BLOOD LEAD AND ENVIRONMENTAL MONITORING STUDY FOR RICO TOWNSITE

Phase I Data Summary Report

Prepared for
Atlantic Richfield Company
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Butte, MT

Prepared by

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ACRONYMS AND ABBREVIATIONS

CDC	U.S. Centers for Disease Control and Prevention
CDPHE	Colorado Department of Public Health and the Environment
DL	detection limit
EDTA	ethylenediaminetetraacetic acid
FOD	frequency of detection
OSHA	Occupational Safety and Health Administration
QAPP	quality assurance project plan
SAP	sampling and analysis plan
USCB	United States Census Bureau
USEPA	U.S. Environmental Protection Agency
XRF	X-ray fluorescence
ZPP	erythrocyte zinc protoporphyrin

EXECUTIVE SUMMARY

This report provides the chemical and statistical analysis results for the first phase of the blood lead and environmental monitoring study conducted for the town of Rico, Colorado. Blood lead and environmental samples were collected in May 2006 to support the following study objectives: 1) further characterize current blood lead levels for Rico residents and collect environmental samples to identify factors influencing exposures; and 2) understand seasonal fluctuations in blood lead levels in order to characterize the potential contribution of the soil contact exposure pathway to blood lead levels. Blood and environmental samples were collected in May 2006 and again in September 2006 to help understand seasonal changes in blood lead levels and the relative contributions of lead in various media to total body burden. A comprehensive report will be issued after analysis of the September 2006 dataset.

One hundred eighteen (118) residents participated in the first phase of the study during May 2006. Blood lead levels were measured for 117 people,[1] with blood measured in units of mass of lead per volume of blood, or micrograms (μg) per deciliter (dL). The blood lead levels for all residents range from levels below the detection limit of 1.4 μg/dL to 26 μg/dL. The median, or middle, concentration measured for all study participants is 1.9 μg/dL. The geometric mean, a statistic commonly used to represent blood lead values, was 1.8 μg/dL. The high participation rate (67 percent of eligible households) supports the overall conclusion that the measured blood lead levels are representative of permanent Rico residents at this time.

Blood lead levels measured in Rico were found to vary significantly with age and sex. Geometric mean blood lead concentrations were higher in men (0.86 μg/dL) compared to women (0.39 μg/dL), which is perhaps due to differences in potential for occupational exposures. In addition, the geometric mean blood lead level was highest for children between the ages of 0 to 6 years (3.0 μg/dL), as compared to older children (1.4 μg/dL) and adults (1.7 μg/dL). Differences in behavior, including hand-to-mouth activity and time spent on the floor, are probable contributors to higher blood lead levels measured in the youngest age group compared to older children and adults.

Two children in the 0 to 6 year age group who provided heel prick blood samples exhibited blood lead levels above 10 μg/dL, the U.S. Centers for Disease Control and Prevention (CDC) and Colorado Department of Public Health and the Environment (CDPHE) risk-management level. These children were referred to the CDPHE's Lead Poisoning Prevention Program and were retested by their personal physician. For both

[1] Blood lead could not be measured for one participant due to small sample size.

children, results of the second samples, collected via venipuncture, were below the risk-management level of 10 μg/dL.

The highest blood lead level observed during the May 2006 sampling event (26 μg/dL) was measured in an adult male who was likely in contact with lead-containing materials while working. This is the only blood lead level exceeding the CDC's and CDPHE's risk-management level of 25 μg/dL for adults. Lead concentrations in house dust and drinking water were not measured in this participant's home; however, lead levels in soil are below current remediation action levels.

The contribution of lead in dust, water, paint, and soil to blood lead levels was evaluated using mathematical models. There was no strong association in simple regression models between individual blood lead levels and concentrations of lead in yard soil or house dust. This may be due to the time of year in which sampling occurred. Repeated sampling, after the summer when participants have had the potential for more exposure to soil, and when soil is more likely to influence the composition of house dust, should elucidate this relationship.

Measurements of behavior and activity factors, including reported time spent recreating in two areas with relatively high soil lead concentrations, work history, and the number of indoor/outdoor dogs in a household, were not found to contribute significantly to blood lead levels. No relationship between blood lead and time spent recreating along the Dolores River Corridor or around the former mining area up Silver Creek Canyon were found. The lack of relationship between these activities may be due to the intentional sampling time; this spring sampling was scheduled to represent typical exposures after winter and early spring, when activities associated with exposure to soil have not yet peaked.

Reported work history was found to be associated with both gender and blood lead level. Residents working outdoors have higher potential soil exposure than those who work indoors, and men in Rico appear to be more likely to work outdoor jobs than women. The number of indoor/outdoor dogs owned per household was not found to contribute to individuals' blood lead. Dogs may transfer lead in outdoor soil to the indoors, influencing residents' exposure to lead. The soil type that dogs come in contact with (i.e., compacted, wet, or dry) is expected to vary with the time of year or, whether or not yard soil is snow-covered. The May sampling event in Rico occurred after loss of snow cover, at a time when soils were relatively dry due to limited spring rains.

Preliminary results from the first phase of this study suggest that yard remediation may have resulted in a reduction of lead concentrations not only in yard soil, but in house dust as well. As more time passes, lead concentrations in house dust from homes with previously remediated yards are likely to continue to decrease. The fall (September) sampling event will allow further evaluation of the influence of seasonality on

relationships between behavior and activity factors, indoor dust concentrations, and blood lead levels.

1 INTRODUCTION

The Rico Townsite has been the location of a variety of mining and mineral processing activities for more than a century. These activities were driven by the presence of a highly mineralized ore body at ground surface. Both the presence of the ore body and associated mining and processing activities led to elevated metal concentrations in Townsite soils. Of the metals, only lead is present in sufficient concentrations to present a potential health risk (SEH 2004).

An evaluation of potential human health risks from lead in Townsite soils was recently completed to support approval of Atlantic Richfield Company's voluntary cleanup plan (Integral 2006d). The human health risk assessment was conducted in 2005 and 2006 to quantify potential human exposures to lead in soil and to identify health-protective risk-based concentrations to guide soil remediation activities with the Townsite (Integral 2006d). In accordance with standard risk assessment practice, exposure to lead is assessed using mathematical models to estimate blood lead levels.

The risk assessment concluded that, prior to remediation, anywhere from 3.7 to 65.1 percent of Rico properties have soil lead concentrations that could cause a greater than 5 percent risk of exceeding the target blood lead level of 10 μg/dL. Due to the predicted potential for blood lead levels to exceed the target blood lead level, a program of cleaning up residential soils in Rico is continuing under the oversight of CDPHE.

This blood lead study is being undertaken independent of the soil cleanup program at the request of Rico residents to provide them with more information regarding factors that may influence exposures to lead in Rico soil. A two-phase blood lead study was designed to characterize blood lead levels during seasons with low and high potential for soil contact to provide additional data to further characterize blood lead levels for Rico and to determine factors and pathways that influence lead exposure.

This report presents results from Phase I of the Blood Lead and Environmental Monitoring Study, completed in May 2006. A comprehensive report will be issued after analysis of the September dataset. Co-located environmental media (e.g., water, dust, paint) and blood samples were collected in order to understand the potential exposure sources of lead to Rico residents. Previously collected soil data also were incorporated in this analysis. Participants of the study were children and adults living year-round in the town of Rico. Individuals and/or families at a total of 66 residences participated in the study; of these, household paint surfaces, household dust, and drinking water were sampled at 63 residences. Three households participated in only the blood draw. A total of 118 blood samples were collected, three of which were not linked to environmental samples due to landlord decline of consent for interior samples. Exposure questionnaires were administered at all 66 residences participating in the study.

2 STUDY OBJECTIVES

To sufficiently characterize the blood lead levels of Rico residents and to understand seasonal changes in these levels, repeated sampling of blood and environmental media was planned for the spring and fall of 2006. As described in the Blood Lead and Environmental Monitoring Study Work Plan (Integral 2006a), sample collection was planned for May and September of 2006 to characterize exposure both following a snow-covered winter and in late summer.

This blood lead study was initiated in order to characterize more completely blood lead levels in the Townsite. This study also provides additional data to aid in understanding potential risks of exceeding the blood lead levels of concern and to determine if there are any seasonal variations in exposure. The objectives of this study are to:

1. Further characterize current blood lead levels for Rico residents and collect appropriate environmental samples to identify factors influencing exposures.
2. Understand seasonal fluctuations in blood lead levels in order to characterize the potential contribution of the soil contact exposure pathway to blood lead levels.

To understand seasonal changes in blood lead levels, additional characterization of the exposure environment and population behavior is necessary. Blood lead samples were linked with co-located samples of environmental media (e.g., yard soil, house dust, drinking water, and paint) in order to understand the relative contributions of lead in these media to total body burden. Blood and environmental sampling occurred during the spring and has been repeated in early fall (September) when soil exposures may potentially be greater. This study design will help to elucidate potential seasonal effects on blood lead levels.

A comprehensive understanding of the impacts of lead contamination on blood lead levels of Rico residents is limited by the small population of the Townsite. The projected 2004 Rico population was approximately 220 permanent residents. There were just 220 water hook-ups to buildings in Town, including commercial and industrial buildings, suggesting less than 200 permanent residences. Given this small sample size, a single sampling event cannot provide a comprehensive characterization of lead exposures to this community. Collection of longitudinal data allows for the understanding of seasonal and temporal variability in exposures (Koch et al. 2002) and will provide a basis for a more robust understanding of current blood lead levels.

Ideally, all study participants will participate in each of the sampling events. This type of repeated-measures sampling scheme, also known as a "within-group sample design," allows participants to act as their own control, so fewer participants are needed to detect

statistically significant differences (Kleinbaum et al. 1998). This strategy is very sensitive to small differences across time.

In addition to providing a more refined understanding of seasonal and temporal variability within the study population, the repeated-measures sampling scheme allows for better characterization of current blood lead levels of Townsite residents. Research aimed at evaluating methods for improving statistical power using repeated-measures has found that random-effects models using all observations and time-varying covariates provided significantly more robust results than single samples alone (Marshall et al. 1998).

3 SITE HISTORY

This section presents background information relevant to this study, including a discussion of the site setting and population, the origin of lead in site soils, a summary of previous yard soil remediation efforts, and an overview of the 2004 blood sampling event. A conceptual site model, information on the effects of high altitude on blood lead levels, and a discussion of the temporal trends of environmental and blood lead levels are also presented.

3.1 SITE SETTING AND POPULATION

The Townsite is located in the southwest part of the San Juan Mountains where very steep mountain slopes and sloping tributary stream valleys abruptly descend upon the gently to moderately sloping, and relatively narrow, Dolores River Valley. Many of the steep draws and gulches formed on the hillsides on both sides of the Dolores River and its Silver Creek tributary are snow avalanche chutes. Elevations in the Townsite area generally range from over 12,000 feet at the crest of the surrounding mountain peaks to about 8,700 feet in the Dolores River Valley (SEH 2004). The elevation along the main street in the Townsite is greater than 8,800 feet.

The projected 2004 population size of the Townsite was approximately 220 permanent residents (USCB 2006a), with additional residents during the summer. Based on 2000 census data (USCB 2006b), the median age of Townsite residents was 35.4 years. Children under 5 years old made up 5.4 percent of the population (or approximately 12 children), 3.4 percent of the population was over 65, and 41 percent consisted of women. The population can be described as homogenous, as 92.7 percent was of a single race (White) and over 80 percent was between 18 and 65 years of age (USCB 2006b).

Following the first phase of this study, it was determined that more than 12 children under age 5 reside in Rico. A total of 23 children under the age of 18 participated in this study, including 17 under the age of 6, and additional non-participating children were noted. This suggests greater than 10 percent of Rico residents are under age 18.

3.2 PHASED YARD SOIL REMEDIATION EFFORTS

Remediation of the yards of 35 homes in the Town of Rico was conducted in 2004 and 2005 with clean up activities concluding by October 2005. Remediation activities began again in the summer of 2006. Throughout the remediation efforts, homes were targeted based on high lead concentrations. The cleanup history of individual properties was considered in evaluating blood lead data.

3.3 PRELIMINARY RICO BLOOD LEAD SURVEY

Blood lead testing of Rico Townsite residents occurred in April and June of 2004. As part of the preliminary blood lead survey, a total of 33 residents participated in the April sampling event, and 16 participated in the June event. Due to the need to maintain confidentiality of the blood lead results, it is not known if individual residents were sampled in both April and June.

The work plan for this study (Integral 2006a) presents a detailed description of the preliminary blood lead survey. In summary, all measured blood lead levels were below the CDC and EPA blood lead level of concern (i.e., 10 μg/dL). Measured blood lead levels ranged from below the detection limit (1 μg/dL) to 8.8 μg/dL. Blood lead levels were highest in the youngest age group, which is consistent with other populations. For all age categories, average blood lead levels were higher in June than in April. The consistency of this trend, while not conclusive due to the very small number of samples, suggests that exposures to lead in soil and dust may increase in the summer after snow melts and the soil dries.

Due to low participation rates, the data collected during the preliminary blood survey are limited in their ability to provide results which are statistically significant. In addition, since it is unknown whether or not the sampling groups represent the same participants (i.e., whether or not any individuals were included in both sampling events), statements about temporal trends must be tempered due to the potential for confounding. Examination of the relationships between concentrations of lead in environmental media and in blood was not part of the 2004 blood study.

3.4 CONCEPTUAL SITE MODEL

A conceptual site model describing the ways in which people may be exposed to lead-containing media was developed for the Rico Townsite risk assessment and is presented here as Figure 3-1. This model was developed for the human health risk assessment (Integral 2006d). The conceptual site model graphically describes the ways in which residents, indoor workers, outdoor workers, and visitors within the study area may come in contact with soil lead. It also depicts the pathways by which lead in outdoor soil and dust may be transferred to other areas or media. Generally, lead in soil has relatively low mobility, which limits its transport to groundwater. Lead is not volatile, but may enter air in dust particles that are eroded from the open land and yard soil into air by wind or mechanical forces. The latter may include traffic on dirt roads. Lead in soil may contribute to indoor dust due to settling of airborne soil particles or by transport of soil into buildings on shoes or pets. Theoretically, lead could also be transferred from soil into homegrown garden vegetables.

Previous investigations of exposures to lead from soil at former mining and smelting sites in the Rocky Mountains have demonstrated that inhalation of resuspended soil particulates is an insignificant exposure pathway. These investigations have also shown that ingestion of homegrown vegetables does not contribute to increased exposure to lead in these communities, many of which have short growing seasons similar to that in Rico. For direct contact with lead in soil and dust, ingestion is the primary exposure route, with dermal absorption being insignificant (the dermal pathway is not included in EPA lead exposure models). Consequently, site-specific exposure pathways of significance include ingestion of soil and dust.

Other "background" sources of lead include lead in drinking water and paint. Lead pipes were used in interior plumbing in the early 1900s and after copper and galvanized steel pipes began to replace lead pipes, lead was still found in solder and flux used to join pipes. Lead also may be found in faucet fixtures.[2] Lead in plumbing systems has been found to leach into drinking water, particularly in areas with soft water. In addition, homes built prior to 1980 are likely to contain lead-based paint. As the paint ages, particularly if the surface is not well maintained, chips will flake off and become incorporated into house dust, which may be inhaled by residents or ingested via hand-to-mouth contact. Children will sometimes chew on painted surfaces, such as windowsills and railings, resulting in consumption of paint chips. This conceptual site model is the basis for the environmental sampling for this study.

3.5 EFFECTS OF HIGH ALTITUDE ON BLOOD LEAD

High altitude populations such as those in Rico may have hematocrit values approximately 20 percent higher than those of people living close to sea level (Integral 2006d). Because lead in the blood is primarily in red blood cells, blood lead concentrations may be modified by factors that affect hematocrit or hemoglobin levels, such as altitude.

Rico residents live at an elevation of 8,800 feet. High altitude populations are expected to have altered blood lead levels in response to lead exposures compared to low altitude populations. High altitude populations have more red blood cells as shown by higher hematocrit and hemoglobin values (Ramirez-Cardich et al. 2004; Beall et al. 1998). Thus, high altitude populations may have a lower lead body burden and reduced health risk compared with low altitude populations with similar blood lead levels.

[2] Chrome-plated brass fixtures and fittings contained up to 30 percent lead until 1988 and up to 8 percent lead until 1998.

3.6 TEMPORAL TRENDS IN BLOOD AND ENVIRONMENTAL LEAD LEVELS

Large-scale studies of lead exposure in children have also demonstrated seasonal variations in environmental-lead measurements and blood lead levels. An overview of these studies conducted by USEPA (1995, 1996), Laidlaw et al. (2005), and Yiin et al. (2000) are detailed in the Work Plan (Integral 2006a). The studies attribute seasonal fluctuations in blood lead to confirmed seasonal variations in environmental samples and differences in exposure levels. In particular, findings support that increased levels of dust may be associated with increased blood lead levels in the summer.

The CDC reports that the primary sources of lead exposure for most children are deteriorating lead-based paint, lead contaminated dust, and lead contaminated residential soil (CDC 2006a). In addition, drinking water is also recognized as a potentially significant source of lead exposure, as lead is commonly present in household plumbing materials and water service lines (CDC 2006b). Neither exposures from drinking water nor indoor lead-based paint would be expected to be influenced by season, though exposure to lead in exterior paint would be expected to be reduced during the winter. However, lead concentrations in household dust are expected to be heavily influenced by lead in residential soil, as a large component of dust is tracked in from yards. As yard soil exposures are significantly impacted by season for the reasons described above, observation of a seasonal trend in blood lead levels implicates ingestion of yard soil and household dust as the primary exposure pathways.

4 FIELD EVENT SUMMARY

To further characterize the blood lead levels of residents of Rico, Colorado and to understand seasonal changes in these levels, repeated sampling of blood and environmental media was planned for May and September 2006. Results of the May sampling event are presented in this report. The results from the September sampling event and analyses of any effects of seasonality will be presented in a subsequent report.

Environmental and blood samples were collected from participating Townsite residents in May 2006. Environmental media, including household dust, paint, and drinking water, were sampled from each of the 63 participating residences. A blood sample was collected from at least one person from each residence and, at most homes, previously measured soil concentrations were evaluated. An additional three residents provided blood samples but did not have environmental samples collected. Exposure questionnaires were administered at all 66 participating residences.

This section describes the sampling population and scheme, the recruitment of study participants, field sampling protocol, an overview of laboratory analysis, and deviations from the Work Plan.

4.1 SAMPLING POPULATION AND SAMPLING SCHEME

A comprehensive understanding of the impacts of lead contamination on blood lead levels of Rico residents is limited by the small population of the Townsite. Rico, Colorado has approximately 220 permanent residents, and there are just 220 water hook-ups to buildings in town, including commercial and industrial buildings, suggesting less than 200 permanent residences. Given this small sample size, a single sampling event cannot provide a comprehensive characterization of lead exposures to this community. Therefore, collection of longitudinal data was planned to allow for the understanding of seasonal and temporal variability in exposures and to provide a basis for a more robust understanding of current blood lead levels.

Ideally, all study participants will participate in both of the planned sampling events—May 2006 and September 2006. The May 2006 sampling event is the first event.[3] This type of repeated-measures sampling scheme, also known as a "within-group sample design," allows participants to act as their own control, so fewer participants are needed to detect statistically significant differences (Kleinbaum et al. 1998). This strategy is very sensitive to small differences across time. In addition to providing a more refined understanding of seasonal and temporal variability within the study population, the repeated-measures

[3] The May 2006 sampling event was intended to capture exposures following the winter season; however, many residents reported that the spring season arrived early and spring/summer activities had already been initiated by the time the May field sampling event began.

sampling scheme will also allow for better characterization of current blood lead levels of residents of the Townsite.

4.2 RECRUITMENT OF PARTICIPANTS

Study participants were recruited with the intent of enrollment for multiple sampling events (discussed previously), up to a total of two events over a 1-year period. Advance notification of the study was provided to Townsite residents through a one page flyer, presented in Attachment A of the Sampling and Analysis Plan (SAP) (Integral 2006b). In addition, an article was published in a local newspaper (The Rico Bugle 2006) to provide additional information on the study and announce the sampling event schedule (Integral 2006b). Integral also participated in a public meeting in Rico on May 24, 2006.

Prior to the recruitment effort, a total of 343 parcels were identified as being potential residences eligible for participation in the study. Parcel maps, including parcel owners, were provided to Integral by Atlantic Richfield and were utilized during study recruitment. The 343 parcels were identified as potential residences based on their location within the Townsite; however, many of the parcels are unimproved (e.g., no homes have been built).

Recruitment of study participants occurred approximately 1 ½ weeks prior to the scheduled field sampling event. A two-member team, consisting of one Integral environmental health scientist and either an Atlantic Richfield staff member or an additional Integral scientist, visited each residence in the Townsite. If the residents were home, the team described the study and its purpose to potential participants, provided the residents with an informational flyer (described above), and answered questions regarding the study.

At the time of the visit, for any residents willing to participate in the study, the recruiting team scheduled a date and time for the environmental sampling and blood draw. If the resident was not the owner of the property, the landlord's contact information was collected in order to obtain consent for the environmental sampling. If the resident was unsure whether they wanted to participate, the team scheduled a follow-up visit with the resident.

If no one was home at a given residence, a minimum of two additional attempts were made to contact the resident on different days, at different times of day. If a next door neighbor was home, the team member sometimes asked the neighbor to suggest a time to try to contact the resident.

4.3 FIELD SAMPLING

This section presents an overview of the confidentiality and consent agreement, field sampling protocol, and the exposure questionnaire administered during the May 2006 field sampling event. Standard operating procedures, quality assurance plans, detailed sample collection methods, and the exposure questionnaire are described in detail in the SAP and Quality Assurance Project Plan (QAPP) (Integral 2006b,c). Detailed descriptions of all sample handling and analysis protocols (e.g., sampling labels, sample custody and tracking procedures, sample preservation, field documentation, and sample packaging and shipping procedures) can also be found in the SAP (Integral 2006b). Any deviations from those plans are described in Section 4.5.

4.3.1 Confidentiality and Consent

A confidentiality and consent form was signed by each homeowner participating in the study. The consent forms are presented as Attachment C in the SAP (Integral 2006b). In addition, a consent form was signed by each adult from whom blood was sampled. Parents of minors signed consent forms if their children were participating in the blood draw. In cases where study participants were renters, as opposed to homeowners, both the participating renter and owner were required to sign the consent forms to permit residential sampling. In instances where the landlord declined to participate, renters could choose to have only their blood drawn. Environmental sampling and blood draws occurred after a signed copy of the confidentiality and consent form was obtained. A copy of the signed form was provided to the residents, and, if applicable, owners, and one copy was kept by the sampling team and is retained in the project file.

4.3.2 Blood Sampling

Blood samples were collected from adults and children via venipuncture by trained phlebotomists. A heel prick (capillary) sample was collected from infants and small children, as determined by the phlebotomists and parents. Venipuncture samples are preferable to capillary samples because a larger sample size is more easily obtained and potential contamination of the sample is minimized.

All sample collection equipment was provided by the analytical laboratory conducting blood lead analyses and was certified as lead-free. Phlebotomists collected venous blood samples using a standard vacutainer needle or butterfly needle and vacutainer tube containing an anticoagulant, ethylenediaminetetraacetic acid (EDTA). The samples were labeled according to the sample nomenclature provided in Attachment B of the SAP (Integral 2006b). Integral staff retained custody of the blood samples and were responsible for shipment of samples to the analytical laboratory.

Phlebotomists collected capillary samples by puncturing the infant's foot with an automated heel incision device and collecting blood squeezed from the foot in a pediatric

sample tube containing EDTA. To reduce the potential for environmental contamination of heel prick samples, phlebotomists thoroughly cleaned the entire bottom surface of the child's foot to remove dust and dirt that could potentially enter the pediatric sample tube during sample collection. Contamination of capillary samples can be difficult to avoid because blood is captured in tubes by capturing droplets of blood formed at the puncture wound, and it is usually difficult to hold the foot still as young children or infants will resist when their foot is held still and squeezed to obtain blood.

4.3.3 House Dust Sampling

At each residence, one composite house dust sample was collected using a high volume small surface sampler (HVS3), manufactured by CS3, Inc. A detailed description of the HVS3 is included within the SAP (Integral 2006b). At each home, dust was collected from high-traffic areas where residents, and particularly children, were expected to spend to spend a significant portion of their time while at home. At least three locations, preferably a main living space, interior of the entrance way and, in homes with children, a child's bedroom were included in each composite sample. The exact area sampled varied by the housekeeping practices and floor types in individual homes. A minimum area of 0.25 m by 0.25 m was sampled at each of the three composite locations. Additional areas were sampled as needed to ensure sufficient sample mass of 1 g of dust.

Sample labeling and storage protocol are presented in the SAP (Integral 2006b). Quality control measures, including decontamination procedures are described in detail in the QAPP (Integral, 2006c).

4.3.4 Drinking Water Sampling

Two drinking water samples were collected from the primary drinking water faucet at each residence. The first water sample was collected in a pre-labeled sample container from the cold water faucet 10 minutes following a 3-minute purge by Integral staff. Instructions were provided for residents on collection of the second sample. The second water sample was collected by residents the morning following the initial collection after allowing water to stand in the pipes overnight. This "first-draw" water sample was recovered by Integral staff on the day following the initial sample collection. In cases where residents used a filter on the primary drinking water faucet, samples were collected both from the filtered faucet and an additional, non-filtered faucet.

In addition, when possible, Integral staff determined the composition of plumbing under the kitchen sink at each residence sampled. Details of methods used to identify pipe composition are included in the SAP (Integral 2006b). Details of quality control and assurance measures, including sample custody, duplicate, matrix spike, and reference sample analyses, accuracy, and completeness are found in the QAPP (Integral 2006c).

4.3.5 Paint Analysis

Nondestructive paint analysis was conducted by Integral field staff using a Niton® lead-in-paint analyzer. The device uses X-ray fluorescence (XRF) technology to provide a quantitative estimate of the lead content on painted surfaces and a semi-quantitative estimate of the depth of lead-based paint, if present.

Using the Niton® lead-in-paint analyzer, the lead content of approximately six interior painted surfaces and two exterior painted surfaces, per residence, was quantified. Areas selected for analysis were smooth and free of dirt. Target interior surfaces included at least one wall and trim in three primary living areas (e.g., living room, kitchen, child's room). Unpainted surfaces were not analyzed (e.g., paneling, wallpaper, wood). Two target exterior surfaces were selected based on surface type (e.g., siding vs. trim). Each surface was analyzed in triplicate and the average value calculated.

The Niton® lead-in-paint analyzer is capable of detecting lead at various depths, the presence of lead is not necessarily an indication of a completed exposure pathway. A qualitative index used for characterizing the number of layers of paint assigns a value of 1–10 to each detected sample. Depth indices greater than 4 indicate that leaded paint is deeply buried below non-leaded paint.

In addition, a semi-quantitative assessment of the condition of the painted surfaces was performed. Each surface was rated on a scale of 1 to 3 to rank the condition of the paint from intact to extremely deteriorated. A score of 1 was assigned when paint was intact and adhering completely to the painted surface. A score of 3 was assigned when paint was extremely deteriorated, with paint flaking and loosely adhering to the painted surface. A score of 2 was assigned for paint in intermediate condition. The score was combined with results of lead content testing to obtain a paint hazard score.

For the statistical data analysis (see Section 6), the results of the paint assessment were considered either "positive" or "negative," to evaluate potential relationships between blood lead levels and presence of lead in paint.

A detailed description of the sampling device and operating procedures can be found within the SAP (Integral 2006b). Quality control and assurance measures can be found in the QAPP (Integral 2006c).

4.3.6 Exposure Questionnaire

At each residence, at least one participant was interviewed regarding environmental conditions, occupational history, and behaviors that might affect their potential for lead exposure. Specifically, the interview included questions regarding the residents' home and its condition (e.g., age of the house; interior/exterior paint; repainting, sanding, stripping, and refinishing activities; etc.); condition of the exterior of the home (e.g., bare

areas in the yard; abandoned cars, motorcycles, or other machinery in yard; dirt vs. paved driveway; etc.); activities and behaviors of all residents (e.g., smoking; cottage industries; use of pesticides/herbicides; etc.); occupational histories of all residents; and general demographic information (e.g., educational/socioeconomic status; age and gender; ethnicity; etc.).

Information specific to residents' activities within the Townsite was also collected. Participants were shown a map of Rico and were asked to locate areas at which they or their family members recreate or spend significant time throughout the year. The complete questionnaire can be found in Attachment D of the Work Plan (Integral 2006a).

4.4 DESCRIPTION OF LABORATORY PROCEDURES

Laboratory instrumental analysis of samples collected during the course of this investigation were performed by laboratories that have established protocols and quality assurance procedures that meet or exceed EPA, Occupational Safety and Health Administration (OSHA), and CDC guidelines. Standard analyses employed EPA, OSHA, or CDC-approved or recommended methods if available, as well as associated quality assurance procedures. Detailed descriptions of laboratory analysis and procedures are presented in the SAP and QAPP (Integral 2006b,c).

In summary, laboratory analysis of lead in drinking water, household dust, and blood was conducted. Analysis of lead in paint was conducted in the field during sampling, and subsequent laboratory testing was not performed. Blood samples were analyzed for lead and several blood parameters useful in interpretation of blood lead data (i.e., erythrocyte zinc protoporphyrin (ZPP), hematocrit, and hemoglobin). The analytical methods used to analyze blood samples, as well as laboratory quality control measures, instrument calibration, and data management are presented in the QAPP (Integral 2006c).

4.5 DEVIATIONS FROM WORK PLAN/SAMPLING AND ANALYSIS PLAN

The following section presents deviations from the field sampling protocol and laboratory analysis presented in the Work Plan, SAP, and QAPP. Very few deviations from the original sampling plan documents occurred; deviations by sample type are presented below.

4.5.1 Blood Samples

The analytical laboratory, Quest Diagnostics, initially reported a detection limit for lead in blood of 3 μg/dL although the QAPP (Integral 2006c) specified a detection limit of 1 μg/dL. Ultimately, a final detection limit of 1.4 μg/dL was obtained, which is considered sufficiently low to allow for evaluation of seasonal fluctuations in blood lead

levels. Quest Diagnostics verified the validity of the lowered limit by performing a series of serial dilutions of their calibration standards.

Field duplicates of blood samples were not collected as described in the QAPP. The QAPP states that duplicate analysis will occur for "1 in every 20 samples or once per sample delivery group, whichever is greater." Field duplicate blood samples were not collected to avoid unnecessary burden to study participants. Following review of internal quality control/quality assurance records from Quest Diagnostics, this deviation is not thought to impact the reliability of the data.

4.5.2 Environmental Samples

Field duplicates were collected for three dust samples as described in the QAPP. However, to obtain sufficient sample size for one of the residences, the laboratory combined the duplicate and original dust samples. As a result, only two field duplicates were reported for household dust.

In addition, household dust samples were not weighed by the laboratory before or after being sieved. This data gap prevents calculation of lead loading for residences, which is a measure of lead per unit area, as opposed to concentration (mass of lead per mass of dust). Lead loading measurements are useful when evaluating potential exposures in homes with very high dust mass per unit area. This is because reasonable assumptions regarding dust ingestion are often violated in these situations. The majority of homes in this study did not appear to have dust loadings high enough to necessitate alternate lead measurements; however, dust loading will be evaluated in the fall sampling event.

Field blanks were not collected for water samples because no sampling equipment was used that could potentially contaminate samples.

Paint analysis was not always conducted in triplicate (e.g., three of four walls) in each room tested. When the house was less than 10 years old, there was decreased likelihood that lead-based paint would be detected. In this case, only one or two walls were tested for each room evaluated. This deviation is not expected to impact the reliability of lead paint testing as leaded paint is not expected to be present in homes built after 1978. In addition, XRF readings were collected for 10 nominal seconds[4] instead of 30 nominal seconds. A reduced measurement time is not expected to impact the quality of the data obtained for lead-in-paint analysis because readings were found to stabilize in fewer than 10 nominal seconds.

[4] Nominal seconds are true clock seconds that are slowed down to compensate for electronic "dead time" that occurs when the XRF instrument is taking a measurement.

4.5.3 Exposure Questionnaire

In some cases, question 10 of the exposure questionnaire ("what is the highest grade of school that you finished") was not asked. In these instances, the interviewer determined that the question may be too personal for the respondents or the respondents indicated that they did not want to answer certain types of questions.

5 RESULTS

This section provides an overview of the results for the initial phase of this study. A brief description of the study population is presented, followed by a discussion of data validation, an overview of the samples that were collected, and basic summary statistics (e.g., average, median, and maximum values). Data analysis and interpretation is presented in Section 6.

5.1 DESCRIPTION OF STUDY POPULATION

An overview of study participation is provided in Table 5-1. Of the 98 households determined to be eligible for the study, for which year-round residency in Rico was required, 14 (14 percent) were unable to be contacted, 11 (11 percent) declined participation in the study, and 7 (7 percent) were scheduled to participate, but subsequently canceled. Overall, 66 (67 percent) of the eligible parcels/households participated in the study. The number of participants from each household ranged from 1 to 5, and averaged 2.1.

The total number of study participants, grouped by age and gender, are provided in Tables 5-2 and 5-3. Adults, over 18 years in age, comprised 77 percent of the study population. Participation of males and females was approximately equal. Of the 138 individuals residing in participating households, 118 provided blood samples.

5.2 DATA VALIDATION

Data generated in the field and at the laboratories were verified and validated according to criteria and procedures described in the project QAPP (Integral 2006c). The resulting Data Quality Summary is provided as Appendix A.

Quality assurance of data was performed using USEPA (2002) guidelines for inorganic data, but in the context of data quality objectives specified in the QAPP. Data qualifiers defined in USEPA (2002) guidelines were applied to the project data.

The following laboratory deliverables were reviewed during data validation:

- The case narratives discussing analytical problems (if any) and laboratory procedures
- Chain-of-custody documentation
- Method blank results to assess laboratory contamination
- Results for laboratory duplicate analyses to assess analytical precision
- Results for matrix spike and laboratory control samples to assess accuracy
- Analytical results for analyses performed.

Data qualifiers were assigned during data validation if applicable control limits were not met, in accordance with the USEPA data validation guidelines (USEPA 2002) and the quality control requirements included in the analytical methods (Integral 2006c).

Data qualified as estimated was used for all intended purposes and has been appropriately qualified in the project database. Any data limitation of data qualified as estimated has been included in the quality assurance report. No data were rejected.

5.3 OVERVIEW OF SAMPLES COLLECTED

Blood samples were collected from 118 individuals. Of these samples, 26 could not be analyzed for hemoglobin, 24 could not be analyzed for hematocrit, 7 could not be analyzed for ZPP and 1 could not be analyzed for lead (BL) due to small sample sizes or exceedances of hold time.

Lead was sampled in environmental media, including soil, house dust, paint, and water. Environmental media samples were collected from 63 of the 66 households included in the study. The number of samples obtained for individual media varied slightly, depending on the conditions of the residence (i.e. whether the interior/exterior surfaces were painted, the presence of adequate amount of dust for collection) and collection of samples by residents (i.e., whether first-draw samples were collected by residents). Up to four types of water samples were obtained from each residence (filtered and unfiltered purged samples; filtered and unfiltered first-draw samples). Unfiltered, purged and unfiltered, first-draw water was sampled at most residences (61 and 57 respectively). In addition, some residences also had a filtered water tap. Filtered, purged and filtered, first-draw samples were collected at 18 and 15 residences, respectively.

Questionnaire results were gathered from all 66 households participating in the study.

5.4 SUMMARY STATISTICS

This section presents summary statistics, including samples sizes, frequency of detection, means, ranges, and standard deviations, for the biological and environmental samples collected in this study. It also presents information on the distributions of the datasets. Table 5-4 provides a summary of the summary and distributional statistics employed in this section and in Section 5.5. This information was used in Section 6 to conduct more detailed statistical analyses to determine potential sources of lead exposure.

5.4.1 Individual Blood Data

Summary statistics for individual blood data are presented in Table 5-5. The frequency of detection (FOD) for hematocrit, hemoglobin, and ZPP was 100 percent. Detectable levels of lead were present in 74 percent of the samples.

Blood lead levels ranged from <1.4 to 26 μg/dL, with a geometric mean of 1.8 μg/dL for all groups combined. All blood lead results are presented in Appendix A. Tables 5-6 and 5-7 present blood lead data by age group and gender. Geometric mean blood lead levels were highest for the 0 to 6 year age group (3.0 μg/dL), as compared to older children (1.4 μg/dL) and adults (1.7 μg/dL), though the maximum individual level was collected from an adult male. Geometric mean blood lead concentrations were also higher in males (0.86 μg/dL), as compared to females (0.39 μg/dL).

Two children in the 0 to 6 year age group, who provided heel prick samples, exhibited blood lead levels higher than 10 μg/dL, the CDC and CDPHE risk-management level. Children with blood lead levels exceeding the risk-management level of 10 μg/dL were referred to the CDPHE's Lead Poisoning Prevention Program and were retested by their personal physician. The CDC recommends that children exhibiting elevated blood lead levels from a heel prick, or capillary, sample should be retested with collection of a venous blood sample because capillary samples are more easily influenced by environmental contamination (i.e., dirt or dust on child's foot). For both children, results of the retests collected via venipunture were below the risk-management level of 10 μg/dL.

The highest blood lead level observed (26 μg/dL) was measured in an adult man who was likely in contact with lead-containing materials while working. This is the only blood lead level exceeding the CDC's and CDPHE's risk-management level of 25 μg/dL for adults. Lead concentrations in house dust and drinking water were not measured in this participant's home; however, lead levels in soil are below current remediation action levels.

5.4.2 Household Data

Environmental samples and questionnaire results were assessed for individual households enrolled in the study. Table 5-8 shows summary statistics for environmental samples. Lead was found at detectable levels in all soil and house dust samples. The FOD for lead in water samples ranged from 88 to 100 percent. Overall, 2.6 percent (4 of 151) of all the water samples collected throughout this study were above the EPA's drinking water standard of 15 μg/L.[5]

Table 5-9 provides results for the assessment of lead in exterior and interior paint. Five of 62 houses assessed had positive results for lead in exterior paint, and 8 of 61 residences assessed had positive results for lead in interior paint. With the exception of one exterior

5 Of these samples, two were collected from faucets used as a drinking water sources. The plumbing for one of these faucets had been recently installed and solder had not yet been purged from the system. The other was from a home whose plumbing was less than two years old. The other two samples exceeding the drinking water standard were not from the city's drinking water system but were either spring water or rainwater.

paint sample, lead was not present in surficial paint. The remainder of surfaces either had no lead detected or had unpainted surfaces in which the presence of lead would not be expected.

Summary statistics for selected questionnaire results are presented in Table 5-10. A number of questions were asked regarding occupation, behavior and activity patterns as part of the survey. However, only a subset of questionnaire items was determined to have the potential to demonstrate trends with the blood lead data. For example, while potential exposures to lead batteries or leaded ceramics were investigated, so few residents had potential for this type of exposure that it was not considered as part of the statistical analysis. However, for all residents with blood lead levels above the CDC's level of concern, all questionnaire responses were reviewed and considered.

Three types of questionnaire responses were retained for inclusion in the statistical analysis. Residents were asked about their recreational habits, specifically in regards to activities occurring in areas with relatively high soil lead concentrations. Residents were asked how often they recreated along the Dolores River Corridor and around the mine site up the Silver Creek Canyon roads and trails. Recreational habits were examined separately by season, to investigate changes due to the presence or absence of snow-cover.

The number of indoor/outdoor dogs owned at a given residence was also retained, as dogs moving from the yard into the home have the potential to track a significant amount of yard soil into the home. Remediation history at the residence was considered (e.g., whether or not the yard soil had been replaced), as was age of the house (as an indicator of potential for lead-based paint).

Recreation along both the Dolores River Corridor and around the abandoned mine area up Silver Creek Canyon was more prevalent in the summer season as compared to the winter season (Table 5-10). Fifty percent and 44 percent of households responded positively to recreating at these two sites two or more times per week during the summer season (Dolores River Corridor and abandoned mine area, respectively). The age of houses ranged from 1 to 123 years, and the number of dogs per household ranged between 0 and 4, with 41 of the 66 households having one or more dogs.

5.5 EVALUATION OF DISTRIBUTIONS

The distribution of data was evaluated for blood lead, environmental media, and age. Distribution evaluation is necessary to determine the type of statistical analysis required. If data are normally distributed, certain characteristics of the data set can be accurately estimated based on indicators such as mean and standard deviation. If data are lognormally distributed, a log-transformation can be employed, and the data can be treated as if they were normal. If a data set is not normally distributed and cannot be

transformed to fit a normal distribution, nonparametric statistical methods are required, which make fewer assumptions about the inherent spread of the data.

Figures 5-1a through 5-1f show normality plots for log-transformed data. Evaluations of distributions for blood data are based on datapoints from each individual, whereas the evaluation of distributions for environmental media samples is based on datapoints for each household. These figures show the expected distribution based on a lognormal transformation as compared to the actual distributions found. The closer the data points fall to the central line, the more the data conforms to a lognormal distribution. Table 5-11 contains results from statistical tests for normality (Shapiro-Wilk's W test and Chi Square test). For these tests, *p* values less than 0.05 indicates that the null hypothesis, that there is no difference between the actual distribution of the data and a normal distribution, can be rejected. Therefore, *p* values below 0.05 indicate a poor fit. As shown in these tables, log-transformed data distributed higher p-values than did transformed data.

Data for all of the blood analytes (ZPP, hematocrit, hemoglobin, and lead), lead in yard soil, and lead in water samples exhibited tendencies towards lognormal distributions. Lead in house dust conformed more closely to a normal distribution compared to a lognormal distribution, however for this analysis data for lead in house dust was transformed so that it could more adequately be included in the statistical analysis and models along with other transformed data. Blood lead and environmental media data were transformed to the natural logarithm for further statistical analysis.

6 STATISTICAL ANALYSIS

This section presents the analysis of results obtained from the May 2006 sampling event. Specifically, examinations of association between blood lead levels and environmental media and questionnaire results are presented. For all analyses, samples with lead concentrations below the detection limit (DL) were assumed to contain concentrations at half of the DL (USEPA 1989).

As discussed previously, two children and one adult had blood lead levels exceeding CDC and CDPHE risk-management levels. All three individuals were referred to the CDPHE's Lead Poisoning Prevention Program. The adult with elevated blood lead did not elect to obtain an additional blood lead analysis prior to the fall blood study sampling event. Additional blood samples were collected from the two children by their personal physicians approximately one month after the initial capillary samples were collected by Integral during the May field event. Though the results of the retest for these children were below 10 μg/dL, the retest results are greater than the median blood lead level for the 0 to 6 year age group. Since the retest values were not collected as part of this study, they were not included in the statistical analyses summarized in this report. However, all statistical analyses were run both with and without the three elevated blood lead results included, in order to observe any impact that these outlying values may have had on the analyses.

Table 6-1 provides a summary of all statistical analyses performed to provide the results presented throughout this section.

6.1 BLOOD LEAD

The relationship between age and blood lead was analyzed. Across groups defined by age (0–6, 7–18, and > 18 years), there was a significant difference in log-transformed levels of blood lead, indicating that young children had significantly higher blood lead levels than older children and adults (analysis of variance (ANOVA), n=117, p=0.01; Figure 6-1a). Behavior patterns, such as hand to mouth activity and time spent on low lying surfaces, differ between young children and older children and adults. Specific media and lifestyle factors that are predictive of blood lead are thereby likely to differ by age.

The relationship between gender and blood lead was also significant. Log-transformed blood lead levels were significantly higher in males, as compared to females (independent t-test; n= 117, p<0.01) (Figure 6-1b). Differences in behavior and environments, including occupational differences (e.g., frequency of work in construction which could result in more exposure to soil), represent potential differences in exposure between males and females.

The relationship between ZPP and blood lead was also analyzed. ZPP concentrations, a precursor of heme, increase in the presence of lead and have been found to be significantly correlated with elevated blood lead levels (Froom et al. 1998; Soldin et al. 2003; Suga et al. 1981). However, blood lead is not the only potential influence on ZPP concentrations. Other factors, such as pre-existing blood-related illnesses, can impact ZPP levels. Further, the relationship between blood lead and ZPP generally is weak at lower blood lead levels (less than 40 µg/dL) and would not be reliable for prediction of blood lead levels in individuals (Cárdenas-Bustamante et al. 2001; Froom et al. 1998). In the current study no association between blood lead and ZPP levels was observed. A simple linear regression between log-transformed ZPP and blood lead did not show a significant relationship between the parameters (n=111; p=0.70).

6.2 YARD SOIL AND HOUSE DUST

The relationship between the log-transformed concentrations of lead in yard soil and house dust was examined. Overall, lead concentrations were lower in house dust than in yard soil. However, lead levels in yard soil were significantly correlated with corresponding concentrations in house dust (n=53; r^2=0.33; p<0.01; Figure 6-2). This significant correlation suggests that yard soil is a dominant contributor to lead loading in indoor dust.

Yard soil sampling was completed prior to the summer 2005 soil remediation activities, whereas sampling for house dust took place close to a year after the remediation efforts, in May 2006. Twelve of the 66 residences underwent yard soil remediation during these activities. Therefore, for these 12 residences, the soil sampling results presented in this report represent pre-remediation levels, while lead concentrations in household dust are post-remediation. In homes with remediated yards, the current lead levels in soil are necessarily much lower than they were prior to soil removal. Therefore, the potential for remediation to impact the observed relationship between lead in yard soil and house dust in this dataset was examined by evaluating the correlation with the remediated residences excluded. Excluding these residences slightly improved the correlation (n=41; r^2=0.38; p<0.01), and with this exclusion, lead concentrations in yard soil were found to predict 35 percent of the variability in lead concentrations in house dust.

Lead levels in soil from the 12 residences that were later remediated were compared to lead levels in soil from the non-remediated residences. Since yards with lead concentrations greater than 1,200 mg/kg were targeted for remediation, the former group clearly had higher concentrations than the latter. This was confirmed by independent t-test results (n=55; p<0.01; Figure 6-3a). The relationship between yard remediation and lead concentrations in house dust was similarly evaluated, but was not found to be statistically significant (independent t-test; n=62; p=0.4). Mean lead levels in house dust from remediated residences were higher than mean lead levels in dust from residences

that were not remediated (Figure 6-3b), however this may reflect residual dust tracked or blown into residences prior to remediation.

The strong relationship found between lead concentrations in yard soil and house dust suggests that if house dust had been sampled prior to remediation, lead concentrations in house dust from remediated and non-remediated residences likely would have shown the same pattern as yard soil (i.e., significantly higher concentrations of lead would have been present in the house dust of residences to be remediated). During this sampling event, lead concentrations in house dust were still higher in remediated residences than non-remediated residences, but this difference was not significant. This suggests that as more time passes, lead concentrations in house dust from homes with previously remediated yards will continue to decrease.

6.3 WATER SAMPLES

The relationships between lead levels in the four different types of water samples (unfiltered, purged; unfiltered, first-draw; filtered, purged; and filtered, first-draw) were examined. Log-transformed lead concentrations in purged and first-draw water samples demonstrated a statistically significant relationship for both filtered and unfiltered samples (filtered purged vs. first-draw: n=14; r^2=0.65; p=0.01; unfiltered purged vs. first-draw: n=56; r^2=0.29; p=0.03). The clear demonstration of this expected relationship between lead levels in purged and first-draw water samples taken from the same house demonstrates the ability of the analytical data to show correlations within this data set, even at the low concentrations of lead found in water samples. However, a similar relationship was not observed between log-transformed lead concentrations in filtered and unfiltered samples from the same household (purged: n=17; p=0.08; first-draw: n=14; p=0.52). This lack of association may be due to small sample sizes, given that only 29 percent (17 out of 63) residences had filtered systems that could be included in this analysis.

In order to evaluate whether purging and filtering water had a significant effect in reducing lead concentrations in water, the relationship between log-transformed lead concentrations in purged and first-draw water samples was also analyzed. Lead concentrations in purged water samples were significantly lower than in first-draw samples from the same household (t-test for dependent samples, filtered: n=14; p=0.01; unfiltered: n=56; p<0.01; Figures 6-4a and 6-4b). The difference in purged versus first-draw samples suggests that running water from the pipes significantly reduces levels of lead in water. Similarly, log-transformed lead concentrations in filtered water samples were significantly lower than in unfiltered samples from the same household (t-test for dependent samples; first-draw: n=14, p<0.01; purged: n=17, p<0.01; Figures 6-4c and 6-4d). This result suggests that filtration systems are effective in reducing concentrations of lead in water.

As described in Section 5.4.2, just 2.6 percent (4 of 151) of all the water samples collected throughout this study were above the EPA's drinking water standard of 15 μg/L, and of those 4, only one sample was collected from a current drinking water source. Lead level reductions due to purging and filtering were minimal. Overall, water is not considered a significant pathway for lead exposure to Rico residents.

6.4 CORRELATIONS AND REGRESSIONS

A systematic approach was employed to evaluate the relationship between blood lead levels and environmental and questionnaire results. The relationship between blood lead levels and lead concentrations in individual media were first examined separately. Full models were then developed to include all potential sources and confounders in order to understand all potential predictors and interactions.

6.4.1 Media Specific Associations with Blood Lead Levels

The relationship between blood lead and lead concentrations in individual media, including yard soil, house dust, water, and paint were analyzed. Models for the initial evaluation of these parameters did not consider potential confounding, such as including more than one participant per household or age, and gender, but were conducted to provide a baseline for further analysis.

No significant relationship between blood lead and concentrations of lead in yard soil was found. A simple regression of log-transformed blood lead and lead in yard soil (n=102) resulted in the following equation: $y = -0.034x + 0.80$, but this relationship was not significant (p=0.63). When the three outlying blood lead levels (i.e., those equal to or exceeding the level of concern set by EPA and the CDC) were excluded from this analysis, the results were unchanged.

As with yard soil, a significant association between blood lead and concentrations of lead in house dust was not found in this initial, two-factor model (simple logarithmic regression, n=113, p=0.80). When the three outlying blood lead levels (i.e., those equal to or exceeding the level of concern set by EPA and the CDC) were excluded from this analysis, the results were unchanged.

While a relationship between blood lead and lead in yard soil has been observed by others, concentrations of lead in soil and blood lead have also been observed to vary seasonally (USEPA 1995, 1996; Laidlaw et al. 2005; Yiin et al. 2000). The May sampling event in Rico Townsite occurred at a time of year that followed a snow-covered winter. Study participants would have only had potential exposure to yard soil and soil-associated house dust for a short time prior to sampling, following snow melt. However, many residents noted that snow melted earlier than usual this year and residents were able to initiate spring/summer activities prior to the May sampling event. Since the half-life of lead in blood is on the order of 4 to 6 weeks, lead exposure from the previous

summer and fall would not necessarily be evident. The sampling event scheduled for September will allow for further investigation into the associations between soil, house dust, and blood lead, as well as the influence of seasonality on exposure.

The association between blood lead and lead concentrations in drinking water was also not significant. In order to evaluate this relationship, the water sample taken from the source that was most likely to represent the main drinking water source at a given residence was chosen to represent their exposure. In the case that a household had a filtered tap, it is reasonable to assume that this would be their primary source of water. For these residences, lead concentrations from the filtered, purged water sample were compared to levels of blood lead. For households without a filtered system, the concentration of lead in the unfiltered, purged water sample was compared to levels of blood lead. A simple regression of log-transformed blood lead and representative water yielded an insignificant association (n=110, p=0.73). When the three outlying blood lead levels (i.e., those equal to or exceeding the level of concern set by the EPA and the CDC) were excluded from this analysis, the results were unchanged.

The presence of lead-based paint in the exterior of houses was found to be a significant predictor of blood lead at the $\alpha = 0.05$ level. Log-transformed blood lead was significantly higher in individuals residing in houses in which lead was detected in exterior surfaces, as compared to houses in which either no lead was detected in paint or no painted exterior surfaces were present (n=113, p=0.02; Figure 6-5a). However, the validity of this observation is uncertain. Given the number of multiple comparisons made with blood lead, a true significance level of $\alpha = 0.01$ (0.05/5) would be needed to demonstrate significance. In addition, exterior lead was detected in only 5 of 58 houses surveyed, and within these households blood lead data was only available for 11 individuals.

Further, lead was generally detected below several layers of paint. In the absence of chipping or wearing paint, it is unlikely that paint at this depth would constitute a significant exposure for individuals. In light of the small sample size, potential for confounding from other factors not accounted for in this simplified model, and the limited likelihood of exposure to lead in paint buried below layers of non-lead paint, the significant association between blood lead and the presence of lead in exterior paint should be viewed with caution.

The relationship between blood lead and the presence of lead-based paint in the interior of homes was not found to be statistically significant (n=110; p= 0.08). However, blood lead was higher in individuals residing in houses in which lead was detected in paint than those living in homes in which either no lead was detected or no painted interior surfaces were present (Figure 6-5b). As was the case with exterior paint samples, lead was generally detected below several layers of paint. This pathway is thereby not expected to be a likely source of exposure to lead.

For both the interior and exterior paint analyses, the results were unchanged when the three outlying blood lead levels (i.e., those equal to or exceeding the level of concern set by the EPA and the CDC) were excluded.

The relationship between lead in paint and surrounding media was also explored. There was no significant difference in log-transformed concentrations of lead in yard soil in residences in which exterior lead paint was detected and not detected (independent *t*-test; n=53, p=0.34). The association between log-transformed concentrations of lead in house dust and the presence of lead in interior paint was marginally, although not statistically, significant (independent *t*-test; n=61, p=0.07).

6.4.2 Behavior and Activity Associations with Blood Lead Levels

The relationship between blood lead levels and behavior and activity factors, including reported time spent recreating in two areas with relatively high soil lead concentrations, and the number of indoor/outdoor dogs in a household, were analyzed. The initial evaluation of these parameters did not include potential confounders including the household effect, age, and gender, but were conducted to provide a baseline for further analysis.

No significant associations between blood lead and positive responses for time spent recreating along the Dolores River Corridor, or around the Silver Creek Canyon mine site were found. Correlations between log-transformed blood lead and responses for winter and summer recreation activity in the Dolores River Corridor and the mine site were not significant (n=117; Dolores, summer: p=0.42; Mine, summer: p=0.71; Dolores, winter: p=0.66; Mine, winter: p=0.52). It is anticipated that the questionnaire results may not yield a very specific or accurate estimate of the time spent by individuals in these recreation areas. Questionnaires were completed on a household basis, and were not specific to each individual's recreational habits. Additionally, the form of the response (either positive or negative for recreating two or more times per season) did not allow for quantitative relationships to be deciphered.

A significant association between lead concentration in house dust and the number of indoor/outdoor dogs owned per household was not found (n=62, p=0.28). Dogs may transfer lead in outdoor soil to the indoor environment, and thereby influence residents' exposure to lead. The soil type that dogs come in contact with (i.e., compacted/wet or dusty) is expected to vary with the time of year (i.e., snow-covered or not). The May sampling event in Rico Townsite occurred at a time of year that followed a snow-covered winter. Subsequent planned sampling events will allow for further investigations into the influence of seasonality on associations between dog ownership, indoor dust concentrations, and blood lead.

A significant association was found between occupational history and blood lead level. Study participants who reported outdoor occupations, such as construction or landscaping, had significantly higher blood lead levels than those who did not (independent *t*-test; n = 95; $p < 0.01$). Gender was also significantly related to occupational history; participants reporting outdoor occupations were significantly more likely to be male than female (independent *t*-test; n = 95; $p < 0.01$).

6.4.3 Overall Associations

Results from the individual assessments of associations between blood lead and 1) age and gender, 2) environmental media, and 3) activity and behavior factors, were considered collectively in order to determine major predictors of blood lead. In addition to the individual factors discussed thus far, the effect of household was considered in the development of models to predict levels of blood lead.

This full model, which is a multiple regression, provides more power than the partial models described above. Multiple regression is an attempt to consider the simultaneous influence of several variables on the response variable at once. The multivariate model may reveal relationships that are completely hidden in the simple univariate models described above.

As evidenced by Figure 6-1a, blood lead levels in children age 0–6 are greater than blood lead for other age groups. The difference may be due to differences in significant exposure pathways for each age group and thereby warrants separate analysis. Therefore, the final analyses of combined predictors of blood lead were analyzed separately for children 0 to 6 years of age and older children and adults. For each of the defined age groups, a backwards multiple regression was conducted, including log-transformed blood lead; log-transformed concentrations of lead in yard soil, house dust, and water; the presence of lead based paint in interior and exterior surfaces; and gender. Occupational history was not included in this model, as the relationship between gender and occupation is so strong that it would likely confound the results. However, the influence of gender on results for the adult population should be viewed, at least in part, as an indicator of a potential occupational exposure pathway.

For children aged 0–6, the most predictive model for blood lead included gender, concentrations of lead in house dust, and the presence of exterior paint. The model was marginally significant[6] (n=15; p=0.07) and explained 32 percent of the observed variability in blood lead. The most significant factor in the model was house dust (partial p= 0.05). The results of this model suggest that for most of the children, house dust was the driving source of exposure, but that for a few children, exterior paint was the most highly correlated factor. The influence of exterior paint on these children's exposure

[6] Marginal significance for this study is defined as $0.05 \leq \alpha \leq 0.10$.

confounded, and therefore obscured, the association between blood lead and house dust that existed for the majority of the children.

For older children and adults (age 7+), gender was determined to be the only significant predictor of blood lead. The best fit model explained 14 percent of the observed variability in blood lead (n=82, $p<0.01$).

7 SUMMARY OF FINDINGS

The following section summarizes the analysis of data collected during the Phase I blood lead and environmental sampling event conducted in Rico, Colorado in May 2006. These data were collected to support the Blood Lead and Environmental Monitoring Study for the Rico Townsite Work Plan.

The objectives of this study include:

1. Further characterize current blood lead levels for Rico and collect appropriate environmental samples to identify factors influencing exposures; and
2. Understand seasonal fluctuations in blood lead levels in order to characterize the potential contribution of the soil contact exposure pathway to blood lead levels.

7.1 BLOOD LEAD RESULTS

Blood lead levels were measured for 117 individuals. Blood lead ranged from below the limit of detection of 1.4 μg/dL to 26 μg/dL, with a median concentration of 1.9 μg/dL.

- A total of 16 children aged 0 to 6 years participated in this study. Blood lead levels in this population ranged from below the limit of detection of 1.4 μg/dL to 17 μg/dL, with a median value of 2.6 μg/dL and a geometric mean of 3.0 μg/dL.
- Among older children and adults (7 years of age and older), blood lead levels ranged from below the limit of detection of 1.4 μg/dL to 26 μg/dL. The geometric mean blood lead level for older children was 1.4 μg/dL, while the value for adults was 1.7 μg/dL.
- Of the 16 children aged 0 to 6 years, two exhibited blood lead levels higher than the CDC's and CDPHE's risk management level of 10 μg/dL for children. These children were referred to the CDPHE's Lead Poisoning Prevention Program and were retested by their personal physician. For both children, results of the second samples, collected via venipuncture, were below the risk-management level of 10 μg/dL.
- Among older children and adults (7 years of age and older), the blood lead level of one individual exceeded risk management levels. This individual was an adult male; his blood lead level of 26 μg/dL exceeded the CDC's and CDPHE's risk management level of 25 μg/dL for adults. His blood lead level was likely the result of occupational exposure.

Overall, blood lead levels were found to vary significantly with both age and gender. Blood lead levels were higher in men compared to women, perhaps due to differences in occupational exposures. Blood lead levels were also highest for children aged 0 to 6 years compared to older children and adults. Differences in behavior, including hand-to-mouth activity and time spent on the floor, are probable contributors to this difference.

The contribution of lead in dust, water, paint, and soil to blood lead levels was evaluated using mathematical models. There was no strong association in simple regression models between individual blood lead levels and concentrations of lead in yard soil or house dust. However, the most predictive multiple regression model for blood lead levels in children aged 0–6 included gender, lead concentration in house dust, and the presence of exterior paint. In this model, house dust demonstrated the largest partial association. These results suggest that for most of the children, of the media sampled, house dust was the driving source of exposure, but that for a few children, exterior paint was the most highly correlated factor.

7.2 DUST, SOIL, AND HOUSE DUST RESULTS

Environmental samples were collected at 63 residences. The median concentration of lead in house dust was 485 mg/kg. The median concentration of lead in yard soil was 672 mg/kg, though this includes the 12 homes whose yards were subsequently remediated. The median concentration of lead in drinking water was 0.44 μg/L. This result represents purged water samples collected from the most likely drinking water source.

The statistical analysis of between- and within-media associations also yielded the following results:

- Lead concentrations in filtered water were significantly lower than concentrations of lead in unfiltered water from the same households.
- Lead concentrations in purged water were significantly lower than concentrations of lead in first-draw water sampled from the same households.
- Yard remediation may have resulted in a reduction of lead concentrations not only in yard soil, but in house dust as well. As more time passes, lead concentrations in house dust from homes with previously remediated yards are likely to continue to decrease.

Exposure to yard soil and house-dust is expected to vary between winter and summer seasons; although Rico residents reported that the spring season began earlier than usual this year. Subsequent planned sampling events will allow for further investigations into the associations between blood lead and concentrations of lead in yard soil and house-dust, as well as the effect of seasonality.

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FIGURES

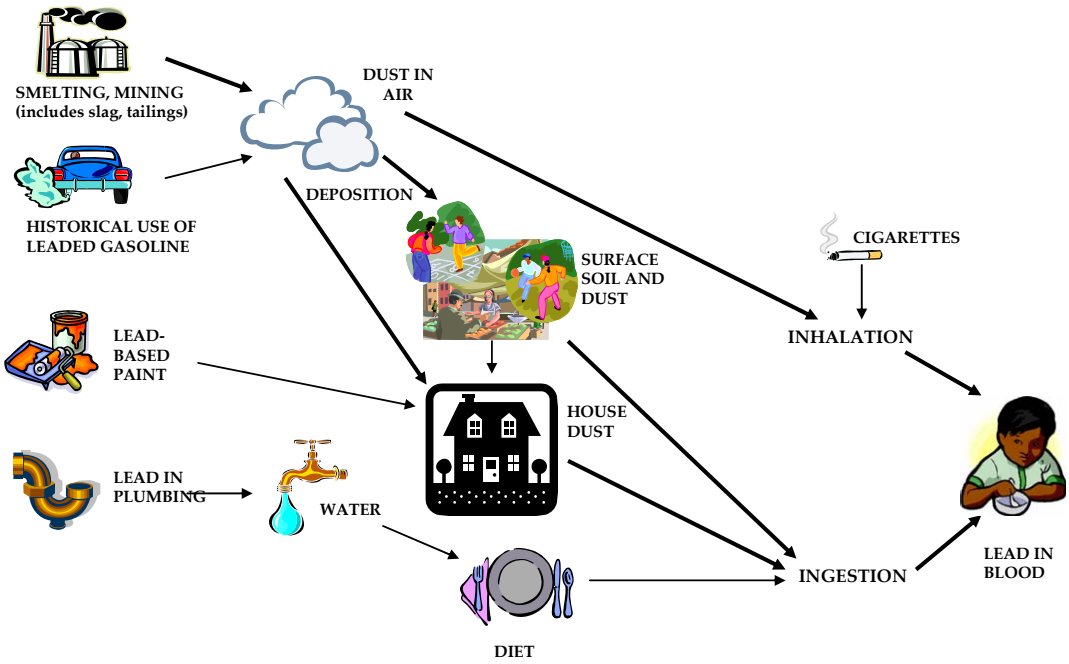

Figure 3-1. Conceptual Site Model

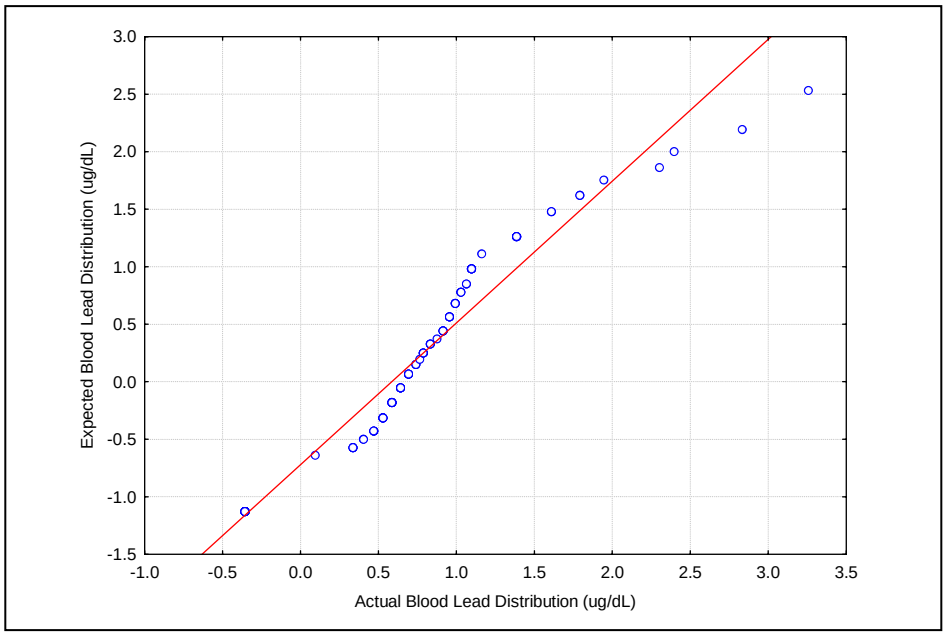

Figure 5-1a. P-plot of Log-transformed Blood Lead Data.

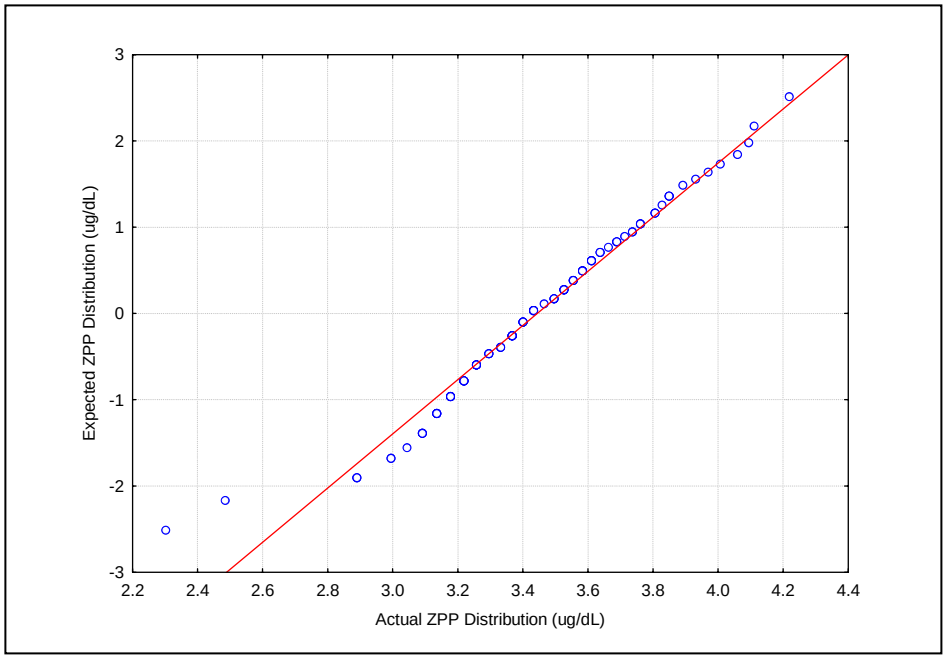

Figure 5-1b. P-plot of Log-transformed ZPP Data.

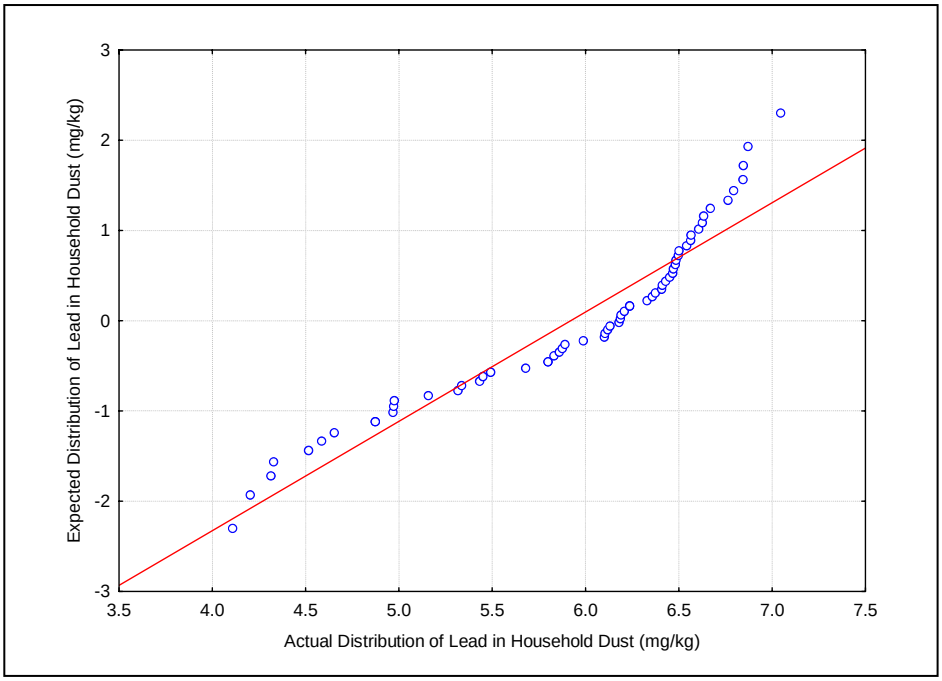

Figure 5-1c. P-plot of Log-transformed Household Dust Data.

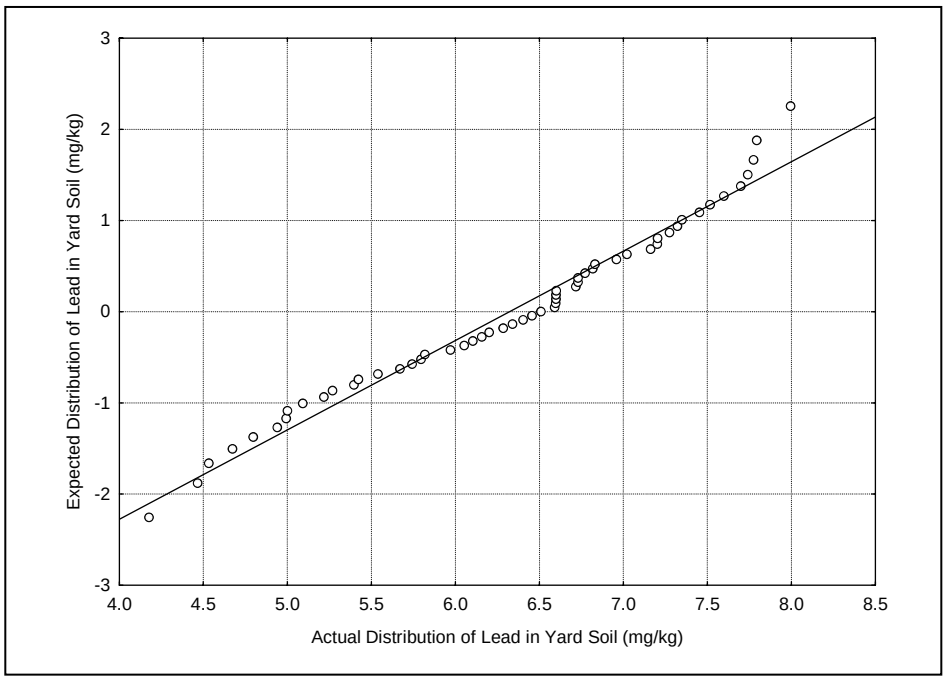

Figure 5-1d. P-plot of Log-transformed Yard Soil Data.

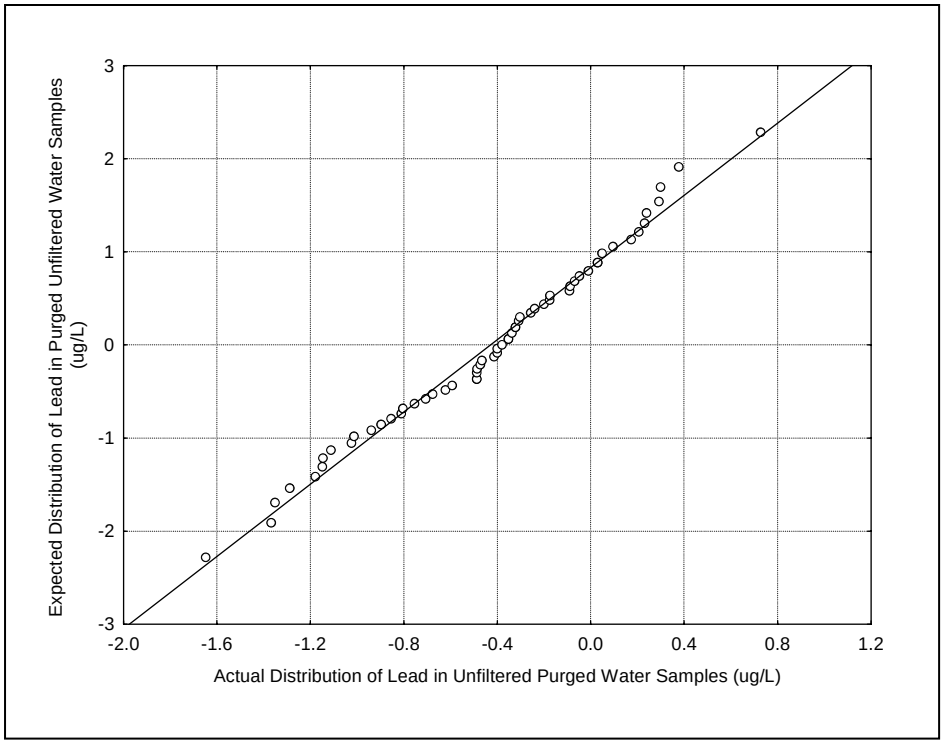

Figure 5-1e. P-plot of Log-transformed Purged Unfiltered Water Samples.

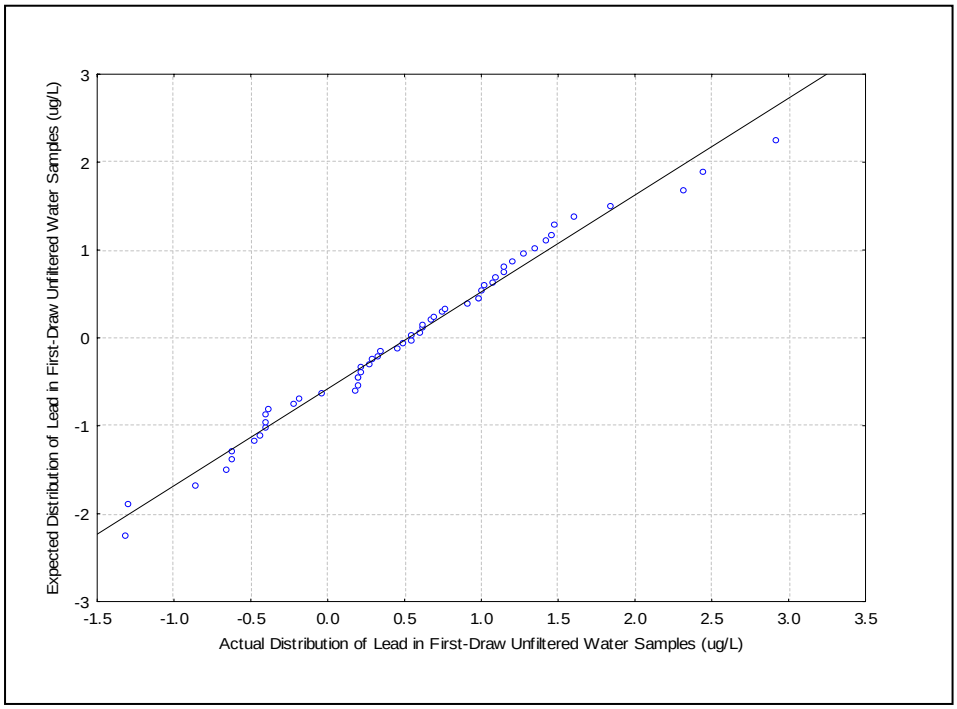

Figure 5-1f. P-plot of Log-transformed First-Draw Unfiltered Water Samples.

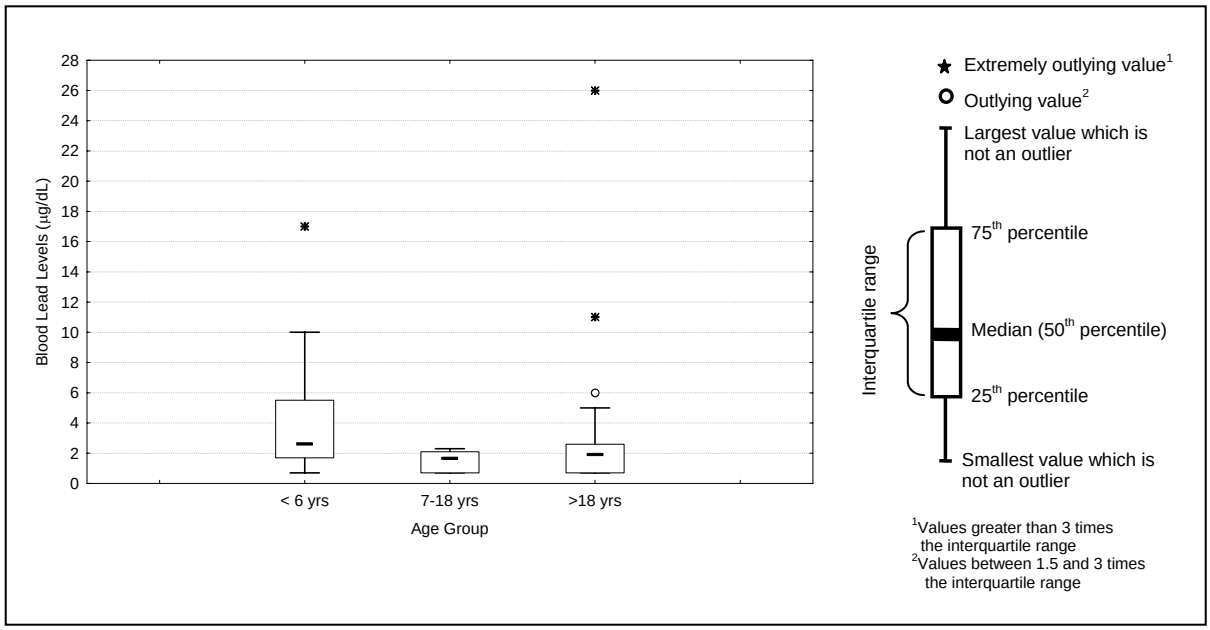

Figure 6-1a. Blood Lead Levels by Age Group.

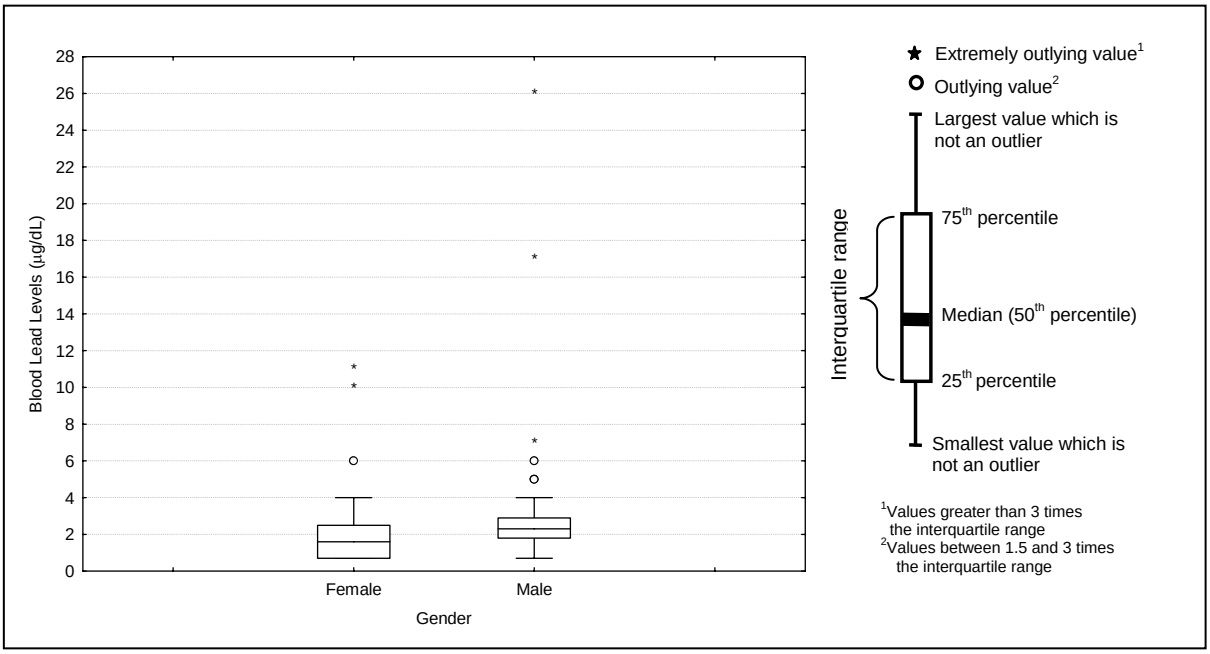

Figure 6-1b. Blood Lead Levels by Gender.

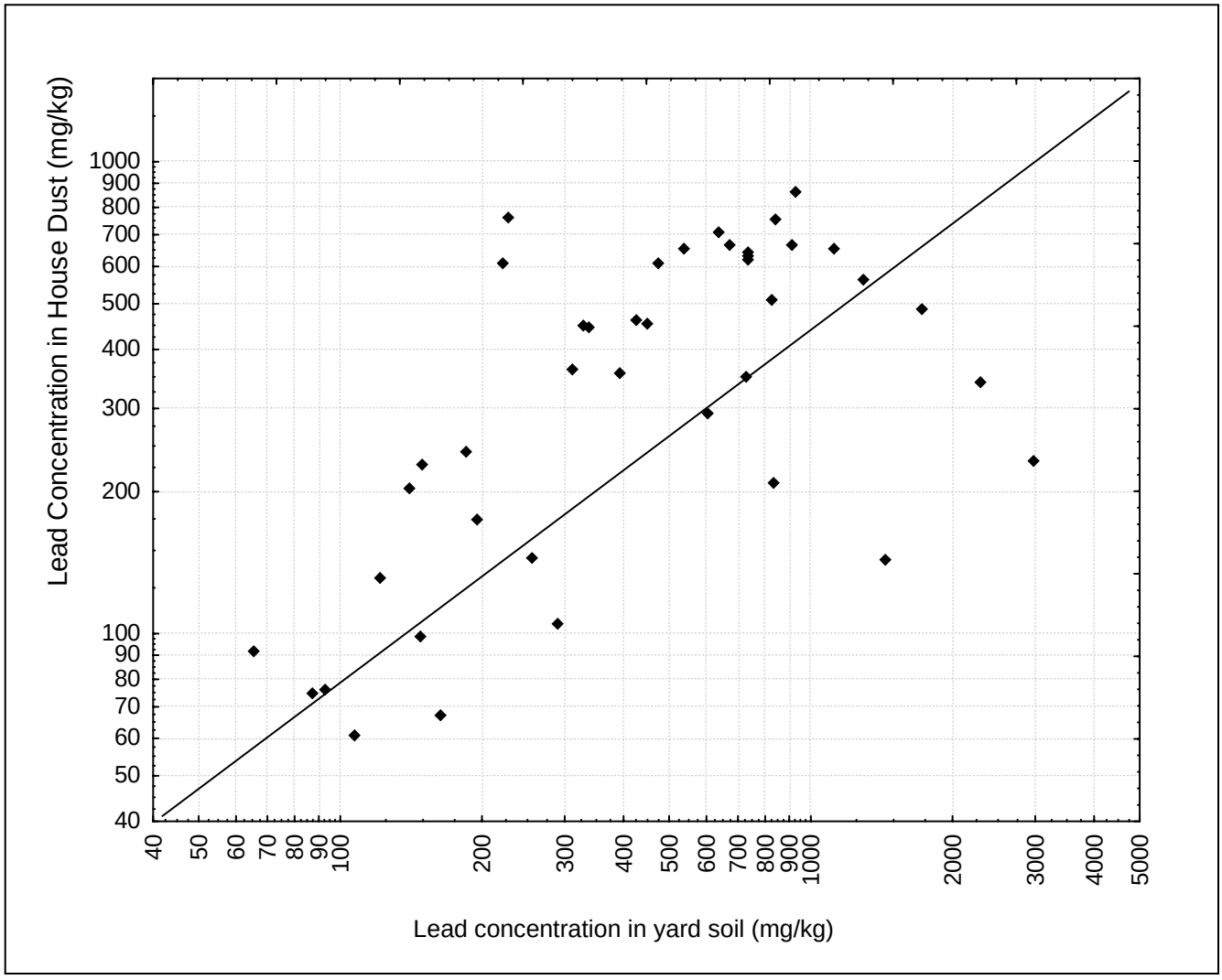

Figure 6-2. Relationship between Yard Soil and Household Dust Lead Concentrations, Excluding Residences that were Subsequently Remediated.

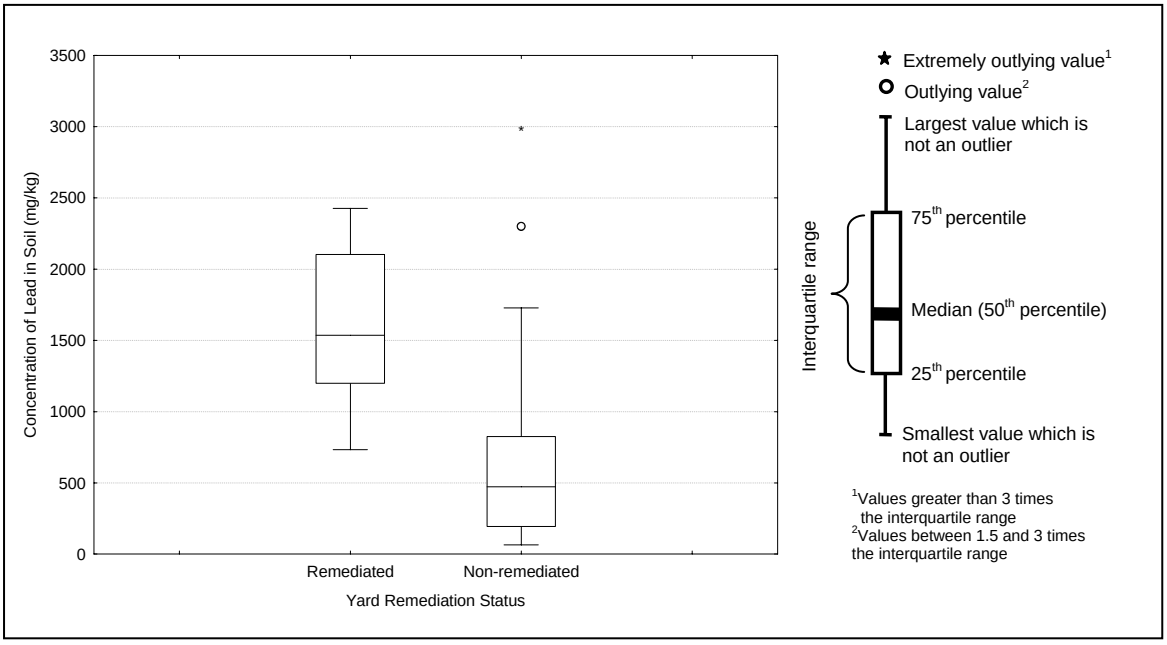

Figure 6-3a. Comparison of Lead Concentrations in Yard Soil in Remediated and Non-Remediated Yards (Prior to Clean-up).

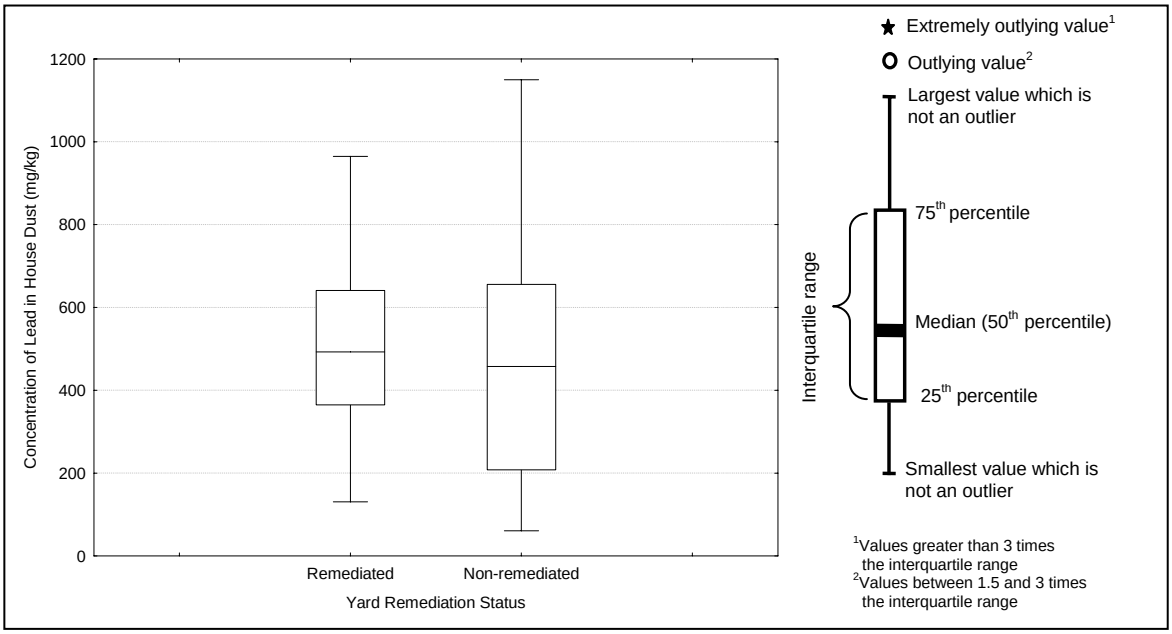

Figure 6-3b. Comparison of Lead Concentrations in House Dust in Residences with Remediated Yards (Following Clean-up) and Non-Remediated Yards.

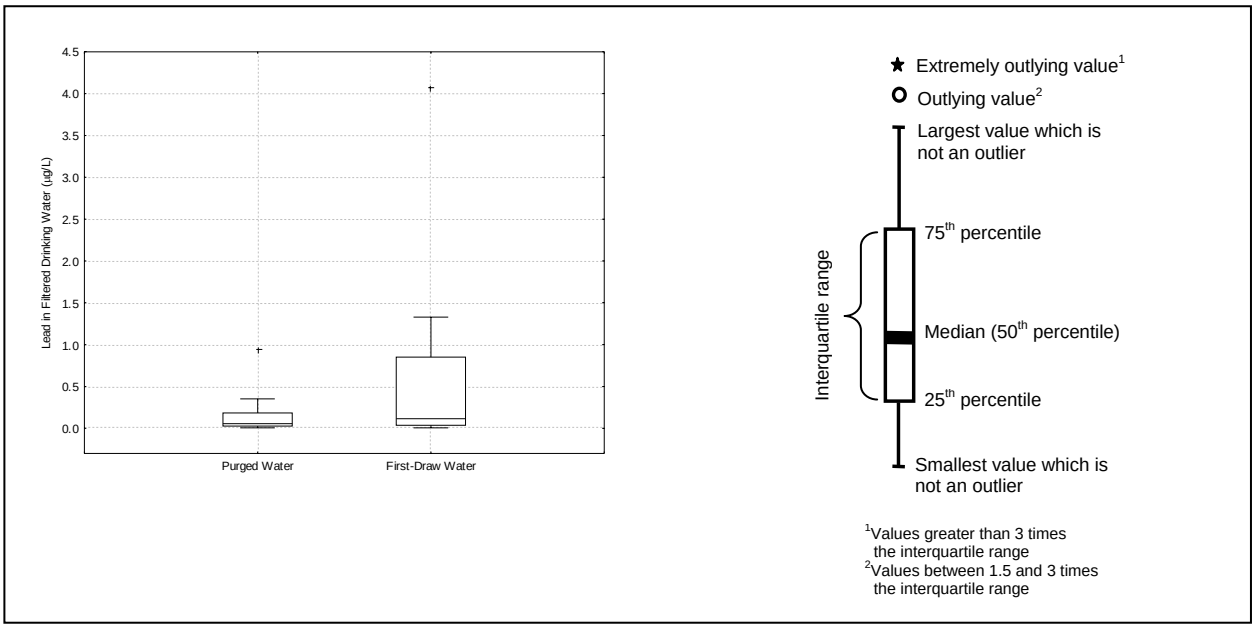

Figure 6-4a. Comparison of Lead Concentrations in Purged and First-Draw Filtered Drinking Water.

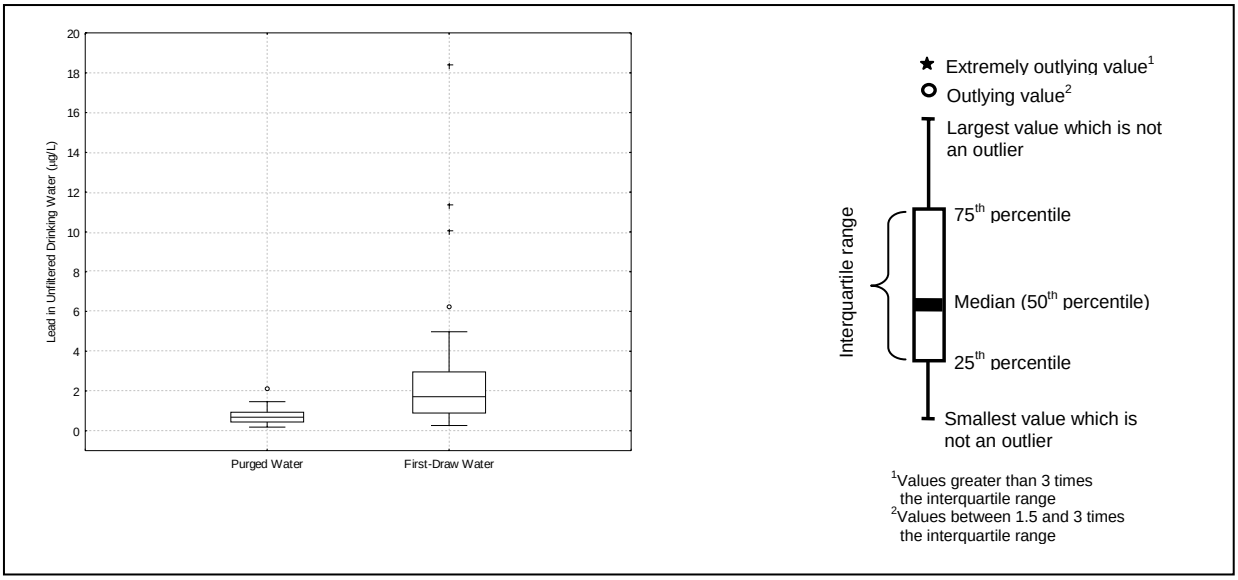

Figure 6-4b. Comparison of Lead Concentrations in Purged and First-Draw Unfiltered Drinking Water.

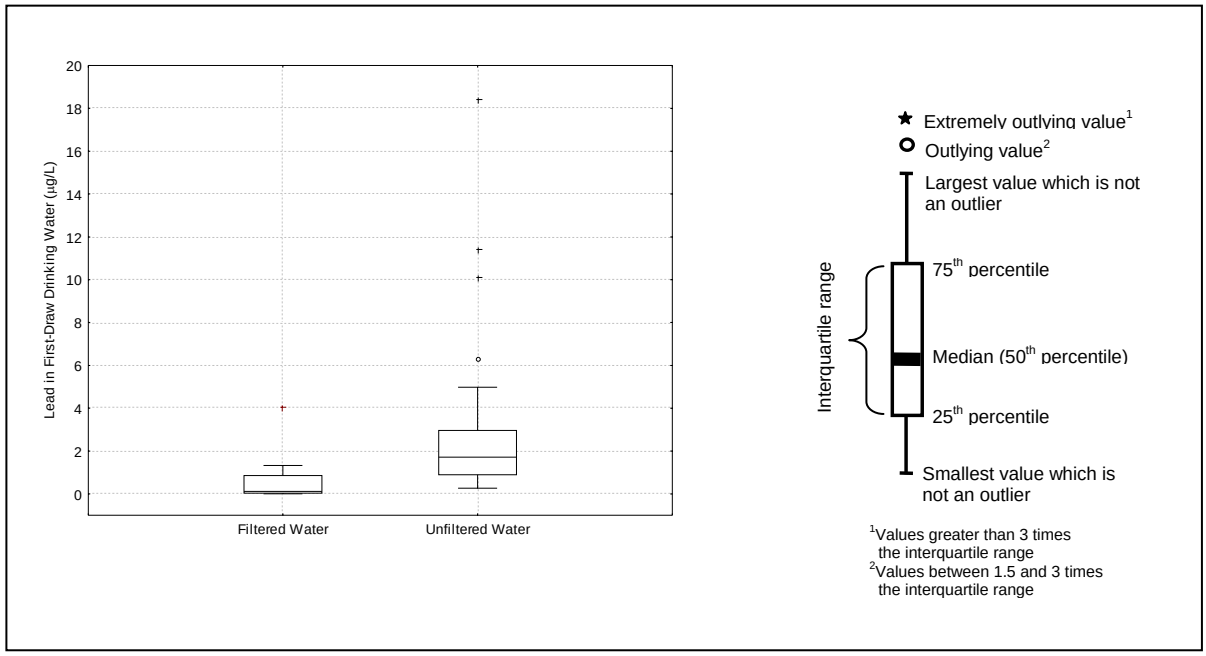

Figure 6-4c. Comparison of Lead Concentrations in Filtered and Unfiltered First-Draw Drinking Water.

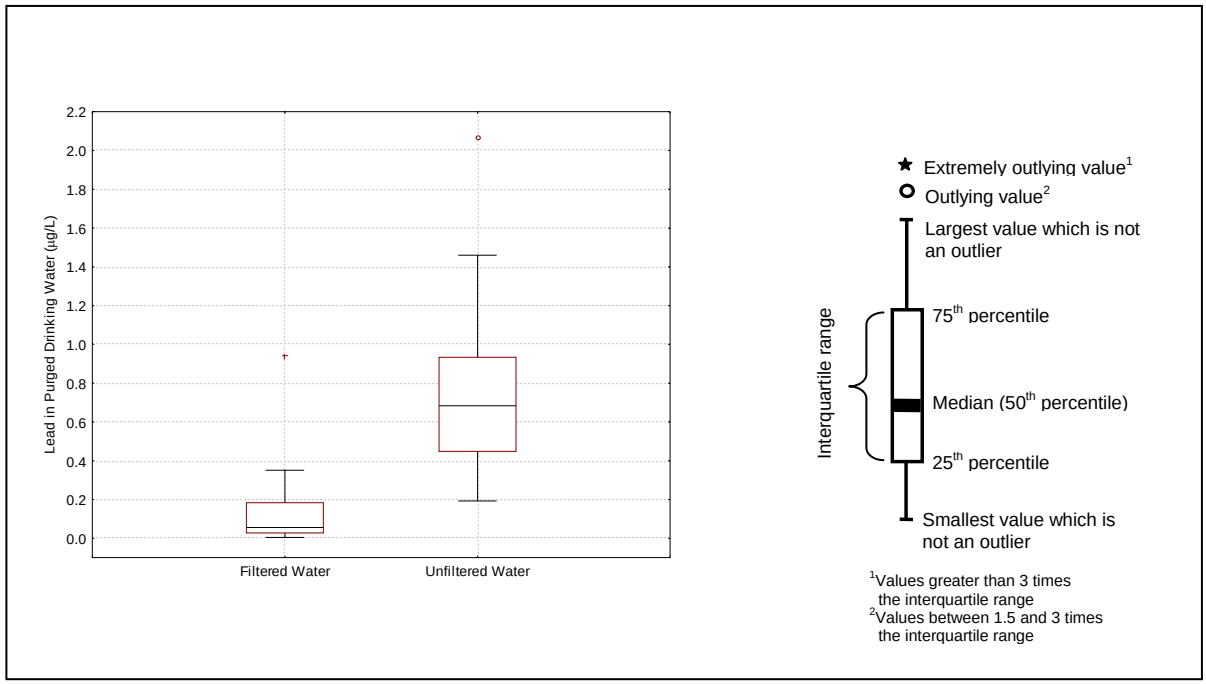

Figure 6-4d. Comparison of Lead Concentrations in Filtered and Unfiltered Purged Drinking Water.

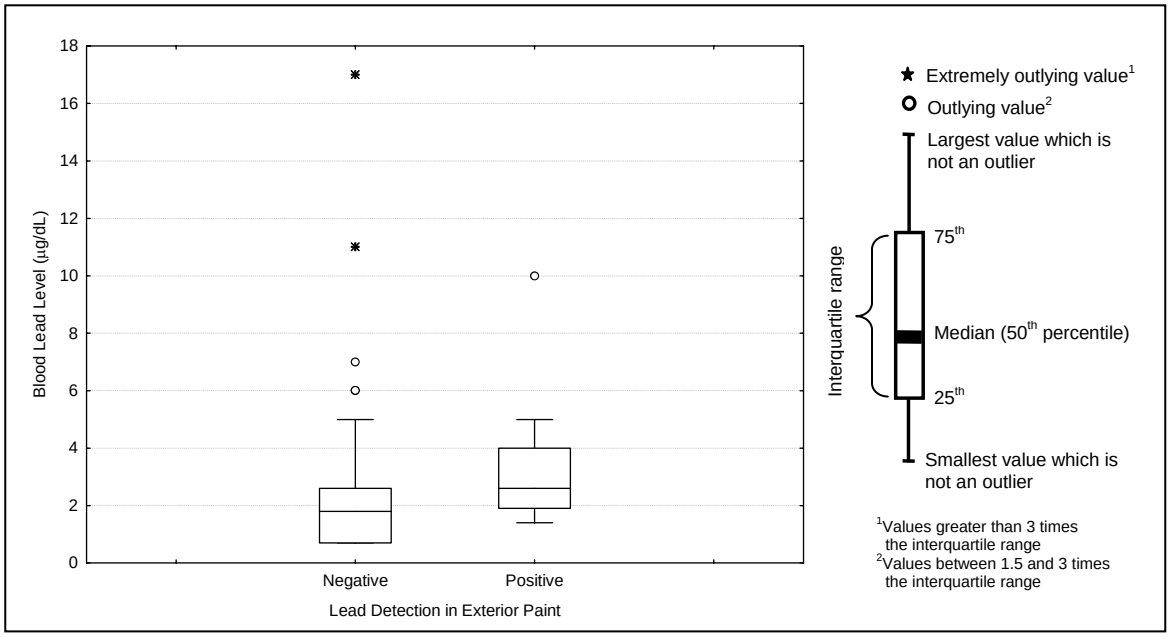

Figure 6-5a. Blood Lead Levels and Presence of Lead in Exterior Paint.

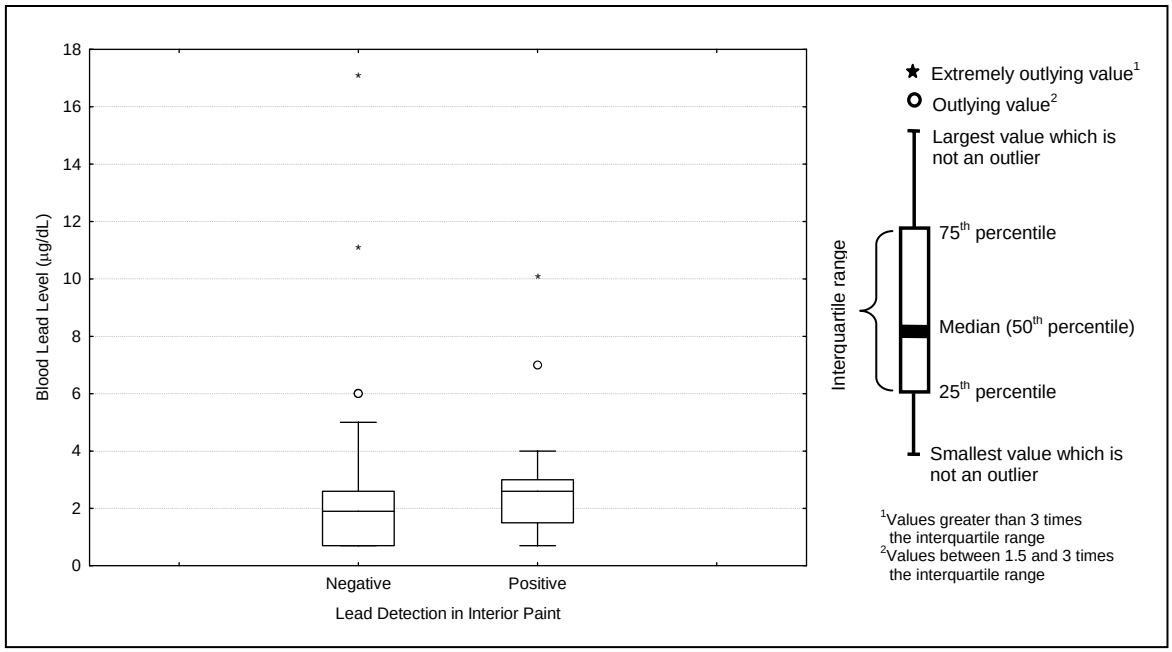

Figure 6-5b. Blood Lead Levels and Presence of Lead in Interior Paint.

TABLES

Table 5-1. Summary of Participating Households.

Household Information	Number
Eligible Households Identified	98
Households Participating [a]	66
Environmental media sampled	63
Only blood drawn	3
Individuals Participating Per Household	
Average	2.1
Minimum	1
Maximum	5

[a] Three of the 66 households participating were renters whose landlords declined consent; environmental media were not sampled at these locations.

Table 5-2. Study Participants by Age.

Age Group (years)[a]	Number of Participants
0–6	17[b]
7–18	6
Adult (>18)	95

[a] Age is age at time of study, defined as May 15, 2006.

[b] A single blood sample taken from this group did not yield enough blood for analysis.

Table 5-3. Study Participants by Gender.

Gender	Number of Participants
Female	64[a]
Male	54

[a] A single blood sample taken from this group did not yield enough blood for analysis.

Table 5-4. Summary of Within-Variable Statistical Evaluations.

Variable	Evaluation	Statistical Test	Section of Text
Age	Descriptive statistics	--	5.1
	Analysis of distribution	Shapiro-Wilk's W test, Chi-square test	5.5
Gender	Descriptive statistics	--	5.1
Blood lead	Descriptive statistics	--	5.4.1
	Analysis of distribution	Shapiro-Wilk's W test, Chi-square test	5.5
ZPP	Descriptive statistics	--	5.4.1
	Analysis of distribution	Shapiro-Wilk's W test, Chi-square test	5.5
Hematocrit	Descriptive statistics	--	5.4.1
	Analysis of distribution	Shapiro-Wilk's W test, Chi-square test	5.5
Hemoglobin	Descriptive statistics	--	5.4.1
	Analysis of distribution	Shapiro-Wilk's W test, Chi-square test	5.5
Lead in soil	Descriptive statistics	--	5.4.2
	Analysis of distribution	Shapiro-Wilk's W test, Chi-square test	5.5
Lead in housedust	Descriptive statistics	--	5.4.2
	Analysis of distribution	Shapiro-Wilk's W test, Chi-square test	5.5
Lead in water	Descriptive statistics	--	5.4.2
	Analysis of distribution	Shapiro-Wilk's W test, Chi-square test	5.5
	Relationship between filtered and unfiltered water (w/in house)	Pearson's correlation	6.3
	Relationship between first-draw and purged water (w/in house)	Pearson's correlation	6.3
	Effect of filtering	dependent *t*-test	6.3
	Effect of purging	dependent *t*-test	6.3
Lead in exterior paint	Descriptive statistics	--	5.4.2
	Analysis of distribution	Shapiro-Wilk's W test, Chi-square test	5.5
Lead in interior paint	Descriptive statistics	--	5.4.2
	Analysis of distribution	Shapiro-Wilk's W test, Chi-square test	5.5
Recreation activity	Descriptive statistics	--	5.4.2
Yards remediated	Descriptive statistics	--	5.4.2
Age of house	Descriptive statistics	--	--
Number of indoor/outdoor dogs	Descriptive statistics	--	5.4.2

Notes:

Recreation activity refers to reported activity for two individual seasons (summer and winter) in two recreation areas (Dolores River Corridor and around the old mine site up to the Silver Creek Canyon roads and trails).

ZPP = erythrocyte zinc protoporphyrin

-- = no test conducted

Table 5-5. Summary Statistics for Blood Data.

Parameter	Units	N	FOD (%)	Mean	Standard Deviation	Geometric Mean	Minimum	Median	Maximum
Blood lead	µg/dL	117[a]	74	2.5	3.1	1.8	<1.4	1.9	26
Hematocrit	%	94	100	46.2	3.86	46.0	35.9	46.1	54.2
Hemoglobin	g/dL	92	100	15.6	1.19	15.6	12.3	15.5	18.3
ZPP	µg/dL	111	100	33	10	31	10	31	68

Notes:
FOD = frequency of detection. All non detects were included as 1/2 the Detection Limit (DL); DL Blood Lead = 1.4 ug/dL.
N = number of samples
ZPP = erythrocyte zinc protoporphyrin

[a]Although 118 samples were collected, insufficient sample size prevented lead analysis in 1 sample.

Table 5-6. Blood Lead Data by Age Group.

Age Group (years)	N	Mean (µg/dL)	Standard Deviation (µg/dL)	Geometric Mean (µg/dL)	Minimum (µg/dL)	Median (µg/dL)	Maximum (µg/dL)
0–6	16	4.3	4.2	3.0	<1.4	2.6	17
7–18	6	1.5	0.70	1.4	<1.4	1.7	2.3
Adult (>18)	95	2.3	2.8	1.7	<1.4	1.9	26
All	117	2.5	3.1	1.8	<1.4	1.9	26

Notes:
N = number of samples

Table 5-7. Blood Lead Data by Gender.

Gender	N	Mean (µg/dL)	Standard Deviation (µg/dL)	Geometric Mean (µg/dL)	Minimum (µg/dL)	Median (µg/dL)	Maximum (µg/dL)
Female	63	2.0	1.9	0.39	<1.4	1.6	11
Male	54	3.2	3.9	0.86	<1.4	2.3	26
All	117	2.5	3.1	1.8	<1.4	1.9	26

Notes:
N = number of samples

Table 5-8. Lead Levels Measured in Environmental Media.

Parameter	Units	N	FOD (%)	Mean	Standard Deviation	Geometric Mean	Minimum	Median	Maximum
Soil	mg/kg	55	100	838	715	557	65.2	672	2970
Household dust	mg/kg	62	100	470	270	373	61.0	485	1150
Purged filtered water	µg/L	17	88	0.144	0.229	0.060	0.005	0.056	0.939
Purged unfiltered water	µg/L	59	100	0.733	0.360	0.651	0.193	0.684	2.07
First-draw filtered water	µg/L	14	93	0.604	1.10	0.140	0.005	0.115	4.08
First-draw unfiltered water	µg/L	56	100	2.54	3.01	1.69	0.268	1.72	18.4

Notes:

FOD = frequency of detection. All non detects were included as ½ the Detection Limit (DL); DL for water samples = 0.009 µg/L.
N = number of samples

Table 5-9. Lead Levels Measured in Exterior and Interior Household Paint.

Parameter	N	Negative[a]	Positive
Exterior paint	62	57	5
Interior paint	61	53	8

Notes:
N = number of samples
[a] Negative results for exterior and interior paint represent houses where no lead was detected and houses with unpainted surfaces.

Table 5-10. Questionnaire Results for Location of Recreation and Yard Remediation.

Parameter	N	Yes[a]	No
Dolores river corridor—summer	66	33	33
Dolores river corridor—winter	66	11	55
Mine site area—summer	66	29	37
Mine site area—winter	66	9	57
Yard remediated	66	12	54

Notes:
All results are counts.
[a] A "Yes" for visits for recreation activities was described as visiting two or more times per defined season.

Table 5-11. Results of Statistical Tests for Normality.

Variable Name	Statistical *p* Values	
	Shapiro-Wilk's W Test	Chi-Square Test
Non-transformed data		
Blood lead	<0.1	<0.1
Hematocrit	0.85	0.83
Hemoglobin	0.52	0.10
ZPP	0.01	<0.1
Lead in purged unfiltered water	<0.01	0.13
Lead in first-draw filtered water	<0.1	---
Lead in first-draw unfiltered water	<0.1	<0.1
Lead in purged filtered water	<0.1	---
Lead in household dust	0.06	0.50
Lead in soil	<0.1	<0.1
Log-transformed data		
Log-transformed blood lead	<0.1	<0.1
Log-transformed hematocrit	0.64	0.98
Log-transformed hemoglobin	0.44	0.10
Log-transformed ZPP	0.04	0.62
Log-transformed lead in purged unfiltered water	0.71	0.60
Log-transformed lead in first-draw filtered water	0.94	---
Log-transformed lead in first-draw unfiltered water	0.71	0.69
Log-transformed lead in purged filtered water	0.93	---
Log-transformed lead in household dust	<0.1	<0.1
Log-transformed lead in soil	0.14	0.34

Notes:

A *p* value less than 0.05 indicates that the null hypothesis, that there is no difference between the actual distribution of the data and a normal distribution, can be rejected. Larger *p* values indicate a closer fit to normality.

Log-transformed values are the natural logarithm of individual data points.

--- Sample size limitations prevented estimation of Chi-square test result.

ZPP = erythrocyte zinc protoporphyrin

Table 6-1. Summary of Between-Variable Statistical Evaluations.

Evaluation Category	Relationship Evaluated	Statistical Test	Section of Text
Within blood	ZPP and blood lead	Simple linear regression	6.1
Blood and demographics	Blood lead and age	ANOVA	6.1
Blood and demographics	Blood lead and gender	Independent *t*-test	6.1
Between environmental media	Lead in yard soil and housedust	Pearson's correlation	6.2
Between environmental media	Presence of lead based paint (exterior) and lead in yard soil	Independent *t*-test	6.4.1
Between environmental media	Presence of lead based paint (interior) and lead in house-dust	Independent *t*-test	6.4.1
Environmental media and other parameters	Yard remediation and lead in housedust	Independent *t*-test	6.2
Environmental media and other parameters	Yard remediation and lead in yard soil	Independent *t*-test	6.2
Environmental media and other parameters	Lead in yard soil and housedust; within unremediated yards	Independent *t*-test	6.4.1
Blood and environmental media	Blood lead and lead in yard soil	Simple linear regression	6.4.1
Blood and environmental media	Blood lead and lead in house-dust	Simple linear regression	6.4.1
Blood and environmental media	Blood lead and lead in water	Simple linear regression	6.4.1
Blood and environmental media	Blood lead and presence of lead based paint (exterior)	Independent *t*-test	6.4.1
Blood and environmental media	Blood lead and presence of lead based paint (interior)	Independent *t*-test	6.4.1
Blood and behavior/activity	Blood lead and recreation activity	Pearson's correlation	6.4.2
Blood and behavior/activity	Lead in housedust and number of indoor/outdoor dogs owned	Pearson's correlation	6.4.2
Blood and behavior/activity	Blood lead levels and occupational history	Independent *t*-test	6.4.2
Other; overall associations	Blood lead and environmental media and gender, age 0–6	Multiple linear regression	6.4.3
Other; overall associations	Blood lead and environmental media and gender, age 7+	Multiple linear regression	6.4.3

Notes:
ANOVA = analysis of variance
ZPP = erythrocyte zinc protoporphyrin

APPENDIX A

DATA QUALITY SUMMARY

BLOOD LEAD AND ENVIRONMENTAL MONITORING STUDY FOR RICO TOWNSITE

Appendix A
Data Quality Summary

Prepared for

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August 31, 2006

CONTENTS

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

CAS	Columbia Analytical Services
DQOs	data quality objectives
MDL	method detection limit
MRL	method reporting limit
QAPP	quality assurance project plan
RPD	relative percent difference
ZPP	erythrocyte zinc protoporphyrin
USEPA	U.S. Environmental Protection Agency

1 INTRODUCTION

This report summarizes the data quality of analyses performed on house dust, drinking water, and blood samples collected during the Blood Lead and Environmental Monitoring Study for the Rico Townsite, located in Rico, Colorado. Samples were collected May 16–27, 2006. A detailed description of the Rico blood lead and environmental monitoring sampling is included in the project work plan (Integral 2006a).

All samples were analyzed for total lead. In addition, house dust samples were analyzed for total solids, and blood samples were analyzed for hemoglobin, hematocrit, and erythrocyte zinc protoporphyrin (ZPP). All samples were analyzed according to the sample preparation and analytical procedures in the project Quality Assurance Project Plan (QAPP) (Integral 2006b).

House dust and drinking water samples were analyzed by Columbia Analytical Services (CAS), Kelso, Washington. Blood samples were analyzed by Quest Diagnostics, Denver, Colorado. All samples were prepared and analyzed by methods detailed in Table 3-1 of the QAPP (Integral 2006b).

2 DATA QUALITY AND USABILITY

Data generated in the field and at the laboratories were verified and validated according to the criteria and procedures described in the project QAPP (Integral 2006b). Data quality and usability were evaluated based on the results of the data validation and the data quality objectives (DQOs) for the Rico data shown in Table 1 of the QAPP (Integral 2006b).

Results reported by the laboratories were 100 percent complete. No results were rejected (assigned an *R* qualifier) during the quality assurance review. Therefore, the completeness after data validation was 100 percent, which exceeded the standard environmental investigation quality assurance completeness goal of 95 percent.

2.1 DATA VALIDATION

Data validation was conducted by Integral Consulting Inc. as described in the project QAPP (Integral 2006b). Data verification and validation was performed using U.S. Environmental Protection Agency (USEPA) data validation guidelines for inorganic data (USEPA 2002a,b), but in the context of data quality objectives specified in the project QAPP (Integral 2006b). Data qualifiers defined in USEPA guidelines were applied to the project data (USEPA 2002a,b).

The following laboratory deliverables were reviewed during data validation:

- Case narratives discussing analytical problems (if any) and laboratory procedures
- Chain-of-custody documentation
- Method blank results to assess laboratory contamination
- Results for laboratory duplicate analyses to assess analytical precision
- Results for matrix spike and laboratory control samples to assess accuracy
- Analytical results for analyses performed.

Data qualifiers were assigned during data validation if applicable control limits were not met, in accordance with USEPA data validation guidelines (USEPA 2002a) and the quality control requirements included in the analytical methods shown in Table 3-1 of the QAPP (Integral 2006b).

2.2 DATA QUALITY

The discussion below includes a comparison of the reported detection limits to the detection limits specified in the project QAPP (Integral 2006b), followed by a summary of the qualified data for each parameter group and any limitations to the usability of the data.

2.2.1 Reported Detection Limits

Data for the Rico Blood Lead and Environmental Monitoring Study were reported to the method detection limit (MDL) in most cases. In several cases, the MDL and method reporting limit (MRL) were elevated at the laboratory or during data validation because either matrix interference or the presence of another analyte interfered with the quantification of a given analyte. MDLs and MRLs were also elevated when results were restated as undetected during data validation because of possible sample contamination, as indicated by the presence of target analytes in an associated method blank or equipment blank.

Quest Diagnostics established an MRL of 1.4 µg/dL for total lead in the blood samples, for research purposes upon request from Integral Consulting, from their standard MRL of 3 µg/dL. Quest verified the validity of the lowered MRL by performing a series of serial dilutions of their calibration standards.

2.2.2 Field Quality Control Samples

Field replicates were collected to assess the variability of the results. Field replicate samples were generated by collecting an additional sample at a designated location or from a study participant, processing this sample separately in the same manner as the original sample, and submitting the replicate as a separate sample for analysis at the laboratories.

The comparability of the replicate results was assessed by calculating the relative percent difference (RPD) of the results. Because there is no standard control limit for comparison of field replicate results, an RPD of 50 was established as a conservative target control limit for detected results greater than 5 times the reporting limit. Greater variability is expected for results within 5–10 times the reporting limit because the background signal variations (i.e., "noise") are greater relative to the lower analyte levels. The precision of the results is acceptable. Sample data were not qualified based solely on the field replicate results.

2.2.2.1 Summary of Qualified Data

Selected data not meeting the data quality criteria were qualified as undetected or estimated during validation, in accordance with the QAPP. Data qualified as undetected are usable for all intended purposes. Data qualified as estimated are usable for all intended purposes, with the knowledge that these data may be less precise or less accurate than unqualified data. Validated analytical results of the Rico biomonitoring samples are presented in Tables 1 through 3.

The precision and accuracy of the Rico biomonitoring data were acceptable. Overall, the data quality was good and will meet the objectives and goals set forth for this project.

3 REFERENCES

Integral. 2006a. Blood lead and environmental monitoring study for Rico Townsite. Work plan. Prepared for Atlantic Richfield Company, Butte, MT. Prepared by Integral Consulting Inc., Mercer Island, WA.

Integral. 2006b. Blood lead and environmental monitoring study for Rico Townsite. Appendix C. Quality Assurance Project Plan. Prepared for Atlantic Richfield Company, Butte, MT. Prepared by Integral Consulting Inc., Mercer Island, WA.

USEPA. 2002a. Guidance on environmental data verification and validation. EPA AQ/G-8. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

USEPA. 2002b. USEPA Contract laboratory program national functional guidelines for inorganic data review. 540-R-01-008. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

TABLES

Table 1. Rico Blood Lead and Environmental Monitoring Study—House Dust Analytical Results.

Sample ID	Sample Type	Date Collected	Sample Matrix	Sample Mass (g)	Total Lead (mg/kg)	Total Solids (percent)
ARR-HD-R01	N	05/23/2006	Solid	1.04	131	95.2
ARR-HD-R02	N	05/18/2006	Solid	1.01	577	97.7
ARR-HD-R05	N	05/19/2006	Solid	1.01	398	97.4
ARR-HD-R05D	FD	05/19/2006	Solid	1.03	512	92.5
ARR-HD-R07	N	05/18/2006	Solid	0.563	561	97.0
ARR-HD-R08	N	05/18/2006	Solid	0.516	965	98.3
ARR-HD-R09	N	05/17/2006	Solid	1.04	448	97.7
ARR-HD-R11	N	05/24/2006	Solid	0.396	233	94.7
ARR-HD-R12	N	05/19/2006	Solid	1.01	487	96.3
ARR-HD-R13	N	05/16/2006	Solid	1.00	341	95.3
ARR-HD-R14	N	05/24/2006	Solid	1.04	497	97.7
ARR-HD-R15	N	05/22/2006	Solid	0.957	488	97.2
ARR-HD-R16	N	05/23/2006	Solid	1.02	293	96.5
ARR-HD-R17	N	05/19/2006	Solid	1.04	711	90.8
ARR-HD-R19	N	05/22/2006	Solid	1.00	408	96.4
ARR-HD-R20	N	05/17/2006	Solid	1.01	919	98.8
ARR-HD-R21	N	05/22/2006	Solid	1.01	351	96.0
ARR-HD-R22	N	05/24/2006	Solid	1.01	894	97.0
ARR-HD-R24	N	05/21/2006	Solid	1.03	653	98.4
ARR-HD-R26	N	05/22/2006	Solid	1.01	174	95.7
ARR-HD-R27	N	05/24/2006	Solid	1.01	243	97.8
ARR-HD-R29	N	05/24/2006	Solid	1.01	229	97.8
ARR-HD-R32	N	05/23/2006	Solid	0.771	98.2	97.1
ARR-HD-R33	N	05/21/2006	Solid	0.278	208	93.9
ARR-HD-R34	N	05/21/2006	Solid	1.03	204	97.7
ARR-HD-R35	N	05/22/2006	Solid	1.03	741	97.0
ARR-HD-R37	N	05/25/2006	Solid	0.928	131	95.2
ARR-HD-R38	N	05/17/2006	Solid	1.01	511	98.0
ARR-HD-R40	N	05/20/2006	Solid	1.03	761	97.1
ARR-HD-R41	N	05/17/2006	Solid	1.01	666	98.4
ARR-HD-R43	N	05/20/2006	Solid	0.768	330	98.4
ARR-HD-R46	N	05/21/2006	Solid	1.02	357	97.2
ARR-HD-R48	N	05/16/2006	Solid	1.03	447	98.8
ARR-HD-R50	N	05/16/2006	Solid	1.02	644	96.0
ARR-HD-R52	N	05/19/2006	Solid	1.02	755	98.6
ARR-HD-R54	N	05/22/2006	Solid	0.244	866	90.0
ARR-HD-R56	N	05/25/2006	Solid	0.753	483	96.8
ARR-HD-R57	N	05/18/2006	Solid	1.04	695	95.4
ARR-HD-R58	N	05/19/2006	Solid	1.03	145	99.1
ARR-HD-R60	N	05/23/2006	Solid	1.02	511	96.8
ARR-HD-R61	N	05/20/2006	Solid	1.00	587	98.0
ARR-HD-R62	N	05/17/2006	Solid	1.02	144	97.1
ARR-HD-R63	N	05/25/2006	Solid	1.04	656	97.5
ARR-HD-R64	N	05/21/2006	Solid	1.05	646	97.8
ARR-HD-R67	N	05/19/2006	Solid	1.02	788	100
ARR-HD-R70	N	05/17/2006	Solid	1.01	621	98.4
ARR-HD-R71	N	05/22/2006	Solid	1.03	607	96.5

Table 1. Rico Blood Lead and Environmental Monitoring Study—House Dust Analytical Results.

Sample ID	Sample Type	Date Collected	Sample Matrix	Sample Mass (g)	Total Lead (mg/kg)	Total Solids (percent)
ARR-HD-R71D	FD	05/22/2006	Solid	1.00	661	97.0
ARR-HD-R75	N	05/19/2006	Solid	1.02	710	98.0
ARR-HD-R79	N	05/26/2006	Solid	1.00	652	98.7
ARR-HD-R82	N	05/22/2006	Solid	1.02	460	96.4
ARR-HD-R84	N	05/18/2006	Solid	1.03	362	97.4
ARR-HD-R86	N	05/17/2006	Solid	1.03	74.8	95.2
ARR-HD-R87	N	05/26/2006	Solid	0.248	61	NA
ARR-HD-R88	N	05/18/2006	Solid	1.03	105	98.4
ARR-HD-R89	N	05/23/2006	Solid	0.325	67	93.2
ARR-HD-R92	N	05/25/2006	Solid	1.04	76	96.7
ARR-HD-R93	N	05/18/2006	Solid	1.02	137	98.3
ARR-HD-R94	N	05/25/2006	Solid	1.02	94.8	98.7
ARR-HD-R96	N	05/19/2006	Solid	0.597	1150	95.1
ARR-HD-R97	N	05/25/2006	Solid	0.231	607	94.4
ARR-HD-R98	N	05/23/2006	Solid	1.02	609	97.5
ARR-HD-R101	N	05/22/2006	Solid	1.01	939	96.3
ARR-HD-R102	N	05/24/2006	Solid	1.01	330	96.3

Notes:

FD = field duplicate

N = normal environmental sample

Table 2. Rico Blood Lead and Environmental Monitoring Study—Drinking Water Analytical Results.

Sample ID	Sample Type	Date Collected	Sample Matrix	Units	Total Lead
ARR-FB-01	FB	05/21/2006	Water	mg/L	1.84
ARR-FB-02	FB	05/21/2006	Water	mg/L	2.92
ARR-FB-03	FB	05/23/2006	Water	mg/L	0.221
ARR-FB-04	FB	05/25/2006	Water	mg/L	1.22
ARR-WF-R01	N	05/23/2006	Water	mg/L	0.739
ARR-WF-R02-01	N	05/18/2006	Water	mg/L	0.628
ARR-WF-R02-02	N	05/18/2006	Water	mg/L	0.272
ARR-WF-R05	N	05/19/2006	Water	mg/L	0.329
ARR-WF-R07	N	05/18/2006	Water	mg/L	0.914
ARR-WF-R08	N	05/18/2006	Water	mg/L	2.07
ARR-WF-R09-01	N	05/17/2006	Water	mg/L	0.448
ARR-WF-R09-02	N	05/17/2006	Water	mg/L	0.009 *U*
ARR-WF-R11	N	05/24/2006	Water	mg/L	0.426
ARR-WF-R12-01	N	05/19/2006	Water	mg/L	0.987
ARR-WF-R12-02	N	05/19/2006	Water	mg/L	0.039
ARR-WF-R13	N	05/16/2006	Water	mg/L	1.93
ARR-WF-R14	N	05/24/2006	Water	mg/L	0.671
ARR-WF-R15	N	05/22/2006	Water	mg/L	0.615
ARR-WF-R16-01	N	05/23/2006	Water	mg/L	0.774
ARR-WF-R16-02	N	05/23/2006	Water	mg/L	0.24
ARR-WF-R17	N	05/19/2006	Water	mg/L	0.739
ARR-WF-R17D	FD	05/19/2006	Water	mg/L	0.508
ARR-WF-R19-01	N	05/22/2006	Water	mg/L	1.19
ARR-WF-R19-02	N	05/22/2006	Water	mg/L	0.067
ARR-WF-R20	N	05/17/2006	Water	mg/L	0.703
ARR-WF-R21	N	05/22/2006	Water	mg/L	1.46
ARR-WF-R22-01	N	05/24/2006	Water	mg/L	0.684
ARR-WF-R22-02	N	05/24/2006	Water	mg/L	0.04
ARR-WF-R24	N	05/21/2006	Water	mg/L	1.03
ARR-WF-R26	N	05/22/2006	Water	mg/L	0.445
ARR-WF-R27	N	05/24/2006	Water	mg/L	0.202
ARR-WF-R29	N	05/24/2006	Water	mg/L	1.35
ARR-WF-R32	N	05/23/2006	Water	mg/L	1.27
ARR-WF-R33	N	05/21/2006	Water	mg/L	0.391
ARR-WF-R34	N	05/21/2006	Water	mg/L	0.363
ARR-WF-R35	N	05/22/2006	Water	mg/L	0.317
ARR-WF-R37-01	N	05/25/2006	Water	mg/L	0.84
ARR-WF-R37-02	N	05/25/2006	Water	mg/L	0.939
ARR-WF-R38A	N	05/17/2006	Water	mg/L	0.184
ARR-WF-R38B	N	05/17/2006	Water	mg/L	1.1
ARR-WF-R40	N	05/20/2006	Water	mg/L	41.5
ARR-WF-R41	N	05/17/2006	Water	mg/L	0.953
ARR-WF-R43	N	05/20/2006	Water	mg/L	0.787
ARR-WF-R46-01	N	05/21/2006	Water	mg/L	0.553
ARR-WF-R46-02	N	05/21/2006	Water	mg/L	0.023
ARR-WF-R48	N	05/16/2006	Water	mg/L	0.318
ARR-WF-R50	N	05/16/2006	Water	mg/L	0.255

Table 2. Rico Blood Lead and Environmental Monitoring Study—Drinking Water Analytical Results.

Sample ID	Sample Type	Date Collected	Sample Matrix	Units	Total Lead
ARR-WF-R52	N	05/19/2006	Water	mg/L	0.537
ARR-WF-R54	N	05/22/2006	Water	mg/L	0.308
ARR-WF-R56	N	05/25/2006	Water	mg/L	0.714
ARR-WF-R57-01	N	05/18/2006	Water	mg/L	0.487
ARR-WF-R57-02	N	05/18/2006	Water	mg/L	0.012 *J*
ARR-WF-R57-03	N	05/18/2006	Water	mg/L	186
ARR-WF-R58-01	N	05/19/2006	Water	mg/L	0.614
ARR-WF-R58-02	N	05/19/2006	Water	mg/L	0.066
ARR-WF-R60-01	N	05/23/2006	Water	mg/L	0.917
ARR-WF-R60-02	N	05/23/2006	Water	mg/L	0.009 *U*
ARR-WF-R60-03	N	05/23/2006	Water	mg/L	0.477
ARR-WF-R61-01	N	05/20/2006	Water	mg/L	0.67
ARR-WF-R61-02	N	05/20/2006	Water	mg/L	0.076
ARR-WF-R62	N	05/17/2006	Water	mg/L	1.87
ARR-WF-R63	N	05/25/2006	Water	mg/L	0.614
ARR-WF-R64	N	05/21/2006	Water	mg/L	0.408
ARR-WF-R67	N	05/19/2006	Water	mg/L	0.661
ARR-WF-R70	N	05/17/2006	Water	mg/L	0.276
ARR-WF-R71-01	N	05/22/2006	Water	mg/L	0.735
ARR-WF-R71-02	N	05/22/2006	Water	mg/L	0.027
ARR-WF-R75	N	05/19/2006	Water	mg/L	1.05
ARR-WF-R79	N	05/26/2006	Water	mg/L	0.47
ARR-WF-R82	N	05/22/2006	Water	mg/L	0.677
ARR-WF-R82D	FD	05/22/2006	Water	mg/L	0.729
ARR-WF-R84	N	05/18/2006	Water	mg/L	1.03
ARR-WF-R86A	N	05/17/2006	Water	mg/L	0.045
ARR-WF-R86B	N	05/17/2006	Water	mg/L	0.934
ARR-WF-R87	N	05/26/2006	Water	mg/L	0.855
ARR-WF-R87D	FD	05/26/2006	Water	mg/L	0.595
ARR-WF-R88	N	05/18/2006	Water	mg/L	0.839
ARR-WF-R89	N	05/23/2006	Water	mg/L	1.34
ARR-WF-R92-01	N	05/25/2006	Water	mg/L	1.23
ARR-WF-R92-02	N	05/25/2006	Water	mg/L	0.351
ARR-WF-R93	N	05/18/2006	Water	mg/L	0.259
ARR-WF-R94	N	05/25/2006	Water	mg/L	0.725
ARR-WF-R96	N	05/19/2006	Water	mg/L	0.606
ARR-WF-R97	N	05/25/2006	Water	mg/L	0.819
ARR-WF-R98	N	05/23/2006	Water	mg/L	0.509
ARR-WF-R101	N	05/22/2006	Water	mg/L	0.354
ARR-WF-R102-01	N	05/24/2006	Water	mg/L	1.26
ARR-WF-R102-02	N	05/24/2006	Water	mg/L	0.047
ARR-WS-R01	N	05/23/2006	Water	mg/L	1.22
ARR-WS-R05	N	05/20/2006	Water	mg/L	1.39
ARR-WS-R07	N	05/19/2006	Water	mg/L	2.13
ARR-WS-R09-01	N	05/18/2006	Water	mg/L	1.22
ARR-WS-R09-02	N	05/18/2006	Water	mg/L	0.056
ARR-WS-R11	N	05/25/2006	Water	mg/L	0.535

Table 2. Rico Blood Lead and Environmental Monitoring Study—Drinking Water Analytical Results.

Sample ID	Sample Type	Date Collected	Sample Matrix	Units	Total Lead
ARR-WS-R12-01	N	05/19/2006	Water	mg/L	0.274
ARR-WS-R12-02	N	05/19/2006	Water	mg/L	4.08
ARR-WS-R13	N	05/17/2006	Water	mg/L	0.828
ARR-WS-R14	N	05/24/2006	Water	mg/L	1.71
ARR-WS-R15	N	05/23/2006	Water	mg/L	2.76
ARR-WS-R16-01	N	05/24/2006	Water	mg/L	1.72
ARR-WS-R16-02	N	05/24/2006	Water	mg/L	0.851
ARR-WS-R17	N	05/20/2006	Water	mg/L	1.28
ARR-WS-R17D	FD	05/20/2006	Water	mg/L	1.14
ARR-WS-R19-01	N	05/23/2006	Water	mg/L	4.38
ARR-WS-R19-02	N	05/23/2006	Water	mg/L	0.142
ARR-WS-R20	N	05/24/2006	Water	mg/L	11.4
ARR-WS-R21	N	05/23/2006	Water	mg/L	10.1
ARR-WS-R22-01	N	05/25/2006	Water	mg/L	3.87
ARR-WS-R22-02	N	05/25/2006	Water	mg/L	0.036
ARR-WS-R24	N	05/21/2006	Water	mg/L	4.29
ARR-WS-R26	N	05/23/2006	Water	mg/L	0.638
ARR-WS-R29	N	05/25/2006	Water	mg/L	1.23
ARR-WS-R33	N	05/21/2006	Water	mg/L	1.41
ARR-WS-R34	N	05/21/2006	Water	mg/L	0.676
ARR-WS-R35	N	05/23/2006	Water	mg/L	1.81
ARR-WS-R37-01	N	05/26/2006	Water	mg/L	1.96
ARR-WS-R38A	N	05/17/2006	Water	mg/L	1.33
ARR-WS-R38B	N	05/17/2006	Water	mg/L	0.515
ARR-WS-R40	N	05/21/2006	Water	mg/L	105
ARR-WS-R41	N	05/18/2006	Water	mg/L	4.17
ARR-WS-R43	N	05/21/2006	Water	mg/L	2.69
ARR-WS-R46-01	N	05/22/2006	Water	mg/L	1.31
ARR-WS-R46-02	N	05/22/2006	Water	mg/L	0.061
ARR-WS-R48	N	05/17/2006	Water	mg/L	3.15
ARR-WS-R50	N	05/17/2006	Water	mg/L	1.99
ARR-WS-R52	N	05/19/2006	Water	mg/L	1.62
ARR-WS-R54	N	05/23/2006	Water	mg/L	0.532
ARR-WS-R56	N	05/26/2006	Water	mg/L	2.68
ARR-WS-R57-01	N	05/19/2006	Water	mg/L	0.421
ARR-WS-R57-02	N	05/19/2006	Water	mg/L	0.016 *J*
ARR-WS-R58-01	N	05/19/2006	Water	mg/L	2.97
ARR-WS-R58-02	N	05/19/2006	Water	mg/L	0.174
ARR-WS-R60-01	N	05/24/2006	Water	mg/L	1.84
ARR-WS-R60-01	N	05/24/2006	Water	mg/L	0.009 *U*
ARR-WS-R61-01	N	05/20/2006	Water	mg/L	3.16
ARR-WS-R61-02	N	05/20/2006	Water	mg/L	1.26
ARR-WS-R62	N	05/17/2006	Water	mg/L	38.3
ARR-WS-R63	N	05/26/2006	Water	mg/L	0.671
ARR-WS-R64	N	05/21/2006	Water	mg/L	2.11
ARR-WS-R67	N	05/19/2006	Water	mg/L	2.7
ARR-WS-R70	N	05/25/2006	Water	mg/L	1.56

Table 2. Rico Blood Lead and Environmental Monitoring Study—Drinking Water Analytical Results.

Sample ID	Sample Type	Date Collected	Sample Matrix	Units	Total Lead
ARR-WS-R71-01	N	05/20/2006	Water	mg/L	2.95
ARR-WS-R75	N	05/19/2006	Water	mg/L	6.27
ARR-WS-R79	N	05/27/2006	Water	mg/L	0.663
ARR-WS-R82D [a]	FD	05/23/2006	Water	mg/L	3.57
ARR-WS-R84	N	05/19/2006	Water	mg/L	1.87
ARR-WS-R86A	N	05/18/2006	Water	mg/L	0.038
ARR-WS-R86B	N	05/17/2006	Water	mg/L	0.807
ARR-WS-R87	N	05/26/2006	Water	mg/L	4.66
ARR-WS-R87D	FD	05/26/2006	Water	mg/L	1.44
ARR-WS-R88	N	05/19/2006	Water	mg/L	18.4
ARR-WS-R89	N	05/24/2006	Water	mg/L	3.32
ARR-WS-R92-01	N	05/26/2006	Water	mg/L	1.33
ARR-WS-R92-02	N	05/26/2006	Water	mg/L	0.325
ARR-WS-R93	N	05/19/2006	Water	mg/L	0.676
ARR-WS-R94	N	05/25/2006	Water	mg/L	0.616
ARR-WS-R96	N	05/19/2006	Water	mg/L	4.98
ARR-WS-R97	N	05/25/2006	Water	mg/L	0.269
ARR-WS-R98	N	05/24/2006	Water	mg/L	1.24
ARR-WS-R101	N	05/23/2006	Water	mg/L	1.2
ARR-WS-R102-01	N	05/25/2006	Water	mg/L	0.947
ARR-WS-R102-02	N	05/25/2006	Water	mg/L	0.087

Notes:

FD = field duplicate
J = the associated numerical value is an estimated quantity
N = normal environmental sample
U = the material was analyzed for, but was not detected. The associated numerical value is the sample quantitation limit.

[a] Two sample containers were left with the resident at this location; the resident only chose to fill one container.

Table 3. Rico Blood Lead and Environmental Monitoring Study—Blood Lead Analytical Results.

Sample ID	Sample Type	Date Collected	Date Reported	Hemoglobin (g/dL)	Hematocrit (%)	Blood Lead (µg/dL)	ZPP (µg/dL)
ARR-WB, R01-01	N	5/23/2006	5/28/2006	15.9	46.8	<1.4	38
ARR-WB, R02-01	N	5/18/2006	5/22/2006	15.5	44.4	2.2	34
ARR-WB, R05-01 [a]	N	5/19/2006	5/23/2006	--	--	1.6	38
ARR-WB, R07-01	N	5/18/2006	5/23/2006	16.4	50.8	1.4	29
ARR-WB, R07-02 [b]	N	5/18/2006	5/24/2006	--	--	1.5	--
ARR-WB, R07-02 [b]	FD	5/18/2006	5/24/2006	--	--	<1.4	--
ARR-WB, R08-01	N	5/18/2006	5/23/2006	15.5	48.3	2	28
ARR-WB, R08-02	N	5/18/2006	5/23/2006	14.5	44.3	1.8	41
ARR-WB, R09-01	N	5/17/2006	5/22/2006	15.5	46.0	<1.4	47
ARR-WB, R09-02	N	5/17/2006	5/22/2006	17.2	50.1	1.9	22
ARR-WB, R11-01 [a]	N	5/24/2006	5/29/2006	--	--	2.0	26
ARR-WB, R12-01	N	5/17/2006	5/22/2006	15.3	44.4	<1.4	31
ARR-WB, R12-02	N	5/17/2006	5/22/2006	15.3	44.8	2.9	25
ARR-WB, R12-03	N	5/17/2006	5/22/2006	13.7	39.9	2.7	47
ARR-WB, R12-04	N	5/17/2006	5/22/2006	14.0	39.4	2.3	21
ARR-WB, R12-05 [c]	N	5/17/2006	5/22/2006	--	--	--	--
ARR-WB, R13-01	N	5/16/2006	5/22/2006	16.6	52.1	2.8	24
ARR-WB, R13-02	N	5/16/2006	5/22/2006	15.8	48.2	<1.4	31
ARR-WB, R14-01	N	5/24/2006	5/29/2006	14.9	45.1	<1.4	23
ARR-WB, R14-02	N	5/26/2006	5/31/2006	15.8	47.4	2.5	25
ARR-WB, R15-01	N	5/22/2006	5/26/2006	15.6	46.5	3.0	18
ARR-WB, R16-01	N	5/23/2006	5/28/2006	14.6	42.3	1.7	23
ARR-WB, R16-02	N	5/23/2006	5/28/2006	16.5	46.7	<1.4	61
ARR-WB, R17-01 [a]	N	5/19/2006	5/23/2006	--	--	2.2	30
ARR-WB, R19-01	N	5/22/2006	5/26/2006	14.2	41.7	<1.4	40
ARR-WB, R19-02	N	5/22/2006	5/26/2006	16.6	49.3	1.9	37
ARR-WB, R19-03 [b]	N	5/22/2006	5/26/2006	--	--	6	--
ARR-WB, R20-01	N	5/17/2006	5/22/2006	16.6	49.7	1.9	30
ARR-WB, R20-02	N	5/17/2006	5/22/2006	17.5	51.7	4.0	30
ARR-WB, R21-01	N	5/22/2006	5/26/2006	15.4	44.8	1.9	42
ARR-WB, R22-01	N	5/24/2006	5/29/2006	17.7	53.5	<1.4	26
ARR-WB, R22-02	N	5/24/2006	5/29/2006	15.1	45.8	<1.4	35
ARR-WB, R23-01	N	5/17/2006	5/22/2006	15.1	44.4	2.0	24
ARR-WB, R24-01	N	5/21/2006	5/25/2006	15.3	44.7	3.0	45
ARR-WB, R24-02	N	5/21/2006	5/25/2006	13.4	40.3	<1.4	35
ARR-WB, R26-01	N	5/22/2006	5/26/2006	15.5	45.1	<1.4	47
ARR-WB, R26-02 [d]	N	5/22/2006	5/26/2006	--	--	2.5	68
ARR-WB, R27-01	N	5/24/2006	5/29/2006	15.2	46.2	1.8	30
ARR-WB, R29-01 [a]	N	5/24/2006	5/29/2006	--	--	<1.4	29
ARR-WB, R31-01	N	5/25/2006	5/31/2006	17.2	51.6	26.0	23
ARR-WB, R32-01	N	5/23/2006	5/26/2006	13.6	39.5	<1.4	38
ARR-WB, R32-02	N	5/23/2006	5/26/2006	16.1	46.2	1.7	33
ARR-WB, R33-01	N	5/21/2006	5/25/2006	15.9	47.3	5.0	36
ARR-WB, R33-02	N	5/21/2006	5/25/2006	15.0	44.7	<1.4	40
ARR-WB, R33-03	N	5/21/2006	5/25/2006	14.6	43.2	2.1	23
ARR-WB, R33-04	N	5/21/2006	5/25/2006	14.3	42.3	4.0	28
ARR-WB, R33-05 [b]	N	5/21/2006	5/25/2006	--	--	3.0	--
ARR-WB, R34-01	N	5/21/2006	5/25/2006	15.5	46.8	1.7	31

Table 3. Rico Blood Lead and Environmental Monitoring Study—Blood Lead Analytical Results.

Sample ID	Sample Type	Date Collected	Date Reported	Hemoglobin (g/dL)	Hematocrit (%)	Blood Lead (µg/dL)	ZPP (µg/dL)
ARR-WB, R34-02	N	5/21/2006	5/25/2006	16.6	49.0	4.0	33
ARR-WB, R34-03	N	5/21/2006	5/25/2006	14.6	42.7	1.9	35
ARR-WB, R35-01	N	5/22/2006	5/26/2006	14.3	42.2	1.4	29
ARR-WB, R35-02	N	5/23/2006	5/28/2006	17.2	49.3	2.2	18
ARR-WB, R37-01	N	5/25/2006	5/30/2006	16.3	49.2	<1.4	20
ARR-WB, R37-02	N	5/25/2006	5/30/2006	15.4	46.5	<1.4	25
ARR-WB, R38-01	N	5/17/2006	5/22/2006	14.3	42.4	<1.4	22
ARR-WB, R38-02	N	5/20/2006	5/25/2006	18.0	52.6	2.4	29
ARR-WB, R40-01 [a]	N	5/20/2006	5/25/2006	--	--	2.7	25
ARR-WB, R41-01	N	5/17/2006	5/22/2006	13.4	39.8	1.4	45
ARR-WB, R41-02	N	5/17/2006	5/22/2006	16.8	48.1	2.6	23
ARR-WB, R41-03 [b]	N	5/17/2006	5/22/2006	--	--	10.0	--
ARR-WB, R43-01 [a]	N	5/20/2006	5/25/2006	--	--	1.5	39
ARR-WB, R46-01	N	5/21/2006	5/25/2006	16.1	47.7	2.1	31
ARR-WB, R46-02	N	5/21/2006	5/25/2006	17.5	51.3	<1.4	34
ARR-WB, R46-03	N	5/21/2006	5/25/2006	14.9	43.7	<1.4	24
ARR-WB, R48-01	N	5/16/2006	5/22/2006	13.9	42.1	1.8	36
ARR-WB, R50-01	N	5/16/2006	5/22/2006	15.3	46.6	2.8	34
ARR-WB, R50-02	N	--	5/22/2006	14.2	41.8	5.0	37
ARR-WB, R52-01	N	5/17/2006	5/22/2006	14.3	41.8	1.4	26
ARR-WB, R52-02	N	5/17/2006	5/22/2006	14.8	42.8	1.6	24
ARR-WB, R52-03 [a]	N	5/19/2006	5/23/2006	--	--	<1.4	34
ARR-WB, R54-01	N	5/22/2006	5/25/2006	17.4	51.5	4	28
ARR-WB, R55-01	N	5/21/2006	5/25/2006	18.3	52.8	2.1	31
ARR-WB, R56-01	N	5/25/2006	5/31/2006	15.4	46.2	<1.4	29
ARR-WB, R57-01 [b]	N	5/18/2006	5/24/2006	--	--	2.3	--
ARR-WB, R57-01 [b]	FD	5/18/2006	5/24/2006	--	--	2	--
ARR-WB, R57-02	N	5/18/2006	5/23/2006	16.8	51.4	1.8	34
ARR-WB, R57-03	N	5/18/2006	5/23/2006	14.9	45.6	1.8	55
ARR-WB, R58-01 [a]	N	5/19/2006	5/23/2006	--	--	1.7	37
ARR-WB, R58-02 [a]	N	5/19/2006	5/23/2006	--	--	1.7	45
ARR-WB, R58-03 [a]	N	5/19/2006	5/23/2006	--	--	1.6	43
ARR-WB, R60-01	N	5/23/2006	5/28/2006	15.2	44.1	1.9	25
ARR-WB, R60-02	N	5/23/2006	5/28/2006	14.2	40.8	2.5	10
ARR-WB, R60-03	N	5/23/2006	5/28/2006	16.3	47.6	2.6	12
ARR-WB, R61-01 [a]	N	5/20/2006	5/25/2006	--	--	2	24
ARR-WB, R61-02	N	5/24/2006	5/29/2006	14.2	42.8	<1.4	30
ARR-WB, R62-01	N	5/17/2006	5/22/2006	16.2	47.6	2.6	35
ARR-WB, R63-01	N	5/25/2006	5/31/2006	16.0	48.9	<1.4	26
ARR-WB, R63-02	N	5/25/2006	5/31/2006	14.7	44.2	2.6	29
ARR-WB, R64-01	N	5/21/2006	5/25/2006	15.0	44.3	1.7	42
ARR-WB, R64-02	N	5/21/2006	5/25/2006	16.5	48.5	4.0	36
ARR-WB, R67-01 [a]	N	5/19/2006	5/23/2006	--	--	<1.4	27
ARR-WB, R70-01 [e]	N	5/17/2006	5/22/2006	--	38.0	<1.4	60
ARR-WB, R71-01	N	5/22/2006	5/26/2006	15.5	45.9	3.0	30
ARR-WB, R71-02	N	5/22/2006	5/26/2006	15.7	45.5	3.0	25
ARR-WB, R71-03	N	5/22/2006	5/26/2006	12.3	35.9	7.0	31

Table 3. Rico Blood Lead and Environmental Monitoring Study—Blood Lead Analytical Results.

Sample ID	Sample Type	Date Collected	Date Reported	Hemoglobin (g/dL)	Hematocrit (%)	Blood Lead (µg/dL)	ZPP (µg/dL)
ARR-WB, R73-01	N	5/23/2006	5/26/2006	17.4	50.8	2.9	58
ARR-WB, R75-01 [a]	N	5/19/2006	5/23/2006	--	--	3	32
ARR-WB, R75-02 [a]	N	5/19/2006	5/23/2006	--	--	1.8	26
ARR-WB, R79-01	N	5/26/2006	5/31/2006	17.3	52.7	3.2	37
ARR-WB, R82-01	N	5/22/2006	5/26/2006	14.9	43.5	<1.4	27
ARR-WB, R82-02	N	5/22/2006	5/26/2006	16.7	48.1	2.6	22
ARR-WB, R84-01	N	5/18/2006	5/23/2006	17.3	54.2	1.6	49
ARR-WB, R86-01	N	5/17/2006	5/22/2006	17.2	51.2	<1.4	29
ARR-WB, R86-02	N	5/17/2006	5/22/2006	16.0	45.9	2.5	20
ARR-WB, R86-03 [e]	N	5/17/2006	5/22/2006	--	43.0	17.0	53
ARR-WB, R87-01	N	5/26/2006	5/31/2006	14.6	43.5	11.0	33
ARR-WB, R87-02	N	5/26/2006	5/31/2006	17.5	54.2	6.0	40
ARR-WB, R88-01	N	5/18/2006	5/23/2006	15.9	49.4	<1.4	36
ARR-WB, R89-01	N	5/23/2006	5/28/2006	14	40.4	<1.4	33
ARR-WB, R89-02	N	5/23/2006	5/28/2006	17	49	2.3	22
ARR-WB, R92-01	N	5/25/2006	5/29/2006	15.2	45.5	<1.4	26
ARR-WB, R93-01	N	5/18/2006	5/23/2006	14.9	46.1	2	51
ARR-WB, R93-02 [b]	N	5/18/2006	5/23/2006	--	--	2.3	--
ARR-WB, R93-02b	FD	5/18/2006	5/23/2006	--	--	2.1	--
ARR-WB, R94-01	N	5/22/2006	5/26/2006	17	50.1	2.7	27
ARR-WB, R94-02	N	5/25/2006	5/31/2006	15.6	48.6	1.5	36
ARR-WB, R96-01 [a]	N	5/19/2006	5/23/2006	--	--	2.3	43
ARR-WB, R97-01	N	5/25/2006	5/31/2006	15.3	47.1	2.8	43
ARR-WB, R98-01	N	5/23/2006	5/28/2006	15.3	45	2.7	26
ARR-WB, R101-01	N	5/22/2006	5/26/2006	15.6	45.2	4	46
ARR-WB, R102-01 [a]	N	5/24/2006	5/29/2006	--	--	2.5	29

Notes:

N = normal biological sample

FD = field duplicate

-- = no data available

[a] Unable to perform a valid hemoglobin and hematocrit test due to the age of the specimen.

[b] Unable to perfom hematocrit, hemoglobin, and ZPP analyses due to insufficient quantity of sample received.

[c] Unable to perform any blood analyses due to insufficient quantity of sample received.

[d] The sample for hematocrit and hemoglobin analysis was received clotted. It was determined that medically useful information could not be expected. No results have been generated as the integrity of the sample was compromised.

[e] Unable to perform hemoglobin analysis due to insufficient quantity of sample received.