Final Community Involvement Plan

Sulphur Bank Mercury Mine Site
Clearlake Oaks, California

Prepared for

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1.0 Introduction

The U.S. Environmental Protection Agency (EPA) is working to clean up the former Sulphur Bank Mercury Mine site (Site) in Clearlake Oaks, California. The Site was initially mined for sulfur and later for mercury between 1865 and 1957. Today the approximately 220-acre Site contains waste rock, **mine tailings**[1], and a flooded open mine pit. The mine waste extends into the Oaks Arm of Clear Lake along the shoreline of the Site. EPA's **remedial investigation** found **mercury**, **arsenic,** and antimony in the mine wastes. Mercury is present in the bottom sediment of Clear Lake and it has **bioaccumulated** in the food web. Mercury levels in fish from the lake led the State of California to issue an advisory to limit fish consumption.

This community involvement plan (CIP or Plan) describes EPA's community involvement activities being conducted as part of the cleanup. This CIP was prepared under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), also known as Superfund. See Appendix A for a description of the Superfund process. Appendix B provides community resources.

Community involvement and feedback will ultimately affect the cleanup activities and potential future uses of the Site. This CIP summarizes feedback from neighborhood residents, community members, and community organizations regarding work at the Site and explains EPA's strategies for community participation in the cleanup process. This CIP also describes EPA's process of understanding and addressing community concerns and priorities.

[1] Words in bold can be found in the glossary.

2.0 Site Description

The Site is located on the eastern shore of Clear Lake, in Lake County, California, approximately 1 mile from the town of Clearlake Oaks. Clear Lake is the largest natural freshwater lake wholly in California (see Figure 2-1). The Clear Lake basin is within the California Coast Range and contains oak-madrone forest, chaparral, and grassland vegetation. Higher elevations have dense stands of conifers. Elevations in the county range from 1,326 feet above mean sea level (amsl) in Clear Lake basin to 7,056 feet amsl at the peak of Snow Mountain, which lies in the Mendocino National Forest north of Clear Lake. Mt. Konocti rises to an elevation of 4,300 feet amsl on the southern shore of Clear Lake and is a dominant feature in the viewshed.

The Clear Lake basin attracts large quantities of waterfowl, including mallard, western grebe, coot, various species of goose, osprey, plover, and merganser. Clear Lake has many species of fish. In addition to the native Clear Lake hitch (called chi by the native Pomo Indians), the lake contains catfish, crappie, largemouth bass, trout, and carp. Clear Lake is a source of water for Clearlake Oaks County Water District that provides municipal drinking water to more than 4,700 people.

The Elem Pomo Nation, also known as Elem Indian Colony of Pomo Indians (EIC), have made their home in the Clear Lake Basin for the last 9,000 years[2]. The Elem currently have a 50-acre reservation on the northeast shore of Clear Lake, immediately adjacent to the Site. The reservation was originally formed under the name Sulphur Bank Rancheria in 1949.

Mine wastes at the Site are contaminated with elevated concentrations of mercury, arsenic, and antimony. **Surface water** and **groundwater** from the Site have contaminated Clear Lake and the wetland north of the mine. As a result, fish in Clear Lake contain mercury concentrations in excess of the federal guidelines for human consumption. To address this, the State Office of Environmental Health Hazard Assessment issued a fish consumption advisory that provides guidelines for the quantity of fish from the lake that people may safely consume. EPA has concluded that mine waste piles present an unacceptable risk to human health and animals. Ingestion of surface soils and inhalation of dust are the primary ways that humans are exposed to mercury, arsenic, and antimony from the waste piles.

[2] White, G., and D.A. Fredrickson (1992) A Research Design for the Anderson Flat Project, Archeological Data Recovery Investigations at Sites CA-LAK-72, 509, 501,536, 538, 542, and 1375, Lake County, California. Prepared for California Department of Transportation, District 1, Eureka.

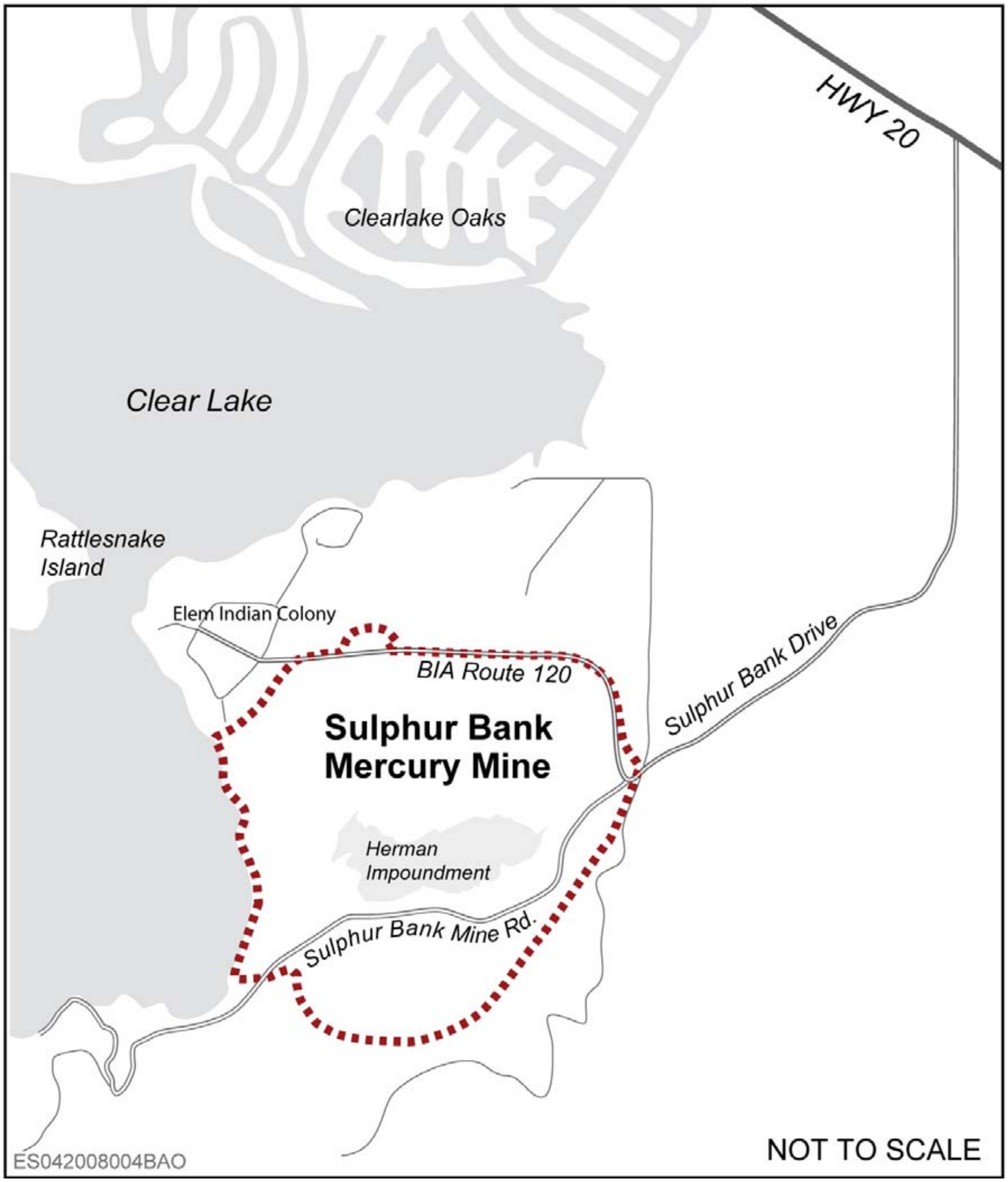

FIGURE 2-1
SITE LOCATION

3.0 Mining History

Mining took place on the eastern shore of Clear Lake during the nineteenth and twentieth centuries, at what is today the Sulphur Bank Mercury Mine. The Site was mined for sulfur from 1865 to 1871. Mercury, also called quicksilver, was mined intermittently by underground methods from 1873 to 1906. The Site was also mined by open-pit methods periodically between 1915 and 1957. Large-scale open-pit mining began in 1927. This created Herman Pit, which has since filled with water. The flooded pit is now called Herman Impoundment. Sulphur Bank was one of the largest mercury mines in the state. The mine has been inactive since 1957.

Historically, mining has been an important source of jobs and revenue in Lake County and particularly in Clear Lake basin. A town called Sulphur Banks grew up around the mine during the quicksilver boom period. In 1874, the town had 1,000 residents, 600 of whom were Chinese immigrants who worked in the mines.

Mercury was first discovered in fish in Clear Lake in the late 1970s by the California Department of Fish and Game. Growing public concern led to the formation of the Clear Lake Mercury Task Force in 1983. In 1990, the former Sulphur Bank Mercury Mine was listed as a Superfund site by EPA. The Site currently contains approximately 3 million cubic yards of mine waste and an unlined mine pit (Herman Impoundment). EPA's remedial investigation studies have detected mercury, arsenic, and antimony in the mine wastes.

Mercury has also been detected in the sediment at the bottom of Clear Lake and has bioaccumulated in the fish and other aquatic organisms. More detailed discussions regarding the health concerns associated with exposure to mercury and arsenic are included in Appendix C and Appendix D, respectively.

4.0 Community Profile[3]

4.1 Early Inhabitants[4]

The Clear Lake area was inhabited predominantly by the Pomo who lived in an area stretching from Sebastopol in Sonoma County in the south, to beyond Fort Bragg in the north, and from Stonyford in the east to the Pacific Coast in the west. They occupied all but the very southern end of the lake. Twelve distinct Pomo groups lived within the Clear Lake basin. The Eastern Pomo lived around Clear Lake proper and Upper Lake. They lived adjacent to the Northern Pomo, Central Pomo, and Patwin. The Eastern Pomo had permanent villages inland from the shore of Clear Lake and along streams. The Southeastern Pomo, which included the Elem, inhabited several villages along the southeastern shore of Clear Lake and Rattlesnake Island.

4.1.1 Subsistence and Settlement

Acorns were the staple food for the Pomo. Acorns were eaten in the form of bread or mush, and supplemented by seeds, roots, berries, fish, and game. Acorns were stored in large outdoor granaries or caches. The most common meal consisted of dried fish and acorn mush with seasonal meats and vegetables. Other dietary staples included waterfowl, clams, clover, and tule. Fishing activities revolved around the spawning season, and techniques varied according to fish species. Suckers were caught using conical basket traps; pike were speared with a fish gig; and hitch and chay were caught with a brush fish dam. Fish traps were also used to catch blackfish and carp; the fish were dried and stored.

Each territory had a main village. Houses were circular in shape and were constructed of tule. Poles were placed in the ground, the tops were bound together, and the frame was thatched with tule. The dwelling interior was lined with mats. Each dwelling housed several related nuclear families, each with its own fire and entrance door. The storage facilities, central baking pit, and mortar stone were shared by all inhabitants of the house. During summer, the Pomo used brush shelters consisting of a brush roof on four or more posts or relied on the shade canopy provided by the pepperwood tree.

4.1.1.1 Social Organization

Social organization among the Pomo was largely based on kinship. Succession appears to have been largely based on kinship. The Pomo appear to have had bilateral descent (i.e., property and skills could be passed through the mother or father). Craft specialties were generally passed down through lineages and taught to family members.

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3 The information provided in this section was taken from the *Archaeological Survey for the Sulphur Bank Mercury Mine Remediation Project, Lake County, California Draft Report* prepared by Pacific Legacy, Inc. (2008).

4 The information for this section was taken from several sources but primarily the following: *Handbook of North American Indians, Volume 8, California*, Robert F. Heizer, editor (specifically McLendon and Lowy 1978; McLendon and Oswalt 1978); *Handbook of the Indians of California* by A.L. Kroeber (1925); *The Ethno-geography of the Pomo and Neighboring Indians* (1908) and *Pomo Structures* (1916) by S. A. Barrett; *Pomo Geography* by Fred B. Kniffen (1939); and *The Pomo Indians of California and Their Neighbors* by Brown and Andrews (1969).

4.1.1.2 Intergroup Relations

Some warfare occurred between communities surrounding Clear Lake, although battles ceased when an important figure was injured or slain. The 1851 population in Clear Lake was estimated at 1,000 native persons, including Wappo and Miwok groups. Territorial boundaries were well defined but not strictly enforced. Pomo people could hunt and gather on uninhabited areas in neighboring territories. Although groups of people regularly traveled to other areas, such as the coast, to trade, most Pomo never traveled outside of their own communities. Not all neighboring tribes viewed land ownership and gathering rights similarly. The practices ranged from no private land ownership to exclusive gathering rights to certain trees and seed- and bulb-producing fields. Although some groups held exclusive use of boat landings, the use of Clear Lake was communal.

Clamshell beads were the medium of exchange for the Pomo people and provided a standard of value and means for storing wealth. Clamshell beads had standardized values as did magnesite cylinders. The Pomo created clamshell disks by breaking shells into small pieces, then roughly shaping, drilling, and stringing them. Finally, they rubbed them with a wet hand on a flat stone until smooth and round. The value of the clamshell depended on the diameter and thickness of the disk and the degree of polish. Although the use of clamshell beads was a more prevalent practice, the Pomo occasionally bartered. The Pomo traded fish, acorns, skins, and magnesite for fiber cord, arrows, bows, shellfish, seaweed, abalone, fur, and clamshells.

4.1.2 Elem Indian Colony[5]

When Europeans arrived in the Clear Lake area, the Southeastern Pomo lived in a village on Rattlesnake Island approximately 0.5 mile north of the Site. EIC is located only a few hundred meters from the central village site of Rattlesnake Island. Researchers have proposed that the current EIC represents the overflow area of the Elem village at Rattlesnake Island. After European contact, this overflow area became the main settlement of the Elem. As S. A. Barrett, the first ethnographer of the Pomo, observed on a 1903 visit to Rattlesnake Island, "This village was formerly the largest in the Southeastern [Pomo] dialect area and was only abandoned about thirty-five or forty years ago, when its inhabitants removed to the adjacent mainland, where they now live" (Barrett, 1908).

4.2 Historical Background

4.2.1 Spanish Era

Spanish interest in upper California (Alta California) started in the 1760s, with rumors that Russia was planning to expand its colonial sphere southward from Alaska into California. In response, the Spanish government sent Father Junípero Serra and Spanish settlers northward from Mexico. In 1769, Mission San Diego and the first presidio were established. This was followed by a string of settlements and missions northward that ended with

[5] The information for this section is taken from several sources but primarily: "Pomo Lands on Clear Lake" in *University of California Publications in American Archaeology and Ethnology* 20: 77-92 by E. W. Gifford (1923); "Pomo Geography" in *University of California Publications in American Archaeology and Ethnology* 36(6):353-400 by F. B. Kniffen (1939); and *An Archaeological Survey of Proposed Development Areas at El-em Indian Colony*, *Lake County*, *California* by D. Fredrickson (1975).

Mission San Francisco Solano in Sonoma County in 1823. There is no record of Spanish era exploration or settlement in Lake County.

4.2.2 Mexican Era

In 1821, Mexico gained independence from Spain, and the following year, California was declared a territory of the Mexican Republic. Apart from sending in new governors and a small number of soldiers, Mexican intervention was minimal over the next several years. In 1834, the Mexican governor of California downgraded the missions to the status of parish churches and divided their vast holdings into individual land grants (*ranchos*). This process, called secularization, brought an influx of Mexican settlers to California and allowed for the emergence of a new class of wealthy landowners known as *los rancheros*. During the Spanish era, supplies and the economy were tied directly to Spain. With Mexican secularization and more economic independence, an emphasis on local ranching and agricultural activities grew in California.

The first non-native exploration of the Lake County area was probably by trappers and hunters heading to the Russian settlements of Fort Ross and Bodega. In 1832 or 1833, a party of American trappers working for Hudson's Bay Company, led by Ewing Young, passed through the Clear Lake area. In 1836, Captain Salvador Vallejo and Ramon Carillo led an expedition from Mission San Francisco Solano at Sonoma into the Clear Lake region.

In 1839, Salvador Vallejo and his brother, Juan Antonio, applied for a land grant from the Mexican government for sixteen leagues of land including Upper Clear Lake, and Bachelor, Scotts, and Big Valleys. They built a log cabin and corral in Big Valley, where they ranched cattle. Governor Micheltorena approved their Rancho Lupyomi Grant in 1844. In 1847, Vallejo left Clear Lake, selling his land and part of the cattle herd to Charles Stone, a Mr. Shirland, and the Kelsey brothers (Andrew and Benjamin). Charles Stone and Andrew Kelsey moved onto the ranch and employed native laborers to build an adobe house near the present-day town of Kelseyville. According to several sources, Stone and Kelsey mistreated their employees by forcing them to work around the clock and withholding wages and food. By 1849, the two were murdered by their workers.

Two other Mexican land grants were made in Lake County. Rancho Callayomi consisted of three leagues of land in Loconoma Valley near current Middleton, which was granted to Robert T. Ridley in 1844. Ridley was an English sailor who became a naturalized Mexican citizen and married into the Briones family. Rancho Guernoc consisted of six leagues in Coyote Valley at the south edge of the county. In 1845, the rancho was granted to George Rock who had arrived in Coyote Valley in 1837 and built a cabin there.

In the 1840s, relations between Mexico and the United States became strained as the United States expanded westward toward the Pacific Ocean. The political stress erupted into the Mexican-American War from 1846 to 1848. At the close of the war, Alta California became part of the United States with the signing of the Treaty of Guadalupe Hidalgo.

4.2.3 American Era

In 1848, shortly after the Mexican-American War, James Marshall discovered gold on the American River, and the California Gold Rush began. The discovery of gold brought tens of thousands of gold seekers from around the world who pushed further into California. The wealth and expanding population in California curtailed the usual territory phase, and California became a state in 1850.

Prior to the Gold Rush, there were few non-native residents in the area. Lake County was formed in 1861 by state act. The new county was created from the southwestern portion of Colusa County, the northern portion of Napa County, and a southeastern portion of Mendocino County. Lakeport was named the county seat, and a courthouse was built there. In 1867, the courthouse and all its records burned. While a new courthouse was built in 1870, the county seat was temporarily moved to Lower Lake.

As Lake County grew and developed during the late nineteenth century, the economy turned to farming, mining, and resorts that capitalized on the mineral springs. As Gold Rush fever declined, agriculture expanded during the 1870s and 1880s and became an economic mainstay for the state of California. Lake County’s economy was varied and included stock ranching and lumber production. Its agricultural produce included wheat and other grains, opium poppies, Bartlett pears, and wine grapes.

Residents of Lake County began discovering exploitable minerals in the 1850s and 1860s. Lake County mineral resources included gold, silver, copper, borax, sulfur, asbestos, and quicksilver (mercury), which were found in the western Mayacamas Mountains, the eastern hills, and Bear Mountain. The most productive of the Lake County quicksilver mines were in the Mayacamas District and included the Sulphur Bank, Bradford (Mirabel), and Great Western Mines.

4.3 Lake County Demographics

Between 1980 and 2000, the population of Lake County grew approximately 60 percent, to a total of 58,309 people. According to the 2000 U.S. Census, 3.2 percent of the total population of Lake County is American Indian (see Figure 4-1). By 2020, Lake County’s population is expected to increase to 93,000 residents.

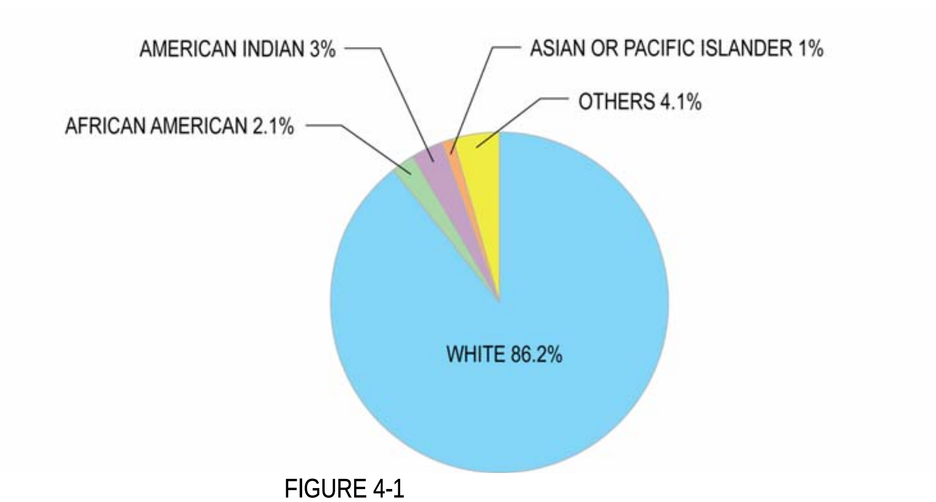


FIGURE 4-1
LAKE COUNTY POPULATION DISTRIBUTION BY RACE

4.4 Local Economy

Currently, the number of people employed in Lake County is about 24,000. Between 2000 and 2004, Lake County employment increased by 2.4 percent, resulting in 330 additional jobs. The county's unemployment rate was 8.8 percent in 2004; however, seasonal jobs such as agriculture and tourism had higher-than-average rates of unemployment.

As population has increased, Lake County has become increasingly urbanized. However, despite ongoing urbanization, total cropland and gross agricultural production value have increased steadily since the 1950s[6]. Currently, 43 percent of Lake County is devoted to agriculture, more than to any other land use. The remaining distribution of land use is shown on Figure 4-2.

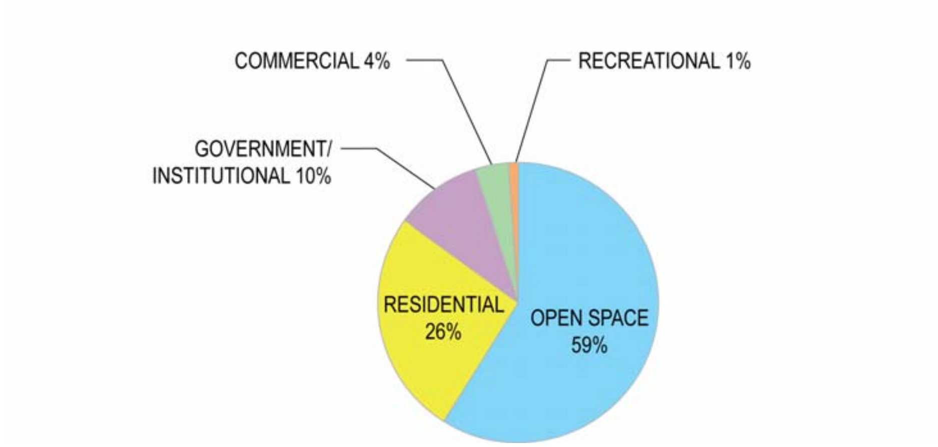


FIGURE 4-2
LAKE COUNTY NONAGRICULTURAL LAND USE

The increase in agricultural production can be attributed to improved farming techniques and to new varieties of high-yield crops. The primary crops grown in Lake County are pears, wine grapes, and walnuts. In 1997, these crops accounted for 39 percent of the cultivated land in the County, but were responsible for more than 75 percent of gross annual agricultural production (*Lake County General Plan Background Report*, 2003). Vineyard reintroduction has been a substantial trend in Lake County in recent years. Pear and walnut orchards that replaced vineyards during prohibition are being converted back into vineyards. Grassland, oak savanna, and oak woodland are also being converted into vineyards, mostly by developers from neighboring wine-growing counties such as Sonoma and Napa, where land is more expensive and environmental regulations are more stringent.

Agricultural production has also been a source both of economic productivity and environmental pollution. **Runoff** from agricultural operations near Clear Lake have resulted in **nutrient loading** that affects the lake's aquatic ecosystem.

Tourism, retail businesses, and **geothermal** resource extraction are also important to the Lake County economy. In 2000, tourism-related economic activity provided 4,860 jobs and generated approximately $2.4 million in local tax revenue. Lake County's principal recreational activities include boating, fishing, water skiing, and picnicking. Many lakes

[6] URS Mintier & Associates. 2003. *Lake County General Plan Background Report.* February.

within the county offer such recreational opportunities, but Clear Lake continues to be the area's largest attraction. Lake County also has abundant open space that offers opportunities for hiking and camping.

Retail businesses are also very important to Lake County because they are the source of sales tax revenue, Lake County's second largest source of discretionary revenue. However, sales tax revenue generated within the county's two incorporated cities, Clearlake and Lakeport, goes to the cities rather than to the county.

Geothermal extraction has played a major role in the local economy. Geothermal activity exists in the southwest portion of Lake County in an area known as The Geysers. Geothermal resources, or steam rights, can be leased by landowners. These resources are used to generate energy and for various other purposes, including heating and cooling homes, drying lumber, aggregating cement slabs, heating water for fish farming, and food processing. The amount of energy generated from The Geysers has declined over time[7]; however, recent innovations in resource management techniques have stabilized production.

[7] URS Mintier & Associates. 2003. *Lake County General Plan Background Report.* February.

5.0 Community Involvement

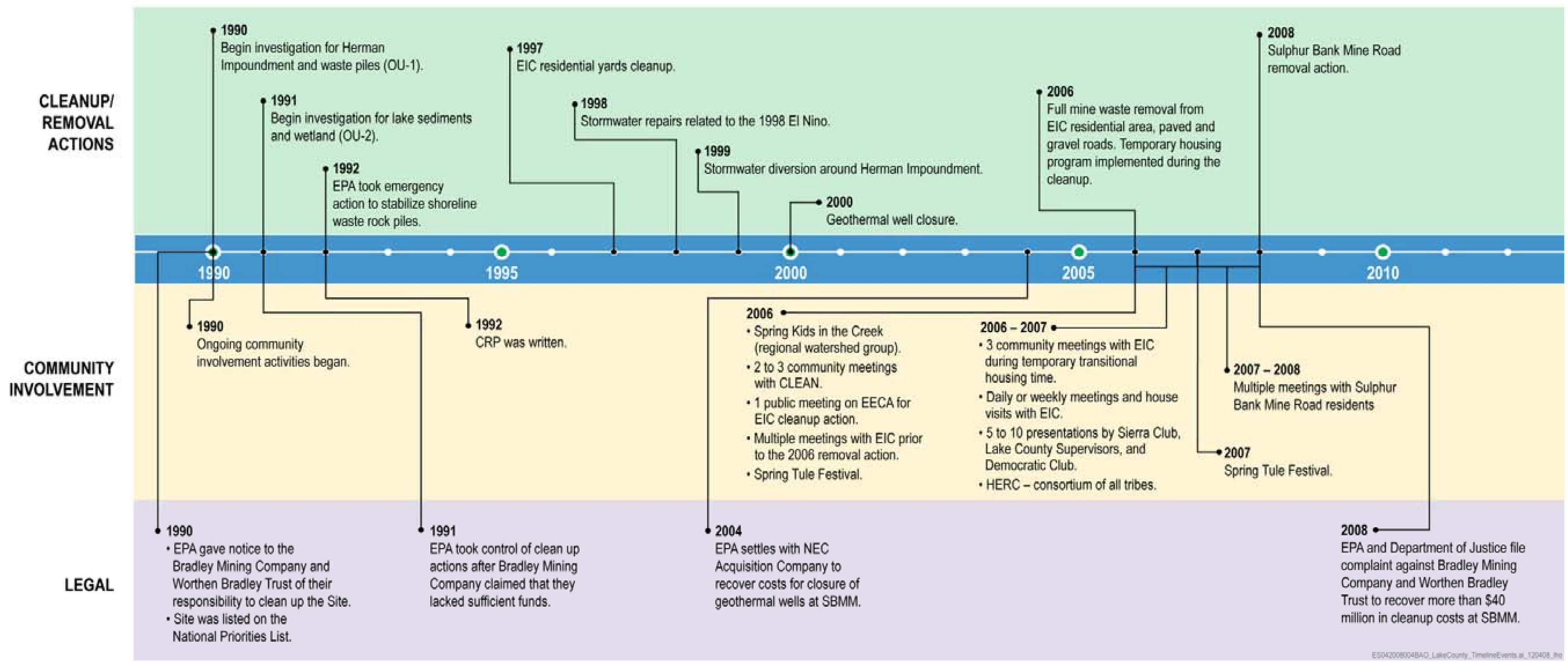
This CIP is the second such plan undertaken for the Site. The first plan was a community relations plan (CRP) in 1992. Like this CIP, the CRP described the history of the Site, community context, and community concerns. It also set forth a strategy for disseminating information to the public, incorporating community concerns into the remedial investigation/feasibility study (RI/FS), and involving the community in the **remedy** process. The community outreach approach includes community meetings, discussions, workshops, open houses, press releases, fact sheets, and public meetings and will be implemented as-needed basis. A timeline of events is provided on Figure 5-1.

Community involvement is sought at every stage of the Superfund process. This CIP is intended to be a flexible working document that is responsive to community concerns. In this Plan, EPA updates the strategies in the CRP to reflect current Site conditions and community concerns regarding cleanup status. This CIP will continue to be revised as concerns emerge and as new information becomes available.

To gain an updated understanding of community concerns related to the Site, EPA conducted interviews with community members and public officials. Interviewees included members of community groups, business owners, Site neighbors, tribal members and leaders, local public officials, and regulatory agency staff.

EPA has continued to publish fact sheets to keep the public informed of progress and significant events while Site cleanup alternatives are being evaluated. In addition, EPA has held many meetings with local residents, community organizations, and tribal members to discuss the cleanup activities at the Site.

A technical assistance grant was awarded to the Clear Lake Environmental Action Network (CLEAN). CLEAN is a community group that formed in July 2003 to ensure that concerned individuals have full participation and understanding of proposed EPA mitigation efforts at the Site. CLEAN members consist of Lake County residents, property owners, business owners, and other concerned individuals. With the aid of a community technical advisor, CLEAN disseminates information, monitors and evaluates EPA remedial actions, and provides a public forum where community representatives can voice their concerns. CLEAN organizes meetings with EPA on behalf of the community and performs public outreach by publishing newsletters, maintaining an Internet presence, organizing quarterly public meetings, initiating contact with local government, maintaining a dialog with local media, organizing presentations for interested parties, and disseminating information at local events. Stakeholder relationships are shown on Figure 5-2.



Notes:
OU-1 = Operable Unit 1
OU-2 = Operable Unit 2
HERC = Hinthil Environmental Resource Consortium
EECA = engineering evaluation and cost analysis

FIGURE 5-1
TIMELINE OF EVENTS

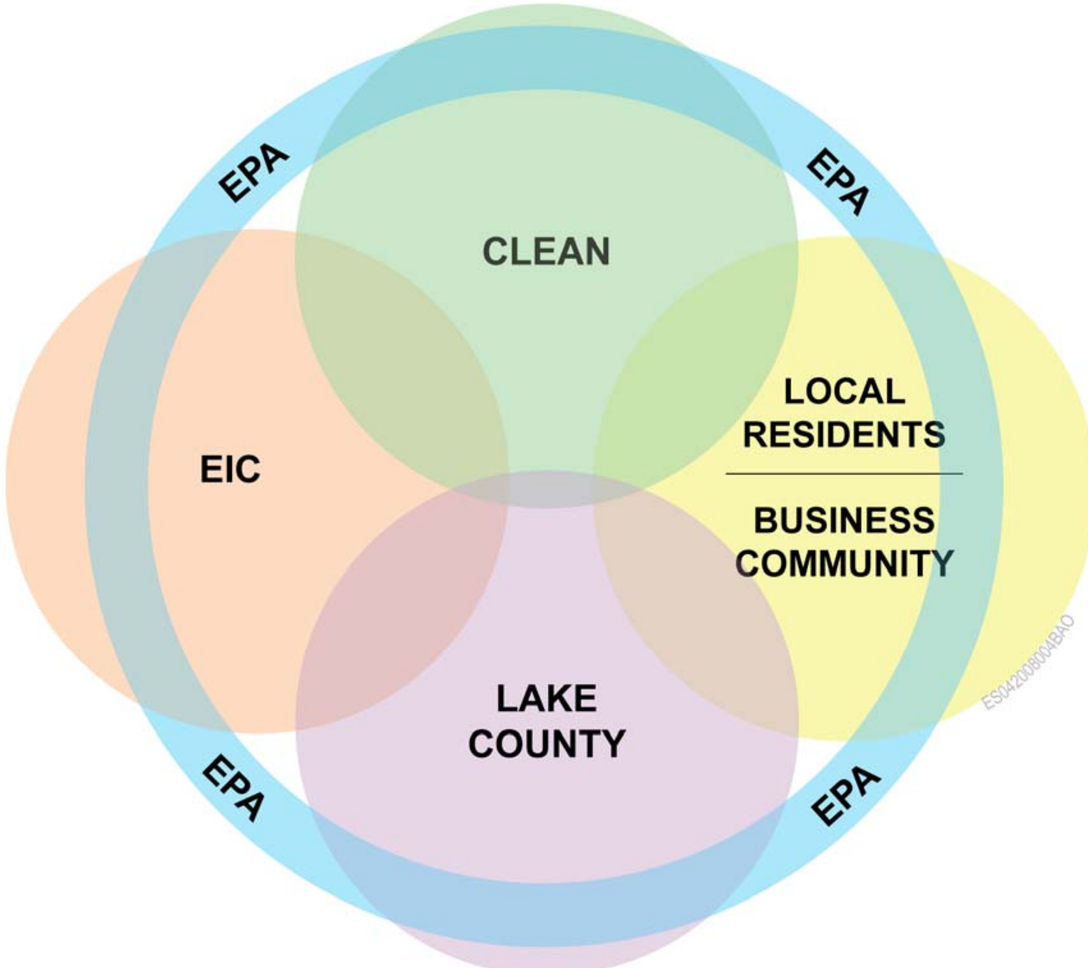


FIGURE 5-2
STAKEHOLDER RELATIONSHIPS

5.1 EPA Cleanup Approach

EPA is cleaning up the Site in two phases: (1) **emergency actions** to prevent short-term harm to nearby residents and the lake and (2) a long-term remedial phase. For the remedial phase, the Site has been divided into two **operable units**. In Operable Unit 1 (OU-1), EPA will develop and implement a cleanup plan to address the Herman Impoundment and the mine waste piles located on the mine property. In Operable Unit 2 (OU-2), EPA will develop and implement a cleanup plan to address the contaminated sediments in Clear Lake and the resulting mercury accumulation in fish and other organisms.

5.2 EPA Cleanup Actions

Cleanup actions performed at the Site to date include the following:

- **Erosion control emergency response**. In 1992, EPA cut back the slope of the mine waste pile located along the shore of Clear Lake, covered the slope with clean material, and reseeded the area. These measures were performed to eliminate the erosion of mine wastes containing mercury and arsenic into Clear Lake. In 1996, EPA raised a small earthen dam at Herman Impoundment as a temporary flood control measure.

- **Soil removal from Elem Indian Colony**. In 1997, EPA removed up to 18 inches of mercury- and arsenic-contaminated soil from 17 residential yards in the EIC. EPA covered the yards with clean fill material and topsoil. Varying amounts of contaminated mine waste remained in the residential yards.
- **Surface water diversion**. In 1999 and 2000, EPA constructed surface water diversions on the Site to reduce the potential for contaminated water from Herman Impoundment from discharging to Clear Lake. The diversion work included construction of a 4,000-foot pipeline that allows clean water from the surrounding hills to flow around the Site without being contaminated by mine wastes or causing an overflow of Herman Impoundment.
- **Well closure emergency response**. During the 1970s, mine owners allowed exploratory drilling for geothermal wells near Herman Impoundment. EPA became concerned that the wells were not properly sealed and that they might be subject to violent releases of geothermal gas. EPA conducted an emergency investigation of the wells in late 2000 and early 2001 and took action to properly close three wells that had not been properly sealed.
- **OU-1: Herman Impoundment and waste rock piles investigation**. In 1990, EPA began to investigate the nature and extent of contamination associated with Herman Impoundment and the waste rock piles. EPA initially completed a remedial action/ feasibility study (RI/FS) and issued a proposed cleanup plan for OU-1 in 1994. However, because of the comments received and additional data collected, EPA decided to re-open the RI/FS. In early 2001, EPA completed a hydrogeological study of groundwater movement. EPA completed the remedial investigation in 2002 and is currently performing a feasibility study to develop and evaluate **cleanup alternatives** for Herman Impoundment and the waste rock piles in OU-1.
- **OU-2: Lake Sediments and North Wetland investigation**. In 1991, EPA began investigating the contamination in lake sediments. EPA funded a University of California at Davis study of lake sediments and elevated mercury levels in fish and other organisms. In 2000, EPA held a conference on mercury contamination in which national experts participated. EPA is currently studying contamination in North Wetland and is conducting studies to determine the extent of sediment contamination in Clear Lake.
- **Full mine waste removal from EIC**. In June 2006, EPA began to remove 28,000 cubic yards of mercury- and arsenic-contaminated soil from the EIC residential area. EPA removed mine wastes from 14 residential yards, several inactive gravel roadways, and from beneath the entire paved roadway system. Clean fill was imported and used to prepare foundations. Clean topsoil was brought in to cover the yards and open areas. EPA installed five new homes; refurbished seven existing homes; repaved the roadway; installed new curbs, sidewalks, water system, and storm drains; and improved the sewer system. All EIC residents participated in the Temporary Transitional Housing Program during the mine waste removal action. In December 2006, 15 of 17 households returned to their permanent homes at the EIC. EPA completed the installation of two

additional mobile homes and completed several roadway improvements in June 2007. The remaining two households have returned to their permanent homes.

- **Removal of mine waste from Sulphur Bank Mine Road**. In January and February 2008, EPA removed approximately 3,000 cubic yards of mine waste from residential areas along Sulphur Bank Mine Road and along Ward Road. Mine waste was removed from residential yards and driveways and along portions of the roadways. Clean fill and topsoil were brought in to replace the removed mine waste.

EPA plans to issue a proposed plan in March 2009 and sign a Record of Decision for contaminant sources located at the mine property (OU-1) in December 2009.

5.3 Community Concerns

During August and September 2005, EPA conducted interviews with community stakeholders to get a sense of their concerns about the Site. Twenty-one interviews, some of which included multiple interviewees, were conducted with community members; community organization representatives; local, state, and federal agency representatives; and elected officials (see Appendix B). Interviewees were asked questions from a standard list (see Appendix E).

The following questions represent the most common concerns expressed by the community interviews.

Why is the cleanup process going so slowly?

The interviewees expressed concern that cleanup is progressing too slowly and that little has been done even though EPA had been involved at the Site for several years. Interviewees suggested that public confidence had eroded because of the lack of knowledge regarding the cleanup status. A comment made by one member of the County Board of Supervisors summarizes the common sentiment, "Everyone is in agreement that we need to stop studying the problem and do something about it. That is public consensus. Whatever is the best technology available, let's use it."

What is EPA doing to protect Tribal interests?

More than one interviewee expressed concern about the exposure of Tribal members to high mercury levels at Clear Lake. Because fish from Clear Lake was traditionally a staple of the Elem diet, they worried mercury contamination disproportionately affects their health. In particular, community members expressed concerned about pregnant women consuming mercury-contaminated fish and children ingesting mercury when they play. Some community members expressed concern about the lack of information regarding the mercury threat.

EPA's communication with the public is generally good, but could be improved.

Interviewees expressed that although EPA generally does a good job informing the public, there is room for improvement. More than one interviewee pointed out that although a lot of information is available to the public, much of it is technical and not easily understood by community members lacking technical training. This leads to confusion about the health risks of fish consumption and recreational uses of Clear Lake. It might also cause potential tourists to perceive that the lake is more contaminated than it actually is. The technical nature of the language also leads to confusion regarding the status of the cleanup process and creates the impression that EPA is not working closely enough with local agencies, such as the Lake County Sanitation District or the California Regional Water Quality Control Board. One supervisor suggested that high staff turnover at EPA might result in inconsistent information about the cleanup.

Will negative public perceptions of the Site affect property values?

Some community members are concerned about the effect of the negative public perception of the Superfund site on property values. They expressed apprehension that they would not be able to sell their homes and relocate if the property values were to drop significantly. In addition, local business owners, such as members of the Resort and Restaurant Owners Association, are concerned that continual press about the mercury contamination might drive customers away, reduce tourism, and weaken the local economy.

What are the health risks associated with the Site?

Community members are concerned about health risks associated with high mercury and hydrogen sulfide concentrations around Clear Lake. In particular, they expressed concern that some locals and tourists do not understand that eating fish from the lake could result in mercury poisoning. Interviewees also questioned whether EPA is aware of all the contaminated areas around Clear Lake. In addition, they are concerned about the health effects related to the cleanup, especially that mercury-laden dust might be stirred up by the use of heavy equipment, thereby affecting air quality. Health issues for mercury and arsenic are summarized in Appendices C and D, respectively.

How is water quality affected by contaminants and by the cleanup process?

Interviewees are concerned about water quality, particularly in regard to drinking water safety and mercury levels in fish. They are concerned about further watershed contamination during cleanup. In particular, they voiced concern about potential runoff of mercury-laden sediment into the lake, the potential use of Lake County Sanitation District infrastructure to transport fluid waste from the Site, and potential leakage to the Site from Little Borax Lake. Interviewees also feared that EPA might complete the first portion of the Site cleanup effort (OU-1) and abandon actions needed to clean up the lake (OU-2).

What will happen to the Site after it is cleaned up?

Some interviewees questioned what would happen to the Site after cleanup. For example, they asked whether the state would pay for the future operations and maintenance of a treatment plant, how the Site could be improved aesthetically, and whether it would be safe to build on the contaminated land.

How does the Site affect recreational use of the lake?

Interviewees expressed concern about the potential for the Site to negatively impact interest and participation in recreational activities on Clear Lake, such as bass fishing, hiking, birding, and sightseeing. One interviewee also questioned whether the presence of Herman Impoundment would be hazardous for recreational users of the lake.

Will geologic conditions affect the cleanup process?

More than one interviewee expressed concern that an earthquake could occur prior to cleanup, resulting in the release of contaminated materials. Another concern was that cleanup activity could result in a toxic gas release from a geothermal site, such as at Herman Impoundment.

5.4 Community Involvement Strategy

EPA will use the results of the 2005 interviews and previous interviews, as well as meetings with community members, local organizations, elected officials, and Tribal representatives conducted during 2006 and 2007, to inform and determine community involvement strategies. To address many of the concerns and issues posed in the community interviews, EPA is committed to working with the community in developing strategies and activities as follows:

- EPA will continue to conduct community meetings at pivotal milestones and brief local and Tribal officials in an effort to include the community in developing the cleanup plan and address their concerns.
- EPA will continue to strategize, coordinate, and implement community outreach strategies with the EIC, Lake County, and Clearlake Oaks governments; community organizations, such as CLEAN; Hinthil Environmental Resource Consortium (a group that includes the environmental departments of the six Tribes around the lake); environmental organizations (for example, the Sierra Club and Audubon Society); and religious and civic groups.
- EPA will continue to communicate through face-to-face meetings, use of mass media (e.g., television, radio, newspaper, internet), and direct mail distribution of easy-to-read fact sheets to inform and involve the affected community, the real estate community, state and local officials, and Tribal members.
- EPA will continue the **technical assistant grants** until the Site is removed from the **National Priorities List**.

6.0 Health Concerns

6.1 Evaluation of Risk to Human Health and the Environment

Risk evaluations indicate that contamination at the Site poses an unacceptable risk to human health and the environment.

6.2 Consumption of Mercury-contaminated Fish

One of the primary health threats associated with the Site is the consumption of mercury-contaminated fish. This problem was identified in 1970 by the California Department of Health Services. All species of Clear Lake fish that have been tested were contaminated with mercury. Large fish and fish from the higher levels of the food chain, such as the channel catfish and largemouth bass, have mercury levels that exceed federal human consumption guidelines. These data led the California Environmental Protection Agency to issue consumption guidelines for fish caught in Clear Lake.

The Central Valley Regional Water Quality Control Board prepared the Basin Plan Amendment (2002) to control mercury levels in Clear Lake. The Basin Plan Amendment was designed to reduce concentrations of methyl mercury in fish to 60 percent of their existing levels. This amendment proposes to achieve this by reducing the discharge of mercury from the Site by 95 percent and by reducing the mercury concentration in the surface sediment by 70 percent.

6.3 Contact with Mine Wastes

EPA evaluated exposure scenarios that consider potential future uses of the Site. EPA concluded that the mine-related waste rock piles present an unacceptable risk to human and animal health. Ingestion of surface soils and inhalation of dust are the primary pathways of concern for human exposure. The mine wastes must be capped or covered to prevent exposure.

Appendix A
Superfund Process

APPENDIX A

Superfund Process

In 1980, the United States Congress passed the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), also known as Superfund, in response to growing concerns about health and environmental threats posed by contaminated sites.

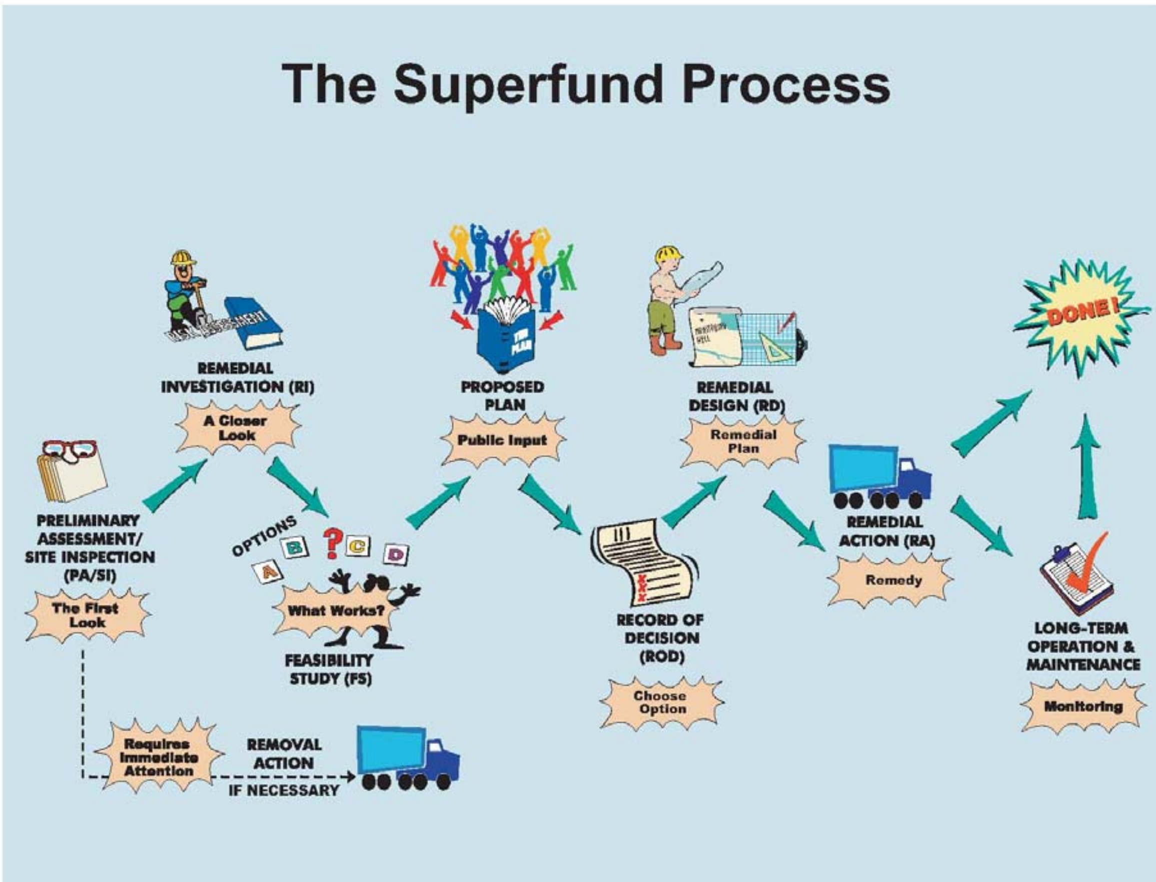


FIGURE A-1
THE SUPERFUND PROCESS

Figure A-1 presents the major components of the Superfund Process. This process consists of the following steps:

1. **Site Discovery**: An individual or organization reports a suspected contaminated site to the U.S. Environmental Protection Agency (EPA).

2. **Preliminary Assessment/Site Inspection**: Readily available reports and documents about the site are reviewed to determine whether hazardous substances were involved and whether people or sensitive habitats are potentially affected by the site.

3. **National Priorities Listing (NPL)**: If EPA determines that further investigation of the site is necessary, the Hazard Ranking System criteria are used to determine how significant the threat level is. A numerical ranking is assigned. EPA considers the ranking and letters from the community and state and local governments when deciding whether to propose to add the site to the NPL. Sites proposed for NPL listing are published in the Federal Register and must be approved by the state governor. The public has 60 days to comment on the proposed listing. If a site is listed on the NPL, federal funds are made available for further investigation and for community federal assistance under a technical assistance grant. After a site is placed on the NPL, EPA begins preparation of a CIP, informs the community of the availability of the technical assistance grant, and establishes an **information repository**.

4. **Remedial Investigation**: EPA conducts a more detailed study (a remedial investigation) to determine the nature and extent of contamination. The remedial investigation includes a risk assessment to evaluate risks to human health and the environment.

5. **Feasibility Study**: EPA performs an evaluation of various cleanup alternatives in a feasibility study. If the risk assessment indicates that site conditions present an unacceptable risk to human health or the environment, EPA will use the information developed in the feasibility study to identify a preferred alternative in the proposed plan.

6. **Proposed Plan:** The proposed plan summarizes the remedial investigation and feasibility study (RI/FS), identifies the preferred alternative, and identifies the associated costs. If, however, the risk is determined to be low enough that cleanup is not warranted, EPA would propose no remedial action. The public has a minimum of 30 days to comment on the proposed plan either in writing or at a public meeting. The proposed plan, including the RI/FS, is made available to the public in the local information repository.

7. **Remedy Selection**: After considering public concerns, the EPA issues a Record of Decision, which states how the site contamination will be addressed. The Record of Decision is placed in the information repository.

8. **Remedial Design/Remedial Action**: The remedial design is a series of engineering reports that detail the cleanup process, or remedial action.

9. **Operation and Maintenance**: EPA performs an in-depth review of the site every 5 years after the remedial action is started to ensure that the remedy is still effective. If no remedial action is taken, EPA will still perform a 5-year review to ensure that the no action decision is still appropriate. The 5-year review is usually performed in addition to ongoing site monitoring.

10. **NPL De-listing**: EPA may remove a site from the NPL if it determines that no further action is required to protect human health or the environment. To de-list a site, EPA publishes a notice of intent in the Federal Register. The public has at least 30 days to comment on the de-listing. EPA must respond to any significant comments or new data. EPA places the de-listing report in the information repository.

Appendix B
Community Resources

APPENDIX B

Community Resources

EPA Contacts

EPA Region 9 Headquarters
Environmental Protection Agency
75 Hawthorne Street
San Francisco, CA 94105

Rick Sugarek
Remedial Project Manager
415/972-3151
sugarek.richard@epa.gov

Janet Yocum
On Site Coordinator
415/972-3053
yocum.janet@epa.gov

Community Organizations

CLEAN
P.O. Box 926
Clearlake Oaks, CA 95423
707/998-0135
info@cleanlake.org

Public Information Repositories

Lake County Library
1425 North High Street
Lakeport, CA 95453

Redbud Library
4700 Golf Avenue
Clearlake, CA 95422

The most complete collection of documents is the official EPA site file, which is maintained at the following location:

Superfund Records Center
Mail Stop SFD-7C
95 Hawthorne Street, Room 403

San Francisco, CA 94105
415/536-2000

Enter main lobby of 75 Hawthorne Street, go to 4th floor of the South Wing Annex.

Web Sites

EPA National Priorities List Web Site
(Superfund site search)
http://www.epa.gov/superfund/sites/npl/npl.htm

U.S. Department of Health and Human Services
http://www.hhs.gov/

Agency for Toxic Substances and Disease Registry
http://www.atsdr.cdc.gov/

California Department of Health Services
http://www.dhs.ca.gov/

Elected Officials – Elem Indian Colony

Elem Tribal Chairman, Elem Tribal Office
P.O. Box 989
Clearlake Oaks 95423
707/998-9424

Elected Officials – Lake County

Lake County Board of Supervisors
255 North Forbes Street
Lakeport, CA 95453
707/263-2368

Ed Robey – 1st District
ed_r@co.lake.ca.us

Jeff Smith – 2nd District
jeff_s@co.lake.ca.us

Denise Rushing – 3rd District
deniser@co.lake.ca.us

Anthony Farrington – 4th District
anthonyf@co.lake.ca.us

Rob Brown – 5th District
rbrown@co.lake.ca.us

Elected Officials – State of California

State Senator Pat Wiggins
Capitol Office: 916/651-4002
District Office: 707/445-6508
senator.wiggins@senate.ca.gov

Assemblywoman Patty Berg
Capitol Office: 916/319-2001
District Office: 707/576-2526
assemblymember.berg@assembly.ca.gov

Elected Officials – United States Congress

Senator Barbara Boxer
Capitol Office: 202/224-3553
California Office: 916/448-2787
senator@boxer.senate.gov

Senator Dianne Feinstein
Capitol Office: 202/224-3841
California Office: 415/393-0707
senator@feinstein.senate.gov

Representative Mike Thompson – District 1
Capitol Office: 202/225-3311
California Office: 707/226-9898
http://mikethompson.house.gov/contact/email.asp

Elem Indian Colony Government

Michael Schaver
Environmental Director
Elem Environmental Department
13300 East Highway 20, Suite J
Clearlake Oaks, CA 95423
707/998-9411

Lake County Government

County Public Health Office
7000-B South Center Drive
Clearlake, CA 95422
707/994-9433

Department of Public Works
255 North Forbes Street
Lakeport, CA 95453
707/263-2341

State of California Government

Department of Toxic Substances Control
1001 I Street
Sacramento, CA 95814-2828
800/728-6942

Department of Health Services
P.O. Box 997413
Sacramento, CA 95899

Central Valley Regional Water Quality Control Board
11020 Sun Center Drive #200
Rancho Cordova, CA 95670-6114
916/464-3291

Local Media

Lake County Record-Bee
P.O. Box 849
Lakeport, CA 95453
707/263-5636

Lake County News
P.O. Box 305
Lakeport, CA 95453
707/245-4550

Appendix C
Mercury

PUBLIC HEALTH STATEMENT
MERCURY
CAS#: 7439-97-6

Division of Toxicology **March 1999**

This Public Health Statement is the summary chapter from the Toxicological Profile for Mercury. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™, is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-888-422-8737.

This public health statement tells you about mercury and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. Mercury has been found in at least 714 of the 1,467 current or former NPL sites. However, the total number of NPL sites evaluated for this substance is not known. As more sites are evaluated, the sites at which mercury is found may increase. This information is important because exposure to this substance may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance or by skin contact. If you are exposed to mercury, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider the other chemicals to which you're exposed, as well as your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS MERCURY?

Mercury occurs naturally in the environment and exists in several forms. These forms can be organized under three headings: metallic mercury (also known as elemental mercury), inorganic mercury, and organic mercury. Metallic mercury is a shiny, silver-white metal that is a liquid at room temperature. Metallic mercury is the elemental or pure form of mercury (i.e., it is not combined with other elements). Metallic mercury metal is the familiar liquid metal used in thermometers and some electrical switches. At room temperature, some of the metallic mercury will evaporate and form mercury vapors. Mercury vapors are colorless and odorless. The higher the temperature, the more vapors will be released from liquid metallic mercury. Some people who have breathed mercury vapors report a metallic taste in their mouths. Metallic mercury has been found at 714 hazardous waste sites nationwide.

Inorganic mercury compounds occur when mercury combines with elements such as chlorine, sulfur, or oxygen. These mercury compounds are also called mercury salts. Most inorganic mercury compounds are white powders or crystals, except for mercuric sulfide (also known as cinnabar) which is red and turns black after exposure to light.

When mercury combines with carbon, the compounds formed are called "organic" mercury compounds or organomercurials. There is a potentially large number of organic mercury compounds; however, by far the most common organic mercury compound in the environment is methylmercury (also known as monomethylmercury). In the past, an organic mercury compound called phenylmercury was used in some commercial products. Another organic mercury compound called dimethylmercury is also used in small amounts as a reference standard for some chemical tests. Dimethylmercury is the only organic mercury compound that has been identified at hazardous waste sites. It was only found in extremely small amounts at two hazardous waste sites nationwide, but it is very harmful to people and animals. Like the inorganic mercury compounds, both methylmercury and phenylmercury exist as "salts" (for example, methylmercuric chloride or phenylmercuric acetate). When pure, most forms of methylmercury and phenylmercury are white crystalline solids. Dimethylmercury, however, is a colorless liquid.

Several forms of mercury occur naturally in the environment. The most common natural forms of mercury found in the environment are metallic mercury, mercuric sulfide (cinnabar ore), mercuric chloride, and methylmercury. Some microorganisms (bacteria and fungi) and natural processes can change the mercury in the environment from one form to another. The most common organic mercury compound that microorganisms and natural processes generate from other forms is methylmercury. Methylmercury is of particular concern because it can build up in certain edible freshwater and saltwater fish and marine mammals to levels that are many times greater than levels in the surrounding water.

Mercury is mined as cinnabar ore, which contains mercuric sulfide. The metallic form is refined from mercuric sulfide ore by heating the ore to temperatures above 1,000 degrees Fahrenheit. This vaporizes the mercury in the ore, and the vapors are then captured and cooled to form the liquid metal mercury. There are many different uses for liquid metallic mercury. It is used in producing of chlorine gas and caustic soda, and in extracting gold from ore or articles that contain gold. It is also used in thermometers, barometers, batteries, and electrical switches. Silver-colored dental fillings typically contain about 50% metallic mercury. Metallic mercury is still used in some herbal or religious remedies in Latin America and Asia, and in rituals or spiritual practices in some Latin American and Caribbean religions such as Voodoo, Santeria, and Espiritismo. These uses may pose a health risk from exposure to mercury both for the user and for others who may be exposed to mercury vapors in contaminated air.

Some inorganic mercury compounds are used as fungicides. Inorganic salts of mercury, including ammoniated mercuric chloride and mercuric iodide, have been used in skin-lightening creams. Mercuric chloride is a topical antiseptic or disinfectant agent. In the past, mercurous chloride was widely used in medicinal products including laxatives, worming medications, and teething powders. It has since been replaced by safer and more effective agents. Other chemicals containing mercury are still used as antibacterials. These products include mercurochrome (contains a small amount of mercury, 2%), and thimerosal and phenylmercuric nitrate, which are used in small amounts as preservatives in some prescription and over-the-counter medicines. Mercuric sulfide and mercuric oxide may be used to color paints, and mercuric sulfide is one of the red coloring agents used in tattoo dyes.

Methylmercury is produced primarily by microorganisms (bacteria and fungi) in the environment, rather than by human activity. Until the 1970s, methylmercury and ethylmercury compounds were used to protect seed grains from fungal infections. Once the adverse health effects of methylmercury were known, the use of methymercury and ethylmercury as fungicides was banned. Up until 1991, phenylmercuric compounds were used as antifungal agents in both interior and exterior paints, but this use was also banned because mercury vapors were released from these paints.

1.2 WHAT HAPPENS TO MERCURY WHEN IT ENTERS THE ENVIRONMENT?

Mercury is a naturally occurring metal found throughout the environment. Mercury enters the environment as the result of the normal breakdown of minerals in rocks and soil from exposure to wind and water, and from volcanic activity. Mercury releases from natural sources have remained relatively constant in recent history, resulting in a steady rise in environmental mercury. Human activities since the start of the industrial age (e.g., mining, burning of fossil fuels) have resulted in additional release of mercury to the environment. Estimates of the total annual mercury releases that result from human activities range from one-third to two-thirds of the total mercury releases. A major uncertainty in these estimates is the amount of mercury that is released from water and soils that were previously contaminated by human activities as opposed to new natural releases. The levels of mercury in the atmosphere (i.e., the air you breathe in the general environment) are very, very low and do not pose a health risk; however, the steady release of mercury has resulted in current levels that are three to six times higher than the estimated levels in the preindustrial era atmosphere.

Approximately 80% of the mercury released from human activities is elemental mercury released to the air, primarily from fossil fuel combustion, mining, and smelting, and from solid waste incineration. About 15% of the total is released to the soil from fertilizers, fungicides, and municipal solid waste (for example, from waste that contains discarded batteries, electrical switches, or thermometers). An additional 5% is released from industrial wastewater to water in the environment.

With the exception of mercury ore deposits, the amount of mercury that naturally exists in any one place is usually very low. In contrast, the amount of mercury that may be found in soil at a particular hazardous waste site because of human activity can be high (over 200,000 times natural levels). The mercury in air, water, and soil at hazardous waste sites may come from both natural sources and human activity.

Most of the mercury found in the environment is in the form of metallic mercury and inorganic mercury compounds. Metallic and inorganic mercury enters the air from mining deposits of ores that contain mercury, from the emissions of coal-fired power plants, from burning municipal and medical waste, from the production of cement, and from uncontrolled releases in factories that use mercury. Metallic mercury is a liquid at room temperature, but some of the metal will evaporate into the air and can be carried long distances. In air, the mercury vapor can be changed into other forms of mercury, and can be further transported to water or soil in rain or snow. Inorganic mercury may also enter water or soil from the weathering of rocks that contain mercury, from factories or water treatment facilities that release water contaminated with mercury, and from incineration of municipal garbage that contains mercury (for example, in thermometers, electrical switches, fluorescent light bulbs, or batteries that have been thrown away). Inorganic or organic compounds of mercury may be released to the water or soil if mercury-containing fungicides are used.

Microorganisms (bacteria, phytoplankton in the ocean, and fungi) convert inorganic mercury to methylmercury. Methylmercury released from microorganisms can enter the water or soil and remain there for a long time, particularly if the methylmercury becomes attached to small particles in the soil or water. Mercury usually stays on the surface of sediments or soil and does not move through the soil to underground water. If mercury enters the water in any form, it is likely to settle to the bottom where it can remain for a long time.

Mercury can enter and accumulate in the food chain. The form of mercury that accumulates in the food chain is methylmercury. Inorganic mercury does not accumulate up the food chain to any extent. When small fish eat the methylmercury in food, it goes into their tissues. When larger fish eat smaller fish or other organisms that contain methylmercury, most of the methylmercury originally present in the small fish will then be stored in the bodies of the larger fish. As a result, the larger and older fish living in contaminated waters build up the highest amounts of methylmercury in their bodies. Saltwater fish (especially sharks and swordfish) that live a long time and can grow to a very large size tend to have the highest levels of mercury in their bodies. Plants (such as corn, wheat, and peas) have very low levels of mercury, even if grown in soils containing mercury at significantly higher than background levels. Mushrooms, however, can accumulate high levels if grown in contaminated soils.

1.3 HOW MIGHT I BE EXPOSED TO MERCURY?

Because mercury occurs naturally in the environment, everyone is exposed to very low levels of mercury in air, water, and food. Between 10 and 20 nanograms of mercury per cubic meter (ng/m^3) of air have been measured in urban outdoor air. These levels are hundreds of times lower than levels still considered to be "safe" to breathe. Background levels in nonurban settings are even lower, generally about 6 ng/m^3 or less. Mercury levels in surface water are generally less than 5 parts of mercury per trillion parts of water (5 ppt, or 5 ng per liter of water), about a thousand times lower than "safe" drinking water standards. Normal soil levels range from 20 to 625 parts of mercury per billion parts of soil (20–625 ppb; or 20,000–625,000 ng per kilogram of soil). A part per billion is one thousand times bigger than a part per trillion.

A potential source of exposure to metallic mercury for the general population is mercury released from dental amalgam fillings. An amalgam is a mixture of metals. The amalgam used in silver-colored dental fillings contains approximately 50% metallic mercury, 35% silver, 9% tin, 6% copper, and trace amounts of zinc. When the amalgam is first mixed, it is a soft paste which is inserted into the tooth surface. It hardens within 30 minutes. Once the amalgam is hard, the mercury is bound within the amalgam, but very small amounts are slowly released from the surface of the filling due to corrosion or chewing or grinding motions. Part of the mercury at the surface of the filling may enter the air as mercury vapor or be dissolved in the saliva. The total amount of mercury released from dental amalgam depends upon the total number of fillings and surface areas of each filling, the chewing and eating habits of the person, and other chemical conditions in the mouth. Estimates of the amount of mercury released from dental amalgams range from 3 to 17 micrograms per day (µg/day). The mercury from dental amalgam may contribute from 0 to more than 75% of your total daily mercury exposure, depending on the number of amalgam fillings you have, the amount of fish consumed, the levels of mercury (mostly as methylmercury) in those fish, and exposure from other less common sources such as mercury spills, religious practices, or herbal remedies that contain mercury. However, it should be kept in mind that exposure to very small amounts of mercury, such as that from dental amalgam fillings, does not necessarily pose a health risk.

Whether the levels of exposure to mercury vapor from dental amalgam are sufficiently high to cause adverse health effects, and exactly what those effects are, continues to be researched and debated by scientists and health officials. U.S. government summaries on the effects of dental amalgam conclude that there is no apparent health hazard to the general population, but that further study is needed to determine the possibility of more subtle behavioral or immune system effects, and to determine the levels of exposure that may lead to adverse effects in sensitive populations. Sensitive populations may include pregnant women, children under the age of 6 (especially up to the age of 3), people with impaired kidney function, and people with hypersensitive immune responses to metals. If you belong to this group, you should discuss your medical condition with your dentist prior to any dental restoration work. Removal of dental amalgams in people who have no indication of adverse effects is not recommended and can put the person at greater risk, if performed improperly. Chelation therapy (used to remove metals from the body tissues) itself presents some health risks, and should be considered only when a licensed occupational or environmental health physician determines it necessary to reduce immediate and significant health risks due to high levels of mercury in the body.

Some religions have practices that may include the use of metallic mercury. Examples of these religions include Santeria (a Cuban-based religion whose followers worship both African deities and Catholic saints), Voodoo (a Haitian-based set of beliefs and rituals), Palo Mayombe (a secret form of ancestor worship practiced mainly in the Caribbean), and Espiritismo (a spiritual belief system native to Puerto Rico). Not all people who observe these religions use mercury, but when mercury is used in religious, ethnic, or ritualistic practices, exposure to mercury may occur both at the time of the practice and afterwards from contaminated indoor air. Metallic mercury is sold under the name "azogue" (pronounced ah-SEW-gay) in stores called "botanicas." Botanicas are common in Hispanic and Haitian communities, where azogue may be sold as an herbal remedy or for spiritual practices. The metallic mercury is often sold in capsules or in glass containers. It may be placed in a sealed pouch to be worn on a necklace or in a pocket, or it may be sprinkled in the home or car. Some people may mix azogue in bath water or perfume, or place azogue in devotional candles. Because metallic mercury evaporates into the air, these practices may put anyone breathing the air in the room at risk of exposure to mercury. The longer people breathe the contaminated air, the greater their risk will be. The use of metallic mercury in a home or an apartment not only threatens the health of the people who live there now, but also threatens the health of future residents who may unknowingly be exposed to further release of mercury vapors from contaminated floors or walls.

Metallic mercury is used in a variety of household products and industrial items, including thermostats, fluorescent light bulbs, barometers, glass thermometers, and some blood pressure devices. The mercury in these devices is contained in glass or metal, and generally does not pose a risk unless the item is damaged or broken, and mercury vapors are released. Spills of metallic mercury from broken thermometers or damaged electrical switches in the home may result in exposure to mercury vapors in indoor air. You must be careful when you handle and dispose of all items in the home that contain metallic mercury.
Very small amounts of metallic mercury (for example, a few drops) can raise air concentrations of mercury to levels that may be harmful to health. The longer people breathe the contaminated air, the greater the risk to their health. Metallic mercury and its vapors are extremely difficult to remove from clothes, furniture, carpet, floors, walls, and other such items. If these items are not properly cleaned, the mercury can remain for months or years, and continue to be a source of exposure.

It is possible for you to be exposed to metallic mercury vapors from breathing contaminated air around hazardous waste sites, waste incinerators, or power plants that burn mercury-containing fuels (such as coal or other fossil fuels), but most outdoor air is not likely to contain levels that would be harmful. Exposure to mercury compounds at hazardous waste sites is much more likely to occur from handling contaminated soil (i.e., children playing in or eating contaminated surface soil), drinking well-water, or eating fish from contaminated waters near those sites. Not all hazardous sites contain mercury, and not all waste sites that do contain mercury have releases of mercury to the air, water, or surface soils.

You can be exposed to mercury vapors from the use of fungicides that contain mercury. Excess use of these products may result in higher-than-average exposures. You may also be exposed to mercury from swallowing or applying to your skin outdated medicinal products (laxatives, worming medications, and teething powders) that contain mercurous chloride. Exposure may also occur from the improper or excessive use of other chemicals containing mercury, such as skin-lightening creams and some topical antiseptic or disinfectant agents (mercurochrome and thimerosal).

Workers are mostly exposed from breathing air that contains mercury vapors, but may also be exposed to other inorganic mercury compounds in the workplace. Occupations that have a greater potential for mercury exposure include manufacturers of electrical equipment or automotive parts that contain mercury, chemical processing plants that use mercury, metal processing, construction where building parts contain mercury (e.g., electrical switches, thermometers), and the medical professions (medical, dental, or other health services) where equipment may contain mercury (e.g., some devices that measure blood pressure contain liquid mercury). Dentists and their assistants may be exposed to metallic mercury from breathing in mercury vapor released from amalgam fillings and to a much lesser extent from skin contact with amalgam restorations. Family members of workers who have been exposed to mercury may also be exposed to mercury if the worker's clothes are contaminated with mercury particles or liquid.

Some people may be exposed to higher levels of mercury in the form of methylmercury if they have a diet high in fish, shellfish, or marine mammals (whales, seals, dolphins, and walruses) that come from mercury-contaminated waters. Methylmercury accumulates up the food chain, so that fish at the top of the food chain will have the most mercury in their flesh. Of these fish, the largest (i.e., the oldest) fish will have the highest levels. The Food and Drug Administration (FDA) estimates that most people are exposed, on average, to about 50 ng of mercury per kilogram of body weight per day (50 ng/kg/day) in the food they eat. This is about 3.5 micrograms (μg) of mercury per day for an adult of average weight. This level is not thought to result in any harmful effects. A large part of this mercury is in the form of methylmercury and probably comes from eating fish. Commercial fish sold through interstate commerce that are found to have levels of methylmercury above an "action level" of 1 ppm (established by the FDA) cannot be sold to the public. This level itself is below a level associated with adverse effects. However, if you fish in contaminated waters and eat the fish you catch, you may be exposed to higher levels of mercury. Public health advisories are issued by state and federal authorities for local waters that are thought to be contaminated with mercury. These advisories can help noncommercial (sport and subsistence) fishermen and their families to avoid eating fish contaminated with mercury. Foods other than fish that may contain higher than average levels of mercury include wild game, such as wild birds and mammals (bear) that eat large amounts of contaminated fish. People in the most northern climates may be exposed to high levels of mercury from eating meat or fat from marine mammals including whales, dolphins, walruses, and seals. These marine mammals are at or near the top of their marine food chain. Plants contain very little methylmercury or other forms of mercury. Mushrooms grown in mercury-contaminated soil may contain levels of mercury that could pose some risk to health, if large amounts were eaten.

1.4 HOW CAN MERCURY ENTER AND LEAVE MY BODY?

A person can be exposed to mercury from breathing in contaminated air, from swallowing or eating contaminated water or food, or from having skin contact with mercury. Not all forms of mercury easily enter your body, even if they come in contact with it; so it is important to know which form of mercury you have been exposed to, and by which route (air, food, or skin).

When you swallow small amounts of metallic mercury, for example, from a broken oral thermometer, virtually none (less than 0.01%) of the mercury will enter your body through the stomach or intestines, unless they are diseased. Even when a larger amount of metal mercury (a half of a tablespoon, about 204 grams) was swallowed by one person, very little entered the body. When you breathe in mercury vapors, however, most (about 80%) of the mercury enters your bloodstream directly from your lungs, and then rapidly goes to other parts of your body, including the brain and kidneys. Once in your body, metallic mercury can stay for weeks or months. When metallic mercury enters the brain, it is readily converted to an inorganic form and is "trapped" in the brain for a long time. Metallic mercury in the blood of a pregnant woman can enter her developing child. Most of the metallic mercury will accumulate in your kidneys, but some metallic mercury can also accumulate in the brain. Most of the metallic mercury absorbed into the body eventually leaves in the urine and feces, while smaller amounts leave the body in the exhaled breath.

Inorganic mercury compounds like mercurous chloride and mercuric chloride are white powders and do not generally vaporize at room temperatures like elemental mercury will. If they are inhaled, they are not expected to enter your body as easily as inhaled metallic mercury vapor. When inorganic mercury compounds are swallowed, generally less than 10% is absorbed through the intestinal tract; however, up to 40% may enter the body through the stomach and intestines in some instances. Some inorganic mercury can enter your body through the skin, but only a small amount will pass through your skin compared to the amount that gets into your body from swallowing inorganic mercury.

Once inorganic mercury enters the body and gets into the bloodstream, it moves to many different tissues. Inorganic mercury leaves your body in the urine or feces over a period of several weeks or months. A small amount of the inorganic mercury can be changed in your body to metallic mercury and leave in the breath as a mercury vapor. Inorganic mercury accumulates mostly in the kidneys and does not enter the brain as easily as metallic mercury. Inorganic mercury compounds also do not move as easily from the blood of a pregnant woman to her developing child. In a nursing woman, some of the inorganic mercury in her body will pass into her breast milk.

Methylmercury is the form of mercury most easily absorbed through the gastrointestinal tract (about 95% absorbed). After you eat fish or other foods that are contaminated with methylmercury, the methylmercury enters your bloodstream easily and goes rapidly to other parts of your body. Only small amounts of methylmercury enter the bloodstream directly through the skin, but other forms of organic mercury (in particular dimethylmercury) can rapidly enter the body through the skin. Organic mercury compounds may evaporate slowly at room temperature and may enter your body easily if you breathe in the vapors. Once organic mercury is in the bloodstream, it moves easily to most tissues and readily enters the brain. Methylmercury that is in the blood of a pregnant woman will easily move into the blood of the developing child and then into the child's brain and other tissues. Like metallic mercury, methylmercury can be changed by your body to inorganic mercury. When this happens in the brain, the mercury can remain there for a long time. When methylmercury does leave your body after you have been exposed, it leaves slowly over a period of several months, mostly as inorganic mercury in the feces. As with inorganic mercury, some of the methylmercury in a nursing woman's body will pass into her breast milk.

1.5 HOW CAN MERCURY AFFECT MY HEALTH?

The nervous system is very sensitive to mercury. In poisoning incidents that occurred in other countries, some people who ate fish contaminated with large amounts of methylmercury or seed grains treated with methylmercury or other organic mercury compounds developed permanent damage to the brain and kidneys. Permanent damage to the brain has also been shown to occur from exposure to sufficiently high levels of metallic mercury. Whether exposure to inorganic mercury results in brain or nerve damage is not as certain, since it does not easily pass from the blood into the brain.

Metallic mercury vapors or organic mercury may affect many different areas of the brain and their associated functions, resulting in a variety of symptoms. These include personality changes (irritability, shyness, nervousness), tremors, changes in vision (constriction (or narrowing) of the visual field), deafness, muscle incoordination, loss of sensation, and difficulties with memory.

Different forms of mercury have different effects on the nervous system, because they do not all move through the body in the same way. When metallic mercury vapors are inhaled, they readily enter the bloodstream and are carried throughout the body and can move into the brain. Breathing in or swallowing large amounts of methylmercury also results in some of the mercury moving into the brain and affecting the nervous system. Inorganic mercury salts, such as mercuric chloride, do not enter the brain as readily as methylmercury or metallic mercury vapor.

The kidneys are also sensitive to the effects of mercury, because mercury accumulates in the kidneys and causes higher exposures to these tissues, and thus more damage. All forms of mercury can cause kidney damage if large enough amounts enter the body. If the damage caused by the mercury is not too great, the kidneys are likely to recover once the body clears itself of the contamination.

Short-term exposure (hours) to high levels of metallic mercury vapor in the air can damage the lining of the mouth and irritate the lungs and airways, causing tightness of the chest, a burning sensation in the lungs, and coughing. Other effects from exposure to mercury vapor include nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation. Damage to the lining of the mouth and lungs can also occur from exposure to lower levels of mercury vapor over longer periods (for example, in some occupations where workers were exposed to mercury for many years). Levels of metallic mercury in workplace air are generally much greater than the levels normally encountered by the general population. Current levels of mercury in workplace air are low, due to increased awareness of mercury's toxic effects. Because of the reduction in the allowable amount of mercury in workplace air, fewer workers are expected to have symptoms of mercury toxicity. Most studies of humans who breathed metallic mercury for a long time indicate that mercury from this type of exposure does not affect the ability to have children. Studies in workers exposed to metallic mercury vapors have also not shown any mercury-related increase in cancer. Skin contact with metallic mercury has been shown to cause an allergic reaction (skin rashes) in some people.

In addition to effects on the kidneys, inorganic mercury can damage the stomach and intestines, producing symptoms of nausea, diarrhea, or severe ulcers if swallowed in large amounts. Effects on the heart have also been observed in children after they accidentally swallowed mercuric chloride. Symptoms included rapid heart rate and increased blood pressure. There is little information on the effects in humans from long-term, low-level exposure to inorganic mercury.

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body; for some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

Studies using animals indicate that long-term oral exposure to inorganic mercury salts causes kidney damage, effects on blood pressure and heart rate, and effects on the stomach. Study results also suggest that reactions involving the immune system may occur in sensitive populations after swallowing inorganic mercury salts. Some animal studies report that nervous system damage occurs after long-term exposure to high levels of inorganic mercury. Short-term, high-level exposure of laboratory animals to inorganic mercury has been shown to affect the developing fetus and may cause termination of the pregnancy.

Animals exposed orally to long-term, high levels of methylmercury or phenylmercury in laboratory studies experienced damage to the kidneys, stomach, and large intestine; changes in blood pressure and heart rate; adverse effects on the developing fetus, sperm, and male reproductive organs; and increases in the number of spontaneous abortions and stillbirths. Adverse effects on the nervous system of animals occur at lower doses than do harmful effects to most other systems of the body. This difference indicates that the nervous system is more sensitive to methylmercury toxicity than are other organs in the body. Animal studies also provide evidence of damage to the nervous system from exposure to methylmercury during development, and evidence suggests that the effects worsen with age, even after the exposure stops.

Some rat and mice strains that are susceptible to autoimmune responses develop kidney damage as a result of an immune response when exposed to relatively low levels of mercury vapor or mercury chloride.

Animals given inorganic mercury salts by mouth for most of their lifetime had increases in some kinds of tumors at the highest dose tested. Rats and mice that received organic mercury (methylmercury or phenylmercury) in their drinking water or feed for most of their lives had an increased incidence of cancer of the kidney, but this affected only the males that received the highest amount of mercury given (not the females). Since the high doses caused severe damage to the kidneys prior to the cancer, these animal studies provide only limited information about whether mercury causes cancer in humans. As a result, the Department of Health and Human Services (DHHS) and the International Agency for Research on Cancer (IARC) have not classified mercury as to its human carcinogenicity. The Environmental Protection Agency has determined that mercury chloride and methylmercury are possible human carcinogens.

1.6 HOW CAN MERCURY AFFECT CHILDREN?

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans. Potential effects on children resulting from exposures of the parents are also considered.

Children are at risk of being exposed to metallic mercury that is not safely contained, to mercury that may be brought home on work clothes or tools, or to methylmercury-contaminated foods. Methylmercury eaten or swallowed by a pregnant woman or metallic mercury that enters her body from breathing contaminated air can also pass into the developing child. Inorganic mercury and methylmercury can also pass from a mother's body into breast milk and into a nursing infant. The amount of mercury in the milk will vary, depending on the degree of exposure and the amount of mercury that enter the nursing woman's body. There are significant benefits to breast feeding, so any concern that a nursing woman may have about mercury levels in her breast milk should be discussed with her doctor. Methylmercury can also accumulate in an unborn baby's blood to a concentration higher than the concentration in the mother.

For similar exposure routes and forms of mercury, the harmful health effects seen in children are similar to the effects seen in adults. High exposure to mercury vapor causes lung, stomach, and intestinal damage and death due to respiratory failure in severe cases. These effects are similar to those seen in adult groups exposed to inhaled metallic mercury vapors at work.

Children who had been exposed to excessive amounts of mercurous chloride tablets for worms or mercurous chloride-containing powders for teething discomfort had increased heart rates and elevated blood pressure. Abnormal heart rhythms were also seen in children who had eaten grains contaminated with very high levels of methylmercury.

Other symptoms of poisonings in children who were treated with mercurous chloride for constipation, worms, or teething discomfort included swollen red gums, excessive salivation, weight loss, diarrhea and/or abdominal pain, and muscle twitching or cramping in the legs and/or arms. Kidney damage is very common after exposure to toxic levels of inorganic mercury. Metallic mercury or methylmercury that enters the body can also be converted to inorganic mercury and result in kidney damage.

Children who breathe metallic/elemental mercury vapors, eat foods or other substances containing phenylmercury or inorganic mercury salts, or use mercury-containing skin ointments for an extended period may develop a disorder known as acrodynia, or pink disease. Acrodynia can result in severe leg cramps; irritability; and abnormal redness of the skin, followed by peeling of the hands, nose, and soles of the feet. Itching, swelling, fever, fast heart rate, elevated blood pressure, excessive salivation or sweating, rashes, fretfulness, sleeplessness, and/or weakness may also be present. It was once believed that this syndrome occurred only in children, but recent reported cases in teenagers and adults have shown that they can also develop acrodynia.

In critical periods of development before they are born, and in the early months after birth, children and fetuses are particularly sensitive to the harmful effects of metallic mercury and methylmercury on the nervous system. Harmful developmental effects may occur when a pregnant woman is exposed to metallic mercury and some of the mercury is transferred into her developing child. Thus, women who are normally exposed to mercury vapors in the workplace (such as those working in thermometer/barometer or fluorescent light manufacturing or the chlor-alkali industry) should take measures to avoid mercury vapor exposures during pregnancy. Exposures to mercury vapors are relatively rare outside of the workplace, unless metallic mercury is present in the home.

As with mercury vapors, exposure to methylmercury is more dangerous for young children than for adults, because more methylmercury easily passes into the developing brain of young children and may interfere with the development process.

Methylmercury is the form of mercury most commonly associated with a risk for developmental effects. Exposure can come from foods contaminated with mercury on the surface (for example, from seed grain treated with methylmercury to kill fungus) or from foods that contain toxic levels of methylmercury (as in some fish, wild game, and marine mammals). Mothers who are exposed to methylmercury and breast-feed their infant may also expose the child through the milk. The effects on the infant may be subtle or more pronounced, depending on the amount to which the fetus or young child was exposed. In cases in which the exposure was relatively small, some effects might not be apparent, such as small decreases in IQ or effects on the brain that may only be determined by the use of very sensitive neuropsychological testing. In instances in which the exposure is great, the effects may be more serious. In some such cases of mercury exposure involving serious exposure to the developing fetus, the effects are delayed. In such cases, the infant may be born apparently normal, but later show effects that may range from the infant being slower to reach developmental milestones, such as the age of first walking and talking, to more severe effects including brain damage with mental retardation, incoordination, and inability to move. Other severe effects observed in children whose mothers were exposed to very toxic levels of mercury during pregnancy include eventual blindness, involuntary muscle contractions and seizures, muscle weakness, and inability to speak. It is important to remember, however, that the severity of these effects depends upon the level of mercury exposure and the length of exposure. The very severe effects just mentioned were reported in large-scale poisoning instances in which pregnant and nursing women were exposed to extremely high levels of methylmercury in contaminated grain used to make bread (in Iraq) or seafood (in Japan) sold to the general population.

Researchers are currently studying the potential for less serious developmental effects, including effects on a child's behavior and ability to learn, think, and solve problems that may result from eating lower levels of methylmercury in foods. A main source of exposure to methylmercury for the pregnant woman and the young child is from eating fish. Most fish purchased in the market in the United States do not have mercury levels that pose a risk to anyone, including pregnant women. Since mercury accumulates in the muscles of fish, larger fish that feed on smaller fish and live for long periods usually have larger concentrations of methylmercury than fish that feed on plants. For example, shark and swordfish normally contain the highest levels of mercury out of all ocean fish. Scientists have an ongoing debate about the value of fish in the diet versus any risk from increased exposure of pregnant women to methylmercury that may be in the fish. The safety of most fish sold commercially in the United States is regulated by the FDA. These fish pose no health risk to those who purchase and eat them. Only fish or wildlife containing relatively high levels of methylmercury are of concern.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO MERCURY?

If your doctor finds that you have been exposed to significant amounts of mercury, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

Children may be exposed to metallic mercury if they play with it. Metallic mercury is a heavy, shiny, silver liquid. When metallic mercury is spilled, it forms little balls or beads. Children are sometimes exposed to metallic mercury when they find it in abandoned warehouses or closed factories, and then play with it or pass it around to friends. Children have also taken metallic mercury from school chemistry and physics labs. Broken thermometers and some electrical switches are other sources of metallic mercury. Sometimes children find containers of metallic mercury that were improperly disposed of, or adults may bring home metallic mercury from work, not knowing that it is dangerous.

To protect your children from metallic mercury, teach them not to play with shiny, silver liquids. Schoolteachers (particularly science teachers) and school staff need to know about students' fascination with metallic mercury. Teachers and school staff should teach children about the dangers of getting sick from playing with mercury, and they should keep metallic mercury in a safe and secured area (such as a closed container in a locked storage room) so that children do not have access to it without the supervision of a teacher. Metallic mercury evaporates slowly, and if it is not stored in a closed container, children may breathe toxic mercury vapors.

In the past, mercurous chloride was widely used in medicinal products such as laxatives, worming medications, and teething powders. These older medicines should be properly disposed of and replaced with safer and more effective medicines. Other chemicals containing mercury, such as mercurochrome and thimerosal (sold as Merthiolate and other brands), are still used as antiseptics or as preservatives in eye drops, eye ointments, nasal sprays, and vaccines. Some skin-lightening creams contain ammoniated mercuric chloride and mercuric iodide. These and all other mercury-containing medicines should be kept safely out of the reach of children to prevent an accidental poisoning. Nonmedicinal products, including some fungicides that contain mercury compounds and paints that contain mercuric sulfide or mercuric oxide, should also be safely stored out of the reach of children.

You should check to see if any medicines or herbal remedies that you or your child use contain mercury. Some traditional Chinese and Hispanic remedies for stomach disorders (for example, herbal balls) contain mercury, and if you give these remedies to your children, you may harm them. If you are pregnant or nursing a baby and you use mercury-containing ethnic or herbal remedies, you could pass some of the mercury to your unborn child or nursing infant.

If you use metallic mercury or azogue in religious practices, you may expose your children or unborn child to mercury or contaminate your home. Such practices in which mercury containing substances have traditionally been used include Santeria (a Cuban-based religion whose followers worship both African deities and Catholic saints), Voodoo (a Haitian-based set of beliefs and rituals), Palo Mayombe (a secret form of ancestor worship practiced mainly in the Caribbean), or Espiritismo (a spiritual belief system native to Puerto Rico).

Metallic mercury is used in a variety of household products and industrial items, including thermostats, fluorescent light bulbs, barometers, glass thermometers, and some blood pressure measuring devices. You must be careful when you handle and dispose of all items in the home that contain metallic mercury.

If small amounts of mercury are spilled, be very careful cleaning it up. Do not try to vacuum spilled metallic mercury. Using a vacuum cleaner to clean up the mercury causes the mercury to evaporate into the air, creating greater health risks. Trying to vacuum spilled metallic mercury also contaminates the vacuum cleaner. Also, take care not to step on the mercury and track it into other areas of the home. Metallic mercury vapors are very toxic and have no odor. Do not remain unnecessarily in that room, and try not to let metallic mercury contact your eyes, skin, or clothing. If you think you have been exposed directly to metallic mercury, wash yourself thoroughly and discard contaminated clothing by placing them in a sealed plastic bag. Perhaps the most important thing to remember if you break a household thermometer is do not panic.

The amount of mercury contained in an oral thermometer is small and does not present an immediate threat to human health. However, if it is not properly cleaned up and disposed of, it may present a health risk over time, particularly to infants, toddlers, and pregnant women.

If a thermometer breaks on a counter top or uncarpeted floor, remove children from the area. Mercury is not absorbent, so do not try to wipe or blot it up with a cloth or paper towel; that will only spread the mercury and break it up into smaller beads, making it more difficult to find and remove. Instead, clean up the beads of metallic mercury by using one sheet of paper to carefully roll them onto a second sheet of paper, or by sucking very small beads of mercury into an eye dropper. After picking up the metallic mercury in this manner, put it into a plastic bag or airtight container. The paper and eye dropper should also be bagged in a zip-lock plastic container. All plastic bags used in the cleanup should then be taken outside of the house or apartment and disposed of properly, according to instructions provided by your local health department or environmental officials. Try to ventilate the room with outside air, and close the room off from the rest of the home. Use fans (that direct the air to the outside and away from the inside of the house) for a minimum of one hour to speed the ventilation.

If a thermometer breaks and the liquid/metallic mercury spills onto a carpeted floor, try to collect the mercury beads in the manner described in the above paragraph. Depending on the cut or pile of the carpeting, however, it may not be possible to collect all of the spilled mercury. Regardless, do not vacuum. Instead, call your local (county, city, or state) health department and tell them of your situation. (You may also call the Agency for Toxic

Substances and Disease Registry [ATSDR] toll-free at 1-888-42-ATSDR [1-888-422-8737] to obtain additional guidance, if local assistance cannot be obtained.)

If larger amounts of metallic mercury are found (for example, a jar of liquid mercury), it should be contained in an airtight container, and you should call your local health department for instructions on how to safely dispose of it. If the mercury is in an open container or the container does not have a lid, place a piece of plastic wrap around the top of the container to prevent vapors from escaping; then wash your hands thoroughly. If a larger amount is spilled, leave the area and contact your local health department and fire department. Do not simply throw metallic mercury away, but instead seek professional help.

ATSDR and EPA strongly recommend against the use of metallic (liquid) mercury that is not properly enclosed in glass, as it is in thermometers. This form of mercury should not be used or stored in homes, automobiles, day-care centers, schools, offices, or other public buildings. If you notice a child with metallic mercury on his or her clothing, skin, or hair, call the fire department and let them know that the child needs to be decontaminated.

Metallic or inorganic mercury can be carried into the home from a workers' contaminated clothing and shoes. Increased exposure to mercury has been reported in children of workers who are exposed to mercury at work, and increased levels of mercury were measured in places where work clothes were stored and in some washing machines. The children most likely to be exposed to risky levels of mercury are those whose parents work in facilities that use mercury (for example, a scientific glassware manufacturing plant or a chlor-alkali chemical plant), but where no protective uniforms or footgear are used. In some reported cases in which children were exposed in this way, protective clothing was used in the workplace by the parent, but work gloves, clothes, and boots, which were contaminated with mercury, were taken home, thus exposing family members. If you have questions or concerns about exposure to mercury at work, you have a right to obtain information from your employer about your safety and health on the job without fear of punishment. The Occupational Safety and Health Administration (OSHA) requires employers to provide Material Safety Data Sheets (MSDSs) for many of the chemicals used at the workplace. Information on these sheets should include chemical names and hazardous ingredients, important properties (such as fire and explosion data), potential health effects, how you get the chemical(s) in your body, how to properly handle the materials, and what to do in an emergency. Your occupational health and safety officer at work can and should tell you whether chemicals you work with are dangerous and likely to be carried home on your clothes, body, or tools, and whether you should be showering and changing clothes before you leave work, storing your street clothes in a separate area of the workplace, or laundering your work clothes at home separately from other clothes.

Your employer is legally responsible for providing a safe workplace and should freely answer your questions about hazardous chemicals. Your OSHA-approved state occupational safety and health program or OSHA can also answer any further

www.atsdr.cdc.gov/ Telephone: 1-888-422-8737 Fax: 770-488-4178 E-Mail: atsdric@cdc.gov

questions you might have, and help your employer identify and correct problems with hazardous substances. If you would like to make a formal complaint about health hazards in your workplace, your OSHA-approved state occupational safety and health program or OSHA office will listen to your complaint and inspect your workplace when necessary.

One way in which people are routinely exposed to extremely small amounts of mercury is through the gradual (but extremely slow) wearing-away process of dental amalgam fillings, which contain approximately 50% mercury. The amount of mercury to which a person might be exposed from dental amalgams would depend on the number of amalgams present and other factors. The Centers for Disease Control and Prevention (CDC) has determined that dental amalgam fillings do not pose a health risk, although they do account for some mercury exposure to those having such fillings. People who frequently grind their teeth or often chew gum can add to the small amount of mercury normally released from those fillings over time. If you are pregnant, the decision of whether to have dental amalgam or a non-mercury material used for fillings, or whether existing amalgam fillings should be repaired or replaced during pregnancy, should be made in consultation with your dentist. The practice of having all your dental amalgam fillings replaced with non-mercury filling materials just to remove the possibility of mercury exposure is not recommended by ATSDR. In fact, the removal of the mercury amalgam fillings would actually expose the patient to a greater amount of mercury for a while. Other sources of mercury may increase your overall exposure, such as the amount of fish consumed per week, especially if caught in local waters contaminated with mercury or of certain species known to be higher in mercury content (shark and swordfish), or an exposure to mercury from a nearby hazardous waste site or incinerator.

You or your children may be exposed to methylmercury when eating certain types of fish caught from contaminated waters, or when eating certain types of wildlife from mercury contaminated areas. Most states, Native American tribes, and U.S. Territories have issued fish and/or wildlife advisories to warn people about methylmercury contaminated fish and/or wildlife. Most of the methylmercury advisories relate to specific types of freshwater or saltwater fish or shellfish, or freshwater turtles. Each state, Native American tribe, or U.S. Territory sets its own criteria for issuing fish and wildlife advisories. A fish or wildlife advisory will specify which bodies of water or hunting areas have restrictions. The advisory will tell you what types and sizes of fish or game are of concern. The advisory may completely ban eating fish or tell you to limit your meals of a certain type of fish. For example, an advisory may tell you to eat a certain type of fish no more than once a month; or an advisory may tell you to eat only certain parts of fish or game, or how to prepare it to decrease your exposure to methylmercury. The fish or wildlife advisory may be stricter to protect pregnant women, nursing women, and young children. To reduce your children's exposure to methylmercury, you should follow the instructions recommended in the fish or wildlife advisories. Information on Fish and Wildlife Advisories in your state is available from your state public health or natural resources department. Signs may also be posted in certain fishing and hunting areas with information about contaminated fish or wildlife. FDA currently advises that pregnant women and women of childbearing age who may become pregnant limit their consumption of shark and swordfish to no more that one meal per month. This advice is given because methylmercury levels are relatively high in these fish species. Women of childbearing age are included in this advice because dietary practices immediately before the pregnancy could have a direct bearing on fetal exposure during pregnancy, particularly during the earlier months of pregnancy.

FDA further advises that persons other than pregnant women and women of childbearing age in the general population limit their regular consumption of shark and swordfish (which typically contains methylmercury around 1 ppm) to about 7 ounces per week (about one serving) to stay below the acceptable daily intake for methylmercury. For fish species with methylmercury levels averaging 0.5 ppm, regular consumption should be limited to 14 ounces per week. Recreational and subsistence fishers who eat larger amounts of fish than the general population and routinely fish the same waterbodies may have a higher exposure to methylmercury if these waters are contaminated. People who consume greater than 100 grams of fish (approximately 3.5 ounces) every day are considered high-end consumers. This is over 10 times more than the amount of fish consumed by members of the general population (6.5 g/day). No consumption advice is necessary for the top ten seafood species that make up about 80% of the seafood sold in the United States: canned tuna, shrimp, pollock, salmon, cod, catfish, clams, flatfish, crabs, and scallops. The methylmercury in these species is generally less than 0.2 ppm, and few people eat more than the suggested weekly limit of fish (i.e., 2.2 pounds).

If you are concerned about a mercury exposure or think that you or your child are experiencing the adverse effects of mercury, you should consult with a doctor or public health official who is familiar with the health effects of mercury.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO MERCURY?

There are reliable and accurate ways to measure mercury levels in the body. These tests all involve taking blood, urine, or hair samples, and must be performed in a doctor's office or in a health clinic. Nursing women may have their breast milk tested for mercury levels, if any of the other samples tested are found to contain significant amounts of mercury. Most of these tests, however, do not determine the form of mercury to which you were exposed. Mercury levels found in blood, urine, breast milk, or hair may be used to determine if adverse health effects are likely to occur. Mercury in urine is used to test for exposure to metallic mercury vapor and to inorganic forms of mercury. Measurement of mercury in whole blood or scalp hair is used to monitor exposure to methylmercury. Urine is not useful for determining whether exposure has occurred to methylmercury. Levels found in blood, urine, and hair may be used together to predict possible health effects that may be caused by the different forms of mercury.

Blood and urine levels are used as markers to determine whether someone has been exposed to mercury. They are used to determine whether exposure to mercury has occurred and to give a rough idea of the extent of exposure, but they do not tell exactly how much exposure has occurred. Except for methylmercury exposures, blood is considered useful if samples are taken within a few days of exposure. This is because most forms of mercury in the blood decrease by one-half every three days if exposure has been stopped. Thus, mercury levels in the blood provide more useful information after recent exposures than after long-term exposures. Several months after an exposure, mercury levels in the blood and urine are much lower. Hair, which is considered useful only for exposures to methylmercury, can be used to show exposures that occurred many months ago, or even more than a year ago if the hair is long enough and careful testing methods are used. After short-term exposures to metallic mercury, mercury vapor can be detected in the breath, but this occurs to a significant extent only within a few days after exposure, and is not a method normally used to determine if mercury exposure has occurred.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA). Recommendations, on the other hand, provide valuable guidelines to protect public health, but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals; then they are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it for the substance in which you are interested. Some regulations and recommendations for mercury include the following:

EPA and FDA have set a limit of 2 parts inorganic mercury per billion (ppb) parts of water in drinking water. EPA is in the process of revising the Water Quality Criteria for mercury. EPA currently recommends that the level of inorganic mercury in rivers, lakes, and streams be no more than 144 parts mercury per trillion (ppt) parts of water to protect human health (1 ppt is a thousand times less than 1 part per billion, or ppb). EPA has determined that a daily exposure (for an adult of average weight) to inorganic mercury in drinking water at a level up to

2 ppb is not likely to cause any significant adverse health effects. FDA has set a maximum permissible level of 1 part of methylmercury in a million parts (ppm) of seafood products sold through interstate commerce (1 ppm is a thousand times more than 1 ppb). FDA may seize shipments of fish and shellfish containing more than 1 ppm of methylmercury, and may seize treated seed grain containing more than 1 ppm of mercury.

OSHA regulates levels of mercury in the workplace. It has set limits of 0.1 milligrams of mercury per cubic meter of air (mg/m^3) for organic mercury and 0.05 mg/m^3 for metallic mercury vapor in workplace air to protect workers during an 8-hour shift and a 40-hour work week. NIOSH recommends that the amount of metallic mercury vapor in workplace air be limited to an average level of 0.05 mg/m^3 during a 10-hour work shift.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop F-32
Atlanta, GA 30333

Information line and technical assistance:

Phone: 888-422-8737
FAX: (770)-488-4178

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

To order toxicological profiles, contact:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 800-553-6847 or 703-605-6000

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological profile for mercury. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Appendix D
Arsenic

PUBLIC HEALTH STATEMENT
Arsenic
CAS#: 7440-38-2

Division of Toxicology and Environmental Medicine **August 2007**

This Public Health Statement is the summary chapter from the Toxicological Profile for Arsenic. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™, is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-800-232-4636.

This public health statement tells you about arsenic and the effects of exposure to it.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites are then placed on the National Priorities List (NPL) and are targeted for long-term federal clean-up activities. Arsenic has been found in at least 1,149 of the 1,684 current or former NPL sites. Although the total number of NPL sites evaluated for this substance is not known, the possibility exists that the number of sites at which arsenic is found may increase in the future as more sites are evaluated. This information is important because these sites may be sources of exposure and exposure to this substance may harm you.

When a substance is released either from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. Such a release does not always lead to exposure. You can be exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to arsenic, many factors will determine whether you will be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider any other chemicals you are exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS ARSENIC?

Arsenic is a naturally occurring element that is widely distributed in the Earth's crust. Arsenic is classified chemically as a metalloid, having both properties of a metal and a nonmetal; however, it is frequently referred to as a metal. Elemental arsenic (sometimes referred to as metallic arsenic) is a steel grey solid material. However, arsenic is usually found in the environment combined with other elements such as oxygen, chlorine, and sulfur. Arsenic combined with these elements is called inorganic arsenic. Arsenic combined with carbon and hydrogen is referred to as organic arsenic.

Most inorganic and organic arsenic compounds are white or colorless powders that do not evaporate. They have no smell, and most have no special taste. Thus, you usually cannot tell if arsenic is present in your food, water, or air.

Inorganic arsenic occurs naturally in soil and in many kinds of rock, especially in minerals and ores that contain copper or lead. When these ores are heated in smelters, most of the arsenic goes up the stack and enters the air as a fine dust. Smelters may collect this dust and take out the arsenic as a compound called arsenic trioxide (As_2O_3).

However, arsenic is no longer produced in the United States; all of the arsenic used in the United States is imported.

Presently, about 90% of all arsenic produced is used as a preservative for wood to make it resistant to rotting and decay. The preservative is copper chromated arsenate (CCA) and the treated wood is referred to as "pressure-treated." In 2003, U.S. manufacturers of wood preservatives containing arsenic began a voluntary transition from CCA to other wood preservatives that do not contain arsenic in wood products for certain residential uses, such as play structures, picnic tables, decks, fencing, and boardwalks. This phase out was completed on December 31, 2003; however, wood treated prior to this date could still be used and existing structures made with CCA-treated wood would not be affected. CCA-treated wood products continue to be used in industrial applications. It is not known whether, or to what extent, CCA-treated wood products may contribute to exposure of people to arsenic.

In the past, inorganic arsenic compounds were predominantly used as pesticides, primarily on cotton fields and in orchards. Inorganic arsenic compounds can no longer be used in agriculture. However, organic arsenic compounds, namely cacodylic acid, disodium methylarsenate (DSMA), and monosodium methylarsenate (MSMA), are still used as pesticides, principally on cotton. Some organic arsenic compounds are used as additives in animal feed. Small quantities of elemental arsenic are added to other metals to form metal mixtures or alloys with improved properties. The greatest use of arsenic in alloys is in lead-acid batteries for automobiles. Another important use of arsenic compounds is in semiconductors and light-emitting diodes.

1.2 WHAT HAPPENS TO ARSENIC WHEN IT ENTERS THE ENVIRONMENT?

Arsenic occurs naturally in soil and minerals and it therefore may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching. Volcanic eruptions are another source of arsenic. Arsenic is associated with ores containing metals, such as copper and lead. Arsenic may enter the environment during the mining and smelting of these ores. Small amounts of arsenic also may be released into the atmosphere from coal-fired power plants and incinerators because coal and waste products often contain some arsenic.

Arsenic cannot be destroyed in the environment. It can only change its form, or become attached to or separated from particles. It may change its form by reacting with oxygen or other molecules present in air, water, or soil, or by the action of bacteria that live in soil or sediment. Arsenic released from power plants and other combustion processes is usually attached to very small particles. Arsenic contained in wind-borne soil is generally found in larger particles. These particles settle to the ground or are washed out of the air by rain. Arsenic that is attached to very small particles may stay in the air for many days and travel long distances. Many common arsenic compounds can dissolve in water. Thus, arsenic can get into lakes, rivers, or underground water by dissolving in rain or snow or through the discharge of industrial wastes. Some of the arsenic will stick to particles in the water or sediment on the bottom of lakes or rivers, and some will be carried along by the water. Ultimately, most arsenic ends up in the soil or sediment. Although some fish and shellfish take in arsenic, which may build up in tissues, most of this arsenic is in an organic form called arsenobetaine (commonly called "fish arsenic") that is much less harmful.

1.3 HOW MIGHT I BE EXPOSED TO ARSENIC?

Since arsenic is found naturally in the environment, you will be exposed to some arsenic by eating food, drinking water, or breathing air. Children may also be exposed to arsenic by eating soil. Analytical methods used by scientists to determine the levels of arsenic in the environment generally do not determine the specific form of arsenic present. Therefore, we do not always know the form of arsenic a person may be exposed to. Similarly, we often do not know what forms of arsenic are present at hazardous waste sites. Some forms of arsenic may be so tightly attached to particles or embedded in minerals that they are not taken up by plants and animals.

The concentration of arsenic in soil varies widely, generally ranging from about 1 to 40 parts of arsenic to a million parts of soil (ppm) with an average level of 3–4 ppm. However, soils in the vicinity of arsenic-rich geological deposits, some mining and smelting sites, or agricultural areas where arsenic pesticides had been applied in the past may contain much higher levels of arsenic. The concentration of arsenic in natural surface and groundwater is generally about 1 part in a billion parts of water (1 ppb), but may exceed 1,000 ppb in contaminated areas or where arsenic levels in soil are high. Groundwater is far more likely to contain high levels of arsenic than surface water. Surveys of U.S. drinking water indicate that about 80% of water supplies have less than 2 ppb of arsenic, but 2% of supplies exceed 20 ppb of arsenic. Levels of arsenic in food range from about 20 to 140 ppb. However, levels of inorganic arsenic, the form of most concern, are far lower. Levels of arsenic in the air generally range from less than 1 to about 2,000 nanograms (1 nanogram equals a billionth of a gram) of arsenic per cubic meter of air (less than 1–2,000 ng/m^3), depending on location, weather conditions, and the level of industrial activity in the area. However, urban areas generally have mean arsenic levels in air ranging from 20 to 30 ng/m^3.

You normally take in small amounts of arsenic in the air you breathe, the water you drink, and the food you eat. Of these, food is usually the largest source of arsenic. The predominant dietary source of arsenic is seafood, followed by rice/rice cereal, mushrooms, and poultry. While seafood contains the greatest amounts of arsenic, for fish and shellfish, this is mostly in an organic form of arsenic called arsenobetaine that is much less harmful. Some seaweeds may contain arsenic in inorganic forms that may be more harmful. Children are likely to eat small amounts of dust or soil each day, so this is another way they may be exposed to arsenic. The total amount of arsenic you take in from these sources is generally about 50 micrograms (1 microgram equals one-millionth of a gram) each day. The level of inorganic arsenic (the form of most concern) you take in from these sources is generally about 3.5 microgram/day. Children may be exposed to small amounts of arsenic from hand-to-mouth activities from playing on play structures or decks constructed out of CCA-treated wood. The potential exposure that children may receive from playing in play structures constructed from CCA-treated wood is generally smaller than that they would receive from food and water.

In addition to the normal levels of arsenic in air, water, soil, and food, you could be exposed to higher levels in several ways, such as the following:

- Some areas of the United States contain unusually high natural levels of arsenic in rock, and this can lead to unusually high levels of arsenic in soil or water. If you live in an area like this, you could take in elevated amounts of arsenic in drinking water. Children may be taking in higher amounts of arsenic because of hand-to-mouth contact or eating soil in areas with higher than usual arsenic concentrations.
- Some hazardous waste sites contain large quantities of arsenic. If the material is not properly disposed of, it can get into surrounding water, air, or soil. If you live near such a site, you could be exposed to elevated levels of arsenic from these media.
- If you work in an occupation that involves arsenic production or use (for example, copper or lead smelting, wood treating, or pesticide application), you could be exposed to elevated levels of arsenic during your work.
- If you saw or sand arsenic-treated wood, you could inhale some of the sawdust into your nose or throat. Similarly, if you burn arsenic-treated wood, you could inhale arsenic in the smoke.
- If you live in a former agricultural area where arsenic was used on crops, the soil could contain high levels of arsenic.
- In the past, several kinds of products used in the home (rat poison, ant poison, weed killer, some types of medicines) had arsenic in them. However, most of these uses of arsenic have ended, so you are not likely to be exposed from home products any longer.

1.4 HOW CAN ARSENIC ENTER AND LEAVE MY BODY?

If you swallow arsenic in water, soil, or food, most of the arsenic may quickly enter into your body. The amount that enters your body will depend on how much you swallow and the kind of arsenic that you swallow. This is the most likely way for you to be exposed near a waste site. If you breathe air that contains arsenic dusts, many of the dust particles settle onto the lining of the lungs. Most of the arsenic in these particles is then taken up from the lungs into the body. You might be exposed in this way near waste sites where arsenic-contaminated soils are allowed to blow into the air, or if you work with arsenic-containing soil or products. If you get arsenic-contaminated soil or water on your skin, only a small amount will go through your skin into your body, so this is usually not of concern.

Both inorganic and organic forms leave your body in your urine. Most of the inorganic arsenic will be gone within several days, although some will remain in your body for several months or even longer. If you are exposed to organic arsenic, most of it will leave your body within several days.

1.5 HOW CAN ARSENIC AFFECT MY HEALTH?

Scientists use many tests to protect the public from harmful effects of toxic chemicals and to find ways for treating persons who have been harmed.

One way to learn whether a chemical will harm people is to determine how the body absorbs, uses, and releases the chemical. For some chemicals, animal testing may be necessary. Animal testing may also help identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method for getting information needed to make wise decisions that protect public health. Scientists have the responsibility to treat research animals with care and compassion. Scientists must comply with strict animal care guidelines because laws today protect the welfare of research animals.

Inorganic arsenic has been recognized as a human poison since ancient times, and large oral doses (above 60,000 ppb in water which is 10,000 times higher than 80% of U.S. drinking water arsenic levels) can result in death. If you swallow lower levels of inorganic arsenic (ranging from about 300 to 30,000 ppb in water; 100–10,000 times higher than most U.S. drinking water levels), you may experience irritation of your stomach and intestines, with symptoms such as stomachache, nausea, vomiting, and diarrhea. Other effects you might experience from swallowing inorganic arsenic include decreased production of red and white blood cells, which may cause fatigue, abnormal heart rhythm, blood-vessel damage resulting in bruising, and impaired nerve function causing a "pins and needles" sensation in your hands and feet.

Perhaps the single-most characteristic effect of long-term oral exposure to inorganic arsenic is a pattern of skin changes. These include patches of darkened skin and the appearance of small "corns" or "warts" on the palms, soles, and torso, and are often associated with changes in the blood vessels of the skin. Skin cancer may also develop. Swallowing arsenic has also been reported to increase the risk of cancer in the liver, bladder, and lungs. The Department of Health and Human Services (DHHS) has determined that inorganic arsenic is known to be a human carcinogen (a chemical that causes cancer). The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans. EPA also has classified inorganic arsenic as a known human carcinogen.

If you breathe high levels of inorganic arsenic, then you are likely to experience a sore throat and irritated lungs. You may also develop some of the skin effects mentioned above. The exposure level that produces these effects is uncertain, but it is probably above 100 micrograms of arsenic per cubic meter ($\mu g/m^3$) for a brief exposure. Longer exposure at lower concentrations can lead to skin effects, and also to circulatory and peripheral nervous disorders. There are some data suggesting that inhalation of inorganic arsenic may also interfere with normal fetal development, although this is not certain. An important concern is the ability of inhaled inorganic arsenic to increase the risk of lung cancer. This has been seen mostly in workers exposed to arsenic at smelters, mines, and chemical factories, but also in residents living near smelters and arsenical chemical factories. People who live near waste sites with arsenic may have an increased risk of lung cancer as well.

If you have direct skin contact with high concentrations of inorganic arsenic compounds, your skin may become irritated, with some redness and swelling. However, it does not appear that skin contact is likely to lead to any serious internal effects.

Almost no information is available on the effects of organic arsenic compounds in humans. Studies in animals show that most simple organic arsenic compounds (such as methyl and dimethyl compounds) are less toxic than the inorganic forms. In animals, ingestion of methyl compounds can result in diarrhea, and lifetime exposure can damage the kidneys. Lifetime exposure to dimethyl compounds can damage the urinary bladder and the kidneys.

1.6 HOW CAN ARSENIC AFFECT CHILDREN?

This section discusses potential health effects in humans from exposures during the period from conception to maturity at 18 years of age.

Children are exposed to arsenic in many of the same ways that adults are. Since arsenic is found in the soil, water, food, and air, children may take in arsenic in the air they breathe, the water they drink, and the food they eat. Since children tend to eat or drink less of a variety of foods and beverages than do adults, ingestion of contaminated food or juice or infant formula made with arsenic-contaminated water may represent a significant source of exposure. In addition, since children often play in the soil and put their hands in their mouths and sometimes intentionally eat soil, ingestion of contaminated soil may be a more important source of arsenic exposure for children than for adults. In areas of the United States where natural levels of arsenic in the soil and water are high, or in areas in and around contaminated waste sites, exposure of children to arsenic through ingestion of soil and water may be significant. In addition, contact with adults who are wearing clothes contaminated with arsenic (e.g., with dust from copper- or lead-smelting factories, from wood-treating or pesticide application, or from arsenic-treated wood) could be a source of exposure. Because of the tendency of children to taste things that they find, accidental poisoning from ingestion of pesticides is also a possibility. Thus, although most of the exposure pathways for children are the same as those for adults, children may be at a higher risk of exposure because of normal hand-to-mouth activity.

Children who are exposed to inorganic arsenic may have many of the same effects as adults, including irritation of the stomach and intestines, blood vessel damage, skin changes, and reduced nerve function. Thus, all health effects observed in adults are of potential concern in children. There is also some evidence that suggests that long-term exposure to inorganic arsenic in children may result in lower IQ scores. We do not know if absorption of inorganic arsenic from the gut in children differs from adults.

There is some evidence that exposure to arsenic in early life (including gestation and early childhood) may increase mortality in young adults.

There is some evidence that inhaled or ingested inorganic arsenic can injure pregnant women or their unborn babies, although the studies are not definitive. Studies in animals show that large doses of inorganic arsenic that cause illness in pregnant females can also cause low birth weight, fetal malformations, and even fetal death. Arsenic can cross the placenta and has been found in fetal tissues. Arsenic is found at low levels in breast milk.

In animals, exposure to organic arsenic compounds can cause low birth weight, fetal malformations, and fetal deaths. The dose levels that cause these effects also result in effects in the mothers.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO ARSENIC?

If your doctor finds that you have been exposed to substantial amounts of arsenic, ask whether your children might also have been exposed. Your doctor might need to ask your state health department to investigate.

Many communities may have high levels of arsenic in their drinking water, particularly from private wells, because of contamination or as a result of the geology of the area. The north central region and the western region of the United States have the highest arsenic levels in surface water and groundwater sources, respectively. Wells used to provide water for drinking and cooking should be tested for arsenic. As of January 2006, EPA's Maximum Contaminant Level (MCL) for arsenic in drinking water is 10 ppb. If you have arsenic in your drinking water at levels higher that the EPA's MCL, an alternative source of water should be used for drinking and cooking should be considered.

If you use arsenic-treated wood in home projects, personal protection from exposure to arsenic-containing sawdust may be helpful in limiting exposure of family members. These measures may include dust masks, gloves, and protective clothing. Arsenic-treated wood should never be burned in open fires, or in stoves, residential boilers, or fire places, and should not be composted or used as mulch. EPA's Consumer Awareness Program (CAP) for CCA is a voluntary program established by the manufacturers of CCA products to inform consumers about the proper handling, use, and disposal of CCA-treated wood. You can find more information about this program in Section 6.5. Hand washing can reduce the potential exposure of children to arsenic after playing on play structures constructed with CCA-treated wood, since most of the arsenic on the children's hands was removed with water.

If you live in an area with a high level of arsenic in the water or soil, substituting cleaner sources of water and limiting contact with soil (for example, through use of a dense groundcover or thick lawn) would reduce family exposure to arsenic. By paying careful attention to dust and soil control in the home (air filters, frequent cleaning), you can reduce family exposure to contaminated soil. Some children eat a lot of soil. You should prevent your children from eating soil. You should discourage your children from putting objects in their mouths. Make sure they wash their hands frequently and before eating. Discourage your children from putting their hands in their mouths or engaging in other hand-to-mouth activities. Since arsenic may be found in the home as a pesticide, household chemicals containing arsenic should be stored out of reach of young children to prevent accidental poisonings. Always store household chemicals in their original labeled containers; never store household chemicals in containers that children would find attractive to eat or drink from, such as old soda bottles. Keep your Poison Control Center's number by the phone.

It is sometimes possible to carry arsenic from work on your clothing, skin, hair, tools, or other objects removed from the workplace. This is particularly likely if you work in the fertilizer, pesticide, glass, or copper/lead smelting industries. You may contaminate your car, home, or other locations outside work where children might be exposed to arsenic. You should know about this possibility if you work with arsenic.

Your occupational health and safety officer at work can and should tell you whether chemicals you work with are dangerous and likely to be carried home on your clothes, body, or tools and whether you should be showering and changing clothes before you leave work, storing your street clothes in a separate area of the workplace, or laundering your work clothes at home separately from other clothes. Material safety data sheets (MSDS) for many chemicals used should be found at your place of work, as required by the Occupational Safety and Health Administration (OSHA) in the U.S. Department of Labor. MSDS information should include chemical names and hazardous ingredients, and important properties, such as fire and explosion data, potential health effects, how you get the chemical(s) in your body, how to properly handle the materials, and what to do in the case of emergencies. Your employer is legally responsible for providing a safe workplace and should freely answer your questions about hazardous chemicals. Your state OSHA-approved occupational safety and health program or OSHA can answer any further questions and help your employer identify and correct problems with hazardous substances. Your state OSHA-approved occupational safety and health program or OSHA will listen to your formal complaints about workplace health hazards and inspect your workplace when necessary. Employees have a right to seek safety and health on the job without fear of punishment.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO ARSENIC?

Several sensitive and specific tests can measure arsenic in your blood, urine, hair, or fingernails, and these tests are often helpful in determining if you have been exposed to above-average levels of arsenic in the past. These tests are not usually performed in a doctor's office. They require sending the sample to a testing laboratory.

Measurement of arsenic in your urine is the most reliable means of detecting arsenic exposures that you experienced within the last several days. Most tests measure the total amount of arsenic present in your urine. This can sometimes be misleading, because the nonharmful forms of arsenic in fish and shellfish can give a high reading even if you have not been exposed to a toxic form of arsenic. For this reason, laboratories sometimes use a more complicated test to separate "fish arsenic" from other forms. Because most arsenic leaves your body within a few days, analysis of your urine cannot detect if you were exposed to arsenic in the past. Tests of your hair or fingernails can tell if you were exposed to high levels over the past 6–12 months, but these tests are not very useful in detecting low-level exposures. If high levels of arsenic are detected, this shows that you have been exposed, but unless more is known about when you were exposed and for how long, it is usually not possible to predict whether you will have any harmful health effects.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations *can* be enforced by law. The EPA, the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA) are some federal agencies that develop regulations for toxic substances. Recommendations provide valuable guidelines to protect public health, but *cannot* be enforced by law. The Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH) are two federal organizations that develop recommendations for toxic substances.

Regulations and recommendations can be expressed as "not-to-exceed" levels, that is, levels of a toxic substance in air, water, soil, or food that do not exceed a critical value that is usually based on levels that affect animals; they are then adjusted to levels that will help protect humans. Sometimes these not-to-exceed levels differ among federal organizations because they used different exposure times (an 8-hour workday or a 24-hour day), different animal studies, or other factors.

Recommendations and regulations are also updated periodically as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for ARSENIC include the following:

The federal government has taken several steps to protect humans from arsenic. First, EPA has set limits on the amount of arsenic that industrial sources can release into the environment. Second, EPA has restricted or canceled many of the uses of arsenic in pesticides and is considering further restrictions. Third, in January 2001, the EPA lowered the limit for arsenic in drinking water from 50 to 10 ppb. Finally, OSHA has established a permissible exposure limit (PEL), 8-hour time-weighted average, of 10 $\mu g/m^3$ for airborne arsenic in various workplaces that use inorganic arsenic.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department, or contact ATSDR at the address and phone number below.

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses that result from exposure to hazardous substances.

Toxicological profiles are also available on-line at www.atsdr.cdc.gov and on CD-ROM. You may request a copy of the ATSDR ToxProfiles™ CD-ROM by calling the toll-free information and technical assistance number at 1-800-CDCINFO (1-800-232-4636), by e-mail at cdcinfo@cdc.gov, or by writing to:

Agency for Toxic Substances and Disease Registry
Division of Toxicology and Environmental Medicine
1600 Clifton Road NE
Mailstop F-32
Atlanta, GA 30333
Fax: 1-770-488-4178

Organizations for-profit may request copies of final Toxicological Profiles from the following:

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Phone: 1-800-553-6847 or 1-703-605-6000
Web site: http://www.ntis.gov/

Appendix E
Interview Questions

APPENDIX E

Interview Questions

Person(s) Interviewed:
Phone day:
Phone eve:
Email:
Address:
Interview Date:

HISTORY

- How long have you lived/worked in the area?
- When did you first become aware of the environmental contamination at the Sulphur Bank Mercury Mine Superfund site?
- Do you live near the Site or know people who do?
- What do you know about the Sulphur Bank Mercury Mine site?

CONCERNS

- What are your concerns about the Site and its cleanup?
- What would you say are your biggest concerns about the Site?
- What would you like to see happen with the Site in the future?
- How is your interaction with the Elem Indian Colony?

COMMUNITY INVOLVEMENT

- How did you get information about the Site?
- Have you participated in other activities related to the Site prior to this interview? For example, have you attended any meetings, or written any letters
- What has your experience been with government agencies (tribal, local, state, or federal) at the site?
- If you had a question about the site, who would you contact? Why?
- What groups or people do you know are concerned about the Site?
- Do you think those people or groups are representing your concerns regarding the Site?
- What other local activities, organizations, or civic groups are you involved with?
- How would you like to be involved in future Site activities? How would you suggest we involve your neighbors?

COMMUNICATION & MEDIA

- How would you like to receive information about the Site from EPA in the future: fact sheets, internet, news media, workshops, public notices, public meetings, posters in the neighborhood, or neighborhood/community group?
- What days and location would be best for public meetings?
- Personally, where would work best for you?
- How can your interactions with officials be improved? How effective has U.S. EPA or Tribal EPA communications been in the past?
- What suggestions might you have for U.S. EPA or Tribal EPA?
- Do you know where the information repository, or where information about the Site is housed?
- Do you think keeping information about the Site at the Lake County Library and Redbud Library are good locations? Could you suggest any other locations?
- Would you like to be added to the mailing list?
- Do you know of any non-English speaking communities near the site?

ADDITIONAL QUESTIONS

- What other individuals or organizations do you think we should contact about the Site?
- Is there anything else you would like to share about your thoughts, concerns, or experience with the site?
- What environmental activities are you personally involved in?

Appendix F
Glossary

APPENDIX F

Glossary

arsenic – a metalloid; arsenic can form toxic compounds. (See Appendix D for more information)

bioaccumulation – the buildup of a chemical in tissues of fish or other organisms over time.

cleanup alternatives – actions taken to deal with a release or threat of release of a hazardous substance that could affect humans or the environment.

emergency actions – steps taken to remove contaminated materials that pose immediate threats to the safety of workers, residents, the environment, or property.

feasibility study – A study that includes the development, description, and evaluation of potential cleanup alternatives for a site, such as one on the National Priorities List. It usually starts as soon as the remedial investigation is underway; together, they are commonly referred to as the "RI/FS."

geothermal energy – energy created by hot water or steam extracted from reservoirs within the Earth's crust.

groundwater – the supply of water found beneath the Earth's surface, usually in aquifers, which supply wells and springs.

information repository – a file that contains accurate, up-to-date documents on a Superfund site. The file is usually located in a public building (for example, a school, library, or city hall) that is convenient for local residents.

mercury – a heavy metal; mercury can accumulate in the environment and is highly toxic if breathed or swallowed. (See Appendix C for more information)

mine tailings – the material left over after the process of separating the valuable fraction from the worthless fraction of ore.

National Priorities List – EPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under Superfund. The list is based primarily on the score a site receives from the Hazard Ranking System. EPA is required to update the National Priorities List at least once a year.

nutrient loading – the introduction of excessive amounts of nutrients such as nitrogen or phosphorus from fertilizers into the soil or water.

operable unit – term used to identify each separate portions (geographic or contaminate-based) of the Superfund site. A typical operable unit would be a portion of a site that can be cleaned up separately from other areas.

remedial investigation – an in-depth study designed to gather data needed to determine the nature and extent of contamination at a Superfund site. The remedial investigation is usually done performed with a feasibility study; together they are usually referred to as the "RI/FS".

remedy – cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a Superfund site.

responsible party – individuals or groups that may be liable for cleanup at a Superfund site.

runoff – that part of precipitation, snow melt, or irrigation water that drains off the land into streams or other surface water. Runoff can carry pollutants from the air and land into receiving waters.

surface water – all water naturally open to the atmosphere (for example, rivers, lakes, reservoirs, ponds, streams, impoundments, seas, and estuaries).

technical assistance grant – as part of the Superfund program, technical assistance grants of up to $50,000 are provided to citizens' groups to obtain assistance in interpreting information related to cleanups at Superfund sites or those proposed for inclusion in the National Priorities List. Grants are used by the groups to hire technical advisors to help them understand the site-related technical information for the duration of response activities.

Appendix G
Acronym List

APPENDIX G

Acronym List

amsl	above mean sea level
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act if 1980
CIP	Community Involvement Plan
CLEAN	Clear Lake Environmental Action Network
CRP	Community Relations Plan
EIC	Elem Indian Colony of Pomo Indians
EPA	U.S. Environmental Protection Agency
NPL	National Priorities List
OU-1	Operable Unit 1
OU-2	Operable Unit 2
Plan	Community Involvement Plan
RI/FS	remedial investigation/feasibility study
Site	Sulphur Bank Mercury Mine Superfund site