Health Consultation

Determination if Site-Specific Interior Dust Clean-up Levels are Protective of Public Health

HERCULANEUM LEAD SMELTER SITE

HERCULANEUM, JEFFERSON COUNTY, MISSOURI

EPA FACILITY ID: MOD006266373

JANUARY 15, 2004

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

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December 17, 2003

Prepared by:

Missouri Department of Health and Senior Services
Division of Environmental Health and Communicable Disease Prevention
Section for Environmental Public Health
under cooperative agreement with the
Agency for Toxic Substances and Disease Registry

STATEMENT OF ISSUES AND BACKGROUND

Statement of Issues

The Missouri Department of Health and Senior Services (DHSS) and the Agency for Toxic Substances and Disease Registry (ATSDR), were asked by the U.S. Environmental Protection Agency (EPA) to participate in a Herculaneum Lead Smelter Site workgroup. The workgroup consisted of two consultants (Dr. Scott Clark, Ph.D., PE, CIH and Dr. David Sterling, Ph.D., CIH), community members, representatives from the Missouri Department of Natural Resources (MDNR), ATSDR, DHSS and EPA. The workgroup was tasked with evaluating interior lead dust clean-up levels for Herculaneum. The workgroup submitted a final report, entitled the "Technical Report for Focus Group Recommendations, Herculaneum, MO" to the Community Action Group on October 6, 2003. Site-specific recommendations for establishing lead dust sampling protocols, setting clearance standards, determining if additional clean-up actions are necessary and developing a model work plan were included in the report.

EPA asked that DHSS, in cooperation with ATSDR, review the submitted report to determine if the site-specific interior lead dust clean-up levels that have been recommended by the work group, are protective of public health. This Health Consultation will review the recommendations of their report and make a determination if the clean-up levels are protective of public health.

Background

The Herculaneum lead smelter is an active facility that has been in operation in this community since 1892. The Doe Run Company currently owns and operates the smelter. The facility is located at 881 Main Street in Herculaneum, Missouri, approximately 25 miles south of St. Louis, Missouri, on the Mississippi River. The smelter abuts residential neighborhoods on the north, west, and south, with the Mississippi River on the east. A lead ore concentrate, consisting of approximately 80% lead sulfide, is processed at the smelter. The ore is transported by truck from eight lead mines operated by the company near Viburnum, Missouri, approximately 75 miles south-southwest of Herculaneum. The 52-acre Herculaneum facility consists of a smelter plant, 24-acre waste slag storage pile, and an onsite sulfuric acid plant (1).

The city of Herculaneum has an estimated population of 2,805 people, according to the 2000 US Census. Several homes are within 200 feet of the smelter plant, and currently at least three homes are within 200 feet of the slag pile, one of which is occupied. Figures 1 and 2 display the location of the smelter in relationship to the community (2). Three schools are in the city: a high school, a middle school and a junior high school. The elementary school is approximately two miles away in Pevely, MO. There are no licensed day-care facilities in the city of Herculaneum.

Environmental sampling has indicated that there is lead contamination throughout the community. For example, lead has been found in yard soils at concentrations up to 33,100 parts per million (ppm) (3) and in ambient air ranging from non-detectable (ND) to 85 micrograms per cubic meter ($\mu g/m^3$) (4). Lead concentrations on streets have been as high as 300,000 ppm (5), with loading levels up to 8.72 milligrams per square foot or mg/ft^2 (6). Although multiple sources of lead could be contributing to the overall contamination, an Exposure Investigation (EI) conducted by ATSDR in 2001 indicated that lead in paint and water at the two homes evaluated did not appear to be significant sources of lead exposure in the children who lived in these homes and had elevated blood lead concentrations (7).

Efforts to address the overall lead contamination in the community have intensified since September 2001, when the MDNR and the EPA confirmed that spillage of lead concentrate was occurring along transportation routes in the city (8). This information prompted DHSS to alert MDNR that the risks to the public surrounding the site were clear and present and that they were an imminent and substantial endangerment to the health of residents of Herculaneum (8). Subsequently, MDNR and EPA directed the Doe Run Company to expedite activities to clean-up existing contamination and reduce/eliminate future contamination throughout Herculaneum. The Doe Run Company, with oversight from MDNR and EPA, has implemented several exposure reduction activities since that time including addressing street lead contamination, controlling fugitive dust and smelter air emissions, soil removal/replacement and cleaning the interior of homes with elevated lead dust levels (8).

Despite the actions taken to address existing lead contamination in Herculaneum, active sources of contamination remain. The smelter is currently operational, and is expected to remain operational for the foreseeable future. Although many controls have been added to reduce fugitive dusts and stack emissions from the smelter, the smelter is still permitted to emit up to 858.8 pounds lbs of lead per day (9). Lead concentrate is trucked in for processing on a daily basis. Improvements have been made in the hauling procedures; however, small concentrate spills still occur, and concentrate is tracked out of the facility by the haul trucks. These factors together continually contribute to elevated soil lead levels. Elevated soil lead levels increase the lead loading levels at the exterior entry of homes, which in turn increases the interior lead dust levels in Herculaneum. A speciation study of samples collected from Herculaneum streets, soil and houses concluded that 30% of household dust comes from exterior soil and 50% is from road dust (6).

Many of the homes in Herculaneum have lead dust levels that pose a potential health threat to the residents living in them. As a result, in October of 2002, EPA asked Drs. Clark and Sterling, with input from the workgroup members, to evaluate current clean-up levels, establish lead dust sampling protocols, set acceptable clearance standards, determine if additional clean-up actions are necessary and develop a model work plan.

In addition to recommending a lead dust clean-up level, the report discusses clean-up strategies and monitoring plans to ensure that these actions will effectively reduce exposures to an acceptable level (6). For interior clean-ups, the report recommends following the protocol in the

HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing (10). The report recommends collecting interior samples before and after cleanup and on a quarterly basis thereafter to verify the effectiveness of the clean-up. The need for soil removal and replacement, long term interior and exterior monitoring, and continued health communication and education were reiterated in the report. The report also suggests the formation of an Oversight Board for continuing evaluation of the clean-up process and the establishment of a trust fund to help fund the clean-up of attics and walls as houses are renovated.

Discussion

In considering an appropriate and protective dust lead clean-up level for this site, Drs. Clark and Sterling and the EPA work group members reviewed the available Herculaneum environmental data and studies. They concluded that there was not enough existing data (blood lead screening data and the corresponding environmental data) to determine a dust lead clean-up level using only site-specific data (6). Thus, the available Herculaneum information was combined with studies conducted at other lead sites to form the basis for the Herculaneum Interior Dust Technical Report and Work Plan. Data from sites other than Herculaneum were considered for this report because they have similar contaminants and exposure pathways. The Technical Report is attached as appendix A and is referenced in this Health Consultation.

In developing a recommendation for a site-specific interior dust lead clean-up level for Herculaneum, scientific evidence was evaluated which indicates that the current EPA lead dust standard, 40 $\mu g/ft^2$ for floors, may not be protective of public health at this site. The EPA standard was designed primarily for houses where lead-based paint is the primary lead source (6). However, lead paint is not the only source of lead exposure in Herculaneum. For over 100 years, the smelter has released lead in their stack emissions as well as in fugitive dust from activities throughout the smelter, which has built-up in soil and other media over time. Although lead emissions from the smelter are declining, the smelter is still allowed to release up to 858.8 pounds of lead per day into the atmosphere (9). This continuing deposition and the historical environmental burden that has accumulated must be taken into account in the development of any interior lead dust clean-up level (6).

Additional evidence supporting the need for a site-specific interior lead dust clean-up level lower than 40 $\mu g/ft^2$ can be found at the Big River Mining Site, a nearby lead mining area of Missouri (6). The Big River Mining Site is similar to Herculaneum in that elevated lead concentrations were present in several site media and people were being exposed to that lead through several exposure pathways. Because of the multiple exposure pathways present at the site, a site-specific floor clean-up level of 24 $\mu g/ft^2$ was proposed and determined to be protective of public health at the Big River Mining Site (11).

Another factor that must be considered in determining clean-up levels for lead is the relative bioavailability. Relative bioavailability is a measure of how readily lead, or any other chemical, is taken up by the body. In general, the relative bioavailability of lead is approximately 30%. A

study was conducted to determine the relative bioavailability of lead from Herculaneum. The study concluded that the site-specific relative bioavailability of lead from Herculaneum was approximately 36%, which is higher than average (12).

Drs. Clarke and Sterling's review of these scientific studies and other lead site data analysis, were used as the scientific basis to propose an interior lead dust clean-up level of 20 $\mu g/ft^2$ for Herculaneum residences (6).

Currently, one-half of the houses in Herculaneum that have had interior clean-ups completed have average floor dust lead levels of less than 20 $\mu g/ft^2$ (6). With additional interior house dust lead removal, lead-based paint stabilization and ongoing street cleaning to remove lead, an interior lead dust clean-up level of 20 $\mu g/ft^2$ appears to be attainable (6).

Additional strategies to ensure that the actions taken at Herculaneum are effective and will effectively reduce exposures to an acceptable level were discussed in the report (6). For interior clean-ups, the report recommends following the protocol in the HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing (10). These are standard procedures used in interior lead abatements. The report recommends collecting interior samples before and after cleanup to verify the effectiveness of the cleanup. Quarterly sampling of home interiors is recommended in the report to ensure that there is minimal recontamination occurring and to ensure the long-term effectiveness of the cleanup. The need for soil removal and replacement, long term interior and exterior monitoring, and continued health communication and education were reiterated in the report. These activities are ongoing, and are expected to continue.

Child Health Initiative

Children and adults are exposed to lead in many of the same ways. However, children are not small adults. They differ in the behaviors that lead to their exposures as well as their susceptibility to toxic effects from lead exposures. Children are more likely to play outdoors and bring food into contaminated areas. They are also shorter than adults, so are more likely to breathe dust and soil that are close to the ground. Children are smaller, resulting in higher doses of chemical exposure per pound of body weight.

Further, children have rapidly developing body systems that can sustain permanent damage if toxic exposures occur during critical growth stages. Compared to adults, children absorb more of the lead they take into their bodies, retain more of the lead they take in, and are more sensitive to its effects.

Children in this community are being exposed to lead inside their homes as well as outside in their yards, playgrounds, parks, and while attending school. This community is faced with continuing widespread environmental contamination that is very different from other communities. Therefore, because children depend on adults for risk identification and management decisions, it is prudent that further lead exposure be prevented by such efforts as

lowering the interior lead dust clean-up level for this community and controlling other sources of lead in this community.

Conclusion

DHSS and ATSDR concur with the site-specific dust lead clean-up level (20 $\mu g/ft^2$) in the context of related activities (use of the HUD Guidelines, pre- and post-cleanup sampling, long-term quarterly sampling, continued soil replacements, health communication and education) proposed in the "Technical Report for Focus Group Recommendations, Herculaneum, MO."

The lead smelter in Herculaneum has operated for over 100 years, and will continue to operate and be a source of lead in the community for the foreseeable future. Several environmental media have elevated lead concentrations (soil, air, interior dust, road dust). Additionally, the lead present in Herculaneum has a relative bioavailability which is higher than average. These factors combined indicate that a site-specific interior lead dust clearance level lower than 40 $\mu g/ft^2$ is appropriate to create a margin of safety for the residents of Herculaneum. Based on the available information about the site and the information reviewed in this report, an interior lead dust clearance level of 20 $\mu g/ft^2$ offers that margin of safety.

The prudent public health actions outlined in the clean-up protocol and monitoring recommendations in the report are the logical steps necessary to ensure continuation of a safer environment for the residents of Herculaneum, Missouri.

Recommendations

1. EPA and MDNR should provide oversight to assure that procedures are implemented to attain and maintain the interior lead dust clearance levels in residences in Herculaneum as outlined in the Herculaneum Technical Report and Work Plan. In particular, the regulatory agencies should ensure that the HUD guidelines are followed for indoor clean-ups, that pre- and post-clean-up and longer-term quarterly samples are collected and analyzed to ensure effectiveness of the cleanup and that remedial efforts to decrease lead concentrations in other media should continue.

When additional information becomes available, DHSS will evaluate it thoroughly and, if appropriate, update existing assessment documents. ATSDR and DHSS will respond appropriately to any request for additional information or action.

PUBLIC HEALTH ACTION PLAN

The Public Health Action Plan (PHAP) for the Herculaneum Lead Smelter site contains a description of actions to be taken by the DHSS, ATSDR, and others. The purpose of the PHAP is to ensure that this health consultation not only identifies public health hazards, but also provides an action plan to mitigate and prevent adverse human health effects resulting from present and/or future exposure to hazardous substances at or near the site. Implicit in this plan is a commitment from DHSS and/or ATSDR to follow-up on this plan to ensure that it is implemented. The public health actions to be implemented by DHSS, ATSDR and /or cooperators are as follows:

1. DHSS/ATSDR will continue to evaluate any additional data that become available regarding human exposure or contaminants at the site, including identifying additional exposure pathways and evaluating health impacts of risk reduction and remediation plans.

2. DHSS/ATSDR developed and are implementing a comprehensive health education plan in this community. Those efforts will continue and will focus on increased childhood lead testing, awareness of lead poisoning, its adverse health effects, how to reduce exposures, especially for children, as well as residential interior lead dust clean-up and soil replacement.

3. DHSS and the Jefferson County Health Department (JCHD) should continue health education activities for both the people in the community and area health care providers. These activities should focus on awareness of lead poisoning, its adverse health effects, how to reduce exposures, and encourage blood lead testing, especially for children.

3. JCHD/DHSS/ATSDR will continue to assure case management of children with elevated BLLs.

4. DHSS/ATSDR are in the preliminary stages of initiating health study activities in this community.

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Attachments:

Figure 1- Site Map
Figure 2- Aerial Map
Appendix A – Technical Report for Focus Group Recommendations, Herculaneum, MO

Certification

This health consultation for the Herculaneum Lead Smelter Site was prepared by the Missouri Department of Health and Senior Services under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved methodology and procedures at the time the health consultation was initiated.

Technical Project Officer, SPS, SSAB, DAC

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this health consultation and concurs with its findings.

Section Chief, SPS, DHAC, ATSDR

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12. Casteel, Stan W., Evans, Tim E., Bratton, William J. and Hammon, Tracy L. Bioavailability of Lead In Test Materials. Doe Run Experiment 1. Draft. June 2001.

Figure 1

Map of Herculaneum, MO

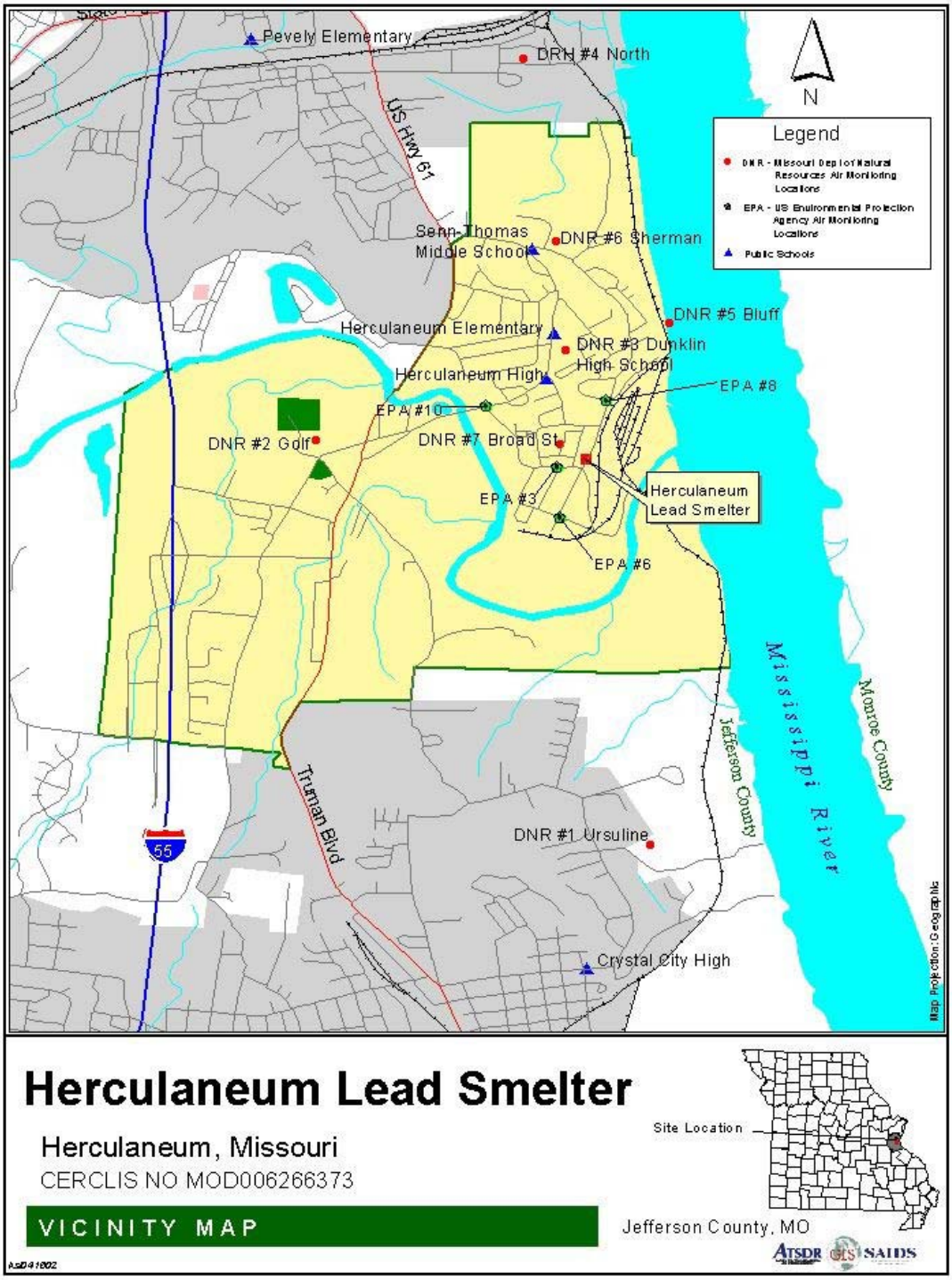
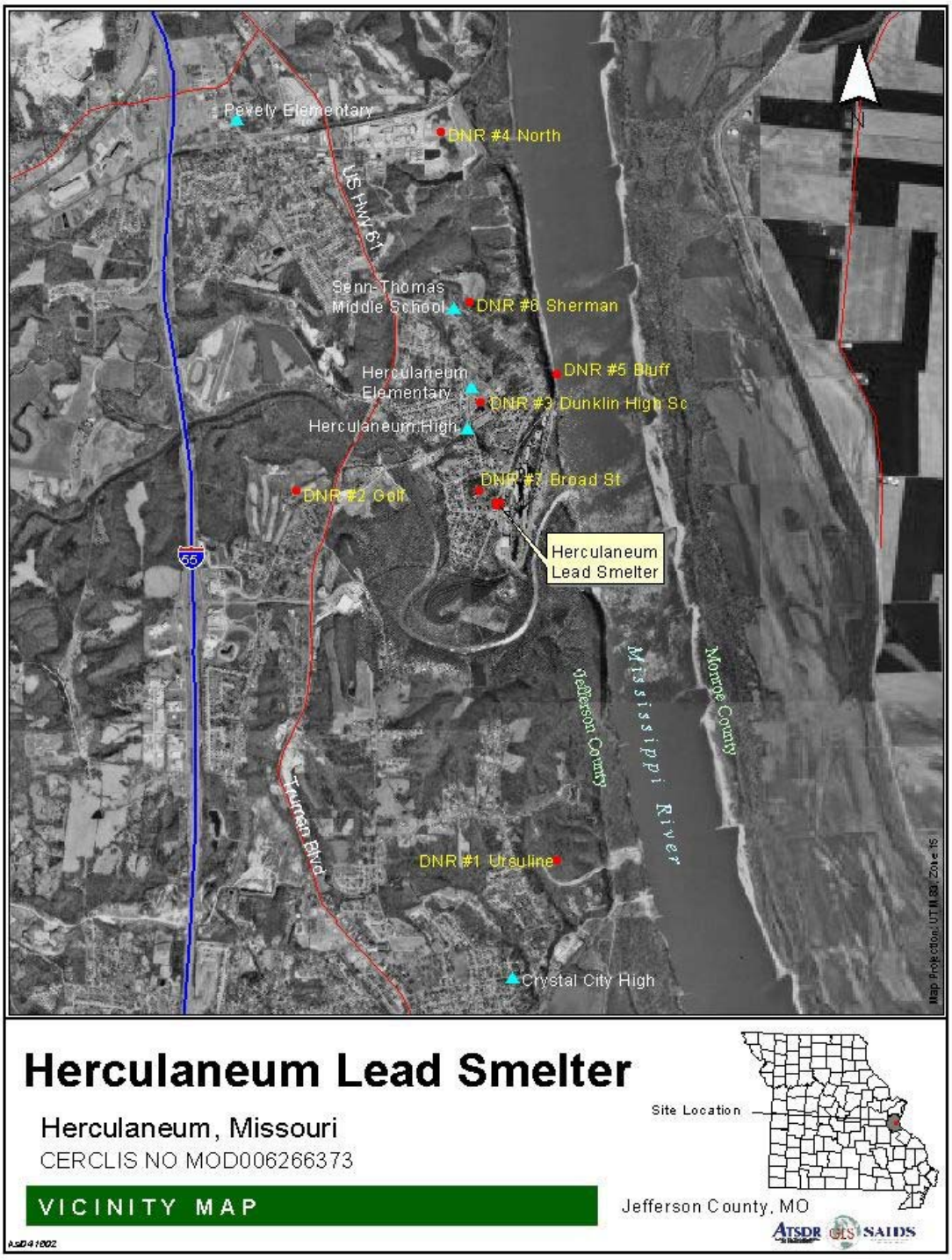


Figure 2

Aerial Map of Herculaneum, MO



Appendix A

Technical Report for Focus Group Recommendations
Herculaneum, MO

Technical Report for Focus Group Recommendations
Herculaneum, MO

October 6, 2003

Prepared By

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Contents

1. Background

A. Site Background (From SOW for - **Contract No. 68-S7-01-41, Task Order 0108)**

The Herculaneum Lead Smelter, located approximately 25 miles south of the St. Louis metropolitan area in Herculaneum, Missouri, is an active lead smelter that began its operations in 1892. Many studies have been conducted to help characterize the impact the smelter has had, or is currently having, on the surrounding community of Herculaneum, Missouri. Both past and present studies have indicated lead levels that exceed the current cleanup level for soil. This soil cleanup level is sometimes exceeded by more than 300 times. Current studies have shown that the road dust along haul routes contains extremely high concentrations of lead, which are of greatest concentration along the routes bringing lead ore to the smelter. These levels decrease in concentration as one moves away from the smelter along the routes taken by the empty trucks. In some instances, the lead concentration in road dust exceeded 190,000 milligrams per kilogram (mg/kg).

In addition to high levels of lead found in soil and road dust, several children have exhibited elevated blood lead levels (EBL). To help reduce the children's risk of exposure to lead, the soil from several yards were excavated and replaced with soil with lead levels below 240 mg/kg (mg/kg = ppm). The first groups of yards excavated were those surrounding homes with children exhibiting EBL. Eventually, all homes with soil lead concentrations above 400 mg/kg will be excavated.

For the surrounding community of Herculaneum, Missouri, cleanup or action levels were established for air, soil, and interior floor dust wipe and interior windowsill dust wipe samples. No levels were established for road dust or indoor carpet dust samples. The soil cleanup level of 400 mg/kg was established using the EPA Region 9 Preliminary Remediation Goals. The air action level of 1.5 micrograms per cubic meter (µg/m) was established using the National Ambient Air Quality Standards. The interior floor dust wipe cleanup level of 40 micrograms per square foot (µg/ft2) and interior windowsill dust wipe cleanup level of 250 µg/ft2 were established using standards developed by the Department of Housing and Urban Development (HUD). The HUD standards are based on protocols established for lead-based paint cleanup. Because these levels do not account for lead arising from sources other than lead-based paint, such as lead smelter activities, Tetra Tech START was tasked to coordinate the establishment of a proposed set of site-specific, scientifically-based interior lead dust cleanup levels. These proposed levels are to be developed by lead dust experts, with input from a Focus Group which would consist of members of the community, several federal and state agencies, and the potential responsible party.

B. Focus Group Objectives

EPA will engage members of the community; lead dust experts; and representatives from the Missouri Department of Natural Resources (MDNR), Missouri Department of Health and Senior Services, (MDHSS), Agency for Toxic Substances and Disease Registry (ATSDR), Jefferson

County Health Department, and the Doe Run Company to participate in the observation of the development of a site-specific, health-based, cleanup standard and action strategy for lead dust contamination present in home interiors:

i. Identify, provide and review critical and relevant studies on interior lead dust.
ii. Provide and review site-specific environmental data.
iii. Recommend site-specific health-based indoor dust cleanup level goals.
iv. Recommend site-specific sampling protocols.

2. Recommended Site-Specific Interior Cleanup Level -

Background

In developing a recommendation for site-specific, scientifically-based dust lead clean-up levels for Herculaneum, one of the factors to consider is the considerable scientific evidence that the current US EPA standard of 40 $\mu g/ft^2$ for floors is too high to ensure that less than 5% of the children have a blood level greater than 10 µg/dl (Lanphear et al, 1998). Additional evidence is from the Big River Site, a lead mining area of Missouri (Sterling et al, 1999). Another major consideration is that the EPA standard was designed to deal primarily with houses where lead-based paint (LBP) is the primary lead source. In Herculaneum, in addition to the lead-based paint that has been detected in some of the houses, there is also the additional source associated with the lead smelter activities. A portion of the exposure from smelter-related activities has been through the air for over 100 years. Fallout from these emissions has built-up in the soil and other deposition locations over time. Although lead from smelter emissions is apparently on the decline, Herculaneum has an historical environmental burden that has accumulated when the air lead levels and other emissions were considerably higher than at present.

An additional more recent lead source is spillage from ore concentrate that is now being trucked to the smelter on haulage roads that pass through residential areas of Herculaneum. We feel this is a major contribution to indoor dust based on: the lead speciation report by Johnson and Abraham (2002) indicating that the majority of house dust is derived from the soil and road; and the bioavailability report by Casteel et al. (2001) indicating that the ore concentrate was found to be an estimated 71% as bioavailable as the lead in lead acetate. In addition, the available dust lead data from the Herculaneum site exhibits a strong correlation of house dust lead with distance from smelter. House dust lead loading decreased as distance from smelter increased. For example, levels at one-half mile were about one-half of those at one-quarter mile; levels at one mile were about one-eighth of those at one-quarter mile. However, exterior dust lead levels were not correlated with distance from smelter, suggesting that they may be related to spillage from lead ore concentrate trucks that pass through the community.

The available blood lead data and corresponding environmental lead data for Herculaneum do not allow a determination with any certainty of the exact dust lead cleanup level to recommend using only site-specific data. An analysis of the limited amount of blood lead data available did

reveal a very strong correlation with distance from the smelter as mentioned in the previous paragraph with house dust lead loading. This suggests house dust is one of the major contributors of lead exposure to children. Floor clean-up levels of less than 24 µg/ft2 determined from the Big River lead mining site (Sterling et al., 1999) in St. Francois, MO, were found to be associated with no more than 5% of the blood lead values above 10 µg/dl. Over 80% of the sites evaluated from the Big River study had soil levels greater than 400 ppm, the soil clean up level presently being used in Herculaneum, and the lead dust is primarily from ore concentrate, also similar to that used in Herculaneum.

Suggested Workplan

Based on the above and similar findings by Lanphear et al. (1998) that the current EPA standard for floors of 40 µg/ ft^2 is not sufficiently protective, a floor lead clean-up goal that is lower than the current EPA standard for floors is recommended. From a scientific basis, and supported by Sterling et al. (1999), a goal of 20 µg/ft2 is recommended. Using the most recent data available, 12 of the 17 houses in Herculaneum have floor dust lead levels of less than 20 µg/ft^2 measured during the last sampling period of each house. With additional interior house dust lead removal, lead-based paint stabilization and repeated exterior lead dust street cleaning, the latter on an expanded area basis, the goal of 20 µg/ft2 appears to be attainable. There is no corresponding literature available for windowsill clean-up goals; however similar reasoning would suggest a goal of 125 µg/ft2. Currently 50% of the houses have windowsill lead levels consistently less than this value at the time of the last sampling period. There is a statistically significant trend for house dust levels to decrease with time, which may be related to long-term impact of soil replacement, street cleaning and cleaning of additional homes.

3. Recommended Site-Specific Interior Cleanup Protocols -

Background

For 15 of the 17 houses for which data has been presented, the special lead dust removal occurred prior to May 2002, the date that major emission control efforts at the Herculaneum smelter were in place. A communication provided to the Focus Group by Doe Run indicated that this premature cleaning might be responsible for some houses not meeting the HUD cleanup goal. We suggest that consideration be given to cleaning these houses again.

For 4 of these 17 houses, at least one dust wipe sample during the last recontamination sampling for that house had a lead level that exceeded either the EPA floor or window sill standard. Three of the 17 houses in the last sampling period exceeded the EPA floor standard. Four houses exceeded the windowsill standard, which included the same 3 houses above. Of the 3 exceeding the floor dust sample, 2 had interior lead-based paint present. These findings suggest that the soil removal and replacement at the house and/or the household cleaning program were generally sufficient to bring dust lead levels below the present EPA health-based standard and to the proposed clean-up level. If houses that were cleaned before completion of the major smelter emission control improvements were put into place are recleaned, as recommended in this report,

levels are likely to further decrease. The excedences of current EPA dust lead limits may be due to high levels of lead dust found in street samples, deficiencies in the house cleaning protocol, contamination from neighboring house areas that have not received either soil abatement or house clean up, contamination dust reservoirs in the house (e.g. attic spaces, basements and wall cavities), the presence of LBP, or continued contamination from the smelter operations or some combination of these factors.

The results of the carpet cleaning efforts are similar to those reported in Ewers et al. (1994) and Yiin et al., (2002), where the difficulty in cleaning carpets was demonstrated. These data support the recommendation that consideration be given to replacing some of the carpets. Establishing objective criteria involving actual dust lead measurements of individual carpets would be difficult and expensive. It would involve determining the loading (µg/ft), cleaning the carpet, retesting and determining if the cleanup level was met. If not met, replacement would be warranted. It is likely that the cost of this procedure would be at least as high as the cost of replacement. Review of the literature doesn't provide any explicit information as to when a carpet should be replaced when routine or even extensive cleaning fails to adequately reduce lead loading. In the Ewers, et al. (1994) study naturally soiled carpet was taken from homes and vacuumed at a rate of 1 min/m^2 using high efficiency vacuums. After four cleaning cycles of the carpets (total of 4 min/m^2) the cumulative average amount of lead removed was 74% of total that was removed after a total of 10 min/m^2. Ewers, et al. (1994) found that surface lead loading can actually increase after the first one or two vacuum cycles, however, on average lead loading will usually be reduced after the third cleaning. Lewis, et al. (2002) studied various aspects of lead loading, pile density, and wear on removal of lead-contaminated dust using a dry vacuuming process and typical home vacuum cleaners. Using artificially soiled carpets they found that lower initial lead leading did not affect of lead removal effect on removal from high or low-density carpet. At high loading, however, pile density had a major effect on lead removal with 54% more lead removal from low-density carpets. More importantly, at high levels of loading carpet wear has a significant effect on lead removal, particularly with low-density carpets (or possibly inexpensive carpets). In summary, it appears that many carpets may be able to be cleaned to reduce lead loading below HUD action levels. However it may take a number of thorough cleanings and the carpets may not remain clean if the carpet is heavily contaminated or worn. If carpet wipe dust lead levels do not meet the established goal after thorough cleaning, particularly if the carpet shows visible signs of wear, than it be removed from the house. It is recommended that, where feasible, new carpets not be put back into the housing, since it is easier to clean a solid hard surface more effectively than cleaning carpets. Some floors would have to be treated to fill cracks and other repairs made to make them cleanable and smooth enough for walking directly on them.

The carpets of many of the houses have been sampled using both the HUD wipe method and a HEPA sampling method on side-by-side areas. The HEPA method uses the same equipment as is used in the street and exterior entry dust sample collection. The vacuum method produces a sample that can be tested for both lead concentration (ppm) and lead loading (µg/ft^2). Statistical analysis has shown that the concentration and loading are correlated (r-squared = 0.75, $p < 0.0001$). The vacuum method sample has an average loading value about 150 times that of the wipe method since it is capable of capturing dust from below the carpet surface.

A brief examination of the X-Ray Fluorescence (XRF) paint lead monitoring results from Herculaneum revealed that 8 of the 15 houses for which data were available showed lead-based paint (>= 1.0 mg of lead per square centimeter) on interior and/or exterior surfaces. For the houses where exterior results were not provided, it was not noted whether or not exterior painted surfaces were present or tested. It is important that housing units be examined for lead-based paint using the protocol specified in the HUD Guidelines when elevated blood lead children are present or where dust lead level goals cannot be met. If the Jefferson County Health Department needs additional resources to conduct such an expanded testing program, it would be helpful if such resources were made available. Emergency paint lead stabilization and abatement funds/skills should be made available such as for EBL events or other homes where young children move in and lead dust goal levels have not been achieved.

Suggested Workplan

A. Basic Considerations

Ideally, cleaning should be performed in a manner so that residents can re-occupy the home the same day. In order for this to be accomplished, the analytical method used to determine if the cleanup goals had been met must be capable of providing results soon after dust wipes are collected, preferably within an hour. If floors have to be sealed, an overnight relocation will be required because the sealing material will take some time to dry. Residents should, if possible, not have more than one-overnight relocation. Doe Run and/or the cleanup contractor should be responsible for quickly replacing or fixing any items damaged by the cleanup with items of equal or greater replacement value. Prior to the initiation of any cleanup activity in a home the resident and the contracted cleanup team should meet to review a standard cleanup contract outlining the process and specific responsibilities of those involved. Consideration should be given to documenting pre-cleaning conditions through use of a video camera with the recording to be destroyed after satisfactory completion of the cleaning. Any special circumstances or issues associated with the residence and the scheduled cleanup will be noted and incorporated into the contract at that time. At a minimum, cleanup shall be performed following the protocol set forth in HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing. Sampling of lead levels shall be performed in all locations specified in the protocol and any other areas determined to be needed such as because of use as a living area or otherwise affecting the living area. If a Herculaneum or house-specific interior cleanup plan specifies more stringent or more extensive cleanup measures, the plan shall take precedence over the HUD Guidelines. A brochure should be developed, probably using an existing brochure as a starting point, to assist the residents in performing some special lead dust clean-up operations on their own. If overnight relocation is required, adequate provisions for relocation and lodging should be made.

B. Cleaning Method

The lead dust clean-up protocol in the HUD Guidelines for the Evaluation and Control of Lead

Based Paint Hazards in Housing (HUD, 1995) should be specifically followed. These guidelines specify important details such as the amount of time needed for the cleaning process for both carpets (HUD Chapter 11) and hard surface areas. Cleanup shall also include furniture and play area items. Cleaning should be performed in a manner so that residents can re-occupy the home the same day whenever feasible. Performing a post clean-up test method that provides immediate results is needed to facilitate this happening. Re-cleaning should occur in any room, and similar surfaces in rooms not tested, that exceed the set value for the sampling method used.

4. Recommended Site-Specific Interior Sampling Protocol

A. Pre-Cleaning Monitoring

Sampling for lead in house dust should be performed ***prior*** to all cleaning activities, and should occur no more than seven days prior to cleaning. A modified HUD evaluation protocol should be used which involves the collection of a minimum of seven to nine dust wipe samples taken from a minimum of 4 floors and 3 windows (Galke et al., 1999). Two children's bedrooms should be sampled if there is more than one child under the age of 6 living in the home. Recommended sampling locations include: floor sampling from the interior entry, doorways to the kitchen, youngest child's playroom area (may be living room) and bedroom, and second child's bedroom if present; interior window sills from the child's bedrooms, playroom and kitchen. Additional floor samples must be collected in the attic and/or basement if used as a living or play area, or otherwise accessed frequently.

B. Post Cleaning Evaluation Of Interior Cleaning Performance

Portable x-ray fluorescence analyzers (NITON, Inc.) are capable of providing rapid analysis of dust wipes as soon as they are collected as has been documented by research of the authors of this report. Readings should be taken for 60 nominal seconds as specified by the manufacturer. If results from floor dust wipe samples are at or above a value determined through site-specific developed calibration curves, the level shall assume to be at or above the clean-up level established and cleaning shall be repeated. Evaluation of cleaning should be performed. All testing for lead in house dust following cleaning should occur no sooner than one-hour after, and no later than 24 hours after cleaning is complete. Subsequent testing of cleaning should consist of samples alternating from one side to the other of the doorway or window for the first two times. If additional re-cleaning and testing is needed, samples should be taken from alternate windowsill and floor areas.

If carpet lead dust wipe results are greater than set value, and the carpet is not considered cleanable (i.e. would be damaged, etc.), then resident is eligible for carpet replacement, which includes removal of padding and cleaning of subfloor. Preferable to carpet replacement, as mentioned earlier, is ensuring that the uncarpeted floor is cleanable and otherwise appropriate for residential use. Otherwise, decisions will be based on post cleaning results. Collection of a wipe from an immediately adjacent area from which a carpet vacuum sample had just been collected

may provide useful additional information to be used in the decision-making concerning possible carpet replacement. If a carpet test following any cleaning, and particularly re-cleaning, exceeds set point, then resident should be considered for carpet replacement or making the floor cleanable.

An occupant satisfaction survey will be developed and used following the completion of all cleaning activities. The form should be designed to determine the resident satisfaction of the overall process and allow feedback for modification of the process and procedures as needed.

C. Follow-up Monitoring

All homes where cleaning is performed are to be checked on a quarterly basis if resources are available. Sampling will be performed in a similar manner and locations as the pre-cleaning monitoring. If one room exceeds the standard, a cleaning of that room must be offered. If two or more rooms exceed the standard, a cleaning of the entire house must be offered. If levels are found to be greater than or equal to 20 $\mu g/ft^2$ for two follow-up tests, a more thorough inspection for lead re-contamination sources will be performed. This inspection should include lead-based paint; evidence of dust lead seepage from attics, air ducts and walls and outdoor sources. The results of this inspection will form the basis for the development of a site-specific intervention plan, and corrective measures taken. A complete inspection and determination of potential source such as above should also be performed for all elevated blood lead events. In addition, interim control measures shall be performed/provided, such as walk off doormats for entryways to reduce the tracking of dust, sod for bare yard areas, and so on.

Homes cleaned on one or more occasions prior to the adoption of the Revised Interior Cleanup Plan shall be considered part of this plan, and are eligible for home quarterly follow-up based on the same guidelines. These houses should be considered for additional cleaning if dust lead goals have not been achieved. Issues associated with difficulty with obtaining initial and follow-up access into homes for cleaning and monitoring need to be addressed.

5. Other Action Items

A. Additional Sampling (other than interior)

<u>Soil Replacement and Monitoring</u>

Background

A significant amount of interior dust comes from exterior sources. This connection has already been recognized in the Herculaneum cleanup project, insofar as residents are not eligible for interior cleaning unless they first have their yard soil tested and replaced where necessary. Yard remediation should be done in the most effective manner possible with the least amount of inconvenience to residents. Soil contamination poses two risks: residents can be exposed to lead directly from soil dust while they are outside their own and neighbors yards, and soil dust

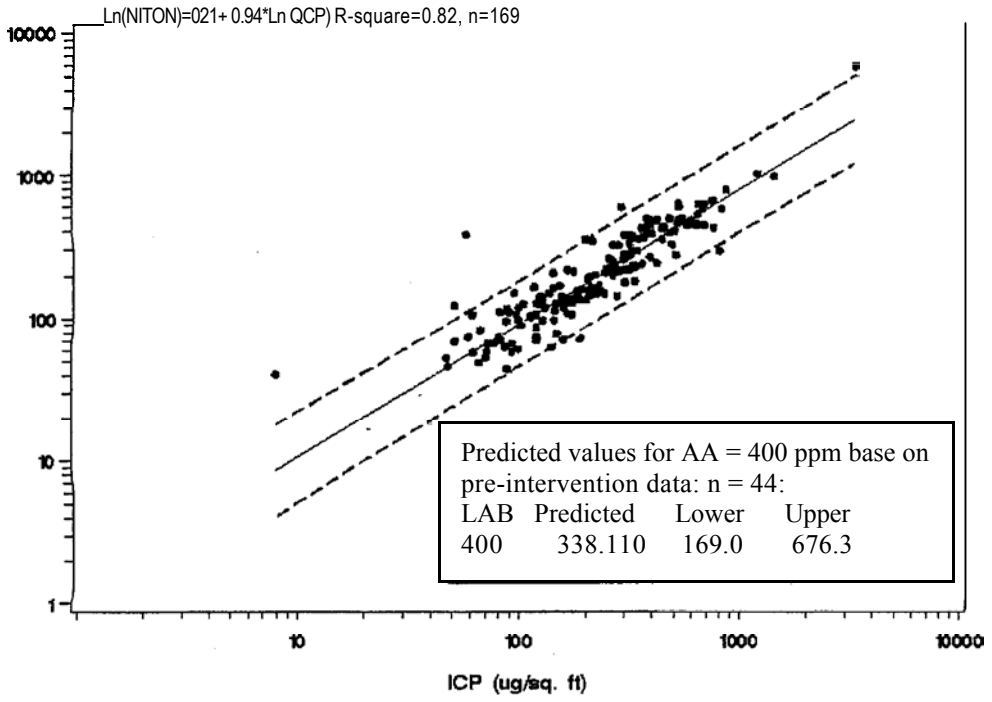
(containing lead) can contribute to household dust and hence to interior lead exposure. It is important that all residents eligible for soil testing and replacement participate in the program to help reduce potential for recontamination of neighboring areas.

The current US EPA standard of 400 ppm for bare soil in residential areas appears to be appropriate for Herculaneum. Post intervention soil lead measurements in Herculaneum to check for recontamination show an overall mean of 87 ppm. An ATSDR Health Consultation noted one home in Herculaneum that had its soil replaced in 1999 with soil containing 14 ppm lead (ATSDR, 2002), had levels above 400 ppm in testing performed in 2001. This shows that recontamination has occurred. Since replacement soil containing only 14 ppm was apparently available in 1999, we recommend that replacement soils have a lead level less than the current guideline of 100 ppm, provided that the soil also meets agronomic requirements.

Using the soil preparation methods practiced at the time of this data collection the field portable XRF (X-ray fluorescence analyzer) device gave lead measurements that tended to underestimate the soil lead concentrations. For example as demonstrated in Figure 1, using the pre-replacement available data the XRF must give a reading of 170 ppm or less for there to be a 95% certainty that the soil lead concentration (as measured by atomic absorption (AA) analysis) is in fact less than 400 ppm (Clark and Sterling, 2002). It may be useful to investigate other methods of preparing soil samples, such as by a simple sieving process that can be performed in the field, so that the XRF results more closely match those obtained with atomic absorption. Another field portable lead-testing method that could be investigated for possible use is Anodic Stripping Voltammetry (ASV).

Figure 1

Relationship Between Soil Lead Levels Measured by Field Portable XRF and by ICP Method (Pre-intervention)



Suggested Workplan

It is important to increase the participation of residents in the soil sampling and replacement program. Use of sod rather than grass seed could increase the percentage of residents who participate in the program. The yard remediation procedure should not take longer than one week; from the time removal of old soil begins until the time the sod has been completely installed. In addition this work should be completed during the workweek (i.e. bare soil should not be left exposed over a weekend). There should be a minimum of six inches of topsoil; the soil should have a low lead content (less than 100 ppm and as close as possible to the national average of 40 ppm). However, the replaced soil/sod must meet the agronomic needs for which it is intended.

Based on a review of the results of the post-intervention soil monitoring protocol, there does not appear to be any evidence that the replaced soil is becoming contaminated during the first year since soil replacement. Since soil recontamination would be initiated with the top layers of soil becoming contaminated from fallout or ground level transport of lead containing particles, the top one-inch soil lead sample would not readily reflect such contamination. Surface scraping samples are a more sensitive indicator of contamination of the replaced soil by lead dust and were instituted by the EPA in Herculaneum during 2003. We did not have the opportunity to review the additional surface soil sampling data and so cannot comment on those results. If a written protocol is not yet prepared, a protocol for a soil-scraping sample is available in the Protocol from the Three City Urban Soil-Lead Abatement Demonstration Project (EPA 1993).

We suggest that quarterly monitoring include a collection of soil surface-scraping samples B.

B. Long-Term Monitoring

Long-term monitoring is important to evaluate the success of any intervention implementation programs, to detect needed modifications/changes, and to help determine the need for continuing corrective actions. This monitoring should be performed at homes that participate in the cleaning program and/or soil replacement program, at selected sentinel homes and at selected street sample locations. Long-term sampling method types should include those for settled dust within homes (wipes and carpet vacuum samples), exterior and interior dust fall, soil scraping and cores, and street and exterior entry dust vacuums. Methods for all sample collections have been previously described here and/or elsewhere.

Dustfall data would provide another way to monitor the impact of emission control measures associated with the smelter and its operations and the neighborhood dust lead removal efforts. Protocols for interior dust fall are available from the Trail, B.C. Task Force and from the US EPA Urban Soil Lead Demonstration Project (EPA/600/AP-93/0010, August 1993). Exterior dust fall measure should be obtained at areas that can be kept secured, such as air monitoring stations and/or by the EPA trailer or school, and that are representative based on distance and typography. We understand that EPA/Tetra Tech are considering and performing a dustfall trial. They should reference and/or discuss the dustfall method that they are developing.

We also recommend two exterior dust vacuum samples being added to the house testing protocol: an exterior entry sample and a street sample. These samples can be collected by the procedure that is currently being used in Herculaneum to collect street dust samples. At the time of the completion of this report, it is our understanding that this additional monitoring had already been added to the Herculaneum sampling protocol.

Table 1: Recommended Long-term Sample Locations, Types and Frequency

	Locations				
Sample Type	Sentinel	Interior Cleaning	Soil Replacement	Streets	Other
Dust Wipe	Quarterly	Quarterly			
Dust Vacuum - Carpet	Quarterly	Quarterly			
Dust Vacuum - exterior entry	Quarterly	Quarterly		Quarterly	
Dust Vacuum - street	Quarterly	Quarterly		Quarterly	
Dust Fall - Interior	Quarterly	Quarterly			

Dust Fall - Exterior					Quarterly - secure location
Soil Sera in -					
Soil Core	Bi-annually		Bi-annually		

C. Trust Fund

It is more cost effective to perform attic and wall cleanup at the same time as home renovations are underway, or as additional lead-based paint hazard reduction measures are performed. Timing is the issue, and if these activities were going to occur after much of the other lead exposure reduction measures were to be implemented, then it would make sense to establish some procedure to make sure funds were still available to support these efforts. The time when ceilings and walls are removed/replaced/repaired also presents good opportunity for considering whether additional insulation is needed for the home. The need for such insulation is independent from the lead issue, but it would be more economical to perform when access to wall space and attics is available. Other activities that might be included in such a fund are:

- Home renovations that will disturb areas not previously sampled and may be contaminated, such as air ducts, wall partitions, attics, ceilings, and basements;
- Further sampling and intervention needed when goals cannot be met - such as house dust levels after two follow-ups, recontamination of yards, and so on;
- Additional investigations and corrective action resulting from EBL events;
- Monitoring and cleaning needed when families are moving into previously untested homes with children;
- Long term relocation during home remediation; and,
- Permanent relocation, such as home buy out. A mechanism/plan is needed to eventually bring these into lead safe housing condition for re-occupancy or to be replaced by new housing.

D. Health Communication -

Background

Implementation of an effective workplan requires that Herculaneum residents believe that the plan is effective, they must trust the individuals that will be implementing the plan, and they must participate in the plan. Such trust cannot be expected unless the residents are provided sufficient information about, and input into, the process. This can be best achieved through some or all of the following educational/communication methods.

Community-specific literature is needed. This information is also needed for painters, remodelers, hardware stores in addition to homeowners and renters. It would also be useful to develop or locate existing education modules that can be used in the public schools at various grades. If there is a vocational school in the area that has home improvement courses, they might be able to disseminate the educational materials.

Educational materials should be prepared for such activities as renovations, attic access and wall interior remediation. The results of the exploration of Doe Run test and other homes could provide site-specific intervention techniques and photos of situations that occur in Herculaneum.

It is necessary to provide for the disclosure to present and future home occupants and owners on existing and potential lead hazards. This is important and is required by law when there is information on lead hazards. This information disclosure also should include real estate agents, financial institutions, etc.

The broad representation of the Task Force can help develop appropriate delivery modes for educational materials. It would be useful to invite others to observe some of the Task Force and other related meeting and/or to hold the Task Force meetings in conjunction with PTO's, and so on. There may be a teacher(s) in the school system that is interested in using some aspect of the Task Force activities as a class project or for extra credit. The State of California produced a `lead calendar' a couple of years ago which used drawings by school kids to illustrate a number of points- the effects of lead on children, ways lead exposure occurred, ways to reduce lead exposure, etc. There are a number of such examples. Maybe some can be developed here.

A focus group could also explore reasons why soil replacement and special home treatment for lead removal programs do not seem to be acceptable to a number of community members.

E. Task Force

All Herculaneum work plan activities shall have an ongoing evaluation such as by a Community Oversight Board.

Such a board could consist of members from the following groups:

- The Herculaneum Community Advisory Group
- US EPA
- Other agencies (DNR, ATSDR, etc.)
- Doe Run Corporation
- Contractors
- Outside experts

The Board could review comments or complaints made by residents. The Board could report grievances and recommend courses of action to remedy such grievances to the responsible parties.

To aid the Board, residents should be given evaluation forms to complete upon conclusion of any workplan activities. These evaluation forms should be simple to complete and submit to the Board.

On an annual basis all workplan activities shall be evaluated in order to:

- *Assess the effectiveness of the plan.* Measures of effectiveness include community participation rates, level of community satisfaction with the decontamination program, efficiency of the protocol, and attainment of lead contamination goals.
- *Recommend and implement changes to the plan, if* deemed necessary to increase the effectiveness of the cleanup process. The cleanup plan shall maintain its basic structure and function in any revisions, but specifics such as cleanup procedure, lead clearance goal levels, or grievance reporting mechanisms may be modified to better achieve Herculaneum health goals.

6. Other Action Recommendations

A. Impact of Street Dust Lead on the Environment

Background

Since lead in dust is mobile, it can move from site to site within a community. Such movement varies with time and varies between communities depending on the sources and activities occurring. Street dust lead has been found to contribute to the loading at the exterior entry to housing, which then impacts interior dust lead levels. In Herculaneum, spillage of lead concentrate from haulage activities can contribute to high street dust lead levels in some areas. In areas where paint lead is the major source, soil and exterior entry dust lead has been contributing to soil lead. Lead levels in various environmental compartments (street dust, other exterior dust, soil and interior dust) are interrelated. Since the sources of the lead can vary, the pathways among the environmental lead variables can also vary. In the HUD Evaluation (Clark et al., 2003), which involved houses in many areas of the country, it was found that in general lead from housing (exterior dust and soil) affected lead levels on streets. (In Herculaneum the reverse may be true, especially along the haulage routes.) In addition, the HUD evaluation results showed that lead at the exterior entry of the house moved toward the interior portions of the house. A study of samples in Herculaneum from streets, soil and houses concluded that 30% of household dust comes from exterior soil and 50% is from road dust (Johnson and Abraham, 2002). Similar conclusions about the contribution of soil to interior dust were reached in several other studies conducted outside of Herculaneum: One study estimated that 30% of household dust carne from soil (Calabrese and Stanek, 1992). Another study found that 37% of household dust came from soil (Sterling et al, 1998). Yet another study estimated that 50% of household dust originated in soil (Forbes et al, 1986). Monitoring all three locations can help in subsequent corrective actions for homes where re-contamination continues to be a problem.

Dust lead levels on Herculaneum streets are the highest reported (Clark and Sterling 2002), probably due in part to the transport of lead concentrate through the streets in Herculaneum. A review of the street cleaning data presented at the September 2002 Focus Group Meeting

revealed a considerable overlap in lead dust concentration and loading between primary and secondary lead concentrate haul routes Overall, concentrations and loadings appear to be lower on the secondary haul routes than along primary haul routes. There is, however, a considerable overlap in the ranges of values with maximum values at sampling locations varying from 5900 to 190,000 ppm (mg/Kg) compared to 37,000 to 94,000 for the primary routes. Values at secondary route sampling stations ranged from 1,009 to 34,900 ppm (median 3,700) and 0.72 to 7.22-mg/ft^2 (median 1.34), compared to 8,100 to 40,000 ppm (median 16,000) and 0.77 to 8.72 mg/ft^2 (median 2.38) for the primary route stations. The overlap raises the question of whether other streets in Herculaneum have similarly high levels. Concentrations of lead in street dust in Herculaneum (median of 16,000 ppm and 3,700 ppm on primary and secondary routes, respectively) are much higher than those in Trail where levels were 1123 ppm before the new smelter was built and 888 ppm afterwards. The street dust lead loadings in Trail decreased from 20 mg/ft^2 before the smelter was installed to 11 mg/ ft^2 afterwards. The Trail levels are much higher than those in Herculaneum, median of 2.38 mg/ft^2 and 1.34 mg/ ft^2 on primary and secondary routes, respectively.

Suggested Workplan

To evaluate the relationship between exterior entry dust lead and lead levels in street and house dust, we recommend that the sampling method presently used in Herculaneum to obtain street samples should be employed at all homes being monitored to sample their exterior entry areas and adjacent street dust. Additionally, street dust monitoring locations should be established near the smelter - especially near entries and exits to property (haulage roads, employee and supplier entry roads etc) to help monitor the effectiveness of smelter emissions and haulage spillage reduction activities. Sampling sites on streets that are not primary or secondary haulage routes should also be selected.

The frequency of the monitoring for street dust should be quarter, but with the additional sampling specified here and in later sections following. Depending on the results of this expanded street dust sampling, the need for cleaning these other areas can be assessed. If levels are similar to primary or secondary haulage routes, cleaning should be considered on a similar frequency.

B. Sentinel housing

Houses of representative ages and locations in regards to distance from the smelter and ore haulage routes should be included. It is possible that this has already occurred. It should be possible to find data on the age of the Herculaneum housing stock to make sure that the houses sampled are representative of the housing in the community.

C. Test housing/Attics/Walls

Attics are usually very dusty. Since attics are usually designed to have ventilation that is adequate to prevent moisture build-up, there are openings to the outside air. These openings have allowed

air contaminants to enter the house over the years and the particles to settle. Sealing the attics would have to be performed in a manner that would preserve the ventilation characteristics while at the same time trying to minimize entry into the living space. Provided the ceilings are intact, most of the attic contaminating that enters the living space probably comes through the access to the attic (trap doors, pull-down stairs, regular stairs etc). It would first have to be determined the type of access to the attics and the use of the attics. This can range from very limited through a trap door of some type to fully finished attics. It is likely that many of the homes have the former type. If that were the case it probably would be more effective to prepare a better trap door, taking care to prevent house contamination during the process. If the ceilings below the attics are in poor condition and contain lead-based paint, then replacement may be warranted since patching plaster is expensive. To obtain a smooth finish, moreover, it is usually more economical to replace the plaster ceiling with drywall. If that were done, it would make sense to clean the attic at the same time since the dust would be disturbed in the process. The basic cleanup effort needed for this task, would amount to a major portion of the attic clean up.

In order to explore the level of lead contamination in attics and within wall, and the impact of attic fan use, it would be useful to explore contamination levels and useful remediation techniques in some vacant houses that have been purchased by Herculaneum. Various approaches could be taken to clean attics, ductwork and walls; the extent of lead contamination in these areas could be determined and the extent to which these locations of lead dust contaminate the living space could be explored. As long as attics are not part of the living space, site-specific clean-up levels would not need to be achieved, only a significant reduction in available lead dust and a reduction of its impact on living areas.

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