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EXECUTIVE SUMMARY

INTRODUCTION

This document presents the Feasibility Study (FS) for the Off-Facility Soils Operable Unit of the Vasquez Boulevard and Interstate 70 (VB/I70) Superfund Site located in the north-central section of Denver, Colorado. The purpose of the FS is to identify and evaluate a range of remedial alternatives to address human health concerns associated with potential exposure to contaminated soils and homegrown vegetables in residential yards. This FS has been prepared in accordance with EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.

The VB/I70 site covers an area of approximately four square miles in north-central Denver, Colorado. For the purpose of investigation and remedy development, the site has been divided into 3 operable units (OUs). The residential soils evaluated in this report are known as the Off-Facility Soils Operable Unit 1 (OU1) portion of the site. The locations of the former Omaha & Grant Smelter and Argo Smelter are identified as On-Facility Soils OU2 and OU3, respectively. The site is composed of a number of neighborhoods that are largely residential, including Swansea/Elyria, Clayton, Cole, and portions of Globeville. Most residences at the site are single-family dwellings, but there are also some multi-family homes and apartment buildings. There are approximately 4,000 residential properties within the site boundaries. The site also contains a number of schools, parks, and playgrounds, as well as commercial and industrial properties.

The site came to the attention of the U.S. Environmental Protection Agency (USEPA) following studies directed by the Colorado Department of Public Health and Environment (CDPHE) at the nearby Globe Smelter. These studies had identified elevated concentrations of arsenic and/or lead in residential yards within Globeville, and also extending into the Elyria and Swansea neighborhoods.

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The USEPA Emergency Response Program conducted two removal assessment-sampling programs, known as Phase I and Phase II, at residential properties within the VB/I70 study area during 1998. The sampling results at 18 properties warranted time critical soil removal based on surface soil concentrations exceeding 450 mg/Kg arsenic or 2,000 mg/Kg lead.

Based on the Phase I and Phase II results, the USEPA determined that residential properties within the VB/I70 site contained soils with arsenic or lead at levels that could present human health concerns over long-term exposures. On this basis, the site was proposed for listing and was added to the National Priorities List (NPL) on July 22, 1999.

SUMMARY OF REMEDIAL INVESTIGATION FINDINGS

A study and two additional investigations were performed between 1998 and 2000 in support of the Baseline Human Health Risk Assessment:

- Physico-Chemical Characterization Study
- Residential Risk Based Sampling Investigation
- Phase III Field Investigation

Data generated from these investigations are reported in the Remedial Investigation (RI) report, which was issued in final form in July 2001. The Baseline Human Health Risk Assessment was also issued in final form in July 2001. Key RI and risk assessment findings with respect to the development of and evaluation remedial alternatives for VB/I70 OU1 are as follows:

- Generally, metals concentrations are highest in the first two inches of soil and decrease with depth.

- Ninety-one percent of the properties contain mean lead concentrations below the EPA screening level for lead in soil of 400 mg/Kg.

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- It is estimated that background levels of arsenic are well-characterized as a lognormal distribution with a mean of 8 mg/Kg and a standard deviation of 3.6 mg/Kg. Based on this, background levels may range up to about 15 mg/Kg or slightly higher.

- Lead levels in bulk soils range from below the detection limit (about 52 mg/Kg) up to a maximum of more than 1,000 mg/Kg. If it is assumed that the upper range of lead concentrations resulting from natural and area-wide anthropogenic sources is about 400 mg/Kg, then the mean of all samples that are less than 400 mg/Kg is about 195 mg/Kg.

- There is only a weak correlation between the occurrence of elevated lead and elevated arsenic in soil, suggesting that the main sources of lead and the main sources of arsenic in yard soil are not likely to be the same.

- Some residential properties contain arsenic at concentrations substantially higher than the expected natural levels. Properties with elevated levels of arsenic occur at widely scattered locations across the site with no clear spatial pattern. At an affected property, the contamination appears to be distributed across the yard area, with a fairly clear boundary between the affected property and the adjacent property. The chemical form of arsenic is predominantly arsenic trioxide.

- Lead also occurs at elevated levels in soil at some residential properties. Elevations occur in all neighborhoods of the site, but levels tend to be higher on the western part of the site than the eastern part.

- Lead was detected in paint at most locations where paint was sampled, with 130 out of 144 samples having values above 1 mg/cm^2. These data suggest that interior and/or exterior leaded paint might be a source of lead exposure in area children, either directly (by paint chip ingestion), or indirectly (by ingestion of dust or soil containing paint chips).

- Using EPA's IEUBK model to evaluate the risk to children, it is estimated that about 45% of residences have levels that exceed USEPA's health-based goal (no more than a 5% chance that a child will have a blood lead value above 10 µg/dL). Of these, many (about 71%) have mean lead concentrations lower than 400 ppm (the USEPA screening level for lead in soil). This is mainly because the site-specific relative bioavailability for lead (84%) is higher than the default value (60%). In order to help determine whether the IEUBK model is yielding reliable predictions at the VB/I70 site, USEPA compared the IEUBK model predictions to actual observations of blood lead levels in the population of children currently living at the site. Even though the available data are from studies that were not designed to support risk assessment, they do support the following:

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A. Elevated blood lead levels occur in children residing within the site.
B. Soil is not likely to be the main source of elevated blood lead levels.
C. Elevations are not clearly different from areas outside VB/I70.

In order to investigate the uncertainty of the IEUBK model predictions, USEPA performed alternate IEUBK modeling by revising the model parameters using newly published data. Using the most-recent data available on soil intake rates by children measured during a study by Stanek and Calabrese, the IEUBK model predicts that there are no residences where USEPA's health based goal will be exceeded.

- Mean arsenic concentrations in surface soils in schools and parks range from below the method detection limit of 11 mg/Kg to 26 mg/Kg. The mean lead concentrations range from 67 to 256 mg/Kg.

- In some cases, levels of arsenic in yard soil are sufficiently elevated to pose a reasonable maximum exposure (RME) excess lifetime cancer risk above a level of 1E-04. Based on current data, about 3 percent of all properties fall into this category. Monte Carlo modeling performed as part of the uncertainty analysis in the Baseline Human Health Risk Assessment indicates that the RME point estimate is located at or above the 99th percentile of the probability distribution of risk. Non-cancer risks from chronic or sub-chronic RME exposures to arsenic are also above a level of human health concern at some properties. All of these properties are also predicted to have RME cancer risks above 1E-04.

- Screening level calculations suggest that high level intake of soil associated with pica behavior in children might be of acute non-cancer concern at a large number of properties at the site. Because data are so sparse on the actual magnitude and frequency of soil pica behavior, and considering that discussions continue to occur nationally on the most appropriate acute Reference Dose (RfD) for arsenic, it is difficult to judge which (if any) of these properties should be considered to be an authentic acute health risk to children. In this regard, it should be noted that even though many people are exposed to arsenic levels in soils that are predicted to be of acute concern, both within the VB/I70 site and elsewhere across the country and around the world, to the best of USEPA's knowledge, there has never been a single case of acute arsenic toxicity reported in humans that was attributable to arsenic in soil. Thus, these results for the acute pica scenario are considered to be especially uncertain, since they predict a very substantial risk for which there is no corroborating medical or epidemiological evidence.

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REMEDIAL ACTION OBJECTIVES

The overall Remedial Action Objective (RAO) is to protect human health. Based on the findings of the risk assessment, the exposure pathways of concern for residents in VB/I70 OU1 are incidental ingestion of soil and dust in and about the home and yard, and ingestion of home-grown vegetables. The contaminants of concern are arsenic and lead. The following are the RAOs for OU1:

RAOs for Arsenic in Soil

A. For residents of the VB/I70 site, prevent exposure to soil containing arsenic in levels predicted to result in an excess lifetime cancer risk associated with ingestion of soil and ingestion of home grown garden vegetables which exceeds 1×10^{-4} using reasonable maximum exposure assumptions.

B. For residents of the VB/I70 site, prevent exposure to soil containing arsenic in levels predicted to result in a chronic or sub-chronic hazard quotient associated with ingestion of soil and ingestion of home grown garden vegetables which exceeds 1 using reasonable maximum exposure assumptions.

C. For children with pica behavior who reside in the VB/I70 site, reduce the potential for exposures to arsenic in soil that result in acute effects.

RAO for Lead in Soil

D. Limit exposure to lead in soil such that no more than 5 percent of young children (72 months or younger) who live within the VB/I70 site are at risk for blood lead levels higher than 10 ug/dL from such exposure.

This objective is consistent with EPA's guidance that EPA should "...limit exposure to soil lead levels such that a typical child or group of similarly exposed children would have an estimated risk of no more than 5 percent of exceeding the 10 ug/dL blood lead level."

Preliminary Remediation Goals (PRGs) were established based on the evaluation and findings of the Baseline Human Health Risk Assessment. PRGs are contaminant levels in soils that are protective of human health for the various exposure scenarios. The PRGs were set at background concentrations for

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both lead and arsenic. It is estimated that background levels of arsenic are well-characterized as a lognormal distribution with a mean of 8 mg/Kg and a standard deviation of 3.6 mg/Kg. Based on this, background levels may range up to about 15 mg/Kg or slightly higher. Lifetime cancer risk associated with exposure to background concentrations of arsenic are approximately $1x10^{-5}$. Lead levels in bulk soils range from below the detection limit (about 52 mg/Kg) up to a maximum of more than 1,000 mg/Kg. If it is assumed that the upper range of lead concentrations resulting from natural and area-wide anthropogenic sources is about 400 mg/Kg, then the mean of all samples that are less than 400 mg/Kg is about 195 mg/Kg.

In addition to these PRGs, EPA has established Preliminary Action Levels in this FS. These are exposure point concentrations (EPCs) above which some remedial action is warranted. An EPC is a conservative estimate of the mean concentration within an individual yard. These action levels are: (1) an EPC of 47 mg/Kg arsenic, which is the level at which the Baseline Human Health Risk Assessment predicts the RME acute non-cancer Hazard Quotient is greater than 1 for the Case 2 pica scenario; (2) an EPC of 240 mg/Kg arsenic, which is the level at which the Baseline Human Health Risk Assessment predicts RME lifetime cancer risks exceed 10^{-4}; (3) an EPC of 208 mg/Kg lead, which equates to a less than 5% chance that any child will have a blood lead value above 10 ug/dL based on the IEUBK model adjusted by using site-specific data on the levels of lead in house dust and the relative bioavailability of lead in site soils; and (4) an EPC of 540 mg/Kg lead, which also equates to a less than 5% chance that any child will have a blood lead value above 10 ug/dl based on an alternate IEUBK model run (see Appendix C). These concentrations equate to the EPCs used in the Baseline Human Health Risk Assessment and any evaluation of concentrations of lead or arsenic in residential yard soils must use the same sampling methodology as the RI and same evaluation methodology as the risk assessment to provide comparable results.

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DEVELOPMENT OF REMEDIAL ALTERNATIVES

Based on site conditions and RAOs, a range of General Response Actions (GRAs) were identified. GRAs are general categories of remedial activities (e.g. no action, institutional controls, containment, etc.) that may be taken, either singly or in combination, to satisfy the requirements of the RAOs. Remedial technologies and process options are more specific applications of the GRAs. Remedial technologies and process options were identified for each GRA and screened in accordance with procedures described in RI/FS guidance. In the first screening step, remedial technologies that have limited or no potential for implementation at the site were eliminated. Remedial technologies and process options that passed the initial screening test were then subjected to a second, more rigorous, screening evaluation of their anticipated effectiveness, potential implementability and relative cost. The remedial technologies and process options that survived the screening were carried forward for consideration in the development of remedial alternatives.

Based on this process, five remedial alternatives were identified as follows:

- Alternative 1 - No Action
- Alternative 2 – Community Health Program, Tilling/Treatment (Lead), Targeted Removal and Disposal (Arsenic)
- Alternative 3 – Community Health Program, Targeted Removal and Disposal
- Alternative 4 – Community Health Program, Expanded Removal and Disposal
- Alternative 5 – Removal and Disposal

Detailed descriptions of the alternatives are provided below.

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Alternative 1 - No Action

The no action alternative provides a baseline for the evaluation of other alternatives in accordance with the NCP. No additional protective or remediation measures would be taken for the no-action option. Soils have already been removed from 48 residential properties at the site.

In general, the no-action alternative may be viable if constituent concentrations are below remedial action levels. This alternative may also be appropriate for materials or soils which do not pose unacceptable risks to human health or the environment, if implementation of remedial actions would create a greater risk, or if the cost of remediation is excessive when compared to the risk reduction.

Alternative 2 – Community Health Program, Tilling/Treatment (Lead), Targeted Removal and Disposal (Arsenic)

Alternative 2 contains the following principal components:

- Implementation of a community health program.

The community health program alternative for the VBI70 site would be composed of two separate (but partially overlapping) elements: the first designed to address risks to area children from lead in un-remediated soils above the preliminary action level of 208 mg/Kg; and the second designed to address risks to area children from pica ingestion of arsenic in un-remediated soil above the preliminary action level of 47 mg/Kg. Each of these two main elements of the program is described below. Participation in one or both elements of the program would be strictly voluntary, and there would be no charge to eligible residents and property owners for any of the services offered by the community health program.

PUBLIC HEALTH PROGRAM TO REDUCE RISKS FROM LEAD

The program for reduction of lead risks is intended to be general. That is, it is intended to assess risks from lead from any and all potential sources of exposure, with response actions tailored to address

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the different types of exposure source which may be identified. The lead program will consist of three main elements:

1) Community and individual education about potential pathways of exposure to lead, and the potential health consequences of excessive lead exposure.

2) A biomonitoring program by which any child (up to 72 months old) may be tested to evaluate actual exposure.

3) A program to respond to any observed lead exposures that are outside the normal range. This will include any necessary follow-up sampling, analysis, and investigation to help identify the likely source of exposure, and to implement an appropriate response that will help reduce the exposure.

A key component of the response program is that all potential sources of lead at a property would be sampled, including soil and interior/exterior paint. If soil is judged to be the most likely source of exposure, a series of alternative actions will be evaluated to identify the most effective way to reduce that exposure. These will include a wide range of potential alternatives, including such things as education, sodding or capping of contaminated soil, tilling/treatment, etc. If exterior paint is the source of lead contamination in soil, remediation of the paint may be considered. If the main source is judged to be non-soil related, responses may include things such as education and counseling, or referral to environmental sampling/response programs offered by other agencies, as appropriate.

PUBLIC HEALTH PROGRAM TO REDUCE RISKS FROM PICA INGESTION OF ARSENIC

Chronic cancer and non-cancer risks from incidental ingestion of arsenic in soil will be addressed by the soil removal/disposal component of this remedial alternative. The public health alternative for arsenic is designed to focus specifically on the potential risks to young children from pica behavior. The program for arsenic will consist of three main elements:

1) Community and individual education about identification and potential hazards of pica behavior and the potential health consequences of excessive acute oral exposure to arsenic.

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2) A biomonitoring program by which any child may be tested to evaluate actual soil pica exposure to arsenic.

3) A program to respond to any observed inorganic arsenic exposures that are outside the normal range. This will include any necessary follow-up sampling, analysis, and investigation to help identify the likely source of exposure, and to implement an appropriate response that will help reduce the exposure.

- In yards with arsenic EPCs greater than 240 mg/Kg accessible soils would be removed to a depth of 12 inches and transported offsite for disposal at an appropriate facility. The excavation areas would be backfilled with clean soil containing arsenic and lead below PRGs, and pre-remediation yard features restored. Based on RI data, it is estimated that this would occur at a total of 113 residential properties within the entire site.

- In yards with lead EPCs greater than 540 mg/Kg, surface soils would be tilled to a depth of 6 inches and treated with phosphate. Pre-remediation yard features would then be restored. Based on RI data, it is estimated that this would occur at a total of 89 residential properties at the site (it is estimated that 8 of the properties with lead EPCs above 540 mg/Kg also have arsenic EPCs above 240 mg/Kg and would therefore be remediated by soil removal).

- To date, EPA has sampled the soil at approximately 75% of the residential properties within the VBI70 site boundary. Because the spatial pattern of lead and arsenic contamination is variable between properties, it is not possible to assess potential risks at a specific property without data from that property. Therefore, upon request from the owner or current resident (if access is granted by the owner), EPA will provide a program of on-going testing for lead and arsenic in soil at any residential property within the site boundaries that has not already been adequately tested. If the lead EPC exceeds 540 mg/Kg and the arsenic EPC is below 240 mg/Kg, soil at the property would be tilled and treated with phosphate. If the arsenic EPC exceeds 240 mg/Kg, soil would be removed and disposed offsite. This sampling program will operate for as long as the remedy operates.

Alternative 3 – Community Health Program, Targeted Removal and Disposal

Alternative 3 contains the following principal components:

- Implementation of a community health program, identical to the one described for Alternative 2, except that in future response actions on soils would entail removal and offsite disposal.

- In yards with arsenic EPCs greater than 240 mg/Kg or with lead EPCs above 540 mg/Kg accessible soils would be removed to a depth of 12 inches and transported offsite for disposal at an appropriate facility. The excavation areas would be backfilled with clean soil containing arsenic and lead below PRGs, and pre-remediation yard features restored. Based on RI data, it is estimated that this would occur at a total of 202 residential properties (105 properties for arsenic only, 8 for both arsenic and lead, and 89 for lead only).

- Implementation of a sampling program identical to the one described under Alternative 2. Under this alternative, at properties with lead EPCs greater than 540 mg/Kg or with arsenic EPCs greater than 240 mg/Kg, soil would be removed and disposed offsite.

Alternative 4 – Community Health Program, Expanded Removal and Disposal

Alternative 4 contains the following principal components:

- Implementation of a community health program, identical to the one described for Alternative 3.

- In yards with arsenic EPCs greater than 128 mg/Kg or with lead EPCs above 540 mg/Kg accessible soils would be removed to a depth of 12 inches and transported offsite for disposal at an appropriate facility. The excavation areas would be backfilled with clean soil containing arsenic and lead below PRGs, and pre-remediation yard features restored. Based on RI data, it is estimated that this would occur at a total of 403 residential properties (306 properties for arsenic only, 31 for both arsenic and lead, and 66 for lead only).

- Implementation of a sampling program identical to the one described under Alternative 2. Under this alternative, at properties with lead EPCs greater than 540 mg/Kg or with arsenic EPCs greater than 128 mg/Kg, soil would be removed and disposed offsite.

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Alternative 5 – Removal and Disposal

Alternative 5 contains the following principal components:

- In yards with arsenic EPCs greater than 47 mg/Kg or with lead EPCs above 208 mg/Kg accessible soils would be removed to a depth of 12 inches and transported offsite for disposal at an appropriate facility. The excavation areas would be backfilled with clean soil containing arsenic and lead below PRGs, and pre-remediation yard features restored.

This alternative would also include sampling of properties that were not sampled during the RI with soil removal at properties where lead or arsenic exceed the action levels. It is estimated that soil removal would be required at a total of 2,122 residential properties.

COMPARATIVE ANALYSIS OF ALTERNATIVES

The remedial alternatives were evaluated against the threshold and balancing criteria specified in the NCP and FS Guidance to ensure that the selected remedial alternative will: protect human health and the environment; comply with or include a waiver of Applicable or Relevant and Appropriate requirements (ARARs); be cost-effective; utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and address the statutory preference for treatment as a principal element. The modifying criteria of State and Community acceptance will be addressed by the USEPA after the FS is completed and prior to the finalization of the Record of Decision.

The nine evaluation criteria specified in the National Contingency Plan (NCP) are:

- Threshold Criteria
  - Overall Protection of Human Health and the Environment
  - Compliance with ARARs

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- Primary Balancing Criteria
  - Short-Term Effectiveness
  - Long-Term Effectiveness and Permanence
  - Reduction of Toxicity, Mobility and Volume Through Treatment
  - Implementability
  - Cost

- Modifying Criteria
  - State Acceptance
  - Community Acceptance

Detailed analyses were performed for each alternative, applying each of the threshold and primary balancing criteria. The remedial alternatives were also evaluated comparatively, relative to one another, within each criterion.

The No Action Alternative is not evaluated in the comparative analysis, but is considered as the baseline condition. The Baseline Human Health Risk Assessment indicates that no further action would be effective in preventing exposures to arsenic in soil above a 1×10^{-4} lifetime cancer risk, a chronic hazard greater than 1, or a sub-chronic hazard quotient greater than 1 for residents who have average or central tendency exposures. However, if no further action is taken at the site, screening level calculations suggest that high rates of soil intake associated with soil pica behavior in children might result in doses of arsenic which exceed an acute hazard quotient of 1, even for the central tendency pica exposure scenario. Also, no further action would not meet the RAOs for arsenic since they are established to be protective of RME exposures.

For lead, in order to help determine whether the IEUBK model is yielding reliable predictions at the VB/I70 site, USEPA compared the IEUBK model predictions to actual observations of blood lead levels in the population of children currently living at the site. Even though the available data are from studies that were not designed to support risk assessment, they do support the following:

A. Elevated blood lead levels occur in children residing within the site.
B. Soil is not likely to be the main source of elevated blood lead levels.
C. Elevations are not clearly different from areas outside VB/I70.

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One alternative IEUBK model run using recently published data on soil ingestion rates for children (Stanek & Calabrese, 2000), the site-specific relative bioavailability and site specific soil/dust ratio adjustments predicts that no further action would be effective in achieving the RAO for lead. The IEUBK model run using default assumptions for all parameters except the site specific relative bioavailability and soil/dust ratio predicts that no further action would not be effective in achieving the RAO for lead in soil. The range of results reflects the uncertainty in predicting whether further action is required to achieve the RAO for lead at the site.

A summary of the comparative analysis is provided below.

Overall Protection of Human Health

There is not a large difference is the performance of each of the alternatives against this criterion. Overall, however, the highest level of protection of human health as measured by the requirements of the RAOs, would be achieved by Alternative 3. Removal and offsite disposal of yard soils with arsenic EPCs above 240 mg/Kg or lead EPCs greater than 540 mg/Kg would be effective in preventing exposure to these soils, which are of the greatest concern with respect to human health risk. For other properties, implementation of a community health program would be expected to be effective in managing the remaining risks from soils due to the components of education, biomonitoring, source sampling and analysis, and response actions as necessary. In addition, the community health program would provide additional protection for the community, because it would provide the mechanism for evaluating other sources of lead (such as lead paint) that may cause exposures in the future, and for evaluating soil pica behavior which may be associated with other risks in addition to the risk of acute arsenic exposure.

Alternative 2 may provide a similar level of protection compared to Alternative 3, but there is some uncertainty associated with the tilling/treatment component to address soils with lead EPCs above 540 mg/Kg. Uncertainties are associated with the effect of tilling on surface soil concentrations (concentration profiles were not generated with depth or in different yard locations for the target properties, and therefore the resultant lead concentrations in surface soil after tilling are difficult to

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predict). Also, the effectiveness of phosphate treatment is uncertain (site-specific testing would be required to determine the chemical form and application rate; this would lead to a delay of at least a year in implementing this portion of the remedy).

Alternative 4 differs from Alternative 3 by adding soil removal from properties with arsenic concentrations greater than 128 mg/Kg. This alternative was developed and evaluated based on CDPHE comments regarding cleanup goals at the adjacent Globeville site (see Appendix D). Based on the findings of the Baseline Human Health Risk Assessment, this arsenic EPC corresponds to a point estimate risk level of 8×10^{-5}. Therefore the additional removal would address risks within EPA's acceptable risk range and would provide this level of protection for the 99th percentile of the exposed population; exposures which are very likely not occurring at the site. The RAO to prevent additional lifetime cancer risk due to ingestion of arsenic in soil and homegrown vegetables was established based on the findings of the risk assessment, consistent with the guidance set out in the OSWER Directive 9355.0-30 "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions". In part, this guidance states that "Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less that 10^{-4}, and the non-carcinogenic hazard quotient is less than 1, action is not warranted unless there are adverse environmental impacts." The directive further states that consideration of uncertainties in the baseline risk assessment may lead a risk manager to decide that risks lower than 10^{-4} are unacceptable, triggering the need for remedial action. EPA considered the uncertainty in the arsenic risk calculations for VB/I70 to determine whether remedial action is needed at properties where risks are predicted to be less than or equal to 10^{-4}. The uncertainty analysis in the Baseline Human Health Risk Assessment indicates that actual risks are much more likely to be lower than the calculated point estimates of risks. Providing protection at the 1×10^{-4} risk level based on the point estimates of risk is likely to provide a level of protectiveness for the RME scenario in the range of 2×10^{-5} to 7×10^{-5}. Therefore, it is not necessary to perform soil removals where arsenic EPCs exceed 128 mg/Kg in order to achieve protectiveness in this range for the RME scenario.

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Alternative 5 would provide the highest level of long-term protection and permanence against risks associated with soils because soils with arsenic and lead at levels of concern would be removed from the site. However, the extensive removals would entail short-term risks to the community due to the presence and operation of heavy equipment and the large number of truck trips required to dispose excavated soil offsite and to transport clean fill to the site. In addition, from a community perspective Alternative 5 may not provide the highest overall protection since it is likely that other sources of lead exist that would not be identified under this alternative and the occurrence of soil pica behavior would not be affected. The USEPA sponsored a study in urban areas of Baltimore, Boston and Cincinnati to investigate the efficacy of soil and dust abatement techniques in reducing blood lead values in children (USEPA 1995). Because of the study design, this investigation is usually referred to as the "three cities study". Among the key findings of this study was the conclusion that:

"... soil abatement alone will have little or no effect on reducing exposure to lead unless there is a substantial amount of lead in soil and unless this lead is the primary source of lead in house dust"

The report did not rigorously define "substantial", but it was only when soil lead levels were higher than 1,000 to 2,000 mg/Kg that a benefit from soil remediation was detectible. Conversely, in two cities where soil lead levels were mainly less than 1,000 mg/Kg, no substantial decrease in blood leads could be detected following soil remediation. As noted earlier, 99% of all properties tested in Phase III at the VB/I70 site have soil lead concentrations below 700 mg/Kg, with only three properties being above 1,000 mg/Kg. Also recall that, at the VB/I70 site, available data indicate that only about 34% of the mass of interior dust appears to be derived from yard soil. Thus, it appears that neither of the two conditions needed for soil removal to be effective are likely to apply at most properties at the VB/I70 site.

Compliance with Applicable or Relevant and Appropriate Requirements

All of the remedial alternatives evaluated in the comparative analysis would be expected to comply with ARARs. ARARs relating to the generation of fugitive dust and lead concentrations in ambient air would be applicable to the range of engineering actions under evaluation. Although the potential exists for dust generation during soil tilling and excavation, and transport and backfilling

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activities, engineering controls would be readily implementable and effective to achieving compliance with the applicable regulations. ARARs relating to the characterization, transport and disposal of solid wastes would be applicable for excavated soils and would be met by standard construction and transportation practices.

Short-Term Effectiveness

Alternative 3 provides the highest level of short-term effectiveness. Soil removal actions could be quickly and effectively implemented with little risk to workers or the community. Implementation of the community health program would be expected to be effective in managing the risks in other portions of the site related to lead and arsenic in soils due to the components of education, biomonitoring, soil sampling and analysis, and response actions when warranted.

Alternative 2 provides a slightly lower level of short-term effectiveness than Alternative 3, primarily because tilling/treatment actions would be delayed while treatability testing was performed and because there would be some uncertainties with the immediate effectiveness of the tilling/treatment activities due to lack of data on lead concentrations with depth and at different locations in the targeted yards.

Alternative 4 provides a slightly lower level of short-term effectives than Alternative 3, primarily because additional removals at properties with arsenic EPCs greater than 128 mg/Kg would entail greater risks due to the larger scope of removal actions and transportation of excavated soil and clean backfill through neighborhood streets, while not contributing to additional long-term protection of human health as set out by the requirements of the RAOs.

Alternative 5 would provide the lowest level of short-term effectiveness because of increased risks to workers and the community due to the long-term operation of heavy equipment in the residential areas and by truck traffic associated with transportation of excavated soil offsite and import of clean backfill (approximately 43,000 truck trips would be required).

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Long-Term Effectiveness and Permanence

Alternative 5 would provide the highest level of long-term effectiveness and permanence against risks associated with soils, because all soil with lead or arsenic EPCs above levels of concern would be removed from the site. However, from a community perspective it may not provide the highest overall protection since it is likely that there are other sources of lead (such as lead-based paint), which would not be evaluated and the occurrence of soil pica behavior would not be affected. Alternatives 2, 3 and 4 would provide a high level of long-term effectiveness by addressing soils with lead or arsenic EPCs at levels above risk-based objectives by tilling and treatment and/or removal. Risks associated with remaining yard soils would be effectively managed by implementation of a community health program under these alternatives. The program would provide the additional benefit to the community of providing a mechanism for identifying sources of lead exposure other than soils and abatement (abatement of exterior lead-paint would be performed under this program if soils at a property are an issue, or by referral to another program if soils are not an issue), and a program to reduce the likelihood of soil pica behavior in children within VB/I70.

Reduction of Toxicity, Mobility or Volume Through Treatment

Alternatives 3, 4 and 5 do not contain a treatment component and therefore Alternative 2 would result in the highest reduction of toxicity and mobility due to treatment. However, there are uncertainties with the treatment process and site-specific testing would have to be performed to evaluate the chemical form and application rate of phosphate and to evaluate the overall treatment effectiveness once implemented.

Implementability

Alternatives 3, 4 and 5 would be readily implementable with standard equipment and services, and adequate personnel would be readily available for this type of work. The construction technologies required to implement these alternatives are commonly used and widely accepted. For Alternative 2, tilling of residential soils may be difficult to implement. Areas of accessible soils within yards are

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relatively small and typically have features such as trees or large shrubs, which would make access and implementation of deep tilling difficult unless the features were removed and replaced. It is likely that due to access constraints tilling would have to be performed using rototillers, which typically have a working depth of about 6 inches. Lead concentrations with depth have not been generated for the target properties and if deeper tilling is found to be necessary to meet the RAOs it would be difficult to implement.

Cost

Estimated costs for each alternative considered in the comparative analysis are shown below. These costs include direct and indirect capital costs and review costs for 30 years (there are no operation and maintenance costs associated with any of the alternatives).

Remedial Alternative	Net Present Worth Cost (Millions)
Alternative 2	10.6
Alternative 3	11.1
Alternative 4	17.5
Alternative 5	61.0 (1)

Note: (1) Of this amount, approximately $15.6 million is associated with remediation of properties with arsenic EPCs above 47 mg/Kg but below 128 mg/Kg.

All alternatives meet the threshold requirements of protection of human health and compliance with ARARs. Alternative 3 provides a greater level of overall certainty for protecting human health compared to Alternative 2 and entails lower costs than Alternatives 4 and 5.

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