AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

Evaluation of Exposure to Contaminants at the University of California, Berkeley, Richmond Field Station,
1301 South 46th Street
RICHMOND, CONTRA COSTA COUNTY, CALIFORNIA
EPA FACILITY ID: CAD980673628
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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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PUBLIC HEALTH ASSESSMENT

Evaluation of Exposure to Contaminants at the University of California, Berkeley, Richmond Field Station, 1301 South 46th Street

RICHMOND, CONTRA COSTA COUNTY, CALIFORNIA

EPA FACILITY ID: CAD980673628

Prepared by:

California Department of Public Health
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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List of Acronyms

ATSDR—Agency for Toxic Substances and Disease Registry

bgs—below ground surface

CAG—Community Advisory Group

Cal/EPA—California Environmental Protection Agency

CCCHSD—Contra Costa County Health Services Department

CDPH—California Department of Public Health

CSF—cancer slope factor

CHHSL—California Human Health Screening Levels

COCs—contaminants of concern

CREG—Cancer Risk Evaluation Guideline for one in a million excess cancer risk

DTSC—Department of Toxic Substances Control (of Cal/EPA)

EBRPD—East Bay Regional Parks District

EHIB—Environmental Health Investigations Branch

EMEG—Environmental Media Evaluation Guide (ATSDR)

EPA—U.S. Environmental Protection Agency

I.Q.—Intelligence Quotient

LOAEL—Lowest Observable Adverse Effect Level

ml—milliliter

MRL—Minimal Risk Level (ATSDR)

NA—not analyzed or not applicable

ND—not detected

NOAEL—No Observable Adverse Effect Level

NPL—National Priorities List (EPA)

NS—not sampled

NTP—National Toxicology Program

OEHHA—Office of Environmental Health Hazard Assessment (of Cal/EPA)

PCBs—polychlorinated biphenyls

PHA—public health assessment

PM 10—particulate matter that is less than 10 microns in aerodynamic diameter

ppm—parts per million

ppb—parts per billion

PRP—potentially responsible party

RCRA—Resource, Conservation, and Recovery Act

REL—Reference Exposure Level (OEHHA)

RFS—Richmond Field Station

RfC—reference concentration (EPA)

RfD—reference dose (EPA)

RI—remedial investigation

RI/FS—remedial investigation/feasibility study

RMEG—Reference Dose Media Evaluation Guide based on EPA's RfD (ATSDR)

RWQCB—Regional Water Quality Control Board (of Cal/EPA)

UC—University of California

$\mu g/m^3$—micro gram per cubic meter of air

VOC—volatile organic compound

Summary

This public health assessment (PHA) looks at the possible ways people could come into contact with contaminants at the Richmond Field Station (RFS), and responds to workers' health concerns related to the site. The purpose of the PHA is to help determine what follow-up activities are needed to reduce or eliminate exposure.

The PHA has three parts. The first is a review of existing environmental data to evaluate the potential health impact from exposures to contaminants found at the site. The review addresses the following: contamination in the Western Stege Marsh; metal contamination in on-site soils; airborne contaminants generated or released during remedial activities conducted in September 2002 and September 2003; and contaminants in indoor air. Second, the PHA describes health concerns collected from on-site workers and former workers. Third, the PHA evaluates these health concerns based on environmental data review described above, the health effects known to be associated with certain chemicals found on-site, and what is known about the cause of the health effects/concerns expressed by RFS workers.

RFS is operated by the University of California (UC), Berkeley, in Richmond, California. The RFS site is located at 1301 South 46th Street, Richmond, California. UC purchased the land in 1950. RFS is currently used as a research and teaching facility.

Between 1870 and 1950, much of RFS property belonged to the California Cap Company, which made explosives. The California Cap Company manufactured mercury fulminate on-site for the production of blasting caps. This resulted in mercury contamination to the soil and marsh sediments.

From 1897 to 1985, the adjacent property directly east, was owned and operated by Stauffer Chemical Company. This property is now referred to as Zeneca/Campus Bay. At various times, Stauffer produced/manufactured sulfuric acid, superphosphate fertilizer, pesticides, herbicides, and other chemicals. The production of sulfuric acid generated pyrite cinder wastes that were deposited on RFS and the Zeneca property. The pyrite cinders are a source of low pH conditions and metals including arsenic, cadmium, copper, lead, mercury, selenium, and zinc. Naturally occurring radionuclides are associated with the production of superphosphate fertilizer and may also be elevated in soil, sediment, and groundwater on the RFS site. Other historic activities conducted on the Zeneca property involving radionuclides may also be present in soil, sediment, and groundwater. Zeneca is currently undergoing investigation and clean-up activities. At the time of this writing, radionuclides associated with Stauffer activities have not been characterized at the Zeneca site or the RFS.

From 1999 to 2005, investigations and clean-up activities were underway at RFS under the oversight of the California Regional Water Quality Control Board (RWQCB), San Francisco Bay Region. In May 2005, the California Environmental Protection Agency's Department of Toxic Substances Control (DTSC) took over as the lead oversight agency for RFS.

In April 2005, due to ongoing community concerns about the RFS, the Department of Toxic Substances Control (DTSC) and the Contra Costa County Health Services Department requested

assistance from the California Department of Public Health (CDPH) (formerly California Department of Health Services) to evaluate the potential health impact posed by the site. Since that time, CDPH has been conducting PHA activities at RFS.

In August 2007, a public comment draft of the public health assessment was released to the public and other stakeholders for review and comment. The comments and CDPH responses are provided in Appendix F.

CDPH evaluated the possible exposure pathway/activities (past, current, and future) to contaminants at RFS, using environmental data collected from the site. The conclusions of this evaluation are as follow.

CDPH concludes the following exposure pathways/activities do not pose a public health hazard:

- Past exposure to airborne mercury during remedial activities conducted between August 2003 and September 2003.

- Past, current and future exposure to metals and PCBs for adults from recreating in the marsh.

- Past exposure to metals and PCBs for children/teenagers from recreating in the marsh.

- Current exposure to metals and PCBs for adults and children/teenagers from restoring the Western Stege Marsh in areas that have been excavated.

CDPH concludes the following exposure pathways/activities pose a public health hazard:

- Current and future exposure to children/teenagers who regularly play in the Western Stege Marsh.

CDPH identified potential exposures of health concern for children/teenagers who regularly play in the Western Stege Marsh, from exposure to the highest concentrations of metals and PCBs in surface water and/or sediment. The most sensitive (primary) noncancer endpoints associated with COCs include skin effects (arsenic), renal effects (cadmium), neurodevelopmental (methylmercury), gastrointestinal symptoms (copper), immune effects (PCBs), and decreases in erythrocyte copper, zinc-superoxide dismutase (ESOD) activity (zinc). COCs associated with an increased cancer risk are arsenic (skin, liver, bladder, and lung) and PCBs (liver, biliary). It is important to note that this conclusion is based on conservative assumptions meant to identify the possibility for exposures of health concern, so that steps can be taken to mitigate or prevent these exposures from occurring. Actual exposures to children/teenagers would be much less. Access to the marsh should remain restricted.

- Past exposure to RFS maintenance workers who regularly worked in soil containing the highest levels of metals and PCBs in RFS soil prior to removal/excavation activities.

- Current, and future exposure to RFS maintenance workers who regularly work in soil containing the highest levels of metals and PCBs in non-excavated areas of RFS.

CDPH identified a public health hazard for RFS maintenance workers who regularly worked/work in soil containing the highest levels of metals and PCBs in RFS soil. The primary noncancer endpoints associated with COCs include skin effects (arsenic), immune changes (PCBs), renal effects (cadmium, inorganic mercury), and gastrointestinal symptoms (copper). COCs associated with an increased cancer risk are arsenic (skin, liver, bladder, and lung) and PCBs (liver, biliary). This conclusion is based on conservative assumptions, actual exposures are likely much less. A worker's exposure can be mitigated if proper protective equipment (e.g., gloves, respiratory protection, etc.) is used while working in RFS soil.

CDPH was unable to determine if a future health hazard exists from restoration activities in the marsh for the reason that follows. It is possible that contamination may be migrating through surface and/or groundwater from non-remediated areas of the marsh, the uplands, and/or the adjacent Zeneca site, into the remediated portion of the marsh. As a precautionary measure, children/teenagers should not participate in restoration activities until additional investigation and remediation are completed. If adults chose to participate in restoration activities, they should be made aware of the potential issues (data gaps) and be provided appropriate protective equipment.

Additionally, there is a potential for elevated levels of natural occurring radionuclides associated with historic operations at the adjacent Zeneca site to have migrated into the Western Stege Marsh. This is of primary concern for the portions of the marsh that have not been remediated/excavated.

CDPH was unable to determine whether RFS workers are being exposed to contaminants in indoor air as a result of vapor intrusion, due to a lack of data. Limited indoor air sampling indicates a potential health risk from exposure to formaldehyde in indoor air that occurred between September 2005 and October 2005. These data are insufficient to draw conclusions about the source of formaldehyde in indoor air or the potential impact of future exposure.

CDPH made efforts to collect and understand the health concerns that RFS workers believe are related to contamination at RFS. In the PHA, CDPH responds to these concerns by stating whether contaminants are associated with the health concern expressed, and whether these are present at levels where health effects have been seen in the scientific literature. The majority of the health concerns expressed by workers cannot be linked to chemical exposures at the site, based on the exposure and toxicological information available. Two exceptions are irritation of the eyes, nose, and throat, and mild respiratory effects that may have occurred from exposure to formaldehyde and airborne dust.

RFS workers also expressed concern about exposure from simply walking around the RFS. CDPH evaluated potential exposure to resuspension of contaminated soil/dust, using health conservative assumptions. Based on the current information, simply walking on the grounds at the RFS would not expose people to contaminants at levels of health concern.

On the basis of these findings, CDPH and the federal Agency for Toxic Substances and Disease Registry recommend the following.

Site Characterization

- UC should conduct additional characterization of on-site soil and groundwater throughout RFS to identify other areas where potential contamination may exist. Chemicals used in research activities at RFS, as well as known contaminants from historic uses of RFS and Zeneca-related (former Stauffer Chemical) contaminants should be analyzed. Characterization of soil and groundwater in the area where the Forest Products building should include additional analyses of pentachlorophenol and chlorophenol byproducts. Soil gas sampling should occur in areas where volatile contamination is suspected. Site characterization activities should be conducted under the direction of DTSC.
- UC should conduct additional indoor air sampling in Buildings 163 and 175 to identify whether formaldehyde is elevated above levels typical of indoor air. Arsenic should also be measured. Results of sampling will determine the need for further sampling or investigation.
- UC should analyze for radionuclides associated with historic activities at the Zeneca site (former Stauffer Chemical) in on-site upland soil and groundwater, and sediment from the Western Stege Marsh, if radionuclide contamination is identified during investigations at the Zeneca site.
- UC should provide all of RFS staff access to up to date maps showing locations of current and historic structures and soil sampling locations, along with the associated level of contamination. (Status: The UC has provided computer access to the remedial documents generated for the site.)

Environmental Monitoring

- UC should annually sample sediment and unfiltered water in the marsh to identify whether contaminants are migrating from the non-remediated areas of the marsh, the uplands, and Zeneca site.
- UC should conduct groundwater monitoring in the Western Stege Marsh to determine whether contaminants are migrating from the uplands or the adjacent Zeneca site into the marsh.
- Future soil disturbing/dust generating activities should be monitored for air quality within in the RFS and along the perimeter of the site to ensure safe air quality for workers, residents, and other people in the area.

Training

- UC should offer Hazardous Waste Operations and Emergency Response training to workers whose work may involve handling or digging in soils on the RFS site.
- UC should train workers annually in how to identify cinders and what action to take if such material is identified. (Status: The UC has implemented a training program for RFS maintenance workers.)

Note: The Environmental Health Investigations Branch (EHIB) of CDPH, under a cooperative agreement with the federal Agency for Toxic Substance and Disease Registry (ATSDR), conducted this PHA of UC Richmond Field Station. In 2008, CDPH/ATSDR will release a PHA for the adjacent Zeneca site—that contains exposure information that may be applicable to RFS workers.

Background and Statement of Issues

The Environmental Health Investigations Branch (EHIB), within the California Department of Public Health (CDPH) (formerly the California Department of Health Services), under cooperative agreement with the federal Agency for Toxic Substance and Disease Registry (ATSDR), is conducting a public health assessment (PHA) of the Richmond Field Station (RFS), operated by the University of California (UC) in Richmond, California. The PHA will include a review of existing environmental data to evaluate the potential health impact from exposures to site-related contaminants, a collection of exposure and health concerns, and a response to these concerns based on review of the data. The PHA is an evaluation of the site to help determine what follow-up activities are needed: additional site characterization, health education, health study, or specific measures to reduce or eliminate exposure. Specifically, we will address the following exposure pathways (situations): contamination in the RFS marsh; metal contamination in on-site soils; airborne contaminants generated/released during remedial activities conducted in September 2002 and September 2003; and contaminants in indoor air. CDPH will be releasing a PHA for the adjacent Zeneca site—its current owners are Cherokee Simeon Ventures—that contains exposure information that may be applicable to RFS workers.

The RFS site is located at 1301 South 46th Street, Richmond, California. In 1950, UC Berkeley purchased the land known as RFS (Appendix B, Figure 1). The property is located along the Richmond shoreline and consists of tidal mudflats, marsh, grasslands, and the upland areas where most of the facilities/buildings are located. RFS is currently used as a research and teaching facility. The Northern Regional Library of the UC Office of the President and the U.S. Environmental Protection Agency (EPA)'s Regional Laboratory are also located at RFS.

Between 1870 and 1950, much of RFS property belonged to the California Cap Company, an explosives manufacturer. The California Cap Company manufactured mercury fulminate on-site for the production of blasting caps. Operations at the California Cap Company resulted in mercury contamination to the soil and marsh sediments (1).

From 1897 to 1985, the adjacent property directly east was owned and operated by Stauffer Chemical Company. This property is now referred to as Zeneca/Campus Bay. At various times, Stauffer produced/manufactured sulfuric acid, superphosphate fertilizer, pesticides, herbicides, and other chemicals. The production of sulfuric acid generated pyrite cinder wastes that were deposited on RFS and the Zeneca property. The pyrite cinders are a source of low pH conditions and metals including arsenic, cadmium, copper, lead, mercury, selenium, and zinc. Naturally occurring radionuclides associated with the production of superphosphate fertilizer may also be elevated in soil, sediment, and groundwater on the RFS site. Other historic activities conducted on the Zeneca property involving radionuclides may also be present in soil, sediment, and groundwater. Zeneca is currently undergoing investigation and clean-up activities. At the time of this writing, radionuclides associated with Stauffer activities have not been characterized at the Zeneca site or the RFS.

In 1999, the California Regional Water Quality Control Board (RWQCB), San Francisco Bay Region, identified contamination (metals and low pH conditions) in sediments from the Western Stege Marsh (Appendix B, Figure 1). As a result, RWQCB requested that UC investigate the extent of contamination in the marsh and the southern portion of the upland area. Elevated concentrations of polychlorinated biphenyls (PCBs) were also found in the sediment in and adjacent to Meeker Slough located along the western boundary of Western Stege Marsh. The source of PCB contamination is still under investigation.

Since 1999, investigations and clean-up activities have been underway at RFS (1). Clean-up activities include restoring the native marsh and creating additional marsh habitat. Three phases of excavation and removal of contaminated material from RFS have occurred.

- Phase 1. From August 2002 to January 2003, 28,000 cubic yards of contaminated soil (pyrite cinder waste and mercury) and marsh sediment were removed from an area bordered by Zeneca to the east and East Bay Regional Park Bay Trail to the south (Appendix B, Figure 2).

- Phase 2. From August 2003 to March 2004, 31,000 cubic yards of contaminated material (pyrite cinder waste and mercury-contaminated sediment) were removed. PCBs were also removed from an area at the outfall of a storm drain in Meeker Slough (Appendix B, Figure 2).

- Phase 3. From August 2004 to November 2004, 3,300 cubic yards of soil contaminated with metals and PCBs were removed from the upland areas.

Clean-up work is prohibited in the Western Stege Marsh during the months of February through August, due to the presence of the endangered California Clapper Rail.

In April 2005, due to ongoing community concerns about RFS, the Contra Costa County Health Services Department and the California Environmental Protection Agency’s Department of Toxic Substances Control (DTSC) requested assistance from CDPH to evaluate the potential health impact posed by the facility. Since that time, CDPH has been conducting PHA activities at RFS. In May 2005, DTSC formally became the lead regulatory agency overseeing environmental investigations and cleanup at the site.

In April 2007, under order from DTSC, the UC released a Draft Current Conditions Report, which provides a summary of past activities/site uses, and the current conditions at the site based on past analytical data (2). In the report a number of areas and/or past activities at RFS are described that may have resulted in contamination to the environment. For example, prior to the 1980s, solvents and other laboratory chemicals were disposed of down drains, leading to the sanitary sewer (2). It is common for old sewer lines made of clay pipe to be compromised and leak. There has been no investigation of soil, soil gas, or groundwater along these sewer lines. Drum storage areas and above ground storage tanks containing various petroleum products, hydraulic fluids, and chemical wastes, have also been identified. Areas where polychlorinated biphenyl (PCB)-containing equipment (transformers, switches, and capacitors) was stored has also been identified. The report identifies a number of other areas where data gaps exist, such as the ‘Bulb’ area where miscellaneous site debris and drums may have been buried; groundwater quality in the western portion of the Transition area; and the effectiveness of the Biologically Active Permeable Barrier (BAPB), which was installed to treat subsurface contamination (dissolved metals in groundwater) that might be migrating into the marsh (2). All the above mentioned examples represent gaps in fully understanding the environmental conditions at RFS.

In August 2007, a public comment draft of the PHA was released to the public and other stakeholders for review and comment. The comments and CDPH responses are provided in Appendix E.

Land Use

RFS occupies approximately 150 acres in a primarily industrial area. The property is comprised of upland areas and offshore areas. The offshore area consists of an inner and outer portion of the Western Stege Marsh (Appendix B, Figure 1). The outer portion of the Western Stege Marsh is located south of the East Bay Regional Parks District (EBRPD) Bay Trail and includes approximately 60 acres of tidal mud flat, marsh, and open water; this portion of the RFS property is not been evaluated in this report. The upland area is located north of the Western Stege Marsh and occupies approximately 90 acres (1). Interstate 580 bounds RFS to the north.

The Richmond Redevelopment Agency owns the property on the western shore and most of Meeker Slough. The nearest residential area, Marina Bay, is located to the west of RFS. RFS is bounded to the east by the Zeneca property (Appendix B, Figure 1). Adjacent to the Zeneca property, to the east, are a number of small businesses.

There are a number of other contaminated sites in the area: Zeneca (formerly Stauffer Chemical Company), Liquid Gold Oil Corporation, Bio-Rad Laboratories, Marina Bay Project, Blair Landfill, and Stege Property Pistol Range.

Demographics

Approximately 400 people work in different departments at RFS, consisting of academics, researchers, laboratory staff, students, maintenance workers, security staff, and administrative staff. Approximately 50 people work at the EPA laboratory.

Environmental Contamination/Pathway Analysis/Toxicological Evaluation

This section examines the pathways for exposure to contamination from the RFS site. We will examine each of the media (groundwater, sediment, surface water in Western Stege Marsh, soil, and air) to determine whether or not contamination is present and if people in the community or at RFS are exposed to (or in contact with) the contamination. If people are exposed to contamination in any of the media, we will evaluate whether there is enough exposure to pose a public health hazard. This analysis will systematically evaluate each of the media. Table 1 in Appendix C presents a summary of the exposure pathways identified at this site.

Exposure pathways are means by which people in areas surrounding the sites could have been or could be exposed to contaminants from the site. For target populations to be exposed to environmental contamination, there must be a mechanism by which the contamination comes into direct contact with a human population. This is called an exposure pathway. Exposure pathways are classified as either completed, potential, or eliminated (3).

In order for an exposure pathway to be considered completed, the following five elements must be present: a source of contamination, an environmental medium and transport mechanism, a point of exposure, a route of exposure, and a receptor population. For a population to be exposed to an environmental contaminant, a completed exposure pathway (all five elements) must be present (3). The following is an example of a completed exposure pathway: a contaminant from a hazardous waste site (source) is released to the air (medium-transport mechanism); the wind blows the contaminant through air into the community (point of exposure) where community members breathe the air (route of exposure and receptor population) (Appendix C, Table 1).

Potential exposure pathways are either 1) not currently complete but could become complete in the future, or 2) indeterminate due to a lack of information. Pathways are eliminated from further assessment if one or more elements are missing and are never likely to exist.

Description of Toxicological Evaluation

In a toxicological evaluation, we evaluate the exposures that have occurred to site-related contaminants, based on the most current studies we can find in the scientific literature. There is not enough available information to thoroughly evaluate exposure to multiple chemicals or possible cancer and noncancer adverse effects of exposure to very low levels of contaminants over long periods of time. Some introductory information follows to help clarify how we evaluate the possible health effects that may occur from exposure to the contaminants identified for follow-up.

When individuals are exposed to a hazardous substance, several factors determine whether harmful effects will occur and the type and severity of those health effects. These factors include the dose (how much), the duration (how long), the route by which they are exposed (breathing, eating, drinking, or skin contact), the other contaminants to which they may be exposed, and their individual characteristics such as age, sex, nutrition, family traits, lifestyle, and state of health. The scientific discipline that evaluates these factors and the potential for a chemical exposure to adversely impact health is called toxicology.

Environmental and Health Screening Criteria

The following section briefly discusses the method used to identify contaminants of concern (COCs) for further evaluation and to determine whether levels of contaminants in various environmental media pose a health hazard from adverse noncancer or cancer health effects.

As a preliminary step in assessing the potential health risks associated with contaminants at the RFS site, CDPH compared contaminant concentrations to media-specific environmental guideline comparison values (CVs). Those concentrations that exceed the CV are identified as COCs for further evaluation of potential health effects. ATSDR’s comparison values are media-specific concentrations that are estimates of a daily human exposure to a contaminant that is unlikely to cause cancer or noncancer (health effects other than cancer) adverse health effects. The following CVs were applied in the current evaluation:

- Cancer Risk Evaluation Guide (CREG). CREGs are media-specific comparison values used to identify concentrations of cancer-causing substances that are unlikely to result in an increase of cancer rates in a population exposed over an entire lifetime. CREGs are derived from EPA's cancer slope factors, which indicate the relative potency of cancer-causing chemicals. Not all chemicals have a CREG (4).

- Environmental Media Evaluation Guide (EMEG). EMEGs are estimates of chemical concentrations that are not likely to cause an appreciable risk of deleterious, noncancer health effects for fixed durations of exposure. EMEGs might reflect several different types of exposure: acute (1-14 days), intermediate (15-364 days), and chronic (365 or more days). EMEGs are based on ATSDR's Minimal Risk Levels (MRLs) (see Glossary in Appendix A for a more complete description of EMEGs) (4, 5).

- Reference Dose Media Evaluation Guides (RMEGs). RMEGs are estimates of chemical concentrations that are not likely to cause an appreciable risk of deleterious, noncancer health effects for chronic exposure. RMEGs are based on EPA's References Doses (RfDs) (see Glossary in Appendix A for a more complete description of EMEGs) (6).

- California Human Health Screening Levels (CHHSLs). CHHSLs are screening levels for chemicals in soil and soil gas used to aid in clean-up decisions based on the protection of public health and safety (7).

- Reference Exposure Levels (RELs) and Reference Concentrations (RfCs). RELs and RfCs are estimates of chemical concentrations in air that are not likely to cause an appreciable risk of deleterious, noncancer health effects for fixed durations of exposure. The California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, RELs and EPA RfCs are used to evaluate inhalation exposure (8).

- Preliminary Remediation Goals (PRGs). EPA's Preliminary Remedial Goals (PRGs) are risk-based concentrations used in initial screening-level evaluations of environmental measurements. PRGs are used if there is no EMEG or RMEG available (9).

If a contaminant is not found at levels greater than its comparison/screening value, CDPH concludes the levels of corresponding contamination are not likely to cause illness and no further evaluation is conducted.

If a contaminant in soil or water is found at levels greater than its comparison value, CDPH designates the contaminant as a COC, and exposure doses are calculated. These values (exposure dose estimates) are then used to examine the potential human exposures in greater detail. CDPH uses the following health-based comparison values (or health guidelines) to identify those contaminants that have the possibility of causing noncancer adverse health effects (cancer health effects evaluation discussed later).

- Minimal Risk Level (MRL). MRLs are estimates of daily human exposure to a substance that is likely to be without an appreciable risk of adverse, noncancer health effects over a specified duration of exposure. MRLs are based on the NOAEL (No Observed Adverse Effect Level) or the LOAEL (Lowest Observed Adverse Effect Level) or the Benchmark Dose (BMD) (see Glossary in Appendix A for description of NOAEL, LOAEL, and BMD).

- Reference Dose (RfD). RfDs are estimates of daily human exposure to a substance that is likely to be without an appreciable risk of adverse, noncancer health effects over a specified duration of exposure. RFDs are based on the NOAEL, LOAEL, or BMD.

The toxicity studies used to determine the various health comparison values are usually conducted on adult animals or adult humans, mostly worker populations. In an effort to be protective of sensitive populations such as children, an uncertainty factor is included in the derivation of health comparison values.

COCs that exceed health comparison values are evaluated on an individual basis, relative to the concentrations shown to cause health effects. In situations when multiple COCs are present and none of the contaminants individually exceed their respective health comparison value, it is possible that exposure to multiple contaminants (chemical mixtures) may pose a noncancer health risk. Chemicals can interact in the body resulting in effects that might be additive, greater than additive, or less than additive. If additive, the dose of each chemical would have an equal weight in its ability to cause harmful effects. In that case, the combined dose for the two chemicals is an indication of the degree to which possible harmful effects could occur in people. When the chemicals act in a greater than additive manner, which is known as synergism, one chemical is enhancing the effect of the other chemical. In that case, the combined dose for the two chemicals underestimates the potential toxicity of the mixture of two chemicals. For chemicals that act in a less than additive manner, which is known as an antagonistic effect, the combined dose overestimates the potential toxicity of the mixture of two chemicals.

Currently, the accepted methodology for evaluating noncancer exposure to chemical mixtures is by looking at the additive effect. CDPH evaluated the additive effect of exposure to COCs by first estimating the hazard quotient (ratio of the daily dose to the contaminants corresponding health comparison value – RfD, MRL, REL, or RfC) for each contaminant. The hazard quotients are summed to obtain the hazard index. If the hazard index is above 1, then exposure may pose a noncancer health risk and the mixture is evaluated further (see Glossary in Appendix A for additional information).

Cancer health effects are evaluated in terms of a possible increased cancer risk. Cancer risk is the theoretical chance of getting cancer. In California, 41.5% of women and 45.4% of men will be diagnosed with cancer in their lifetime (about 43% combined) (10). This is referred to as the background cancer risk. We say “excess cancer risk” to represent the risk above and beyond the background cancer risk. If we say that there is a “one-in-a-million” excess cancer risk from a given exposure to a contaminant, we mean that if one million people are chronically exposed to a carcinogen at a certain level over a lifetime, then one cancer above the background risk may appear in those million persons from that particular exposure. For example, in a million people, it is expected that approximately 430,000 individuals will be diagnosed with cancer from a variety of causes. If the entire population was exposed to the carcinogen at a level associated with a one-in-a-million cancer risk, 430,001 people may get cancer, instead of the expected 430,000.

Cancer risk numbers are a quantitative or numerical way to describe a biological process (development of cancer). This approach uses a mathematical formula to predict an estimated number of additional cancers that could occur due to the exposure modeled. The model is based on the assumption that there are no absolutely safe toxicity values for chemicals that can cause cancer, meaning that the model assumes that no matter how low, even for extremely low exposures, there is always the possibility that a true carcinogen could cause a cancer. The models typically use information from higher exposure scenarios and then extend an estimate of risk into lower exposure scenarios using the assumption that lower levels would still be carcinogenic. The calculations take into account the level of exposure, frequency of exposure, length of exposure to a particular carcinogen, and an estimate of the carcinogen's potency.

EPA and OEHHA have developed cancer slope factors and unit risk values for many carcinogens. A slope factor/unit risk is an estimate of a chemical's carcinogenic potency, or potential, for causing cancer. Unit risk values or cancer slope factors are created from studies of persons (workers) or animals to see how much illness developed as a result of exposure. In order to take into account the uncertainties in the science (such as making predictions of health outcomes at lower levels when we only have information about high exposures), the risk numbers used are plausible upper limits of the actual risk, based on conservative assumptions. In other words, the theoretical cancer risk estimates are designed to express the highest risk that is plausible for the particular exposure situation, rather than aiming to estimate what is the most likely risk. Given that there is uncertainty to these predictions, it is considered preferable to overestimate, rather than underestimate risk. If adequate information about the level of exposure, frequency of exposure, and length of exposure to a particular carcinogen is available, an estimate of the theoretical increased cancer risk associated with the exposure can be calculated using the cancer slope factor or unit risk for that carcinogen. Specifically, to obtain lifetime risk estimates from inhalation exposure, the contaminant concentration is multiplied by the unit risk for that carcinogen. To obtain lifetime risk estimates for other pathways, a chronic exposure dose is estimated, that is then multiplied by the slope factor for that carcinogen.

Cancer risk estimates are a tool to help determine if further action is needed and they should not be interpreted as an accurate prediction of the exact number of cancer cases that actually occur. The actual risk is unknown and may be as low as zero (11).

CDPH evaluated six completed pathways of exposure related to the RFS site (Appendix C, Table 1). Data are presented in tables in Appendix C. In the following pages, we describe our evaluation of these pathways. A brief summary of the toxicological characteristics of the COCs identified by CDPH is presented in Appendix D. Additional information on COCs is also provided in the Evaluation of Community Concerns section. The toxicological evaluation of the completed exposure pathways involves the use of exposure assumptions. The authors used conservative estimates and assumptions to ensure potential health hazards from chemicals are identified and evaluated. It is important to note that some of the metals (arsenic, copper, zinc, etc.) found in RFS soil and sediment are naturally occurring, contributing to the overall concentration.

Evaluation of Marsh Sediments and Surface Water at the Richmond Field Station

The RFS marsh/lagoon area is accessible by the Marina Bay trail, the connector trails from the Marina Bay residential neighborhood, and from RFS via a locked fence. There are many anecdotes about kids and sometimes adults going off the trail and playing in the water and mud. From the early 1990s, it has been known that the marsh area contained contamination from the former California Cap Company and from other nearby sources. In 2003, UC consultants conducted two remediation activities in the marsh area: 31,000 cubic yards of pyrite cinder waste and mercury-contaminated sediment were removed from an area of known PCB contamination, and 28,000 cubic yards of sediment and fill were removed from the marsh area closest to the RFS site (Appendix B, Figure 3). Fill from other parts of RFS, as well as sediments and soils from other locations, were brought in to fill the excavated area. The fill was sampled according to regulatory guidelines to show that it was clean enough to be used for fill. Children and adults have engaged in restoration of the remediated area, planting wetland grasses.

Surface and subsurface sediment samples taken in the non-remediated marsh area of RFS have elevated arsenic, cadmium, copper, lead, mercury, zinc, and total PCBs (surface sampling data shown in Table 2, Appendix C) (12). Recent surface soil/sediment data in the remediated area show low levels of PCBs and elevated levels of some metals (arsenic, cadmium, copper, lead, mercury, and zinc), perhaps indicating that chemicals may be migrating from the non-excavated areas as a result of the changing water levels in the marsh area (12, 13).

The most recent (2006) filtered surface water samples show low levels of the same chemicals, while unfiltered surface water data from the early 1990s show elevated levels of arsenic, cadmium, copper, chromium, and zinc (Appendix C, Table 3) (14, 15). These contaminants exceed comparison values and will be evaluated further.

Past Exposure to Adults and Children/Teenagers Playing in the Marsh Prior to 2003 (Phase 1 and Phase 2 Excavations/Removals)

CDPH evaluated past exposure to an adult and child/teenager (8-15 years of age; old enough to play unattended) playing in the Phase 1 and Phase 2 areas of the marsh, prior to remedial activities. We evaluated past exposure to surface water in the marsh using data (unfiltered samples) collected in 1991. The amount of exposure a person might have received from playing in the marsh depends on how often that person might have come near to or in contact with the marsh. Exposure also depends on the types of play and activity, i.e., splashing, wading, etc. If an adult or child/teenager played in the marsh and splashed in the water, they may have absorbed contaminants through the skin, or accidentally/incidentally ingested some of the chemicals in the sediment and surface water. We did not estimate inhalation of soil/sediment particles for two reasons: 1) resuspension of sediment would be minimal due to the moist/wet conditions in the marsh and; 2) emission factors are not available for this type of scenario. To estimate exposure we assumed an individual engaged in activities in the marsh during the warmer months (May to October), 4 days per week (100 days per year), for an hour at a time. We assumed the adults may have been exposed for the past 26 years and children for 10 years (16).

CDPH estimated the exposure dose from ingestion and dermal contact (touching) to children/teenager and adults from surface water and sediment in the marsh, prior to remediation. CDPH used the average concentration of contaminants in sediment and surface water from the Phase 1 and Phase 2 areas to estimate past exposure (Appendix C, Tables 3 and 4). The other assumptions used in the dose estimations are shown in the footnotes to Tables 5 and 7 in Appendix C (16). It is important to note that the estimated exposure doses from surface water are very uncertain for a number of reasons: surface water data is limited; laboratory methods are not consistent between sampling events and; contaminant concentrations in surface water are not static due to the tidal influences and seasonal changes.

Prior to 2003, when remedial/removal activities occurred in the marsh, CDPH determined that an adult or child/teenager who engaged in activities in the marsh on a regular basis, would not have experienced noncancer health effects from exposure to individual COCs in sediment and surface water. Estimated exposure doses are below health comparison values for individual contaminants (Appendix C, Table 5).

The estimated hazard index for an adult from exposure to multiple contaminants/COCs (metals and PCBs) in sediment and surface water prior to 2003 is estimated at 0.08 and 0.5, respectively. (Appendix C, Table 6). Since the estimated hazard index is below 1.0, noncancer adverse health effects are not likely to have occurred or be occurring to adults from exposure to contaminants in sediment and surface water in the marsh.

The hazard index (1.6) for a child/teen from exposure to surface water exceeds 1.0, indicating the possibility for noncancer health effects, from potential additive exposure (Appendix C, Table 6). (It is important to re-emphasize that the hazard index is based on surface water data from one sampling event, which makes this evaluation very uncertainty.) Whenever the hazard index for a mixture of chemicals exceeds 1.0, exposures are evaluated further.

Per ATSDR’s guidance, the first step in the evaluation is a comparison of the estimated dose of each chemical to its NOAEL (when available). In situations when a NOAEL is not available, a tenfold uncertainty factor was applied to the LOAEL as a proxy for a NOAEL. If the estimated dose of one or more of the individual chemicals/contaminant are less than 10% (0.1 x NOAEL) of its respective NOAEL, then additive or interactive (synergistic or antagonistic) effects are unlikely, and no further evaluation is needed (3). None of the estimated doses for COCs exceed 10% of their respective NOAEL (Appendix C, Table 6).

Lead is evaluated based on an internal dose, a blood lead level (BLL) that takes into account total exposure (includes exposure to background sources of lead). Young children (under 2 years old) are the most sensitive to lead exposure. The Centers for Disease Control and Prevention recommended action level for lead exposure in children is 10 micrograms per deciliter (µg/dL). Although children are at greatest risk from lead exposure, adult exposures can also result in harmful health effects. Most adult exposures are occupational and occur in lead-related industries such as lead smelting, refining, and manufacturing industries. The U.S. Department of Health and Human Services recommends that BLLs among all adults be below 25 µg/dL (17). The Childhood Lead Poisoning Prevention Branch of CDPH recommends exposure reduction/mitigation actions for pregnant women with BBLs of 10 µg/dL or greater (18).

State and federal models exist which can be used to estimate an increased BLL from a combination of exposures to lead in air, water, soil, and food. CDPH used the DTSC Lead Risk Assessment Spreadsheet (LeadSpread 7) to estimate BLL for adult (men and women of non-child bearing age). LeadSpread estimates BLL for children under the age of 2[1]. The exposure scenario being evaluated for this exposure pathway is for children 8-15 years old. The EPA Adult Lead Model was used to estimate BLL for women of childbearing age, as it is protective of fetal health (19).

The estimated BLL for adults (men and women of non-child bearing age) from exposure to the average level of lead of 156.1 parts per million (ppm) in the marsh (prior to remediation) is 3.1 µg/dL (95^{th} percentile); exposure to the highest level of lead of 560 ppm would result in an estimated BLL for adults of 5.3 µg/dL. These values include exposure to background sources of lead, such as ambient air, water, and produce. The BLL for women of childbearing age was estimated at 5.3 µg/dL (average level of lead) and 7.0 µg/dL (highest level of lead). These levels are below 10 µg/dL for pregnant women and 25 µg/dL for all other adults, the levels at which exposure reduction actions are recommended (17, 18).

CDPH estimated the theoretical increased cancer risk from past exposure to contaminants considered carcinogenic. Potentially carcinogenic contaminants exceeding health comparison values in surface water and/or sediment are arsenic and PCBs (Appendix C, Tables 2 and 3). The estimated cancer risk for adults and children/teenager is 2 in 100,000 and 8 in 100,000, respectively. These are considered “very low” increased risks. Equations and cancer slope factors used to estimate increased cancer risks are provided in Appendix E.

Current and Future Exposure to Adults and Children/Teenagers Playing in the Marsh

CDPH evaluated current and future exposure to an adult and child/teenager to sediment and surface water in the marsh. The highest (maximum) concentration of contaminants remaining in the marsh was used to evaluate exposure (Appendix C, Tables 2 and 3). CDPH used the maximum concentration in order to identify whether there is a potential health risk under the worst-case scenario, requiring a need for further action. Actual exposures would be much less because an individual would not likely engage in activity in a single area of the marsh for the amount of time assumed (26 years for adults and 10 years for child/teenager) in the exposure dose estimates.

The estimated doses from dermal and ingestion exposure for an adult, are below levels that could result in noncancer adverse health. None of the contaminants in surface water and sediment exceed health comparison values and the hazard index does not exceed 1.0 (Appendix C, Tables 5 and 6).

[1]As a point of reference, exposure to the highest level of lead (560 ppm) in the non-remediated area of the marsh would result in an estimated BLL for a 1-2 year old child of 10.2 µg/dL; the adult BLL is 5.3 µg/dL. It is reasonable to assume that the BLL for a child between 8-15 years old would fall between these two numbers, and below 10 µg/dL.

The estimated dose (0.00005 mg PCBs/kg/day) for a child/teen from dermal and ingestion exposure to PCBs in sediment exceeds health comparison values, suggesting the noncancer health effects (Appendix C, Table 6). However, the estimated doses are below the LOAEL (Lowest Observed Adverse Effect Level) of 0.005 mg PCBs/kg/day shown to cause immune effects (decreased antibody response) in monkeys (20, 21). Since dose estimates are below LOAEL and estimated doses are based on exposure to the maximum concentration of PCBs found in sediment (actual exposures are probably much less), it is unlikely that a child/teen would have experienced health effects from exposure PCBs in sediment. None of the other contaminants (metals) individually exceed their respective health comparison value.

The estimated hazard index (3.2) for a child/teen from exposure to COCs in sediment exceeds 1.0, indicating the possibility for noncancer health effects. PCBs are the primary contributor to the hazard index. Whenever the hazard index for a mixture of chemicals exceeds 1.0, exposures are evaluated further.

CDPH compared the estimated doses for each chemicals/contaminants to their respective NOAEL or adjusted LOAEL. The estimated dose for PCBs in sediment is within 10% of its adjusted LOAEL, suggesting the possibility of interactive or additive effects (Appendix C, Table 6) (3).

The next step is to determine the most sensitive health endpoint/organ system for each chemical (22). For instance, when two chemicals both cause adverse effects to the liver, a liver target toxicity dose is derived for each chemical, added together and compared to the NOAEL or the LOAEL. As the estimated exposure doses approach the LOAEL for an organ system or endpoint the likelihood of specific adverse effects increases.

Current toxicity information indicates that different parts of the body (organs) are affected by the lowest dose of each of the chemicals. The most sensitive (primary) noncaner endpoints associated with COCs include skin effects (arsenic), renal effects (cadmium), nerodevelopmental (methylmercury), gastrointestinal symptoms (copper), decreases in erythrocyte copper, zinc-superoxide dismutase (ESOD) activity (zinc), and immune effects (PCBs). Since the primary noncancer endpoints for COCs differ, target toxicity doses were not calculated. These COCs would not have an additive effect on the target organ, as these chemicals affect different organ systems at the lowest dose. There could be some additive effects from these chemicals through a mechanism not involving the target organ; however, that is not known at this time. Since a worst-case scenario was assumed, exposures are likely much less, reducing the chance for noncancer adverse health effects. However, this evaluation demonstrates the potential for exposures of health concern for children/teenagers. Thus, access to the Western Stege Marsh should remain restricted until investigations and clean-up activities in the marsh and upland areas at the RFS are completed.

The estimated BLL for adults (men and women of non-child bearing age) from exposure to the highest level of lead (410 ppm) in the marsh (after remediation), as well as other sources of lead in their life, is 4.5 µg/dL (95^{th} percentile). The BLL for women of childbearing age was estimated at 6.4 µg/dL (95^{th} percentile). These levels are below 10 µg/dL for pregnant women and 25 µg/dL for all other adults, the levels at which exposure reduction actions are recommended (17, 18).

CDPH estimated the theoretical increased cancer risk from current/future exposure to contaminants considered carcinogenic. Carcinogenic contaminants exceeding comparison values in surface water and sediment are arsenic and PCBs. The estimated cancer risk for adults and child/teenager is 5 in 100,000 and 8 in 100,000, respectively. Cancer risks in this range are considered “very low increased risk.” Equations and cancer slope factors used to estimate increased cancer risks are provided in Appendix E.

Adults or Children/Teenagers Restoring the Excavated Areas of the Richmond Field Station Marsh

CDPH evaluated exposure to an adult and child/teenager (old enough to be part of a restoration project) planting or otherwise working on a restoration project in the excavated area (remediated) of the RFS marsh. Exposure could occur via absorption through the skin or accidentally/incidentally ingested some of the chemicals in the soil/sediment and surface water. We did not estimate inhalation of soil/sediment particles for two reasons: 1) resuspension of sediment would be minimal due to the moist/wet conditions in the marsh and; 2) emission factors are not available for this type of scenario. To estimate exposure, we assumed the person engaged in some type of activity in the marsh for 2.6 hours per day, 100 days per year, for 8 years. CDPH used the average concentration of the contaminant in sediment and surface water to estimate potential exposure.

None of the contaminants exceed individual health comparison values and the hazard index is below “1” (Appendix C, Tables 2 and 7). Thus, noncancer adverse health effects are not expected to occur or be occurring in adults or children/teenagers from potential exposure to metals and PCBs while engaging in restoration activities in the remediated portion of the marsh.

The estimated BLL for an adult from exposure to the average level of lead (76.5 ppm) remaining in the remediated portion of the marsh, as well as other sources of lead in their life, is 2.7 µg/dL. The BLL for women of childbearing age was estimated at 6.4 µg/dL (95^{th} percentile). These levels are below 10 µg/dL for pregnant women and 25 µg/dL for all other adults, the levels at which exposure reduction actions are recommended (17, 18).

CDPH estimated the theoretical increased cancer risk from current/future exposure to contaminants considered carcinogenic. Carcinogenic contaminants exceeding comparison values in surface water and sediment are arsenic and PCBs (Appendix C, Tables 2 and 3). The estimated cancer risk for adults and child/teenager is 4 in 1,000,000 and 5 in 1,000,000, respectively. Cancer risks in this range are considered “no apparent increased risk.” Equations and cancer slope factors used to estimate increased cancer risks are provided in Appendix E.

It is important to note that the highest level of arsenic (590 ppm) in sediment remaining in the marsh was measured in the remediated portion of the marsh, indicating the possibility for contaminants to be migrating into the marsh. We do not expect a person would engage in restoration activities in a single area of the marsh, for the amount of time required to result in adverse health effects. However, the data does point out the need for additional investigation and monitoring of the marsh.

Conclusion of Western Stege Marsh Evaluation

On the basis of available data, CDPH concludes that past exposure from ingestion and dermal contact with surface water and sediment does not pose a health hazard for noncancer adverse health effects for adults and children/teenager who regularly played in the Western Stege Marsh. These exposures pose a very low theoretical increased cancer risk for adults and children/teenagers.

CDPH identified exposures of potential health concern currently, using a worst-case scenario assuming a person is exposed to the highest concentration of contaminants remaining in the marsh. It is important to note that this conclusion is based on conservative assumptions meant to identify the possibility for exposures of health concern, so that steps can be taken to mitigate or prevent these exposures from occurring. Actual exposures to children/teenagers would be much less.

On the basis of available data, CDPH concludes ingestion and dermal exposure to metals and PCBs in surface water and sediment does not pose a noncancer or cancer health hazard for adults or children/teenagers who participate in restoration activities in the Western Stege Marsh. However, limited data suggests the possibility of recontamination of the marsh from other areas/media. Thus, as a precautionary measure children/teenagers should not to participate in restoration activities until additional investigation and remediation is completed. If adults chose to participate in restoration activities, they should be made aware of the data gaps and be provided appropriate protective equipment.

As indicated above, it is possible that contamination may be migrating through surface and/or groundwater from non-remediated areas of the marsh, the uplands, and/or the adjacent Zeneca site, into the remediated portion of the marsh. Thus, UC should periodically (bi-annually) sample the sediment and unfiltered surface water in the Western Stege Marsh to identify whether contaminants are migrating into the marsh. Groundwater should also be monitored to identify whether contaminants are migrating into the marsh from the Zeneca site. Lastly, there is also a possibility for radionuclides associated with superphosphate fertilizer production on the adjacent Zeneca site, to have migrated into the Western Stege Marsh; the areas of primary concern are the portions of the marsh that have not been remediated/excavated. At the time of this writing, investigations and characterization of radionuclides in soil, sediment, and groundwater on the Zeneca site are incomplete. Once characterization of radionuclides on the Zeneca site is completed, a determination can be made whether characterization of radionuclides in the Western Stege Marsh is needed. Access to the Western Stege Marsh should continue to be restricted.

Evaluation of Soil at the Richmond Field Station

Workers have expressed concerns about exposure to contaminants at RFS. Some workers at RFS maintain the facilities by performing landscaping, plumbing repairs, digging trenches, etc. For certain projects, outside contractors (PG&E, telephone company, etc.) work on RFS and dig in the soil. For the other projects, full-time employees of the university who work in the maintenance unit conduct these activities, that is, they dig in surface and subsurface soils.

CDPH reviewed the available soil data and evaluated possible exposure for the RFS worker who might dig in the soil in an area where contamination still exists. This type of activity presents the greatest risk for exposure to on-site soil.

Soil investigations in the past focused on those parts of the site associated with known past manufacturing processes or storage areas or suspected areas of contamination: the California Cap Company explosives storage area, California Cap Company test pit area, forest products area, California Cap Company shell manufacturing area, Zeneca-related pyrite cinders area, mercury-bearing area, Heron Drive area, and the western storm drain.

In 2004, contractors for UC removed soils from five of these areas (Appendix B, Figure 4) (23). Most of the soil samples were analyzed for metals and PCBs (measured as Aroclor mixtures). The main COCs in surface to near surface soils on RFS are arsenic, cadmium, copper, lead, mercury, Aroclor 1248, Aroclor 1254, Aroclor 1258, and Aroclor 1260 (Appendix B Figures 5a and 5b; Appendix C, Table 8) (23).

In October 2007 (after the public comment release of this PHA), the UC conducted a Time-Critical Removal Action of contaminated soil near the former Forest Products Laboratory. The soil removed contained highest levels of arsenic in RFS soil (24). It is important to note that soil at RFS has not been fully characterized, indicating the possibility for maintenance workers to be exposed to contaminants at levels not yet identified. Many of these metals (arsenic, copper, zinc, etc.) are naturally occurring in the environment, which contributes to the overall concentration and exposure.

CDPH estimated exposure for two lengths of employment: long-term (23 years) employment, and the past 7 years of employment (Appendix C, Table 9). Because of the lack of characterization at the RFS, we used the most public health protective approach by assuming short-term (7 years) and long-term (23 years) workers were/are exposed to the highest concentrations of metals measured in soil, which are present in non-remediated areas. With respect to PCBs, we assumed short-term workers would not have worked in any of the excavated areas or “PCB hot spot” areas since they were already identified (Appendix C, Table 8). According to the UC, the other areas of known contamination are now fenced, reducing the chance for a worker to unknowingly dig in contaminated soil without adequate protection (25).

Evaluation of Past Exposure (Long-Term) to Maintenance Workers Prior to Soil Excavation/Removal

CDPH assumed that the RFS worker dug a trench or holes in the soil in an area that was contaminated with the highest concentrations of chemicals detected in the Field Station surface and near surface soil. CDPH assumed that they dug without protection for 2 hours a day, 100 days per year, for 23 years, and during the digging they were exposed through the skin and through incidental ingestion of the soil and inhalation (breathing) of contaminated soil particulates. CDPH used soil data to estimate the concentration a worker may breathe from resuspension of soil into the air during excavation/soil disturbing activities (Appendix C, Table 9).

CDPH estimated an exposure dose for the field station worker routinely digging in soil containing the highest/maximum concentrations of contaminants found in soil, prior to remedial actions (soil excavation) (Appendix C, Tables 8 and 10). Dose estimates for ingestion, inhalation and dermal exposure to arsenic and PCBs exceed health comparison values, suggesting the possibility for workers to have experienced noncancer health effects (Appendix C, Table 10). However, the estimated doses are below the LOAEL of 0.014 mg arsenic/kg/day shown to cause skin effects in people and the LOAEL of 0.005 mg PCBs /kg day shown to cause immune effects (decreased antibody response) in monkeys (20, 21). Since dose estimates are below LOAEL and estimated doses are based on exposure to the maximum concentration of arsenic and PCBs found in soil, it is possible, but not probable that workers would have experienced health effects from ingestion, inhalation and dermal exposure to arsenic and PCBs in soil. None of the other contaminants (metals) individually exceed their respective health comparison value.

The hazard index for the field station worker from exposure to the remaining COCs (metals) is estimated at 1.5 indicating the possibility for noncancer health effects and the need for further evaluation (Appendix C, Table 10).

Per ATSDR's guidance, CDPH compared the estimated doses for a maintenance worker to 10% of the NOAEL (0.1 x NOAEL) for each chemical (Appendix C, Table 10) (3). The estimated doses for arsenic, copper and PCBs are within 10% of the NOAEL, suggesting the possibility of interactive or additive effects.

The most sensitive (primary) noncancer endpoints associated with COCs include skin effects (arsenic), renal (kidney) effects (cadmium, inorganic mercury) and gastrointestinal symptoms (copper) (21, 26-29). Since renal effects are the most sensitive endpoint associated with cadmium and inorganic mercury exposure, the interaction of these metals is evaluated further. Studies have shown that interactions with metals can influence the absorption, distribution, and excretion of one of more of the metals involved. For example, supplementation with zinc has been shown to provide some protection from the nephrotoxic (damaging and/or toxic to the kidney) effects of inorganic mercury (28). Zinc supplementation has also been shown to reduce oral absorption of cadmium (29). It is unclear whether the interaction between cadmium and inorganic mercury has on an additive effect (acting together, that is, a sum of the individual doses), a synergistic effect (combined toxic effects are greater than each chemical alone), or an antagonistic effect (one chemicals counteracting the effect of the other chemical, creating a less toxic effect) on the kidney. In situations where the interactions between chemicals are not understood, it is assumed that the effects are additive.

CDPH estimated a kidney target toxicity dose from exposure to cadmium and inorganic mercury (Appendix C, Table 10). The kidney target toxicity dose (0.00023 mg/kg/day) from exposure to cadmium and inorganic mercury is below the NOAEL for both cadmium (0.0021 mg cadmium/kg/day) and inorganic mercury (0.23 mg mercury/kg/day) (28, 29). Thus, it is unlikely that long-term workers experienced renal effects from combined exposure to cadmium and inorganic mercury in soil at the RFS, though the possibility cannot be ruled out.

The primary noncancer endpoints for the remaining COCs (including PCBs) differ, thus target toxicity doses were not calculated. These three COCs (arsenic, copper, and PCBs) would not have an additive effect on the target organ, as these chemicals affect different organ systems at the lowest dose. There could be some additive or interactive effects from these chemicals through a mechanism not involving the target organ; however, that is not known at this time.

CDPH used the USEPA Adult Lead model to estimate BLL for maintenance workers. The adult lead model is recommended for evaluating working women of childbearing age, as it is protective of fetal health (19). The estimated BLL level for workers from exposure to the highest level of lead in soil (1,140 ppm) prior to remediation, as well as other sources of lead exposure typical for an adult, is 9.6 µg/dL. This level is below 10 µg/dL for pregnant women and 25 µg/dL for all other adults, the levels at which exposure reduction actions are recommended (17, 18).

In conclusion, estimated exposure to RFS maintenance workers from ingestion, dermal contact, and inhalation of the highest level of contaminants in soil could have resulted in noncancer health effects. This conclusion is based on conservative assumptions (actual ingestion, dermal contact, and inhalation exposures are likely much less) meant to identify and mitigate exposure. The primary endpoints associated with exposures are immune effects (PCBs), skin effects (arsenic), and to a lesser extent, renal effects (cadmium, inorganic mercury) and gastrointestinal symptoms (copper).

Evaluation of Current Exposure (Short-Term) to Maintenance Workers

CDPH estimated current exposure to the field station worker who routinely digs in soil that contains the highest/maximum amount of contaminants measured in the non-excavated areas (Appendix C, Tables 8 and 10). Note: CDPH did not include soil data from the former Forest Products Laboratory areas that were removed in October 2007, in estimating current exposure (24).

Arsenic is the only COC that exceeds health comparison values. The estimated dose (0.0026 mg arsenic/kg/day) is approximately five times lower than the LOAEL (0.014 mg arsenic/kg/day) shown to cause skin effects. Since doses estimates are below LOAEL and estimated doses are based exposure to the maximum concentration of arsenic (700 ppm) found in soil (actual exposures are probably much less), it is unlikely that workers would have experienced health effects from exposure to arsenic in soil. None of the other COCs individually exceed their respective health comparison value.

The hazard index for the field station worker from exposure to the remaining COCs (metals and PCBs) is estimated at 1.8, indicating the possibility for noncancer health effects (Appendix C, Table 10). It is important to note that exposure estimates were based on the highest concentrations of contaminants measured in soil that are not found in the same locations. Thus, in order for a worker's exposure to exceed the hazard index, she/he would have to routinely (2 hours a day, 100 days per year for 7 years) dig in soil from those areas at RFS where the maximum levels of each contaminant were measured. It is also possible that contaminant levels in other non-excavated areas, where sampling has not yet been conducted, could be higher.

CDPH compared the estimated doses for a maintenance worker to 10% of the NOAEL (0.1 x NOAEL) for each chemical (Appendix C, Table 10). The estimated doses for arsenic and copper are within 10% of the NOAEL, suggesting the possibility of interactive or additive effects.

CDPH estimated a kidney target toxicity dose from exposure to cadmium and inorganic mercury (see discussion in the section above) (Appendix C, Table 10). The kidney target toxicity dose (0.00023 mg/kg/day) from exposure to cadmium and inorganic mercury is below both the NOAEL for cadmium (0.0021 mg cadmium/kg/day) and the NOAEL for inorganic mercury (0.23 mg mercury/kg/day) (28, 29). Thus, it is unlikely that short-term workers experienced renal effects from combined exposure to cadmium and inorganic mercury in soil at the RFS, though the possibility cannot be ruled out.

Target toxicity doses were not calculated for the remaining COCs, because the primary endpoints of concern are not the same (discussed in the section above). The primary noncancer endpoints associated with COCs include skin effects (arsenic), immune effects (PCBs), and gastrointestinal symptoms (copper). These COCs would not have an additive effect on the target organ, as these chemicals affect different organ systems at the lowest dose. There could be some additive or interactive effects from these chemicals through a mechanism not involving the target organ; however, that is not known at this time.

The estimated BLL level for workers from exposure to the highest level of lead (1,140 ppm) remaining in soil is 9.6 µg/dL. This level is below 10 µg/dL for pregnant women and 25 µg/dL for all other adults, the levels at which exposure reduction actions are recommended (17, 18).

Cumulative Theoretical Increased Cancer Risk from Past, Current, and Future Exposure

CDPH estimated the theoretical increased risk of cancer for a long-term worker digging in the excavated areas (prior to removals/excavations in 2004) to be 7 in 10,000. Digging in soil from non-excavated areas would add (5 in 100,000) to the cancer risk for a short-term worker; the cumulative theoretical increased cancer risk for an RFS worker from 30 years[2] of exposure is estimated to be 7 in 10,000, which is considered a low increased risk. Increased cancer risks in this range (greater than 1 in 10,000) are considered unacceptable risks, based on regulatory guidance (11). The increased cancer risks are based on exposure to maximum concentrations; the actual risk would likely be less. The chemicals associated with an increased cancer risk are arsenic (skin, liver, bladder, and lung) and PCBs (liver, biliary). Equations and cancer slope factors used to estimate increased cancer risks are provided in Appendix E.

[2]Theoretical increased cancer risks assume 30 years of exposure and are calculated based on 23 years exposure to the highest concentrations of contaminants prior to remedial actions, plus 7 years of exposure to the highest concentrations of contaminants remaining in soil. Equation used to estimate theoretical increased cancer risk is provided in the footnotes to Table 10.

Conclusion of Soil Evaluation

CDPH concludes that exposure to RFS maintenance workers from ingestion, dermal contact, and inhalation of soil poses a health hazard for both noncancer and cancer health effects (unacceptable theoretical increased cancer risk). Adequate training and the use of proper protective equipment can reduce potential risk of exposure to RFS workers. Additional characterization of on-site soil and groundwater throughout the RFS is needed to identify other areas where potential contamination may exist. Chemicals used in research activities at RFS, as well as known contaminants from past uses of RFS and the adjacent Zeneca (former Stauffer Chemical) site, should be analyzed. Characterization of soil and groundwater in the area where the Forest Products Laboratory is located should include additional analyses for pentachlorophenol and chlorophenol byproducts (30).

Evaluation of Ambient Air During Remedial Work

During discussions with RFS employees, CDPH was informed that a great deal of dust was generated during past remedial work at RFS and the adjacent Zeneca/Campus Bay, which is believed to have resulted in a number of health effects. Dust is made up of various sizes of particulate matter. Particulate matter less than 10 microns in aerodynamic diameter, known as PM 10[3], is considered among the most harmful of all air pollutants, because when these particles are inhaled, they can become lodged deep in the lungs, potentially resulting in a number of respiratory and cardiovascular effects (31, 32). CDPH reviewed available air monitoring data in an effort to understand exposures that may have occurred as a result of these activities.

Air monitoring of total dust (PM 10 was not measured) and mercury vapor was conducted during Phase 1 and Phase 2 remedial activities at the RFS (1, 33). Phase 1 and Phase 2 activities consisted of removal and treatment of mercury-contaminated soils from the marsh and upland areas of RFS (Appendix B, Figure 2).

Dust

Between September 16, 2002, and December 6, 2002, total dust concentrations were measured from six locations along the site perimeter to monitor airborne dust leaving the remedial area of the mercury contamination. Dust monitors were placed on the site perimeter for the duration of each workday. The average dust concentrations did not exceed the site-specific dust action level[4] of 2 milligrams per cubic meter (mg/m^3) or 2,000 $\mu g/m^3$ (33). However, on several days, the maximum concentration of dust measured from at least one location exceeded the dust action level of 2 mg/m^3 (2,000 $\mu g/m^3$) (Note: there were a number of days when maximum dust concentrations were not recorded). Dust was measured as high as 39.75 mg/m^3 (39,750 $\mu g/m^3$) (34).

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[3]As a point of reference, the 24-hour average California Ambient Air Quality Standard for PM 10 is 50$\mu g/m^3$.

[4]A site-specific action level and PEL (permissible exposure level) of 2.16 mg/m^3, approved by the California Regional Water Quality Control Board, San Francisco Region, is based on PEL for dust (5 mg/m^3), which was modified to be protective of the highest mercury level in soil. The level at which dust becomes visible (dust visibility threshold) is approximately 2 mg/m^3.

Between August 11, 2003, and November 26, 2003, total dust was measured at seven locations along the site perimeter, during Phase 2 remedial work. Average dust concentrations ranged from 0.000-0.125 mg/m^3 (1,250 $\mu g/m^3$) (1). Average dust concentrations did not exceed the site-specific dust action level of 2 mg/m^3 (2,000 $\mu g/m^3$). On numerous days (more than 35 days), the maximum dust concentration measured from at least one location exceeded the site-specific dust action level of 2 mg/m^3 (2,000 $\mu g/m^3$). Dust levels were measured as high as 9.344 mg/m^3 (9,344 $\mu g/m^3$).

Part of the remedial work included mixing powdered activated carbon with excavated materials to neutralize pH and stabilize metals and mercury. During powdered activated carbon reagent addition, there were some detections of carbon dust outside the work area. Carbon dust levels did not exceed 2 mg/m^3. However, some of this dust did deposit on structures in the area (33).

In conclusion, it is possible for RFS workers to have experienced irritation of the eyes, nose, throat, and respiratory tract from breathing dust (particulate matter) generated during Phase 1 and Phase 2 remedial work. It is not known what chemicals were attached to the dust particles (except carbon), and thus not possible to evaluate health effects from potential exposure to other chemicals.

Mercury Vapor

Between November 21, 2002, and December 6, 2002, URS Corporation (URS) conducted air monitoring for mercury vapor during the Phase 1 remedial work at RFS. Mercury levels in the air at the work site were monitored using a Jerome Mercury Vapor Analyzer with a detection limit of 0.003 mg/m^3 (3 $\mu g/m^3$). According to a URS summary statement (data not provided), mercury was not detected above the detection limit (33). While this instrument may be appropriate for monitoring worker exposures to mercury vapor, non-worker (residential) exposure standards are set at lower levels. For example, the acute REL for inorganic mercury is 0.0018 mg/m^3 (1.8 $\mu g/m^3$).

During the early part of the Phase 2 remedial work, between September 12, 2003, and September 23, 2003, UC health and safety personnel monitored for mercury levels in the air at the work site using a Jerome Mercury Vapor Analyzer with a detection limit of 0.003 mg/m^3 (3 $\mu g/m^3$) (Appendix C, Table 11). Of the 125 samples collected during this sampling effort, 15 samples (collected at various times during each day) had detectable concentrations of mercury, ranging from 0.003-0.006 mg/m^3 (3-6 $\mu g/m^3$).

It is difficult to determine the level of mercury outside of the Phase 2 work area, either off-site or in other areas of RFS, since dilution with the ambient air would occur. In an effort to gain a better understanding of airborne mercury levels outside of the work area, CDPH obtained data collected by EPA Region 9 Laboratory located on the south west side of RFS (Appendix B, Figure 4).

EPA conducted air monitoring at the laboratory from August 26, 2003, until September 28, 2003 (35). The location of the excavation areas in relation to the laboratory ranged from approximately 150 feet to several hundred feet. Mercury was detected in air on several days at concentrations ranging from 0.01 µg/m3 to 0.9 µg/m^3 (35). Mercury levels did not exceed the acute REL of 1.8 µg/m^3. On two days (September 10 and September 12), mercury levels exceeded the chronic MRL of 0.2 µg/m^3 for time periods of less than an hour (Appendix B, Figure 6). The acute REL is the most appropriate comparison value for looking at short-term exposure; we included the chronic MRL as additional information to help put the exposure into context (e.g., chronic MRL: a constant exposure level occurring for greater than 365 days, without appreciable health risk). While these do not provide information about levels of airborne mercury in other areas of the RFS, particularly areas predominantly downwind of the excavation, they do show a decrease in levels outside the work area, at the EPA laboratory. The highest value (0.9 µg/m^3) was measured on September 10, 2003, and cannot be compared with data collected at the work area because there were no samples reported for that day (Appendix B, Figure 6; Appendix C, Table 11).

It appears that exposure to low level airborne mercury may have occurred in the vicinity of the Phase 2 work area. However, based on the available data, short-term exposures at the levels measured in air during the remedial work would not be expected to result in noncancer adverse health effects.

Future remedial activities at the site should include adequate dust suppression methods and perimeter air monitoring, with detection limits comparable to residential standards.

Evaluation of Exposure to RFS Workers from Walking Outside at the RFS

RFS workers have expressed concerns about exposure to site-related contaminants in outdoor air, during times when no remedial work is occurring. Much of the RFS is covered by either, asphalt, sidewalks or vegetation, which provides a barrier limiting resuspension of soil/dust.

CDPH estimated the potential air concentrations from resuspension of COCs in soil, using an emission factor that was developed assuming fugitive dust from contaminated soils are continuous, lasting an extended period of time (years) (Appendix C, Table 12).

None of the estimated air concentrations exceed screening values for noncancer or cancer health effects (Appendix C, Table 12). Thus, RFS workers or visitors to the RFS are not being exposed to contaminants at levels of health concern from walking outside at the RFS.

Evaluation of Indoor Air

During times when no remedial work is occurring, workers at RFS have expressed concerns that site-related contaminants are present in indoor air, either from soil being tracked indoors or through soil gas migration, resulting in health effects. In response to these concerns, UC health and safety personnel conducted indoor and outdoor air sampling at RFS, between August 16, 2005, and October 20, 2005.

Indoor Air Quality in General

Evaluating indoor air quality is complicated because indoor air typically contains many chemicals and is generally considered unhealthy (35). Several studies over the years have compared the overall quality of indoor versus outdoor air (35-37). The findings have consistently shown that the overall air quality indoors is invariably worse than the outdoor air quality. There are numerous reasons for the marked difference between indoor and outdoor air quality. Many buildings have very poor air circulation and air turnover rates. This means that any chemical released into the air of a building will remain there. If chemicals are consistently released into buildings, the total concentration of that chemical will increase. Many of the construction materials used in home and office construction contain various substances (volatile chemicals) that continue to release chemicals into the air. Plywood, insulation, foam, and resins are examples of construction materials that have been shown to release, or off-gas, chemicals into the indoor air. (See Table 13 in Appendix C for a limited list of chemicals known be associated with household products) This is further complicated at RFS due to potential use of chemicals for research activities that may be impacting indoor air.

Metals in Indoor Air at the Richmond Field Station

It is possible for site-related contaminants present in soil to become airborne and enter buildings at RFS. On August 16, 2005, indoor air particulate samples were collected in Buildings 163 and 175, in an effort to address concerns expressed by workers in these buildings (34) (Appendix B, Figure 7; Appendix C, Table 14). A sample was also collected from the rooftop of Building 175. Samples were analyzed for metals (arsenic, cadmium, nickel, lead, mercury, selenium, and zinc). Arsenic was detected in Buildings 163 and 175 at 0.098 $\mu g/m^3$ and 0.085 $\mu g/m^3$, respectively (34). Arsenic is not a commonly found contaminant in indoor air. These levels do not exceed noncancer comparison values for acute exposure (0.19 $\mu g/m^3$). However, these levels exceed the cancer comparison value (0.0002 $\mu g/m^3$) for arsenic. On September 20, 2005, Buildings 163 and 175 were resampled, and arsenic was not detected above the detection limit (0.05 $\mu g/m^3$) (Appendix C, Table 13). No other metals were detected in indoor air during these sampling events.

On December 6, 2005, indoor air samples were collected in Building 478 and analyzed for arsenic. Arsenic was not detected at a laboratory detection limit of 0.05 $\mu g/m^3$ (38).

These data are too limited to quantify exposures and draw conclusions about potential health impacts from breathing arsenic in indoor air. These data show the potential for arsenic to enter Buildings 163 and 175 at levels of concern for prolonged/chronic exposure (greater than 365 days). UC should take steps to identify and mitigate the source of arsenic in indoor air. Additional indoor air sampling should be conducted on an intermittent basis to ensure workers are not being exposed to arsenic at levels of health concern.

Mercury Vapor in Indoor Air at the Richmond Field Station

Unlike other metals, mercury can be a vapor at room temperature. Due to worker concerns about mercury contamination affecting indoor air at RFS, mercury vapor samples were collected in Buildings 102, 163, and 175, during the August 2005 sampling event (Appendix B, Figure 7). Mercury was not detected at the laboratory detection limit of 0.52-0.84 $\mu g/m^3$ (0.00052-0.00084 mg/m^3) (34).

Volatile Organic Chemicals in Indoor Air at the Richmond Field Station

It is possible for the indoor air in buildings at the RFS to be affected by groundwater contaminated with volatile organic chemicals (VOCs) as a result of past activities at the RFS and through potential migration of VOC-contaminated groundwater from the adjacent Zeneca site. In cases when the groundwater is close to the surface (within 30 feet), VOCs in the groundwater can be pulled into buildings. This is known as soil gas migration/vapor intrusion. Groundwater in the RFS area is shallow, ranging from 6-15 feet below ground surface (bgs) (depending on location and the time of year), creating the potential for soil gas to migrate from VOC-contaminated groundwater into buildings. Once inside the building, these gases or vapors can be inhaled. While soil gas can be an important source of in-building air contaminants, it is only one of several contributors to the total air contaminants found inside a building (discussed above).

An important factor for evaluating soil gas migration is having an understanding of the extent of VOC contamination in groundwater. There has not been adequate characterization of the groundwater at the RFS, which limits the ability for CDPH to evaluate the soil gas pathway. The following describes indoor air sampling that has been conducted at RFS.

On September 21, 2005, indoor air samples collected from Buildings 163 and 175 were analyzed for VOCs (Appendix B, Figure 7; Appendix C, Table 14). With the exception of formaldehyde, none of the VOCs exceed noncancer comparison values. Formaldehyde was measured in Building 163 at 410 $\mu g/m^3$, exceeding noncancer comparison values for acute exposure (exposure to a chemical for 14 days or less in duration). In studies of short-term exposure (less than 8 hours) to formaldehyde, irritant effects of the nasal passage and throat were seen at levels ranging from about 490 $\mu g/m^3$ to 3,700 $\mu g/m^3$ (39). Thus, it is possible for RFS workers to have experienced irritant effects of the nose and throat from exposure to formaldehyde in Building 163, between September 21, 2005, and October 20, 2005, when sampling indicated formaldehyde in Building 163 at levels below health concern (Appendix C, Table 14). In Building 175, formaldehyde levels exceeded comparison values for chronic exposure. It is not possible to determine whether workers in Building 175 are being chronically exposed to formaldehyde, based on one sampling event.

It is worth noting that formaldehyde was measured in outdoor air (roof of Building 175) at a level that exceeds chronic REL of 3$\mu g/m^3$ (Appendix C, Table 14). This is not unusual since formaldehyde is a common contaminant in outdoor air, due to many sources. According to the California Air Resources Board, formaldehyde is present in outdoor air an average level of 3.7 $\mu g/m^3$, up to 14.7 $\mu g/m^3$, depending on the location (40). Formaldehyde is present at higher levels in outdoor air in urban areas compared to rural areas. For example, the Chevron refinery, located approximately 3.6 miles southwest of RFS, reports releasing 5,000-86,000 pounds of formaldehyde to the air each year (41).

Five contaminants (benzene, formaldehyde, methylene chloride, tetrachloroethylene, and trichloroethylene) detected exceed cancer comparison values that are developed assuming daily exposure for a lifetime (Appendix C, Table 13). Exceeding these values indicates the possibility of an increased risk of cancer greater than one-in-a-million. CDPH did not estimate the increased cancer risks because one sampling event does not provide enough information to draw conclusions about exposure that is assumed to be over a lifetime (70 years).

On December 6, 2005, indoor air samples were collected inside Building 478, and analyzed for a limited number of VOCs: tetrachloroethylene (PCE), trichloroethylene (TCE), and vinyl chloride (38) (Appendix B, Figure 7). None of the VOCs were detected above laboratory detection limits. However, the detection limits were not sensitive enough to draw conclusions about exposure or a correlation with levels typically found in indoor air.

Characterization of the groundwater at the RFS is needed to evaluate the potential for VOCs to be affecting indoor air in buildings, as a result of soil gas migration. Soil gas sampling should also be conducted in areas where VOC contamination is suspected. For example, past activities at the Forest Products Laboratory may have resulted in VOC-contamination of soil and groundwater in this area (30). It is also possible for VOC-contaminated groundwater to be migrating onto the RFS from the adjacent Zeneca property. Additional indoor air sampling should be conducted in Building 163 and 175 to determine if formaldehyde is elevated above levels typical of indoor air.

Quality Assurance and Quality Control

In preparing this PHA, ATSDR and CDPH used information in the referenced documents and assumed that adequate assurance and quality control measures were followed, with regard to chain-of-custody, laboratory procedures, and data reporting. Most of the documents used in the health assessment are prepared for regulatory agencies, which undergo review to ensure that proper quality control measures were followed.

Community Health Concerns and Evaluation

Introduction and Purpose

Community members are often concerned about contaminated sites. The collection, documentation, and response to community health concerns are critical to the PHA process. This section outlines CDPH efforts to engage with workers at RFS and provides an overview of the health- and exposure-related concerns reported by RFS workers to CDPH. In addition, this section provides a response to the concerns with educational information and specifically addresses the health and other concerns within the framework and limitations of the PHA.

Background

RFS is adjacent to the former Stauffer Chemical Company site, an area currently referred to as Zeneca/Campus Bay. Remedial activities at Zeneca/Campus Bay created community and RFS worker concerns about exposure. The community was also concerned that RWQCB was not conducting rigorous oversight of the remediation of Zeneca/Campus Bay and RFS.

Community advocates petitioned the Richmond City Council to support a change in the regulatory agency overseeing site cleanup. In July 2004, the Contra Costa County Health

Services Department (CCCHSD) supported the community's position, citing DTSC as the agency with the adequate expertise to provide oversight for complex sites such as Zeneca/Campus Bay and RFS (42). UC staff communicated with the Richmond City Council, requesting that the RFS be excluded from the a resolution being considered to petition the transfer, contending that the inclusion of the RFS in the transfer request was a result of confusion due to its proximity with the Zeneca/Campus Bay site (43, 44).

Community advocates were concerned when UC selected Cherokee Simeon Ventures (CSV) to develop an academic research complex at RFS because CSV was also involved at the Zeneca/Campus Bay site; this prompted the community to advocate that both sites be regulated by DTSC (45). After receiving input from CCCHSD, the Richmond City Council and the Contra Costa County Board of Supervisors supported the transfer of regulatory oversight of both sites to DTSC that occurred in May 2005. In June 2005, DTSC formed a Community Advisory Group (CAG), as a result of a community petition for public involvement in the clean-up process at the Zeneca site. CAG obtained RFS worker representation in September 2005, after CAG members expanded their purview to include other sites in the area.

In May 2005, CDPH and CCCHSD attended an interagency briefing and coordination meeting at the RFS. At that meeting, both health agencies committed themselves to develop a provisional joint health statement that would provide an evaluation of any immediate exposure risks associated with the Zeneca/Campus Bay and RFS sites. The health statement was released in June 2005 and shared with RFS workers at a meeting on RFS. UC management and the unions also distributed the June 2005 provisional joint health statement. The provisional joint health statement was updated in February 2006. Highlights of the provisional joint health statement were shared with the community at DTSC CAG meetings on June 30, 2005, and February 8, 2006.

Aside from RFS-related concerns, RFS workers and union advocates were also concerned about possible exposures to workers that may have occurred during remedial activities at Zeneca/Campus Bay. Zeneca-related concerns will be addressed in a separate PHA to be released in 2007.

Process for Gathering Community Health Concerns

CDPH staff first became aware of workers' health concerns in April 2005, when contacted by DTSC about the site. Some community members had documented the illnesses and deaths of some RFS workers and they shared a list of those concerns (without identifying information) to CDPH.

EHIB staff worked with the Occupational Health Branch of CDPH to determine the appropriate mechanisms to reach workers and to prepare relevant health and safety information and referrals. In October 2005, EHIB staff met with UC management, and medical, health and safety personnel to provide an overview of the PHA process and receive input from UC regarding conditions at the RFS.

CDPH organized two public availability sessions. The first session, held on October 24, 2005, was held on site at RFS. The second session, held on October 25, 2005, was held at the CDPH Richmond campus, approximately 2 miles from the RFS site, in order to accommodate those who could not attend the previous session or felt more comfortable speaking with CDPH staff off site. To publicize both sessions, CDPH worked with UC management and labor unions at the RFS. UC management sent electronic copies of the flyer to all managers and posted the flyer throughout the RFS campus. Labor union representatives sent the session flyers to union stewards and workers via e-mail. CDPH staff documented the concerns of 17 current and former workers of RFS at the two public availability sessions.

In addition, CDPH worked through labor union and community networks to invite workers who were not able to attend either session to contact CDPH via mail, e-mail, and telephone. CDPH staff also presented the PHA process at the October 2005 CAG meeting. After these outreach efforts, CDPH responded to phone calls and e-mails from several more current and former workers of RFS. Some family members of former RFS workers contacted CDPH to report some additional health concerns. These community members wanted to include the health problems suffered by the former RFS worker in their family in the PHA. CDPH staff documented the concerns of seven additional current and former workers of RFS through these outreach efforts.

Historical Concerns

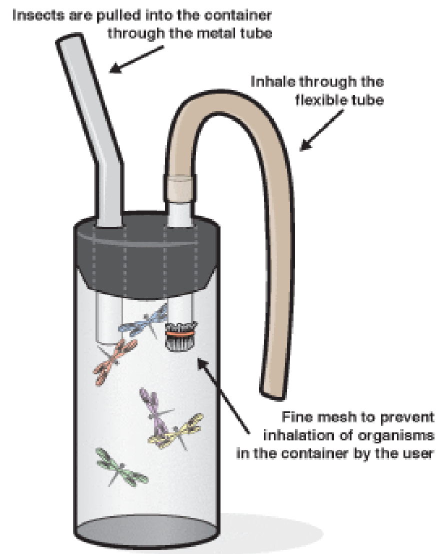
CDPH received a compilation of health- and exposure-related concerns recorded by RFS workers between 1961 and 1972. The compilation is primarily focused on health concerns related to emissions from the Stauffer Chemical Company. Workers described strong chemical odors that resembled onions and garlic; some described the odors as sulfur. Workers reported health effects such as nausea, vomiting, irritation of the nose, throat, and eyes, nosebleeds and irritation of nasal membranes, and dull to severe headaches. A more complete overview of these historical concerns will be provided in the PHA for the Zeneca/Campus Bay, former Stauffer Chemical site, to be released in spring 2008.

In June 2005, a former RFS employee told a local radio station he was ordered to dump drums filled with what he believed to be radioactive waste from Lawrence Berkeley National Laboratories in the marshland area of RFS in the 1960s (46). A formal statement was filed with DTSC in August 2005, and the agency conducted a magnetometer survey in the area in October 2005 in an attempt to locate the drums. Although metal was detected, subsequent investigations revealed the metal to be concrete cylinders with steel casings. The former employee later told DTSC that that the drums may have been buried in an area known as the “Bulb”, as it had been many years since the drums had been buried and changes to the topography confused his recall of the events. DTSC continues to investigate the possible location of the drums.

The former RFS employee who stated he was ordered to dump drums filled with what he believed to be radioactive waste from Lawrence Berkeley National Laboratories at RFS in the 1960s maintained that, after handling the contents of the drums, he experienced severe health effects. The former worker described swelling of his feet and gums and bleeding through his ears, nose, and eyes.

Current/General Concerns

An RFS worker expressed concern over potential exposure to elevated levels of arsenic in soil via ingestion. In 2004, the worker operated an insect aspirator at an area containing elevated levels of arsenic. The insect aspirator (see illustration at right) is a container with two narrow tubes; it functions when one tube is placed on the ground and the other tube is used to suction insects into the container. A mesh material prevents insects from entering the mouth of the operator, but soil particles are able to pass through it. The worker aspirated soil several times when collecting ants at the RFS.



The worker was concerned about the lack of information from UC management to staff regarding areas known to contain high levels of contaminants. Although the UC had reported high levels of arsenic in a report, the worker was not informed of these findings.

In addition to health and exposure concerns, workers expressed frustration to what they believe to be improper handling of the site by RWQCB and the lack of information about the characterization and clean-up process. Workers called for a better characterization and proper remediation of the site.

In addition, some workers expressed distrust of UC medical providers and reported seeking outside care for health issues they considered as site-related. UC management and representatives were concerned that if workers did not report illnesses through UC mechanisms, UC would be unable to assist workers with health issues that might be related to the site. Some members of UC management were worried that workers were experiencing stress related to the site.

Participants asked for additional safety training and better access to protective gear for workers who spend the bulk of their time outdoors on RFS grounds. Some stated that they had asked for protective gear or equipment but were made to feel bad about asking. Others stated that there was a greater need for information dissemination beyond the RFS website that was not accessible by all. In general, workers wanted UC to develop a more responsive, prompt, and transparent approach to dealing with workers' concerns and requests.

Community Health Concerns Evaluation

CDPH documented the health concerns of 24 current and former RFS workers. These participants in the PHA process described a number of concerns and health effects that occurred or are occurring. This section discusses their health concerns in greater detail.

Some community members made an effort to document a list of illnesses and deaths of some RFS workers in 2005. The information was collected anecdotally and was comprised of 26 cases.

The following table presents the health effects and concerns expressed by workers to CDPH. In response to these concerns, CDPH provides a brief description about the health effects, their known causes, including environmental or chemical agents, in particular the ones associated with RFS.

Health Concerns/Effects Expressed to CDPH	
Noncancer health effects concerns	**Cancer health effects/concerns**
Headaches/migraines	Thyroid cancer
Inability to focus	Breast cancer
Allergies/sinus problems	Liver cancer
Eye irritation	*Pancreatic cancer*
Nose irritation/dryness/nose bleeds	*Kidney cancer*
Impaired sense of smell	*Throat cancer*
Coughing/sneezing/choking	
Dry mouth/loss of voice	
Skin irritation	
Stomach ache/diarrhea	
Weight gain	
Numbness in feet and hands	
Chronic fatigue	
Fertility concerns	
Developmental issues for children in utero	
Positive blood test for arsenic	
Positive blood test for mercury	
Swelling of feet, gums; bleeding of ears, nose and eyes*	
Heart disease	
Embolism	
Thyroid problems	
Asthma	
Abdominal pain	
Head and tongue tumors, not yet diagnosed	
Arsenic poisoning	
Bacterial meningitis	

*one-time incident in the past involving the possible handling of radioactive material.
Health effects are organized as either related or not related to cancer.
Items in *italics* denote health concerns/effects documented by community members.
Due to the possibility of overlap between CDPH- and community-collected health concerns, repeated concerns appear only once.

Cancer Risk Factors and Health Disparities

Cancer as a whole is the second leading cause of death in the United States after heart disease. However, grouping cancer together is very misleading because there are many different types of cancer, and each type has different causes and risk factors. It is rarely possible to know why a particular individual develops cancer, but studies have found certain risk factors to be associated with specific cancers. For example, prolonged exposure to sunlight is a risk factor for skin cancer and cigarette smoking is a risk factor for lung cancer. Usually, there are several factors that work together to cause cancer. For example, a number of factors may increase a persons risk for lung cancer: cigarette smoking; having a genetic susceptibility; exposure to another cancer causing agent, like asbestos; and poor diet.

Gender is another factor that influences cancer risk. Lung cancer is now the leading cause of cancer in both men and women. With the exception of lung cancer, men and women differ in cancer risk. The second and third most common cancers in men are colon and prostate, respectively. For women, the second and third most common cancers are breast and colon, respectively (47).

Age is another important risk factor because people at different ages have different levels of risk for certain cancers. For example, in men the risk for testicular cancer decreases with age but the risk for prostate cancer increases with age. In general, the older a person gets, the more likely he/she will get cancer. Thus, more cancer cases will occur in populations that have greater proportion of elderly persons.

People of different ethnic and racial backgrounds get cancer following different patterns. These differences are known as cancer health disparities—they are inequalities that occur when members of one group of people do not enjoy the same health status as other groups (48). Cancer health disparities occur as a result of differences in lifestyle, income, education, access to healthcare, and/or environmental and biological factors (48). The American Cancer Society reports that African American men have the highest cancer related death rate of 339 deaths per 100,000 in the United States, followed by white men with a rate of 243 deaths per 100,000, and Hispanic men with a rate of 171 deaths per 100,000. African American women have the highest rate of cancer related death with a rate of 194 deaths per 100,000, followed by white women with a rate of 165 deaths per 100,000, and American Indian women with a rate of 114 deaths per 100,000 (47).

Evaluation of Cancer Health Concerns at the Richmond Field Station

Workers and former workers of RFS community reported receiving a diagnosis of cancer, or knowing someone diagnosed with cancer, or concern about the risk of cancer from exposures occurring while working at the field station. Diagnosing cancer related to environmental exposure is particularly difficult for a number of reasons: first, it is unknown how long someone must be exposed to cause a particular cancer; second, it is unknown how much time must pass between the environmental exposure and the development of the cancer (latency); lastly, it is difficult to quantify past exposure because we are exposed to numerous chemicals on a daily basis. In the absence of this information, it is difficult to make a

It is important to note the current scientific understanding of exposure to chemicals and related health effects is limited. Most of the information has been derived from studies on animals or workers who have received much higher levels of exposure than typically seen at sites where environmental contamination exists, such as RFS. This is further complicated by the fact that most studies look at chemicals on an individual basis, not as mixtures (exposure to multiple chemicals). These limitations add uncertainty to the conclusions about potential health impact as a result of exposure to contaminants at RFS.

diagnosis of cancer that is directly related to an environmental exposure. Doctors who treat cancer (oncologists) normally focus on treatment, rather than speculate about why their patient developed cancer.

Former/current workers expressed concern about the following cancers: thyroid cancer, breast cancer, liver cancer, pancreatic cancer, kidney cancer, and throat cancer. This section describes the known causes of six different cancers with which members of the community have expressed concerns. The cancers will be addressed as they relate to the environmental contaminants of greatest concern identified by CDPH, based on a review of available site-related environmental data. The contaminants of greatest concern are mercury, arsenic, copper, lead, PCBs, and formaldehyde. The cancers will be described in context of known environmental causes and a determination of whether arsenic, copper, mercury, lead, PCBs, and formaldehyde are known causes, based on the current understanding/scientific knowledge.

Thyroid Cancer

The thyroid gland is an organ found in the front of the neck. The thyroid gland secretes the hormone thyroxin, essential for normal body growth in infancy and childhood. Thyroid cancer is cancer of the thyroid gland and is an uncommon form of cancer, with only about 30,000 new cases expected to occur in 2006 in the United States. Thyroid cancer occurs more frequently in women; most studies show that for every man with thyroid cancer, there are three women with thyroid cancer. Thyroid cancer mainly affects young people with two thirds of cases occurring between ages 25 and 55 years (49). The best known environmental risk factor for the development of thyroid cancer is from exposures to ionizing radiation[5], especially those exposures that occur 10 to 40 years prior to presentation or onset of disease (50). Studies have indicated that commercial PCB mixtures are carcinogenic in animals based on induction of tumors in the thyroid (20). No studies were located showing an association with exposure to mercury, arsenic, copper, lead, or formaldehyde, and thyroid cancer.

Breast Cancer

Until recently, breast cancer was the most common cancer in women. Over 212,900 women in the United States will be diagnosed with breast cancer in 2006 (47). There are three periods in a woman's life that affect breast cancer risk: age at the time of first menstrual period; age at first full-term pregnancy; and age of menopause (51).

Research is being done to learn how the environment might affect breast cancer risk. There are some links between breast cancer risk and exposure to estrogenic compounds, such as dioxin and diethylstilbestrol. However, a clear link between breast cancer and exposure to contaminants such as PCBs and pesticides, at levels commonly found in the environment, has not been shown at this time (52). Exposure to ionizing radiation is an established risk factor for breast cancer (53). There are some occupational risk factors for breast cancer. In large epidemiologic studies of occupation and cancer, jobs with higher education have increased breast and decreased cervical

[5]Ionizing radiation is any one of several types of particles and rays given off by radioactive material, high-voltage equipment, nuclear reactions, and stars. The types that are normally important to your health are alpha particles, beta particles, X rays, and gamma rays.

cancer rates; this finding may be confounded (influenced) by socioeconomic class and advanced maternal age (older age of mother) at first childbirth (53). A variety of studies have examined the possible relationship between breast cancer and exposure to permanent hair dyes. In two studies, regular use of permanent hair dyes was found among those with breast cancer as opposed to controls (53, 54). Case-control studies of the general population are inconclusive with respect to associations between environmental exposures to PCBs and risk of breast cancer (20). There is not strong evidence in the scientific literature showing an association between exposure to mercury, arsenic, copper, lead, or formaldehyde, and breast cancer.

Liver Cancer

The liver is the largest internal organ in the body. It is found just under the right lung and diaphragm. More than 500 vital functions have been identified with the liver. The liver regulates most chemical levels in the blood and excretes a product called bile that helps to break down fats, preparing them for further digestion and absorption. The American Cancer Society estimates there will be about 18,000 new cases of liver cancer in the United States in 2007. Liver cancer is twice as common in men as in women; this is probably due to greater male exposure to causative agents, such as alcohol, smoking, anabolic steroids and occupationally-related chemicals (vinyl chloride, etc.). There are two main types of malignant liver cancer: hepatocellular carcinoma and hemangiosarcoma. The more common cell type for liver cancer is hepatocellular carcinoma. The three primary risk factors for hepatocellular carcinoma worldwide include hepatitis B virus, alcohol, and aflatoxins (cancer-causing substances are made by a fungus that can contaminate peanuts, wheat, soybeans, groundnuts, corn, and rice) (55). A second form of liver cancer, hepatic hemangiosarcoma, is much more uncommon than hepatocellular carcinoma and is closely identified with occupational causes. The two major occupational and environmental causes include vinyl chloride and inorganic arsenic (55-57). Epidemiological studies have indicated that arsenic exposure is associated with liver cancer. Most commonly, the exposure to inorganic arsenic has been from the contamination of the drinking water.

There is conclusive evidence that commercial PCB mixtures are carcinogenic in animals based on the development of tumors in the liver (20). There is evidence showing an association between formaldehyde and cirrhosis of the liver, which can lead to liver cancer. No studies were located showing an association between exposure to mercury and liver cancer.

It is not possible to determine the cause of the liver cancer case expressed to CDPH. We identified potential exposures to arsenic, PCBs, and formaldehyde, which could have increased an individual’s risk of developing liver cancer, if they were exposed under the conservative scenarios assumed. The estimated risk is considered a “low increased risk.”

Pancreatic Cancer

The pancreas is a gland found behind the stomach and is about 6 inches long and less than 2 inches wide. The pancreas consists of separate glands that secrete enzymes which break down fats and proteins in foods, so the body can use them and make hormones (such as insulin) that help balance the amount of sugar in the blood. The American Cancer Society predicts that, in

2007, about 33,730 people in the United States will be found to have pancreatic cancer and about 32,300 will die of the disease. This kind of cancer is the fourth leading cause of cancer death. Pancreatic cancer is difficult to diagnose and tends to be diagnosed when the disease is advanced. There is a strong association between tobacco smoke and pancreatic cancer (58). There is evidence that DDT and its metabolites, certain fungicides, herbicides, solvents, PCBs, and ionizing radiation could be associated with pancreatic cancer (20, 55). There is limited evidence suggesting a link between formaldehyde and pancreatic cancer. There is not adequate understanding of the levels of formaldehyde in indoor air at RFS, due to limited data. Thus, it is not possible to determine if there is a connection between the exposure and the case of pancreatic cancer. No studies were located showing a strong link between mercury, copper, or lead and pancreatic cancer.

Kidney Cancer

The kidneys are two bean-shaped organs. One is just to the left and the other to the right of the backbone. The lower rib cage protects the kidneys. The kidneys filter the blood and help the body get rid of excess water, salt, and waste products in the form of urine. Urine travels through long tubes (ureters) to the bladder where it is stored until the person passes the urine, or urinates. There are two main types of kidney cancers: renal cell and renal pelvis cancers. The American Cancer Society predicts that there will be about 38,890 new cases of kidney cancer in the year 2006 in this country. About 12,840 people will die each year from this disease. These numbers include both adults and children. Most people with this cancer are older. It is very uncommon among people under age 45. According to the National Institute of Cancer, some identified risk factors for fatal cancer include, smoking, alcohol consumption, obesity, and hypertension.

Epidemiologic studies from Taiwan and Argentina have found that arsenic ingestion from the drinking water can cause cancers of the kidney with prolonged exposure (59). It is unknown whether inhaling arsenic contaminated dust can cause kidney cancer. Occupational exposures suspected of causing kidney cancer include: polycyclic aromatic hydrocarbons, asbestos, lead salts, cadmium, petroleum products, distilled fuels, and aliphatic hydrocarbons. No studies were located showing a strong link between kidney cancer and exposure to copper, lead, mercury, PCBs, and formaldehyde.

Throat Cancer

Cancer of the throat may include many different anatomical regions such as the nasopharynx, esophagus, and nasal sinuses. CDPH is not aware of which throat cancer the former/current RFS worker developed. Nasopharyngeal cancer develops in the nasopharynx, an area in the back of the nose toward the base of the skull. The nasopharynx is a box-like chamber about 1½ inch on each edge. It lies just above the soft palate, just in back of the entrance into the nasal passages. Although it is considered an oral cancer, nasopharyngeal cancer is different from most oral cancers. It tends to spread widely, is not often treated by surgery, and has different risk factors from most oral cancers. Nasopharyngeal cancer is relatively rare in most parts of the world. In North America, it occurs in seven out of every one million persons (47). The International Agency for Research on Cancer has concluded that formaldehyde causes nasopharyngeal cancer (60). The additional risk of nasopharyngeal cancer from exposure to formaldehyde at RFS could not be quantified, due a lack of exposure data/air monitoring data.

The nasal sinus refers to the nasal cavity and the paranasal sinuses. The nose opens into the nasal passageway, or cavity. This cavity runs along the top of the palate (the roof of the mouth, the shelf that separates the nose from the mouth) and turns downward to join the passage from the mouth to the throat. The term paranasal means "around or near the nose." Sinuses are cavities or small tunnels. The nasal cavity and paranasal sinuses help filter, warm, and humidify the air we breathe. They also give your voice resonance, lighten the weight of the skull, and provide a bony framework for the face and eyes. Cancers of the nasal cavity and paranasal sinuses are rare. About 2,000 people in the United States develop cancer of the nasal cavity and paranasal sinus each year. Men are about 50% more likely than women to get this cancer. Nearly 80% of the people who get this cancer are between the ages of 45 and 85 (47).

The esophagus is a muscular tube that connects the mouth to the stomach. It carries food and liquids to the stomach. It is about 10-13 inches long. In the United States, the American Cancer Society estimates that there will be about 14,550 new cases of this cancer in 2006. About 13,770 people will die of the disease. This cancer is 3 to 4 times more common among men than among women and 50% more common among African Americans than among whites.

There is no strong evidence in the scientific literature showing an association between exposure to arsenic, copper, lead, mercury, PCBs, and cancer of nasal sinuses or esophagus.

Evaluation of Noncancer Health Concerns at the Richmond Field Station

The RFS community also reported noncancer health concerns. These concerns included asthma, headaches, inability to focus, allergies, sinus problems, eye irritation, nose irritation, impaired sense of smell, cough, dry mouth, loss of voice, skin irritation, diarrhea, weight gain, numbness in hands and feet, chronic fatigue, cardiovascular disease, thyroid problems, bacterial meningitis, and fertility issues. This wide range of symptom complaints could have many possible explanations and all of the symptoms do occur in absence of an environmental exposure.

It is possible that exposure to dust contaminated with arsenic or mercury, or indoor formaldehyde exposure could contribute to one or many of these symptoms, but it is difficult to be certain. CDPH is unable to make definitive conclusions about the cause of these noncancer health concerns. The sampling data available provide an understanding of contaminant levels for limited time periods, and conditions may have varied on other days. Also, exposures to chemicals occur on a daily basis and it is not possible to assign health effects without considering everyday exposures. Formaldehyde, for example, is found in building materials, adhesives, pressed wood products, and some clothing and draperies (35).

In this section, we will provide a general background of some of the noncancer health concerns reported to CDPH. In addition, we will provide information regarding possible environmental factors that cause or exacerbate these noncancer health concerns. It is important to note that many studies analyzing the link between chemicals and health concerns do not characterize exposure levels. In other words, the dose is often unknown. Some studies involve exposing animals to high levels of chemicals and it is difficult to determine what dosage would exert the same effects in humans or if the same effects would occur in humans. Other studies involve populations exposed to varying amounts of chemicals in the past, such as through drinking water systems, and exposure levels are estimates. Some studies are case studies that describe unusual circumstances such as individuals unknowingly eating contaminants in food, or suicide attempts involving high ingestion of a chemical. In this review, we will report dosages if they were available in the scientific literature.

Overall, the levels of arsenic, copper, lead, PCBs, and mercury detected at RFS are not expected to have caused the noncancer health concerns listed. It is possible that eye, nose and throat irritation, and respiratory effects could have occurred, if formaldehyde levels were consistently elevated.

Asthma

Asthma is a disorder of the airways in which they become inflamed, causing airflow in and out of the lungs to be restricted (61). This results in periodic attacks of wheezing, shortness of breath, chest tightness, and coughing. Asthma can be triggered by inhaling pet dander, dust mites, molds, pollens, and cockroach allergens. Respiratory infections, exercise, cold air, stress, food, drug allergies, and tobacco smoke can also trigger asthma attacks. Exposure to environmental pollutants also triggers asthma. Exposure to low levels of formaldehyde (100 $\mu g/m^3$) caused coughing among adult asthmatics who were later exposed to mite allergens (62). The level of formaldehyde measured in Building 163 (September 21, 2005) on one occasion could have caused similar effects in RFS workers who are asthmatic. Dust can also exacerbate asthma. No link has been established between asthma and arsenic, copper, lead, PCBs, or mercury.

Bacterial Meningitis

Meningitis is an infection that causes inflammation of the membranes covering the brain and spinal cord. Bacterial meningitis is caused by bacterial strains (such as streptococcus); about 17,500 cases of bacterial meningitis occur each year in the United States (63). Bacterial meningitis has not been linked with arsenic, copper, formaldehyde, lead, PCBs, or mercury.

Cardiovascular Concerns

Workers and former workers of RFS reported two types of cardiovascular concerns: heart disease and embolism. Heart disease is a term used to describe any disorder that affects the heart’s ability to function normally (63). Heart disease is most commonly caused by the narrowing or blockage of the coronary arteries, a process that occurs over time. Other causes of heart disease are hypertension, abnormal function of the heart valves, abnormal electrical rhythm of the heart, and weakening of the heart’s pumping function by infection or toxins (63). Lifestyle choices such as diet, physical activity, and smoking also affect one’s chances of developing heart disease (64).

Embolism is the interruption of blood flow to an organ or body part due to one or more blood clots (65). This resulting lack of blood flow starves tissues of oxygen, resulting in tissue damage or death. Embolism can occur in the brain (causing a stroke) or in the heart (causing a heart attack), and occur less commonly in the kidneys, intestines, and eyes (65). Risk factors for embolism include injury or damage to an artery wall, infection of the heart, and an increased amount of platelets in the blood (platelets are involved in blood clotting) (65).

Although several studies have looked at the possible relationship between increased levels of copper in the blood and risk of heart disease, it is unclear whether copper directly affects heart disease or is a marker of inflammation associated with heart disease (27). Data from animal studies suggests an increase in blood pressure in rats exposed to 14 mg copper carbonate/kg/day in the diet for 15 weeks (27). Exposure to copper at this high level is not expected to have occurred at RFS.

There is limited evidence that links arsenic exposure to ischemic heart disease after acute and long-term exposure, but exposure levels have not been well characterized (21, 66, 67). Intravenous doses of arsenic used in arsenic trioxide therapy for one type of leukemia showed effects on the cardiovascular system; intravenous doses were generally 0.15 mg arsenic /kg/day (21). Exposure to arsenic at this level is not expected to have occurred at RFS.

A number of occupational studies looking at PCB exposure and cardiovascular disease and blood pressure have produced inconsistent results. In animal studies, cardiovascular effects were not seen at levels ranging from approximately 5-10 mg/kg/day PCBs[6]. This implies that high doses of PCBs are not associated with cardiovascular problems.

Lead has been linked to cardiovascular effects in rats. Factors such as age, blood pressure, body mass, smoking, alcohol consumption, and family history of cardiovascular disease make human studies more complex and difficult to draw conclusions about cause-and-effect (26). An increase in blood pressure in women and men has been associated with a median blood lead of 2.3 ug/dL (26).

Exposure to particulates (less than 10 micrometers in diameter) in dust can cause shortness of breath, chest tightness in people with cardiovascular disease. It has also been associated with increased risk of hospitalization for lung and heart-related respiratory illness. The elderly and people with existing cardiovascular disease have an increased risk of premature death, from exposures that exceed air quality standards (32).

No link between formaldehyde exposure and heart disease appears in the scientific literature. One study investigating formaldehyde exposure levels in mice found no effects on the heart tissue of exposed mice (39).

Developmental Concerns for Children In Utero

In utero growth is a delicate process that is vulnerable to damage during the all trimesters of pregnancy (68). Damage can occur as a result of alcohol consumption, use of prescription and recreational drugs, infection, radiation (such as from X rays or radiation therapy), and nutritional deficiencies (68). Formaldehyde, lead, and copper are considered to have toxic effects on the

[6]The studies looked at various Aroclors.

fetus, based on findings from animals studies (21, 26, 27, 39, 58). However, an exposure dose that is associated with these effects in humans was not located. Studies of the effect of mercury exposure in utero focus primarily on exposure via ingestion of mercury contaminated fish (28). Animal studies have shown the possibility for developmental effects from exposure to PCBs at levels greater than 0.01 mg PCBs /kg/day. Exposure doses estimated for workers at RFS are much lower than levels shown to cause developmental effects (Appendix C, Table 9).

Irritation of Eyes, Nose, and Sinuses

The sinuses are air-filled cavities within the bones of the face around the cheek, eyes, forehead, and near the middle of the skull (69). Each of the cavities has an opening that leads to the nose. Irritation of the sinuses can be caused by sinusitis—an inflammation caused by a viral, bacterial, or fungal infection (70). Each year, over 30 million adults and children get sinusitis. Some symptoms of sinusitis include nasal congestion and discharge, sore throat, cough, and the loss of the sense of smell (70).

Nosebleeds occur most commonly as a result of dryness, nose picking, injuries, allergies, or cocaine use, although the cause sometimes cannot be determined (71). The nose has many blood vessels close to the surface of the skin. These blood vessels help to warm and humidify the air that enters the lungs (71). Because of their proximity to the surface of the skin, these blood vessels are easy to injure (71).

The eyes are sensitive and can respond to irritation to any number of factors such as smoke, wind, dust, and fumes (72). Dry eyes are a common source of discomfort, and persons already suffering from dry eyes are more sensitive to irritants such as smoke or wind. Dry eyes are more likely to be experienced by adults over 40 (72).

It is possible that formaldehyde could have caused some of the symptoms reported by RFS workers (eyes, nose, and throat irritation), since elevated levels of formaldehyde were detected in Building 163, on one occasion. Exposure to airborne dust generated during Phase 1 and Phase 2 remedial activities could also result in irritation of the eyes, nose, and throat.

Irritation of Skin

Irritation of the skin can occur as a result of an allergic reaction or injury to the skin's surface (73). Detergents, soaps, cleaners, waxes, and chemicals can irritate the skin because they wear down the oily protective layer of the skin's surface (73). Restaurant, maintenance, and chemical workers may experience this condition more commonly because of their regular use of chemicals (73). Arsenic can cause skin lesions at chronic exposure doses ranging from 0.002 to 0.02 mg arsenic/kg/day (21). No effects on the skin have been seen in lower exposure levels ranging from 0.0004 to 0.01 mg arsenic/kg/day (21). Dermal effects have been observed via the inhalation route, but studies have not characterized the exposure concentrations required to produce dermal effects (21). Exposures estimated for RFS workers would not be expected to cause effects on the skin.

PCBs can cause skin conditions, such as acne and rashes, in people who were exposed to high levels of PCBs and dioxins in contaminated rice. Exposures estimated at RFS would not be expected to cause these effects (20).

Formaldehyde has also been linked with skin irritation (58). Studies have not found increased skin irritation symptoms for exposure to airborne formaldehyde at levels ranging from 490 $\mu g/m^3$-3,685 $\mu g/m^3$; however, subtle skin effects have been found among people who have increased sensitivity to formaldehyde (a condition called formaldehyde atopic eczema) in studies of short-term exposure (39). During one sampling event (September 21, 2005), formaldehyde was measured at 410 $\mu g/m^3$ in Building 163, which is lower than the lowest level shown to cause skin irritation.

Skin reactions to inhalation of metallic mercury vapor (inorganic mercury) include skin rashes and heavy perspiration (28). Exposures estimated in this PHA would not be expected to cause these effects. Most mercury at RFS is likely inorganic mercury, though it is possible methylization of mercury to occur in sediment. No studies were located linking exposure to organic mercury to dermal effects.

Numbness in Feet and Hands

Numbness and tingling can be experienced in any part of the body, but are usually felt in the hands, feet, arms, or legs (74). There are many causes of numbness and tingling of the extremities, including remaining in the same position (sitting or standing) for a long period of time, injuring or pressuring a nerve, lack of blood supply to an area of the body, carpal tunnel syndrome, lack of vitamin B12, some medications, radiation therapy, and diabetes and other medical conditions (74). Toxic effects of lead, arsenic, and mercury on the nerves include numbness in the feet and hands, although exposure doses are not characterized (28, 58). In one study, neurological symptoms, including numbness, weakness, and neuralgia of limbs, were seen from exposure to high levels of PCBs (20). However, the findings from the studies of these groups cannot be attributed solely to exposure to PCBs since the victims also were exposed to dioxins and other chlorinated chemicals (20).

Diminished Mental Capacities (difficulty concentrating, fatigue)

Diminished mental capacities (such as difficulty concentrating) can be a result of a variety of factors. For example insomnia, depression, generalized anxiety disorder, chronic fatigue syndrome, poor nutrition, and inflammation of the thyroid can cause poor concentration (75-80). The Collaborative on Health and the Environment cites “limited” evidence of a link between arsenic exposure and cognitive impairment (58). Effects such as lethargy, mental confusion, hallucinations, seizure, and coma occurred in humans after exposure to over 2 mg arsenic/kg/day of inorganic arsenic via the oral route (21). Exposure to arsenic at RFS would not result in levels this high. Headache and fatigue have been reported at lower levels, between 0.004 and 0.006 mg arsenic/kg/day (21). Exposure doses estimated for to RFS maintenance workers range from 0.00023-0.00028 mg arsenic/kg/day, which are lower than the levels associated with headache and fatigue.

Lead is also associated with cognitive impairment, mostly I.Q. Children are at greater risk than adults because they are more likely to have contact with contaminated surfaces (by crawling on the floor or putting objects in their mouths) (26). Children also absorb a larger fraction of ingested lead than adults (26). Lead poisoning in adults can cause memory and concentration problems (81). Blood lead levels over 40 µg/dL are associated with neurobehavioral effects in adults (decreased cognitive function, verbal memory and learning, visual memory, manual dexterity) but exposure doses are not characterized (26). Blood lead levels estimated for RFS workers are well below 40 µg/dL and thus would not be expected to cause neurobehavioral effects.

Some studies in workers suggest that exposure to PCBs may cause depression and chronic fatigue, but it is not known the exposure levels at which these effects occur (20).

Fertility Concerns

Infertility is the inability of a couple to become pregnant after 12 months of unprotected intercourse, either because the woman is unable to become pregnant or the man is unable to impregnate the woman (82). There is no single cause for infertility. Some causes are physical, such as pelvic infection, poor nutrition, hormone imbalance, and scarring of the uterine walls and fallopian tubes due to sexually transmitted disease (82). Other causes may relate to age, stress, smoking, and use of drugs or alcohol. For example, the heavy use of marijuana and some prescription drugs (cimetidine, spironolactone, and nitrofurantoin) affect sperm count (82).

Exposure to environmental toxins such as formaldehyde and lead has been linked to reduced fertility (58). One study with female wood workers found that exposure to formaldehyde was associated with delayed conception (83). Some studies suggest that lead can affect both female and male fertility. Alterations in sperm and decreased fertility have been observed in men whose blood lead level was in the range of 30-40 µg/dL (26). Lead levels in women's ovarian follicles were suspected of adversely affecting female reproduction, although exposure levels were not characterized (84). On the other hand, several studies have found no significant association between lead and pre-term delivery in women or alterations in sperm count in men (26). Lead exposure from RFS would result in blood lead levels (BLLs) below 30 µg/dL.

Limited information in humans does not suggest a link between PCB exposure and male reproductivity. Reproductive effects have been seen in women from exposure in the workplace and from eating contaminated fish. Reproductive impairment has been seen in animal studies (20). Further studies looking at a variety of reproductive outcomes are needed to understand the reproductive toxicity of PCBs.

Thyroid Problems

Thyroid conditions can involve either a change in the pace of the thyroid gland (causing it to be overactive or underactive) or thyroid nodules, which are small lumps (85). The term hyperthyroidism describes the condition of having an overactive thyroid gland. Hyperthyroidism speeds up the body's metabolism, resulting in the function of many body systems speeding up and producing too much heat. Hypothyroidism describes the condition of having an underactive thyroid gland. Hypothyroidism results in low levels of thyroid hormone, and most body functions slow down. With hypothyroidism, the body consumes less oxygen and produces less heat. Thyroid nodules occur in about 5% of the population, and it is estimated that almost half of the general population has thyroid nodules but many people are not aware of them until they grow in size (85). Thyroid nodules occur as a result of an enlargement of a collection of thyroid cells or because fluid collects and forms a cyst. Thyroid nodules can appear individually or in greater numbers (85). No reports were found describing the effects of arsenic or copper on the thyroid (58). Some animal studies found no effects of formaldehyde on the thyroid (39). Changes in thyroid hormone levels occurred in workers who had blood lead levels greater than 40 µg/dL (26). Lead exposure estimate for RFS is well below 40 µg/dL.

Studies in animals, including rodents and nonhuman primates, provide strong evidence of thyroid hormone involvement in PCB toxicity. The levels of exposure in these studies range from 0.1 mg PCBs/kg/day (less serious effects) to 12.5 mg PCBs/kg/day (serious effects); these doses associated with PCB toxicity are higher than exposures estimated at RFS (Appendix C, Table 9) (20).

Other Health Concerns

RFS workers and former workers reported other health concerns such as abdominal pain, headaches and migraines, dry mouth, loss of voice, weight gain, stomachache, and diarrhea. These health concerns are common and occur as a result of a variety of reasons. Because of their ubiquitous nature, we are unable to assess their connection with exposures from RFS.

Toxicity by Chemical of Concern

To better understand the health concerns, we will describe some of the primary noncancer symptoms/health effects associated with COCs (arsenic, copper, formaldehyde, lead, PCBs, and mercury).

Arsenic

Arsenic is a naturally occurring element that is normally found combined with other elements. Arsenic toxicity varies depending upon its form. The soluble inorganic forms are well absorbed from the digestive tract and distributed widely throughout the body. (Inorganic arsenic is most likely form of arsenic at RFS.) Arsenic is cleared rapidly from the blood (21). Most arsenic that is absorbed from the gastrointestinal tract and lungs is excreted in the urine within a couple of days (21). Although arsenic may concentrate in small amounts in the liver, kidney, lung, spleen, aorta, and upper gastrointestinal tract, it is also rapidly cleared from these tissues once exposure ceases. Arsenic that remains and accumulates in the body is stored mainly in the skin and hair (21). People who may show increased sensitivity to arsenic include those on protein-poor diets or those with choline (a B vitamin) deficiency. Inorganic arsenic is detoxified in humans by liver enzymes. Those individuals with low liver enzyme activity or liver damage such as alcoholic- or viral-induced cirrhosis may be more sensitive to the effects of arsenic than are people with normal liver enzyme activity (21). Studies of the chronic oral effects of arsenic show that although some people can ingest up to 150 µg arsenic/kg/day without noticeable effects, doses as low as 20 to 60 µg arsenic/kg/day may result in one or more signs of arsenic toxicity in more sensitive individuals. Adverse health effects from arsenic exposure include: digestive tract irritation, disturbances of the blood and nervous systems, skin and blood vessel injuries, and liver or kidney injury. The most sensitive effects are the changes in pigmentation of the skin and the appearance of calluses. The ATSDR MRL (0.3 µg arsenic/kg/day) is based on these effects.

CDPH calculated an exposure dose for a person (worker/teenager) who incidentally ingests and has dermal contact with on-site soil and marsh sediments using the maximum levels of arsenic detected in surface soil and near surface soil; exposure doses do not exceed the MRL, thus noncancer adverse health effects are not likely to have occurred or be occurring (Appendix C, Tables 5, 7, and 9). Some uncertainty exists in estimating the amount of worker exposure, since contaminant concentrations may have been higher or lower in areas not characterized at RFS.

Cadmium

Cadmium is a natural-occurring metal found in the earth's crust. The average level of cadmium in U.S. soil is about 250 ppb (0.25 ppm). The main source of cadmium exposure is from cigarette smoke and food (29). The average person eats about 30 µg of cadmium in food each day, but only 1-3 µg of cadmium is absorbed in the body each day. Cadmium from cigarette smoke is thought to be of greater health concern than cadmium taken in from food. There are no known benefits from cadmium intake. Breathing very high levels cadmium can cause severe lung damage and death. At lower levels, over long periods of time, breathing cadmium can damage the lung, kidneys, and bones. In animal studies, breathing cadmium has been shown to affect the liver and immune system (29). Lung cancer has been associated with inhalation of cadmium in some animal studies. It remains unclear whether breathing cadmium causes lung cancer in people. Eating or drinking cadmium over long periods of time can lead to cadmium buildup in the kidneys (29). Eating or drinking cadmium has not been shown to cause cancer, but more research is needed before definitive conclusions can be reached. Dermal (skin) contact with cadmium is not known to cause adverse health effects in people or animals (29).

CDPH calculated exposure doses for children and adults who engage in activities in the Western Stege Marsh and RFS maintenance workers who are exposed to cadmium in soil. Exposure doses do not exceed the MRL, thus noncancer adverse health effects are not likely to have occurred or be occurring (Appendix C, Tables 5, 7, and 9). Some uncertainty exists in estimating the amount of worker exposure, since contaminant concentrations may have been higher or lower in areas not characterized at RFS.

Copper

Copper is a natural-occurring metal found in soil, rocks, water, and air. Copper is an essential nutrient for plants and animals, including people. The greatest potential source of copper exposure is through drinking water, especially in water that is first drawn in the morning after sitting in copper piping and brass faucets overnight (27). Copper is commonly use in agriculture and other industries.

Long-term exposure to copper dust can irritate your nose, mouth, and eyes, and cause headaches, dizziness. Ingesting high levels of copper (91 µg copper/kg/day) can cause nausea, vomiting, and diarrhea (gastrointestinal effects) (27). At very high levels, copper can cause liver and kidney damage. It is not known whether copper causes cancer (27).

The exposure levels estimated for an RFS worker are below levels shown to cause gastrointestinal effects (Appendix C, Table 9).

Formaldehyde

Formaldehyde is a colorless, flammable gas at room temperature. Formaldehyde is used in many industries. It is used in the production of fertilizer, paper, plywood, and urea-formaldehyde resins. Formaldehyde is found in many products used every day around the house, such as antiseptics, medicines, cosmetics, dish-washing liquids, fabric softeners, shoe-care agents, carpet cleaners, glues and adhesives, lacquers, paper, plastics, and some types of wood products (24). Most formaldehyde in the air also breaks down during the day. The breakdown products of formaldehyde in air include formic acid and carbon monoxide. Formaldehyde does not seem to build up in plants and animals, and although formaldehyde is found in small amounts in some food. It has a pungent, distinct odor.

The most common symptoms from exposure to formaldehyde include irritation of the eyes, nose, and throat, along with increased tearing. These symptoms occur at air concentrations of about 490-3700 $\mu g/m^3$ (39). Formaldehyde can also cause or exacerbate allergic asthma (62). Workers studies have shown increased nasal (nose) and throat cancer.

It is possible that workers in Building 163 could have experienced irritation of the eyes, nose, and throat based on September 21, 2005, when formaldehyde was measured at levels exceeding health-based standards. It is important to note that this conclusion is based on a single reading measured on September 21, 2005.

Lead

Lead is a natural-occurring metal found in all parts of the environment. Most of the lead found in the environment is due to human activities including burning fossil fuels, mining, and manufacturing.

The nervous system is the most sensitive target of lead exposure. Children are the most sensitive to the neurological effects of lead because their brains and nervous systems are still developing. Lead also affects renal function, blood cells, and the metabolism of vitamin D and calcium (17). Lead can also cause hypertension, reproductive toxicity, and developmental effects, in utero.

Studies on reproductive toxicity have shown increased miscarriages and stillbirths in women working in the lead industry at the turn of the century, when exposure levels were very high (17). The effect of low-level lead exposures on pregnancy outcomes is not clear, as studies have shown inconsistent findings (26). Exposure mitigation measures are recommended for pregnant women with BLLs of 10 µg/dL.

The lowest level at which lead has an adverse effect on the kidney remains unknown. Most documented renal effects for occupational workers have been observed in acute high-dose exposures and high-to-moderate chronic exposures (BLL greater than 60 µg/dL) (26). The estimated BLLs in each pathway evaluated were less than 10 µg/dL for youth and less than 25 µg/dL for adults and RFS workers. Thus, adverse kidney effects would not be expected.

Studies on developmental effects, including congenital abnormalities, and post birth effects on growth or neurologic development indicate that lead, that readily crosses the placenta, adversely affects fetus viability as well as fetal and early childhood development (26). There may be an increased risk of reduced birth weight and premature birth from prenatal exposure to low lead levels (e.g., maternal BLLs of 14 µg/dL) (26). The estimated BLL (7.6 µg/dL) for maintenance RFS workers maintenance is lower than levels shown to cause developmental effects.

It is unlikely that the average worker (not maintenance workers) at the RFS are being exposed to lead-contaminated soil at levels that would result in elevated BLLs. The estimated BLL (9.6 µg/dL) for maintenance workers was less the level at which exposure reduction actions are recommended (10 µg/dL for pregnant woman and 25 µg/dL for all other adults).

Mercury

Mercury is a natural-occurring metal in the environment. Metallic or elemental mercury is the main form of mercury released into the air by natural processes. Inorganic or elemental is probably the predominant form of mercury in soil at RFS, though sampling analyses to confirm this assertion were not available at the time of this writing. In the environment inorganic mercury can be methylated by microorganisms to form methylmercury (organic). It is possible for the mercury to be methylated in sediment from the Western Stege Marsh. Methylmercury will accumulate in the tissues of organisms. The most common ways people are exposed to mercury is through eating fish that may contain some methylmercury in their tissues and from the release of elemental mercury from dental fillings.

Inhalation of sufficient levels (below 1,000 $\mu g/m^3$) of metallic mercury vapor has been associated with systemic toxicity (kidney and central nervous system), respiratory, cardiovascular, and gastrointestinal effects in humans and animals (28). Commonly reported kidney effects from mercury exposure include blood in the urine and decreased urine output (28). Neurological symptoms could include weakness, numbness, tremors, and changes in balance (28). In animal studies, reproductive effects (subtle behavioral changes) were seen from exposure to metallic mercury at 50 $\mu g/m^3$. Airborne levels measured at RFS are well below levels shown to cause adverse health effects.

It is not likely that low-level mercury exposure in dust resulted in health effects reported by RFS workers. If mercury-related symptoms are suspected, it is possible to measure mercury in the blood and urine, near the time of exposure. However, determining the source of the mercury would be difficult, because mercury is a common contaminant found in blood (86).

CDPH calculated an exposure dose for a person (worker/teenager) who incidentally ingests and has dermal contact with on-site soil (inorganic) and marsh sediments (assumed to be methylmercury) using the maximum levels of mercury detected in soil and sediment; exposure doses do not exceed MRL (Appendix C, Tables 5, 7, and 9)

PCBs

PCBs are complex mixtures of synthetic organic chemicals that vary in their degree of toxicity. PCBs stopped being manufactured in the United States in 1977, due to evidence that they accumulate and persist in the environment and can cause toxic effects. Small amounts of PCBs can be found in almost all outdoor and indoor air, soil, sediments, surface water, and animals. Some studies in workers suggest that exposure to PCBs causes irritation of the nose, lungs, gastrointestinal discomfort, changes in the blood and liver, depression, and chronic fatigue. Neurobehavioral and immunological changes in children have also been associate with exposure to PCBs. Animal studies have indicated that breathing high levels of PCBs for several months can result in liver and kidney damage (20). Other effects of PCBs in animals include changes in the immune system, behavioral alterations, and impaired reproduction. PCBs are not known to cause birth defects. In worker studies, PCBs were associated with certain types of cancer such as cancer of the liver and biliary tract (20).

PCBs were found in on-site soil in some areas of RFS. The exposure levels estimated for an RFS worker are below levels shown to cause noncancer adverse health effects.

Zinc

Zinc is one of the most common, naturally occurring elements (metal) found in the environment. Zinc is found in soil, air, water, and is present in all food. It is an essential element needed by the body (87). The average person ingests about 5.2 -16.2 mg of zinc per day from dietary sources. Breathing high levels of zinc dust or fumes (generally associated with welding or smelting occupations) can develop a reversible disease known as metal fume fever. Not much is know about the long-term effects of breathing zinc dust or fumes. Ingesting high levels of zinc (10-15 times greater than the Recommended Daily Allowance of 11 mg/day) can result in stomach cramps, nausea, and vomiting (87). Long-term ingestion (several months) of high levels of zinc can damage the pancreas, cause anemia and decrease high-density lipoprotein (HDL) cholesterol levels. Certain zinc compounds have been shown to cause skin irritation in animal studies. It is likely that people would experience skin irritation as well. There is insufficient information to know whether zinc causes cancer (87).

CDPH calculated exposure doses for children and adults who engage in activities in the Western Stege Marsh who are exposed to zinc in surface water and sediment. Exposure doses do not exceed the MRL, thus noncancer adverse health effects are not likely to have occurred or be occurring (Appendix C, Tables 5 and 7).

The following are general questions asked during CDPH discussions with RFS workers.

- What are the effects of the combination of chemicals?

Data on the health effects from exposure to multiple chemicals (chemical mixtures) are very limited. The effects of multiple chemical exposures can be additive, synergistic (combined toxic effects of two or more chemicals are greater than each chemical alone), or antagonistic (two chemicals interfere with each other's actions, leading to a less toxic compound). Inhibition effects occur when a chemical that does not have a toxic effect on a certain organ system decreases the apparent effect of a second chemical on that organ system.

- What is the effect of exposure to chemicals during pregnancy for the fetus and development of the child after birth?

The effect of chemical exposure to a fetus depends on the timing of exposure during pregnancy and the amount (dose) of exposure. Depending on the chemical, exposure can cause loss of fetus, abnormal skeletal growth, functional changes such as lesser thyroid hormone, and irreversible neurodevelopmental effects. Studies have shown developmental effects in children exposed to lead and mercury.

- Does the presence of chemicals in the environment decrease immune function because the immune system might be "distracted" dealing with the chemicals, and thus create a susceptibility to develop illnesses that run in one's family (such as thyroid problems)?

There is a great deal of debate on this topic within the scientific community. Animal studies clearly show exposure to chemical agents can suppress the immune system, which can result in disease. However, data on whether this is true for humans is much more limited (88).

Studies have shown that chemical exposure can affect immunity in three major ways:
by causing hypersensitivity reactions, including allergy, which can be harmful to organs and tissue and; autoimmunity, in which the immune cells attack themselves; or by immunosuppression—a reduction in immune response and activities of the immune system (88).

Some researchers who study immunotoxicology, specifically, adverse effects on the immune system as a result of exposure to environmental chemicals, contend that certain chemicals can affect immunity, increasing a person's susceptibility to disease. Age, genetics, preexisting disease, lifestyle, diet, drugs, stress, are all factors that play a role in immune function. These factors may compound the effects of chemical exposure by further compromising immune function and increasing the chance for disease. There is thought that some immunologic disorders appear only after toxic exposure from the environment invokes a previously undetected genetic condition, while other disorders appear under ordinary environmental conditions (88).

- Can people walk outside safely on RFS grounds?

Yes, it is safe for people to walk on RFS grounds. The main exposure concern is it to RFS maintenance workers who may dig and come into contact with contaminated soil. The primary route of exposure (way the contaminant gets into the body) is through incidental ingestion, dermal exposure and inhalation (resuspension of soil/dust). Much of the RFS is paved, has sidewalks or vegetation (grass, etc.) covering the soil, which limits soil contact and resuspension of soil into the air. Simply walking on the RFS grounds would not expose people to contaminants that would pose a health risk.

- Is there a risk from walking/biking along the Bay Trail?

No, there is no health risk to Bay Trail users from exposure to contaminants at RFS. It is possible that Bay Trail users could have been exposed to contaminated dust generated during past remedial activities (cleanup and excavation work). DTSC will ensure that future remedial work will be conducted using adequate dust control measures.

- Is there radioactive waste at RFS?

DTSC is investigating allegations that drums containing radioactive waste were dumped in the bay. DTSC is also investigating potential radioactive contamination at the neighboring Zeneca site. At this time there is no evidence of radioactive contamination at the RFS site.

- Are there health risks from the power line (EMF) near RFS?

Exposure risks from EMFs are out of the scope of this health assessment. Information about EMFs can be obtained online at http://www.niehs.nih.gov/emfrapid/ and at http://www.dhs.ca.gov/ehib/emf/general.html.

Health Outcome Data

Health outcome data (HOD) record certain health conditions that occur in populations. These data can provide information on the general health of communities living near a hazardous waste site. They also can provide information on patterns of specified health conditions. Some examples of health outcome databases are the California Cancer Registry, birth defects registries, and vital statistics. Information from local hospitals and other health care providers also can be used to investigate patterns of disease in a specific population. These data are recorded based on the geographic area where a person lives, not where they work. A HOD review would not provide information reflective of the work force at RFS or visitors or people restoring the marsh. Thus, a review of HOD was not conducted for this site.

Children's Health Considerations

CDPH and ATSDR recognize that, in communities with contaminated water, soil, air, or food (or all of these combined, depending on the substance and the exposure situation), infants and children can be more sensitive than adults to chemical exposures. This sensitivity results from several factors: 1) children might have higher exposures to environmental toxins than adults because, pound for pound of body weight, children drink more water, eat more food, and breathe more air than adults; 2) children play indoors and outdoors close to the ground, which increases their exposure to toxins in dust, soil, surface water, and ambient air; 3) children have a tendency to put their hands in their mouths, thus potentially ingesting contaminated soil particles at higher rates than adults; some children even exhibit an abnormal behavior trait known as “pica,” that causes them to ingest non-food items, such as soil; 4) children’s bodies are rapidly growing and developing, thus they can sustain permanent damage if toxic exposures occur during critical growth stages; and 5) children and teenagers more readily than adults can disregard no trespassing signs and wander onto restricted property. CDPH considered children in the pathways evaluated in this PHA.

Conclusions

CDPH evaluated the completed exposure pathways (past, current, and future) to contaminants at RFS, using available environmental data collected from the site. CDPH classifies each completed exposure pathways based on the pathways’ potential for posing a health hazard.

<u>No apparent public health hazard</u>

- Past exposure to airborne mercury during remedial work.

The available data do not indicate that people were exposed to levels of airborne mercury between August and September 2003 that would be expected to cause adverse health effects.

- Past, current and future exposure to metals and PCBs for adults from recreating in the Western Stege Marsh.

- Past exposure to metals and PCBs for youth from recreating in the Western Stege Marsh.

- Current exposure to metals and PCBs for youth and adults from restoring the Western Stege Marsh in areas that have been excavated.

<u>Public health hazard</u>

- Current and future exposure to children/teenagers who regularly play in the Western Stege Marsh.

CDPH identified potential exposures of health concern for children/teenagers who regularly play in the Western Stege Marsh, from exposure to the highest concentrations of metals and PCBs in surface water and/or sediment. The most sensitive (primary) noncancer endpoints associated with COCs include skin effects (arsenic), renal effects (cadmium), neurodevelopmental (methylmercury), gastrointestinal symptoms (copper), immune effects (PCBs), and decreases in erythrocyte copper, zinc-superoxide dismutase (ESOD) activity (zinc). COCs associated with a theoretical increased cancer risk are arsenic (skin, liver, bladder, and lung) and PCBs (liver, biliary). It is important to note that this conclusion is based on conservative assumptions meant to identify the possibility for exposures of health concern, so that steps can be taken to mitigate or prevent these exposures from occurring. Actual exposures to children/teenagers would be much less. Access to the marsh should remain restricted.

- Past, current, and future exposure to RFS maintenance workers.

CDPH identified a public health hazard for RFS maintenance workers who regularly worked in soil containing the highest levels of metals and PCBs in RFS soil prior to excavation/removal activities.

- Current, and future exposure to RFS maintenance workers.

CDPH identified a public health hazard for RFS maintenance workers who regularly work in soil containing the highest levels of metals and PCBs in non-excavated areas of RFS.

The primary noncancer endpoints associated with COCs include skin effects (arsenic), immune changes (PCBs), renal effects (cadmium, inorganic mercury), and gastrointestinal symptoms (copper). COCs associated with an increased cancer risk are arsenic (skin, liver, bladder, and lung) and PCBs (liver, biliary). These conclusions are based on conservative assumptions, actual exposures (past, current, future) are likely much less. A worker's exposure can be mitigated if proper protective equipment (e.g. gloves, respiratory protection, etc.) is used while working in RFS soil.

CDPH was unable to determine if a future health hazard exists from restoration activities in the marsh, for the reason that follows. It is possible that contamination may be migrating through surface and/or groundwater from non-remediated areas of the marsh, the uplands, and/or the adjacent Zeneca site, into the remediated portion of the marsh. As a precautionary measure children/teenagers should not participate in restoration activities until additional investigation and remediation is completed. If adults chose to participate in restoration activities they should be made aware of the potential issues (data gaps) and be provided appropriate protective equipment.

Additionally, there is a potential for elevated levels of natural occurring radionuclides associated with historic operations at the adjacent Zeneca site to have migrated into the Western Stege Marsh. This is of primary concern for the portions of the marsh that have not been remediated/excavated.

CDPH was unable to determine whether RFS workers are being exposed to contaminants in indoor air as a result of vapor intrusion, due to a lack of data. Limited indoor air sampling indicates a potential health risk from exposure to formaldehyde in indoor air that occurred between September 2005 and October 2005. These data are insufficient to draw conclusions about the source of formaldehyde in indoor air or the potential impact of future exposure.

CDPH evaluated potential exposure from resuspension of contaminated soil/dust, using health conservative assumptions. Based on the current information, simply walking on the grounds at the RFS would not expose people to contaminants at levels of health concern.

CDPH has conducted a number of outreach activities at RFS, in an effort to collect and understand the health concerns that RFS employees believe are related to contamination at RFS. The majority of the health concerns expressed by workers cannot be clearly linked to chemical exposures at the site, with the exception of eye, nose and throat irritation, and mild respiratory effects that may have occurred from exposure to formaldehyde and airborne dust. A number health and safety concerns expressed to CDPH has resulted in recommendations for worker training and better communication (maps, reports, etc.) by UC management to RFS workers.

Recommendations

1. CDPH and ATSDR recommend that future soil disturbing/dust generating activities be monitored for air quality within the RFS and along the perimeter of the site to ensure safe air quality for workers, residents, and other people in the area.

2. CDPH and ATSDR recommend UC conduct additional characterization of on-site soil and groundwater throughout RFS to identify other areas where potential contamination may exist. Chemicals used in research activities at RFS, as well as known contaminants from historic uses of RFS and Zeneca-related (former Stauffer Chemical) contaminants should be analyzed. Characterization of soil and groundwater in the area where the Forest Products should include additional analyses of pentachlorophenol and chlorophenol byproducts. Soil gas sampling should occur in areas where volatile contamination is suspected. Site characterization activities should be conducted under the direction of DTSC.

3. CDPH and ATSDR recommend UC annually sample the sediment and unfiltered water in the RFS marsh to identify whether contaminants are migrating from the non-remediated areas of the marsh, uplands, and adjacent Zeneca site. The sampling should continue until the site has been fully characterized and characterized and remediation completed in areas that could impact the marsh.

4. CDPH and ATSDR recommend that UC conduct groundwater monitoring in the Western Stege Marsh to determine whether contaminants are migrating from the uplands or the adjacent Zeneca site into the marsh.

5. CDPH and ATSDR recommend UC analyze for radionuclides associated with historic activities at the Zeneca site (former Stauffer Chemical), in on-site soil, groundwater, and sediment from the Western Stege Marsh, if radionuclide contamination is identified during investigations at the Zeneca site.

6. CDPH and ATSDR recommend UC conduct additional indoor air sampling in Buildings 163 and 175 to identify whether formaldehyde is elevated above levels typical of indoor air. Arsenic should also be analyzed. Results of sampling will determine the need for further sampling or investigation.

7. CDPH and ATSDR recommend UC provide all of RFS staff access to up to date maps showing locations of current and historic structures and soil sampling locations, along with the associated level of contamination. (Status: The UC has provided computer access to the remedial documents generated for the site.)

8. CDPH and ATSDR recommend UC offer Hazardous Waste Operations and Emergency Response (HAZWOPER) training to workers whose work may involve handling or digging in soils on the RFS site. (Status: UC provided HAZWOPER training to maintenance workers in January 2008.)

9. CDPH and ATSDR recommend UC train workers annually in how to identify cinders and what actions to take if such material is identified. (Status: UC has implemented a training program for RFS maintenance workers.)

Public Health Action Plan

The Public Health Action Plan (PHAP) for this site contains a description of actions taken, to be taken, or under consideration by ATSDR and CDPH or others at and near the site. The purpose of the PHAP is to ensure that this PHA not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The first section of the PHAP contains a description of actions completed. The second section is a list of additional public health actions that are planned for the future.

Actions Completed

- CDPH/ATSDR worked with the Occupational Health Branch of CDPH to determine the appropriate mechanisms to reach workers and to prepare relevant health and safety information and referrals (May-September 2005).

- CDPH/ATSDR gathered community (RFS employees) concerns through meeting with workers at RFS and by conducting two public availability sessions (October 2005).

- CDPH/ATSDR and the Contra Costa County Health Services Department released a Provisional Joint Health Statement, providing an evaluation of current exposure from contaminants at RFS and adjacent Zeneca sites (June 2005; update in February 2006).

- CDPH/ATSDR recommended that RFS Western Stege Marsh be fenced and posted to eliminate exposure to contaminants remaining in the marsh (action completed in December 2006).

- CDPH contacted the Office of Environmental Health Hazard Assessment (OEHHA) regarding the posting of fish advisories relative to the San Francisco Bay, along the shoreline in the Marina Bay area (December 2007).

Ongoing Actions

- CDPH/ATSDR will continue to provide health outreach and education to the community/RFS workers and recommend that health education activities be tailored to meet the workers needs.

Actions Planned

- CDPH will disseminate information summarizing the findings of this comprehensive PHA and hold a public meeting to discuss the results.

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Certification

This public health assessment, Evaluation of Exposure to Contaminants at the University of California Richmond Field Station, Richmond, California, was prepared by the California Department of Health Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the public health assessment was begun. Editorial review was conducted by the cooperative agreement partner.

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The Division of Public Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with the findings.

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Appendix A. Glossary of Terms

Absorption
How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.

Acute Exposure
Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Adverse Health Effect
A change in body function or the structures of cells that can lead to disease or health problems.

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

Background Level
An average or expected amount of a chemical in a specific environment or, amounts of chemicals that occur naturally in a specific environment.

Benchmark Dose
A dose or concentration that produces a predetermined change in response rate of an adverse effect (called the benchmark response or BMR) compared to background.

Cancer Risk
The potential for exposure to a contaminant to cause cancer in an individual or population is evaluated by estimating the probability of an individual developing cancer over a lifetime as the result of the exposure. This approach is based on the assumption that there are no absolutely "safe" toxicity values for carcinogens. U.S. EPA and the California EPA have developed cancer slope factors and inhalation unity risk factors for many carcinogens. A slope factor is an estimate of a chemical's carcinogenic potency, or potential, for causing cancer.

If adequate information about the level of exposure, frequency of exposure, and length of exposure to a particular carcinogen is available, an estimate of excess cancer risk associated with the exposure can be calculated using the slope factor for that carcinogen. Specifically, to obtain risk estimates, the estimated, chronic exposure dose (which is averaged over a lifetime or 70 years) is multiplied by the slope factor for that carcinogen.

Cancer risk is the theoretical chance of getting cancer. In California, 41.5% of women and 45.4% of men (about 43% combined) will be diagnosed with cancer in their lifetime (13). This is referred to as the "background cancer risk." The term "excess cancer risk" represents the risk above and beyond the "background cancer risk." A "one-in-a-million" excess cancer risk from a given exposure to a contaminant means that if one million people are chronically exposed to a carcinogen at a certain level, over a lifetime, then one cancer above the background risk may appear in those million persons from that particular exposure. For example, in a million people, it is expected that approximately 430,000 individuals will be diagnosed with cancer from a variety of causes. If the entire population was exposed to the carcinogen at a level associated with a one-in-a-million cancer risk, 430,001 people may get cancer, instead of the expected 430,000. Cancer risk numbers are a quantitative or numerical way to describe a biological process (development of cancer). In order to take into account the uncertainties in the science, the risk numbers used are plausible upper limits of the actual risk, based on conservative assumptions.

Chronic Exposure
A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than 1 year to be chronic.

Completed Exposure Pathway
See Exposure Pathway.

Concern
A belief or worry that chemicals in the environment might cause harm to people.

Concentration
How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant
See Environmental Contaminant.

CREG (ATSDR Cancer Risk Evaluation Guide for 1 in 1,000,000 increased cancer risk)
Like EMEGs, water CREGs are derived for potable water used in homes, including water used for drinking, cooking, and food preparation. Soil CREGs apply only to soil that is ingested.

A theoretical increased cancer risk is calculated by multiplying the dose and the CSF. When developing CREG, the target risk level (10^{-6}), which represents a theoretical risk of one excess cancer case in a population of one million, and the CSF are known. The calculation seeks to find the substance concentration and dose associated with this target risk level.

To derive water and soil CREGs, ATSDR uses CSFs developed by the U.S. EPA and reported in the Integrated Risk Information System (IRIS). The IRIS summaries, available at http://www.epa.gov/iris/, provide detailed information about the derivation and basis of the CSFs for individual substances. ATSDR derives CREGs for lifetime exposures, and therefore uses exposure parameters that represent exposures as an adult. An adult is assumed to ingest 2 L/day of water and weigh 70 kg. For soil ingestion, ATSDR assumes a soil ingestion rate of 100 mg/day, for a lifetime (70 years) of exposure.

Dermal Contact
A chemical getting onto your skin. (See Route of Exposure.)

Dose
The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day."

Dose/Response
The relationship between the amount of exposure (dose) and the change in body function or health that result.

Duration
The amount of time (days, months, and years) that a person is exposed to a chemical.

EMEG (ATSDR Environmental Media Evaluation Guide)
Water EMEGs are derived for potable water used in homes. Potable water includes water used for drinking, cooking, and food preparation. Exposures to substances that volatilize from potable water and are inhaled, such as volatile organic compounds (VOCs) released during showering, are *not* considered when deriving EMEGs.

To derive the water EMEGs, ATSDR uses the chronic oral MRLs from the Toxicological Profiles, available at http://www.atsdr.cdc.gov/toxpro2.html. Ideally, the MRL is based on an experiment in which the chemical was administered in water. However, in the absence of such data, an MRL based on an experiment in which the chemical was administered by gavage or in food may have been used. The Toxicological Profiles for individual substances provide detailed information about the MRL and the experiment on which it was based.

Children are usually assumed to constitute the most sensitive segment of the population for water ingestion because their ingestion rate per unit of body weight is greater than the adults' rate. An EMEG for a child is calculated assuming a daily water ingestion rate of 1 liter per day (L/day) for a 10-kilogram (kg) child. For adults, a water EMEG is calculated assuming a daily water ingestion rate of 2 liters per day and a body weight of 70 kg.

Soil EMEGS: ATSDR uses the chronic oral MRLs from its Toxicological Profiles. Many chemicals bind tightly to organic matter or silicates in the soil. Therefore, the bioavailability of a chemical is dependent on the media in which it is administered. Ideally, an MRL for deriving a soil EMEG should be based on an experiment in which the chemical was administered in soil. However, data from this type of study is seldom available. Therefore, often ATSDR derives soil EMEGs from MRLs based on studies in which the chemical was administered in drinking water, food, or by gavage using oil or water as the vehicle. The Toxicological Profiles for individual substances provide detailed information about the MRL and the experiment on which it was based.

Children are usually assumed to be the most highly exposed segment of the population because their soil ingestion rate is greater than adults' rate. Experimental studies have reported soil ingestion rates for children ranging from approximately 40 to 270 milligrams per day (mg/day), with 100 mg/day representing the best estimate of the average intake rate (EPA 1997). ATSDR calculates an EMEG for a child using a daily soil ingestion rate of 200 mg/day for a 10-kg child.

Environmental Contaminant
A substance (chemical) that gets into a system (person, animal, or environment) in amounts higher than that found in Background Level, or what would be expected.

Environmental Media
Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. Environmental Media is the second part of an Exposure Pathway.

Exposure
Coming into contact with a chemical substance (for the three ways people can come in contact with substances, see Route of Exposure).

Exposure Assessment
The process of finding the ways people come in contact with chemicals, how often, and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway
A description of the way that a chemical moves from its source (where it began), to where, and how people can come into contact with (or get exposed to) the chemical. ATSDR defines an exposure pathway as having five parts: 1) a source of contamination, 2) an environmental media and transport mechanism, 3) a point of exposure, 4) a route of exposure, and 5) a receptor population. When all five parts of an exposure pathway are present, it is called a Completed Exposure Pathway.

Frequency
How often a person is exposed to a chemical over time; for example, every day, once a week, or twice a month.

Hazard Index
The sum of the Hazard Quotients (see below) for all chemicals of concern (COCs) identified, which an individual is exposed. If the Hazard Index (HI) is calculated to be less than 1, then no adverse health effects are expected as a result of exposure. If the Hazard Index is greater than 1, then adverse health effects are possible. However, an HI greater than 1.0, does not necessarily suggest a likelihood of adverse effects. The HI cannot be translated to a probability that adverse effects will occur, and is not likely to be proportional to risk

Hazard Quotient
The ratio of estimated site-specific exposure to a single chemical from a site over a specified period to the estimated daily exposure level, at which no adverse health effects are likely to occur. If the Hazard Quotient is calculated to be less than 1, then no adverse health effects are expected as a result of exposure. If the Hazard Quotient is greater than 1, then adverse health

effects are possible. The Hazard Quotient cannot be translated to a probability that adverse health effects will occur, and is unlikely to be proportional to risk. It is especially important to note that a Hazard Quotient exceeding 1 does not necessarily mean that adverse effects will occur.

Hazardous Waste
Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Comparison Value
Media specific concentrations that are used to screen contaminants for further evaluation.

Health Effect
ATSDR deals only with Adverse Health Effects (see definition in this glossary).

Ingestion
Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (see Route of Exposure).

Inhalation
Breathing. It is a way a chemical can enter your body (see Route of Exposure).

LOAEL
Lowest-Observed-Adverse-Effect-Level (LOAEL). LOAEL is the lowest dose of a chemical in a study (animals or people), or group of studies, that produces statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control.

Noncancer Evaluation, ATSDR's Minimal Risk Level (MRL), U.S. EPA's Reference Dose (RfD) and Reference Concentration (RfC), and California EPA's Reference Exposure Level (REL)
MRL, RfD, RfC, and REL are estimates of daily exposure to the human population (including sensitive subgroups), below which noncancer adverse health effects are unlikely to occur. MRL, RfD, RfC, and REL only consider noncancer effects. Because they are based only on information currently available, some uncertainty is always associated with MRL, RfD, RfC, and REL. "Uncertainty" factors are used to account for the uncertainty in our knowledge about their danger. The greater the uncertainty, the greater the "uncertainty" factor and the lower MRL, RfD, RfC or REL.

When there is adequate information from animal or human studies, MRLs and RfDs are developed for the ingestion exposure pathway, whereas RELs and RfCs are developed for the inhalation exposure pathway.

Separate noncancer toxicity values are also developed for different durations of exposure. ATSDR develops MRLs for acute exposures (less than 14 days), intermediate exposures (from 15 to 364 days), and for chronic exposures (greater than 1 year). The California EPA develops RELs for acute (less than 14 days) and chronic exposure (greater than 1 year). EPA develops

RfDs and RfCs for acute exposures (less than 14 days), and chronic exposures (greater than 7 years). Both MRL and RfD for ingestion are expressed in units of milligrams of contaminant per kilograms body weight per day (mg/kg/day). REL, RfC, and MRL for inhalation are expressed in units of milligrams per cubic meter (mg/m^3).

NOAEL
No-Observed-Adverse-Effect-Level. NOAEL is the highest dose of a chemical at which there were no statistically or biologically significant increases in the frequency or severity of adverse effects seen between the exposed population (animals or people) and its appropriate control. Some effects may be produced at this dose, but they are not considered adverse, nor precursors to adverse effects

PHA
Public Health Assessment. A report or document that looks at chemicals at a hazardous waste site and determines if people could be harmed from coming into contact with those chemicals. The PHA also recommends possible further public health actions if needed.

Plume
A line or column of air or water containing chemicals moving from the source to areas further away. A plume can be a column or clouds of smoke from a chimney, contaminated underground water sources, or contaminated surface water (such as lakes, ponds, and streams).

Point of Exposure
The place where someone can come into contact with a contaminated environmental medium (air, water, food, or soil). For example, the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or the backyard area where someone might breathe contaminated air.

Population
A group of people living in a certain area or the number of people in a certain area.

PRG
EPA Preliminary Remediation Goals (PRGs) are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations that are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements.

PRP
Potentially Responsible Party. A company, government, or person that is responsible for causing the pollution at a hazardous waste site. PRPs are expected to help pay for the cleanup of a site. Health Hazard

ATSDR Hazard Categories
Depending on the specific properties of the contaminant(s), the exposure situations, and the health status of individuals, a public health hazard may occur. Sites are classified using one of the following public health hazard categories:

Urgent Public Health Hazard
This category applies to sites that have certain physical hazards or evidence of short-term (less than 1 year), site-related exposure to hazardous substances that could result in adverse health effects. These sites require quick intervention to stop people from being exposed. ATSDR will expedite the release of a health advisory that includes strong recommendations to immediately stop or reduce exposure to correct or lessen the health risks posed by the site.

Public Health Hazard
This category applies to sites that have certain physical hazards or evidence of chronic (long-term, more than 1 year), site-related exposure to hazardous substances that could result in adverse health effects. ATSDR will make recommendations to stop or reduce exposure in a timely manner to correct or lessen the health risks posed by the site.

Indeterminate Public Health Hazard
This category applies to sites where critical information is lacking (missing or has not yet been gathered) to support a judgment regarding the level of public health hazard. ATSDR will make recommendations to identify the data or information needed to adequately assess the public health risks posed by this site.

No Apparent Public Health Hazard
This category applies to sites where exposure to site-related chemicals might have occurred in the past or is still occurring, but the exposures are not at levels likely to cause adverse health effects. ATSDR may recommend any of the following public health actions for sites in this category:

- Cease or further reduce exposure (as a preventive measure)
- Community health/stress education
- Health professional education
- Community health investigation

No Public Health Hazard
This category applies to sites where no exposure to site-related hazardous substances exists. ATSDR may recommend community health education for sites in this category.

For more information, consult Chapter 9 and Appendix H in the 2005 ATSDR Public Health Assessment Guidance Manual (http://www.atsdr.cdc.gov/HAC/PHAManual/index.html).

Qualitative Description of Estimated Increased Cancer Risks
The qualitative interpretation for estimated increased cancer risks are as follow:

Quantitative Risk Estimate	Qualitative Interpretation
Less than 1 in 100,000	No apparent increased risk
1 in 100,000 to 9 in 100,000	Very low increased risk
1 in 10,000 to 9 in 10,000	Low increased risk
1 in 1,000 to 9 in 1,000	Moderate increased risk
Greater than 9 in 1,000	High increased risk

Receptor Population
People who live or work in the path of one or more chemicals, and who could come into contact with them (see Exposure Pathway).

RMEG (Reference Dose Media Evaluation Guides)
If no MRL is available to derive an EMEG, ATSDR develops RMEGs using EPA's reference doses (RfDs), available at http://www.epa.gov/iris/, and default exposure assumptions, which account for variations in intake rates between adults and children. EPA's reference concentrations (RfCs), available at http://www.epa.gov/iris/, serve as RMEGs for air exposures. Like EMEGs, RMEGs represent concentrations of substances (in water, soil, and air) to which humans may be exposed without experiencing adverse health effects. RfDs and RfCs consider lifetime exposures, therefore RMEGs apply to chronic exposures.

Route of Exposure
The way a chemical can get into a person's body. There are three exposure routes: 1) breathing (also called inhalation), 2) eating or drinking (also called ingestion), and 3) getting something on the skin (also called dermal contact).

Safety Factor
Also called Uncertainty Factor. When scientists do not have enough information to decide if an exposure will cause harm to people, they use uncertainty factors and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is not likely to cause harm to people.

Source (of Contamination)
The place where a chemical comes from, such as a smokestack, landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first point of an exposure pathway.

Sensitive Populations
People who may be more sensitive to chemical exposures because of certain factors such as age, sex, occupation, a disease they already have, or certain behaviors (cigarette smoking). Children, pregnant women, and older people are often considered special populations.

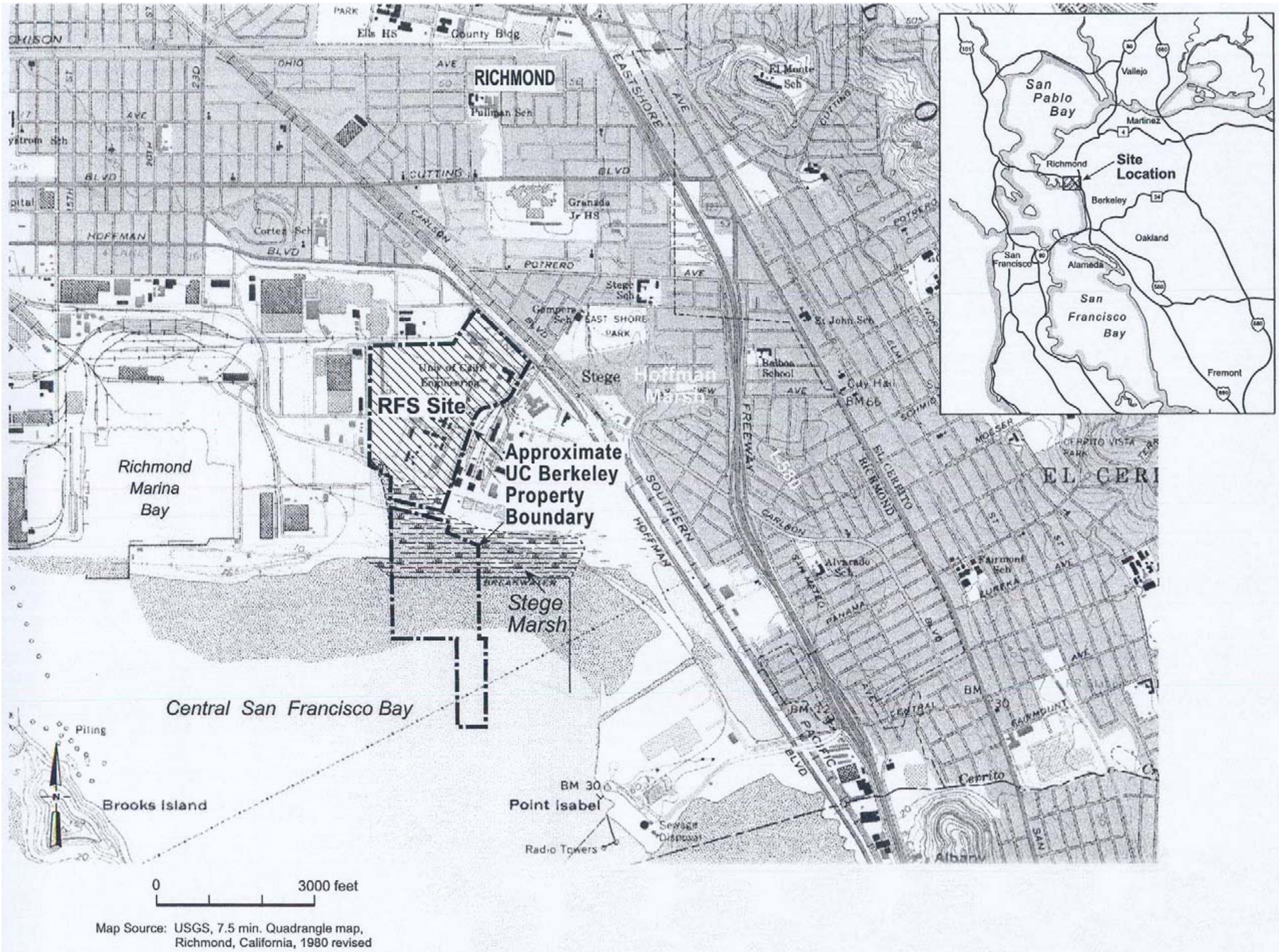
Toxic
Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose determines the potential harm of a chemical and whether it would cause someone to get sick.

Toxicology
The study of harmful effects of chemicals on humans or animals.

Volatile Organic Chemical (VOC)
Substances containing carbon and different proportions of other elements such as hydrogen, oxygen, fluorine, chlorine, bromine, sulfur, or nitrogen. These substances easily volatilize (become vapors or gases) into the atmosphere. A significant number of VOCs are commonly used as solvents (paint thinners, lacquer thinner, degreasers, and dry-cleaning fluids).

Appendix B. Figures

Figure 1. Site Location Map, University of California, Berkeley, Richmond Field Station, Richmond, California

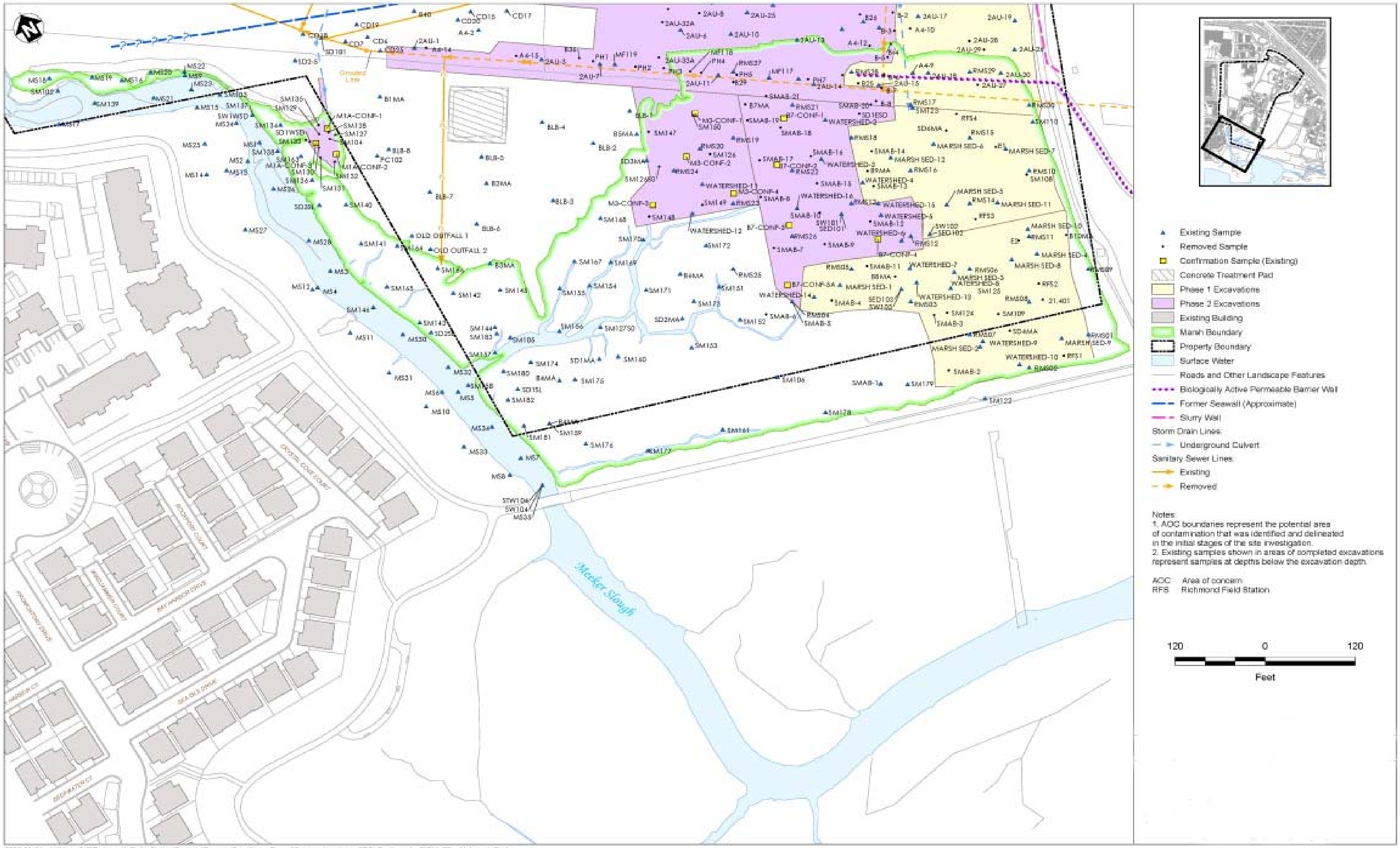


Data source (23)

Figure 2. Location of Phase 1 and Phase 2 Remedial Areas in the Western Stege Marsh, University of California, Berkeley, Richmond Field Station, Richmond, California

Data source (1)

Figure 3. Soil and Sediment Sampling Locations in the Western Stege Marsh and Southern Portion of the site, University of California, Berkeley, Richmond Field Station, Richmond, California



Data source (2)

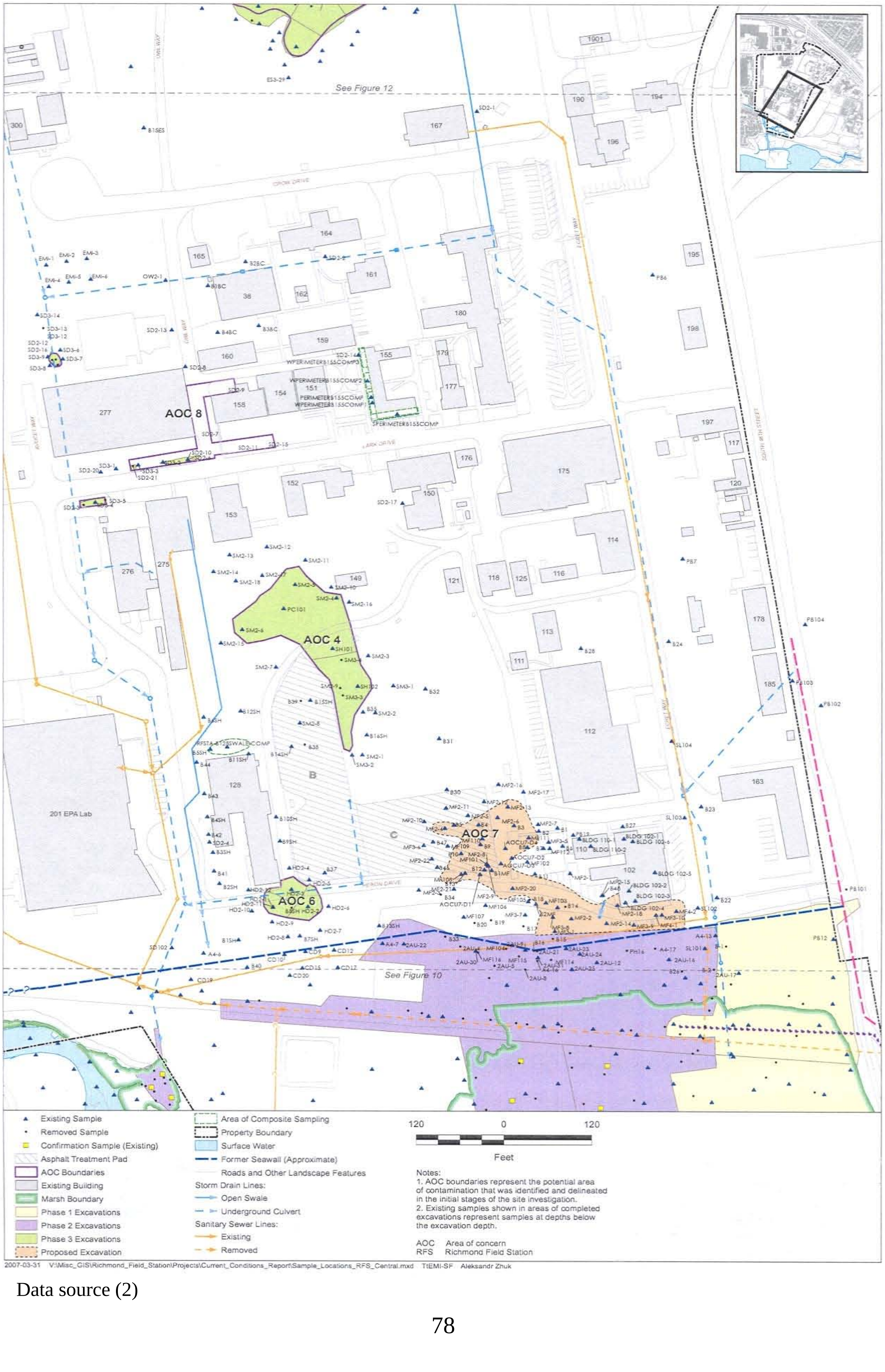
Figure 4. Location of Completed and Proposed Remediation Areas, University of California, Berkeley, Richmond Field Station, Richmond, California

Data source (2)

Figure 5a. Soil and Sediment Sampling Locations in the Northern Portion of the Site, University of California, Berkeley, Richmond Field Station, Richmond, California

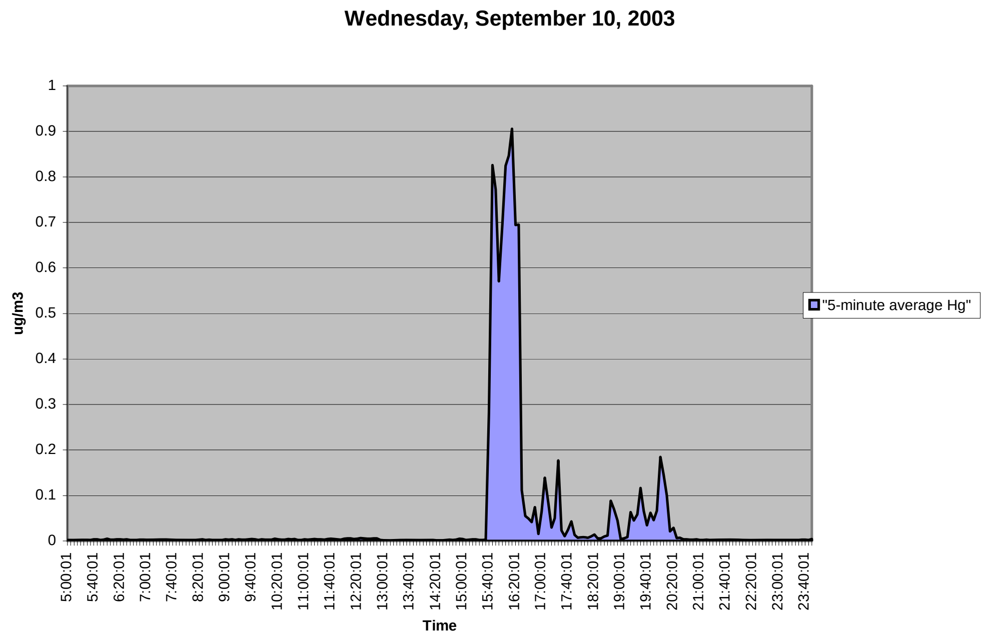
Data source (2)

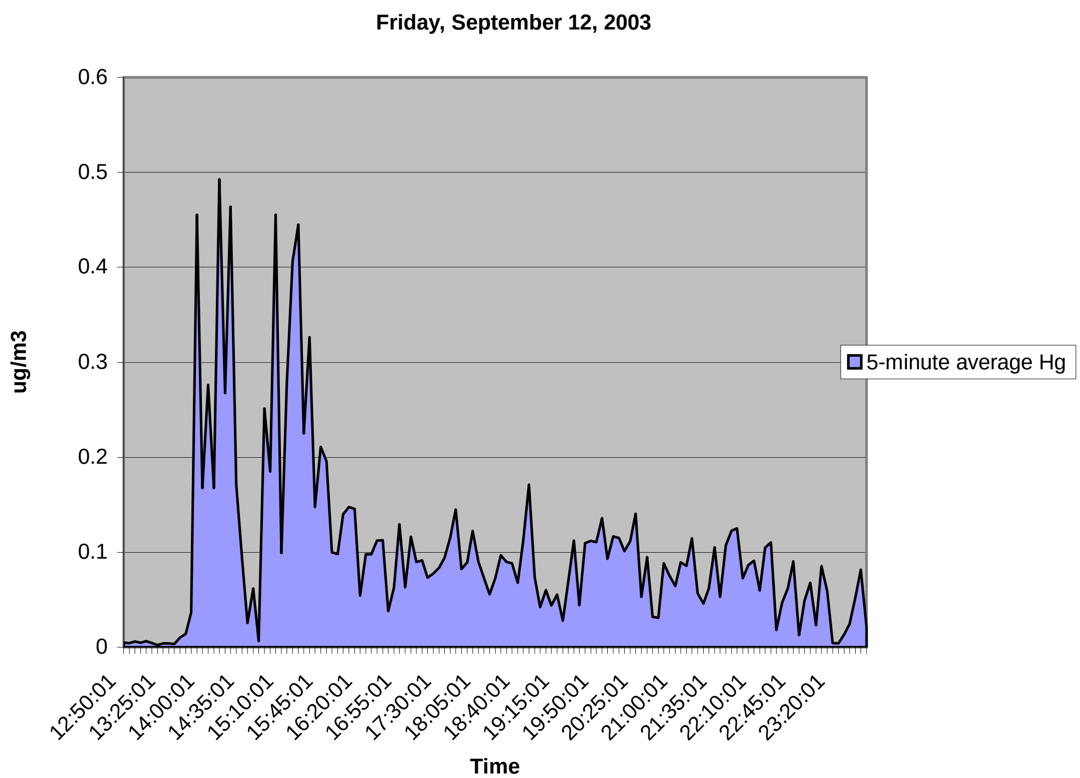
Figure 5b. Soil and Sediment Sampling Locations in the Central Portion of the Site, University of California, Berkeley, Richmond Field Station, Richmond, California



Data source (2)

Figure 6. Monitoring Results For the Two Days When Airborne Mercury Exceeded the Chronic Minimal Risk Level (MRL) at the U.S. Environmental Protection Agency Laboratory, University of California, Berkeley, Richmond Field Station, Richmond, California

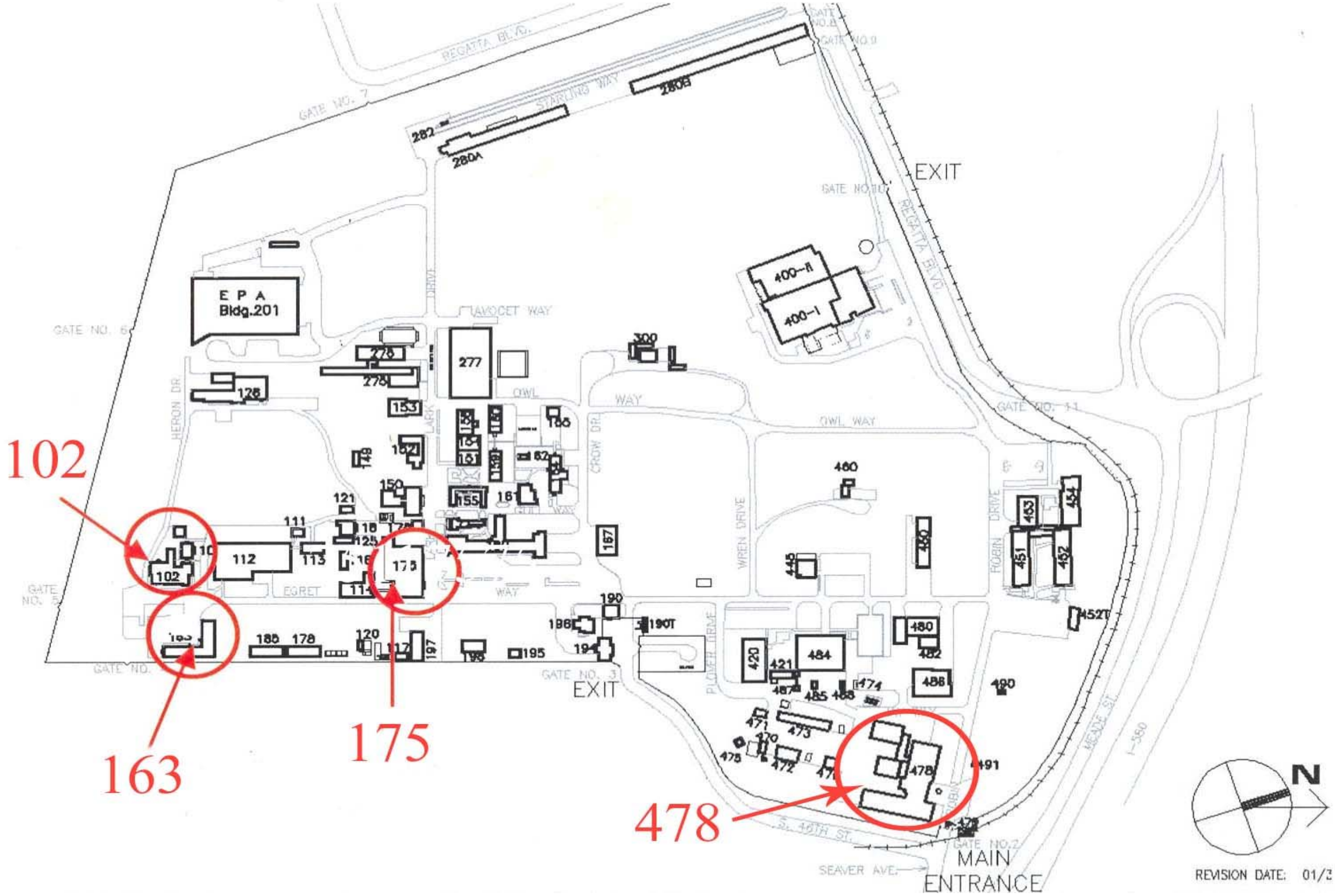




Data source (35)

MRL for mercury in air = 0.2 μg/m^3. The chronic MRL is a level at which exposure occurring for greater than 364 days would not be expected to result in noncancer adverse health effects. The Office of Environmental Health Hazard Assessment's Acute Reference Exposure Level for mercury in air = 1.8 μg/m^3. The acute REL is a level at which exposure occurring for 1-14 days would not result in noncancer adverse health effects.

Figure 7. Indoor Air Sampling Locations, University of California, Berkeley, Richmond Field Station, Richmond, California



Data sources (34, 38)

Appendix C. Tables

Table 1. Completed Exposure Pathways (Situations), University of California, Berkeley, Richmond Field Station, Richmond, California

Pathway Name	Contaminants of Concern	Pathway Elements					
		Source	Environmental Media	Point of Exposure	Route of Exposure	Potentially Exposed Population	Time
Western Stege Marsh, sediment and surface water	Metals, PCBs	RFS	Sediment, Water	Marsh	Ingestion (drinking), dermal (skin)	Adults and children/teenagers who come into contact with marsh sediment and surface water	Past, current, future
Western Stege Marsh restoration, sediment and surface water	Metals, PCBs	RFS	Sediment, Water	Marsh	Ingestion (drinking), dermal (skin)	Adults and children/teenagers who come into contact with marsh sediment and surface water during restoration activities	Current, future
On-site soil	Metals, PCBs	RFS	Soil	Soil	Ingestion (eating), dermal (skin)	RFS workers who dig in the soil	Past, current, future
Outdoor air during remedial work	Metals, dust	RFS	Air	Outdoor air	Inhalation (breathing)	Bay Trail users, Marina Bay residents, RFS workers	Past, current, future
Outdoor air	Metals, PCBs	RFS	Air	Outdoor air	Inhalation (breathing)	RFS workers	Current
Indoor air	Metals, VOCs	RFS	Air	Indoor air	Inhalation (breathing)	RFS workers	Current, future

Table 2. Summary of Contaminants Detected in Sediments in the Western Stege Marsh, University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical	Sediment in Marsh Still in Place (0-2 ft) Maximum Concentration at 0 ft (at 1-2 ft) (ppm)	Sediment/Surface Soil in Marsh Removed (0-1 ft) Maximum Concentration (ppm)	Post Restoration Removal Area (0-0.5 ft) Maximum Concentration (ppm)	Comparison/Screening Value (ppm)
Metals				
Arsenic	260[1] (520[2])	2,210[15]	590[23]	20 Chronic EMEG (child) 200 Chronic EMEG (adult) 0.07 Residential CHHSL 0.39 Residential PRG (Background = 3.5)
Cadmium	<0.32 (9.8[3])	33.7[16]	6.6[23]	10 Chronic EMEG (child) 100 Chronic EMEG (adult) 1.7 Residential CHHSL (Background = 0.36)
Copper	740[4] (1,500[2])	1,330[17]	900[24]	500 Chronic EMEG (child) 7,000 Chronic EMEG (adult) 3,000 Residential CHHSL 3,100 Residential PRG (Background = 28.7)
Lead	560[5]	814[18]	410[24]	150 Cal-modified PRG (Background = 23.9)
Mercury	69[4] (100[2])	10.6[19]	34[23]	23 Residential PRG (Background = 0.26)
Zinc	1,100[6] (4,200[7])	3,930[17]	1,700[24]	20,000 Chronic EMEG (child) 200,000 Chronic EMEG (adult) 23,000 Residential CHHSL (Background = 149)
Pesticides				
α-BHC (hexachloro cyclohexane)	0.0049[8]	<0.0076-<0.5	NA	0.09 Residential PRG
α-Chlordane	0.12[5]	NA	NA	30 Chronic EMEG (child) 400 Chronic EMEG (adult)
γ-Chlordane	0.15[5]	<0.0076-<0.5	NA	1.6 Residential PRG
DDD	<0.05-<0.12	0.178[20]	NA	3 CREG 2.4 Residential PRG
DDE	0.11[9]	<0.005-<0.5	NA	1.7 Residential PRG
DDT	<0.05-<0.12	0.54	NA	2 CREG 400 Intermediate EMEG
Dieldrin	0.8[5]	<0.005-<0.5	NA	3 Chronic EMEG (child) 40 Chronic EMEG (adult)
Endosulfan	0.0044[10]	<0.005-<0.5	NA	100 Chronic EMEG (child) 1,000 Chronic EMEG (adult)

Table 2. Summary of Contaminants Detected in Sediments in the Western Stege Marsh, University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical	Sediment in Marsh Still in Place (0-2 ft)	Sediment/Surface Soil in Marsh Removed (0-1 ft)	Post Restoration Removal Area (0-0.5 ft)	Comparison/Screening Value (ppm)
	Maximum Concentration at 0 ft (at 1-2 ft) (ppm)	Maximum Concentration (ppm)	Maximum Concentration (ppm)	
Methoxychlor	0.28	<0.005-<0.5	NA	300 Intermediate EMEG (child)
Pebulate	0.14[11]	NA	NA	33,800 Residential PRG
Polychlorinated Biphenyls (PCBs)				
PCBs-Aroclor 1248	39[12] (65[13])	1.4[21]	2.1[23]	0.50 Residential PRG
PCBs-Aroclor 1254	7.7[14] (25[13])	0.50[22]	0.39[6]	0.22 Residential PRG
PCBs-Aroclor 1260	0.69 (3.5[13])	<0.015-<1.9	0.096[6]	0.50 Residential PRG

Data sources (2, 12, 89, 90)
ft: feet; ppm: parts per million; NA: not analyzed; PCBs: Polychlorinated Biphenyls
PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal, based on noncancer health effects unless noted
EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (see Glossary, Appendix A)
CREG: Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide for 1 in 1,000,0000 increased cancer risk (see Glossary, Appendix A)
RMEG: U.S. Environmental Protection Agency Reference Dose Media Evaluation Guide (see Glossary, Appendix A)
([1–24]) = Sample locations for contaminants exceeding screening values: [1]SM179 at 0 ft; [2]MS16 at 2 ft; [3]SM155 at 0 ft; [4]MS15 at 0 ft; [5]MS22 at 0-0.5 ft; [6]Watershed 11 at 0-0.2 ft; [7]MS16 at 2.0 ft; [8]MS28 at 0 ft; [9]MS35 at 0 ft; [10]MS1 at 0-0.5 ft; [11]SM172 at 0.05 ft; [12]SM138 at 0-0.5 ft; [13] MS22 at 1-1.5ft; [14]Old Outfall 2 at 0-0.2 ft; [15]B10MA at 0 ft; [16]SD6MA at 0ft; [17]RFS-1 at 0 ft; [18]SD6MA at 0ft: [19]SD6MA at 0ft; [20]B8MA; [21]SM135 at 0-0.5 ft; [22]SM123 at 0-0.5 ft; [23]RMS18 at 0-0.5ft; [24]RMS26 at 0-0.5ft

Table 3. Contaminants Detected in Surface Water in the Western Stege Marsh, University of California, Berkeley, Richmond Field Station, Richmond, California

Contaminant	Past Concentrations (maximum / average concentrations detected in 1991 and 2002) (µg/L)	Current Concentrations (maximum concentration detected in 2006) (µg/L)	Comparison/Screening Value (Source) (µg/L)
Arsenic	1,570 / 744.2 (1991) † 59 (2002) †	18†	3 (child EMEG) 10 (adult EMEG)
Cadmium	53.8 / 6.1 (1991) † <5.0 (2002)	<5.0	1 (child EMEG) 17 (adult EMEG)
Copper	2,360 / 244.2 (1991) † 440† (2002)	23	100 (child EMEG) 400 (adult EMEG)
Chromium	132 / 15.0 (1991) <10 (2002)	<10	20,000 (child EMEG) 50,000 (adult EMEG)
Mercury	0.4 / 0.19 (1991) <0.2 (2002)	0.26	3 (child EMEG)* 10 (adult EMEG)*
Zinc	7,900 / 841.6 (1991) † 550 (2002)	470	3,000 (child EMEG) 10,000 (adult EMEG)
PCBs (as Aroclor 1248)	Not analyzed (1991) 1.4 / 0.0004 (2002)†	<0.96	0.02 (CREG)

Data sources (2, 14, 15)
µg/L: microgram per liter
CREG: Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide for 1 in 1,000,0000 increased cancer risk (see Glossary, Appendix A)
EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (see Glossary, Appendix A)
*EMEG for methylmercury (based on the potential for methylization of mercury in sediments and surface water)
†Values exceed health comparison screening values and are evaluated further
PCBs: Polychlorinated biphenyls

Table 4. Range of Concentrations for Contaminants Exceeding Comparison Values in Sediment Removed During Phase 1 and Phase 2 Remedial Activities in the Western Stege Marsh, University of California, Berkeley, Richmond Field Station, Richmond, California

Contaminant	Range of Concentrations (0-1 ft) (ppm)	Average Concentration (ppm)	Comparison/Screening Value (Source) (ppm)
Arsenic	<2.60-2,210	251.7	20 Chronic EMEG (child) 200 Chronic EMEG (adult)
Cadmium	1.60-33.70	7.5	10 Chronic EMEG (child) 100 Chronic EMEG (adult)
Copper	13.0-1,330	273.7	500 Chronic EMEG (child) 7,000 Chronic EMEG (adult)
Lead	8.90-814	156.1	150 Cal-modified PRG
Mercury	<0.044-10.6	5.2	23 Residential PRG
Zinc*	40.0-3,930	764.6	20,000 Chronic EMEG (child) 200,000 Chronic EMEG (adult) (Background = 158)
Total PCBs	<0.015-1.54	0.22	0.4 (CREG)

ft: feet; ppm: parts per million
*Zinc concentrations do not exceed comparison values in sediment; however, since past concentrations of zinc in surface water (Table 3) exceed comparison values, sediment was included in evaluation. Half the method detection limit was used for non-detects in calculating the average
CREG: Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide for 1 in 1,000,0000 increased cancer risk (see Glossary, Appendix A)
EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (see Glossary, Appendix A)

Table 5. Noncancer Dose Estimates for Contaminants Exceeding Screening Values in Sediment and Surface Water in the Western Stege Marsh and Health Comparison Values, University of California, Berkeley, Richmond Field Station, Richmond, California

Contaminant	Total Noncancer Dose Estimates Child/Teen (mg/kg/day)		Total Noncancer Dose Estimates Adult (mg/kg/day)		Toxicity/Health Comparison Value (source) (mg/kg/day)
	Past (prior to 2003)	**Current** (as of 2006)	**Past** (prior to 2003)	**Current** (as of 2006)	
Arsenic	Sediment 0.00007	Sediment 0.00017	Sediment 0.00002	Sediment 0.00003	0.0003 (MRL) 0.0008 (NOAEL)
	Surface water 0.00027	Surface water 0.000006	Surface water 0.00014	Surface water 0.0000005	
Cadmium	Sediment 0.0000007	Sediment 0.0000006	Sediment 0.0000002	Sediment 0.0000002	0.0002 (MRL) 0.0021 (NOAEL)
	Surface water 0.000002	Surface water ND	Surface water 0.000001	Surface water ND	
Copper	Sediment 0.00004	Sediment 0.00007	Sediment 0.00001	Sediment 0.00003	0.01 (MRL) 0.042 (NOAEL)
	Surface water 0.00009	Surface water 0.000008	Surface water 0.00005	Surface water 0.000004	
Mercury	Sediment 0.000008	Sediment 0.00001	Sediment 0.0000002	Sediment 0.000003	0.0003 (MRL)* 0.0013 (NOAEL)
	Surface water 0.00000007	Surface water 0.00000009	Surface water 0.00000004	Surface water ND	
Zinc	Sediment 0.00006	Sediment 0.0002	Sediment 0.00002	Sediment 0.00003	0.3 (MRL) 0.83 (NOAEL)
	Surface water 0.00029	Surface water 0.0002	Surface water 0.00016	Surface water 0.00009	
PCBs	Sediment 0.000002	Sediment 0.00005	Sediment 0.0000004	Sediment 0.00001	0.02 (MRL) 0.0005 (LOAEL-a)
	Surface water 0.00001	Surface water ND	Surface water 0.0000001	Surface water ND	

Data source (5). Maximum surface sediment values used for estimating current exposure doses; "past" calculation for surface water based on sample collected in 1991, prior to any remedial actions in the marsh; dose estimates include ingestion and dermal exposure; ND: not detected at laboratory detection limit; MRL: Agency for Toxic Substances and Disease Registry Minimal Risk Level; *MRL for methylmercury (based on the potential for methylization of mercury in sediments and surface water); NOAEL: No Observed Adverse Effect Level; LOAEL:-a Lowest Observed Adverse Effect Level – adjusted by a factor of 10 as a proxy for a NOAEL

Exposure assumptions used in estimating dermal dose surface water (16, 91, 92)

CW = concentration in water (mg/L)
P = permeability constant (cm/hour) (chemical specific: arsenic 0.001, cadmium 0.001, copper 0.001, mercury 0.001, zinc 0.0006)
Conversion factor = liters to cm^2
SA = Skin surface area (cm^2) (adult = 5809 cm^2) from EPA exposure factors handbook, averaging the 50^{th} percentile for lower legs feet and hands of females and males with that of the forearms of males (data not supplied for women). Skin surface area (child = 5323 cm^2) from EPA exposure factors handbook, averaging the 50^{th} percentile for total body surface area for males and females ages 8-15 multiplied by the percentage of total surface area that the legs, hands, and feet.
ET = exposure time (1 hour/day)
EF = exposure frequency (100 days/year)
ED = exposure duration – years of exposure (child: 10 years) (Adult: 26 years)
BW = body weight (kg) (for child 41.9 kg: average of 50^{th} percentile of females and males ages 8-15) (for adult 71.8 kg: average of women and men)
AT = averaging time (days) (ED * 365 days/year) for non carcinogen; averaging time for carcinogen dose is equal to 70 years * 365 days/year

Equation: (CW)(P)(0.001L/cm^2)(SA)(ET)(EF)(ED)/(BW)(AT)

Exposure assumptions used in estimating dermal dose from sediment (3, 16, 91)

CS = concentration in sediment (mg/kg)
SSA = soil to skin adherence factor (0.2 mg/cm^2) child/teenager; (0.07 mg/cm^2) adult
CF = Conversion factor (10^{-6} kg/mg)
SA = Skin surface area (cm^2 /event) – Skin surface area (adult = 5809 cm^2) from U.S. Environmental Protection Agency, Exposure Factors Handbook, averaging the 50^{th} percentile for lower legs feet and hands of females and males with that of the forearms of males (data not supplied for women). Skin surface area (child = 5323 cm^2) from EPA exposure factors handbook, averaging the 50^{th} percentile for total body surface area for males and females ages 8-15 multiplied by the percentage of total surface area that the legs, hands, and feet.
AF = Absorption factor (unitless) (chemical specific: arsenic 0.03, copper 0.01, mercury 0.01, zinc 0.001, PCBs 0.15)
Skin surface area (adult) from the U.S. Environmental Protection Agency (EPA) exposure factors handbook, averaging the 50^{th}
EF = exposure frequency (100 events/year)
ED = exposure duration – years of exposure (child: 10 years) (adult: 26 years)
BW = body weight (for child 41.9 kg: average of 50^{th} percentile of females and males ages 8-15) (for adult 71.8 kg: average of women and men)
AT = averaging time (ED * 365 days/year) for non carcinogen

Equation: (CS)(SSA)(CF)(SA)(AF)(EF)(ED)/(BW)(AT)

Exposure assumptions used in estimating ingestion dose from surface water

Cw = chemical Concentration in Water (mg/L)
IR = ingestion rate (0.05 liter/hour)
ET = exposure time (1 hour/day)
EF = exposure frequency (100 days/year)
ED = exposure duration – years of exposure (child: 10 years) (adult: 26 years)
BW = body weight (kg) (for child 41.9 kg: average of 50^{th} percentile of females and males ages 8-15) (for adult 71.8 kg: average of women and men)
AT = averaging time (days) (ED * 365 days/year) for non carcinogen; averaging time for carcinogen dose is equal to 70 years * 365 days/year

Equation: (CW)(IR)(ET)(EF)(ED)/(BW)(AT)

Exposure assumptions used in estimating ingestion dose from sediment (3, 16)

CS = chemical concentration in sediment (mg/kg)
IR = ingestion rate (mg/day) – (adult 100 mg/day)(child 200 mg/day) – over 16 hours (time spent awake)
ET = exposure time (1 hour/day)
EF = exposure frequency (100 days/year)
ED = exposure duration – years of exposure (child: 10 years) (adult: 26 years)
CF = conversion factor (10^{-6} kg/mg)
BW = body weight (kg) (for child 41.9 kg: average of 50^{th} percentile of females and males ages 8-15) (for adult 71.8 kg: average of women and men)
AT = averaging time (days) (ED * 365 days/year) for non carcinogen
IR adjusted to account for 1 hour ET

Equation: (CS)(IR)(ET)(EF)(ED)(CF)/(BW)(AT)(16)

Table 6. Estimated Hazard Quotients and Hazard Index for Children and Adults Recreating in the Western Stege Marsh, University of California, Berkeley, Richmond Field Station, Richmond, California

Contaminant	Hazard Quotients			
	Surface Water Past (prior to 2003)	Surface Water Current/Future	Sediment Past (prior to 2003)	Sediment Current/Future
Arsenic	0.9 (child/teen) 0.5 (adult)	0.02 (child/teen) 0.01 (adult)	0.2 (child/teen) 0.06 (adult)	0.6 (child/teen) 0.1 (adult)
Cadmium	0.01 (child/teen) 0.006 (adult)	ND	0.003 (child/teen) 0.001 (adult)	0.003 (child/teen) 0.0008 (adult)
Copper	0.009 (child/teen) 0.005 (adult)	0.0008 (child/teen) 0.0004 (adult)	0.004 (child/teen) 0.0003 (adult)	0.002 (child/teen) 0.0009 (adult)
Mercury	0.0002 (child/teen) 0.0001 (adult)	0.03 (child/teen) 0.001 (adult)	0.002 (child/teen) 0.0005 (adult)	0.03 (child/teen) 0.009 (adult)
Zinc	0.001 (child/teen) 0.0005 (adult)	0.0005 (child/teen) 0.0003 (adult)	0.0001 (child/teen) 0.00004 (adult)	0.0005 (child/teen) 0.0001 (adult)
Total Polychlorinated biphenyls (PCBs)	0.7 (child/teen) 0.5 (adult)	ND	0.08 (child/teen) 0.02 (adult)	2.7 (child/teen) 0.6 (adult)
Hazard Index				
	1.6 (child/teen) 0.5 (adult)	0.05 (child/teen) 0.01 (adult)	0.3 (child/teen) 0.08 (adult)	3.2 (child/teen) 0.7 (adult)

Hazard quotient: intake dose/toxicity value
Hazard Index: sum of hazard quotients
Hazard quotients include ingestion and dermal exposure
ND: not detected at laboratory detection limit

Table 7. Average Concentration of Contaminants in Sediment from the Remediated Portions of the Western Stege Marsh and Noncancer Dose Estimates, Health Comparison Values and Hazard Quotient and Hazard Index for Adults and Youth Restoring the Western Stege Marsh, University of California, Berkeley, Richmond Field Station, Richmond, California

Contaminant	Average Contaminant Concentration (mg/kg)	Estimated Dose (mg/kg/day)	Toxicity/Health Comparison Values (source) (mg/kg/day)	Hazard Quotient
Arsenic	53.9	Sediment 0.00002 (child/teen) 0.00001 (adult) Surface water 0.00002 (child/teen) 0.000009 (adult)	0.0003 (MRL) 0.0008 (NOAEL)	Sediment 0.08 (child/teen) 0.04 (adult) Surface water 0.05 (child/teen) 0.03 (adult)
Cadmium		Sediment 0.0000004 (child/teen) 0.0000001 (adult) None for surface water	0.0002 (MRL) 0.0021 (NOAEL)	Sediment 0.0002 (child/teen) 0.00005 (adult)
Copper 1.64	133	Sediment 0.00004 (child/teen) 0.00001 (adult) Surface water 0.00002 (child/teen) 0.00001 (adult)	0.01 (MRL) 0.042 (NOAEL)	Sediment 0.004 (child/teen) 0.001 (adult) Surface water 0.002 (child/teen) 0.001 (adult)
Mercury		Sediment 0.0000007 (child/teen) 0.0000004 (adult) Surface water 0.00002 (child/teen) 0.00001 (adult)	0.0003 (MRL)* 0.0013 (NOAEL)	Sediment 0.003 (child/teen) 0.001 (adult) Surface water 0.001 (child/teen) 0.0008 (adult)

3.32

Table 7. Average Concentration of Contaminants in Sediment from the Remediated Portions of the Western Stege Marsh and Noncancer Dose Estimates, Health Comparison Values and Hazard Quotient and Hazard Index for Adults and Youth Restoring the Western Stege Marsh, University of California, Berkeley, Richmond Field Station, Richmond, California

Contaminant	Average Contaminant Concentration (mg/kg)	Estimated Dose (mg/kg/day)	Toxicity/Health Comparison Values (source) (mg/kg/day)	Hazard Quotient
PCBs	0.213	Sediment 0.0000003 (child/t teen) 0.0000002 (adult) None for surface water	0.00002 (MRL) 0.0005 (LOAEL-a)	Sediment 0.01 (child/teen) 0.008 (adult)
Hazard Index				Sediment 0.1 (child/teen) 0.05 (adult) Surface water 0.1 (child/teen) 0.07 (adult)

Data source (12)
Dose estimates include ingestion and dermal exposure to sediment
MRL: Agency for Toxic Substances and Disease Registry Minimal Risk Level (http://www.atsdr.cdc.gov/mrls/)
NOAEL: No Observed Adverse Effect Level
LOAEL:-a Lowest Observed Adverse Effect Level – adjusted by a factor of 10 as a proxy for a NOAEL
*MRL for methylmercury (based on the potential for methylization of mercury in sediments)
Hazard Quotient: intake dose/toxicity value
Hazard Index: sum of hazard quotients

Exposure assumptions used in estimating dermal dose sediment (3, 16, 91, 92)
CS = concentration in sediment (mg/kg)
SSA = soil to skin adherence factor (0.2 mg/cm^2) child/teenager; (0.07 mg/cm^2) adult
CF = Conversion factor (10^{-6} kg/mg)
SA = Skin surface area (cm^2 /event) – Skin surface area (adult = 5809 cm^2) from U.S. Environmental Protection Agency, Exposure Factors Handbook, averaging the 50th percentile for lower legs feet and hands of females and males with that of the forearms of males (data not supplied for women). Skin surface area (child = 5323 cm^2) from EPA exposure factors handbook, averaging the 50th percentile for total body surface area for males and females ages 8-15 multiplied by the percentage of total surface area that the legs, hands, and feet.

AF = Absorption factor (unitless) (chemical specific: arsenic 0.03, copper 0.01, mercury 0.01, zinc 0.001, PCBs 0.15)
Skin surface area (adult) from the U.S. Environmental Protection Agency (EPA) exposure factors handbook, averaging the 50^{th}
EF = exposure frequency (100 events/year)
ED = exposure duration – years of exposure (child: 8 years) (adult: 8 years)
BW = body weight (for child 41.9 kg: average of 50^{th} percentile of females and males ages 8-15) (for adult 71.8 kg: average of women and men)
AT = averaging time (ED * 365 days/year) for non carcinogen; AT for carcinogens (365 days/year*70 years)
Equation: (CS)(SSA)(CF)(SA)(AF)(EF)(ED)/(BW)(AT)

Exposure assumptions used in estimating ingestion dose from sediment (3, 16)
CS = chemical concentration in sediment (mg/kg)
IR = ingestion rate (mg/day) – (adult 100 mg/day)(child 200 mg/day) over 16 hours (time spent awake) (IR adjusted to account for 2.6 ET)
ET = exposure time (2.6 hour/day)
EF = exposure frequency (100 days/year)
ED = exposure duration – years of exposure (child: 8 years) (adult: 8 years)
CF = conversion factor (10^{-6} kg/mg)
BW = body weight (kg) (for child 41.9 kg: average of 50^{th} percentile of females and males ages 8-15) (for adult 71.8 kg: average of women and men)
AT = averaging time (days) (ED * 365 days/year) for non carcinogen; AT for carcinogens = (365 days/year*70 years)
Equation: (CS)(IR)(ET)(EF)(ED)(CF)/(BW)(AT)(16)

Exposure assumptions used in estimating dermal dose from surface water (3, 16, 91, 92)
CW = concentration in water (mg/L)
P = permeability constant (cm/hour) (chemical specific: arsenic 0.001, cadmium 0.001, copper 0.001, mercury 0.001, zinc 0.0006)
Conversion factor = liters to cm^2
SA = Skin surface area (cm^2) (adult = 5809 cm^2) from EPA exposure factors handbook, averaging the 50^{th} percentile for lower legs feet and hands of females and males with that of the forearms of males (data not supplied for women). Skin surface area (child = 5323 cm^2) from EPA exposure factors handbook, averaging the 50^{th} percentile for total body surface area for males and females ages 8-15 multiplied by the percentage of total surface area that the legs, hands, and feet.
ET = exposure time (2.6 hour/day)
EF = exposure frequency (100 days/year)
ED = exposure duration – years of exposure (child: 8 years) (adult: 8 years)
BW = body weight (for child 41.9 kg: average of 50^{th} percentile of females and males ages 8-15) (for adult 71.8 kg: average of women and men)
AT = averaging time (ED * 365 days/year) for non carcinogen; AT for carcinogens = (365 days/year*70 years)
Equation: (CW)(P)(0.001L/cm^2)(SA)(ET)(EF)(ED)/(BW)(AT)

Exposure assumptions used in estimating ingestion dose from surface water (3, 16)
CW = chemical concentration in water (mg/L)
IR = ingestion rate (0.05 liter/hour)
ET = exposure time (2.6 hour/day)
EF = exposure frequency (100 days/year)
ED = exposure duration – years of exposure (child: 8 years) (adult: 8 years)
BW = body weight (kg) (for child 41.9 kg: average of 50^{th} percentile of females and males ages 8-15) (for adult 71.8 kg: average of women and men)
AT = averaging time (days) (ED * 365 days/year) for non carcinogen; AT for carcinogens = (365 days/year*70 years)
Equation: (CW)(IR)(ET)(EF)(ED)/(BW)(AT)

Table 8. Summary of Contaminants Detected in the Richmond Field Station Soil and Comparison/Screening Values, University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical	Surface and Near Surface Soil in Exposed, Non- excavated Areas (0-4 ft bgs)		Surface Soil and Near Surface Soil in Excavated Areas (0-4 ft bgs)		Comparison/Screening Value (ppm) (Background Level)
	Maximum Concentration (ppm)	Average Concentration (ppm)	Maximum Concentration (ppm	Average Concentration (ppm)	
Metals					
Antimony	4.8	4.1	ND (<3.1)		380 CHHSL 342 Industrial PRG
Arsenic	1,300[1] (removed 10/07) 700[15]	15.9	150[2]	10.7	200 Chronic EMEG 0.24 CHHSL 1.6 Industrial PRG (Background = 3.5)
Barium	310	226	Not analyzed		63,000 CHHSL 175,000 Industrial PRG
Beryllium	2.5	0.47	1.0	0.45	1,700 CHHSL 1,300 Industrial PRG
Cadmium	437[3]	3.34	6.1[4]	1.84	100 chronic EMEG 7.5 CHHSL 450 Industrial PRG (Background = 0.36)
Chromium	110	36.2	170	39.7	10,000 CHHSL 734,000 Industrial PRG
Copper	13,000[5]	104	4,000[6]	286	3,800 CHHSL 3,100 Industrial PRG (Background = 28.7)
Lead	1,140[7]	35.1	1,000[10]	57.5	800 Industrial PRG (23.9 Background)
Mercury	270[9]	26.7	140[10]	4.24	180 CHHSL 310 Industrial PRG (Background = 0.26)

Table 8. Summary of Contaminants Detected in the Richmond Field Station Soil and Comparison/Screening Values, University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical	Surface and Near Surface Soil in Exposed, Non- excavated Areas (0-4 ft bgs)		Surface Soil and Near Surface Soil in Excavated Areas (0-4 ft bgs)		Comparison/Screening Value (ppm) (Background Level)
	Maximum Concentration (ppm)	Average Concentration (ppm)	Maximum Concentration (ppm	Average Concentration (ppm)	
Molybdenum	3.6	2.44	Not analyzed		4,800 CHHSL 5,580 Industrial PRG
Nickel	230	45.2	78	48.5	16,000 CHHSL 22,000 Industrial PRG
Selenium	4.5	0.85	3.1	0.76	4,800 CHHSL 5,590 Industrial PRG
Silver	1.9	0.66	1.1	0.13	4,800 CHHSL 5,480 Industrial PRG
Thallium	9.4	1.23	2.7	0.67	63 CHHSL 87.9 Industrial PRG
Vanadium	60	46.4	Not analyzed		6,700 CHHSL 4,790 Industrial PRG
Zinc	2,150	115	480	108	100,000 CHHSL 330,000 Industrial PRG
Pesticides					
α-BHC (hexachloro-cyclohexane)	ND (<0.058)		0.0418	0.0418	0.36 Industrial PRG
γ-Chlordane	0.092	0.089	ND (<0.038)		1.7 CHHSL 5.6 Industrial PRG
DDD	ND (<0.0075)		0.33	0.22	3 CREG 9.0 CHHSL 12.1 Industrial PRG
DDE	0.047	0.073	ND (<0.0075)		6.3 CHHSL 8.5 Industrial PRG

Table 8. Summary of Contaminants Detected in the Richmond Field Station Soil and Comparison/Screening Values, University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical	Surface and Near Surface Soil in Exposed, Non- excavated Areas (0-4 ft bgs)		Surface Soil and Near Surface Soil in Excavated Areas (0-4 ft bgs)		Comparison/Screening Value (ppm) (Background Level)
	Maximum Concentration (ppm)	Average Concentration (ppm)	Maximum Concentration (ppm	Average Concentration (ppm)	
DDT	0.38	0.13	0.22	0.13	400 Intermediate EMEG 6.3 CHHSL 7.2 Industrial PRG 2 CREG
Dieldrin	0.0082	0.036	ND (<0.0075)		40 Chronic EMEG (adult) 0.13 CHHSL 0.16 Industrial PRG
Polychlorinated biphynels (PCBs)					
PCBs-Aroclor 1248	5.2[11]	1.46	430[11]	15.2	0.78 Industrial PRG
PCBs-Aroclor 1254	0.69[12]	0.13	7.1[13]	0.47	0.74 Industrial PRG
PCBs-Aroclor 1260	0.33[14]	0.07	15[11]	0.55	0.73 Industrial PRG

Data sources (2, 7, 23, 90)
Average concentration calculated using ½ the detection limit for non-detects.
ft: feet; bgs: below ground surface; ppm: parts per million
ND: not detected; detection limit not available; NA: not analyzed
CHHSL: California Environmental Protection Agency Human Health Screening Level for industrial/commercial land use
PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal
EMEG: Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide for an adult resident (intermediate: exposure duration lasting between 14-365 days; chronic: exposure duration lasting longer than 365 days) (see Glossary, Appendix A)
CREG: Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide for 1 in 1,000,0000 increased cancer risk (see Glossary, Appendix A)
RMEG: U.S. Environmental Protection Agency Reference Dose Media Evaluation Guide (see Glossary, Appendix A)

([1–14]) = Sample locations for contaminants exceeding screening values: [1] WTA45 at 0-0.5ft; [2] FP2-5 at 0ft; [3] B2MF at 1.5 ft; [4] SH2-7 at 0 ft; [5] BI6SH at 1-3 ft; [6] TP2-7 at 0 ft; [7] B2MF at 1 ft; [8] SM2-4 at 0 ft; [9] AOCU7-D1 at 0ft; [10] SH101 at 0 ft; [11]SD2-10 at 0.5-1 ft; [12]HD2-9 at 0 ft; [13]HD2-1 at 0 ft; [14]SD2-9 at 0.5-1 ft; [15]BLB-2 at 3 ft;

Table 9. Estimated Concentration of Contaminants in Ambient Air from Resuspension of Soil During Excavation/Soil Disturbing Activities and Comparison Values, University of California, Berkeley, Richmond Field Station, Richmond, California

Contaminant	Soil Concentration (mg/kg)	Estimated Concentration in Ambient Air (µg/m^3)	Air Comparison Value (µg/m^3)
Arsenic	1,300 (prior to 10/2007) 700	1.3 0.7	0.03 Chronic REL 0.00045 PRG†
Cadmium	437	0.437	0.02 Chronic REL 0.001 PRG†
Copper	13,000	13	Not available
Mercury	270	0.27	Not available
Total PCBs	452	0.452	0.0034 PRG†

Data sources (2, 8, 9, 23)
REL: Office of Environmental Health Hazard Assessment Reference Exposure Level
PRG†: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal for ambient air (exposure occurring for greater than 364 days; based upon cancer endpoint (level reflects 1 in 1,000,000 increased cancer risk, considered no apparent increased risk)

Conversion from soil to an ambient air concentration: CA = (CS/PEF)(1000 µg/mg)
CA = concentration in air µg/mg^3
CS = concentration in soil
PEF = particulate emission factor for PM-10 during excavation/soil disturbing activities (1.0E+6) (93)

Table 10. Non Cancer Dose Estimates, Health Comparison Values and Hazard Index for Richmond Field Station Workers Who Dig in On-Site Soil, University of California, Berkeley, Richmond Field Station, Richmond, California

Contaminant	Estimated Dose Long-Term Past Exposure (maximum concentration) (mg/kg/day)	Estimated Dose Short-Term Current Exposure (maximum concentration) (mg/kg/day)	Toxicity/Health Comparison Value (Source) (mg/kg/day)	Hazard Quotient
Arsenic	0.00049	0.00026	0.0003 (MRL) 0.0008 (NOAEL)	4.4 (long-term) 2.4 (short-term)
Cadmium	0.00014	0.00014	0.0002 (MRL) 0.0021 (NOAEL)	0.7 (long-term) 0.7 (short-term)
Copper	0.0045	0.0045	0.01 (MRL) 0.042 (NOAEL)	0.5 (long-term) 0.5 (short-term)
Mercury	0.00009	0.00009	0.02 (RfD)* 0.23 (NOAEL)	0.3 (long-term) 0.3 (short-term)
			Hazard Index (metals) →	5.9 (long-term) 3.9 (short-term)
Total PCBs	0.00024	0.000003	0.00002 (MRL) 0.0005 (LOAEL-a)	12.3 (long-term) 0.3 (short-term)

Dose estimates include ingestion, dermal contact, and inhalation exposure
*RfD for mercuric chloride

Hazard quotient: intake dose/toxicity value
Hazard Index: sum of hazard quotients
LOAEL: Lowest Observed Adverse Effect Level; adjusted by a factor of 10 as a proxy for a NOAEL
Conversion from REL to RfDi used for calculating inhalation portion of hazard quotient
RfDi (mg/kg-day) = (REL)(µg/m^3)(20 m$^{3/}$day)(1/70 kg)(0.001mg/µg)
RfDi = reference dose inhalation: arsenic = 0.000009; cadmium = 0.000006

Exposure assumptions used in estimating dermal dose (16, 91, 92)

CS = concentration in soil (mg/kg)
SSA = soil to skin adherence factor (0.07 mg/cm^2)
CF = conversion factor (10^{-6} kg/mg)
AF = absorption factor (unitless) (chemical specific: arsenic 0.03, copper 0.01, mercury 0.01, PCBs 0.15)
SA = Skin surface area (cm^2 /event) – Skin surface area (adult = 5210 cm^2) from U.S. Environmental Protection Agency, Exposure Factors Handbook, averaging the 50^{th} percentile for hands, arms, forearms of males.
EF = exposure frequency (100 events/year)
ED = exposure duration – years of exposure (long-term: 23 years) (short-term: 7 years)
BW = body weight (71.8 kg: average of women and men)
AT = averaging time (ED * 365 days/year)

Equation: (CS)(SSA)(CF)(SA)(AF)(EF)(ED)/(BW)(AT)

Exposure assumptions used in estimating inhalation dose (16, 91, 93)

CA = estimated concentration in ambient air ($\mu g/m^3$)
IR = Inhalation rate 20 $\mu g/m^3$/day for an 8-hour workday
EF = exposure frequency (100 events/year)
ED = exposure duration – years of exposure (long-term: 23 years) (short-term: 7 years)
CF = conversion factor 0.001 (mg/µg)
BW = body weight (71.8 kg: average of women and men)
AT = averaging time (ED * 365 days/year)
IR rate averaged to account for 2 hour exposure period

Equation: (CA)(IR/4)(ET)(EF)(ED)(CF)/(BW)(AT)

Exposure assumptions used in estimating ingestion dose (16, 93)

CS = chemical concentration in soil (mg/kg)
IR = ingestion rate (330 mg/day): estimated intake for adults engaged in outdoor activities over an 8 hour time period
ET = exposure time (2 hours/day)
EF = exposure frequency (100 days/year)
ED = exposure duration – years of exposure (long-term: 23 years) (short-term: 7 years)
CF = Conversion Factor (10^{-6} kg/mg)
BW = body weight (kg) (71.8 kg: average of women and men)
AT = averaging time (days) (ED * 365 days/year)
IR rate averaged to account for 2 hour exposure period

Equation: (CS)(IR/4)(ET)(EF)(ED)(CF)/(BW)(AT)

Table 11. Mercury Levels Measured in Ambient Air On-Site During the Phase 2 Remedial Work (2003), University of California, Berkeley, Richmond Field Station, Richmond, California

Date	9/12	9/13	9/15	9/15	9/15	9/15	9/15	9/15	9/16	9/16	9/16	9/16	9/17	9/17	9/17	9/19	9/19	9/22	9/22	9/23	9/23	
Time →			9:30	10:30	11:30	13:30	14:30	16:30	8:30	11:30	13:30	16:30	9:30	11:30	14:00	10:30	14:30	11:30	14:30	11:30	13:30	MEAN
Station																						
1	**0.004**	<0.003	0.006	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003		<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	**0.003**	0.00065
2	**0.004**	<0.003	**0.004**	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.00038
3	**0.006**	<0.003	**0.006**	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	**0.003**	<0.003	**0.004**	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.00090
4	<0.003	<0.003	**0.004**	<0.003	**0.005**	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	**0.005**	<0.003	<0.003	<0.003	<0.003	<0.003	**0.004**	<0.003	<0.003	**0.004**	0.00105
5	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003		<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.00000
6	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003		<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.00000
7	<0.003	<0.003																				
8	**0.004**	<0.003																				
9	<0.003	<0.003																				
10	<0.003	<0.003																				

Detected values in **bold**
Samples collected using a Jerome Mercury Vapor Analyzer (field instrument) with a detection limit of 3 μg/m^3 (0.003 mg/m^3)
Acute Reference Exposure Level (REL) = 1.8 μg/m^3

Table 12. Estimated Levels of Contaminants in Ambient Air from Resuspension of Soil and Screening Values, University of California, Berkeley, Richmond Field Station, Richmond, California

Contaminant	Average Soil Concentration (mg/kg)	Estimated Ambient Air Concentration (µg/m^3)	Ambient Air Screening Values (source) (µg/m^3)
Arsenic	15.9	0.00001	0.03 (REL) 0.00045 (PRG) †
Cadmium	3.34	0.000003	0.02 (REL) 0.001 (PRG) †
Copper	286	0.0002	Not available
Mercury	4.24	0.00002	Not available
Total PCBs	16.2	0.00001	Not available

Data sources (2, 8, 9, 23)
REL: Office of Environmental Health Hazard Assessment Reference Exposure Level
PRG†: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal for ambient air (exposure occurring for greater than 364 days; based upon cancer endpoint (level reflects 1 in 1,000,000 increased cancer risk, considered no apparent increased risk)

Conversion from soil to an ambient air concentration: CA = (CS/PEF)(1000 µg/mg)
CA = concentration in air µg/mg^3
CS = concentration in soil
PEF = particulate emission factor for PM-10 residential (no construction activities underway) (1.32E+9) (93)

Table 13. Common Sources of Chemicals Found in Indoor Air, University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical Name	Sources
Acetone	Used as a common solvent.
Acetonitrile	Found in certain lithium batteries. Used to make plastics, synthetic rubber, and acrylic fibers. Used as a common solvent in laboratories.
Acrolein	Used in plastics, perfumes, aquatic herbicides. Also found in cigarette smoke and automobile exhaust.
Benzene	Found in cigarette smoke, gasoline, crude oil, and used as a solvent. May be an ingredient of household products such as glues, paints, furniture wax, and detergents.
2-Butanone	Found in paints, coatings, glues, cleaning agents, and cigarette smoke. It occurs naturally in some fruit and trees. Also known as Methyl Ethyl Ketone or MEK.
tert-Butyl alcohol	Found as flavors, in perfumes, in paint remover, as a gasoline booster, and in solvents.
Carbon disulfide	Used in the manufacturing of rayon, in soil disinfectants, and in solvents.
Chlorobenzene	Used as a solvent for paints, pesticides.
Chloroethane	Used as a refrigerant, solvent. Also used in making cellulose, dyes, medicinal drugs.
Chloromethane	Byproduct of burning grasses, wood, cigarettes, charcoal, or plastic. Found in styrofoam insulation, aerosol propellants, and chlorinated swimming pools.
Dichlorodifluoromethane	Used as a refrigerant, aerosol propellant, and solvent. Also known as Freon 12.
cis-1,2-Dichloroethene	Found in perfumes, dyes, lacquers, solvents, and products made from natural rubber.
Ethylbenzene	Used as a common solvent, and found in gasoline, inks, insecticides, and paints. Also found in cigarette smoke.
4-Ethyltoluene	Used as a solvent, found in kerosene and light vapor oil.
Formaldehyde	Used in production of adhesives and binders for wood, plastics, textiles, furniture, carpet, leather and related industries. Also found in vehicle emissions, cigarette smoke, disinfectants and food.

Table 13. Common Sources of Chemicals Found in Indoor Air, University of California, Berkeley, Richmond Field Station, Richmond, California

Chemical Name	Sources
Heptane/Hexane	Found in petroleum products, is often mixed with other solvents, and is used as a filling for thermometers.
Isooctane	Found in petroleum, gasoline, solvents, and thinners. A component of the “odor” of gasoline.
Methyl t-butyl ether	Used as an additive in unleaded gasoline.
Pentane	Found in petroleum, gasoline.
Propene	A flammable propellant, produced from petroleum cracking.
Styrene	Found in synthetic rubbers, resins, insulators.
Tetrachloroethylene	Used in dry cleaning and as a degreaser. When clothes are brought home from the drycleaners, they often release small amounts of tetrachloroethylene into the air.
Toluene	Used as a common solvent, and found in gasoline, paints and lacquers. Also found in cigarette smoke.
1,1,1-Trichloroethane	Used as a degreaser, in solvents, and as an aerosol propellant.
Trichloroethylene	Used as a degreasing agent. It is also a common ingredient in cleaning agents, paints, adhesives, varnishes, and inks.
Trichlorofluoromethane	Used as refrigerant, aerosol propellant, and solvent. Also known as Freon 11.
1,2,4-Trimethylbenzene	Used to make drugs and dyes, in gasoline and certain paints and cleaners.
1,3,5-Trimethylbenzene	Component in diesel exhaust.
Xylenes	Used as a solvent, cleaning agent, and thinner for paints, and in fuels and gasoline.

Data source (94)

Table 14. Contaminants Detected in Indoor and Outdoor Air on the Richmond Field Station, and Health Comparison Values, University of California, Berkeley, Richmond Field Station, Richmond, California

Contaminant	Date Sampled	Sample Location Sample Results (µg/m³)			Health Comparison Value (µg/m³)
		Building 163	Building 175	Building 175 Roof	
Arsenic (metal)	8/16/05 9/20/05	**0.098*** < 0.05	**0.085*** < 0.05	< 0.08	0.19 (acute REL) 0.03 (chronic REL) 0.0002 (CREG)
Volatile Organic Chemicals					
Acetone	9/21/05	25	17	7.6	30,881 (MRL) 365 (PRG)
Benzene	9/21/05	**1.3**	< 0.30	< 0.30	60 (REL) 0.10 (CREG) 160 (MRL)
Bromoethane	9/21/05	11	< 0.68	< 0.68	19.4 (MRL)
Bromoform	9/21/05	6.3	< 1.2	< 1.2	0.9 (CREG)
Carbon Disulfide	9/21/05	19	< 0.40	< 0.40	800 (chronic REL)
Chloroform	9/21/05	< 0.62	< 0.62	**0.78**	300 (REL) 0.04 (CREG)
Chloromethane	9/21/05	< 0.39	2.1	< 0.39	90 (RfC)
1,2-Dibromoethane	9/21/05	**1.8**	< 0.90	< 0.90	9 (RfC) 0.002 (CREG)
Dichlorodifluoromethane	9/21/05	2.5	3.7	2.5	200 (RfC)
Formaldehyde	9/21/05 10/20/05	**410*** **0.16, 0.12, 0.16**	**37*** not sampled	**12*** not sampled	94 (acute REL) 3 (chronic REL) 40 (acute MRL) 0.08 (CREG)
Freon 11 (Trichlorofluoromethane)	9/21/05	1.2	1.7	1.2	730 (PRG)
Hexane	9/21/05	< 0.49	1.9	< 0.49	7,000 (REL) 2,100 (MRL) 210 (PRG)

Table 14. Contaminants Detected in Indoor and Outdoor Air on the Richmond Field Station, and Health Comparison Values, University of California, Berkeley, Richmond Field Station, Richmond, California

Contaminant	Date Sampled	Sample Location Sample Results (µg/m^3)			Health Comparison Value (µg/m^3)
		Building 163	Building 175	Building 175 Roof	
Methylene chloride	9/21/05	**4.0**	2.0	0.45	3.0 (CREG) 4.1 (PRG†)
Propene	9/21/05	6.2	3.6	< 0.17	not available
Styrene	9/21/05	0.73	< 0.27	< 0.27	260 (MRL) 900 (REL) 1,100 (PRG)
Tetrachloroethylene	9/21/05	< 0.79	< 0.79	**2.6**	270 (MRL) 35 (REL) 0.32 (PRG†)
Toluene	9/21/05	2.8	7.3	< 0.45	300 (MRL) 300 (REL) 400 (PRG)
Trichlororethylene	9/21/05	**1.4**	< 0.59	< 0.59	40 (RfC) 540(REL) 0.017 (PRG†)
1,2,4-Trimethylbenzene	9/21/05	< 0.37	0.65	< 0.37	6.2 (PRG)
m,p-Xylene	9/21/05	< 0.93	2.2	< 0.93	700 (chronic REL)
o-Xylene	9/21/05	< 0.45	0.61	< 0.45	700 (chronic REL)

*exceeds noncancer health comparison
bolded values exceed cancer comparison values
REL: Office of Environmental Health Hazard Assessment Reference Exposure Level
CREG: Agency for Toxic Substances and Disease Registry Cancer Risk Evaluation Guide for 1 in 1,000,0000 increased cancer risk (see Glossary, Appendix A)
PRG: U.S. Environmental Protection Agency Region 9 Preliminary Remediation Goal (exposure occurring for greater than 364 days
PRG† is based upon cancer endpoint (level reflects 1 in 1,000,000 increased cancer risk, considered no apparent increased risk)
MRL: Agency for Toxic Substances and Disease Registry Chronic Minimal Risk Level (http://www.atsdr.cdc.gov/mrls/)
RfC: U.S. Environmental Protection Agency Reference Concentration (http://www.epa.gov/iris/search.htm)

Appendix D. Toxicological Summaries

This appendix provides background information from toxicological profiles published by the Agency for Toxic Substances and Disease Registry, information developed by the California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, and the U.S. Environmental Protection Agency. It highlights the toxicological effects of chemicals of concern (chemicals exceeding health comparison or screening values) detected in air, soil, surface water, or groundwater, in and around the Richmond Field Station site.

Arsenic (21)

- Naturally occurring element commonly found in surface soil and surface water.
- Arsenic trioxide is the primary form marketed and consumed, with 90% used in the production of wood preservatives (copper chromated arsenic).
- Various organic arsenicals are still used in herbicides and as antimicrobials in animal and poultry feed.
- Long-term exposures of lower levels of arsenic through drinking water (170-800 ppb) can lead to a condition known as “blackfoot disease.”
- Other effects include gastrointestinal irritation, and contact with skin can cause discoloration (hypo-or hyper-pigmentation), wart-like growths, and skin cancer.
- Acute oral minimal risk level (MRL) = 0.005 mg/kg/day (gastrointestinal effects in humans).
- Chronic oral minimal risk level (MRL) = 0.0003 mg/kg/day (dermal effects in humans).
- Oral reference dose (RfD) = 0.0003 mg/kg/day (dermal effects in humans).
- Acute reference exposure level (REL) = 0.19 $\mu g/m^3$ (reproductive, developmental effects in mice).
- Chronic reference exposure level (REL) = 0.03 $\mu g/m^3$ (developmental, cardiovascular, nervous system in mice).
- Ambient air preliminary remedial goal (PRG)(U.S. Environmental Protection Agency) = 0.001 $\mu g/m^3$.
- Oral cancer slope factor = 1.5 mg/kg/day.
- Inhalation slope factor = 12 mg/kg/day.
- Inhalation unit risk (U.S. Environmental Protection Agency) = 0.0043 $\mu g/m^3$.
- Carcinogenicity: known human carcinogen due to its ability to cause skin cancer, with oral exposures increasing the risks of liver, bladder, and lung cancer (U.S. Environmental Protection Agency); carcinogenic to humans (International Agency for Research on Cancer).

Cadmium (6, 29, 95)

- Naturally occurring element (metal); also occurs as a result of industrial processes.
- Not usually found as a pure metal, but as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide).
- Enters the body primarily through inhalation and ingestion; people are exposed to cadmium mostly from food and cigarette smoke.
- Inhalation of high levels of cadmium can severely damage the lungs and cause death.
- Chronic exposure (inhalation) to low levels can cause kidney (renal) damage.
- Chronic oral minimal risk level (MRL) = 0.0002 mg/kg/day (kidney damage in humans).
- Chronic reference exposure level (REL) = 0.02 $\mu g/m^3$ (kidney and respiratory damage in humans).
- Ambient air preliminary remedial goal (PRG)(U.S. Environmental Protection Agency) = 0.001 $\mu g/m^3$.
- Inhalation slope factor = 15 mg/kg/day.

- Carcinogenicity: probable human carcinogen (limited human, sufficient animal evidence) (U.S. Environmental Protection Agency); human carcinogen (sufficient human evidence) (International Agency for Research on Cancer).

Copper (27)

- Naturally occurring metal found in rocks, soil sediment, and water.
- Occurs naturally in all plant and animals.
- Essential element for humans, plants and other animals.
- Long-term exposure to copper dust can irritate your nose, mouth, and eyes, and cause headaches, dizziness, nausea, and diarrhea.
- Common effects from ingestion of higher than normal levels of copper include nausea, vomiting, stomach cramps, or diarrhea.
- Intermediate oral minimal risk level (MRL) = 0.01 mg/kg/day (gastrointestinal effects in humans).
- Carcinogenicity: not classifiable as a human carcinogen due to a lack of studies (U.S. Environmental Protection Agency); not reviewed (International Agency for Research on Cancer).

Formaldehyde (39)

- Colorless flammable gas at room temperature.
- Commonly contaminant found in indoor and outdoor air.
- Common health effects include irritation of the eyes, nose, and throat, along with increased tearing, which occurs at air concentrations of about 400-3,000 parts per billion (491-3655 µg/m^3).
- Acute inhalation minimal risk level (MRL) = 40 µg/m^3 (respiratory effects in humans).
- Intermediate inhalation minimal risk level (MRL) = 30 µg/m^3 (respiratory effects in monkeys).
- Acute reference exposure level (REL) = 94 µg/m^3 (eye irritation in humans).
- Chronic reference exposure level (REL) = µg/m^3 (respiratory effects in humans).
- Inhalation unit risk (U.S. Environmental Protection Agency) = 0.000013 µg/m^3.
- Carcinogenicity: probable human carcinogen, based on limited evidence in humans (site-specific respiratory neoplasms) and sufficient evidence in animals (nasal squamous cell carcinomas in mice and rats) (U.S. Environmental Protection Agency).

Lead (17, 26)

- Naturally occurring metal found in small amounts in the earth's crust; most of the high levels of lead found in the environment are from human activities.
- People may be exposed to lead by eating foods or drinking water that contains lead, spending time in areas where leaded paints have been used or are deteriorating, lead pipes, and drinking from leaded-crystal glassware.
- People who live near hazardous waste sites may be exposed to lead and chemicals containing lead by breathing the air, swallowing dust and dirt containing lead, or drinking lead-contaminated water
- Lead affects the nervous system, the blood system, the kidneys, and the reproductive system.
- Low blood levels (30 µg/dL) may contribute to behavioral disorders; lead levels in young children have been consistently associated with deficits in reaction time and with reaction behavior. These effects on attention occur at blood lead levels extending below 30 µg/dL, and possibly as low as 15-20 µg/dL; the developing nervous system of a young child can be adversely affected at blood lead levels below 10 µg/dL.
- Health effects associated with lead are not based on an external dose, but on internal dose that takes into account total exposure.

- Federal agencies and advisory groups have defined childhood lead poisoning as a blood lead level of 10 µg/dL.
- Occupational Safety and Health Administration requires workers with a blood lead level above 50 µg/dL be removed from the workroom where lead exposure is occurring.
- Carcinogenicity: probable human carcinogen (renal tumors in mice) (U.S. Environmental Protection Agency); possibly carcinogenic to humans (limited evidence of kidney, brain and lung cancer) (International Agency for Research on Cancer).

Mercury (28)

- 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. Toxicity depends on the form of mercury.
- 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.
- Spills of metallic mercury from broken thermometers or damaged electrical switches in the home may result in exposure to mercury vapors in indoor air that could be harmful to health; microorganisms (bacteria, phytoplankton in the ocean, and fungi) convert inorganic mercury to methylmercury.
- Ingestion of fish one of the most common ways people are exposed to methylmercury.
- Exposure to high levels (above 500 $\mu g/m^3$ and above 1.9 mg/kg/day) of metallic, inorganic, or organic mercury can permanently damage the brain, kidneys, and developing fetus.
- Chronic inhalation minimal risk level (MRL) = 0.2 $\mu g/ m^3$ (neurological effects in humans).
- Intermediate oral minimal risk level (MRL) (inorganic mercury/mercuric chloride) = 0.002 mg/kg/day (renal effects in mice).
- Chronic minimal risk level (MRL) (methylmercury) = 0.0003 mg/kg/day (neurodevelopment effects in humans).
- Carcinogenicity: mercury chloride and methylmercury are possible human carcinogens (U.S. Environmental Protection Agency); not classified (International Agency for Research on Cancer).

Polychlorinated Biphenyls (PCBs) (6, 20, 95)

- Produced in the United States between 1933-1977 for use as coolants and lubricants.
- Mixtures of up to 209 individual chlorinated compounds (known as congeners).
- Though no longer manufactured, PCBs are still released during some industrial processes, from hazardous waste sites; illegal or improper disposal of industrial wastes, consumer products; leaks from old electrical transformers containing PCBs; and burning of some wastes in incinerators.
- Food most common source of PCBs uptake in the general population.
- Bioaccumulate in food chains and are stored in fatty tissues.
- Do not readily break down in the environment and thus may remain there for very long periods of time.
- Most common health effect observed from exposure to PCBs are skin rashes and acne.
- Reproductive effects have been shown in women exposed to high levels of PCBs in the work place or from eating contaminated fish.
- High levels of PCBs may cause liver damage.
- Intermediate minimal risk level (MRL) for Aroclor 1254 = 0.00003 mg/kg/day (developmental effects).
- Chronic minimal risk level (MRL) for Aroclor 1254 = 0.00002 mg/kg/day (immunological effects).

- Oral cancer slope factor = 2 mg/kg/day (liver cacner)
- Inhalation cancer slope factor = 5 mg/kg/day (liver cancer)
- Limited human (workers) and animal studies have shown an association with liver and biliary cancer.
- Carcinogenicity: probable human carcinogen, based on sufficient evidence of carcinogenicity in animals (U.S. Environmental Protection Agency); probably carcinogenic to humans (International Agency for Research on Cancer).

Zinc (87)

- Naturally occurring metal found in rocks, soil sediment, and water.
- Essential element for humans and animals.
- Ingestion of high levels of zinc can cause stomach cramps, nausea and vomiting.
- Inhalation of high levels of zinc dust or fumes can cause metal fume fever.
- Intermediate minimal risk level (MRL) (zinc and zinc compounds) = 0.3 mg/kg/day (decreases in erythrocyte SOD and serum ferritin levels in humans).
- Carcinogenicity: not classifiable as a human carcinogen due to a lack of studies (U.S. Environmental Protection Agency); not reviewed (International Agency for Research on Cancer).

Appendix E. Exposure Assumptions and Equations Used for Estimating Increased Cancer Risk and Cancer Slope Factors

Exposure assumptions used in estimating increased cancer risk from dermal contact with sediment (3, 11, 16, 91, 92)
CS = concentration in sediment (mg/kg)
SSA = soil to skin adherence factor (0.2 mg/cm^2) child/teenager; (0.07 mg/cm^2) adult
CF = Conversion factor (10^{-6} kg/mg)
SA = Skin surface area (cm^2 /event) – Skin surface area (adult = 5809 cm^2) from U.S. Environmental Protection Agency (EPA), Exposure Factors Handbook, averaging the 50^{th} percentile for lower legs feet and hands of females and males with that of the forearms of males (data not supplied for women). Skin surface area (child = 5323 cm^2) from EPA exposure factors handbook, averaging the 50^{th} percentile for total body surface area for males and females ages 8-15 multiplied by the percentage of total surface area that the legs, hands, and feet.
AF = Absorption factor (unitless) (chemical specific: arsenic 0.03, copper 0.01, mercury 0.01, zinc 0.001, PCBs 0.15)
Skin surface area (adult) from the EPA Exposure Factors Handbook, averaging the 50^{th}
EF = exposure frequency (100 events/year)
ED = exposure duration – years of exposure (child: 8 years) (adult: 8 years)
BW = body weight (for child 41.9 kg: average of 50^{th} percentile of females and males ages 8-15) (for adult 71.8 kg: average of women and men)
AT = averaging time (days) – (365 days/year)(70 years)
Equation for estimating theoretical increased cancer risk: [(CS)(SSA)(CF)(SA)(AF)(EF)(ED)/(BW)(AT)] (cancer slope factor)

Exposure assumptions used in estimating increased cancer risk from ingestion of sediment (3, 11, 16)
CS = chemical concentration in sediment (mg/kg)
IR = ingestion rate (mg/day) – (adult 100 mg/day)(child 200 mg/day) over 16 hours (time spent awake) (IR adjusted to account for 2.6 ET)
ET = exposure time (2.6 hour/day)
EF = exposure frequency (100 days/year)
ED = exposure duration – years of exposure (child: 8 years) (adult: 8 years)
CF = conversion factor (10^{-6} kg/mg)
BW = body weight (kg) (for child 41.9 kg: average of 50^{th} percentile of females and males ages 8-15) (for adult 71.8 kg: average of women and men)
AT = averaging time (days) – (365 days/year)(70 years)
Equation for estimating theoretical increased cancer risk: [(CS)(IR/16)(ET)(EF)(ED)(CF)/(BW)(AT)](cancer slope factor)

Exposure assumptions used in estimating increased cancer risk from dermal contact with surface water (3, 11, 16, 91, 92)
CW = concentration in water (mg/L)
P = permeability constant (cm/hour) (chemical specific: arsenic 0.001, cadmium 0.001, copper 0.001, mercury 0.001, zinc 0.0006)
Conversion factor = liters to cm^2
SA = Skin surface area (cm^2) (adult = 5809 cm^2) from EPA Exposure Factors Handbook, averaging the 50^{th} percentile for lower legs feet and hands of females and males with that of the forearms of males (data not supplied for women). Skin surface area (child = 5323 cm^2) from EPA exposure factors handbook, averaging the 50^{th} percentile for total body surface area for males and females ages 8-15 multiplied by the percentage of total surface area that the legs, hands, and feet.
ET = exposure time (2.6 hour/day)
EF = exposure frequency (100 days/year)
ED = exposure duration – years of exposure (child: 8 years) (adult: 8 years)
BW = body weight (for child 41.9 kg: average of 50^{th} percentile of females and males ages 8-15) (for adult 71.8 kg: average of women and men)
AT = averaging time (days) – (365 days/year)(70 years)
Equation for estimating theoretical increased cancer risk: [(CW)(P)(0.001L/cm^2)(SA)(ET)(EF)(ED)/(BW)(AT)](cancer slope factor)

Exposure assumptions used in estimating increased cancer risk from ingestion of surface water (3, 11, 16)
CW = chemical concentration in water (mg/L)
IR = ingestion rate (0.05 liter/hour)
ET = exposure time (2.6 hour/day)
EF = exposure frequency (100 days/year)
ED = exposure duration – years of exposure (child: 8 years) (adult: 8 years)

BW = body weight (kg) (for child 41.9 kg: average of 50^{th} percentile of females and males ages 8-15) (for adult 71.8 kg: average of women and men)
AT = averaging time (days) – (365 days/year)(70 years)
Equation for estimating theoretical increased cancer risk: [(CW)(IR)(ET)(EF)(ED)/(BW)(AT)](cancer slope factor)

Exposure assumptions used in estimating increased cancer risk from dermal contact with soil (11, 16, 91, 92)
CS = concentration in soil (mg/kg)
SSA = soil to skin adherence factor (0.07 mg/cm^2)
CF = conversion factor (10^{-6} kg/mg)
AF = absorption factor (unitless) (chemical specific: arsenic 0.03, copper 0.01, mercury 0.01, PCBs 0.15)
SA = Skin surface area (cm^2 /event) – Skin surface area (adult = 5210 cm^2) from EPA, Exposure Factors Handbook, averaging the 50^{th} percentile for hands, arms, forearms of males.
EF = exposure frequency (100 events/year)
ED = exposure duration – years of exposure (long-term: 23 years) (short-term: 7 years)
BW = body weight (71.8 kg: average of women and men)
AT = averaging time (days) – (365 days/year)(70 years)
Equation for estimating theoretical increased cancer risk: [(CS)(SSA)(CF)(SA)(AF)(EF)(ED)/(BW)(AT)](cancer slope factor)

Exposure assumptions used in estimating increased cancer risk from soil ingestion (11, 16, 93)
CS = chemical concentration in soil (mg/kg)
IR = ingestion rate (330 mg/day): estimated intake for adults engaged in outdoor activities over an 8 hour time period
ET = exposure time (2 hours/day)
EF = exposure frequency (100 days/year)
ED = exposure duration – years of exposure (long-term: 23 years) (short-term: 7 years)
CF = Conversion Factor (10^{-6} kg/mg)
BW = body weight (kg) (71.8 kg: average of women and men)
AT = averaging time (days) – (365 days/year)(70 years)
IR rate averaged to account for 2-hour exposure period
Equation for estimating theoretical increased cancer risk: [(CS)(IR/4)(ET)(EF)(ED)(CF)/(BW)(AT)](cancer slope factor)

Exposure assumptions used in estimating increased cancer risk from inhalation of soil particles (11, 16, 93)
CA = estimated concentration in ambient air ($\mu g/m^3$)
IR = Inhalation rate 20 $\mu g/m^3$/day for an 8-hour workday
EF = exposure frequency (100 events/year)
ED = exposure duration – years of exposure (long-term: 23 years) (short-term: 7 years)
CF = conversion factor 0.001 (mg/µg)
BW = body weight (71.8 kg: average of women and men)
AT = averaging time (days) – (365 days/year)(70 years)
IR rate averaged to account for 2 hour exposure period
Equation: [(CA)(IR/4)(ET)(EF)(ED)(CF)/(BW)(AT)](cancer slope factor)

Cancer slope factors used to estimate increased cancer risk (6, 95)

Contaminant	**Cancer Slope Factor (Type) (mg/kg/day)**
Arsenic	1.5 (oral) 12 (inhalation)
Cadmium	15 (inhalation)
Polychlorinated biphynels (PCBs)	5 (oral) 2 (inhalation)

Note: There is no oral cancer slope factor for cadmium

Appendix F. Public Comments and CDPH Response to Comments

Public Comments and Responses from the California Department of Public Health

On August 13, 2007, this Public Health Assessment (PHA) for the RFS site was released in draft for public comment. The comment period was open for 6 weeks, ending on September 24, 2007. As part of the release, this PHA was placed in several libraries in the area for public review and comment. The PHA was mailed to more than 100 addresses from the CDPH mailing list for the RFS site. This list contains former workers, residents of the nearby neighborhood, other community stakeholders, civic, political interested parties, and government agencies. The PHA is also available on the CDPH web site at www.ehib.org.

CDPH received comments from the following individuals and/or groups: California Department of Toxic Substances Control; Richmond Southeast Shoreline Area Community Advisory Group – Toxics Committee; a private citizen; Coalition of University Employees Local 3, University of Professional and Technical Employees CWA 9119; Stratacor; University of California, Berkeley; and Edcomb Law Group. The comments are provided in the following pages. Comments about typographical errors are excluded. When appropriate, a response from CDPH is provided in *italics*.

Comments submitted by the Department of Toxic Substances Control

Background

The Richmond Field Station (RFS) covers approximately 150 acres, consisting of offshore and upland areas. The offshore area includes the inner and outer portion of Western Stege Marsh, the two portions separated by the East Bay Regional Parks District (EBRPD) Bay Trail. The upland area occupies about 90 acres and is currently used as a research and teaching facility. The primary chemicals of potential concern (COPCs) include mercury fulminate released on the site by a facility that manufactured explosives from 1870 to 1950 and the metals, arsenic, cadmium, copper, lead, mercury, selenium and zinc, contained in pyrite cinders deposited on-site and generated by activities on the adjacent Zeneca property. The Human and Ecological Risk Division (HERD) have been requested to provide technical support for this site and previously reviewed the initial release of a public health assessment for this site.

Document Reviewed

The HERD reviewed a document entitled "Public Comment Draft - Public Health Assessment - Evaluation of Exposure to Contaminants at the University of California, Berkeley, Richmond Field Station, 1301 South 46th Street, Richmond, California ...".

This report is not dated, but the end of the public comment period is given as September 24, 2007. The report was prepared by the California Department of Health Services (CDPH) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry. The HERD received this document on August 13, 2007.

General Comments

This report summarizes the evaluation for the community performed by the CDPH to determine if possible exposure to contaminants in environmental media could have occurred or may occur, resulting in potential health risks to workers or visitors to the site. The report concludes that there are potential health hazards posed to maintenance workers who regularly work in upland soil potentially contaminated with elevated arsenic and polychlorinated biphenyls (PCBs) and to children/adolescents who regularly play in Western Stege Marsh due to the presence of residual metals and PCBs in sediments and surface water. The report also concludes that there is some indeterminate risk to workers restoring Western Stege Marsh, because there is no data to exclude the possibility that there may be radioactive materials in soil and/or toxic chemicals migrating from the neighboring site through groundwater and to workers. Similarly, there is some indeterminate risk to persons working in certain upland facilities because there are no data excluding the possibility that there may be vapors from the sub-surface intruding indoors.

The HERD read the entire report but focused its review on those sections that had been the subject of previous HERD Comments. For the most part, HERD comments have been satisfactorily addressed in this public comment version. However, the HERD has some additional comments with respect to the information that would be presented in a human health risk assessment as opposed to a public health assessment.

Specific Comments

1. Calculating the hazard index from historic, current, and future exposure to adults and children/teenagers playing in or restoring the marsh. The hazard index from exposure to surface water is reported separately from the hazard index from exposure to sediments for all public health evaluations for the marsh. In quantitative health risk assessments performed to support site investigation and cleanup activities, these hazard indices are usually summed across environmental media. The HERD understands that the reason for keeping these environmental-medium-specific hazard indices separate is to highlight the medium responsible for driving the hazard for the concerned community.

<u>*CDPH response:*</u> *Comment noted.*

2. Estimating blood lead levels in adults from exposure to lead in soils. In this public health assessment, the evaluation of exposure to adults was done using the DTSC leadspread model. The HERD recommends that the U.S. Environmental Protection Agency (US EPA) Adult Lead Model (ALM) also be used to estimate the blood lead levels in the developing fetus. The results of using the ALM should provide information to the public on the possible effects of elevated soil lead on female workers of child-bearing age in the upland area and female volunteers or recreators in the marsh area.

<u>*CDPH response:*</u> *The final PHA provides estimated BLLs using the ALM.*

3. Addressing the risk posed by arsenic at background concentrations. Even at background concentrations, arsenic in soil poses an elevated cancer risk in residential and commercial

land use scenarios. Risk from background arsenic as it relates to the receptors evaluated in this public health assessment should be discussed.

CDPH response: A brief discussion of the contribution of background concentrations of metals relative to exposure is provided. CDPH did not quantify the risk from background concentrations of arsenic or other metals that are naturally occurring. The main purpose of the PHA is to identify exposure potential health concern, so that steps can be taken to mitigate or reduce these exposures. The levels of metals used in these evaluations are well above levels consistent with background.

4. Evaluating exposure to soil in the upland area. Exposure pathways evaluated for human receptors in the upland area were limited to incidental soil ingestion and dermal contact with soil. The HERD disagrees with the statement that inhalation of contaminated particulates (dust) could be a significant exposure pathway. Generally, the inhalation of dust pathway poses risks up to two orders of magnitude less than the risk posed by incidental soil ingestion. However, all potentially complete exposure pathways should be evaluated in this public health assessment.

CDPH response: The inhalation of contaminated particulates has be quantified and added to the final PHA. It is true that inhalation of particulates poses a lower risk (less than one-order of magnitude) than incidental soil ingestion. However, in the case of the long term worker, the increased cancer risk from inhalation exposure was estimated at 5.9×10^{-5}. Thus, the statement made in the draft PHA ("inhalation of contaminated particulates could be a significant pathway") is appropriate from a qualitative stance, when the most public health protective goal is to reduce exposures below a 10^{-5} increased risk.

5. Calculating cancer risks. It would be informative to include a table of the estimated chronic daily dose, the cancer slope factors (CSFs) for each carcinogenic chemical, and the cumulative cancer risk posed for each exposure scenario evaluated in this public health assessment. The equation used to calculate the cancer risks should be included as a footnote to such a table.

CDPH response: All the equations and exposure parameter used to estimate noncancer doses and increased cancer risks are provided as footnotes to tables or in an appendix.

6. Comparing environmental media concentrations to screening levels. In Tables 2 through 4, environmental media contaminant concentrations from the marsh area are listed and compared to risk-based screening values. Although these comparisons were used only to screen detected chemicals for further evaluation, the HERD cautions that such comparisons may be technically inappropriate and are likely extremely conservative. Screening values are generally calculated by assuming unrestricted land use but are being used here in a recreational setting where exposure would be much less, since recreators would not be expected to spend 16 to 24 hours a day every day in the marsh area.

CDPH response: CDPH uses a conservative approach in screening contaminants for further evaluation, to ensure that any potential exposures of concern are identified. When a contaminant *warrants further evaluation, then exposure doses are calculated using exposure assumptions appropriate for the pathway being evaluated.*

Conclusions

This report has been revised from its initial release version and addresses previous comments made by the HERD. Using a very conservative approach, the report identities several activities where exposure to COPCs could result in adverse health effects. However, the HERD has additional concerns described in the specific comments above that should be discussed in a future revision.

Members of the Toxics Committee of the Richmond Southeast Shoreline Area (RSSA) Community Advisory Group (CAG) reviewed the document, *Public Comment Draft Public Health Assessment at the University of California Berkeley (UCB) Richmond Field Station* (RFS), hereafter referred to as the PHA. Thank you for preparing the report. We understand that there is no single way to produce a PHA, but that generally it should raise awareness, change attitudes toward potential health risks, and increase the community's ability to use the base-line assessment in future decision-making. There is a dearth of health data regarding the effects, and possible synergism, of multiple pollutants in sites such as RFS, and the report helps us proceed in a commonsense approach of precaution. We appreciate your efforts on behalf of the community.

We also want to extend our appreciation to the California Department of Public Health Environmental Health Investigative Branch (DPH) for the focus placed on the RFS and Cherokee sites during the last three years. The DPH reports, summary documents and direct involvement have given the public and RSSA CAG in-depth reference and encouragement to stay firm on issues requiring ongoing enforcement action. In addition, the continued connection of DPH and Contra Costa County Health Services Department to the unfolding site investigation allows the public to evaluate issues relating to ongoing health risk.

The quantity, volume and complexity of data relating to the RFS and Cherokee sites are overwhelming for the most seasoned of experts. Even with the extensive data available, it becomes immediately apparent that large areas of the RFS have not been adequately characterized including among others, areas along the 2,500-foot north-south property line shared with Cherokee. The DPH successfully distilled many of the outstanding issues while working with sometimes insufficient data.

Comments submitted by the Richmond Southeast Shoreline Area Community Advisory Group (Toxics Committee)

The following public comments on the document are submitted by the Toxics Committee on behalf of the RSSA CAG.

General Comments

Evaluation of Risk to Community, Including Risk of Unusual Cancers

To see whether chemicals may be harmful to people, the DPH looks at the ways people could come into contact with the chemicals. The report emphasizes workers at the RFS site, but it does not contain a full and accurate description of the community and its subpopulations. Nearby Harbor Front Tract businesses and temporary residents such as sport fishers or subsistence fishers harvesting from contiguous Bay waters, people living in parked trailers and in the marsh, and recreational users of the Bay trail are also at risk. Spread of environmental hazards via groundwater and dust would expand the potential area affected by site pollutants at RFS. The report should explore or suggest an effective outreach strategy to all potentially affected people.

- Findings of the report might run counter to community-based efforts for the safe disposal and recycling of hazardous waste. If a significantly polluted site such as RFS poses no danger to the community, then what can the community say to a resident who improperly disposes of used automobile oil, paint, solvents, and other toxics?
- Signage has recently been added at the shoreline in various areas to warn people of potential danger. Testing of people harvesting fish and shellfish may be impractical, but testing of the organisms harvested would appear to be prudent. Rather than simply focusing on testing of groundwater, the report should call for future sampling of organism tissues. In particular, because shellfish have the ability to accumulate toxins in their tissues, we recommend that common species be evaluated for such toxins/carcinogens as PCBs, arsenic, and mercury. Consumption advisories may need to be expanded to an outright ban on eating either particular species or generally for all organisms in the area.
- Evaluate the fish/shellfish sampling data to determine if a continued consumption advisory is warranted to protect public health, or conversely, if any advisory to the fishing public can be eliminated or modified based upon negative data. (If needed, ATSDR may be available to assist in review of the data with the advantage of a larger sampling base.) This would provide baseline data for future tissue sampling, since a measure of a successful cleanup operation at the site would be a reduction of bioaccumulation.
- If the tissue sampling has negative results, this would give the community more confidence in the findings of the PHA.
- This information may assist other resource and permitting agencies who are studying the food chain linking endangered or threatened species in the area.

<u>1) CDPH Response</u>*: The main focus of the PHA, relating to potentially exposed populations, is RFS workers and people who restore or recreate in the West Stege Marsh, as these groups are at greatest risk of exposure. With respect to the other populations (people living in parked trailers and in the marsh) mentioned, the exposure assumptions used to evaluate the West Stege Marsh are highly conservative and protective of these populations. We are not aware of anybody living in the East or West Stege Marsh. Since our involvement in April 2005, staff regularly walk or bicycle on the Bay Trail along the East and West Stege Marsh and have never seen anybody living or recreating in the East or West Stege Marsh. This is not meant to suggest that it is not possible for someone to have lived in the marsh; it is meant to illustrate the difficulty in conducting outreach to transient populations, as suggested by the comment. The marsh is posted and fenced, which restricts access.*

We are not aware of any available site-specific fish data adequate to evaluate the fish consumption pathway. It is our understanding that the potential spread of contamination from RFS to the south side of the Bay Trail will be addressed by DTSC in the future. There are fish *consumption advisories for the entire San Francisco Bay, as a result of mercury contamination (not attributed to RFS). CDPH will contact Cal/EPA's Office of Environmental Health Hazard Assessment, the agency responsible for fish advisories, and inquire about posting along the Southeast Shoreline.*

Without a foundation of community-based data, the public anecdotally has found that rare and very rare forms of cancers have occurred in the area around the site. The report should either 1) inform readers of elevated rates of unusual or rare cancers or, if CDPH has evidence to the contrary, 2) make a statement to the effect that overall, for the years 1995-present, there does not appear to be significant elevation in frequency of unusual or rare cancers in the general vicinity of RFS and, further, that the types of cancers found in the area have been found broadly within the surrounding regions.

When DPH states that there is an indeterminate public health hazard due to lack of data, DPH should act in the most health-protective manner by stating that the hazard is presumed to be present until ruled out by additional evidence.

2) CDPH Response: Though the public has anecdotally found elevated numbers of rare and very rare forms of cancer in RFS workers or nearby workers, these findings may not reflect an unusual occurrence. If these observations include various different forms of cancer, not only one form, these findings may reflect what is expected in this population. In addition, as discussed in the Health Outcome Data section (page 46 of the public comment draft), the California Cancer Registry collects information on where an individual with cancer lives, not where the individual works. Thus, we would be able to get information on the cancer rates among the residents in the general vicinity of RFS, but not expected rates among the worker population at RFS or other workers nearby. The cancers that people have spoken to us about have occurred in RFS workers or nearby workers, not residents from that area. Therefore, conducting a cancer statistics review among residents for the area surrounding the RFS would not accurately capture whether or not there was an elevated rate of cancer among RFS workers.

Characterization of Radionuclides

The document implies that the only radionuclides that might be present at the RFS are those that were in use at the Cherokee site. This is a serious oversight. UCB staff have themselves employed numerous radioisotopes in the course of their work since 1951. As the CAG noted in its review of the Draft RFS Current Conditions Report, these radioisotopes should be listed and characterized with respect to nature, quantity and mode of disposal. Radioisotope analyses of soil and ground water should employ sampling based on an unbiased grid format approved by the radiation health division of the DPH. Do not, as stated in Recommendation #5, wait until the radionuclides of the Cherokee site have been thoroughly characterized, to conduct a thorough search for radionuclides at the RFS.

3) CDPH response: We agree that radioisotopes associated with research activities should be listed and characterized with respect to nature, quantity, and mode of disposal. In the PHA, we recommend that the site be fully characterized, based on its former and current uses. We have added further clarification in the final PHA with respect to the need for additional characterization.

Occupational Exposure to RFS Employees

The RFS Interim Soil Management Plan, approved by DTSC on 5/25/07, includes a section that allows known (and unknown) contaminated soil to be dug/excavated from a hole or trench, set aside during construction, and reburied in the same location. There is no requirement to sample and test the soil or to dispose of the soil as a potential or known hazard. The practice was approved after UC submitted a 14-year-old DTSC 1993 ruling for the Fremont-based Union Sanitary District in which the Sanitary District stated rate payers would not understand why they were required to pay the additional expense of removing hazardous waste material from newly dug trenches. The Sanitary District was allowed to dig trenches, stockpile the hazardous waste and refill the trenches with the hazardous material after pipes were installed. DTSC approved the same practice for the RFS based on UC's submission of the 1993 ruling.

The UC 5/16/07 letter to DTSC further describes a ruling from the California Occupational Safety and Health Agency (Cal OSHA) which states training per 8 CCR 5192, Hazardous Waste Operations and Emergency Response (HAZWOPER), is not required for RFS employees or contractors (http://www.dir.ca.gov/Title8/5192.html). No documentation was provided to show what sort of site description information UC provided to Cal OSHA to draw the conclusion that this training should be voluntary, and no document has been provided demonstrating that Cal OSHA does not require HAZWOPER training for RFS employees or contractors.

The PHA affirmatively states that there is a public health hazard to RFS maintenance workers who regularly work in soil containing the highest levels of metals and PCBs in unexcavated areas. This conclusion implies that all workers would need to be properly trained (i.e., receive HAZWOPER training per Title 8 CCR 5192) and informed about the chemical hazards. Will UC be implementing such a program, in accordance with Cal OSHA rules and regulations?

Statements by RFS employees suggest that UCB safety training is superficial. UCB should engage a reputable outside agency to offer safety training to RFS employees. RFS employees would be well advised to bring both potential and confirmed health hazards to the attention of Cal OSHA.

4) CDPH response: CDPH recommended hazardous Waste Operations (HAZWOPER) training for RFS maintenance workers in the Provisional Health Statement, released in June 2005. In July 2007, prior to the release of the PHA, CDPH inquired with UC Environmental Health and Safety staff as to the status of this recommendation; we were told that they (UC) is not required by the California Occupational Safety and Health Administration (Cal-OSHA) to have their workers go through HAZWOPER training. CDPH believes that HAZWOPER training would be of benefit to RFS maintenance workers, regardless if it is required by Cal/OSHA.

Soil and groundwater across the entire site need additional analytical testing to understand what chemicals are present, at what concentrations, and whether there are radionuclides present at the site. What are UC's current plans for completing such additional testing, as this seems critical to being able to conclude that the site is safe for current workers?

5) CDPH response: It has been our understanding that the UC will conduct additional characterization at the request of DTSC. However, since the release of the public comment draft

PHA, the UC has stated that they would collect any additional data that CDPH feels is necessary to address potential exposure concerns. We have added information to the final PHA outlining gaps in the data, based on information in the UC Current Conditions Report and other site-related documents.

The PHA states there is an indeterminate public health hazard from contaminants in indoor air from vapor intrusion. Given the potential risks associated with vapor intrusion, how is UC going to go about, and in what time frame, determining whether there are, in fact, current risks associated with breathing the air in the occupied buildings? This would seem to be one of the most pertinent questions that should be answered immediately, given the ongoing occupancy of the buildings at the RFS by hundreds of employees.
Employees of RFS and other tenants are still tending gardens on site, even though the PHA warns against digging in the soil on site. A system should be implemented to warn against the dangers of such gardening.

6) CDPH response: Since the release of the PHA, the UC has forwarded a "Statement of Work for Air Sampling Services" to CDPH for review. The UC is planning on conducting indoor air sampling over a 6-month period, to address indoor air quality concerns expressed by workers, as well as the recommendation in the PHA for additional testing of formaldehyde and arsenic. Characterization of groundwater and soil gas is still needed to address the potential for vapor intrusion, which is one of the recommendations in the PHA. DTSC comments on the UC Current Conditions Report outlined a need for characterization that will address this pathway. Once all the data is collected, an evaluation of the potential for vapor intrusion can be conducted. CDPH agrees that RFS workers should be kept informed of the locations where contamination has been identified. This is one of the recommendations in the PHA.

Recommendation #1 supports air monitors on the periphery of the RFS during future soil disturbing activities, but there must also be air monitors interior to the RFS to protect persons on the site closer to the dust generating activities. CDPH did not attempt to account for potential inhalation exposures to contaminated dust/particulates due to uncertainties in this estimation. Although it is true that there may be uncertainties associated with estimating the amount of particulates that could be present in the air, and the concentrations of chemicals that could be attached to the dust particles, USEPA and DTSC have recommended approaches for evaluating dust exposures, and this exposure pathway is typically evaluated in any risk assessment. The inhalation of particulates should not be discounted, but should be incorporated into the quantitative analysis using standard particulate emission factors recommended by DTSC and USEPA. This is particularly important because it is the primary pathway through which all individuals at the site could be exposed to chemicals. In fact, the PHA itself states in numerous places that inhalation of contaminated particulates could be a significant exposure route, adding to a worker's overall risk.

7) CDPH response: CDPH revised the dose estimates for RFS maintenance workers to reflect the inhalation pathway. Estimates of the concentration of contaminants in ambient air when no remedial work is occurring at the site have also been added. We have modified Recommendation #1 to include monitoring within the RFS, as well the perimeter.

The PHA states that pathways are eliminated from further assessment if they are likely never to become complete. This approach is imprudent. No one can predict with certainty whether a pathway will be become complete. It would be advisable to evaluate the hazards on the assumption that the pathway may become complete at some future time.
Designation of the concentrations of chemical toxins and radionuclides that are unlikely to adversely affect human health is an inexact science. The PHA admits that current toxicological and statistical methods cannot account for adverse synergistic interactions, individual differences in the ability to detoxify chemical toxins and to repair genetic and organic damage, and the uncertainty of "safe levels" inferred from animal and microbial studies. But the PHA does not state the obvious conclusion: the acceptable "one in a million excess deaths "may be contributed by a small, highly susceptible component of the human population. Is this environmental justice? Allowable exposure limits should be set to take into account those individuals with compromised immune systems.

8) CDPH response: ATSDR has criteria for eliminating pathways from further assessment, as described in the PHA. The health conservative approach taken by CDPH in identifying potential exposures of concern results in recommendations that are directed at mitigating exposure, usually through additional remedial activities, which serves to further reduce the chance for incomplete or eliminated pathways to become complete in the future.

For chemicals that are considered carcinogenic, the acceptable risk is set at 1 additional cancer, above what is expected, in 1,000,000 people (please see Environmental Health Screening Criteria section). It is true that many of the values that are used to quantify risk are derived from animal studies; these values are set with uncertainty factors in an attempt to account for the uncertainties in knowledge, such as extrapolating from animals to humans and sensitive populations.

As in the case of radionuclides, the PHA, like the RFS Draft Current Conditions Report fails to recognize that UCB-RFS workers have employed numerous chemicals since 1951 that may have been released into the environment. The PHA should request a full accounting of chemicals and radioisotopes used at the RFS, rather than take the view that all of the contamination is due to previous industrial occupants.

9) CDPH response: CDPH recommended that the site be fully characterized based on activities carried out by UC research activities, historic uses at the RFS, and historic activities at the adjacent Zeneca. Please refer to CDPH responses 3 and 5 above.

Chronic Low-level Exposure
The PHA needs to alert the reader that there is little to no scientific data to evaluate the potential impact of compound combinations and/or long-term low level exposures. emphasize a summary of unknowns that directly affect on-site workers and visitors, including 1) lack of site characterization, 2) impact on health from chemicals attached to dust particles, 3) lack of ongoing air monitoring, and 4) potential impact of dust inhalation from any source. The PHA has not fully explored the cumulative impact of chronic exposure to low levels of multiple chemicals and radionuclides, which may be present just below their individual action levels but interact synergistically over longer periods of time.

<u>10) CDPH response:</u> There is no prescribed method for evaluating the synergistic effect of low level (below individual action levels) exposure.

<u>Non-Cancer Health Effects</u>

The report is confusing, and seemingly contradictory, in how it discusses the potential for adverse non-cancer health effects. The report makes "conclusions" regarding the potential for non-cancer health effects based on three different criteria: a) comparison of doses of individual chemicals to health comparison values; b) the calculated cumulative hazard index based on exposure to multiple chemicals; and c) comparison of doses to "lowest observed adverse effects levels." The use of these related parameters, and the corresponding conclusions regarding the potential for no-cancer health effects, is confusing at best.

As one example, the fourth paragraph on page 12 of the PHA includes a statement that "CDPH determined that an adult or child/teenager who engaged in activities in the marsh on a regular basis, would not have experienced noncancer health effects from exposure to individual COCs in sediment and surface water. Estimated exposure doses are below health comparison values for individual contaminants (Appendix C, Table 5)". The impression one gets from this paragraph is that exposures would not be expected to cause adverse noncancer health effects. The very last paragraph on the same page, however, goes on to say that "The hazard index (1.6) for a child/teen from exposure to surface water exceeds 1.0, indicating the possibility for noncancer health effects (Appendix C, Table 6)." CDPH appears to be trying to draw a distinction between individual chemical doses that are below the comparison values, but cumulatively, when/if exposed to all chemicals, there could be a potential for noncancer effects (based on the noncancer HI exceeding 1). Whatever distinction CDPH is attempting to make needs to be clarified. Furthermore, statements in the PHA that one would not expect to see adverse health effects from exposure to individual COCs detract from the more important point regarding exposure to the mixture as a whole (which is, obviously, the reality of how people were/are exposed). We request that CDPH remove conclusory health statements based on comparisons of individual compounds to the health comparison values, as they are misleading when the actual exposures are to a mixture of compounds.

Another example of the confusion regarding the potential for noncancer health effects occurs on page 14. The fourth paragraph states:

"The estimated dose (0.00005 mg PCBs/kg/day) for a child/teen from dermal and ingestion exposure to PCBs in sediment exceeds health comparison values, suggesting the noncancer health effects (Appendix C, Table 6). However, the estimated doses are below the LOAEL (Lowest Observed Adverse Effect Level) of 0.005 mg PCBs/kg/day shown to cause immune effects (decreased antibody response) in monkeys. Since dose estimates are below LOAEL and estimated doses are based on exposure to the maximum concentration of PCBs found in sediment (actual exposures are probably much less), it is possible, but not probable that a child/teen would have experienced health effects from exposure to PCBs in sediments."

From this paragraph, it would appear that CDPH is relying heavily on the actual reported LOAELs observed in the toxicological studies, more than the ultimate health comparison values cited earlier in the report (which are always lower than the LOAELs). However, the very next paragraph in the PHA states that "the estimated hazard index (3.1) for a child/teen from exposure to COCs in sediments exceeds 1.0, indicating the possibility for noncancer health effects." We observe that the hazard index from PCBs alone is 2.6, and thus the PCBs are the most significant contributor.

The PHA should provide a clearer description of the criteria being used to draw conclusions as to whether certain levels of exposure have the potential to cause adverse noncancer health effects. The distinctions that the report is perhaps trying to draw (e.g., difference between 'possible' versus 'probable'; difference between 'health comparison values' versus the LOAELs; and difference between comparisons of individual compounds to the comparison value versus the cumulative impact of all chemicals) need to be clarified.

11) CDPH response: *CDPH staff recognizes that understanding how potential toxicological evaluation can be confusing, as there are multiple steps involved. Please refer to the Environmental Health Screening Criteria section for a description of the steps used to evaluate noncancer and cancer health effects.*

The descriptive language (e.g. possible, not probable, etc.) is meant to provide some context for what the 'calculations/numbers' mean, also taking into account the other assumptions used to estimate exposure. We make every effort not to make definitive statements that either dismiss or create undue alarm, in situations where there is so much uncertainty. We have modified the text based on the comment

Evaluation of Lead Exposure

The PHA states that CDPH used the DTSC Lead Risk Assessment Spreadsheet (LeadSpread 7) to estimate the blood lead levels (BLL) for adults. USEPA has developed a methodology for evaluating exposure and the potential for adverse health effects resulting from nonresidential exposure to lead in the environment, in Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil (TRW ALM, USEPA 2003). The USEPA methodology results in a blood lead concentration of concern for the protection of fetal health (in women of child-bearing age) and presents an algorithm for predicting quasi-steady state blood lead concentrations among adults who have relatively steady patterns of site exposure. We understand that DTSC prefers use of the USEPA Adult Lead Model for evaluating adult, nonresidential exposures to lead, and thus request that this model be used for evaluating adult lead exposures.

12) CDPH response: *The PHA has been revised to include the estimated BBL using EPA's Adult Lead Model. Consistent with the initial evaluation using LeadSpread 7, the results do not exceed 10µg/dL for pregnant women or 25µg/dL for all other adults, the levels at which exposure reduction actions are recommended.*

Recent Developments That Concern Human Health

Since the 2005 Interim Health Statement was produced, other important health-related developments at the site have come to light and somehow need to be accounted for. Since new light has been shed on toxic material moved from the adjacent Cherokee site to the RFS, studying the sites separately may “compartmentalize” and/or diminish the stated health effects of the entire area. An appendix or some other supplement should be inserted about crucial new health impacts such as the emergency removal action in the area of the Wood Products Laboratory and the “removal action” of the plume of volatile organic compounds along the northeast RFS border with the Cherokee property. The PHA does not take into account that other sources of radionuclides have recently been uncovered at the Cherokee site besides the orthophosphate plant. What is more, UCB has failed to note that the magnetometer positive area at the RFS "Bulb" dump may be the burial site of steel drums containing radioactive waste. The site was originally marked with a discarded skate board. No warning has been given to RFS employees not to dig at the site. The site also has no warning sign. And RFS employees are currently being herded into the Forest Products Laboratory, even though the PHA indicates that building and its surroundings still pose a potential risk.

13) CDPH response: CDPH has had discussions with DTSC regarding the removal action scheduled to take place on the RFS and Cherokee property/Zeneca site. DTSC is requiring and overseeing the implementation of control measures to protect the public and RFS workers from exposure. We are not aware of any “crucial new health impacts” associated with these activities, as indicated by the comment.

We are in the process of evaluating potential off-site exposures related to contaminants from the Zeneca site, which will be described in a PHA. Information regarding potential radiological issues associated with the Zeneca site is being reviewed by the Radiologic Health Branch (RHB) of CDPH. RHB will also provide the public health interpretation of any data that may be collected.

With respect to the magnetometer anomaly detected in the “Bulb,” it is our understanding that this area will be investigated further. We agree that workers should be aware of areas where contamination has been identified. During the September 5, 2007 meeting at the RFS, when the findings of the PHA were presented to the workers, UC management stated that all areas of known contamination, as well as the Bulb, are fenced.

Access to West Stege Marsh

The PHA states there is an indeterminate public health hazard due to lack of data on current and future exposures to persons restoring excavated areas of West Stege Marsh. The PHA recommends that access be restricted from the West Stege Marsh area, based on potential risks associated with contacting the sediments and surface water in this area. It also appears, from information in the PHA, that there is still significant contamination in the West Stege Marsh area. Is access to the West Stege Marsh currently restricted, and what are the plans to ensure that these restrictions remain effective and protective?

The PHA states that it is being produced under cooperative agreement with the federal Agency for Toxic Substance and Disease Registry (ATSDR). Please ensure that a copy of the draft and final Public Health Assessment are sent to ATSDR. Also, please clarify whether ATSDR had an oversight capacity in preparation of the draft PHA.

14) CDPH response: The West Stege Marsh is currently fenced and posted. The most public health protective approach is for access to the marsh to remain restricted until remediation is *completed at the site and it can be determined that the area is not at risk of contaminant migration from other areas, including the Zeneca site. DTSC has regulatory authority over the site and can make determinations as to restrict access long-term.*

ATSDR staff reviewed the initial (technical) draft of the PHA. Technical review comments were incorporated and a public draft was then released.

Specific Comments

“There is no evidence that indoor air quality at the Richmond Field Stations poses any health hazard.” However, there should be some additional sampling for at least formaldehyde and arsenic.” This statement is included in the two-page summary/information document prepared by the Contra Costa County Health Services. The PHA does not mention that there are other chemicals detected in the indoor air of building 163 that are above the ATSDR Cancer Risk Evaluation Levels: benzene, bromoform, 1,2-dibromoethane, and trichloroethylene (see PHA Table 12). Evaluation of exposure to these chemicals should be included in the PHA. Additional testing to confirm no indoor air issues should include additional groundwater and soil gas characterization, not just future indoor air monitoring for formaldehyde.

15) CDPH response: *The draft PHA (page 24) and the final PHA provides a discussion of the chemicals that exceed ATSDR Cancer Risk Evaluation Levels, and evaluates these data appropriately based on the limited data set. In the draft PHA and the final PHA, we recommended additional characterization of the RFS site to address the potential for vapor intrusion impacts to indoor air. The types of sampling necessary for evaluating vapor intrusion include soil gas and groundwater sampling. These activities will be carried out under the direction and oversight of DTSC.*

“Walking on the grounds at the Richmond Field Station does not pose a health risk from exposure to chemicals in the soil.” This statement is included in the two-page summary/information document prepared by the Contra Costa County Health Services. The report did not adequately analyze this exposure scenario. The conceptual site model on Table 1 does not identify the receptor/exposure scenario of walking on the grounds. What are the pathways of exposure for the individual walking on the grounds? Most likely it would be inhalation of airborne particulates. However, the PHA very explicitly states that inhalation of particulates is not evaluated. The basis from which the statement that there is no health risk is not known. “Daily contact” with soils would occur for the non-intrusive workers who work in the buildings daily but still get exposed via inhalation of particulates, and direct contact with soil less extensive than the worker doing maintenance. Some direct exposure does occur, and should be evaluated and include inhalation of the indoor air which is not adequately characterized. How does UC know that exposures associated with breathing the outdoor air do not pose a risk to workers who are present at the site on a routine basis? Are there currently exposed soils that contribute to inhalation exposures, which also contribute to daily (albeit minimal) soil ingestion exposures, that need to be mitigated? If so, those soils should be covered immediately while the additional investigations are being conducted. Do not allow surface or subsurface digging activities until employees and contractors have been appropriately trained.

16) CDPH response: *The concern about exposure while walking on the RFS grounds was expressed to us by a worker and presented in the Community Health Concerns section in the PHA. CDPH did not identify "walking on the grounds at the Richmond Field Station" as a potential exposure pathway. Thus, it was not included in Table 1 of the PHA. Professional judgment is used when identifying exposure pathways for evaluation. To a large degree the RFS is either paved, has sidewalks, or is covered by vegetation (grass), which provides a barrier, reducing the chance for dust generation from simply walking around RFS. The PHA evaluates the worst-case exposure (actual exposures much less) for RFS maintenance workers who would have the most contact with soil. Any intermittent exposure received by other workers at RFS would be much less. However, to more completely address these concerns, the final PHA has been modified to include an evaluation of this scenario and identify it as a potential exposure pathway.*

It is worth noting that the average arsenic value in soil is within the range of background for the area. Thus, this is the level that could be present in ambient air in other areas not impacted by industrial or anthropogenic sources.

On page 14, the text of the report states that CDPH estimated the theoretical increased cancer risk from historic exposure to contaminants considered carcinogenic. The report, however, does not provide any tables with the calculated cancer risks, nor the methods used to estimate the cancer risks. Further clarification, including any back-up calculations, should be provided.

17) CDPH response: *The cancer risk estimates are provided in the text. When possible, we try to provide as much information in text as it is easier for the reader to follow. The equations and cancer slope factors used to derive the cancer risk estimates are provided in Appendix E.*

The first paragraph on page 21 states that the average dust concentrations did not exceed the site-specific dust action level of 2 milligrams per meter cubed. It is not clear from the footnote on this page how the 2 mg/m3 dust action level was derived. Is it considered the dust action level because, as stated in footnote 5, 'dust becomes visible at approximately 2 mg/m3?' Or, was this value established, as also mentioned in footnote 5, to account for the presence of mercury? Please clarify how the 2 mg/m3 dust action level is deemed to be health protective.

18) CDPH response: *The site-specific action level or permissible exposure level (PEL) for dust (2.16 mg/m^3) was developed to be health protective of mercury. The PHA has been revised to add further clarification.*

The second paragraph on page 22 states that on two days mercury levels exceeded the chronic MRL of 0.2 ug/m3 for time periods of less than one hour. The report should note that the Chronic Reference Exposure Level for mercury, established by OEHHA, is 0.09 ug/m3. As chronic RELs would clearly be considered health comparison values, it is unclear why the report refers to chronic RELs for volatile compounds (e.g., Table 12) and not for mercury.

19) CDPH response: *We have revised the PHA to note the chronic REL, as suggested by the comment. CDPH used the acute REL in the evaluation, as it is the most appropriate comparison value for the short-term exposure being evaluated.*

On page 23, the report should acknowledge that the analytic detection limit for arsenic of 0.05 ug/m3 is not low enough to demonstrate that the levels of arsenic are below the Cancer Risk Evaluation Guide. As indicated in Table 12, the CREG for arsenic is 0.002 ug/m3.

On the second paragraph on page 24, the report states that there has not been adequate characterization of the groundwater along the east and northeast side of RFS, which limits the ability for CDPH to evaluate the soil gas pathway. We agree with this statement, but we believe that the report should clearly acknowledge that soil gas data, in combination with additional groundwater data, are critical to determining whether vapor intrusion represents a significant exposure pathway at the site.

20) CDPH response: Comment noted. In the draft PHA and the final PHA, we recommended additional characterization of the RFS site to address the potential for vapor intrusion to be impacting indoor air. The types of sampling necessary for evaluating vapor intrusion include soil gas and groundwater sampling. These activities will be carried out under the direction and oversight of DTSC.

The description of concerns about burial of steel drums that may contain radioactive material on page 27 creates confusion. The burial site of steel drums alleged to contain radioactive waste by Rick Alcaraz has been identified at the RFS "Bulb". The pertinent question that relates to public health is, what are UCB and Department of Toxic Substances Control going to do to determine whether the buried material contains radioactive waste?

21) CDPH response: The discussion presented is accurate based on the information provided to CDPH at that time. The text has been modified to add further clarification.

In November 2007, Levine Fricke, contractor to the RFS, submitted a work plan to DTSC for investigation of the magnetic anomaly detected in the "Bulb".

On page 36, the report should describe the current data/studies that suggest a potential link between exposure to dust and cardiovascular disease.

22) CDPH response: The PHA has been modified to reflect the comment.

On page 44, the second paragraph under the PCB discussion states that "the exposure levels estimated for an RFS worker are below levels shown to cause noncancer health effects." The basis for this conclusion is unclear, as the HI presented for the RFS worker exposed to PCBs is 1.2 (long-term HI, as presented in Table 9). The report should provide a clearer description of the basis for reaching conclusions about the potential for exposures to result in adverse noncancer health effects.

23) CDPH response: In the Evaluation of Past Exposure (Long-Term) to Maintenance Workers section, the estimated exposure to PCBs for RFS workers is compared to exposure levels shown in the literature to cause health effects, which is the basis for the statement referenced in the *comment. We have modified the text in the Community Concerns Evaluation section to add clarity.*

Recommendation number 5 on page 49 states that additional indoor air sampling in building 163 and 175 should be conducted to identify whether formaldehyde is elevated above levels typical of indoor air. It should be noted that on page 25, the report states that the indoor air samples collected from building 478 did not have detection limits that were sensitive enough to fully evaluate the health impact to employees working at the RFS. Thus, building 478 should also be included in any upcoming indoor air sampling program. Further, based on the fact that a number of other VOCs, in addition to formaldehyde, were detected during the indoor monitoring at levels that exceed cancer comparison values (benzene, bromoform, 1,2-dibromomethane and TCE), these chemicals should also be included in any subsequent indoor air monitoring program.

24) CDPH response: There is a prescribed (step-wise) approach for evaluating the vapor intrusion pathway. Generally, an evaluation of the environmental conditions relating to soil, groundwater, and soil gas are conducted before an indoor air monitoring program would be initiated. As discussed in the PHA, there are many chemicals typically present in indoor air, which make it difficult to determine the contribution, if any, from vapor intrusion. It is not unusual for background levels for some chemicals, such as benzene, to exceed cancer comparison values. Thus, it is important to understand the environmental conditions that underlay a building when evaluating the vapor intrusion pathway. CDPH made a number of recommendations for site characterization, aimed at addressing the vapor intrusion pathway.

CDPH recommended additional sampling for formaldehyde and arsenic in indoor air to help determine whether there is an active source (other than vapor intrusion) for these contaminants in indoor air, or if the detections were unusual, as the data seems to indicate.

We urge CDPH to work with DTSC to ensure that the recommendations set forth in the PHA, including those necessary for adequate site characterization, are implemented, and that the requests in these comments are given due consideration.

Please note that only the topics specified in this letter were reviewed by Toxics Committee members. Absence of commentary on a topic not specified in this letter does not imply agreement or disagreement with the conclusions that are given in the PHA.

References

Toxics Committee of the Richmond Southeast Shoreline Area Community Advisory Group, Comments on Draft Current Conditions Report, Richmond Field Station, University of California Berkeley, June 2007
UCRFS Draft Interim Soil Management Plan 2/16/07
http://rfs.berkeley.edu/documents/DraftInterimSMP_RFS.pdf
DTSC Comments on Draft Interim Soil Management Plan 3/15/07
http://rfs.berkeley.edu/documents/Draft_SMP_Comments.pdf
UCRFS Letter to DTSC Soil Management Procedures 5/16/07
http://rfs.berkeley.edu/documents/RFSSoilManagementProceduresMay2007.pdf

Attachment to 5/16/07 Letter, DTSC Ruling Union Sanitary District 12/2/1993
http://rfs.berkeley.edu/documents/UtilityExcavationRegInterpretations.pdf
DTSC Letter to UC Soil Management Procedures 5/25/07
http://rfs.berkeley.edu/documents/2007.05.25.DTSC.SoilManagementConcurrenceletter.pdf

Comments from Private Citizens (CDPH received comments from one individual)

Thank you for providing the draft document entitled *Public Health Assessment. Evaluation of Exposure to Contaminants at the University of California, Berkeley, Richmond Field Station, 1301 South 46th Street, Richmond, Contra Costa County, California*, hereafter referred to as the draft-PHA. The California Department of Public Health (CDPH) prepared the draft-PHA under an agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). I am a retired toxicologist and former member of the Community Advisory Group (CAG) and also former head of the Toxics Committee of the CAG. While my familiarity with Richmond Field Station (RFS) issues originated with my past tenure on the CAG, my comments and recommendations on the draft-PHA are made independently any CAG or Toxics Committee member.

This copy is being sent to you by electronic mail per instructions in the draft-PHA. A paper copy will be sent by postal service. Confirmation of the receipt of these copies will be appreciated.

General Comments

There are three major conclusions to be drawn from the information in the draft-PHA. They are listed below and will be discussed in more detail. Please note that my approach is to consider the protection of the public health of the exposed group(s) to the maximum extent possible. I am not looking for a level of toxin that can remain because of calculations that are used to allow toxin levels that are thought to be of minimal consequence.

1. Lack of adequate characterization of current and historical exposures prevents an unequivocal conclusion regarding the potential adverse health effects to people coming into contact with toxins associated with the RFS. The authors discuss some of the implications of incomplete characterization throughout the document. However, confusion arises within the draft-PHA because of language that is used to minimize potential exposure related adverse health effects.

2. Oversimplification of some complex toxicologic phenomena prevents an unequivocal conclusion on the potential health risk to people who are exposed to toxins associated with the RFS. Such lack of understanding is not the fault of the authors; it is the state of knowledge about some toxicologic phenomena, which are under continuous investigation. Nevertheless, the simplified treatment of complex issues can leave the reader with the impression that the analyses described in the draft-PHA are based on substantive understandings.

3. In view of the lack of information, much of which will not be corrected in the short term, a public health approach to the health concerns at the RFS would be to apply the Precautionary

Principle and work to maximize cleanup operations, work to minimize exposures where total removal may not be possible and maintain contact with exposed populations to document health concerns.

Historic exposure

The draft-PHA refers to historic and current exposures. The term "historic", however, could refer to one of two time intervals. They are (1) the years that are initiated by the beginning of industrial/manufacturing activities in the area (late 19th century, p. 5) and (2) the initiation of environmental/cleanup activities. The latter historic exposure interval appears to be initiated sometime in the 1990s, see e.g., p.6 (1999), and p.12 (1991). For workers, there is no "historic" interval, but rater a "past exposure" (long-term) time of 23 years (1984, p.17). Regardless of the exact starting exposure date, the years that are initiated by the 1980s to 1990s do not constitute "historic" exposures. True historic exposures include those that were experienced by the populations that lived and worked in the area prior to the 1980s/1990s; e.g., families that migrated into the area during the war-time manufacturing activities in the 1940s. These early exposures could impact on physiologic defense mechanisms that lead to decreased protective responses in later life. They could also provide some information leading to potential locations of toxic materials. The draft-PHA is lacking in any information that suggests attempts were made to obtain the levels of chemicals that were emitted during these early, i.e., "historic" times. In the absence of such information, there should be discussion on the potential adverse effects that could be expressed in later life.

Recommendation. Research the types and levels of chemicals used during early manufacturing/industrial activities. In the absence of such data, clearly discuss the uncertainty that such lack of knowledge adds to the calculation of potential risk.

1) CDPH response: The main purpose of the PHA is to identify exposure of potential health concern and make recommendations to reduce or mitigate exposure. This is accomplished by evaluating existing environmental data, as prescribed by ATSDR. The type of research suggested by the comment would be very resource and time intensive which would slow down the identification and implementation of public health protective actions to reduce/mitigate current exposures. When data is available from the past, it is used to estimate exposure as far back as feasible. We agree with the comment that the use of the word "historic" may create confusion, even though time periods are clearly stated. Thus, we have revised the text based on the comment. The text now reads, "past" exposures, rather than "historic" exposures.

CDPH uses conservative assumptions in an effort to reduce some of the uncertainty inherent in this type of evaluation. Discussion of uncertainty is provided in the context of each pathway.

Current exposures

Site characterization has been considered incomplete. The lack of adequate characterization is a major limitation of the assessment, because the dose estimate can be no more reliable than the environmental monitoring data. Incomplete characterization is not the fault of the authors of the draft-PHA; they can only work with environmental monitoring data that are available. However, the implications of incomplete characterization should be thoroughly discussed. Attempts to overcome the limitations by applying exposure factors for maximally exposed individuals does not address the issue of the need to more properly evaluate the level of toxins at the RFS.

Recommendation. Describe, in detail, the effect of the limitations of incomplete characterization on the health assessment process. Specify what corrections are needed, i.e., where additional monitoring is required.

2) CDPH response: The final PHA includes additional discussion on the data gaps and need for additional characterization. Recommendations for additional characterization and monitoring are also provided. Additional characterization at the RFS will be conducted under the direction and oversight of DTSC.

Risk assessment issues

To evaluate the relationship between exposure to one or more chemicals and known adverse health effects, measured or estimated doses are compared to toxicologic comparison values (CVs) that were developed by Federal (United States Environmental Protection Agency (USEPA), Agency for Toxic Substances and Disease Registry (ATSDR)) or California agencies (Office of Environmental Health Hazard Assessment (OEHHA), Department of Toxic Substances Control (DTSC)). CVs are based on human or experimental animal data to which are applied uncertainty factors (UFs). The UFs are an acknowledgement of the lack of knowledge that exists in the derivation of the various CVs. UFs have also been called safety factors (SFs) and the latter term is found in the draft-PHA on pg. 62 and 65. The use of the term, SF, however, leaves an incorrect impression that its use will lead to a CV that is "safe". A more accurate explanation is that the CV is a level below which exposure is expected to lead to no more than a negligible effect.

Recommendation. Replace the term "safety factor" with "uncertainty factor" and articulate that a CV is a dose level or air concentration that is not expected to elicit an adverse effect under the conditions of its derivation. In particular, the CV should not be considered a dose or concentration that is "safe".

3) CDPH response: The comment references a term found in a definition within the glossary of the PHA. As acknowledged by the comment, the term ("safety factor") is synonymous with the term "uncertainty factor". Further, the definition in the glossary of the PHA discusses the uncertainty and the derivation of the CVs. The various CVs used in the PHA are also described in the Environmental Screening Criteria section, within the body of the PHA. While the definition is accurate as currently written, we have modified the text to reflect the term "uncertainty factor" to address the comment.

According to the draft-PHA (p.9), threshold doses (or points of departure) for environmental standards/recommended levels are based on no (or lowest) observed adverse effect levels (NOAELs/LOAELs). The NOAEL/LOAEL methodology has been the traditional approach in this process. However, in recent years, a different methodology has been utilized. It is the benchmark dose (concentration) (BMD/BMC) methodology and has been used by USEPA (Barnes et al., 1995), OEHHA (1999), and ATSDR (2006). Not all toxicologic data are amenable to BMD/BMC methodology. However, an advantage for its use is the ability to take into consideration the whole experimental dose range rather than one datum. Castorina and Woodrufff (2003) showed that many chemicals are associated with risk at the RfD or RfC, and among the chemicals that were evaluated are some that are discussed in the draft-PHA (benzene, chloroform).

Recommendation. Clarify that CVs, e.g., MRLs, RfD, may be based on NOAEL/LOAEL or BMD/BMC methodology.

4) CDPH response: The PHA has been revised based on the comment.

The authors of the draft-PHA acknowledge that exposure to contaminants at the RFS rarely occur to single isolated toxins, but to mixtures. The application of quantitative methods to the determination of potential risk to exposure to mixtures is an ongoing research activity. At the present time there are a number of suggested approaches and the one used by authors of the draft-PHA is among many described by Sexton and Hattis (2007). The major assumption is the risk of exposure to the mixture is an additive function of individual risks, which the draft-PHA authors acknowledge. An important weakness of this approach is omission of consideration of UFs. This omission could be corrected by substituting the CV for the NOAEL/LOAEL (or BMD/BMC).

Recommendation. Discuss the rationale for choosing the approach that is based NOAEL/LOAEL (or BMC/BMC) over one that uses a CV that incorporates health protective uncertainty factors.

5) CDPH response: The evaluation of exposure is conducted using a step-wise approach, prescribed by ATSDR (please refer to the Environmental Health and Screening Criteria section). CVs and the NOAEL and LOAEL are considered, depending on the level of exposure/pathway scenario. The approaches utilized are described relative to each pathway.

Specific Comments

Page 9, par.6-7. MRLs and RfDs may be based on NOAEL/LOAEL methodology or on BMD/BMC methodology. As described above, the BMD/BMC approach shows that a MRL or RfD is not a "safe" level but may be associated with risk.

Recommendation. Reword the last sentence in each paragraph to include BMD/BMC methodology as well as NOAEL/LOAEL methodology as a basis for MRL and RfD determinations. Include in the Glossary, an explanation of BMD/BMC methodology.

6) CDPH response: The PHA has been revised based on the comment.

Pg.14 (Table 6), 17 and 19 (Tables 8-9), Hazard Quotient Exceedence. In each case the table and accompanying text shows the estimated dose of a single chemical (total PCBs or arsenic) exceeds a health CV. Such exceedence suggests a potential health risk to the exposed individual under the described scenario. The potential risk is then minimized in the draft-PHA by comparing the estimated dose to the experimental threshold dose (the LOAEL). Such an approach is not protective of public health. The public health protective approach is to start with the threshold dose and apply the UFs to overcome the lack of knowledge. For example on p.14 and Table 6, the estimated total PCB dose of 0.00005 mg/kg-day for a child/teen playing in the marsh, exceeds the CV by 2.6-fold (hazard quotient=2.6) but the risk is minimized by comparing to an experimental LOAEL that does not incorporate UFs. (It would be helpful to see the value of the CV on the same table or in the text.) The same approach is taken for past-exposed long-term maintenance workers (arsenic and total PCBs, p.17) and current short-term maintenance workers (arsenic, p.19). These analyses are based on single chemicals.

The decision to minimize the potential risk to exposure to each of the above single chemicals is supported in the draft-PHA by the use of a maximum level of the chemical in the soil. However, given the incomplete characterization of the RFS, use of the maximum soil level may be appropriate for public health protection.

Recommendation. In the absence of additional explanation, the conclusion that exposure to single chemical can be minimized because the estimated dose is less than an experimental LOAEL, should not be used. What are the values of the CVs? What UFs were used to convert the threshold doses (LOAELs) to the CVs?

7) CDPH response: There are no CVs for evaluating chemical mixtures/multiple chemicals. Since CVs have only been developed for individual chemicals, the fist step in the evaluating exposure is looking at chemicals individually. Please refer to the Evaluation of Marsh Sediments and Surface Water at the Richmond Field Station and Evaluation of Soil at the Richmond Field Station sections in the PHA for a description of the evaluation of multiple chemicals.

The PHA is written to be accessible ("lay friendly") to the general public. The depth of discussion ("what UFs are used to convert threshold doses (LOAELs) to CVs") requested by the comment can create additional confusion for the average person who is trying to understand the complexity inherent with these issues. The CVs are presented and referenced in the PHA; the toxicological information used to derive these values is also referenced. The majority (if not all) of the toxicological information can be easily accessed on-line for those individuals who wish to have a more in depth understanding of the toxicological information for the chemicals evaluated.

CDPH does not minimize the possibility of effects from exposure to multiple chemicals, or the possibility for higher levels of chemicals in uncharacterized areas, which is why the site has been classified as posing a health hazard for a number of the exposure pathways evaluated.

Pg. 22-25 and Table 12, Air levels. An asterisk is attached to the measured air levels that exceed a health CV for non-cancer endpoints. Some air levels are represented as "less than" (<). What, exactly, does this representation mean? Is it related to a limit of detection (LOD)? No explanation is given in the footnote to Table 12. If "<" a particular contaminant level is the laboratory LOD, what value was used in the exposure assessment? A common approach is to use one-half LOD (½ x LOD). An important point to consider is that a sample result that is below a LOD does not necessarily mean the absence of the chemical. It only means the chemical cannot be detected with the methodology in use.

Recommendation. Explain, in the footnote, the use of air levels that are "less than" a particular amount in terms of comparing such levels to CVs. If air levels for non-detectable level are estimated as ½ x LD, specify in the footnote to Table 12.

<u>8) CDPH response:</u> CDPH did not compare non-detects to comparison values, as this does not provide additional information for evaluating exposure, with such limited data. The PHA provides a number of recommendations for the collection of additional data, aimed at evaluating potential impacts to indoor air.

Among the health CVs are those for cancer (CREG and cancer PRG) as well as non-cancer (MRL, non-cancer PRG, RfC, REL). Exceedences of health CVs refer only to non-cancer endpoints through the use of asterisks attached to the appropriate chemicals. However, some air levels exceed cancer CVs. They are arsenic, benzene, bromoform, chloroform, 1,2-dibromoethane, formaldehyde, methylene chloride, tetrachloroethylene and trichloroethylene. These chemicals are volatile organic chemicals (VOCs) and are known to the State of California to cause cancer (OEHHA 2007).

Although discussion on the cancer CV exceedences can be found on pg. 23-24 of the narrative, no symbols are attached to these chemicals in Table 12. Arsenic is discussed in the text (p.23) where the authors state that a resampling of air in buildings 163 and 175 showed levels below the LOD. Clearly, the first samplings suggest a level of concern for those exposed to this air prior to the first sampling date. Also, if an air level that is ½ x LOD is used for comparison, the air levels of arsenic at both sampling times in both buildings and on the roof of one building are in exceedence to the cancer CV (CREG). Air levels of formaldehyde are in exceedence of the cancer CV at each sampling time, inside both buildings and on the roof of one building. The available data on arsenic and formaldehyde suggest exposure to the air associated with these buildings should be avoided. The air results of some of the other chemicals support this conclusion.

Recommendation. Show, directly on the table, with explanation in the footnotes, where air levels are in exceendence of cancer CVs. Indicate that the chemicals with air levels in exceedence of the cancer CVs are on the Proposition 65 list of chemicals known to cause cancer.

<u>9) CDPH response:</u> The data and exceedences are shown and described in the PHA. The interpretation and resulting recommendations presented in the PHA are appropriate based on the limited data. We have highlighted the contaminants that exceed cancer and noncancer comparison values.

Since the release of the public comment draft PHA, the UC has forwarded a "Statement of Work for Air Sampling Services" to CDPH for review. The UC is planning on conducting indoor air sampling over a 6-month period, to address indoor air quality concerns expressed by workers, as well as the recommendation in the PHA for additional testing of formaldehyde and arsenic.

The five VOCs with air levels in exceedence of cancer CVs are acknowledged to provide an increased life-time (70 year) cancer risk of greater than one in a million (pg. 24-25). An estimated risk is not calculated because of the paucity of monitoring results, i.e., only one sampling event (p.25). This is a characterization issue that limits the ability to quantitatively describe the impact of exposure to the chemicals at the RFS. This problem is further discussed in the second and third paragraphs on p.25. Specifically while the air levels of three VOCs were below the LODs, those LODs were too insensitive for an adequate assessment of health impact. The meaning of the insensitive LODs in the context of health impact is unclear. If an air level of ½ x LOD is used, how did that value compare to the cancer CV? Is the insensitivity related to analytical methodology (i.e., more sensitive methods are available and should have been used)? Adequate evaluation of indoor air levels is further compromised by a lack of characterization of groundwater VOC levels. These specific problems are endemic of the overall lack of adequate characterization at the RFS. While suggestions are given in the draft-PHA regarding the need for further monitoring, recommendations to inform members of the RFS community and to limit access to the buildings noted in pg.22-25 and Table 12 and Fig.7, were not found.

Recommendation. Air monitoring under established protocols should be implemented. In the meantime, a precautionary approach should be initiated. Members of the RFS community should be informed about the air monitoring results and the implications of preliminary quantitative evaluations. Access to the buildings should be limited.

10) CDPH response: The PHA has been revised to add further clarification relative to the utility of the limited indoor air sampling collected in December 2005 (referenced by the comment). Since the release of the public comment draft PHA, the UC has forwarded a "Statement of Work for Air Sampling Services" to CDPH for review. The UC is planning on conducting indoor air sampling over a 6-month period, to address indoor air quality concerns expressed by workers, as well as the recommendation in the PHA for additional testing of formaldehyde and arsenic. VOCs will be included in the proposed indoor air study. In addition, the UC has committed to involving the RFS community in the development of the air sampling work plan.

P.63. Glossary, NOAEL. The definition is stated in two sentences. The last sentence reads "Effects may be produced at this dose, but they are not to be adverse.". This sentence is incorrect. The NOAEL is defined as stated in the first sentence. The absence of a real response at the NOAEL may be due a lack of response at that level or it may be due to the insensitivity of the experiment to detect a response that is statistically greater than that seen in a control sample. The insensitivity could be a related to the measurement system or to a small sample size. The adversity of the response is not a function of the dose at the NOAEL; it is a function of the response that is being measured.

Recommendation. Correct the definition of the NOAEL to show its meaning in the context of a dose-response study.

11) CDPH response: The definition is accurate as written. The last sentences has been modified slightly and now reads "Some effects may be produced at this level, but they are not considered adverse, nor precursors to adverse effects."

Pg.69, 71, 72, 74, Sampling maps (Figs.3,5,7). The figures show locations where sampling took place. Were the sampling plans (Figs 3,5,7) used to quantify environmental levels adequate? Were other agencies, e.g., the CA Air Resources Board (CARB) or the Department of Toxic

Substances Control (DTSC), consulted for this determination? Agencies such as the CARB and DTSC have units that deal with environmental sampling protocols and could be an important resource.

Recommendation. Request the units within CARB and DTSC that have expertise in sampling protocols to review the sampling plans used to monitor contaminants at the RFS.

12) CDPH response: The figures referenced in the comment were obtained from regulatory reports produced by consultants for the UC. The DTSC is responsible for regulatory oversight at the RFS and reviews all the regulatory documents produced by the UC for the RFS.

P.76, Exposure pathways. Marina Bay residents are correctly identified as a potentially exposed off-site population to outdoor air during remedial operations. Marina Bay residents will also be a "potentially exposed population" during non-operation times if the wind conditions cause disturbance to the soil. Were other residential populations considered? The Richmond Annex is downwind from the RFS. There are also communities to the north of the RFS. Were they considered for potential exposures during appropriate wind conditions.

Recommendation. Evaluate (and include in the draft-PHA) potentially exposed off-site residents in addition to those in Marina Bay.

13) CDPH response: Professional judgment is used when identifying exposure pathways for evaluation. To a large degree the RFS is either paved, has sidewalks, or is covered by vegetation (grass), which provides a barrier, reducing the chance for dust generation "during non-operation times." The PHA evaluates the worst-case exposure (actual exposure probably much less) for RFS maintenance workers who would have the most contact with soil. Any intermittent exposure received off-site would be minimal.

We have added an evaluation of the potential air concentration from resuspension of the COCs in soil, using an emission factor that was developed assuming fugitive dust from contaminated soils are continuous, lasting an extended period of time (years). The estimated air concentrations (using the average soil concentration) and available ambient air screening values can be found in Appendix C, Table 12, of the final PHA. The estimated air concentrations are not at levels of health concern for noncancer or cancer health effects.

It is worth noting that the average arsenic value in soil is within the range of background form the area. Thus, this is the level that could be present in ambient air in other areas not impacted by industrial or anthropogenic sources.

Air-borne toxins (free or adsorbed to particulates) can deposit onto plants and water surfaces. Was such deposition onto plant and water surfaces taken into consideration? The footnotes to the tables are not clear.

Recommendation. Clearly show that deposition of air-borne toxins onto plant or water surfaces is taken into account in exposure calculations.

<u>14) CDPH response:</u> In the draft PHA, dermal, and ingestion exposure to soil, sediment, and surface water was evaluated and is footnoted on the tables (Please refer to Tables 5, 7, and 9). In the final PHA, inhalation exposure for RFS maintenance workers is include in the dose calculations. The main purpose of the PHA is to identify exposures of health concern and make recommendations to mitigate/reduce these exposures, as timely as possible. On the basis of available information, CDPH concluded on-site soil, sediment, and surface water pose a health hazard under certain exposure scenarios. As a result a number of recommendations were made to mitigate these exposures, identify other areas where contamination may exist, and protect public health. We recognize that it is possible for contaminants to have deposited on plant surfaces, and for workers to come into contact with plants. The contribution of this exposure to the overall dose would not change the conclusions of the PHA or resulting recommendations. Nor would it provide information linking exposure to health outcome. Additionally, there is no data available to evaluate a "plant surface" pathway.

<u>Particulates</u>. Particulate matter is discussed only in the context of the adsorbed inorganic or organic chemical or as nuisance dust. Particulate matter, however, can itself be toxic. No information was found in the draft-PHA on the level of particulate matter less than or equal to 10 μM (including 2.5 μM). The adverse health implications of particulate matter in this size range are known and should be discussed.
Recommendation. Monitor the air – using acceptable air monitoring protocols – for particulate matter and express the results as a distribution of particulate diameter. Where possible, establish the chemical identity of the particulate matter. Apply standards/recommended exposure levels to the results.

<u>15) CDPH response:</u> In the draft PHA (Evaluation of Ambient Air During Remedial Work), particulate matter less than or equal to 10 microns in aerodynamic diameter (PM10) is discussed in terms of it being one of the most harmful of all air pollutants. We have expanded the discussion to include some of the potential health implications. In addition, a discussion of the health effects associated with exposure to PM10 is also provided in the Community Concerns section, under Cardiovascular Concerns, in the final PHA.

Summary and Conclusions

The authors of the draft-PHA have undertaken a difficult investigation into the potential health risks experienced by members of the RFS community who were, are now and/or will be exposed in the future to contaminants associated with the site. Incomplete characterization of the current exposure conditions and lack of knowledge about historic exposures (i.e., exposures from early manufacturing/industrial activities) prevent adequate risk characterization. Attempts were made to overcome the difficulty by applying maximum risk assessment default values to maximum contaminant levels. Although well-meaning, this approach cannot conceal the inability to carry out an adequate quantitative health assessment under such conditions. To be protective, to the maximum extent possible, a precautionary approach should be applied and emphasized. Specifically, where there are suggestions of exposure related health risks, access to such locations should be restricted. The exposed populations should be informed about the potential risks. When access to such locations is absolutely necessary, impacted individuals should be informed and protected and given the option (without retaliation) to not enter the location.

Some specific recommendations, many of which are discussed above, are listed below.'

- A major investigation into the chemicals associated with historic industrial/manufacturing activities should be undertaken.
- In addition to continuing the monitoring activities, as described in the draft-PHA, a determination should be made regarding the validity of the sampling protocols on which the current exposure data are dependent.
- Correct the misconceptions about some risk assessment terminologies that could lead to a misunderstanding on the part of readers not familiar with the nuances of risk assessment approaches. Some (but not all) examples are replacement of SFs with UFs, corrected meaning of the term NOAEL. More recommendations are found above.
- If the estimated dose of a single chemical exceeds a CV, do not minimize the potential risk by then comparing to an experimental LOAEL.
- Where contaminant levels are below the LOD, apply a default equation to arrive at a level to use in the calculation of an estimated dose. One widely equation is ½ x LOD.
- Clearly state that in some buildings, the air levels of arsenic or formaldehyde may be associated with a cancer risk.
- Monitor the air for particulate matter, its size distribution and chemical identity.
- List those chemicals detected at the RFS, that are known to the State of California to cause cancer and reproductive/developmental toxicity.

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Sexton K and Hattis D. 2007. Assessing cumulative health risks from exposure to environmental mixtures – three fundamental questions. Environ Health Persp. 115(5):825-832 and supplemental material therein.

Comments submitted by Claudette Bégin, Vice President of the Coalition of University Employees (CEU), Local 3

I am writing on behalf of CUE Local 3 representing clericals at UC Berkeley in response to the CDPH/CCHSD Public Health Assessment.

First, let me thank you for doing this health assessment in a conscientious way. We appreciate the major effort you and your staff made to encourage staff at the Richmond Field Station to come forward in a confidential environment with their health problems and concerns about the hazards of working at the Richmond Field Station. We are absolutely convinced that more employees would have come forward if RFS employees had not been intimidated by a series of actions that UC managers took. Two of our members were harassed for speaking up about the hazards during the dangerous "clean up" authorized by the Water Board – harassed to the point that they became ill from the harassment itself, beyond the health effects they reported to their supervisors and to the Tang Center. Another member was told (after the problems experienced by the other two members) that management knew she had attended a union meeting and was told to not make calls with her door closed (even calls to her doctor). We hope that the open presentation of the report onsite at Richmond Field Station will make RFS employees more comfortable about coming forward with their concerns.

We agree with the precautionary, conservative principle used in the report. UC Environmental Health and Safety (EH&S) stated in a meeting with UCB unions that they were opposed to the potential hazard findings presented and described as conservative in the Health Assessment Report. (Mark Freiberg, director of EH&S, however, told the Community Advisory Group (CAG) at their September meeting that he supported the conservative approach. We are not sure if this was change of position or merely a comment to a different audience.)

We believe that hazards, which are being investigated but absent from UC's Current Conditions Report should have been included in the Health Assessment Report as a future concern. For example, the radioactive waste buried at the bulb at the Richmond Field Station site itself and the processing of uranium at the Stauffer/Zeneca site next door. We are concerned because we suspect other hazards lurk in the data gaps of the incomplete characterization of the site. UC ignores any of our requests or concerns even in areas that have not been adequately characterized. Therefore, we believe that the Health Assessment should state that the Health Assessment Report should not state that the RFS site is safe to walk around. There should be some clear, limiting description added to the statement of safety, such as the statement of safety is based on the UC's Current Conditions Report (which is not complete), barring any further findings of hazardous substances.

<u>CDPH response</u>: *The PHA evaluates the worst-case exposure (actual exposure probably much less) for RFS maintenance workers who would have the most contact with contaminated soil and potentially exposed through ingestion, dermal contact, and inhalation. For other workers, the primary route of potential exposure from soil is through inhalation of soil particulates. To a large degree the RFS is either paved, has sidewalks, or is covered by vegetation (grass), which provides a barrier, reducing the chance for dust generation from simply walking around RFS.*

We have added an evaluation of the potential air concentration from resuspension of the COCs in soil, using an emission factor that was developed assuming fugitive dust from contaminated soils are continuous, lasting an extended period of time (years). The estimated air concentrations (using the average soil concentration) and available ambient air screening values can be found in Appendix C, Table 12, of the final PHA. The estimated air concentrations are not at levels of health concern for noncancer or cancer health effects.

It is worth noting that the average arsenic value in soil is within the range of background form the area. Thus, this is the level that could be present in ambient air in other areas not impacted by industrial or anthropogenic sources.

We recognize there are concerns that drums, allegedly containing radioactive waste, were buried at the "bulb." It is our understanding the anomaly detected during the magnetometer survey was at approximately 20-30 feet below the ground surface. RFS employees would not come into contact with potentially contaminated soils at these depths. In response to these allegations, the UC conducted a radiation meter survey in the "bulb" area. No radiological activity at levels exceeding naturally occurring background levels was detected. The anomaly does not appear to pose a current risk at the surface. Future investigation of the anomaly detected at the bulb will be carried out under the direction of DTSC with measures in place to protect public health.

UC has indicated they are willing to investigate and follow your guidelines. Please make them very explicit since they have previously refused to investigate when asked by the coalition of UCB unions. One, they told us they could not do anything beyond what had been historically reported until the DTSC order came forward. They have also refused to investigate specific situations when unions asked, requiring specific individuals working at the Richmond Field Station to come forward. In particular, we have been concerned with the lack of thorough air sampling in buildings at RFS, especially after union representatives and our members have reported ill effects (headaches, increased allergy reactions, etc.). Also we have a tendency to not trust air sampling done when many of the outdoor air sampling equipment gets clogged. When clogged, we suppose the equipment is disabled and data is not being gathered.

<u>CDPH response</u>: Additional information relating data gaps and characterization has been added to the final PHA.

Since the release of the public comment draft PHA, the UC has forwarded a "Statement of Work for Air Sampling Services" to CDPH for review. The UC is planning on conducting indoor air sampling over a 6-month period, to address indoor air quality concerns expressed by workers, as well as the recommendation in the PHA for additional testing of formaldehyde and arsenic. VOCs will be included in the proposed indoor air study. In addition, the UC has committed to involving the RFS community in the development of the air sampling work plan.

We are concerned that the incidence of cancer rate is not being considered. It seems clear to us that if the rate is higher than normal or if a particular type of cancer is manifested in greater numbers, this should be investigated. We appreciate that cancer is prevalent in our society but we are also mindful that chemicals and other hazards have been used at many times previous historical rate since World War II paralleling increased levels of cancer in our society. Hence the concern, when many hazards are present at RFS and on its neighboring sites, that cancer and other diseases relating to thyroid and immune function are related to the hazards experienced by workers there. The incidence of thyroid diseases seems high to us.

CDPH response: *Though the public has anecdotally found elevated numbers of rare and very rare forms of cancer, these findings may not reflect an unusual occurrence. If these observations include various different forms of cancer, not only one form, these findings may reflect what is expected in this population. In addition, as discussed in the Health Outcome Data section (page 46 of the public comment draft), the California Cancer Registry collects information on where an individual with cancer lives, not where the individual works. Thus, we would be able to get information on the cancer rates among the residents in the general vicinity of RFS, but not expected rates among the worker population at RFS. The cancers that people have spoken to us about have occurred in RFS workers or nearby workers, not residents from that area. Therefore, conducting a cancer statistics review among residents for the area surrounding the RFS would not accurately capture whether or not there was an elevated rate of cancer among RFS workers.*

At the RFS presentation, it was noted that the Health Assessment Report looked forward based on the Current Conditions. Many of the employees working at the RFS have been there for over 5 years or even decades. They have been impacted by the hazards over time, and as you know those hazards could have a lingering effect with prolonged exposure.

CDPH response: In the PHA, past exposure to RFS workers and the public (West Stege Marsh) was evaluated.

Although there is not as much scientific data to show the relationship and impact of low dosage exposure over prolonged use and/or in combination to many hazards, I can cite a few that I am aware of (and I am not a scientist):

Stephen Rappaport, Ph.D., adjunct professor, SPH Division of Environmental Health Sciences , "Applying Biomarkers of Exposure: the Importance of Cumulative Exposure", reported at the 2007 SPH Spring Research Symposium, that workers in China experienced serious health problems from a much lower exposure level of benzene than had previously been considered dangerous.

Rachel's Environment and Health News #723, April 26, 2001; revised May 24, 2001 cited physician Janette D. Sherman's book's challenge to the medical profession: "How else (ed. Referring to endocrine-disrupting chemicals etc.) can we explain the doubling, since 1940, of a woman's likelihood of developing breast cancer, increasing in tandem with prostate and childhood cancers." Cancer research has focused on the effects of cancer instead of prevention, allowing a blind eye to cancer causing substances in our society. By putting off employee concerns of cancer and immune related diseases at RFS, the blind eye effect continues.

Arlene Blum biochemist at UC Berkeley, is blazing a trail (Berkeleyan Sept 12, 2007) to investigate the levels and effects of toxic chemicals found in our homes, one of the areas where the use of chemicals proliferate.

Exposure to second hand smoke is considered dangerous today despite the exposure not being as significant as that a smoker receives.

Air pollution has been proven to be a cause (not just a contributor or aggravator) of asthma even in areas where pollution is not above EPA guidelines.

An employee requested biomarking at the RFS presentation, namely having all employees' blood and urine tested. We believe this has merit, especially in light of the gaps in characterization of the site. Blood and urine testing of all who work there could reveal effects of long-term exposure.

<u>CDPH response:</u> *Biological testing for the presence of chemicals such as metals, PCBs, and volatile organic chemicals (VOCs) is possible. However, these tests would not provide a measure of long-term exposure, as most of these chemicals (metals, VOCs) are eliminated from the body in a relatively short amount of time (days to weeks). Further, biological testing would not provide information as to whether a person would develop adverse health effects.*

We believe UC should be required to document instances of employees coming forward with complaints of health effects, whether simply to their supervisors or when they visit the Occupational Health Clinic at UCB campus. UC has told us that they have no statistics about employees being affected by the Water Board clean up or other instances of illness employees thought were related to their work at RFS. Yet employees have informed us that they went to the UCB's Occupational Clinic and have reported health problems to their supervisors and at RFS meetings. Some supervisors have attempted to help employees after higher managers have not responded, by purchasing air filters with their own funds. Employees should not be required to come forward several times to different levels of UCB management in order for UC to acknowledge they have received reports of problems. We believe their ignoring past employee reporting and their demand for employees to come forward again in order for them to perform any appropriate preventative and/or corrective action is a form of harassment.

In summary we appreciate the report but believe it should have mentioned the potential impacts of ongoing investigations and should have included some additional recommendations to UC. Those additional recommendations would include their documenting employee work related health problems.

We are not convinced the site is safe for workers at Richmond Field Station. The history of self monitoring by UC of its site and the management of problems has not inspired confidence in their statements that they see worker safety as paramount. Therefore, we believe that the Health Assessment should state that the Health Assessment Report should not state that the RFS site is safe to walk around. There should be some clear, limiting description added to the statement of safety, such as the statement of safety is based on the UC's Current Conditions Report (which is not complete), barring any further findings of hazardous substances. Because there have been so many instances of illness in that area of the site (in Forest Products Building and at Security Gate nearby), we are also concerned that UC is ignoring staff and union concerns about moving staff into buildings in which other employees have become ill and which are very close to contaminated areas due for considerable clean up.

In addition, UC management has told workers (not their union representatives) that their departments presently located in the Marchant Building, San Pablo Avenue, Berkeley will be moved to the Richmond Field Station. We insist that no other departments be moved to the RFS site until it has been totally characterized.

We applaud your concern for the employees and hope you will stand fast against UC's wish to limit additional costs and/or delays to their renovations of RFS. UCB unions stand together in our concern for all employees and in our vigilance for their safety and well-being.

Comments submitted by Joan Lichterman, Systemwide Safety & Health Director of the University Professional and Technical Employees (UPTE)-CWA 9119

I am writing to commend the Department of Public Health and the Contra Costa Health Services Department for using the precautionary principle in preparing the Public Health Assessment of the UC Berkeley Richmond Field Station, for the reasons identified in the report. My only criticism is that I wish the report from the outset had made more explicit why it used the precautionary principle. However, I understand some of the constraints under which you are working, and appreciate the care, attention to detail, thoughtfulness, and hard work that you all put into the public health assessment and this report. Thank you!

The following comments support the reasoning of the PHA. On behalf of workers at the Richmond Field Station as well as workers, business owners, and residents who spend significant time near the Southeast Richmond shoreline, I fervently hope your departments are not swayed by the claims of site-responsible parties that people who work and live in the area are in no present danger.

1. Despite UC Berkeley's claims, the site has not been thoroughly characterized, and there are too many unknowns to state with certainty that workers who are there every day are safe. For example, environmental assessments conducted in the past showed arsenic in the soil near the Forest Products Lab adjacent to the site's main gate, and arsenic was removed from the area earlier, I believe in 2004. (I don't remember now whether the report discussing arsenic in that area was prepared by URS Corp. or Blasland, Bouck & Lee, Inc. However, I have seen photographs of an area adjacent to the Forest Products Lab from which arsenic was removed in 2004, which an UPTE member took.)
   As of this writing, the University is dealing with a time-critical removal action (TCRA) for additional arsenic found in surface soils in 2006, in an area that supposedly was thoroughly cleaned up earlier. Why did it take two more years to discover that additional arsenic was present in the surface soils if just that small area reportedly had been characterized already? And why it has taken so long to prepare a TCRA is beyond my comprehension, especially as (a) the area is quite windy, and (b) several employees I know who worked at RFS in the past few years had irritated throats, nosebleeds, nausea, frequent stomachaches, headaches, chronic tiredness, and inability to concentrate, among other symptoms. (One woman who worked indoors also suffered from hair loss, and her children would get stomachaches when they rode in her car.) We understand that they reported these symptoms to UC EH&S senior staff. UC unions were made aware of problems at RFS when a number of workers started telling us of their illnesses, of their fears after they started counting how many of their former colleagues were suffering from or had died of cancers, and of harassment by RFS on-site managers.

Again, this is an area that supposedly was characterized. What about all the areas at RFS that have not been examined? I think it is grossly arrogant for the University to assume they know everything that took place on that site since 1870, when its previous owner, the California Cap Company, started manufacturing explosives there.

<u>CDPH response:</u> In the PHA, CDPH identifies data gaps and recommends additional characterization of the RFS site, including additional analyses near the Forest Products Lab.

2. If the University is aware of all of its sites that need remediation, and truly cares for its employees, why have they consistently waited for orders from the DTSC to do what they know needs to be done in areas that already have been characterized?

<u>CDPH response</u>: On September 5, 2007, CDPH presented the findings of the PHA to RFS staff at the RFS. During that meeting, the UC Director of Environmental Health and Safety stated the UC would collect any additional data that CDPH feels is necessary to address potential exposure concerns. We have added information to the final PHA outlining gaps in the data, based on information in the UC Current Conditions Report and other site-related documents. Additional characterization will be carried out under the direction of DTSC.

3. Although scientific data exist concerning the health effects of acute exposure to high levels of various contaminants of concern (COCs), no one knows the effects of long-term exposure to low levels of those same COCs because scientists lack the analytical tools to determine them—as UC Environment, Health & Safety officials acknowledged in a meeting with union representatives on August 29, 2007.

<u>CDPH response</u>: Comment noted.

4. At the same meeting, UC EH&S officials also acknowledged that scientists lack the analytical tools to determine the effect of exposure to multiple COCs. This fact also supports the need to follow the precautionary principle. Not only are workers at RFS likely to be exposed to multiple COCs originating from the Field Station itself, but from dust-borne (and possibly vapor-borne) contaminants from the neighboring Stauffer Chemical/Zeneca site.

<u>CDPH response</u>: Comment noted.

5. Information about several past historical uses of the Stauffer Chemical/Zeneca site has come to light recently, which needs to be examined. One concerns the manufacture and shipping of superphosphate fertilizers immediately adjacent to the California Cap Company. According to the DTSC's "Final RFS Site Investigation and Remediation Order" of September 15, 2006, part of this parcel of land was transferred back and forth between the two sites: 2.3.5.1 Section A is a 6524-acre portion of the Southeastern Section. M.C.C. Stege conveyed this property to the California Cap Company in 1892. In 1920, the California Cap Company conveyed an undivided one third interest of a 0.813-acres portion of this property to Stauffer Chemical Company. Also in 1920, the California Cap Company conveyed an undivided one third interest of a 0.813 acre portion of' the property to the Union Superphosphate Company. In 1949, Stauffer Chemical Company conveyed an undivided two-thirds of' a 0.813 portion

of the property to California Cap Company. California Cap Company then conveyed this property to the UC Regents in 1950. [p. 5]

Because of this transfer, it is possible that some radioactive decay products of superphosphate fertilizers are present in the soil of the Richmond Field Station.

The second concerns the recent discovery of Stauffer Chemical Co. patents for electron beam furnaces and indications that uranium was smelted on the site, as well as patents on tantalum containers for plutonium fuel and historical evidence that "Stauffer Metals, Inc. was one of 109 USA corporations that handled natural uranium metal in support of the atomic weapons program" (Toxics Committee Summary, Community Advisory Group, September 13, 2007). Apparently the buildings in which these activities took place were destroyed and broken up prior to any environmental oversight and monitoring, and the material may have been scattered throughout at least the Stauffer/Zeneca site. Further information is needed about both of these activities, as well as extensive site testing, before anyone can claim that these sites pose no danger to people in the immediately adjacent as well as surrounding areas.

The member of the CAG's Toxics Committee who discovered these Stauffer patents stated, "To date we do not have a complete accounting of all the electron beam furnaces, their locations or uses on the Stauffer site. Given the extensive modifications and upgrades reflected in the patents, it is apparent that the number of electron beam furnaces and ongoing construction/ development was not fixed. It is also apparent that the electron beam furnaces were used for a broad range of experiments as the patent designers continued to upgrade the equipment after problems were identified." She also noted, "None of the electron beam patents have been identified or referenced in the Zeneca/Stauffer (Bayer-CropScience)/ Cherokee-Simeon/Campus Bay historical documents written by Levine Fricke LFR," the main environmental firm on whose analyses successive site-responsible parties have relied for many years.

<u>CDPH response:</u> CDPH is aware of this information. The PHA provides recommendations to address these issues relative to the RFS.

6. The analysis about recontamination of the marsh given by consultant Stuart Siegel at the last CAG meeting (September 13, 2007) flies in the face of UC statements that the marsh has been remediated and poses no hazards.

<u>CDPH response:</u> In the PHA, recommendations for additional monitoring of the West Stege Marsh are outlined.

In sum, to avoid writing a book, I think we must accept the precautionary principle on which the Public Health Assessment recommendations are based because there are so many unknowns about the Richmond Field Station and Stauffer/Zeneca/Cherokee-Simeon/Campus Bay sites. I have read a number of the environmental reports about these sites, as well as UC Berkeley "Draft Current Conditions Report" (April 5, 2007), and I must agree with the Toxics Committee's analysis of that report: "Overall the Report is inadequate, in some cases inaccurate and generally incomplete." This in keeping with UC's propensity to circle the wagons when it is challenged. UC officials from the campus's Environment, Health & Safety office can profess repeatedly in one paragraph how devoted they are to the health of the University's workers, and on the other hand state: "While there is no evidence that digging in unfenced areas at the RFS poses a health risk, such activity can potentially damage underground utilities or sensitive plant or animal species" (September 5, 2007 Department of Public Health meeting- message from the Director of EH&S, posted September 19 at http://rfs.berkeley.edu/news.html). Claim that no more site analysis is needed, and deny that humans who work at RFS face any level of risk. (But we must protect underground utilities and sensitive plant and [other] animal species.)

In the meanwhile, a pregnant woman who developed thyroid cancer while she was working at Richmond Field Station wonders why the doctors can't figure out why her toddler is obese, despite eating a healthy diet and having no detectable medical problems. As the chair of the Toxics Committee said in a recent correspondence:
When toxicologists calculate that there will be only one more cancer death per million for a given dose of pollutant[,] that estimate assumes uniform human susceptibility and is an extrapolation from animal or microbial tests or from limited human exposure data. Children and infants are frequently given greater protection. However, adults who are genetically more susceptible (but not readily recognizable as such) will bear the greater burden of exposure to a particular pollutant. More of them will die and many will die earlier than they would have had they not been exposed to a triggering disease agent.

The message from recent science is to remove as much of any pollutant as you can from environments being remediated. This is the best reason I can think of for fully characterizing all of the sites along the Southeast Richmond shoreline. I look forward to the day when more is known about these sites, and especially to the day when toxicologists, epidemiologists, and medical professionals have the tools to track the health effects of exposures to environmental contaminants.

Comments submitted by William G. Reifenrath, Ph.D. of Statacor, Inc.

The following comment is provided for subject draft report. The comments include my observations as a tenant of the Richmond Field Station during the remediation efforts and my perceptions from the public meetings I attended.

1. Page 14: "Increased cancer risks in this range (1/10,000) are considered to be the upper-end of what is considered an acceptable risk". This conclusion seems to be at odds with the public comments by Mark Freiberg, EHS and others at the Public Health meeting held at RFS on September 5, 2007, that we are taking the most conservative approach to evaluate health risks.

CDPH response: Comment noted.

2. Page 21: "However, some of this dust did deposit on structures in the area". This is a gross understatement (see attached photos). A serious effort to contain dust in October, 2003 remediation was not done (see photos). This cavalier approach to dust/dirt containment continued in 2005, when access roads were coated with dust and the street cleaning efforts resulted in turning the dust to mud, which coated vehicles (see photos).

<u>CDPH response</u>: Comment noted. We have modified the text based on the comment.

3. Page 21: "It is not known what chemicals were attached to the dust particles" and therefore it was "not possible to evaluate health effects from potential exposure to other chemicals [other than carbon]". Buildings downwind from the dust operations were inundated with dust and occupants were needlessly exposed to potentially contaminated soil. Common sense would have dictated firstly that operations be halted until adequate dust containment procedures were instituted. A tent surrounding the soil/carbon dust mixing operation would have largely mitigated the problem. I personally walked the site with Anna Moore, EHS, who was in charge of the project at the time. She refused to halt operations. I also complained to the Contractor, Matthew D. Marks, Envirocon, Inc. Sacramento, CA., who was conducting the dust mixing operation. I also walked the grounds with the RFS manager at the time. Dust mitigation consisted of running a garden hose from Bldg. 112 and connecting to little misters and an individual with a sprayer (see photos), while dust clouds billowed 100 ft into the air. My comments did not result in improved dust abatement procedures. Instead, in an effort to speed the work, dust mixing operations were conducted after normal working hours (at least until dusk), when winds are known to pick up at the site. Common sense would have dictated secondly that buildings and occupants be monitored directly downwind from the dust mixing operations. According to the report, various samples were taken from Buildings 102, 163, 175, 478, and the EPA laboratory (Bldg. 201). An examination of the area maps and the prevailing wind pattern shows that these buildings are either upwind from the dust mixing operations or along the perimeter of the dust fall-out zone. It would have made more sense to monitor buildings 149-155 and 158, which were located in the direct down-wind fall-out zone. This apparently was not done. Thirdly, common sense would dictate that if you are going through the trouble to collect dust samples, why not analyze them for heavy metals or other potential contaminants? According to the report, this was not done.

<u>CDPH response</u>: In the PHA, CDPH recommends air monitoring be conducted within the RFS property and along the site perimeter when remedial activities that generate dust are conducted. In addition to dust, site-related contaminants should also be monitored. Wind patterns should be considered in locating air monitors, as suggested by the comment.

4. Page 21: The mercury vapor analyzer did not have the sensitivity to measure to non-worker residential exposure standards. Why were more sensitive instruments not employed?

<u>CDPH response</u>: The remedial actions were conducted under the oversight of the Bay Area Regional Water Quality Control Board. It is not uncommon for detection limits to be set based on worker standards. The mercury vapor analyzer was used to monitor worker exposure at the excavation site. Because of ongoing community concerns, CDPH was asked to evaluate the potential off-site implications of past excavation work. The standards we use to evaluate residential exposure are lower than those for workers.

5. Page 22: EPA laboratory measurements. These measurements were made by the EPA as part of their laboratory quality control. The EPA building was not in the direct fall-out zone, as verified by personally walking the site during the height of the dust mixing operations.

Furthermore, to my knowledge, these were indoor measurements of filtered air. These samples would therefore not be representative of levels in the direct down-wind fall-out zone. Since elevated background levels of mercury were found in the EPA building, it would have been prudent to make measurements in the fall-out zone, where buildings did not have air filters. This apparently was not done.

CDPH response: In the PHA, CDPH acknowledges that the EPA building is not downwind of the excavation. EPA collected samples in the building, as well as outdoors, as indicated by the comment. The data presented in the PHA are results from the outdoor samples.

6. Pages 23, 25: Arsenic measurements: Again, it appears that instruments with inadequate sensitivity were used for monitoring.

CDPH response: It is not uncommon for detection limits to be set based on worker standards. Because of ongoing community concerns, CDPH was asked to evaluate the potential off-site implications of past excavation work. The standards we use to evaluate residential exposure are lower than those for workers.

7. Page 25: ATSDR and CDPH assumed adequate quality control and did not conduct their own audit.

CDPH response: The data reviewed for the PHA consists primarily of environmental data collected under the oversight of a state or federal regulatory agency. One aspect of the regulatory review process is to ensure the data meets proper QA/QC standards.

8. Page 26: At the Public Health meeting held at RFS on September 5, 2007, many of the problems listed above were blamed by panel members on poor oversight by the Regional Water Quality Control Board. Yet, according to the report, the University of California apparently objected to transfer of oversight authority to the Department of Toxic Substances Control.

CDPH response: UC representatives encouraged the City of Richmond to exclude the RFS from a resolution petitioning the transfer of regulatory oversight for both the Zeneca and RFS sites. Mark Freidberg, Director of UC Environmental Health & Safety, spoke at the February 15, 2005, Richmond City Council meeting (video available online) and the Berkeley Daily Planet cited an email from the UC Community Relations office to the Richmond City Council, both offering the same message.

The above comments are provided in the spirit that they will be used to improve any future remediation efforts conducted at the Richmond Field Station and are not intended to make any person or agency(s) a scapegoat. The Station and its occupants were needlessly exposed to potentially toxic dust/dirt, environmental monitoring was grossly inadequate, and quality control is suspect. This situation should not be allowed to happen again.

<u>Comments submitted by UC Berkeley, Office of the Vice Provost, Academic Planning and Facilities</u>

The University of California, Berkeley (UC Berkeley) has reviewed the Draft Public Health Assessment (Draft PHA) prepared by the Department of Public Health (DPH) for UC Berkeley's Richmond Field Station (RFS). As a professor in the UC Berkeley School of Public Health and as Vice Provost, I submit UC Berkeley's comments on the Draft PHA in this letter.

We appreciate the opportunity to provide comments on the Draft PHA. We support the health assessment process and believe this work is of utmost importance. The health and safety of University students, faculty, staff, visitors and the surrounding community is our highest priority as we clean up contaminants left by historic industrial uses on and near the RFS. We also appreciate the effort made by DPH staff in collecting data from multiple sources and reaching out to provide a resource to the RFS community.

We are providing these comments to you in order to strengthen this important work by making it more accurate. We are also providing some recommendations that we believe will make the document more accessible and meaningful for both the general public and technically-knowledgeable readers.

In providing these comments, we want to stress that many of the corrections we are providing-and many of the uncertainties that DPH believes still exist—could have been resolved had DPH staff communicated its preliminary findings to University staff prior to issuance of the draft document. In some cases, collection of a few additional environmental samples would likely have resolved the uncertainties. Similarly, data on exposure durations and information about actual RFS conditions were readily available, and could-have been incorporated into this Draft PHA.

<u>CDPH response</u>: CDPH does not agree that the uncertainties identified in the PHA could have been resolved with "collection of a few additional environmental samples," as asserted by the comment. There are a number of areas at the RFS where contamination could be present, as a result past activities carried out by the UC at the RFS in addition to activities carried out by former tenants/owners. The final PHA describes a number of these areas and resulting data gaps. Additionally, DTSC outlined a number of data gaps in their recent comments (October 2007) on the UC Current Conditions Report.

Because the Draft PHA did not use the most current and accurate information, risks in many cases are grossly overstated or misrepresented, which has unfortunately caused undue alarm. As a result, some in the RFS community (which includes employees, visitors, students, and contractors) now believe that the RFS is unsafe. In fact, one longtime contract group unfortunately quit working at RFS because of the damage caused by the misleading information contained in the draft PHA.

<u>CDPH response</u>: CDPH utilized data presented in all the remedial reports released by the UC, including the most recent Current Conditions Report (April 2007). If the UC has data that has not previously been made available to CDPH or the public, we request these data be forwarded.

The PHA used health protective assumptions in identifying contaminants at levels of health concern. Context for these assumptions is described on numerous occasions in the PHA.

It would be misleading to say the site poses no risk to maintenance workers (those who come into contact with soil), given the data gaps/characterization needs that have been identified.

We would appreciate more open communication with University technical staff while DPH staff work on future health assessments. This request applies to both the finalization of the Draft PHA and to the health assessment being prepared for the adjacent former Zeneca property. If DPH staff conclude that there are undetermined health risks to the RFS community due to lack of data on the effects of historic activities at the former Zeneca site, we would appreciate the opportunity to participate in resolving those areas of undetermined risk through additional environmental assessment before a draft report is issued. Such communication will facilitate the incorporation of exposure assumptions that are conservative but realistic.

We found the Draft PHA to be generally disorganized and misleading due to selective presentation of conclusions and recommendations, unrealistic exposure scenarios and the use of terminology that biases interpretation toward risks that may not exist. Some examples (and recommended changes) are presented below, with detailed comments and recommendations contained in the sections that follow. We request that our comments be incorporated into the Final PHA, and would be happy to work with DPH to provide whatever additional information DPH needs to ensure that the Final PHA is a meaningful, relevant, and scientifically-valid document. The comments are numbered sequentially to facilitate discussion on recommended changes.

General Comments

The University has spent nearly $20 million to investigate and remove legacy pollutants at the RFS since 1999. More than 60,000 cubic yards of wastes were removed from the RFS during three phases of work from 2002 through 2004. These actions have led to a significantly improved environment for human and ecological residents of the RFS and for the neighboring City of Richmond community.

The Draft PHA bases its findings on upland soil conditions on two remaining areas of soil affected by legacy pollutants. One of these, a small area near the former Forest Products Laboratory, will be remediated in early October 2007. The other area, the former California Cap Company mercury fulminate manufacturing plant, is also slated for cleanup. Both areas are access-restricted, with fences and warning signs. Both areas are off-limits to anyone at the RFS, including facility maintenance staff that might otherwise dig in these soils.

<u>CDPH response:</u> *The UC Current Conditions provides information on a number of areas and past activities at the RFS where contamination could be present. In the final PHA we describe some of these data gaps. DTSC outlined the need for more characterization at the RFS in their comments on the Current Conditions Report. Future characterization of the RFS will be conducted under the direction and oversight of DTSC.*

1. **Confusion between past, current, and future health risks.** The Draft PHA unfortunately merges findings for past, current and future exposures to RFS maintenance workers who regularly work in soil. This leads to confusing and sometimes inaccurate conclusions regarding current potential exposure risk compared with historic exposures. We recommend that the document clearly separate the analyses of past exposure from the assessment of current and future exposure potential. The University's removal of significant pollutant source areas and the University's implementation of exposure control measures (such as training facilities maintenance workers on potential soil contaminants) has significantly reduced any potential risk posed by current conditions. We are confident that the current actual risk is far lower than the risk presented in the Draft PHA.

CDPH response: The PHA discusses exposure to past and current workers in separate sections. As stated in the public comment draft PHA and the final PHA, concentrations of contaminants in soil are at levels of health concerns for both past and current workers. In the PHA, it is acknowledged that conservative assumptions were used, which likely overestimate exposure. This approach was taken because of the data gaps that remain at the site and to ensure exposures of health concern are identified and mitigated.

We agree with the comment that providing training to workers and implementing control measures is a positive step toward reducing exposure. The PHA recommends additional training for maintenance workers who may come into contact with contamination in soil.

2. **Biased summary of risks.** Key points regarding safe conditions are not highlighted in the summary. The Draft PHA (page 45) and the two page summary of the Draft PHA completed by CDPH for the September 5, 2007 meeting at the RFS, explicitly concluded that it is safe to walk on the grounds of the RFS and on the Bay Trail. However, this fundamentally important point was omitted from the Summary and Conclusion section of the Draft PHA. Instead, that section of the Draft PHA described the RFS as an inadequately characterized area containing a number of "indeterminate health risks," suggesting that the RFS may be a dangerous place and creating a climate of fear. The fact that it is safe to walk on the RFS and Bay Trail should be included as a principal finding in the Summary and Conclusion of the Final PHA.

CDPH response: CDPH has included a statement about walking on the RFS in the summary and conclusions of the final PHA.

3. **Misleading language.** The repeated statement of the presence of "indeterminate health risks" is biased toward the assumption of an actual risk being present that has not been ruled out by sampling. An alternative description should be used instead, such as, "there is insufficient data to determine whether any health risk exists." This might help prevent further unwarranted alarm and unnecessary anxiety among some in the RFS community. We ask that vague and misleading language such as this be eliminated in Final PHA.

CDPH response: Changes to the text have been made for clarification.

4. **Selective analysis of existing mitigations.** The Draft PHA correctly cites the restriction of access to the marsh as a control which prevents exposure to an "indeterminate health risk" (to adults and children in the Stege Marsh). However, the Draft PHA ignores an even more restrictive barrier to access in two upland soils areas. The Final PHA should cite the access restrictions of fencing in the uplands as an appropriate measure to control exposure and incorporate this control into the exposure assessments.

CDPH response: The text has been modified based on the comment.

5. **Report is disorganized.** The Draft PHA scatters conclusions and recommendations throughout the report. In one instance, a recommendation is made (page 23, sampling for arsenic in indoor air) that does not appear in the recommendations section. The Final PHA should include a section that summarizes all of the conclusions and recommendations by exposure pathway and that references the source pages in the document.

CDPH response: The accidental omission of "sampling for arsenic" in indoor air in the conclusions has been corrected. The PHA is written for lay audiences. In effort to relay complex issues we provide conclusion and recommendations after each section so that a clear understanding is gained as one reads through the document. A summary of the conclusions is provided at the beginning of the PHA.

6. **Unrealistic exposure durations.** The Draft PHA contains assumptions about exposure durations that are extremely unrealistic (and in at least one case, impossible). We recommend the use of realistic exposure durations in the Final PHA.

CDPH response: The comment is not specific. With respect to maintenance workers, it is our understanding that some workers have been at the RFS for over 23 years. Our interviews with workers provided a basis for assumptions relating to exposure duration. Other assumptions, such as the frequency that a worker digs in soil, were based on a recommendation from the Associate Director of UC Environmental Health and Safety (Greg Haet, UC Berkeley, email communication, June 15, 2007) .

7. **Incorrect or incomplete data used.** As an example, the Draft PHA suggests that indoor air at B478 (the former Forest Products Laboratory) could be affected by soil gas migration from contaminated groundwater from the Zeneca site, yet recent soil gas analyses along 46th St. and groundwater sampling in the vicinity do not indicate that such a problem exists. DTSC has reviewed the recent soil-gas data as presented in Zeneca's Lot 1 Remedial Investigation Report (dated July 27, 2007) and has verbally indicated to UC Berkeley staff that although VOCs are present in groundwater in this area, VOCs are not migrating upward and there is no increased health risk for the vapor intrusion pathway.

CDPH response: The limited groundwater data collected near B478 was not available prior to the initial release of the PHA. Since the public comment release, CDPH has reviewed the limited groundwater data. Our conclusion that additional sampling (groundwater, soil gas) is warranted has not changed, based on these limited data. In the PHA it is suggested that the Zeneca site could be one potential source of VOC contamination on the RFS. We also indicate there is a *potential for other sources of VOCs, as a result of UC operations. DTSC comments on the UC Current Conditions Report outline data gaps that need to be addressed before such a conclusion can be reached.*

8. **Broad scientific and technical imprecision.** There are numerous examples in the Draft PHA where a broad generalization is used to suggest an actual health effect, without any evidence of a link between the effect and exposure. An example is the discussion on formaldehyde detected in one indoor air sample in an unoccupied room in one building (B163). The text in the Draft PHA can be interpreted to imply that formaldehyde was potentially linked to a broader concern of eye irritation at RFS. In fact, there appears to be no documentation that links the effect with any exposure in the area where the sample was taken.

<u>CDPH response</u>: *The concentration of formaldehyde measured in Building 163 on at least one occasion was at levels that can cause headaches and a number of irritant effects. CDPH staff heard concerns from several workers, who expressed that they were suffering from similar symptoms. The PHA clearly states the time period in which the formaldehyde was elevated.*

9. **Inappropriate application of maximum concentrations to assess risk.** The Draft PHA bases its assessment of current and future risk on exposure to maximum concentrations of contaminants. This is an invalid approach because many of the types of exposures described in the draft PHA are not physically possible to achieve.

<u>CDPH response</u>: *It is not uncommon to evaluate a worst-case scenario for a site that is not well characterized, such as the RFS. A conservative approach was taken to identify exposure of potential health concern so that steps can be taken to mitigate these exposures.*

10. **Presentation of irrelevant health effects information**. The Draft PHA contains approximately fourteen pages of detailed descriptions of potential health effects of various chemicals. However, the Draft PHA concludes that levels of chemicals detected at the RFS are *not* expected to have caused such noncancer health concerns (except possibly for upper respiratory tract and eye discomfort in one instance). Detailed discussion of the *potential* health risks of chemicals tends to mislead many into believing risks of those diseases are posed at the RFS, when the evidence does not actually support such a conclusion. Therefore, we recommend that the generic discussion of health risks of chemicals be moved to an appendix in the Final PHA (similar to Appendix D, Toxicological Summaries).

<u>CDPH response:</u> The discussion the comment is referring to, is part of the community concerns evaluation section, and provides information relative to health concerns expressed to CDPH. No changes have been made based on the comment.

11. **Inappropriate process.** Finally, although it is not described as such, the Draft PHA is primarily a screening-level assessment, with the purpose of separating pathways, receptors and chemicals that are not a concern from those that warrant further evaluation. After a screening-level assessment is completed, immediate response actions are generally not recommended (unless an imminent threat to public health exists). Instead, if unacceptable

risks or hazards are noted at the screening level (i.e., the analysis cannot demonstrate compliance with screening-level exit criteria), then the logical next step, according to the tiered processes in USEPA and state guidance, is to refine the risk and hazard estimates by an increasingly site-specific evaluation, using more refined estimates of site-specific exposure. While the Draft PHA frequently notes that actual exposures for all receptors may be far lower than assumed, it still recommends exposure control and mitigation actions (most of which are already in place), rather than recommending that the exposure assumptions be refined further.

The Final PHA should clarify that this is a screening level risk assessment and should recommend that exposure estimates be refined and more realistic estimates of risks and hazards be generated in order to determine whether response actions such as mitigation or exposure controls are necessary.

<u>CDPH response:</u> *The PHA is not intended to take the place of a Human Health Risk Assessment, which is a document required under the remedial process. The purpose of the PHA is to identify exposures of potential health concerns and make recommendations to reduce or mitigate these exposures. Given the lack of characterization at the site, refining the risk calculations to reflect a more likely exposure scenario would not be prudent at this time. CDPH agrees that once the site is completely characterized, a Human Health Risk Assessment utilizing "refined" estimates should be conducted by the UC, under the oversight of DTSC.*

Specific Comments—Exposure Assessment

12. Many of the exposure assumptions are not simply conservative; they are invalid, because they are physically impossible to achieve. For example, the Draft PHA states that RFS maintenance workers are subject to an increased *current and future* health risk and assumes that workers are exposed to the highest concentrations of contaminants during all digging, but does not take into account that the two areas where the highest concentrations are located are fenced off and are not accessible to workers. Moreover, even if the areas were not fenced, material containing the highest concentrations of contaminants is not co-located, making simultaneous exposure to peak levels of each contaminant impossible. This same type of assumption was used for restoration workers and for children and adults playing in the marsh.

<u>CDPH response:</u> *Comment noted. Please see CDPH response to comment # 9 above.*

13. The assumed exposure frequency in the Draft PHA for RFS workers digging in soil is listed as 100 days per year, for two hours per day, up to 7 years or 23 years, although no source or justification is provided. Default exposure frequencies and exposure durations for excavation and utility workers are typically far lower. More importantly, the actual exposure frequencies and durations at the RFS are far lower. For example, actual data for the most recent year indicates that two workers dug in soil for only 31 and 34 hours each over the most recent year (and this digging was performed by trained workers instructed on how to identify and respond to cinders and other contaminated soils.) The risk assessments for current and future exposures should be recalculated based on more realistic exposure times.

<u>CDPH response</u>: With respect to maintenance workers, it is our understanding that some workers have been at the RFS for over 23 years. Our interviews with workers provided a basis for assumptions relating to exposure duration. The assumptions related to the frequency (2 hours/day, 100 days/year) that a worker digs in soil, was based on a recommendation from the Associate Director of UC Environmental Health and Safety (Greg Haet, UC Berkeley, email communication, June 15, 2007).

CDPH supports the UC in training RFS workers in how to identify visible cinders. It is our understanding that this training was implemented over the past year or two. In the PHA, CDPH evaluated past exposure, which took place before these trainings were implemented. It is important to note that other types of chemical contamination are usually not visible to the naked eye. Given the data gaps that have been identified by CDPH and DTSC, we hope the UC is providing adequate personal protective equipment to workers who dig in soil anywhere on the RFS where the possibility of contamination exists.

14. Even for a screening-level evaluation, many of the exposure factor values are unrealistically conservative, and no source citations, rationale or justification are provided for the selected values, as noted below. (Although citations of numbered references from the reference list are provided, the specific source and justification for each assumption cannot be readily understood.)

<u>CDPH response</u>: The sources are appropriately described and referenced. Please see footnotes to tables and the list of references.

15. The Western Stege Marsh recreational pathways turned out to be driver pathways, but at the same time the Draft PHA says access "should continue to be restricted". The real issue is whether to call this a complete pathway at all. Even if it were considered a complete pathway, it is one with rare occurrence and short duration (the classic "trespasser" type of scenario).

<u>CDPH response</u>: Comment noted.

16. In Table 1, adults and children who may come into contact with marsh sediments and surface water are presented as key receptors. However, the text says that reports of such activities are "anecdotal" without any citations. We have not observed or received reports of any adults or children playing in the marsh (on weekdays or weekends) in recent years. If such recreational exposure exists at all, it most likely occurs only on the edges of the marsh. Therefore, a more realistic exposure point concentration (EPC) would be based upon the chemical concentrations found at the edge of the marsh, extending out to a depth that would be "wadable" by children, teenagers or adults.

<u>CDPH response:</u> CDPH used the average concentration of contaminants in the marsh for estimating potential exposures to individuals who may have recreated in the marsh in the past. We recognize the marsh does not appear to be used by recreators currently, as the marsh is fenced and posted. We do not have the same level of confidence that it was not used in years

past.

17. Maximum concentrations were used to represent post-remediation conditions in the marsh (page 14, Table 5, page 15, Table 6) and in upland soils for both pre-remediation and post-remediation conditions (page 17, Table 9), as a "worst-case" scenario. However, this approach conflicts with longstanding and the most current standards of practice for risk assessment (for example, USEPA guidance). While comparison of maximum concentrations to screening values is commonly done in early assessment stages, EPCs for estimation of site-specific risks and hazards are typically based on the lower of the maximum or the 95% Upper Confidence Limit (UCL) on the mean (USEPA 1989), as long as the sample size is large enough for calculation of a UCL. In the most recent guidance (USEPA 2007 a, b), USEPA explicitly recommends that the 95% UCL on the mean be used instead of the maximum (based on a review of sample size, data distribution and detection frequency).

<u>CDPH response:</u> *We have added an evaluation of the average concentration for the restoration pathway. As stated a number of times in the PHA, while exposure to the highest concentration is not likely to occur, it does indicate the need for further evaluation of marsh sediments to ensure that the marsh is not being re-contaminated from other areas. Sediment sampling conducted during June of 2006 revealed the presence of elevated levels of arsenic (590 ppm) in the remediated portion of the marsh. As stated in the PHA, while it is unlikely that an individual would be exposed to sediment from the specific location where the highest level was measured, for the amount of time assumed, these data (June 2006 sampling) indicate the presence of contaminants in the remediated portion of the marsh at levels of health concern. This demonstrates the need for further action/investigation in the remediated and non-remediated portions of the West Stege Marsh to determine whether the marsh is being re-contaminated.*

18. No source citation is provided for the assumed rate of incidental ingestion of surface water from the marsh (50 ml/hr). This may be based upon USEPA's default rate for recreational exposure, where 50 ml/hr is assumed to be the incidental water ingestion rate for swimmers (USEPA 1989). If so, this assumption would result in a gross overestimation of incidental ingestion of surface water by waders in a tidal marsh. Several recently issued guidance documents (ODEQ 2000) and large human health risk assessments have *eliminated* the route of incidental ingestion of water when considering non-swimming recreational or occupational exposures to surface water and sediment (L WG 2007, Exponent 2000).

<u>CDPH response:</u> *The exposure assumptions used in the PHA are cited and referenced. No references were provided for the citations presented in the above comment. The UC appears to be referencing remedial documents prepared by environmental consulting firms, as support for eliminating incidental ingestion of surface water. CDPH does not consider consultant reports "guidance documents." With respect to current and future exposure, the primary exposures of concern identified in the West Stege Marsh are from sediment, not surface water.*

19. The dermal absorption factor (referenced as AF in the PHA) provides an estimate of the desorption of a chemical from soil and subsequent absorption across the skin and into the bloodstream (USEPA 1989b). It is a chemical-specific value based on evaluation of available biological data and the physical/chemical characteristics of the chemical.

The sources and accuracy of the values cited in the PHA for dermal absorption factors from sediment are not clear. For some inorganic chemicals (copper, mercury, zinc), the PHA appears to use default AF values without providing a rationale. However, this is contrary to the current practice. USEPA (2004), which is the most current guidance for evaluation of the dermal exposure pathway, recommends that AFs for inorganic chemicals should be used only if chemical-specific data are available and has withdrawn the previous default value of 0.0 1 for inorganics. Therefore, the AFs for copper, mercury and zinc should be zero since there are no chemical-specific values available for these metals.

<u>CDPH response:</u> *The assumptions used to estimate dermal exposures are appropriately cited and referenced in the PHA. The EPA guidance recommends chemical-specific data be used when available and default assumptions when necessary. Please refer to the Appendix B-4 of the EPA guidance referenced by the comment, which shows the AF utilized in the PHA. The EPA guidance indicates that only those chemicals that contribute to more than 10% of the dose from oral exposure are considered important enough to carry forward in the "risk assessment process." In the example calculation presented in the EPA guidance document, copper, mercury and zinc did not contribute to 10% of the oral dose, thus were not considered chemicals needing further assessing. The EPA guidance does not state that these compounds should not be evaluated, as suggested by the comment. For the purposes of the PHA, we estimated dermal exposures to copper, mercury, and zinc, using published default assumptions to ensure exposures of concern are identified.*

20. The analysis of indoor air quality data in the Draft PHA is incomplete and misleading. The Draft PHA states (page 24) that five volatile organic contaminants "exceed cancer comparison values," but provides no information on how concentrations of these contaminants at RFS compare with indoor air in typical office buildings. EPA Indoor Environments Division's technical data (USEPA 1995) indicates that concentrations at RFS are on the *low* end of the spectrum of concentrations found in typical office buildings. Rather than providing perspective and context, the Draft PHA leads one to think that contaminant levels in indoor air at RFS are unusual and dangerous.

<u>CDPH response:</u> *The PHA discusses the results/concentrations of contaminants found in indoor air relative to their potential for causing noncancer health effects. Additional context was/is provided with regard to potential outdoor sources of contaminants. The PHA discusses the limitations in drawing conclusions about cancer risk, based on one sampling event. Further, with respect to the indoor air sampling conducted in Building 478, the detection limits were too high to make comparisons to levels typical of in indoor air. For example, the detection limit for trichloroethylene for this sampling event ranged from 519 µg/m^3 to 603 ug/m^3; the level typically found in indoor air is estimated at 0.5µg/m^3(90th percentile of 21 studies complied by USEPA). The text has not been modified based on the comment.*

21. The Draft PHA states that additional analysis is needed to "evaluate the potential for VOCs to be affecting indoor air in buildings in these areas," referring to buildings on the northeast side of RFS. However, the Draft PHA provides no technical basis for this conclusion. Soil gas and groundwater samples collected in the past year in the vicinity of B478 do not indicate that VOCs pose a health risk to occupants of B478.

<u>CDPH response:</u> While the data referenced by the comment provide some useful information, they are not sufficient to adequately evaluate or rule out the potential soil gas pathway into B478.

Specific Comments—Risk Characterization

22. It is difficult to interpret the results of the initial screening comparisons. A large number of screening values are used in the initial screening exercise (e.g., CREGs, CMEGs, PRGs, CHHSLs). The Draft PHA provides neither a hierarchy of selection nor any discussion of which screening values may be the most appropriate to use. For example, in Table 2, the "Comparison/Screening Value[s]" for arsenic span more than three orders of magnitude, from a "0.07 [ppm] Residential CHHSL" to a "200 [ppm] Chronic EMEG (adult)"; without further justification, these screening values cannot all be applicable. No context or explanation as to the magnitude and frequency of exceedances, nor are the implications of the exceedances discussed (for example, what would be the importance of 1 exceedance out of 100 results?).

<u>CDPH response:</u> The PHA describes the various health comparison values citied in the PHA (please refer to Description of Toxicological Evaluation section). Some contaminants, such as arsenic have comparison values for both cancer and noncancer health effects, which is the reason for the "span" between the values. Cancer comparison values are noted in the tables. If more than one comparison value is available, CDPH uses the most conservative value to screen for Contaminants of Concern (COCs). CDPH describes the contaminants that exceed screening values in the evaluation section of each exposure pathway.

23. The risk characterization text for non-cancer effects undermines the implications of the hazard quotient (HQ) and hazard index (HI) values presented in the tables. For example, the estimated HI for child/teen playing in the Marsh is 3.1 (Table 6). The text discussion (on page 14) points out that additivity of the chemicals included in this HI is not warranted, i.e., "current toxicity information indicates that different parts of the body are affected by the lowest dose of each of the chemicals". The typical next step would be to separate HQs by target organ and evaluate whether the HI for any target organ exceeds 1.0. However, this step was not performed, leaving the impression that non-cancer adverse effects exceed the recommended threshold levels.

<u>CDPH response:</u> Target toxicity doses were calculated when appropriate.

24. Cancer risk calculations are not shown and tables of estimated cancer risks are not presented. It is not possible to evaluate whether the cancer estimates are accurately calculated and which chemicals and exposure routes (e.g., ingestion, dermal contact) are the risk drivers.

<u>CDPH response:</u> It is possible for cancer risk estimates to be calculated/evaluated based on the information provided. Cancer risk equations and slope factors can be found in Appendix E of the

final PHA.

25. Although risk and hazard estimates were developed separately for pre-remediation and post-remediation periods in the Marsh, the summary text combines these periods as past/current/future exposure into a single, misleading conclusion. This implies the potential for unacceptable risks to have occurred during a long interval of undisturbed high exposure. In reality, EPCs varied by area, by site and receptor activity, and by spatial and vertical distribution patterns for the chemicals.

CDPH response: Comment noted.

26. The Draft PHA recommends additional soil characterization at the RFS, but provides little basis for this recommendation. For example, the Draft PHA states (page 3) that "Chemicals used in research activities at RFS, as well as known contaminants from historic uses of RFS and Zeneca…should be analyzed." However, hundreds of samples already have been taken at RFS. This information, combined with assessment of historic uses, has formed the basis for the clean-up UC Berkeley has performed at RFS to date. The Draft PHA doesn't provide sufficient justification for additional characterization of soils at RFS. Other than the Forest Products Lab area already identified based on a historic use assessment, if DPH has information that there have been spills from RFS research labs that could have contaminated soils at RFS, that information should be provided to University technical staff as soon as possible.

CDPH response: Additional clarification and justification has been added to the PHA, based on information and data gaps outlined in the UC Current Conditions report. In addition, DTSC outlined numerous data gaps and the need for additional characterization in their comments on the UC Current Conditions Report. The comments were sent to the UC, Office of Environmental Health and Safety (EH&S), in a letter dated October 18, 2007.

Specific Comments—Miscellaneous

27. The Draft PHA states (page 26) that UC Berkeley "...objected to the transfer [from RWQCB to DTSC oversight]..." Aside from being factually untrue (note that UC never spoke or corresponded with the California Environmental Protection Agency to try to influence this decision), this information is not relevant to assessment of public health risk.

CDPH response: UC staff communicated to the Richmond City Council in February of 2005; at the time, the Richmond City Council was preparing to vote on a resolution requesting that the regulatory oversight of the Zeneca and RFS be transferred from the RWQCB to DTSC. EH&S Director, Mark Freiberg, spoke at the February 15, 2005, Richmond City Council meeting. Mr. Frieberg characterized the resolution as being overly broad, suggesting the RFS be excluded from the resolution, stating the RWQCB was the right agency to provide oversight. A video archive is available at (skip to 4:19:00 for testimony):
http://richmond.granicus.com/MediaPlayer.php?view_id=2&clip_id=282&publish_id=&event_id=. *Additionally, Irene Hegarty of UC Berkeley's community relations wrote an email to the Richmond City Council a few days before the February 15th city council meeting with a*

similar request to exclude the RFS from the resolution. We have modified the text in the final PHA to add further clarity and reference (link) to the February 15, 2005, Richmond City Council meeting video.

The collection and documentation of community concerns is an important aspect of the PHA. The "background" part of the Community Concerns Evaluation section serves to provide context for the activities at the site. In this particular situation, RFS workers and/or community members interviewed felt it was important that issues surrounding the transfer of oversight be presented.

28. Many of the actions recommended (page 48) in the Draft PHA were completed by the University prior to the issuance of the Draft PHA, or are currently in progress. Examples of actions completed include recommendations numbers 6 (Forest Products Lab assessment), 7 (maps) and 9 (worker training). Other recommendations are already in progress or are items on which UC Berkeley is currently working with DTSC. We ask that completed items be removed from the list of recommendations in the Final PHA.

<u>*CDPH response:*</u> *For the purpose of transparency, rather than remove a recommendation we indicate when the actions/activities outlined in the recommendation have been completed. As of December 2007, recommendation number 6 has not been completed.*

29. In the Final PHA, the risk assessment conclusions and findings should be presented more clearly with uncertainties identified in the context of additional evaluation needs and data gaps. An uncertainty section should be added that describes the sources of uncertainty and discusses the level of confidence in the risk assessment. Sources of uncertainty that are inherent to the risk assessment process should be identified, as well as sources of uncertainty or assumptions that may benefit from additional evaluation. Recommendations to increase the level of confidence or reduce the level of uncertainty in the risk assessment should also be included.

<u>*CDPH response*</u>*: The uncertainties with the data and assumptions used in the PHA have been clearly stated throughout the document.*

<u>**Comments submitted by William D. Marsh, Edgcomb Law Group on behalf of Zeneca Inc.**</u>

We appreciate the opportunity to provide comments on the Draft PHA. We believe that an accurate Final PHA, with the recommendations we have proposed, can serve as tool for ensuring the ongoing safety of RFS workers and the public.

Thank you for the opportunity to provide comments and feedback to the Department of Public Health's public comment draft of the Public Health Assessment (PHA) for the University of California, Berkeley Richmond Field Station (the "RFS Site"). We are writing on behalf of Zeneca Inc., the former owner of the property adjacent to the RFS Site (the "CSV site"), and have the following comments.

General Comments

1. The PHA is over 100 pages in length and was issued for public review. While the body notes that the exposure estimates are conservative, many individuals may not read the entire report. Hence, it would be prudent to emphasize at the beginning of the Summary section that the exposure conclusions are based on conservative risk assumptions in order to identify possible issues of concern and that actual exposures, if any, are expected to be much less.

<u>CDPH response</u>: *Comment noted. The summary states the conservative nature of the assumptions in a number of places.*

2. Exposure risks are overestimated throughout the PHA by the assumptions inherent in the various comparison values used. Thus, the compounding effect of the various assumptions and safety factors should be more clearly communicated. For example, DPH assumed that, for 23 years, an upland maintenance work would be exposed to the highest concentrations of chemicals in soil which had been excavated and removed from the RFS Site; a highly unlikely scenario.

<u>CDPH response:</u> *The conservative approach used in estimating exposure is described numerous times throughout the PHA. The 23-year exposure scenario used in the PHA is based on interviews of RFS workers. It is important to keep in mind remedial activities at the RFS did not begin until 2002. Further, the site has not been fully characterized, limiting the ability to draw definitive conclusions about exposure.*

3. Please clarify that Stauffer produced or manufactured different chemicals at various times from 1897 to 1985 – as written, the PHA gives the impression that each of the chemicals mentioned was continuously produced during that time period.

<u>CDPH response</u>: *We have modified the text to reflect the comment.*

4. Since 1999, the RFS Site (and adjacent CSV site) has undergone extensive remediation to lessen the severity of potential exposures to the public with considerable State regulatory involvement, oversight, and approval. Some comment regarding those efforts is warranted and should be included in the PHA.

<u>CDPH response:</u> *The PHA provides a summary of the remedial actions completed at the RFS.*

Risk Assumption Calculation Comments

1. While estimating the risk for the recreational user of the East Stege Marsh (ESM), LFR assumed in the 2002 health risk assessment that 100mg/kg soil was ingested and then factored that 1/12th of this amount would be ingested in the estimated 1 hour per day spent at the RFS site. This appears to be a reasonable approach. The PHA assumes that the entire 100mg/kg was ingested in the estimated 1 hour per day spent at the WSM. We suggest that the 1/12 factor be utilized in calculating the exposure for recreational users.

CDPH response: CDPH did not assume 100 mg/kg soil was ingested in 1 hour, as suggested by the comment. CDPH used a factor of 1/24th, in estimating an ingestion dose for sediment (please refer to the footnotes to Table 5 of the public comment draft PHA). The final PHA has been modified to reflect a more conservative estimate, as indicated by the comment.

2. Please confirm the calculations for the historical teenage recreational user risk estimation. We note that the estimate is higher for the historical exposure scenario despite that scenario having a lower arsenic concentration.

CDPH response: CDPH reviewed the calculations and did not find an error. It is unclear which calculations (sediment, surface water?) the comment is referencing. Historic surface water concentrations were much higher than those used to estimate current exposure, which may be the reason for the confusion indicated by the comment.

3. Please review the calculations for the recreational user. It appears that exposures for the recreational user is more appropriately determined using 95% upper confidence limits (UCL) of the post-removal concentrations rather than the maximum concentrations of in-place sediments as used in the PHA.

CDPH response: Under this scenario, we assume a recreational user could access the un-remediated portions of the marsh. Maximum concentrations were used to identify (under a worst-case scenario) if contamination represents a potential health concern, requiring further action. As stated in the PHA, "actual exposures would be much less." It is worth noting that the highest level of arsenic in surface sediment was measured in the remediated portion of the marsh in June 2006.

4. There is an apparent inconsistency in the PHA regarding non-toxic dust exposures during excavation activities. The PHA states that dust exposures during excavation activities could have caused short-term discomfort. However, the average measured dust concentration did not exceed the total dust criterion.

CDPH response: As stated in the PHA, there were a number of occasions when dust levels exceeded the total dust criteria in individual monitors. In addition, there were many days when monitoring did not occur at all. Further, there is photo documentation showing significant amounts of dust being generated during the excavation and carbon mixing activities.

Additional Clarifications and Comments

1. Please clarify that the referenced mercury contamination to soil and marsh sediments was only at the RFS Site.

CDPH response: It is unclear exactly where clarification needs to occur. The PHA is specific to the RFS. Further, the evaluation of sediments is discussed in terms of the Western Stege Marsh.

2. Please delete the statement that all of the cinders were placed at the RFS Site "prior to 1950" – there is no evidence cited to support this contention.

<u>CDPH response:</u> *The text has been revised to reflect the comment.*

3. Please correct the statement that Stauffer was "later known as Zeneca" – we will provide the ownership history of the former Zeneca site if necessary.

<u>CDPH response:</u> *The text has been revised to reflect the comment.*

4. For clarification, Stauffer produced sulfuric acid from pyrite cinders beginning in around 1919 – a difference process was used before that time.

<u>CDPH response:</u> *The text has been revised to reflect the comment.*

5. Existing sampling data consistently demonstrate that elevated naturally occurring radioactive materials (NORM) are not present above background concentrations at the RFS Site and at the adjacent CSV site. This appears to be inconsistent with the PHA statement that NORM is potentially elevated in soil, sediment, and groundwater at the RFS Site. Please clarify that sampling at the RFS Site and at the adjacent CSV site indicates that NORM is not present above background concentrations. Moreover, we suggest that any such conclusion be omitted until a final determination is made following submission of the radiological report for the CSV site that is currently being prepared.

<u>CDPH response:</u> *It is premature to draw conclusion about the presences of NORM on the adjacent Zeneca site, relative to background concentrations. CDPH appropriately identified a data gap associated with the Zeneca site that may have implications for the RFS property. No changes have been made to the text.*

6. Please revise the statement in the PHA that radiological sampling should be conducted at the RFS Site if radiation is found at the CSV Site. It appears that what is meant by this statement is that any such determination will be made following review of the historical sampling as well as any additional sampling at the CSV site based on the levels detected, if any are detected above background, and a thorough analysis of fate and transport.

<u>CDPH response</u>*: The specificity of future actions relating to radiological sampling will be defined by DTSC, in collaboration with the Radiologic Health Branch of CDPH.*

7. Please correct the statement that indoor air at UC's former Forest Products Laboratory is potentially affected by migration of contaminated groundwater from the CSV Site. Recent soil gas analysis and groundwater sampling in the area indicate that no such problem exists.

<u>CDPH response</u>*: The text has been revised based on the additional data, which was not available to CDPH prior to the initial draft of the PHA.*

8. Please correct the statement that clean-up work is prohibited at the RFS Site during the clapper rail breeding season. Work is only prohibited in the WSM area.

<u>CDPH response</u>: The text has been revised to reflect the comment