Public Health Assessment for

OMAHA LEAD REFINERY
OMAHA, DOUGLAS COUNTY, NEBRASKA
EPA FACILITY ID: NESFN0703481
June 7, 2004

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

Comment Period Ends:

AUGUST 6, 2004

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency=s best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency=s opinion, indicates a need to revise or append the conclusions previously issued.

Please address comments regarding this report to:

Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Attn: Chief, Program Evaluation, Records, and Information Services Branch, E-60
1600 Clifton Road, N.E., Atlanta, Georgia 30333

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PUBLIC HEALTH ASSESSMENT

OMAHA LEAD REFINERY

OMAHA, DOUGLAS COUNTY, NEBRASKA

EPA FACILITY ID: NESFN0703481

Prepared by:

Superfund Site Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced.
(The legal definition of a health assessment is included on the inside front cover.) If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment program allows the scientists flexibility in the format or structure of their response to the public health issues at hazardous waste sites. For example, a public health assessment could be one document or it could be a compilation of several health consultations, the structure may vary from site to site. Nevertheless, the public health assessment process is not considered complete until the public health issues at the site are addressed.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is

not available. When this is so, the report will suggest what further public health actions are needed.

Conclusions: The report presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high risk groups (such as children, elderly, chronically ill, and people engaging in high risk practices), they will be summarized in the conclusion section of the report. Ways to stop or reduce exposure will then be recommended in the public health action plan.

ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Interactive Process: The health assessment is an interactive process. ATSDR solicits and evaluates information from numerous city, state and federal agencies, the companies responsible for cleaning up the site, and the community. It then shares its conclusions with them. Agencies are asked to respond to an early version of the report to make sure that the data they have provided is accurate and current. When informed of ATSDR's conclusions and recommendations, sometimes the agencies will begin to act on them before the final release of the report.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Chief, Program Evaluation, Records, and Information Services Branch, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E60), Atlanta, GA 30333.

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List of Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
ASARCO	American Smelting and Refining Company
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminant of Concern
CREG	Cancer Risk Evaluation Guide
CVs	Comparison Values
DCHD	Douglas County Health Department
EMEG	Environmental Media Evaluation Guide
EPA	United States Environmental Protection Agency
HUD	Department of Housing and Urban Development
IARC	International Agency of Research on Cancer
IRIS	Integrated Risk Information System
IEUBK	Integrated Exposure Update Biokinetic Model for Lead in Children
LSOC	Lead Safe Omaha Coalition
MCL	Maximum Contaminant Level
ppm	parts per million
mg/kg/day	milligrams per kilogram per day
MRL	Minimal Risk Level
NCEH	National Center for Environmental Health
NHHS	Nebraska Health and Human Services
NOAEL	No Observed Adverse Effect Level
NPL	National Priority List
OCS	On-Scene Coordinator
OSHA	Occupational Safety and Health Administration
PHA	Public Health Assessment
RBC	Risk-Based Concentration
RfD	Reference Dose
RMEG	Reference Dose Media Evaluation Guide
RPM	Remedial Project Manager
SDWA	Safe Drinking Water Act
TRI	Toxic Release Inventory
µg/dL	micrograms per deciliter
XRF	x-ray fluorescence

Summary

The Agency for Toxic Substances and Disease Registry (ATSDR), in Atlanta, Georgia, is one of the agencies of the U.S. Department of Health and Human Services. ATSDR is required to conduct a Public Health Assessment (PHA) for sites proposed for the U.S. Environmental Protection Agency's (EPA's) National Priorities List (NPL). ATSDR conducts PHAs under authorities provided by the Superfund law (Comprehensive Environmental Response, Compensation, and Liability Act of 1980 [CERCLA]) and its amendments. The Omaha Lead site was proposed for the National Priorities List on February 26, 2002 and listed on April 30, 2003.

The Omaha Lead site includes residential properties, childcare facilities, schools, and other properties in the city of Omaha, Douglas County, Nebraska. Those properties have been contaminated with lead from air emissions from lead refining operations and other sources. The site area covers about 8,840 acres. It roughly extends south from Ames Avenue to L Street and eastward from 45th Street to the Missouri River, excluding the central business district. ATSDR's evaluation of the 2000 Census data indicates that about 86,000 residents live within the identified site area. Nine thousand seven hundred of these are children 6 and younger.

The American Smelting and Refining Company (ASARCO) operated a lead refinery on the west bank of the Missouri River in downtown Omaha from the early 1870s. The company closed the 23-acre refinery site in 1997. ASARCO is considered to have been the primary source for the soil contamination in the Omaha Lead initial site investigation area. Other sources of lead contamination may include lead-based paint and lead deposited from automobiles that used leaded gasoline in the past.

As part of this PHA, ATSDR used a database on child blood lead levels from the Douglas County Health Department (DCHD) and a database containing the available soil lead data from EPA. The soil database provided by EPA contained results for lead for 13,500 samples from about 2,200 locations, including 278 locations in Council Bluff and Carter Lake, Iowa. The other samples were taken in or near Omaha, Nebraska. Most of these were taken within 5 miles of the former ASARCO facility.

Soil data show that most of the locations where the lead concentrations exceed the EPA Action Level of 400 parts of lead per million parts of soil (ppm) lie within or next to the Omaha Lead site. EPA is removing soil that contains more than 400 ppm of lead from homes and daycare facilities that have a child or children with blood lead concentrations exceeding 10 micrograms per deciliter (µg/dL). In the removal action, residences are cleaned up based on a priority list where the properties with the highest lead levels are done first.

DCHD provided ATSDR with the results of its surveillance of blood lead testing completed for children 6 years old and younger in Douglas County since 1992. From this data set, ATSDR selected 12,754 records from July 2000 through August 2002, which is similar to the period for EPA's soil lead testing. For the Omaha Lead initial site investigation area, 9.7% had blood lead levels of 10 µg/dL or greater compared to 5.5% for Douglas County, 2.0% for Nebraska, and 3.1% and the United States.

Of the 289 children in the Omaha Lead initial site investigation area with elevated blood lead levels, one had a level greater than 69 µg/dL and two had levels between 45 and 69 µg/dL. Of the remaining children with elevated levels, 101 had blood lead levels between 15 µg/dL and 44 µg/dL, and 185 had levels of 10–14 µg/dL. Those children with blood lead levels 10–20 µg/dL are at risk of having decreases in IQ, and slightly impaired hearing and growth. Those children with levels of 20–40 µg/dL could experience problems in metabolizing vitamin D. Children with levels greater than 40 µg/dL could experience anemia and other blood-related problems.

From the available information, ATSDR concludes that the ongoing exposure to lead of children under 6 years old living in or near the Omaha Lead initial site investigation area is putting them at risk of experiencing lead-related health effects. This exposure is evidenced by the presence of nearly 300 children with blood lead levels of 10 µg/dL or greater in or near the site area. ATSDR concludes that the main sources for the lead in children are lead-based paint and soil contaminated with lead emitted from the operation of the ASARCO refinery.

Soil testing and soil removal actions were ongoing at the time this PHA was completed. ATSDR has evaluated the effects of EPA's current clean-up and removal actions on human health. ATSDR concludes that the EPA clean-up criterion is protective of public health as a result of the removal of lead contaminated soil and the elimination of continued exposure to children.

ATSDR recommends that EPA continue to investigate and remove soil contaminated with lead at levels greater than the current action level of 400 ppm or a level based on the ongoing human health risk assessment from homes with children 6 years of age and younger and daycare facilities. In addition, DCHD, the National Center for Environmental Health (NCEH), Nebraska Health and Human Services (NHHS), and ATSDR should initiate a plan regarding lead hazards that would increase public knowledge regarding lead hazards, promote primary prevention activities, and promote and facilitate yearly blood lead testing for all children 6 years and under living in or near the Omaha Lead initial site investigation area. Aggressive blood lead testing of young children would increase the likelihood of identifying children currently exposed. This would allow timely interventions such mitigation of lead-based paint and clean up of contaminated soil.

Introduction

The Agency for Toxic Substances and Disease Registry (ATSDR), in Atlanta, Georgia, is one of the agencies of the U.S. Department of Health and Human Services. ATSDR is required to conduct a Public Health Assessment (PHA) for sites proposed for the U.S. Environmental Protection Agency's (EPA's) National Priorities List (NPL), under authorities provided by the Superfund law (Comprehensive Environmental Response, Compensation, and Liability Act of 1980 [CERCLA]) and its amendments. The Omaha Lead site was proposed for the National Priorities List on February 26, 2002 and listed on April 30, 2003.

ATSDR researches and prepares PHAs to evaluate a community's exposure to contaminants at hazardous waste sites. ATSDR also makes recommendations regarding the public health activities that may be necessary. The evaluation may include some or all of the following broad categories of public health activities:

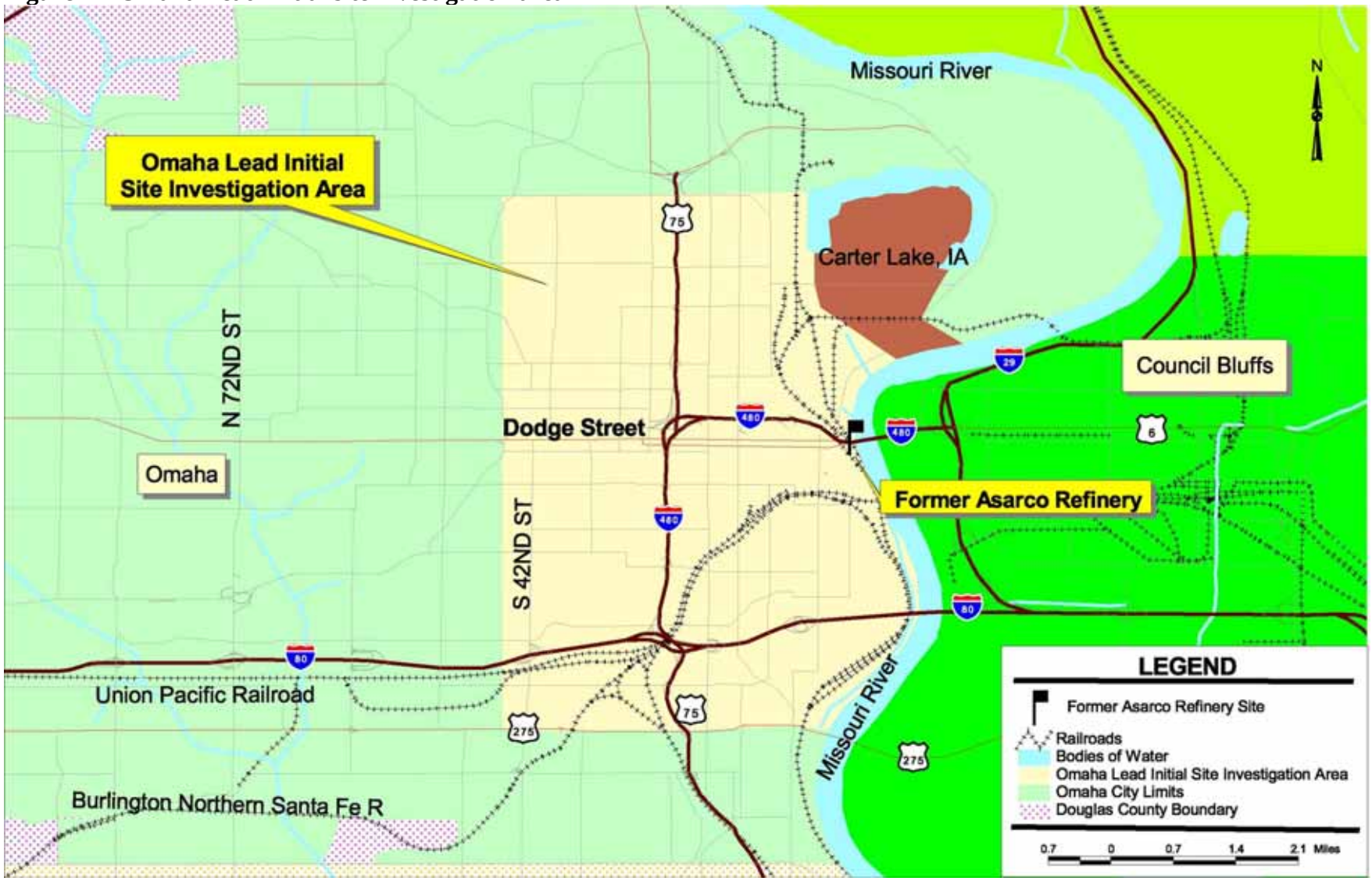
- assessing how people might be exposed to contaminants;
- evaluating possible health effects from exposure to contaminants for a variety of appropriate public health actions;
- recommending medical tests, health education, and health promotion;
- making recommendations to local, state, and federal agencies; and
- involving and working effectively with the community.

Site Background

Site Location

The Omaha Lead site is comprised of residential properties, childcare facilities, schools, and other properties in the city of Omaha, Douglas County, Nebraska. Those properties have been contaminated with lead due to air emissions from lead refining operations and probably other sources [1]. As indicated on Figure 1, the site area covers approximately 8,840 acres extending from approximately Ames Avenue to L Street and from 45th Street to the west side of the central business district and the west bank of the Missouri River north and south of the central business district. These boundaries represent EPA's initial site investigation area. These boundaries will be adjusted based on the sampling data obtained during the remedial investigation. ATSDR's evaluation of 2000 U. S. Census data indicates that approximately 86,000 residents live within the identified site area. Approximately 9,700 of these are children 6 years old and under.

Figure 1 – Omaha Lead initial site investigation area



Site History

ASARCO Facility

The American Smelting and Refining Company (ASARCO) operated a lead refinery on approximately 23 acres on the west bank of the Missouri in downtown Omaha from the 1870s until 1997 [1, 2]. The refinery is thought to be the primary source for the soil lead contamination in the Omaha Lead initial site investigation area. Several other businesses in the Omaha area, including Gould Battery, used lead in their manufacturing process and may have contributed to the lead contamination [3]. Others sources of lead contamination may include lead-based paint and lead deposited from automobiles that used leaded gasoline in the past.

The ASARCO facility has since been cleaned up under the State of Nebraska Remedial Action Plan Monitoring Act Program [2]. It was turned over to the city, which has turned the property into a park. The "Lewis and Clark Landing" park also includes a restaurant. The area where the ASARCO facility was located is not considered to be part of the Omaha Lead site.

The investigation and clean-up of the ASARCO facility indicated that area groundwater and the Missouri River had been minimally contaminated by lead and other metals from ASARCO [4-8]. However, there was considerable concern that emissions from the ASARCO refinery had contaminated soil in the Omaha area [2].

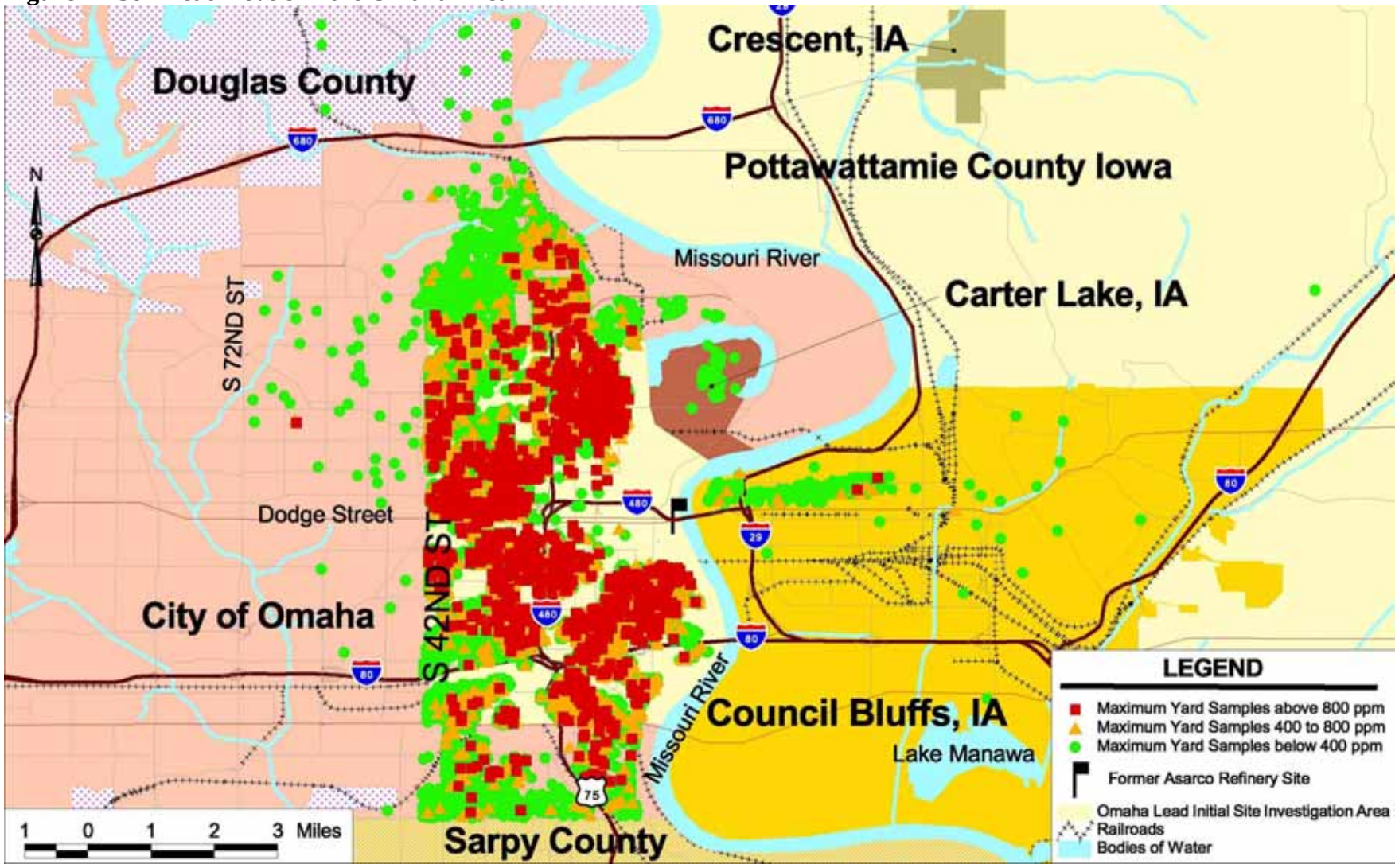
Soil Contamination

EPA started an evaluation of the extent of the soil contamination by modeling the atmospheric deposition patterns around the ASARCO facility [9]. The modeling was performed to get a better understanding of the deposition of lead in emissions from the smoke stack in an attempt to focus soil testing in areas that were likely to be the most heavily impacted by contamination. The model indicated that the highest concentrations of lead were likely to be along the direction of the prevailing winds, which were northerly or southerly.

In March 1999, EPA began collecting soil samples from residential properties in Omaha, and Council Bluffs and Carter Lake, Iowa, in order to characterize the extent of the contamination and to prioritize soil removal actions [2]. Previous soil sampling was also conducted by the Douglas County Health Department (DCHD), EPA, and other interested parties. Based on a conversation with Don Bahnke, EPA RPM, on April 9, 2004, EPA had collected soil samples from 15,500 properties in the Omaha area.

Figure 2 shows results from EPA's soil sampling in the Omaha and Council Bluffs areas. As indicated on this figure, most of the locations where the lead concentration exceeds the EPA Action Level of 400 parts of lead per million parts of soil (ppm) lie within or next to the Omaha Lead site. The background soil lead concentration for the Omaha area is 26 ppm, based on soil sampling conducted approximately 8 miles north of the ASARCO facility [10].

Figure 2 - Soil Lead Levels in the Omaha Area



In August 1999, EPA executed an Action Memorandum for the Omaha Lead site [11]. The memorandum described the time-critical removal action for the site, which focuses on soil removal in the eastern portion of Omaha, Nebraska, and Council Bluffs, Iowa. Soil containing more than 400 ppm was removed from residences and licensed daycare facilities where children had elevated blood lead concentrations which initially defined as exceeding 15 micrograms per deciliter (µg/dL) [12]. The blood lead level used for determining removal actions has since been decreased to 10 µg/dL. Residences with the highest contamination level are given priority. In addition, the removal action included highly contaminated properties—initially those with soil lead levels greater than 2,500 ppm. Recently, the lead concentration considered "highly contaminated" was reduced to greater than 1,200 ppm.

As of January 29, 2004, EPA has cleaned up the soil from 403 properties that met these removal criteria [12]. Of those, 224 were residences of a child with elevated blood levels, 82 were licensed childcare facilities, and 97 were highly contaminated properties. Two of the 403 properties lie outside of what is now considered the Omaha Lead site. Both were licensed childcare facilities; one was on 64th Street in Omaha, the other was in Council Bluffs. Those facilities were identified and cleaned-up before the existing site area was determined.

Don Bahnke advised ATSDR that EPA resumed its time critical removal action in the Spring of 2004 and will remediate 284 contaminated properties. EPA plans to test 12,000 residential properties this year.

Concern about Blood Lead Levels in Children

In 1997, the Centers for Disease Control and Prevention recommended that local government analyze the available lead poisoning data and issue targeted screening guidelines [13]. In November 1998, DCHD released the available blood lead screening results. It concluded that blood lead levels in Douglas County exceeded the national average [14]. For example, about 2,850 children were screened for lead poisoning by DCDH from July 1, 1997 to June 30, 1998. The results indicated that nearly 600 children (about 21%) had blood lead levels of 10 µg/dL or greater.

The Nebraska surveillance data for 1994 to 2000 indicate that 1-in-18 children tested in Douglas County (which includes Omaha) had elevated blood lead levels [15]. Blood lead levels greater than 10 µg/dL are considered to be elevated. According to data for 1992 to 1998, about 29% to 42% of the children tested in the three downtown Omaha zip codes areas have elevated blood lead levels. Those zip codes areas (68110, 68102, and 68108) are within the most contaminated areas [15]. In comparison, the *1998 Nebraska Surveillance Report on Lead Poisoning Among Children Less Than Age Six*, prepared by the Nebraska Health and Human Services, indicates that 7.1%, 12.0%, and 7.3% of children in Nebraska had elevated blood lead levels in 1996, 1997, and 1998, respectively [14]. In general, the available data indicates a decreasing trend in the number of children with elevated blood lead levels with increasing distance from downtown Omaha [1,2].

Demographics

Table 1 shows demographic data for the Omaha Lead initial site investigation area identified on Figure 1. Within this site area, there are distinct differences between the portions north and south of Dodge Street (U.S. Highway 6) which roughly divides the site in half. The area north of this highway is 55% African-American while south of it Whites make up 75% of the population. Likewise, the percentage of individuals of Hispanic origin is greater (24%) south of Dodge Street than north of it (7%).

Table 1 – Demographic Characteristics of Omaha Lead Initial Site Investigation Area

Population Parameter	Total Site Area	Area North Of Dodge Street	Area South Of Dodge Street
Total	86,826	33,637	53,189
Whites (%)	52,070 (60%)	11,966 (36%)	40,104 (75%)
African-American (%)	21,388 (25%)	18,405 (55%)	2,983 (6%)
American Indian (%)	1,130 (1%)	434 (1%)	696 (1%)
Asian (%)	1,483 (2%)	782 (2%)	701 (1%)
Other & Multiple Race (%)	10,755 (12%)	2,050 (6%)	8,705 (16%)
Hispanic Origin* (%)	14,861 (17%)	2,194 (7%)	12,667 (24%)
Children 6 and Younger	9,700	3,948	5,752
Adults 65 and Older	9,142	3,015	6,127
Females 15 – 44	21,659	8,901	12,758
Total housing units	34,060	12,271	21,789
Percent pre-1950s housing	63%	60%	65%
Mean population density (people per square mile)	6,349	5,629	6,728

* Hispanic origin is not a racial category in the census so the percent Hispanic can't be compared to the racial parameters.
Source: 2000 U.S. Census

Land Use and Natural Resource

Land-use within the Omaha Lead site is residential, commercial, and industrial [1, 2]. The Missouri River is the eastern boundary of the site area. The river supports recreational fishing and boating. Surface water runoff from the Omaha Lead site is discharged from the sewer system into the Missouri River. Drinking water within the site area comes from the Omaha city water system, which uses water from wells and surface water from the Missouri River. Information regarding the presence of private wells in this area was unavailable [1].

Discussion

Data Used

The data used in preparing this PHA included a database on child blood lead levels from DCHD and 2 databases containing the available soil lead data from EPA.

In 2002, EPA provided ATSDR with a database containing lead measurements for 13,500 samples from about 2,200 locations, including 278 locations in Council Bluff and Carter Lake, Iowa. All other samples were taken in or near Omaha, Nebraska. Most of these were taken within 5 miles of the former ASARCO facility.

In 2004, EPA provided ATSDR with a database with the results for the maximum non-drip line sample taken at the 11,712 locations sampled by EPA in Omaha and Council Bluffs. It is these soil sampling data that are displayed on Figures 2 and 3.

Many of the samples in EPA's database came from the site investigation where a minimum of five samples were collected from each property [2]. Following EPA guidance for remediating lead sites, 4 of those soil samples were collected far enough from the house to avoid likely contamination by lead-based paint from the house [16]. The fifth soil sample was collected at the drip line, which is soil within 3 feet of the house to evaluate whether there is the lead in soil from peeling lead-based paint on the house. All these samples were analyzed for lead using x-ray fluorescence (XRF). XRF allows samples to be analyzed in the field. Portions of about 10% of the samples underwent laboratory analysis to validate the XRF results. The laboratory analysis used EPA methods 3010 and 6010 [17]. The laboratory also analyzed the samples for molybdenum, zirconium, strontium, rubidium, selenium, arsenic, mercury, zinc, copper, nickel, cobalt, iron, manganese, chromium, barium, antimony, cadmium, and silver.

DCHD has collected the results of blood lead testing for children 6 years and younger in Douglas County since 1992. That data set includes results from than 44,000 individuals. From this data set, ATSDR was able to select the 12,754 records from July 2000 through August 2002, corresponding to the period for EPA's soil lead testing. These results are for capillary and venous testing.

The blood lead results are reports of tests by private physicians or were obtained at clinics and other efforts of the DCHD Childhood Lead Poisoning Prevention Program, or [18]. Since July 1997, there has been a state requirement that the results of all blood lead tests in Nebraska be reported to the health department in the county of residence for the person tested. However, DCHD indicated to ATSDR that there was not complete reporting of levels below 10µg/dL until 2000.

However, most of the DCHD data came from voluntary participation in the testing. DCHD recommends annual testing of all children 3 years old and younger [18]. They also recommend annual testing of children 3–6 years old who are at high risk of exposure to lead. DCHD defines "high risk" as children in Douglas County who :

- live or visit east of 72nd Street,
- live or visit a home built before 1978 that needs repair, is being repaired or renovated, or has the original windows and porch, and
- put many things in their mouths including toys, fingers, and soil.

Mandatory testing is required for children at ages 12 and 24 months if they are participating in the Medicaid program [19].

Contaminant of Concern

The available data indicate that lead is the primary contaminant of concern (COC) for the Omaha Lead site. Therefore, this PHA focuses on the potential health effects associated with lead exposure. If additional data reveal the presence of other contaminants at this site at levels of potential concern for human health, exposure to the contaminants will be evaluated in an addendum to this PHA.

Lead Overview

As indicated in Figures 2 (page 9) and 3 (page 20), lead is present in the soil of residential and commercial property within the area encompassing the Omaha Lead site. During industrial operations in Omaha, lead was released from emission stacks to the air and settled to the ground in neighboring communities [3, 9]. Lead particles from emissions deposit on the soil, become tightly bound to soil particles, and are retained in the upper portions of the surface soil after deposition. Because lead does not dissipate, biodegrade, or decay, the risk of exposure is long-term.

Other sources of lead in the environment include exhaust from vehicles that burned leaded gasoline (this use was phased out in the 1980s) [20]. Lead from interior and exterior lead-based paint may also be present in houses and soil surrounding houses built before 1978.

Individuals may be exposed to lead in soil on their property through incidental ingestion of soil during activities such as gardening and outdoor play [21]. Individuals may also be exposed to lead from inhaling dust.

The biologic fate of lead is well known [21, 22]. When ingested, it is absorbed directly, distributed throughout the body through the bloodstream, and excreted. Lead is primarily distributed to the kidneys, bone marrow, liver, brain, bones, and teeth. Bone and tissue have been found to contain 95% of the total amount of lead stored in the body. Therefore, collecting and analyzing a blood sample for lead accurately measures recent and ongoing exposures but doesn't measure the amount of lead being stored.

Lead and Health Effects in Children 6 Years and Younger

In residential settings, children ages 6 years and younger are considered to be at greater risk for health effects from lead exposure than are older children and adults [23]. The reasons for children's increased vulnerability include the following:

1) children's developing nervous system;
2) hand-to-mouth behavior exhibited by children which increases the opportunity for soil ingestion or the ingestion of lead-containing dust or paint chips;
3) the efficiency of lead absorption from the gastrointestinal tract is greater for children than adults; and
4) iron and calcium deficiencies, which are prevalent in children, may enhance the absorption and increase the toxic effects of lead [22].

Most children with lead poisoning have no obvious symptoms, and therefore, the condition often remains undiagnosed and untreated [24].

Fetuses are at even greater risk from lead exposure than children [20, 24]. Because lead crosses the placenta, a woman exposed during pregnancy can transmit lead to her fetus. Lead in the bones of women who were exposed before pregnancy may be mobilized because of the physiological stresses of pregnancy resulting in exposure to the fetus.

Studies of lead exposure to children and the developing fetus have demonstrated an association between lead and several health effects [20, 22, 24, 25]. These health effects include physical and mental impairments, hearing difficulties, impaired neurological development, and reduced birth weight and gestational age [20,26]. They can also include behavioral effects such as impulsivity, aggression, and short attention span when exposure levels are high and distractibility, poor organization, a lack of persistence, and daydreaming when exposure levels are low [27]. The neurotoxicity of lead is a particular concern. Some health effects, such as impaired academic performance and motor skills, may persist as a result of lead exposure, even when blood lead concentrations return to normal levels [28].

Evaluation of Health Effects of Lead

For the evaluation of most chemicals, ATSDR compares the exposure dose to a health guideline established for the individual contaminant. The exposure dose is the amount of a contaminant that gets into a person's body. Health guidelines used by ATSDR usually are ATSDR's Minimal Risk Level (MRLs) or EPA's Reference Dose (RfD). ATSDR has developed MRLs for many contaminants commonly found at hazardous waste sites. MRLs are estimates of daily exposure to a contaminant below which noncancer adverse health effects are unlikely to occur. Public health effects are not expected to occur at exposure doses below the MRL. MRLs are developed for different routes of exposure, such as ingestion and inhalation. They are also developed for different lengths of exposure, such as acute (less than 14 days), intermediate (15–365 days), and chronic (365 days or more). RfDs are estimates of daily, lifetime exposure of human populations to a possible hazard that is not likely to cause noncancerous health effects.

ATSDR has not derived MRLs for lead exposure nor has EPA developed an RfD for inorganic lead and lead compounds. This is because clear dose-response relationships can't be established using environmental concentrations of lead [20, 29].

EPA has classified lead as a "probable human carcinogen," on the basis of studies in animals [29]. Several studies reported an increased incidence of kidney cancer among subjects who ingested and had direct skin contact with several lead compounds. The available human studies of lead exposure are inadequate for supporting or refuting the findings of animal studies regarding the cancer-causing potential of lead.

As indicated above, no health guidelines or threshold levels have been established for the health effects resulting from exposure to lead in various environmental media. However, good evidence does link health effects to blood lead levels [20, 22, 23, 24]. Levels of 10 µg/dL and perhaps even lower, in children's blood have been associated with small decreases in IQ and slightly impaired hearing and growth [20, 24, 30]. Concentrations of 20 µg/dL and greater are associated with changes in nerve conduction velocity. Vitamin D metabolism, which is important in bone development, can suffer at concentrations of 30 µg/dL [24]. In children, lead begins to affect hemoglobin synthesis at 40 µg/dL. Colic, anemia, kidney disease, and diseases of the brain occur at blood lead levels between 60 µg/dL and 100 µg/dL. The Centers for Disease Control and Prevention (CDC) consider blood lead levels of greater than 10 µg/dL in children to be "elevated" and of public health concern [24].

Therefore, in this document we will use blood lead levels or a prediction of blood lead levels to evaluate the possible health consequences of exposure to lead. The next section discusses the relationship of soil lead levels to blood lead levels.

Relationship of Soil Lead Levels to Blood Lead Levels

A great deal of variation has been reported regarding the correlation of soil lead concentrations and blood lead levels. An ATSDR study of several different communities reported that lead soil concentrations greater than 500 ppm were associated with average blood lead levels greater than 10 µg/dL in children [25]. One study reported a correlation between a soil lead concentration of 250 ppm and an estimated blood lead level of 2 µg/dL [31]. CDC reported that, in general, blood lead levels increase 3–7 µg/dL for every 1,000 ppm increase in the soil lead concentration, based on the available scientific literature [24]. The variations reported among studies reflect the different sources and absorptions of lead and lead-containing compounds, different exposure conditions (i.e., ground cover, seasonal variations) and different exposed populations [22]. In addition, health conditions, such as iron deficiencies, can enhance lead absorption and toxicity [20, 24].

Several studies indicate that the increase in blood lead concentration as a function of soil lead concentration is not linear. That is, at higher soil lead concentrations, the rate of increase in blood lead levels is not as great [32]. According to this study, an increase in soil lead concentrations from 100 ppm to 1,000 ppm was linked a change of the predicted blood lead level from 7.3 µg/dL to 13.0 µg/dL, an increase of 5.7 µg/dL. However,a soil lead concentration of

2,100 ppm was linked to an estimated blood lead level of 15.2 μg/dL, a change of only 2.2 μg/dL.

To deal with this problem of nonlinearity, EPA developed the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) [33]. The IEUBK model is used to predict the risk of elevated blood lead levels in children (under the age of 7 years) that are exposed to environmental lead from many sources. The model also predicts the risk (e.g., probability) that a typical child, exposed to specified media lead concentrations, will have a blood lead level greater or equal to the level associated with adverse health effects (10 μg/dL). The IEUBK model is EPA's primary tool for identifying clean up levels for lead-contaminated soil.

The following factors are considered in the IEUBK model [33]:

- *Intake of lead in soil, house dust, air, water, and food.* Whenever possible, sampling data on lead in these various media are used to identify site-specific intake rates. Media-specific default intake rates are used in the model if sampling data are not available. These default rates are carefully determined from available research data.
- *Uptake of lead from the contaminated media into the bloodstream.* Only a fraction of the lead that an individual takes in makes it into the bloodstream. Typically, default uptake rates are used in the IEUBK model.
- *Biokinetics of lead within the body.* The biokinetics of lead, or where lead goes within the body and how fast it is eliminated, is also considered in the IEUBK model through default values which are used to calculate a mean blood lead concentration.
- *Distribution of blood lead concentrations within the population of concern.* The most probable distribution of blood lead levels within a population based on the mean identified in the biokinetic component is then calculated using default assumptions on distribution. This is used to determine the probability that a child will have a blood lead concentration above a specific level. The default value for this level is 10 μg/dL.

The validity of IEUBK model was calibrated against two different blood and soil lead community studies [33]. Subsequent comparisons involved well-conducted blood and environmental lead studies of children with adequate exposure characterizations. Those comparisons demonstrate reasonably close agreement between mean observed and predicted blood lead concentrations, and between observed and predicted exceedances of 10 μg/dL. These studies focused on communities with at least 15% of the children having blood lead concentrations greater than 10 μg/dL.

EPA seeks to limit the risk that children will have blood lead concentrations above 10 μg/dL [33]. They recommend "that a soil lead concentration be determined so that a typical child or group of children exposed to lead at this level would have an estimated risk of no more than 5% of exceeding a blood lead level of 10 μg/dL" [34]. Using default inputs, the IEUBK model identifies 400 ppm as the soil lead concentration where 5% of the children would have blood lead levels about 10 μg/dL. EPA directs its remedial project managers (RPM) and on-scene coordinators (OSC) that 400 ppm soil lead be used as the screening level for evaluating clean-up

of lead-contaminated soil [16,34]. They further direct that actual remediation levels be based largely on the results of entering site-specific values into the IEUBK model.

Current Standards, Regulations, and Recommendations for Lead

The following paragraphs briefly detail some of the regulations and standards regarding exposure to lead.

EPA regulates lead under the Clean Air Act and has designated lead as a hazardous air pollutant [20]. Before the Clean Air Act, the amount of lead discharged from industrial sources was not restricted. Contaminants were released to the air from the stacks at industrial facilities, settled out of the air onto nearby soil, and accumulated over time.

In the early 1970s, EPA began to phase-out the use of lead in gasoline because of its effects on the environment from automobile emissions [20]. By 1988, less than 1% of gasoline contained lead as compared to the amount of lead-containing gasoline used in 1970. In 1990, Congress stated that it would be unlawful for automotive gasoline to contain lead or lead additives after December 31, 1995.

The Lead-Based Paint Poisoning Prevention Act prohibits the use of lead-based paint in residential structures built or renovated by any federal agency [35]. The Act also gives the Department of Housing and Urban Development (HUD) authority to create regulations focused on the removal of lead from housing built before 1978. In addition to HUD, EPA, the U.S. Department of Health and Human Services, and the Department of Labor's Occupational Safety and Health Administration (OSHA) are the primary federal agencies responsible for promulgating regulations aimed at minimizing lead exposure.

In compliance with the Toxic Substance Control Act (TSCA) §403, EPA published a final rule for dangerous levels of lead in 2001. That rule establishes a soil-lead hazard of 400 ppm for bare soil in play areas and 1,200 ppm for bare soil in non-play areas of the yard [36]. As recognized in the TSCA §403 rule, lead contamination at levels equal to or exceeding the 400 ppm and 1,200 ppm standards may pose serious health risks. The potential risks are site-specific and may warrant timely response actions. However, the soil-lead hazard levels under the TSCA §403 Rule should not be used to modify approaches to addressing brownfields, NPL sites, state Superfund sites, federal CERCLA removal actions, and CERCLA non-NPL facilities.

Exposure Pathway Analysis

ATSDR identifies human exposure pathways by examining environmental and human components that might lead to contact with COCs [37]. A pathway analysis considers five principal elements:

1) a source of contamination,
2) transport through an environmental medium,
3) a point of exposure,
4) a route of human exposure, and
5) a receptor population.

Completed exposure pathways are those for which the five elements are present and exposure to a contaminant has occurred in the past, is currently occurring, or will occur in the future. ATSDR regards those people who contact contaminants as being exposed. That exposure can occur through breathing airborne contaminants, drinking water known to be contaminated, or playing or digging in contaminated soil. The identification of an exposure pathway does not imply that health effects will occur. Exposures may or may not be substantive. Thus, even if exposure has occurred, human health effects may not necessarily result.

ATSDR reviewed site history, information on site activities, and the available sampling data for the Omaha Lead site. From this review, ATSDR identified numerous exposure pathways that warranted consideration. The primary completed exposure pathway is discussed in the following section. A discussion of the additional pathways that have been considered, but eliminated for further evaluation on the basis of available data, also follows. Each of the pathways identified at Omaha Lead are summarized in Appendix A.

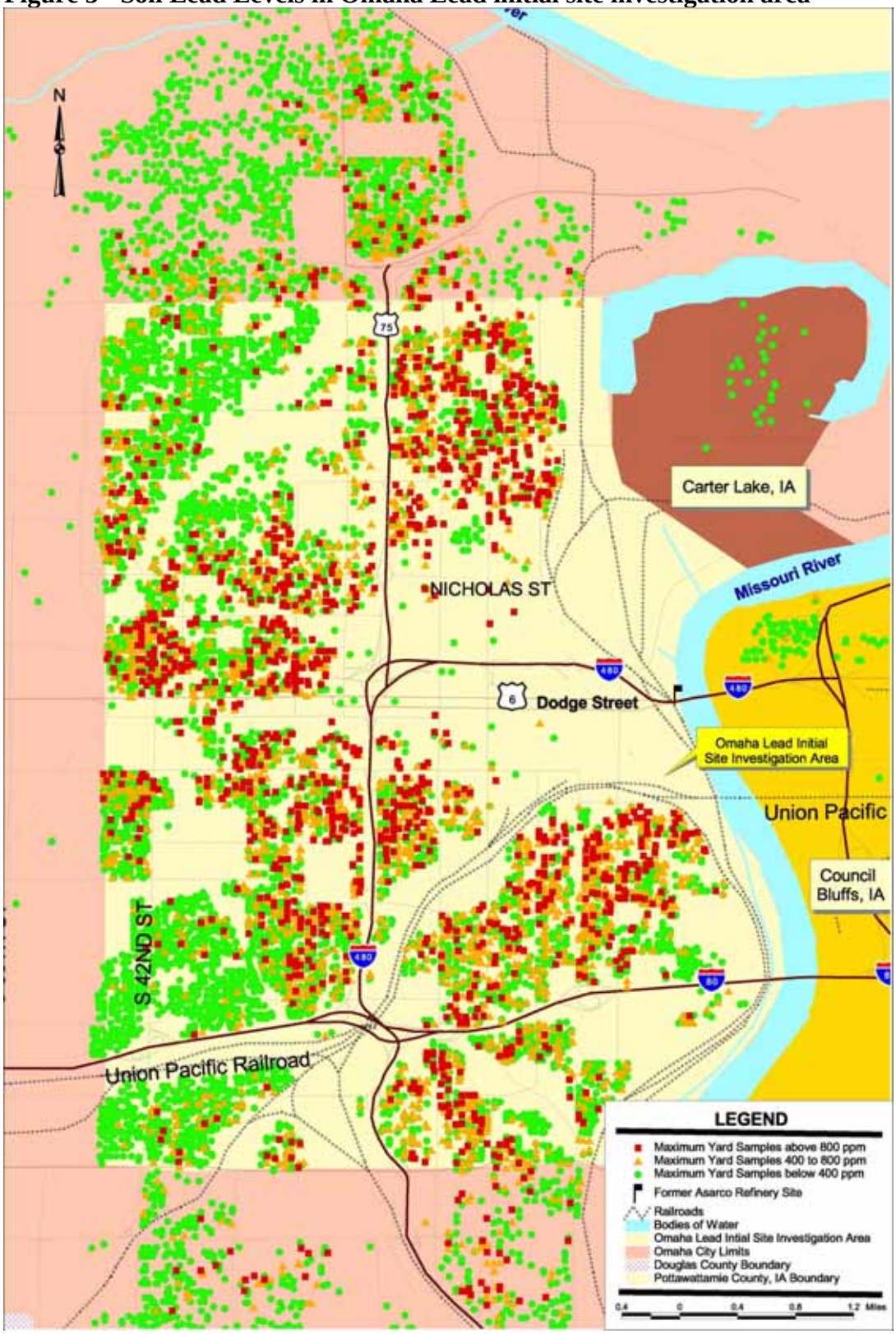
Completed Exposure Pathways

Lead-Based Paint

Lead-based paint in homes is not related to the Omaha Lead NPL site but it is a very important current source of exposure to lead for many children 6 and younger in the Omaha area. Therefore, this exposure pathway is described here so that readers will be knowledgeable about this source of lead exposure.

Individuals are exposed to lead-based paint through ingestion of dust or soil contaminated with small particles of lead-based paint or through direct ingestion of paint chips. Exposure to lead-based paint occurs in or around homes which were painted inside or out with lead-based paint and where that paint is peeling, chipping, or otherwise deteriorating. Homes most likely to have lead-based paint are those built before 1950 but lead paint was also used in some homes built between 1950 and 1978 [18]. Use of paint containing lead in homes was banned in 1978 so it is unlikely the homes built after 1978 contain lead-based paint. As indicated in Table 1 on page 12, 63% of the housing in the Omaha Lead initial site investigation area was built prior to 1950 so there is a good chance that a child living in the Omaha Lead initial site investigation area could be exposed to lead which came from lead-based paint.

Figure 3 - Soil Lead Levels in Omaha Lead initial site investigation area



Soil

On the basis of EPA's sampling results, soil within the site area identified in Figures 2 and 3 is considered a completed exposure pathway. Exposure to lead from the ASARCO facility has occurred since 1870. However, the sampling results indicate that not every location within this area is contaminated above EPA's soil action level of 400 ppm [1, 2]. Likewise, some of the lead found in the soil in the site area may have come from lead-based paint or other sources not related to the site. In addition, the soil sampling results provided by EPA indicated that the site-related lead contamination extends beyond the site study area identified by EPA when they proposed Omaha Lead for the National Priorities List (NPL). Don Bahnke, the EPA RPM for Omaha Lead, indicated to ATSDR on March 24, 2004 that "*EPA will follow the trail of contamination wherever it goes*". Clean up of residential yards will done whenever the soil levels exceed the 400 ppm action level currently being used or a new level that may be identified in the ongoing risk assessment.

Individuals swallow soils as an incidental consequence of typical outdoor activities such as working in the yard, gardening, and playing. The soil exposure pathway is an especially important pathway for children, who exhibit hand-to-mouth behavior and have consequently higher soil ingestion rates .

ASARCO Refinery Emissions

When the ASARCO Refinery was operating prior to 1997, its airborne emissions were likely a significant completed exposure pathway as indicated by a 1977 investigation of metals levels in children living near operating smelters [38]. The extent of soil contamination displayed on Figures 2 and 3 likely represents where exposure to airborne emissions from the ASARCO Refinery occurred. Individuals living or working in this area inhaled lead particulates from the opening of the refinery in 1870 until it ceased operation in 1997.

Ingestion of Homegrown Produce

Some Omaha residents grow fruits and vegetables in their home gardens. Lead can be absorbed from the soil and taken up by plants [20]. In addition, lead-contaminated soil may adhere to plant surfaces, especially potatoes, carrots, and similar "root" vegetables. Thus, consumption of plants grown in lead-contaminated soil could be another source of exposure. Recent research indicates that this pathway would be a concern only for those children who consume large amounts (about a pound a day) of homegrown produce [39]. It does not appear to be a significant pathway for adults.

DCHD has developed guidelines for gardening in and around the Omaha Lead site (see Appendix C, page 41) [18]. These guidelines recommend careful trimming and washing of plants grown in soil with lead levels less than 1,000 ppm. They recommend that produce not be grown or eaten if the lead concentrations are greater than 1,000 ppm in the garden's soil.

Considered and Eliminated Exposure Pathways

Drinking Water

Drinking water within a 4-mile radius of the site is provided by public water suppliers. The Metropolitan Utilities District, a local drinking water supplier, operates 52 groundwater wells and one surface water intake. Metropolitan Utilities District supplied drinking water to 600,000 customers in Omaha and Papillon, Nebraska and Carter Lake, Iowa. The drinking water supply for Council Bluff, Crescent, and Underwood, Iowa is provided by the Council Bluffs Waterworks, which supplies about 57,000 customers. Most of the water supplied by Council Bluffs Waterworks comes from surface water intakes. It is unknown whether any private wells exist within the downtown Omaha area [1, 2].

Water from municipal water suppliers is routinely tested to evaluate compliance with the Safe Drinking Water Act to ensure that contaminants, including lead, are below established health-based levels [40]. Under certain conditions, the piping in older homes can contain lead solder that can introduce lead into the home's water supply. Because of the dissolved mineral content and alkaline pH of the water in Omaha, leaching of lead solder from pipes in this area is not expected. Therefore, exposure to harmful concentrations of lead in drinking water is not expected.

Information regarding the presence or potential uses of private wells within the Omaha Lead site is unavailable [2]. As previously discussed, high lead concentrations are present in the top few inches of surface soil. Because lead particles typically adhere to the surface soil and are not readily transported to subsurface soil, it is unlikely that lead has polluted groundwater in the Omaha area. Therefore, it is unlikely for any private wells that may exist in the area to be contaminated with lead from Omaha Lead.

Surface Water

In general, surface water runoff enters the Missouri River, which is east of Omaha [2]. The Missouri River supports recreational fishing and boating and serves as a drinking water source. Surface water intakes are located upstream and downstream of the Omaha Lead Site. The high volume of water in the Missouri River reduces the potential exposure to affected surface water. The limited duration and frequency of recreational activities that might involve contact with surface water further reduces potential exposure. However, no surface water data was available for evaluation to confirm those assessments.

Fish Ingestion

Soil runoff is not expected to have much affect on surface water, so fish are unlikely to contain significant quantities of lead [2]. Although specific data is unavailable, eating fish from the Missouri River is not expected to result in hazardous exposure to lead.

Evaluation

Distribution of Elevated Soil and Blood Lead Levels in the Omaha Lead Site Area

Figures 3–5 display the distribution of elevated soil lead and blood lead levels in and around the Omaha Lead site. The soil lead maps (Figures 2 and 3) display the ***maximum*** lead level for each location sampled by EPA through 2003. Table 2 shows the ***mean*** soil lead levels at each location for several of the areas sampled through 2002. The mean soil lead levels are the highest in that portion of the Omaha Lead site north of Dodge Street (U.S. Highway 6).

The blood lead levels for Douglas County and the Omaha Lead site are displayed in Figures 4 and 5, respectively. Those results are from testing conducted from July 2000 through August 2002. This period was chosen because it is similar to the period used for EPA's soil sampling results. Table 2 shows the mean blood lead levels and percent with levels of 10 μg/dL or greater in the Omaha area for children 6 years and younger. As with the soil lead results, the highest concentrations are in that portion of the Omaha Lead initial site investigation area north of Dodge Street (U.S. Highway 6). From July 2000 through August 2002, there were 289 children 6 years old and younger who had blood lead concentrations of 10 μg/dL or greater.

Table 2 – Soil and Blood Lead for the Omaha Area*

	Number of Locations Sampled	Mean Soil Lead Level in Parts per Million (ppm)	Number of Blood Samples	Percent Children with Blood Levels of 10 μg/dL or Greater
Douglas County	1,953	387	12,754	5.5
Site Investigation Area	1,300	437	2,970	9.7
Site Area North of Dodge Street	671	460	1,228	10.8
Site Area South of Dodge Street	629	417	1,742	8.8
Council Bluffs, Iowa	253	105	none	none

* The soil lead sampling results are from electronic files provided to ATSDR by EPA in 2002. They are the mean of the samples taken at each location tested for which ATSDR was able to obtain an address match. The blood lead sampling data were provided in an electronic file provided by the Douglas County Department of Health (DCHD).

Figure 4 - Blood Lead Testing by Douglas County Health Department.

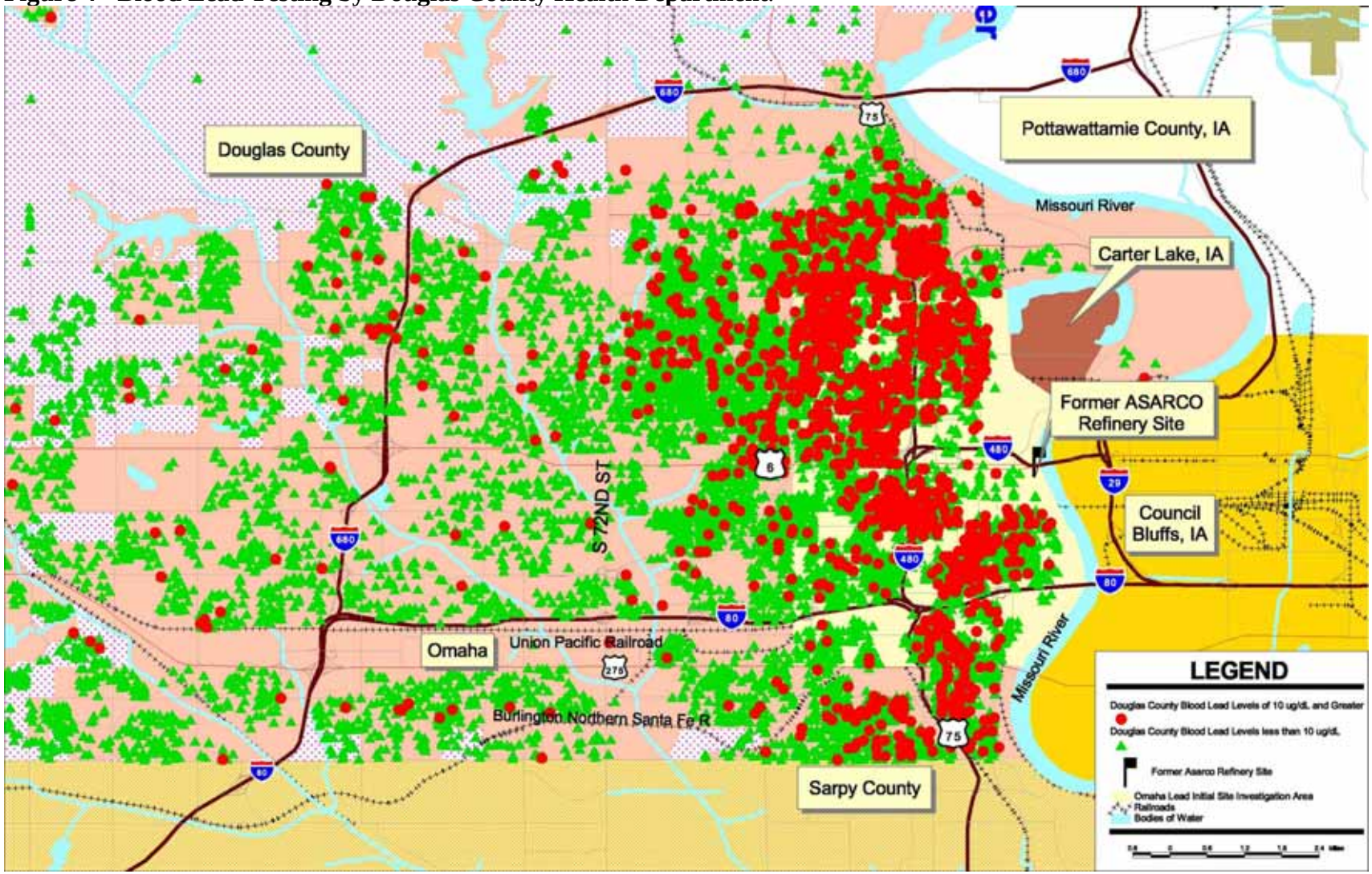
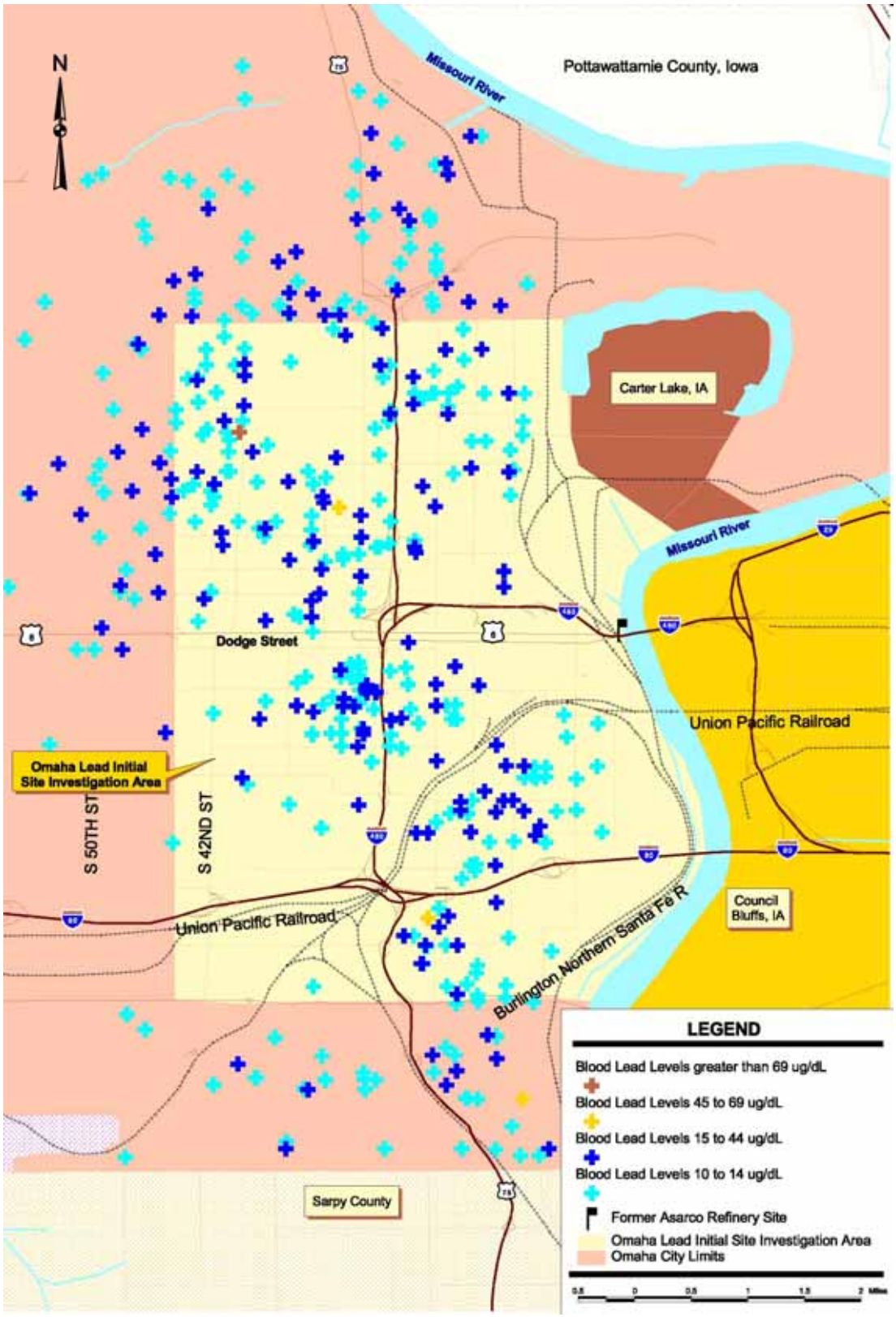


Figure 5 - Elevated Blood Lead Levels in Omaha Lead initial site investigation area.



As indicated on Table 2, 9.7% of the children tested in the Omaha Lead initial site investigation area had blood lead levels of 10 µg/dL or greater compared to 5.5% of Douglas County children. In 2001, 2.0% of Nebraska children and 3.1% in the U.S. had elevated blood levels [30].

Possible Health Consequences from Elevated Soil and Blood Lead Levels

ATSDR considers soil lead concentrations to be a public health risk if they are likely to result in blood lead levels of 10 µg/dL or greater in at least 5% of exposed children 6 years and younger. For the Omaha Lead site, EPA is using 400 ppm as the initial soil concentration at which this risk is seen, and for which they will undertake actions which would effectively reduce the health risk for children [1]. These may include treatment of the soil, clean up of the contaminated soil, or other appropriate actions. Don Bahnke, the EPA remedial project manager (RPM) for the Omaha Lead site, has indicated that this soil concentration may change to reflect the results of the human health risk assessment being developed for the Omaha Lead site.

Therefore, ATSDR considers residential soil contaminated at concentrations that exceed EPA's clean-up level to be a public health risk, whether that level is the current 400 ppm or a revised number that also meets the 5% risk criteria discussed on page 17.

One hundred eighty-five of the 289 children in the Omaha Lead initial site investigation area had blood lead levels of 10–14 µg/dL while 101 of the 289 children were between 15 µg/dL and 44 µg/dL. Two had levels between 45 µg/dL and 69 µg/dL and one child had a level greater than 69 µg/dL Those children with blood lead levels of 10–20 µg/dL are at risk of having decreases in IQ of up to 11 points, and slightly impaired hearing and growth [24]. Those children with levels from 20 µg/dL to 40 µg/dL could experience problems in metabolizing vitamin D, which is important in bone development. Children with levels greater than 40 µg/dL could experience anemia and other blood-related problems. Colic, kidney disease, and diseases of the brain have been observed in children with blood lead levels greater than 60 µg/dL.

Sources of Lead Exposure for Children with Blood Lead Levels above 10 µg/dL

Our review of the available data indicates that there are two major sources of lead for children living in the Omaha Lead site area—lead-based paint and past emissions from the ASARCO refinery. Douglas County's recent review of the blood lead data from 1996 through 2001 indicates that 96% of the children with blood lead levels of 15 µg/dL or greater lived in homes built before 1950 [19]. Nearly all pre-1950 homes were painted both inside and out with paint that could contain up to 50% lead [19, 30]. Thus, children 6 years and younger living in pre-1950 homes likely are exposed to lead from paint if the lead-based paint has not been sealed or removed.

Our evaluation indicates that most of the children with elevated blood lead levels live in areas where the mean soil lead concentration exceeds 400 ppm. ATSDR review of EPA's soil sampling data indicates that 42% (3689/8697) of the properties sampled in the Omaha Lead initial site investigation area through 2003 had at least one location where the lead level exceeded 400 ppm. Therefore, lead in soil is likely a significant source of exposure to lead, also.

Eliminating or Reducing the Lead Exposure of Children

Eliminating or reducing the blood lead levels of children in or near the Omaha Lead site involves identifying specific locations where exposure to lead-contaminated soil and lead-based paint is occurring. This is being done through:

1. Primary prevention activities that evaluate, identify, and promote control of residential lead hazards through ongoing temporary mitigation or permanent elimination.
2. Effective intervention for children with known lead exposure to prevent or reduce further exposure to mitigate adverse health effects.

As part of this effort, DCHD has developed the following case management plan for every child reported to have a blood level of 10 µg/dL or greater [18]:

1. Provide general patient/family education.
2. Coordinate care and follow-up testing following CDC guidelines between patient, physician or other primary medical provider, and DCHD.
3. Provide family education, including a home visit with assessment of possible exposure sources and exposure history for confirmed blood lead levels 15 µg/dL and above. Refer individuals and families as needed for follow-up care or intervention.
4. Conduct environmental assessment for lead-based paint with lead hazard reduction follow-up and enforcement (confirmed blood lead levels of 15 µg/dL and above).
5. Coordinate free venous or capillary retesting.
6. Refer their address to EPA for soil testing and possible remediation if the child's residence is in the 7 ZIP Codes east of 45th Street that encompass the Omaha Lead Site [11].

Steps 4 and 6 of this plan provide a mechanism to address lead-based paint and lead-contaminated soil as exposure sources for the children identified as having elevated blood lead levels by DCHD's program. About 30% of the total number of eligible children—those 6 years and younger, in or near the Omaha Lead site—was tested. DCHD identified a similar percentage for testing in the site area for 2002 [41].

Public health actions to deal with the lead exposure of children in the Omaha site area should focus on increasing the percentage of children 6 years and younger that are tested. This would help locate and then mitigate exposures due to lead-based paint or clean up lead-contaminated soil. The various agencies involved with this site should develop and initiate a detailed plan to do that.

ATSDR Children's Health Concerns

ATSDR has established an ongoing initiative to protect children from exposure to hazardous substances. ATSDR recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contamination of their water, soil, air, or food. Because of their immature and developing organs, infants and children are usually more susceptible to toxic substances than are adults. Children are smaller, which results in higher

doses when compared with adults. Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care. ATSDR's evaluation contained within this document considered children as a susceptible subpopulation.

As indicated earlier, the occurrence of elevated blood lead levels in children 6 years and younger is concentrated in or near the Omaha Lead site. These children are at risk of a variety of lead-related effects, including slight decreases in intelligence, impaired hearing and growth, behavioral changes, and other effects. The main sources of exposure to lead in or near the Omaha Lead site appear to be lead-based paint and soil contaminated with lead emitted from the ASARCO refinery. The ongoing efforts to reduce exposure to both these sources need to continue and, if possible, be enhanced.

Health Outcome Data Evaluation

Health outcome data may help determine whether the incidence rates of certain adverse health effects are higher than expected in the area potentially affected by site contaminants. ATSDR conducts a review of health outcome data when the toxicological evaluation of a completed exposure pathway indicates the likelihood of adverse health outcomes. The evaluation of health outcome data may give a general picture of the health of a community, or it may confirm the presence of excess disease or illness in a community. However, elevated rates of a particular disease may not necessarily be caused by hazardous substances in the environment. Other factors, such as personal habits, socioeconomic status, and occupation, also may influence the development of disease. In contrast, even if elevated rates of disease are not found, a contaminant may still have caused illness or disease.

The Superfund law requires that health outcome (for example, mortality and morbidity) data be considered in a PHA [42]. Steps to achieve that are discussed in the *ATSDR Public Health Assessment Guidance Manual* and a 1996 revision to that guidance [37, 43]. The main requirements for evaluating health outcome data include the following:

- presence of a completed human exposure pathway,
- great enough contaminant levels to result in measurable health effects,
- sufficient persons in the completed pathway for health effects to be measured, and
- a health outcome database in which disease rates for population of concern can be identified.

The Omaha Lead site meets the requirements for conducting a health outcome data evaluation. There are 3 major completed current or past exposure pathways for lead (lead-based paint, residential soil, and ASARCO air emissions), with up to 86,000 individuals in those pathways. Site-related exposure has been occurring since 1870. As discussed earlier, lead levels are high enough to cause adverse health effects. Lead is classified as a probable carcinogen, though little is known about the relationship between dose and carcinogenic effect [20, 29]. ATSDR requested that Nebraska Health and Human Services System (NHHSS) evaluate cancer data for the Omaha Lead initial site investigation area. NHHSS agreed and their evaluation should be completed no later than September 2004.

Community Health Concerns

ATSDR is conducting a number of activities to communicate to the community about ATSDR activities related to Omaha Lead and to solicit health concerns. These include:

1. coordinating the development of the ATSDR Health Education plan with ATSDR's Division of Health Education and Promotion, community representatives, DCHD, EPA, NHHSS, NDEQ, and the University of Nebraska Cooperative Extension Service;
2. meeting with community leaders and elected officials, physicians and other health professionals, health clinic directors, and neighborhood groups to brief them on ATSDR's health education activities, identify their health-related concerns and questions, and to determine the best ways to deliver health education to meet the unique needs of this culturally diverse community; and
3. participating in the biweekly EPA Public Availability Sessions, and meetings of the Citizens Advisory Group for the Omaha Lead site (also held biweekly), health-based clinics, neighborhood groups, churches, and other community groups to provide technical assistance and health education.

Conclusions

ATSDR concludes that the ongoing exposure to lead of children 6 years old and younger living in or near the Omaha Lead site is a serious public health problem. Our review of the data for the period July 2000 to August 2002 indicate that nearly 300 children in or near the site had blood lead levels of 10 µg/dL or greater. The sources for the lead are lead-based paint and soil contaminated with lead emitted from the operation of the ASARCO refinery.

Public health actions to deal with the lead exposure of children in the Omaha Lead initial site investigation area should focus on increasing the percentage of children 6 years and younger that are tested. This would help locate and then mitigate exposures due to lead-based paint or clean up lead-contaminated soil. There should also continue to be a strong focus on primary prevention which is making homes lead-safe through mitigation of lead-based paint.

ATSDR, DCHD, National Center for Environmental Health (NCEH), Nebraska Health and Human Services (NHHS), and EPA need to work together to develop a plan to do this and to identify the additional resources necessary to implement it. This plan should focus on increasing public knowledge regarding lead hazards, promoting primary prevention activities, and encouraging and facilitating yearly blood lead testing for all children 6 years and under. Aggressive blood lead testing of young children would increase the likelihood of identifying children currently exposed. This would allow timely interventions such as mitigation of lead-based paint and clean up of contaminated soil.

Soil testing and soil removal actions were ongoing when this PHA was completed. ATSDR has evaluated whether EPA's cleanup and removal actions are protective for human health. The EPA soil lead cleanup criterion of 400 ppm is considered protective of public health because it triggers removal of lead-contaminated soil and eliminating continued exposure to children,.

ATSDR concludes that health outcome data for the Omaha Lead initial site investigation area should be evaluated because residents within 4 to 5 miles of the ASARCO facility were exposed to lead in the air from 1870 to 1997 and in soil from 1870 to the present day. About 86,000 individuals currently live in the Omaha Lead initial site investigation area.

ATSDR has assigned a Public Health Hazard Category of *current public health hazard* for exposures evaluated in this PHA. Appendix B presents a description of each of the Public Health Hazard Categories considered during the classification process.

Recommendations

ATSDR recommends that EPA continue to investigate and remove lead-contaminated soil (greater than 400 ppm) from properties (particularly, homes with children 6 years of age and under and daycare facilities).

ATSDR recommends that DCHD, in cooperation with NCEH, NHHS, EPA, and ATSDR, develop and implement a plan to increase the percentage of children 6 years of age and younger in and near the Omaha Lead initial site investigation area that participate in the childhood lead blood screening program. These agencies should also identify the resources needed to implement the plan. ATSDR recommends that this plan focus on educating residents living in high risk areas (which include both old housing and soil contamination) how to reduce their risk in the long term by implementing primary prevention strategies as well as learning short term interim strategies. The plan should also encourage residents of the effected area to have children under 7 years of age tested on a yearly basis to detect exposure above the level of concern.

ATSDR recommends that NHHS evaluate cancer data for the Omaha Lead initial site investigation area to determine the rates for that area and whether they differ from those for Douglas County and the State of Nebraska.

Public Health Actions

The public health action plan describes the actions designed to mitigate or prevent adverse human health effects that might result from exposure to hazardous substances associated with site contamination. ATSDR commits to do two public health actions at the Omaha Lead site.

1. ATSDR is working with DCHD, NCEH, EPA, and NHHS to initiate a plan to increase the percentage of children 6 years of age and younger in and near the Omaha Lead site who participate in the childhood blood lead screening program. ATSDR will work to identify and request or obtain the resources to implement those efforts. ATSDR will work to insure that this plan focuses on educating residents living in high risk areas (which include both old housing and soil contamination) about how to reduce their risk in the long term by implementing primary prevention strategies as well as learning short term interim strategies.

The plan should also encourage residents of the affected area to have children under 7 years of age tested on a yearly basis to detect exposure above the level of concern.

2. NHHS is currently evaluating cancer data for Omaha Lead initial site investigation area. This evaluation should be completed by September 2004.

The public health action plan for Omaha Lead will be updated as additional data become available.

Site Team

John Crellin, Ph.D.
Senior Environmental Epidemiologist
Division of Health Assessment and Consultation

Annmarie DePasquale, MPH
Environmental Health Scientist
Division of Health Assessment and Consultation

Youlanda Outin
Health Communication Specialist
Division of Health Assessment and Consultation

Paula Peters
Health Education Specialist
Division of Health Education and Promotion

Theresa NeSmith
Health Education Specialist
Division of Health Education and Promotion

Sue Casteel
ATSDR Region 7
Regional Representative
Division of Regional Operations

Denise Jordan-Izaquirre
ATSDR Region 7
Senior Regional Representative
Division of Regional Operations

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Appendix A - Exposure Pathways for the Omaha Lead Site

Appendix A - Exposure Pathways for Omaha Lead

PATHWAY NAME	ENVIRONMENTAL MEDIA and TRANSPORT MECHANISMS	POINT OF EXPOSURE	ROUTE OF EXPOSURE	EXPOSURE POPULATION	TIME	NOTES	COMPLETE EXPOSURE PATHWAY?
Lead-based paint ***(Not a site-related exposure pathway)***	Lead present in house dust, soil, and paint chips due to the use of lead-based	House dust, soil, and paint chips in homes with deteriorating lead-based paint	Incidental ingestion	Residents (particularly children 6 and younger)	Past, Present, Future	Available data indicates that 96% of children with blood lead levels above 10 µg/dL live in homes built prior to 1950	YES
Soil	Lead present in soil as a result of operations at the site	Surface soil in Omaha	Incidental ingestion, inhalation	Residents (particularly children 6 and younger)	Past, Present, Future	Available data indicates elevated soil lead and blood lead levels among children in the Omaha area	YES
ASARCO Refinery Emissions	Air-borne lead emissions from ASARCO Refinery	Likely the same area as where soil lead levels are elevated	Inhalation	Residents	Past		YES
Ingestion of Homegrown Produce	Uptake of lead from soil by fruits and vegetables grown in residential gardens	Produce consumption	Ingestion	Residents	Past, Present, Future	Based on the climate and small garden size, only small quantities of fruits and vegetables are expected to be grown in residential gardens.	YES
Drinking Water	Movement of lead from soil to groundwater	Municipal drinking water	Ingestion, inhalation (showering), direct contact	City water supply users	Past, Present, Future	Continued monitoring of municipal water supply	NO
Surface Water	Movement of lead from soil and groundwater to surface water	Missouri River and streams that drain into it from Nebraska	Direct contact	Residents	Past, Present, Future	No contaminants have been detected in surface water samples collected in 1996 and 1999	NO
Fish Uptake	Movement of lead from soil and groundwater to surface water	Fish consumption	Ingestion	Residents	Past, Present, Future	It is unlikely for fish to contain significant quantities of lead due to limited runoff	NO

Appendix B - Levels Of Public Health Hazard

Appendix B

Levels of Public Health Hazard

ATSDR classifies exposure pathways at hazardous waste sites according to their level of public health hazard. The following classifications indicate whether people could be harmed by exposure pathways and site conditions:

Urgent Public Health Hazard:	This category applies to exposure pathways and sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.
Public Health Hazard:	The category applies to exposure pathways and sites that have certain physical features or evidence of chronic (long-term), site-related chemical exposure that could result in adverse health effects.
Indeterminate Public Health Hazard:	The category applies to exposure pathways and sites where important information is lacking about chemical exposures, and a health determination cannot be made.
No Apparent Public Health Hazard:	The category applies to pathways and sites where exposure to site-related chemicals may have occurred in the past or is still occurring, however, the exposure is not at levels expected to cause adverse health effects.
No Public Health Hazard:	The category applies to pathways and sites where there is evidence of an absence of exposure to site-related chemicals.

Appendix C – Gardening Guidelines

Gardening Guidelines [18]

Soil Lead Levels < 400 ppm

- Discard old and outer leaves of vegetables. Peel root crops before eating. Do NOT compost these materials. Wash all vegetables with a 1% vinegar in water solution (1–2 oz. of vinegar in 1 gallon of water) or soapy water (taking care to rinse the soap off prior to consumption). There is more concern about lead contamination from the dirt on the exterior surfaces of unwashed produce than from the amount of lead absorbed by the plant itself.
- Locate gardens away from roads, driveways, old painted structures, potential lead sources, and old garbage dump sites. Lay out gardens to keep leafy greens and other hard-to-wash vegetables far from potential lead sources.
- Give planting preference to fruiting crops (tomatoes, peppers, squash, cucumbers, peas, beans, corn, etc.) rather than leafy vegetables such as lettuce and spinach or root crops such as carrots and radishes.
- Add organic matter to your soil, such as peat moss, compost, and manure. Organic compounds bind lead and make it less available to the plants. Suggested amounts: add three to four 4 cubic feet bales of peat moss to a 100 sq. foot garden plot.
- Maintain the soil pH above 6.5. It is hard for plants to uptake lead when the soil pH is above this level. Lead is also less available to plants when soil phosphorus levels are high.

Soil Lead Levels 400–1,000 ppm - Follow the above practices and also:

- Avoid growing leafy vegetables and root crops in this soil. Grow these crops in raised beds or containers with lead free soil.
- Topsoil of this kind can be purchased from nurseries and garden stores.

Soil Lead Levels > 1,000 ppm

- Do NOT garden in this soil.
- Install raised beds or try container gardening.

What about soil that has not been tested for lead?

- Assume the soil may have some lead contamination if it is in an area by housing built before 1978 or near past or present industrial sites. Use the above suggestions as a guide to reducing lead exposure.
- Consider having the soil tested for lead, especially if the buildings on the property were built before 1978. Also, consider testing if children younger than 7 years of age play in bare soil on the property or you grow vegetables in potentially contaminated soil.

These guidelines were developed by Douglas County Health Department [18].

Appendix D - ATSDR Plain-Language Glossary

Appendix D

ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR serves the public by using the best science to take responsive public health actions and It provide trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR=s toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption
For a person or animal, absorption is the process through which a substance enters the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with **chronic**].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with **intermediate duration exposure** and **chronic exposure]**.

Additive effect
A biologic response to exposure to multiple substances that equals the sum of responses to the individual substances [compare with **antagonistic effect** and **synergistic effect]**.

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems.

Aerobic
Requiring oxygen [compare with **anaerobic**].

Ambient
Surrounding (for example, *ambient* air).

Anaerobic
Requiring the absence of oxygen [compare with **aerobic**].

Analyte
A substance measured in the laboratory. A chemical a laboratory tests for in a sample (such as water, air, or blood). For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Analytic epidemiologic study
A study that evaluates a proposed association between exposure to hazardous substances and disease.

Antagonistic effect
A biologic response to exposure to multiple substances that is **less** than would be expected if the known effects of the individual substances were added together [compare with **additive effect** and **synergistic effect**].

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation
Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study
A study to confirm human exposure to a hazardous substance. It does that through **biomedical testing** or by measuring a substance (an **analyte**), its **metabolite**, or another marker of exposure in human body fluids or tissues [also see **exposure investigation**].

Biologic monitoring
Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing
Testing people to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP
See **Community Assistance Panel**.

Cancer
Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk for developing cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Case study
A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number
A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see **Comprehensive Environmental Response, Compensation, and Liability Act of 1980**]

Chronic
Occurring over a long time (more than 1 year) [compare with **acute**].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with **acute exposure** and **intermediate duration exposure**].

Cluster investigation
A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)
A group of people, from a community and from health and environmental agencies, who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see **exposure pathway**].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as **Superfund**, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect
A disease or injury that happens as a result of exposures that might have occurred in the past.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see **route of exposure**].

Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease prevention
Measures used to prevent a disease or reduce its severity.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD
United States Department of Defense.

DOE
United States Department of Energy.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An Aexposure dose@ is how much of a substance is encountered in the environment. An Aabsorbed dose@ is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [**dose**] to a substance and the resulting changes in body function or health (response).

Environmental media
Soil, water, air, **biota** (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and **biota** (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The **environmental media and transport mechanism** is the second part of an **exposure pathway**.

EPA
United States Environmental Protection Agency.

Epidemiologic surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [**acute exposure**], of intermediate duration, or long-term [**chronic exposure**].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction
A method of estimating the amount of people-s past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a **source of contamination** (such as an abandoned business); an **environmental media and transport mechanism** (such as movement through groundwater); a **point of exposure** (such as a private well); a **route of exposure** (eating, drinking, breathing, or touching); and a **receptor population** (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a **completed exposure pathway**.

Exposure registry
A system of ongoing follow-up of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

Groundwater
Water beneath the earth=s surface in the spaces between soil particles and between rock surfaces [compare with **surface water**].

Half-life (t_2)
The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)
The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a

public health assessment, which reviews the exposure potential of each pathway and chemical [compare with **public health assessment**].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to estimate the possible association between the occurrence and exposure to hazardous substances.

Health promotion
The process of enabling people to increase control over, and to improve, their health.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard
The category used in ATSDR=s public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with **prevalence**].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see **route of exposure**].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see **route of exposure**].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with **acute exposure** and **chronic exposure**].

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with **in vivo**].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with **in vitro**].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Medical monitoring
A set of medical tests and physical exams specifically designed to evaluate whether an individual=s exposure could negatively affect that person=s health.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite
Any product of **metabolism**.

mg/kg
Milligram per kilogram.

mg/cm^2
Milligram per square centimeter (of a surface).

mg/m^3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period

(acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see **reference dose**].

Morbidity
State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality
Death. Usually the cause (a specific disease, condition, or injury) is stated.

Mutagen
A substance that causes **mutations** (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites
(National Priorities List or **NPL)**
EPA=s list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

No apparent public health hazard
A category used in ATSDR=s public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR=s public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see **National Priorities List for Uncontrolled Hazardous Waste Sites]**

Physiologically based pharmacokinetic model (PBPK model)
A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see **exposure pathway**].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)
A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific period [contrast with **incidence**].

Prevalence survey
The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public availability session
An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public health action
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with **health consultation**].

Public health hazard
A category used in ATSDR=s public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or **radionuclides** that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are **no public health hazard**, **no apparent public health hazard**, **indeterminate public health hazard**, **public health hazard**, and **urgent public health hazard**.

Public health statement
The first chapter of an ATSDR **toxicological profile**. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public meeting
A public forum with community members for communication about a site.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA [see **Resource Conservation and Recovery Act (1976, 1984)**]

Receptor population
People who could come into contact with hazardous substances [see **exposure pathway**].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see **exposure registry** and **disease registry**].

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD
See **reference dose**.

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [**inhalation**], eating or drinking [**ingestion**], or contact with the skin [**dermal contact**].

Safety factor [see **uncertainty factor]**

SARA [see **Superfund Amendments and Reauthorization Act**]

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see **population**]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or environment.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an **exposure pathway**.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Substance-specific applied research
A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's **toxicological profiles**. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with **groundwater**].

Surveillance [see **epidemiologic surveillance**]

Survey
A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see **prevalence survey**].

Synergistic effect
A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see **additive effect** and **antagonistic effect**].

Teratogen
A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people=s sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a **safety factor**].

Urgent public health hazard
A category used in ATSDR=s public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Other Glossaries and Dictionaries
Environmental Protection Agency - http://www.epa.gov/OCEPAterms/
National Center for Environmental Health (CDC) - http://www.cdc.gov/nceh/dls/report/glossary.htm
National Library of Medicine (NIH) - http://www.nlm.nih.gov/medlineplus/mplusdictionary.html