. Arsenic: conceptual site model for Trail, British Columbia.

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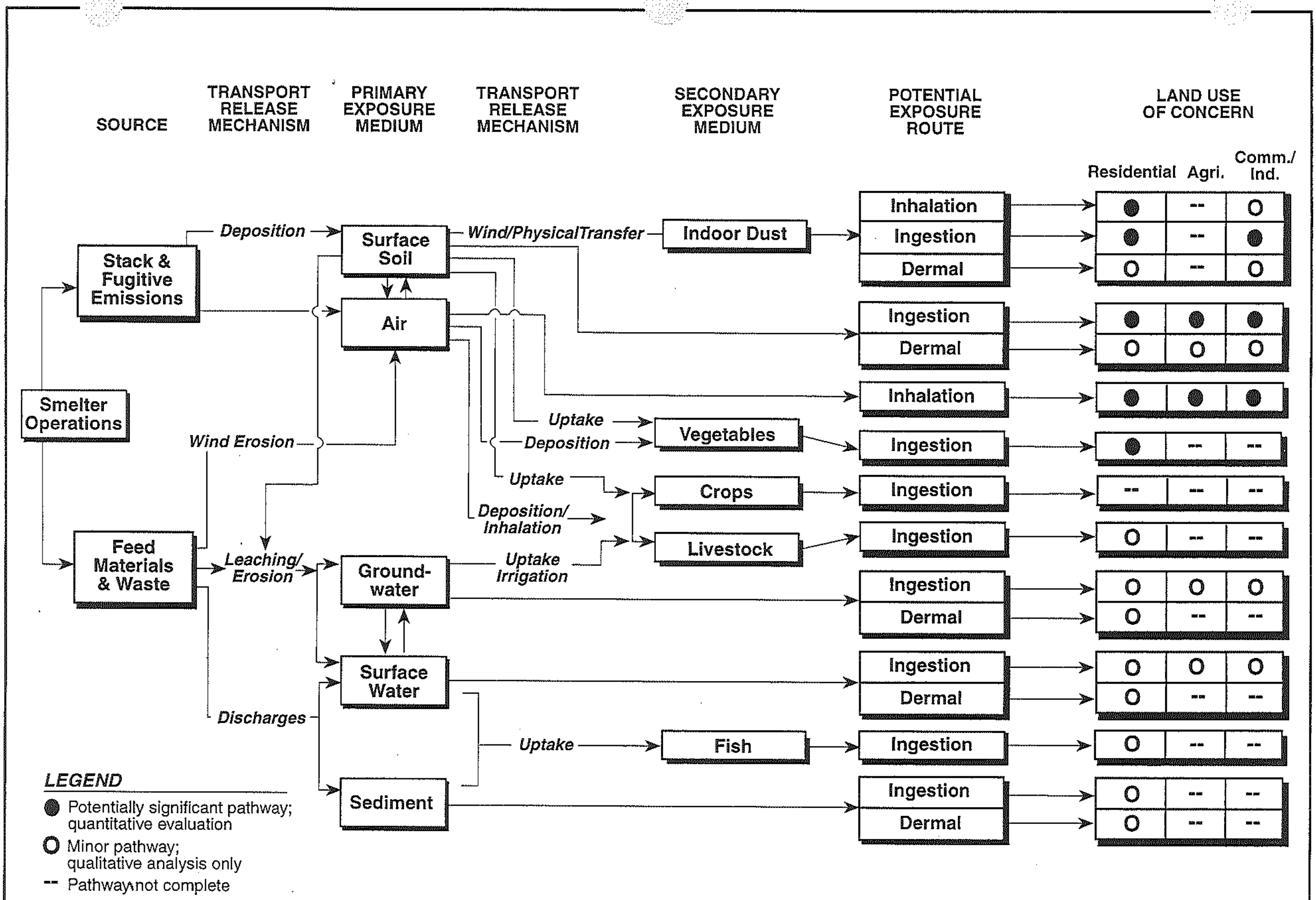

Figure 3. Cadmium: conceptual site model for Trail, British Columbia.

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maximum values, but when combined with the other variables, result in an estimate of the maximum exposure that is reasonably expected to occur at the site (U.S. EPA 1989).

Where possible, assumptions regarding exposure rates were based on site-specific information from Trail. For example, site-specific considerations were incorporated into assumptions regarding chemical concentrations and relative bioavailability (discussed further below). If site-specific information was not available, then guidance from BCE or Canadian Council of Ministries of the Environment (CCME) was incorporated. In the absence of guidance from Canadian regulatory agencies, recommendations from U.S. EPA were followed. If no guidance was available, then professional judgement was used in determining the appropriate input value for the calculations. Tables 4–9 contain information regarding the source or derivation of each value incorporated into the exposure calculations. Below is a discussion of some parameters that affect all the exposure scenarios, followed by a description of some parameters for specific exposure scenarios.

EXPOSURE ASSUMPTIONS APPLIED TO ALL SCENARIOS

Oral Bioavailability

Chemicals can occur in soils as different physical or mineralogic species, with varying solubilities. Toxicity studies for metals typically are performed using soluble compounds. For most chemicals, the toxicity values used by regulatory agencies are not adjusted to absorbed dose (i.e., the dose response evaluation is based on the administered dose). This approach can lead to overly conservative estimates of risk of exposure to a particular chemical in a medium other than the one used in the toxicity or epidemiology studies on which the toxicity values are based.

Because of this issue, Exponent conducted an assessment of Trail soils to determine an appropriate adjustment factor that would address the differences between the amounts of metals absorbed during toxicity studies and the amounts likely to be absorbed following exposure to these metals in soils from Trail. A full description of the theory, methodologies used, and findings of the bioavailability assessment is presented as Task 4 of Technical Memorandum 2.1 (Exponent 1998). Based on this study, Exponent conservatively estimated that Trail soil samples contain arsenic with a relative bioavailability of 55 percent, and cadmium with a relative bioavailability of 33 percent. These values have been incorporated into the calculation of exposure to arsenic and cadmium via the ingestion route for all exposure scenarios evaluated.

For antimony, no site-specific evaluation of Trail soils has been conducted. However, there is adequate information from the literature to support an adjustment for oral absorption of antimony from Trail soils. The toxicity value (RfD) for antimony is based on a study of potassium antimony tartrate administered in water. No discussion is provided in the documentation of this value regarding absorption, or applicability to other forms of antimony or antimony in mixed media. A draft toxicological profile for antimony from the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) does discuss absorption. This document indicates that gastrointestinal absorption of antimony salts in humans is less than 10 percent. It also specifically cites the recommendation of 10 percent for antimony tartrate and 1 percent for all other forms of antimony as values for gastrointestinal absorption of different forms of antimony in humans.

Because the RfD for antimony that is incorporated into this risk evaluation was based on administration of antimony tartrate, and we would not expect the antimony in Trail soils to be in this form, this information suggests that it would be appropriate to adjust the calculated exposure of antimony from soils downward by a factor of 10. This adjustment should be adequately conservative (i.e., health protective) because it doesn't address the additional impacts that would be expected based on the difference between absorption from water (as in the toxicity testing) and absorption from soil. It also ignores the high degree of uncertainty (and associated conservative modifying factor) associated with the derivation of the RfD for antimony.

AVERAGING TIME

Averaging time is determined in several different ways in the exposure assessment, to accommodate the needs for the risk characterization. First, for assessing carcinogenic risks, the appropriate averaging time is an individual's full lifetime (i.e., 75 years). Expressed in days, this is 27,375 days. To evaluate noncarcinogenic risks, however, the exposure duration is the appropriate averaging time to incorporate into exposure and risk calculations. To ensure that the higher childhood exposures are not resulting in unacceptable risks, the risks from noncarcinogenic chemicals are assessed separately for the childhood and adult exposure periods. Therefore, specific childhood and adult averaging times are presented in the tables of exposure assumptions. Finally, because noncancer risks from exposure to cadmium (i.e., exposures via ingestion) are appropriately evaluated based on the full period of exposure to cadmium (i.e., from 6 months of age when soil ingestion exposures begin, until death), 74.5 years (27,193 days) is the appropriate averaging period for assessing risks from long-term exposure to cadmium. Because of all of these considerations, four separate averaging times appear in the tables on exposure assumption.

RESIDENTIAL EXPOSURES

The residential exposure scenario evaluates incidental soil and dust ingestion, and inhalation exposures, for an individual who resides in Trail for their entire lifetime (75 years), and separates childhood exposures from age 6 months to 5 years (children under 6 months are assumed to have negligible exposure). The exposure calculations assume that an individual is at home for all but 2 weeks each year, and that direct exposures to soil are avoided during the 3 months of each year that snow is assumed to cover the ground. The 75-year lifetime exposure duration is longer than the 30-year duration that would normally be incorporated into exposure calculations and risk evaluations, but an earlier risk assessment conducted by BCE documents that it is foreseeable that an individual would reside in Trail for a whole lifetime (BCE 1995). Hence, the calculations incorporate a 75-year exposure duration.

For ingestion of soil and dust, it is assumed that 30 percent of the daily soil ingestion rate is contributed from soil, and 70 percent of the daily ingestion rate is contributed from dust (i.e., FI_s equals 0.3 and FI_d equals 0.7). These values are derived from information provided by BCE (1995). Specifically, this BCE document states that Canadians spend about 80 percent of each 24-hour day inside. Assuming that eight of those inside hours are spent sleeping, the time spent inside while awake (i.e., the period during which dust ingestion might occur) is 11.2 hours per day, and the remaining 4.8 waking hours are spent outside (i.e., the period during which soil ingestion might occur). Thus, the fraction of waking hours spent indoors is 70 percent, and the fraction of waking hours spent outdoors is 30 percent. This information could also affect exposures to indoor and outdoor air. However, as discussed above, no reliable indoor air concentration data are available, and therefore, indoor air concentrations were assumed to be equal to the measured outdoor concentrations, and no time-activity information was incorporated into the exposure calculations.

Inhalation rates incorporated into the exposure assessment are based on values from BCE (1996) for long-term average exposures. Specifically, the 24-hour inhalation rate for adults was assumed to be 23 m^3/day, and the 24-hour inhalation rate for children was assumed to be 5 m^3/day. These values were selected to ensure that the exposures (and accompanying risks) calculated for residents of Trail are comparable to risks calculated at other sites (i.e., using recommended values), and because direction from BCE indicates that Canadian regulatory values should be given precedence in determining exposure assumptions for this evaluation. It should be noted, however, that a recent reevaluation of available studies of inhalation rates suggested a long-term average daily inhalation rate of 11.3 m^3/day for women, 15.2 m^3/day for men, 4.5 m^3/day for infants (<1 year old), and 7.7 m^3/day for children (0.5–10 years old, average for males and females) (U.S. EPA 1997). Therefore, inhalation exposures in this risk assessment may be overestimated for adults, and possibly for children.

This evaluation did not incorporate calculations of exposures to COPCs that might be associated with the consumption of homegrown produce. Uptake from soil into produce has been documented for some of the COPCs in Trail. In Technical Memorandum 2.1, Exponent evaluated the potential exposures to arsenic or cadmium from ingestion of homegrown produce relative to exposures from incidental ingestion of soil. Based on information available from the literature regarding uptake of metals into plants, and ingestion rates for leafy and nonleafy vegetables, this analysis indicated that potential exposure to arsenic via ingestion of homegrown produce is below the potential exposure from soil, ranging from four- to seventeen-fold below exposure via soil ingestion. The opposite was the case for cadmium, with exposure to cadmium from ingestion of homegrown produce possibly exceeding exposure from soil ingestion by a factor of greater than three.

There is a high degree of uncertainty associated with this literature-based analysis of potential exposures via consumption of homegrown produce (as opposed to being based on empirical, site-specific data). This uncertainty arises from several factors, including conducting the evaluation based on literature information regarding uptake of metals into plants, and the lack of information regarding personal behaviors in terms of types and amounts of crops harvested, or how they are prepared (including whether they are washed). Therefore, the findings of that assessment were used to support the need for collecting site-specific information on this subject, and such efforts are underway by the Trail Lead Program. No evaluation of potential exposures or risks from ingestion of homegrown produce is provided in this Phase 2 risk evaluation. Should data become available, they may be incorporated into future assessments of risk (i.e., during Phase 3).

Exposure assumptions associated with incidental ingestion exposures to soil and dust under the residential exposure scenario are presented in Table 4. Assumptions associated with inhalation exposures under the residential exposure scenario are presented in Table 5.

COMMERCIAL EXPOSURES

The exposure assumptions associated with the commercial scenario are intended to characterize potential exposures by adults and children in commercial areas of Trail. The adult scenario is intended to characterize exposures during a 10-hour work shift, 5 days per week, 48 weeks per year (i.e., excluding 10 holidays and 10 vacation days). For children, it is assumed that they might accompany a parent to a commercial area for up to 8 hours, 5 days per week, 48 weeks per year. The only available BCE guidance (*Overview of CSST Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites*, BCE 1996) specifically addresses exposures in commercial areas and indicates exposure by children and adults for 12 hours per day, 5 days per week, 48 weeks per year. It was determined that some of these values were unrealistically high for Trail and were not consistent with other Canadian guidance (CCME 1996); therefore, the values were amended to be more appropriate to site-specific conditions.

The relative proportions of soil and dust ingested under the residential exposure scenario were incorporated for commercial exposures (i.e., 70 percent from dust, and 30 percent from soil). Similarly, the relative bioavailability of metals in soil and dust was assumed to be the same as under the residential exposure scenario (i.e., 55 percent for arsenic, 33 percent for cadmium, and 10 percent for antimony).

For assessing inhalation exposures, inhalation rates under the commercial exposure scenario were expressed as hourly rates rather than the daily averages used in assessing residential exposures. For adults, the inhalation rate was based on the average rate for light and moderate activity levels during short-term exposure periods, as presented by U.S. EPA (1997). The inhalation rate for children was based on an average of inhalation rates for sedentary (napping) and light activity levels during short-term exposure periods, as presented by U.S. EPA (1997). This approach is similar to the approach used by BCE in their evaluation of the site (BCE 1995) (i.e., they used an average of these activity levels based on inhalation rate information from U.S. EPA); however, updated information from EPA was incorporated into the estimation.

This methodology, however, results in a logical incompatibility with the assumptions for residential inhalation exposures, presented above. Specifically, if a child is exposed under the commercial scenario for 8 hours per day, at an inhalation rate of 0.7 m^3/hour, then the 8-hour inhalation volume is calculated to be 5.6 m^3. This value contrasts with the assumed 24-hour average inhalation rate under the residential exposure scenario of 5 m^3. This difference results from inhalation rates that are based on different sets of scientific data (i.e., long-term versus short-term inhalation studies), as well as from trying to incorporate regulatory recommendations, where possible, with information from the literature or other available sources. The discrepancies between these values for inhalation rates will not significantly affect the final estimates of exposure or risk. Exponent estimates that, at worst, exposure estimates based on these assumptions may be off by a factor of 1.5 (biased low under residential exposures) for children, and 2 (biased high under residential exposures) for adults. The impacts of this variability will be discussed again in the Risk Characterization section of this report.

Exposure assumptions associated with incidental ingestion exposures to soil and dust under the commercial exposure scenario are presented in Table 6. Assumptions associated with inhalation exposures under the commercial exposure scenario are presented in Table 7.

AGRICULTURAL EXPOSURE SCENARIO

The exposure assumptions associated with the agricultural scenario were intended to characterize the potential exposures that might be incurred by a family who lives on and farms agricultural land around Trail. These exposures were the same (except for the concentrations of COPCs) as those experienced under the residential exposure scenario, except that they also incorporated exposures that would be associated with periods of intense farm work, such as plowing or tilling. The exposures associated with "residential" exposures on farms were calculated separately from the exposures associated with the intense farm work and are presented as residential exposures.[1] Issues associated with the assumptions regarding the "residential" component of the agricultural exposures are discussed above under the Residential Exposure Scenario. Exposure assumptions that are unique to the agricultural scenario (i.e., those associated with plowing or tilling) include the assumed soil ingestion rate, inhalation rates, the exposure frequency, and the exposure duration.

Little information is available regarding the specific exposures of farmers around Trail. Therefore, the assumptions of exposure incorporated into this assessment were based

[1] That is, the "residential" aspect of farming-associated risk is presented along with other residential risks, differing only in that the concentration data used in the calculations are representative of agricultural sampling locations (i.e., Waneta).

largely on professional judgement and precedent established by their use in other risk assessments of farming and ranching communities.

The exposure assumptions for soil ingestion rate and exposure frequency (480 mg/day, and 14 days/year, respectively) were based on values presented in a report titled *Baseline Risk Assessment for the Anaconda Smelter NPL Site, Anaconda, Montana* (CDM 1996). In that assessment, the goal was to evaluate the possible high-level exposures associated with plowing or other high-contact-rate activities that might occur occasionally during agricultural work. Because of the similarities between the target populations being evaluated in Anaconda and Trail, and the similarities in the regional location (i.e., western North America, with similar climates), these values were determined to be applicable in Trail.

It was assumed that agricultural tilling operations require the expenditure of energy associated with a moderate level of activity. Therefore, an inhalation rate of 1.6 m^3/hour was used to characterize agricultural exposures, based on the inhalation rate presented in U.S. EPA (1997) for a moderate activity level. Note that Fox (1990) presents a different inhalation rate for moderate levels of activity, and references U.S. EPA (1989) as the basis for that value. Because U.S. EPA (1997) provides updated information for exposure values, the updated inhalation rate was used in this assessment, rather than that from U.S. EPA 1989 (or from Fox 1990).

The exposure duration of 55 years was intended to include the period when a teenager might be learning the farming trade, through retirement (i.e., ages 15–70), and is based on professional judgement and conversations with staff at BCE (Fox 1998, pers. comm.).

Assumptions used in estimating exposures incurred under the agricultural exposure scenario are summarized and presented in Tables 8 and 9.

TOXICITY ASSESSMENT

The basic objective of a toxicity assessment is to identify the adverse health effects that a chemical causes, and how the appearance of these adverse effects depends on dose. In addition, the toxic effects of a chemical may depend on the route of exposure (oral or inhalation in this evaluation) and the duration of exposure (subchronic, chronic, or lifetime). Thus, a full description of the toxic effects of a chemical includes a listing of what adverse health effects the chemical may cause, and how the occurrence of these effects depends on dose, route, and duration of exposure.

Most chemicals can cause adverse health effects at a high enough dose. However, when the dose is sufficiently low, no adverse effect is observed. Therefore, in characterizing the non-cancer effects of a chemical, the key issue is the threshold dose at which an adverse effect first becomes evident. Doses below the threshold are considered to be safe, while doses above the threshold are likely to cause an effect. To be conservative, non-cancer risk evaluations are not based directly on the threshold exposure level, but on a toxicity value that incorporates uncertainty factors to ensure that the threshold will not be exceeded. The toxicity value for oral exposures is referred to as the Reference Dose (RfD). For inhalation exposures, the value is the Reference Concentration (RfC). The RfD or RfC is an estimated lifetime daily exposure that is likely to be without an appreciable risk of deleterious effects.

For chemicals believed to cause cancer following exposure, it is assumed that the dose-response curve for cancer has no threshold, and that any exposure has an associated risk of causing cancer. Therefore, the carcinogenic slope factor, or CSF, is the slope of the dose-response line for carcinogenic effects from exposure.[2] The CSF is used to estimate the incremental lifetime risk of developing cancer, corresponding to the estimated exposure levels calculated in the exposure assessment.

Toxicity values (i.e., the CSFs, RfDs, and RfCs) were obtained mostly from BCE, and are listed in Tables 10 and 11. As indicated in Tables 10 and 11, BCE recommends the use of toxicity values from Health Canada when they are available, and then defaults to values from U.S. EPA's Integrated Risk Information System (IRIS), when none are available from Health Canada.

Because BCE allows the use of toxicity factors from other sources,[3] when appropriate, additional toxicity values were used in this assessment. First, no toxicity value was

[2] In fact, the cancer slope factor is often an upper 95th percentile confidence limit on the slope of the dose-response line, and is therefore an upper-bound estimate of risk.

[3] Examples include U.S. EPA's health effects assessment tables (HEAST), U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry

provided by BCE for assessing risks from inhalation exposures to antimony. Because it was a goal of this risk evaluation to characterize risks for all routes of exposure, a U.S. EPA inhalation toxicity criterion for antimony was incorporated to the extent possible. Specifically, the RfC for antimony trioxide was used to assess inhalation exposures to antimony. Although the EPA documentation for this value indicates that this toxicity criterion is specific to antimony trioxide, and should not be applied to other forms of antimony, antimony trioxide is the expected form of antimony in air following thermal reactions such as those related to smelting.

Second, risks from exposure to cadmium were also assessed using an alternative cadmium toxicity value. As described in Technical Memorandum 2.1, there are significant background sources of exposure to cadmium. Therefore, we derived an estimate of tolerable daily cadmium intake that accounts for background exposures in determining risks associated with incremental cadmium exposures above background in Trail. This approach considered background exposures from food, drinking water, air, and smoking. Separate estimates of acceptable cadmium exposure levels have been developed for nonsmokers and smokers. These toxicity values, referred to as "absorbed-dose RfDs" represent the benchmark absorbed dose for cadmium. This is in contrast to the RfD value provided by BCE, which is presented as an *administered dose*. Risk estimates for noncancer endpoints of toxicity from cadmium were evaluated using both the toxicity value provided by BCE and the absorbed-dose RfD values for smokers and non-smokers. Because of the difference between the toxicity values for cadmium with regard to being expressed as administered or absorbed doses, the exposure estimate used to evaluate risks with each of these RfDs was also different. This is discussed further below.

Generally, it is not appropriate to evaluate risks from one route of exposure (e.g., inhalation) based on a toxicity value derived from a different route of exposure (e.g., ingestion) (U.S. EPA 1989). However, because the absorbed dose RfD for cadmium is expressed as an absorbed, rather than administered, dose, and because the target organ of toxicity is remote from the point of exposure (i.e., toxicity is related to accumulation of cadmium in the kidney following systemic absorption and distribution), the absorbed dose RfD has the additional benefit of being appropriate for assessing toxicity of integrated inhalation and ingestion exposures. Therefore, this is how it was used in this risk evaluation.

All toxicity values, as well as their endpoint of toxicity and source, are presented in Tables 10 and 11.

(ATSDR), the World Health Organization (WHO), the open scientific literature, and special-purpose derivations (Fox 1995).

RISK CHARACTERIZATION

Characterizing risks for Trail involved taking all the information regarding exposures to site-related compounds, and combining estimates of exposure with information regarding toxicity, to yield estimates of risks.

For noncarcinogenic chemicals, risk estimates are provided in the form of Hazard Indices (HIs). HIs represent the estimated exposure divided by the RfD (for oral exposures), or the air concentration divided by the RfC (for inhalation exposures). As such, HIs indicate the site-related exposures in comparison to an "acceptable" exposure. If an HI value is below unity (i.e., HI <1), then it can be reasonably assumed that the exposure will not be associated with toxicity. As HI values increase above unity, the potential for toxicity increases. RfDs and RfCs are generally based on administered doses (RfDs) or air exposure concentrations (RfCs), and they are generated for evaluating risks associated with specific routes of exposure. It is not appropriate to extrapolate from one route to another (i.e., to assess risks from inhalation exposure based on an RfD) using these toxicity criteria (U.S. EPA 1989). In this risk evaluation, there is an exception to this rule in the use of the absorbed-dose RfD. This specific RfD can be used to assess chronic toxicity from exposure to cadmium from any exposure pathway, as long as the exposure is expressed on an absorbed-dose basis.

For carcinogenic chemicals, risk estimates are calculated by multiplying the average lifetime daily dose by the carcinogenic slope factor (CSF), expressed in $(mg/kg\text{-}d)^{-1}$. This yields a unitless estimate of risk, and should be interpreted as the probability of increased incidence of cancer in a lifetime. Therefore, a cancer risk estimate of 1×10^{-5} indicates a probability of 1/100,000, or 1 cancer in a population of 100,000 exposed to the average lifetime daily dose. A subcommittee of the Canadian Council of Ministries of the Environment (subcommittee on Environmental Quality Criteria for Contaminated Sites) has adopted the position that site-related risks arising from human exposure to carcinogenic chemicals should be remediated to levels within the range of $10^{-4}\times10^{-7}$ (CCME 1996). Additionally, the Contaminated Site Regulations from BCE specify 10^{-5} as a default acceptable risk (a higher acceptable risk can be achieved on the recommendation of the local Medical Health Officer, following community consultation).[4]

Estimates of noncancer and carcinogenic risks have been generated for the six residential neighborhoods identified above, for two commercial districts of Trail, and under an agricultural exposure scenario based on land use and concentration data for Waneta. Estimates of risks from inhalation exposures and ingestion exposures for each of these

[4] B.C. Regulation 375/96, Waste Management Act Contaminated Sites Regulation, Part 6, Remediation Standards. Deposited December 16, 1996, effective April 1, 1997.

exposure locations and exposure scenarios are also provided. Following presentation of risks using toxicity values (CSFs, RfDs and RfCs) provided by Canadian and U.S. regulatory agencies, this evaluation also provides an estimate of risks from exposure to cadmium based on absorbed doses. Because all of these calculations are provided separately (for the reader who chooses to follow or reproduce the calculations), there are a large number of tables presenting the risks. In addition to detailed tables of risk calculations that are specific to exposure pathways and scenarios, summary tables are also provided. The tables are organized as described below.

First, risk estimates for residential exposures via ingestion and inhalation are presented on a neighborhood-specific basis (Tables 12a–16b). Then tables presenting risks associated with exposures under the commercial exposure scenario are presented for the two commercial districts evaluated (i.e., East Trail and West Trail) (Tables 17a–18b). Finally, risks associated with all exposures that might occur in agricultural areas are presented (Tables 19a–20b). These detailed tables of risk estimates provide the chemical-specific data that were incorporated into the calculations (i.e., chemical exposure-point concentration, bioavailability), calculated estimates of the chronic daily intake for both carcinogenic and noncancer risk evaluations, toxicity values that were incorporated into the risk equations, and calculated carcinogenic and noncancer risk estimates on a chemical-specific, and where appropriate, a pathway-specific basis. Thus, these tables provide detailed information regarding the derivation of the final risk estimate.

Following the detailed risk calculation tables, summary tables are also provided. Table 21 summarizes the noncancer hazard indices in each neighborhood under the residential exposure scenario, as well as noncancer risks calculated for the commercial and agricultural exposure scenarios. Table 22 summarizes the cancer risks for each exposure scenario, neighborhood, and COPC. These tables provide a quick overview of the risk calculations.

In Table 21, HIs for noncancer endpoints of toxicity have not been added together. It was determined that it would not be appropriate to add the calculated HI values, because the toxic endpoint for each metal is different, and would not be expected to affect the toxicity of the other metals. For cancer risks, risk estimates are provided on a chemical-specific basis, and a final estimate of total cancer risk across all chemicals is also provided (Table 22).

As can be seen in Table 21, calculated HI values are uniformly below the value of 1 for every COPC, under every exposure scenario. As discussed above, this indicates that there is little likelihood of adverse noncancer health effects from exposure to COPCs in Trail. The highest noncancer risks calculated under the residential exposure scenarios are found in Rivervale and Tadanac. The maximum HI value is 0.3, which is based on childhood ingestion exposures to arsenic in Rivervale.

As discussed above, this risk evaluation also assessed noncancer risks from exposure to cadmium based on an absorbed dose. This method was used to allow for incorporation of background exposures to cadmium, and also for assessment of potential noncancer risks from exposure to cadmium associated with both the inhalation and ingestion exposure pathways. Table 23 presents the HI values associated with the evaluation of exposures and associated risks from integrated inhalation and ingestion exposures. In this instance, an HI value greater than 1 would indicate that an individual in Trail is experiencing exposure to cadmium from combined background and site-related exposures, such that concentrations of cadmium may accumulate in the kidney to the level of potential toxicity.

This evaluation, based on absorbed doses of cadmium, indicates that all calculated HI values are below 1, for both smokers and nonsmokers. Because smokers will be exposed to cadmium from cigarettes, they are at higher risk for experiencing adverse effects from cadmium. The calculations presented here indicate that the highest HI value of 2×10^{-1} is for a smoker residing in Waneta (either under the residential exposure scenario, or the farm family scenario). Further investigation indicates that this value is dominated by exposures via inhalation. Because air concentrations of metals were not measured directly in Waneta, and data from another sampling station[5] were used as a surrogate for this area, there is significant uncertainty associated with this estimate. However, because calculated values for all areas, including neighborhoods close to the Cominco Metals facility, are below 1, there should be no concern that individuals in Trail are experiencing kidney toxicity from exposure to cadmium in environmental media (i.e., soil or air).

Calculated cancer risks from exposure to all chemicals and routes of exposure under the residential exposure scenario range from 2×10^{-4} to 3×10^{-4}, with the highest calculated risk found in Rivervale (Table 22). Without exception, the cancer risk estimates are dominated by risks from inhalation exposures to arsenic. Cancer risks from inhalation exposures to cadmium are approximately an order of magnitude lower than for arsenic. Generally, the cancer risks associated with ingestion exposures to arsenic (i.e., from soil and dust) are also well below the estimates associated with inhalation exposures. The exceptions are for Rivervale and Tadanac, where carcinogenic risks associated with residential ingestion exposures to arsenic approach 1×10^{-4}.

For exposures under the commercial scenario, estimated cancer risks for all chemicals and routes of exposure range from 8×10^{-5} to 1×10^{-4}. As with residential exposures, these risks are dominated by inhalation exposures to arsenic. However, for the commercial district of East Trail, the risks associated with exposure to arsenic via soil ingestion are not much lower that those associated with inhalation. Cancer risks associated with exposure to cadmium (via inhalation only; cadmium is not known to cause cancer following oral exposures) are 1×10^{-5} for either commercial area evaluated.

For exposures under the agricultural exposure scenario, total cancer risks from all chemicals and routes of exposure are 1×10^{-4} for a family living in the agricultural area,

[5] Air data from quarterly monitoring reports for the sampling station in Columbia Gardens were used, and the exposure was estimated from the maximum reported concentration. Future risk assessment efforts will attempt to update this information with additional data.

and 1×10^{-5} for field activities. Because of the way these exposure scenarios and calculations were set up, these values can be added to estimate the total cancer risk that an individual might incur if they both live and work in the agricultural area. In this case, the total cancer risk for an individual living in agricultural areas, and working on a farm is 1×10^{-4}. Under this exposure scenario, cancer risks from exposure to cadmium are at least an order of magnitude lower than the risks from exposure to arsenic, ranging from 6×10^{-8} (for field activities) to 4×10^{-6} (for a farm family). For arsenic, ingestion and inhalation risks for the resident farm family are approximately equal (4×10^{-5} and 5×10^{-5}, respectively). For the field activities, cancer risks associated with soil ingestion (1×10^{-5}) are more than an order of magnitude higher than the risks associated with inhalation of particulates (8×10^{-7}).

Several components of this evaluation give rise to uncertainty in the final estimates of exposure and risk. Some of these components result from the lack of appropriate or adequate data to accurately assess exposures. Others arise from inherent variability in such factors as individual inhalation rates, soil ingestion rates, exposure duration, and others. The toxicity factors used in calculating risks are based on conservative (i.e., health-protective) assumptions regarding the potential for toxicity. Table 24 summarizes some of the key sources of uncertainty in this assessment.

Some of these uncertainties can be addressed by collecting additional data (e.g., exposures from consumption of homegrown produce can be assessed on the basis of site-specific information on COPCs in vegetables). Others, such as the variability resulting from differences in human physiology or behavior, can best be accounted for by incorporating a stochastic analysis as part of the risk assessment effort. The usefulness of this approach can be evaluated as part of the Phase 3 risk assessment for Trail.

Finally, major uncertainty in the final risk estimates arise from the way in which toxicity factors are derived. To ensure protection of the public health, toxicity factors err toward overestimating risk (potentially by a substantial amount). Although the uncertainty introduced by use of conservative toxicity factors is high, risk assessments that face regulatory review can rarely deviate from the dictated toxicity values. The approaches used by regulatory agencies to derive toxicity values reflect policy decisions, as well as technical analysis of data. Changing the toxicity values dictated by regulatory agencies requires an effort that is likely beyond the scope of risk assessment for Trail.

CONCLUSIONS

Exponent has completed a risk evaluation for exposures in Trail to antimony, arsenic, and cadmium. This evaluation focused on risks associated with exposures in the neighborhoods around Trail where soil data indicated that metals concentrations exceed regulatory screening criteria. These neighborhoods were selected on the basis of Phase 1 risk assessment efforts for Trail, and of analyses conducted during the Phase 2 effort. This evaluation incorporated all available data of good technical quality that were applicable to the exposure scenarios evaluated. Specifically, soil data collected from the period 1989 to 1997 were aggregated, and available air data from the period July 1997 to July 1998 were used. Because a new smelter was brought on line at the Cominco facility in March 1997, and the old smelter closed down in May 1997, it was determined that air data collected prior to July 1997 would not be representative of current or future exposures around Trail.

The exposure scenarios evaluated included residential populations, commercial workers, and families living and working on a farm in an agricultural area near Trail. Potential ingestion of soil and dust, and inhalation of airborne particulates, were evaluated. Estimated exposures were compared with toxicity values that were provided by BCE, generated by U.S. EPA (for inhalation exposures to antimony) and listed in the IRIS database, or determined specifically as part of the Phase 2 risk assessment efforts (for absorbed-dose exposures to cadmium).

The results of this evaluation indicate that the risks for noncancer endpoints of toxicity are low, as demonstrated by the fact that all calculated hazard index values, for all COPCs, and under all exposure scenarios, are less than 1. In addition, HIs for exposure to cadmium are less than 1, even after taking into account anticipated background exposures to cadmium (i.e., HI values based on the absorbed-dose RfD for cadmium).

Calculated cancer risks from this evaluation range from 1×10^{-5} to 3×10^{-4}. The calculated cancer risks are dominated by risks associated with inhalation exposures to arsenic. In interpreting this cancer risk estimate, it is important to note that, because of the means by which the carcinogenic slope factor is derived and exposures are estimated, these values represent upper-bound estimates of cancer risk, and actual cancer risks may be as low as zero.

Risks associated with the residential exposure scenario are the highest of all scenarios evaluated. This is to be expected, as this exposure scenario incorporates the longest exposure duration (75 years) and the highest exposure rates (e.g., 24 hour/day). Because the calculations for the residential exposure scenario evaluate exposures for an individual who is at home all day, every day, it represents a worst-case exposure scenario, and should not be added to exposures associated with the commercial worker. For the agricultural farm family and agricultural worker, these risks are appropriately additive, and the risk assessment has taken this into account.

It appears that inhalation exposures are the result of a single source, because exposure-point concentrations for COPCs in air show much less variability between neighborhoods than do exposure-point concentrations for soil (e.g., a two-fold variability for concentrations of arsenic in air, versus a ten-fold variability in soil arsenic concentrations) (Table 1). This suggests that the sources of the elevated concentrations of COPCs need to be determined before an effective plan can be developed for remediation. A source evaluation for lead in air (TLP 1995) supports the position that a single source is responsible for concentrations of COPCs in air. In this analysis, the TLP established that smelter emissions far outweighed re-entrainment of outdoor soils or dust as the source of lead in the air. This conclusion was based on analyses of seasonality (e.g., air lead concentrations related to precipitation or snow cover), wind direction versus air concentrations, and measured fallout of lead from air.

Because inhalation exposures appear to be tied to a single source, and the ingestion exposures evaluated in this assessment are tied more closely to exposures to COPCs in soil, the results of the risk analysis can be used to guide future actions regarding remediation in Trail. Therefore, some interpretation in the context of these separate exposure sources is provided below.

RISKS FROM INHALATION EXPOSURES

As described above, the highest calculated carcinogenic risks result from estimated inhalation exposure, and fall in the range of 9×10^{-7} to 2×10^{-4}. The new Cominco smelter has now been on line for more than a year, and the air data used in this assessment were collected during that time. It is likely that optimization of the new smelter operations will reduce air concentrations of COPCs (and associated risks). For this reason, it will be important to track these concentrations over time. In addition, the brief analysis of air data that was conducted as part of this risk assessment raised some issues regarding the available database. For example, the fact that concentrations (expressed as $\mu g/m^3$) of PM_{10} did not display a clear distinction from concentrations of TSP is surprising. Expressed on a $\mu g/m^3$ basis, PM_{10} concentrations should be consistently lower than TSP concentrations. That this was not evident in the available data suggests that further data evaluation may be warranted.

RISKS FROM INCIDENTAL SOIL INGESTION EXPOSURE

As described above, and discussed in depth in the Phase 1 risk assessment report (PTI 1997), background exposures to cadmium, and the fact that chronic cadmium toxicity is related to a lifetime of cadmium accumulation in the kidney, can be important considerations in evaluating environmental exposures to cadmium. When cadmium risks were evaluated by comparing the RfD to a lifetime average dose, the resulting hazard indices were all 0.01 or less. Although exposures due to cadmium in homegrown produce were not included in this evaluation, these low hazard indices indicate that cadmium doses from plants would need to be 100 times greater than the predicted doses from soil before any health risks would occur. Because homegrown produce is unlikely to contribute doses more than 10 times the soil doses, no risks of adverse health effects are anticipated from the produce pathway.

To ensure that risks from cadmium exposure in Trail were not underestimated, cadmium risks were also evaluated on the basis of an absorbed dose. These calculations confirm that total exposures in Trail (from background, ingestion, and inhalation) are indeed below the threshold believed to result in toxic effects, although in this case, the highest hazard index was 0.2.

Risks associated with exposure to antimony were also predicted to be negligible. It should be noted that the toxicity data available to support the antimony oral toxicity value are of very poor quality, and were based on studies of a pharmaceutical preparation designed to enhance solubility and bioavailability of the compound. Due to the poor study quality, U.S. EPA applied a very large uncertainty factor in deriving the RfD. Considering this large uncertainty factor and the low hazard indices calculated for antimony exposures in Trail, we conclude that no further evaluation of antimony is required.

Estimated carcinogenic risks from ingestion routes of exposure to COPCs in soil range from 1×10^{-5} to 9×10^{-5}. All of this risk is attributable to incidental ingestion exposures to arsenic, because arsenic is the only COPC believed to be carcinogenic following oral exposure. Consistently, these values are below the corresponding risks from inhalation. In attempting to determine whether these risk estimates indicate a significant health concern, it is important to consider these estimated exposures and risks within an appropriate context.

As described above in the Introduction and in Technical Memorandum 2.1 (Exponent 1998), inorganic arsenic is present naturally in soil, food, water, and air. Consequently, all people are exposed naturally to some level of arsenic each day. Adult nonsmokers are thought to have an average absorbed daily dose of almost 9 μg/day. For populations that do not have elevated arsenic concentrations in their drinking water, ingestion of arsenic in food is the primary source of exposure. Air is a negligible contributor to background exposures.

Consequently, it is appropriate to compare estimates of the amount of arsenic ingested in soil and dust in Trail with these background exposures. For the cancer risk estimates, the highest estimated daily intakes of arsenic from soil and dust were for Rivervale, where the chronic daily intake of arsenic from soil and dust ingestion totaled 0.053 μg/kg-day. For a 70-kg person, this yields an intake of 3.7 μg/day. If 80 percent of ingested arsenic is absorbed, this equals an absorbed dose of 3 μg/day, which is approximately one-third of the expected background exposure of almost 9 μg/day. This comparison provides the perspective that, on average, incremental exposures to arsenic from soil and dust in Trail will increase total exposures to about 30 percent more than background exposures alone.

In addition to the point that exposures to arsenic from soil in Trail are small relative to background exposures, the carcinogenic slope factor (CSF, with which risk estimates are derived from calculated exposure) for arsenic likely overestimates risks from oral exposures to arsenic. These issues are described more fully in the *Recommendations* document that was prepared as part of the Phase 1 effort for Trail (PTI 1997). This likely overestimate of risk suggests that, although calculated risks for ingestion exposures to arsenic from soil approach the 10^{-4} range (i.e., the highest calculated cancer risk from ingestion was 9×10^{-5}), actual risks are likely to be much lower. Because the appropriateness of the CSF used to generate risk estimates for ingestion exposures to arsenic has recently been called into question, this value is currently under review by the U.S. EPA. It would be appropriate to reevaluate the calculated ingestion risks for Trail when a new CSF becomes available.

Taken together, the findings of this evaluation indicate that there is no imminent threat to human health in Trail from metals other than lead. Further, the potential for adverse health effects from long-term residence in Trail are very limited. The main focus of ongoing study should be to continue air monitoring for arsenic and cadmium. Specifically, PM_{10} should be measured, and detection limits should be low enough to support any future risk evaluations.

No adverse health effects are anticipated from exposure to cadmium and antimony in soil. For arsenic, noncancer risks are not anticipated from exposure via soil. Predicted cancer risks from exposure to arsenic in soil in Trail are within a range of risks considered to be acceptable by some regulatory agencies (i.e., a range of 1×10^{-6} to 1×10^{-4}). A determination of whether the predicted risks are acceptable to the community of Trail should include consideration of the uncertainties associated with predicting cancer risks from arsenic in soil at the relatively low exposure levels observed in Trail, based on studies of populations exposed to very high arsenic levels in drinking water. In addition, the exposures to arsenic in Trail soils should be compared to natural exposures to inorganic arsenic in the diet and drinking water.

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Tables

TABLE 1. EXPOSURE-POINT CONCENTRATION SUMMARY TABLE

	Antimony	Arsenic	Cadmium
Residential soil (mg/kg)			
East Trail	107 *L*	92.0 *L*	37.2 *L*
Rivervale	140 *P,L*	169 *L*	14.3 *L*
Tadanac	75.9 *L*	107 *L*	34.1 *L*
Waneta	26.0 *M*	28.7 *M*	5.00 *M*
West Trail	33.4 *L*	59.5 *L*	29.9 *L*
Residential air ($\mu g/m^3$)			
East Trail	NC	0.025 *M*	0.014 *M*
Rivervale[a]	NC	0.032 *L*	0.010 *L*
Tadanac[b]	0.025 *L*	0.030 *L*	0.014 *L*
Waneta[c]	0.005 *M*	0.020 *M*	0.020 *M*
West Trail	0.018 *L*	0.038 *L*	0.008 *L*
Commercial soil (mg/kg)			
East Trail	78.0 *M*	185 *M*	103 *M*
West Trail	28.0 *P,M*	40.0 *M*	26.7 *M*
Commercial air ($\mu g/m^3$)			
Downtown	0.025 *L*	0.030 *L*	0.014 *L*
East Trail	NC	0.025 *M*	0.014 *M*
Agricultural soil (mg/kg)	50.0 *M*	72.9 *M*	13.2 *M*

NC – no concentration data available
L – the exposure-point concentration for this analyte for this location is the UCLM
M – the exposure-point concentration for this analyte for this location is the maximum
P – the exposure-point concentration for this analyte for this location is predicted by the equation: $[\text{Antimony}] = 0.509 \times [\text{Arsenic}]^{1.075} \times 1.041$ (see text for details)

[a] Used air concentration data from the Oasis station.
[b] Used air concentration data from the Downtown station.
[c] Used air concentration data from the Columbia Gardens station.

TABLE 2. SUMMARY OF SOIL CONCENTRATION DATA

(All concentration terms expresses as mg/kg)

Neighbourhood	Land Use[a]	Statistic	Antimony	Arsenic	Cadmium
East Trail	Commercial	Count	1	6	6
		Minimum	78.0	16.0	7.25
		Average	78.0	65.2	32.5
		Maximum	[78.0]	[185]	[103]
		UCLM	--	250	224
East Trail	Residential	Count	12	60	60
		Minimum	11.6	13.0	5.30
		Average	54.6	72.5	29.9
		Maximum	144	340	129
		UCLM	[107]	[92.0]	[37.2]
Rivervale	Residential	Count	15 [b]	15	15
		Minimum	8.35 [b]	13.0	2.27
		Average	67.6 [b]	87.8	9.26
		Maximum	350 [b]	420	30.0
		UCLM	[140] [b]	[169]	[14.3]
Tadanac	Residential	Count	13	15	15
		Minimum	12.5	17.2	5.90
		Average	47.7	74.0	25.7
		Maximum	103	140	37.9
		UCLM	[75.9]	[107]	[34.1]
Waneta	Agricultural	Count	6	6	6
		Minimum	10.0	15.9	2.90
		Average	25.2	41.2	7.27
		Maximum	[50.0]	[72.9]	[13.2]
		UCLM	63.9	87.6	13.3
Waneta	Residential	Count	1	4	4
		Minimum	26.0	3.00	1.30
		Average	26.0	16.5	3.42
		Maximum	[26.0]	[28.7]	[5.00]
		UCLM	--	975	17.4
West Trail	Commercial	Count	6 [b]	6	6
		Minimum	8.35 [b]	13.0	1.10
		Average	19.4 [b]	28.4	13.6
		Maximum	[28.0] [b]	[40.0]	[26.7]
		UCLM	31.1 [b]	43.5	246
West Trail	Residential	Count	14	53	53
		Minimum	3.60	12.3	4.00
		Average	20.5	49.2	23.5
		Maximum	53.5	190	88.0
		UCLM	[33.4]	[59.5]	[29.9]

Note: All calculations involving non-detects used one-half the detection limit.

UCLM – 95 percent Upper Confidence Limit on the Mean; calculated assuming a lognormal distribution

-- – not applicable

[ ] – indicates value selected as the exposure-point concentration.

[a] The "Residential" category includes areas designated as "Parks/Recreational", and the "Commercial" category includes areas designated as "Institutional."

[b] These values were predicted based on arsenic concentrations using the equation $[\text{Antimony}] = 0.509 \times [\text{Arsenic}]^{1.075} \times 1.041$ (see text for details)

TABLE 3. SUMMARY OF AIR CONCENTRATION DATA

(All concentration terms expressed as $\mu g/m^3$)

Neighbourhood	Antimony	Arsenic	Cadmium
Columbia Gardens (TSP)[a]			
Count	3	3	3
Minimum	0.005	0.005	0.005
Average	0.005	0.010	0.010
Maximum	[0.005]	[0.020]	[0.020]
UCLM	0.005	4.00	4.00
East Trail (PM_{10})			
Count	0	4	4
Minimum	--	0.002	0.001
Average	--	0.014	0.008
Maximum	--	[0.025]	[0.014]
UCLM	--	2.54	1.95
Downtown (TSP)			
Count	211	360	360
Minimum	0.003	0.005	0.005
Average	0.023	0.027	0.013
Maximum	0.200	0.180	0.080
UCLM	[0.025]	[0.030]	[0.014]
Oasis (PM_{10})			
Count	0	58	58
Minimum	--	0.005	0.005
Average	--	0.025	0.009
Maximum	--	0.150	0.040
UCLM	--	[0.032]	[0.010]
West Trail (PM_{10})			
Count	34	34	34
Minimum	0.006	0.006	0.006
Average	0.014	0.027	0.007
Maximum	0.055	0.184	0.018
UCLM	[0.018]	[0.038]	[0.008]

Note: All calculations involving non-detects used one-half the detection limit.

UCLM – 95 percent Upper Confidence Limit on the Mean; calculated assuming a lognormal distribution

[ ] – indicates value selected as the exposure-point concentration.

[a] Data for this location were from quarterly reports.

TABLE 4. EXPOSURE ASSUMPTIONS,
RESIDENTIAL—SOIL AND DUST INGESTION

Symbol	Definition	Value	Units	Source/Comment
C_s	Chemical concentration in soil	chemical-specific	mg/kg	
C_d	Chemical concentration in dust	chemical-specific	mg/kg	
IR_a	Ingestion rate, adult	20	mg/day	BCE 1996
IR_c	Ingestion rate, child	80	mg/day	BCE 1996
FS	Fraction ingested from source	1	unitless	
CF	Conversion factor	1E-06	kg/mg	
EF_s	Exposure frequency to soil	263	day/yr	BCE 1995; assumes 2 wks gone, and 3 month snowcover
EF_d	Exposure frequency to dust	350	day/yr	BCE 1996; assumes 2 wks gone
ED_a	Exposure duration, adult	70	yr	BCE 1996
ED_c	Exposure duration, child	4.5	yr	BCE 1996
FI_s	Fraction ingested from soil	0.30	unitless	BCE 1995
FI_d	Fraction ingested from dust	0.70	unitless	BCE 1995
RBA	Relative bioavailability	chemical-specific	unitless	Exponent 1998
BW_a	Body weight, adult	70	kg	BCE 1996
BW_c	Body weight, child	13	kg	BCE 1996
AT_c	Averaging time–carcinogenic	27,375	day	75 yr × 365 day/yr
$AT_{nc\text{-}a}$	Averaging time–noncarcinogenic, adult	25,550	day	ED_a × 365 day/yr
$AT_{nc\text{-}c}$	Averaging time–noncarcinogenic, child	1,643	day	ED_c × 365 day/yr
AT_L	Averaging time–noncarcinogenic, lifetime[a]	27,193	day	(ED_a + ED_c) × 365 day/yr

[a] Used only in the absorbed dose assessment for cadmium.

Cancer:

$$\textbf{Risk} = \frac{C_s \times IR_a \times FS \times CF \times EF_s \times ED_a \times FI_s \times RBA \times CSF}{BW_a \times AT_c} + \frac{C_d \times IR_a \times FS \times CF \times EF_a \times ED_a \times FI_d \times RBA \times CSF}{BW_a \times AT_c}$$

$$+ \frac{C_s \times IR_c \times FS \times CF \times EF_s \times ED_c \times FI_s \times RBA \times CSF}{BW_c \times AT_c} + \frac{C_d \times IR_c \times FS \times CF \times EF_c \times ED_c \times FI_d \times RBA \times CSF}{BW_c \times AT_c}$$

Non-cancer:

$$\textbf{Hazard Index, adult} = \frac{C_s \times IR_a \times FS \times CF \times EF_a \times ED_a \times FI_s \times RBA}{BW_a \times AT_{nc\text{-}a} \times RfD} + \frac{C_d \times IR_a \times FS \times CF \times EF_a \times ED_a \times FI_d \times RBA}{BW_a \times AT_{nc\text{-}a} \times RfD}$$

$$\textbf{Hazard Index, child} = \frac{C_s \times IR_c \times FS \times CF \times EF_c \times ED_c \times FI_s \times RBA}{BW_c \times AT_{nc\text{-}c} \times RfD} + \frac{C_d \times IR_c \times FS \times CF \times EF_c \times ED_c \times FI_d \times RBA}{BW_c \times AT_{nc\text{-}c} \times RfD}$$

Note: for assessing noncancer lifetime exposure to cadmium, AT_L replaces both $AT_{nc\text{-}a}$ and $AT_{nc\text{-}c}$ and the adult and child hazard indicies are summed.

TABLE 5. EXPOSURE ASSUMPTIONS, *RESIDENTIAL—INHALATION*

Symbol	Definition	Value	Units	Source/Comment
C_A	Chemical concentration in air	chemical-specific	$\mu g/m^3$	
IR_a	Inhalation rate, adult	23	m^3/day	BCE 1996[a]
IR_c	Inhalation rate, child	5	m^3/day	BCE 1996[a]
CF	Conversion factor	1E-03	mg/μg	
FS	Fraction inhaled from source	1	unitless	
EF	Exposure frequency	350	day/yr	BCE 1996; assumes 2 wks gone
ED_a	Exposure duration, adult	70	yr	BCE 1996
ED_c	Exposure duration, child	4.5	yr	BCE 1996
ABS	Absorption fraction[b]	chemical-specific	unitless	
BW_a	Body weight, adult	70	kg	BCE 1996
BW_c	Body weight, child	13	kg	BCE 1996
AT_c	Averaging time–carcinogenic	27,375	day	75 yr × 365 day/yr
AT_L	Averaging time–noncarcinogenic, lifetime[b]	27,193	day	$(ED_a + ED_c) \times 365$ day/yr

[a] Daily inhalation rate for long-term exposure periods, from BCE 1996.

[b] Used only in the absorbed dose assessment for cadmium.

Cancer:

$$\textbf{Risk} = \frac{C_A \times IR_a \times CF \times FS \times EF_a \times ED_a \times CSF}{BW_a \times AT_c} + \frac{C_A \times IR_c \times CF \times FS \times EF_c \times ED_c \times CSF}{BW_c \times AT_c}$$

Non-cancer:

$$\textbf{Hazard Index} = \frac{C_A}{RfC \times 1{,}000\ \mu g/mg}$$

TABLE 6. EXPOSURE ASSUMPTIONS, *COMMERCIAL—SOIL AND DUST INGESTION*

Symbol	Definition	Value	Units	Source/Comment
C_s	Chemical concentration in soil	chemical-specific	mg/kg	
C_d	Chemical concentration in dust	chemical-specific	mg/kg	
IR_a	Ingestion rate, adult	20	mg/day	BCE 1996
IR_c	Ingestion rate, child	80	mg/day	BCE 1996
FS_a	Fraction ingested from source, adult	0.6	unitless	BCE 1996; assumes 10 of 16 waking hours spent in commercial areas
FS_c	Fraction ingested from source, child	0.66	unitless	Assumes 8 of 12 waking hours spent in commercial areas
CF	Conversion factor	1E-06	kg/mg	
$EF_{s\text{-}a}$	Exposure frequency to soil, adult	185	day/yr	BCE 1996; assumes 5 day/wk and 3 months snowcover
$EF_{s\text{-}c}$	Exposure frequency to soil, child	185	day/yr	BCE 1996; assumes 5 day/wk and 3 months snowcover
$EF_{d\text{-}a}$	Exposure frequency to dust, adult	240	day/yr	CCME 1996; assumes 5 day/wk, 48 wk/yr
$EF_{d\text{-}c}$	Exposure frequency to dust, child	240	day/yr	CCME 1996; assumes 5 day/wk, 48 wk/yr
ED_a	Exposure duration, adult	70	yr	BCE 1996
ED_c	Exposure duration, child	4.5	yr	BCE 1996
FI_s	Fraction ingested from soil	0.30	unitless	BCE 1995
FI_d	Fraction ingested from dust	0.70	unitless	BCE 1995
RBA	Relative bioavailability	chemical-specific	unitless	Exponent 1998
BW_a	Body weight, adult	70	kg	BCE 1996
BW_c	Body weight, child	13	kg	BCE 1996
AT_c	Averaging time–carcinogenic	27,375	day	75 yr × 365 day/yr
$AT_{nc\text{-}a}$	Averaging time–noncarcinogenic, adult	25,550	day	ED_a × 365 day/yr
$AT_{nc\text{-}c}$	Averaging time–noncarcinogenic, child	1,643	day	ED_c × 365 day/yr
AT_L	Averaging time–noncarcinogenic, lifetime[a]	27,193	day	(ED_a + ED_c) × 365 day/yr

[a] Used only in the absorbed dose assessment for cadmium.

Cancer:

$$\text{Risk} = \frac{C_s \times IR_a \times FS_a \times CF \times EF_{s\text{-}a} \times ED_a \times FI_s \times RBA \times CSF}{BW_a \times AT_c} + \frac{C_d \times IR_a \times FS_a \times CF \times EF_{d\text{-}a} \times ED_a \times FI_d \times RBA \times CSF}{BW_a \times AT_c}$$

$$+ \frac{C_s \times IR_c \times FS_c \times CF \times EF_{s\text{-}c} \times ED_c \times FI_s \times RBA \times CSF}{BW_c \times AT_c} + \frac{C_d \times IR_c \times FS_c \times CF \times EF_{d\text{-}c} \times ED_c \times FI_d \times RBA \times CSF}{BW_c \times AT_c}$$

Non-cancer:

$$\text{Hazard Index, adult} = \frac{C_s \times IR_a \times FS_a \times CF \times EF_{s\text{-}a} \times ED_a \times FI_s \times RBA}{BW_a \times AT_{nc\text{-}a} \times RfD} + \frac{C_d \times IR_a \times FS_a \times CF \times EF_{d\text{-}a} \times ED_a \times FI_d \times RBA}{BW_a \times AT_{nc\text{-}a} \times RfD}$$

$$\text{Hazard Index, child} = \frac{C_s \times IR_c \times FS_c \times CF \times EF_{s\text{-}c} \times ED_c \times FI_s \times RBA}{BW_c \times AT_{nc\text{-}c} \times RfD} + \frac{C_d \times IR_c \times FS_c \times CF \times EF_{d\text{-}c} \times ED_c \times FI_d \times RBA}{BW_c \times AT_{nc\text{-}c} \times RfD}$$

Note: for assessing noncancer lifetime exposure to cadmium, AT_L replaces both $AT_{nc\text{-}a}$ and $AT_{nc\text{-}c}$ and the adult and child hazard indicies are summed.

TABLE 7. EXPOSURE ASSUMPTIONS, *COMMERCIAL—INHALATION*

Symbol	Definition	Value	Units	Source/Comment
C_A	Chemical concentration in air	chemical-specific	$\mu g/m^3$	
IR_a	Inhalation rate, adult	1.3	m^3/hr	U.S. EPA 1997[a]
IR_c	Inhalation rate, child	0.7	m^3/hr	U.S. EPA 1997[b]
CF	Conversion factor	1E-03	$mg/\mu g$	
ET_a	Exposure time, adult	10	hr/day	CCME 1996
ET_c	Exposure time, child	8	hr/day	
EF_a	Exposure frequency, adult	240	day/yr	CCME 1996; assumes 5 day/wk, 48 wk/yr
EF_c	Exposure frequency, child	240	day/yr	CCME 1996; assumes 5 day/wk, 48 wk/yr
ED_a	Exposure duration, adult	70	yr	BCE 1996
ED_c	Exposure duration, child	4.5	yr	BCE 1996
ABS	Absorption fraction[c]	chemical-specific	unitless	
BW_a	Body weight, adult	70	kg	BCE 1996
BW_c	Body weight, child	13	kg	BCE 1996
AT_c	Averaging time–carcinogenic	27,375	day	75 yr × 365 day/yr
AT_L	Averaging time–noncarcinogenic, lifetime[c]	27,193	day	(ED_a + ED_c) × 365 day/yr

[a] Average inhalation rate for light and moderate activity levels during short-term exposure periods, from U.S. EPA 1997.
[b] Average inhalation rate for sedentary and light activity levels during short term exposure periods, from U.S. EPA 1997.
[c] Used only in the absorbed dose assessment for cadmium.

Cancer:

$$\textbf{Risk} = \frac{C_A \times IR_a \times CF \times ET_a \times EF_a \times ED_a \times CSF}{BW_a \times AT_c} + \frac{C_A \times IR_c \times CF \times ET_c \times EF_c \times ED_c \times CSF}{BW_c \times AT_c}$$

Non-cancer:

$$\textbf{Hazard Index} = \frac{C_A}{RfC \times 1{,}000\ \mu g/mg}$$

TABLE 8. EXPOSURE ASSUMPTIONS, *AGRICULTURAL—SOIL INGESTION*

Symbol	Definition	Value	Units	Source/Comment
C_s	Chemical concentration in soil	chemical-specific	mg/kg	
IR	Ingestion rate	480	mg/day	U.S. EPA 1995[a]
CF	Conversion factor	1E-06	kg/mg	
FS	Fraction ingested from source	1	unitless	
EF	Exposure frequency	14	day/yr	U.S. EPA 1995[a]
ED	Exposure duration	55	yr	Ages 15–70
RBA	Relative bioavailability	chemical-specific	unitless	Exponent 1998
BW	Body weight, adult	70	kg	BCE 1996
AT_c	Averaging time–carcinogenic	27,375	day	75 yr × 365 day/yr
AT_{nc}	Averaging time–noncarcinogenic	20,075	day	ED × 365 day/yr
AT_L	Averaging time–noncarcinogenic, lifetime[b]	20,075	day	ED × 365 day/yr

[a] Scenario evaluates possible high-level exposures associated with plowing or other high-contact-rate activities that might occur occasionally under an agricultural scenario. Value from U.S. EPA 1995, Baseline human health risk assessment: Anaconda Smelter NPL site.

[b] Used only in the absorbed dose assessment for cadmium.

Cancer:

$$\text{Risk} = \frac{C_s \times IR \times CF \times FS \times EF \times ED \times RBA \times CSF}{BW \times AT_c}$$

Non-cancer:

$$\text{Hazard Index} = \frac{C_s \times IR \times CF \times FS \times EF \times ED \times RBA}{BW \times AT_{nc} \times RfD}$$

TABLE 9. EXPOSURE ASSUMPTIONS, *AGRICULTURAL—INHALATION*

Symbol	Definition	Value	Units	Source/Comment
C_s	Chemical concentration in soil	chemical-specific	mg/kg	
IR	Inhalation rate	1.6	m^3/hr	Fox 1990, U.S. EPA 1997[a]
PC_a	Particulate concentration in air	150	$\mu g/m^3$	U.S. EPA 1995[b]
CF	Conversion factor	1E-09	kg/μg	
FS	Fraction inhaled from source	1	unitless	
ET	Exposure time	8	hr/day	
EF	Exposure frequency	14	day/yr	
ED	Exposure duration	55	yr	Ages 15–70
ABS	Absorption fraction[c]	chemical-specific	unitless	
BW	Body weight, adult	70	kg	BCE 1996
AT_c	Averaging time–carcinogenic	27,375	day	75 yr × 365 day/yr
AT_L	Averaging time–noncarcinogenic, lifetime[c]	20,075	day	ED × 365 day/yr

[a] Fox 1990 used values for "moderate activity" from Exposure Factors Handbook, U.S. EPA 1989. These values have been updated by U.S. EPA, and the updated values are reflected here.

[b] The value was derived for dust loading to air for an agricultural worker during plowing activities. Units are expressed as μg of soil-derived respirable dust per m^3 of air. When multiplied by the metal concentration in soil, this yields the air-dust concentration of metals. U.S. EPA 1995, Baseline human health risk assessment: Anaconda Smelter NPL site.

[c] Used only in the absorbed dose assessment for cadmium.

Cancer:

$$\textbf{Risk} = \frac{C_s \times IR \times PC_a \times CF \times FS \times EF \times ED \times CSF}{BW \times AT_c}$$

Non-cancer:

$$\textbf{Hazard Index} = \frac{C_s \times PC_a \times CF}{RfC \times 1{,}000\ \mu g/mg}$$

TABLE 10. TOXICITY VALUES FOR NONCARCINOGENIC CHEMICALS OF POTENTIAL CONCERN

Chemical	RfD (mg/kg-day)	RfC (mg/m^3)	Critical Effect	Basis	Source	Date[a]
Oral route						
Antimony	4.0E-04 [b]	--	Longevity, blood glucose, and chlolesterol	Rat, chronic oral bioassay	IRIS	5/5/98
Arsenic	0.002 [b]	--	Skin, blood, CNS effects	--	HC/BCE 1995	1998
Cadmium	8.1E-04 [b]	--	Kidney toxicity	WHO tolerable daily intake	HC	1989
Cadmium, non-smokers	2.0E-05	--	Kidney toxicity	Absorbed dose, calculated	Exponent	July 1998
Cadmium, smokers	1.0E-05	--	Kidney toxicity	Absorbed dose, calculated	Exponent	July 1998
Inhalation route						
Antimony (antimony trioxide)	--	2.0E-04	Pulmonary toxicity, chronic interstitial inflammation	Rat, 1-year inhalation study	IRIS	5/5/98

-- = Not applicable, or not presented in source document
NA = Not available
IRIS = EPA Integrated Risk Information System (IRIS), online electronic data files (U.S. EPA 1998).
HC = Health Canada. 1989 Priority substances list document for cadmium. Environmental Substances Division, Bureau of Chemical Hazards (Health Canada 1989).

[a] Indicates the date of the source document or the date of contact. For IRIS, it is the date of the last file update.
[b] Value from G. Fox, BC Environment Toxicologist, personal communication with G. Hook, Exponent Environmental Group, Boulder, Colorado, on 7/2/98, regarding BCE toxicity values.

TABLE 11. TOXICITY VALUES FOR CARCINOGENIC CHEMICALS OF POTENTIAL CONCERN

Chemical	Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight of Evidence	Type of Cancer	Basis of Slope Factor	Source	Date[a]
Oral route						
Arsenic	1.75 [b]	I (carcinogenic to humans)	Skin cancer	Human, drinking water exposure	HC	1996
Inhalation route						
Arsenic	15 [b]	A (human carcinogen)	Lung cancer	Human, occupational exposure	IRIS	5/29/98
Cadmium	6.3 [b]	B1 (probable human carcinogen)	Lung cancer	Human, occupational exposure	IRIS	5/5/98

-- = Not applicable, or not presented in source document
NA = Not available
HC = Health Canada. Health-based Tolerable Daily Intakes/concentrations and tumorigenic doses/concentrations for priority substances (Health Canada 1996).
IRIS = EPA Integrated Risk Information System (IRIS), online electronic chemical data files (U.S. EPA 1998).

[a] Indicates the date of the source document or the date of contact. For IRIS, it is the date of the last file update.
[b] Value from G. Fox, BC Environment Toxicologist, personal communication with G. Hook, Exponent Environmental Group, Boulder, Colorado, on 7/2/98, regarding BCE toxicity values.

TABLE 12a. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES
Residential scenario—Soil and dust ingestion
East Trail

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Soil concentration	mg/kg	107	92.0	37.2	
Dust concentration	mg/kg	107	92.0	37.2	
Relative bioavailability	unitless	0.10	0.55	0.33	
Carcinogenic Effects					
Chronic daily intake, soil	mg/kg-day	1.5E-06	7.0E-06	1.7E-06	
Chronic daily intake, dust	mg/kg-day	4.6E-06	2.2E-05	5.2E-06	
Cancer slope factor, oral	$(mg/kg\text{-}day)^{-1}$	NA	1.75	NA	
Risk	unitless	--	5E-05	--	5E-05
Noncarcinogenic Effects					
Chronic daily intake, soil-adult	mg/kg-day	6.6E-07	3.1E-06	7.6E-07	
Chronic daily intake, dust-adult	mg/kg-day	2.1E-06	9.7E-06	2.4E-06	
Chronic daily intake, soil-child	mg/kg-day	1.4E-05	6.7E-05	1.6E-05	
Chronic daily intake, dust-child	mg/kg-day	4.4E-05	2.1E-04	5.1E-05	
Chronic daily intake, lifetime[a]	mg/kg-day	NA	NA	7.0E-06	
Reference dose, oral	mg/kg-day	4.0E-04	0.002	8.1E-04	
Hazard index, adult	unitless	7E-03	6E-03	NA	
Hazard index, child	unitless	1E-01	1E-01	NA	
Hazard index, lifetime[a]	unitless	NA	NA	9E-03	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation
[a] RfD for cadmium is based on lifetime accumulation. See text for further details.

Note: Scientific notation examples:

$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$

$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$

$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE 12b. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES

Residential scenario—Soil and dust inhalation

East Trail

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Air concentration	μg/m³	NC	0.025	0.014	
Absorption fraction	unitless	0.50	0.33	0.25	
Carcinogenic Effects					
Chronic daily intake	mg/kg-day	--	7.9E-06	4.4E-06	
Cancer slope factor, inhalation	$(mg/kg\text{-}day)^{-1}$	NA	15	6.3	
Risk	unitless	--	1E-04	3E-05	1E-04
Noncarcinogenic Effects					
Reference concentration, inhalation	mg/m³	2.0E-04	NA	NA	
Hazard index	unitless	--	--	--	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation

Note: Scientific notation examples:
$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$
$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$
$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE 13a. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES

Residential scenario—Soil and dust ingestion

Rivervale

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Soil concentration	mg/kg	140	169	14.3	
Dust concentration	mg/kg	140	169	14.3	
Relative bioavailability	unitless	0.10	0.55	0.33	
Carcinogenic Effects					
Chronic daily intake, soil	mg/kg-day	1.9E-06	1.3E-05	6.5E-07	
Chronic daily intake, dust	mg/kg-day	6.0E-06	4.0E-05	2.0E-06	
Cancer slope factor, oral	$(mg/kg\text{-}day)^{-1}$	NA	1.75	NA	
Risk	unitless	--	9E-05	--	9E-05
Noncarcinogenic Effects					
Chronic daily intake, soil-adult	mg/kg-day	8.6E-07	5.7E-06	2.9E-07	
Chronic daily intake, dust-adult	mg/kg-day	2.7E-06	1.8E-05	9.1E-07	
Chronic daily intake, soil-child	mg/kg-day	1.9E-05	1.2E-04	6.3E-06	
Chronic daily intake, dust-child	mg/kg-day	5.8E-05	3.8E-04	1.9E-05	
Chronic daily intake, lifetime[a]	mg/kg-day	NA	NA	2.7E-06	
Reference dose, oral	mg/kg-day	4.0E-04	0.002	8.1E-04	
Hazard index, adult	unitless	9E-03	1E-02	NA	
Hazard index, child	unitless	2E-01	3E-01	NA	
Hazard index, lifetime[a]	unitless	NA	NA	3E-03	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation
[a] RfD for cadmium is based on lifetime accumulation. See text for further details.

Note: Scientific notation examples:

$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$

$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$

$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE 13b. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES

Residential scenario—Soil and dust inhalation

Rivervale

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Air concentration	$\mu g/m^3$	NC	0.032	0.010	
Absorption fraction	unitless	0.50	0.33	0.25	
Carcinogenic Effects					
Chronic daily intake	mg/kg-day	--	1.0E-05	3.2E-06	
Cancer slope factor, inhalation	$(mg/kg\text{-}day)^{-1}$	NA	15	6.3	
Risk	unitless	--	2E-04	2E-05	2E-04
Noncarcinogenic Effects					
Reference concentration, inhalation	mg/m^3	2.0E-04	NA	NA	
Hazard index	unitless	--	--	--	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation

Note: Scientific notation examples:

3E-06 = 3×10^{-6} = 0.000003
1.2E-05 = 1.2×10^{-5} = 0.000012
5E+02 = 5×10^{2} = 500

TABLE 14a. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES
Residential scenario—Soil and dust ingestion
Tadanac

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Soil concentration	mg/kg	75.9	107	34.1	
Dust concentration	mg/kg	75.9	107	34.1	
Relative bioavailability	unitless	0.10	0.55	0.33	
Carcinogenic Effects					
Chronic daily intake, soil	mg/kg-day	1.0E-06	8.1E-06	1.5E-06	
Chronic daily intake, dust	mg/kg-day	3.2E-06	2.5E-05	4.8E-06	
Cancer slope factor, oral	$(mg/kg\text{-}day)^{-1}$	NA	1.75	NA	
Risk	unitless	--	6E-05	--	6E-05
Noncarcinogenic Effects					
Chronic daily intake, soil-adult	mg/kg-day	4.7E-07	3.6E-06	6.9E-07	
Chronic daily intake, dust-adult	mg/kg-day	1.5E-06	1.1E-05	2.2E-06	
Chronic daily intake, soil-child	mg/kg-day	1.0E-05	7.8E-05	1.5E-05	
Chronic daily intake, dust-child	mg/kg-day	3.1E-05	2.4E-04	4.6E-05	
Chronic daily intake, lifetime[a]	mg/kg-day	NA	NA	6.4E-06	
Reference dose, oral	mg/kg-day	4.0E-04	0.002	8.1E-04	
Hazard index, adult	unitless	5E-03	7E-03	NA	
Hazard index, child	unitless	1E-01	2E-01	NA	
Hazard index, lifetime[a]	unitless	NA	NA	8E-03	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation
[a] RfD for cadmium is based on lifetime accumulation. See text for further details.

Note: Scientific notation examples:

$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$

$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$

$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE 14b. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES

Residential scenario—Soil and dust inhalation

Tadanac

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Air concentration	$\mu g/m^3$	0.025	0.030	0.014	
Absorption fraction	unitless	0.50	0.33	0.25	
Carcinogenic Effects					
Chronic daily intake	mg/kg-day	4.0E-06	9.5E-06	4.4E-06	
Cancer slope factor, inhalation	$(mg/kg\text{-}day)^{-1}$	NA	15	6.3	
Risk	unitless	--	1E-04	3E-05	2E-04
Noncarcinogenic Effects					
Reference concentration, inhalation	mg/m^3	2.0E-04	NA	NA	
Hazard index	unitless	1E-01	--	--	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation

Note: Scientific notation examples:
3E-06 = 3×10^{-6} = 0.000003
1.2E-05 = 1.2×10^{-5} = 0.000012
5E+02 = 5×10^{2} = 500

TABLE 15a. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES
Residential scenario—Soil and dust ingestion
Waneta

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Soil concentration	mg/kg	26.0	28.7	5.00	
Dust concentration	mg/kg	26.0	28.7	5.00	
Relative bioavailability	unitless	0.10	0.55	0.33	
Carcinogenic Effects					
Chronic daily intake, soil	mg/kg-day	3.6E-07	2.2E-06	2.3E-07	
Chronic daily intake, dust	mg/kg-day	1.1E-06	6.7E-06	7.0E-07	
Cancer slope factor, oral	$(mg/kg\text{-}day)^{-1}$	NA	1.75	NA	
Risk	unitless	--	2E-05	--	2E-05
Noncarcinogenic Effects					
Chronic daily intake, soil-adult	mg/kg-day	1.6E-07	9.7E-07	1.0E-07	
Chronic daily intake, dust-adult	mg/kg-day	5.0E-07	3.0E-06	3.2E-07	
Chronic daily intake, soil-child	mg/kg-day	3.5E-06	2.1E-05	2.2E-06	
Chronic daily intake, dust-child	mg/kg-day	1.1E-05	6.5E-05	6.8E-06	
Chronic daily intake, lifetime[a]	mg/kg-day	NA	NA	9.4E-07	
Reference dose, oral	mg/kg-day	4.0E-04	0.002	8.1E-04	
Hazard index, adult	unitless	2E-03	2E-03	NA	
Hazard index, child	unitless	4E-02	4E-02	NA	
Hazard index, lifetime[a]	unitless	NA	NA	1E-03	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation
[a] RfD for cadmium is based on lifetime accumulation. See text for further details.

Note: Scientific notation examples:

$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$

$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$

$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE 15b. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES

Residential scenario—Soil and dust inhalation

Waneta

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Air concentration	$\mu g/m^3$	0.005	0.020	0.020	
Absorption fraction	unitless	0.50	0.33	0.25	
Carcinogenic Effects					
Chronic daily intake	mg/kg-day	7.9E-07	6.3E-06	6.3E-06	
Cancer slope factor, inhalation	$(mg/kg\text{-}day)^{-1}$	NA	15	6.3	
Risk	unitless	--	9E-05	4E-05	1E-04
Noncarcinogenic Effects					
Reference concentration, inhalation	mg/m^3	2.0E-04	NA	NA	
Hazard index	unitless	3E-02	--	--	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation

Note: Scientific notation examples:
$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$
$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$
$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE 16a. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES
Residential scenario—Soil and dust ingestion
West Trail

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Soil concentration	mg/kg	33.4	59.5	29.9	
Dust concentration	mg/kg	33.4	59.5	29.9	
Relative bioavailability	unitless	0.10	0.55	0.33	
Carcinogenic Effects					
Chronic daily intake, soil	mg/kg-day	4.6E-07	4.5E-06	1.4E-06	
Chronic daily intake, dust	mg/kg-day	1.4E-06	1.4E-05	4.2E-06	
Cancer slope factor, oral	$(mg/kg\text{-}day)^{-1}$	NA	1.75	NA	
Risk	unitless	--	3E-05	--	3E-05
Noncarcinogenic Effects					
Chronic daily intake, soil-adult	mg/kg-day	2.1E-07	2.0E-06	6.1E-07	
Chronic daily intake, dust-adult	mg/kg-day	6.4E-07	6.3E-06	1.9E-06	
Chronic daily intake, soil-child	mg/kg-day	4.4E-06	4.4E-05	1.3E-05	
Chronic daily intake, dust-child	mg/kg-day	1.4E-05	1.4E-04	4.1E-05	
Chronic daily intake, lifetime[a]	mg/kg-day	NA	NA	5.6E-06	
Reference dose, oral	mg/kg-day	4.0E-04	0.002	8.1E-04	
Hazard index, adult	unitless	2E-03	4E-03	NA	
Hazard index, child	unitless	5E-02	9E-02	NA	
Hazard index, lifetime[a]	unitless	NA	NA	7E-03	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation
[a] RfD for cadmium is based on lifetime accumulation. See text for further details.

Note: Scientific notation examples:

$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$

$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$

$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE 16b. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES

Residential scenario—Soil and dust inhalation

West Trail

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Air concentration	$\mu g/m^3$	0.018	0.038	0.008	
Absorption fraction	unitless	0.50	0.33	0.25	
Carcinogenic Effects					
Chronic daily intake	mg/kg-day	2.8E-06	1.2E-05	2.5E-06	
Cancer slope factor, inhalation	$(mg/kg\text{-}day)^{-1}$	NA	15	6.3	
Risk	unitless	--	2E-04	2E-05	2E-04
Noncarcinogenic Effects					
Reference concentration, inhalation	mg/m^3	2.0E-04	NA	NA	
Hazard index	unitless	9E-02	--	--	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation

Note: Scientific notation examples:

$3E-06 = 3 \times 10^{-6} = 0.000003$

$1.2E-05 = 1.2 \times 10^{-5} = 0.000012$

$5E+02 = 5 \times 10^{2} = 500$

TABLE 17a. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES

Commercial scenario—Soil and dust ingestion

East Trail

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Soil concentration	mg/kg	78.0	185	103	
Dust concentration	mg/kg	78.0	185	103	
Relative bioavailability	unitless	0.10	0.55	0.33	
Carcinogenic Effects					
Chronic daily intake, soil	mg/kg-day	4.8E-07	6.2E-06	2.1E-06	
Chronic daily intake, dust	mg/kg-day	1.4E-06	1.9E-05	6.3E-06	
Cancer slope factor, oral	$(mg/kg\text{-}day)^{-1}$	NA	1.75	NA	
Risk	unitless	--	4E-05	--	4E-05
Noncarcinogenic Effects					
Chronic daily intake, soil-adult	mg/kg-day	2.0E-07	2.7E-06	8.9E-07	
Chronic daily intake, dust-adult	mg/kg-day	6.2E-07	8.0E-06	2.7E-06	
Chronic daily intake, soil-child	mg/kg-day	4.8E-06	6.3E-05	2.1E-05	
Chronic daily intake, dust-child	mg/kg-day	1.5E-05	1.9E-04	6.4E-05	
Chronic daily intake, lifetime[a]	mg/kg-day	NA	NA	8.5E-06	
Reference dose, oral	mg/kg-day	4.0E-04	0.002	8.1E-04	
Hazard index, adult	unitless	2E-03	5E-03	NA	
Hazard index, child	unitless	5E-02	1E-01	NA	
Hazard index, lifetime[a]	unitless	NA	NA	1E-02	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation
[a] RfD for cadmium is based on lifetime accumulation. See text for further details.

Note: Scientific notation examples:

$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$

$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$

$5E{+}02 = 5 \times 10^{2} = 500$

TABLE 17b. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES

Commercial scenario—Soil and dust inhalation

East Trail

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Air concentration	$\mu g/m^3$	NC	0.025	0.014	
Absorption fraction	unitless	0.50	0.33	0.25	
Carcinogenic Effects					
Chronic daily intake	mg/kg-day	--	3.3E-06	1.8E-06	
Cancer slope factor, inhalation	$(mg/kg\text{-}day)^{-1}$	NA	15	6.3	
Risk	unitless	--	5E-05	1E-05	6E-05
Noncarcinogenic Effects					
Reference concentration, inhalation	mg/m^3	2.0E-04	NA	NA	
Hazard index	unitless	--	--	--	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation

Note: Scientific notation examples:

3E-06 = 3×10^{-6} = 0.000003

1.2E-05 = 1.2×10^{-5} = 0.000012

5E+02 = 5×10^{2} = 500

TABLE 18a. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES

Commercial scenario—Soil and dust ingestion

West Trail

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Soil concentration	mg/kg	28.0	40.0	26.7	
Dust concentration	mg/kg	28.0	40.0	26.7	
Relative bioavailability	unitless	0.10	0.55	0.33	
Carcinogenic Effects					
Chronic daily intake, soil	mg/kg-day	1.7E-07	1.4E-06	5.4E-07	
Chronic daily intake, dust	mg/kg-day	5.2E-07	4.1E-06	1.6E-06	
Cancer slope factor, oral	$(mg/kg\text{-}day)^{-1}$	NA	1.75	NA	
Risk	unitless	--	1E-05	--	1E-05
Noncarcinogenic Effects					
Chronic daily intake, soil-adult	mg/kg-day	7.3E-08	5.7E-07	2.3E-07	
Chronic daily intake, dust-adult	mg/kg-day	2.2E-07	1.7E-06	7.0E-07	
Chronic daily intake, soil-child	mg/kg-day	1.7E-06	1.4E-05	5.4E-06	
Chronic daily intake, dust-child	mg/kg-day	5.2E-06	4.1E-05	1.6E-05	
Chronic daily intake, lifetime[a]	mg/kg-day	NA	NA	2.2E-06	
Reference dose, oral	mg/kg-day	4.0E-04	0.002	8.1E-04	
Hazard index, adult	unitless	7E-04	1E-03	NA	
Hazard index, child	unitless	2E-02	3E-02	NA	
Hazard index, lifetime[a]	unitless	NA	NA	3E-03	

NA – not available or not applicable

NC – no concentration data available

-- – insufficient information to complete calculation

[a] RfD for cadmium is based on lifetime accumulation. See text for further details.

Note: Scientific notation examples:

$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$

$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$

$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE 18b. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES

Commercial scenario—Soil and dust inhalation
Downtown (West Trail)

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Air concentration	µg/m^3	0.025	0.030	0.014	
Absorption fraction	unitless	0.50	0.33	0.25	
Carcinogenic Effects					
Chronic daily intake	mg/kg-day	1.6E-06	3.9E-06	1.8E-06	
Cancer slope factor, inhalation	(mg/kg-day)$^{-1}$	NA	15	6.3	
Risk	unitless	--	6E-05	1E-05	7E-05
Noncarcinogenic Effects					
Reference concentration, inhalation	mg/m^3	2.0E-04	NA	NA	
Hazard index	unitless	1E-01	--	--	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation

Note: Scientific notation examples:
3E-06 = 3×10^{-6} = 0.000003
1.2E-05 = 1.2×10^{-5} = 0.000012
5E+02 = 5×10^{2} = 500

TABLE 19a. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES

Farm family scenario—Soil and dust ingestion
Waneta—Agricultural Areas

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Soil concentration	mg/kg	50.0	72.9	13.2	
Dust concentration	mg/kg	50.0	72.9	13.2	
Relative bioavailability	unitless	0.10	0.55	0.33	
Carcinogenic Effects					
Chronic daily intake, soil	mg/kg-day	6.9E-07	5.5E-06	6.0E-07	
Chronic daily intake, dust	mg/kg-day	2.1E-06	1.7E-05	1.9E-06	
Cancer slope factor, oral	$(mg/kg\text{-}day)^{-1}$	NA	1.75	NA	
Risk	unitless	--	4E-05	--	4E-05
Noncarcinogenic Effects					
Chronic daily intake, soil-adult	mg/kg-day	3.1E-07	2.5E-06	2.7E-07	
Chronic daily intake, dust-adult	mg/kg-day	9.6E-07	7.7E-06	8.4E-07	
Chronic daily intake, soil-child	mg/kg-day	6.7E-06	5.3E-05	5.8E-06	
Chronic daily intake, dust-child	mg/kg-day	2.1E-05	1.7E-04	1.8E-05	
Chronic daily intake, lifetime[a]	mg/kg-day	NA	NA	2.5E-06	
Reference dose, oral	mg/kg-day	4.0E-04	0.002	8.1E-04	
Hazard index, adult	unitless	3E-03	5E-03	NA	
Hazard index, child	unitless	7E-02	1E-01	NA	
Hazard index, lifetime[a]	unitless	NA	NA	3E-03	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation
[a] RfD for cadmium is based on lifetime accumulation. See text for further details.

Note: Scientific notation examples:

$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$

$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$

$5E{+}02 = 5 \times 10^{2} = 500$

TABLE 19b. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES
Farm family scenario—Soil and dust inhalation
Waneta—Agricultural Areas

Parameters	Units	Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Soil concentration	mg/kg	50.0	72.9	13.2	
Absorption fraction	unitless	0.50	0.33	0.25	
Carcinogenic Effects					
Chronic daily intake	mg/kg-day	1.2E-06	3.5E-06	6.3E-07	
Cancer slope factor, inhalation	$(mg/kg\text{-}day)^{-1}$	NA	15	6.3	
Risk	unitless	--	5E-05	4E-06	6E-05
Noncarcinogenic Effects					
Reference concentration, inhalation	mg/m^3	2.0E-04	NA	NA	
Hazard index	unitless	4E-02	--	--	

NA – not available or not applicable
NC – no concentration data available
-- – insufficient information to complete calculation

Note: Scientific notation examples:
3E-06 = 3×10^{-6} = 0.000003
1.2E-05 = 1.2×10^{-5} = 0.000012
5E+02 = 5×10^{2} = 500

TABLE 20a. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES

Agricultural field activities scenario—Soil ingestion

Waneta

Parameters		Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Soil concentration	mg/kg	50.0	72.9	13.2	
Relative bioavailability	unitless	0.10	0.55	0.33	
Carcinogenic Effects					
Chronic daily intake	mg/kg-day	9.6E-07	7.7E-06	8.4E-07	
Cancer slope factor, oral	$(mg/kg\text{-}day)^{-1}$	NA	1.75	NA	
Risk	unitless	--	1E-05	--	1E-05
Noncarcinogenic Effects					
Chronic daily intake	mg/kg-day	1.3E-06	1.1E-05	1.1E-06	
Reference dose, oral	mg/kg-day	4.0E-04	0.002	8.1E-04	
Hazard index	unitless	3E-03	5E-03	1E-03	

NA – not available or not applicable

-- – insufficient information to complete calculation

Note: Scientific notation examples:

$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$

$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$

$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE 20b. CANCER RISK ESTIMATES AND NONCANCER HAZARD INDICES
Agricultural field activities scenario—Soil inhalation
Waneta

Parameters		Antimony	Arsenic	Cadmium	All Chemicals
Chemical-specific terms					
Soil concentration	mg/kg	50.0	72.9	13.2	
Absorption fraction	unitless	0.50	0.33	0.25	
Carcinogenic Effects					
Chronic daily intake	mg/kg-day	1.9E-08	5.6E-08	1.0E-08	
Cancer slope factor, inhalation	$(mg/kg\text{-}day)^{-1}$	NA	15	6.3	
Risk	unitless	--	8E-07	6E-08	9E-07
Noncarcinogenic Effects					
Reference concentration, inhalation	mg/m^3	2.0E-04	NA	NA	
Hazard index	unitless	4E-02	--	--	

NA – not available or not applicable

-- – insufficient information to complete calculation

Note: Scientific notation examples:

3E-06 = 3×10^{-6} = 0.000003

1.2E-05 = 1.2×10^{-5} = 0.000012

5E+02 = 5×10^{2} = 500

TABLE 21. SUMMARY OF NONCANCER HAZARD INDICIES

Neighbourhood/Pathway		Antimony	Arsenic	Cadmium
Residential scenarios				
East Trail				
Adult	Ingestion	7E-03	6E-03	9E-03 [a]
Child	Ingestion	1E-01	1E-01	NA
Adult & child	Inhalation	--	--	--
Rivervale				
Adult	Ingestion	9E-03	1E-02	3E-03 [a]
Child	Ingestion	2E-01	3E-01	NA
Adult & child	Inhalation	--	--	--
Tadanac				
Adult	Ingestion	5E-03	7E-03	8E-03 [a]
Child	Ingestion	1E-01	2E-01	NA
Adult & child	Inhalation	1E-01	--	--
Waneta				
Adult	Ingestion	2E-03	2E-03	1E-03 [a]
Child	Ingestion	4E-02	4E-02	NA
Adult & child	Inhalation	3E-02	--	--
West Trail				
Adult	Ingestion	2E-03	4E-03	7E-03 [a]
Child	Ingestion	5E-02	9E-02	NA
Adult & child	Inhalation	9E-02	--	--
Commercial scenarios				
East Trail				
Adult	Ingestion	2E-03	5E-03	1E-02 [a]
Child	Ingestion	5E-02	1E-01	NA
Adult & child	Inhalation	--	--	--
West Trail/Downtown				
Adult	Ingestion	7E-04	1E-03	3E-03 [a]
Child	Ingestion	2E-02	3E-02	NA
Adult & child	Inhalation	1E-01	--	--
Agricultural scenario				
Waneta (farm family)				
Adult	Ingestion	3E-03	5E-03	3E-03 [a]
Child	Ingestion	7E-02	1E-01	NA
Adult & child	Inhalation	4E-02	--	--
Waneta (field activities)				
Adult	Ingestion	3E-03	5E-03	1E-03
Adult	Inhalation	4E-02	--	--

NA – not applicable
-- – insufficient information to complete calculation
[a] Cadmium hazard index applies to entire lifetime.

Note: Scientific notation examples
$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$
$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$
$5E+02 = 5 \times 10^{2} = 500$

TABLE 22. SUMMARY OF CANCER RISK ESTIMATES

Neighbourhood/Pathway	Antimony	Arsenic	Cadmium	All Chemicals
Residential scenarios				
East Trail				
Ingestion	--	5E-05	--	5E-05
Inhalation	--	1E-04	3E-05	1E-04
Total carcinogenic risk	--	2E-04	3E-05	2E-04
Rivervale				
Ingestion	--	9E-05	--	9E-05
Inhalation	--	2E-04	2E-05	2E-04
Total carcinogenic risk	--	2E-04	2E-05	3E-04
Tadanac				
Ingestion	--	6E-05	--	6E-05
Inhalation	--	1E-04	3E-05	2E-04
Total carcinogenic risk	--	2E-04	3E-05	2E-04
Waneta				
Ingestion	--	2E-05	--	2E-05
Inhalation	--	9E-05	4E-05	1E-04
Total carcinogenic risk	--	1E-04	4E-05	2E-04
West Trail				
Ingestion	--	3E-05	--	3E-05
Inhalation	--	2E-04	2E-05	2E-04
Total carcinogenic risk	--	2E-04	2E-05	2E-04
Commercial scenarios				
East Trail				
Ingestion	--	4E-05	--	4E-05
Inhalation	--	5E-05	1E-05	6E-05
Total carcinogenic risk	--	9E-05	1E-05	1E-04
West Trail/Downtown				
Ingestion	--	1E-05	--	1E-05
Inhalation	--	6E-05	1E-05	7E-05
Total carcinogenic risk	--	7E-05	1E-05	8E-05
Agricultural scenario				
Waneta (farm family)				
Ingestion	--	4E-05	--	4E-05
Inhalation	--	5E-05	4E-06	6E-05
Total carcinogenic risk	--	9E-05	4E-06	1E-04
Waneta (field activities)				
Ingestion	--	1E-05	--	1E-05
Inhalation	--	8E-07	6E-08	9E-07
Total carcinogenic risk	--	1E-05	6E-08	1E-05

-- – insufficient information to complete calculation

Note: Scientific notation examples

3E-06 = 3×10^{-6} = 0.000003

1.2E-05 = 1.2×10^{-5} = 0.000012

5E+02 = 5×10^{2} = 500

TABLE 23. SUMMARY OF NONCANCER HAZARD INDICIES, CADMIUM EXPOSURES—ABSORBED DOSE

Neighbourhood	Cadmium Hazard Index[a] Non-Smokers	Smokers
Residential scenarios		
East Trail	6E-02	1E-01
Rivervale	4E-02	9E-02
Tadanac	6E-02	1E-01
Waneta	8E-02	2E-01
West Trail	4E-02	8E-02
Commercial scenarios		
East Trail	3E-02	6E-02
West Trail/Downtown	2E-02	5E-02
Agricultural scenario		
Waneta (farm family)	8E-02	2E-01
Waneta (field activities)	2E-03	3E-03

[a] Hazard index is calculated using an absorbed dose RfD, which applies to the total amount of cadmium absorbed from both ingestion and inhalation.

Note: Scientific notation examples:

$3E\text{-}06 = 3 \times 10^{-6} = 0.000003$

$1.2E\text{-}05 = 1.2 \times 10^{-5} = 0.000012$

$5E\text{+}02 = 5 \times 10^{2} = 500$

TABLE 24. SUMMARY OF KEY SOURCES OF UNCERTAINTY

Parameter	Source of Uncertainty	Probable Effect on Risk Estimate		Options for Reducing Uncertainty
		Estimated Magnitude	Direction	
Outdoor air concentration	Incomplete PM_{10} data (used TSP data)	Unknown	Overestimation	Collect additional PM_{10} data
Outdoor air concentration	Many results less than detection limit—used one-half detection limit	Unknown	Unknown	Use more sensitive detection limits in collection of new data
Indoor air concentration	No indoor air data—assumed equal to outdoor	1.5x	Overestimation	Collect indoor air samples
Indoor dust concentration	No reliable indoor dust data—assumed equal to outdoor soil concentration	Unknown	Overestimation	Indoor dust samples were collected by TLP in Aug/Sept '98.
Antimony concentrations in soil	Few observations for some neighborhoods —predicted based on arsenic concentration data	0.93x–2.0x (based on E. and W. Trail)	Unknown	Collect additional data on antimony in soil
Exposure via consumption of local produce	No reliable data on concentrations of COPCs in local produce—pathway not evaluated	1.25x for arsenic, 4x for cadmium	Underestimation	Samples of local produce were collected by TLP in Aug/Sept '98
Exposure Assumptions (see Tables 4-9)	Variability in human physiology and behavior	Unknown	Overestimation	Bound impact on final exposure and risk estimates with stochastic analysis
Oral RfD for antimony	Extrapolation required in derivation of RfD from animal studies	Up to 1000x (10x for animal to human; 10x for human variability; 10x for LOAEL to NOEL)	Overestimation	Technical reanalysis of toxicology data, or close tracking for updates to regulatory values
Inhalation RfC for antimony	Extrapolation required in derivation of RfC from animal studies	Up to 300x (3x for animal to human; 10x for human variability; 10x for data inadequacies)	Overestimation	Technical reanalysis of toxicology data, or close tracking for updates to regulatory values
Oral RfD for arsenic	Technical basis for derivation unknown	Unknown	Likely overestimation	Technical reanalysis of toxicology data, or close tracking for updates to regulatory values

TABLE 24. (cont.)

Parameter	Source of Uncertainty	Probable Effect on Risk Estimate		Options for Reducing Uncertainty
		Estimated Magnitude	Direction	
Oral RfD for cadmium	Assumptions regarding accumulation in the kidney, and sources of exposure	Up to 8x	Overestimation	Technical reanalysis of toxicology data, or close tracking for updates to regulatory values
CSF for arsenic	Extrapolation from high exposure to low exposure • Whether threshold exists • Whether doses are estimated correctly in study that forms the basis for the CSF • Applicability of study population to Canadian populations	Calculated risks represent an upper-bound estimate. Actual risks may be as low as zero.	Overestimation	Technical reanalysis of toxicology data, or close tracking for updates to regulatory values
CSF for cadmium	Extrapolation from high exposure to low exposure	Calculated risks represent an upper-bound estimate. Actual risks may be as low as zero.	Overestimate	Technical reanalysis of toxicology data, or close tracking for updates to regulatory values

Appendix A

Data

TABLE A-1. SOIL DATA USED IN RISK EVALUATION

Property ID	UTM_X	UTM_Y	Neighbourhood	Land Use	Antimony (mg/kg)	Arsenic (mg/kg)	Cadmium (mg/kg)
P890018	452159	5433859	Casino	Residential		13	1.5
P890138	451496	5433796	Casino	Residential		3	0.9
ET1	448674	5438413	East Trail	Park/Rec	54	85	16.2
ET2	448996	5438643	East Trail	Residential	34	44	16.2
ET3	449221	5438451	East Trail	Residential	75	91	33.5
G03	449516	5438082	East Trail	Park/Rec		13	9.2
G06	449057	5438442	East Trail	Residential		13	19.0
G07	449618	5438312	East Trail	Park/Rec		40	5.3
G14	449320	5438129	East Trail	Residential		60	32.0
G15	449166	5438309	East Trail	Residential		45	38.0
G16	448733	5438484	East Trail	Commercial		30	38.0
G17	448670	5438991	East Trail	Residential		55	16.0
G18	448467	5439244	East Trail	Park/Rec		13	12.0
G37	449980	5438226	East Trail	Park/Rec		65	9.7
G41	449667	5438149	East Trail	Commercial		65	8.6
G42	449497	5438257	East Trail	Residential		13	8.7
G43	449063	5438412	East Trail	Residential		35	11.0
G44	448819	5438467	East Trail	Commercial		55	13.0
G45	449321	5438268	East Trail	Residential		30	6.1
G46	449304	5438091	East Trail	Residential		140	75.0
Nov97-mapID-13[a]	449223	5438159	East Trail	Park/Rec	12		
Nov97-mapID-14[a]	448537	5439178	East Trail	Park/Rec	18		
Nov97-mapID-15[a]	448827	5438878	East Trail	Institutional	78		
P890019	448692	5438613	East Trail	Residential		61	21.6
P890024	448976	5438451	East Trail	Residential		256	52.6
P890109	448746	5438314	East Trail	Residential		13	7.0
P890110	448622	5438920	East Trail	Residential		13	6.1
P890111	449075	5438448	East Trail	Residential		69	15.6
P890154	448537	5438998	East Trail	Residential		39	11.4
P890162	448791	5438348	East Trail	Residential		117	55.0
P890197	449072	5438554	East Trail	Residential		85	62.5
P890198	449073	5438345	East Trail	Residential		88	36.6
P890200	449210	5438461	East Trail	Residential		67	33.4
P890216	448992	5438427	East Trail	Residential		13	5.4
P890219	449120	5438531	East Trail	Residential		21	8.2
P890220	449160	5438462	East Trail	Residential		91	41.8
P890238	449055	5438487	East Trail	Residential		117	41.9
P890262	449029	5438530	East Trail	Residential		39	30.3
P890263	449148	5438256	East Trail	Residential		53	19.8
P890300.	449413	5438297	East Trail	Institutional		16	7.3
P890306	448375	5439214	East Trail	Park/Rec		18	9.8
P890307	449131	5438120	East Trail	Park/Rec		62	29.4
P900071	448758	5438676	East Trail	Residential	55	77	40.0
P910010	449179	5438419	East Trail	Residential		100	39.0
P910011	448651	5438712	East Trail	Residential		63	27.5
P910029	449467	5438405	East Trail	Residential		63	37.7
P910040	449033	5438519	East Trail	Residential		160	27.0
P910047	448986	5438370	East Trail	Residential		340	129
P910064	448449	5439123	East Trail	Residential		65	44.0
P910068	448514	5439052	East Trail	Residential		24	14.5
P910099	449721	5438178	East Trail	Residential		52	17.3
P910108	449426	5438172	East Trail	Residential	26	37	12.6

TABLE A-1. (cont.)

Property ID	UTM_X	UTM_Y	Neighbourhood	Land Use	Antimony (mg/kg)	Arsenic (mg/kg)	Cadmium (mg/kg)
P910130	449316	5438284	East Trail	Residential		39	24.6
P910137	449275	5438386	East Trail	Residential		150	60.0
P910143	449856	5438231	East Trail	Residential		108	38.0
P910156	448849	5438694	East Trail	Residential		78	39.0
P910157	448575	5439034	East Trail	Residential		29	19.0
P910169	448747	5438510	East Trail	Commercial		185	103
P910172	448532	5438751	East Trail	Residential		88	23.5
P910178	448969	5438558	East Trail	Residential		125	63.0
P910203	449404	5438160	East Trail	Institutional		40	25.5
P910208	449040	5438602	East Trail	Residential		60	29.0
P910217	448634	5438981	East Trail	Residential		92	20.0
P910218	449588	5438104	East Trail	Residential		50	25.0
P920002	449144	5438581	East Trail	Residential		27	11.8
P920003	449271	5438232	East Trail	Residential		48	17.0
P920326	448914	5438487	East Trail	Residential	95	140	58.5
P940060	448698	5438592	East Trail	Residential	101	131	65.2
P970004	448780	5438817	East Trail	Residential	24	41	22.9
P970009	448131	5438033	East Trail	Residential	17	25	12.8
P980001	448657	5438602	East Trail	Residential	144	179	82.5
G04	450593	5438559	Glenmerry	Institutional		13	7.8
G05	450694	5438491	Glenmerry	Residential		13	4.6
G27	451084	5438277	Glenmerry	Residential		45	9.9
G28	450902	5438246	Glenmerry	Residential		25	7.9
G38	450889	5438331	Glenmerry	Residential		13	9.6
G70	450855	5438733	Glenmerry	Park/Rec		13	2.0
G71	451547	5438648	Glenmerry	Residential		13	12.0
P890006	450851	5438296	Glenmerry	Residential		95	10.3
P890020	451004	5438550	Glenmerry	Residential		32	7.0
P890027	451059	5438226	Glenmerry	Residential		87	17.5
P890048	452242	5438307	Glenmerry	Residential		25	8.3
P890054	451003	5438321	Glenmerry	Residential		20	4.9
P890056	451114	5438687	Glenmerry	Residential		51	16.0
P890091	451944	5438382	Glenmerry	Residential		22	7.7
P890125	451021	5438197	Glenmerry	Residential		40	5.8
P890139	451522	5438362	Glenmerry	Residential		39	6.9
P890169	451490	5438279	Glenmerry	Residential		68	17.0
P890177	451805	5438250	Glenmerry	Residential		9	2.7
P890196	450659	5438448	Glenmerry	Residential		13	12.9
P890229	451409	5438519	Glenmerry	Residential		113	18.7
P890237	450953	5438547	Glenmerry	Residential		56	17.3
P890280	450967	5438330	Glenmerry	Residential		56	12.0
P890287	451436	5438376	Glenmerry	Residential		58	12.7
P890301	451901	5438358	Glenmerry	Residential		21	3.1
P890308	450847	5438444	Glenmerry	Residential		11	4.6
P900029	450926	5438263	Glenmerry	Residential		187	78.5
P910023	450822	5438278	Glenmerry	Residential		35	15.0
P910041	451152	5438396	Glenmerry	Residential		22	13.3
P910063	451915	5438419	Glenmerry	Residential		73	12.5
P910123	451124	5438491	Glenmerry	Residential		35	12.0
P910166	451299	5438387	Glenmerry	Residential		45	11.0
P910182	451839	5438358	Glenmerry	Residential		24	16.5
P910188	450885	5438273	Glenmerry	Residential		13	9.1
P910210	451975	5438543	Glenmerry (Centennial Park)	Park/Rec		38	16.1

TABLE A-1. (cont.)

Property ID	UTM_X	UTM_Y	Neighbourhood	Land Use	Antimony (mg/kg)	Arsenic (mg/kg)	Cadmium (mg/kg)
P910211	451019	5438841	Glenmerry (Andy Bileski Park)	Park/Rec		62	6.9
P910216	450708	5438453	Glenmerry	Residential		22	12.8
P920747	451284	5438507	Glenmerry	Residential		13	8.8
P950099	452064	5438316	Glenmerry	Residential		13	8.9
P950100	452272	5438313	Glenmerry	Residential		13	3.3
P950102	450685	5438478	Glenmerry	Residential		13	3.4
P950103	450922	5438193	Glenmerry	Residential		19	10.3
P950104	451858	5438318	Glenmerry	Residential		43	18.5
G20	445790	5438228	Lower Warfield	Residential		13	4.4
G21	445474	5437856	Lower Warfield	Residential		13	4.4
G63	446340	5438244	Lower Warfield (Annable)	Residential		13	4.9
G64	446703	5438266	Lower Warfield (Annable)	Residential		13	3.6
G65	446492	5438186	Lower Warfield (Annable)	Residential		13	5.5
LW1	446800	5439024	Lower Warfield	Industrial	60	78	20.9
LW2	446201	5439148	Lower Warfield	Industrial	24	27	7.5
LW3	445773	5438890	Lower Warfield	Industrial	10	14	11.1
P890005	445086	5437325	Lower Warfield	Residential		10	0.6
P890047	445173	5437536	Lower Warfield	Residential		8	2.2
P890049	445465	5437411	Lower Warfield	Residential		40	7.4
P890053	445403	5437699	Lower Warfield	Residential		11	3.2
P890092	445763	5438032	Lower Warfield	Residential		22	6.0
P890099	446588	5438183	Lower Warfield	Residential		27	15.0
P890105	445081	5437373	Lower Warfield	Residential		9	1.0
P890172	445677	5437665	Lower Warfield	Residential		18	3.1
P890182	445081	5437390	Lower Warfield	Residential		36	20.5
P890199	445426	5437819	Lower Warfield	Residential		10	4.5
P890211	446341	5437950	Lower Warfield	Residential		12	2.5
P890224	445610	5438035	Lower Warfield	Residential		24	4.2
P890267	445452	5437574	Lower Warfield	Residential		7	2.9
P890269	445221	5437637	Lower Warfield	Residential		10	1.3
P890278	445727	5437483	Lower Warfield	Residential		3	2.6
P890302	445116	5437676	Lower Warfield	Park/Rec		15	1.9
P890316	445769	5438436	Lower Warfield	Park/Rec		9	0.8
P890317	446316	5438364	Lower Warfield	Park/Rec		19	3.5
P890318	445618	5437910	Lower Warfield	Park/Rec		10	1.1
P890321	445876	5437993	Lower Warfield	Park/Rec		12	2.0
P890322	445116	5437676	Lower Warfield	Park/Rec		12	1.7
P890326	445154	5437511	Lower Warfield	Park/Rec		8	1.0
P910139	445135	5437144	Lower Warfield	Residential		13	5.3
P910142	444988	5437570	Lower Warfield	Residential		13	5.4
P910213	445378	5437756	Lower Warfield	Residential		13	4.1
P910214	445482	5437774	Lower Warfield	Residential		13	2.8
P890022	450022	5439274	Miral Heights	Residential		15	1.2
P890037	449953	5439302	Miral Heights	Residential		15	2.9
P890045	450033	5439290	Miral Heights	Residential		13	1.1
P890107	450071	5439074	Miral Heights	Residential		5	0.5
P890118	450045	5439210	Miral Heights	Residential		3	0.6
P890147	450060	5439054	Miral Heights	Residential		15	1.8
P890325	450089	5438978	Miral Heights	Park/Rec		10	2.9
P890113	456410	5435787	Montrose	Residential		11	3.8
P890268	457216	5436487	Montrose	Residential		13	2.6
P910117	456776	5436256	Montrose	Residential		13	1.8

TABLE A-1. (cont.)

Property ID	UTM_X	UTM_Y	Neighbourhood	Land Use	Antimony (mg/kg)	Arsenic (mg/kg)	Cadmium (mg/kg)
P890064	445887	5442685	Oasis	Residential		22	6.6
P890163	445707	5442388	Oasis	Residential		13	4.0
P910025	445882	5442657	Oasis	Residential		13	14.0
P910055	445508	5442841	Oasis	Residential		22	3.8
G54	446270	5440868	Rivervale	Residential		80	8.3
G55	446275	5440968	Rivervale	Residential		210	16.0
G56	446211	5441236	Rivervale	Residential		80	4.6
G57	446136	5441313	Rivervale	Residential		40	5.2
G58	446171	5441480	Rivervale	Residential		70	5.7
G59	446110	5441579	Rivervale	Residential		140	9.3
G60	446088	5441691	Rivervale	Residential		420	30.0
G61	446030	5441322	Rivervale	Industrial		55	9.6
G62	446118	5441003	Rivervale	Industrial		175	12.0
P890039	446269	5441734	Rivervale	Residential		13	12.0
P890069	446262	5441434	Rivervale	Residential		30	4.1
P890209	446267	5441330	Rivervale	Residential		37	3.2
P890223	446196	5441637	Rivervale	Residential		24	5.2
P890230	446260	5441513	Rivervale	Residential		29	8.2
P890324	446263	5440980	Rivervale	Residential		17	2.3
P910161	446198	5441353	Rivervale	Residential		53	5.8
P910200	446429	5440728	Rivervale	Residential		75	19.0
G22	449958	5438318	Shavers Bench	Park/Rec		13	12.0
G23	449859	5438410	Shavers Bench	Residential		30	22.0
G24	449680	5438638	Shavers Bench	Residential		13	14.0
G25	449422	5438544	Shavers Bench	Park/Rec		35	8.4
G26	449486	5438533	Shavers Bench	Residential		13	20.0
G36	449351	5438710	Shavers Bench	Residential		13	4.4
G39	449882	5438292	Shavers Bench	Residential		25	29.0
G40	449812	5438315	Shavers Bench	Residential		25	20.0
P890033	449655	5438628	Shavers Bench	Residential		18	4.8
P890070	449266	5438651	Shavers Bench	Residential		8	4.4
P890076	449801	5438500	Shavers Bench	Residential		87	23.6
P890079	449760	5438483	Shavers Bench	Residential		42	14.1
P890112	449724	5438441	Shavers Bench	Residential		56	21.5
P890117	449592	5438656	Shavers Bench	Residential		60	15.3
P890129	449726	5438635	Shavers Bench	Residential		15	5.2
P890157	449924	5438544	Shavers Bench	Residential		37	7.6
P890159	449866	5438322	Shavers Bench	Residential		52	18.3
P890284	449683	5438517	Shavers Bench	Residential		15	13.7
P890285	449473	5438614	Shavers Bench	Residential		61	16.7
P890309	449945	5438442	Shavers Bench	Park/Rec		23	5.4
P890327	449309	5438642	Shavers Bench	Residential		13	5.2
P910001	449246	5438637	Shavers Bench	Residential		13	6.7
P910038	449789	5438296	Shavers Bench	Residential		27	10.2
P910097	449926	5438289	Shavers Bench	Residential		80	34.0
P910186	450095	5438665	Shavers Bench	Park/Rec		29	9.9
P950107	449481	5438447	Shavers Bench	Park/Rec		13	26.0
G10	447294	5440556	Sunningdale	Residential		30	13.0
G11	447494	5440371	Sunningdale	Residential		35	22.0
G12	447826	5440329	Sunningdale	Residential		13	9.8
G13	447967	5440090	Sunningdale	Park/Rec		25	5.7
G19	447825	5440424	Sunningdale	Residential		13	9.5
G29	447875	5440183	Sunningdale	Residential		13	12.0

TABLE A-1. (cont.)

Property ID	UTM_X	UTM_Y	Neighbourhood	Land Use	Antimony (mg/kg)	Arsenic (mg/kg)	Cadmium (mg/kg)
G30	447788	5440240	Sunningdale	Residential		13	15.0
G31	447720	5440287	Sunningdale	Residential		30	18.0
G32	447679	5440360	Sunningdale	Residential		13	9.1
G33	447643	5440436	Sunningdale	Residential		13	16.0
G34	447553	5440828	Sunningdale	Residential		13	5.7
G35	447896	5440317	Sunningdale	Residential		13	4.3
P890135	447551	5440368	Sunningdale	Residential		30	3.2
P890190	447370	5440451	Sunningdale	Residential		43	12.4
P890232	447718	5440365	Sunningdale	Residential		11	1.6
P890251	447560	5440377	Sunningdale	Residential		48	11.3
P890312	447758	5440763	Sunningdale	Residential		11	5.1
P910135	447329	5440490	Sunningdale	Residential		13	11.1
P910141	447726	5440722	Sunningdale	Residential		43	11.7
P950105	447886	5440039	Sunningdale	Park/Rec		13	4.2
P950106	447893	5440107	Sunningdale	Park/Rec		13	10.8
SUN_UNK[a]	447531	5440506	Sunningdale	Park/Rec		19	5.9
G47	447759	5439321	Tadanac	Park/Rec		86	27.0
G49	446921	5439733	Tadanac	Industrial		110	38.0
G50	446971	5439688	Tadanac	Industrial		40	12.0
G51	447240	5439832	Tadanac	Industrial		570	195
G52	447411	5439676	Tadanac	Industrial		425	160
G53	447652	5439397	Tadanac	Industrial		635	200
Nov97-mapID-10[a]	447272	5439926	Tadanac	Institutional	65		
Nov97-mapID-11[a]	447322	5439995	Tadanac	Residential	68		
Nov97-mapID-12[a]	447389	5440094	Tadanac	Park/Rec	103		
Nov97-mapID-5[a]	447852	5439177	Tadanac	Residential	19		
Nov97-mapID-6[a]	447907	5439188	Tadanac	Residential	17		
Nov97-mapID-7[a]	447575	5439749	Tadanac	Residential	91		
Nov97-mapID-8[a]	447648	5439786	Tadanac	Residential	39		
Nov97-mapID-9[a]	447683	5439827	Tadanac	Park/Rec	37		
P890023	447451	5439784	Tadanac	Residential		43	18.7
P890071	447327	5439804	Tadanac	Residential		140	29.8
P890085	447492	5439815	Tadanac	Residential		117	36.0
P890122	447413	5439870	Tadanac	Residential		63	30.5
P890146	447845	5439430	Tadanac	Residential		35	18.2
P890217	447704	5439548	Tadanac	Residential		105	25.0
P890293	447559	5439779	Tadanac	Residential	34	51	16.6
P890305	447277	5439848	Tadanac	Institutional		67	22.6
P890313	447697	5439416	Tadanac	Park/Rec		36	34.8
P900003	447373	5439764	Tadanac	Residential		129	32.5
P900016	447588	5439627	Tadanac	Residential	49	60	22.5
P910209	447261	5439932	Tadanac	Institutional		103	41.2
P930065	447380	5439897	Tadanac	Residential	13	17	5.9
P950062	447329	5439933	Tadanac	Residential	59	114	37.9
P980004	447548	5439657	Tadanac	Residential	38	61	21.0
TAD1	447207	5439863	Tadanac	Industrial	395	469	133
TAD2	447230	5440003	Tadanac	Institutional	10	6	8.2
TAD3	447232	5439891	Tadanac	Institutional	28	67	10.9
TAD4	447476	5439646	Tadanac	Industrial	276	344	116
TAD5	447559	5439669	Tadanac	Residential	54	54	29.4
TAD6	447790	5439201	Tadanac	Industrial	104	127	35.7

TABLE A-1. (cont.)

Property ID	UTM_X	UTM_Y	Neighbourhood	Land Use	Antimony (mg/kg)	Arsenic (mg/kg)	Cadmium (mg/kg)
G67	444804	5438109	Upper Warfield	Residential		30	4.7
G68	445014	5438029	Upper Warfield	Residential		13	1.3
G69	445078	5437963	Upper Warfield	Residential		13	4.5
P890014	445001	5437753	Upper Warfield	Residential		9	3.8
P890036	444718	5438140	Upper Warfield	Residential		3	2.0
P890038	445106	5437896	Upper Warfield	Residential		8	9.1
P890060	445016	5438048	Upper Warfield	Residential		3	0.8
P890116	444993	5437872	Upper Warfield	Residential		18	5.3
P890160	444898	5437951	Upper Warfield	Residential		11	1.6
P890234	444779	5438050	Upper Warfield	Residential		6	3.0
P890246	445087	5437747	Upper Warfield	Residential		3	1.4
P890272	444891	5437873	Upper Warfield	Residential		35	7.9
P890319	445185	5438099	Upper Warfield	Park/Rec		9	2.5
P890320	444711	5438043	Upper Warfield	Park/Rec		7	1.3
P910115	444815	5438163	Upper Warfield	Residential		13	2.6
G72	453690	5437380	Waneta	Commercial		40	3.2
G73	454502	5436914	Waneta	Residential		13	1.3
P890195	454753	5436919	Waneta	Commercial		13	6.0
P910212	454691	5436856	Waneta (Green Gables Park)	Commercial		13	3.2
P950001	455104	5436274	Waneta	Residential		3	2.7
P960001	454997	5437051	Waneta	Residential		21	4.7
WAN1	455406	5433861	Waneta	Commercial	10	22	4.2
WAN2	455570	5434894	Waneta	Park/Rec	26	29	5.0
WAN3	455666	5432688	Waneta	Agricultural	50	73	13.2
WAN4	455934	5433274	Waneta	Agricultural	10	16	8.3
WAN5	456146	5434863	Waneta	Agricultural	29	55	6.8
WAN6	456184	5432516	Waneta	Agricultural	32	49	6.5
WAN7	456292	5432953	Waneta	Agricultural	20	25	2.9
WAN8	456716	5433590	Waneta	Agricultural	10	29	5.9
G01	447911	5438259	West Trail	Industrial		35	46.0
G02	447833	5438330	West Trail	Commercial		30	11.0
G08	447766	5438042	West Trail	Residential		13	11.0
G09	447871	5438023	West Trail	Residential		13	9.0
G66	447260	5438619	West Trail	Industrial		25	9.4
Nov97-mapID-16[a]	447037	5438692	West Trail	Park/Rec	10		
Nov97-mapID-17[a]	447445	5438323	West Trail	Park/Rec	24		
Nov97-mapID-18[a]	448001	5438028	West Trail	Residential	9		
Nov97-mapID-19[a]	448435	5437679	West Trail	Park/Rec	21		
Nov97-mapID-20[a]	449193	5437599	West Trail	Park/Rec	12		
Nov97-mapID-21/22[a]	449057	5437820	West Trail	Residential	4		
P890002	448181	5438046	West Trail	Residential		45	35.0
P890043	447637	5438372	West Trail	Commercial		32	17.2
P890051	447894	5438158	West Trail	Residential		23	16.1
P890063	448049	5437730	West Trail	Residential		49	19.7
P890101	447641	5438015	West Trail	Residential		42	8.5
P890120	448262	5437867	West Trail	Residential		31	20.4
P890140	447619	5438356	West Trail	Commercial		29	26.7
P890144	447100	5438617	West Trail	Residential		21	18.1
P890167	446985	5438386	West Trail	Residential		18	4.6
P890173	447172	5438414	West Trail	Residential		36	14.0
P890176	447334	5438357	West Trail	Residential		57	29.4
P890179	448688	5437811	West Trail	Residential		57	17.9

TABLE A-1. (cont.)

Property ID	UTM_X	UTM_Y	Neighbourhood	Land Use	Antimony (mg/kg)	Arsenic (mg/kg)	Cadmium (mg/kg)
P890188	448380	5437736	West Trail	Residential		26	4.8
P890189	447959	5437943	West Trail	Residential		40	13.8
P890193	448795	5437695	West Trail	Residential		21	4.7
P890208	449083	5437733	West Trail	Residential		75	14.7
P890231	448078	5437892	West Trail	Residential		40	15.1
P890241	447589	5438138	West Trail	Residential		18	4.0
P890253	448016	5437769	West Trail	Residential		30	9.1
P890256	448478	5437800	West Trail	Residential		81	33.7
P890258	448910	5437746	West Trail	Residential		28	9.3
P890276	449112	5437696	West Trail	Residential		48	33.0
P890279	447346	5438493	West Trail	Residential		25	14.5
P890290	448597	5437861	West Trail	Residential		73	34.0
P890303	448155	5437944	West Trail	Institutional		27	4.7
P890310	447838	5438058	West Trail	Residential		17	4.7
P890311	447436	5438332	West Trail	Park/Rec		26	17.4
P890315	448629	5437725	West Trail	Residential		15	4.8
P890323	447053	5438643	West Trail	Park/Rec		12	7.2
P900068	449211	5437719	West Trail	Residential		105	44.0
P910002	447514	5438267	West Trail	Residential		60	37.3
P910008	448812	5437780	West Trail	Residential		58	29.0
P910028	448584	5437811	West Trail	Residential		135	34.0
P910044	447462	5438234	West Trail	Residential		45	29.5
P910070	448791	5437790	West Trail	Residential		190	88.0
P910072	447377	5438474	West Trail	Commercial		40	21.0
P910092	447097	5438544	West Trail	Residential		112	79.0
P910093	448116	5437666	West Trail	Park/Rec		44	26.1
P910112	447575	5438232	West Trail	Residential		75	67.0
P910116	447460	5438214	West Trail	Residential	54	57	28.1
P910132	448184	5437675	West Trail	Residential		34	14.4
P910167	448056	5437848	West Trail	Residential		13	18.0
P910174	447504	5438275	West Trail	Residential		93	44.0
P910177	447354	5438350	West Trail	Residential		75	61.0
P910187	447387	5438308	West Trail	Residential		42	22.9
P910196	448280	5437908	West Trail	Residential		98	46.3
P910205	447211	5438539	West Trail	Residential		13	11.0
P910206	447766	5438288	West Trail	Commercial		13	1.1
P910215	448844	5437815	West Trail	Residential		170	32.0
P920494	448099	5438012	West Trail	Residential	18	35	11.4
P950053	447487	5438197	West Trail	Residential	14	26	7.9
P950072	447105	5438520	West Trail	Residential	29	27	17.5
P960025	447095	5438428	West Trail	Residential	13	22	10.6
P970016	447778	5437798	West Trail	Residential	11	22	10.3
P970017	449245	5437653	West Trail	Residential	29	38	17.5
P980002	449010	5437782	West Trail	Residential	40	45	32.3

Note: All values represent an average over time at each location.
Data used to calculate the average are from sampling events in 1989 through April 1998.
All non-detects are presented as one-half the detection limit.
A blank space indicates that the analyte was not measured at this location.

Property ID assigned by Exponent for grouping purposes.

TABLE A-2. DAILY AIR CONCENTRATION DATA USED IN RISK EVALUTION

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-06	Butler Park	East Trail	449146	5438129	7/9/97		0.008	0.001	TRUE	TRUE
PA-06	Butler Park	East Trail	449146	5438129	7/15/97		0.002	0.005	TRUE	TRUE
PA-06	Butler Park	East Trail	449146	5438129	7/21/97		0.025	0.010	TRUE	TRUE
PA-06	Butler Park	East Trail	449146	5438129	7/27/97		0.019	0.014	TRUE	TRUE
PA-11	Downtown	West Trail	448370	5438096	7/1/97	0.012	0.005	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/2/97	0.025	0.005	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/3/97		0.060	0.040	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	7/4/97	0.031	0.040	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/5/97	0.003	0.040	0.040	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/6/97	0.031	0.030	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/7/97	0.012	0.005	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/8/97	0.105	0.110	0.060	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/9/97		0.010	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	7/10/97	0.012	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/11/97	0.003	0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/12/97	0.003	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/13/97	0.013	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/14/97	0.012	0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/15/97		0.005	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	7/16/97	0.031	0.050	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/17/97	0.030	0.050	0.050	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/18/97	0.025	0.040	0.050	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/19/97	0.012	0.010	0.040	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/20/97	0.012	0.005	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/21/97		0.040	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	7/22/97	0.006	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/23/97	0.037	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/24/97	0.024	0.005	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/25/97	0.030	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/26/97	0.037	0.040	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/27/97		0.060	0.030	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	7/28/97	0.048	0.040	0.040	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/29/97	0.091	0.050	0.040	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/30/97	0.025	0.040	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	7/31/97	0.136	0.100	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/1/97	0.111	0.080	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/2/97		0.050	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	8/3/97	0.018	0.060	0.040	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-11	Downtown	West Trail	448370	5438096	8/4/97	0.003	0.010	0.060	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/5/97	0.055	0.020	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/6/97	0.038	0.030	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/7/97	0.038	0.060	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/8/97		0.070	0.040	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	8/9/97	0.037	0.005	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/10/97	0.025	0.005	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/11/97	0.036	0.050	0.040	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/12/97	0.088	0.080	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/13/97	0.098	0.070	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/14/97		0.020	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	8/15/97	0.069	0.060	0.040	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/16/97	0.068	0.120	0.070	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/17/97	0.068	0.070	0.040	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/18/97	0.025	0.040	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/19/97	0.049	0.070	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/20/97		0.020	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	8/21/97	0.006	0.005	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/22/97	0.061	0.060	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/23/97	0.012	0.070	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/24/97	0.013	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/25/97	0.003	0.005	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/26/97		0.010	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	8/27/97	0.006	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/28/97	0.012	0.040	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/29/97	0.003	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/30/97	0.012	0.040	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	8/31/97	0.018	0.010	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/1/97		0.005	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	9/2/97	0.074	0.020	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/3/97	0.037	0.100	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/4/97	0.012	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/5/97	0.018	0.030	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/6/97	0.003	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/7/97		0.010	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	9/9/97	0.018	0.020	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/10/97	0.049	0.080	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/11/97	0.031	0.040	0.010	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-11	Downtown	West Trail	448370	5438096	9/12/97	0.025	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/13/97		0.005	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	9/14/97	0.037	0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/15/97	0.019	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/16/97	0.003	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/17/97	0.076	0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/18/97	0.112	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/19/97	0.135	0.030	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	9/20/97	0.025	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/21/97	0.006	0.005	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/22/97	0.044	0.020	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/23/97	0.097	0.070	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/26/97	0.003	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/27/97	0.003	0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/28/97	0.003	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/29/97	0.003	0.005	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	9/30/97	0.011	0.020	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/1/97		0.005	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	10/2/97	0.003	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/3/97	0.003	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/4/97	0.003	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/5/97	0.003	0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/6/97	0.003	0.010	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/7/97		0.005	0.050	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	10/8/97	0.003	0.005	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/9/97	0.032	0.080	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/10/97	0.003	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/11/97	0.012	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/12/97	0.003	0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/13/97		0.005	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	10/14/97	0.006	0.040	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/15/97	0.012	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/16/97	0.025	0.040	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/17/97	0.057	0.040	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/18/97	0.003	0.040	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/19/97	0.024	0.005	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	10/20/97		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/21/97		0.005	0.010	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-11	Downtown	West Trail	448370	5438096	10/22/97		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/23/97		0.030	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/24/97		0.020	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/25/97		0.005	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	10/26/97		0.020	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/27/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/28/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/29/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/30/97		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	10/31/97		0.010	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	11/1/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/2/97		0.010	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/3/97		0.020	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/4/97		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/5/97		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/6/97		0.030	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	11/7/97		0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/8/97		0.005	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/9/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/10/97		0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/11/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/12/97		0.005	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	11/13/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/14/97		0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/15/97		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/16/97		0.040	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/17/97		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/18/97		0.020	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	11/19/97		0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/20/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/21/97		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/22/97		0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/23/97		0.050	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/24/97		0.010	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	11/25/97		0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/26/97		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/27/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/28/97		0.005	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-11	Downtown	West Trail	448370	5438096	11/29/97		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	11/30/97		0.020	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	12/1/97		0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/2/97		0.050	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/3/97		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/4/97		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/5/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/6/97		0.020	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	12/7/97		0.030	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/8/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/9/97		0.040	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/10/97		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/11/97		0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/12/97		0.020	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	12/13/97		0.050	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/14/97		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/15/97		0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/16/97		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/17/97		0.020	0.050	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/18/97		0.020	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	12/19/97		0.030	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/20/97		0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/21/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/22/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/23/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/24/97		0.020	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	12/25/97		0.010	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/26/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/27/97		0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/28/97		0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/29/97		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	12/30/97		0.020	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	12/31/97		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/1/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/2/98	0.005	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/3/98	0.010	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/4/98	0.010	0.030	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/5/98	0.005	0.010	0.005	FALSE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-11	Downtown	West Trail	448370	5438096	1/6/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/7/98	0.010	0.030	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/8/98	0.005	0.070	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/9/98	0.005	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/10/98	0.040	0.050	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/11/98	0.020	0.030	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	1/12/98	0.090	0.130	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/13/98	0.030	0.030	0.080	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/14/98	0.020	0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/15/98	0.010	0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/16/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/17/98	0.020	0.020	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	1/18/98	0.005	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/19/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/20/98	0.005	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/21/98	0.010	0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/22/98	0.200	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/23/98	0.030	0.030	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	1/24/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/25/98	0.020	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/26/98		0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/27/98	0.040	0.030	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/28/98	0.020	0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/29/98	0.010	0.010	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	1/30/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	1/31/98	0.020	0.050	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/1/98	0.020	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/2/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/3/98	0.030			FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/4/98	0.005	0.010	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	2/5/98	0.030	0.080	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/6/98	0.010	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/7/98	0.005	0.040	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/8/98	0.005	0.040	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/9/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/10/98	0.005	0.090	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	2/11/98	0.005	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/12/98	0.010	0.060	0.040	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-11	Downtown	West Trail	448370	5438096	2/13/98	0.005	0.060	0.050	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/14/98	0.020	0.090	0.080	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/15/98	0.005	0.040	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/16/98	0.005	0.050	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	2/17/98	0.005	0.060	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/18/98	0.010	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/19/98	0.020	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/20/98	0.190	0.090	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/21/98	0.020	0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/22/98	0.005	0.010	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	2/23/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/24/98	0.005	0.080	0.060	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/25/98	0.020	0.070	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/26/98	0.005	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/27/98	0.010	0.050	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	2/28/98	0.020	0.020	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	3/1/98	0.010	0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/2/98	0.020	0.060	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/3/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/4/98	0.005	0.030	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/5/98	0.005	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/6/98	0.020	0.040	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	3/7/98	0.005	0.010	0.040	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/8/98	0.005	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/9/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/10/98	0.030	0.050	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/11/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/12/98	0.010	0.010	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	3/13/98	0.005	0.070	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/14/98	0.010	0.080	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/15/98	0.005	0.040	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/16/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/17/98	0.010	0.030	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/18/98	0.020	0.020	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	3/19/98	0.010	0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/20/98	0.010	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/21/98	0.010	0.020	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/22/98	0.005	0.020	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-11	Downtown	West Trail	448370	5438096	3/23/98	0.005	0.040	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/24/98	0.100	0.090	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	3/25/98	0.050	0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/26/98	0.005	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/27/98	0.005	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/28/98	0.005	0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/29/98	0.010	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	3/30/98	0.005	0.010	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	3/31/98	0.005	0.060	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/1/98	0.040	0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/2/98	0.005	0.040	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/3/98	0.010	0.080	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/4/98	0.005	0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/5/98	0.020	0.180	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	4/6/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/7/98	0.005	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/8/98	0.005	0.080	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/9/98	0.020	0.070	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/10/98	0.005	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/11/98	0.005	0.005	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	4/12/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/13/98	0.005	0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/14/98	0.005	0.005	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/15/98	0.010	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/16/98	0.010	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/17/98	0.020	0.020	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	4/18/98	0.010	0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/19/98	0.010	0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/20/98	0.010	0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/21/98	0.040	0.050	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/22/98	0.070	0.020	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/23/98	0.020	0.040	0.030	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	4/24/98	0.010	0.030	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/25/98	0.005	0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/26/98	0.030	0.060	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/27/98	0.010	0.050	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/28/98	0.020	0.030	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	4/29/98	0.010	0.030	0.005	FALSE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-11	Downtown	West Trail	448370	5438096	4/30/98	0.010	0.050	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/1/98		0.040	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/2/98		0.030	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/3/98		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/4/98		0.030	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/5/98		0.040	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	5/6/98		0.050	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/7/98		0.030	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/8/98		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/9/98		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/10/98		0.060	0.050	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/11/98		0.020	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	5/12/98		0.040	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/13/98		0.040	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/14/98		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/15/98		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/16/98		0.060	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/17/98		0.005	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	5/18/98		0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/19/98		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/20/98		0.010	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/21/98		0.010	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/22/98		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/23/98		0.005	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	5/24/98		0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/25/98		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/26/98		0.040	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/27/98		0.030	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/28/98		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/29/98		0.010	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	5/30/98		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	5/31/98				FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/1/98		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/2/98		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/3/98		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/4/98		0.040	0.010	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	6/5/98		0.005	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/6/98		0.010	0.010	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-11	Downtown	West Trail	448370	5438096	6/7/98		0.020	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/8/98		0.005	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/9/98		0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/10/98		0.020	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	6/11/98		0.020	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/12/98		0.110	0.020	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/13/98		0.090	0.030	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/14/98		0.005	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/15/98		0.005	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/16/98		0.020	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	6/17/98		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/18/98		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/19/98		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/20/98		0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/21/98		0.020	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/22/98		0.060	0.020	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	6/23/98		0.020	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/24/98		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/25/98		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/26/98		0.010	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/27/98		0.005	0.005	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/28/98		0.005	0.005	FALSE	TRUE
PA-11	Downtown	West Trail	448370	5438096	6/29/98		0.030	0.010	FALSE	FALSE
PA-11	Downtown	West Trail	448370	5438096	6/30/98		0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/1/97		0.005	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/2/97		0.005	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/3/97		0.050	0.020	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/4/97		0.020	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/5/97		0.030	0.030	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/6/97		0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/7/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/8/97		0.080	0.030	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/9/97		0.020	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/10/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/11/97		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/12/97		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/13/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/14/97		0.030	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-02	Glenmerry	Glenmerry	451147	5438242	7/15/97		0.005	0.020	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/16/97		0.110	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/17/97		0.030	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/18/97		0.050	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/19/97		0.005	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/20/97		0.005	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/21/97		0.040	0.030	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/22/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/23/97		0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/24/97		0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/25/97		0.005	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/26/97		0.060	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/27/97		0.050	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/28/97		0.020	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/29/97		0.040	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/30/97		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	7/31/97		0.060	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/1/97		0.080	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/2/97		0.070	0.020	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/3/97		0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/4/97		0.010	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/5/97		0.030	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/6/97		0.040	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/7/97		0.080	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/8/97		0.040	0.020	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/9/97		0.030	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/10/97		0.005	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/11/97		0.040	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/12/97		0.040	0.030	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/13/97		0.090	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/14/97		0.020	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/15/97		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/16/97		0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/17/97		0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/18/97		0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/19/97		0.050	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/20/97		0.030	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/21/97		0.005	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-02	Glenmerry	Glenmerry	451147	5438242	8/22/97		0.010	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/23/97		0.070	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/24/97		0.005	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/25/97		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/26/97		0.005	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/27/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/28/97		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/29/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	8/31/97		0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/1/97		0.005	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/2/97		0.040	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/3/97		0.080	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/4/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/5/97		0.050	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/6/97		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/7/97		0.040	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/8/97		0.010	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/9/97		0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/10/97		0.070	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/11/97		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/12/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/13/97		0.030	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/14/97		0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/15/97		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/16/97		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/17/97		0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/18/97		0.030	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/19/97		0.040	0.020	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/20/97		0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/21/97		0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/22/97		0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/27/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/28/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/29/97		0.005	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	9/30/97		0.030	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/1/97		0.005	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/2/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/3/97		0.005	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-02	Glenmerry	Glenmerry	451147	5438242	10/4/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/5/97		0.030	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/6/97		0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/7/97		0.010	0.030	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/8/97		0.005	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/9/97		0.070	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/10/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/11/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/12/97		0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/13/97		0.005	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/14/97		0.040	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/15/97		0.005	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/16/97		0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/17/97		0.040	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/18/97		0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/19/97		0.010	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/20/97		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/21/97		0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/22/97		0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/23/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/24/97		0.020	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/25/97		0.005	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/26/97		0.020	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/27/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/28/97				FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/29/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/30/97		0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	10/31/97		0.010	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/1/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/2/97		0.030	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/3/97		0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/4/97		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/5/97		0.020	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/6/97		0.020	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/7/97		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/8/97		0.030	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/9/97		0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/10/97		0.010	0.010	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-02	Glenmerry	Glenmerry	451147	5438242	11/11/97		0.030	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/12/97		0.010	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/13/97		0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/14/97		0.030	0.030	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/15/97		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/16/97		0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/17/97		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/18/97		0.020	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/19/97		0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/20/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/21/97		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/22/97		0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/23/97		0.070	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/24/97		0.005	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/25/97		0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/26/97		0.030	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/27/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/28/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/29/97		0.030	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	11/30/97		0.020	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/1/97		0.020	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/2/97		0.050	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/3/97		0.050	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/4/97		0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/5/97		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/6/97		0.040	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/7/97		0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/8/97		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/9/97		0.030	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/10/97		0.030	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/11/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/12/97		0.005	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/13/97		0.070	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/14/97		0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/15/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/16/97		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/17/97		0.020	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/18/97		0.010	0.005	FALSE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-02	Glenmerry	Glenmerry	451147	5438242	12/19/97		0.030	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/20/97		0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/21/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/22/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/23/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/24/97		0.040	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/25/97		0.005	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/26/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/27/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/28/97		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/29/97		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/30/97		0.070	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	12/31/97		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/1/98	0.005	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/2/98	0.005	0.010	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/3/98	0.030	0.060	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/4/98	0.030	0.090	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/5/98	0.005	0.010	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/6/98	0.005	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/7/98	0.010	0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/8/98	0.005	0.090	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/9/98	0.005	0.120	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/10/98	0.005	0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/11/98	0.020	0.030	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/12/98	0.070	0.160	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/13/98	0.020	0.020	0.040	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/14/98	0.060	0.060	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/15/98	0.005	0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/16/98	0.005	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/17/98	0.010	0.010	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/18/98	0.050	0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/19/98	0.020	0.030	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/20/98	0.005	0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/21/98	0.010	0.030	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/22/98	0.210	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/23/98	0.020	0.030	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/24/98	0.005	0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/25/98	0.030	0.010	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-02	Glenmerry	Glenmerry	451147	5438242	1/26/98		0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/27/98	0.020	0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/28/98	0.030	0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/29/98	0.030	0.040	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/30/98	0.005	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	1/31/98	0.020	0.070	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/1/98	0.060	0.040	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/2/98	0.030	0.030	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/3/98	0.040	0.060	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/4/98	0.030	0.040	0.020	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/5/98	0.030	0.090	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/6/98	0.020	0.030	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/7/98	0.005	0.050	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/8/98	0.005	0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/9/98	0.005	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/10/98	0.005	0.040	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/11/98	0.005	0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/12/98	0.010	0.060	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/13/98	0.005	0.040	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/14/98	0.020	0.070	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/15/98	0.010	0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/16/98	0.005	0.060	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/17/98	0.005	0.100	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/18/98	0.010	0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/19/98	0.005	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/20/98	0.140	0.080	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/21/98	0.110	0.070	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/22/98	0.005	0.005	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/23/98	0.005	0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/24/98	0.020	0.080	0.040	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/25/98	0.010	0.030	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/26/98	0.005	0.040	0.030	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/27/98	0.005	0.060	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	2/28/98	0.040	0.020	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/1/98	0.020	0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/2/98	0.020	0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/3/98	0.005	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/4/98	0.010	0.020	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-02	Glenmerry	Glenmerry	451147	5438242	3/5/98	0.005	0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/6/98	0.030	0.040	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/7/98	0.005	0.005	0.040	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/8/98	0.010	0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/9/98	0.005	0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/10/98	0.040	0.100	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/11/98	0.005	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/12/98	0.020	0.030	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/13/98	0.005	0.060	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/14/98	0.030	0.070	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/15/98	0.005	0.050	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/16/98	0.005	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/17/98	0.005	0.030	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/18/98	0.010	0.010	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/19/98	0.030	0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/20/98	0.020	0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/21/98	0.010	0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/22/98	0.005	0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/23/98	0.005	0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/24/98	0.005			FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/25/98	0.005			FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/26/98	0.020	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/27/98	0.040	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/28/98	0.030	0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/29/98	0.020	0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/30/98	0.020	0.030	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	3/31/98	0.010	0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/1/98	0.030	0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/2/98	0.020	0.080	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/3/98	0.020	0.360	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/4/98	0.005	0.070	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/5/98	0.005	0.610	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/6/98	0.010	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/7/98	0.020	0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/8/98	0.005	0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/9/98	0.005	0.070	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/10/98	0.005	0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/11/98	0.005	0.010	0.005	FALSE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-02	Glenmerry	Glenmerry	451147	5438242	4/12/98	0.005	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/13/98	0.005	0.030	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/14/98	0.005	0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/15/98	0.020	0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/16/98	0.005	0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/17/98	0.005	0.030	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/18/98	0.010	0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/19/98	0.020	0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/20/98	0.030	0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/21/98	0.030	0.050	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/22/98	0.005	0.060	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/23/98	0.005	0.050	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/24/98	0.020	0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/25/98	0.010	0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/26/98	0.020	0.050	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/27/98	0.010	0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/28/98	0.010	0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/29/98		0.040	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	4/30/98		0.070	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/1/98		0.050	0.030	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/2/98		0.040	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/3/98		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/4/98		0.040	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/5/98		0.060	0.030	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/6/98		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/7/98		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/8/98		0.050	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/9/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/10/98		0.040	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/11/98		0.020	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/12/98		0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/13/98		0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/14/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/15/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/16/98		0.070	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/17/98		0.005	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/18/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/19/98		0.020	0.010	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-02	Glenmerry	Glenmerry	451147	5438242	5/20/98				FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/21/98				FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/22/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/23/98		0.005	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/24/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/25/98		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/26/98		0.030	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/27/98		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/28/98		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/29/98		0.010	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/30/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	5/31/98				FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/1/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/2/98		0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/3/98		0.030	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/4/98		0.030	0.010	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/5/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/6/98		0.040	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/7/98		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/8/98		0.010	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/9/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/10/98		0.010	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/11/98		0.060	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/12/98		0.080	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/13/98		0.070	0.020	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/14/98		0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/15/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/16/98		0.005	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/17/98		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/18/98		0.030	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/19/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/20/98		0.040	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/21/98		0.020	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/22/98		0.090	0.020	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/23/98		0.030	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/24/98		0.010	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/25/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/26/98		0.005	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-02	Glenmerry	Glenmerry	451147	5438242	6/27/98		0.005	0.005	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/28/98		0.005	0.005	FALSE	TRUE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/29/98		0.020	0.010	FALSE	FALSE
PA-02	Glenmerry	Glenmerry	451147	5438242	6/30/98		0.040	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/1/97	0.015	0.005	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/2/97	0.018	0.005	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/3/97		0.020	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	7/4/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/5/97	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/6/97	0.025	0.005	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/7/97	0.027	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/8/97	0.026	0.050	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/9/97		0.020	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	7/10/97	0.008	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/11/97	0.028	0.040	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/12/97	0.012	0.005	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/13/97	0.006	0.005	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/14/97	0.016	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/15/97		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	7/16/97	0.004	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/17/97	0.007	0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/18/97	0.003	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/19/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/20/97	0.008	0.010	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/21/97		0.010	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	7/22/97	0.015	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/23/97	0.024	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/24/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/25/97	0.031	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/26/97	0.015	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/27/97		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	7/28/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/29/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/30/97	0.038	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/31/97	0.008	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/1/97	0.026	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/2/97		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	8/3/97	0.005	0.010	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-24	Oasis	Oasis	445609	5442295	8/4/97	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/5/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/6/97	0.003	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/7/97	0.008	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/8/97		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	8/9/97	0.019	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/10/97	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/11/97	0.010	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/12/97	0.004	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/13/97	0.012	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/14/97		0.040	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	8/15/97	0.006	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/16/97	0.019	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/17/97	0.004	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/19/97	0.004	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/20/97		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	8/21/97	0.023	0.030	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/22/97	0.024	0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/23/97	0.008	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/24/97	0.013	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/25/97	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/26/97		0.010	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	8/27/97	0.008	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/28/97	0.003	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/29/97	0.003	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/30/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	8/31/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/1/97		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	9/2/97	0.021	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/3/97	0.003	0.060	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/4/97	0.004	0.010	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/5/97	0.008	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/6/97	0.004	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/7/97		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	9/8/97	0.005	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/9/97	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/10/97	0.015	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/11/97	0.034	0.070	0.010	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-24	Oasis	Oasis	445609	5442295	9/12/97	0.008	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/13/97		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	9/14/97	0.019	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/15/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/16/97	0.011	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/17/97	0.003	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/18/97	0.013	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/19/97	0.018	0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	9/20/97	0.003	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/21/97	0.007	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/22/97	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/23/97	0.004	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/24/97	0.003	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/25/97		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	9/26/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/27/97	0.004	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/28/97	0.004	0.005	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/29/97	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	9/30/97	0.004	0.010	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/1/97		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	10/2/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/3/97	0.018	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/4/97	0.012	0.005	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/5/97	0.004	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/6/97	0.013	0.010	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/7/97		0.020	0.050	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	10/8/97	0.016	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/9/97	0.011	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/10/97	0.003	0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/11/97	0.013	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/12/97	0.013	0.050	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/13/97		0.010	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	10/14/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/15/97	0.004	0.005	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/16/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/17/97	0.019	0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/18/97	0.005	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/19/97		0.005	0.005	FALSE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-24	Oasis	Oasis	445609	5442295	10/20/97	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/21/97	0.004	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/22/97		0.005	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/23/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/24/97		0.005	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/25/97		0.020	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	10/26/97		0.030	0.030	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/27/97		0.020	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/28/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/29/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/30/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	10/31/97		0.020	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	11/1/97		0.020	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/2/97		0.020	0.030	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/3/97		0.060	0.040	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/4/97		0.020	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/5/97		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/6/97		0.020	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	11/7/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/8/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/9/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/10/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/11/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/12/97		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	11/13/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/14/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/15/97		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/16/97		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/17/97		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/18/97		0.040	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	11/19/97		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/20/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/21/97		0.030	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/22/97		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/23/97		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/24/97		0.010	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	11/25/97		0.030	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/26/97		0.020	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-24	Oasis	Oasis	445609	5442295	11/27/97		0.030	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/28/97		0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/29/97		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	11/30/97		0.020	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	12/1/97		0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/2/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/3/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/4/97		0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/5/97		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/6/97		0.020	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	12/7/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/8/97		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/9/97		0.050	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/10/97		0.130	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/11/97		0.100	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/12/97		0.120	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	12/13/97		0.050	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/14/97		0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/15/97				FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/16/97				FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/17/97		0.040	0.060	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/18/97		0.020	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	12/19/97		0.070	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/20/97		0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/21/97		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/22/97		0.100	0.080	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/23/97		0.060	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/24/97		0.020	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	12/25/97		0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/26/97		0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/27/97		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/28/97		0.030	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/29/97		0.040	0.030	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	12/30/97		0.170	0.020	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	12/31/97		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/1/98	0.005	0.010	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/2/98	0.010	0.010	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/3/98	0.005	0.005	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-24	Oasis	Oasis	445609	5442295	1/4/98	0.020	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/5/98	0.050	0.050	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	1/6/98	0.005	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/7/98	0.040	0.050	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/8/98	0.005	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/9/98	0.005	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/10/98	0.005	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/11/98	0.020	0.050	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	1/12/98	0.020	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/13/98	0.030	0.040	0.070	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/14/98	0.005	0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/15/98	0.070	0.070	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/16/98	0.090	0.070	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/17/98	0.080	0.050	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	1/18/98	0.010	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/19/98	0.010	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/20/98	0.040	0.070	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/21/98	0.030	0.060	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/22/98	0.330	0.300	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/23/98	0.005	0.040	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	1/24/98	0.020	0.040	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/25/98	0.060	0.030	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/26/98		0.050	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/27/98	0.050	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/28/98	0.005	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/29/98	0.005	0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	1/30/98	0.020	0.040	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	1/31/98	0.005	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/1/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/2/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/3/98	0.005	0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/4/98	0.005	0.020	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	2/5/98	0.040	0.080	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/6/98	0.005	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/7/98	0.005	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/8/98	0.005	0.050	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/9/98	0.005	0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/10/98	0.005	0.060	0.005	FALSE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-24	Oasis	Oasis	445609	5442295	2/11/98	0.030	0.080	0.040	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/12/98	0.005	0.070	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/13/98	0.010	0.060	0.030	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/14/98	0.040	0.100	0.040	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/15/98	0.020	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/16/98	0.005	0.050	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	2/17/98	0.005	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/18/98	0.005	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/19/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/20/98	0.020	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/21/98	0.020	0.040	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/22/98	0.020	0.030	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	2/23/98	0.020	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/24/98	0.005	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/25/98	0.005	0.040	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/26/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/27/98	0.020	0.070	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	2/28/98	0.010	0.010	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	3/1/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/2/98	0.005	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/3/98	0.020	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/4/98	0.080	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/5/98	0.005	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/6/98	0.010	0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	3/7/98	0.020	0.020	0.030	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/8/98	0.010	0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/9/98	0.020	0.030	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/10/98	0.040	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/11/98	0.010	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/12/98	0.005	0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	3/13/98	0.005	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/14/98	0.005	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/15/98	0.010	0.050	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/16/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/17/98	0.005	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/18/98	0.010	0.020	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	3/19/98	0.005	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/20/98	0.005	0.010	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-24	Oasis	Oasis	445609	5442295	3/21/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/22/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/23/98	0.005	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/24/98	0.030	0.040	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	3/25/98	0.040	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/26/98	0.010	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/27/98	0.030	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/28/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/29/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	3/30/98	0.010	0.040	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	3/31/98	0.010	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/1/98	0.005	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/2/98	0.005	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/3/98	0.005	0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/4/98	0.005	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/5/98	0.005	0.070	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	4/6/98	0.010	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/7/98	0.010	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/8/98	0.010	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/9/98	0.005	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/10/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/11/98	0.005	0.020	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	4/12/98	0.005	0.040	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/13/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/14/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/15/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/16/98	0.005	0.010	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/17/98	0.005	0.030	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	4/18/98	0.005	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/19/98	0.005	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/20/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/21/98	0.005	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/22/98	0.050	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/23/98	0.005	0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	4/24/98	0.005	0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/25/98	0.005	0.030	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/26/98	0.010	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/27/98	0.005	0.010	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-24	Oasis	Oasis	445609	5442295	4/28/98	0.005	0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	4/29/98	0.005	0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	4/30/98	0.005	0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/1/98		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/2/98		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/3/98		0.020	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/4/98		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/5/98		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	5/6/98		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/7/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/8/98		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/9/98		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/10/98		0.040	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/11/98		0.010	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	5/12/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/13/98		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/14/98		0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/15/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/16/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/17/98		0.030	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	5/18/98		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/19/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/20/98		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/21/98		0.010	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/22/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/23/98		0.070	0.010	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	5/24/98		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/25/98		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/26/98		0.050	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/27/98		0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/28/98		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/29/98		0.005	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	5/30/98		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	5/31/98				FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/1/98		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/2/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/3/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/4/98		0.070	0.005	FALSE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-24	Oasis	Oasis	445609	5442295	6/5/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/6/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/7/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/8/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/9/98		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/10/98		0.010	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	6/11/98		0.030	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/12/98		0.060	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/13/98		0.050	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/14/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/15/98		0.010	0.020	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/16/98		0.020	0.020	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	6/17/98		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/18/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/19/98		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/20/98		0.060	0.010	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/21/98		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/22/98		0.010	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	6/23/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/24/98		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/25/98		0.030	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/26/98		0.020	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/27/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/28/98		0.020	0.005	FALSE	TRUE
PA-24	Oasis	Oasis	445609	5442295	6/29/98		0.010	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	6/30/98		0.005	0.005	FALSE	FALSE
PA-24	Oasis	Oasis	445609	5442295	7/9/97		0.005	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	7/15/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	7/21/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	7/27/97		0.020	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	8/2/97		0.010	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	8/8/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	8/14/97		0.020	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	8/20/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	8/26/97		0.010	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	9/1/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	9/7/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	9/13/97		0.005	0.005	TRUE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-24	Oasis	Oasis	445609	5442295	9/19/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	9/25/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	10/1/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	10/7/97		0.040	0.040	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	10/13/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	10/19/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	10/25/97		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	10/31/97		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	11/6/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	11/12/97		0.005	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	11/18/97		0.020	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	11/24/97		0.020	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	11/30/97		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	12/6/97		0.020	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	12/12/97		0.110	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	12/18/97				TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	12/24/97		0.010	0.005	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	12/30/97		0.150	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	1/5/98		0.040	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	1/11/98		0.050	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	1/17/98		0.050	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	1/23/98		0.070	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	1/29/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	2/4/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	2/10/98		0.050	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	2/16/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	2/22/98		0.030	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	2/28/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	3/6/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	3/12/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	3/18/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	3/24/98		0.090	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	3/30/98		0.050	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	4/5/98		0.060	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	4/11/98		0.020	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	4/17/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	4/23/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	4/29/98		0.040	0.010	TRUE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-24	Oasis	Oasis	445609	5442295	5/5/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	5/11/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	5/17/98				TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	5/23/98		0.070	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	5/29/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	6/4/98		0.070	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	6/10/98		0.040	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	6/16/98		0.030	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	6/22/98		0.010	0.010	TRUE	TRUE
PA-24	Oasis	Oasis	445609	5442295	6/28/98		0.010	0.010	TRUE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	7/3/97		0.060	0.020	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	7/9/97		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	7/15/97		0.005	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	7/21/97		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	7/27/97		0.020	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	8/2/97		0.010	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	8/8/97		0.020	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	8/14/97		0.020	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	8/20/97		0.010	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	8/26/97		0.010	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	9/1/97		0.005	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	9/7/97		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	9/13/97		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	9/19/97		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	9/25/97		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	10/1/97		0.005	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	10/7/97		0.010	0.050	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	10/13/97		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	10/19/97		0.020	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	10/25/97		0.010	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	10/31/97		0.020	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	11/6/97		0.010	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	11/12/97		0.020	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	11/18/97		0.020	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	11/24/97		0.030	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	11/30/97		0.005	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	12/6/97		0.020	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	12/12/97		0.070	0.010	FALSE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-15	Warfield subst.	Upper Warfield	445640	5438199	12/18/97				FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	12/24/97		0.010	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	12/30/97		0.030	0.020	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	1/5/98		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	1/11/98		0.020	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	1/17/98		0.020	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	1/23/98		0.040	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	1/29/98		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	2/4/98		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	2/10/98		0.020	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	2/16/98		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	2/22/98		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	2/28/98		0.010	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	3/6/98		0.020	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	3/12/98		0.010	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	3/18/98		0.010	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	3/24/98		0.020	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	3/30/98		0.040	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	4/5/98		0.140	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	4/11/98		0.010	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	4/17/98		0.010	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	4/23/98		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	4/29/98		0.050	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	5/5/98		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	5/11/98		0.010	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	5/17/98		0.020	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	5/23/98		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	5/29/98		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	6/4/98		0.050	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	6/10/98		0.020	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	6/16/98		0.030	0.010	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	6/22/98		0.005	0.005	FALSE	TRUE
PA-15	Warfield subst.	Upper Warfield	445640	5438199	6/28/98		0.010	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			7/1/97		0.005	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			7/2/97		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			7/3/97		0.050	0.030	FALSE	TRUE
PA-56	West Trail	West Trail			7/4/97		0.060	0.030	FALSE	FALSE
PA-56	West Trail	West Trail			7/5/97		0.010	0.030	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-56	West Trail	West Trail			7/6/97		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			7/7/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			7/8/97		0.090	0.040	FALSE	FALSE
PA-56	West Trail	West Trail			7/9/97		0.010	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			7/10/97		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			7/11/97		0.030	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			7/12/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			7/13/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			7/14/97		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			7/15/97		0.005	0.020	FALSE	TRUE
PA-56	West Trail	West Trail			7/16/97		0.050	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			7/17/97		0.020	0.030	FALSE	FALSE
PA-56	West Trail	West Trail			7/18/97		0.050	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			7/19/97		0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			7/20/97		0.005	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			7/21/97		0.020	0.020	FALSE	TRUE
PA-56	West Trail	West Trail			7/22/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			7/23/97		0.030	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			7/24/97		0.005	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			7/25/97		0.010	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			7/26/97		0.040	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			7/27/97		0.060	0.020	FALSE	TRUE
PA-56	West Trail	West Trail			7/28/97		0.020	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			7/29/97		0.060	0.030	FALSE	FALSE
PA-56	West Trail	West Trail			7/30/97		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			7/31/97		0.080	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			8/1/97		0.070	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			8/2/97		0.060	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			8/3/97		0.040	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			8/4/97		0.005	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			8/5/97		0.040	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			8/6/97		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			8/7/97		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			8/8/97		0.040	0.020	FALSE	TRUE
PA-56	West Trail	West Trail			8/9/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			8/10/97		0.005	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			8/13/97		0.090	0.030	FALSE	FALSE
PA-56	West Trail	West Trail			8/14/97		0.020	0.010	FALSE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-56	West Trail	West Trail			8/15/97		0.050	0.030	FALSE	FALSE
PA-56	West Trail	West Trail			8/16/97		0.040	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			8/17/97		0.050	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			8/18/97		0.040	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			8/19/97		0.050	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			8/20/97		0.010	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			8/21/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			8/22/97		0.020	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			8/23/97		0.080	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			8/24/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			8/25/97		0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			8/26/97		0.020	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			8/27/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			8/28/97		0.030	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			8/29/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			8/30/97		0.040	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			8/31/97		0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			9/1/97		0.005	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			9/2/97		0.010	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			9/3/97		0.090	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			9/4/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			9/5/97		0.010	0.030	FALSE	FALSE
PA-56	West Trail	West Trail			9/6/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			9/7/97		0.005	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			9/10/97		0.090	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			9/11/97		0.030	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			9/12/97		0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			9/13/97		0.020	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			9/14/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			9/15/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			9/16/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			9/17/97		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			9/18/97		0.030	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			9/19/97		0.020	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			9/20/97		0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			9/21/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			9/22/97		0.005	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			9/23/97		0.060	0.010	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-56	West Trail	West Trail			9/24/97		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			9/25/97		0.005	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			9/26/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			9/27/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			9/28/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			9/29/97		0.005	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			9/30/97		0.020	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			10/1/97		0.005	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			10/2/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			10/3/97		0.005	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			10/4/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			10/5/97		0.030	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			10/6/97		0.005	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			10/7/97		0.010	0.080	FALSE	TRUE
PA-56	West Trail	West Trail			10/8/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			10/9/97		0.040	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			10/10/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			10/11/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			10/12/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			10/13/97		0.005	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			10/14/97		0.040	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			10/15/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			10/16/97		0.005	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			10/17/97		0.040	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			10/18/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			10/19/97		0.010	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			10/20/97				FALSE	FALSE
PA-56	West Trail	West Trail			10/21/97				FALSE	FALSE
PA-56	West Trail	West Trail			10/22/97		0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			10/23/97		0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			10/24/97		0.030	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			10/25/97		0.010	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			10/26/97		0.020	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			10/27/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			10/28/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			10/29/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			10/30/97		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			10/31/97		0.020	0.005	FALSE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-56	West Trail	West Trail			11/1/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/2/97		0.030	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			11/3/97		0.040	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			11/4/97		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			11/5/97		0.030	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			11/6/97		0.020	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			11/7/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/8/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/9/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/10/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/11/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/12/97				FALSE	TRUE
PA-56	West Trail	West Trail			11/13/97				FALSE	FALSE
PA-56	West Trail	West Trail			11/14/97				FALSE	FALSE
PA-56	West Trail	West Trail			11/15/97				FALSE	FALSE
PA-56	West Trail	West Trail			11/16/97		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			11/17/97		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/18/97		0.020	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			11/19/97		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/20/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/21/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/22/97		0.010	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			11/23/97		0.080	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			11/24/97		0.005	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			11/25/97		0.030	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/26/97		0.010	0.030	FALSE	FALSE
PA-56	West Trail	West Trail			11/27/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/28/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/29/97		0.030	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			11/30/97		0.010	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			12/1/97		0.010	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			12/2/97		0.090	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			12/3/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/4/97		0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			12/5/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/6/97		0.020	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			12/7/97		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/8/97		0.005	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-56	West Trail	West Trail			12/9/97		0.030	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			12/10/97		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/11/97		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/12/97		0.020	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			12/13/97		0.060	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/14/97		0.040	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/15/97		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/16/97		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/17/97		0.020	0.040	FALSE	FALSE
PA-56	West Trail	West Trail			12/18/97		0.020	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			12/19/97		0.040	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/20/97		0.030	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			12/21/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/22/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/23/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/24/97		0.020	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			12/25/97		0.005	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			12/26/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/27/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/28/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/29/97		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			12/30/97		0.070	0.020	FALSE	TRUE
PA-56	West Trail	West Trail			12/31/97		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/1/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/2/98	0.005	0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			1/3/98	0.005	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/4/98	0.010	0.030	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/5/98	0.005	0.010	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			1/6/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/7/98	0.005	0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/8/98	0.005	0.070	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			1/9/98	0.005	0.040	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/10/98	0.005	0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			1/11/98	0.010	0.010	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			1/12/98	0.100	0.130	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			1/13/98	0.020	0.030	0.120	FALSE	FALSE
PA-56	West Trail	West Trail			1/14/98	0.020	0.030	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			1/15/98	0.005	0.020	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-56	West Trail	West Trail			1/16/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/17/98	0.010	0.020	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			1/18/98	0.005	0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/19/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/20/98	0.005	0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			1/21/98	0.010	0.040	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			1/22/98	0.220	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/23/98	0.030	0.030	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			1/24/98	0.005	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/25/98	0.020	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/26/98		0.080	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			1/27/98	0.050	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/28/98	0.020	0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/29/98	0.005	0.005	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			1/30/98	0.005	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			1/31/98	0.005	0.040	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			2/1/98	0.020	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/2/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/3/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/4/98	0.005	0.005	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			2/5/98	0.040	0.100	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			2/6/98	0.010	0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/7/98	0.005	0.030	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/8/98	0.005	0.040	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/9/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/10/98	0.005	0.070	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			2/11/98	0.005	0.040	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/12/98	0.020	0.060	0.040	FALSE	FALSE
PA-56	West Trail	West Trail			2/13/98	0.005	0.060	0.060	FALSE	FALSE
PA-56	West Trail	West Trail			2/14/98	0.020	0.070	0.040	FALSE	FALSE
PA-56	West Trail	West Trail			2/15/98	0.010	0.030	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/16/98	0.005	0.040	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			2/17/98	0.005	0.040	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/18/98	0.010	0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/19/98	0.005	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/20/98	0.140	0.080	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			2/21/98	0.020	0.030	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/22/98	0.005	0.005	0.005	FALSE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-56	West Trail	West Trail			2/23/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			2/24/98	0.020	0.110	0.130	FALSE	FALSE
PA-56	West Trail	West Trail			2/25/98	0.010	0.070	0.050	FALSE	FALSE
PA-56	West Trail	West Trail			2/26/98	0.020	0.040	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			2/27/98	0.010	0.060	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			2/28/98	0.030	0.030	0.030	FALSE	TRUE
PA-56	West Trail	West Trail			3/1/98	0.020	0.030	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/2/98	0.040	0.060	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/3/98	0.010	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/4/98	0.005	0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/5/98	0.005	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/6/98	0.020	0.040	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			3/7/98	0.005	0.020	0.100	FALSE	FALSE
PA-56	West Trail	West Trail			3/8/98	0.005	0.030	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			3/9/98	0.005	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/10/98	0.030	0.090	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			3/11/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/12/98	0.005	0.010	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			3/13/98	0.005	0.070	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/14/98	0.005	0.070	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			3/15/98	0.005	0.070	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			3/16/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/17/98	0.005	0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			3/18/98	0.010	0.010	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			3/19/98	0.010	0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			3/20/98	0.010	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/21/98	0.010	0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			3/22/98	0.010	0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/23/98	0.005	0.030	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			3/24/98	0.070	0.090	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			3/25/98	0.050	0.030	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			3/26/98	0.010	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/27/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/28/98	0.005	0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/29/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			3/30/98	0.005	0.020	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			3/31/98	0.005	0.050	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			4/1/98	0.020	0.010	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-56	West Trail	West Trail			4/2/98	0.010	0.040	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			4/3/98	0.010	0.120	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/4/98	0.010	0.040	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			4/5/98	0.020	0.190	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			4/6/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/7/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/8/98	0.005	0.080	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/9/98	0.010	0.060	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			4/10/98	0.005	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/11/98	0.005	0.010	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			4/12/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/13/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/14/98	0.005	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/15/98	0.005	0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/16/98	0.005	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/17/98	0.020	0.030	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			4/18/98	0.005	0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			4/19/98	0.010	0.030	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			4/20/98	0.010	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/21/98	0.020	0.030	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/22/98	0.010	0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/23/98	0.005	0.020	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			4/24/98	0.005	0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/25/98	0.005	0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			4/26/98	0.020	0.040	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			4/27/98	0.010	0.040	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			4/28/98	0.020	0.030	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			4/29/98	0.010	0.030	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			4/30/98	0.005	0.040	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/1/98		0.040	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			5/2/98		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			5/3/98		0.030	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			5/4/98		0.020	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			5/5/98		0.040	0.020	FALSE	TRUE
PA-56	West Trail	West Trail			5/6/98		0.060	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			5/7/98		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/8/98		0.030	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			5/9/98		0.005	0.005	FALSE	FALSE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-56	West Trail	West Trail			5/10/98		0.060	0.030	FALSE	FALSE
PA-56	West Trail	West Trail			5/11/98		0.020	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			5/12/98		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			5/13/98		0.040	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			5/14/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/15/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/16/98		0.070	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/17/98		0.005	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			5/18/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/19/98		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/20/98		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/21/98		0.005	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			5/22/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/23/98		0.005	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			5/24/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/25/98		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/26/98		0.040	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/27/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/28/98		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/29/98		0.005	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			5/30/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			5/31/98				FALSE	FALSE
PA-56	West Trail	West Trail			6/1/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/2/98		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/3/98		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			6/4/98		0.030	0.010	FALSE	TRUE
PA-56	West Trail	West Trail			6/5/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/6/98		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/7/98		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/8/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/9/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/10/98		0.005	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			6/11/98		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			6/12/98		0.100	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			6/13/98		0.050	0.020	FALSE	FALSE
PA-56	West Trail	West Trail			6/14/98		0.030	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			6/15/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/16/98		0.020	0.005	FALSE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony ($\mu g/m^3$)	Arsenic ($\mu g/m^3$)	Cadmium ($\mu g/m^3$)	PM10[a]	NAPS[b]
PA-56	West Trail	West Trail			6/17/98		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/18/98		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/19/98		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/20/98		0.020	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/21/98		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			6/22/98		0.030	0.020	FALSE	TRUE
PA-56	West Trail	West Trail			6/23/98		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/24/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/25/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/26/98		0.010	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/27/98		0.005	0.005	FALSE	FALSE
PA-56	West Trail	West Trail			6/28/98		0.005	0.005	FALSE	TRUE
PA-56	West Trail	West Trail			6/29/98		0.020	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			6/30/98		0.010	0.010	FALSE	FALSE
PA-56	West Trail	West Trail			1/5/98	0.006	0.006	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			1/11/98	0.012	0.012	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			1/17/98	0.025	0.031	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			1/23/98	0.012	0.049	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			1/29/98	0.006	0.006	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			2/4/98	0.006	0.006	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			2/10/98	0.012	0.061	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			2/16/98	0.012	0.061	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			2/22/98	0.006	0.006	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			2/28/98	0.031	0.031	0.018	TRUE	TRUE
PA-56	West Trail	West Trail			3/6/98	0.018	0.025	0.012	TRUE	TRUE
PA-56	West Trail	West Trail			3/12/98	0.006	0.012	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			3/18/98	0.006	0.012	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			3/24/98	0.055	0.043	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			3/30/98	0.018	0.025	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			4/5/98	0.018	0.184	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			4/11/98	0.006	0.006	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			4/17/98	0.018	0.031	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			4/23/98	0.006	0.018	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			4/29/98	0.012	0.049	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			5/5/98	0.012	0.025	0.012	TRUE	TRUE
PA-56	West Trail	West Trail			5/11/98	0.037	0.025	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			5/17/98	0.006	0.012	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			5/23/98	0.006	0.006	0.006	TRUE	TRUE

TABLE A-2. (cont.)

TLP_NO	Name	Neighbourhood	P_X	P_Y	Date	Antimony (μg/m^3)	Arsenic (μg/m^3)	Cadmium (μg/m^3)	PM10[a]	NAPS[b]
PA-56	West Trail	West Trail			5/29/98	0.006	0.006	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			6/4/98	0.031	0.037	0.012	TRUE	TRUE
PA-56	West Trail	West Trail			6/10/98	0.006	0.025	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			6/16/98	0.006	0.031	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			6/22/98	0.012	0.025	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			6/28/98	0.025	0.006	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			7/4/98	0.012	0.006	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			7/10/98	0.018	0.025	0.012	TRUE	TRUE
PA-56	West Trail	West Trail			7/16/98	0.006	0.006	0.006	TRUE	TRUE
PA-56	West Trail	West Trail			7/22/98	0.006	0.006	0.012	TRUE	TRUE

Note: All non-detects are presented as one-half the detection limit.

[a] If the value in this column is "true," then the associated results are for PM_{10} particles. If the value is "false," then the associated results are for TSP particles.

[b] If the value in this column is "true," then the associated date is a National Air Pollution Surveillance date.

TABLE A-3. QUARTERLY AIR MONITORING DATA USED IN RISK EVALUATION: COLUMBIA GARDENS

(All units µg/SM³, unless otherwise noted)

Parameter		19-Sep-97 TSP		18-Dec-97 TSP		16-Feb-98 TSP
TSP		21.6		10.4		3.7
Aluminum		0.14		0.02		0.24
Antimony	<	0.01	<	0.01	<	0.01
Arsenic		0.02	<	0.01	<	0.01
Barium		0.01	<	0.01		0.01
Bismuth	<	0.01	<	0.01	<	0.01
Cadmium	<	0.01	<	0.01		0.02
Calcium		0.25	<	0.01		0.43
Chromium	<	0.01	<	0.01	<	0.01
Cobalt	<	0.01	<	0.01	<	0.01
Copper		0.03		0.02		0.03
Gallium	<	0.01	<	0.01	<	0.01
Indium	<	0.01	<	0.01	<	0.01
Iron		0.38		0.10		0.84
Lead		0.29		0.05		0.39
Lithium	<	0.01	<	0.01	<	0.01
Magnesium		0.07	<	0.01		0.20
Manganese		0.02	<	0.01		0.02
Mercury	<	0.001	<	0.001	<	0.001
Molybdenum	<	0.01	<	0.01	<	0.01
Nickel	<	0.01	<	0.01	<	0.01
Phosphorus		0.08	<	0.01		0.03
Potassium	<	0.01	<	0.01	<	0.01
Selenium			<	0.01	<	0.01
Silica	<	0.01	<	0.01	<	0.01
Silver	<	0.01	<	0.01	<	0.01
Sodium		1.88		1.23		1.86
Sulfur		1.88		0.09		2.75
Tellurium	<	0.01		0.02	<	0.01
Thallium	<	0.01	<	0.01	<	0.01
Tin	<	0.01	<	0.01	<	0.01
Zinc		0.81		0.36		2.48
Volume (SM³)		1597.7		1628.3		1610.0

Appendix B

Statistics

EIGENVALUES OF UNIT SCALED X'X

	1	2
	1.968	0.032

CONDITION INDICES

	1	2
	1.000	7.822

VARIANCE PROPORTIONS

	1	2
CONSTANT	0.016	0.984
LNAS	0.016	0.984

DEP VAR: LNSB N: 20 MULTIPLE R: 0.947 SQUARED MULTIPLE R: 0.896
ADJUSTED SQUARED MULTIPLE R: .890 STANDARD ERROR OF ESTIMATE: 0.350

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-0.189	0.311	0.000	.	-0.606	0.552
LNAS	0.964	0.077	0.947	1.000	12.450	0.000

CORRELATION MATRIX OF REGRESSION COEFFICIENTS

	CONSTANT	LNAS
CONSTANT	1.000	
LNAS	-0.968	1.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	18.979	1	18.979	155.007	0.000
RESIDUAL	2.204	18	0.122		

WARNING: CASE 1 IS AN OUTLIER (STUDENTIZED RESIDUAL = 3.240)

DURBIN-WATSON D STATISTIC 1.714
FIRST ORDER AUTOCORRELATION -.010

Drop 1st case - outlier

EIGENVALUES OF UNIT SCALED X'X

	1	2
	1.975	0.025

CONDITION INDICES

	1	2
	1.000	8.909

VARIANCE PROPORTIONS

	1	2

CONSTANT	0.012	0.988
LNAS	0.012	0.988

DEP VAR: LNSB N: 19 MULTIPLE R: 0.964 SQUARED MULTIPLE R: 0.930
ADJUSTED SQUARED MULTIPLE R: .926 STANDARD ERROR OF ESTIMATE: 0.283

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-0.675	0.293	0.000	.	-2.303	0.034
LNAS	1.075	0.071	0.964	1.000	15.052	0.000

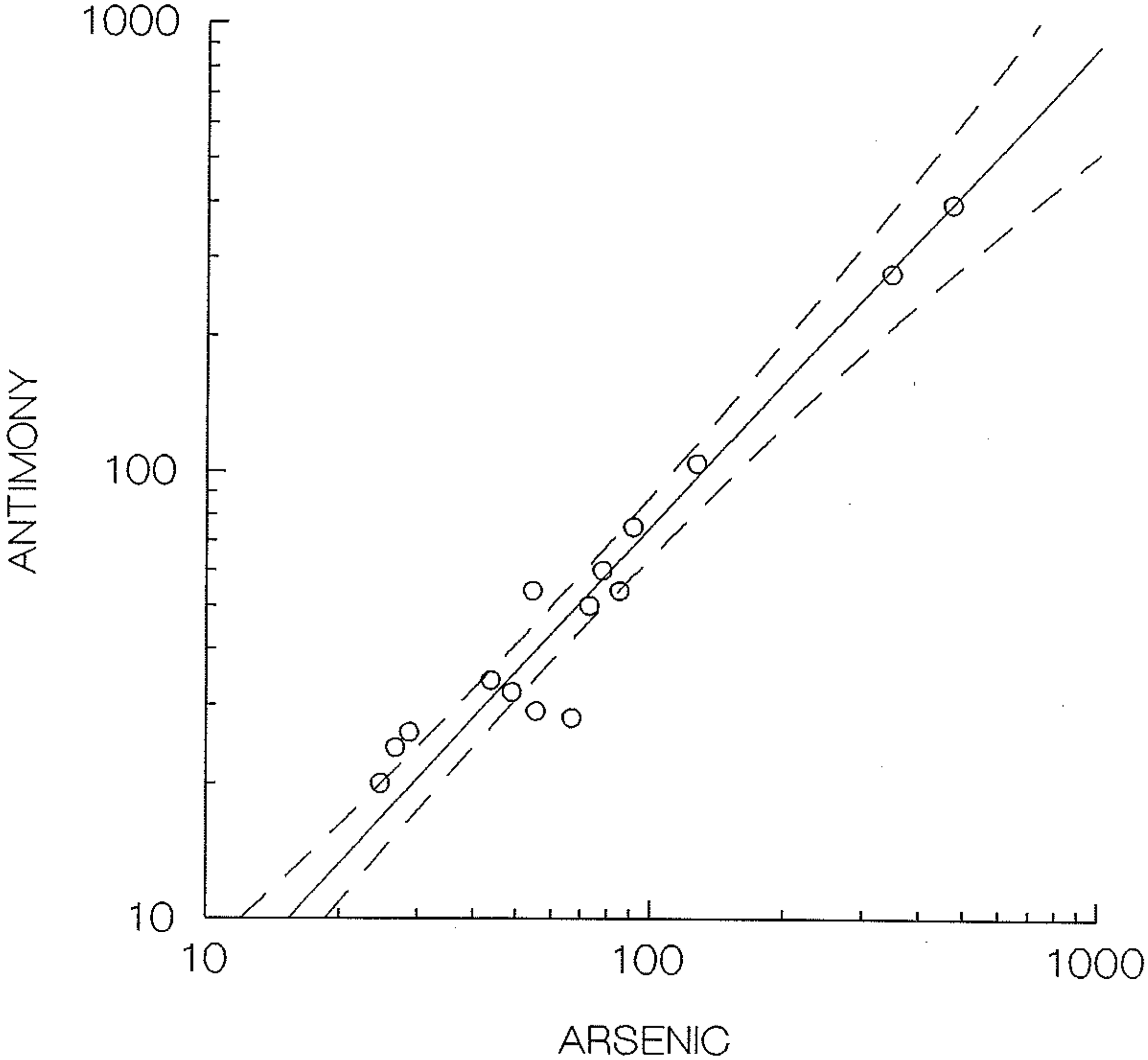
CORRELATION MATRIX OF REGRESSION COEFFICIENTS

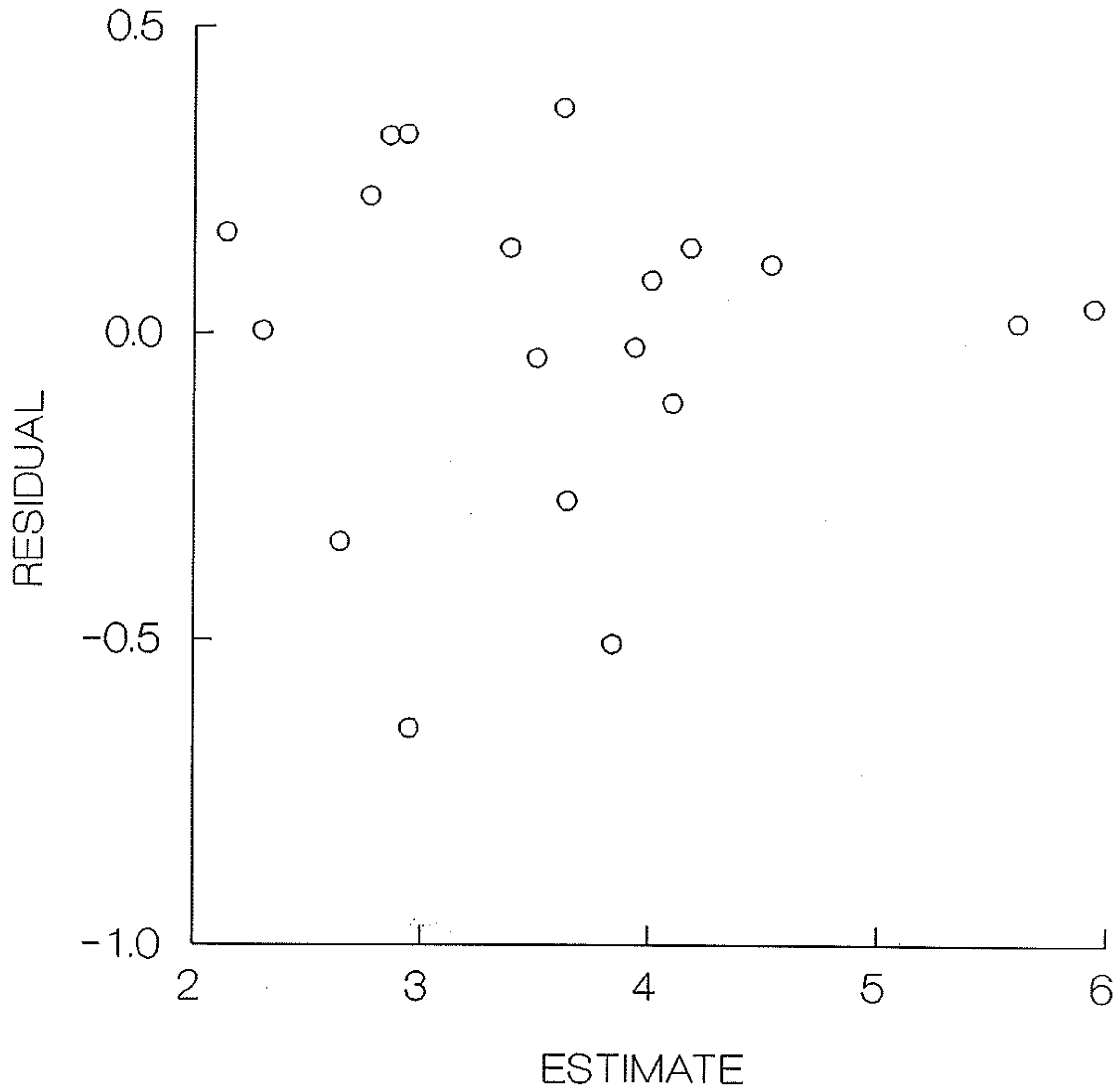
	CONSTANT	LNAS
CONSTANT	1.000	
LNAS	-0.975	1.000

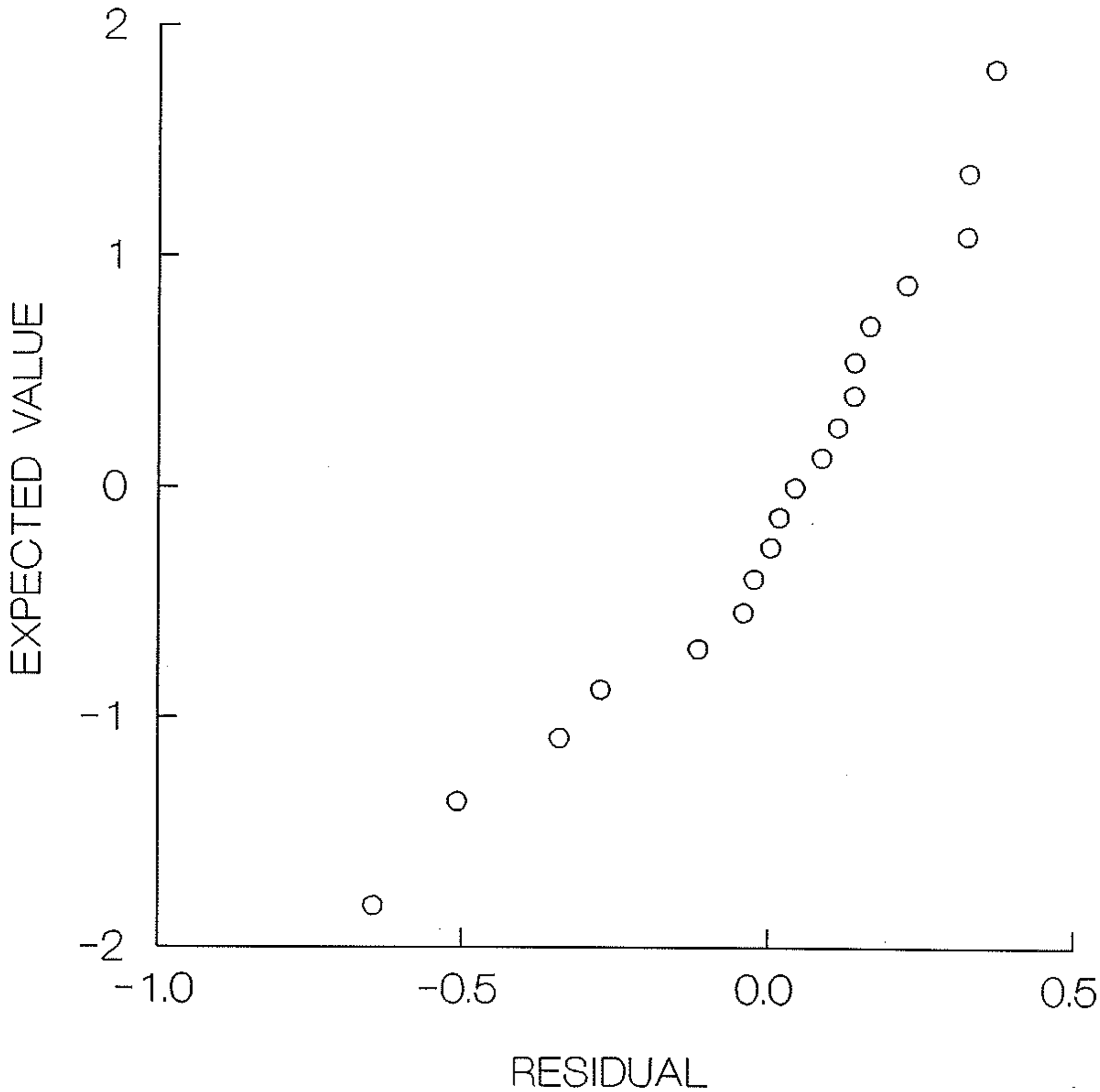
ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	18.159	1	18.159	226.551	0.000
RESIDUAL	1.363	17	0.080		

DURBIN-WATSON D STATISTIC 2.242
FIRST ORDER AUTOCORRELATION -.131


ANTIMONY
1000
100
10
10
100
1000
ARSENIC


0.5
0.0
-0.5
-1.0
RESIDUAL
2
3
4
5
6
ESTIMATE


EXPECTED VALUE
2
1
0
−1
−2
−1.0
−0.5
0.0
0.5
RESIDUAL

Appendix C

Technical Memorandum 2.1

Exponent™

Technical Memorandum 2.1

Prepared for

Trail Lead Program
300-843 Rossland Avenue
Trail, British Columbia
VIR 4S8

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Exponent
4940 Pearl East Circle
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July 1998

QA ID No.: 8600BB5.001 0101 0798 RN 47

CONTENTS

INTRODUCTION

In previous recommendations regarding risk assessment of non-lead constituents in Trail, British Columbia (PTI 1997a), several strategic considerations were identified that could potentially affect methodological approaches and risk estimates for risk assessments conducted for the Trail community. This technical memorandum is the first of a series that will address these strategic considerations in sufficient detail that they might be incorporated into screening-level risk calculations for Trail. This memorandum addresses four technical issues.

Task 1 addresses technical issues associated with toxicological evaluation of exposure to cadmium. Specifically, we provide information regarding the derivation of the current oral tolerable daily intake (TDI) for cadmium, and then use information from the literature and regulatory agencies to make appropriate adjustments to this toxicity criterion for application at Trail. Of particular concern regarding this issue is the determination of background exposures to cadmium from diet and other sources, so that an appropriate assessment of the potential health impacts from exposure to this metal in soils can be made.

Task 2 addresses the magnitude of human exposures to arsenic from background sources such as air, food, water, cigarette smoke, and background soil arsenic concentrations. The application of this information in further risk assessment for the site is different than the information for cadmium described in Task 1. For arsenic, risk-based soil screening levels can fall well below background concentrations of arsenic in soil. To understand the public health significance of soil-related exposures, and the potential benefits of remedial actions, it is important to understand the magnitude of exposures to arsenic from soil in relation to background exposures from all sources.

Task 3 addresses the specific issue of the potential for human exposure to arsenic and cadmium via the ingestion of homegrown produce. This memorandum provides a literature-based screening of the potential for exposure via this route, relative to potential exposures from soil. This screening procedure will indicate whether a need exists for sampling and analyzing garden produce from Trail.

Finally, Task 4 describes the findings of *in vitro* studies of the relative bioavailability of arsenic and cadmium in Trail soil samples. These data are used to derive relative absorption factors, which are used to adjust exposure estimates to account for differences in the bioavailability of different forms of arsenic and cadmium.

TASK 1. ADJUST REFERENCE DOSE FOR CADMIUM

The critical toxic effect for ingested cadmium is kidney toxicity. Cadmium naturally present in the diet and in cigarette smoke accumulates in the kidney, with concentrations typically increasing until about 50 years of age. Toxicity occurs if excess exposure to cadmium causes the kidney concentration to increase above a critical level. In this task, a methodology developed for application at Bartlesville, Oklahoma, is used to derive a tolerable daily intake (TDI) for cadmium that accounts for background exposures in determining risks associated with incremental cadmium exposures above background in Trail. This approach considers background exposures from food, drinking water, air, and smoking. Separate estimates of TDI levels have been developed for nonsmokers and smokers.

BC Environment's residential soil matrix standards for threshold (i.e., noncarcinogenic) substances are derived by assigning an "allowable" portion of the tolerable daily intake (TDI) to soil exposures (BC Environment 1996a). This procedure is consistent with the procedures from the Canadian Council for Ministries of the Environment (CCME) national soil quality criteria protocol, which call for adjusting the TDI by subtracting the estimated daily intake (EDI) for each substance.. Due to a general absence of reliable EDI estimates for most substances, BC Environment elected to allot 20 percent of the total TDI to soil exposures. For threshold substances, the standards are also based on soil ingestion rates for young children, although it is noted that for some specific chemicals, different receptors and age classes may be appropriate. For cadmium, soil matrix standards were adjusted based on the results of clinical studies, rather than strictly adhering to this procedure (BC Environment 1996b).

As described in our recommendations for human health risk assessment for Trail (PTI 1997a), evaluation of cadmium exposures presents some unique issues that require reevaluation of both EDI and the age classes of receptors for whom exposure estimates are quantified.

BASIS FOR CADMIUM TOXICITY VALUES

When toxicity values for human health risk assessment are not available from BC Environment or other Canadian agencies, BC Environment allows the use of toxicity values derived by other countries, including the United States. Toxicity values for calculating safe intake levels of cadmium are available from two U.S. agencies: the U.S. Environmental Protection Agency (EPA) and the Agency for Toxic Substances and Disease Registry (ATSDR) (U.S. EPA 1998; ATSDR 1993a). Both toxicity values are based on toxicokinetic or empirical models that predict the accumulation of cadmium in the kidney over a period of 50 years. Typically, cadmium concentrations in the kidney increase gradually throughout life until about age 50, and most of the accumulation is due to dietary intake of cadmium. Consequently, risk estimates for cadmium should account for long-term exposures during both childhood and adulthood, as well as for background sources of exposure.

The critical effect of concern for chronic cadmium exposures is proteinuria, an early indicator of renal tubular dysfunction. Numerous studies in humans and laboratory animals have demonstrated that proteinuria develops only when cadmium concentrations in the kidney exceed a critical level, generally believed to be 200 μg/g (wet weight) in kidney cortex. In deriving the chronic oral reference dose (RfD) for cadmium, EPA determined a no-observed-adverse-effect level (NOAEL) based on a toxicokinetic model that predicted the daily cadmium intake from food or water necessary to result in a kidney cortex concentration of 200 μg/g at age 50, and applied a ten-fold safety factor:

Chronic oral RfD (food) = 1 μg/kg-day
= 10 μg/kg-day (NOAEL) ÷ 10 (Uncertainty Factor)

The NOAEL of 10 μg/kg-d is based on a toxicokinetic model that predicts that a cadmium intake of 352 μg/d for an adult is necessary to reach a critical concentration of 200 μg/g in kidney cortex at age 50, assuming that 5 percent of ingested cadmium is absorbed initially and that 0.01 percent of the total cadmium body burden is excreted per day (Friberg et al. 1974). EPA assumed a 70-kg body weight for an adult and 2.5 percent cadmium absorption from food to calculate the NOAEL (352 μg/d ÷ 70 kg × 5/2.5 absorption = 10 μg/kg-d) (U.S. EPA 1998).

ATSDR's minimal risk level (MRL) for cadmium is based on a NOAEL derived from a dose-response analysis for a Japanese population over 50 years of age, which experienced lifetime exposure to cadmium in rice irrigated with contaminated river water. ATSDR applies a 3-fold uncertainty factor to the NOAEL.

Chronic oral MRL = 0.7 μg/kg-d
= 2.1 μg/kg-d (NOAEL) ÷ 3 (Uncertainty Factor)

The NOAEL of 2.1 μg/kg-d is the intake level that, over 50 years, will result in a total cadmium intake of 2,000 mg, which was the estimated intake level necessary to observe elevated urinary β_2-microglobulin in the Japanese study population (Nogawa et al. 1989). A kinetic model of cadmium metabolism predicts that this intake will produce elevated β_2-microglobulin levels in about 5 percent of a nonsmoking European population (body weight = 70 kg) (assuming a log-normal distribution in critical concentrations in the kidney, with 10 percent of the population having a critical concentration of 180 μg/g or less and 50 percent having a critical concentration of 250 μg/g or less [Kjellstrom 1986]). ATSDR also cites a lowest-observed-adverse-effect level (LOAEL) of 7.5 μg/kg-d from a study of lifetime exposure to cadmium in drinking water in a Japanese population (Shiwen et al. 1990).

Although the derivation of the EPA RfD and ATSDR MRL are different, the target acceptable doses are similar. For the remainder of this analysis, the focus is on the EPA RfD and appropriate adjustments needed to account for background exposures.

According to Friberg et al. (1974), which is the source of the toxicokinetic model that EPA used to derive the cadmium RfD, studies in U.S. populations indicate that background exposures to cadmium result in a kidney cortex concentration of 50 μg/g at age 50, or 25 percent of the critical concentration of 200 μg/g. This information suggests that a cadmium RfD that accounts for background exposures could be derived by multiplying the current RfD by 0.75 (i.e., 75 percent of the current RfD can be allotted to cadmium exposures in excess of typical background exposures):

$$RfD_{adj} = RfD \times 0.75 = 1\ \mu g/kg\text{-}d \times 0.75 = 0.75\ \mu g/kg\text{-}d$$

The daily cadmium intakes estimated by Friberg et al. (1974) to be necessary to achieve kidney cortex concentrations of 50 μg/g (background) and 200 μg/g (critical effect level) at age 50 are shown in Table 1. However, the intake estimates required in the model to achieve 50 μg/g of cadmium accumulation in the kidney are significantly above current estimates of actual background intake, suggesting that the validity of the assumptions in the model (and consequently the RfD) should be reassessed.[1] Therefore, rather than relying on the simple calculation above, we used information from the literature regarding background intakes of cadmium (i.e., from food, drinking water, air, and smoking) and cadmium absorption to derive appropriate estimates for Trail.

DETERMINATION OF ESTIMATED DAILY INTAKE OF CADMIUM

As described above, the accumulation of cadmium in the kidneys reflects lifetime exposure to cadmium from all sources, including background exposures. An accurate determination of the estimated daily intake (EDI) from sources other than soil will allow for a more accurate determination of actual cadmium exposures. We estimated background exposure to cadmium in the community of Trail to derive adjusted RfDs for smokers and nonsmokers for use in estimating total exposures of both populations.

[1] The estimate of the background cadmium concentration in kidney cortex at age 50 (i.e., 50 μg/g) from Friberg et al. (1974) was based on data reported from several industrialized countries, including Sweden, up to the early 1970s. However, Friis et al. (1998) report a significant reduction in cadmium levels in human kidney cortex in Sweden since the 1970s. Specifically, the geometric mean cadmium concentration decreased from approximately 20 μg/g in the 1970s to less than 14 μg/g for individuals approximately 50 years old. Significant decreases were observed in both smokers and nonsmokers, indicating changes in other environmental exposures. These new data suggest that the portion of the critical concentration of cadmium in kidney cortex that is attributable to background exposure may be significantly less for present-day populations than originally estimated by Friberg et al. (1974).

Background cadmium exposure was estimated for four common exposure pathways: food, drinking water, air, and smoking. Because absorption of cadmium differs for each of these pathways, we determined that comparisons would be facilitated if all discussions are presented in terms of an *absorbed* dose, rather than an *ingested* dose. Therefore, the cadmium RfD was converted from an ingested dose to an absorbed dose before estimating exposures from the different pathways. As described above, the oral cadmium RfD for food is 1 μg ingested cadmium per kg body weight per day. In deriving this RfD, the EPA assumed that 2.5 percent of cadmium in food is absorbed (U.S. EPA 1998). Multiplying the RfD of 1 μg/kg-d by 0.025 (2.5 percent) yields an adjusted RfD of 0.025 μg absorbed cadmium per kg body weight per day. Below, the daily absorbed dose of cadmium from each of the four pathways is estimated and subtracted from this adjusted cadmium RfD to determine the allowable daily dose of cadmium from additional site-related exposures (e.g., via soil and air) that would not pose appreciable risk of adverse health effects.

The contribution of background cadmium exposure to daily absorbed dose was calculated as follows:

- **Food**—The estimated daily dietary intake (i.e., the ingested dose) of cadmium for Canadians is approximately 0.19 μg/kg-d. This value is based on the average dietary cadmium intake of 13.5 μg/d for males and females ages 20–65 years obtained in a total diet survey conducted by Health and Welfare Canada from 1986 to 1988 (Dabeka and McKenzie 1995), and assumes an average adult body weight of 70 kg (BC Environment 1996a). Assuming 2.5 percent absorption of cadmium from food, the estimated daily absorbed dose of cadmium from the diet is 0.0048 μg/kg-d.

- **Drinking water**—The average cadmium concentration in drinking water for Trail was assumed to be 0.1 μg/L. Because recent tests of raw water entering the City of Trail water treatment plant have not detected cadmium above the method detection limit of 0.2 μg/L (PTI 1997a), one-half the detection limit was selected as a surrogate value for finished drinking water. Assuming that 5 percent of cadmium in water is absorbed (U.S. EPA 1998) and that a 70-kg person ingests 1.5 L/day (BC Environment 1996a), the estimated daily absorbed dose of cadmium from drinking water is 0.0001 μg/kg-d.

- **Air**—The average background air concentration of cadmium for the region surrounding Trail was assumed to be 0.001 $\mu g/m^3$. This concentration was based on U.S. data indicating that mean ambient air concentrations of cadmium are generally less than 0.001 $\mu g/m^3$ in sparsely populated areas (ATSDR 1993a). Assuming that a 70-kg person inhales 23 m^3/d (BC Environment 1996a) and that 100 percent of the cadmium inhaled is of respirable size (i.e., $<10\ \mu m$), the estimated cadmium intake via inhalation of ambient air would be 0.0003 μg/kg-d. Models of cadmium deposition and absorption in the human lung suggest that between 5 and 50 percent of particles in the range of 0.1 to 10 μm are deposited in the lung and that between 50 and 100 percent of cadmium deposited in the alveoli is absorbed (ATSDR 1993a). Consequently, 25 percent of the estimated cadmium intake was conservatively assumed to be deposited and absorbed, resulting in an estimated daily absorbed dose of cadmium from ambient air of approximately 0.0001 μg/kg-d.

- **Smoking**—The amount of cadmium absorbed from smoking one pack of cigarettes per day is approximately 1 μg/d (WHO 1992). This value is based on data indicating that smoking a pack of 20 cigarettes daily results in the inhalation of 2–4 μg cadmium per day, of which 25–50 percent may be absorbed via the lungs (cadmium absorption from cigarette smoke is generally greater than that from ambient air because of the very small particle sizes in cigarette smoke). Assuming that someone begins smoking at age 16, the average daily absorbed dose of cadmium at age 50 for a person who smokes one pack per day is approximately 0.0100 μg/kg-d.

Subtracting this estimate of absorbed cadmium from background sources from the absorbed dose cadmium RfD of 0.025 μg/kg-d results in an allowable absorbed dose for all other pathways (i.e., ingestion of soil and homegrown produce) of 0.020 μg/kg-d for nonsmokers and 0.010 μg/kg-d for people who smoke one pack of cigarettes per day. These values are proposed as the absorbed cadmium toxicity factors, or as the TDIs, to assess the risk of health effects from exposure to cadmium in soil in Trail.

The application of these toxicity values in assessing the risk of cadmium exposure in Trail will raise several issues that will require an assessment of community values in deciding what level of risk is acceptable. As noted previously, EPA used an uncertainty factor of 10 in deriving their cadmium RfD. Consequently, it is possible that adverse effects might not be observed at total cadmium doses of 10 times the RfD. The community may want a role in deciding how much of a safety margin they need. Some of the data in the literature suggest that the critical kidney concentration of cadmium may be less than the 200 μg/g used by EPA in deriving the reference dose, thus reducing the actual margin of safety above the reference dose. This issue should be described in greater detail in the risk assessment.

Another issue that will require community input once the risk assessment is complete is the level of protection afforded to various subpopulations. Smokers have a much greater "background" cadmium exposure than nonsmokers. Should remediation goals be set so that smokers are not at added risk from cadmium in soil, regardless of how much they smoke? Or should the margin of safety be smaller for smokers than for nonsmokers? Similarly, people who eat homegrown produce may have higher exposures to soil cadmium than people who don't eat homegrown produce. Should remediation goals be set so that people can garden anywhere, or should gardening be restricted in some way (e.g., requiring clean soil) as a means of limiting the scope of soil cleanup? Some of these decisions may not be necessary if risks are within acceptable ranges for various populations, but some thought should be given to how the issues would be addressed as the risk assessment proceeds.

Finally, the bioavailability of cadmium from Trail soils will be important. Because the TDI provided here is expressed as an absorbed dose, it will be important to assess the fraction of soil cadmium that is absorbed before evaluating risks with this TDI.

TASK 2. EVALUATE BACKGROUND EXPOSURE TO ARSENIC

In the Phase I effort for Trail, we recommended that in evaluating the significance of arsenic concentrations in soil and dust, it is important to consider other common sources of arsenic exposure (PTI 1997a). Because arsenic occurs naturally in the environment and is present in most foods, arsenic exposure is a typical part of everyday life. We recommended developing a summary of background arsenic intake from various sources. The purpose of this evaluation was to evaluate literature and BC Environment databases to derive an estimate of background exposures to arsenic for people living in southeastern British Columbia. This information provides a basis of comparison for evaluating the magnitude of arsenic exposures from soil relative to other sources.

Mean background exposures to inorganic arsenic for the community of Trail are estimated to be approximately 4.0–4.6 μg/day for young children, 8.7–8.9 μg/day for adult nonsmokers, and 10.5–10.7 μg/day for adult smokers. These exposures represent estimated average daily doses of inorganic arsenic that are absorbed into the body from air, food, drinking water, background soil, and cigarette smoke. The assumptions used to derive the estimated absorbed daily doses attributable to each of these sources of exposure are described below.

AIR

A background absorbed dose of 0.02 μg arsenic/day from air for an adult was calculated on the basis of an ambient air concentration of 0.003 μg arsenic/m^3 air, a daily adult inhalation rate of 23 m^3 (BC Environment 1996a), and an assumption of 30 percent absorption (U.S. EPA 1984). An inhalation rate of 5 m^3/d for children ages 0.6–4 years (BC Environment 1996a) reduces the estimated absorbed dose to <0.01 μg arsenic/day from air for this age group. The arsenic air concentration of 0.003 μg arsenic/m^3 is based on U.S. data indicating that air concentrations range from <0.001 to 0.003 μg/m^3 in sparsely populated areas (ATSDR 1993b). Thus, the use of 0.003 μg/m^3 provides an upper-bound estimate of typical background exposures to arsenic in air. No data were found for background air concentrations of arsenic in southeastern British Columbia (Wood 1998, pers. comm.)

FOOD

Recent analyses suggest that the average intake of inorganic arsenic from the Canadian diet is 10.4 μg/d for adults ages 20–39 years and 4.8 μg/d for children ages 1–4 years

(Yost et al. 1998).[2] Assuming that 80 percent of ingested inorganic arsenic is absorbed into the body (Uthus 1994)[3], the estimated absorbed daily dose of arsenic from food is 8.3 μg/d for an adult and 3.8 μg/d for a young child.

As noted in our recommendations for risk assessment at Trail (PTI 1997a), although there is general agreement regarding typical amounts of arsenic intake from the diet, little information is available regarding the expected range of intakes. Dabeka et al. (1993) conducted a survey of total arsenic in food samples collected from six Canadian cities, and determined that dietary intakes of total arsenic varied by as much as 53 percent among the cities. This result might be explained in part by the wide variability of total arsenic content that was observed both within food groups (e.g., less than 1.3 to as much as 536 ng/g in samples of meat and poultry) and between food groups (e.g., the mean arsenic content for ten food groups [excluding fish and shellfish, which contain high levels of organic arsenic] ranged from 3.0 to 24.5 ng/g). The variation in individual intakes would be even greater than the variation in average intake observed among city populations.

DRINKING WATER

Estimated absorbed arsenic doses of 0.4 μg/d and 0.2 μg/d from drinking water for adults and children, respectively, were derived assuming 1) an arsenic concentration of 0.25 μg/L, 2) ingestion rates of 1.5 L/d for adults and 0.8 L/d for children ages 0.6–4 years (BC Environment 1996a), and 3) complete gastrointestinal absorption of arsenic in water (U.S. EPA 1992a). Because recent tests of raw water entering the City of Trail water treatment plant have not detected arsenic above the method detection limit of 0.5 μg/L (PTI 1997a), one-half the detection limit was selected as a surrogate value for arsenic concentrations in finished drinking water. In North America, background concentrations of arsenic in groundwater range from below 1 μg/L to well above 50 μg/L (Borum and Abernathy 1994). Therefore, the drinking water data from Trail indicate that residential exposure to arsenic from Trail drinking water may fall well below exposures in other parts of North America.

[2] Unlike inorganic arsenic, organic forms of arsenic generally are not thought to be of health concern and thus were not considered in this assessment. The intake estimates for inorganic arsenic were derived by combining data from a Canadian dietary survey that reports total arsenic intake from foods with data from studies by the Ontario Ministry of the Environment reporting the proportion of total arsenic in foods that is present as acid-extractable (i.e., bioaccessible) inorganic arsenic (Yost et al. 1998).

[3] Uthus (1994) suggests that absorption of arsenic from food ranges from 80 to 100 percent; thus, the assumption that 80 percent of the acid-extractable inorganic arsenic is absorbed into the body represents a conservative estimate (i.e., absorption might be up to 100 percent).

BACKGROUND SOIL

Absorbed arsenic doses from soil of 0.01–0.16 μg/day for adults and 0.04–0.66 μg/day for young children were estimated assuming a background soil concentration range of 1–14.9 mg/kg for the Kootenay Region[4], soil ingestion rates of 0.02 g/d for adults and 0.08 g/d for children 0.6–4 years old (BC Environment 1996a), and 55 percent gastro-intestinal absorption of arsenic from soil.[5]

SMOKING

EPA has estimated that the absorbed arsenic dose attributable to smoking is 1.8 μg per pack of cigarettes smoked (U.S. EPA 1984). This estimate is based on data indicating that 6 μg arsenic is inhaled for each pack of cigarettes, and that 30 percent of the inhaled arsenic is absorbed.

CONCLUSION

Based on the estimates of average background exposures to air, food, water, soil, and cigarette smoke in Trail, total background daily absorbed doses of inorganic arsenic are likely to average 4.0–4.6 μg/d for young children, 8.7–8.9 μg/d for adult nonsmokers, and 10.5–10.7 μg/d for adults who smoke one pack of cigarettes per day. The diet is by far the most significant source of arsenic exposure when drinking water concentrations are low, contributing approximately 90 percent or more to the total background exposures for young children and nonsmoking adults. In comparison to dietary intake, the average background concentration of arsenic in soils is estimated to contribute 1–13 percent of the total background exposure for young children, and less than 2 percent of the total background exposure for adults. These background absorbed arsenic doses are very similar to those presented previously (PTI 1997a).

These values for background arsenic exposure will be discussed in the upcoming screening risk assessment to be conducted for Trail. Once air, average soil concentrations within exposure units, and bioaccessibility data become available, we will be able not only to express the theoretical health risks associated with exposures to environmental arsenic in Trail, but also to communicate those exposures relative to normal background exposures for areas not affected by smelter operations.

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[4] Kootenay Region background values from Jungen, J., BC Environment (pers. comm. with G. Hook, Exponent, Boulder, CO).

[5] Based on a site-specific evaluation of bioaccessibility conducted on Trail soils, and discussed in Task 4 of this document.

TASK 3. SCREEN PLANT CONCENTRATIONS OF ARSENIC AND CADMIUM

Because arsenic and cadmium in soil can be taken up into plants, human consumption of homegrown produce grown in soils containing these metals may constitute a potentially significant exposure pathway. In this task, screening calculations were performed to determine whether potential exposures to these CoPCs from homegrown produce are significant relative to exposures from soil ingestion, typically considered the primary pathway of exposure to chemicals in soil.

EXPOSURE ALGORITHMS AND ASSUMPTIONS

Tables 2 and 3 present the exposure algorithms and assumptions used to derive summary factors for estimating absorbed doses for the garden vegetable and soil ingestion pathways, respectively. These summary factors are expressed in units of kg soil/kg body weight-day and, when multiplied by the arsenic or cadmium soil concentrations (mg/kg), provide an estimate of the chronic daily absorbed dose of the metal (mg/kg body weight-day). Thus, the magnitude of the summary factor is directly proportional to the magnitude of the estimated dose, and can be used to compare the relative importance of individual exposure pathways to total exposure. Key assumptions in deriving the intake factors for the exposure pathways are described below.

For the homegrown-produce pathway, critical assumptions include the degree of uptake of cadmium and arsenic from soil into produce (i.e., a bioconcentration factor), the daily produce (leafy and non-leafy) intake rate, the fraction of produce consumed that is homegrown, and the fractions of the chemicals ingested that are absorbed into the body. The transport of chemicals from soil to plants differs for vegetative growth (leaves and stems) and non-vegetative growth (fruits, seeds, and tubers). Thus, bioconcentration factors for chemicals are specific for the vegetative portions of food crops and the non-vegetative (reproductive) portions.[6] Baes et al. (1984) provides separate bioconcentration factors for vegetative and non-vegetative crops. They report that leafy vegetables are the only food crops for which vegetative bioconcentration factors are appropriate; bioconcentration factors for non-vegetative growth represent the appropriate uptake values for all other food crops (including non-leafy vegetables). Although non-leafy vegetables represent the majority of vegetables consumed by humans (Baes et al. 1984; U.S. EPA 1996a), leafy vegetables still constitute a portion of the human diet, and cadmium and arsenic are both known to be taken up into leafy vegetables. Therefore, in this screening evaluation, con-

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[6] It should be noted that neither arsenic nor cadmium is concentrated or accumulated in plants. "Bioconcentration factors" for both elements are much less than one (i.e., plant concentrations are lower than soil concentrations).

sumption rates and metals concentrations were assessed for both non-leafy and leafy vegetables. The bioconcentration factors used for arsenic were 0.006 for non-leafy vegetables and 0.04 for leafy vegetables, and for cadmium were 0.15 and 0.55, respectively (Baes et al. 1984). These factors relate to dry-weight concentrations in soil and dry-weight plant tissue concentrations.

Three kinds of information were used to derive an ingestion rate for leafy and non-leafy vegetables on a dry-weight basis. First, a total vegetable ingestion rate of 250 g/day (wet weight), reported by Health Canada (1994) for Canadians 20 years old or older, was used in our calculations.[7] The Health Canada rate is based on the Nutrition Canada Survey, which is the most appropriate available value for the target population.

Second, because the bioconcentration factors reported by Baes et al. (1984) are based on dry weight, vegetable consumption rates needed to be converted to dry-weight intake rates. Based on data in the EPA's *Exposure Factors Handbook* (U.S. EPA 1996a), the mean moisture content of non-leafy vegetables (e.g., beans, carrots, corn, eggplant, okra, parsnips, potatoes, squash, tomatoes, and turnips) is approximately 80 percent (or 20 percent dry weight). For leafy vegetables (e.g., asparagus, broccoli, cabbage, cauliflower, various greens, lettuce, and spinach), the mean moisture content is approximately 90 percent (or 10 percent dry weight). Third, the 250-g/day ingestion rate from the Canadian survey did not provide adequate information to apportion intake among leafy and non-leafy vegetables. Therefore, U.S. data were used for this purpose. Of the total vegetables ingested, 7 percent were assumed to be leafy, and 93 percent non-leafy, based on data (dry-weight) from EPA (1996a). This information was combined (see Appendix A), and the ingestion rate for non-leafy vegetables based on dry weight was estimated to be 42.6 g/d and 3.2 g/d for leafy vegetables.

Another key assumption for the garden produce pathway is the fraction of produce that is assumed to be homegrown vs. commercially purchased. Based on information available from the CCME (CCME 1993), approximately 7 percent of the Canadian diet is composed of homegrown produce; therefore, a fractional intake value of 0.07 was assumed in our calculations.

Arsenic is present in foods in many forms, which vary in toxicity. Thus, the fraction of arsenic that is assumed to be inorganic is critical, because organic arsenical compounds are not considered to be toxic at concentrations encountered in food. A value of 0.65 (65 percent) inorganic arsenic was selected, based on estimates of the inorganic arsenic fraction for four food categories (legumes, fruit, vegetables, and potatoes), provided in Yost et al. (1998). Finally, the fraction of inorganic arsenic ingested from homegrown produce that is absorbed into the body was assumed to be 80 percent (Uthus 1994). Oral absorption of cadmium from homegrown produce was assumed to be 2.5 percent, consistent with EPA's assumption used in deriving the RfD for cadmium in food. All other assumptions used were standard EPA default values (U.S. EPA 1991).

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[7] Versus the U.S. EPA default value for vegetable consumption of 200 g/d.

To the extent possible, default values from Canadian regulatory agencies were used in evaluating the soil ingestion pathway. Two exceptions regarding key assumptions for the soil ingestion pathway relate to the bioavailability of cadmium and arsenic from soil and the daily ingestion rate. As discussed in our previous recommendations (PTI 1997a), inorganic elements in soil are frequently less bioavailable than soluble forms (e.g., metal salts dissolved in water). Thus, adjustments for bioavailability of arsenic and cadmium from soil may be appropriate in evaluating a soil ingestion pathway. Site-specific data regarding the bioavailability of arsenic and cadmium in Trail soils have become available recently (see Task 4, below). This research suggests that the appropriate upper-bound relative bioavailability adjustment factors for arsenic and cadmium from Trail soil are 55 percent and 33 percent, respectively. Therefore, a bioavailability factor of 0.55 was assumed for arsenic, and of 0.008 for cadmium. The cadmium value was derived by multiplying the bioavailability factor of 0.025 for dietary cadmium by a relative bioavailability adjustment of 0.33, which represents the relative bioavailability of soil cadmium compared to dietary cadmium (Schoof and Freeman 1995; Schilderman 1997). As discussed above, soil ingestion rates of 20 mg/d for adults and 88 mg/d for children 0.6–4 years old (BC Environment 1996a) were assumed in this evaluation.

PATHWAY COMPARISON

Summary factors for comparing relative doses of cadmium and arsenic from garden produce versus ingested soil were derived using the algorithms and assumptions shown in Tables 2 and 3. Results of these calculations are presented in Table 4. These results indicate that the summary factors for arsenic based on carcinogenic effects were 8.0×10^{-8} for the garden vegetable pathway and 2.5×10^{-7} for the soil ingestion pathways, respectively, applying the site-specific relative bioavailability factor. The summary factors for arsenic based on noncarcinogenic effects were 2.0×10^{-7} for the garden vegetable pathway, and 3.0×10^{-6} for the soil ingestion pathways, applying the site-specific relative bioavailability factor.

For cadmium, the summary factors were 2.0×10^{-7} for the garden vegetable pathway, and 4.4×10^{-8} for the soil ingestion pathway when the site-specific relative bioavailability adjustment factor is applied.

The technical approach used in this task generally results in a conservative assessment of the potential for human exposures to arsenic and cadmium from ingestion of homegrown produce. These calculations indicate that, for arsenic, potential exposures via ingestion of homegrown produce are below potential exposures from soil, ranging from four- to seventeen-fold below exposures via soil ingestion. The opposite is the case for cadmium. This analysis suggests that exposure to cadmium from ingestion of homegrown produce might exceed exposures from soil ingestion by a factor of greater than three. This conclusion suggests a slightly smaller discrepancy between exposures via the two exposure pathways than the 10-fold difference in the BC Environment soil quality matrix standards for cadmium, which are 35 μg/g based on soil ingestion exposures, but only 3 μg/g for exposures due to ingestion of both soil and homegrown produce.

Although the available data on garden produce from the Trail vicinity are difficult to interpret due to data quality and documentation issues, it is potentially instructive to compare the results of these screening calculations to site data. Data from 1977 and 1978 provide collocated soil concentration and vegetable concentration data for several areas. Assuming that the data are reported on a dry-weight basis, an evaluation of the data from Tadanac (where soil concentrations of arsenic and cadmium were among the highest measured), suggests that site-specific bioconcentration factors for arsenic range from 0.006 to 0.02 for non-leafy vegetables (carrots and beets were evaluated) and 0.002 to 0.02 for leafy vegetables (lettuce and parsley were evaluated). These data are consistent with the assumptions regarding bioconcentration values (0.006 for non leafy and 0.04 for leafy vegetables) that were incorporated into this assessment.

For cadmium, site-specific bioconcentration factors ranged from 0.013 to 0.036 for non-leafy vegetables, and 0.12 to 0.22 for leafy vegetables. These values are almost ten-fold lower than the assumptions incorporated into the calculations above for non-leafy vegetables (i.e., 0.15), and slightly below the assumed value for leafy vegetables (i.e., 0.55). If the lower site-specific values were confirmed, it would suggest that cadmium exposures from homegrown produce might be roughly equivalent to or below soil ingestion exposures, rather than four-fold greater. Obviously, any comparisons based on the data on metals concentrations in vegetables from Trail must be interpreted with caution, given the limited nature of the data and potential data quality issues.

Conversely, it is important to point out that this analysis focused exclusively on the uptake of metals *into* garden produce. No assessment was conducted to determine the amount of metals in soils that might adhere to the outside of the vegetables. A site report of the 1990 garden produce and soil sampling (McCunn 1991) specifically concludes that washing of vegetables results in a significant reduction in metal values, indicating that adhered soils may cause a significant component of exposure to metals in garden produce. Thus, the relative contribution from ingestion of garden produce could be higher than estimated in this evaluation.

In summary, this evaluation suggests that potential human exposure to metals in soil via the consumption of garden produce cannot be ruled out as being insignificant relative to direct exposure. Additional site-specific concentrations of cadmium in garden produce would be instructive in assessing exposures of the population. A decision regarding whether or not to proceed with site-specific studies should be made after soil screening levels are developed using the adjusted RfD produced in this study (see Task 1, above). Preliminary calculations suggest that such screening levels will indicate that there are not widespread health risks due to exposures to cadmium in Trail soils.

TASK 4: ESTIMATE RELATIVE BIOAVAILABILITY OF ARSENIC AND CADMIUM FROM TRAIL SOILS

INTRODUCTION

This section describes Exponent's testing of soil samples from Trail, British Columbia, to determine the bioavailability of arsenic and cadmium in soil, relative to the bioavailability of more soluble forms of these elements. Arsenic and cadmium can occur in soils as different physical or mineralogic species, with varying solubilities. Bioavailability typically decreases with decreasing solubility in different forms of a chemical. This study assessed the oral bioavailability of arsenic and cadmium in Trail soils using data from a physiologically based extraction test (*in vitro* test) to simulate the processes that control dissolution of chemicals in the human gastro-intestinal (GI) tract. This approach is consistent with that used in previous investigations of bioavailability performed by Exponent at various metals-affected sites (e.g., ODEQ 1994; PTI 1995, 1997b,c; U.S. EPA 1996b). The protocol for the *in vitro* test is attached as part of Appendix B.

Substrates for the *in vitro* testing included composite soil samples from the three neighborhoods of Trail that were most heavily affected by past emissions from the Cominco smelter (i.e., Tadanac, East Trail, and West Trail), and a composite soil sample from the smelter property boundary. Also included in the *in vitro* testing were appropriate quality assurance samples, as well as a comparison sample of soil from Bartlesville, Oklahoma. The Bartlesville soil was evaluated in a previous study of the relative bioavailability of cadmium in soil compared to a soluble cadmium compound, using both animal (*in vivo*) and *in vitro* tests. The specifics of the *in vitro* test procedure used in the present study are discussed in the section on *Bioaccessibility Testing,* after a brief overview of the subject of bioavailability.

Toxicity studies for metals typically are performed using soluble compounds. For most chemicals, the toxicity values used by regulatory agencies are not adjusted to absorbed dose (i.e., the dose response evaluation is based on the administered dose). This approach can lead to overly conservative estimates of risk of exposure to a particular chemical in a medium other than the one used in the toxicity or epidemiology studies on which the toxicity values are based.

For example, the U.S. EPA uses a cancer slope factor (CSF) and a reference dose (RfD) to assess the cancer risks and other adverse health effects, respectively, that might be associated with oral exposure to arsenic (U.S. EPA 1998). The CSF and the RfD were derived from an epidemiological study that characterized health effects in a population of Taiwanese who consumed drinking water containing arsenic (Tseng 1977; Tseng et al. 1968). In contrast to arsenic in drinking water (soluble arsenic), arsenic forms in soils generally exist as mineral phases or soil-arsenic complexes that are incompletely dissolved and absorbed during transit through the GI tract. The solubility of these different forms of arsenic appears to be a critical factor controlling arsenic bioavailability (ATSDR 1993b; U.S. EPA 1992a). Therefore, a downward adjustment should be made in exposure estimates for arsenic in soil, to reflect the lower bioavailability of arsenic in soil relative to arsenic in drinking water.

The situation is similar for cadmium. Regulatory agencies assess risks from cadmium exposure from soils using an RfD based on cadmium uptake from food (see Task 1 for a detailed discussion of cadmium toxicity) (U.S. EPA 1998). Because cadmium may exist in soil in mineral phases that have limited solubility, a correction factor should be applied to exposure estimates to reflect the difference in absorbed dose between ingestion of cadmium in food and in soil.

For the purpose of this study, "absolute bioavailability" is defined as that fraction of the ingested element that is absorbed into systemic circulation. The term "relative bioavailability" is used to describe the bioavailability of the element in soil relative to the bioavailability of the element dissolved in water or in food. Finally, bioaccessibility is defined as the fraction of the ingested element that dissolves in the gastrointestinal tract and is available for absorption.

A relative absorption factor (RAF), which represents the relative bioavailability, is used to adjust the dose or intake of arsenic from soil so that it is comparable to the arsenic doses from water used to generate the toxicity values. Thus, for assessing oral exposure to arsenic in soil:

$$\text{RAF} = \frac{\text{fraction of element absorbed from soil}}{\text{fraction of element absorbed from dissolved form}}$$

It is important to note that relative bioavailability can be estimated without knowing the absolute bioavailability of a chemical. Similarly, the relative bioavailability adjustment applies equally to chemicals with very different absolute bioavailability. Arsenic and cadmium illustrate this concept. Soluble forms of arsenic are nearly completely absorbed—approximately 80 percent—while only 5 percent of soluble cadmium forms are absorbed. If the RAF for both of these elements in soil was 0.5, the absolute bioavailability would be 40 percent for arsenic and 2.5 percent for cadmium. However, estimates of exposure could be adjusted without determining the absolute bioavailability.

To assess the bioavailability of arsenic and cadmium in soil samples from Trail, an approach was used that relies on previous work Exponent has performed to assess the bioavailability of inorganic elements. The physiologically based extraction test (*in vitro* test), which simulates human GI-tract chemistry and function (Ruby et al. 1996, included in Appendix B), was used to determine the fraction of arsenic and cadmium that would be soluble and available for absorption in the GI tract (i.e., the fraction that is bioaccessible). The use of bioaccessibility data to estimate the relative bioavailability of inorganic elements is supported by good agreement that has been observed between relative bioavailability estimates based on *in vivo* bioavailability data and those based on *in vitro* bioaccessibility data for a series of arsenic- and lead-bearing samples tested in both kinds of studies (Ruby et al. 1996).

At this time, the *in vitro* test has not undergone extensive assessment to validate its use in determining cadmium bioavailability from *in vitro* data. However, the predictive power of the *in vitro* test for such disparate inorganic elements as arsenic and lead (Ruby et al. 1996) suggests that it will also yield data that predict the relative bioavailability of other elements, such as cadmium. Because cadmium occurs in the environment primarily as a divalent cation, it is expected to behave similarly to lead.

BIOACCESSIBILITY TESTING

Methods

Study Substrates

Trail Lead Program personnel collected soil samples from three neighborhoods in Trail, (i.e, Tadanac, East Trail, and West Trail), including samples from near the Cominco property boundary, and shipped them to Exponent's Boulder, Colorado laboratory. The samples were received at the Boulder laboratory on November 21, 1997, and were noted to have been previously sieved to a small particle size, and dried to a very low soil moisture content.

Exponent personnel composited the individual samples from each neighborhood into single samples for each neighborhood by combining equal weights of the subsamples in a 500-mL high-density polyethylene (HDPE) jar, and homogenizing the sample on an end-over-end mechanical tumbler for 1 hour, at 30 rpm. Table 5 lists the individual subsamples that were combined into the composite neighborhood samples for Tadanac, East Trail, and West Trail. The Cominco property boundary sample (CTCPB-4) had been composited previously (and sieved to the <250-μm particle size fraction) by Trail Lead Program personnel and therefore required no additional sample preparation by Exponent personnel.

Each of the three neighborhood composite samples (i.e., Tadanac, East Trail, and West Trail) was split into two equal parts, one of which was sieved to the <250-μm particle size fraction for evaluation in the *in vitro* assay. This size fraction is representative of particles that adhere to children's hands and may be ingested (Duggan and Inskip 1985). Also, the <250-μm size fraction has become a standard for assessing exposure to metals in soil in studies conducted by Dr. Robert Bornschein of the University of Cincinnati. In the sieving process, it was noted that each of the three neighborhood samples consisted only of <250-μm particles, because each sample passed entirely through this size sieve screen.

Concentrations of arsenic and cadmium were determined on the <250-μm size fraction of each of the four composite samples (see *Analytical Methods*, below), and those concentrations are listed in Table 6. The bioaccessibility of arsenic and cadmium in the samples was assessed according to the methods of Ruby et al. (1996, Appendix B). The current *in* *vitro* protocol (attached as part of Appendix B) does not include the intestinal-phase extraction (as presented in Ruby et al. 1996), because results obtained at the lower pH of the stomach phase tend to exceed those from the intestinal phase, for these analytes in this type of substrate.

Analytical Methods

Extracts from the *in vitro* procedure were submitted to the Department of Geological Sciences, at the University of Colorado, Boulder, for analysis of arsenic and cadmium concentrations by inductively coupled plasma (ICP; Method 6010A, U.S. EPA 1992b). The soil samples used in the *in vitro* testing (<250-μm size fraction) were submitted to ACZ Laboratories, Inc., Steamboat Springs, Colorado, where they were subjected to microwave digestion (Method 3051, U.S. EPA 1995), followed by graphite furnace atomic absorption spectrometry (GF/AA; Method 7060A, U.S. EPA 1995) for determination of arsenic concentrations, and ICP (Method 6010A, U.S. EPA 1992b) for determination of cadmium concentrations.

Quality Assurance

Quality assurance samples associated with the *in vitro* testing included: 1) duplicate analysis of the Tadanac sample, to evaluate precision and the reproducibility of the method; 2) analysis of a standard reference material,[8] to assess laboratory accuracy and as a comparison material across *in vitro* tests; 3) matrix samples (i.e., blanks and spikes submitted as blind samples), to evaluate potential contamination and assess laboratory accuracy; and 4) soluble arsenic and cadmium spikes analyzed by the *in vitro* protocol, to assess the recovery of the elements from the test system.

Results from the quality assurance samples analyzed by the laboratories (Tables 7 and 8) indicate good analytical accuracy and precision. In analyzing the *in vitro* extracts, the laboratory control limits for laboratory control samples, matrix blanks, and matrix spikes were met. In a full analytical data package associated with the analysis of the solid samples, ACZ Laboratories, Inc. documented that they met analytical laboratory control limits for method blanks, calibration samples, matrix spikes, laboratory control samples, and duplicate samples. There was good recovery of the arsenic (100 percent) and cadmium (115 percent) in the standard reference material (NIST SRM 2710), and from the spiked stomach solution submitted as a blind matrix spike. There was no arsenic or cadmium detected in the blank stomach solution above the stated detection limits of the method.

Additionally, an aliquot of the spiked stomach solution was submitted as a matrix spike and was evaluated in an *in vitro* cell, in the same manner at the other test substrates. Results for

[8] National Institute of Standards and Technology [NIST] Standard Reference Material [SRM 2710] Montana soils.

these extracts indicated good recovery of arsenic and cadmium from the test system (Tables 7 and 8).

Results

Arsenic

The bioaccessibility of arsenic was similar among the four Trail samples, ranging from 45 to 55 percent (Table 9). An average of 50 percent (±4.3 percent; one standard deviation) was calculated for all four of the Trail samples, based on maximum soluble arsenic in the stomach phase. Results from the duplicate analysis of the composite Tadanac sample were averaged to calculate the mean and to report the range. The small relative percent difference (i.e., 2.9 percent, based on maximum soluble arsenic) between the duplicate *in vitro* results for the Tadanac sample indicates good reproducibility of the method for arsenic.

Extraction of the NIST SRM 2710 Montana soil produced 51 percent bioaccessible arsenic in the *in vitro* test (maximum value) (Table 9). This value is consistent with results reported by Medlin (1997) for *in vitro* analysis of the same substrate. For six analyses of SRM 2710, Medlin (1997) produced arsenic bioaccessibility results ranging from 40 to 56 percent,[9] with a mean of 51 percent.

The *in vitro* results obtained for arsenic in the four Trail samples are similar to those reported for soil samples collected at other smelter sites. In samples collected at five smelter sites in the United States, the average percent bioaccessible arsenic in soil has been determined to range from 16 to 49 percent (Table 10). In addition, samples of soil from the Anaconda, Montana smelter site were fed to *Cynomolgus* monkeys, to evaluate arsenic bioavailability in an animal model that is physiologically similar to humans. In the monkey model, the arsenic was determined to have a relative absorption value of 20 percent (Freeman et al. 1995). As can be noted in Table 10, the soils from Anaconda, Montana produced 49 percent bioaccessible arsenic in the *in vitro* test, (maximum of the stomach phase, at a pH of 1.3) (Ruby et al. 1996).[10] This result suggests that, for substrates of this type, the *in vitro* extraction produces estimates of relative arsenic bioavailability that are higher (i.e., more conservative) than what would be obtained from a feeding study in the monkey animal model.

Therefore, based on data from the current study, we conservatively estimate that the Trail samples contain arsenic with relative bioavailability of 50 to 55 percent, the mean and

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[9] Values estimated from data presented in Figure 14 (at 1 hour of the test) of Medlin (1997).

[10] Additional *in vitro* tests of the Anaconda soil at a pH of 1.5 have produced similar arsenic bioaccessibility results (i.e., maximum values of the stomach phase) (Exponent, unpublished data).

upper-bound values, respectively, which were measured using *in vitro* extractions of the samples.

Cadmium

The bioaccessibility of cadmium also was similar among the four composite samples, ranging from 41 to 67 percent (Table 11). The sample composited from the smelter property boundary soil exhibited slightly lower cadmium bioaccessibility in this test, compared to the other composites (i.e., 41 percent, versus 56 to 67 percent for the three neighborhood samples). An average of 56 percent (±10.9 percent; one standard deviation) was calculated for all four of the Trail samples, based on maximum soluble cadmium in the stomach phase. Results from the duplicate analysis of the Tadanac sample were averaged before calculating the mean. If one excludes the data from the property boundary soil sample, the calculated average bioaccessibility becomes 61 percent.

The results from the duplicate extraction of the Tadanac sample (13.7 percent relative percent difference, based on maximum soluble cadmium) indicate that the method is reproducible for cadmium.

Because the bioavailability of cadmium in a Bartlesville, Oklahoma, soil was determined previously in rats (see below, and PTI 1994b), a sample of the Bartlesville soil was also evaluated in the *in vitro* test. Results from the current evaluation of Bartlesville soil indicate 73 percent (maximum value) bioaccessible cadmium in the sample (Table 11). This value is comparable to the mean value (70 percent) obtained from duplicate analysis of the Bartlesville soil in previous *in vitro* tests,[11] and indicates good agreement between *in vitro* extractions of this material.

In vitro extraction of the NIST SRM 2710 Montana soil sample produced 83 percent bioaccessible cadmium (maximum value). This result is nearly identical to that obtained previously in duplicate *in vitro* tests (mean of the maximum values) on the same substrate,[12] again demonstrating the reproducibility of the method.

For cadmium in soil, data are available for a single substrate that has been evaluated by both *in vivo* and *in vitro* methodologies. The animal model involved a rat feeding study, in which the relative bioavailability of cadmium was determined using a composite residential soil sample (BVRSC-01) from Bartlesville, Oklahoma, the site of a former zinc smelter (PTI 1994b). A relative cadmium bioavailability value of 33 percent, the mean

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[11] The value is the mean of the maximum measurements for duplicate *in vitro* extractions performed at a pH of 1.3 (PTI 1994c).

[12] Duplicate extractions produced 84 percent bioaccessible cadmium (mean of the maximum values) at a pH of 1.5, assuming that the concentration of cadmium in the substrate is equal to that reported by NIST in a study on levels of acid-leachable analytes in standard reference materials (Kane 1995).

value from male and female rats, was obtained based on blood and kidney tissue concentrations in animals fed rodent chow mixed with soil cadmium, versus those fed rodent chow mixed with soluble cadmium (cadmium chloride). The bioavailability of cadmium in the Trail soils can be estimated by comparing the bioaccessibility data for cadmium in the Trail samples with that for the Bartlesville sample. The available historical *in vitro* data for the Bartlesville sample are discussed above.

Because the Trail site soil samples exhibited an *in vitro* cadmium bioaccessibility that is lower (mean of 56 percent, maximum of 67 percent) than that measured in the Bartlesville soil (73 percent) (Table 10), these data indicate that the Trail samples would have a lower relative cadmium bioavailability than that estimated for the Bartlesville soil (33 percent).

If one assumes that the relation is linear, then comparison of the site *in vitro* data to those for the Bartlesville soil suggest a site relative cadmium bioavailability ranging from a mean of 25 percent to a maximum of 30 percent (relative $\text{bioavailability}_{\text{Site}}$ = relative $\text{bioavailability}_{\text{rat}} \times [\textit{in vitro}_{\text{Site}}/\textit{in vitro}_{\text{Bartlesville}}]$). Because limited data are available to assess the true relation between bioaccessibility and bioavailability for cadmium, the most conservative approach is to simply assume that the relative bioavailability of cadmium in the Trail soils is less than 33 percent.

CONCLUSIONS

In vitro testing indicates that, on average, arsenic in the Trail site soil samples has a relative bioavailability of 50 percent, with an upper-bound estimate of 55 percent relative bioavailability. Comparison of the *in vitro* data to those from Bartlesville, Oklahoma, suggests that the relative bioavailability of cadmium in the site soil samples is less than 33 percent.

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Tables

LIST OF TABLES

TABLE 1. NECESSARY DAILY CADMIUM INTAKES TO REACH BACKGROUND AND CRITICAL KIDNEY CONCENTRATIONS AT AGE 50[a]

	Daily Cadmium Intake (μg/day)	
Cadmium Excretion per Day (% of body burden)	Background Renal Cortex Concentration (50 μg/g)	Critical Renal Cortex Concentration (200 μg/g)
0	41	164
0.005	62	248
0.01	88	352

Source: Friberg et al. (1974)

[a] Intake estimates are for adults and assume 5 percent gastrointestinal absorption and 90 percent initial retention of absorbed cadmium.

TABLE 2. EXPOSURE ALGORITHM FOR CONSUMPTION OF HOMEGROWN VEGETABLES

Summary Factor (kg/kg-day) =

$$\frac{(CF \times EF \times ED \times FI \times ABS \times I \times [\{BCF_{leafy} \times IR_{leafy}\} + \{BCF_{nonleafy} \times IR_{nonleafy}\}])}{(BW \times AT)}$$

where:

CF	Conversion factor (kg/g)
EF	Exposure frequency (days/year)
ED	Exposure duration (years)
FI	Fraction ingested from homegrown sources (unitless)
ABS	Fraction of chemical that is absorbed (unitless)
I	Fraction of chemical that is inorganic (unitless)
IR_{leafy}	Ingestion rate for leafy vegetables (g/day dry wt)
$IR_{nonleafy}$	Ingestion rate for non-leafy vegetables (g/day dry wt)
BCF_{leafy}	Bioconcentration factor for leafy vegetables (dry weight basis)
$BCF_{nonleafy}$	Bioconcentration factor for nonleafy vegetables (dry weight basis)
BW	Body weight (kg)
AT	Averaging time: - carcinogenic effects: 75 years x 365 days/year - noncarcinogenic effects: ED x 365 days/year

Exposure Assumptions[a]

Parameter	Homegrown Vegetables
CF	1×10^{-3}
EF	365
ED	30
FI	0.07[b]
IR_{leafy}	3.2[c]
$IR_{nonleafy}$	42.6[d]
BW	70

	Arsenic	Cadmium
ABS	0.8[e]	0.025[f]
I	0.65[g]	1.0
BCF_{leafy}	0.04[h]	0.55[h]
$BCF_{nonleafy}$	0.006[h]	0.15[h]

Notes on following page

TABLE 2. (cont.)

[a] All expsoure assumptions from BC Environment (1996a) unless otherwise noted.
[b] From CCME (1993)
[c] Ingestion rate for leafy vegetables estimated as follows:
    250 g/day (wet weight) from Health Canada (1994)
    of which, 7 percent estimated to be leafy from U.S. EPA (1996a)
    and of which, 90 percent estimated to be water from U.S. EPA (1996a)
[d] Ingestion rate for nonleafy vegetables estimated as follows:
    250 g/day (wet weight) from Health Canada (1994)
    of which, 93 percent estimated to be nonleafy from U.S. EPA (1996a)
    and of which, 80 percent estimated to be water from U.S. EPA (1996a)
[e] From Uthus (1994)
[f] From U.S. EPA (1998) [IRIS file for cadmium]
[g] From Yost et al. (1998)
[h] From Baes et al. (1984)

TABLE 3. EXPOSURE ALGORITHM FOR INCIDENTAL INGESTION OF SOIL

Summary Factor (carcinogenic effects) (kg/kg-day) =

$$\frac{(CF \times EF \times FI \times RBA \times [\{IR_{child} \times ED_{child}/BW_{child}\}+\{IR_{adult} \times ED_{adult}/BW_{adult}\}])}{AT_c}$$

Summary Factor (noncarcinogenic effects) (kg/kg-day) =

$$\frac{(CF \times ED_{child} \times EF \times FI \times RBA \times IR_{child})}{AT_n \times BW_{child}}$$

where:

CF	Conversion factor (kg/mg)
EF	Exposure frequency (days/year)
ED	Exposure duration (years)
FI	Fractional intake from contaminated source (unitless)
IR	Ingestion rate of soil (mg soil/day)
RBA	Relative bioavailability factor (unitless)
BW	Body weight (kg)
AT	Averaging time: - carcinogenic effects: 75 years x 365 days/year - noncarcinogenic effects: ED x 365 days/year

Exposure Assumptions[a]

Parameter		Soil	
CF		1×10^{-6}	
EF		365	
FI		1	
	Adult		Child
BW	70		14.5[b]
ED	25[b]		5[b]
IR	20		80
	Arsenic		Cadmium
RBA	0.55[c]		0.008[c]

Notes:

[a] All exposure assumptions from BC Environment (1996a) unless otherwise noted.

[b] From BC Environment (1990).

[c] Relative bioavailability factor estimate from site-specific *in vitro* testing (this report, Section 4).

TABLE 4. SUMMARY FACTORS

Pathway	Arsenic		Cadmium,
	Cancer Effects (kg/kg-day)[a]	Noncancer Effects (kg/kg-day)[a]	Noncancer Effects (kg/kg-day)[a]
Consumption of homegrown produce	8.0E-08	2.0E-07	2.0E-07
Incidental ingestion of soil	2.5E-07	3.0E-06	4.4E-08

[a] (kg soil)/(kg body weight)

TABLE 5. TRAIL SOIL SAMPLES USED TO PREPARE COMPOSITE SAMPLES EVALUATED IN THE *IN VITRO* TESTS

East Trail	Tadanac / West Trail
EH809109304005 [a]	**Tadanac**
EH809208108003	EH809209174001
EH809208127040	EH809110073001
EH809109304007	EH809110073002
EH809110304003	EH809110035002
EH809208064003	EH809110103005
EH809209014003	EH809110103006
EH809209018006	EH809110094002
EH809209024001	**West Trail**
EH809110024002	EH809110023004
EH809209024002	EH809110113001
EH809110075006	EH809110113003 [a]
EH809208108004	EH809110173007
EH809208058005	EH809110305002
EH809209018005	EH809111015001
EH809110213013	EH809111045002 [a]
EH809209084004	EH809208067030
EH809208127030	EH809208188020
EH809208214040	EH809208287005
EH809110073006	EH809209088006
EH809110013004	EH809209167003
EH809110085005	EH809209177005
EH809110113009	
EH809208078001	
EH809208147040	
EH809209164002	
EH809208078002	
EH809208048003	
EH809208064002	
EH809110024001	
EH809208284002	
EH809109304006 [a]	
EH809109304008 [a]	
EH089208048004 [a]	
EH089110313003	

[a] Not added to composite due to low sample mass.

TABLE 6. TOTAL ARSENIC AND CADMIUM CONCENTRATIONS IN TRAIL SOIL COMPOSITES (<250μm) EVALUATED IN *IN VITRO* TESTS

(All units mg/kg)

Sample ID	Arsenic	Cadmium
East Trail	200	81.7
Property Boundary soil	460	82.7
Tadanac soil	149	62.7
West Trail	119	66.7

TABLE 7. ARSENIC *IN VITRO* QA/QC SAMPLE RESULTS FOR TRAIL

Sample ID	Concentration	Measured Concentration	Percent Recovery
Solid			
NIST SRM 2710	590 mg/kg [a]	590 mg/kg	100%
Matrix Samples			
Blank stomach solution	--	0.15 U mg/L	--
Spiked stomach solution	0.5 mg/L	0.550 mg/L	110%
In Vitro Samples			
Spiked stomach solution	0.5 mg/L	0.525 mg/L (at 0.5 hrs of test)	105%
Spiked stomach solution	0.5 mg/L	0.557 mg/L (at 1.0 hrs of test)	111%

[a] Value from a NIST study of acid-leachable analytes in standard reference materials (Kane 1995).
U = Not detected; value represents detection limit.
-- = Not applicable.

TABLE 8. CADMIUM *IN VITRO* QA/QC SAMPLE RESULTS FOR TRAIL

Sample ID	Concentration	Measured Concentration	Percent Recovery
Solid			
NIST SRM 2710	20 mg/kg [a]	23 mg/kg	115%
Matrix Samples			
Blank stomach solution	--	0.015 U mg/L	--
Spiked stomach solution	0.5 mg/L	0.518 mg/L	104%
In Vitro Samples			
Spiked stomach solution	0.5 mg/L	0.482 mg/L (at 0.5 hrs of test)	96%
Spiked stomach solution	0.5 mg/L	0.456 mg/L (at 1.0 hrs of test)	91%

[a] Value from a NIST study of acid-leachable analytes in standard reference materials (Kane 1995).
U = Not detected; value represents detection limit.
-- = Not applicable.

TABLE 9. *IN VITRO* ARSENIC RESULTS FOR TRAIL

Sample ID	Time (hr)	pH (s.u.)	Eh (mV)	Arsenic Conc. in Substrate (mg/kg)	Mass of Soil Tested (g)	Arsenic Conc. in Extract (mg/L)	Volume of Extract (L)	Calculated Mass of Arsenic in Soil Tested (mg)	Calculated Mass of Arsenic in Extract (mg)	Arsenic Bioaccessibility
East Trail	0.5	1.56	--	200	1.5	0.863	0.15	0.30	0.13	43%
East Trail	1.0	1.56	677	200	1.5	1.108	0.15	0.30	0.17	55%
West Trail	0.5	1.65	--	119	1.5	0.538	0.15	0.18	0.08	45%
West Trail	1.0	1.58	--	119	1.5	0.594	0.15	0.18	0.09	50%
Property Boundary Soil	0.5	1.58	--	460	1.5	1.915	0.15	0.69	0.29	42%
Property Boundary Soil	1.0	1.58	--	460	1.5	2.345	0.15	0.69	0.35	51%
Tadanac	0.5	1.61	--	149	1.5	0.542	0.15	0.22	0.08	36%
Tadanac	1.0	1.61	699	149	1.5	0.66	0.15	0.22	0.10	44%
Tadanac duplicate	0.5	1.47	--	149	1.5	0.61	0.15	0.22	0.09	41%
Tadanac duplicate	1.0	1.47	417	149	1.5	0.68	0.15	0.22	0.10	46%
NIST SRM 2710 Montana Soil	0.5	1.60	--	590 [a]	1.5	2.712	0.15	0.89	0.41	46%
NIST SRM 2710 Montana Soil	1.0	1.60	--	590 [a]	1.5	2.988	0.15	0.89	0.45	51%

[a] Value from a NIST study of acid-leachable analytes in standard reference materials (Kane 1995).

-- = No analysis performed.

TABLE 10. *IN VITRO* RESULTS FOR ARSENIC IN SMELTER-SITE SOIL SAMPLES

Smelter Site	Sample	Bioaccessible Arsenic (%)
Anaconda, MT	Residential soil (ARS-II)	49 [a]
Bartlesville, OK	Residential soil	35 [b]
Murray Smelter, UT	Facility soil	47 [c]
Pallas Yard, UT	Facility soil	25 [d]
Palmerton, PA	Location 2 soil	16 [c]
Palmerton, PA	Location 4 soil	32 [c]

Notes:

[a] *In vitro* data at pH of 1.3 from Ruby et al. (1996).

[b] *In vitro* data at pH of 1.3 from PTI (1994a).

[c] *In vitro* data at pH of 1.5 from Medlin (1997).

[d] *In vitro* data at pH of 1.5 from PTI (1997c).

TABLE 11. *IN VITRO* CADMIUM RESULTS FOR TRAIL

Sample ID	Time (hr)	pH (s.u.)	Eh (mV)	Cadmium Conc. in Substrate (mg/kg)	Mass of Soil Tested (g)	Cadmium Conc. in Extract (mg/L)	Volume of Extract (L)	Calculated Mass of Cadmium in Soil Tested (mg)	Calculated Mass of Cadmium in Extract (mg)	Cadmium Bioaccessibility
East Trail	0.5	1.56	--	81.7	1.5	0.523	0.15	0.12	0.08	64%
East Trail	1.0	1.56	677	81.7	1.5	0.545	0.15	0.12	0.08	67%
West Trail	0.5	1.65	--	66.7	1.5	0.368	0.15	0.10	0.06	55%
West Trail	1.0	1.58	--	66.7	1.5	0.372	0.15	0.10	0.06	56%
Property Boundary Soil	0.5	1.58	--	82.7	1.5	0.311	0.15	0.12	0.05	38%
Property Boundary Soil	1.0	1.58	--	82.7	1.5	0.343	0.15	0.12	0.05	41%
Tadanac	0.5	1.61	--	62.7	1.5	0.339	0.15	0.09	0.05	54%
Tadanac	1.0	1.61	699	62.7	1.5	0.361	0.15	0.09	0.05	58%
Tadanac duplicate	0.5	1.47	--	63	1.5	0.412	0.15	0.09	0.06	66%
Tadanac duplicate	1.0	1.47	417	63	1.5	0.383	0.15	0.09	0.06	61%
NIST SRM 2710 Montana Soil	0.5	1.60	--	20 [a]	1.5	0.162	0.15	0.03	0.02	81%
NIST SRM 2710 Montana Soil	1.0	1.60	--	20 [a]	1.5	0.166	0.15	0.03	0.02	83%
Bartlesville Soil[b]	0.5	1.60	--	174 [c]	1.5	1.278	0.15	0.26	0.19	73%
Bartlesville Soil[b]	1.0	1.58	380	174 [c]	1.5	1.27	0.15	0.26	0.19	73%

[a] Value from NIST study of acid-leachable analytes in standard reference materials (Kane 1995).
[b] Composite of Bartlesville residential soil (BVRSC-01)
[c] Value from PTI (1994) and is the result of multiple analyses (reported as 174 ± 2 ppm).
-- = No analysis performed.

Appendix A

Derivation of Vegetable Ingestion Rates

DERIVATION OF VEGETABLE INGESTION RATES

Ingestion rates for non-leafy and leafy vegetables, on a dry-weight basis, can be derived using the following information:

Total vegetable ingestion = 250 g/d

Mean moisture content for non-leafy vegetables = 80%
(or dry weight = 20%, or 0.2)

Mean moisture content for leafy vegetables = 90%
(or dry weight = 10%, or 0.1)

7% of vegetable consumption is leafy vegetables (dry weight)

93% of vegetable consumption is non-leafy vegetables (dry weight).

On the basis of this information, we can establish dry-weight leafy and non-leafy vegetable consumption as follows:

x = g/d dry-weight non-leafy vegetable consumption

y = g/d dry-weight leafy vegetable consumption

$$\left(\frac{1}{0.2}\right)(x)+\left(\frac{1}{0.1}\right)(x)=250\text{ g/d}$$

$$x=\left(\frac{93}{7}\right)y$$

$$x=(13.3)y$$

$$\left(\frac{1}{0.2}\right)(13.3y)+\left(\frac{1}{0.1}\right)(y)=250\text{ g/d}$$

$$66.5y+10y=250\text{ g/d}$$

$77.5y = 250$ g/d

$y = 3.2$ g/d leafy vegetable consumption

$x = (13.3)\ (3.2) = 42.6$ g/d non-leafy vegetable consumption.

Appendix B

In Vitro Testing

IN VITRO BIOACCESSIBILITY TESTING

The *in vitro* extraction test is designed to determine the fraction of an inorganic element that is solubilized and available for absorption in the gastrointestinal tract. The *in vitro* method was designed to replicate gastrointestinal-tract parameters for a human child, including stomach pH and chemistry, soil-to-solution ratio, stomach mixing, and stomach emptying rate.

IN VITRO TEST METHOD

The reaction is carried out in a sealed container (Figure 1), to minimize interactions between the reaction fluid and atmospheric oxygen, and the potential for cross contamination. Argon gas was introduced into the reaction vessel at the beginning of the *in vitro* assay to purge it of atmospheric oxygen, to simulate the anoxic conditions present in the gastrointestinal tract.

The *in vitro* test is conducted according to the following method (all chemicals from Sigma Chemical Company, unless otherwise noted):

- Prepare the stomach solution by adding the following compounds to 1 L of deionized water (stirred continually on a stir plate)
  - 1.25 g pepsin (50 mg, activity of 800–2,500 units/mg)
  - 0.50 g citrate (Fisher Chemical Co.)
  - 0.50 g malate (Aldrich Chemical Co.)
  - 420 μL lactic acid (synthetic syrup 85 percent w/w)
  - 500 μL acetic acid (97 percent w/w; Fisher Chemical Co.).
- Adjust the pH of the stomach solution to 2.0 by adding a measured volume of concentrated HCl.
- Add 150 mL of stomach solution to the 200-mL acrylic reaction vessel.
- Sparge the stomach solution with argon for 10 minutes to remove oxygen.
- Add 1.5 g of soil and seal the reaction vessel.

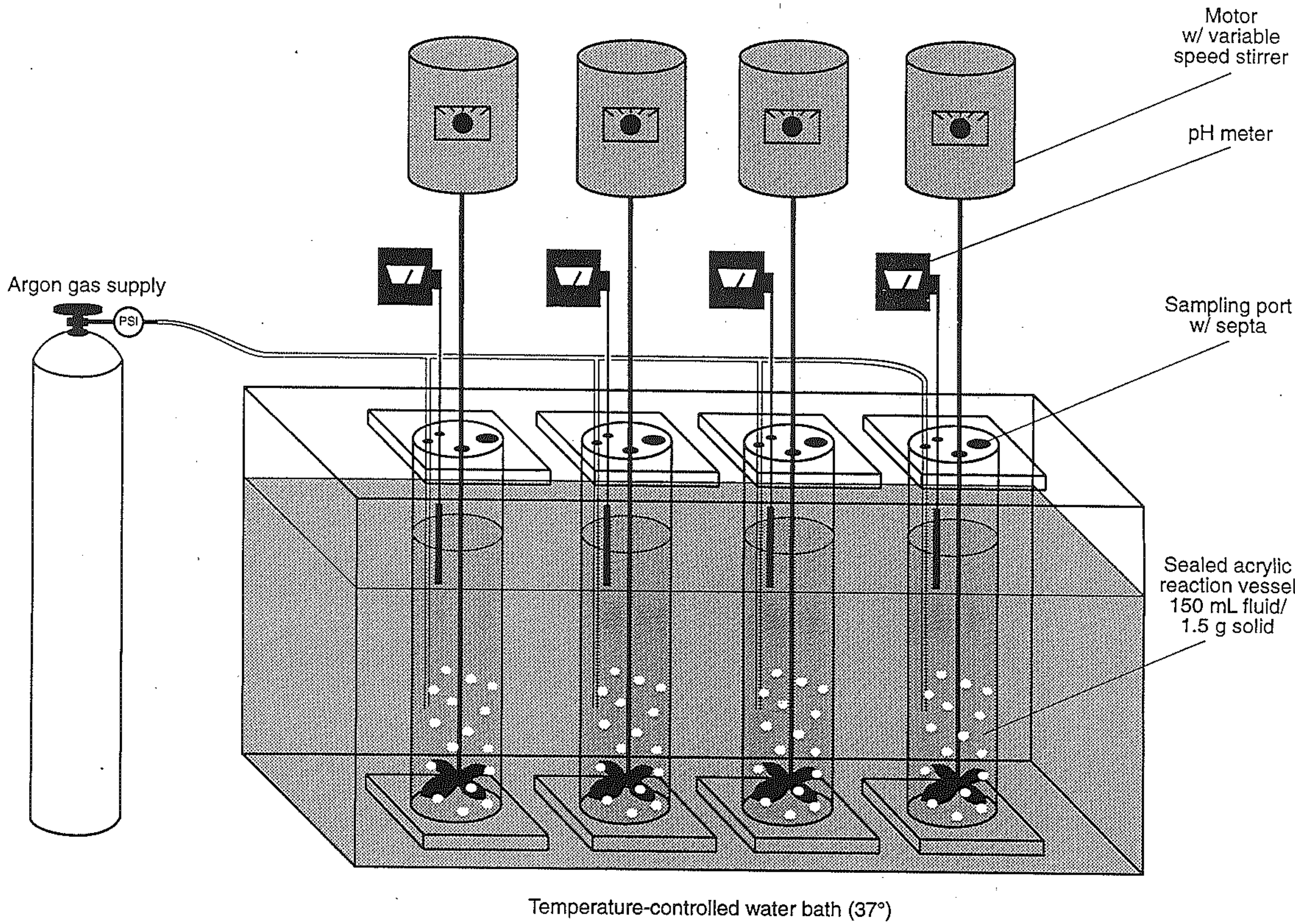

Figure 1. Schematic of *in vitro* experimental system.

- Submerge the reaction vessel approximately half-way into a temperature-controlled water bath heated to maintain a constant 37 °C in the reaction vessel.
- Allow the soil/stomach solution to stand (no agitation) for 10 minutes.
- Stir the mixture with a plastic propeller stir rod mounted in a rheostat-controlled motor (Arrow Engineering Model 1750 motor on a rheostat setting of 2, resulting in approximately 150 rpm for the stir rod).
- Check the pH at 5-minute intervals, and readjust to pH 2.0 with HCl if necessary.
- Collect a 5-mL sample at 30 minutes and a 50-mL sample at 60 minutes, using a stainless-steel hypodermic syringe. Filter the samples through a 0.45-μm acetate syringe filter.
- After the final sample is collected, measure and record the pH and final volume of the flask contents.
- Preserve the 5-mL and 50-mL stomach-phase samples with 50 μL and 500 μL concentrated nitric acid, respectively.
- Refrigerate the samples, and ship on ice to the laboratory.
- Analyze the appropriate stomach-phase samples for arsenic, beryllium, cadmium, or lead concentration, by the analytical method described in the work plan.

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Estimation of Lead and Arsenic Bioavailability Using a Physiologically Based Extraction Test

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The physiologically based extraction test (PBET) is an *in vitro* test system for predicting the bioavailability of metals from a solid matrix and incorporates gastrointestinal tract parameters representative of a human (including stomach and small intestinal pH and chemistry, soil-to-solution ratio, stomach mixing, and stomach emptying rates). For lead (Pb), the results of the PBET are linearly correlated with results from a Sprague-Dawley rat model ($r^2 = 0.93$ between *in vitro* and *in vivo* results, $n = 7$). For arsenic (As), the results of the PBET are overpredicting bioavailability study results in rabbit and primate models (2–11% difference between *in vitro* and *in vivo* results, depending on the animal model). The PBET was not designed to supplant bioavailability studies using animal models, but rather to estimate Pb and As bioavailability when animal study results are not available. Dissolution of Pb in the acidic stomach environment was strongly pH dependent; the extent of dissolution decreased by 65% when stomach pH was increased from 1.3 to 2.5. Arsenic solubility decreased by only 16% over the same pH range. Lead was removed from solution to a greater extent than As by neutralization during the small intestinal simulation, consistent with adsorption and precipitation reactions occurring for Pb—but not As—at neutral pH values. In addition to providing mechanistic explanations for controls on Pb and As bioavailability, the PBET allows estimates of site-specific Pb and As bioavailability from soil for the purpose of exposure assessment.

Introduction

When assessing risks associated with lead (Pb)-contaminated soils, one exposure pathway typically evaluated is soil ingestion by children. Standard procedures recommended by the U.S. Environmental Protection Agency (EPA) for estimating soil Pb exposures in children assume that 30% of ingested soil Pb will be absorbed into the systemic circulation (i.e., will be bioavailable) (*1*). However, recent studies suggest that Pb bioavailability may be dependent on the form and solubility of Pb present (*2–4*) and site-specific soil chemistry (*5*). Studies in rats of the bioavailability of Pb derived from mining wastes or smelter emissions have confirmed the dependence of Pb bioavailability on Pb form (*6–9*). Therefore, application of a default 30% bioavailability value may not be appropriate for all types of Pb contamination.

To address this issue, development and validation of a physiologically based extraction test (PBET) for site-specific estimation of soil Pb bioavailability was undertaken (*10*). This test was based on the premise that the form and solubility of Pb in a soil or mine waste will control its bioavailability in an animal model or in humans. This paper describes method development and validation of an *in vitro* test method that is predictive of Pb bioavailability in an animal model. In addition, the PBET has been used to screen for Pb bioavailability of Pb-containing soils and waste materials to determine whether a Pb bioavailability study in an animal model would be warranted. The PBET also appears to be useful in studying the gastrointestinal (GI) tract parameters that control lead bioavailability (e.g., stomach pH and residence time, lead mineralogy, and soil type) and in evaluating the efficacy of *in situ* soil amendments designed to reduce lead bioavailability.

In evaluating arsenic (As)-related risk, the U.S. Environmental Protection Agency (EPA) has derived a cancer slop factor (CSF) and a reference dose (RfD) for use in assessing the cancer risks and other noncancer adverse health effects, respectively, that might be associated with oral exposures to As (*11*). Oral toxicity values typically are derived from animal or human studies that characterize adverse health effects in response to an orally administered dose. However, the administered dose of a compound is seldom completely absorbed, and for many compounds, there are significant differences in the extent of oral absorption from different media. This can lead to overly conservative and costly assumptions in assessing the potential risk of exposure to a particular compound in a medium other than the one used in the studies on which toxicity values are based. The oral toxicity values for As were derived from epidemiological studies of As in drinking water (*12, 13*). Studies investigating the absorption of soluble As ingested by humans suggest that close to 100% of soluble inorganic As is absorbed from the gastrointestinal tract (*14*). In contrast to As in drinking water (soluble As), As in soils generally exists as mineral forms or soil–As complexes that will be incompletely solubilized during transit through the gastrointestinal tract. Recent research indicates that As must be dissolved in order to be absorbed (*15*); therefore, As in soil will be less well absorbed than arsenic in drinking water. Therefore, a bioavailability adjustment factor may be necessary to accurately assess potential risks associated with ingestion of soil As by correcting for the difference in absorption between As in soil and in drinking water.

Reduced absorption of arsenic from soils, relative to

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soluble forms, has been demonstrated in rabbits, dogs, microswine, and monkeys. Arsenic bioavailability from Netherlands soils produced only 8.3% absolute As bioavailability in dogs, when compared to intravenous administration of soluble As (*16*). The soil tested in this study was described as bog ore, with arsenic bound to clay surfaces within it, specifically iron and aluminum oxides. Soil samples affected by smelter emissions were used in studies of New Zealand White rabbits and *Cynomolgus* monkeys, resulting in 48 and 20% As bioavailability, respectively, relative to soluble As (*17, 15*), based on urinary As data. House dust studied in the *Cynomolgus* monkey model resulted in 28% relative As bioavailability (*15*). Recent studies of As bioavailability from mining and smelting wastes in a microswine model also indicate reduced As bioavailability relative to soluble As. These studies indicate that As adsorbed to organic material or clay surfaces in soils, or present as As mineral phases, results in limited As bioavailability in animal models. Because As bioavailability appears to be limited by As form and solubility, the PBET was also developed for As bioavailability estimation. The PBET provides a tool for screening site-specific exposure to As in the absence of As bioavailability data from an animal model. The bioavailability adjustment determined from the PBET can be incorporated into an As risk assessment by use of a bioavailability adjustment factor (ranging from 0 to 1) to adjust soil As exposure estimates so that they are expressed in the same terms as water As exposure estimates.

For the purpose of this paper, the absolute bioavailability of Pb and As is defined as that fraction of ingested Pb and As that is absorbed into systemic circulation. The term "relative bioavailability" is used to describe the bioavailability of Pb and As in mine waste or soil relative to that of Pb and As dissolved in water. Because the bioavailability of Pb and As dissolved in water has been determined in humans, the measurement of relative bioavailability in animal models allows correction of these experimental values back to humans. For example, the bioavailability of Pb in the diet of children (e.g., soluble Pb) is approximately 50% (*1*). If relative Pb bioavailability from a particular soil was determined to be 20% in an appropriate animal model, then this value could be corrected for the known uptake of soluble Pb in children (correction factor of 0.5) to arrive at an estimated 10% absolute Pb bioavailability for this substrate in children. This extrapolation from the animal model to children does not require that the animal mimic or be equivalent to children, but rather that Pb from the test material behave proportionally the same relative to soluble Pb in children and the animal model. Similarly, because the bioavailability of As dissolved in water has been determined in humans, the measurement of relative As bioavailability in animal models provides the most relevant data for correction back to a human model. Finally, the term "bioaccessibility" is used to define the fraction of total Pb and As that dissolves in the stomach and is available for absorption during transit through the small intestine. The bioaccessibility of Pb and As provides a measure of solubility in the gastrointestinal tract. The fraction of bioavailable Pb and As will be less than the fraction of bioaccessible Pb and As, due to incomplete uptake of solubilized Pb and As in the small intestine.

The PBET was designed around pediatric GI tract parameters for a child 2–3 years old, believed to be at the greatest risk to metal exposure from accidental soil ingestion. This approach was taken to develop a test based on the biological model of interest (e.g., humans, specifically, children) based on the premise that replicating the conditions in the model of interest would produce the most relevant data. Because bioavailability of the test materials could not be measured directly in children, the PBET could not be validated against this particular model. Therefore, animal models were relied upon for comparison to the PBET results, based on the premise that data from appropriate animal models can be extrapolated to humans for the purpose of exposure assessment. Thus, the validation of the PBET is specific to the animal models used, and the usefulness of the test in predicting human exposure is based on extrapolation of these animal data to humans.

It should be noted that the PBET is a screening-level test and does not mimic the entire physiological process controlling uptake of Pb and As. It has not been designed to simulate transport of Pb and As across the intestinal epithelium. As a result, the test cannot evaluate the dose dependency of absorption. *In vivo* studies indicate that saturation of uptake mechanisms results in dose-dependent uptake of Pb (*6, 18, 19*), causing uptake to decrease at higher Pb doses; this phenomenon has not been observed for As at environmental dose levels (*17*). Because the PBET tests only for Pb solubility constraints, it will tend to overestimate Pb bioavailability if dose-dependent uptake causes a significant reduction in Pb uptake. Pb and As absorption in the small intestine may also create a disequilibrium in the small intestinal fluid, which results in additional dissolution of Pb and As (i.e., the small intestine provides a sink for Pb and As); this eventuality has not been evaluated in the PBET. In addition, the PBET, as described herein, does not account for the presence of food in the gastrointestinal tract. Although nutritional status is known to effect Pb and As uptake (*20*), the PBET has been used to mimic fasting conditions, which produce the most soluble Pb and As, and, hence, the most conservative condition. Despite these limitations, which are the topic of ongoing research, the PBET appears to produce data that correlate well with measures of Pb and As bioavailability in animal models.

This paper provides data for seven Pb and three As substrates that were evaluated using both the PBET and animal models, compares the PBET results to those from the animal bioavailability studies, and suggests a screening-level method for extrapolating PBET data to evaluations of human exposure to Pb and As in soil.

Test Materials

Substrates evaluated for Pb bioaccessibility in the PBET included two composite mine waste materials from Butte, MT (BMW-I and BMW-II, Table 1); two composite residential soil samples from the vicinity of historical zinc and lead smelters in Bartlesville, OK (BVS) and the Salt Lake City, UT (SCS) areas, respectively; two composite tailings samples from the Copperton tailings, UT (CT-1 and CT-2); and a composite stream channel sample from the Bingham Creek channel, UT (CT-3). The Bingham Creek channel sample contains Pb that is probably related to historical mining and milling operations conducted in the area. These substrates were tested for Pb bioavailability using dosed-feed oral bioavailability studies in Sprague-Dawley rats (*6, 8, 21, 22*), allowing comparison of the PBET results to bioavailability data from a rat model.

Arsenic bioaccessibility was evaluated in two composite residential soil samples (ARS-I and ARS-II, Table 2) and

TABLE 1

Lead Test Material Composition

sample origin	Butte mine waste no. 1	Butte mine waste no. 2	Bartlesville soil	Salt Lake City soil	Copperton tailings no. 1	Copperton tailings no. 2	Bingham Creek Channel
sample identifier	BMW-I	BMW-II	BVS	SCS	CT-1	CT-2	CT-3
lead concn (mg/kg)	3940	3908	1388	2090	7220	6890	10 230
pH	3.6	3.7	7.0	7.5	2.4	2.8	4.9
total organic carbon (%)	2.6	4.1	12.8	NA[b]	0.6	1.8	2.9
particle size (GMS ± GSD)	23 ± 4	42 ± 44	23 ± 4	NA	38 ± 3	23 ± 5	21 ± 5
mineralogic analysis	% Pb Mass Distribution in Mineral Phases						
phase							
anglesite	29	53	11	17	62	50	40
galena	19	24	4		6	6	1
manganese–lead oxide	13		47	3		1	8
lead phosphate	26	8	10	30		1	3
iron-lead oxide		4	11	10			4
iron-lead sulfate	8	7	4	6	32	21	3
cerussite	5			9		21	28
slag			5				
metal-lead oxide[a]			5	15			4
lead oxide		3		4			9
lead-organic carbon			1				
elemental lead			2	6			
no. of particles counted	302	160	94	142	136	303	174

[a] Metals in metal–lead oxide are primarily Zn, Cu, As, Ba, and Cr. [b] NA = not available.

TABLE 2

Arsenic Test Material Composition

sample origin	Anaconda residential soil no. I	Anaconda residential soil no. II	Anaconda house dust no. I
sample identifier	ARS-I	ARS-II	AHD-I
arsenic concn (mg/kg)	3900	410	170
pH	6.6	7.8	7.6
total organic carbon (%)	7.4	12	42
particle size (GMS ± GSD)	19 ± 23	25 ± 4	31 ± 3
mineralogic analysis	% As mass distribution in mineral phases		
metal–arsenic oxide[a]	51	46	58
iron–arsenic oxide	35	17	9
metal–arsenic sulfide[b]	1	7	11
arsenic phosphate	1	7	6
slag	7	7	8
iron–arsenic sulfate	3	5	1
metal–arsenic silicate[c]	2	11	7
no. of particles counted	306	587	207

[a] Metals in metal–arsenic oxide are primarily Cu, Zn, Fe, and Al in varying proportions. [b] Metal–arsenic sulfides are a combination of enargite (Cu_3AsS_4), arsenopyrite (FeAsS), and complex solid solutions containing Cu, Te, Pb, Bi, or other metals. [c] Metals in metal–arsenic silicate are primarily Fe and Al in varying proportions.

one composite house dust sample (AHD-I) from the vicinity of a historical copper smelter in Anaconda, MT, while As bioavailability from these three samples was determined in either New Zealand White rabbits or *Cynomolgus* monkeys (*17, 15,* respectively).

Methods

Selection of PBET Parameters. Rationale for the selection of PBET parameters for gastric and small intestinal pH values, soil mass, and fluid volume, stomach mixing and emptying rate, and small intestinal transit time is described below. The rationale for selection of stomach and small intestinal fluid composition, titration of reaction fluid pH on entering the small intestinal phase, and the method for collection of *in vitro* extract samples are discussed in a previous publication (*10*). In cases where only limited information was available to support selection of a test parameter, a conservative value was selected to maintain the overall conservative nature of the test.

Gastric and Small Intestinal pH. Because pediatric gastric pH is quite variable among individuals, and depends strongly on nutritional status, selecting an appropriate value is a difficult task. Research on pediatric gastric pH using both *in vivo* (ref 23, pH electrode emplaced in lower esophagus, $n = 154$) and *in vitro* (ref 24, aspiration of stomach fluid followed by pH measurement, $n = 105$) measurements of pH resulted in mean fasting pH values of 1.7–1.8. Both studies recorded fasting pH ranges from 1 to 4. Following ingestion of food, pediatric gastric pH values rise to >4 (*23*) and subsequently return to basal values within 2 h as food is emptied from the stomach. This behavior is consistent with adults, whose mean fasting gastric pH of approximately 2.0 (*25*) increases to 4–5 following ingestion of a meal (*26*). Gastric pH values

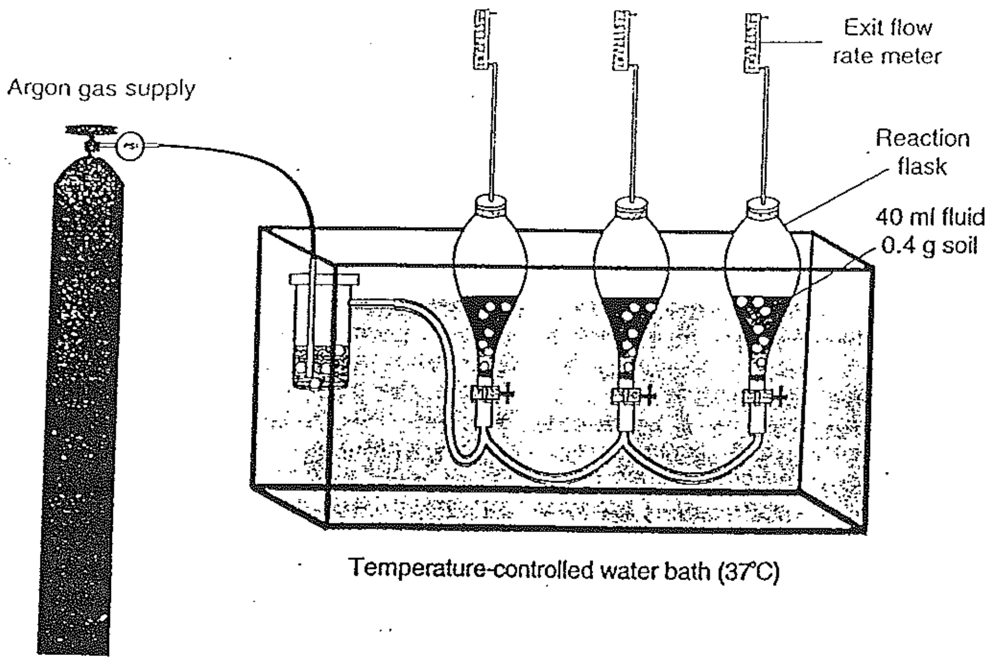

FIGURE 1. Schematic of PBET experimental system.

selected for use in the PBET to represent fasting, "average," and fed states were 1.3, 2.5, and 4.0. The fasting gastric pH value of 1.3 is consistent with an earlier version of the *in vitro* test system and is based on fasting gastric pH measured in rabbits (*10*). The "average" gastric pH value of 2.5 was selected to provide an intermediate pH for testing in the PBET and represents a nutritional status intermediate between fasting and fed states. The gastric pH value of 4.0 is consistent with recent ingestion of food.

A small intestinal pH value of 7.0 was selected for use in the PBET, consistent with measured small intestinal pH values in humans (*27*).

Soil Mass and Fluid Volume. The mass of material used in the reaction vessel was selected after considering EPA's estimate of the mass of soil ingested by a 2- to 3-year-old child (estimated at 0.135 g/day, ref 1) and the minimum feasible soil sample size. A soil mass of 0.4 g was chosen as a minimum value that would ensure a homogeneous split of soil for each test. The volume of fluid in the reaction vessel was maintained at 40 mL, so the solid-to-fluid volume ratio was kept constant, at 1:160 (assuming a density of 1.6 g/cm^3 for the test soil). Soil-to-fluid ratios in the range of 1:5 to 1:25 have been observed to affect dissolution of metals in extraction procedures of this type (*28*), most likely due to diffusion-limited dissolution kinetics, and with this in mind, the soil-to-fluid ratio was selected such that this parameter would not control the test results. Because insufficient data were available for fasting children to support any particular solid-to-fluid volume, a fluid volume of 40 mL was selected arbitrarily to represent a fasting child.

Stomach Mixing. Mixing in the stomach is accomplished by peristalsis, wherein peristaltic constrictor rings force the stomach contents toward the pylorus; the majority of the material cannot pass through the relatively small pylorus into the duodenum, so it is squirted backward through the peristaltic ring toward the body of the stomach (*29*). This mechanism provides for thorough mixing of the stomach contents. Mixing in the PBET was achieved by placing the fluid in a 250-mL polyethylene separatory funnel with a 70-μm frit seated in the bottom, and passing argon (1.0 L/min) through the reaction mixture (Figure 1). Prior to introduction into the separatory funnel, the argon was hydrated and brought to 37 °C by passing through a temperature-controlled water trap. This experimental setup allows control of the mixing rate by adjusting the argon flow and provides turbulent mixing of the reaction mixture as the soil particles are suspended in the test fluid. It is possible that this mixing mechanism may be overly aggressive, thereby overestimating mixing in the child's stomach, an eventuality that will be evaluated in future studies.

Stomach Emptying Rate. The human stomach empties in an exponential fashion, with the fastest emptying rate occurring immediately after a meal is ingested. In adults, approximately 80% of stomach emptying occurs during the first hour after ingestion of a meal, with complete emptying occurring within 2 h (*30*). A recent study using epigastric impedance to measure stomach emptying in healthy children found a half-emptying time ($t_{1/2}$) of 13.5 min for orange squash (n = 45) and 17.0 min for orange squash with 1.25 percent fat content [n = 12 (*31*)]. Since four consecutive $t_{1/2}$ intervals result in approximately 94% emptying, these data suggest that a child's stomach empties in 54–68 min for these two meal types. On the basis of these observations, a stomach incubation time of 1 h was selected for the PBET, despite the fact that a stomach emptying time of 1 h is based on the presence of food while the other PBET parameters are based on a fasting individual. Stomach emptying times in the absence of food are expected to be more rapid than 1 h, as described below.

Small Intestinal Transit Time. As a result of peristaltic waves that move chyme (semifluid digested food material) along the small intestine, 3–5 h is required for passage of chyme from the top of the small intestine to the entrance to the large intestine in adults (*29*). Studies of orocoecal transit time (from ingestion to the ileocecal valve at the entrance to the large intestine) in healthy children (n = 7) after ingestion of a semisolid meal resulted in an average orocoecal transit time of 4.5 h (*32*). Subtracting a 1-h stomach transit time from the above value results in a pediatric small intestinal transit time of 3.5 h. It should be noted that orocecal transit times following ingestion of a fluid meal are considerably shorter: approximately 60 min (*32, 33*). On the basis of these data, a 4-h small intestinal transit time was selected for the PBET.

Sample Preparation. All samples were oven dried (24 h at 50 °C) and sieved to <250 μm. Lead and As concentrations in the test materials were measured by digestion [method 3050 (*34*)] and GFAA [methods 7420 and 7060, respectively (*34*)]. Sample pH was measured using the soil slurry method [method 9045 (*34*)]. Total organic carbon (TOC) was measured by weight loss on ignition at 430 °C. Particle size distribution was measured using the electrozone method (Particle Data Laboratories, Elmhurst, IL). Lead and As mineralogies were evaluated using an electron microprobe by the method of ref 2 to identify Pb- and As-bearing phases. Lead and As mass distribution among phases in each sample was calculated by correcting the percent occurrence data by the Pb or As concentration and specific gravity of each phase and normalizing the resultant data to 100%.

PBET Procedure. Gastric solution for the PBET was prepared by adjusting 1 L of DI water to the selected pH with 12 N HCl and adding 1.25 g of pepsin (activity of 800–2500 units/mg), 0.50 g of citrate (Fisher Chemical Co.), 0.50 g of malate (Aldrich Chemical Co.), 420 μL of lactic acid (synthetic syrup), and 500 μL of acetic acid (Fisher Chemical Co.). All chemicals were from Sigma Chemical Co. unless otherwise noted. Forty mL of stomach solution was combined with 0.4 g of test material in a 250-mL polyethylene separatory funnel. The funnel was submerged approximately half-way in a temperature-controlled water bath maintained at 37 °C (Figure 1). The substrate/stomach solution mixture was allowed to stand (no agitation) for 10 min, after which argon gas was purged through the reaction vessel at 1 L/min to provide mixing, as described in the section on Stomach Mixing. The pH was checked after 5 min, and every 10 min thereafter, and the pH was adjusted with HCl as necessary. Samples (2 mL each) were collected at 20, 40, and 60 min and centrifuged at approximately 2100*g* for 25 min, and the liquid fraction was decanted. The 2-mL sample volume was replaced with gastric solution to maintain a 40-mL volume in the reaction flask. After 1 h, the reaction was titrated to pH 7 by adding a 5-in.-long dialysis bag (8000 MWCO, Spectra/Por cellulose ester tubing) containing approximately 1 g of $NaHCO_3$ and 2 mL of DI water. The exact amount of $NaHCO_3$ was determined by calculating the amount of HCl added to each vessel and the amount of $NaHCO_3$ necessary to neutralize it. The dialysis bag was removed when the reaction vessel reached pH 7, and 70 mg of bile salts (porcine) and 20 mg of pancreatin (porcine) were added. Samples (2 mL) were obtained from the small intestinal incubation at 1 and 3 h after the reaction flask reached equilibrium at pH 7. Lead and As concentrations in the extracts were determined by ICP [method 6010 (*34*)].

The bioaccessibility of Pb from sample BMW-I was determined using the PBET in triplicate at gastric pH values of 1.3, 2.5, and 4.0. Sample BVS was evaluated at gastric pH values of 1.3 and 3.0, and all of the other Pb substrates were analyzed at gastric pH values of 1.3 and 2.5. Both samples ARS-I and ARS-II were evaluated at gastric pH values of 1.3 and 2.5, and sample AHD-I was evaluated at a pH of 2.5. Soluble Pb and As spikes (spiked at 5 mg/L) were performed at pH values of 1.3 and 2.5 to evaluate recovery of soluble Pb and As (no soil present) from the test system. Pb and As bioaccessibility (%) was calculated as the fraction present in the fluid phase divided by total Pb or As in the reaction vessel, times 100.

Results

Lead concentrations in the seven substrates tested ranged from 1388 to 10 230 mg/kg (Table 1), providing an order-of-magnitude range in the Pb concentrations tested. Arsenic concentrations ranged from 170 to 3900 mg/kg (Table 2). Sample pH values reflected sample provenance, with tailings and mine-waste materials producing acidic pH values (range of 2.4–4.9) and residential soils and house dust producing near-neutral pH values (range of 6.6–7.8). TOC varied, as expected, based on the origin of the test materials. The tailings-derived materials exhibited TOC values of 0.6–2.9%, the Butte mine-waste materials contained 2.6–4.1% TOC, and the residential soils from Bartlesville and Anaconda ranged from 7.4 to 12.8% TOC (Tables 1 and 2). The Anaconda house dust contained 42% TOC, consistent with house dusts containing a sizable component of exfoliated skin cells, hair, food particles, mites, and insect parts (*35*). Volume-based particle size distribution was determined to provide the geometric mean size (GMS) and geometric standard deviation (GSD) of the test substances. The GMS ranged from 19 to 42 μm for the test substances, indicating that particles were within the size fraction (<100 μm) that adheres to children's hands and may be ingested (*36*).

Pb and As Mineralogy. Results from the electron microprobe analyses (Table 1) indicate that the Pb mass distribution in the mineral phases of samples BMW-I and BMW-II, from Butte, are dominated by galena (PbS), its oxidation product anglesite ($PbSO_4$), and lead phosphates of variable composition. The occurrence of anglesite and galena is consistent with a mining waste provenance, as is the observation that Pb particles in BMW samples were frequently encapsulated (or included) in sulfide (pyrite) or silicate (quartz, feldspar) minerals. In contrast, sample BVS, from Bartlesville, was dominated by soil alteration phases (manganese–lead oxide, iron–lead oxide, and lead phosphate); Pb phases resulting from natural soil weathering processes. This observation is consistent with the average of 66% of mineral-phase Pb attributed to soil Pb alteration phases in Bartlesville soils (*21*). In addition, Pb particles in Bartlesville soils were generally not included within other mineral phases (i.e., they were present as liberated particles), rendering them available for dissolution. Similarly, sample SCS contained primarily soil alteration Pb phases, with the addition of metal–lead oxides (metal = As, Zn, and Cu) and cerussite (Table 1) to the Pb phases occurring in sample BVS. The tailings material samples (CT-1 and CT-2) exhibited a lead mineralogy consistent with a surficial tailings environment, comprising galena, anglesite, and an iron–lead sulfate with a chemistry representative of lead jarosite [$PbFe_6(SO_4)_4(OH)_{12}$]. Cerussite ($PbCO_3$), which was observed in one of the samples, was a primary mineral phase in the orebody from which the tailings were derived. Lead solubility from the tailings materials will be controlled by the limited solubility of anglesite in gastric fluid (*3*) and by the rinding of anglesite and cerussite particles by Pb jarosite, which is stable in acidic solutions [pH < 4, (*37*)]. The sample composed of tailings mixed with stream channel material (CT-3) contained a Pb mineralogy similar to the two tailings samples (CT-1 and CT-2), with the addition of

TABLE 3

Comparison of Pb PBET Results (% Bioaccessibility) and Pb Bioavailability Data

time[a] (h)		BMW-I pH 1.3[b]	BMW-I pH 2.5[b]	BMW-I pH 4.0[b]	BMW-II pH 1.3[d]	BMW-II pH 2.5[d]	BVS pH 1.3[c]	BVS pH 3.0[d]	SCS pH 1.3[c]	SCS pH 2.5[b]
0.33	stomach	7.0 ± 2.0	2.7 ± 1.6	1.1 ± 0.6	22	6	68	22	72	11 ± 4
0.66	phase	8.3 ± 2.0	3.1 ± 2.1	1.1 ± 0.8	31	10	70	25	75	20 ± 2
1.0		9.5 ± 0.4	3.8 ± 1.6	1.3 ± 0.6	35	13	69	26	83	22 ± 6
2.2	small	3.6 ± 2.7	0.94 ± 1.2	0.84 ± 0.2						
3.2	intestine	2.0 ± 0.4	1.4 ± 0.6	0.60 ± 0.2	4	5	16	13	27	8 ± 2
4.2	phase	1.0 ± 1.4	0.94 ± 0.2	0.48 ± 0.2	4	3	12	11	25	7 ± 0
rel Pb bioaccessibility (%) based on stomach data[e]		9.5	3.8	1.3	35	13	70	26	83	22
rel Pb bioaccessibility (%) based on small intestinal data[f]		4.6	2.7		8.3	9.8	29	29	54	18
relative Pb bioavailability in rats[g] (%)			9.3		22.5		35		41	

time[a] (h)		CT-1 pH 1.3[d]	CT-1 pH 2.5[d]	CT-2 pH 1.3[d]	CT-2 pH 2.5[d]	CT-3 pH 1.3[d]	CT-3 pH 2.5[d]	soluble Pb spike pH 1.3[c]	soluble Pb spike pH 2.5[c]
0.33	stomach	12	6.8	8	4	39	22	95	96
0.66	phase	14	8	9	6	42	24	99	98
1.0		16	8	10	6	49	24	108	104
2.2	small								
3.2	intestine	1.2	0.3	0.7	0.7	5	7	53	41
4.2	phase	1.7	0.2	0.4	1.0	8	7	43	41
rel Pb bioaccessibility (%) based on stomach data[e]		16	8	10	6	49	24	48	41
relative Pb bioaccessibility based on small intestinal data[f]		3.0	0.6	1.1	2.1	14	17		
rel Pb bioavailability in rats[g] (%)		14.7		8.7		36			

[a] Time from start of PBET assay. [b] Average ±95% upper confidence limit (1.96σ) on triplicate PBET results. [c] Average of duplicate PBET results. [d] Single PBET test. [e] Relative Pb bioaccessibility values based on stomach data are maximum solubilized Pb in the stomach phase, corrected for maximum recovery of soluble Pb spike in the stomach phase. [f] Relative Pb bioaccessibility (%) based on small intestinal data are average solubilized Pb in the small intestinal phase, corrected for the average recovery of soluble Pb spike in the small intestinal phase. [g] Values presented are relative Pb bioavailability in rats, based on blood-Pb data from dosed-feed studies in Sprague-Dawley rats.

soil Pb alteration phases (e.g., ferromanganese lead oxides, lead phosphate, and metal–lead silicate, Table 1). The presence of more soluble Pb phases (e.g., lead oxide, cerussite, and lead silicates) in the stream channel sample suggests that it will yield a greater fraction of bioaccessible Pb than the two tailings material samples. It should be noted that surface-adsorbed Pb (not detectable by electron microprobe) also constitutes a fraction of the bulk Pb pool that will probably be readily desorbed and more bioaccessible in the acidic gastric environment than the mineralogic phases.

Arsenic mass distribution was similar in samples ARS-I, ARS-II, and AHD-1 and consisted primarily of metal–As oxides (metal = Cu, Zn, Fe, and Al in varying proportions) and iron–arsenic oxides, with minor As contribution from slag, metal–arsenic silicate, As phosphate, metal–arsenic sulfides, and iron–arsenic sulfate (Table 2). As with Pb, surface-adsorbed As most likely constitutes a fraction of the bulk As pool in soil, and is generally adsorbed to hydrous iron and aluminum oxides.

PBET Results for Pb. Triplicate PBET analyses of sample BMW-I at three pH values indicated reproducible results, with reproducibility generally better in the gastric than the small intestinal portion of the test, based on upper 95% confidence limits on the triplicate analyses (Table 3). Results indicate that Pb dissolution in the gastric environment is strongly pH dependent, with an average 57% decrease in soluble Pb when gastric pH was raised from 1.3 to 2.5 (3.0 for BVS) for the seven samples tested. Increasing stomach pH from 2.5 to 4.0 for BMW-I resulted in a further 66% decrease in stomach-solubilized Pb for sample BMW-I (Table 3). On entering the small intestinal phase, solubilized Pb decreased by 74 ± 18%, consistent with extensive adsorption and precipitation reactions removing Pb from solution as the pH increased. It should be noted that solubilized Pb in the test is operationally defined as that portion of Pb remaining in solution after relatively low-speed centrifugation (2500*g* for 25 min). Solubilized Pb in the small intestinal phase remained generally constant or decreased slightly as the incubation time increased for all seven test substrates. Soluble Pb spikes were approximately 100% recovered in the stomach phase of the test, independent of pH, with recoveries of approximately 48 and 41% in the small intestinal phase when gastric pH values were 1.3 and 2.5, respectively (Table 2).

Comparison of the PBET Pb bioaccessibility values for the seven substrates indicates that the model is sensitive to changes in substrates, with tailings and mine waste producing less bioaccessible Pb than the Pb-bearing soils. These results are consistent with Pb solubility expectations for the various substrates based on the Pb mineralogy data. Galena, anglesite, and lead jarosite contained less bioaccessible Pb than did Pb phases such as lead oxide, cerussite, manganese–lead oxide, and metal–lead oxide. Lead bioaccessibility also varied with pH and TOC of the test material. Acidic pH of the test material results in decreased Pb bioaccessibility, most likely due to formation of soil alteration Pb phases such as anglesite and lead jarosite that are stable in the acidic gastric environment. Neutral soil pH results in soil alteration phases such as cerussite

TABLE 4

Comparison of As PBET Results (% Bioaccessibility) and As Bioavailability Data

time[a] (h)		ARS-I		ARS-II		AHD-I	soluble As spike	
		pH 1.3[b]	pH 2.5[c]	pH 1.3[b]	pH 2.5[c]	pH 2.5[c]	pH 1.3[c]	pH 2.5[d]
0.33	stomach	45	33	43	38			83 ± 4
0.66	phase	49	41	48	44	29	102	93 ± 11
1.0		55	40	49	45	34	103	90 ± 16
2.2	small	50	34	44	30	36	96	99 ± 20
3.2	intestinal phase	50	30	44	32	32	98	95 ± 17
rel As bioaccessibility[e] (%)		50	32	44	31	34		
rel As bioavailability (%) in animal models[f]		48 (rabbits)		20 (monkeys)		28 (monkeys)		

[a] Time from start of PBET assay. [b] Single PBET tests. [c] Averages of duplicate PBET results. [d] Average ±95% upper confidence limit (1.96σ) on five PBET runs. [e] Relative As bioaccessibility (%) calculated as average soluble As mass in small intestinal simulation divided by total As mass in the reaction vessel, corrected for recovery of soluble As spike in small intestinal simulation. [f] Values presented are As bioavailability from soil (dosed in capsules to fasting animals) based on recovery of urinary arsenic relative to recovery of As from sodium arsenate dosed by gavage (*14, 15*). Bioavailability of sodium arsenate (administered by gavage) was 50 and 68% in rabbits and monkeys, respectively, compared to intravenous sodium arsenate.

and ferromanganese lead oxides that appear to have greater solubility in the gastric environment. In addition, organic carbon may provide a sorption surface for soil Pb that will be readily desorbed in the gastric environment, causing elevated soil TOC to result in a greater fraction of bioaccessible Pb, consistent with the observed results (Tables 1 and 3).

Comparison of PBET Results for Pb to Animal Studies. Dosed-feed Pb bioavailability studies in Sprague-Dawley rats were performed such that Pb-bearing soil blended in feed could be compared to lead acetate (a soluble Pb salt) blended in feed, yielding the Pb bioavailability from soil relative to Pb acetate. In addition, lead acetate blended in feed was compared to an intravenous injection of lead acetate (100% bioavailability) to determine the absolute bioavailability of lead acetate (*38*). All of the Pb bioavailability data reported herein are based on measurements of blood Pb in rats.

As previously discussed, for the purpose of developing a bioavailability parameter for exposure assessment, measures of relative bioavailability (i.e., bioavailability of Pb from the test material relative to the bioavailability of Pb in water) are more useful than absolute bioavailability. Measures of relative bioavailability were developed in the Sprague-Dawley rat model for test substrates BVS (*21*), SCS (*7*), and BMW-II (*6*), whereas measures of absolute Pb bioavailability were developed for the other Pb substrates (*22*). However, absolute Pb bioavailability may be corrected to obtain relative bioavailability values, based on the use of a correction for the 15% bioavailability of lead acetate in a dosed-feed Sprague-Dawley rat bioavailability study (*38*). For example, material BMW produced 1.4% absolute Pb bioavailability (*22*), which when corrected for the bioavailability of lead acetate (1.4/0.15), yields an estimate of 9.3% relative Pb bioavailability. Relative Pb bioavailability estimates for all seven test substrates are presented in Table 3.

The PBET data were treated in a similar manner (bioaccessibility of Pb from the test substrate was corrected for the recovery of a soluble Pb spike) to arrive at relative bioaccessibility values for both the stomach and small intestinal phase data (Table 3). The recovery of the soluble Pb spike in the stomach phase (100% at both pH 1.3 and 2.5) was used to correct the stomach phase bioaccessibility values, and the recoveries of the soluble Pb spike in the small intestinal phase (48 and 41% at pH values of 1.3 and 2.5, respectively) were used to correct the small intestinal phase bioaccessibility.

Relative Pb bioaccessibility (*X* axis) and relative Pb bioavailability (*Y* axis) values were compared using a linear regression model. At a simulated stomach pH of 2.5, this model yields an r^2 of 0.93 ($n = 7$), based on bioaccessibility calculated from the stomach phase data, and an r^2 of 0.76, based on the small intestinal phase data. The difficulty in achieving a good correlation based on small intestinal phase data is most likely due to the complex nonequilibrium chemical system for Pb in the small intestinal phase (described in ref 3), causing poor reproducibility of the test system and variability in the fraction of Pb that was precipitated or adsorbed during the small intestinal simulation. Although use of the small intestinal phase data would be preferable as a measure of Pb bioaccessibility, the correlation between *in vitro* and *in vivo* results was considerably greater for the stomach phase data. In addition, the correlation between stomach phase relative Pb bioaccessibility and relative Pb bioavailability values was equally good at stomach pH values of 1.3 and 2.5 ($r^2 = 0.93$ in both cases). Although identical r^2 values at pH levels of 1.3 and 2.5 may be coincidental (with only seven observations, it is not possible to establish the significance of this finding), these data suggest that extractability of Pb varies consistently as a function of pH over the range from 1.3 to 2.5 for the seven materials tested.

For the purpose of estimating relative Pb bioavailability in Sprague-Dawley rats based on PBET data, a simulated stomach pH of 2.5 was selected as the most appropriate value, because the linear regression for the pH 2.5 data yielded a *y* intercept closer to 0 (3.2 for pH 2.5 versus 6.8 for pH 1.3) and a slope closer to 1 (1.4 for pH 2.5 and 0.44 for pH 1.3). These data suggest that the stomach pH of 2.5 more closely resembles the conditions found in the Sprague-Dawley rat during a dosed-feed Pb bioavailability study than the pH value of 1.3.

PBET Results for Arsenic. In contrast to Pb, As dissolution did not exhibit a strong pH dependency, with dissolved As from ARS-I and ARS-II (stomach phase) decreasing by only 25 and 8%, respectively, as system pH was raised from 1.3 to 2.5 (Table 4). These data suggest that stomach pH is less important in controlling As bioaccessibility than it is for Pb. On titration to pH 7, solubilized As decreased by only 20 ± 10%, compared to 60 ± 14% for Pb, consistent with the lack of adsorption and precipitation reactions involving As at neutral pH conditions (39).

Arsenic bioaccessibility (%) derived from the PBET (Table 4) was calculated by averaging the two small intestinal values (duplicate measurements ensured that the small intestinal simulation had reached equilibrium As concentration). These values represent the fraction of As from the test material that is dissolved in the small intestinal fluid and is therefore bioaccessible. Subsequently, dissolved As from the test material was divided by the fraction of soluble As recovered from the soluble As spike, yielding As bioaccessibility relative to a soluble As source (i.e., As in drinking water). Because As recovery from the soluble As spike was close to 100% for both pH 1.3 and 2.5 (Table 4), the spike recovery was assumed to be 100% for the purpose of correcting the PBET data. Relative arsenic bioaccessibility estimated by this method for ARS-I was 50 and 32% at pH values of 1.3 and 2.5, respectively, and 44 and 31%, respectively, for ARS-II (Table 4). House dust (AHD-I) relative arsenic bioaccessibility estimated by this method was 34% (stomach pH of 2.5). These data confirm the difference in As solubility between residential soils and house dusts and soluble As forms, with the soil and house dust As being approximately 3 times less bioaccessible than soluble As at a stomach pH of 2.5.

Comparison of PBET Results for As to Animal Studies. Because fasting stomach pH in rabbits is approximately 1.3 (*10*), it is most appropriate to use pH 1.3 PBET data for comparison to an As bioavailability study in fasted rabbits (soil ARS-I). For the purpose of establishing relative As bioavailability from ARS-I, the absolute As bioavailability in rabbits (24%) was corrected for the bioavailability of soluble As in rabbits (50%), yielding a relative bioavailability of 48% (*17*). Application of a similar calculation to the PBET data for ARS-I at a stomach pH of 1.3 yields a relative As bioaccessibility of 57%, comparable to the rabbit data (48%).

Relative As bioavailability was evaluated for materials ARS-II and AHD-I in *Cynomolgus* monkeys, because this animal model has greater physiological and anatomical similarity to humans than does the rabbit. For the purpose of establishing relative As bioavailability from ARS-II, the absolute As bioavailability in fasted monkeys (14%) was corrected for absorption of soluble As (68%), yielding a relative As bioavailability of 20% (*38*). A similar calculation for house dust, which produced 19% absolute bioavailability, yielded a relative As bioavailability of 28% (Table 4). By a similar calculation, the PBET relative As bioaccessibilities from ARS-II were 44 and 31% at pH values of 1.3 and 2.5, respectively, and 34% from AHD-I at a pH of 2.5 (Table 4). No stomach pH data were found in the literature for *Cynomolgus* monkeys. Monkeys of the species *Macaca mulatta*, the most closely related species to *Cynomolgus* monkeys (*Macaca fascicularis*), have a fasting stomach pH of 1.8 to 2.0. Therefore, data from the pH 2.5 PBET were likely to be most comparable to the As bioavailability study results in monkeys. Indeed, comparison of these data indicate that the PBET results using a stomach pH of 2.5 provide a conservative estimate of relative As bioavailability for ARS-II and AHD-I in monkeys (the PBET overestimates monkey results by 4–11%).

Discussion

This study demonstrates that the PBET is useful in evaluating the geochemical and physiological factors controlling the bioaccessibility of Pb and As in the gastrointestinal tract. Lead bioaccessibility was observed to be more dependent on stomach pH than was As. When the acidic stomach environment is neutralized, Pb is largely removed from solution by precipitation and adsorption reactions, while As is not.

PBET data were consistent with lead speciation results. Sample BMW-I and BMW-II, which contained primarily less soluble Pb phases (e.g., galena, anglesite, and lead phosphate; Table 1) and a greater degree of Pb phase encapsulation, resulted in minimal Pb bioaccessibility. The Pb-bearing soil samples (BVS and SCS), which contained more soluble Pb phases (metal–lead oxide, lead oxide, cerussite), produced greater fractions of bioaccessible Pb. In addition, the samples derived from tailings materials (CT-1 and CT-2) also produced limited Pb bioaccessibility, due to the presence of anglesite and lead jarosite, which have limited solubility in the acidic gastric environment. Arsenic speciation results indicated that the soil samples ARS-I and ARS-II contained similar As mineralogy, consistent with the nearly identical As bioaccessibility observed for these samples during PBET evaluation. Because mineralogy and bioaccessibility results for ARS-I and ARS-II are nearly identical, differences between rabbit and monkey study results are most likely due to differences between the animal models, rather than between the substrates tested.

The PBET model provided consistent results across a wide pH range and was sensitive to different types of Pb-bearing materials, as reflected in the ability of the test to accurately predict different Pb bioavailability values measured in a Sprague-Dawley rat model. Application of the PBET data at a stomach pH of 2.5 in a linear regression model (relative Pb bioaccessibility on *Y* axis) yielded results that predicted relative Pb bioavailability in rats ($r^2 = 0.93$, $n = 7$). On the basis of this linear correlation, with a y intercept of 3.2 and slope of 1.4, the PBET data can be used to estimate relative Pb bioavailability in the Sprague-Dawley rat model.

Relative Pb bioavailability from the Sprague-Dawley rat model can be used to estimate absolute Pb bioavailability in children, based on the premise that Pb bioavailability from the test substance relative to soluble Pb is similar in both the rat and child models. Interpretation of the data in this manner does not require the assumption that the rat is equivalent to the child, but only that the two Pb forms behave proportionally in the two models. Because only 50% of Pb in the diet (assumed to be soluble Pb) is absorbed by children (*1*), the relative Pb bioavailability from the rat model can be applied to the child by applying a correction factor (0.50) to the relative Pb bioavailability estimate, to arrive at an absolute Pb bioavailability. The absolute Pb bioavailability estimate generated in this fashion can be compared to the EPA default assumption of 30% absolute Pb bioavailability from soil to determine whether a Pb bioavailability correction for soil is warranted.

Results of the PBET indicate good predictive ability for As bioavailability from soil, producing data that are consistent with results from rabbit and monkey As bioavailability studies. Application of the PBET at a stomach pH of 2.5, followed by correction for As bioaccessibility from a soluble As form, results in relative As bioaccessibility data that provide a conservative predictor of relative As bioavailability in monkeys (4–11% overprediction), the animal model likely to best predict As bioavailability in humans. Because the PBET overpredicts As bioavailability in animal models, a bioavailability study using monkeys is recommended for situations where the accuracy of As bioavailability values is a primary consideration. However, the PBET has been used to develop As bioavailability adjustments ranging from 10 to 25% for soils and house dusts in Oklahoma and Michigan, and these results have been accepted by state regulatory agencies for the purpose of site-specific exposure assessment.

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Appendix D

Technical Memorandum 2.2

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Technical Memorandum 2.2

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LIST OF TABLES

Tables are found following the References and Figures.

ACRONYMS AND ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
BC Environment	British Columbia Ministry of the Environment, Land and Parks
COPC	chemical of potential concern
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
PM_{10}	respirable fraction
RfC	Reference Concentration
TLV-TWA	Threshold Limit Value-Time Weighted Average
TSP	total suspended particulates
UCLM	95 percent upper confidence limit on the mean

TASK 5. EVALUATION OF SOIL TRANSECT DATA

In Phase I (Problem Formulation for Non-Lead Constituents in Trail), Exponent (then PTI Environmental Services) staff used the available data to determine contaminants of potential concern (COPCs) for the site. Comparison of the metals concentrations from the available data set against soil screening criteria indicated that concentrations of mercury, selenium, thallium, and tin could be of potential health concern at some locations. However, mapping of the concentration data demonstrated that the only area where concentrations of these metals exceeded soil screening criteria was along the boundary of the Cominco Metals site. Therefore, Exponent recommended that new soil samples be collected from transects in Tadanac to establish whether the elevated concentrations of these metals are widespread, or are constrained to the property boundary. As part of that recommendation, Exponent also suggested that confirmatory samples be collected from East Trail and West Trail to establish that concentrations of these metals were not elevated in those areas.

Consistent with those recommendations, Exponent received data for 22 new soil samples collected in Tadanac, East Trail, and West Trail, plus three reference samples from Glenmerry, Nelson, and Butler. The task reported herein involved evaluating the new data collected by the Trail Lead Program to determine which metals need to be considered COPCs for the site. The analytical process used to evaluate the data is described below, followed by an interpretation of the findings.

In summary, the new data indicate that soil concentrations of mercury, selenium, thallium, and tin exceed soil screening levels only in the area along the Cominco property boundary, and that concentrations of these metals elsewhere in Tadanac or other Trail neighborhoods do not exceed the soil screening criteria. Therefore, (non-lead) COPCs for the site can be limited to arsenic, cadmium, and antimony, and subsequent efforts can focus on these elements.

DATA ANALYSIS

Exponent received data for 22 new samples collected in Tadanac, East Trail, and West Trail (Table 1). Of these, 12 were from Tadanac (including one duplicate), arranged in three transects aligned from the Cominco property toward the Columbia River. Seven samples were collected in West Trail (including one duplicate), and three in East Trail. Data were handled using the following methods.

1. The data were subjected to a brief data quality and usability review by Exponent chemists, and they proved to be of good quality, acceptable for use in risk assessment.

2. All duplicate samples from a given location were averaged before being combined with data from previous sampling events.

3. Data from the transects in Tadanac were evaluated to determine whether trends in concentrations were apparent. Figures 1 through 5 show the concentration as a function of proximity to the site, for antimony, mercury, selenium, thallium, and tin, respectively. In these figures, "zones" are defined by proximity to the Cominco property. Zone 1 represents the samples collected closest to the Cominco property, and Zones 2–4 are successively farther away from the property boundary. Zone 4 is farthest from the Cominco property and closest to the Columbia River. The figures demonstrate that the concentrations decrease substantially between Zone 1 and Zone 2.

4. The 22 data points from the 1997 sampling event were combined with previous data of good quality and aggregated by neighborhood.

5. Samples collected from locations along the Cominco property boundary in Tadanac were removed from the data set (Table 2 provides a list of the locations removed, and Table 3 presents data used for comparison to criteria).

6. The data were evaluated to determine whether they were better represented by a normal or lognormal distribution. This was necessary because the statistics to be compared against the soil screening concentrations (e.g., upper confidence limit on the mean, and 90th percentile values) are calculated differently depending on the distribution of the data. Our analysis indicated that, once the values from along the Cominco property boundary are removed from the sample population, the concentrations in Tadanac are best represented by a normal distribution. (As described further below, the data set for East and West Trail was too small to determine distribution shapes.)

7. Summary statistics were completed for those neighborhoods for which new data were provided (Tadanac, East Trail, West Trail), and were compared to soil screening concentrations. Table 4 provides the results of this data treatment and comparison to screening criteria. This effort essentially updates the information provided in Table 3 of the Phase I Technical Memorandum, "Evaluation of New Data and Determination of Contaminants of Potential Concern" (Appendix E of the Phase I report) to reflect the new soil data.

FINDINGS

Incorporation of the soil sampling data collected in 1997 into the database for Trail was instructive in understanding the concentrations of metals in soil in Trail. First, as described above, collecting data in transects in Tadanac demonstrated that, for many metals, the elevated concentrations in Tadanac are limited to the area close to the Cominco property boundary, and do not represent generally excessive soil concentrations in Tadanac. This finding allows us to establish that it is appropriate to exclude the property boundary samples from an evaluation of the residential areas of Tadanac, and also provides enough data to evaluate Tadanac with at least limited statistical power.

Based on the 12 samples from 11 locations in residential areas of Tadanac, soil screening criteria from the British Columbia Ministry of Environment, Land and Parks (BC Environment)[1] are not exceeded for any of the metals measured except antimony. Prior data indicated that Tadanac was the only neighborhood where concentrations of these metals exceeded urban/residential criteria, which resulted in mercury, selenium, thallium, and tin being included as COPCs for the site. Based on the evaluation incorporating the most recent data, however, mercury, selenium, thallium, and tin can be removed from the list of COPCs for the site.

In Tadanac, concentrations of antimony continue to exceed the urban/residential soil screening criterion. In fact, approximately two thirds of the measured values in the neighborhood exceed the criterion. This trend is reflected in the East Trail and West Trail neighborhoods as well, as described below.

In East Trail and West Trail, the small number of samples (six total, including new and prior data sets) precluded determination of an appropriate data distribution shape (i.e., normal or lognormal). Assuming a lognormal distribution (the more conservative assumption, because it would bias estimates high), calculated UCLM (95 percent upper confidence level on the mean) values equaled or exceeded the maximum detected concentration for each metal. This situation is not uncommon for small data sets, but it indicates that the UCLM is not an appropriate statistic to use in evaluating these data. However, except for antimony, the maximum detected concentrations fall below the urban/residential soil screening criterion. For this reason, the new soil data confirm the determination from the Phase I review of site data that concentrations of metals in East Trail and West Trail soils do not indicate the need for mercury, selenium, thallium, or tin to be included as COPCs. The maximum concentration of antimony in East Trail and West Trail exceeds the soil screening criterion, and in East Trail, the maximum antimony concentration is more than two times the soil criterion.

CONCLUSIONS

The evaluation of new soil data from Tadanac, East Trail, and West Trail indicates that only antimony, arsenic, and cadmium (in addition to lead) need to be carried through in further risk assessment efforts. Although previous data from the area indicated that mercury, selenium, thallium, and tin may need to be included as COPCs, the elevated concentrations of these metals are limited to the area along the Cominco property

[1] UCLM and 90th percentile concentrations were below soil screening criteria, and the maximum detected concentrations were below two times the criteria.

boundary, and do not extend into residential or commercial areas of Trail. Therefore, while it may be appropriate to review the concentrations of these four metals in the soil along the Cominco property boundary when final remedial decisions are made, these metals do not need to be included in future risk assessment of the site.

TASK 6. COMPARISON OF AIR DATA AGAINST SCREENING CRITERIA

INTRODUCTION

Exponent conducted a screening of available air data to determine whether the concentrations of metals in air around Trail present a potential health risk, and to determine appropriate COPCs for future risk assessment of the site. Prior efforts by Exponent, based on evaluations of metals concentrations in Trail soils, have identified arsenic, cadmium, and antimony as the COPCs for the non-lead risk assessment efforts for the site (see Task 5, above). However, before other metals can be conclusively eliminated from consideration as COPCs for the site, all potential exposure pathways of concern need to be evaluated. Therefore, Exponent has compiled air data from Trail, and compared the concentrations of metals in these samples to health-based screening criteria. This screening indicates that concentrations of arsenic, cadmium, and lead exceed the screening criteria, and merit further evaluation for potential impacts on the health of area residents. It also indicates that the detection limits for nickel, arsenic, and cadmium exceed available screening concentrations. Air concentrations of antimony (the only other metal identified as a COPC for the site) did not exceed the health-based screening criterion at any location during the sampling period.

AVAILABLE DATA

Due to the conversion to a new smelter at the Cominco facility in 1997, much of the historical air data collected from the Trail vicinity are no longer appropriate for use in human health risk assessment. In March 1997, Cominco started bringing a new, more efficient smelter on line, and operation of the old smelter ceased in May 1997. Therefore, this evaluation focused solely on air data from the five quarters (March 1997 through February 1998) during start-up of the new smelter. During this period, the new smelter has been run below capacity, with a maximum of 80 percent of capacity achieved in December. Data from the March 1997 monitoring period may be spurious because of instabilities associated with converting operations to the new facility, and may not be representative of future conditions. Although smelter throughput will increase in the future, it is anticipated that emissions will not increase above those recorded for 1997, because the new smelter will reach maximum efficiency, and fewer upset conditions will occur than during the transitional period.

Data for this period were provided by the Trail Lead Program for sampling stations located in nine neighborhoods around Trail: Genelle, Oasis, Warfield, Downtown, West Trail, Glenmerry, Northpoint, Columbia Gardens, and Waneta. Data for 24-hour samples are reported for March, June, September, and December 1997, and February 1998.[2] For some locations, data were not available for every quarter: for Genelle, Northpoint, and Waneta, data are available for only four of the five sampling periods. The data are available as total suspended particulates (TSP) and/or respirable fraction (PM_{10}) data. Tables 5 through 13 present the data, by neighborhood, and indicate the sampling period and the sample type (i.e., TSP or PM_{10}). Table 14 summarizes the exceedances. Overall, these data are expected to represent a conservative estimate of future conditions in Trail, and to provide an adequate basis for a comparison to standards.

SCREENING CRITERIA

No health-based screening criteria are available from BC Environment. Exponent staff spoke with several individuals within BC Environment, and were ultimately directed to the regional office in Nelson. Staff in this office indicated that the only formal air standards available were the Pollution Control Objectives for the Mining, Smelting, and Related Industries, but that these are not health-based, are outdated (published in 1979), and would not be appropriate for use in screening air data for Trail (Crosier 1998, pers. comm.). BC Environment staff indicated that they did not have a set of preferred standards, but that they were familiar with the values available from the Air Quality Program of the Washington State Department of Ecology (Ecology), and considered those standards to be adequate or overly conservative (Crosier 1998, pers. comm.). Therefore, Exponent staff determined that the values from Ecology would be appropriate for the initial screening. As discussed further below, after completion of this initial screening, it was determined that no further analysis with additional, less restrictive, screening criteria would be required.

The Ecology screening criteria were developed under the Washington Clean Air Act, and represent "such levels of air quality as will protect human health and safety." For chemicals considered known or probable human carcinogens (Class A Toxic Air Pollutants, as defined by Ecology), the screening criteria are established at the annual average concentration that is associated with an increased cancer risk of one in one million. For chemicals associated with a threshold for toxicity (i.e., noncarcinogens, and Class B Toxic Air Pollutants, as defined by Ecology), the screening criteria are the inhalation Reference Concentrations (RfCs), as established by the U.S. Environmental Protection Agency (EPA), or for compounds without an established RfC, are determined by dividing the occupational Threshold Limit Value-Time Weighted Average (TLV-TWA) by 300 to calculate a 24-hour TWA acceptable level. Of the chemicals included in the air quality database from Trail, four are defined as Class A pollutants: arsenic, cadmium, nickel,

[2] Data from the Trail vicinity are reported in units of standard cubic meters (Sm^3), and these units are retained throughout this document when referring to these data. Units of cubic meters (m^3) are used in instances where concentrations are reported as such (e.g., background concentrations).

and lead.[3] All other compounds included in the database from Trail are considered Class B compounds.

COMPARISON OF DATA TO SCREENING CRITERIA

Tables 5 through 13 provide the data for the nine sampling stations around Trail, and compare the measured concentrations to the screening criteria. Any exceedances of the criteria are shaded. Table 14 provides a summary of all monitoring locations, with an indication of the frequency with which screening criteria were exceeded, and whether the analytical detection limit exceeded the screening criterion (i.e., arsenic, cadmium, and nickel). As demonstrated in the tables, the comparison of Trail data to the screening criteria indicated that arsenic, cadmium, and lead are the only compounds for which measured concentrations exceed health-based screening criteria. The exceedances for arsenic, cadmium, and lead are based on measured concentrations (as opposed to a detection limit that exceeded the screening criterion) for at least one of the sampling periods at all of the sampling locations, except for arsenic at the Northpoint station. Measured arsenic and cadmium concentrations in TSP and PM_{10} fractions exceed the screening criterion by more than two orders of magnitude in some instances. For lead, measured concentrations exceed the screening criterion by less than an order of magnitude. For many of the monitoring locations, the standards were exceeded only during the March 1997 sampling period. Because this represents the time frame of the transition between the old and new smelter, it may not be representative of long-term average exposure concentrations.

It is interesting to view the results of this monitoring in comparison to background concentrations of these metals. No information regarding background air concentrations for metals was available for areas around Trail (B. Wood 1998, pers. comm.) Therefore, toxicological profiles by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) were reviewed for background concentrations. Excluding data from the March sampling period (due to the potential non-representativeness of these data, as described above), the maximum measured concentrations of arsenic, cadmium, and lead were 0.04 $\mu g/Sm^3$, 0.02 $\mu g/Sm^3$, and 2.2 $\mu g/Sm^3$, respectively.

According to air data collected from areas around the United States, arsenic concentrations range from 0.001 to 0.003 $\mu g/m^3$ in remote areas, and 0.02 to 0.03 $\mu g/m^3$ in urban areas. This suggests that the concentrations in Trail exceed concentrations for remote areas, but annual average concentrations (0.01–0.02 $\mu g/Sm^3$) fall within the range for urban areas. In addition, the screening criterion for arsenic is an order of magnitude *below* arsenic concentrations in remote areas, and two orders of magnitude below average urban concentrations.

For cadmium, ATSDR reports mean air concentrations as low as 0.001 $\mu g/m^3$ for remote areas, and in the range of 0.005 to 0.04 $\mu g/m^3$ for urban areas. As with arsenic, the

[3] Although lead is not considered a carcinogen by Ecology, it is defined as a Class A compound, and a special screening concentration is provided.

measured air concentrations of cadmium exceed values for remote areas, but long-term average concentrations (0.01–0.02 $\mu g/Sm^3$) fall within the range for urban areas. Again, the health-based screening criterion for cadmium (0.00056 $\mu g/m^3$) is below measured background urban and rural air concentrations for this element.

Measured lead concentrations in Trail are as much as an order of magnitude above the screening criterion of 0.5 $\mu g/m^3$. Concentrations of lead in ambient air are as low as 7.6×10^{-5} $\mu g/m^3$ in remote areas such as the Antarctica. In urban areas, the average concentration measured in the U.S. in 1988 was 0.1 $\mu g/m^3$. These possible "background" concentrations fall below the screening criterion. Average concentrations in Trail over the 1997 sampling period are above these background concentrations for most of the stations sampled.

Nickel, silver, sodium, and sulfur also showed occasional exceedances of the screening criteria:

- The detection limit for nickel in the database (0.01 $\mu g/Sm^3$) is greater than the screening criterion (0.0021 $\mu g/Sm^3$). Of 54 data records for Trail, actual measured concentrations of nickel only exceeded the detection limit in two instances, and the average over the several quarters of data never exceeded the detection limit for any of the sampling stations. It is also important to note that the screening criterion for nickel is based on exposure to nickel subsulfide or nickel refinery dust. To the extent that these compounds are not representative of nickel in air around Trail, the screening criterion is not appropriate.

  According to ATSDR (1995), annual mean nickel concentrations in 11 Canadian cities measured during 1987–1990, ranged from 0.001 to 0.02 $\mu g/m^3$, while nickel concentrations in remote areas were 0.0001 to 0.0004 $\mu g/m^3$. Therefore, the detection limit and the maximum detected concentration for nickel (0.01 $\mu g/Sm^3$) are above the range for remote areas but within the range of Canadian urban background concentrations.

  Based on the low frequency of detection and the low concentrations within the range of urban background, the available data do not indicate the need to further assess risks from inhalation of nickel.

- Site air silver concentrations exceeded the health-based standard in three instances (Downtown, West Trail, and Glenmerry sampling stations), all in September 1997. Each of these exceedances was observed in TSP data, and long-term averages for all locations fall below the standard. Because concentrations of silver in site air are generally below screening concentrations, the available data indicate no need for further evaluation of this metal in the current risk assessment efforts.

- The comparison of site data for sodium and sulfur to health-based screening concentrations indicates occasional exceedances of the screening concentrations. For all locations, the long-term average concentrations of these two chemicals are below the screening concentrations, indicating a low probability of health effects from these chemicals in air. Interpretation of these data is further complicated because the screening values represent health-based concentrations for exposure to sodium hydroxide and sulfuric acid. If these elements in the Trail vicinity do not occur in these specific compounds, then the comparison is not appropriate, and specific exceedances noted are not valid. In general, however, we believe that this screening indicates a low probability of health effects from inhalation of sodium and sulfur in Trail.

CONCLUSIONS

Exponent used available data from nine air-sampling locations around Trail, and compared the measured concentrations to conservative, health-based screening concentrations available from Ecology. Although these screening criteria are likely to be more conservative (i.e., health protective) than required by BC Environment, they were selected for use in this evaluation as an appropriate initial phase. It was assumed that by comparing to these conservative screening concentrations, we could screen out any chemicals that are not of potential human health concern, and focus further evaluation on a subset of the chemicals that were measured in site air.

Using air data from the period during which the new smelter has been operational at the Cominco facility, and comparing concentrations to screening criteria based on potential health effects from inhalation of ambient air, the only metals that require further analysis in risk assessment of the Trail site are arsenic, cadmium, and lead. These are a subset of the metals already identified as COPCs for the site based on evaluation of soil data. Therefore, no compounds need to be added to the list of COPCs based on the evaluation of air data for Trail.

The analytical detection limits for arsenic, cadmium, and nickel are above the health-based screening criteria for these metals. Because of a reasonable frequency of measured concentrations of arsenic and cadmium above the detection limit (and above the health-based screening criterion for each metal), the available data indicate the need for further evaluation of these metals in risk assessment of the site. Because there was a very low frequency of detection for nickel (2 of 54 analyses) and the detected and long-term average concentrations fall within the range of urban background, it would be inappropriate to include nickel as a COPC for the site based on these data.

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PTI. 1997. Recommendations for subsequent risk assessment for non-lead constituents at Trail, British Columbia. Prepared for Trail Lead Program. PTI Environmental Services, Boulder, CO.

Wood, B. 1998. Personal communication (conversation June 3rd, 1998, with G. Hook, Exponent, Boulder, CO). British Columbia Ministry of Environment, Lands and Parks, Nelson, BC.

Figures

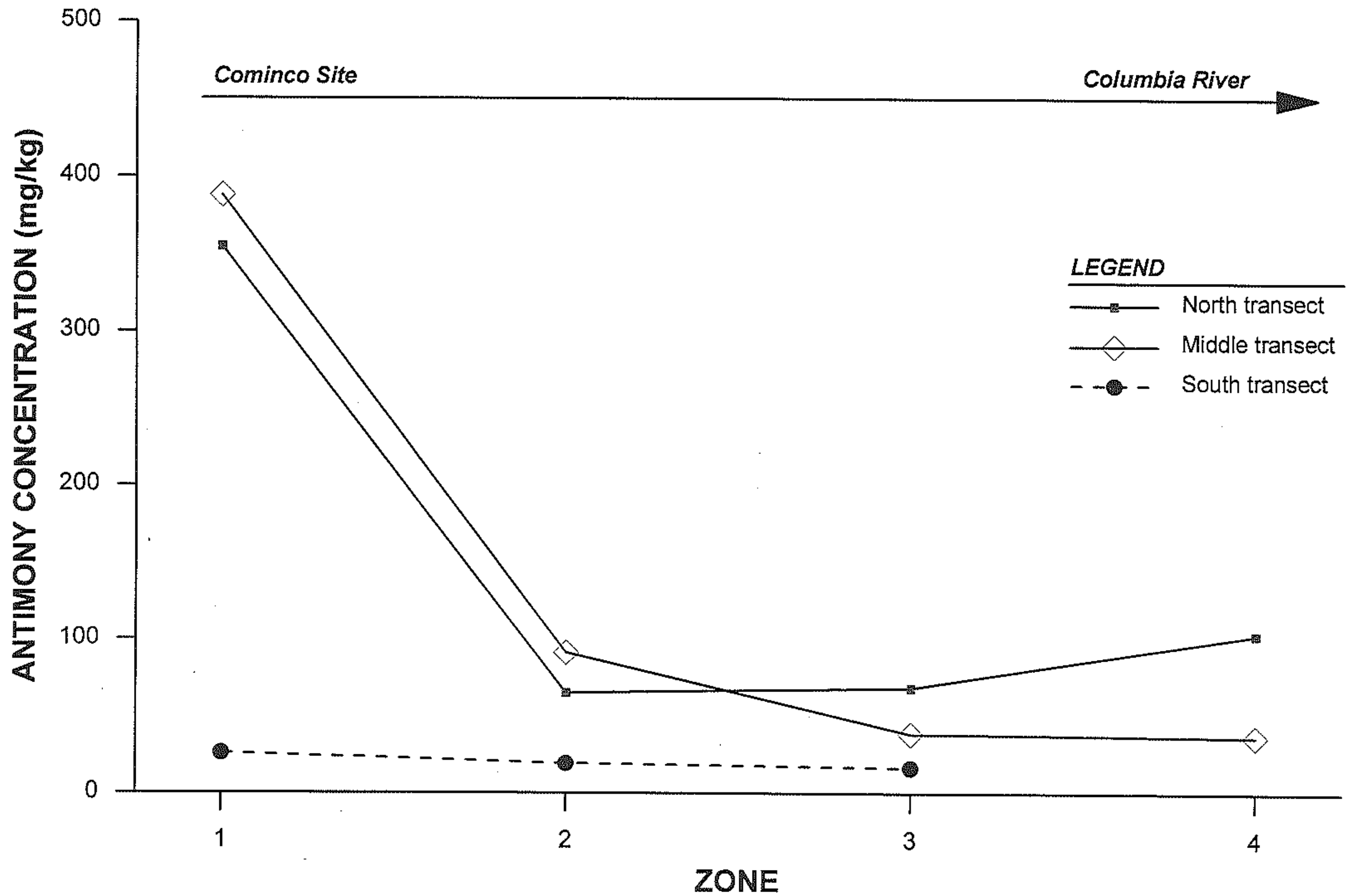

Figure 1. Antimony concentrations along three transects from the November 1997 sampling, Trail, B.C.

i:\datamgmt\cbb5\transect.pre 042098

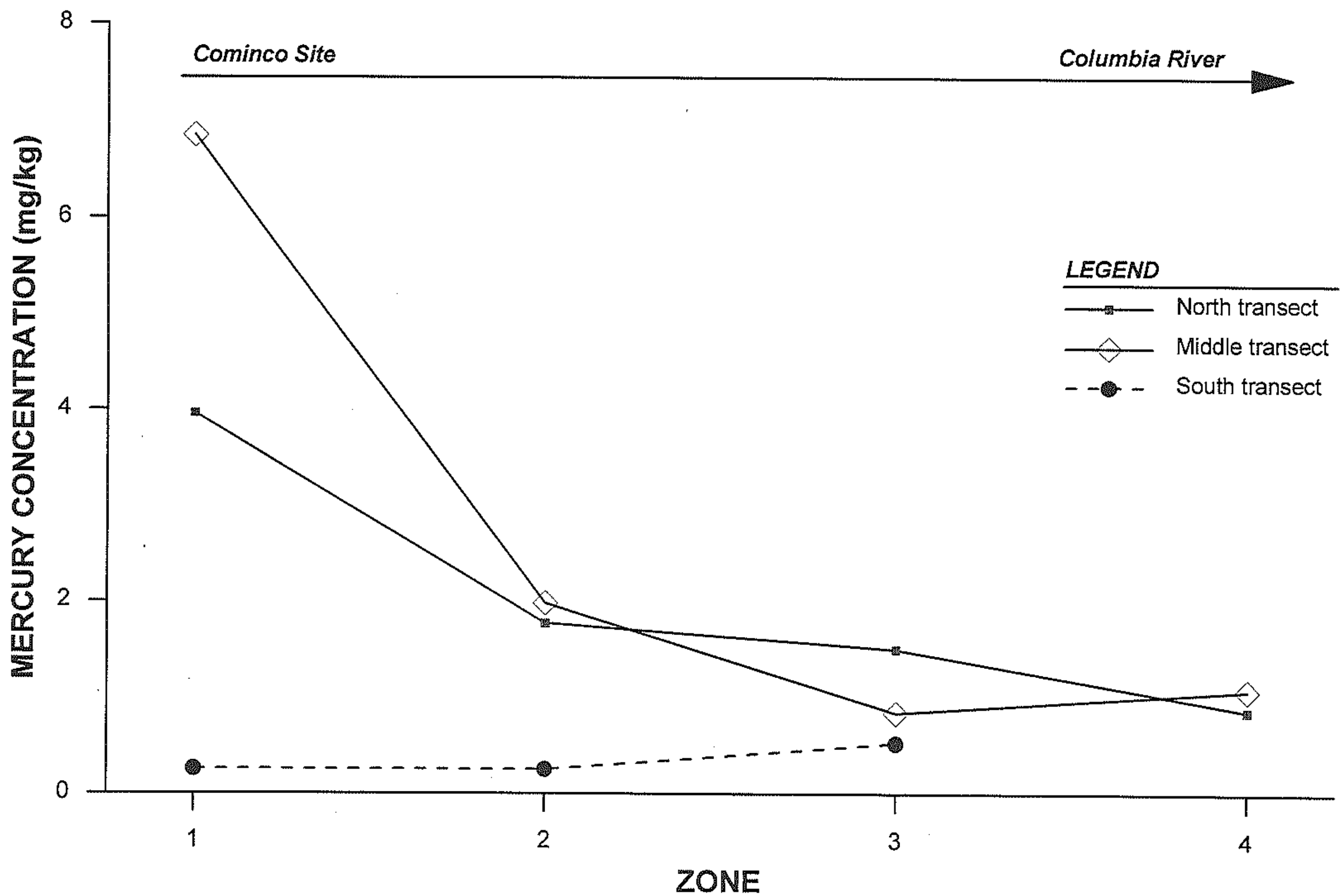

Figure 2. Mercury concentrations along three transects from the November 1997 sampling, Trail, B.C.

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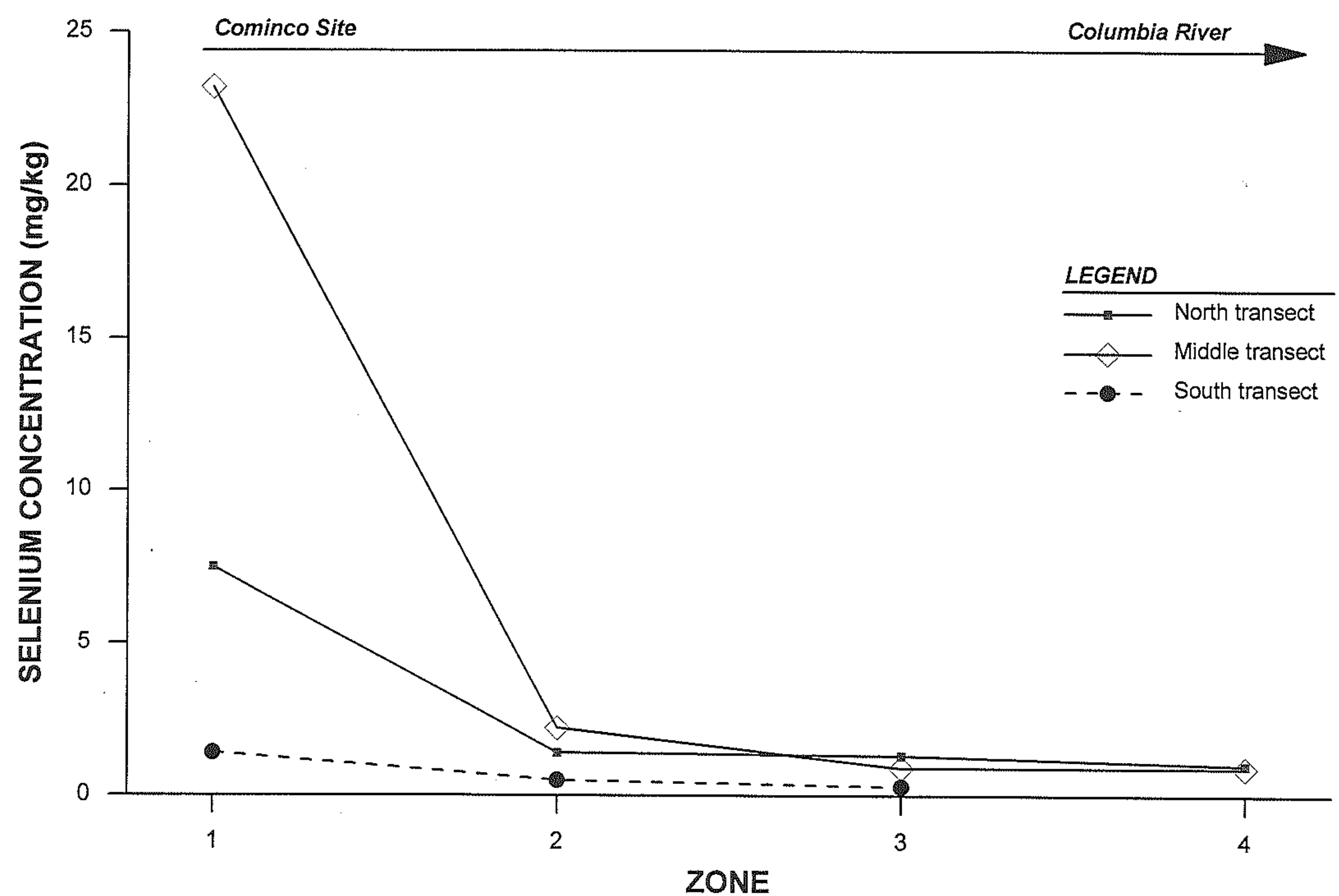

Figure 3. Selenium concentrations along three transects from the November 1997 sampling, Trail, B.C.

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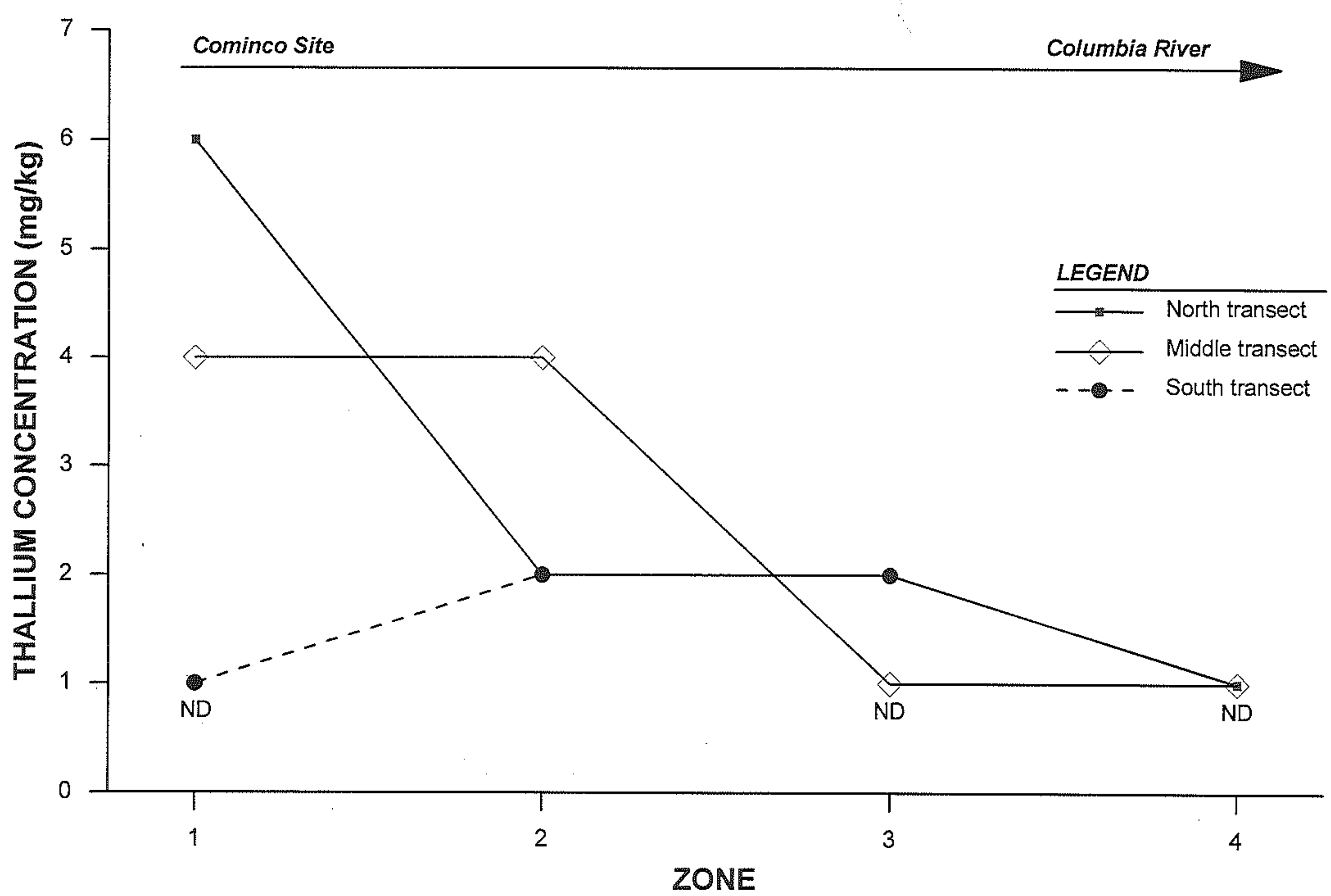

Figure 4. Thallium concentrations along three transects from the November 1997 sampling, Trail, B.C.

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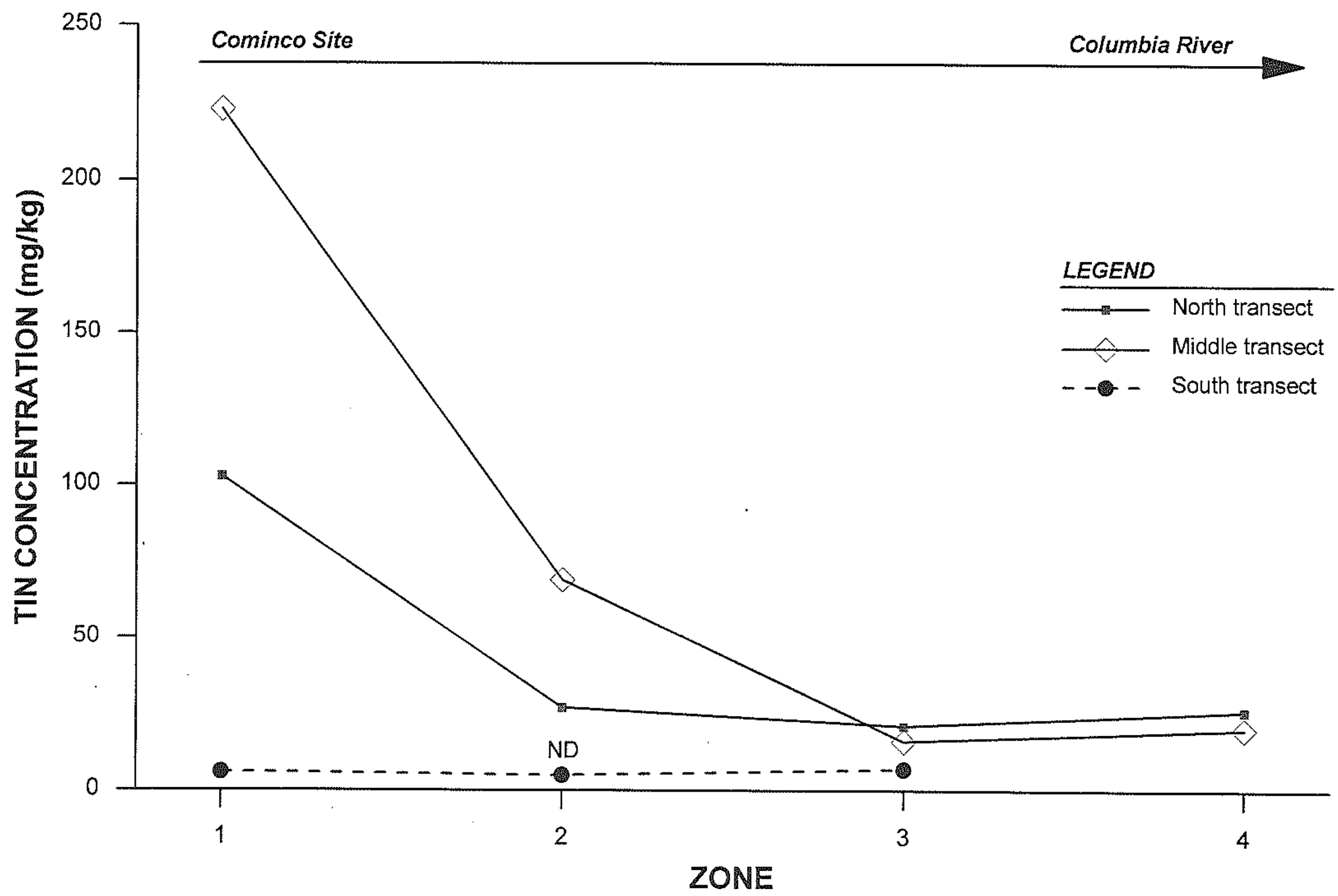

Figure 5. Tin concentrations along three transects from the November 1997 sampling, Trail, B.C.

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Tables

TABLE 1. ANALYTICAL RESULTS FROM THE NOVEMBER 1997 SOIL SAMPLING EVENT, TRAIL, B.C.

Sample ID	Duplicates	Neighbour-hood	Antimony (mg/kg)	Mercury (mg/kg)	Selenium (mg/kg)	Thallium (mg/kg)	Tin (mg/kg)	Moisture (%)
EH809711124001		Tadanac	355	3.96	7.5	6	103	13.2
EH809711124002		Tadanac	388	6.85	23.2	4	223	10.3
EH809711124003		Tadanac	26.3	0.239	2.1	1 U	7	8.1
EH809711124004	Dup of 4003	Tadanac	25.7	0.273	0.7	1 U	5	8.3
EH809711124005		Tadanac	19.3	0.251	0.5	2	5 U	13.6
EH809711124006		Tadanac	16.5	0.524	0.3	2	7	15.9
EH809711124007		Tadanac	91.1	1.98	2.2	4	69	12.5
EH809711124008		Tadanac	38.5	0.835	0.9	1 U	16	36.1
EH809711124009		Tadanac	36.6	1.07	0.9	1 U	20	26.0
EH809711124010		Tadanac	65.1	1.77	1.4	2	27	19.9
EH809711124011		Tadanac	68.4	1.50	1.3	2	21	20.2
EH809711124012		Tadanac	103	0.856	1.0	1 U	26	21.8
EH809711134001		East Trail	11.6	0.328	0.2	1 U	5 U	14.3
EH809711134002		East Trail	17.9	0.260	0.3	1 U	8	7.5
EH809711134003		East Trail	78.0	0.496	0.5	1 U	13	10.5
EH809711134004		West Trail	10.3	0.228	0.5	1 U	13	9.6
EH809711134005		West Trail	24.2	0.245	0.3	1 U	5 U	13.3
EH809711134006		West Trail	8.48	0.103	0.2	1 U	5 U	10.9
EH809711134007		West Trail	20.6	1.25	0.5	1 U	9	23.1
EH809711134008		West Trail	11.8	0.379	0.4	1 U	5	25.8
EH809711134009		West Trail	4.11	0.085	0.1	1 U	5 U	5.1
EH809711134010	Dup of 4009	West Trail	3.07	0.091	0.1	1 U	5 U	4.8
EH809711124013		Glenmerry	87.4	0.297	1.2	1 U	13	1.0
EH809711124014		Nelson	1.34	0.062	0.2	1 U	5 U	3.2
EH809711124015		Butler	21.4	0.277	0.3	1 U	5 U	0.5

U = Not detected; value represents detection limit.

TABLE 2. SAMPLE LOCATIONS EXCLUDED FROM SUMMARY STATISTICS
(Assumed to be along the Cominco property boundry)

November 1997
EH8097111240010
EH8097111240020
EH8097111240030
EH8097111240040
June 1997
EH8097061140080
EH8097061140100
EH8097061140140

TABLE 3. DATA AGGREGATED BY NEIGHBOURHOOD, TRAIL, B.C., 1989–November 1997

Neighbourhood	Antimony (mg/kg)	Mercury (mg/kg)	Selenium (mg/kg)	Thallium (mg/kg)	Tin (mg/kg)	Moisture (%)
Tadanac	10	0.325	0.2	1.2	2.5	12.6
Tadanac	28	0.267	0.9	2.7	5	18
Tadanac	54	0.812	2	3.8	25	18.2
Tadanac	19.3	0.251	0.5	2	2.5	13.6
Tadanac	16.5	0.524	0.3	2	7	15.9
Tadanac	91.1	1.98	2.2	4	69	12.5
Tadanac	38.5	0.835	0.9	0.5	16	36.1
Tadanac	36.6	1.07	0.9	0.5	20	26
Tadanac	65.1	1.77	1.4	2	27	19.9
Tadanac	68.4	1.5	1.3	2	21	20.2
Tadanac	103	0.856	1	0.5	26	21.8
East Trail	54	0.136	1.1	0.25	6	15.9
East Trail	34	0.487	0.8	3.9	8	10.3
East Trail	75	1.57	2.8	0.25	30	14.3
East Trail	11.6	0.328	0.2	0.5	2.5	14.3
East Trail	17.9	0.26	0.3	0.5	8	7.5
East Trail	78	0.496	0.5	0.5	13	10.5
West Trail	10.3	0.228	0.5	0.5	13	9.6
West Trail	24.2	0.245	0.3	0.5	2.5	13.3
West Trail	8.5	0.103	0.2	0.5	2.5	10.9
West Trail	20.6	1.25	0.5	0.5	9	23.1
West Trail	11.8	0.379	0.4	0.5	5	25.8
West Trail	3.6	0.088	0.1	0.5	2.5	4.95

Note: This data set excludes samples near the Cominco property border.
All non-detects are presented as one-half the detection limit.
All duplicate samples were averaged.

TABLE 4. SUMMARY STATISTICS FOR DATA AGGREGATED BY NEIGHBOURHOOD, TRAIL, B.C.: 1989, 1991, JUNE 1997, AND NOVEMEBER 1997

(All units ppm unless otherwise noted)

Neighbourhood		Antimony	Mercury	Selenium	Thallium	Tin
B.C. Urban/Parks Criterion		**20**	**2**	**3**	**6.3** [a]	**50**
Tadanac	Count	11	11	11	11	11
	Average	48.2	0.926	1.05	1.93	20.1
	Maximum	103	1.98	2.20	4.00	69.0
	UCLM	65.1	1.25	1.40	2.60	30.4
	90th percentile	87.8	1.70	1.87	3.50	44.2
	Max > 2x criteria	Yes	No	No	No	No
East Trail	Count	6	6	6	6	6
	Average	45.1	0.546	0.950	0.98	11.3
	Maximum	78.0	1.57	2.80	3.90	30.0
	Max > 2x criteria	Yes	No	No	No	No
West Trail	Count	6	6	6	6	6
	Average	13.2	0.382	0.333	0.5 [b]	5.75
	Maximum	24.2	1.25	0.500	0.5 [b]	13.0
	Max > 2x criteria	No	No	No	No	No

Note: One-half the detection limit was used for all non-detect results.
B.C. soil screening criteria were obtained from Schedules 4 and 5 of the B.C. Waste Management Act, Contaminated Sites Regulation (B.C. Reg. 375/96).
The UCLM and 90th percentile were calculated based on a normal distribution.
Highlighting indicates exceedance of the criterion.

[a] BCE provides no urban/residential standard for thallium. The value of 6.3 mg/kg is based on residential soil screening values from U.S. EPA.

[b] Thallium was not detected in any samples from West Trail at a detection limit of 1 ppm.

TABLE 5. AIR DATA AND COMPARISON TO STANDARDS: GENELLE

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97	27-Jun-97		18-Dec-97		16-Feb-98		TSP	PM_{10}
		TSP	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}	Average	Average
TSP	--	47.1	16.5	6.4	16.2	13.7	2.9	1.3	20.7	7.1
Aluminum	17	0.31	0.06	< 0.01	0.02	0.06	0.20	0.07	0.15	0.04
Antimony	1.7	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Arsenic	0.00023	0.30	< 0.01	< 0.01	0.03	0.04	< 0.01	< 0.01	0.09	0.02
Barium	1.7	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Bismuth	33	< 0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Cadmium	0.00056	0.04	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Calcium	6.7	0.13	< 0.01	< 0.01	0.06	< 0.01	0.31	0.25	0.13	0.09
Chromium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.07	0.09	0.01	0.08	0.03	0.13	0.02	0.09	0.02
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.82	0.34	0.11	0.18	0.11	0.57	0.22	0.48	0.14
Lead	0.5	1.61	< 0.01	< 0.01	0.54	0.35	0.10	0.06	0.56	0.14
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.15	0.04	< 0.01	< 0.01	< 0.01	0.16	0.07	0.09	0.03
Manganese	0.40	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	0.02	< 0.01	< 0.01	< 0.01	0.02	0.01	0.01	0.01	0.01
Potassium	6.7	0.32	0.41	1.13	< 0.01	< 0.01	0.12	< 0.01	0.21	0.38
Selenium	0.67	< 0.01			< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01
Silica	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	0.033	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	6.7	< 0.01	5.61	7.94	1.25	< 0.01	3.74	3.74	2.65	3.89
Sulfur	3.3	2.97	0.81	0.79	2.89	2.58	1.70	1.27	2.09	1.54
Tellurium	0.33	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	0.02	0.02	< 0.01	< 0.01	0.01	0.01
Zinc	3.3	1.87	0.19	0.04	0.44	0.19	0.32	0.13	0.70	0.12
Volume (SM³)	--	1550.8	1603.2	1637.8	1602.5	1603.9	1605.9	1603.9	1590.6	1615.2

Highlighting indicates exceedance of screening criterion.

TABLE 6. AIR DATA AND COMPARISON TO STANDARDS: OASIS

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97		27-Jun-97		19-Sep-97		18-Dec-97		16-Feb-98		TSP	PM_{10}
		TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}	Average	Average
TSP	--	26.9	23.8	9.7	3.9	9.7	6.4	18.2	16.2	1.1	1.0	13.1	10.3
Aluminum	17	0.06	0.03	0.04	< 0.01	0.02	0.03	< 0.01	0.04	0.17	0.05	0.06	0.03
Antimony	1.7	0.02	0.02	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	0.01	0.01
Arsenic	0.00023	0.13	0.14	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03	0.03
Barium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Bismuth	33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cadmium	0.00056	0.05	0.05	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01
Calcium	6.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.19	0.18	0.04	0.04
Chromium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.02	< 0.01	0.28	0.08	0.20	0.14	0.22	0.18	< 0.01	0.14	0.15	0.11
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.23	0.14	0.14	0.08	0.10	0.05	0.17	0.08	0.45	0.05	0.22	0.08
Lead	0.5	1.81	1.71	< 0.01	< 0.01	0.03	< 0.01	0.66	0.37	0.11	0.05	0.52	0.43
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.15	0.05	0.04	0.01
Manganese	0.40	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	< 0.01	0.02	< 0.01	< 0.01	0.03	0.03	< 0.01	< 0.01	0.02	< 0.01	0.01	0.01
Potassium	6.7	0.28	0.76	0.28	0.15	0.12	< 0.01	< 0.01	< 0.01	0.19	< 0.01	0.18	0.19
Selenium	0.67	< 0.01	< 0.01					< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01
Silica	--	< 0.01	0.06	1.13	< 0.01	< 0.01	0.12	< 0.01	< 0.01	< 0.01	< 0.01	0.23	0.04
Silver	0.033	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	6.7	< 0.01	< 0.01	6.27	8.41	0.59	0.61	< 0.01	0.62	1.28	3.67	1.63	2.66
Sulfur	3.3	3.50	3.00	0.81	0.72	0.59	0.85	4.69	3.26	5.19	2.34	2.96	2.03
Tellurium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.02	< 0.01	< 0.01	0.01	0.01
Zinc	3.3	2.12	1.46	0.08	0.04	0.09	0.05	0.78	0.35	0.76	0.18	0.77	0.42
Volume (SM³)	--	1599.5	1635.8	1594.8	1663.9	1709.2	1639.0	1646.9	1603.9	1567.6	1636.7	1623.6	1635.9

Highlighting indicates exceedance of screening criterion.

TABLE 7. AIR DATA AND COMPARISON TO STANDARDS: WARFIELD

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 TSP	27-Jun-97 TSP	19-Sep-97 TSP	18-Dec-97 TSP	16-Feb-98 TSP	TSP Average
TSP	--	31.4	23.9	13.6	26.6	3.6	19.8
Aluminum	17	0.08	0.14	0.07	0.02	0.32	0.13
Antimony	1.7	0.02	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Arsenic	0.00023	0.03	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Barium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01
Bismuth	33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cadmium	0.00056	0.04	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Calcium	6.7	0.06	0.12	< 0.01	0.06	0.36	0.12
Chromium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.02	< 0.01	< 0.01	< 0.01	0.03	0.01
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.29	0.37	0.15	0.16	0.82	0.36
Lead	0.5	1.57	0.04	< 0.01	0.21	0.22	0.41
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.02	0.07	0.03	0.03	0.25	0.08
Manganese	0.40	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	< 0.01	0.03	0.04	< 0.01	0.04	0.02
Potassium	6.7	< 0.01	0.45	0.12	< 0.01	0.06	0.13
Selenium	0.67	< 0.01			< 0.01	< 0.01	0.01
Silica	--	< 0.01	0.30	< 0.01	< 0.01	< 0.01	0.06
Silver	0.033	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	6.7	1.21	7.26	0.61	< 0.01	1.82	2.18
Sulfur	3.3	3.38	2.54	1.51	5.10	2.56	3.02
Tellurium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	3.3	1.57	0.42	0.11	0.48	1.08	0.73
Volume (SM³)		1656.1	1653.0	1652.8	1652.8	1652.8	1653.5

Highlighting indicates exceedance of screening criterion.

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TABLE 8. AIR DATA AND COMPARISON TO STANDARDS: DOWNTOWN

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 TSP	27-Jun-97 TSP	19-Sep-97 TSP	18-Dec-97 TSP	16-Feb-98 TSP	TSP Average
TSP	--	28.0	35.2	42.5	21.8	4.6	26.4
Aluminum	17	0.21	0.22	0.20	< 0.01	0.32	0.19
Antimony	1.7	0.02	< 0.01	0.10	0.01	< 0.01	0.03
Arsenic	0.00023	0.05	< 0.01	0.03	< 0.01	< 0.01	0.02
Barium	1.7	0.01	< 0.01	0.02	< 0.01	0.01	0.01
Bismuth	33	< 0.01	< 0.01	0.42	< 0.01	< 0.01	0.09
Cadmium	0.00056	0.06	< 0.01	0.01	0.02	< 0.01	0.02
Calcium	6.7	< 0.01	0.19	0.17	0.06	0.38	0.16
Chromium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.05	0.02	0.14	0.10	0.08	0.08
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.43	0.60	0.78	0.24	0.79	0.57
Lead	0.5	1.24	0.23	2.02	0.50	0.26	0.85
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.07	0.17	0.12	< 0.01	0.26	0.13
Manganese	0.40	< 0.01	< 0.01	0.01	< 0.01	0.02	0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	0.02	0.04	0.05	< 0.01	0.04	0.03
Potassium	6.7	0.59	0.36	0.34	< 0.01	0.06	0.27
Selenium	0.67	< 0.01			< 0.01	< 0.01	0.01
Silica	--	< 0.01	0.39	< 0.01	< 0.01	< 0.01	0.08
Silver	0.033	< 0.01	< 0.01	0.10	< 0.01	< 0.01	0.03
Sodium	6.7	< 0.01	8.41	1.13	< 0.01	2.50	2.41
Sulfur	3.3	1.80	1.87	2.64	4.82	2.33	2.69
Tellurium	0.33	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	3.3	1.24	1.01	2.36	1.49	0.87	1.39
Volume (SM³)		1609.7	1546.1	1777.2	1603.9	1598.2	1627.0

Highlighting indicates exceedance of screening criterion.

TABLE 9. AIR DATA AND COMPARISON TO STANDARDS: WEST TRAIL

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 TSP	27-Jun-97 TSP	19-Sep-97 TSP	18-Dec-97 TSP	16-Feb-98 TSP	16-Feb-98 PM_{10}	TSP Average	PM_{10} Average
TSP	--	26.2	25.7	22.0	14.7	1.9	1.0	18.1	1.0
Aluminum	17	0.06	< 0.01	0.05	< 0.01	0.06	0.02	0.04	0.02
Antimony	1.7	< 0.01	0.01	0.04	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Arsenic	0.00023	0.16	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.04	< 0.01
Barium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Bismuth	33	< 0.01	< 0.01	0.20	< 0.01	< 0.01	< 0.01	0.04	< 0.01
Cadmium	0.00056	0.09	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01
Calcium	6.7	0.06	< 0.01	< 0.01	< 0.01	0.26	0.19	0.07	0.19
Chromium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.12	0.03	0.08	0.05	0.05	0.21	0.06	0.21
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.27	0.29	0.29	0.15	0.23	0.09	0.25	0.09
Lead	0.5	2.00	0.24	1.00	0.25	0.10	0.04	0.72	0.04
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.02	0.01	0.01	< 0.01	0.08	0.04	0.03	0.04
Manganese	0.40	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	0.17	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.00	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	< 0.01	0.02	0.04	< 0.01	< 0.01	0.01	0.02	0.01
Potassium	6.7	0.78	0.73	< 0.01	< 0.01	< 0.01	< 0.01	0.31	< 0.01
Selenium	0.67	< 0.01			< 0.01	0.01	< 0.01	0.01	< 0.01
Silica	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	0.033	< 0.01	< 0.01	0.04	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Sodium	6.7	< 0.01	6.99	1.17	1.91	3.20	1.87	2.66	1.87
Sulfur	3.3	2.12	1.84	2.17	3.85	2.32	1.58	2.46	1.58
Tellurium	0.33	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.01	< 0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.01	< 0.01
Zinc	3.3	1.50	0.99	1.64	0.89	0.55	0.16	1.11	0.16
Volume (SM³)		1600.5	1574.4	1702.4	1567.2	1563.1	1601.1	1601.5	1601.1

Highlighting indicates exceedance of screening criterion.

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TABLE 10. AIR DATA AND COMPARISON TO STANDARDS: GLENMERRY

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 TSP	27-Jun-97 TSP	19-Sep-97 TSP	18-Dec-97 TSP	16-Feb-98 TSP	TSP Average
TSP	--	28.0	24.8	28.3	16.3	4.0	20.3
Aluminum	17	0.17	0.10	0.11	0.02	0.08	0.10
Antimony	1.7	0.02	< 0.01	0.08	< 0.01	< 0.01	0.02
Arsenic	0.00023	0.03	0.02	0.03	< 0.01	< 0.01	0.02
Barium	1.7	0.01	< 0.01	0.02	< 0.01	< 0.01	0.01
Bismuth	33	0.02	0.01	0.50	< 0.01	< 0.01	0.11
Cadmium	0.00056	0.03	< 0.01	0.02	< 0.01	< 0.01	0.01
Calcium	6.7	0.19	0.13	0.12	0.12	0.19	0.15
Chromium	1.7	< 0.01	0.03	< 0.01	< 0.01	< 0.01	0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.05	0.05	0.19	0.08	0.26	0.13
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.40	0.47	0.64	0.16	0.13	0.36
Lead	0.5	1.12	0.28	2.20	0.24	0.09	0.79
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.08	0.09	0.02	< 0.01	0.05	0.05
Manganese	0.40	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.00
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.01
Phosphorus	0.33	0.05	< 0.01	0.06	0.05	< 0.01	0.03
Potassium	6.7	0.65	0.41	0.06	< 0.01	< 0.01	0.23
Selenium	0.67	< 0.01			< 0.01	< 0.01	0.01
Silica	--	< 0.01	0.57	< 0.01	< 0.01	< 0.01	0.12
Silver	0.033	< 0.01	< 0.01	0.09	< 0.01	< 0.01	0.02
Sodium	6.7	0.62	8.17	2.38	1.20	3.79	3.23
Sulfur	3.3	1.49	1.82	2.80	3.45	1.85	2.28
Tellurium	0.33	< 0.01	< 0.01	< 0.01	0.02	< 0.01	0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	0.02	< 0.01	0.01
Zinc	3.3	0.68	1.11	3.04	0.37	0.32	1.10
Volume (SM³)		1608.5	1590.3	1678.6	1660.5	1583.5	1624.3

Highlighting indicates exceedance of screening criterion.

TABLE 11. AIR DATA AND COMPARISON TO STANDARDS: NORTHPOINT

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97		19-Sep-97		18-Dec-97		16-Feb-98	TSP Average	PM_{10} Average
		TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}	PM_{10}		
TSP	--	27.1	15.0	16.0	5.3	< 0.0	0.6	0.9	14.4	5.5
Aluminum	17	0.10	0.06	0.06	0.04	< 0.01	0.02	0.04	0.05	0.04
Antimony	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	0.00023	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Barium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Bismuth	33	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Cadmium	0.00056	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Calcium	6.7	2.02	0.37	0.36	0.06	< 0.01	< 0.01	0.62	0.79	0.27
Chromium	1.7	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.07	0.05	0.08	< 0.01	< 0.01	0.02	0.07	0.05	0.03
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.28	0.12	0.09	0.09	< 0.01	0.02	0.13	0.12	0.09
Lead	0.5	0.88	0.50	0.07	0.02	< 0.01	< 0.01	0.02	0.32	0.13
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.10	< 0.01	0.04	< 0.01	< 0.01	< 0.01	0.07	0.05	0.02
Manganese	0.40	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	0.03	< 0.01	0.06	0.03	< 0.01	< 0.01	< 0.01	0.03	0.01
Potassium	6.7	0.60	< 0.01	0.07	0.06	< 0.01	< 0.01	< 0.01	0.23	0.02
Selenium	0.67	< 0.01	< 0.01			< 0.01	< 0.01	< 0.01	0.01	0.01
Silica	--	0.19	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.07	< 0.01
Silver	0.033	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	6.7	< 0.01	1.87	3.55	2.50	< 0.01	0.62	2.50	1.19	1.87
Sulfur	3.3	1.39	1.19	1.35	0.56	< 0.01	< 0.01	1.71	0.91	0.86
Tellurium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	3.3	0.30	0.19	0.06	0.05	< 0.01	< 0.01	0.07	0.12	0.08
Volume (SM³)		1585.0	1600.1	1407.7	1601.8	1407.7	1600.4	1601.0	1466.8	1600.8

Highlighting indicates exceedance of screening criterion.

TABLE 12. AIR DATA AND COMPARISON TO STANDARDS: COLUMBIA GARDENS

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 TSP	27-Jun-97 TSP	19-Sep-97 TSP	18-Dec-97 TSP	16-Feb-98 TSP	TSP Average
TSP	--	34.4	28.4	21.6	10.4	3.7	19.7
Aluminum	17	0.18	0.27	0.14	0.02	0.24	0.17
Antimony	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	0.00023	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.01
Barium	1.7	0.02	0.01	0.01	< 0.01	0.01	0.01
Bismuth	33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cadmium	0.00056	0.04	< 0.01	< 0.01	< 0.01	0.02	0.02
Calcium	6.7	0.18	0.25	0.25	< 0.01	0.43	0.22
Chromium	1.7	< 0.01	0.03	< 0.01	< 0.01	< 0.01	0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.03	0.04	0.03	0.02	0.03	0.03
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.60	0.89	0.38	0.10	0.84	0.56
Lead	0.5	1.53	0.12	0.29	0.05	0.39	0.48
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.09	0.13	0.07	< 0.01	0.20	0.10
Manganese	0.40	< 0.01	0.02	0.02	< 0.01	0.02	0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.01
Phosphorus	0.33	0.04	0.04	0.08	< 0.01	0.03	0.04
Potassium	6.7	0.35	0.08	< 0.01	< 0.01	< 0.01	0.09
Selenium	0.67	< 0.01			< 0.01	< 0.01	0.01
Silica	--	0.06	0.12	< 0.01	< 0.01	< 0.01	0.04
Silver	0.033	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	6.7	< 0.01	8.11	1.88	1.23	1.86	2.62
Sulfur	3.3	2.58	1.99	1.88	0.09	2.75	1.86
Tellurium	0.33	< 0.01	< 0.01	< 0.01	0.02	< 0.01	0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	3.3	1.72	1.60	0.81	0.36	2.48	1.39
Volume (SM³)		1627.0	1602.5	1597.7	1628.3	1610.0	1613.1

Highlighting indicates exceedance of screening criterion.

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TABLE 13. AIR DATA AND COMPARISON TO STANDARDS: WANETA

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 PM_{10}	27-Jun-97 PM_{10}	19-Sep-97 PM_{10}	18-Dec-97 PM_{10}	PM_{10} Average
TSP	--	20.0	7.2	8.3	2.5	9.5
Aluminum	17	0.04	< 0.01	0.02	0.04	0.03
Antimony	1.7	0.02	< 0.01	< 0.01	< 0.01	0.01
Arsenic	0.00023	0.03	< 0.01	< 0.01	< 0.01	0.01
Barium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Bismuth	33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cadmium	0.00056	0.03	< 0.01	< 0.01	< 0.01	0.01
Calcium	6.7	0.13	0.06	< 0.01	< 0.01	0.05
Chromium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.29	0.17	0.10	0.16	0.18
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.23	0.14	0.04	0.02	0.11
Lead	0.5	1.25	< 0.01	0.04	< 0.01	0.32
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	< 0.01	0.03	< 0.01	< 0.01	0.01
Manganese	0.40	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.00
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	0.03	0.03	0.02	< 0.01	0.02
Potassium	6.7	0.66	1.22	0.06	< 0.01	0.49
Selenium	0.67	< 0.01			< 0.01	0.01
Silica	--	0.06	< 0.01	< 0.01	< 0.01	0.02
Silver	0.033	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	6.7	0.63	8.74	0.61	1.84	2.96
Sulfur	3.3	2.00	1.00	1.54	< 0.01	1.13
Tellurium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	0.02	< 0.01	< 0.01	0.01
Zinc	3.3	0.40	0.05	0.09	0.01	0.14
Volume (SM³)		1599.8	1601.1	1627.0	1627.0	1613.7

Highlighting indicates exceedance of screening criterion.

TABLE 14. AIR DATA: SUMMARY BY SAMPLING LOCATION

	Genelle		Oasis		Warfield	Downtown	West Trail		Glenmerry	Northpoint		Columbia Gardens	Waneta	Is Detection Limit > Standard
	TSP	PM_{10}	TSP	PM_{10}	TSP	TSP	TSP	PM_{10}	TSP	TSP	PM_{10}	TSP	PM_{10}	
Number of samples	4	3	5	5	5	5	5	1	5	3	4	5	4	--
TSP	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aluminum	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Antimony	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Arsenic[a]	4 / 2	3 / 1	5 / 1	5 / 1	5 / 1	5 / 2	5 / 2	1 / 0	5 / 3	3 / 0	4 / 0	5 / 1	4 / 1	Yes
Barium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Bismuth	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Cadmium[a]	4 / 1	3 / 0	5 / 1	5 / 1	5 / 1	5 / 3	5 / 1	1 / 0	5 / 2	3 / 1	4 / 0	5 / 2	4 / 1	Yes
Calcium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Chromium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Cobalt	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Copper	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Gallium	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Iron	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Lead	2	0	2	1	1	2	2	0	2	1	0	1	1	No
Lithium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Magnesium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Manganese	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Mercury	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Molybdenum	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Nickel[a]	4 / 0	3 / 0	5 / 0	5 / 0	5 / 0	5 / 0	5 / 0	1 / 0	5 / 1	3 / 0	4 / 0	5 / 1	4 / 0	Yes
Phosphorus	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Potassium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Selenium[b]	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Silica	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Silver	0	0	0	0	0	1	1	0	1	0	0	0	0	No
Sodium	0	1	0	1	1	1	1	0	1	0	0	1	1	No
Sulfur	0	0	3	0	2	1	1	0	1	0	0	0	0	No
Tellurium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Thallium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Tin	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Zinc	0	0	0	0	0	0	0	0	0	0	0	0	0	No

[shaded box] Highlighting indicates exceedance of screening criterion.

-- Not applicable; no criterion available.

[a] Because the detection limit is greater than the screening criterion for this analyte, two values are listed: number of exceedances / exceedances above detection limit.

[b] Selenium was not measured at each sampling period. See Tables 1–9 for details.

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October 20, 2000

Steve Hilts
Trail Lead Program
300-843 Rossland Avenue
Trail, British Columbia
V1R 458

Subject: Addendum to Technical Memorandum 2.2

Dear Steve:

As we have been discussing via e-mail, the health-based screening value for hexavalent chromium was erroneously omitted from the screening of air concentration data conducted during the Phase 2 risk assessment efforts. Attached is a discussion of this omission, the findings of a screening incorporating a value for hexavalent chromium, and tables from Technical Memorandum 2.2, updated to include hexavalent chromium.

I apologize for this oversight. Although the analytical detection limit precludes a meaningful screening of the air data against the standard for this metal, the limitations on the health-based screening that are imposed by the detection limit should have been included in the discussion presented in Technical Memorandum 2.2.

I hope that this information is useful to you and the Task Force.

Sincerely,

Yvette Lowney, M.P.H.
Senior Toxicologist

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Addendum to Technical Memorandum 2.2

As part of the Phase 2 human health risk assessment for non-lead constituents in Trail, Exponent performed a screening of available air concentration data against health-based standards. This was done to determine whether the concentrations of metals in the air around Trail present a potential health risk, and to determine appropriate contaminants of potential concern (COPCs) for further risk assessment of the site. The results of this screening were presented to the Trail Lead Program in July 1998, as part of Technical Memorandum 2.2.

It has subsequently come to our attention at Exponent that the health-based criteria used in this screening failed to incorporate a value for hexavalent chromium. Only data for total chromium in air are available from air monitoring stations in the vicinity of Trail. Therefore, the chromium air concentration data from air sampling stations around Trail were compared to health-based standards for total chromium. The screening indicated that air concentrations consistently fell below the screening concentration. However, a screening against the standard for hexavalent chromium should have been included in the assessment to provide an indication of whether health risks might be presented from inhalation of this form of the metal. This addendum presents the results of the screening of air concentration data against the health-based screening concentration for hexavalent chromium.

Attached are revised versions of Tables 5 through 14 of Technical Memorandum 2.2. These revised tables include screening information for both total chromium and hexavalent chromium. The standard selected for screening of hexavalent chromium is the value provided by the Air Quality Program of the Washington State Department of Ecology. This is also the source of the other screening values included in the tables. As describe above, the only air concentration data for chromium reflect total chromium. There are no specific data for hexavalent chromium, therefore the screening was conducted against the monitoring data for total chromium.

As presented in these tables, this screening indicates that the concentration of hexavalent chromium measured in the vicinity of Trail never exceeds the detection limit (0.01 ug/SM^3) in the respirable (i.e., PM_{10}) particle size fraction. However, because the screening value (0.000083 ug/SM^3) is below the limit of detection for hexavalent chromium, it is not possible to determine whether the standard was exceeded at any location. There are three air sampling stations (Glenmerry, Northport, and Columbia Gardens) where the measured concentration of total chromium in the total suspended particulate (TSP) fraction does exceed the detection limit. It should be noted, however, that even at each of these locations, there is no consistent exceedance of the detection limit—detectable concentrations were recorded for only one sampling period over the year at each location (June, 1997 for Glenmerry and Columbia Gardens, and September, 1997 for Northport).

Because of the detection limit used in the analysis of the air concentration data, and because hexavalent chromium was not specifically measured, it is not possible to determine whether hexavalent chromium exists at air concentrations that exceed health-based standards. The screening criterion of 0.000083 $\mu g/SM^3$ is based on a target risk level of 1 in 1 million. Therefore, with a detection limit of 0.01 $\mu g/SM^3$, and all non-detect data reported, it can only be established that health risks are below 1 in 10,000. Improved analytical detection limits for chromium, and measuring specifically for hexavalent chromium in air would allow for a more discriminating assessment of potential risks posed by inhalation of this metal.

TABLE 5. AIR DATA AND COMPARISON TO STANDARDS: GENELLE

(All units $\mu g/SM^3$, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 TSP	27-Jun-97 TSP	27-Jun-97 PM_{10}	18-Dec-97 TSP	18-Dec-97 PM_{10}	16-Feb-98 TSP	16-Feb-98 PM_{10}	TSP Average	PM_{10} Average
TSP	--	47.1	16.5	6.4	16.2	13.7	2.9	1.3	20.7	7.1
Aluminum	17	0.31	0.06	< 0.01	0.02	0.06	0.20	0.07	0.15	0.04
Antimony	1.7	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Arsenic	0.00023	0.30	< 0.01	< 0.01	0.03	0.04	< 0.01	< 0.01	0.09	0.02
Barium	1.7	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Bismuth	33	< 0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Cadmium	0.00056	0.04	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Calcium	6.7	0.13	< 0.01	< 0.01	0.06	< 0.01	0.31	0.25	0.13	0.09
Chromium (total)	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chromium (hexavalent)[a]	0.000083	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.07	0.09	0.01	0.08	0.03	0.13	0.02	0.09	0.02
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.82	0.34	0.11	0.18	0.11	0.57	0.22	0.48	0.14
Lead	0.5	1.61	< 0.01	< 0.01	0.54	0.35	0.10	0.06	0.56	0.14
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.15	0.04	< 0.01	< 0.01	< 0.01	0.16	0.07	0.09	0.03
Manganese	0.40	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	0.02	< 0.01	< 0.01	< 0.01	0.02	0.01	0.01	0.01	0.01
Potassium	6.7	0.32	0.41	1.13	< 0.01	< 0.01	0.12	< 0.01	0.21	0.38
Selenium	0.67	< 0.01			< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01
Silica	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	0.033	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	6.7	< 0.01	5.61	7.94	1.25	< 0.01	3.74	3.74	2.65	3.89
Sulfur	3.3	2.97	0.81	0.79	2.89	2.58	1.70	1.27	2.09	1.54
Tellurium	0.33	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	0.02	0.02	< 0.01	< 0.01	0.01	0.01
Zinc	3.3	1.87	0.19	0.04	0.44	0.19	0.32	0.13	0.70	0.12
Volume (SM^3)	--	1550.8	1603.2	1637.8	1602.5	1603.9	1605.9	1603.9	1590.6	1615.2

Highlighting indicates exceedance of screening criterion.

[a] Only total chromium was measured; data is repeated on this line to allow comparison with the hexavalent chromium standard.

boulder\groups\data management\cbb5\air_data\quarterly\area_compRev.xls genelle 10/23/00 (10:07 AM)

TABLE 6. AIR DATA AND COMPARISON TO STANDARDS: OASIS

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97		27-Jun-97		19-Sep-97		18-Dec-97		16-Feb-98		TSP Average	PM_{10} Average
		TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}		
TSP	--	26.9	23.8	9.7	3.9	9.7	6.4	18.2	16.2	1.1	1.0	13.1	10.3
Aluminum	17	0.06	0.03	0.04	< 0.01	0.02	0.03	< 0.01	0.04	0.17	0.05	0.06	0.03
Antimony	1.7	0.02	0.02	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	0.01	0.01
Arsenic	0.00023	0.13	0.14	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03	0.03
Barium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Bismuth	33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cadmium	0.00056	0.05	0.05	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01
Calcium	6.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.19	0.18	0.04	0.04
Chromium (total)	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chromium (hexavalent)[a]	0.000083	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.02	< 0.01	0.28	0.08	0.20	0.14	0.22	0.18	< 0.01	0.14	0.15	0.11
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.23	0.14	0.14	0.08	0.10	0.05	0.17	0.08	0.45	0.05	0.22	0.08
Lead	0.5	1.81	1.71	< 0.01	< 0.01	0.03	< 0.01	0.66	0.37	0.11	0.05	0.52	0.43
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.15	0.05	0.04	0.01
Manganese	0.40	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	< 0.01	0.02	< 0.01	< 0.01	0.03	0.03	< 0.01	< 0.01	0.02	< 0.01	0.01	0.01
Potassium	6.7	0.28	0.76	0.28	0.15	0.12	< 0.01	< 0.01	< 0.01	0.19	< 0.01	0.18	0.19
Selenium	0.67	< 0.01	< 0.01					< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01
Silica	--	< 0.01	0.06	1.13	< 0.01	< 0.01	0.12	< 0.01	< 0.01	< 0.01	< 0.01	0.23	0.04
Silver	0.033	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	6.7	< 0.01	< 0.01	6.27	8.41	0.59	0.61	< 0.01	0.62	1.28	3.67	1.63	2.66
Sulfur	3.3	3.50	3.00	0.81	0.72	0.59	0.85	4.69	3.26	5.19	2.34	2.96	2.03
Tellurium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.02	< 0.01	< 0.01	0.01	0.01
Zinc	3.3	2.12	1.46	0.08	0.04	0.09	0.05	0.78	0.35	0.76	0.18	0.77	0.42
Volume (SM³)	--	1599.5	1635.8	1594.8	1663.9	1709.2	1639.0	1646.9	1603.9	1567.6	1636.7	1623.6	1635.9

Highlighting indicates exceedance of screening criterion.

[a] Only total chromium was measured; data is repeated on this line to allow comparison with the hexavalent chromium standard.

TABLE 7. AIR DATA AND COMPARISON TO STANDARDS: WARFIELD

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 TSP	27-Jun-97 TSP	19-Sep-97 TSP	18-Dec-97 TSP	16-Feb-98 TSP	TSP Average
TSP	--	31.4	23.9	13.6	26.6	3.6	19.8
Aluminum	17	0.08	0.14	0.07	0.02	0.32	0.13
Antimony	1.7	0.02	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Arsenic	0.00023	0.03	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Barium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01
Bismuth	33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cadmium	0.00056	0.04	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Calcium	6.7	0.06	0.12	< 0.01	0.06	0.36	0.12
Chromium (total)	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chromium (hexavalent)[a]	0.000083	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.02	< 0.01	< 0.01	< 0.01	0.03	0.01
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.29	0.37	0.15	0.16	0.82	0.36
Lead	0.5	1.57	0.04	< 0.01	0.21	0.22	0.41
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.02	0.07	0.03	0.03	0.25	0.08
Manganese	0.40	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	< 0.01	0.03	0.04	< 0.01	0.04	0.02
Potassium	6.7	< 0.01	0.45	0.12	< 0.01	0.06	0.13
Selenium	0.67	< 0.01			< 0.01	< 0.01	0.01
Silica	--	< 0.01	0.30	< 0.01	< 0.01	< 0.01	0.06
Silver	0.033	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	6.7	1.21	7.26	0.61	< 0.01	1.82	2.18
Sulfur	3.3	3.38	2.54	1.51	5.10	2.56	3.02
Tellurium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	3.3	1.57	0.42	0.11	0.48	1.08	0.73
Volume (SM³)		1656.1	1653.0	1652.8	1652.8	1652.8	1653.5

Highlighting indicates exceedance of screening criterion.

[a] Only total chromium was measured; data is repeated on this line to allow comparison with the hexavalent chromium standard.

TABLE 8. AIR DATA AND COMPARISON TO STANDARDS: DOWNTOWN

(All units μg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 TSP	27-Jun-97 TSP	19-Sep-97 TSP	18-Dec-97 TSP	16-Feb-98 TSP	TSP Average
TSP	--	28.0	35.2	42.5	21.8	4.6	26.4
Aluminum	17	0.21	0.22	0.20	< 0.01	0.32	0.19
Antimony	1.7	0.02	< 0.01	0.10	0.01	< 0.01	0.03
Arsenic	0.00023	0.05	< 0.01	0.03	< 0.01	< 0.01	0.02
Barium	1.7	0.01	< 0.01	0.02	< 0.01	0.01	0.01
Bismuth	33	< 0.01	< 0.01	0.42	< 0.01	< 0.01	0.09
Cadmium	0.00056	0.06	< 0.01	0.01	0.02	< 0.01	0.02
Calcium	6.7	< 0.01	0.19	0.17	0.06	0.38	0.16
Chromium (total)	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chromium (hexavalent)[a]	0.000083	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.05	0.02	0.14	0.10	0.08	0.08
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.43	0.60	0.78	0.24	0.79	0.57
Lead	0.5	1.24	0.23	2.02	0.50	0.26	0.85
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.07	0.17	0.12	< 0.01	0.26	0.13
Manganese	0.40	< 0.01	< 0.01	0.01	< 0.01	0.02	0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	0.02	0.04	0.05	< 0.01	0.04	0.03
Potassium	6.7	0.59	0.36	0.34	< 0.01	0.06	0.27
Selenium	0.67	< 0.01			< 0.01	< 0.01	0.01
Silica	--	< 0.01	0.39	< 0.01	< 0.01	< 0.01	0.08
Silver	0.033	< 0.01	< 0.01	0.10	< 0.01	< 0.01	0.03
Sodium	6.7	< 0.01	8.41	1.13	< 0.01	2.50	2.41
Sulfur	3.3	1.80	1.87	2.64	4.82	2.33	2.69
Tellurium	0.33	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	3.3	1.24	1.01	2.36	1.49	0.87	1.39
Volume (SM³)		1609.7	1546.1	1777.2	1603.9	1598.2	1627.0

Highlighting indicates exceedance of screening criterion.

[a] Only total chromium was measured; data is repeated on this line to allow comparison with the hexavalent chromium standard.

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TABLE 9. AIR DATA AND COMPARISON TO STANDARDS: WEST TRAIL

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 TSP	27-Jun-97 TSP	19-Sep-97 TSP	18-Dec-97 TSP	16-Feb-98 TSP	16-Feb-98 PM_{10}	TSP Average	PM_{10} Average
TSP	--	26.2	25.7	22.0	14.7	1.9	1.0	18.1	1.0
Aluminum	17	0.06	< 0.01	0.05	< 0.01	0.06	0.02	0.04	0.02
Antimony	1.7	< 0.01	0.01	0.04	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Arsenic	0.00023	0.16	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.04	< 0.01
Barium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Bismuth	33	< 0.01	< 0.01	0.20	< 0.01	< 0.01	< 0.01	0.04	< 0.01
Cadmium	0.00056	0.09	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01
Calcium	6.7	0.06	< 0.01	< 0.01	< 0.01	0.26	0.19	0.07	0.19
Chromium (total)	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chromium (hexavalent)[a]	0.000083	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.12	0.03	0.08	0.05	0.05	0.21	0.06	0.21
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.27	0.29	0.29	0.15	0.23	0.09	0.25	0.09
Lead	0.5	2.00	0.24	1.00	0.25	0.10	0.04	0.72	0.04
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.02	0.01	0.01	< 0.01	0.08	0.04	0.03	0.04
Manganese	0.40	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	0.17	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.00	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	< 0.01	0.02	0.04	< 0.01	< 0.01	0.01	0.02	0.01
Potassium	6.7	0.78	0.73	< 0.01	< 0.01	< 0.01	< 0.01	0.31	< 0.01
Selenium	0.67	< 0.01			< 0.01	0.01	< 0.01	0.01	< 0.01
Silica	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	0.033	< 0.01	< 0.01	0.04	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Sodium	6.7	< 0.01	6.99	1.17	1.91	3.20	1.87	2.66	1.87
Sulfur	3.3	2.12	1.84	2.17	3.85	2.32	1.58	2.46	1.58
Tellurium	0.33	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.01	< 0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.01	< 0.01
Zinc	3.3	1.50	0.99	1.64	0.89	0.55	0.16	1.11	0.16
Volume (SM³)		1600.5	1574.4	1702.4	1567.2	1563.1	1601.1	1601.5	1601.1

Highlighting indicates exceedance of screening criterion.

[a] Only total chromium was measured; data is repeated on this line to allow comparison with the hexavalent chromium standard.

TABLE 10. AIR DATA AND COMPARISON TO STANDARDS: GLENMERRY

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 TSP	27-Jun-97 TSP	19-Sep-97 TSP	18-Dec-97 TSP	16-Feb-98 TSP	TSP Average
TSP	--	28.0	24.8	28.3	16.3	4.0	20.3
Aluminum	17	0.17	0.10	0.11	0.02	0.08	0.10
Antimony	1.7	0.02	< 0.01	0.08	< 0.01	< 0.01	0.02
Arsenic	0.00023	0.03	0.02	0.03	< 0.01	< 0.01	0.02
Barium	1.7	0.01	< 0.01	0.02	< 0.01	< 0.01	0.01
Bismuth	33	0.02	0.01	0.50	< 0.01	< 0.01	0.11
Cadmium	0.00056	0.03	< 0.01	0.02	< 0.01	< 0.01	0.01
Calcium	6.7	0.19	0.13	0.12	0.12	0.19	0.15
Chromium (total)	1.7	< 0.01	0.03	< 0.01	< 0.01	< 0.01	0.01
Chromium (hexavalent)[a]	0.000083	< 0.01	0.03	< 0.01	< 0.01	< 0.01	0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.05	0.05	0.19	0.08	0.26	0.13
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.40	0.47	0.64	0.16	0.13	0.36
Lead	0.5	1.12	0.28	2.20	0.24	0.09	0.79
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.08	0.09	0.02	< 0.01	0.05	0.05
Manganese	0.40	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.00
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.01
Phosphorus	0.33	0.05	< 0.01	0.06	0.05	< 0.01	0.03
Potassium	6.7	0.65	0.41	0.06	< 0.01	< 0.01	0.23
Selenium	0.67	< 0.01			< 0.01	< 0.01	0.01
Silica	--	< 0.01	0.57	< 0.01	< 0.01	< 0.01	0.12
Silver	0.033	< 0.01	< 0.01	0.09	< 0.01	< 0.01	0.02
Sodium	6.7	0.62	8.17	2.38	1.20	3.79	3.23
Sulfur	3.3	1.49	1.82	2.80	3.45	1.85	2.28
Tellurium	0.33	< 0.01	< 0.01	< 0.01	0.02	< 0.01	0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	0.02	< 0.01	0.01
Zinc	3.3	0.68	1.11	3.04	0.37	0.32	1.10
Volume (SM³)		1608.5	1590.3	1678.6	1660.5	1583.5	1624.3

Highlighting indicates exceedance of screening criterion.

[a] Only total chromium was measured; data is repeated on this line to allow comparison with the hexavalent chromium standard.

TABLE 11. AIR DATA AND COMPARISON TO STANDARDS: NORTHPORT

(All units μg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 TSP	17-Mar-97 PM$_{10}$	19-Sep-97 TSP	19-Sep-97 PM$_{10}$	18-Dec-97 TSP	18-Dec-97 PM$_{10}$	16-Feb-98 PM$_{10}$	TSP Average	PM$_{10}$ Average
TSP	--	27.1	15.0	16.0	5.3	< 0.0	0.6	0.9	14.4	5.5
Aluminum	17	0.10	0.06	0.06	0.04	< 0.01	0.02	0.04	0.05	0.04
Antimony	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	0.00023	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Barium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Bismuth	33	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Cadmium	0.00056	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Calcium	6.7	2.02	0.37	0.36	0.06	< 0.01	< 0.01	0.62	0.79	0.27
Chromium (total)	1.7	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Chromium (hexavalent)[a]	0.000083	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.07	0.05	0.08	< 0.01	< 0.01	0.02	0.07	0.05	0.03
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.28	0.12	0.09	0.09	< 0.01	0.02	0.13	0.12	0.09
Lead	0.5	0.88	0.50	0.07	0.02	< 0.01	< 0.01	0.02	0.32	0.13
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.10	< 0.01	0.04	< 0.01	< 0.01	< 0.01	0.07	0.05	0.02
Manganese	0.40	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	0.03	< 0.01	0.06	0.03	< 0.01	< 0.01	< 0.01	0.03	0.01
Potassium	6.7	0.60	< 0.01	0.07	0.06	< 0.01	< 0.01	< 0.01	0.23	0.02
Selenium	0.67	< 0.01	< 0.01			< 0.01	< 0.01	< 0.01	0.01	0.01
Silica	--	0.19	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.07	< 0.01
Silver	0.033	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	6.7	< 0.01	1.87	3.55	2.50	< 0.01	0.62	2.50	1.19	1.87
Sulfur	3.3	1.39	1.19	1.35	0.56	< 0.01	< 0.01	1.71	0.91	0.86
Tellurium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	3.3	0.30	0.19	0.06	0.05	< 0.01	< 0.01	0.07	0.12	0.08
Volume (SM³)		1585.0	1600.1	1407.7	1601.8	1407.7	1600.4	1601.0	1466.8	1600.8

[shaded box] Highlighting indicates exceedance of screening criterion.

[a] Only total chromium was measured; data is repeated on this line to allow comparison with the hexavalent chromium standard.

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TABLE 12. AIR DATA AND COMPARISON TO STANDARDS: COLUMBIA GARDENS

(All units μg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 TSP	27-Jun-97 TSP	19-Sep-97 TSP	18-Dec-97 TSP	16-Feb-98 TSP	TSP Average
TSP	--	34.4	28.4	21.6	10.4	3.7	19.7
Aluminum	17	0.18	0.27	0.14	0.02	0.24	0.17
Antimony	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	0.00023	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.01
Barium	1.7	0.02	0.01	0.01	< 0.01	0.01	0.01
Bismuth	33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cadmium	0.00056	0.04	< 0.01	< 0.01	< 0.01	0.02	0.02
Calcium	6.7	0.18	0.25	0.25	< 0.01	0.43	0.22
Chromium (total)	1.7	< 0.01	0.03	< 0.01	< 0.01	< 0.01	0.01
Chromium (hexavalent)[a]	0.000083	< 0.01	0.03	< 0.01	< 0.01	< 0.01	0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.03	0.04	0.03	0.02	0.03	0.03
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.60	0.89	0.38	0.10	0.84	0.56
Lead	0.5	1.53	0.12	0.29	0.05	0.39	0.48
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	0.09	0.13	0.07	< 0.01	0.20	0.10
Manganese	0.40	< 0.01	0.02	0.02	< 0.01	0.02	0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.01
Phosphorus	0.33	0.04	0.04	0.08	< 0.01	0.03	0.04
Potassium	6.7	0.35	0.08	< 0.01	< 0.01	< 0.01	0.09
Selenium	0.67	< 0.01			< 0.01	< 0.01	0.01
Silica	--	0.06	0.12	< 0.01	< 0.01	< 0.01	0.04
Silver	0.033	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	6.7	< 0.01	8.11	1.88	1.23	1.86	2.62
Sulfur	3.3	2.58	1.99	1.88	0.09	2.75	1.86
Tellurium	0.33	< 0.01	< 0.01	< 0.01	0.02	< 0.01	0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	3.3	1.72	1.60	0.81	0.36	2.48	1.39
Volume (SM³)		1627.0	1602.5	1597.7	1628.3	1610.0	1613.1

Highlighting indicates exceedance of screening criterion.

[a] Only total chromium was measured; data is repeated on this line to allow comparison with the hexavalent chromium standard.

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TABLE 13. AIR DATA AND COMPARISON TO STANDARDS: WANETA

(All units µg/SM³, unless otherwise noted)

Parameter	Washington State Standards	17-Mar-97 PM_{10}	27-Jun-97 PM_{10}	19-Sep-97 PM_{10}	18-Dec-97 PM_{10}	PM_{10} Average
TSP	--	20.0	7.2	8.3	2.5	9.5
Aluminum	17	0.04	< 0.01	0.02	0.04	0.03
Antimony	1.7	0.02	< 0.01	< 0.01	< 0.01	0.01
Arsenic	0.00023	0.03	< 0.01	< 0.01	< 0.01	0.01
Barium	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Bismuth	33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cadmium	0.00056	0.03	< 0.01	< 0.01	< 0.01	0.01
Calcium	6.7	0.13	0.06	< 0.01	< 0.01	0.05
Chromium (total)	1.7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Chromium (hexavalent)[a]	0.000083	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt	0.17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Copper	0.67	0.29	0.17	0.10	0.16	0.18
Gallium	--	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Indium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Iron	17	0.23	0.14	0.04	0.02	0.11
Lead	0.5	1.25	< 0.01	0.04	< 0.01	0.32
Lithium	0.080	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium	33	< 0.01	0.03	< 0.01	< 0.01	0.01
Manganese	0.40	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Mercury	0.17	< 0.001	< 0.001	< 0.001	< 0.001	< 0.00
Molybdenum	17	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nickel	0.0021	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Phosphorus	0.33	0.03	0.03	0.02	< 0.01	0.02
Potassium	6.7	0.66	1.22	0.06	< 0.01	0.49
Selenium	0.67	< 0.01			< 0.01	0.01
Silica	--	0.06	< 0.01	< 0.01	< 0.01	0.02
Silver	0.033	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sodium	6.7	0.63	8.74	0.61	1.84	2.96
Sulfur	3.3	2.00	1.00	1.54	< 0.01	1.13
Tellurium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Thallium	0.33	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Tin	6.7	< 0.01	0.02	< 0.01	< 0.01	0.01
Zinc	3.3	0.40	0.05	0.09	0.01	0.14
Volume (SM³)		1599.8	1601.1	1627.0	1627.0	1613.7

Highlighting indicates exceedance of screening criterion.

[a] Only total chromium was measured; data is repeated on this line to allow comparison with the hexavalent chromium standard.

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TABLE 14. AIR DATA: SUMMARY BY SAMPLING LOCATION

	Genelle		Oasis		Warfield	Downtown	West Trail		Glenmerry	Northport		Columbia Gardens	Waneta	Is Detection Limit > Standard
	TSP	PM_{10}	TSP	PM_{10}	TSP	TSP	TSP	PM_{10}	TSP	TSP	PM_{10}	TSP	PM_{10}	
Number of Samples	4	3	5	5	5	5	5	1	5	3	4	5	4	--
Number of Exceedances														
TSP	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aluminum	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Antimony	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Arsenic[a]	4 / 2	3 / 1	5 / 1	5 / 1	5 / 1	5 / 2	5 / 2	1 / 0	5 / 3	3 / 0	4 / 0	5 / 1	4 / 1	Yes
Barium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Bismuth	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Cadmium[a]	4 / 1	3 / 0	5 / 1	5 / 1	5 / 1	5 / 3	5 / 1	1 / 0	5 / 2	3 / 1	4 / 0	5 / 2	4 / 1	Yes
Calcium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Chromium (total)	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Chromium (hexavalent)	4 / 0	3 / 0	5 / 0	5 / 0	5 / 0	5 / 0	5 / 0	1 / 0	5 / 1	3 / 1	4 / 0	5 / 1	4 / 0	Yes
Cobalt	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Copper	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Gallium	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Iron	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Lead	2	0	2	1	1	2	2	0	2	1	0	1	1	No
Lithium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Magnesium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Manganese	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Mercury	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Molybdenum	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Nickel[a]	4 / 0	3 / 0	5 / 0	5 / 0	5 / 0	5 / 0	5 / 0	1 / 0	5 / 1	3 / 0	4 / 0	5 / 1	4 / 0	Yes
Phosphorus	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Potassium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Selenium[b]	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Silica	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Silver	0	0	0	0	0	1	1	0	1	0	0	0	0	No
Sodium	0	1	0	1	1	1	1	0	1	0	0	1	1	No
Sulfur	0	0	3	0	2	1	1	0	1	0	0	0	0	No
Tellurium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Thallium	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Tin	0	0	0	0	0	0	0	0	0	0	0	0	0	No
Zinc	0	0	0	0	0	0	0	0	0	0	0	0	0	No

[shaded box] Highlighting indicates exceedance of screening criterion.

-- Not applicable; no criterion available.

[a] Because the detection limit is greater than the screening criterion for this analyte, two values are listed: number of exceedances / exceedances above detection limit.

[b] Selenium was not measured at each sampling period. See Tables 5–13 for details.

Appendix E

Quality Control Results

TRAIL LEAD PROGRAM

QC Results for Analysis of Special Soil Samples for Human Health Risk Assessment

December, 1997

Laboratory QC - Reference Materials

		Method Blank 1	Method Blank 2	MESS Found Value	MESS Target Value	% Recovery	2709 Found Value	2709 Target Value	% Recovery
Total Metals									
Antimony	T-Sb	<0.05	<0.05	0.33	1.09	30%	1.93	7.9	24%
Mercury	T-Hg	<0.005	<0.005	0.105	0.092	114%	1.52	1.4	109%
Selenium	T-Se	<0.1	<0.1	0.7	0.7	100%	1.2	1.6	75%
Thallium	T-Tl	<1	<1	-	-		<1	<1	100%
Tin	T-Sn	<5	<5	<5	<5	100%	-	-	

Laboratory QC - Replicates

		EH80 971112 4012	EH80 971112 4012	RPD	EH80 971113 4006	EH80 971113 4006	RPD	EH80 971113 4010	EH80 971113 4010	RPD
Total Metals										
Antimony	T-Sb	103	90.6	13%	8.48	13.4	0%	3.07	4.58	0%
Mercury	T-Hg	0.856	1.02	17%	0.103	0.088	16%	0.091	0.085	7%
Selenium	T-Se	1.0	1.2	18%	0.2	0.2	0%	0.1	0.1	0%
Thallium	T-Tl	<1	<1	0%	<1	<1	0%	<1	<1	0%
Tin	T-Sn	26	22	17%	<5	<5	0%	<5	<5	0%

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QC Results for Analysis of Special Soil Samples for Human Health Risk Assessment

December, 1997

Field QC - Equipment Rinsate Blank

		EH80 971112 4016
Total Metals		
Antimony	T-Sb	<0.2
Mercury	T-Hg	<0.00005
Selenium	T-Se	<0.001
Thallium	T-Tl	<0.0001
Tim	T-Sn	<0.03

Field QC - Reference Material

		Trail urban reference soil Found value (97/12)	Trail urban reference soil Found value (97/06)	Percent recovery
Total Metals				
Antimony	T Sb	87.4	98	89%
Mercury	T Hg5	0.297	0.256	116%
Selenium	T Se	1.2	1.8	67%
Thallium	T Tl	<1	3.4	29%
Tin	T Sn	13	12	108%

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QC Results for Analysis of Special Soil Samples for Human Health Risk Assessment

December, 1997

Field QC - Duplicates

		EH80 971112 4003	EH80 971112 4004	RPD	EH80 971113 4009	EH80 971113 4010	RPD
Total Metals							
Antimony	T Sb	26.3	25.7	2%	4.11	3.07	29%
Mercury	T Hg	0.239	0.273	13%	0.085	0.091	7%
Selenium	T Se	2.1	0.7	100%	0.1	0.1	0%
Thallium	T Tl	<1	<1	0%	<1	<1	0%
Tin	T Sn	5	<5	0%	<5	<5	0%

Field QC - Repeat samples from same locations as June '97

		EH80 971112 4001	EH80 970611 4008	RPD	EH80 971112 4002	EH80 970611 4010	RPD	EH80 971112 4003	EH80 970611 4014	RPD
Total Metals										
Antimony	T Sb	355	395	11%	388	276	34%	26.3	104	119%
Mercury	T Hg	3.96	3.65	8%	6.85	4.74	36%	0.239	1.04	125%
Selenium	T Se	7.5	14.3	62%	23.2	10.4	76%	2.1	4.1	65%
Thallium	T Tl	6	17	96%	4	14.3	113%	<1	7.5	153%
Tin	T Sn	103	108	5%	223	133	51%	7	50	151%

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QC Results for Analysis of Paired Soil/Dust Samples for Human Health Risk Assessment

April, 1998

Laboratory QC - Blanks

		Method Blank 1 (µg/g)	Method Blank 2 (µg/g)	Method Blank 3 (µg/g)	Method Blank 4 (µg/g)
Total Metals					
Antimony	T-Sb	<0.05	<0.05	<0.05	<0.05
Arsenic	T-As	<0.05	<0.05	<0.05	<0.05
Cadmium	T-Cd	<0.1	<0.1	<0.1	<0.1
Lead	T-Pb	<2	<2	<2	<2

Laboratory QC - Reference Materials

		2711 Target Value	2711 Found Value	2711 % Recovery	2711 Found Value	2711 % Recovery	2711 Found Value	2711 % Recovery	2711 Found Value	2711 % Recovery
Total Metals										
Antimony	T-Sb	19.4	11.2	58%	11.6	60%	10.1	52%	8.7	45%
Arsenic	T-As	105.0	104.0	99%	101.0	96%	104.0	99%	99.0	94%
Cadmium	T-Cd	41.7	39.5	95%	39.0	94%	38.3	92%	38.2	92%
Lead	T-Pb	1160	1050	91%	1050	91%	1040	90%	1050	91%

Laboratory QC - Replicates

		EH80 980420 4002 (µg/g)	EH80 980420 4002a (µg/g)	RPD	EH80 980427 4006 (µg/g)	EH80 980427 4006a (µg/g)	RPD	HVS3 980420 4002 (µg/g)	HVS3 980420 4002a (µg/g)	RPD
Total Metals										
Antimony	T-Sb	117	113	3%	28	33.7	18%	67.9	70.8	4%
Arsenic	T-As	151	136	10%	53.3	50.6	5%	46.6	47.8	3%
Cadmium	T-Cd	75.5	73.8	2%	17.1	16.4	4%	53.8	54.5	1%
Lead	T-Pb	4850	4650	4%	1070	1110	4%	1710	1580	8%

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QC Results for Analysis of Paired Soil/Dust Samples for Human Health Risk Assessment

April, 1998

Field QC - Equipment Rinsate Blank

		EH99 980422 4001 (µg/g)
Total Metals		
Antimony	T-Sb	<0.2
Arsenic	T-As	<0.02
Cadmium	T-Cd	<0.01
Lead	T-Pb	<0.05

Field QC - Reference Material

		Trail urban reference soil (Butler) Target value	Trail urban reference soil (Butler) Found value	Percent recovery	Trail urban reference soil (Glen) Target value	Trail urban reference soil (Glen) Found value	Percent recovery	NIST 1648 Urban Partic. Target value	NIST 1648 Urban Partic. Found value	Percent recovery
Total Metals										
Antimony	T-Sb	n/a	36.6		93	123	133%	45	35	78%
Arsenic	T-As	n/a	83.8		148	184	124%	115	133	116%
Cadmium	T-Cd	n/a	21.3		18	17.9	98%	75	65.6	87%
Lead	T-Pb	1049	1150	110%	3006	3090	103%	6550	6100	93%

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QC Results for Analysis of Paired Soil/Dust Samples for Human Health Risk Assessment

April, 1998

Field QC - Duplicates

		EH80 980421 4009	EH80 980421 4010	RPD	EH80 980422 4001	EH80 980422 4002	RPD	HVS3 980422 4003	HVS3 980422 4004	RPD
Total Metals										
Antimony	T-Sb	34.8	31.1	11%	34.8	31	12%	32.4	21.1	42%
Arsenic	T-As	30.3	26.5	13%	51	50.6	1%	21.3	20.7	3%
Cadmium	T-Cd	17.1	18.3	7%	16.7	17.1	2%	17.7	16.3	8%
Lead	T-Pb	1380	1490	8%	1230	1230	0%	733	695	5%

Field QC - Duplicates: Redigests of Field Duplicate Pair with high R.P.D.'s

			EH80 980422 4001	EH80 980422 4002	RPD
Total Metals					
Antimony	T-Sb		34.8	37.2	7%
Arsenic	T-As		51	50.8	0%
Cadmium	T-Cd		16.7	16.1	4%
Lead	T-Pb		1230	1140	8%

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QC Results for Analysis of Paired Soil/Dust Samples for Human Health Risk Assessment

April, 1998

Field QC - Duplicates: Redigests of Random 15% of Soil Samples

Sample Number	Antimony	Arsenic	Cadmium	Lead
EH80 980420 4004	12.6	18.9	5.8	236
EH80 980420 4004 redigest	11.4	21.4	5.1	226
Relative Percent Difference	10%	12%	13%	4%
EH80 980421 4003	13.1	23.5	12.0	663
EH80 980421 4003 redigest	21.7	26.2	14.0	853
Relative Percent Difference	49%	11%	15%	25%
EH80 980421 4006	36.1	51.4	17.5	1270
EH80 980421 4006 redigest	42.0	56.0	20.2	1750
Relative Percent Difference	15%	9%	14%	32%
EH80 980422 4002	31.0	50.6	17.1	1230
EH80 980422 4002 redigest	37.2	50.8	16.1	1140
Relative Percent Difference	18%	0%	6%	8%
EH80 980422 4004	113	136	73.8	4650
EH80 980422 4004 redigest	108	138	71.0	4550
Relative Percent Difference	5%	1%	4%	2%
EH80 980424 4001	24.3	33.7	13.9	883
EH80 980424 4001 redigest	30.0	36.5	15.0	1040
Relative Percent Difference	21%	8%	8%	16%

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QC Results for Analysis of Paired Soil/Dust Samples for Human Health Risk Assessment

August/September, 1998

Laboratory QC - Blanks

		Method Blank 1 (µg/g)	Method Blank 2 (µg/g)	Method Blank 3 (µg/g)	Method Blank 4 (µg/g)	Method Blank 5 (µg/g)	Method Blank 6 (µg/g)	Method Blank 7 (µg/g)	Method Blank 8 (µg/g)	Method Blank 9 (µg/g)
Total Metals										
Antimony	T-Sb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Arsenic	T-As	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	T-Cd	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Lead	T-Pb	<2	<2	<2	<2	<2	<2	<2	<2	<2

Laboratory QC - Reference Materials

		2711 Target Value	2711 Found Value	2711 % Recovery	2711 Found Value	2711 % Recovery	2711 Found Value	2711 % Recovery	2711 Found Value	2711 % Recovery
Total Metals										
Antimony	T-Sb	19.4	15.0	77%	19.0	98%	11.3	58%	17.0	88%
Arsenic	T-As	105.0	111.0	106%	111.0	106%	21.0	20%	105.0	100%
Cadmium	T-Cd	41.7	43.3	104%	42.5	102%	40.7	98%	42.0	101%
Lead	T-Pb	1160	1170	101%	1180	102%	1180	102%	1250	108%

Laboratory QC - Reference Materials

		2711 Target Value	2711 Found Value	2711 % Recovery	2711 Found Value	2711 % Recovery	2711 Found Value	2711 % Recovery	2711 Found Value	2711 % Recovery
Total Metals										
Antimony	T-Sb	19.4	16.0	82%	16.6	86%	15.2	78%	18.7	96%
Arsenic	T-As	105.0	105.0	100%	104	99%	110	105%	105	100%
Cadmium	T-Cd	41.7	43.0	103%	41	98%	41.4	99%	41.5	100%
Lead	T-Pb	1160	1220	105%	1240	107%	1210	104%	1250	108%

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QC Results for Analysis of Paired Soil/Dust Samples for Human Health Risk Assessment

August/September, 1998

Laboratory QC - Replicates

		EH80 980810 4001 (µg/g)	EH80 980810 4001a (µg/g)	RPD	EH80 980813 3001 (µg/g)	EH80 980813 3001a (µg/g)	RPD	EH80 980817 3001 (µg/g)	EH80 980817 3001a (µg/g)	RPD
Total Metals										
Antimony	T-Sb	12	10	18%	14	12	15%	72	80	11%
Arsenic	T-As	18	14	25%	29	33	13%	117	127	8%
Cadmium	T-Cd	6.3	6	5%	7.4	7.3	1%	25.2	25.4	1%
Lead	T-Pb	302	282	7%	555	564	2%	2660	2630	1%

Laboratory QC - Replicates

		EH80 980819 3001 (µg/g)	EH80 980819 3001a (µg/g)	RPD	EH80 980824 4001 (µg/g)	EH80 980824 4001a (µg/g)	RPD	HVS3 980811 4004 (µg/g)	HVS3 980811 4004a (µg/g)	RPD
Total Metals										
Antimony	T-Sb	3	4	29%	8.7	8.4	4%	42	46	9%
Arsenic	T-As	12	13	8%	15	18	18%	37	48	26%
Cadmium	T-Cd	2.5	2.5	0%	3.9	4.1	5%	23	25.9	12%
Lead	T-Pb	144	146	1%	185	200	8%	983	1130	14%

Laboratory QC - Replicates

		HVS3 980817 4001 (µg/g)	HVS3 980817 4001a (µg/g)	RPD	HVS3 980817 4006 (µg/g)	HVS3 980817 4006a (µg/g)	RPD	HVS3 980820 3001 (µg/g)	HVS3 980820 3001a (µg/g)	RPD
Total Metals										
Antimony	T-Sb	99	84	16%	47	46	2%	23	23	0%
Arsenic	T-As	65	66	2%	33	32	3%	16	16	0%
Cadmium	T-Cd	71	73.7	4%	26.2	25.4	3%	18.4	20	8%
Lead	T-Pb	2350	2350	0%	1210	1060	13%	528	521	1%

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QC Results for Analysis of Paired Soil/Dust Samples for Human Health Risk Assessment

August/September, 1998

Laboratory QC - Replicates

		HVS3 980825 4002 (µg/g)	HVS3 980825 4002a (µg/g)	RPD	EH80 980826 4004 (µg/g)	EH80 980826 4004a (µg/g)	RPD	EH80 980901 4001 (µg/g)	EH80 980901 4001a (µg/g)	RPD
Total Metals										
Antimony	T-Sb	30	32	6%	5.7	4.9	15%	18	20	11%
Arsenic	T-As	20	18	11%	24	26	8%	24	25	4%
Cadmium	T-Cd	25.1	22.8	10%	3.5	3.6	3%	8.4	9.4	11%
Lead	T-Pb	813	743	9%	153	154	1%	594	657	10%

Laboratory QC - Replicates

		HVS3 980826 4002 (µg/g)	HVS3 980826 4002a (µg/g)	RPD	HVS3 980827 4004 (µg/g)	HVS3 980827 4004a (µg/g)	RPD	HVS3 980903 4001 (µg/g)	HVS3 980903 4001 (µg/g)	RPD
Total Metals										
Antimony	T-Sb	8.9	10.5	16%	64	74	14%	60	81	30%
Arsenic	T-As	13	14	7%	41	39	5%	31	37	18%
Cadmium	T-Cd	7.1	7.7	8%	45	49	9%	18.1	27.4	41%
Lead	T-Pb	236	248	5%	1710	1770	3%	973	1240	24%

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QC Results for Analysis of Paired Soil/Dust Samples for Human Health Risk Assessment

August/September, 1998

Field QC - Soil Equipment Rinsate Blank

		EH99 980902 4001 (µg/g)
Total Metals		
Antimony	T-Sb	<0.2
Arsenic	T-As	<0.2
Cadmium	T-Cd	<0.01
Lead	T-Pb	<0.05

Field QC - Reference Material

		Trail reference soil (Butler) Target value	Trail reference soil (Butler) Found value	Percent recovery	Trail reference soil (Glen) Target value	Trail reference soil (Glen) Found value	Percent recovery	Trail reference soil (Glen) Target value	Trail reference soil (Glen) Found value	Percent recovery
Total Metals										
Antimony	T-Sb	n/a	32		93	109	118%	93	102	110%
Arsenic	T-As	n/a	75		148	186	126%	148	185	125%
Cadmium	T-Cd	n/a	20.2		18	18.8	103%	18	18.7	102%
Lead	T-Pb	1049	1210	115%	3006	3470	115%	3006	3490	116%

		NIST 1648 Urban dust Target value	NIST 1648 Urban dust Found value	Percent recovery	NIST 1648 Urban dust Target value	NIST 1648 Urban dust Found value	Percent recovery
Total Metals							
Antimony	T-Sb	45	36	80%	45	56	124%
Arsenic	T-As	115	95	83%	115	144	125%
Cadmium	T-Cd	75	54.7	73%	75	87.5	117%
Lead	T-Pb	6550	4930	75%	6550	8140	124%

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QC Results for Analysis of Paired Soil/Dust Samples for Human Health Risk Assessment

August/September, 1998

Field QC - Duplicates

		EH80 980826 4001	EH80 980826 4002	RPD	EH80 9980817 4001	EH80 980817 4002	RPD	EH80 980826 4003	EH80 980826 4004	RPD
Total Metals										
Antimony	T-Sb	6	7	15%	19	19	0%	25	24	4%
Arsenic	T-As	2	2	18%	13	13	0%	3	4	3%
Cadmium	T-Cd	112	126	12%	725	701	3%	160	153	4%
Lead	T-Pb	3	3	4%	8	10	20%	6	6	12%

Field QC - Duplicates

		EH80 980820 4002	EH80 980820 4003	RPD	EH80 980826 4005	EH80 980826 4006	RPD
Total Metals							
Antimony	T-Sb	30	29	3%	101	101	0%
Arsenic	T-As	13	12	5%	15	15	3%
Cadmium	T-Cd	769	760	1%	2370	2320	2%
Lead	T-Pb	22	20	10%	63	67	6%

Field QC - Duplicates

		HVS3 980817 4005	HVS3 980817 4006	RPD	HVS3 980806 4002	HVS3 980806 4003	RPD	HVS3 980827 4003	HVS3 980827 4004	RPD
Total Metals										
Antimony	T-Sb	32	33	3%	19	19	0%	41	41	0%
Arsenic	T-As	29	26	9%	17	16	3%	49	45	9%
Cadmium	T-Cd	1350	1210	11%	809	735	10%	1640	1710	4%
Lead	T-Pb	48	47	2%	33	31	6%	72	64	12%

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QC Results for Analysis of Paired Soil/Dust Samples for Human Health Risk Assessment

August/September, 1998

Field QC - HVS3 Equipment Rinsate Blank

		HVS3 980817 4002 (mg)	HVS3 980903 4004 (mg)	HVS3 980828 4005 (mg)
Total Metals				
Antimony	T-Sb	<0.0001	<0.0001	<0.0001
Arsenic	T-As	<0.0001	0.0001	<0.0001
Cadmium	T-Cd	<0.002	<0.002	<0.002
Lead	T-Pb	0.002	0.004	0.001