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Memorandum

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Subject: *Screening Level Risk Evaluation for Proposed Stormwater Basins, BPSOU, Montana*

1 Introduction

In accordance with a forthcoming amendment to the Record of Decision (ROD) for the Butte Priority Soils Operable Unit (BPSOU) (U.S. Environmental Protection Agency [EPA] 2006), tailings, mining wastes, and contaminated soils deposited near the former Silver Bow Creek location by past mining operations would be removed, and several stormwater basins or sedimentation bays, would be created in the excavated areas. These basins would be used to reduce the amount of contaminated stormwater and sediments reaching Silver Bow Creek and improve the quality of water in the creek. Four proposed stormwater basins have been considered in this memorandum—Buffalo Gulch, Diggings East, Northside Tailings, and Grove Gulch. **Figure 1-1** presents the general location of each stormwater basin; artist renderings of the anticipated future stormwater basins are also depicted.

Concerns have been raised in the Butte community as to whether these proposed stormwater basins could pose a potential future risk to individuals recreating in these areas and to wildlife. The purpose of this memorandum is to provide a screening level evaluation of potential human health and ecological risks from exposures to surface water and sediment in these proposed stormwater basins.

2 Data Summary

2.1 Overview of Available Data

Because these stormwater basins do not yet exist, there are no surface water or sediment samples for these areas. Therefore, stormwater and suspended sediment samples collected from storm drains and culverts during past storm events were used as surrogates to estimate what potential surface water and sediment concentrations could be in these future stormwater basins.

Surface water data were collected under the BPSOU *Interim Surface Water Monitoring Plan* (IMP) (Atlantic Richfield Company [AR] 2007). Over the years, AR has revised the IMP and created several IMP addenda as appropriate to meet project needs (AR 2013a, 2013b, 2013c, 2014a, 2014b, 2014c, 2015a, 2016a, 2016b), with each revision and addendum being reviewed and approved by EPA. Surface water data were collected using ISCO automatic samplers. Data are subjected to data validation in accordance with an approved data management plan (AR 1992) and reported in annual surface water data summary reports (DSRs) (AR 2015b, 2015c, 2015d, 2015e, 2015f, 2015g, 2015h, 2016c, 2017a, 2017b, 2018a, 2018b). Data were reported with both laboratory-assigned data qualifiers and data validation-assigned qualifiers. Surface water data used in the stormwater basin evaluation were collected from 2010 to 2017 and include data that are screening quality, which have use restrictions, or are enforcement quality, which are unrestricted. All surface water data were approved by EPA.

Suspended sediment data used in the stormwater basin evaluation were collected under the *Lower Blacktail Creek/Upper Silver Bow Creek Sediment Sampling and Analysis Plan* (AR 2010) and reported in the *2010-2011 Sediment and Benthic Macroinvertebrate Monitoring DSR* (AR 2012). Suspended sediment data were collected using D-Tec crest samplers during three storm events in June of 2010. Sediment data were not validated,[1] and only laboratory-assigned data qualifiers were reported. The data have not been approved or rejected by EPA but are used in this evaluation to quantify screening level risk estimates.

Available surface water and suspended sediment sampling locations were reviewed and culled to focus on those locations that were most representative for each stormwater basin. The following sampling stations were included in this evaluation (see **Figure 2-1**):

Stormwater Basin	Surface Water Stations	Suspended Sediment Stations
Buffalo Gulch	BG-01, BG-CLV-1	BG-01
Diggings East	MSD-CLV-CASEY	MSD-HAB, MSD-CASEYSD
Northside Tailings	BG-CH-C1, BG-CH-C1A	none
Grove Gulch	GG-01, GG-CH-01	none

Two stormwater basins (Buffalo Gulch and Diggings East) were selected for the risk evaluation based on availability of surface water and suspended sediment data for use in estimating medium-specific concentrations. Based on an inspection of the available surface water data (see **Figure 2-2**), measured concentrations for surface water stations contributing to the Northside Tailings and Grove Gulch stormwater basins are similar to, or lower than, concentrations for stations contributing to the Buffalo Gulch and Diggings East stormwater basins. Therefore, it is expected

[1] These samples were collected outside of the EPA administrative order and are not subject to validation.

future conditions in the Northside Tailings and Grove Gulch stormwater basins will be similar to, or better than, the Buffalo Gulch and Diggings East stormwater basins.

The metals included in this risk evaluation include arsenic, cadmium, copper, lead, mercury, and zinc as these were the key contaminants of concern (COCs) identified in the BPSOU ROD (EPA 2006) that were analyzed in both surface water and sediment and likely to be the greatest contributors to estimated risks.

2.2 Exposure Point Concentrations

Based on the assumption that random exposure occurs over an exposure area, risk from a chemical within an exposure area is related to the arithmetic mean concentration of that chemical over the entire exposure area (EPA 1989). Since the true arithmetic mean concentration cannot be calculated with certainty from a limited number of measurements, EPA recommends the 95% upper confidence limit (95UCL) of the arithmetic mean for each exposure area be used as the exposure point concentration (EPC) when calculating exposure and risk at that location (EPA 1992).

The most appropriate mathematical approach for computing the 95UCL of a dataset depends on a number of factors, including the number of data points available, the shape of the distribution of the values, and the degree of censoring (EPA 2002). Because of the complexity of this process, the EPA Technical Support Center has developed a software application called ProUCL v5.1.00 (EPA 2015) to assist in the estimation of 95UCL values. ProUCL calculates 95UCLs for a dataset using several strategies and recommends which 95UCL is considered preferable based on the properties of the dataset. A minimum of 8 to 10 samples is recommended when calculating 95UCLs. If this minimum number of samples is not met, the EPC is set equal to the mean concentration. If the minimum detection frequency requirements for ProUCL are not met, the EPC is set equal to the maximum detected value. If ProUCL provides more than one “recommended” 95UCL to use, the higher value is used as the EPC.

The mathematical approach for deriving the EPCs for surface water and sediment is described in detail below.

2.2.1 Approach for Surface Water

The EPCs for surface water are based on the 95UCL calculated using ProUCL. Surface water data are plentiful and show fairly consistent concentrations over time. Data used in this risk evaluation are based on total recoverable metal concentrations in stormwater samples collected over the last 10 years. Total recoverable concentrations are likely to be most representative of drinking water ingestion scenarios. The last 10 years are assumed to be representative of current (and future) surface water conditions given that actions implemented at the site (e.g., installation of hydrodynamic devices) are not anticipated to impact samples collected during this period.

Figure 2-2 presents the surface water concentrations for four representative metals (arsenic, copper, lead, mercury) for stormwater monitoring locations that will contribute water to the

proposed stormwater basins. As noted above, North Side Tailings Area and Grove Gulch stormwater basins were not evaluated quantitatively due to the lack of suspended sediment data but are shown to provide a frame of reference for the Buffalo Gulch and Diggings East basins. Except for mercury, temporal patterns are consistent among the COCs (see **Figure 2-2**). For mercury (see **Figure 2-2, Panel D**), one sampling date (October 1, 2016; see circled values in figure) shows uncharacteristically high results, which suggests these results are influenced by laboratory issues. For this reason, mercury results for samples collected on this sampling date were excluded from the EPC calculations.

Summary statistics for surface water and the ProUCL-calculated EPC for all COCs used in exposure and risk calculations are presented in **Table 2-1**. The detailed sample results and ProUCL output are presented in **Appendix A.**

2.2.2 Approach for Sediment

The EPCs for sediment are based on suspended sediment collected during the 2010 storm events. Suspended sediment concentration data are available for multiple size fractions[2] (greater than [>] 2 millimeters [mm], 1 to 2 mm, 0.063 to 1 mm, and less than [<] 0.063 mm). Results for the <0.063-mm size fraction have been selected for use in the human health risk evaluation because this is the size fraction most likely to adhere to hands and be incidentally ingested (EPA 2016a). For the ecological risk evaluation, the estimated bulk sediment concentration (i.e., mass-weighted concentration across all size fractions < 2 mm) was used to compute the EPC as wildlife could potentially ingest coarser sediment particles than humans (Bennett et al. 2011). The > 2 mm size fraction includes larger pebbles and rocks, which are not representative of sediments; analysis of metals was not performed for this size fraction. Because the number of suspended sediment samples is small (i.e., only three or four samples per location), a meaningful 95UCL cannot be calculated. For this reason, the sediment EPCs are based on the mass-weighted[3] average.

The detailed results for each suspended sediment sample and the EPCs for all COCs used in exposure and risk calculations are presented in **Table 2-2**. The sediment EPCs for human receptors are presented in the row titled "EPC (< 0.063 mm)," and the sediment EPCs for ecological receptors are presented in the row titled "EPC (Bulk Sediment)".

3 Human Health Evaluation

For the human health risk evaluation, focus was placed on determining if acute exposures from visiting the stormwater basins could result in adverse health effects. Acute exposures were evaluated because it is not anticipated the stormwater basins will be visited regularly for long durations (i.e., exposures are likely to be infrequent and recreational in nature). The sections below describe the receptor populations of interest and present the contaminant exposure-related risk estimates.

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[2] Corresponding mesh sizes are as follows: No. 10 (2 mm), No. 18 (1 mm), No. 230 (0.063 mm)
[3] The calculations were mass-weighted to account for the unequal suspended sediment mass represented by each collected sample.

3.1 Receptor populations

Recreational adolescents (6 to 16 years) playing in or near the stormwater basins were selected as the population of interest for risk evaluation. This receptor is most likely to explore the shoreline of the stormwater basins, resulting in a greater opportunity for exposure. In addition, focus was placed on the lower end of the age range of this receptor population (i.e., 6 years of age) because younger children can be more vulnerable to some pollutants than adults due to differences in behavior and biology, leading to greater exposure and/or unique windows of susceptibility during development.

While it is possible local hunters could consume game, such as ducks and geese, that frequent these stormwater basins, this exposure scenario is likely to be a minor contributor to overall exposures. As demonstrated in a recent EPA memorandum (Griffin 2017), hypothetical human consumption of tissues collected from snow geese that died in November 2016 due to the ingestion of water from the Berkeley Pit would not result in unacceptable risks for either a short-term or chronic exposure scenario. The estimated water concentrations in the stormwater basins are several orders of magnitude below levels in the Berkeley Pit at the time of the geese kill[4]. Therefore, it is assumed hunter exposure to metals via waterfowl ingestion is likely to be negligible for these stormwater basins.

3.2 Exposures to Non-Lead Contaminants

This section summarizes acute exposure and risk to humans from non-lead COCs. (Risks from lead are evaluated using a different approach and are presented in **Section 3.3**). This includes a description of the basic methods and data used to evaluate exposure and risk from non-lead COCs, the estimated hazard ratios, and a discussion of the uncertainties in the evaluation.

3.2.1 Exposure Assessment

The human exposure pathways evaluated in this risk evaluation include incidental ingestion of sediment and surface water during recreational scenarios. Dermal contact with surface water and sediment and inhalation of airborne dust derived from dried sediment were not evaluated quantitatively but are discussed qualitatively in the uncertainty discussion presented in **Section 3.2.4**.

Acute exposure to non-lead COCs was evaluated using standard chronic exposure equations recommended by EPA, except the acute dose was assumed to occur during a single exposure day and was not averaged across multiple exposure days and years. The daily intake calculations are detailed below.

For surface water:

$$DI_{sw} = EPC_{sw} \cdot IR_{sw} \cdot CF \cdot ET / BW$$

[4] As determined from water sample results exported from Montana's Ground-Water Information Center. Sample ID 222284, Site ID 120678 [Butte Mine Flooding OU Berkeley Pit Lake], Sample Date 12/7/2016.

where:

DI_{sw} = Total daily intake of chemical from surface water (milligrams of chemical per kilogram body weight per day [mg/kg BW-day])

EPC_{sw} = Exposure point concentration for surface water (milligrams of chemical per liter of water [mg/L])

IR_{sw} = Incidental ingestion rate of surface water (milliliters of water per hour [mL/hour])

CF = Conversion factor (1E-03; liters per milliliter [L/mL])

ET = Amount of time receptor is exposed to surface water (hours per day [hour/day])

BW = Body weight of receptor (kilograms [kg])

For sediment:

$$DI_{sed} = EPC_{sed} \cdot IR_{sed} \cdot CF \cdot RBA / BW$$

where:

DI_{sed} = Total daily intake of chemical from sediment (mg/kg BW-day)

EPC_{sed} = Exposure point concentration for sediment (milligrams of chemical per kilogram of sediment [mg/kg])

IR_{sed} = Incidental ingestion rate of sediment (milligrams of sediment per day [mg/day])

CF = Conversion factor (1E-06; kilograms per milligram [kg/mg])

RBA = Relative bioavailability of chemical in sediment (unitless)

BW = Body weight of receptor (kg)

Table 3-1 presents the human health exposure parameters used in this risk evaluation. The selected exposure parameters were based on the EPA *Exposure Factors Handbook* (EPA 2011) or professional judgment when values were not available. Typically, attention is focused on "average" intakes near the central portion of the range and on intakes near the upper end of the range (e.g., the 95th percentile). These two exposure estimates are referred to as central tendency exposure (CTE) and reasonable maximum exposure (RME), respectively. This risk evaluation focuses on RME estimates only to be conservative and because these are typically the focus for Superfund risk management decision-making (EPA 1991). If risk estimates for RME receptors are below a level of concern, risk estimates for CTE receptors will be also.

Accurate assessment of the human health risks resulting from incidental ingestion of metals in sediment requires knowledge of the bioavailability of each metal in the sediment. Because there is no site-specific bioavailability information for metals in sediment, the default arsenic RBA of 0.6 (60%) was assumed (EPA 2012), and RBA for all other non-lead metals was assumed to be 1.0 (100%).

3.2.2 Toxicity Assessment

Toxicity values for short-term (acute) exposures are generally limited. For this risk evaluation, the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs) were used (ATSDR 2018). In deriving the MRLs, ATSDR adopted a practice similar to the EPA Reference Dose (RfD) and Reference Concentration (RfC) methods for deriving substance-specific health guidance levels for non-neoplastic endpoints. MRLs are based on no observed adverse effect levels (NOAELs) and adjusted (lowered) by uncertainty factors such that they are set below levels that might cause adverse health effects in sensitive individuals. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure. MRLs are intended to serve as screening levels and used to identify contaminants and potential health effects that may be of concern. It is important to note that MRLs are not intended to define cleanup or action levels.

ATSDR has derived MRLs for acute (1 to 14 days), intermediate (>14 to 364 days), and chronic (365 days and longer) exposure duration, and for the oral and inhalation routes of exposure. Currently, MRLs for the dermal route of exposure have not been derived because ATSDR has not yet identified a method suitable for this route of exposure. MRLs are generally based on the most sensitive substance-induced end point considered to be of relevance to humans. ATSDR has not used serious health effects (such as irreparable damage to the liver or kidneys or birth defects) as a basis for establishing MRLs. Exposure to a level above the MRL does not mean adverse health effects will occur.

For this risk evaluation, the selected MRL was based on acute exposure when available or the intermediate MRL if an acute MRL was not available. **Table 3-2** presents the selected MRLs**.**

3.2.3 Risk Characterization

The basic approach used to characterize risk was computation of a risk ratio for individual COCs in each medium as presented below.

Risk Ratio = DI / MRL

where:

DI = Daily Intake (mg/kg BW-day)

MRL = Minimum Risk Level (mg/kg BW-day)

The risk ratios were then summed across non-lead COCs and across media to compute a total risk ratio. This is a conservative approach and assumes effects across COCs are additive and act on the same target tissues (EPA 1989). The uncertainties associated with this assumption are discussed in **Section 3.2.4**.

If the total risk ratio is less than or equal to one, exposure is below levels that could result in adverse effects. If the total risk ratio exceeds one, further evaluation of this potential exposure scenario may be warranted (e.g., reviewing the basis of and uncertainties in the underlying exposure and toxicity values). However, as noted above, exposure to a level above the MRL does not mean unacceptable risks are occurring as MRLs are set below levels that might cause adverse health effects in sensitive individuals.

Table 3-3 and **Table 3-4** present detailed calculations of risk ratios for each non-lead COC and pathway for each stormwater basin. In summary, all total risk ratios are less than one, which indicates estimated concentrations of non-lead COCs in sediment and surface water in the stormwater basins are not likely to exceed acute levels of potential health concern in the exposure scenarios examined.

3.2.4 Uncertainty Assessment

Quantitative evaluation of the risks to humans from environmental contamination is frequently limited by uncertainty regarding a number of key data items, including concentration levels in the environment, the true level of human contact with contaminated media, and the true dose-response curves for effects in humans. This uncertainty is usually addressed by making assumptions or estimates for uncertain parameters based on whatever limited data are available. Because of these assumptions and estimates, the results of risk calculations are themselves uncertain and are likely overestimated rather than underestimated due to the conservative nature of assumptions made. The following sections review the main sources of uncertainty in the risk evaluation.

3.2.4.1 Pathways Not Included

As discussed above, humans may be exposed to COCs by a number of pathways, but not all of these pathways were evaluated quantitatively in this risk evaluation. In most cases, this is because the contribution of the pathway omitted is believed to be minor compared to one or more other pathways that were evaluated. For example, exposures from dermal contact with sediment and surface water were not quantified. Even though information is limited on the rate and extent of dermal absorption of metals in soil across the skin, most scientists consider this pathway is likely to be minor in comparison to the amount of exposure occurring by the oral route. This view is based on the recognition that most metals tend to bind to soils, reducing the likelihood they would dissociate from the soil and cross the skin, and ionic species, such as metals, have a relatively low tendency to cross the skin even when contact does occur. Similarly, exposures from inhalation of airborne particulates derived from sediment were also not quantified. It is not expected these stormwater basins would dry out and, even if this were to occur, natural borders of these ponds

and drainages are expected to be vegetated. Therefore, there is low potential for surficial sediments to become suspended in air by wind and inhaled by humans.

Omission of these minor pathways will result in a small underestimation of exposure and risk, but the magnitude of this underestimation is not expected to be significant.

3.2.4.2 Exposure Point Concentrations

The uncertainty associated with the EPCs is due to the temporal variability in the concentrations and number of samples available for the calculation. For surface water, samples are abundant and span a number of years. Because of this, the EPCs calculated for surface water are considered to be reliable estimates of the mean concentrations in the stormwater basin.

For sediment, the number of available samples is limited (three to four samples per EPC), and these samples were only collected during a few storm events in June of 2010. Therefore, estimates of the mean sediment concentrations in the stormwater basins are considered uncertain. Estimated risks calculated using the maximum concentration of COCs in each sediment sample (regardless of sample mass contribution) indicate the resulting total risk ratios would be 0.9 and 2 for the Buffalo Gulch stormwater basin and Diggings East stormwater basin, respectively. Although this evaluation is representative of a highly unlikely scenario, it is informative because the predicted risk ratios remain below or just slightly above acute levels of potential health concern.

3.2.4.3 MRLs

The MRLs are also uncertain because of the lack of precise toxicological information on sensitive individuals within the population of interest (e.g., infants, elderly, and nutritionally or immunologically compromised) to effects of hazardous substances. Consistent with their public health principle of prevention, ATSDR used a conservative (i.e., protective) approach to address these uncertainties. Although human data are preferred, MRLs are often based on animal studies because relevant human studies are lacking. In the absence of evidence to the contrary, ATSDR assumed humans are more sensitive than animals to the effects of hazardous substances. ATSDR notes that MRLs may be up to hundredfold below levels shown to be nontoxic in laboratory animals.

3.2.4.4 Risk Estimates

As noted above, risk ratios were summed across all COCs. Summing HQ values across different chemicals is properly applied only to chemicals inducing the same effect by the same mechanism of action. Consequently, summation of risk ratio values for chemicals that differ in the type of effects or act by different mechanisms could overestimate the potential for effects. Thus, the total risk ratios presented in this risk evaluation are likely to overestimate the true level of human health hazard.

3.3 Exposures to Lead

3.3.1 Overview

Risks from lead are evaluated using a somewhat different approach than for the other COCs. First, because lead is widespread in the environment, exposure can occur from many different sources. Thus, lead risks are usually based on consideration of total exposure (all sources) rather than just site-related sources. Second, because studies of lead exposures and resultant health effects in humans have traditionally been described in terms of blood lead level, lead exposures and risks are typically assessed by describing the levels of lead that may occur in the blood of exposed populations and comparing these to blood lead levels of potential health concern. For convenience, the concentration of lead in blood is usually abbreviated "PbB" and expressed in units of micrograms of lead per deciliter of blood (µg/dL).

EPA recommends the use of the Integrated Exposure Uptake Biokinetic (IEUBK) model to evaluate exposures from lead-contaminated media in children in a residential setting for continuous exposure of sufficient duration to result in a quasi-steady state (EPA 1994). The IEUBK model was not designed to assess short-term (less than 90 days), periodic (less frequent than one exposure per week), or acute (less than or equal to 14 days) exposures (EPA 2003). Because of this, an alternate model was selected to evaluate acute exposure to lead from a short-term exposure scenario. EPA has recommended the use of the All Ages Lead Model (AALM) for evaluating short-term exposure scenarios (EPA 2016b). The AALM is still in development; however, a beta version (FORTRAN 1.0) of this model is available (upon EPA request) and was used in evaluation of potential lead-related risks. The version of the model used to derive acute lead screening values in this appendix was provided by EPA on November 16, 2018.

The AALM was used to evaluate a 1-day “pulse” exposure for a 6-year-old from incidental ingestion of sediment and surface water in a stormwater basin. The model output includes predicted lead concentrations for specified time step intervals with interpolated changes between steps in various body compartments, including but not limited to the blood, plasma, kidney, liver, and bone. The AALM was run using a time step of 0.01 day (about 15 minutes) to allow for maximum precision. This output can be used to determine peak PbB levels following a pulse exposure.

An acute blood lead threshold of 20 µg/dL was identified in Office of Land and Emergency Management (OLEM) Directive 9285.6-54, *Recommendations for Assessing Short-term Exposure Involving Lead at Superfund Sites* (EPA 2016b). Per EPA (2016b), a PbB level of 20 µg/dL could be considered as a short-term elevation in PbB that would trigger a response action. This is based on the interpretation of the Center for Disease Control (CDC) recommendation that PbB levels in the range of 20 to 44 µg/dL would result in a home visit by a public health agency within 24 hours of a referral from a physician (CDC 2012). For the purposes of this evaluation, 20 µg/dL was selected as the peak PbB threshold.

3.3.2 Modeling Inputs

Table 3-5 presents the general input parameters used to evaluate lead risk, recognizing several of the assumptions may differ from those typically used in an evaluation of chronic exposure to lead. The rationale for the selection of each input provided in **Table 3-5** is presented below:

- Receptor gender – A female receptor was selected because female children have a lower body weight than male children (per default inputs in the AALM). A receptor with a lower body weight is more sensitive to exposure compared to a receptor with a higher body weight.

- Receptor age at first pulse exposure – The age at first pulse exposure was 2,190 days (6-year-old).

- Water intake rate – The water intake rate selected for use in the model was based on the sum of the default residential drinking water intake of 0.63 liters per day (L/day) and the incidental surface water ingestion rate of 0.0071 L/day for a total water intake rate of 0.6371 L/day. The default residential drinking water intake rate was based on the value provided in the *Headquarters Lead Consultation Intake Form for the Colorado Smelter Superfund Site* (EPA 2017a). The incidental surface water ingestion rate is consistent with the exposure parameters presented in **Table 3-1**.

- Surface Water Concentration – In modeling exposures to lead in water, two sources of water were assumed—the baseline exposure to lead in drinking water (e.g., at the recreator residence), referred to as source 1, and the pulse exposure to lead in surface water from the stormwater basins, referred to as source 2. The following bullets describe each water source and present the model assumptions for the pulse event.

  - Source 1, default drinking water concentration – The default lead drinking water concentration of 0.9 micrograms per liter (µg/L) was selected, which is based on the value identified in EPA (2017a).

  - Source 2, surface water concentration in stormwater basins – The estimated surface water lead concentrations for the Buffalo Gulch and Diggings East stormwater basins were 430 and 112 µg/L, respectively. The derivation of these concentrations is presented in **Section 2.2.1** and documented on **Table 2-1.**

  - Surface water concentration during pulse – On the day of the pulse event, both water sources contributed to the lead exposure from water ingestion. The fraction contribution from each source was determined based on the ratio of the source-specific water intake rate to the total water intake rate. The fraction from source 1 was 0.99 (0.63/0.6371), and the fraction from source 2 was 0.01 (0.0071/0.6371).

- Sediment/Soil intake rate – The sediment/soil intake rate selected for use in the model was 0.055 grams per day (g/day). This intake rate was selected based on the value identified in

EPA (2017a). This intake rate is inclusive of soil and indoor dust intake with an assumed fraction of 55% for indoor dust and 45% for soil, which is consistent with the default IEUBK model assumption. On the day of the pulse event, the intake rate attributed to soil is assumed to be inclusive of both the sediment incidentally ingested while visiting the stormwater basins and the soil incidentally ingested while at a residence.

- Sediment/Soil concentration – Similar to water, two sources of lead in sediment/soil were assumed in the model—the baseline exposure to lead in surface soil (e.g., at the recreator residence), referred to as source 1, and the pulse exposure to lead in sediment from the stormwater basins, referred to as source 2. The following bullets describe each source and present the model assumptions for the pulse event.
  - Source 1, residential soil lead concentration – A residential soil lead concentration of 400 mg/kg was selected based on the residential soil remediation action level for the site.
  - Source 2, sediment lead concentration in stormwater basins – The estimated sediment lead concentration for the Buffalo Gulch and Diggings East stormwater basins were 1,702 and 925 mg/kg, respectively. The derivation of these concentrations is presented in **Section 2.2.2** and documented on **Table 2-2.**
  - Sediment/Soil concentration during pulse – On the day of the pulse event, both sources contributed to the lead exposure from ingestion of sediment/soil. The fraction contribution from each source was assumed to be 0.75 residential soil and 0.25 sediment from the stormwater basins (as the majority of the exposure time on the day of the pulse event is likely spent at the residence).
- The default value of RBA for lead in soil and dust assumed by the IEUBK model is 0.60 (EPA 2007). Studies of lead RBA at a variety of mine sites suggest this is a typical value, but values at some sites may be higher or lower (EPA 2007). Site-specific studies of lead bioavailability for soils in Butte indicate lead RBA is about 0.20 (URS 2003). For the purpose of modeling PbB using AALM, the default RBA value of 0.60 was conservatively assumed.
- The default lead air concentration of 0.1 micrograms per cubic meter was assumed. This is the value included in the current version of the IEUBK model.
- The concentration of lead in residential indoor dust was calculated from the residential soil concentration using the default soil-to-dust mass fraction of 0.7 from the IEUBK model (EPA 1998a). Site-specific data for Butte suggest the soil-to-dust mass fraction is likely to be closer to 0.26 (Brattin and Griffin 2011); thus, use of the default model value is a conservative assumption.
- Dietary intake rate – The dietary lead intake rate selected for use in the model was 5.95 micrograms of lead per day (µg/day) based on the value identified in EPA (2017a).

- Maternal PbB level – A maternal PbB level of 0.6 µg/dL was selected based on the recommendation provided in OLEM Directive 9285.6-56 (EPA 2017b).

3.3.3 Modeling Results

The maximum predicted PbB levels for a 6-year-old exposed to surface water and sediment in the stormwater basins were less than 3 µg/dL for both Grove Gulch and Diggings East (see **Figure 3-1**). The predicted PbB levels are well below the threshold PbB level of 20 µg/dL for acute exposure, which indicates future recreational exposure to lead in surface water and sediment in the stormwater basins is not of potential health concern.

3.3.4 Uncertainty Assessment

Many of the uncertainties associated with risk evaluation for non-lead COCs also pertain to the lead evaluation (e.g., pathways not included, EPCs). The EPCs used for the lead risk evaluation were based on a mass-weighted mean for sediment and a 95UCL on the mean for surface water for each stormwater basin. Evaluation of the maximum observed concentration for sediment (2,750 mg/kg) and surface water (19,800 µg/L) for either stormwater basin resulted in a maximum predicted PbB level of 4.2 µg/dL during the pulse event, which demonstrates even the worst-case lead concentrations would not result in a predicted PbB level above 20 µg/dL.

Although the lead risk evaluation modeled a single 1-day pulse exposure to surface water and sediment in the stormwater basins, the overall risk conclusions would not change if there were repeated pulse exposures over time. As demonstrated in EPA's *Recommendations for Assessing Short-term Exposure Scenarios Involving Lead at Superfund Sites* (EPA 2016b), when there is adequate time between pulse events allowing PbB levels to return to baseline PbB conditions (which occurs approximately 7 days following each pulse), peak PbB levels associated with repeated pulse exposures will decrease over time (see Figure 1a in EPA 2016b). A supplemental modeling evaluation (detailed results not shown) demonstrates that, even with repeated daily exposures to stormwater and sediment throughout the summer, predicted peak PbB levels would not be above 20 µg/dL.

For lead, there are also uncertainties associated with the true relationship between lead intake levels and the resultant increase in blood lead levels as predicted using the AALM. As noted above, the AALM is still in development; a beta version of this model was used for researching effects of lead exposures under an acute exposure scenario. However, the approach presented is based on the best available science for quantifying acute lead exposures. For these reasons, the lead risk evaluation is considered to be reliable.

4 Ecological Evaluation

4.1 Exposure Assessment

4.1.1 Receptor Populations of Interest

In addition to human receptors, there could also be ecological receptors exposed to sediment and surface water within the stormwater basins. These ecological receptors could include household

pets (e.g., dogs on a walk), migrating waterfowl, and resident wildlife (i.e., birds and mammals adapted to an urban setting, such as coyotes, rabbits, racoons, American robins, Canada geese, starlings). This section evaluates potential ecological risks for both long-term (resident wildlife) and short-term (migrating waterfowl, pets) exposure scenarios. Ecological risks were evaluated in basic accordance with the procedures described in EPA's ecological risk assessment guidance for Superfund (EPA 1997, 1998b).

As noted previously, the purpose of these stormwater basins is to collect stormwater and allow for suspended sediments generated during storm events to settle out, thereby reducing the amount of contaminated stormwater and sediments reaching Silver Bow Creek and improving the quality of water in the creek. As designed, these basins should accumulate contaminated sediments, and they will be maintained by dredging and disposal of captured sediment as needed. It is anticipated these stormwater basins will contain some water throughout the year, but water levels will be highest following stormwater events. Although it is possible aquatic receptors (e.g., fish, invertebrates, and plants) could also have exposures within these stormwater basins, because these basins are not intended to represent quality aquatic habitat, aquatic exposures were not evaluated.

4.1.2 Exposure Pathways of Interest

There are two primary exposure media of interest for this ecological risk evaluation—surface water and sediment. Birds and mammals may be exposed to contaminants by three primary pathways: (1) incidental ingestion of sediment, (2) ingestion of surface water as drinking water, and (3) ingestion of contaminated food. Direct contact (i.e., dermal exposure) of birds and mammals to water and sediment may occur in some cases, and inhalation exposure to contaminants in airborne dusts is possible for all birds and mammals, but these exposure pathways (i.e., dermal and inhalation) are usually considered to be minor compared to exposures from ingestion, especially for metals (EPA 2005). Although birds and mammals can be exposed via ingestion of contamination in or on food items, as noted previously, these stormwater basins are not expected to provide quality habitat, and their urban setting (i.e., proximity to roads and buildings) makes it unlikely they would contribute a significant portion of the total diet. Therefore, this screening level evaluation focuses on ingestion of surface water and sediment only.

4.1.3 Contaminants of Interest

The contaminants of ecological concern for which measured surface water and sediment data are available are the same as those identified above for human health (i.e., arsenic, cadmium, copper, lead, mercury, and zinc). In addition to these metals, water pH is also an important parameter of potential concern. For example, the deaths of snow geese in 1995 and 2016 at the Berkeley Pit have been attributed primarily to ingestion of acidic water with pH levels as low as 2.5 (Stubblefield et al. 1997).

4.1.4 Species of Interest

It is not feasible to evaluate risks for every bird and mammal species that could potentially be exposed at the stormwater basins. For this reason, specific ecological receptors were identified as

surrogates (representative species) for the purposes of evaluating exposure and potential risk. The surrogate species were selected to be representative of other species of similar size and with similar intakes.

There were two avian wildlife surrogates identified—the mallard duck and the marsh wren. The mallard duck represents larger waterfowl, and the marsh wren represents smaller passerines. There were three mammalian wildlife surrogates identified—the red fox, the shrew, and the mink. The red fox represents terrestrial mammals with a moderate home range size, the shrew represents a terrestrial mammal with a small home range, and the mink represents smaller semiaquatic mammals with a higher incidental ingestion of sediment. In addition to these mammalian wildlife species, exposures were also evaluated for a large breed domestic dog (e.g., Labrador retriever).

4.2 Chronic Risk Evaluation

4.2.1 Basic Approach

The basic equation used to calculate the site-specific exposure (or dose) for a bird or mammal to a chemical via ingestion is as follows:

$$Dose_{i,r} = [\ \sum EPC_{i,j} \cdot (IR_j / BW_r)\ ] \cdot EAF_r$$

where:

$Dose_{i,r}$ = Average daily ingested dose of chemical "i" by receptor "r" across all media

$EPC_{i,m}$ = Exposure point concentration of chemical "i" in medium "m" (e.g., mg/kg of sediment or mg/L of water)

$IR_{m,r}$ = Average intake rate of medium "m" by receptor "r" (e.g., kilograms of sediment per day [kg/day] or liters of water per day [L/day])

BW_r = Body weight of receptor "r"

EAF_r = Exposure adjustment factor for receptor "r" accounts for seasonal area use (e.g., migratory waterfowl would not be expected to be present year-round), media inaccessibility (e.g., during winter when stormwater basins are frozen), and home range size considerations (e.g., receptors with larger home ranges would only spend a portion of their time within these stormwater basins)

The calculated site-specific dose is then compared to a literature-based toxicity reference value (TRV) to yield a hazard quotient (HQ):

$$HQ = Dose / TRV$$

If the HQ is less than or equal to one, risk is considered to be acceptable. If the HQ exceeds one, risk of adverse effects in the exposed organisms may be of potential concern, with the potential likelihood and severity of the effects increasing as the magnitude of the HQ increases.

4.2.2 Exposure Point Concentrations

The EPCs for surface water and bulk sediment used in the ecological risk calculations were described previously in **Section 2.2**. See **Table 2-1** and **Table 2-2** for a summary of the EPCs for surface water and bulk sediment, respectively.

4.2.3 Exposure Parameters

Exposure parameters (i.e., intake rates, body weight, exposure adjustment factors) were derived from the *Wildlife Exposure Factors Handbook* (EPA 1993) and other literature sources. In general, wildlife exposure factors were selected to represent average year-round adult exposures. In some cases, no quantitative data could be located; thus, professional judgment was used in selecting exposure parameters. Detailed information on the available exposure information for each surrogate receptor is provided in **Appendix B**, and a summary of the selected chronic exposure parameters is presented in **Table 4-1** (see Panel A).

4.2.4 Toxicity Reference Values

Two types of dose-based TRVs are often identified in the literature. The first TRV is an estimate of the dose that is not associated with any adverse effects and is referred to as the NOAEL TRV. The second TRV is an estimation of the dose causing an observable adverse effect and is referred to as the lowest observed adverse effect level (LOAEL) TRV. The true threshold for adverse effects lies between the NOAEL and LOAEL TRVs. It is expected the adverse effect threshold will vary from species to species within any particular wildlife group. Unfortunately, available toxicity data for birds and mammals are generally not robust enough to develop species-specific TRVs; therefore, a single bird TRV and a single mammal TRV were used to represent all bird and mammal species, respectively.

When evaluating long-term (chronic) exposures from ingestion of contaminated media over the lifetime of the receptor, TRVs derived from studies in which the exposure route was oral (e.g., via ingestion in diet or water or via gavage) and dosing occurred over a long period (chronic exposure) or during a critical life stage were given preference. In addition, to the extent feasible, wildlife TRVs were selected to represent relevant toxicity endpoints for population sustainability (e.g., growth, reproduction, mortality). There are four widely accepted sources of chronic wildlife TRVs used in ecological risk assessment:

- EPA ecological soil screening level TRVs (EPA 2005)
- Los Alamos National Laboratory (LANL) ECORisk database TRVs (LANL 2017)
- EPA Region 9 Biological Technical Advisory Group and California Department of Toxic Substances Control (DTSC) recommended TRVs (DTSC EcoNOTES 4, 5, and 6)
- Oak Ridge National Laboratory TRVs (Sample et al. 1996)

Table 4-2 summarizes the dose-based NOAEL and LOAEL TRVs for birds and mammals from each of these sources and identifies the values selected to evaluate chronic exposures.

The toxicity of an ingested dose depends on how much of the ingested dose is actually absorbed, which in turn depends on the properties of both the chemical and the exposure medium. The absorption fraction from a medium is referred to as the bioavailability. For the purposes of this screening level evaluation, bioavailability was assumed to be 100%. This assumption is likely to be realistic for contaminants in water but may tend to overestimate exposure for contaminants in soil or sediment, especially for metals.

4.2.5 Chronic HQ Results

Appendix C presents the detailed chronic risk calculations, including the estimated site-specific doses and resulting NOAEL and LOAEL HQs, for Buffalo Gulch and Diggings East stormwater basins. **Table 4-3** (Panel A) summarizes the chronic NOAEL and LOAEL HQs for each receptor in each stormwater basin. As seen, HQs are less than or equal to one for the mallard duck and all mammalian surrogate receptors (i.e., red fox, shrew, mink, and domestic dog) for both stormwater basins. These results indicate chronic long-term exposures to surface water and sediment in these stormwater basins are unlikely to result in adverse effects that would negatively impact local mammalian wildlife populations, migrating waterfowl, or domestic pets.

For the marsh wren in the Buffalo Gulch stormwater basin, estimated HQs for both lead and copper are greater than or equal to one based on both the NOAEL and LOAEL TRVs. In the Diggings East stormwater basin, estimated HQs for lead and copper are greater than or equal to one based on the NOAEL; however, only lead has an HQ greater than one based on the LOAEL TRVs. **Appendix C** shows the estimated exposure dose is primarily attributable to incidental ingestion of sediment (i.e., surface water ingestion usually contributes less than 5% of the total exposure dose). These screening level results suggest chronic, long-term exposures to lead (and copper to a lesser degree) in sediment in these stormwater basins have the potential to result in adverse effects in local passerine species with home ranges entirely within these stormwater basins.

4.3 Acute Risk Evaluation

The risk estimates described above provide information on a long-term exposure scenario based on average exposure inputs and chronic toxicity values. However, chronic risk estimates may not account for short-term (episodic) exposure events with higher than average intakes. For example, migratory birds can become dehydrated during migration and have much higher drinking water ingestion rates over a shorter period during stopovers (Isanhart et al. 2011). Therefore, ecological risk estimates were also calculated for an acute exposure scenario.

4.3.1 Basic approach

The basic approach used to calculate the site-specific dose and HQ for the acute exposure scenario is the same as described above for chronic, with the following exceptions:

- The receptor-specific surface water and sediment intake rates ($IR_{m,r}$) represent the high-end of the distribution of potential values rather than the average.
- There is no receptor-specific exposure adjustment factor (EAF_r). It was assumed all surface water and sediment ingested during the acute exposure is derived from the stormwater basin and occurs during a time when exposure media are accessible (e.g., spring or summer).
- The bird and mammal TRVs were derived from toxicity studies with short-term exposure durations and acute effects endpoints (e.g., lethality).

4.3.2 Exposure Parameters

Exposure parameters were derived from the *Wildlife Exposure Factors Handbook* (EPA 1993) and other literature sources. As noted above, surface water and sediment intake rates were selected to represent high-end exposure estimates. Detailed information on the available exposure information for each surrogate receptor is provided in **Appendix B**, and a summary of the selected acute exposure parameters is presented in **Table 4-1** (see Panel B). As shown, acute surface water and sediment intake rates usually increased by a factor of about 2 to 4 compared to the chronic intake values.

4.3.3 Toxicity Reference Values

Because wildlife risk assessments typically focus only on chronic exposures, there are few established literature sources providing acute TRVs. Two sources were identified for the purposes of selecting acute TRVs:

- U.S. Fish and Wildlife Service, contaminant hazard reviews (Eisler 1985, 1987, 1988a, 1988b, 1993, 1998)
- EPA ECOTOX database (EPA 2019) – see **Appendix D** for detailed database output

TRVs derived from studies in which the exposure route was oral (e.g., via ingestion in diet or water or via gavage) and dosing occurred over a short period (i.e., less than 14 days) were given preference. TRVs were selected to represent acute toxicity endpoints, resulting in obvious individual impairment (e.g., survival, gross pathological impacts). **Table 4-4** summarizes the selected dose-based acute TRVs for birds and mammals used to evaluate acute exposures.

In addition to these sources of acute toxicity data, a recent study was also identified in the literature, providing laboratory-based data on acute mallard toxicity following gorge-drinking of simulated acid metalliferous water (AMW) (Isanhart et al. 2011). In this study, ingestion of AMW resulted in death within hours of exposure and was primarily attributed to elevated copper, which ranged from 415 to 1,605 mg/kg BW, and low pH (2.0). As shown, the selected acute avian TRV for copper (693 mg/kg BW; see **Table 4-4**) is within this range.

As noted previously, the acute evaluation also assessed potential ecological exposures to acidic water. The TRV for pH is based on a study conducted by Foster (1999), which showed ingestion of

drinking water at a pH of 3.0, without any addition of metals, was fatal for about two-thirds of exposed ducklings. Therefore, an acute avian TRV for pH of 3.0 was selected for this risk evaluation. If pH levels in stormwater are lower than this TRV, water acidity alone has the potential to be of concern, regardless of the metal concentrations. No acute mammalian TRV for pH was identified.

4.3.4 Acute HQ Results

Appendix E presents the detailed acute risk calculations, including the estimated site-specific doses and resulting HQs, for the Buffalo Gulch and Diggings East stormwater basins. **Table 4-3** (Panel B) summarizes the acute HQs for each receptor in each stormwater basin. As shown, with the exception of the mink, the acute HQs are less than one for all receptors. For the mink, lead and zinc acute HQs are at one for the Buffalo Gulch stormwater basin, due almost entirely to incidental ingestion of sediment. However, review of the underlying acute toxicity data upon which the TRVs are based shows both the mammalian TRVs for lead and zinc are based on toxicity in domestic livestock, which may not be a good predictor for toxicity in smaller mammalian wildlife species.

Review of the available surface water data show measured pH levels range from about 6.5 to 9, which is well above the acute avian threshold. These data support the conclusion that pH levels in surface water are not expected to adversely impact avian receptors using these waters as a drinking water source. Given the generally neutral pH conditions, it is assumed surface water would also not be of potential concern as a drinking water source for mammalian receptors.

4.4 Uncertainty Assessment

There are several uncertainties related to the ecological risk estimates presented in this memorandum. As described in **Section 2**, available site data were used to estimate potential future surface water and bulk sediment concentrations in the stormwater basins. In particular, available sediment data are limited, representing only a few storm events in June of 2010.

This screening level risk evaluation focuses only on ingestion of surface water and sediment, not ingestion of aquatic dietary items, such as aquatic plants, invertebrates, and fish. If these stormwater basins become an important food source for ecological receptors, total metal exposures could be higher, especially for metals that bioaccumulate.

The exposure parameters for the selected avian and mammalian surrogate receptors were derived from literature reports of intake rates and body weights and allometric scaling equations, which may not be representative of site-specific intake rates of typical receptors at this site. In addition, it was assumed the stormwater basins encompassed all, or a large portion of, the total local home range when wildlife are on-site, which is likely to be a conservative assumption given the urban setting and potential future human use of these areas.

HQs were derived assuming 100% bioavailability for all metals. Absorption of metals in sediment is likely to be lower than 100%; therefore, this approach is likely to overestimate risks from incidental ingestion of sediment, which was the primary exposure pathway contributing to total risks.

For ecological receptors that are not of special status (e.g., threatened and endangered), the goal is to ensure sustainability of exposed populations (i.e., maintain normal levels of diversity and density within the population); thus, risks to some individuals in a population may be acceptable if the population is expected to remain healthy and stable. Even if it is possible to accurately predict risks to individuals within the exposed population, estimating the impact of those effects on the population is difficult and uncertain.

Because of the inherent conservatism in the derivation of the exposure estimates and toxicity values, the ecological HQ values presented in this risk evaluation should generally be viewed as screening level estimates, being more likely to be high than low. HQs represent only one line of evidence and, given the inherent uncertainties noted above, should not be used as the sole basis for risk management decision-making. Overall ecological risk conclusions should be based on multiple lines of evidence supported by robust data collected specifically to support ecological risk characterization.

5 Overall Conclusions

The human health risk evaluation showed estimated future concentrations of COCs in surface water and sediment in the proposed stormwater basins are not likely to result in exposures for site recreators that exceed acute levels of potential health concern.

Screening level ecological risk estimates suggest exposures to surface water and bulk sediment in these stormwater basins are unlikely to result in adverse effects that would negatively impact most local wildlife populations, migrating waterfowl, or domestic pets. Additionally, because surface water pH is not expected to be acidic, ingestion of surface water as drinking water is not likely to be of potential concern for any ecological receptors. It is possible incidental ingestion of sediment could be of potential concern for local passerine species (e.g., marsh wren) and semiaquatic mammals (e.g., mink) with home ranges entirely within the Buffalo Gulch stormwater basin (and to a lesser degree from the Diggings East stormwater basin); however, this risk conclusion is uncertain. As appropriate, future collection of sediment data from the stormwater basins could be performed after construction to determine if the screening level exposure estimates presented in this memorandum are representative of future exposure conditions. In addition, it is anticipated future evaluations would assess the effectiveness of these stormwater basins at reducing metals loading and improving water quality in Silver Bow Creek.

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FIGURES

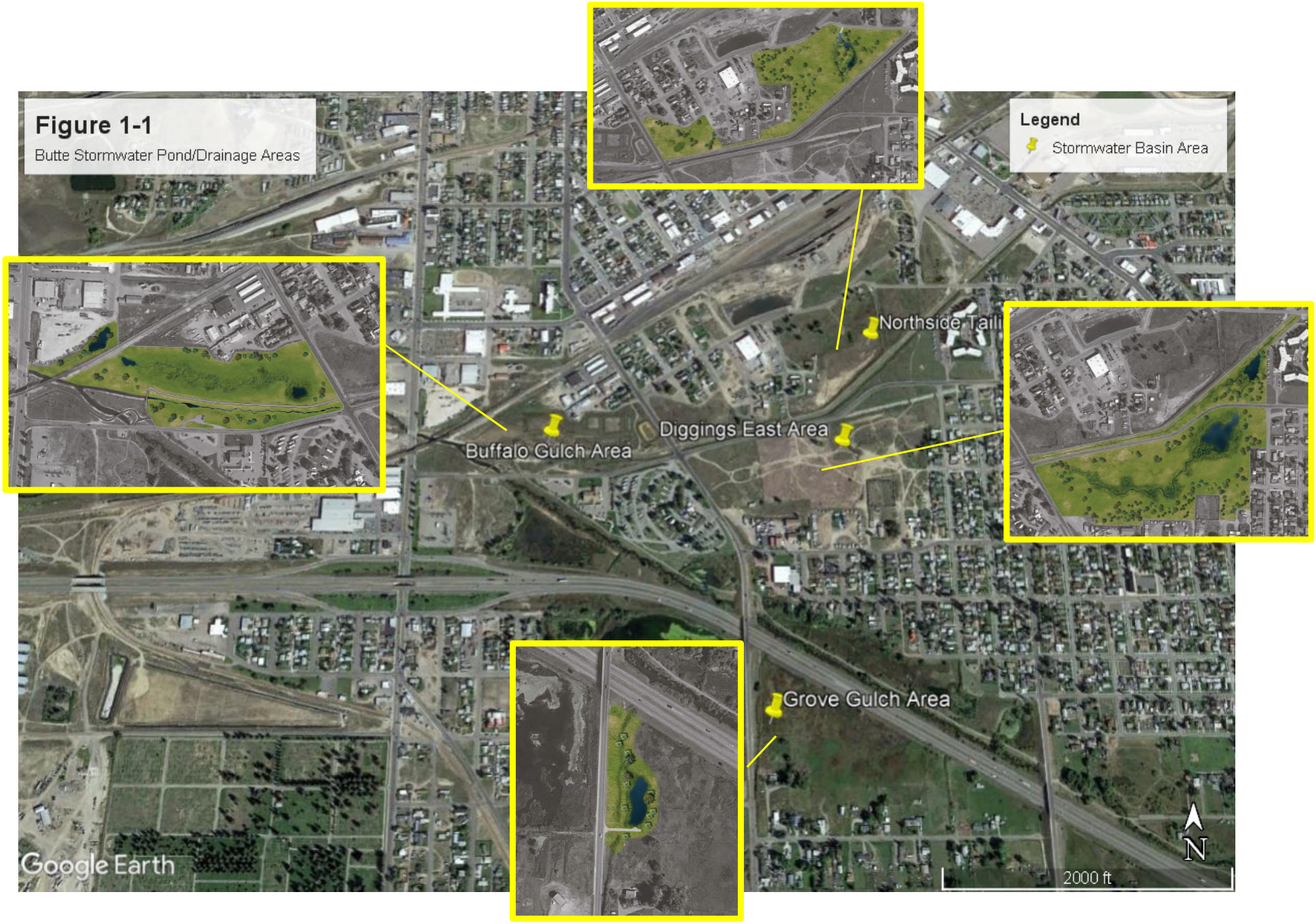
Figure 1-1
Butte Stormwater Pond/Drainage Areas
Legend
Stormwater Basin Area
Northside Taili
Diggings East Area
Buffalo Gulch Area
Grove Gulch Area
Google Earth
2000 ft
N

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Figure 2-1. Locations of Surface Water and Suspended Sediment Stations Stormwater Basin Risk Evaluation
Butte Priority Soils Operable Unit
Silver Bow Creek/Butte Area NPL Site

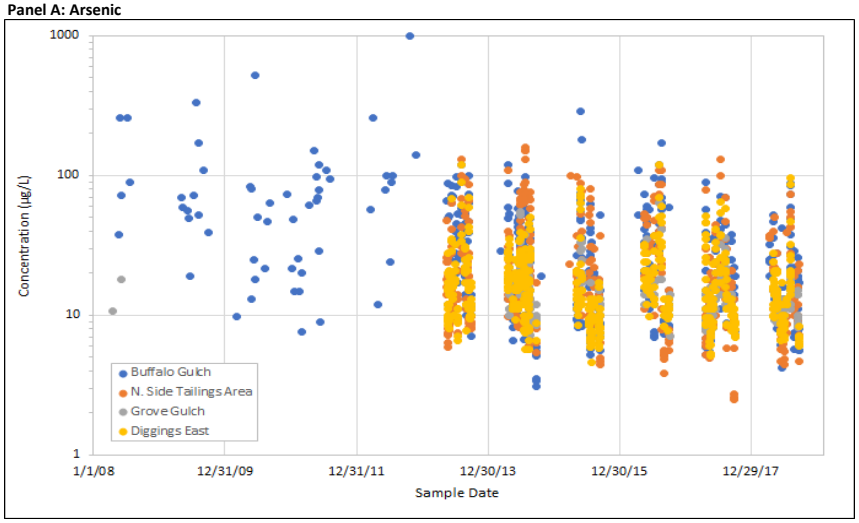
0 1,000 2,000 3,000 Feet

N W E S

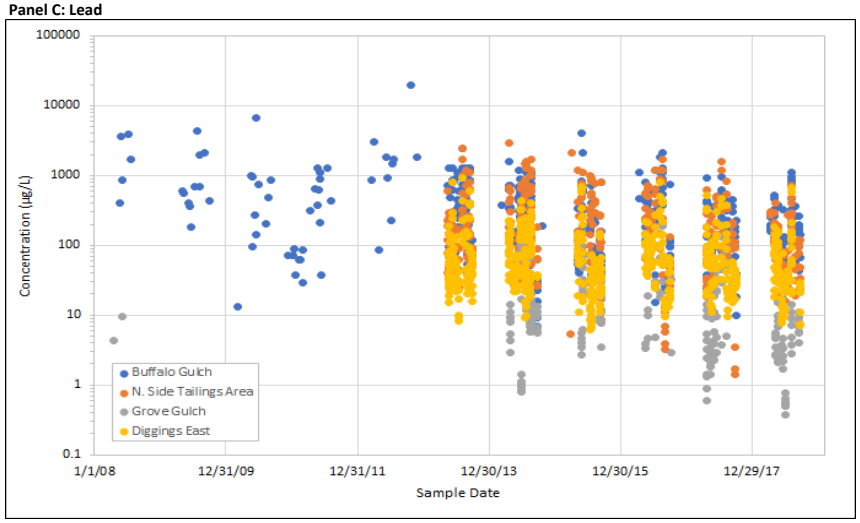
CDM Smith

FIGURE 2-2
SURFACE WATER CONCENTRATIONS
BPSOU STORMWATER BASIN

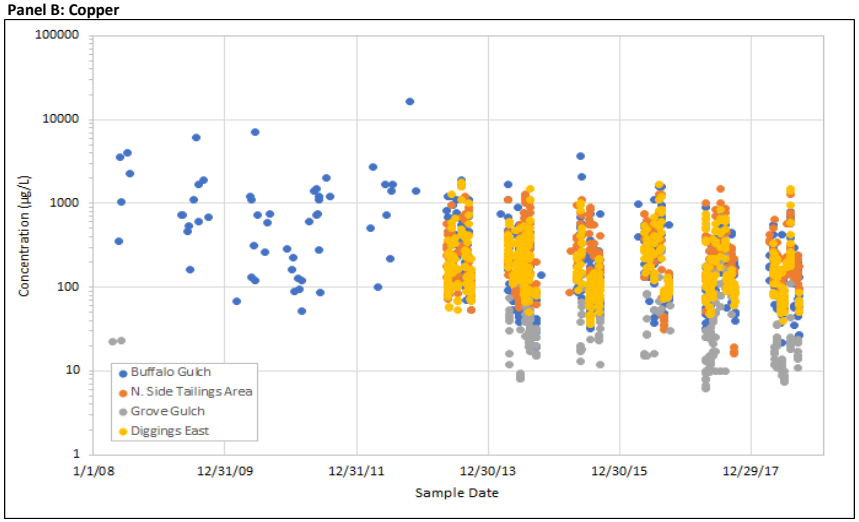
Panel A: Arsenic



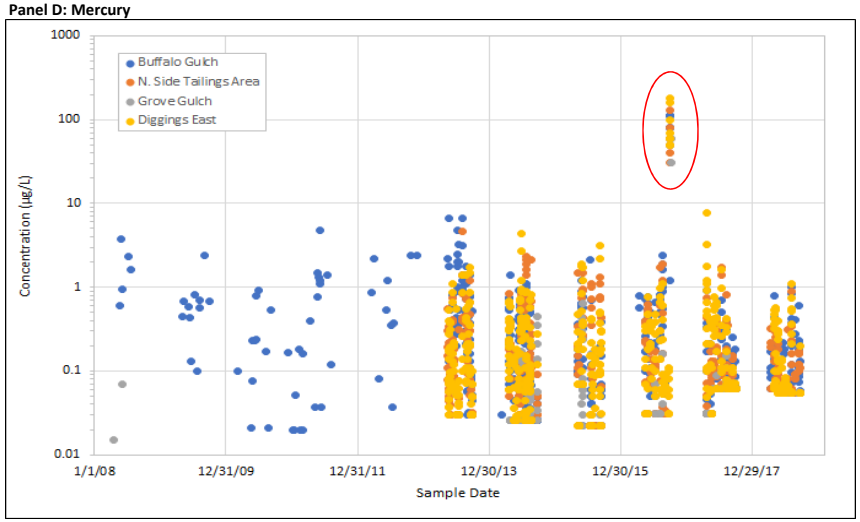
Panel C: Lead



Panel B: Copper



Panel D: Mercury

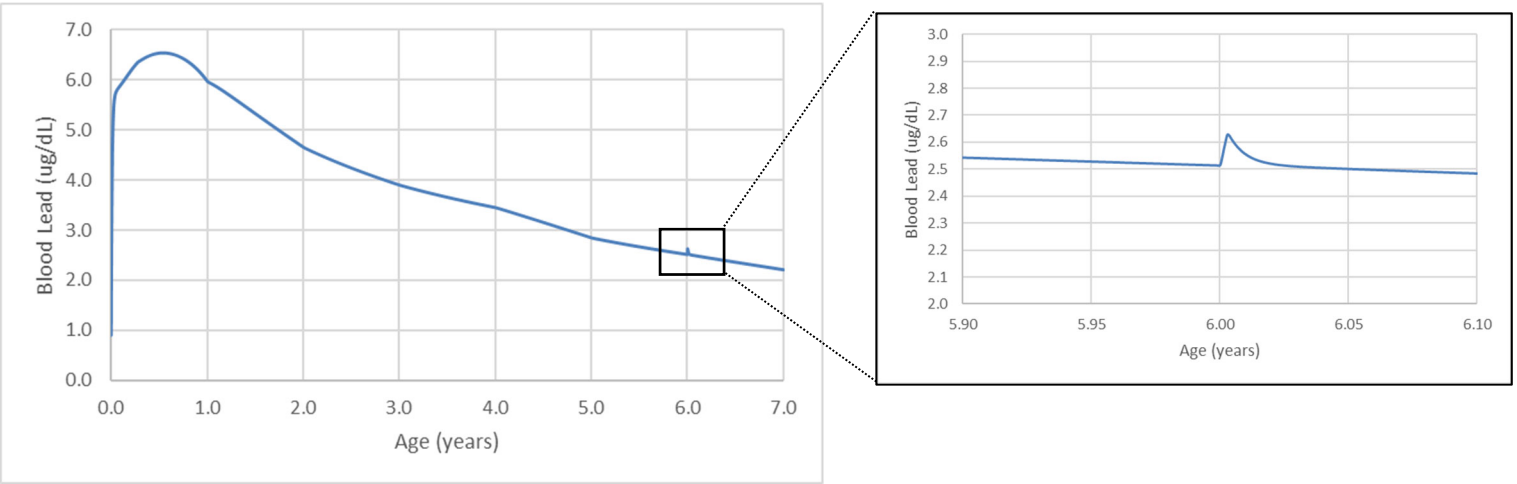


Circled concentration values are suspect and were excluded from the exposure point concentration estimates.

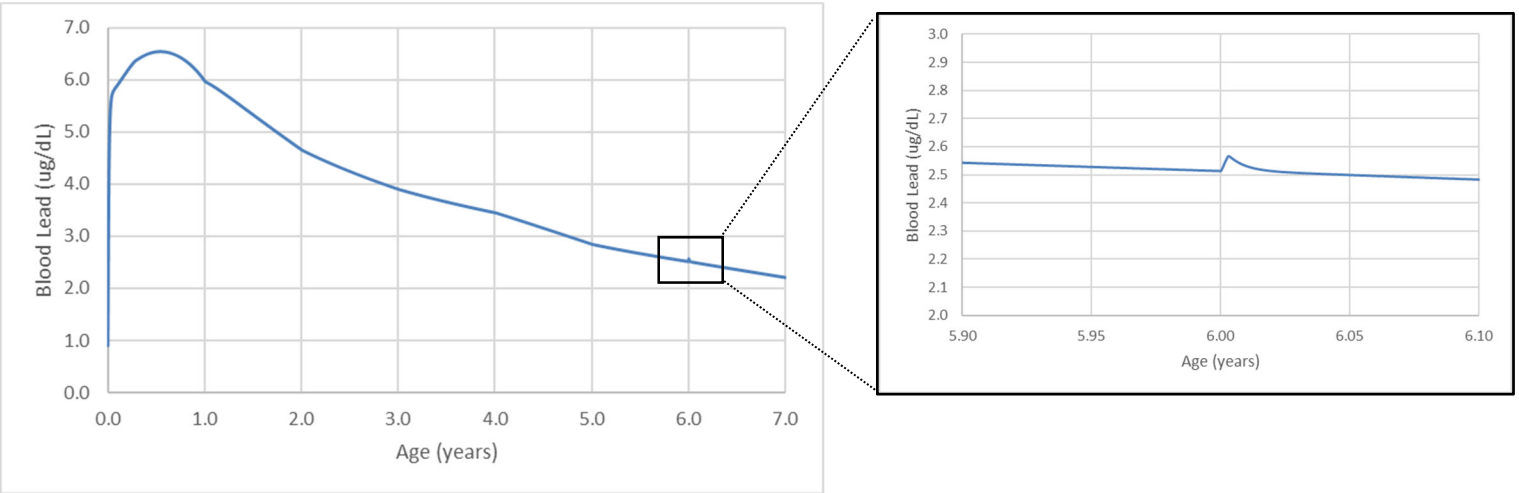
Notes:
µg/L = micrograms per liter
BPSOU = Butte Priority Soils Operable Unit

Figure 3-1. Predicted Blood Lead Levels Following a One-Day Stormwater Basin Exposure Event

Panel A: Buffalo Gulch



Panel B: Diggings East



TABLES

TABLE 2-1
SURFACE WATER DATA
BPSOU STORMWATER BASIN

Pond Location Group	Analyte	N Samples	Minimum	Maximum	Mean	EPC	Basis
Buffalo Gulch	ARSENIC	544	3.1	990	34	45	95% Chebyshev (Mean, Sd) UCL
	CADMIUM	544	0.25	110	3.7	5.1	95% Chebyshev (Mean, Sd) UCL
	COPPER	544	19	16,400	376	545	95% Chebyshev (Mean, Sd) UCL
	LEAD	544	6.6	19,800	404	430	95% H-UCL
	MERCURY	538	0.020	110	0.98	2.5	95% Chebyshev (Mean, Sd) UCL [a]
	ZINC	544	69	43,000	1441	1,977	95% Chebyshev (Mean, Sd) UCL
Diggings East	ARSENIC	554	4.6	120	18	21	95% Chebyshev (Mean, Sd) UCL
	CADMIUM	554	0.13	11	1.1	1.3	95% Chebyshev (Mean, Sd) UCL
	COPPER	554	36	1,800	234	279	95% Chebyshev (Mean, Sd) UCL
	LEAD	554	6.1	920	91	112	95% Chebyshev (Mean, Sd) UCL
	MERCURY	554	0.022	180	1.6	3.8	95% Chebyshev (Mean, Sd) UCL [a]
	ZINC	554	43	3,100	368	441	95% Chebyshev (Mean, Sd) UCL

All concentrations are in µg/L.

N = number

µg/L = microgram per liter

EPC = exposure point concentration

Sd = standard deviation

UCL = upper confidence limit

[a] Excludes results for samples collected on 10/1/16 impacted by laboratory issues

TABLE 2-2
SEDIMENT DATA
BPSOU STORMWATER BASIN

Panel A. Buffalo Gulch

Sample Information						Laboratory Result (mg/kg)					
Sample	Total Weight (g)	Revised Total Weight (g)[a]	Size	% of Sample	Fraction Weight (g)	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
SS-BG-01-061510	381	352	> 2.0 mm	7.6%	29.0	NA	NA	NA	NA	NA	NA
			1.0 - 2.0 mm	7.9%	30.1	241	3.9	246	272	0.085	974
			0.063 - 1.0 mm	72.5%	276.2	53	7.4	603	701	0.43	3,120
			< 0.063 mm	12.0%	45.7	158	16	1,570	1,760	0.98	5,430
SS-BG-01-062110	46.2	41.8	> 2.0 mm	9.5%	4.4	NA	NA	NA	NA	NA	NA
			1.0 - 2.0 mm	18.4%	8.5	82	10	746	385	0.27	4,980
			0.063 - 1.0 mm	54.6%	25.2	96	14	1,140	1,080	0.19	6,230
			< 0.063 mm	17.5%	8.1	244	28	2,690	2,710	1.6	8,910
SS-BG-01-062510	70.8	67.0	> 2.0 mm	5.4%	3.8	NA	NA	NA	NA	NA	NA
			1.0 - 2.0 mm	8.9%	6.3	26	3.7	219	204	0.066	815
			0.063 - 1.0 mm	69.8%	49.4	26	4.0	385	280	0.11	1,640
			< 0.063 mm	14.6%	10.3	62	7.2	685	658	0.055	2,380
					EPC (< 0.063 mm)	153	16	1,569	1,702	0.91	5,377
					EPC (Bulk Sediment)	79	8.3	716	774	0.42	3,302

Panel B. Diggings East

Sample Information						Laboratory Result (mg/kg)					
Sample	Total Weight (g)	Revised Total Weight (g)[a]	Size	% of Sample	Fraction Weight (g)	Arsenic	Cadmium	Copper	Lead	Mercury	Zinc
SS-MSD-HAB-061510	678	516	> 2.0 mm	23.9%	162.0	NA	NA	NA	NA	NA	NA
			1.0 - 2.0 mm	31.7%	214.9	6.0	1.9	73	84	0.018	452
			0.063 - 1.0 mm	42.7%	289.5	19	3.8	194	227	0.031	1,390
			< 0.063 mm	1.7%	11.5	64	7.9	786	1,120	0.92	1,890
SS-MSD-HAB-062110	3.6	3.5	> 2.0 mm	4.1%	0.1	NA	NA	NA	NA	NA	NA
			1.0 - 2.0 mm	4.4%	0.2	69	15	1,950	548	2.3	3,900
			0.063 - 1.0 mm	14.2%	0.5	56	6.3	1,280	348	0.29	5,110
			< 0.063 mm	77.3%	2.8	188	15	4,090	926	0.67	7,590
SS-MSD-HAB-062510	113	103	> 2.0 mm	9.2%	10.4	NA	NA	NA	NA	NA	NA
			1.0 - 2.0 mm	28.8%	32.5	13	3.5	97	88	0.068	703
			0.063 - 1.0 mm	54.2%	61.2	12	1.7	114	259	0.079	632
			< 0.063 mm	6.4%	7.2	50	5.6	678	559	0.031	1,410
SS-MSDCASEYSD-062510	0.3	0.25	> 2.0 mm	16.7%	0.050	NA	NA	NA	NA	NA	NA
			1.0 - 2.0 mm	3.3%	0.010	0.25	1.7	195	156	2.0	927
			0.063 - 1.0 mm	20.0%	0.060	NA	NA	NA	NA	0.23	NA
			< 0.063 mm	73.3%	0.22	297	37	6,980	2,750	1.5	11,600
					EPC (< 0.063 mm)	77	8.4	1,235	925	0.60	2,558
					EPC (Bulk Sediment)	16	3.1	177	197	0.053	997

[a] Revised total weight does not include the weight for the >2.0 mm fraction.
Assumed value, reported as non-detect. Value is based on the minimum concentration detected in all sediment samples.

% = percentage
< = less than
> = greater than
EPC = exposure point concentration
g = gram
mg/kg = milligram per kilogram
mm = millimeter
NA = not applicable

TABLE 3-1
EXPOSURE PARAMETERS FOR ADOLESCENT RECREATIONAL VISITORS
BPSOU STORMWATER BASIN

Exposure Pathway	Exposure Input Parameter	Units	RME	
			Value	Source
General	Body weight (6-year old)	kg	21.7	[1, a]
Incidental Ingestion of Sediment	Ingestion rate	mg/day	50	[2, b]
	Conversion factor	kg/mg	1E-06	
Incidental Ingestion of Surface Water	Ingestion rate	mL/hr	7.1	[1, c]
	Exposure time	hr/d	1	[2]
	Conversion factor	L/mL	1E-03	

Sources:

[1] USEPA 2011. *Exposure Factors Handbook* .

[2] Professional judgement.

Notes:

[a] Mean body weight from Table 8-10 for males and females 6 years old. A receptor with a lower body weight (younger child) is more sensitive to exposure compared to a receptor with a higher body weight; thus, a 6-year-old is the preferred receptor age.

[b] Assumed to be 25% of the default residential soil ingestion rate (200 mg/day).

[c] Incidental ingestion from splashing or hand-to-face contact during wading assumed to be 10% of USEPA (1989) recommended default incidentally ingested during swimming.

% = percent

d = day

HIF = human intake factor

hr = hour

kg = kilogram

L = liter

TABLE 3-2
ATSDR MINIMAL RISK LEVELS
BPSOU STORMWATER BASIN

COC	Oral MRL [a] (mg/kg-day)		
	Acute	Intermediate	Selected Value
ARSENIC	0.005		0.005
CADMIUM		0.0005	0.0005
COPPER	0.01	0.01	0.01
MERCURY [b]	0.007	0.002	0.007
ZINC		0.3	0.3

Notes:
[a] MRLs have been developed for three exposure durations:
Acute = 1-14 days
Intermediate = 15-364 days
[b] MRLs are based on mercuric chloride.

Source: ATSDR. 2018. Minimal Risk Levels.
https://www.atsdr.cdc.gov/mrls/pdfs/atsdr_mrls.pdf. August.

ATSDR = Agency for Toxic Substances and Disease Registry
COC = Contaminant of Concern
mg/kg-day = milligram per kilogram per day
MRL = Minimal Risk Level

TABLE 3-3
RISK RATIOS FOR ADOLESCENT RECREATIONAL VISITORS - BUFFALO GULCH
BPSOU STORMWATER BASIN

Panel A. Incidental Ingestion of Sediment

COC	Csed (mg/kg)	RBA (unitless)	Hazard Ratio		
			DI (mg/kg-d)	MRL (mg/kg-d)	Ratio
ARSENIC	1.5E+02	0.6	2E-04	5E-03	0.04
CADMIUM	1.6E+01	1	4E-05	5E-04	0.07
COPPER	1.6E+03	1	4E-03	1E-02	0.4
MERCURY	9.1E-01	1	2E-06	7E-03	0.0003
ZINC	5.4E+03	1	1E-02	3E-01	0.04
				TOTAL	**0.5**

Panel B. Incidental Ingestion of Surface Water

COC	Csw (mg/L)	RBA (unitless)	Hazard Ratio		
			DI (mg/kg-d)	MRL (mg/kg-d)	Ratio
ARSENIC	4.5E-02	1	1E-05	5E-03	0.003
CADMIUM	5.1E-03	1	2E-06	5E-04	0.003
COPPER	5.5E-01	1	2E-04	1E-02	0.02
MERCURY	2.5E-03	1	8E-07	7E-03	0.0001
ZINC	2.0E+00	1	6E-04	3E-01	0.002
				TOTAL	**0.03**

Total Risk Ratio	**0.5**

Csed = concentration in sediment
Csw = concentration in surface water
COC = Contaminant of Concern
DI = daily intake
mg/kg = milligrams per kilogram
mg/kg-d = milligrams per kilogram body weight per day
mg/L = milligrams per liter
MRL = Minimal Risk Level
RBA = relative bioavailability

TABLE 3-4
RISK RATIOS FOR ADOLESCENT RECREATIONAL VISITORS - DIGGINGS EAST
BPSOU STORMWATER BASIN

Panel A. Incidental Ingestion of Sediment

COC	Csed (mg/kg)	RBA (unitless)	Hazard Ratio		
			DI (mg/kg-d)	MRL (mg/kg-d)	Ratio
ARSENIC	7.7E+01	0.6	1E-04	5E-03	0.02
CADMIUM	8.4E+00	1	2E-05	5E-04	0.04
COPPER	1.2E+03	1	3E-03	1E-02	0.3
MERCURY	6.0E-01	1	1E-06	7E-03	0.0002
ZINC	2.6E+03	1	6E-03	3E-01	0.02
				TOTAL	**0.4**

Panel B. Incidental Ingestion of Surface Water

COC	Csw (mg/L)	RBA (unitless)	Hazard Ratio		
			DI (mg/kg-d)	MRL (mg/kg-d)	Ratio
ARSENIC	2.1E-02	1	7E-06	5E-03	0.001
CADMIUM	1.3E-03	1	4E-07	5E-04	0.0009
COPPER	2.8E-01	1	9E-05	1E-02	0.009
MERCURY	3.8E-03	1	1E-06	7E-03	0.0002
ZINC	4.4E-01	1	1E-04	3E-01	0.0005
				TOTAL	**0.01**

Total Risk Ratio	**0.4**

Csed = concentration in sediment
Csw = concentration in surface water
COC = Contaminant of Concern
DI = daily intake
mg/kg = milligrams per kilogram
mg/kg-d = milligrams per kilogram body weight per day
mg/L = milligrams per liter
MRL = Minimal Risk Level
RBA = relative bioavailability

TABLE 3-5
LEAD RISK EVALUATION INPUTS
BPSOU STORMWATER BASIN

Parameter	Selected input	Source
Receptor gender	Female	AALM model
Receptor age at first pulse exposure	6 year old (2,190 days)	Assumption
Default drinking water intake rate (L/day)	0.63	EPA 2017a
Pulse incidential water intake rate (L/day)	0.0071	See Table 3-1
Default drinking water concentration (µg/L)	0.9	EPA 2017a
Surface water lead concentration (µg/L) - Buffalo Gulch	430	See Table 2-1
Surface water lead concentration (µg/L) - Diggings East	112	See Table 2-1
Fraction of water intake from pulse event	0.01	Ratio of pulse to total intake rate
Sediment/soil/dust intake rate (g soil/day)	0.055	EPA 2017a
Fraction of sediment/soil/dust intake from dust	0.55	IEUBK default
Residential soil lead concentration (mg/kg)	400	Equal to site soil action level for lead
Sediment lead concentration (mg/kg) - Buffalo Gulch	1702	See Table 2-2
Sedimentl lead concentration (mg/kg) - Diggings East	925	See Table 2-2
Fraction of sediment/soil intake from pulse event	0.25	Assumption
Sediment RBA	0.6	EPA 2007
Indoor air lead concentration (µg/m^3)	0.1	IEUBK default
Indoor dust lead concentration (mg/kg)	0.7 * residential soil	IEUBK default
Diet intake rate (µg Pb/day)	5.95	EPA 2017a
Maternal PbB level (µg/dL)	0.6	EPA 2017b

Notes:

EPA. 2007. Estimation of Relative Bioavailability of Lead in Soil and Soil-Like Material Using In Vivo and In Vitro Methods. OSWER 9285.7-77. June.

EPA. 2017a. Headquarters Lead Consultation Intake Form for the Colorado Smelter Superfund Site. Submitted 4/11/17. https://semspub.epa.gov/work/08/1884173.pdf

EPA. 2017b. *Update to the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters and the Integrated Exposure Uptake Biokinetic Model's Default Maternal Blood Lead Concentration at Birth Variable* . U.S. Environmental Protection Agency, Office of Land and Emergency Management. OLEM Directive 9285.6-56.

µg = micrograms
µg/dL – micrograms per deciliter
µg/L – micrograms per liter
g = grams
L = liter
m^3 = cubic meters of air
mg/kg – milligrams per kilogram
Pb = lead
PbB = blood lead
RBA = relative bioavailability
RME = reasonable maximum exposure

Table 4-1. Exposure Factors for Representative Wildlife Species

Panel A: Chronic Exposure Scenario

Receptor Class/Type		Surrogate Receptor	Body Weight (kg)	Water Ingestion Rate (L/day)	Sediment Ingestion Rate (kg dw/day)	Exposure Adjustment Factor (unitless)
Bird	Local Waterfowl	Mallard Duck	1.2	0.065	0.0038	0.67
	Wetland/ Pond	Marsh Wren	0.010	0.0028	0.00038	0.67
Mammal	Terrestrial, Medium	Red Fox	4.5	0.39	0.0050	0.50
	Terrestrial, Small	Shrew	0.017	0.0025	0.000052	0.67
	Semi-Aquatic, Small	Mink	0.56	0.055	0.0021	0.67
	Domestic Pet, Large	Dog	29	2.1	0.055	0.67

Panel B: Acute Exposure Scenario

Receptor Class/Type		Surrogate Receptor	Body Weight (kg)	Water Ingestion Rate (L/event)	Sediment Ingestion Rate (kg dw/event)	Exposure Adjustment Factor (unitless)
Bird	Local Waterfowl	Mallard Duck	1.2	0.14	0.0077	---
	Wetland/ Pond	Marsh Wren	0.010	0.0033	0.00073	---
Mammal	Terrestrial, Medium	Red Fox	4.5	0.57	0.010	---
	Terrestrial, Small	Shrew	0.017	0.0033	0.000071	---
	Semi-Aquatic, Small	Mink	0.56	0.21	0.0040	---
	Domestic Pet, Large	Dog	29	2.7	0.15	---

See **Appendix B** for detailed exposure values, basis for selection, and source information.

kg = kilograms
kg dw/day = kilograms of sediment (on a dry weight basis) per day
kg dw/event = kilograms of sediment (on a dry weight basis) per acute exposure event
L/day = liters of water per day
L/event = liters of water per acute exposure event

Table 4-2. Summary of Chronic Wildlife Toxicity Reference Values

Panel A: Avian Wildlife

COEC	EcoSSL-based TRV						LANL ECORISK TRV						EPA Region 9 BTAG TRV						ORNL TRV					
	NOAEL	Source	Basis	LOAEL	Source	Basis	NOAEL	Source	Basis	LOAEL	Source	Basis	Low TRV	Source	Basis	High TRV*	Source	Basis	NOAEL	Source	Basis	LOAEL	Source	Basis
Arsenic	**2.24**	a	[1]	**4.51**	f	[4]	**2.24**	g	[5]	**22.4**	g	[6]	**5.5**	h	[12]	**22.01**	h	[12]	**5.14**	k	[12]	**12.84**	k	[12]
Cadmium	**1.47**	b	[2]	**6.35**	f	[4]	**1.47**	g	[5]	**8.15**	g	[8]	**0.7**	i	[12]	**10.43**	h	[12]	**1.45**	k	[12]	**20**	k	[12]
Copper	**4.05**	c	[3]	**34.9**	f	[4]	**4.05**	g	[5]	**12.1**	g	[7]	**2.3**	h	[12,14]	**52.26**	h	[12]	**47**	k	[12]	**61.7**	k	[12]
Lead	**1.63**	d	[3]	**44.6**	f	[4]	**1.63**	g	[5]	**3.26**	g	[7]	**0.014**	h	[10,12]	**8.75**	h	[12]	**1.13**	k	[12]	**11.3**	k	[12]
Mercury	---			---			**0.019**	g	[10]	**0.19**	g	[9]	**0.039**	h	[12,15]	**0.18**	h	[12]	**0.45**	k	[12]	**0.9**	k	[12]
Zinc	**66.1**	e	[2]	**171**	f	[4]	**66.1**	g	[5]	**174**	g	[8]	**17.2**	h	[10]	**172**	h	[12]	**14.5**	k	[12]	**131**	k	[12]

Panel B: Mammalian Wildlife

COEC	EcoSSL-based TRV						LANL ECORISK TRV						EPA Region 9 BTAG TRV						ORNL TRV					
	NOAEL	Source	Basis	LOAEL	Source	Basis	NOAEL	Source	Basis	LOAEL	Source	Basis	Low TRV	Source	Basis	High TRV*	Source	Basis	NOAEL	Source	Basis	LOAEL	Source	Basis
Arsenic	**1.04**	a	[2]	**4.55**	f	[4]	**1.04**	g	[5]	**1.66**	g	[7]	**0.32**	h	[12]	**4.7**	h	[12]	**0.126**	k	[10]	**1.26**	k	[12]
Cadmium	**0.77**	b	[3]	**6.87**	f	[4]	**0.77**	g	[5]	**10.3**	g	[8]	**0.06**	h	[12]	**2.64**	h	[12]	**1**	k	[12]	**10**	k	[12]
Copper	**5.6**	c	[3]	**82.7**	f	[4]	**5.6**	g	[5]	**9.34**	g	[7]	**2.67**	h	[12,14]	**631.58**	h	[12]	**11.7**	k	[12]	**15.14**	k	[12]
Lead	**4.7**	d	[3]	**186**	f	[4]	**4.7**	g	[5]	**8.9**	g	[7]	**1**	j	[12]	**240.64**	h	[12]	**8**	k	[12]	**80**	k	[12]
Mercury	---			---			**1.41**	g	[11]	**14.1**	g	[6]	**0.027**	h	[10,16]	**0.27**	h	[6,12,16]	**1**	k	[12]	---		
Zinc	**75.4**	e	[2]	**298**	f	[4]	**75.4**	g	[5]	**741**	g	[8]	**9.6**	h	[10,12]	**411.43**	h	[12]	**160**	k	[12]	**320**	k	[12]

All TRVs are reported as mg/kg BW/day.

* High TRV represents the mid-range for sublethal effects.

Selected TRV for screening level risk estimates

Sources:

a - Ecological Soil Screening Levels for Arsenic, OSWER Directive 9285.7-62. March 2005.
b - Ecological Soil Screening Levels for Cadmium, OSWER Directive 9285.7-65. March 2005.
c - Ecological Soil Screening Levels for Copper, OSWER Directive 9285.7-68. February 2007.
d - Ecological Soil Screening Levels for Lead, OSWER Directive 9285.7-70. March 2005.
e - Ecological Soil Screening Levels for Zinc, OSWER Directive 9285.7-73. June 2007.
f - TechLaw, Inc. memorandum: Close-out Letter for Calculating Effect-based EcoSSLs for Ft. Devens, Ayers, MA. 11/18/2008.
g - Los Alamos National Laboratory, ECORISK Database, Version 4.1.
h - EFA West 1998. Development of TRVs for Conducting ERAs at Naval Facilities in CA.
i - DTSC ERA Note 6, Revised Avian TRV for Cadmium (2/2009)
j - DTSC ERA Note 5, Revised Avian TRV for Lead (11/21/2002)
k - Toxicological Benchmarks for Wildlife: 1996 Revision. ORNL ES/ER/TM-86/R3

BTAG = Biological Technical Advisory Group
COEC = contaminant of ecological concern
EcoSSL = Ecological Soil Screening Levels
EPA = U.S. Environmental Protection Agency
LANL = Los Alamos National Laboratory
LOAEL = lowest observed adverse effect level
mg/kg BW/day = milligrams per kilogram body weight per day
NOAEL = no observed adverse effect level
ORNL = Oak Ridge National Laboratory
TRV = toxicity reference value
UF = uncertainty factor

Basis Notes:

[1] Lowest NOAEL for growth, reproduction, and survival effects
[2] Geomean of NOAELs for growth and reproduction
[3] Highest bounded NOAEL lower than lowest bounded LOAEL for effects on growth, reproduction, or survival
[4] Geomean of EcoSSL LOAELs (inclusive of both unbounded and bounded values) for reproduction and growth
[5] Based on EcoSSL no-effect TRV
[6] LOAEL estimated from NOAEL with UF of 10
[7] LOAEL is the pair to the selected NOAEL
[8] Geomean of EcoSSL bounded LOAELs for reproduction, growth, and survival
[9] LOAEL for critical lifestage for reproduction
[10] NOAEL estimated from LOAEL with a UF of 10
[11] NOAEL for critical lifestage for reproduction
[12] NOAEL or LOAEL from a selected critical study in consideration of supporting toxicity literature
[13] ERA Note 5 also identifies a LOAEL of 1.0 mg/kg/d to aid with risk assessment determinations
[14] Estimated from subchronic study using a UF of 10
[15] NOAEL estimated from LOAEL with a UF of 2
[16] TRV for larger (non-rodent) mammals

Table 4-3. Summary of Estimated Ecological Risks from Ingestion of Stormwater Area Surface Water and Sediment Estimates

Panel A: Chronic Estimates

Receptor Type	Surrogate Receptor	COEC	Buffalo Gulch		Diggings East	
			NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ
Bird	Mallard Duck	Arsenic	8E-02	4E-02	2E-02	8E-03
		Cadmium	3E-02	3E-03	1E-02	1E-03
		Copper	4E-01	1E-01	1E-01	3E-02
		Lead	1E+00	5E-01	3E-01	1E-01
		Mercury	5E-02	5E-03	1E-02	1E-03
		Zinc	1E-01	4E-02	3E-02	1E-02
	Marsh Wren	Arsenic	9E-01	4E-01	2E-01	8E-02
		Cadmium	3E-01	3E-02	1E-01	1E-02
		Copper	4E+00	1E+00	1E+00	4E-01
		Lead	1E+01	6E+00	3E+00	1E+00
		Mercury	6E-01	6E-02	1E-01	1E-02
		Zinc	1E+00	5E-01	4E-01	1E-01
Mammal	Red Fox	Arsenic	4E-02	3E-02	9E-03	6E-03
		Cadmium	6E-03	7E-04	2E-03	3E-04
		Copper	7E-02	4E-02	2E-02	1E-02
		Lead	9E-02	5E-02	2E-02	1E-02
		Mercury	2E-04	2E-05	1E-04	1E-05
		Zinc	3E-02	6E-03	7E-03	2E-03
	Shrew	Arsenic	2E-01	1E-01	3E-02	2E-02
		Cadmium	2E-02	3E-03	8E-03	9E-04
		Copper	3E-01	2E-01	7E-02	4E-02
		Lead	4E-01	2E-01	9E-02	5E-02
		Mercury	8E-04	8E-05	3E-04	3E-05
		Zinc	9E-02	2E-02	3E-02	7E-03
	Mink	Arsenic	2E-01	1E-01	4E-02	2E-02
		Cadmium	3E-02	3E-03	1E-02	1E-03
		Copper	3E-01	2E-01	8E-02	5E-02
		Lead	4E-01	2E-01	1E-01	6E-02
		Mercury	9E-04	9E-05	3E-04	3E-05
		Zinc	1E-01	3E-02	3E-02	8E-03
	Domestic dog	Arsenic	1E-01	6E-02	2E-02	1E-02
		Cadmium	1E-02	2E-03	5E-03	6E-04
		Copper	2E-01	1E-01	4E-02	3E-02
		Lead	2E-01	1E-01	5E-02	3E-02
		Mercury	5E-04	5E-05	2E-04	2E-05
		Zinc	6E-02	1E-02	2E-02	4E-03

See **Appendix C** for detailed chronic risk calculations.

Panel B: Acute Estimates

Receptor Type	Surrogate Receptor	COEC	Buffalo Gulch	Diggings East
			Acute HQ	Acute HQ
Bird	Mallard Duck	Arsenic	3E-02	6E-03
		Cadmium	1E-03	5E-04
		Copper	7E-03	2E-03
		Lead	7E-02	2E-02
		Mercury	3E-03	8E-04
		Zinc	3E-02	9E-03
	Marsh Wren	Arsenic	3E-01	6E-02
		Cadmium	1E-02	5E-03
		Copper	7E-02	2E-02
		Lead	7E-01	2E-01
		Mercury	3E-02	5E-03
		Zinc	3E-01	9E-02
Mammal	Red Fox	Arsenic	7E-02	2E-02
		Cadmium	1E-04	5E-05
		Copper	7E-03	2E-03
		Lead	4E-01	9E-02
		Mercury	7E-05	3E-05
		Zinc	3E-01	1E-01
	Shrew	Arsenic	1E-01	3E-02
		Cadmium	2E-04	9E-05
		Copper	1E-02	3E-03
		Lead	7E-01	2E-01
		Mercury	1E-04	5E-05
		Zinc	6E-01	2E-01
	Mink	Arsenic	2E-01	5E-02
		Cadmium	4E-04	2E-04
		Copper	2E-02	6E-03
		Lead	1E+00	3E-01
		Mercury	2E-04	1E-04
		Zinc	1E+00	3E-01
	Domestic dog	Arsenic	2E-01	3E-02
		Cadmium	3E-04	1E-04
		Copper	2E-02	4E-03
		Lead	8E-01	2E-01
		Mercury	1E-04	3E-05
		Zinc	7E-01	2E-01

See **Appendix E** for detailed acute risk calculations.

HQ > 1

COEC = contaminant of ecological concern
HQ = hazard quotient

Table 4-4. Summary of Acute Wildlife Toxicity Reference Values

COEC	USFWS Eisler Review					ECOTOX Database				
	Avian TRV	Basis	Mammalian TRV	Basis	Source	Avian TRV	Basis	Mammalian TRV	Basis	Source
Arsenic	**17**	[1]	**2.5**	[2]	a	**46**	[11]	**125**	[12]	g
Cadmium	**ns**		**150**	[3]	b	**45**	[13]	**---**		g
Copper	**ns**		**200**	[4]	c	**693**	[14]	**233**	[15]	g
Lead	**75**	[5]	**5**	[6]	d	**>610**	[16]	**---**		g
Mercury	**2.2**	[7]	**18**	[8]	e	**1.0**	[17]	**---**		g
Zinc	**742**	[9]	**350**	[10]	f	**>895**	[18]	**24**	[19]	g

All TRVs are reported as mg/kg BW.

ns = not specified

Selected TRV for screening level risk estimates

Sources:

a - Eisler, R. USFWS Contaminant Hazard Review, Arsenic, Report No. 12, January 1988.

b - Eisler, R. USFWS Contaminant Hazard Review, Cadmium, Report No. 2, July 1985.

c - Eisler, R. USFWS Contaminant Hazard Review, Copper, Report No. 33, January 1998.

d - Eisler, R. USFWS Contaminant Hazard Review, Lead, Report No. 14, April 1988.

e - Eisler, R. USFWS Contaminant Hazard Review, Mercury, Report No. 10, April 1987.

f - Eisler, R. USFWS Contaminant Hazard Review, Zinc, Report No. 26, April 1993.

g - Query of ECOTOX Database, performed December 2018

Basis Notes:

[1] Lethal dose for turkey following single oral exposure to 3-nitro-4-hydroxy phenylarsonic acid

[2] Lowest reported dose for adverse effects (death or malformations in goats) following single oral exposure

[3] Lowest oral dose producing death as cadmium fluoride

[4] Acute oral dose for cattle

[5] Reduced survival in sensitive bird species following Pb2+ exposure

[6] Dose resulting in mortality in bovine calves exposed to lead acetate via milk diet

[7] Low end of acute oral toxicity range for avian species (based on methylmercury)

[8] Single oral dose lethal to deer (LD50)

[9] Lower limit for reduced survival following single oral dose

[10] Acute oral LD50 dose in rats

[11] LD50 for Northern Bobwhite Quail following 8-day exposure to arsenic acid via food

[12] LD50 for domestic sheep following 2-day exposure to arsenenous acid via gavage

[13] LD50 for ring-necked pheasant following 8-day exposure to cadmium chloride via oral capsule

[14] Lowest LD50; for adult domestic chicken following acute exposure via oral capsule

[15] Lowest LD50; for rats administered copper chloride via gavage

[16] Estimated LD50 for Japanese Quail following 5-day exposure to lead nitrate via food

[17] Dose resulting in hatchling mortality following mercuric chloride exposure via food

[18] Estimated LD50 for northern bobwhite quail following 7-day exposure to zinc oxide via food

[19] Dose resulting in fetal death in pregnant sheep

COEC = contaminant of ecological concern

LD50 = lethal dose for 50% of exposed organisms

mg/kg BW = milligrams per kilogram body weight

TRV = toxicity reference value

USFWS = U.S. Fish and Wildlife Service

APPENDICES

APPENDIX A

PROUCL OUTPUT

	A	B	C	D	E	F	G	H	I	J	K	L
1	APPENDIX A											
2	PROUCL OUTPUT FOR STORMWATER											
3												
4	UCL Statistics for Uncensored Full Data Sets											
5												
6	User Selected Options											
7	Date/Time of Computation			ProUCL 5.11/15/2019 3:55:49 PM								
8	From File			ProUCL_Input_DiggingsEast_BuffaloGulch_a.xls								
9	Full Precision			OFF								
10	Confidence Coefficient			95%								
11	mber of Bootstrap Operations			2000								
12												
13												
14	Result (buffalogulch_arsenic)											
15												
16	General Statistics											
17	Total Number of Observations					544	Number of Distinct Observations					148
18							Number of Missing Observations					0
19	Minimum					3.1	Mean					34.3
20	Maximum					990	Median					19
21	SD					58.79	Std. Error of Mean					2.521
22	Coefficient of Variation					1.714	Skewness					9.835
23												
24	Normal GOF Test											
25	Shapiro Wilk Test Statistic					0.427	Shapiro Wilk GOF Test					
26	5% Shapiro Wilk P Value					0	Data Not Normal at 5% Significance Level					
27	Lilliefors Test Statistic					0.302	Lilliefors GOF Test					
28	5% Lilliefors Critical Value					0.0383	Data Not Normal at 5% Significance Level					
29	Data Not Normal at 5% Significance Level											
30												
31	Assuming Normal Distribution											
32	95% Normal UCL						95% UCLs (Adjusted for Skewness)					
33	95% Student's-t UCL					38.45	95% Adjusted-CLT UCL (Chen-1995)					39.58
34							95% Modified-t UCL (Johnson-1978)					38.63
35												
36	Gamma GOF Test											
37	A-D Test Statistic					16.14	Anderson-Darling Gamma GOF Test					
38	5% A-D Critical Value					0.78	Data Not Gamma Distributed at 5% Significance Level					
39	K-S Test Statistic					0.126	Kolmogorov-Smirnov Gamma GOF Test					
40	5% K-S Critical Value					0.0404	Data Not Gamma Distributed at 5% Significance Level					
41	Data Not Gamma Distributed at 5% Significance Level											
42												
43	Gamma Statistics											
44	k hat (MLE)					1.187	k star (bias corrected MLE)					1.182
45	Theta hat (MLE)					28.89	Theta star (bias corrected MLE)					29.02
46	nu hat (MLE)					1292	nu star (bias corrected)					1286
47	MLE Mean (bias corrected)					34.3	MLE Sd (bias corrected)					31.55
48							Approximate Chi Square Value (0.05)					1204
49	Adjusted Level of Significance					0.0496	Adjusted Chi Square Value					1203
50												
51	Assuming Gamma Distribution											
52	95% Approximate Gamma UCL (use when n>=50))					36.64	95% Adjusted Gamma UCL (use when n<50)					36.65
53												
54	Lognormal GOF Test											
55	Shapiro Wilk Test Statistic					0.956	Shapiro Wilk Lognormal GOF Test					
56	5% Shapiro Wilk P Value					0	Data Not Lognormal at 5% Significance Level					
57	Lilliefors Test Statistic					0.0908	Lilliefors Lognormal GOF Test					
58	5% Lilliefors Critical Value					0.0383	Data Not Lognormal at 5% Significance Level					
59	Data Not Lognormal at 5% Significance Level											
60												
61	Lognormal Statistics											
62	Minimum of Logged Data					1.131	Mean of logged Data					3.058
63	Maximum of Logged Data					6.898	SD of logged Data					0.888
64												
65	Assuming Lognormal Distribution											
66	95% H-UCL					34.12	90% Chebyshev (MVUE) UCL					35.8
67	95% Chebyshev (MVUE) UCL					37.72	97.5% Chebyshev (MVUE) UCL					40.39
68	99% Chebyshev (MVUE) UCL					45.63						
69												
70	Nonparametric Distribution Free UCL Statistics											

	A	B	C	D	E	F	G	H	I	J	K	L
71	Data do not follow a Discernible Distribution (0.05)											
72												
73	Nonparametric Distribution Free UCLs											
74					95% CLT UCL	38.44			95% Jackknife UCL			38.45
75					95% Standard Bootstrap UCL	38.39			95% Bootstrap-t UCL			40.19
76					95% Hall's Bootstrap UCL	44.43			95% Percentile Bootstrap UCL			38.56
77					95% BCA Bootstrap UCL	39.63						
78					90% Chebyshev(Mean, Sd) UCL	41.86			95% Chebyshev(Mean, Sd) UCL			45.28
79					97.5% Chebyshev(Mean, Sd) UCL	50.04			99% Chebyshev(Mean, Sd) UCL			59.38
80												
81	Suggested UCL to Use											
82					95% Chebyshev (Mean, Sd) UCL	45.28						
83												
84	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
85	Recommendations are based upon data size, data distribution, and skewness.											
86	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
87	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia											
88												
89												
90	Result (buffalogulch_cadmium)											
91												
92	General Statistics											
93					Total Number of Observations	544			Number of Distinct Observations			170
94									Number of Missing Observations			0
95					Minimum	0.25			Mean			3.704
96					Maximum	110			Median			1.7
97					SD	7.239			Std. Error of Mean			0.31
98					Coefficient of Variation	1.955			Skewness			8.354
99												
100	Normal GOF Test											
101					Shapiro Wilk Test Statistic	0.423			Shapiro Wilk GOF Test			
102					5% Shapiro Wilk P Value	0			Data Not Normal at 5% Significance Level			
103					Lilliefors Test Statistic	0.317			Lilliefors GOF Test			
104					5% Lilliefors Critical Value	0.0383			Data Not Normal at 5% Significance Level			
105	Data Not Normal at 5% Significance Level											
106												
107	Assuming Normal Distribution											
108			95% Normal UCL						95% UCLs (Adjusted for Skewness)			
109					95% Student's-t UCL	4.215			95% Adjusted-CLT UCL (Chen-1995)			4.333
110									95% Modified-t UCL (Johnson-1978)			4.233
111												
112	Gamma GOF Test											
113					A-D Test Statistic	19.21			Anderson-Darling Gamma GOF Test			
114					5% A-D Critical Value	0.789			Data Not Gamma Distributed at 5% Significance Level			
115					K-S Test Statistic	0.132			Kolmogorov-Smirnov Gamma GOF Test			
116					5% K-S Critical Value	0.0407			Data Not Gamma Distributed at 5% Significance Level			
117	Data Not Gamma Distributed at 5% Significance Level											
118												
119	Gamma Statistics											
120					k hat (MLE)	0.918			k star (bias corrected MLE)			0.914
121					Theta hat (MLE)	4.034			Theta star (bias corrected MLE)			4.051
122					nu hat (MLE)	998.8			nu star (bias corrected)			994.6
123					MLE Mean (bias corrected)	3.704			MLE Sd (bias corrected)			3.873
124									Approximate Chi Square Value (0.05)			922.4
125					Adjusted Level of Significance	0.0496			Adjusted Chi Square Value			922.2
126												
127	Assuming Gamma Distribution											
128					95% Approximate Gamma UCL (use when n>=50))	3.993			95% Adjusted Gamma UCL (use when n<50)			3.994
129												
130	Lognormal GOF Test											
131					Shapiro Wilk Test Statistic	0.957			Shapiro Wilk Lognormal GOF Test			
132					5% Shapiro Wilk P Value	1.110E-16			Data Not Lognormal at 5% Significance Level			
133					Lilliefors Test Statistic	0.0979			Lilliefors Lognormal GOF Test			
134					5% Lilliefors Critical Value	0.0383			Data Not Lognormal at 5% Significance Level			
135	Data Not Lognormal at 5% Significance Level											
136												
137	Lognormal Statistics											
138					Minimum of Logged Data	-1.386			Mean of logged Data			0.674
139					Maximum of Logged Data	4.7			SD of logged Data			1.025
140												

	A	B	C	D	E	F	G	H	I	J	K	L
141					Assuming Lognormal Distribution							
142					95% H-UCL	3.644			90% Chebyshev (MVUE) UCL			3.849
143				95% Chebyshev (MVUE) UCL		4.093			97.5% Chebyshev (MVUE) UCL			4.43
144				99% Chebyshev (MVUE) UCL		5.093						
145												
146					Nonparametric Distribution Free UCL Statistics							
147					Data do not follow a Discernible Distribution (0.05)							
148												
149					Nonparametric Distribution Free UCLs							
150					95% CLT UCL	4.214			95% Jackknife UCL			4.215
151				95% Standard Bootstrap UCL		4.21			95% Bootstrap-t UCL			4.388
152				95% Hall's Bootstrap UCL		4.526			95% Percentile Bootstrap UCL			4.259
153				95% BCA Bootstrap UCL		4.341						
154				90% Chebyshev(Mean, Sd) UCL		4.635			95% Chebyshev(Mean, Sd) UCL			5.056
155				97.5% Chebyshev(Mean, Sd) UCL		5.642			99% Chebyshev(Mean, Sd) UCL			6.792
156												
157					Suggested UCL to Use							
158				95% Chebyshev (Mean, Sd) UCL		5.056						
159												
160	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
161	Recommendations are based upon data size, data distribution, and skewness.											
162	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
163	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia											
164												
165												
166	Result (buffalogulch_copper)											
167												
168					General Statistics							
169				Total Number of Observations		544			Number of Distinct Observations			158
170									Number of Missing Observations			0
171				Minimum		19			Mean			376.3
172				Maximum		16400			Median			160.5
173				SD		904.8			Std. Error of Mean			38.79
174				Coefficient of Variation		2.404			Skewness			11.96
175												
176					Normal GOF Test							
177				Shapiro Wilk Test Statistic		0.331			Shapiro Wilk GOF Test			
178				5% Shapiro Wilk P Value		0			Data Not Normal at 5% Significance Level			
179				Lilliefors Test Statistic		0.346			Lilliefors GOF Test			
180				5% Lilliefors Critical Value		0.0383			Data Not Normal at 5% Significance Level			
181					Data Not Normal at 5% Significance Level							
182												
183					Assuming Normal Distribution							
184				95% Normal UCL					95% UCLs (Adjusted for Skewness)			
185				95% Student's-t UCL		440.2			95% Adjusted-CLT UCL (Chen-1995)			461.4
186									95% Modified-t UCL (Johnson-1978)			443.6
187												
188					Gamma GOF Test							
189				A-D Test Statistic		1.838E+28			Anderson-Darling Gamma GOF Test			
190				5% A-D Critical Value		0.791			Data Not Gamma Distributed at 5% Significance Level			
191				K-S Test Statistic		0.137			Kolmogorov-Smirnov Gamma GOF Test			
192				5% K-S Critical Value		0.0408			Data Not Gamma Distributed at 5% Significance Level			
193					Data Not Gamma Distributed at 5% Significance Level							
194												
195					Gamma Statistics							
196				k hat (MLE)		0.871			k star (bias corrected MLE)			0.867
197				Theta hat (MLE)		432.2			Theta star (bias corrected MLE)			434
198				nu hat (MLE)		947.3			nu star (bias corrected)			943.4
199				MLE Mean (bias corrected)		376.3			MLE Sd (bias corrected)			404.1
200									Approximate Chi Square Value (0.05)			873.1
201				Adjusted Level of Significance		0.0496			Adjusted Chi Square Value			872.9
202												
203					Assuming Gamma Distribution							
204	95% Approximate Gamma UCL (use when n>=50))					406.6			95% Adjusted Gamma UCL (use when n<50)			406.7
205												
206					Lognormal GOF Test							
207				Shapiro Wilk Test Statistic		0.967			Shapiro Wilk Lognormal GOF Test			
208				5% Shapiro Wilk P Value		1.4033E-8			Data Not Lognormal at 5% Significance Level			
209				Lilliefors Test Statistic		0.0788			Lilliefors Lognormal GOF Test			
210				5% Lilliefors Critical Value		0.0383			Data Not Lognormal at 5% Significance Level			

	A	B	C	D	E	F	G	H	I	J	K	L
211	Data Not Lognormal at 5% Significance Level											
212												
213	Lognormal Statistics											
214					Minimum of Logged Data	2.944			Mean of logged Data			5.256
215					Maximum of Logged Data	9.705			SD of logged Data			1.036
216												
217	Assuming Lognormal Distribution											
218					95% H-UCL	360.9			90% Chebyshev (MVUE) UCL			381.5
219					95% Chebyshev (MVUE) UCL	405.9			97.5% Chebyshev (MVUE) UCL			439.8
220					99% Chebyshev (MVUE) UCL	506.4						
221												
222	Nonparametric Distribution Free UCL Statistics											
223	Data do not follow a Discernible Distribution (0.05)											
224												
225	Nonparametric Distribution Free UCLs											
226					95% CLT UCL	440.1			95% Jackknife UCL			440.2
227					95% Standard Bootstrap UCL	441.2			95% Bootstrap-t UCL			479.4
228					95% Hall's Bootstrap UCL	686.2			95% Percentile Bootstrap UCL			448.9
229					95% BCA Bootstrap UCL	468						
230					90% Chebyshev(Mean, Sd) UCL	492.7			95% Chebyshev(Mean, Sd) UCL			545.4
231					97.5% Chebyshev(Mean, Sd) UCL	618.6			99% Chebyshev(Mean, Sd) UCL			762.3
232												
233	Suggested UCL to Use											
234					95% Chebyshev (Mean, Sd) UCL	545.4						
235												
236	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
237	Recommendations are based upon data size, data distribution, and skewness.											
238	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
239	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia											
240												
241												
242	Result (buffalogulch_lead)											
243												
244	General Statistics											
245					Total Number of Observations	544			Number of Distinct Observations			191
246									Number of Missing Observations			0
247					Minimum	6.6			Mean			404
248					Maximum	19800			Median			170
249					SD	1011			Std. Error of Mean			43.36
250					Coefficient of Variation	2.503			Skewness			13.92
251												
252	Normal GOF Test											
253					Shapiro Wilk Test Statistic	0.326			Shapiro Wilk GOF Test			
254					5% Shapiro Wilk P Value	0			Data Not Normal at 5% Significance Level			
255					Lilliefors Test Statistic	0.347			Lilliefors GOF Test			
256					5% Lilliefors Critical Value	0.0383			Data Not Normal at 5% Significance Level			
257	Data Not Normal at 5% Significance Level											
258												
259	Assuming Normal Distribution											
260					95% Normal UCL				95% UCLs (Adjusted for Skewness)			
261					95% Student's-t UCL	475.5			95% Adjusted-CLT UCL (Chen-1995)			503
262									95% Modified-t UCL (Johnson-1978)			479.8
263												
264	Gamma GOF Test											
265					A-D Test Statistic	1.838E+28			Anderson-Darling Gamma GOF Test			
266					5% A-D Critical Value	0.797			Data Not Gamma Distributed at 5% Significance Level			
267					K-S Test Statistic	0.112			Kolmogorov-Smirnov Gamma GOF Test			
268					5% K-S Critical Value	0.041			Data Not Gamma Distributed at 5% Significance Level			
269	Data Not Gamma Distributed at 5% Significance Level											
270												
271	Gamma Statistics											
272					k hat (MLE)	0.755			k star (bias corrected MLE)			0.752
273					Theta hat (MLE)	534.9			Theta star (bias corrected MLE)			537
274					nu hat (MLE)	821.9			nu star (bias corrected)			818.7
275					MLE Mean (bias corrected)	404			MLE Sd (bias corrected)			465.8
276									Approximate Chi Square Value (0.05)			753.3
277					Adjusted Level of Significance	0.0496			Adjusted Chi Square Value			753.1
278												
279	Assuming Gamma Distribution											
280					95% Approximate Gamma UCL (use when n>=50))	439.1			95% Adjusted Gamma UCL (use when n<50)			439.2

	A	B	C	D	E	F	G	H	I	J	K	L
281												
282						Lognormal GOF Test						
283					Shapiro Wilk Test Statistic	0.983	Shapiro Wilk Lognormal GOF Test					
284					5% Shapiro Wilk P Value	0.251	Data appear Lognormal at 5% Significance Level					
285					Lilliefors Test Statistic	0.0568	Lilliefors Lognormal GOF Test					
286					5% Lilliefors Critical Value	0.0383	Data Not Lognormal at 5% Significance Level					
287					Data appear Approximate Lognormal at 5% Significance Level							
288												
289						Lognormal Statistics						
290					Minimum of Logged Data	1.887			Mean of logged Data			5.21
291					Maximum of Logged Data	9.893			SD of logged Data			1.212
292												
293						Assuming Lognormal Distribution						
294					95% H-UCL	430			90% Chebyshev (MVUE) UCL			458.5
295					95% Chebyshev (MVUE) UCL	493.8			97.5% Chebyshev (MVUE) UCL			542.6
296					99% Chebyshev (MVUE) UCL	638.6						
297												
298						Nonparametric Distribution Free UCL Statistics						
299						Data appear to follow a Discernible Distribution at 5% Significance Level						
300												
301						Nonparametric Distribution Free UCLs						
302					95% CLT UCL	475.4			95% Jackknife UCL			475.5
303					95% Standard Bootstrap UCL	475.4			95% Bootstrap-t UCL			525.4
304					95% Hall's Bootstrap UCL	793.5			95% Percentile Bootstrap UCL			479.9
305					95% BCA Bootstrap UCL	514.6						
306					90% Chebyshev(Mean, Sd) UCL	534.1			95% Chebyshev(Mean, Sd) UCL			593.1
307					97.5% Chebyshev(Mean, Sd) UCL	674.8			99% Chebyshev(Mean, Sd) UCL			835.5
308												
309						Suggested UCL to Use						
310					95% H-UCL	430						
311												
312	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
313	Recommendations are based upon data size, data distribution, and skewness.											
314	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
315	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia											
316												
317	ProUCL computes and outputs H-statistic based UCLs for historical reasons only.											
318	H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.											
319	It is therefore recommended to avoid the use of H-statistic based 95% UCLs.											
320	Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.											
321												
322												
323	Result (buffalogulch_mercury)											
324												
325						General Statistics						
326					Total Number of Observations	538			Number of Distinct Observations			155
327									Number of Missing Observations			0
328					Minimum	0.02			Mean			0.979
329					Maximum	110			Median			0.13
330					SD	8.2			Std. Error of Mean			0.354
331					Coefficient of Variation	8.377			Skewness			13.18
332												
333						Normal GOF Test						
334					Shapiro Wilk Test Statistic	0.0918	Shapiro Wilk GOF Test					
335					5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level					
336					Lilliefors Test Statistic	0.453	Lilliefors GOF Test					
337					5% Lilliefors Critical Value	0.0385	Data Not Normal at 5% Significance Level					
338						Data Not Normal at 5% Significance Level						
339												
340						Assuming Normal Distribution						
341					95% Normal UCL		95% UCLs (Adjusted for Skewness)					
342					95% Student's-t UCL	1.561			95% Adjusted-CLT UCL (Chen-1995)			1.775
343									95% Modified-t UCL (Johnson-1978)			1.595
344												
345						Gamma GOF Test						
346					A-D Test Statistic	1.859E+28	Anderson-Darling Gamma GOF Test					
347					5% A-D Critical Value	0.856	Data Not Gamma Distributed at 5% Significance Level					
348					K-S Test Statistic	0.222	Kolmogorov-Smirnov Gamma GOF Test					
349					5% K-S Critical Value	0.0426	Data Not Gamma Distributed at 5% Significance Level					
350						Data Not Gamma Distributed at 5% Significance Level						

	A	B	C	D	E	F	G	H	I	J	K	L
351												
352						Gamma Statistics						
353					k hat (MLE)	0.363					k star (bias corrected MLE)	0.363
354					Theta hat (MLE)	2.694					Theta star (bias corrected MLE)	2.7
355					nu hat (MLE)	391					nu star (bias corrected)	390.1
356					MLE Mean (bias corrected)	0.979					MLE Sd (bias corrected)	1.626
357											Approximate Chi Square Value (0.05)	345.3
358					Adjusted Level of Significance	0.0496					Adjusted Chi Square Value	345.2
359												
360						Assuming Gamma Distribution						
361					95% Approximate Gamma UCL (use when n>=50))	1.106					95% Adjusted Gamma UCL (use when n<50)	1.106
362												
363						Lognormal GOF Test						
364					Shapiro Wilk Test Statistic	0.933					Shapiro Wilk Lognormal GOF Test	
365					5% Shapiro Wilk P Value	0					Data Not Lognormal at 5% Significance Level	
366					Lilliefors Test Statistic	0.0921					Lilliefors Lognormal GOF Test	
367					5% Lilliefors Critical Value	0.0385					Data Not Lognormal at 5% Significance Level	
368						Data Not Lognormal at 5% Significance Level						
369												
370						Lognormal Statistics						
371					Minimum of Logged Data	-3.912					Mean of logged Data	-1.861
372					Maximum of Logged Data	4.7					SD of logged Data	1.38
373												
374						Assuming Lognormal Distribution						
375					95% H-UCL	0.467					90% Chebyshev (MVUE) UCL	0.501
376					95% Chebyshev (MVUE) UCL	0.547					97.5% Chebyshev (MVUE) UCL	0.609
377					99% Chebyshev (MVUE) UCL	0.732						
378												
379						Nonparametric Distribution Free UCL Statistics						
380						Data do not follow a Discernible Distribution (0.05)						
381												
382						Nonparametric Distribution Free UCLs						
383					95% CLT UCL	1.56					95% Jackknife UCL	1.561
384					95% Standard Bootstrap UCL	1.557					95% Bootstrap-t UCL	6.986
385					95% Hall's Bootstrap UCL	5.037					95% Percentile Bootstrap UCL	1.596
386					95% BCA Bootstrap UCL	1.82						
387					90% Chebyshev(Mean, Sd) UCL	2.039					95% Chebyshev(Mean, Sd) UCL	2.52
388					97.5% Chebyshev(Mean, Sd) UCL	3.187					99% Chebyshev(Mean, Sd) UCL	4.496
389												
390						Suggested UCL to Use						
391					95% Chebyshev (Mean, Sd) UCL	2.52						
392												
393	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
394	Recommendations are based upon data size, data distribution, and skewness.											
395	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
396	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia											
397												
398												
399	Result (buffalogulch_zinc)											
400												
401						General Statistics						
402					Total Number of Observations	544					Number of Distinct Observations	150
403											Number of Missing Observations	0
404					Minimum	69					Mean	1441
405					Maximum	43000					Median	665
406					SD	2872					Std. Error of Mean	123.1
407					Coefficient of Variation	1.993					Skewness	8.354
408												
409						Normal GOF Test						
410					Shapiro Wilk Test Statistic	0.414					Shapiro Wilk GOF Test	
411					5% Shapiro Wilk P Value	0					Data Not Normal at 5% Significance Level	
412					Lilliefors Test Statistic	0.316					Lilliefors GOF Test	
413					5% Lilliefors Critical Value	0.0383					Data Not Normal at 5% Significance Level	
414						Data Not Normal at 5% Significance Level						
415												
416						Assuming Normal Distribution						
417						95% Normal UCL					95% UCLs (Adjusted for Skewness)	
418					95% Student's-t UCL	1644					95% Adjusted-CLT UCL (Chen-1995)	1690
419											95% Modified-t UCL (Johnson-1978)	1651
420												

	A	B	C	D	E	F	G	H	I	J	K	L
421						Gamma GOF Test						
422					A-D Test Statistic	17.86	Anderson-Darling Gamma GOF Test					
423					5% A-D Critical Value	0.79	Data Not Gamma Distributed at 5% Significance Level					
424					K-S Test Statistic	0.129	Kolmogorov-Smirnov Gamma GOF Test					
425					5% K-S Critical Value	0.0408	Data Not Gamma Distributed at 5% Significance Level					
426						Data Not Gamma Distributed at 5% Significance Level						
427												
428						Gamma Statistics						
429					k hat (MLE)	0.896			k star (bias corrected MLE)			0.892
430					Theta hat (MLE)	1608			Theta star (bias corrected MLE)			1615
431					nu hat (MLE)	974.8			nu star (bias corrected)			970.7
432					MLE Mean (bias corrected)	1441			MLE Sd (bias corrected)			1525
433									Approximate Chi Square Value (0.05)			899.4
434					Adjusted Level of Significance	0.0496			Adjusted Chi Square Value			899.2
435												
436						Assuming Gamma Distribution						
437					95% Approximate Gamma UCL (use when n>=50))	1555			95% Adjusted Gamma UCL (use when n<50)			1555
438												
439						Lognormal GOF Test						
440					Shapiro Wilk Test Statistic	0.965	Shapiro Wilk Lognormal GOF Test					
441					5% Shapiro Wilk P Value	3.408E-10	Data Not Lognormal at 5% Significance Level					
442					Lilliefors Test Statistic	0.09	Lilliefors Lognormal GOF Test					
443					5% Lilliefors Critical Value	0.0383	Data Not Lognormal at 5% Significance Level					
444						Data Not Lognormal at 5% Significance Level						
445												
446						Lognormal Statistics						
447					Minimum of Logged Data	4.234			Mean of logged Data			6.62
448					Maximum of Logged Data	10.67			SD of logged Data			1.048
449												
450						Assuming Lognormal Distribution						
451					95% H-UCL	1432			90% Chebyshev (MVUE) UCL			1514
452					95% Chebyshev (MVUE) UCL	1612			97.5% Chebyshev (MVUE) UCL			1749
453					99% Chebyshev (MVUE) UCL	2017						
454												
455						Nonparametric Distribution Free UCL Statistics						
456						Data do not follow a Discernible Distribution (0.05)						
457												
458						Nonparametric Distribution Free UCLs						
459					95% CLT UCL	1643			95% Jackknife UCL			1644
460					95% Standard Bootstrap UCL	1646			95% Bootstrap-t UCL			1710
461					95% Hall's Bootstrap UCL	1759			95% Percentile Bootstrap UCL			1653
462					95% BCA Bootstrap UCL	1705						
463					90% Chebyshev(Mean, Sd) UCL	1810			95% Chebyshev(Mean, Sd) UCL			1977
464					97.5% Chebyshev(Mean, Sd) UCL	2210			99% Chebyshev(Mean, Sd) UCL			2666
465												
466						Suggested UCL to Use						
467					95% Chebyshev (Mean, Sd) UCL	1977						
468												
469	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
470	Recommendations are based upon data size, data distribution, and skewness.											
471	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
472	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia											
473												
474												
475	Result (diggingseast_arsenic)											
476												
477						General Statistics						
478					Total Number of Observations	554			Number of Distinct Observations			99
479									Number of Missing Observations			0
480					Minimum	4.6			Mean			17.95
481					Maximum	120			Median			13
482					SD	14.17			Std. Error of Mean			0.602
483					Coefficient of Variation	0.79			Skewness			3.255
484												
485						Normal GOF Test						
486					Shapiro Wilk Test Statistic	0.685	Shapiro Wilk GOF Test					
487					5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level					
488					Lilliefors Test Statistic	0.193	Lilliefors GOF Test					
489					5% Lilliefors Critical Value	0.038	Data Not Normal at 5% Significance Level					
490						Data Not Normal at 5% Significance Level						

	A	B	C	D	E	F	G	H	I	J	K	L
491												
492						Assuming Normal Distribution						
493				95% Normal UCL					95% UCLs (Adjusted for Skewness)			
494					95% Student's-t UCL	18.94			95% Adjusted-CLT UCL (Chen-1995)			19.03
495									95% Modified-t UCL (Johnson-1978)			18.96
496												
497						Gamma GOF Test						
498					A-D Test Statistic	14.9			Anderson-Darling Gamma GOF Test			
499					5% A-D Critical Value	0.763			Data Not Gamma Distributed at 5% Significance Level			
500					K-S Test Statistic	0.129			Kolmogorov-Smirnov Gamma GOF Test			
501					5% K-S Critical Value	0.0395			Data Not Gamma Distributed at 5% Significance Level			
502						Data Not Gamma Distributed at 5% Significance Level						
503												
504						Gamma Statistics						
505					k hat (MLE)	2.797			k star (bias corrected MLE)			2.783
506					Theta hat (MLE)	6.417			Theta star (bias corrected MLE)			6.449
507					nu hat (MLE)	3100			nu star (bias corrected)			3084
508					MLE Mean (bias corrected)	17.95			MLE Sd (bias corrected)			10.76
509									Approximate Chi Square Value (0.05)			2956
510					Adjusted Level of Significance	0.0496			Adjusted Chi Square Value			2956
511												
512						Assuming Gamma Distribution						
513					95% Approximate Gamma UCL (use when n>=50))	18.73			95% Adjusted Gamma UCL (use when n<50)			18.73
514												
515						Lognormal GOF Test						
516					Shapiro Wilk Test Statistic	0.944			Shapiro Wilk Lognormal GOF Test			
517					5% Shapiro Wilk P Value	0			Data Not Lognormal at 5% Significance Level			
518					Lilliefors Test Statistic	0.102			Lilliefors Lognormal GOF Test			
519					5% Lilliefors Critical Value	0.038			Data Not Lognormal at 5% Significance Level			
520						Data Not Lognormal at 5% Significance Level						
521												
522						Lognormal Statistics						
523					Minimum of Logged Data	1.526			Mean of logged Data			2.698
524					Maximum of Logged Data	4.787			SD of logged Data			0.569
525												
526						Assuming Lognormal Distribution						
527					95% H-UCL	18.26			90% Chebyshev (MVUE) UCL			18.82
528					95% Chebyshev (MVUE) UCL	19.44			97.5% Chebyshev (MVUE) UCL			20.3
529					99% Chebyshev (MVUE) UCL	21.98						
530												
531						Nonparametric Distribution Free UCL Statistics						
532						Data do not follow a Discernible Distribution (0.05)						
533												
534						Nonparametric Distribution Free UCLs						
535					95% CLT UCL	18.94			95% Jackknife UCL			18.94
536					95% Standard Bootstrap UCL	18.94			95% Bootstrap-t UCL			19.06
537					95% Hall's Bootstrap UCL	19.06			95% Percentile Bootstrap UCL			18.95
538					95% BCA Bootstrap UCL	19.04						
539					90% Chebyshev(Mean, Sd) UCL	19.76			95% Chebyshev(Mean, Sd) UCL			20.57
540					97.5% Chebyshev(Mean, Sd) UCL	21.71			99% Chebyshev(Mean, Sd) UCL			23.94
541												
542						Suggested UCL to Use						
543					95% Chebyshev (Mean, Sd) UCL	20.57						
544												
545	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
546	Recommendations are based upon data size, data distribution, and skewness.											
547	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
548	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia											
549												
550												
551	Result (diggingseast_cadmium)											
552												
553						General Statistics						
554					Total Number of Observations	554			Number of Distinct Observations			128
555									Number of Missing Observations			0
556					Minimum	0.13			Mean			1.097
557					Maximum	11			Median			0.67
558					SD	1.318			Std. Error of Mean			0.056
559					Coefficient of Variation	1.201			Skewness			3.796
560												

	A	B	C	D	E	F	G	H	I	J	K	L
561					Normal GOF Test							
562					Shapiro Wilk Test Statistic	0.596		Shapiro Wilk GOF Test				
563					5% Shapiro Wilk P Value	0		Data Not Normal at 5% Significance Level				
564					Lilliefors Test Statistic	0.234		Lilliefors GOF Test				
565					5% Lilliefors Critical Value	0.038		Data Not Normal at 5% Significance Level				
566					Data Not Normal at 5% Significance Level							
567												
568					Assuming Normal Distribution							
569					95% Normal UCL			95% UCLs (Adjusted for Skewness)				
570					95% Student's-t UCL	1.189		95% Adjusted-CLT UCL (Chen-1995)				1.199
571								95% Modified-t UCL (Johnson-1978)				1.191
572												
573					Gamma GOF Test							
574					A-D Test Statistic	17.36		Anderson-Darling Gamma GOF Test				
575					5% A-D Critical Value	0.773		Data Not Gamma Distributed at 5% Significance Level				
576					K-S Test Statistic	0.129		Kolmogorov-Smirnov Gamma GOF Test				
577					5% K-S Critical Value	0.0399		Data Not Gamma Distributed at 5% Significance Level				
578					Data Not Gamma Distributed at 5% Significance Level							
579												
580					Gamma Statistics							
581					k hat (MLE)	1.466		k star (bias corrected MLE)				1.459
582					Theta hat (MLE)	0.748		Theta star (bias corrected MLE)				0.752
583					nu hat (MLE)	1624		nu star (bias corrected)				1616
584					MLE Mean (bias corrected)	1.097		MLE Sd (bias corrected)				0.908
585								Approximate Chi Square Value (0.05)				1524
586					Adjusted Level of Significance	0.0496		Adjusted Chi Square Value				1524
587												
588					Assuming Gamma Distribution							
589					95% Approximate Gamma UCL (use when n>=50))	1.163		95% Adjusted Gamma UCL (use when n<50)				1.163
590												
591					Lognormal GOF Test							
592					Shapiro Wilk Test Statistic	0.957		Shapiro Wilk Lognormal GOF Test				
593					5% Shapiro Wilk P Value	0		Data Not Lognormal at 5% Significance Level				
594					Lilliefors Test Statistic	0.069		Lilliefors Lognormal GOF Test				
595					5% Lilliefors Critical Value	0.038		Data Not Lognormal at 5% Significance Level				
596					Data Not Lognormal at 5% Significance Level							
597												
598					Lognormal Statistics							
599					Minimum of Logged Data	-2.04		Mean of logged Data				-0.286
600					Maximum of Logged Data	2.398		SD of logged Data				0.8
601												
602					Assuming Lognormal Distribution							
603					95% H-UCL	1.107		90% Chebyshev (MVUE) UCL				1.155
604					95% Chebyshev (MVUE) UCL	1.21		97.5% Chebyshev (MVUE) UCL				1.286
605					99% Chebyshev (MVUE) UCL	1.435						
606												
607					Nonparametric Distribution Free UCL Statistics							
608					Data do not follow a Discernible Distribution (0.05)							
609												
610					Nonparametric Distribution Free UCLs							
611					95% CLT UCL	1.189		95% Jackknife UCL				1.189
612					95% Standard Bootstrap UCL	1.19		95% Bootstrap-t UCL				1.203
613					95% Hall's Bootstrap UCL	1.199		95% Percentile Bootstrap UCL				1.185
614					95% BCA Bootstrap UCL	1.197						
615					90% Chebyshev(Mean, Sd) UCL	1.265		95% Chebyshev(Mean, Sd) UCL				1.341
616					97.5% Chebyshev(Mean, Sd) UCL	1.446		99% Chebyshev(Mean, Sd) UCL				1.654
617												
618					Suggested UCL to Use							
619					95% Chebyshev (Mean, Sd) UCL	1.341						
620												
621	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
622	Recommendations are based upon data size, data distribution, and skewness.											
623	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
624	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia											
625												
626												
627	Result (diggingseast_copper)											
628												
629					General Statistics							
630					Total Number of Observations	554		Number of Distinct Observations				129

	A	B	C	D	E	F	G	H	I	J	K	L
631											Number of Missing Observations	0
632					Minimum	36					Mean	234.1
633					Maximum	1800					Median	150
634					SD	240.5					Std. Error of Mean	10.22
635					Coefficient of Variation	1.027					Skewness	3.106
636												
637					Normal GOF Test							
638					Shapiro Wilk Test Statistic	0.669	Shapiro Wilk GOF Test					
639					5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level					
640					Lilliefors Test Statistic	0.207	Lilliefors GOF Test					
641					5% Lilliefors Critical Value	0.038	Data Not Normal at 5% Significance Level					
642					Data Not Normal at 5% Significance Level							
643												
644					Assuming Normal Distribution							
645			95% Normal UCL				95% UCLs (Adjusted for Skewness)					
646					95% Student's-t UCL	251					95% Adjusted-CLT UCL (Chen-1995)	252.4
647											95% Modified-t UCL (Johnson-1978)	251.2
648												
649					Gamma GOF Test							
650					A-D Test Statistic	13.94	Anderson-Darling Gamma GOF Test					
651					5% A-D Critical Value	0.77	Data Not Gamma Distributed at 5% Significance Level					
652					K-S Test Statistic	0.122	Kolmogorov-Smirnov Gamma GOF Test					
653					5% K-S Critical Value	0.0398	Data Not Gamma Distributed at 5% Significance Level					
654					Data Not Gamma Distributed at 5% Significance Level							
655												
656					Gamma Statistics							
657					k hat (MLE)	1.686					k star (bias corrected MLE)	1.678
658					Theta hat (MLE)	138.9					Theta star (bias corrected MLE)	139.5
659					nu hat (MLE)	1868					nu star (bias corrected)	1859
660					MLE Mean (bias corrected)	234.1					MLE Sd (bias corrected)	180.8
661											Approximate Chi Square Value (0.05)	1760
662					Adjusted Level of Significance	0.0496					Adjusted Chi Square Value	1760
663												
664					Assuming Gamma Distribution							
665					95% Approximate Gamma UCL (use when n>=50))	247.3					95% Adjusted Gamma UCL (use when n<50)	247.4
666												
667					Lognormal GOF Test							
668					Shapiro Wilk Test Statistic	0.958	Shapiro Wilk Lognormal GOF Test					
669					5% Shapiro Wilk P Value	1.110E-16	Data Not Lognormal at 5% Significance Level					
670					Lilliefors Test Statistic	0.0721	Lilliefors Lognormal GOF Test					
671					5% Lilliefors Critical Value	0.038	Data Not Lognormal at 5% Significance Level					
672					Data Not Lognormal at 5% Significance Level							
673												
674					Lognormal Statistics							
675					Minimum of Logged Data	3.584					Mean of logged Data	5.131
676					Maximum of Logged Data	7.496					SD of logged Data	0.758
677												
678					Assuming Lognormal Distribution							
679					95% H-UCL	240					90% Chebyshev (MVUE) UCL	249.9
680					95% Chebyshev (MVUE) UCL	261.1					97.5% Chebyshev (MVUE) UCL	276.6
681					99% Chebyshev (MVUE) UCL	307						
682												
683					Nonparametric Distribution Free UCL Statistics							
684					Data do not follow a Discernible Distribution (0.05)							
685												
686					Nonparametric Distribution Free UCLs							
687					95% CLT UCL	250.9					95% Jackknife UCL	251
688					95% Standard Bootstrap UCL	251.2					95% Bootstrap-t UCL	252.7
689					95% Hall's Bootstrap UCL	252.5					95% Percentile Bootstrap UCL	251.4
690					95% BCA Bootstrap UCL	253.3						
691					90% Chebyshev(Mean, Sd) UCL	264.8					95% Chebyshev(Mean, Sd) UCL	278.7
692					97.5% Chebyshev(Mean, Sd) UCL	297.9					99% Chebyshev(Mean, Sd) UCL	335.8
693												
694					Suggested UCL to Use							
695					95% Chebyshev (Mean, Sd) UCL	278.7						
696												
697	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
698	Recommendations are based upon data size, data distribution, and skewness.											
699	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
700	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia											

	A	B	C	D	E	F	G	H	I	J	K	L
701												
702												
703	Result (diggingseast_lead)											
704												
705						General Statistics						
706					Total Number of Observations	554			Number of Distinct Observations			140
707									Number of Missing Observations			0
708					Minimum	6.1			Mean			91.1
709					Maximum	920			Median			50
710					SD	115.2			Std. Error of Mean			4.894
711					Coefficient of Variation	1.264			Skewness			3.337
712												
713						Normal GOF Test						
714					Shapiro Wilk Test Statistic	0.642			Shapiro Wilk GOF Test			
715					5% Shapiro Wilk P Value	0			Data Not Normal at 5% Significance Level			
716					Lilliefors Test Statistic	0.23			Lilliefors GOF Test			
717					5% Lilliefors Critical Value	0.038			Data Not Normal at 5% Significance Level			
718						Data Not Normal at 5% Significance Level						
719												
720						Assuming Normal Distribution						
721					95% Normal UCL				95% UCLs (Adjusted for Skewness)			
722					95% Student's-t UCL	99.16			95% Adjusted-CLT UCL (Chen-1995)			99.89
723									95% Modified-t UCL (Johnson-1978)			99.27
724												
725						Gamma GOF Test						
726					A-D Test Statistic	11.51			Anderson-Darling Gamma GOF Test			
727					5% A-D Critical Value	0.782			Data Not Gamma Distributed at 5% Significance Level			
728					K-S Test Statistic	0.108			Kolmogorov-Smirnov Gamma GOF Test			
729					5% K-S Critical Value	0.0402			Data Not Gamma Distributed at 5% Significance Level			
730						Data Not Gamma Distributed at 5% Significance Level						
731												
732						Gamma Statistics						
733					k hat (MLE)	1.13			k star (bias corrected MLE)			1.125
734					Theta hat (MLE)	80.61			Theta star (bias corrected MLE)			80.96
735					nu hat (MLE)	1252			nu star (bias corrected)			1247
736					MLE Mean (bias corrected)	91.1			MLE Sd (bias corrected)			85.88
737									Approximate Chi Square Value (0.05)			1166
738					Adjusted Level of Significance	0.0496			Adjusted Chi Square Value			1165
739												
740						Assuming Gamma Distribution						
741					95% Approximate Gamma UCL (use when n>=50))	97.42			95% Adjusted Gamma UCL (use when n<50)			97.44
742												
743						Lognormal GOF Test						
744					Shapiro Wilk Test Statistic	0.973			Shapiro Wilk Lognormal GOF Test			
745					5% Shapiro Wilk P Value	4.5035E-5			Data Not Lognormal at 5% Significance Level			
746					Lilliefors Test Statistic	0.0496			Lilliefors Lognormal GOF Test			
747					5% Lilliefors Critical Value	0.038			Data Not Lognormal at 5% Significance Level			
748						Data Not Lognormal at 5% Significance Level						
749												
750						Lognormal Statistics						
751					Minimum of Logged Data	1.808			Mean of logged Data			4.008
752					Maximum of Logged Data	6.824			SD of logged Data			0.975
753												
754						Assuming Lognormal Distribution						
755					95% H-UCL	96.61			90% Chebyshev (MVUE) UCL			101.8
756					95% Chebyshev (MVUE) UCL	107.8			97.5% Chebyshev (MVUE) UCL			116.2
757					99% Chebyshev (MVUE) UCL	132.6						
758												
759						Nonparametric Distribution Free UCL Statistics						
760						Data do not follow a Discernible Distribution (0.05)						
761												
762						Nonparametric Distribution Free UCLs						
763					95% CLT UCL	99.15			95% Jackknife UCL			99.16
764					95% Standard Bootstrap UCL	99.19			95% Bootstrap-t UCL			100.1
765					95% Hall's Bootstrap UCL	100.3			95% Percentile Bootstrap UCL			99.4
766					95% BCA Bootstrap UCL	99.82						
767					90% Chebyshev(Mean, Sd) UCL	105.8			95% Chebyshev(Mean, Sd) UCL			112.4
768					97.5% Chebyshev(Mean, Sd) UCL	121.7			99% Chebyshev(Mean, Sd) UCL			139.8
769												
770						Suggested UCL to Use						

	A	B	C	D	E	F	G	H	I	J	K	L
771					95% Chebyshev (Mean, Sd) UCL	112.4						
772												
773	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
774	Recommendations are based upon data size, data distribution, and skewness.											
775	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
776	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia											
777												
778												
779	**Result (diggingseast_mercury)**											
780												
781	**General Statistics**											
782					Total Number of Observations	554			Number of Distinct Observations			136
783									Number of Missing Observations			0
784					Minimum	0.022			Mean			1.567
785					Maximum	180			Median			0.0875
786					SD	12.32			Std. Error of Mean			0.523
787					Coefficient of Variation	7.862			Skewness			11.22
788												
789	**Normal GOF Test**											
790					Shapiro Wilk Test Statistic	0.121			**Shapiro Wilk GOF Test**			
791					5% Shapiro Wilk P Value	0			Data Not Normal at 5% Significance Level			
792					Lilliefors Test Statistic	0.47			**Lilliefors GOF Test**			
793					5% Lilliefors Critical Value	0.038			Data Not Normal at 5% Significance Level			
794	**Data Not Normal at 5% Significance Level**											
795												
796	**Assuming Normal Distribution**											
797	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
798					95% Student's-t UCL	2.429			95% Adjusted-CLT UCL (Chen-1995)			2.694
799									95% Modified-t UCL (Johnson-1978)			2.471
800												
801	**Gamma GOF Test**											
802					A-D Test Statistic	106.2			**Anderson-Darling Gamma GOF Test**			
803					5% A-D Critical Value	0.883			Data Not Gamma Distributed at 5% Significance Level			
804					K-S Test Statistic	0.317			**Kolmogorov-Smirnov Gamma GOF Test**			
805					5% K-S Critical Value	0.0427			Data Not Gamma Distributed at 5% Significance Level			
806	**Data Not Gamma Distributed at 5% Significance Level**											
807												
808	**Gamma Statistics**											
809					k hat (MLE)	0.277			k star (bias corrected MLE)			0.277
810					Theta hat (MLE)	5.651			Theta star (bias corrected MLE)			5.657
811					nu hat (MLE)	307.2			nu star (bias corrected)			306.9
812					MLE Mean (bias corrected)	1.567			MLE Sd (bias corrected)			2.977
813									Approximate Chi Square Value (0.05)			267.3
814					Adjusted Level of Significance	0.0496			Adjusted Chi Square Value			267.2
815												
816	**Assuming Gamma Distribution**											
817	95% Approximate Gamma UCL (use when n>=50))					1.799			95% Adjusted Gamma UCL (use when n<50)			1.799
818												
819	**Lognormal GOF Test**											
820					Shapiro Wilk Test Statistic	0.864			**Shapiro Wilk Lognormal GOF Test**			
821					5% Shapiro Wilk P Value	0			Data Not Lognormal at 5% Significance Level			
822					Lilliefors Test Statistic	0.123			**Lilliefors Lognormal GOF Test**			
823					5% Lilliefors Critical Value	0.038			Data Not Lognormal at 5% Significance Level			
824	**Data Not Lognormal at 5% Significance Level**											
825												
826	**Lognormal Statistics**											
827					Minimum of Logged Data	-3.817			Mean of logged Data			-2.07
828					Maximum of Logged Data	5.193			SD of logged Data			1.391
829												
830	**Assuming Lognormal Distribution**											
831					95% H-UCL	0.384			90% Chebyshev (MVUE) UCL			0.412
832					95% Chebyshev (MVUE) UCL	0.449			97.5% Chebyshev (MVUE) UCL			0.501
833					99% Chebyshev (MVUE) UCL	0.601						
834												
835	**Nonparametric Distribution Free UCL Statistics**											
836	**Data do not follow a Discernible Distribution (0.05)**											
837												
838	**Nonparametric Distribution Free UCLs**											
839					95% CLT UCL	2.428			95% Jackknife UCL			2.429
840					95% Standard Bootstrap UCL	2.411			95% Bootstrap-t UCL			2.97

	A	B	C	D	E	F	G	H	I	J	K	L
841					95% Hall's Bootstrap UCL	2.816				95% Percentile Bootstrap UCL		2.464
842					95% BCA Bootstrap UCL	2.768						
843					90% Chebyshev(Mean, Sd) UCL	3.137				95% Chebyshev(Mean, Sd) UCL		3.848
844					97.5% Chebyshev(Mean, Sd) UCL	4.835				99% Chebyshev(Mean, Sd) UCL		6.774
845												
846						**Suggested UCL to Use**						
847					95% Chebyshev (Mean, Sd) UCL	3.848						
848												
849	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
850					Recommendations are based upon data size, data distribution, and skewness.							
851	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
852	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia											
853												
854												
855	**Result (diggingseast_zinc)**											
856												
857						**General Statistics**						
858					Total Number of Observations	554				Number of Distinct Observations		126
859										Number of Missing Observations		0
860					Minimum	43				Mean		367.6
861					Maximum	3100				Median		230
862					SD	395.7				Std. Error of Mean		16.81
863					Coefficient of Variation	1.076				Skewness		3.214
864												
865						**Normal GOF Test**						
866					Shapiro Wilk Test Statistic	0.659				**Shapiro Wilk GOF Test**		
867					5% Shapiro Wilk P Value	0				Data Not Normal at 5% Significance Level		
868					Lilliefors Test Statistic	0.208				**Lilliefors GOF Test**		
869					5% Lilliefors Critical Value	0.038				Data Not Normal at 5% Significance Level		
870						**Data Not Normal at 5% Significance Level**						
871												
872						**Assuming Normal Distribution**						
873					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
874					95% Student's-t UCL	395.3				95% Adjusted-CLT UCL (Chen-1995)		397.8
875										95% Modified-t UCL (Johnson-1978)		395.7
876												
877						**Gamma GOF Test**						
878					A-D Test Statistic	11.72				**Anderson-Darling Gamma GOF Test**		
879					5% A-D Critical Value	0.771				Data Not Gamma Distributed at 5% Significance Level		
880					K-S Test Statistic	0.117				**Kolmogorov-Smirnov Gamma GOF Test**		
881					5% K-S Critical Value	0.0399				Data Not Gamma Distributed at 5% Significance Level		
882						**Data Not Gamma Distributed at 5% Significance Level**						
883												
884						**Gamma Statistics**						
885					k hat (MLE)	1.558				k star (bias corrected MLE)		1.55
886					Theta hat (MLE)	236				Theta star (bias corrected MLE)		237.1
887					nu hat (MLE)	1726				nu star (bias corrected)		1718
888					MLE Mean (bias corrected)	367.6				MLE Sd (bias corrected)		295.3
889										Approximate Chi Square Value (0.05)		1623
890					Adjusted Level of Significance	0.0496				Adjusted Chi Square Value		1622
891												
892						**Assuming Gamma Distribution**						
893			95% Approximate Gamma UCL (use when n>=50))			389.2				95% Adjusted Gamma UCL (use when n<50)		389.3
894												
895						**Lognormal GOF Test**						
896					Shapiro Wilk Test Statistic	0.969				**Shapiro Wilk Lognormal GOF Test**		
897					5% Shapiro Wilk P Value	2.0415E-7				Data Not Lognormal at 5% Significance Level		
898					Lilliefors Test Statistic	0.0668				**Lilliefors Lognormal GOF Test**		
899					5% Lilliefors Critical Value	0.038				Data Not Lognormal at 5% Significance Level		
900						**Data Not Lognormal at 5% Significance Level**						
901												
902						**Lognormal Statistics**						
903					Minimum of Logged Data	3.761				Mean of logged Data		5.553
904					Maximum of Logged Data	8.039				SD of logged Data		0.799
905												
906						**Assuming Lognormal Distribution**						
907					95% H-UCL	379.5				90% Chebyshev (MVUE) UCL		396.1
908					95% Chebyshev (MVUE) UCL	414.8				97.5% Chebyshev (MVUE) UCL		440.8
909					99% Chebyshev (MVUE) UCL	491.9						
910												

	A	B	C	D	E	F	G	H	I	J	K	L
911	**Nonparametric Distribution Free UCL Statistics**											
912	**Data do not follow a Discernible Distribution (0.05)**											
913												
914	**Nonparametric Distribution Free UCLs**											
915					95% CLT UCL	395.3				95% Jackknife UCL		395.3
916					95% Standard Bootstrap UCL	395.5				95% Bootstrap-t UCL		399.2
917					95% Hall's Bootstrap UCL	398				95% Percentile Bootstrap UCL		396.9
918					95% BCA Bootstrap UCL	395.6						
919					90% Chebyshev(Mean, Sd) UCL	418.1				95% Chebyshev(Mean, Sd) UCL		440.9
920					97.5% Chebyshev(Mean, Sd) UCL	472.6				99% Chebyshev(Mean, Sd) UCL		534.9
921												
922	**Suggested UCL to Use**											
923					95% Chebyshev (Mean, Sd) UCL	440.9						
924												
925	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
926	Recommendations are based upon data size, data distribution, and skewness.											
927	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
928	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticia											
929												

APPENDIX B

WILDLIFE EXPOSURE PARAMETER INFORMATION

Appendix B - Detailed Wildlife Exposure Parameters

Mallard Duck

Anas platyrhynchos

Parameter	Symbol	Reported Values	Reference	Values Identified for SLERA
Body Weight	BW	1.225 Mean (kg) - adult males, North America 1.043 Mean (kg) - adult females, North America 1.246 Mean (kg) - adult males in winter, Mississippi 1.095 Mean (kg) - adult females in winter, Mississippi 1.237 Mean (kg) - adult males in winter, Texas 1.088 Mean (kg) - adult females in winter, Texas 1.197 Mean (kg) - adult females in spring, North Dakota	USEPA, 1993	Average of reported means: **1.162** **kg ww**
Food Ingestion Rate	IR_{food}	No measured values available; estimated from avian allometric equation for food ingestion provided in USEPA (1993). Assumes 18% dry matter in food (CF = 0.18 kg food dw / kg food ww).	USEPA, 1993	Estimated from allometric equation: IR_{food} (kg ww/day) = [0.0582*BW (kg ww) $^{0.651}$] / CF (dw/ww) **0.356** **kg ww/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from avian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: IR (L/day) = 0.059 * BW (kg ww) $^{0.67}$ **0.065** **L/day**
Acute Water Ingestion Rate	Acute IR_{water}	Water-fasted mallards consumed ~120 mL/kg BW in one hour (compared to non water-fasted mallards, which consumed less than 12 mL/kg BW for each of 3 hours.	Isanhard et al. 2011	IR (L/event) = IR (mL/kg BW) * CF (mL/L) * BW (kg ww) **0.14** **L/event**
Sediment Ingestion Rate	IR^{sed}	No measured values available; estimated fraction of sediment in the diet is 0.06 (6%) (based on mean acid-soluble ash content in mallard feces). Assumes 18% dry matter in food (CF = 0.18 kg food dw / kg food ww).	Beyer et al., 1998	Based on fraction of sediment/soil in the diet: $IR_{soil/sed}$ = IR_{food} (kg ww/day) * % in diet * CF (dw/ww) **0.0038** **kg dw/day**
Acute Sediment Ingestion Rate	Acute IR^{sed}	No measured values available; estimated fraction of sediment in the diet is 0.12 (12%) (based on 90th percentile acid-soluble ash content in mallard feces). Assumes 18% dry matter in food (CF = 0.18 kg food dw / kg food ww).	Beyer et al., 1998	Based on fraction of sediment/soil in the diet: $IR_{soil/sed}$ = IR_{food} (kg ww/day) * % in diet * CF (dw/ww) **0.0077** **kg dw/day**
Dietary Composition (fraction wet volume)	DF	North Dakota, prairie potholes 75% total invertebrates: average in spring 25% total plants: average in spring	USEPA, 1993	**DFaquatic invert = 75%** **DFaquatic plant = 25%**
Home Range Size	HR	468 Mean (ha) - adult females, total - North Dakota, prairie potholes 111 Mean (ha) - adult females, laying - North Dakota, prairie potholes	USEPA, 1993	
Exposure Adjustment Factor	EAF	Migratory in northern portion of range; leave breeding grounds from September to November returning in spring. Conservatively assumes waterfowl present in Butte and frequenting the stormwater areas year-round, but abiotic exposure media (water/sediment) are frozen and inaccessible for exposure from November through February (exposure occurs from March to October; 8 of 12 months per year; 67% of the year).	USEPA, 1993 Assumption	**0.67** **fraction (unitless)**

References:

USEPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development. December 1993. EPA/600/R-93/187a,b

Beyer, W.N, D.J. Audet, A. Morton, J.K. Campbell, and L. LeCaptain. 1998. Lead Exposure of Waterfowl Ingesting Coeur d'Alene River Basin Sediments. J Environ Qual (27):1533-1538.

Appendix B - Detailed Wildlife Exposure Parameters

Marsh Wren

Cistothorus palustris

Parameter	Symbol	Reported Values	Reference	Values Identified for SLERA
Body Weight	BW	10.6 Mean (g) - Female, breeding (New York) 11.9 Mean (g) - Male, breeding (New York) 9.4 Mean (g) - Adult, female (Georgia) 10.6 Mean (g) - Adult, male (Georgia) 9.4 Mean (g) - Juvenile, both (Georgia)	USEPA, 1993	Average of reported means: **0.010** **kg ww**
Food Ingestion Rate	IR_{food}	0.67 Mean (g/g BW/day) - Adult, both free-living (Georgia, captive) 0.99 Mean (g/g BW/day) - Adult, female free-living (Georgia, captive) 0.96 Mean (g/g BW/day) - Adult, male free-living (Georgia, captive)	USEPA, 1993	Average of reported means (adj by BW): *IR (kg ww/day) = IR (g ww/g BW-day) * BW (kg)* **0.0091** **kg ww/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from avian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: $IR\ (L/day) = 0.059 * BW\ (kg\ ww)^{0.67}$ **0.0028** **L/day**
Acute Water Ingestion Rate	Acute IR_{water}	No measured values available; estimated from avian allometric equation for water ingestion provided in USEPA (1993). Assumes high-end body weight of 13.5 g (based on reported maximum in USEPA, 1993).	USEPA, 1993	Estimated from allometric equation: $IR\ (L/day) = 0.059 * BW\ (kg\ ww)^{0.67}$ **0.0033** **L/day**
Sediment Ingestion Rate	IR^{sed}	No measured values available; estimated fraction of sediment in the diet is assumed to be 0.104 (10.4%) (assumed to be similar to mean for woodcock). Assumes 40% dry matter in food (CF = 0.4 kg food dw / kg food ww).	Beyer et al., 1994	Based on fraction of sediment/soil in the diet: $IR_{soil/sed} = IR_{food}\ (kg\ ww/day) * \%\ in\ diet * CF\ (dw/ww)$ **0.00038** **kg dw/day**
Acute Sediment Ingestion Rate	Acute IR^{sed}	No measured values available; estimated fraction of sediment in the diet is assumed to be 0.2 (20%) (assumed to be similar to maximum for woodcock). Assumes 40% dry matter in food (CF = 0.4 kg food dw / kg food ww).	Beyer et al., 1994	Based on fraction of sediment/soil in the diet: $IR_{soil/sed} = IR_{food}\ (kg\ ww/day) * \%\ in\ diet * CF\ (dw/ww)$ **0.00073** **kg dw/day**
Dietary Composition (fraction wet volume)	DF	Georgia, salt marsh Predominantly terrestrial insects (e.g., beetles, flies, grashoppers, spiders) and some (~5%) aquatic invertebrates (e.g., amphipods, snails)	USEPA, 1993	**DFterrest invert = 95%** **DFaquatic invert = 5%**
Home Range Size	HR	0.0355 Mean across 3 salt marshes (ha) - Adult, male spring (Georgia) 0.17 Mean (ha) - Adult, male spring (west Washington, fresh marsh) 0.07 Mean (ha) - Adult, male spring (Manitoba, fresh cattail marsh)	USEPA, 1993	
Exposure Adjustment Factor	EAF	Migratory wrens breed in northern U.S. and winter in southern U.S. and Mexico. Conservatively assumes passerines present in Butte and frequenting the stormwater areas year-round, but abiotic exposure media (water/sediment) are frozen and inaccessible for exposure from November through February (exposure occurs from March to October; 8 of 12 months per year; 67% of the year). Assumes entire home range is within the stormwater areas.	USEPA, 1993 Assumption	**67%** **fraction (unitless)**

References:

USEPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development. December 1993. EPA/600/R-93/187a,b

Beyer, W.N, E.E. Connor, S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. J Wildlife Manag 58(2):375-382.

Appendix B - Detailed Wildlife Exposure Parameters

Red Fox

Vulpes vulpes

Parameter	Symbol	Reported Values	References	Values Identified for ERA
Body Weight	BW	5.25 Mean (kg) - adult male - spring - Illinois 4.13 Mean (kg) - adult female - spring - Illinois 4.820 Mean (kg) - adult male - fall - Iowa 3.94 Mean (kg) - adult female - fall - Iowa	USEPA, 1993	Average of reported means: **4.5** **kg ww**
Food Ingestion Rate	IR_{food}	0.13 Mean across juvenile age groups (g/g BW/day) - North Dakota, lab 0.075 Mean (g/g BW/day) - adult, before whelp - North Dakota, captive 0.14 Mean (g/g BW/day) - female, after whelp - North Dakota, captive 0.069 Mean (g/g BW/day) - adult, nonbreeding - North Dakota, captive	USEPA, 1993	Reported mean for juveniles (adj by BW): *IR (kg ww/day) = IR (g ww/g BW-day) * BW (kg)* **0.59** **kg ww/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: $IR\ (L/day) = 0.099 * BW\ (kg\ ww)^{0.90}$ **0.39** **L/day**
Acute Water Ingestion Rate	Acute IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993). Assumes high-end body weight of 7.04 kg (based on reported maximum in USEPA, 1993).	USEPA, 1993	Estimated from allometric equation: $IR\ (L/day) = 0.099 * BW\ (kg\ ww)^{0.90}$ **0.57** **L/day**
Sediment Ingestion Rate	IR_{sed}	No measured values available; estimated fraction of sediment in the diet is 0.028 (2.8%), based on mean in scat for red fox. Assumes 30% dry matter in food (CF = 0.3 kg food dw / kg food ww).	Beyer et al., 1994	Based on fraction of soil/sediment in the diet: $IR_{sed} = IR_{food}\ (kg\ ww/day) * \%\ in\ diet * CF\ (dw/ww)$ **0.0050** **kg dw/day**
Acute Sediment Ingestion Rate	Acute IR_{sed}	No measured values available; estimated fraction of sediment in the diet is 0.058 (5.8%), based on maximum in scat for red fox. Assumes 30% dry matter in food (CF = 0.3 kg food dw / kg food ww).	Beyer et al., 1994	Based on fraction of soil/sediment in the diet: $IR_{sed} = IR_{food}\ (kg\ ww/day) * \%\ in\ diet * CF\ (dw/ww)$ **0.0103** **kg dw/day**
Dietary Composition (fraction wet volume)	DF	Red fox feeds on both animal and plant material, mostly small mammals, birds, insects, and fruit; game birds and waterfowl are seasonally important food source.	USEPA, 1993	**DFmammals/birds = 90%** **DFterr plant = 10%**
Home Range Size	HR	Territory sizes vary widely, with territories in urban areas tend to be smaller than those in rural areas and often conform to physical landscape features such as well-traveled roads and streams. 699 Mean (ha) - Adult female, spring (Minnesota woods, fields, swamp) 717 Mean (ha) - Adult male, all year (Winconsin, diverse habitat) 96 Mean (ha) - Adult female, all year (Winconsin, diverse habitat)	USEPA, 1993	
Exposure Adjustment Factor	EAF	Year-round resident in Butte. Assumes entire home range is within the stormwater areas, but abiotic exposure media (water/sediment) are frozen and inaccessible for exposure from November through February (exposure occurs from March to October; 8 of 12 months per year; 67% of the year). Assumes stormwater areas encompass three-fourths of the total local home range size.	USEPA, 1993 Assumption	**0.50** **fraction (unitless)**

References:

USEPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development. December 1993. EPA/600/R-93/187a,b

Beyer, W.N, E.E. Connor, S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. J Wildlife Manag 58(2):375-382.

Appendix B - Detailed Wildlife Exposure Parameters

Short-tailed Shrew

Blarina brevicauda

Parameter	Symbol	Reported Values	References	Values Identified for ERA
Body Weight	BW	15.0 Mean (g) of adults, male & female, New Hampshire 19.21 Mean (g) males, summer, Pennsylvania 17.4 Mean (g) females, summer, Pennsylvania 16.87 Mean (g) males, fall, Pennsylvania 15.58 Mean (g) females, fall, Pennsylvania	USEPA, 1993	Average of reported means: **0.017** **kg ww**
Food Ingestion Rate	IR_{food}	0.49 Mean (g/g BW/day) - adults both sexes - Ohio laboratory 0.62 Mean (g/g BW/day) - adults both sexes - Ohio laboratory	USEPA, 1993	Reported mean across means (adj by BW): *IR (kg ww/day) = IR (g ww/g BW-day) * BW (kg)* **0.0093** **kg ww/day**
Water Ingestion Rate	IR_{water}	Estimated from mammalian allometric equation for water ingestion provided in USEPA (1993). Reported laboratory ingestion rate of 0.223 g/g BW/day is consistent with estimated value.	USEPA, 1993	Estimated from allometric equation: $IR\ (L/day) = 0.099 * BW\ (kg\ ww)^{0.90}$ **0.0025** **L/day**
Acute Water Ingestion Rate	Acute IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993). Assumes high-end body weight of 0.0225 kg (based on reported maximum in USEPA, 1993).	USEPA, 1993	Estimated from allometric equation: $IR\ (L/day) = 0.099 * BW\ (kg\ ww)^{0.90}$ **0.0033** **L/day**
Sediment Ingestion Rate	IR_{sed}	No measured values available; estimated fraction of sediment in the diet is 0.024 (2.4%), based on mean in scat for meadow vole. Assumes 20% dry matter in food (CF = 0.2 kg food dw / kg food ww).	Beyer et al., 1994	Based on fraction of soil/sediment in the diet: $IR_{sed} = IR_{food}\ (kg\ ww/day) * \%\ in\ diet * CF\ (dw/ww)$ **0.000052** **kg dw/day**
Acute Sediment Ingestion Rate	Acute IR_{sed}	No measured values available; estimated fraction of sediment in the diet is 0.038 (3.8%), based on maximum in scat for meadow vole. Assumes 20% dry matter in food (CF = 0.2 kg food dw / kg food ww).	Beyer et al., 1994	Based on fraction of soil/sediment in the diet: $IR_{sed} = IR_{food}\ (kg\ ww/day) * \%\ in\ diet * CF\ (dw/ww)$ **0.000071** **kg dw/day**
Dietary Composition (fraction wet volume)	DF	Shrew feeds primarily on soil invertebrates (e.g., earthworms, slugs, snails, beetles) and some vegetation	USEPA, 1993	**DFsoil invert = 90%** **DFplant = 10%**
Home Range Size	HR	Home range sizes will vary by habitat and season; home ranges in summer overlap both within and between sexes. <0.1 - 0.36 Range (ha) - Adult female, summer (Michigan, bluegrass <0.1 - 1.8 Range (ha) - Adult male, summer (Michigan, bluegrass 0.39 Mean (ha) - Both sexes (Manitoba, bog) 0.03 - 0.07 Range (ha) - Both sexes, high prey density, winter (New York, old field) 0.10 - 0.22 Range (ha) - Both sexes, low prey density, winter (New York, old field)	USEPA, 1993	
Exposure Adjustment Factor	EAF	Year-round resident in Butte. Assumes entire home range is within the stormwater areas, but abiotic exposure media (water/sediment) are frozen and inaccessible for exposure from November through February (exposure occurs from March to October; 8 of 12 months per year; 67% of the year).	USEPA, 1993 Assumption	**0.67** **fraction (unitless)**

References:

USEPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development. December 1993. EPA/600/R-93/187a,b

Beyer, W.N, E.E. Connor, S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. J Wildlife Manag 58(2):375-382.

Appendix B - Detailed Wildlife Exposure Parameters

Mink

Mustela vison

Parameter	Symbol	Reported Values	References	Values Identified for ERA
Body Weight	BW	1.040 Mean (kg) - adult male - summer - Montana 1.233 Mean (kg) - adult male - fall - Montana 0.550 Mean (kg) - adult female- summer - Montana 0.586 Mean (kg) - adult female - fall - Montana 0.777 Mean (kg) - juvenile male - summer - Montana 0.533 Mean (kg) - juvenile female - summer - Montana	USEPA, 1993	Average of reported means for females: **0.56** **kg ww**
Food Ingestion Rate	IR_{food}	0.13 Mean (g/g BW/day) - captive males 0.12 Mean (g/g BW/day) - farm raised males 0.16 Mean (g/g BW/day) - farm raised females	USEPA, 1993	Reported mean for females (adj by BW): *IR (kg ww/day) = IR (g ww/g BW-day) * BW (kg)* **0.089** **kg ww/day**
Water Ingestion Rate	IR_{water}	0.099 Mean (g/g BW/day) - farm raised males 0.028 Mean (g/g BW/day) - farm raised females *(Water density = 1 g/mL)*	USEPA, 1993	Reported mean for males (adj by BW): *IR (L/day) = IR (g/g BW-day) * BW (kg)* **0.055** **L/day**
Acute Water Ingestion Rate	Acute IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993). Assumes high-end body weight of 2.3 kg (based on reported maximum for adult males in USEPA, 1993).	USEPA, 1993	Estimated from allometric equation: $IR\ (L/day) = 0.099 * BW\ (kg\ ww)^{0.90}$ **0.21** **L/day**
Sediment Ingestion Rate	IR_{sed}	No measured values available; estimated fraction of sediment in the diet is assumed to be 0.094 (9.4%) based on professional judgement (assumed to be similar to mean for raccoon). Assumes 25% dry matter in food (CF = 0.25 kg food dw / kg food ww).	Beyer et al., 1994	Based on fraction of soil/sediment in the diet: $IR_{sed} = IR_{food}\ (kg\ ww/day) * \%\ in\ diet * CF\ (dw/ww)$ **0.0021** **kg dw/day**
Acute Sediment Ingestion Rate	Acute IR_{sed}	No measured values available; estimated fraction of sediment in the diet is assumed to be 0.18 (18%) based on professional judgement (assumed to be similar to maximum for raccoon). Assumes 25% dry matter in food (CF = 0.25 kg food dw / kg food ww).	Beyer et al., 1994	Based on fraction of soil/sediment in the diet: $IR_{sed} = IR_{food}\ (kg\ ww/day) * \%\ in\ diet * CF\ (dw/ww)$ **0.0040** **kg dw/day**
Dietary Composition (fraction wet volume)	DF	Mink are opportunistic feeders taking whatever prey is abundant. In many parts of its range, mammals are the most important prey, but mink hunt aquatic prey as well depending on the season. In mink intestines collected from a Montana river, percent frequency of occurrence in samples for food items: 61.5% fish; 19.2% mammals and 26.9% aquatic invertebrates. In mink stomachs, the frequency of occurrence was: 11.5% fish, and 7.2% mammals.	USEPA, 1993 RCG, Hagler Bailly, 1995	**DFfish = 60%** **DFmammals = 20%** **DFaquatic invert = 20%**
Home Range Size	HR	Range size and shape depends on habitat. Shape is linear along streams and circular in marshes. Montana /riverine environment: 7.8 Mean (ha) Female mink in heavy vegetation 20.4 Mean (ha) Female mink in sparse vegetation	USEPA, 1993	
Exposure Adjustment Factor	EAF	Mink are nocturnal and active year-round. Assumes entire home range is within the stormwater areas, but abiotic exposure media (water/sediment) are frozen and inaccessible for exposure from November through February (exposure occurs from March to October; 8 of 12 months per year; 67% of the year). Assumes entire home range is within the stormwater areas.	USEPA, 1993 Assumption	**0.67** **fraction (unitless)**

References:

USEPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development. December 1993. EPA/600/R-93/187a,b

RCG, Hagler Bailly. 1995. Aquatic Resources Injury Assessment Report, Upper Clark Fork River Basin. Report prepared for State of Montana, Natural Resource Damage Litigation Program.

Beyer, W.N, E.E. Connor, S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. J Wildlife Manag 58(2):375-382.

Appendix B - Detailed Wildlife Exposure Parameters

Domestic Dog

Canis sp.

Parameter	Symbol	Reported Values	References	Values Identified for ERA
Body Weight	BW	Assumed large breed dog of 65 pounds	Assumption	**29** **kg ww**
Food Ingestion Rate	IR_{food}	Estimated from mammalian allometric equation for food ingestion provided in USEPA (1993). Assumes 70% dry matter in food (CF = 0.7 kg food dw / kg food ww).	USEPA, 1993	Estimated from allometric equation: $IR\ (kg\ dw/day) = [0.0687 * BW\ (kg\ ww)^{0.822}] / CF\ (dw/ww)$ **1.6** **kg ww/day**
Water Ingestion Rate	IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993).	USEPA, 1993	Estimated from allometric equation: $IR\ (L/day) = 0.099 * BW\ (kg\ ww)^{0.90}$ **2.1** **L/day**
Acute Water Ingestion Rate	Acute IR_{water}	No measured values available; estimated from mammalian allometric equation for water ingestion provided in USEPA (1993). Assumes high-end body weight of 40 kg.	USEPA, 1993 Assumption	Estimated from allometric equation: $IR\ (L/day) = 0.099 * BW\ (kg\ ww)^{0.90}$ **2.7** **L/day**
Sediment Ingestion Rate	IR_{sed}	No measured values available; estimated fraction of sediment in the diet is assumed to be 0.05 (5%). Assumes 70% dry matter in food (CF = 0.7 kg food dw / kg food ww).	Assumption	Based on fraction of soil/sediment in the diet: $IR_{sed} = IR_{food}\ (kg\ ww/day) * \%\ in\ diet * CF\ (dw/ww)$ **0.055** **kg dw/day**
Acute Sediment Ingestion Rate	Acute IR_{sed}	No measured values available; estimated fraction of sediment in the diet is assumed to be 0.1 (10%). Assumes 70% dry matter in food (CF = 0.7 kg food dw / kg food ww).	Assumption	Based on fraction of soil/sediment in the diet: $IR_{sed} = IR_{food}\ (kg\ ww/day) * \%\ in\ diet * CF\ (dw/ww)$ **0.15** **kg dw/day**
Exposure Adjustment Factor	EAF	Assumes abiotic exposure media (water/sediment) are frozen and inaccessible for exposure from November through February (exposure occurs from March to October; 8 of 12 months per year; 67% of the year).	Assumption	**0.67** **fraction (unitless**

References:

USEPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development. December 1993. EPA/600/R-93/187a,b

APPENDIX C

DETAILED CHRONIC ECOLOGICAL RISK CALCULATIONS

APPENDIX C. ECOLOGICAL RISK CALCULATIONS FOR CHRONIC EXPOSURES TO SURFACE WATER AND SEDIMENT
BUFFALO GULCH AREA
BPSOU, Stormwater Ponds/Drainages, Screening Level Ecological Risk Evaluation

Receptor: Mallard Duck

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Exposure Adj. Factor	Dose (mg/kg BW/d)			TRV (mg/kg BW/d)		Hazard Quotient [HQ]	
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/d)	IRsw (L/kg BW/d)		Sediment	Surface Water	Total	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	79	0.045	0.0033	0.056	0.67	0.17	0.0017	0.18	2.24	4.51	8E-02	4E-02
Cadmium	8.3	0.0051	0.0033	0.056	0.67	0.018	0.00019	0.019	0.7	6.35	3E-02	3E-03
Copper	716	0.55	0.0033	0.056	0.67	1.6	0.020	1.6	4.05	12.1	4E-01	1E-01
Lead	774	0.43	0.0033	0.056	0.67	1.7	0.016	1.7	1.63	3.26	1E+00	5E-01
Mercury	0.42	0.0025	0.0033	0.056	0.67	0.00092	0.00009	0.00102	0.019	0.19	5E-02	5E-03
Zinc	3,302	2.0	0.0033	0.056	0.67	7.3	0.07	7.4	66.1	171	1E-01	4E-02

Receptor: Marsh Wren

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Exposure Adj. Factor	Dose (mg/kg BW/d)			TRV (mg/kg BW/d)		Hazard Quotient [HQ]	
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/d)	IRsw (L/kg BW/d)		Sediment	Surface Water	Total	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	79	0.045	0.036	0.27	0.67	1.9	0.0080	1.9	2.24	4.51	9E-01	4E-01
Cadmium	8.3	0.0051	0.036	0.27	0.67	0.20	0.0009	0.20	0.7	6.35	3E-01	3E-02
Copper	716	0.55	0.036	0.27	0.67	17	0.097	17	4.05	12.1	4E+00	1E+00
Lead	774	0.43	0.036	0.27	0.67	19	0.076	19	1.63	3.26	1E+01	6E+00
Mercury	0.42	0.0025	0.036	0.27	0.67	0.0101	0.00045	0.0106	0.019	0.19	6E-01	6E-02
Zinc	3,302	2.0	0.036	0.27	0.67	80	0.35	80	66.1	171	1E+00	5E-01

Receptor: Red Fox

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Exposure Adj. Factor	Dose (mg/kg BW/d)			TRV (mg/kg BW/d)		Hazard Quotient [HQ]	
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/d)	IRsw (L/kg BW/d)		Sediment	Surface Water	Total	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	79	0.045	0.0011	0.085	0.5	0.043	0.0019	0.045	1.04	1.66	4E-02	3E-02
Cadmium	8.3	0.0051	0.0011	0.085	0.5	0.0045	0.00022	0.0048	0.77	6.87	6E-03	7E-04
Copper	716	0.55	0.0011	0.085	0.5	0.39	0.023	0.41	5.6	9.34	7E-02	4E-02
Lead	774	0.43	0.0011	0.085	0.5	0.42	0.018	0.44	4.7	8.9	9E-02	5E-02
Mercury	0.42	0.0025	0.0011	0.085	0.5	0.00023	0.00011	0.00034	1.41	14.1	2E-04	2E-05
Zinc	3,302	2.0	0.0011	0.085	0.5	1.8	0.08	1.9	75.4	298	3E-02	6E-03

Receptor: Shrew

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Exposure Adj. Factor	Dose (mg/kg BW/d)			TRV (mg/kg BW/d)		Hazard Quotient [HQ]	
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/d)	IRsw (L/kg BW/d)		Sediment	Surface Water	Total	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	79	0.045	0.0031	0.149	0.67	0.164	0.0045	0.168	1.04	1.66	2E-01	1E-01
Cadmium	8.3	0.0051	0.0031	0.149	0.67	0.0173	0.00050	0.0178	0.77	6.87	2E-02	3E-03
Copper	716	0.55	0.0031	0.149	0.67	1.48	0.054	1.54	5.6	9.34	3E-01	2E-01
Lead	774	0.43	0.0031	0.149	0.67	1.60	0.043	1.65	4.7	8.9	4E-01	2E-01
Mercury	0.42	0.0025	0.0031	0.149	0.67	0.00087	0.00025	0.00112	1.41	14.1	8E-04	8E-05
Zinc	3,302	2.0	0.0031	0.149	0.67	6.8	0.20	7.0	75.4	298	9E-02	2E-02

APPENDIX C. ECOLOGICAL RISK CALCULATIONS FOR CHRONIC EXPOSURES TO SURFACE WATER AND SEDIMENT
BUFFALO GULCH AREA
BPSOU, Stormwater Ponds/Drainages, Screening Level Ecological Risk Evaluation

Receptor: Mink

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Exposure Adj. Factor	Dose (mg/kg BW/d)			TRV (mg/kg BW/d)		Hazard Quotient [HQ]	
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/d)	IRsw (L/kg BW/d)		Sediment	Surface Water	Total	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	79	0.045	0.0038	0.099	0.7	0.20	0.0030	0.20	1.04	1.66	2E-01	1E-01
Cadmium	8.3	0.0051	0.0038	0.099	0.7	0.021	0.00033	0.021	0.77	6.87	3E-02	3E-03
Copper	716	0.55	0.0038	0.099	0.7	1.8	0.036	1.8	5.6	9.34	3E-01	2E-01
Lead	774	0.43	0.0038	0.099	0.7	1.9	0.028	2.0	4.7	8.9	4E-01	2E-01
Mercury	0.42	0.0025	0.0038	0.099	0.7	0.0010	0.00017	0.0012	1.41	14.1	9E-04	9E-05
Zinc	3,302	2.0	0.0038	0.099	0.7	8.3	0.13	8.4	75.4	298	1E-01	3E-02

Receptor: Domestic Dog

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Exposure Adj. Factor	Dose (mg/kg BW/d)			TRV (mg/kg BW/d)		Hazard Quotient [HQ]	
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/d)	IRsw (L/kg BW/d)		Sediment	Surface Water	Total	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	79	0.045	0.0019	0.071	0.7	0.099	0.0021	0.10	1.04	1.66	1E-01	6E-02
Cadmium	8.3	0.0051	0.0019	0.071	0.7	0.010	0.00024	0.011	0.77	6.87	1E-02	2E-03
Copper	716	0.55	0.0019	0.071	0.7	0.90	0.026	0.92	5.6	9.34	2E-01	1E-01
Lead	774	0.43	0.0019	0.071	0.7	0.97	0.020	0.99	4.7	8.9	2E-01	1E-01
Mercury	0.42	0.0025	0.0019	0.071	0.7	0.00052	0.00012	0.00064	1.41	14.1	5E-04	5E-05
Zinc	3,302	2.0	0.0019	0.071	0.7	4.1	0.093	4.2	75.4	298	6E-02	1E-02

All ND = all samples were non-detect
NC = not calculated

APPENDIX C. ECOLOGICAL RISK CALCULATIONS FOR CHRONIC EXPOSURES TO SURFACE WATER AND SEDIMENT

DIGGINGS EAST AREA

BPSOU, Stormwater Ponds/Drainages, Screening Level Ecological Risk Evaluation

Receptor: Mallard Duck

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Exposure Adj. Factor	Dose (mg/kg BW/d)			TRV (mg/kg BW/d)		Hazard Quotient [HQ]	
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/d)	IRsw (L/kg BW/d)		Sediment	Surface Water	Total	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	16	0.021	0.0033	0.056	0.67	0.034	0.00077	0.035	2.24	4.51	2E-02	8E-03
Cadmium	3.1	0.0013	0.0033	0.056	0.67	0.0068	0.000050	0.0068	0.7	6.35	1E-02	1E-03
Copper	177	0.28	0.0033	0.056	0.67	0.39	0.0104	0.40	4.05	12.1	1E-01	3E-02
Lead	197	0.11	0.0033	0.056	0.67	0.44	0.0042	0.44	1.63	3.26	3E-01	1E-01
Mercury	0.053	0.0038	0.0033	0.056	0.67	0.00012	0.0001	0.0003	0.019	0.19	1E-02	1E-03
Zinc	997	0.44	0.0033	0.056	0.67	2.2	0.02	2.2	66.1	171	3E-02	1E-02

Receptor: Marsh Wren

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Exposure Adj. Factor	Dose (mg/kg BW/d)			TRV (mg/kg BW/d)		Hazard Quotient [HQ]	
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/d)	IRsw (L/kg BW/d)		Sediment	Surface Water	Total	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	16	0.021	0.036	0.27	0.67	0.38	0.0037	0.38	2.24	4.51	2E-01	8E-02
Cadmium	3.1	0.0013	0.036	0.27	0.67	0.074	0.00024	0.074	0.7	6.35	1E-01	1E-02
Copper	177	0.28	0.036	0.27	0.67	4.3	0.049	4.3	4.05	12.1	1E+00	4E-01
Lead	197	0.11	0.036	0.27	0.67	4.8	0.0200	4.8	1.63	3.26	3E+00	1E+00
Mercury	0.053	0.0038	0.036	0.27	0.67	0.0013	0.001	0.002	0.019	0.19	1E-01	1E-02
Zinc	997	0.44	0.036	0.27	0.67	24	0.078	24	66.1	171	4E-01	1E-01

Receptor: Red Fox

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Exposure Adj. Factor	Dose (mg/kg BW/d)			TRV (mg/kg BW/d)		Hazard Quotient [HQ]	
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/d)	IRsw (L/kg BW/d)		Sediment	Surface Water	Total	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	16	0.021	0.0011	0.085	0.5	0.0085	0.00088	0.0093	1.04	1.66	9E-03	6E-03
Cadmium	3.1	0.0013	0.0011	0.085	0.5	0.0017	0.00006	0.0017	0.77	6.87	2E-03	3E-04
Copper	177	0.28	0.0011	0.085	0.5	0.10	0.012	0.11	5.6	9.34	2E-02	1E-02
Lead	197	0.11	0.0011	0.085	0.5	0.11	0.00478	0.11	4.7	8.9	2E-02	1E-02
Mercury	0.053	0.0038	0.0011	0.085	0.5	0.000029	0.0002	0.0002	1.41	14.1	1E-04	1E-05
Zinc	997	0.44	0.0011	0.085	0.5	0.54	0.019	0.56	75.4	298	7E-03	2E-03

Receptor: Shrew

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Exposure Adj. Factor	Dose (mg/kg BW/d)			TRV (mg/kg BW/d)		Hazard Quotient [HQ]	
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/d)	IRsw (L/kg BW/d)		Sediment	Surface Water	Total	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	16	0.021	0.0031	0.149	0.67	0.0321	0.00204	0.0342	1.04	1.66	3E-02	2E-02
Cadmium	3.1	0.0013	0.0031	0.149	0.67	0.0063	0.00013	0.0065	0.77	6.87	8E-03	9E-04
Copper	177	0.28	0.0031	0.149	0.67	0.37	0.028	0.39	5.6	9.34	7E-02	4E-02
Lead	197	0.11	0.0031	0.149	0.67	0.41	0.01116	0.42	4.7	8.9	9E-02	5E-02
Mercury	0.053	0.0038	0.0031	0.149	0.67	0.000111	0.0004	0.0005	1.41	14.1	3E-04	3E-05
Zinc	997	0.44	0.0031	0.149	0.67	2.06	0.044	2.11	75.4	298	3E-02	7E-03

APPENDIX C. ECOLOGICAL RISK CALCULATIONS FOR CHRONIC EXPOSURES TO SURFACE WATER AND SEDIMENT
DIGGINGS EAST AREA
BPSOU, Stormwater Ponds/Drainages, Screening Level Ecological Risk Evaluation

Receptor: Mink

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Exposure Adj. Factor	Dose (mg/kg BW/d)			TRV (mg/kg BW/d)		Hazard Quotient [HQ]	
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/d)	IRsw (L/kg BW/d)		Sediment	Surface Water	Total	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	16	0.021	0.0038	0.099	0.7	0.039	0.0014	0.040	1.04	1.66	4E-02	2E-02
Cadmium	3.1	0.0013	0.0038	0.099	0.7	0.0077	0.000089	0.0078	0.77	6.87	1E-02	1E-03
Copper	177	0.28	0.0038	0.099	0.7	0.44	0.018	0.46	5.6	9.34	8E-02	5E-02
Lead	197	0.11	0.0038	0.099	0.7	0.49	0.00742	0.50	4.7	8.9	1E-01	6E-02
Mercury	0.053	0.0038	0.0038	0.099	0.7	0.00013	0.0003	0.0004	1.41	14.1	3E-04	3E-05
Zinc	997	0.44	0.0038	0.099	0.7	2.5	0.029	2.5	75.4	298	3E-02	8E-03

Receptor: Domestic Dog

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Exposure Adj. Factor	Dose (mg/kg BW/d)			TRV (mg/kg BW/d)		Hazard Quotient [HQ]	
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/d)	IRsw (L/kg BW/d)		Sediment	Surface Water	Total	NOAEL	LOAEL	NOAEL	LOAEL
Arsenic	16	0.021	0.0019	0.071	0.7	0.019	0.0010	0.020	1.04	1.66	2E-02	1E-02
Cadmium	3.1	0.0013	0.0019	0.071	0.7	0.0038	0.000063	0.0039	0.77	6.87	5E-03	6E-04
Copper	177	0.28	0.0019	0.071	0.7	0.22	0.013	0.23	5.6	9.34	4E-02	3E-02
Lead	197	0.11	0.0019	0.071	0.7	0.25	0.00529	0.25	4.7	8.9	5E-02	3E-02
Mercury	0.053	0.0038	0.0019	0.071	0.7	0.000067	0.0002	0.0002	1.41	14.1	2E-04	2E-05
Zinc	997	0.44	0.0019	0.071	0.7	1.2	0.02	1.3	75.4	298	2E-02	4E-03

All ND = all samples were non-detect
NC = not calculated

APPENDIX D

ECOTOX OUTPUT FOR ACUTE TOXICITY VALUES

[provided electronically, see attached Excel spreadsheets]

APPENDIX E

DETAILED ACUTE ECOLOGICAL RISK CALCULATIONS

APPENDIX E. ECOLOGICAL RISK CALCULATIONS FOR ACUTE EXPOSURES TO SURFACE WATER AND SEDIMENT
BUFFALO GULCH AREA
BPSOU, Stormwater Ponds/Drainages, Screening Level Ecological Risk Evaluation

Receptor: Mallard Duck

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Dose (mg/kg BW/event)			Acute TRV (mg/kg BW)	Acute Hazard Quotient [HQ]
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/event)	IRsw (L/kg BW/event)	Sediment	Surface Water	Total		
Arsenic	79	0.045	0.0066	0.12	0.52	0.0054	0.53	17.4	3E-02
Cadmium	8.3	0.0051	0.0066	0.12	0.055	0.00061	0.056	45	1E-03
Copper	716	0.55	0.0066	0.12	4.7	0.065	4.8	693	7E-03
Lead	774	0.43	0.0066	0.12	5.1	0.052	5.2	75	7E-02
Mercury	0.42	0.0025	0.0066	0.12	0.0028	0.00030	0.0031	1	3E-03
Zinc	3,302	2.0	0.0066	0.12	22	0.24	22	742	3E-02

Receptor: Marsh Wren

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Dose (mg/kg BW/event)			Acute TRV (mg/kg BW)	Acute Hazard Quotient [HQ]
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/event)	IRsw (L/kg BW/event)	Sediment	Surface Water	Total		
Arsenic	79	0.045	0.070	0.32	5.5	0.014	5.5	17.4	3E-01
Cadmium	8.3	0.0051	0.070	0.32	0.58	0.0016	0.58	45	1E-02
Copper	716	0.55	0.070	0.32	50	0.17	50	693	7E-02
Lead	774	0.43	0.070	0.32	54	0.14	54	75	7E-01
Mercury	0.42	0.0025	0.070	0.32	0.029	0.00080	0.030	1	3E-02
Zinc	3,302	2.0	0.070	0.32	231	0.63	231	742	3E-01

Receptor: Red Fox

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Dose (mg/kg BW/event)			Acute TRV (mg/kg BW)	Acute Hazard Quotient [HQ]
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/event)	IRsw (L/kg BW/event)	Sediment	Surface Water	Total		
Arsenic	79	0.045	0.0023	0.13	0.18	0.0057	0.18	2.5	7E-02
Cadmium	8.3	0.0051	0.0023	0.13	0.019	0.00064	0.019	150	1E-04
Copper	716	0.55	0.0023	0.13	1.6	0.069	1.7	233	7E-03
Lead	774	0.43	0.0023	0.13	1.8	0.054	1.8	5	4E-01
Mercury	0.42	0.0025	0.0023	0.13	0.0009	0.00032	0.0013	17.88	7E-05
Zinc	3,302	2.0	0.0023	0.13	7	0.25	8	24	3E-01

Receptor: Shrew

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Dose (mg/kg BW/event)			Acute TRV (mg/kg BW)	Acute Hazard Quotient [HQ]
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/event)	IRsw (L/kg BW/event)	Sediment	Surface Water	Total		
Arsenic	79	0.045	0.0042	0.19	0.33	0.0088	0.34	2.5	1E-01
Cadmium	8.3	0.0051	0.0042	0.19	0.035	0.00098	0.036	150	2E-04
Copper	716	0.55	0.0042	0.19	3.0	0.106	3.1	233	1E-02
Lead	774	0.43	0.0042	0.19	3.3	0.083	3.3	5	7E-01
Mercury	0.42	0.0025	0.0042	0.19	0.0018	0.00049	0.0022	17.88	1E-04
Zinc	3,302	2.0	0.0042	0.19	14	0.38	14	24	6E-01

APPENDIX E. ECOLOGICAL RISK CALCULATIONS FOR ACUTE EXPOSURES TO SURFACE WATER AND SEDIMENT
BUFFALO GULCH AREA
BPSOU, Stormwater Ponds/Drainages, Screening Level Ecological Risk Evaluation

Receptor: Mink

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Dose (mg/kg BW/event)			Acute TRV (mg/kg BW)	Acute Hazard Quotient [HQ]
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/event)	IRsw (L/kg BW/event)	Sediment	Surface Water	Total		
Arsenic	79	0.045	0.0072	0.377	0.569	0.0171	0.586	2.5	2E-01
Cadmium	8.3	0.0051	0.0072	0.377	0.0599	0.00190	0.0619	150	4E-04
Copper	716	0.55	0.0072	0.377	5.16	0.205	5.36	233	2E-02
Lead	774	0.43	0.0072	0.377	5.57	0.162	5.73	5	1E+00
Mercury	0.42	0.0025	0.0072	0.377	0.00301	0.00095	0.00396	17.88	2E-04
Zinc	3,302	2.0	0.0072	0.377	23.8	0.74	24.5	24	1E+00

Receptor: Domestic Dog

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Dose (mg/kg BW/event)			Acute TRV (mg/kg BW)	Acute Hazard Quotient [HQ]
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/event)	IRsw (L/kg BW/event)	Sediment	Surface Water	Total		
Arsenic	79	0.045	0.0049	0.093	0.390	0.0042	0.394	2.5	2E-01
Cadmium	8.3	0.0051	0.0049	0.093	0.0411	0.00047	0.0416	150	3E-04
Copper	716	0.55	0.0049	0.093	3.54	0.051	3.59	233	2E-02
Lead	774	0.43	0.0049	0.093	3.82	0.040	3.86	5	8E-01
Mercury	0.42	0.0025	0.0049	0.093	0.00206	0.00023	0.00230	17.88	1E-04
Zinc	3,302	2.0	0.0049	0.093	16.3	0.18	16.5	24	7E-01

All ND = all samples were non-detect
NC = not calculated

APPENDIX E. ECOLOGICAL RISK CALCULATIONS FOR ACUTE EXPOSURES TO SURFACE WATER AND SEDIMENT
DIGGINGS EAST AREA
BPSOU, Stormwater Ponds/Drainages, Screening Level Ecological Risk Evaluation

Receptor: Mallard Duck

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Dose (mg/kg BW/event)			Acute TRV (mg/kg BW)	Acute Hazard Quotient [HQ]
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/event)	IRsw (L/kg BW/event)	Sediment	Surface Water	Total		
Arsenic	16	0.021	0.0066	0.12	0.10	0.0025	0.11	17.4	6E-03
Cadmium	3.1	0.0013	0.0066	0.12	0.020	0.00016	0.020	45	5E-04
Copper	177	0.28	0.0066	0.12	1.2	0.033	1.2	693	2E-03
Lead	197	0.11	0.0066	0.12	1.3	0.013	1.3	75	2E-02
Mercury	0.053	0.0038	0.0066	0.12	0.0004	0.00046	0.0008	1	8E-04
Zinc	997	0.44	0.0066	0.12	7	0.05	7	742	9E-03

Receptor: Marsh Wren

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Dose (mg/kg BW/event)			Acute TRV (mg/kg BW)	Acute Hazard Quotient [HQ]
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/event)	IRsw (L/kg BW/event)	Sediment	Surface Water	Total		
Arsenic	16	0.021	0.070	0.32	1.1	0.007	1.1	17.4	6E-02
Cadmium	3.1	0.0013	0.070	0.32	0.21	0.0004	0.21	45	5E-03
Copper	177	0.28	0.070	0.32	12	0.09	12	693	2E-02
Lead	197	0.11	0.070	0.32	14	0.04	14	75	2E-01
Mercury	0.053	0.0038	0.070	0.32	0.004	0.00122	0.005	1	5E-03
Zinc	997	0.44	0.070	0.32	70	0.14	70	742	9E-02

Receptor: Red Fox

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Dose (mg/kg BW/event)			Acute TRV (mg/kg BW)	Acute Hazard Quotient [HQ]
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/event)	IRsw (L/kg BW/event)	Sediment	Surface Water	Total		
Arsenic	16	0.021	0.0023	0.13	0.04	0.0026	0.04	2.5	2E-02
Cadmium	3.1	0.0013	0.0023	0.13	0.007	0.00017	0.007	150	5E-05
Copper	177	0.28	0.0023	0.13	0.4	0.035	0.4	233	2E-03
Lead	197	0.11	0.0023	0.13	0.4	0.014	0.5	5	9E-02
Mercury	0.053	0.0038	0.0023	0.13	0.0001	0.00049	0.0006	17.88	3E-05
Zinc	997	0.44	0.0023	0.13	2	0.06	2	24	1E-01

Receptor: Shrew

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Dose (mg/kg BW/event)			Acute TRV (mg/kg BW)	Acute Hazard Quotient [HQ]
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/event)	IRsw (L/kg BW/event)	Sediment	Surface Water	Total		
Arsenic	16	0.021	0.0042	0.19	0.07	0.0040	0.07	2.5	3E-02
Cadmium	3.1	0.0013	0.0042	0.19	0.013	0.00026	0.013	150	9E-05
Copper	177	0.28	0.0042	0.19	0.7	0.054	0.8	233	3E-03
Lead	197	0.11	0.0042	0.19	0.8	0.022	0.9	5	2E-01
Mercury	0.053	0.0038	0.0042	0.19	0.0002	0.00075	0.0010	17.88	5E-05
Zinc	997	0.44	0.0042	0.19	4	0.09	4	24	2E-01

APPENDIX E. ECOLOGICAL RISK CALCULATIONS FOR ACUTE EXPOSURES TO SURFACE WATER AND SEDIMENT
DIGGINGS EAST AREA
BPSOU, Stormwater Ponds/Drainages, Screening Level Ecological Risk Evaluation

Receptor: Mink

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Dose (mg/kg BW/event)			Acute TRV (mg/kg BW)	Acute Hazard Quotient [HQ]
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/event)	IRsw (L/kg BW/event)	Sediment	Surface Water	Total		
Arsenic	16	0.021	0.0072	0.377	0.112	0.0077	0.119	2.5	5E-02
Cadmium	3.1	0.0013	0.0072	0.377	0.0220	0.00050	0.0225	150	2E-04
Copper	177	0.28	0.0072	0.377	1.27	0.105	1.38	233	6E-03
Lead	197	0.11	0.0072	0.377	1.42	0.042	1.46	5	3E-01
Mercury	0.053	0.0038	0.0072	0.377	0.00039	0.00145	0.00183	17.88	1E-04
Zinc	997	0.44	0.0072	0.377	7.2	0.17	7.3	24	3E-01

Receptor: Domestic Dog

COEC	Exposure Point Concentration [EPC]		Intake Rate [IR]		Dose (mg/kg BW/event)			Acute TRV (mg/kg BW)	Acute Hazard Quotient [HQ]
	EPCsed (mg/kg)	EPCsw (mg/L)	IRsed (kg/kg BW/event)	IRsw (L/kg BW/event)	Sediment	Surface Water	Total		
Arsenic	16	0.021	0.0049	0.093	0.077	0.0019	0.079	2.5	3E-02
Cadmium	3.1	0.0013	0.0049	0.093	0.0151	0.00012	0.0152	150	1E-04
Copper	177	0.28	0.0049	0.093	0.87	0.026	0.90	233	4E-03
Lead	197	0.11	0.0049	0.093	0.98	0.010	0.99	5	2E-01
Mercury	0.053	0.0038	0.0049	0.093	0.00026	0.00036	0.00062	17.88	3E-05
Zinc	997	0.44	0.0049	0.093	4.9	0.04	5.0	24	2E-01

All ND = all samples were non-detect
NC = not calculated