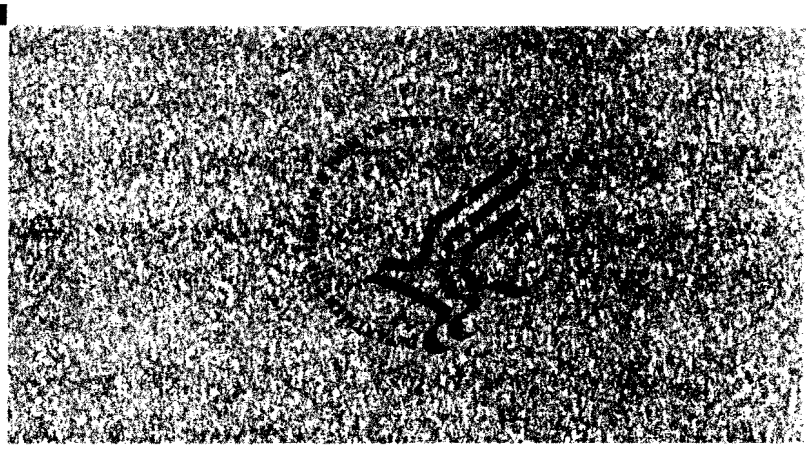
Public Health Assessment for

PACIFIC GAS AND ELECTRIC
(a/k/a HINKLEY SITE)
HINKLEY, SAN BERNARDINO COUNTY, CALIFORNIA
EPA FACILITY ID: CA0000206656
DECEMBER 4, 2000

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



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HINKLEY, SAN BERNARDINO COUNTY, CALIFORNIA

EPA FACILITY ID: CA0000206656

Prepared by:

California Department of Health Services
Under Cooperative Agreement with the
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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FOREWORD

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

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

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

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

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further public health actions are needed.

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

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

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

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

Letters should be addressed as follows:

Attention: Chief, Program Evaluation, Records, and Information Services Branch, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E56), Atlanta, GA 30333.

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SUMMARY

The California Department of Health Services (CDHS) has prepared this public health assessment under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). The public health assessment is a mechanism to provide the community with information on the public health implications of specific hazardous waste sites and to identify those populations for which further health actions or studies are indicated. This assessment reviews and evaluates existing environmental and health outcome data, as well as community concerns gathered by CDHS during the investigation.

The Hinkley site is located 10 miles west of the City of Barstow and 3 miles southeast of the City of Hinkley in San Bernardino County. The Hinkley site, which is part of Pacific Gas and Electric's (PG&E's) natural gas transmission pipeline system, has been operational since 1952. From 1952 to 1966, a chromium-based corrosion inhibitor was used in the cooling towers on-site. The chromium-contaminated waste water was discharged from the cooling towers into unlined evaporation/percolation ponds, with the result that a chromium-contaminated groundwater plume migrated off-site.

CDHS became involved at the site in January, 1998, in response to the health concerns of one family. There is a high level of concern in Hinkley about possible health effects from past and current exposure to hexavalent chromium. The community is concerned about exposures to workers at a former dairy and in the alfalfa fields surrounding the site; exposures to children and others who visited the site and swam in the PG&E swimming pool; exposures to contaminated air from plant exhaust and irrigation mists; and continued exposures to contaminated well water. Health effects attributed to such exposures include cancer, kidney problems, and gastrointestinal problems.

In response to these concerns, CDHS reviewed three sources of existing health outcome data. In 1987 and 1988, 20 Hinkley residents who were exposed to chromium-contaminated well water received medical evaluations at the site. Although there were no findings to suggest that exposures resulted in any health effects associated with hexavalent chromium, these evaluations were limited in scope. An epidemiological study of mortality among PG&E gas generator workers (including Hinkley employees) published in February, 2000 shows no increased mortality in these workers from cancer or other causes. Because this study does not adequately represent the occupational exposures of PG&E Hinkley workers, its ability to find an association between exposure and mortality is weakened and therefore its applicability to the Hinkley site is limited. Finally, a Community Cancer Assessment performed by the regional branch of the California Cancer Registry provides information on cancer incidence in Hinkley during the years 1988-1993. The report concludes that the number of new cancer cases observed in the census tract encompassing Hinkley does not differ significantly from the number of cases that would be expected for a community of this population size and these characteristics.

Through an evaluation of existing environmental data, CDHS determined that in the past there were two completed exposure pathways for hexavalent chromium from the Hinkley site.

The first completed exposure pathway was through the ingestion of groundwater. Prior to 1987, residents who lived over the chromium-contaminated groundwater plume were exposed to levels of chromium above EPA's drinking water standards. CDHS estimated both non-cancer and cancer doses from these past exposures. Although the estimated non-cancer ingestion doses for both children and adults exceeded the health guidance level, CDHS does not expect non-cancer health effects to occur because these doses are 40 to 90 times smaller than the NOAEL (no observable adverse effect level). CDHS estimated a moderately increased cancer risk from the ingestion of hexavalent chromium in groundwater.

The second completed exposure pathway was through inhalation of ambient air. Based on review of limited ambient air data collected in 1988 during Site Characterization Field Activities (on the PG&E site) and at the former Mojave Dairy Irrigation Operation, CDHS does not expect non-cancer health effects in workers and nearby residents from ambient air levels of hexavalent chromium measured at these sites. CDHS estimated no increased cancer risk to workers or residents from hexavalent chromium in ambient air during Site Characterization Field Activities. CDHS estimated a very low increased cancer risk to former Mojave Dairy workers and nearby residents from inhalation of hexavalent chromium. This may, in fact, be an overestimation of actual cancer risk from this source because of limited exposures.

CDHS also identified five potential past exposure pathways.

The first is a potential past exposure pathway to residents living in the vicinity of the Hinkley site from 1952 to 1966. Residents may have been exposed to ambient air levels of hexavalent chromium that "drifted" off the Hinkley site from the cooling tower. However, because there is no past ambient air monitoring data, it is not possible to evaluate the inhalation exposure pathway.

In addition, CDHS identified four potential past exposure pathways—soil, waste-water, ambient air, and groundwater—that may have impacted PG&E employees at the Hinkley site and at the Land Treatment Fields (Table 9). However, because of a lack of knowledge of the nature and magnitude of past activities at the cooling towers, the evaporation/percolation ponds, and the Land Treatment Fields, it is not possible to evaluate the toxicological implications of past worker exposures.

CDHS eliminated three current exposure pathways—groundwater (i.e. private wells), soil, and dairy cow products (i.e., milk, meat, and organs). These exposure pathways were eliminated from further review because the level of chromium detected in these pathways was below health comparison values or within background levels. Based on review of limited ambient air data collected and analysis for total chromium at the Land Treatment Fields, CDHS has concluded that the level of total chromium at the site was within background levels for ambient air. As hexavalent chromium was not measured in these analyses, CDHS could not estimate the potential health risk. In order to estimate the health risk from hexavalent chromium, CDHS recommends that additional ambient air sampling be conducted at the Land Treatment Fields and analyzed for hexavalent chromium.

In summary, based on the available information, the Hinkley site posed a past public health hazard. CDHS determined that in the past, there were two completed historical exposure pathways and five potential past exposure pathways. The Hinkley site poses an indeterminate current and future public health hazard to PG&E workers and nearby residents, although risk appears highly unlikely. Additional ambient air data from the Land Treatment Fields will enable CDHS to better evaluate the health impact of the Hinkley site and to make a more definitive assessment of current and future risk.

BACKGROUND

The California Department of Health Services (CDHS) has prepared this public health assessment under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR, located in Atlanta, Georgia, is a federal agency within the United States Department of Health and Human Services. ATSDR is authorized under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 to conduct public health assessments at hazardous waste sites on the National Priorities List (NPL). This public health assessment evaluates the public health significance of the Pacific Gas and Electric Company's (PG&E) Hinkley Gas Compressor station (referred to as the Hinkley site in this document) and the groundwater remediation activities conducted at PG&E's off-site Land Treatment Fields.

In 1998, several community members requested the Agency for Toxic Substances and Disease Registry (ATSDR) and the Environmental Health Investigations Branch (EHIB) of the California Department of Health Services (CDHS) to determine if there are current and future exposures to chromium from the Hinkley site. This health assessment evaluates the air, groundwater, and soil data obtained by PG&E over the course of the past ten years to determine the health effects of exposures on past, current, and future residents and workers in the vicinity of the Hinkley site and the associated land treatment fields.

A. SITE DESCRIPTION AND HISTORY

The Hinkley site is located 10 miles west of the City of Barstow and 3 miles southeast of the City of Hinkley in San Bernardino County (Figure 1). The Hinkley site is located south of Community Boulevard and between Fairview Road and Sommerset Road. A chromium-contaminated groundwater plume has migrated approximately 1½ miles north-northwest of the Hinkley site and reached a maximum width of approximately one-half mile (3). The Hinkley site, which has been in operation since 1952, occupies approximately 20 acres of a larger PG&E parcel and consists of offices, a warehouse, and equipment and materials for compressing natural gas through the pipeline supply system (2).

On June 6, 1991, PG&E submitted a soil and groundwater remediation workplan and a waste discharge report for the groundwater treatment system to the California Regional Water Quality Control Board—Lahontan Region (LRWQCB) [1]. On September 12, 1991, LRWQCB accepted the workplan and discharge report. The plan called for a series of extraction wells to remove the contaminated water. The contaminated water is sprayed onto a section of each of two PG&E owned and controlled Land Treatment Fields (1). One of PG&E's Land Treatment Fields is located on the corner of Community Boulevard and Sommerset Road (referred to as the East Landfarm); the second one is located north of State Highway 58 and near Mountain View Road (referred to as the Ranch Landfarm). As a result of being sprayed on the fields, through natural processes, hexavalent chromium is converted to trivalent chromium, a less toxic form of chromium. As of 1998, there were approximately 22 homes with private domestic wells in the vicinity of the Hinkley site, the Land Treatment Fields, and the chromium-contaminated groundwater plume (Figure 2).

On September 12, 1991, the LRWQCB accepted the soil and groundwater work plan and the waste discharge report [which was issued as the Waste Discharge Requirement (WDR) Board Order No. 6-91-917] (1). On August 12, 1993, LRWQCB amended the WDR with Board Order No. 6-91-917 to incorporate changes to the East Landfarm (1). On July 17, 1997, the LRWQCB issued revised WDR Board Order No. 6-97-81 to incorporate requirements for the Ranch Land Farm.

The Hinkley site is part of PG&E's natural gas transmission pipeline system that runs from approximately 15 miles southeast of Needles, California (in the Mojave Desert near the Arizona border) to Milpitas, California (located in the San Francisco Bay Area). The natural gas is compressed at the Hinkley site to maintain pressure within the pipeline as it travels from the Arizona border to Milpitas. The heated gas is cooled as it passes through a heat exchanger; the heated water is then cooled in a cooling tower and recycled back to the heat exchanger. From 1952 to 1966, a chromium-based corrosion inhibitor was added to the cooling tower water. As the cooling water is heated and cooled, some of it is lost through evaporation in the cooling tower. This process increases the salts remaining in the water, so a portion of the water is removed (wastewater) and fresh water is added to reduce the salt level (26). The chromium-containing wastewater was discharged into unlined evaporation/percolation ponds located near the cooling tower. In 1966, the chromium-based corrosion inhibitor was replaced with a phosphate-based corrosion inhibitor. The unlined evaporation/percolation ponds were used until 1972. From 1972 to the present, the cooling tower wastewater has been discharged into double-lined evaporation ponds (2–3). Currently, there are three double-lined evaporation ponds.

According to PG&E, in November 1987, as part of PG&E's on-going environmental assessment program and permitting activities, PG&E detected hexavalent chromium (at 0.57 mg/l) in a groundwater sample taken from an inactive water supply well (well #7) at the Hinkley site (2). The level of hexavalent chromium detected in the groundwater sample was above the 1985 EPA drinking water standard, or Maximum Contaminant Level (MCL), for total chromium, which was 0.05 mg/l at that time. The current federal or EPA MCL is 0.10 mg/l; however, the current State of California (CDHS) MCL is 0.05 mg/l. Because this document is written by CDHS, we will evaluate the groundwater based on the current state MCL, 0.05 mg/l. See Appendix A—Glossary under MCL for an explanation of EPA's and CDHS' rationales for regulating chromium at different MCLs.

On December 29, 1987, the Lahontan Regional Water Quality Control Board (LRWQCB) issued Cleanup and Abatement Order No. 6-87-160, ordering PG&E to investigate, clean up, and abate the groundwater and soil contamination at the Hinkley site (1). In response to LRWQCB's Cleanup and Abatement Order, PG&E initiated a focused groundwater sampling program and a comprehensive site investigation in order to determine the extent of the chromium contamination and to characterize the physical and hydrogeologic properties of the soil and groundwater (1). A feasibility study to identify and evaluate potential alternatives to remediate the soil and groundwater contamination was also conducted (1). On October 15, 1988, PG&E submitted a site characterization report and a remedial action plan to LRWQCB (1). The LRWQCB has requested PG&E to perform a numerical model analysis to project the time it will take to clean up the aquifer (26).

On June 12, 1994, the LRWQCB issued the Amended Cleanup and Abatement Order No. 6-87-160A1, mandating that PG&E carry out the following environmental remediation activities: the additional assessment of the hydrogeology and existing groundwater extraction and monitoring system; the destruction of inactive agricultural wells that may provide a conduit for downward migration of chromium to the deeper aquifer; and the design and implementation of additional groundwater extraction wells (1). On December 11, 1996, LRWQCB concluded that PG&E had successfully complied with the Amended Cleanup and Abatement Order (1).

B. SITE VISIT

On January 29, 1998, CDHS staff (Sherry Chan, Industrial Hygienist; Jane Riggan, Public Health Social Worker Consultant; and Deborah Gilliss, Public Health Medical Officer) met with an associate engineering geologist from the Lahontan Region—California Regional Water Quality Control Board and with two representatives (a gas engineer and a supervisor) from PG&E's Technical and Ecological Services Division. The purpose of the meeting was to discuss the historical remediation activities at the Hinkley site and to determine if there are potential current and future exposure pathways to residents in the vicinity of the station.

After the meeting, PG&E's representatives provided CDHS with a driving tour of the Hinkley site. The tour included visits to two cooling towers (to be replaced in the near future), several non-operational scrubbers, a swimming pool, former unlined evaporation ponds, and a land treatment field surrounded by a steel fence (located on the corner of Community Boulevard and Sommerset Road). Across the road (east of Sommerset Road), there were several residences. The tour ended at the second land treatment field north of Highway 58.

After the brief driving tour of the Hinkley site and the two land treatment fields, CDHS met with several community members to discuss health concerns. Please see the Community Health Concern section for a detailed discussion of the meeting with the community members.

C. DEMOGRAPHICS, LAND USE, AND NATURAL RESOURCE USE

DEMOGRAPHICS

According to the 1990 Census, approximately 2026 people live in the Hinkley area. The ethnic breakdown in Hinkley is 90% white; 8.0% "other race"; 1.2% American Indian, Eskimo, or Aleut; 0.4% Asian or Pacific Islander; and 0.3% black. Sixteen percent identified themselves as being of Hispanic origin. In 1990, of the total population, 32% were under 18 years of age and 9% were over 65 years of age. There were 795 housing units in Hinkley, 698 of them occupied and 97 vacant. Of the 795 housing units, 774 were designated non-farm units and 21 were farms (11).

LAND USE

Hinkley is a sparsely populated and unincorporated area, characterized primarily by low-density rural development and agriculture (2). The economic development of Hinkley has been limited by the availability of water. The main economic activities in Hinkley are recreation, railroad and trucking distribution, agriculture (mainly alfalfa production and dairy farms), and support for military activities (2).

NATURAL RESOURCE USE

Hinkley is situated at an elevation of approximately 2,200 feet above sea level and is surrounded by mountains in the central Mojave Desert (3). Because of the site's location, the climate is hot, dry, and often windy. The average wind velocity for the Barstow area (which is located 5 miles east of Hinkley) is 12 miles per hour (mph); the maximum wind gust has been recorded in 1988 at 62 mph (3). The predominant wind direction is from west to east (35). The annual rainfall is low (about 5 inches/year) and evaporation rates are extremely high (3). Surface water appears only during infrequent periods of heavy rain and is quickly absorbed by the ground; thus, the primary source of water in the area is groundwater. As there is no municipal water supplier for Hinkley, residents either pump groundwater from their private wells or else haul water for domestic purposes from a water supplier located in nearby Barstow.

The groundwater underneath the Hinkley site occurs in two water-bearing zones (aquifers) that are separated by a thick "blue clay". The groundwater flows generally from south to north. Groundwater above the blue clay is unconfined or semi-confined, meaning that it has the potential to migrate downwards. The groundwater above the blue clay is referred to as the shallow or upper aquifer; it is located approximately 80 to 150 feet below ground surface (bgs). The shallow aquifer appears to be divided into two contrasting water-bearing zones. The top layer of the shallow aquifer is made up of silty fine-to-medium sand, and the bottom shallower layer consists of coarser sand. The majority of the groundwater is pumped from the shallower, coarser-grained zone (2).

D. HEALTH OUTCOME DATA

One medical evaluation has been performed at the Hinkley site. PG&E hired Environmental Health Associates of Oakland, California to conduct medical evaluations of volunteers from the area in December, 1987 and February, 1988. An epidemiological study of PG&E employees has also been published, and a Community Cancer Assessment of Hinkley has been performed by the California Cancer Registry. CDHS staff reviewed the medical evaluations, epidemiological study, and Community Cancer Assessment and evaluated the findings appearing in the Health Outcome Data Evaluation Section.

COMMUNITY HEALTH CONCERNS

In 1997, a family from Hinkley, concerned about environmental exposures to Chromium VI at the PG&E plant and seeking assistance, wrote letters to the President of the United States, to elected officials, and to several federal agency directors. In January, 1998, discussions between ATSDR and EHIB resulted in the decision that EHIB staff would go to Hinkley to visit the site and the surrounding area and to meet with the family. In addition, ATSDR staff were aware of another resident who had developed a list of Hinkley residents concerned about possible chromium exposure. Prior to the visit, EHIB staff spoke with this resident, who estimated that one-third of the population in Hinkley could be affected by exposure to chromium. The last piece of information that was gathered before the site visit was a complaint filed in a class action lawsuit that had recently been settled against PG&E. The complaint alleged that because of the chromium VI exposure, "plaintiffs suffer or are reasonably certain to suffer in the future from cancer, respiratory problems, autoimmune deficiencies, reproductive problems, birth defects, chronic headaches, and skin problems."

After the PG&E site visit, EHIB staff met with the two families in Hinkley on January 29, 1998. Their concerns about past and current exposures included:

- Exposures that occurred at Vernola Ranch and the old dairy, since demolished, across the street from PG&E;
- Exposure of employees' children and of students who swam in the swimming pool on the PG&E site;
- Exposure to chromium escaping into the air, especially from exhaust coming from the plant at times when the plant releases pressure;
- The chromium-contaminated groundwater plume and whether well water could be affected;
- Exposure from groundwater remediation where chromium-contaminated water used to irrigate alfalfa crops results in a mist that is dispersed by the wind (often gusting to 40-50 mph); and
- Exposure of farm maintenance workers who repair and replace wells over the groundwater plume.

In addition to the exposure concerns, the couple who wrote the initial letters had health concerns related to the cancer death of one of the workers who built the stacks; the condition of an older son who has an extra sixth lumbar vertebrae with nerve compression and a cervical rib in the neck; the condition of a younger son who has kidney failure; the condition of a grandfather who is dying of kidney failure; and the presence of gastric ulcers.

ENVIRONMENTAL CONTAMINATION AND OTHER HAZARDS

The Hinkley site is the primary source of the hexavalent chromium contamination detected in various environmental media. The existence of a public health hazard is dependent on the magnitude of this contamination.

The following conditions were used to select contaminants for further evaluation: 1) concentrations of contaminants on-site and off-site; 2) field data quality, laboratory data quality and sample design; 3) comparison of on-site and off-site concentrations with environmental comparison values; and 4) community health concerns. Comparison values, developed by ATSDR, the United States Environmental Protection Agency (EPA), and the California Occupational Safety and Health Administration (CAL/OSHA), were used to select contaminant for further evaluation and are defined in a glossary in Appendix A.

A. TOXIC CHEMICAL RELEASE INVENTORY (TRI) SEARCH

The Toxic Chemical Release Inventory (TRI) maintained by EPA contains information about estimated annual releases of toxic chemicals from active industrial facilities from 1987 to the present. TRI data can be used to get a general idea of the current environmental emissions occurring at or around a site and whether they may be causing an additional environmental burden to the community. TRI contains information about estimated emission rates of toxic chemicals into the environment via air, water, soil, or underground injection, and whether these releases are routine or accidental.

We searched the TRI for the years 1987 to the present for potential emissions from the Hinkley site. A facility must report releases of toxic chemicals to TRI if the facility meets four criteria: 1) it must be a manufacturing facility; 2) it must have the equivalent of 10 full-time workers; 3) it must either manufacture or process more than 25,000 lbs of the chemical or use more than 10,000 lbs during the year; 4) and it must have released a chemical that is on the TRI list of 350 specific toxic chemicals or chemical categories (12). In addition, we conducted a TRI search for environmental releases from other companies located within the zip code (92347) surrounding the Hinkley site. No records were found in the TRI for the Hinkley site or for any other companies in the vicinity of the Hinkley site (12).

B. ON-SITE CONTAMINATION

SUBSURFACE SOIL SAMPLING INVESTIGATION CONDUCTED AT THE HINKLEY SITE

In 1988, PG&E performed a soil investigation to determine the presence of chemicals associated with historical cooling water discharges and site activities. According to historical photographs and information gathered by PG&E, there were 3 main areas—Areas A, B, and C (Figure 3)—investigated at the Hinkley site that were potentially contaminated by past activities.

According to the environmental investigations, the main contaminant of concern is chromium. In the environment, chromium exists in two major states: hexavalent chromium and trivalent chromium. In the environmental investigation conducted by PG&E, the analytical data included results for hexavalent chromium and total chromium. Total chromium is a mixture of hexavalent chromium and trivalent chromium (a conservative ratio estimate for hexavalent chromium to trivalent chromium is 1 to 6) [6].

Thirty-two soil borings were drilled in three areas (in Areas A, B, and C) near the compressor station where chromium-contaminated wastewater may have been discharged (2). In Area A, 166 soil samples were collected from boreholes (ranging from depths of 0.50 to 80 feet bgs) and analyzed for both hexavalent chromium and total chromium (2). The levels of hexavalent chromium ranged from non-detect to 3.3 mg/kg. The levels of total chromium ranged from non-detect to 584 mg/kg. In Area B, 40 soil samples were collected from boreholes (ranging from depths of 0.50 to 81.5 feet bgs) and analyzed for both hexavalent chromium and total chromium (2). The levels of hexavalent chromium were non-detect. The level of total chromium ranged from non-detect to 19.5 mg/kg. In Area C, 64 soil samples were collected from boreholes (ranging from depths of 0.0 to 41.5 feet bgs) and analyzed for hexavalent chromium (2). The levels of hexavalent chromium ranged from non-detect to 8.0 mg/kg. PG&E excavated all soil that exceeded 500 mg/kg of total chromium, the site clean-up level set by LRWQCB; EPA's Preliminary Remediation Goals (PRGs) for total and hexavalent chromium were not available at this time(26). All levels of total chromium detected in subsurface soil at the Hinkley site were below EPA's PRG of 450 mg/kg for total chromium in industrial soil, with the exception of one sample. All levels of hexavalent chromium detected in the subsurface soil at the Hinkley site were below EPA's PRG of 64 mg/kg for hexavalent chromium in industrial soil. Because one soil sample was above EPA's PRG of 450 mg/kg for total chromium in industrial soil, further investigation is warranted.

In Area A, PG& E's contractor collected twenty-six soil samples from three trenches—Trenches A, B, and C (Figure 4). The trenches were excavated in three locations: Trench A is located near the oil/water separator unit; Trench C is located near the former evaporator ponds; and Trench B is approximately mid-way between Trench A and Trench C. The trenches were approximately 24 feet long, 3 feet wide, and 4 to 5 feet deep. For Trench A, nine soil samples were collected from approximately 1.5 to 3.5 feet below ground surface (bgs) [2]. The level of total chromium ranged from 19.9 mg/kg to 3,750 mg/kg, and the level of hexavalent chromium ranged from non-detect to 10.2 mg/kg. For Trench B, eight soil samples were collected from approximately 1.5 to 4.3 feet bgs [2]. The level of total chromium ranged from 6.7 mg/kg to 2,120 mg/kg, and the level of hexavalent chromium ranged from non-detect to 2.9 mg/kg. For Trench C, nine soil samples were collected from approximately 1.2 to 2.5 feet bgs [2]. The level of total chromium ranged from 21.1 mg/kg to 1,240 mg/kg, and the level of hexavalent chromium ranged from non-detect to 5.8 mg/kg. All levels of hexavalent chromium detected from subsurface trench soil samples at the Hinkley site were below EPA's PRG of 64 mg/kg for industrial soil; thus, no further evaluation is warranted. PG&E excavated all soil that exceeded 500 mg/kg of total chromium; however, the levels of total chromium detected in the remediated trench soil still exceeded EPA's PRG of 450 mg/kg for industrial soil. Thus, further evaluation is warranted.

PG&E's contractor collected four additional shallow subsurface soil samples at depths less tha or equal to one foot (PG8802-07, PG8802-08, PG8802-10, PG8802-11) at the Hinkley site. Th level of hexavalent chromium ranged from non-detect to 0.93 mg/kg. The level of total chromium ranged from 15.50 to 4,730 mg/kg. High levels of total chromium were detected in samples PG8802-10 (3,940 mg/kg) and PG8802-08 (4,730 mg/kg); the samples were collected Areas A and C, respectively (2). All levels of hexavalent chromium detected in shallow subsurface soil at the Hinkley site were below EPA's PRG of 64 mg/kg for industrial soil; thus no further evaluation is warranted. PG&E excavated all soil that exceeded 500 mg/kg of total chromium; however, in several on-site areas, the levels of total chromium detected in the remediated soil still exceeded EPA's PRG of 450 mg/kg for industrial soil. Thus, further evaluation is warranted.

Two soil samples were also collected from a monitoring well borehole, MW-1 (Figure 10), located on the Hinkley site. Soil samples were collected at 80 and 120 feet bgs. The level of hexavalent chromium was non-detect at both depths. The level of total chromium was at 5.9 mg/kg at 80 feet bgs and at 14.8 mg/kg at 120 feet bgs. Levels of total chromium detected in subsurface soil (from borehole MW-1) at the Hinkley site were below EPA's PRG of 450 mg/k for industrial soil, and levels of hexavalent chromium detected in the subsurface soil at the Hinkley site were below EPA's PRG of 64 mg/kg for industrial soil; thus, no further evaluation is warranted.

SURFACE SOIL MONITORING

According to ATSDR, soil samples must be collected from the top three inches of the surface o the soil in order to be defined as "surface" soil. According to this definition, no on-site surface soil monitoring has been conducted.

C. OFF-SITE CONTAMINATION

SUMMARY OF THE GROUNDWATER INVESTIGATION

In December 1987, PG&E's contractors, Harding Lawson Associates (HLA) and Environmental Health Associates (EHA), initiated the preliminary assessment of the chromium-contaminated groundwater plume. According to PG&E, at this time PG&E provided bottled water to all residents with domestic groundwater wells that contained total chromium above the EPA MCL of 0.05 mg/l. (CDHS has no direct information as to whether these residents subsequently drank only bottled water.) In cooperation with the Lahontan Regional Water Quality Control Board (LRWQCB) and the San Bernardino County Department of Environmental Health Services, PG&E's contractors sampled approximately 90 wells (i.e., active and inactive public and private supply wells for domestic, agricultural, and industrial uses) within a nine-square mile area (3). Based on the results of the groundwater investigation, PG&E and their contractors determined

that the contaminated groundwater plume contained total chromium above EPA's MCL (0.05 mg/l). The chromium-contaminated groundwater plume appears to be limited to the shallow aquifer, which is approximately 75 to 105 feet bgs within an area a half-mile wide, extending 1 ½ miles north of the Hinkley site (3,26).

Since 1988, PG&E and their contractors have been monitoring the levels of total chromium and hexavalent chromium in the groundwater in the vicinity of the Hinkley site. According to the quarterly groundwater investigations conducted since 1988, the level of hexavalent chromium ranged from non-detect to 3.64 mg/l, and the level of total chromium ranged from non-detect to 5.8 mg/l (4). Although the levels of total chromium were above CDHS' MCL (0.05 mg/l), and the levels of hexavalent chromium were above ATSDR's RMEG for children (0.05 mg/l) in several of the monitoring wells, there are no active private domestic groundwater wells installed in the chromium-contaminated groundwater at levels above CDHS' MCL (0.05 mg/l) for total chromium. Thus, from a regulatory stand point, no future investigation is warranted.

However, in the May 1988 groundwater sampling investigation, hexavalent chromium was detected at 0.02 mg/l in one active private domestic groundwater well, 26-18 (located near the plume, north of State Route 58 and west of Summerset Road) [2]. There is no regulatory standard or MCL for hexavalent chromium. As of February 1999, the California Environmental Protection Agency—Office of Environmental Health Hazard Assessment (OEHHA) has issued a Public Health Goal (PHG) for hexavalent chromium in drinking water. OEHHA's PHG for non-cancer health effects of hexavalent chromium is 0.07 mg/l and for cancer health effects is 0.00018 mg/l. PHGs established by OEHHA are not regulatory in nature and represent only non-mandatory goals (29). The purpose of the PHG is to provide information about health effects from contaminants in drinking water and to assist the CDHS in establishing primary drinking water standards (CDHS' MCL) [29]. The hexavalent chromium level in well 26-18 was below OEHHA's PHG for non-cancer health effects, but above OEHHA's PHG for cancer health effects; thus, further investigation is warranted.

Since 1989, PG&E has collected groundwater samples from active private domestic wells (Figure 2) located in the vicinity of the Hinkley Site. There are no active private domestic wells above CDHS' MCL located in the contaminated groundwater plume. The groundwater samples were analyzed for total chromium (14). The levels of total chromium ranged from non-detect to 0.05 mg/l (Table 7). No levels of total chromium exceeded CDHS' MCL (0.05 mg/l); thus, from a regulatory stand point, no further investigation is warranted.

SUMMARY OF THE SUBSURFACE SOIL SAMPLING INVESTIGATIONS CONDUCTED AT THE LAND TREATMENT FIELDS

In 1992, PG&E's contractor installed six lysimeters in the land treatment field just north of the Hinkley site (29 acres of the 40-acre land treatment field is being used to remediate the chromium-contaminated groundwater) at depths of 3, 6, and 9 feet bgs (4). Beginning in 1993, the lysimeters are sampled if sufficient volume of soil-pore liquid can be collected and analyzed

for hexavalent and total chromium. These lysimeters are installed in the unsaturated zone (26). The purpose of analyzing the level of chromium in the soil moisture is to determine if the chromium in the irrigated groundwater that is being sprayed onto the surface of the land treatment field is leaching downwards, thus potentially impacting the groundwater. Since 1993, the level of hexavalent chromium in the soil moisture ranged from non-detect to 0.039 mg/l, and the level of total chromium ranged from non-detect to 0.07 mg/kg. According to the low levels of total chromium and hexavalent chromium detected in the soil moisture, it does not appear that the chromium is leaching downward; thus, we do not expect the chromium in the irrigated water to impact the underlying groundwater.

Since 1994, PG&E's contractor has collected soil samples annually from various quadrants of the land treatment field located north of the Hinkley site. The level of hexavalent chromium has been non-detect, and the level of total chromium has ranged from 1 to 24 mg/kg (Table 3). Currently, all levels of total chromium detected in subsurface soil at the Hinkley site are below EPA's PRG of 450 mg/kg for industrial soil, and all levels of hexavalent chromium detected in the subsurface soil at the Hinkley site are below EPA's PRG of 64 mg/kg for industrial soil; thus, no further evaluation is warranted.

SURFACE SOIL MONITORING

According to ATSDR, soil samples must be collected from the top 3 inches of the surface of the soil to be defined as "surface" soil. According to this definition, no off-site surface soil monitoring has been conducted.

SUMMARY OF THE SUBSURFACE SOIL INVESTIGATIONS CONDUCTED IN THE VICINITY OF THE HINKLEY SITE

1. Soil Samples Collected within the Land Treatment Fields but in Areas Outside the Groundwater Remediation Activities

In 1988, PG&E's contractors collected four subsurface soil samples (at depths less than or equal to one foot) at locations within the future land treatment fields (viz., one located north of the Hinkley site and the second one located north of Highway 58). These samples were collected in the land treatment fields, but outside the areas (i.e., the alfalfa plots) designated for the remediation of the chromium-contaminated groundwater. For the three sampling locations adjacent to the land treatment field north of the Hinkley site, the level of hexavalent chromium ranged from non-detect to 0.16 mg/kg, and the level of total chromium ranged from 2.74 mg/kg to 514 mg/kg (Table 1). For the two sampling locations located adjacent to the land treatment field north of the Highway 58, hexavalent chromium was not detected in the soil samples, and the level of total chromium ranged from 2.48 mg/kg to 8.12 mg/kg (Table 1). As for the six sampling locations north of the Hinkley site and the land treatment field (i.e., East Landfarm), the levels of hexavalent chromium were non-detect, and the level of total chromium ranged from 7.93 mg/kg to 53.7 mg/kg (Table 1). All levels of total chromium detected in the subsurface soil

samples were below 210 mg/kg, EPA's PRG for total chromium in residential soil; thus, no further investigation is warranted. A soil sample containing total chromium at 514 mg/kg was collected in an agricultural pond used to remediate the chromium-contaminated groundwater. It was compared to and determined to be above EPA's PRG of 450 mg/kg for industrial soil. Therefore, further investigation is warranted. All levels of hexavalent chromium were below 30 mg/kg, EPA's PRG for hexavalent chromium in residential soil. Therefore, no further investigation is warranted. EPA's residential PRG was used to compare the soil levels because in 1988, the sampling locations were non-industrial properties; however, currently, PG&E owns all the properties where the samples were taken.

2. Soil Samples Collected from the Former Mojave Dairy

As for the eight soil samples collected from the former Mojave Dairy (located north of the Hinkley site), the levels of hexavalent chromium were non-detect, and the levels of total chromium ranged from 18.9 mg/kg to 81.6 mg/kg (Table 1). All levels of total chromium detected in the subsurface soil samples were below 450 mg/kg, EPA's PRG for total chromium in industrial soil, and the levels of hexavalent chromium were non-detect. Therefore, no further investigation is warranted. The former Mojave Dairy is currently owned by PG&E.

3. Soil Samples Collected in the Vicinity of the Hinkley Site and the Land Treatment Fields

In 1988, PG&E's contractors also collected six subsurface soil samples (at depths less than or equal to one foot) from six off-site locations approximately 0.5 to 2.25 miles from the Hinkley site (Table 4). Hexavalent chromium was not detected in the soil samples. The level of total chromium ranged from 1.57 mg/kg to 6.41 mg/kg; these levels were all below 210 mg/kg, EPA's PRG for total chromium in residential soil, and within 3 to 2,000 mg/kg, the range for background levels of total chromium in the western United States (6). Thus, no further investigation is warranted.

4. Soil Samples Collected at the Historic Waste Disposal Area

In response to concerns of PG&E's employees, on November 6 and 7, 1995, PG&E investigated the potential presence of a historic waste disposal area, comprised of three trenches, T-1, T-2, and T-3. Although the historic waste disposal area is located south of the Hinkley site, the property is owned and maintained by PG&E (Figure 11).

According to the subsurface investigation, PG&E and its contractor, Smith Environmental Technologies, Inc. (SETI), determined that trench T-1 was 38 feet long at the surface, 20 feet long at full depth (i.e., at a depth of 12 feet), and from 2 to 4 feet in width (17). The trench fill material included oily rags, fibrous material (non-asbestos), plastic bags, paper and cardboard, bottles and cans, plastic shavings, pieces of bricks, chunks of concrete, and fanbelts. SETI collected 2 soil samples from the green-stained area to be analyzed for potential chromium contamination. The soil samples contained levels of total chromium at 240 and 1,900 mg/kg, and

the levels of hexavalent chromium were non-detect (the detection limit was 0.10 mg/kg). The oily rags were removed and placed in a disposal drum at the Hinkley site. On November 14, 1996, PG&E's contractor, Kern Environmental Inc., excavated approximately 50 cubic yards o soil containing elevated levels of chromium from trench T-1 and transported the contaminated soil to US Ecology's Class I landfill in Beatty, Nevada for proper disposal (17). Soil samples were collected from the sidewalls and the bottom of the excavated trench and analyzed for tota and hexavalent chromium. The levels of total chromium ranged from 2 to 18 mg/kg, and the levels of hexavalent chromium ranged from non-detect to 0.8 mg/kg. Both the levels of hexavalent and total chromium are below EPA's PRGs for industrial soil; thus, no further investigation of this area is warranted.

As for trenches T-2 and T-3, the subsurface investigation determined that these trenches contained only native soil. There was no debris or evidence of artificial fill in either trench T-2 T-3. SETI collected one soil sample from T-2 and T-3 and analyzed both samples for potential total and hexavalent contamination. The levels of total chromium in the soil sample collected from T-2 was 8 mg/kg and from T-3, 8 mg/kg (17). The levels of hexavalent chromium in T-2 and T-3 were both non-detect (the detection limit was 0.1 mg/kg). Both the levels of hexavalen and total chromium are below EPA's PRGs for industrial soil; thus, no further investigation of this area is warranted.

SUMMARY OF THE AMBIENT AIR INVESTIGATIONS OF THE POTENTIAL RELEASE OF AIRBORNE LEVELS OF CHROMIUM DURING THE FOLLOWING ACTIVITIES:

1. Site Characterization Field Activities

During the site characterization field activities, March 10 through August 19, 1988, PG&E's contractor, Ecology & Environment (E&E), conducted air monitoring samples to test for potential worker exposure to hexavalent chromium. Because the highest potential exposure to hexavalent chromium was during the trenching and boring activities at the former disposal area (Area A, B, and C), E&E conducted continuous air monitoring during these activities in order t determine the potential ambient air levels of hexavalent chromium and to evaluate the adequac of the personal protective equipment worn by the workers (3). E&E set up one air monitoring pump up-wind of the work area to determine the background level of hexavalent chromium. Tl other air pump monitored the worker's breathing zone and operated throughout an 8 to 10 hour shift. A total of 52 samples were collected and analyzed for hexavalent chromium. Levels of hexavalent chromium in the air samples were non-detect. *Non-detect* does not indicate the absence of airborne levels of hexavalent chromium, but rather that the hexavalent chromium sampled was below the limit of analytical technique, which in this case was set at 3.06×10^{-8} mg/m^3. The detection limit in this study was below EPA's RfC (i.e., 8.0×10^{-6} mg/m^3) for non-cancer health effects, but above EPA's PRG for hexavalent chromium (i.e., 2.3×10^{-8} mg/m^3) fc cancer health effects.

2. Movaje Dairy Irrigation Operations

On August 2 and 9, 1988, E&E conducted air sampling at the irrigated alfalfa fields (located on the former Mojave Dairy, on the corner of Community Boulevard and Fairview Road) to measure the potential emission of airborne levels of chromium generated by the aerosol-irrigation system. Nine air sampling pumps were set up at three locations near the irrigated alfalfa fields; one location was stationed upwind of the irrigated alfalfa field, and two locations were stationed downwind of the irrigated alfalfa field, near residences bordering the field (3).

One set of air sampling filters for each location was analyzed for total chromium, and the remaining two sets of filters were analyzed for hexavalent chromium (3). The ambient air levels of hexavalent chromium at the three locations ranged from 1.3×10^{-7} to 3.8×10^{-7} mg/m^3 (3). The level of hexavalent chromium in this study was below EPA's RfC (i.e., 8.0×10^{-6} mg/m^3) for non-cancer health effects, but above EPA's PRG for hexavalent chromium (i.e., 2.3×10^{-8}mg/m^3) for cancer health effects.

The levels of total chromium in the ambient air at the three locations ranged from 5.4×10^{-6} to 6.5×10^{-6} mg/m^3 (3). There is no RfC for total chromium. The levels of total chromium were above EPA's PRG for total chromium, 1.6×10^{-7} mg/m^3, for cancer health effects (6,18).

3. Land Treatment Site Operations

On two separate occasions, October 18-20 and November 8-10, 1993, PG&E's contractor, California Industrial Hygiene Services (CIHS), conducted air monitoring investigations to assess the airborne chromium levels at PG&E's land treatment site, located on the corner of Community Boulevard and Sommerset Road, north of the Hinkley site. The land treatment site is part of the groundwater remediation process; the chromium-contaminated groundwater is extracted and used for crop (i.e., alfalfa) irrigation through a central pivot irrigation system designed and maintained by PG&E personnel (5). The purposes of CIHS's air monitoring investigation were to measure airborne levels of chromium in the immediate vicinity of the land treatment site during normal operations; to determine the difference between airborne levels of chromium at the land treatment site vs. background levels; to compare airborne chromium levels measured in 1988 (air sampling investigation conducted by E&E); and to determine the potential eight-hour exposure levels of workers involved in the operation and maintenance activities at the land treatment site (5). Air samples were also collected in a background location (i.e., approximately 4,500 feet northwest and upwind of the land treatment site.)

The central pivot irrigation system travels in a continuous circular pattern (i.e., 360 degrees) for a 24-hour period. Air samples were collected in four locations at the land treatment site. Air samplers were placed 100 feet apart along the eastern perimeter of the land treatment site, positioned 22 to 64 feet from the edge of the circular path traveled by the irrigation system and located predominantly downwind. Sixteen air samples were collected at a "breathing zone" height (i.e., approximately five feet from the ground surface) at the land treatment site. Fourteen air samples were also collected at the background location.

The level of airborne total chromium collected at the land treatment site ranged from less than 1.0×10^{-6} mg/m^3 to less than 3.0×10^{-6} mg/m^3 during both 1993 sampling periods, October 18-20 and November 8-10, respectively. The level of airborne total chromium collected at the background location ranged from less than 1.0×10^{-6} mg/m^3 to 1.0×10^{-5} mg/m^3 during both 1993 sampling periods.

The highest level of total chromium in this study, 3.0×10^{-6} mg/m^3, was above EPA's PRG for total chromium (i.e., 1.6×10^{-7} mg/m^3) but below the level of total chromium detected in the background ambient air, which ranged from less than 1.0×10^{-6} mg/m^3 to 1.0×10^{-5} mg/m^3. There is no RfC for total chromium.

CIHS did not conduct personal monitoring of workers to measure the potential airborne exposur to hexavalent chromium because employees do not normally enter the site when the irrigation system is operating, and the actual time spent on-site by employees is usually only 20 to 30 minutes (5). However, to simulate a worst-case worker exposure scenario, four air samples were collected at the irrigation sites closest to the irrigated areas—in other words, during the 7 to 8 hour time periods when the irrigation system traveled through the 120 degree arc closest to the air samplers (5). The estimated levels of airborne hexavalent chromium ranged from 8.2×10^{-5} t 8.8×10^{-5} mg/m3, all below CAL/OSHA's PEL of 0.05 mg/m^3 for hexavalent chromium; thus, n further investigation is warranted.

ALFALFA LEAF SAMPLING INVESTIGATIONS —SAMPLES COLLECTED FROM AREAS IN THE VICINITY OF THE HINKLEY SITE AND THE LAND TREATMENT FIELDS

1. Site Vicinity

According to PG&E's representatives, alfalfa is sold to nearby dairy farms as feed for the dairy cows. In 1988, PG&E's contractor collected and analyzed alfalfa leaves and root samples for total chromium from areas in the vicinity of the Hinkley site. The levels of chromium in the alfalfa leaves are considered to be of greater public health importance because only the leaves of the alfalfa are harvested for animal feed (3). The level of total chromium in the alfalfa leaf samples ranged from 0.80 to 12.7 mg/kg; the levels of total chromium in the root samples ranged from 1.6 to 8.3 mg/kg (Table 5). The levels of total chromium were below the guideline (1,000 mg/kg) for chromium in mineral feed ingredients for domestic animals as determined by the National Academy of Sciences/National Research Council; thus, no further investigation is warranted (10, 23).

2. Land Treatment Site

Since 1993, PG&E's contractor has collected alfalfa leaf samples annually from the alfalfa crop grown on the Land Treatment Field. The wet weight concentration of hexavalent chromium has

ranged from non-detect to 0.06 mg/kg, and the dry weight concentration is non-detect (Table 6). The wet weight concentration of total chromium has ranged from non-detect to 1 mg/kg, and the dry weight concentration is non-detect (Table 6). All levels of hexavalent and total chromium, both dry and wet weight concentrations, are below the guideline (1,000 mg/kg) for chromium in mineral feed ingredients for domestic animals; thus, no further investigation is warranted (10).

RESULTS OF THE EXAMINATION OF TWO DAIRY COWS THAT LIVED ON THE FORMER MOJAVE DAIRY FARM

In 1988, PG&E hired a veterinarian to obtain gross pathological information, tissue, and milk samples from two dairy cows that lived in the former Mojave Dairy for five years (3). These cows were potentially exposed to hexavalent chromium and total chromium via the following exposure pathways: 1) ingestion of and bathing with contaminated groundwater; 2) ingestion of hay grown at the dairy and irrigated with contaminated groundwater; and 3) via airborne dust and/or water aerosol from the irrigated alfalfa fields.

Cow #1 was dry because of pregnancy; thus, it was not possible to collect a milk sample. The level of total chromium in the milk obtained from Cow #2 was non-detect (the detection limit was 0.12 mg/kg). According to a representative of the California Agricultural Commodities and Regulatory Services, there is no regulatory standard for chromium in milk (in other words, the level of chromium is not measured or monitored in milk sold commercially.) However, the background level of chromium in milk ranges from 0.008 to 0.250 mg/kg (23). Because the level of total chromium in the milk sample was below the limit of detection, 0.12 mg/kg (within the normal background range), no further investigation is warranted.

The veterinarian sacrificed two cows and conducted gross pathological examinations. The veterinarian did not observe any abnormalities in the tissue samples taken from the cows. The detection limit for all tissue and organ samples was 0.12 mg/kg. For Cow #1, the level of total chromium in the liver, kidneys, and muscles was non-detect. As for Cow #2, the level of total chromium in the liver was 0.16 mg/kg, and the level of total chromium was non-detect in the kidney and muscle samples. The normal background levels of total chromium found in cattle tissue/organs are liver (0.04 - 3.8 mg/kg); kidney (0.05 - 6.2 mg/kg); and muscle (0.1 - 0.2 ppm) [22]. Because the levels of total chromium detected in the tissue/organ samples taken from both cows are within normal background levels, no further investigation is warranted.

D. QUALITY ASSURANCE AND QUALITY CONTROL

In preparing this public health assessment, ATSDR and CDHS rely on the information provided in the referenced documents and assume that adequate quality assurance and quality control measures were followed with regard to chain-of-custody, laboratory procedures, and data reporting. The accuracy of the conclusions contained in this public health assessment is determined by the completeness and reliability of the referenced information.

LIMITATIONS OF THE INVESTIGATIONS DESCRIBED IN THIS PRELIMINARY PUBLIC HEALTH ASSESSMENT

Limitations in scope and/or lack of data (data gaps) can be a source of uncertainty associated with any scientific investigation. It is the view of the authors that limitations and data gaps do not necessarily compromise the conclusions of this report, but they must be taken into account when considering the conclusions for making recommendations. The recommendations presented later in the Public Health Recommendation and Action section are aimed at addressing the limitations described below.

Data Gap: Lack of Ambient Air Data Related to Potential Airborne Levels of Hexavalent Chromium Blown Off-site from PG&E's Cooling Towers

Chromium enters the air as a result of natural processes and human activities. Chromate-treated cooling towers are a source of hexavalent chromium emissions into the environment. In general, water is lost from cooling towers through evaporation and drift (31). As the water falls through cooling towers, the air flowing vertically or horizontally in the tower causes the water droplets contaminated with hexavalent chromium to evaporate and to be released into the environment. This latter process is called "drift". Drift is the main "vehicle" by which hexavalent chromium from cooling towers enters the environment (31). Drift may pose a problem to the public and the environment because 1) the water droplets contaminated with hexavalent chromium can act as "seeds" for fog, which may cause nuisance or hazard downwind of the cooling tower; 2) the deposition of drift can cause damage to nearby equipment, piping, structural steel, and vegetation; and 3) the drift can become a public nuisance by damaging the paint of cars and by keeping nearby roads wet (31).

In the past, residents living in the vicinity of the Hinkley site may have been exposed to hexavalent chromium water droplets released from PG&E's cooling tower via drift. There is no past ambient air monitoring data for this community. Without such data, it is impossible to evaluate the potential health impact on residents of inhalation of hexavalent chromium in the ambient air. The inhalation of ambient air levels of hexavalent chromium is therefore considered a potential (rather than a completed) past exposure pathway.

PATHWAYS ANALYSES

This section addresses the pathways by which people in the area surrounding the site could have been and could be exposed to contaminants at, or migrating from, the site. If it is determined that exposure to chemicals not necessarily related to the site is also of concern, that exposure is evaluated as well.

When a chemical is released into the environment, the release does not always lead to exposure. Exposure occurs only when a chemical comes into contact with a person and enters the body. In order for a chemical to pose a human health risk, a complete exposure pathway must exist. A complete exposure pathway consists of five elements: 1) a source and a mechanism of chemical

release to the environment; 2) a contaminated environmental medium such as air, soil, or water; 3) a point where someone contacts the contaminated medium (known as the exposure point); 4) an exposure route such as inhalation, dermal absorption, or ingestion; and 5) the person or people exposed (9).

Exposure pathways are classified as either completed, potential, or eliminated. In completed exposure pathways, all five elements exist. Potential exposure pathways are either 1) not currently complete but capable of becoming complete in the future, or 2) indeterminate because of lack of information. Pathways are eliminated from further assessment if one or more elements are missing and are never likely to exist.

A time frame given for each pathway indicates whether the exposure occurred in the past, is occurring, or will occur in the future. For example, a completed pathway with only a past time frame indicates that exposure did occur in the past but exposure is not occurring now and is not likely to occur in the future. The following discussions describe how people have been or may be exposed to contaminants. The health implications of the completed exposure pathways are discussed in the Public Health Implications section.

A. COMPLETED EXPOSURE PATHWAYS

Residents Living above the Chromium-contaminated Groundwater Plume Who Were Exposed to Chromium-contaminated Groundwater Water from Private Domestic Wells Prior to 1987

In November 1987, PG&E determined that ten private domestic wells serving fourteen homes contained chromium at levels greater than EPA's drinking water standard (MCL) of 0.05 mg/l for total chromium (the current EPA's MCL is 0.10 mg/l). CDHS's current MCL is 0.05 mg/l. As stated in the medical evaluation report, the levels of total and hexavalent chromium detected in the private domestic wells ranged from 0.04 to 1.0 mg/l. Since there were levels of total chromium detected above the MCL, further evaluation is warranted.

Residents Who Own Private Domestic Groundwater Well # 26-18

According to the May 1988 groundwater sampling investigation, the level of hexavalent chromium (0.02 mg/l) in one active private domestic well was below OEHHA's PHG (0.07 mg/l) for non-cancer health effects but above OEHHA's PHG (0.00018 mg/l) for cancer health effects, thus requiring further evaluation.

Workers at the Mojave Dairy Irrigation Operation

CDHS does not expect non-cancer health effects on Mojave Dairy workers and nearby residents because the highest ambient air level of hexavalent chromium, 3.8×10^{-7} mg/m^3 , is below EPA's RfC for hexavalent chromium, 8.0×10^{-6} mg/m^3.

CDHS estimated the increased lifetime excess cancer risk from ambient air levels of hexavalent chromium to be 2.9×10^{-5}. This is considered a very low increased cancer risk for Mojave Dairy workers and nearby residents. However, this may be an overestimation of the cancer risk because

- it is unlikely that workers worked in the alfalfa field during the irrigation operations;
- the cancer risk for hexavalent chromium is based on a 24 hour per day, 7 day per week, lifetime (70 years) exposure to ambient air levels of hexavalent chromium;
- no one lived at the Mojave Dairy.

B. POTENTIAL EXPOSURE PATHWAYS

Potential Exposure to Chromium-Contaminated Ambient Air— Residents Living in the Vicinity of the Hinkley Site

CDHS has identified one historical exposure pathway that may have impacted residents living in the vicinity of the Hinkley site (Table 9). Because hexavalent chromium was used in the cooling towers, residents may have been exposed to hexavalent chromium "drifting" off-site into the ambient air. Since there is no past ambient air monitoring data collected in the community, it is not possible to evaluate this potential inhalation exposure pathway.

Potential Exposure of PG&E Employees and Former Mojave Dairy Employees

CDHS has identified four potential historical exposure pathways— soil, waste-water, ambient air, and groundwater—that may have impacted PG&E employees at the Hinkley site and at the Land Treatment Fields (Table 9). However, the lack of knowledge of the nature and magnitude of past activities surrounding the cooling towers, the evaporation/percolation ponds, and land treatment fields precludes a thorough evaluation of the toxicological implications of past worker exposures. CDHS has contacted the California Occupational Safety and Health (CAL-OSHA) Association that oversees work practices and health concerns of on-site work activities. According to CAL-OSHA, workers' health and safety reports are kept on file for only three years; thus, there is no past information available. Because of the lack of available information, we cannot evaluate potential past exposures to former workers.

Potential Exposure to Chromium-Contaminated Ambient Air from the Site Characterization Field Activities and the Mojave Dairy Irrigation Operations—PG&E Workers and Nearby Residents

CDHS has identified inhalation exposure pathways to ambient air levels of chromium generated during the Site Characterization Field Activities and by the spray irrigation system in the Mojave Dairy. Workers involved in the site characterization field activities, Mojave Dairy workers, and nearby residents may have been exposed to ambient air levels of chromium. Both the Site Characterization Field Activities and the Mojave Dairy irrigation operation have ceased; thus, they represented potential past inhalation exposure pathways.

Potential Exposure to Chromium-Contaminated Ambient Air from the Land Treatment Fields—PG&E Workers and Nearby Residents

CDHS has identified an inhalation exposure pathway to ambient levels of chromium generated by the spray irrigation system in the Land Treatment Fields. PG&E workers and nearby residents may be exposed to ambient air levels of chromium. Thus, the exposure to ambient air levels of chromium is a potential current and future exposure pathway.

C. ELIMINATED EXPOSURE PATHWAYS

Seven exposure pathways relating to soil, groundwater, ambient air, and milk were evaluated in this public health assessment (Table 10). All exposure pathways were eliminated from further review either because the level of chromium was detected below health comparison values or else because chromium was no longer used on-site (i.e., the chromium-based corrosive inhibitor was replaced with a phosphate-based corrosive inhibitor in the cooling towers.)

Chromium-Contaminated Soil—Residents in the Vicinity of the Hinkley Site

The levels of chromium detected in the soil in the vicinity of the Hinkley site were below health comparison values and within normal background levels; thus, there are no current and future exposures at a level of health concern to nearby residents.

Chromium-Contaminated Soil—PG&E Workers at the Land Treatment Fields

The levels of total chromium detected in the soil in the Land Treatment Fields were also below health comparison values; thus, there are no current and future exposures at a level of health concern to PG&E workers at the Land Treatment Fields.

Chromium-Contaminated Groundwater—Residents in the Vicinity of the Hinkley Site

Since December 1987, the levels of total chromium in the groundwater have been below CDHS' MCL (0.05 mg/l); thus, according to regulatory standards, no one living along the perimeter of the chromium-contaminated groundwater plume has been exposed to total chromium above 0.05 mg/l. According to PG&E, residents who drank chromium-contaminated groundwater prior to 1987 were provided with bottled water in 1987 (CDHS does not know whether all the residents used the bottled water.) In 1991, PG&E purchased the homes situated above the contaminated groundwater plume, and the mobile home residents moved their homes from the area. Because of PG&E's groundwater remediation activities and the on-going groundwater monitoring program, no additional private domestic wells have been impacted by total chromium above CDHS' MCL (0.05 mg/l).Thus, there is no current or future health impact from total chromium (via skin absorption, ingestion, and inhalation) on residents living in the vicinity of the Hinkley site.

Chromium-Contaminated Groundwater—Community Members and PG&E Employees Who Used the Swimming Pool Located on the Hinkley Site

According to a PG&E representative, water for the on-site swimming pool is supplied by PG&E's production wells located south (or up-gradient) of the chromium-contaminated groundwater plume. Thus, past, current, and future exposure (via inhalation, ingestion, and dermal contact) to chromium in the swimming pool has been eliminated.

Chromium-Contaminated Ambient Air in the Vicinity of the Cooling Towers—PG&E Workers and Residents Living in the Vicinity of the Hinkley site

In 1966, PG&E replaced the chromium-based corrosion inhibitor used in the cooling tower with a phosphate-based compound, thereby eliminating worker exposure to chromium-contaminated aerosol/dust/soil in the vicinity of the cooling towers.

As hexavalent chromium was no longer used in the cooling towers, there would have been no "drift" of hexavalent chromium into the neighboring areas, and thus the ambient air exposure pathway to residents would also have been eliminated at that time.

Dairy Cow Exposure to Alfalfa Irrigated with Chromium Contaminated Groundwater—Individuals who Consumed Milk, Meat, or Organs from Cows

The levels of total chromium in the liver, kidney, muscle, and milk produced by two dairy cows exposed to both total and hexavalent chromium ranged from non-detect to within normal background levels of chromium. Thus, the ingestion of milk, meat, and organs from cows exposed to chromium-contaminated groundwater does not appear to pose a health concern.

ATSDR CHILD HEALTH INITIATIVE

ATSDR recognizes that infants and children may be more sensitive to exposures, depending on the substance and the exposure situation, than adults in communities with contamination of water, soil, air, and/or food. This sensitivity is a result of several factors: 1) Children may have greater exposures to environmental toxicants 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 outdoors close to the ground, increasing their exposure to toxicants in dust, soil, surface water, and ambient air; 3) Children have a tendency to stick their hands in their mouths while playing, without washing their hands, and they may thus come into contact with and ingest potentially contaminated soil particles at higher rates than adults (also, some children possess an abnormal behavior trait known as "pica," a tendency to ingest non-food items such as soil); 4) Children are shorter than adults and therefore breathe dust, soil, and any vapors close to the ground; 5) Children's bodies are rapidly growing and developing, and they can sustain permanen damage if toxic exposures occur during critical growth stages; and 6) Children and teenagers may disregard no-trespassing signs and wander onto a restricted location. Because children depend

completely on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at sites such as the Hinkley site as part of the ATSDR Child Health Initiative.

CDHS has attempted to identify populations of children in the vicinity of the Hinkley site. According to a PG&E representative, the nearest school/playground, Hinkley's elementary/middle school, is located approximately three miles northwest of the Hinkley site (13). The nearest high school is located in Barstow, approximately 12 miles east of Hinkley (13). The children attending either school would not be impacted by the contaminated groundwater plume or the activities at the Hinkley site because of the distance between the schools and the site. Currently, there may be children living in homes near the Hinkley site, but PG&E and their contractors have been monitoring the area groundwater and have determined that in areas using private domestic wells, the quality of the groundwater meets CDHS's MCL, 0.05 mg/l. CDHS concludes that present and future exposures to on- and off-site groundwater and soil do not represent a public health hazard for children. However, in the past, children who lived in the vicinity of the Hinkley site were exposed to groundwater containing chromium exceeding EPA's MCL via contaminated private domestic wells (2). Refer to the Health Outcome Data Evaluation Section for the health impacts on these children and on other family members who were exposed to the chromium-contaminated groundwater.

PUBLIC HEALTH IMPLICATIONS

A. TOXICOLOGICAL EVALUATION

For data presented in this document, no current and/or future exposures to Hinkley-related contaminants (i.e., total chromium and hexavalent chromium) were identified that would indicate a threat to health. However, a past exposure was identified and will be evaluated in this section. Before discussing the toxicological evaluation of specific exposure pathway conditions, we will present a description of how we conduct toxicological evaluations.

In a toxicological evaluation, we evaluate exposures that have occurred to specific contaminants, relying on the most current studies we can find in the scientific literature. There is not enough available information to permit complete evaluation of the effects of exposure to multiple chemicals or possible non-cancer 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 followup. 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 individual characteristics such as age, sex, nutrition, family traits, life style, and state of health (18). The scientific discipline that evaluates these factors and the potential for a chemical exposure to adversely impact health is toxicology.

This section will evaluate the toxicological risk from the exposure pathway identified in the *Pathways Analyses* section. The approach used to evaluate the potential for adverse health effec (other than cancer) to occur in an individual or a population assumes that there is a level of exposure below which non-cancer, adverse health effects are unlikely to occur. That level is called the threshold level or toxicity value. Our approach compares a dose estimate with the toxicity value. The dose estimate is a calculated estimate of the amount of contaminant in conta with or taken up by the exposed person and is expressed as milligrams contaminant per kilogran body weight per day, or mg/kg/day.

When the dose estimate for a contaminant exceeds the toxicity value for that contaminant, there may be concern for potential non-cancer, adverse health effects as a result of exposure to that contaminant. While a particular exposure may not result in appreciable risk by itself, the combined exposure through several pathways may pose a health threat. Therefore, the risk from all possible pathways affecting a particular population is evaluated.

Toxicity values used to evaluate non-carcinogenic, adverse health effects at the Hinkley site include ATSDR Minimal Risk Levels (MRLs) and EPA Reference Doses (RfDs). Both of these values are estimates of daily exposure to the human population (including sensitive subgroups), below which non-cancer adverse health effects are unlikely to occur. The MRL and the RfD consider only non-cancer effects. Because they are based only on information currently available, some uncertainty is always associated with the MRL and RfD. The uncertainty factor takes into account the differences in response to toxicity for a given contaminant within human and animal populations and between humans and animals, as well as the quality of the data base and the type of toxicological effects (18). The greater the uncertainty in our knowledge, the greater the uncertainty factor and the lower the MRL or RfD.

The toxicity studies used to determine the MRLs and the RfDs are usually conducted on adult animals; thus, these levels are most likely protective of adult humans but may not be fully protective of young children. Because of this, additional uncertainty factors may be incorporate to account for this deficiency.

The potential for exposure to a contaminant to cause cancer in an individual or a population is evaluated by estimating the probability of an individual's developing cancer over a lifetime as tl result of the exposure. This approach is based on the assumption that there are no absolutely "safe" toxicity values for carcinogens. EPA has developed cancer slope 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 wit the exposure can be calculated by use of the slope factor for that carcinogen. Specifically, to obtain risk estimates, the estimated, chronic exposure dose is multiplied by the slope factor for that carcinogen.

Cancer risk is the likelihood, or chance, of getting cancer. We say "excess cancer risk" because we have a "background risk" of about one-in-four chances (25%) of getting cancer. In other words, in a million people, it is expected that 250,000 individuals will get cancer from a variety of causes. 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 exposed to a carcinogen at a certain level over a lifetime, then one cancer above the background chance, or the 250,001st cancer, may appear in those million persons from that particular exposure. (This is a low estimate of background cancer risk, which may be as high as 33%.) In order to take into account the uncertainties in the science, the risk numbers used are plausible upper limits of the actual risk derived from conservative assumptions. In actuality, the risk is probably somewhat lower than that calculated, and, in fact, may be zero.

TOXICOLOGICAL PROFILES FOR CHEMICALS

In the following section, we have included general information about exposure to chromium. The information was obtained from ATSDR's *Toxicological Profile for Chromium*. The discussion of chromium will begin with a general description of the environmental states and toxicology, followed by a separate analysis of the health impacts on the residents who ingested chromium-contaminated groundwater (19).

TOXICOLOGY AND CHEMISTRY OF CHROMIUM

Chromium is a naturally occurring element that is found in soil and in volcanic dust and gases (18). It is found in the environment in three major states: metallic chromium, trivalent chromium, and hexavalent chromium. Trivalent chromium occurs naturally in the environment, whereas hexavalent chromium and metallic chromium are generally produced by industrial processes (18). Total chromium is composed of trivalent chromium and hexavalent chromium. In the environment, the ratio of hexavalent chromium to trivalent chromium is approximately 1 to 6. Furthermore, under certain environmental conditions, hexavalent chromium will transform into trivalent chromium.

Each form of chromium differs in its effect on health. Exposure to metallic chromium is not very common and is not well characterized in terms of levels of exposure or potential health effects (18).

Trivalent chromium is considered an essential nutrient that helps to maintain normal metabolism of glucose, cholesterol, and fat in humans; a daily ingestion of 50 to 200 microgram (ug) per day has been estimated to be safe and adequate; however, very large doses may be harmful (18). Good sources of trivalent chromium include brewer's yeast and fresh foods (18). Long-term studies in which animals were exposed to low levels of chromium compounds in food or water, particularly trivalent chromium compounds, have not discovered harmful health effects (18).

Ingestion of hexavalent chromium poses a relatively low health concern because it is rapidly transformed into trivalent chromium in the gastrointestinal tract. Workers exposed to high levels

of hexavalent chromium in occupational settings may develop adverse health effects via derm contact (e.g., rashes, ulcers, kidney and hematological effects, cardiovascular system effects, e and inhalation (e.g., irritating respiratory effects, nasal septum perforation, nasal ulcerations, bronchitis, pulmonary edema, possible cardiovascular effects, gastrointestinal and hematologi effects, liver and kidney effects, increased risks of death from non-cancer respiratory effects, a lung cancer) [18].

EPA has calculated a Reference Dose (RfD) for long term oral exposure to hexavalent chromium. This value represents an estimate of daily exposure of the human population (including sensitive subgroups), below which non-cancer adverse health effects are unlikely tc occur. The RfD is based on a study of rats who were given 25 mg/l of hexavalent chromium (potassium chromate or K_2Cr0_4) in their drinking water for one year. No significant adverse effects were seen on appearance, weight gain, or food consumption, and there were no pathol changes in the blood or other tissues; the only change noted was that the rats' water consumpt decreased by approximately twenty percent. Thus, according to this study, the NOAEL (no-observable-adverse-effect-level) for the exposed rats was determined to be 2.4 mg hexavalent chromium/kg/day (19). To account for the uncertainty of extrapolating from rats to humans ar to protect particularly sensitive people, EPA divided the "no-observable-adverse-effect-level" an uncertainty factor (or safety factor), resulting in a RfD of 0.005 mg hexavalent chromium/kg/day (19).

Similar no-effect levels have been observed in dogs and humans (18–19). No observable significant effects were observed in female dogs who were given up to 11 mg/l of hexavalent chromium (as potassium chromate or K_2Cr0_4) in drinking water for four years; the calculated doses were 0.012 to 0.30 mg/kg of hexavalent chromium (18). In humans, no adverse health effects were detected (by physical examination) in a family of four persons who drank for 3 y from a private well containing hexavalent chromium at approximately 1 mg/l (0.03 mg/kg/da for a 70-kg human) [18].

Because some hexavalent chromium compounds have been associated with lung cancer in workers and have caused cancer in animals, the USDHHS has determined that certain hexava chromium compounds (viz., calcium chromate, chromium trioxide, lead chromate, strontium chromate, and zinc chromate etc.) are known carcinogens (18). The International Agency for Research on Cancer (IARC) has determined that hexavalent chromium is carcinogenic to humans, according to sufficient evidence in humans for the carcinogenicitiy of hexavalent chromium compounds as found in chromate production, chromate pigment production, and chromium plating industries. IARC's determination is also based on sufficient evidence in experimental animals for the carcinogenicity of calcium chromate, lead chromate, strontium chromate, and zinc chromate, and on limited evidence in experimental animals for the carcinogenicity of chromium acid and sodium dichromate. EPA has classified hexavalent chromium as a known human carcinogen by the inhalation route of exposure. However, the I believes that, at this time, there are insufficient data to classify hexavalent chromium as a carcinogen by the oral route of exposure (30).

On the other hand, the California Environmental Protection Agency recently classified hexavalent chromium as potentially carcinogenic by the oral route (29) and established a cancer potency number for ingestion. The new California standard, which was used for the revision of this document, impacts the toxicological evaluation and changes the hazard category for this site.

EXPOSURE DOSE ESTIMATES

Residents Living above the Chromium-Contaminated Groundwater Plume Who Were Exposed to Chromium-Contaminated Groundwater from their Private Domestic Wells Prior to 1987

CDHS estimated non-cancer ingestion doses (for both children and adults) based on the highest level of hexavalent chromium (1.0 mg/l) detected in the private wells of the residents who lived above the chromium-contaminated groundwater plume. Both the non-cancer ingestion dose for children (0.06 mg/kg/day) and the adult non-cancer ingestion dose (0.027 mg/kg/day) exceed USEPA's chronic RfD of 0.003 mg/kg/day for hexavalent chromium in drinking water. Although the estimated non-cancer doses exceed the health guidance level, and non-cancer health effects are possible, we would not expect children and adults who drank the water to experience non-cancer health effects since these levels are 40 to 90 times lower than the NOAEL, which is the highest dose to cause no effect in animal studies.

Furthermore, in 1996 researchers conducted an exposure assessment study on the ingestion of tap water contaminated with hexavalent chromium (32). This study determined that ingestion of low levels (less than 8 mg/l) of hexavalent chromium in water should be evaluated principally as an exposure to trivalent chromium because low levels of hexavalent chromium are likely to be "reduced" (i.e., changed) rapidly and completely to trivalent chromium (32). In commonly prepared foods and mixed beverages, almost all the hexavalent chromium will be changed within a reasonable time between preparation and consumption (32). And, in the unlikely event that hexavalent chromium is left, it will be further "reduced" or changed by gastric juices found in the stomach (32). The gastric juices can "reduce" 50 to 100 mg/l of hexavalent chromium to trivalent chromium on a daily basis (32). Thus, if we compare the non-cancer ingestion dose for children (0.06 mg/kg/day) and the adult non-cancer ingestion dose (0.027 mg/kg/day) that we estimated earlier to EPA's RfD for trivalent chromium (1 mg/kg/day), we would not expect non-cancer health effects to occur.

CDHS estimated a total lifetime excess cancer risk of 2.6×10^{-3}, based on the highest level of hexavalent chromium (1.0 mg/l) detected in the private wells of residents who lived above the chromium-contaminated groundwater plume. This is considered to be a moderate increased cancer risk, assuming chromium to be carcinogenic through ingestion.

Residents Exposed to Hexavalent Chromium-Contaminated Groundwater Via Their Private Domestic Groundwater Well (# 26-18)

CDHS did not estimate non-cancer ingestion doses (for children or adults) because the level of hexavalent chromium (0.02 mg/l) detected in private well # 28-18 (which is currently being used

for domestic purposes) was below OEHHA's PHG of 0.07 mg/l. We do not expect non-cancer health effects from such low doses.

CDHS did estimate cancer health effects for adults, because the level of hexavalent chromium (0.02 mg/l) was above OEHHA's PHG for cancer health effects (0.00018 mg/l). The total lifetime excess cancer risk is 5.2×10^{-5}. This is considered a very low increased cancer risk. Again, this is the risk that would be predicted when there is an assumption that hexavalent chromium is carcinogenic through ingestion.

Potential Exposure to Chromium-contaminated Ambient Air—PG&E Workers and Nearby Residents Working and Living in the Vicinity of the Land Treatment Fields

1. Site Characterization Field Activities

CDHS does not expect non-cancer health effects in PG&E workers and nearby residents to result from exposures to ambient air because the levels of hexavalent chromium were non-detect (3.06×10^{-8} mg/m^3). As mentioned earlier, ***non-detect*** does not indicate the absence of airborne levels of hexavalent chromium, but rather that the levels of hexavalent chromium were below the limit of analytical technique; in this case, that level was set at 3.06×10^{-8} mg/m^3. The highest levels of hexavalent chromium, if any, that could be measured would be 3.06×10^{-8} mg/m^3, which is below EPA's RfC of 8.0×10^{-6} mg/m^3.

CDHS estimated the increased lifetime excess cancer risk from exposure to these levels of hexavalent chromium in ambient air to be 3.3×10^{-8}. This is considered to be a no-apparent-increased-cancer-risk for PG&E workers and nearby residents.

2. Land Treatment Fields Operation

The levels of total chromium (up to 3.0×10^{-6} mg/m^3) measured at the Land Treatment Fields were within the range of total chromium (1.0×10^{-6} mg/m^3 and 1.0×10^{-5} mg/m^3) detected in the background ambient air. Thus, it does not appear that the Land Treatment Fields operation is an important source of total chromium in ambient air.

In order to better estimate the cancer risk from hexavalent chromium, CDHS recommends that additional ambient air sampling be conducted and analyzed for hexavalent chromium at the Land Treatment Fields.

Summary of the Total Cancer Risk from Hexavalent Chromium via the Inhalation and Ingestion Routes

In addition to estimating the individual cancer risk, we have estimated the total cancer risk for individuals exposed to hexavalent chromium via ingestion of contaminated groundwater from private domestic wells and for individuals potentially exposed to hexavalent chromium via the inhalation of contaminated ambient air during the Site Characterization Field Activities, the Mojave Dairy and the Land Treatment Field Irrigation Operations.

For individuals above the contaminated groundwater plume who ingested hexavalent chromium-contaminated groundwater from their private domestic wells (pre-1988) and who may have been exposed to ambient air levels of hexavalent chromium during the Site Characterization Field Activities and the Mojave Dairy Irrigation Operations, the total cancer risk is 2.6×10^{-3}. This is considered a moderate increased cancer risk. It may be an over-estimation of the cancer risk. This total cancer risk is mainly attributable to the ingestion of the hexavalent chromium-contaminated groundwater and not to the potential inhalation of the contaminated ambient air during the Site Characterization Field Activities or the Mojave Dairy Irrigation Operations. The cancer risk contribution of the inhalation of hexavalent chromium-contaminated ambient air may be an over-estimation because there was no one living on the the Hinkley site during the site characterization field activities or at the Mojave Dairy during the irrigation operations; thus, no one was exposed to ambient air levels of hexavalent chromium on a daily basis (i.e., 24 hours/day and 7 days/week). Also, the cancer risk to a person walking past the Hinkley site during the site characterization field activities or the Mojave Dairy during the irrigation operations would be negligible because of the limited exposure duration (see Table 12.)

For individuals who live near the perimeter of the contaminated groundwater plume and ingested low levels of hexavalent chromium-contaminated groundwater from a private domestic well (post-1988) and may have been exposed to ambient air levels of hexavalent chromium during the Site Characterization Field Activities, the Mojave Dairy and Land Treatment Field Irrigation Operations, the total cancer risk is 2.8×10^{-4}. This is considered a low increased cancer risk (see Table 12.) Again, the total cancer risk may be an over-estimation for the reasons stated in the previous paragraph.

For individuals living near the perimeter of the contaminated groundwater plume who ingested low levels of hexavalent chromium-contaminated groundwater from a private domestic well (post-1988) and may have been exposed to ambient air levels of hexavalent chromium during Land Treatment Field Irrigation Operations, the total cancer risk is 2.5×10^{-4}. This is considered a low increased cancer risk. These are individuals who moved to the Hinkley area after the Site Characterization Field Activities ended (these took place for a limited period of time, March 10 through August 1988) and after the Mojave Dairy Irrigation operation (bought out by PG&E in 1992) ceased (see Table 1). Once again, the total cancer risk may be an over-estimation for the reasons stated in the previous paragraph.

3. HEALTH OUTCOME DATA EVALUATION

MEDICAL EVALUATION

One medical evaluation has been performed at the Hinkley site. PG&E hired Environmental Health Associates (EHS) of Oakland, California to conduct medical evaluations on volunteers from the area in December,1987 and February,1988 (15). CDHS staff reviewed these health evaluations and have summarized EHS's findings in the following sections.

At a public meeting in December 1987, PG&E invited those residents of Hinkley whose well water contained chromium at levels above the USEPA's MCL (0.05 ppm) to receive no-cost medical evaluations. Those residents who could not attend this session were invited to participate on February 9, 1988. Evaluations were performed at the PG&E district office in Hinkley. Medical evaluations consisted of a health history questionnaire, an employment/exposure history, a physical examination (skin, lung and abdominal exams), a dipstick urinalysis, a urine analysis for chromium and creatinine concentrations, and blood chemistries determining liver and kidney function. Five employees not exposed to chromium from the Hinkley district office also volunteered to submit urine samples and to complete exposure questionnaires as a comparison group (15).

Twelve families, consisting of 46 individuals, were determined to have used eight contaminated drinking water wells, but only 20 individuals (10 adults and 10 children) elected to participate in the evaluations. Of these 20 individuals, 9 (45%) were less than 10 years old and 8 (40%) were young adults from 20 to 39 years of age. Seven of the 20 individuals were males (35%) and 13 were females (65%). The majority of volunteers (75%) had lived in Hinkley for longer than three years. All of the study participants used their wells as the primary source of drinking water, and none of the participants had any potential chromium exposure from occupation or hobby. Total and hexavalent chromium levels from these wells ranged from 0.04 to 1.0 ppm.

More frequent symptom complaints voiced by participants included mouth and throat problems in 9 individuals (45%), gastrointestinal complaints in 9 individuals (45%), headaches in 9 individuals (45%), ear problems in 8 individuals (40%), and skin problems in 8 individuals (40%).

The physical examinations disclosed only a few abnormalities, including one individual with hypertension and four individuals with skin abnormalities. No residents were noted to have kidney or liver abnormalities.

All blood tests for kidney function were normal. There were two individuals with elevations of their liver function blood tests. Dipstick urinalyses disclosed two individuals with hematuria (one was a menstruating woman) and one individual with an elevated glucose. Urinalyses to determine urine chromium concentrations demonstrated that as a group, the adults averaged 2.3 ug/L of chromium, the children averaged 1.5 ug/L of chromium, and the five unexposed volunteers had non-detectable levels of chromium in their urine.

The principal finding of these medical evaluations was that both adult and child volunteers from residences with chromium-contaminated drinking water wells had higher levels of urinary chromium than non-exposed volunteers. In this evaluation, eight adults were reported to have a mean of 0.6 ug chromium/gm (gram) creatinine excreted in their urine, with a range of non-detectable to 2.1 ug/gm. Most authors have estimated that normal urinary chromium concentrations are less than 5 ug/gm.

While there were numerous health symptoms reported by the study participants, it is unlikely that these complaints were related to exposure to chromium through inhalation, ingestion or skin contact. The combination of the physical examination and the laboratory tests did not provide supporting evidence that these complaints were related to chromium exposure. Chromium is well documented to produce irritation of the digestive tract, liver and kidney damage, and skin irritation and lesions from acute exposures seen in occupational populations. Hexavalent chromium is also classified as a lung carcinogen. There was no evidence of kidney damage according to the normal laboratory tests for creatinine and blood urea nitrogen. There were elevated liver function values in two individuals; however these values may also be elevated for various other reasons. Urinalysis also showed one individual with elevated urinary glucose. This individual also had hypertension and was being treated for diabetes. It was recommended that all individuals with abnormalities in blood or urine tests have follow-up examinations with their regular physicians (15).

This evaluation demonstrated that those individuals exposed to chromium-contaminated drinking water had elevated levels of chromium in their urine, when compared to a non-exposed population. However, these levels were below reported normal urinary chromium values in both occupational and non-occupational populations. There were no other consistent medical history responses, physical examination findings, or laboratory test results to suggest that the exposed volunteers had sustained health effects from chromium exposure.

MORTALITY AMONG GAS GENERATOR WORKERS

Mortality (death) among a cohort (group) of 51,899 PG&E employees was evaluated by Blot et al. and described in a recent publication (36). The objective of this study was "to evaluate the a priori hypothesis that PG&E employees, particularly trainees and/or workers at the Kettleman, Hinkley, and Topock facilities (where chromate compounds were used until the 1980s in on-site water cooling towers) might have experienced an increased rate of cancer, especially lung cancer." Though not explicitly stated, CDHS assumes (based on the study's evaluation of lung and nasal cancers) that Blot et al. were concerned with inhalation exposure to chromate compounds at the gas generator facilities.

Blot et al. evaluated the numbers and types of mortality among 51,899 men who were employees of PG&E for at least 6 months between September 4, 1954 and December 31, 1986. These men were part of an earlier occupational study of workers at five United States utilities (37). The study also examined the numbers and types of mortality among the subgroup of employees who worked or were trained at one of the three gas generator facilities (Hinkley, Topock, and Kettleman). Five hundred thirteen (1%) of the 51,899 were employees at one of the gas generator facilities, and 3,283 (6%) of the 51,899 were trainees at Kettleman.

Blot et al. collected information about deaths that occurred among the PG&E employees between January 1, 1971 (or 6 months after time of employment, if later than January 1, 1971) and December 31, 1997. Comparisons were made between the number and causes of death among PG&E employees and those that would be expected according to mortality rates in California.

The researchers asked the following questions:

- Were there more deaths than expected?
- Were there more deaths from specific causes, such as cancer, heart disease, respiratory disease than expected?
- Was there a higher excess of deaths from cancer among those workers who worked at PG&E for longer periods of time?

These comparisons were made for the entire cohort of PG&E employees, for the group of gas generator workers, and for the group of Kettleman trainees.

Comparisons between the observed (actual) number of deaths in a population and the number of deaths expected based on a comparison (or reference) population are expressed through a measure called a standardized mortality ratio (SMR). The SMR is equal to the number of observed deaths divided by the number of deaths one would expect based on a reference population. An SMR greater than one indicates that more than the expected number of deaths have occurred in the cohort; an SMR less than one indicates that fewer than the expected number of deaths have occurred in the cohort. Lastly, an SMR equal to one indicates that the same number of deaths occurred as were expected. To account for the imprecision inherent in calculating comparison measures, SMRs are often also reported as a range of numbers called a confidence interval (CI). The confidence interval is a range of numbers that have a 95% chance of representing the true (or most accurate) value of the SMR.

Between 1971 and 1997, 10,591 deaths were identified among the group of PG&E employees, 82 among the gas generator workers, and 122 among the Kettleman trainees. The number of deaths in all three groups was significantly less than the number expected according to California mortality rates. The standardized mortality ratios and SMR confidence intervals for the three groups are:

All PG&E workers: SMR=0.89, 95% CI=0.87–0.91
PG&E Gas Generator workers: SMR=0.79, 95% CI=0.64–0.97
PG&E Kettleman trainees: SMR=0.68, 95% CI=0.56–0.80

The investigators also did not observe more than the expected number of deaths from any of the specific causes they evaluated. Lastly, they did not find a pattern of increasing excess of death from lung or all other cancers among men who were employed at PG&E for longer periods of time. Similar results were obtained for the gas generator workers and the Kettleman trainees.

Lastly, the authors briefly mention that no excess in lung cancer deaths was observed among the gas generator workers in comparison to other PG&E workers (rather than in comparison to California.) However, no data were published to support this comparison to the PG&E workers.

Blot et al. conclude that their "investigation of mortality indicates that occupational exposures had no influence on rates of cancer or other diseases in the PG&E workforce overall, or among employees at the Kettleman, Hinkely and Topock facilities or Kettleman trainees."

Blot et al. acknowledge several limitations of their study, including:

- the absence of any systematically collected data about non-occupational factors that may influence disease risk;
- the low statistical power to rule out small increases in risk among the gas generator plant workforce (because of the small number of workers in this group); and
- the possibility that some of the Kettleman trainees and some of the gas generator employees, particularly those who started prior the 1970s, were missed and not enrolled in the follow-up.

CDHS noted four additional and rather substantial weaknesses in the Blot et al. investigation of mortality among gas generator workers.

First, the study's ability to detect a difference between the observed number and causes of death and the expected number and causes was limited by the fact that the investigators did not accurately identify the group of PG&E employees who were potentially exposed to chromates. The study included all men employed by PG&E between September 1, 1954 and December 31, 1986. This time period was selected because "chromates were used as cooling tower water additives at these facilities from the 1950s until the early 1980s." Thus, in theory, all workers in the study held in common the potential for exposure to chromates.

In actuality, chromate-based coolants were used at Hinkley from 1952 through 1966, when the facility switched to phosphate-based coolants. Thus, the potential for occupational exposure to chromates existed only for those employees who worked at Hinkley during the first 12 years of the study period (1954–1966). Blot et al. treated 20 years' worth of Hinkley employees as if they were exposed to chromates, even though chromate-based coolants were not used during this time. This misclassification—treating unexposed workers as exposed—would reduce the study's ability to identify any association between exposure to chromates and risk of mortality. However, it is not possible to determine whether this flaw would significantly alter the study results from a statistical point of view.

Second, the study's ability to detect an association between exposure to chromates and increased risk of mortality was also limited by the lack of quantitative measurements of occupational exposure to chromates. The investigators did not know whether and to what degree all of the gas generator employees or Kettleman trainees were exposed to chromates. Instead, the study treated all gas generator workers as exposed. This assumption would have classified any unexposed workers as exposed and would have treated the most exposed workers as equal to the least exposed. This misclassification of exposure would weaken the study's ability to detect any association between occupational exposure to chromates and risk of mortality among PG&E employees.

Third, this investigation evaluated mortality (deaths) among PG&E workers rather than morbidity (illness). Mortality studies are easier to perform because death is easier to trace than illness. However, mortality studies demonstrate only associations between an exposure and fatal diseases. Associations between exposures and non-fatal diseases can be measured only through morbidity

studies. Exposure to chromates is associated with an increased risk of lung cancer—a highly fatal disease—and to this extent a mortality study is an appropriate choice for this investigation. However, exposure to chromates is also associated with other conditions, such as nasal septum perforation, nasal ulcerations, bronchitis, as well as with cardiovascular, gastrointestinal, hematological, liver, and kidney health effects that may not be associated with increased mortality. Increased risk of these health outcomes would not have been detected by the Blot et al. mortality study. Yet, these authors conclude that "the study indicates that on-the-job exposures conveyed no excess risk of these diseases." A more accurate statement would have been that exposures did not convey increased risk of death from these diseases.

Fourth, the general California population is not the most appropriate reference (comparison) population for the PG&E employees, and use of the general California population as a comparison group may have contributed to the study's finding that PG&E employees experienced lower-than-expected risk of death. Workers tend to be more healthy and fit and to have lower risks of illness and death than general populations, which include people who are too ill or unfit to be employed. Consequently, using California mortality rates to calculate the number of expected deaths could result in a number of expected deaths that is artificially high and an SMR that is artificially low. Thus, comparing the PG&E workers to the general California population may have contributed to the lower-than-expected risk of death among PG&E employees in the study.

In conclusion, the Blot et al. study of mortality among gas generator workers found no increased risk of death among men employed by PG&E for at least six months between the years 1954 and 1986. However, because of the limitations of the Blot et al. study, CDHS does not consider the study to be an accurate or sufficient evaluation of the association between occupational exposure to chromates and risk of death among employees at the PG&E Hinkley site.

COMMUNITY CANCER ASSESSMENT IN HINKLEY, CALIFORNIA, 1988-1993

Information about cancer incidence (the number of newly diagnosed cancer cases) in Hinkley during the years 1988-1993 is available from a Community Cancer Assessment, performed by the Desert Sierra Cancer Surveillance Program (DSCSP) of the California Cancer Registry (38).

In September 1995, the DSCSP was contacted by a representative of a nationally syndicated television news show inquiring about a potential excess in the number of new cancer cases in Hinkley. In response, the DSCSP initiated a community cancer assessment in the census tract (tract 119) that included a majority of the Hinkley population. The assessment evaluated all cancer sites (combined) as well as several types of cancer that were mentioned during the telephone conversation, including colorectal cancer, breast cancer, nasopharyngeal carcinoma, lung cancer, lymph node cancer, and prostate cancer.

A community cancer assessment compares the number of cancer cases observed in a community to the number of cases that are expected to occur. This comparison of the observed number of cases to the expected number of cases is expressed as an observed-to-expected ratio. An observed-to-expected ratio that is greater than one indicates that more cancers occurred in a community than

would be expected; a ratio less than one indicates that fewer cancers occurred than would be expected; and a ratio equal to one indicates that the same number of cancers occurred as would be expected. Lastly, because of the random nature of cancer, community cancer assessments also calculate a range of values—called a confidence interval—for the observed-to-expected ratio. The confidence interval is a range of numbers that have a 99% chance of representing the true (accurate) value of the observed-to-expected ratio. Confidence intervals that contain the number one indicate that, statistically speaking, the number of observed cancer cases is not different than the expected number of cancer cases.

For the Hinkley community cancer assessment, information about the number of observed cases in census tract 119 was obtained from the regional cancer registry. (By law, all cancers diagnosed in California since January 1, 1988 are reported to one of the regional registries that form the California Cancer Registry.) The number of cancer cases expected to occur during the years 1988-1993 was calculated through a process called indirect standardization. Indirect standardization calculates the expected number of cancer cases in a way that accounts for different rates of cancer in different age, race/ethnic, and gender groups.

A total of 114 new cancer cases were observed during the time period 1988–1993 in census tract 119. The total number of expected new cancer cases for the years 1988–1993 was 91.2. The observed-to-expected ratio for census tract 119 for the years 1988–1993 was 1.25, with a 99% confidence interval of (0.97–1.58). The confidence interval contains the number 1, thus indicating that the number of observed cancers in census tract 119 during 1988–1993 does not differ significantly from the number of cancer cases expected to occur during this time.

In conclusion, the DSCSP cancer case assessment indicates that the number of new cancer cases that occurred from 1988 to 1993 in census tract 119 does not differ significantly from the number expected when one considers the age, sex, race/ethnicity and population size of the census tract. Thus, there is no evidence of excess cancer in the census tract encompassing Hinkley during the years 1988–1993.

C. COMMUNITY HEALTH CONCERNS EVALUATION

We have addressed each of the community concerns about health as follows:

1. *Were employees of the Vernola Ranch and the old dairy (i.e., the former Mojave Dairy, since demolished, across the street from PG&E) exposed to contaminants at levels of health concern?*

   For a discussion of worker exposure at the former Mojave Dairy, see the explanation provided in the Pathway Analyses section. If former workers have health concerns and would like further information, they should contact CAL-OSHA and/or NIOSH, which have jurisdiction over worker's health and safety issues. As for the Vernola Ranch, the groundwater used to irrigate the alfalfa field is pumped from an area approximately one to

two miles south of Community Boulevard near the Mojave River. Thus, there is no exposure to the chromium-contaminated groundwater to employees working in the alfalfa fields. Since 1989, repeated tests by PG&E of private drinking water well 01-02 on the Vernola Ranch have been less than the laboratory detection limit (Table 7). It is not known whether another well on that property could be a potential exposure pathway, as it has not been tested.

2. *Were PG&E employees' children and others who swam in the swimming pool on the PG&E site exposed to chromium at levels of health concern?*

   See the explanation provided in the Pathway Analyses section.

3. *Is there a potential for exposure to airborne levels of chromium from the Hinkley site, especially from the exhaust coming from the site?*

   In 1966, PG&E replaced the chromium-based corrosion inhibitor with a phosphate-based corrosion inhibitor. Thus, since 1966, there has been no exposure to airborne levels of hexavalent and total chromium from the Hinkley site.

4. *Are private domestic wells currently impacted by the chromium-contaminated groundwater plume?*

   See the explanation provided in the Pathway Analyses section.

5. *Are people being exposed chromium above healthy levels in the vicinity of the Land Treatment Fields?*

   See the explanation provided in the Pathway Analyses section.

6. *Are well maintenance workers who repair and replace farm wells over the groundwater plume being exposed to chromium at unhealthy levels?*

   Currently, there are three operating alfalfa farms (viz., Vernola Ranch and the two PG&E land treatment fields) located above the chromium-contaminated groundwater plume. However, the groundwater used to irrigate Vernola Ranch's alfalfa field is pumped from an area approximately one to two miles south of Community Boulevard near the Mojave River. Thus, there is no exposure to the chromium-contaminated groundwater of employees working in the Vernola Ranch alfalfa fields. The PG&E land treatment alfalfa fields are irrigated with chromium-contaminated groundwater. However, it is highly unlikely that well maintenance workers are exposed to chromium at levels above health concerns via the ingestion or inhalation pathways, because the groundwater is not used for drinking and well maintenance workers would not be repairing the wells during the spraying of the alfalfa fields. Furthermore, the low levels of chromium in the groundwater are unlikely to pose a health concern via the dermal route.

7. *Are the following health problems related to the past and current activities conducted at the Hinkley site the cancer death of one of the workers who built the stacks; a young man with an extra sixth lumbar vertebrae with nerve compression and a cervical rib in the neck; a young man with kidney failure; an elderly man who died of kidney failure; gastric ulcers?*

It would be difficult to determine if the cancer deaths and the kidney maladies are the result of exposure to chromium. All may be unrelated to past and current activities at the Hinkley site. As for the young man with an extra sixth lumbar vertebrae and a cervical rib in the neck, this is most likely a congenital condition, since there appears to be no apparent exposure of the parents of the young man (i.e., the family's domestic well was not impacted by the chromium-contaminated groundwater.)

CONCLUSIONS

After reviewing available information, the California Department of Health Services (CDHS) and the Agency for Toxic Substances and Disease Registry (ATSDR) conclude that, in the past, the Hinkley site posed a public health hazard. According to available information, the Hinkley site poses an indeterminate current and future public health hazard to PG&E workers and nearby residents, although risk to health appears highly unlikely. Additional ambient air data from the Land Treatment Fields will enable CDHS to better evaluate the health impact of the Hinkley site and to make a more definitive assessment of current and future risk.

CDHS determined that in the past there were two completed exposure pathways for hexavalent chromium.

The first completed exposure pathway was through the ingestion of groundwater. Prior to 1987, residents who lived over the chromium-contaminated groundwater plume were exposed to levels of chromium above EPA's drinking water standards. CDHS estimated both non-cancer and cancer doses from these past exposures. Although the estimated non-cancer ingestion doses for both children and adults exceeded the health guidance level, CDHS does not expect non-cancer health effects to occur, because these doses are 40 to 90 times smaller than the NOAEL (no observable adverse effect level). CDHS estimated a moderate increased cancer risk from the ingestion of hexavalent chromium in groundwater.

The second completed exposure pathway was through inhalation of ambient air. After reviewing limited ambient air data collected in 1988 during Site Characterization Field Activities (on the PG&E site) and at the former Mojave Dairy Irrigation Operation, CDHS does not expect non-cancer health effects in workers and nearby residents from ambient air levels of hexavalent chromium measured at these sites. CDHS estimated no increased cancer risk to workers or residents from hexavalent chromium in ambient air during Site Characterization Field Activities.

CDHS estimated a very low increased cancer risk to former Mojave Dairy workers and nearby residents from inhalation of hexavalent chromium. This may, in fact, be an overestimation of actual cancer risk from this source because of limited exposures.

CDHS also identified five potential past exposure pathways.

The first is a potential past exposure pathway to residents living in the vicinity of the Hinkley site from 1952 to 1966. Residents may have been exposed to ambient air levels of hexavalent chromium that "drifted" off the Hinkley site from the cooling tower. However, because there is no past ambient air monitoring data, it is not possible to evaluate the inhalation exposure pathway.

In addition, CDHS identified four potential past exposure pathways—soil, waste-water, ambient air, and groundwater—that may have impacted PG&E employees at the Hinkley site and at the Land Treatment Fields (Table 9). However, because of a lack of knowledge about past activities at these sites, it is not possible to evaluate the toxicological implications of past worker exposures.

CDHS eliminated three current exposure pathways—groundwater (i.e. private wells), soil, and dairy cow products (i.e., milk, meat, and organs). These exposure pathways were eliminated from further review because the level of chromium detected was below health comparison values or within background levels. After reviewing limited ambient air data collected and analyzed for total chromium at the Land Treatment Fields, CDHS has concluded that the level of total chromium at the site was within background levels for ambient air. As hexavalent chromium was not measured in these analyses, CDHS could not estimate the potential health risk. In order to estimate the health risk from hexavalent chromium, it would be necessary to conduct additional ambient air sampling at the Land Treatment Fields and to analyze samples for hexavalent chromium.

Three sources of health outcome data were reviewed. In 1987 and 1988, 20 Hinkley residents who were exposed to chromium-contaminated well water received medical evaluations at the site. Although the findings did not suggest that these exposures resulted in health effects associated with hexavalent chromium, the evaluations were limited in scope. A February, 2000 epidemiological study of mortality among PG&E gas generator workers shows no increased mortality from cancer or other causes. However, because this study does not adequately represent the exposures of PG&E Hinkley workers, its applicability to the Hinkley site is limited. Finally, a Community Cancer Assessment performed by the California Cancer Registry provides information on cancer incidence in Hinkley during the years 1988-1993. The report concludes that the number of new cancer cases observed in Hinkley does not differ significantly from the number of cases that would be expected for a community of this population size and characteristics.

PUBLIC HEALTH RECOMMENDATIONS AND ACTIONS

A. ACTIONS COMPLETED

1. In the fall of 1992, PG&E began the groundwater remediation program and on-going groundwater monitoring program. The purpose of the remediation program was to extract the highest level of chromium in the groundwater and prevent the northward migration of the chromium-contaminated groundwater plume.

2. In the fall of 1992/93, PG&E's contractors excavated on-site soil that exceeded 500 mg/kg of chromium (viz., Areas A and C).

3. At the release of the public comment draft, CDHS met with community members to explain the PHA findings.

B. ACTIONS PLANNED

1. CDHS will meet with any interested community member to discuss the content of the Public Health Assessment and the implications for public health.

C. RECOMMENDATIONS FOR FURTHER ACTIONS

1. CDHS has requested the California Air Resources Board (CARB) to conduct additional ambient air monitoring at the Land Treatment Fields. In response to this request, CARB asked CDHS for more detailed information to guide further sampling. This information has since been provided by CDHS.

2. CDHS has requested that the California Regional Water Quality Control Board (RWQCB), Lahontan Region, collect groundwater samples from private domestic wells located along of the perimeter of the contaminated groundwater plume and analyze them for total chromium In response to this request, the RWQCB has asked CDHS to identify the wells to be sampled. This information has since been provided by CDHS.

Certification

This Public Health Assessment was prepared by the California Department of Health Services (CDHS) 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.

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

for RG

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APPENDIX A - GLOSSARY OF HEALTH COMPARISON VALUES

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.

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 health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

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.

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's 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. EPA has developed cancer slope 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 by use of 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 likelihood, or chance, of getting cancer. We say "excess cancer risk" because we have a "background risk" of about one-in-four chances of getting cancer. In other words, in a million people, it is expected that 250,000 individuals would get cancer from a variety of causes. 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 exposed to a carcinogen at a certain level over their lifetimes, then one cancer above the background chance, or the 250,001st cancer, may appear in those million persons from that particular exposure. 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. In actuality, the risk is probably somewhat lower than calculated, and, in fact, may be zero.

Cancer Risk Evaluation Guide (CREG)

Carcinogenic chemicals are selected for follow-up by comparing the levels to the CREG (9). CREGs are derived from EPA cancer slope factors. Cancer slope factors give an indication of the relative carcinogenic potency of a particular chemical. CREG values represent media concentrations which are thought to be associated with an extra lifetime cancer risk of one-in-a-million.

CERCLA

See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

Chronic Exposure

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

Completed Exposure Pathway

See Exposure Pathway.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA was put into place in 1980. It is also known as Superfund. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. ATSDR was created by this act and is responsible for looking into the health issues related to hazardous waste sites.

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.

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".

Duration

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

Environmental Contaminant

A substance (chemical) that gets into a system (person, animal, or the 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.

Environmental Media Evaluation Guide (EMEG)

EMEGs are media-specific values developed by ATSDR to serve as an aid in selecting environmental contaminants that need to be further evaluated for potential health impacts (9). EMEGs are based on non-carcinogenic end-points and do not consider carcinogenic effects. EMEGs are based on the MRLs.

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 5 parts:
Source of Contamination,
Environmental Media and Transport Mechanism,
Point of Exposure,
Route of Exposure, and
Receptor Population.

When all 5 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, twice a month.

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 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. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.

Maximum Contaminant Level (MCL)

The EPA and the CDHS have issued drinking water standards, or MCLs, for contaminants in drinking water (24). The MCLs are set according to known or anticipated adverse human health effects (which also account for sensitive subgroups, such as children, pregnant women, the elderly, etc.), the ability of various technologies to remove the contaminant, their effectiveness, and cost of treatment (24). The MCLs can change as new technologies are developed and as new scientific knowledge are attained. For cancer risk, the MCLs are set at levels that will limit an individual risk of cancer from a contaminant to between 1 in 10,000 (low increased excess risk) to 1 in 1,000,000 (no apparent increased excess risk) over a lifetime (24). As for non-cancer effects, the MCLs are set at levels below which no adverse health effects are expected to occur.

For total chromium, the EPA has adopted an MCL of 100 ppb in 1991 for chromium as a total of two species: trivalent chromium and hexavalent chromium (34). The CDHS adopted the MCL of 50 ppb, based on OEHHA's risk assessment of 1994 (34). The MCL was intended to protect primarily from the hexavalent chromium species (34).

Non-Cancer Evaluation = ATSDR's Minimal Risk Level (MRL) and EPA's Reference Dose (RfD) and Reference Concentration (RfC)

The MRL, RfD and RfC are estimates of daily exposure to the human population (including sensitive subgroups), below which non-cancer adverse health effects are unlikely to occur. The MRL , RfD and RfC consider only non-cancer effects. Because they are based only on information currently available, some uncertainty is always associated with the MRL , RfD. and RfC. "Safety" factors are used to account for the uncertainty in our knowledge about their danger. The greater the uncertainty, the greater the "safety" factor and the lower the MRL, RfD, or RfC.

When there is adequate information from animal or human studies, MRLs and RfDs are developed for the ingestion exposure pathway, whereas RfCs are developed for the inhalation exposure pathway. An MRL, RfD or RfC is an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse (non-carcinogenic) health effects over a specified duration of exposure. No toxicity values exist for exposure by skin contact. Separate non-cancer 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 one year). EPA develops RfDs and RfCs for acute exposures (less than 14 days), subchronic exposures (from two weeks to seven years), and chronic exposures (greater than seven years). Both the MRL and RfD for ingestion are expressed in units of milligrams of contaminant per kilograms body weight per day (mg/kg/day). The RfC for inhalation is expressed in units of mg/m^3 .

Non-Cancer and Cancer Evaluations = EPA's Preliminary Remediation Goals (PRGs)

PRGs are developed by the EPA to estimate contaminant concentrations in the environmental media (soil, air, and water), both in residential and industrial settings, that are protective of humans, including sensitive groups, over a lifetime (6). PRGs were developed for both industrial and residential settings because of the different exposure parameters, such as, different exposure time frames (e.g., industrial setting: workers are exposed for 8 hours/day and 5 days/week vs. residential setting: families are exposed 24 hours/day and 7 days/week); and different "human" exposure points (e.g., industrial setting: healthy adult males vs. residential setting: males, females, young children, and infants), etc. Media concentrations less than the PRGs are unlikely to pose a health threat, whereas levels exceeding a PRG do not automatically determine that a health threat exists, but suggest that further evaluation is necessary.

NPL

The National Priorities List. (Part of Superfund.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious, uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

NOAEL

No Observed Adverse Effect Level. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

No Apparent Public Health Hazard

The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring, but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard

The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

Permissible Exposure Limits (PEL)

PELs are established by the California Occupational Safety and Health Administration (CAL/OSHA) to ensure worker safety from exposure to potentially hazardous chemicals in occupational and industrial settings. PELs are enforceable legal limits that must not be exceed during any 8-hour work shift of a 40-hour work week (9). The PELs were set to ensure worker

safety (i.e., healthy males) and may not be protective of sensitive groups, such as pregnant women, children, the elderly, etc

PHA

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

PHG

Public Health Goal. PHGs are developed for chemical contaminants based on the best available toxicological data in the scientific literature (29). PHGs are set such that levels of contaminants in drinking water would pose no significant health risk to individuals consuming the water on a daily basis over a lifetime (29). The California Safe Drinking Water Act of 1996 (amended Health and Safety Code, Section 116365) requires the Office of Environmental Health Hazard Assessment (OEHHA) to perform risk assessments and adopt PHS for contaminants in drinking water based exclusively on public health considerations (29). PHGs adopted by OEHHA are for use by the CDHS in establishing primary drinking water standards (State MCLs) [29]. Whereas PHGs are to be based solely on scientific and public health considerations without regard to economic cost considerations, drinking water standards adopted by CDHS are to consider economic factors and technical feasibility (29). PHGs established by OEHHA are not regulatory in nature and represent only non-mandatory goals (29).

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 or 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). Examples: 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.

Public Health Assessment(s)

See PHA.

Public Health Hazard

The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Receptor Population

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

Reference Dose based Media Evaluation Guide (RMEG)

RMEGs are equivalent to EMEGs, but are derived from USEPA RfDs instead of ATSDR's MRLs (9).

Route of Exposure

The way a chemical can get into a person's body. There are three exposure routes:

- breathing (also called inhalation),
- eating or drinking (also called ingestion), and
- getting something on the skin (also called dermal contact).

Safety Factor

Also called Uncertainty Factor. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety 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 landfill, a pond, a creek, an incinerator, a tank, or a drum. Contaminant source is the first part of an Exposure Pathway.

Special Populations

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

Superfund Site
See **NPL**.

Toxic

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

Toxicology

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

Uncertainty Factor

See Safety Factor.

Urgent Public Health Hazard

This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.

APPENDIX B - TABLES

Table 1: On-Site Subsurface Soil Samples Collected (depths less than or equal to 1 foot) and Analyzed for Hexavalent Chromium and Total Chromium from the Land Treatment Fields (i.e., irrigated alfalfa fields) and the Hinkley site during the Environmental Sampling Investigation Conducted in 1988 [2]

	Sample ID Number	Cr (VI) (mg/kg)	Cr (T) (mg/kg)
PG8802-02	Land Treatment Field (north of the Hinkley site)	0.16	514
PG8802-03	Land Treatment Field (north of the Hinkley site)	ND	2.74
PG8802-04	North of the Hinkley Site and the Land Treatment Field	ND	9.12
PG8802-06	North of the Hinkley Site and the Land Treatment Field	ND	5.53
PG880316-01	North of the Hinkley Site and the Land Treatment Field	ND	53.7
PG880316-02	North of the Hinkley Site and the Land Treatment Field	ND	13
PG880316-03	North of the Hinkley Site and the Land Treatment Field	ND	7.93
PG880317-01	North of the Hinkley Site and the Land Treatment Field	ND	34.3
PG880317-02	North of the Hinkley Site and the Land Treatment Field	ND	11.1
PG880317-20	Land Treatment Field (north of Highway 58)	ND	8.12
PG880317-21	Land Treatment Field (north of Highway 58)	ND	2.48
SF001	Former Mojave Dairy (north of the Hinkley site)	ND	37.2
SF002	Former Mojave Dairy (north of the Hinkley site)	ND	18.9
SF003	Former Mojave Dairy (north of the Hinkley site)	ND	43
SF004	Former Mojave Dairy (north of the Hinkley site)	ND	29.5
SF005	Former Mojave Dairy (north of the Hinkley site)	ND	81.6

Table 1 (continue): On-Site Subsurface Soil Samples Collected (depths less than or equal to 1 foot) and Analyzed for Hexavalent Chromium and Total Chromium from the Land Treatment Fields (i.e., irrigated alfalfa fields) and the Hinkley site during the Environmental Sampling Investigation Conducted in 1988 [2]

	Sample ID Number	Cr (VI) (mg/kg)	Cr (T) (mg/kg)
SF006	Former Mojave Dairy (north of the Hinkley site)	ND	63.7
SF007	Former Mojave Dairy (north of the Hinkley site)	ND	42.7
SF008	Former Mojave Dairy (north of the Hinkley site)	ND	46.5

- ND = Non Detect
- Detection limits: for the samples identified with a PG prefix = 0.05 mg/kg for Cr (VI); and for the SF prefix = 0.5 mg/kg for Cr(VI).
- Currently, PG&E owns all the properties in which the soil samples were collected.

Table 2: Results of the Lysimeter Sampling at the Land Treatment Field North of the Hinkley Site Conducted from 1994 to 1997 [4]

Sample ID	Cr(VI) (mg/l)	RMEG for child (mg/l)	Cr(T) (mg/l)	MCL for Cr(T) (mg/l)
LS-3T	ND - 0.039	0.05	ND - 0.01	0.10
LS-6C	ND - 0.015	0.05	ND - 0.02	0.10
LS-9C	ND - 0.013	0.05	ND - 0.07	0.10
LW-6T	ND	0.05	ND - 0.01	0.10
LW-9T	ND	0.05	ND - 0.04	0.10
The detection limit for Cr(VI) ranged from 0.005 mg/l to 0.01 mg/l; and for Cr(T), it was 0.01 mg/l.				

Table 3: Results of the Soil Sampling at the Land Treatment Field North of the Hinkley Site Conducted between 1994 to 1997 [4]

SAMPLE ID	QUADRANT AT SITE	DATE OF SAMPLING	SAMPLING DEPTH (feet)	pH (pH unit)	TOTAL IRON (mg/kg)	NITRATE as NO3 (mg/kg)	TOC (mg/kg)	TOTAL CHROMIUM (mg/kg)	HEXAVALENT CHROMIUM (mg/kg)	LAB
HLTA 1-0.5	SE	07/01/94	0.5	7.42	5,660	22	20	14	ND<0.025	APCL
HLTA 1-3	SE	07/01/94	3	7.65	11,300	ND<0.5	29	8	ND<0.025	APCL
HLTA 1-6	SE	07/01/94	6	8.60	17,400	21	7	13	ND<0.025	APCL
HLTA 1-9	SE	07/01/94	9	8.68	8,480	ND<0.5	11	11	ND<0.025	APCL
HLTA 2-0.5	SE	07/01/94	0.5	8.22	8,300	23	42	11	ND<0.025	APCL
HLTA 2-3	SE	07/01/94	3	9.24	19,700	23	26	24	ND<0.025	APCL
HLTA 2-6	SE	07/01/94	6	9.02	4,380	20	7	12	ND<0.025	APCL
HLTA 2-9	SE	07/01/94	9	9.09	5,730	21	7	16	ND<0.025	APCL
NE-.5	NE	10/04/95	0.5	8.33	7,350	2.5	980	12	ND<0.05	APCL
NE-3	NE	10/04/95	3	8.77	5,000	ND<2.5	1100	7	ND<0.05	APCL
NE-6	NE	10/04/95	6	8.92	3,030	2.5	420	3	ND<0.05	APCL
NE-9	NE	10/04/95	9	8.65	4,430	ND<2.5	300	5	ND<0.05	APCL
SW-.5	SW	10/04/95	0.5	8.66	9,320	2.9	1900	11	ND<0.05	APCL
SW-3	SW	10/04/95	3	8.91	15,900	ND<2.5	820	14	ND<0.05	APCL
SW-6	SW	10/04/95	6	8.93	2,690	ND<2.5	260	2	ND<0.05	APCL
SW-9	SW	10/04/95	9	9.07	4,280	ND<2.5	510	4	ND<0.05	APCL
SOUTH-.5	SW	04/04/96	0.5	8.10	4,260	3.4	1400	9	ND<0.05	APCL
SOUTH-3	SW	04/04/96	3	8.16	11,900	3.0	250	9	ND<0.05	APCL
SOUTH-6	SW	04/04/96	6	8.36	12,000	2.6	200	9	ND<0.05	APCL
SOUTH-9	SW	04/04/96	9	8.68	5,870	3.5	240	4	ND<0.05	APCL
EAST-.5	NE	04/04/96	0.5	8.09	4,580	4.3	840	6	ND<0.05	APCL
EAST-3	NE	04/04/96	3	8.34	2,550	4.0	280	2	ND<0.05	APCL
EAST-6	NE	04/04/96	6	8.54	1,690	3.3	ND<100	1	ND<0.05	APCL
EAST-9	NE	04/04/96	9	8.27	1,800	3.5	680	1	ND<0.05	APCL
SS-1-.5	NE	04/11/97	0.5	7.15	10,400	ND<2.7	1600	10.2	ND<0.027	APCL/CL
SS-1-3	NE	04/11/97	3	7.56	13,200	ND<2.7	2400	11.8	ND<0.027	APCL/CL
SS-1-6	NE	04/11/97	6	7.45	5,100	ND<2.7	710	3.2	ND<0.027	APCL/CL
SS-1-9	NE	04/11/97	9	7.32	8,070	ND<2.7	570	5.0	ND<0.027	APCL/CL
SS-2-.5	SW	04/11/97	0.5	7.46	9,910	ND<2.7	4800	13.4	ND<0.027	APCL/CL
SS-2-3	SW	04/11/97	3	7.08	16,700	ND<2.7	2300	18.5	ND<0.027	APCL/CL
SS-2-6	SW	04/11/97	6	7.07	12,500	ND<2.7	2100	7.7	ND<0.027	APCL/CL
SS-2-9	SW	04/11/97	9	6.67	13,200	ND<2.7	300	6.6	ND<0.027	APCL/CL

ABBREVIATIONS:

TOC	Total organic carbon	SW	Sample collected in southwest quadrant
mg/kg	Milligrams per kilogram	ND	Not reported above method detection limit
SE	Sample collected in southeast quadrant	APCL	Applied P & Ch Laboratory
NE	Sample collected in northeast quadrant	CL	Core Laboratories
NA	Data not available		

Table 4: Off-Site Subsurface Soil Samples Collected and Analyzed for Hexavalent Chromium and Total Chromium during the Environmental Sampling Investigation Conducted in 1988 [2]

Sample ID Number	Depths	Location	Cr (VI) (mg/kg)	ATSDR's RMEG Cr(VI) (pica child) (mg/kg)	CAL-EPA's modified PRG for Cr(VI) (mg/kg)	Cr (T) (mg/kg)	USEPA's PRG for Cr (T) (mg/kg)
PG880316-08	less than or equal to 1 foot	approximately 0.5 miles north of the Hinkley site	ND	10	0.20	6.41	210
PG880316-09	less than or equal to 1 foot	approximately 0.5 miles north of the Hinkley site	ND	10	0.20	5.58	210
PG880316-10	less than or equal to 1 foot	approximately 0.5 miles north of the Hinkley site	ND	10	0.20	2.33	210
PG880317-22	less than or equal to 1 foot	approximately 2.25 miles east of the Hinkley site	ND	10	0.20	1.57	210
PG880317-17A	less than or equal to 1 foot	approximately 0.9 miles north of the Hinkley site	ND	10	0.20	1.95	210
PG880317-17B	less than or equal to 1 foot	approximately 0.9 miles north of the Hinkley site	ND	10	0.20	4.97	210

ND = Non Detect
Detection limits: for the samples identified with a PG prefix = 0.05 mg/kg for Cr (VI); and for the SF prefix = 0.5 mg/kg for Cr (VI).

Table 5: Results of the Alfalfa Leaf Sampling Conducted 1988 [3]

Sample Location	Tissue Sampled	Cr(T) (mg/kg)
Former Mojave Dairy[1]	leaf	1.5 - 12.7
Former Mojave Dairy[1]	root	3.10 - 8.30
Background	leaf	0.8 & 0.9
Background	root	1.6 & 1.7
East of Hinkley site	leaf	0.19 - 0.64
2 miles east of the Hinkley site	leaf	0.9 & 2.48
Dairy North of Hwy 58	leaf	1.09
1 = The Mojave Dairy was purchased by PG&E and is no longer in operations.		

Table 6: Results of the Alfalfa Leaf Sampling Conducted 1994 to 1997 [4]

Quadrant of the Land Treatment Field where the Alfalfa Leaf Sample was Collected	[1]Wet Weight Concentration of Cr(VI) (mg/kg)	[2]Dry Weight Concentration of Cr(VI) (mg/kg)	[3]Wet Weight Concentration of Cr(T) (mg/kg)	[4]Dry Weight Concentration of Cr(T) (mg/kg)
Northeast	ND	ND	ND	ND - 2.2
Southeast	ND - 0.06	ND	ND - 1	ND - 4.2
Southwest	ND	ND	ND - 2	ND - 6.7
Northwest	ND	ND	ND - 0.91	ND - 2.9

1 = The detection limit ranged from 0.025 to 0.027 mg/kg.
2 & 3 = The detection limit ranged from 0.10 to 1.0 mg/kg.
4 = The detection limit ranged from 1.2 to 5.0 mg/kg.

Table 7: Groundwater Sampling Results (Total Chromium) Collected from Private Domestic Groundwater Wells Located in the Vicinity of the Hinkley site [13]

Well Number	Date	Total Chromium (mg/l)	Source of Data
01-02	Sep-89	<0.01	PG&E, 1994a
01-02	Dec-89	<0.01	PG&E, 1994a
01-02	Mar-90	<0.01	PG&E, 1994a
01-02	Jun-90	<0.01	PG&E, 1994a
01-02	Sep-90	<0.01	PG&E, 1994a
01-02	Dec-90	<0.01	PG&E, 1994a
01-02	Mar-91	<0.01	PG&E, 1994a
01-02	Jun-91	<0.01	PG&E, 1994a
01-02	Sep-91	<0.01	PG&E, 1994a
01-02	Dec-91	<0.01	PG&E, 1994a
01-02	Mar-92	<0.01	PG&E, 1994a
01-02	Jun-92	<0.01	PG&E, 1994a
01-02	Sep-92	<0.01	PG&E, 1994a
01-02	Dec-92	<0.01	PG&E, 1994a
01-02	Mar-93	<0.01	PG&E, 1994a
01-02	Jun-93	<0.01	PG&E, 1994a
01-02	Sep-93	<0.01	PG&E, 1994a
01-02	Nov-93	<0.01	PG&E, 1994a
01-02	Feb-94	<0.01	Alisto, 1998
01-02	Jun-94	<0.01	Alisto, 1998
01-02	Aug-94	<0.01	Alisto, 1998
01-02	Oct-94	<0.01	Alisto, 1998
01-02 D	Oct-94	<0.01	Alisto, 1998
01-02	Feb-95	<0.01	Alisto, 1998
01-02	Apr-95	<0.01	Alisto, 1998
01-02	Aug-95	<0.01	Alisto, 1998
01-02	Oct-95	<0.01	Alisto, 1998
01-02	Feb-96	<0.01	Alisto, 1998
01-02	Apr-96	<0.01	Alisto, 1998
01-02	Jul-96	<0.01	Alisto, 1998
01-02	Oct-96	<0.01	Alisto, 1998
01-02	Feb-97	<0.01	Alisto, 1998
01-02	Apr-97	<0.01	Alisto, 1998
01-02	Jul-97	<0.01	Alisto, 1998
01-02	Oct-97	<0.01	Alisto, 1998
01-02	Mar-98	—	Alisto, 2000
01-02	May-98	—	Alisto, 2000
01-02	Aug-98	—	Alisto, 2000
01-02	Nov-98	<0.01	Alisto, 2000
01-02	Feb-99	—	Alisto, 2000
01-02	May-99	—	Alisto, 2000
01-02	Aug-99	—	Alisto, 2000
01-02	Nov-99	<0.01	Alisto, 2000
02-01			no data
02-05	Mar-93	<0.01	PG&E, 1994a (1)
02-05	Feb-95	<0.01	PG&E, 1995
02-05	Jul-96	<0.01	Alisto, 1998 (2)
02-05	Oct-96	<0.01	Alisto, 1998
02-05	Feb-97	<0.01	Alisto, 1998
02-05	Apr-97	<0.01	Alisto, 1998
02-05	Jul-97	<0.01	Alisto, 1998
02-05	Oct-97	<0.01	Alisto, 1998
02-05	Mar-98	<0.01	Alisto, 2000
02-05	May-98	<0.01	Alisto, 2000
02-05	Aug-98	<0.01	Alisto, 2000
02-05	Nov-98	<0.01	Alisto, 2000
02-05	Feb-99	<0.01	Alisto, 2000
02-05	May-99	<0.01	Alisto, 2000
02-05	Aug-99	<0.01	Alisto, 2000
02-05	Nov-99	<0.01	Alisto, 2000
02-06			no data
02-07			no data
02-08			no data
02-09			no data
02-13	Jun-93	<0.01	PG&E, 1994a
02-15			no data
?			well with no #
?			well with no #
26-02	Mar-91	0.05	PG&E, 1994a
26-02	Jun-91	0.02	PG&E, 1994a
26-02	Sep-91	0.02	PG&E, 1994a
26-02	Dec-91	<0.01	PG&E, 1994a
26-02	Aug-94	<0.01	Alisto, 1998
26-02	Feb-95	<0.01	Alisto, 1998
26-02	Feb-95	<0.01	Alisto, 1998
26-02	Apr-95	<0.01	Alisto, 1998
26-02	Aug-95	<0.01	Alisto, 1998
26-02	Oct-95	<0.01	Alisto, 1998

Table 7 (continue): Groundwater Sampling Results (Total Chromium) Collected from Private Domestic Groundwater Wells Located in the Vicinity of the Hinkley site [13]

26-02	Feb-96	<0.01	Alisto, 1998
26-02	Apr-96	<0.01	Alisto, 1998
26-02	Jul-96	<0.01	Alisto, 1998
26-02	Oct-96	<0.01	Alisto, 1998
26-02	Feb-97	<0.01	Alisto, 1998
26-02	Apr-97	<0.01	Alisto, 1998
26-02	Jul-97	<0.01	Alisto, 1998
26-02	Oct-97	<0.01	Alisto, 1998
26-02	Mar-98	<0.01	Alisto, 2000
26-02	May-98	<0.01	Alisto, 2000
26-02	Aug-98	<0.01	Alisto, 2000
26-02	Nov-98	—	Alisto, 2000
26-02	Feb-99	<0.01	Alisto, 2000
26-02	May-99	<0.01	Alisto, 2000
26-02	Aug-99	—	Alisto, 2000
26-02	Nov-99	—	Alisto, 2000
26-04	Jun-89	0.01	PG&E, 1994a
26-04	Sep-89	<0.01	PG&E, 1994a
26-04	Dec-89	<0.01	PG&E, 1994a
26-04	Mar-90	<0.01	PG&E, 1994a
26-04	Jun-90	<0.01	PG&E, 1994a
26-04	Sep-90	<0.01	PG&E, 1994a
26-04	Dec-90	<0.01	PG&E, 1994a
26-04	Mar-91	<0.01	PG&E, 1994a
26-04	Jun-91	<0.01	PG&E, 1994a
26-04	Sep-91	<0.01	PG&E, 1994a
26-04	Dec-91	<0.01	PG&E, 1994a
26-04 D	Dec-91	<0.01	PG&E, 1994a
26-04	Mar-92	<0.01	PG&E, 1994a
26-04	Jun-92	<0.01	PG&E, 1994a
26-04	Sep-92	<0.01	PG&E, 1994a
26-04	Dec-92	<0.01	PG&E, 1994a
26-04	Mar-93	<0.01	PG&E, 1994a
26-04	Jun-93	<0.01	PG&E, 1994a
26-04	Sep-93	<0.01	PG&E, 1994a
26-04	Nov-93	<0.01	PG&E, 1994a
26-04	Oct-94	<0.01	Alisto, 1998
26-04	Mar-98	—	Alisto, 2000
26-04	May-98	—	Alisto, 2000
26-04	Aug-98	—	Alisto, 2000
26-04	Nov-98	—	Alisto, 2000
26-04	Feb-99	—	Alisto, 2000
26-04	May-99	<0.01	Alisto, 2000
26-04	Aug-99	—	Alisto, 2000
26-04	Nov-99	—	Alisto, 2000
26-06			no data
26-12	Sep-93	<0.01	PG&E, 1993
26-18	Feb-94	0.01	PG&E, 1994b
26-19	Jun-94	<0.01	PG&E, 1994c
26-37	Mar-93	0.01	PG&E, 1994a
26-37	May-94	0.02	Alisto, 1998
26-37	Aug-94	0.03	Alisto, 1998
26-37	Oct-94	0.02	Alisto, 1998
26-37	Feb-95	<0.01	Alisto, 1998 (4)
26-37	Apr-95	0.02	Alisto, 1998
26-37	Aug-95	<0.01	Alisto, 1998
26-37	Oct-95	0.02	Alisto, 1998
26-37	Feb-96	<0.01	Alisto, 1998
26-37	Apr-96	<0.01	Alisto, 1998
26-37	Jul-96	0.02	Alisto, 1998
26-54	Jun-94	<0.01	PG&E, 1994d
27-12	Mar-92	<0.01	PG&E, 1994a
27-12	Mar-93	<0.01	PG&E, 1994a
35-03			no data
35-04	Aug-97	<0.01	Alisto, 1998
36-03	Jun-89	0.01	PG&E, 1994a
36-03	Sep-89	<0.01	PG&E, 1994a
36-03	Dec-89	0.02	PG&E, 1994a
36-03	Mar-90	<0.01	PG&E, 1994a
36-03	Jun-90	<0.01	PG&E, 1994a
36-03	Sep-90	<0.01	PG&E, 1994a
36-03	Dec-90	<0.01	PG&E, 1994a
36-03	Mar-91	<0.01	PG&E, 1994a
36-03	Jun-91	<0.01	PG&E, 1994a
36-03	Sep-91	0.01	PG&E, 1994a
36-03	Dec-91	<0.01	PG&E, 1994a
36-03	Mar-92	<0.01	PG&E, 1994a
36-03	Jun-92	0.02	PG&E, 1994a
36-03	Sep-92	<0.01	PG&E, 1994a
36-03	Dec-92	<0.01	PG&E, 1994a
36-03	Jun-93	<0.01	PG&E, 1994a

Table 7 (continue): Groundwater Sampling Results (Total Chromium) Collected from Private Domestic Groundwater Wells Located in the Vicinity of the Hinkley site [13]

36-03	Sep-93	<0.01	PG&E, 1994a
36-03	Nov-93	<0.01	PG&E, 1994a
36-03	Feb-94	<0.01	Alisto, 1998
36-03	May-94	<0.01	Alisto, 1998 (5)
36-03 D	May-94	<0.01	Alisto, 1998
36-03	Aug-94	<0.01	Alisto, 1998
36-03	Oct-94	<0.01	Alisto, 1998
36-03	Feb-95	<0.01	Alisto, 1998 (6)
36-03	Apr-95	<0.01	Alisto, 1998 (7)
36-03	Aug-95	<0.01	Alisto, 1998
36-03	Oct-95	<0.01	Alisto, 1998
36-03 D	Oct-95	<0.01	Alisto, 1998
36-03	Feb-96	<0.01	Alisto, 1998
36-03	Apr-96	<0.01	Alisto, 1998
36-03 D	Apr-96	<0.01	Alisto, 1998
36-03	Jul-96	<0.01	PG&E, 1996a
36-03	Jul-96	<0.01	Alisto, 1998
36-03	Oct-96	<0.01	Alisto, 1998
36-03	Feb-97	<0.01	Alisto, 1998
36-03	Apr-97	<0.01	Alisto, 1998
36-03	Jul-97	<0.01	Alisto, 1998
36-03	Mar-98	—	Alisto, 2000
36-03	May-98	—	Alisto, 2000
36-03	Aug-98	—	Alisto, 2000
36-03	Nov-98	<0.01	Alisto, 2000
36-03	Feb-99	—	Alisto, 2000
36-03	Nov-99	<0.01	Alisto 2000
36-35	Jun-89	<0.01	PG&E, 1994a
36-35	Mar-90	<0.01	PG&E, 1994a
36-35 D	Mar-90	<0.01	PG&E, 1994a
36-35	Jun-90	<0.01	PG&E, 1994a
36-35	Sep-90	<0.01	PG&E, 1994a
36-35	Dec-90	<0.01	PG&E, 1994a
36-35	Mar-91	<0.01	PG&E, 1994a
36-35	Jun-91	<0.01	PG&E, 1994a
36-35	Sep-91	0.01	PG&E, 1994a
36-35	Dec-91	<0.01	PG&E, 1994a
36-35 D	Dec-91	<0.01	PG&E, 1994a
36-35	Mar-92	<0.01	PG&E, 1994a
36-35	Jun-92	<0.01	PG&E, 1994a
36-35	Sep-92	<0.01	PG&E, 1994a
36-35	Dec-92	<0.01	PG&E, 1994a
36-35 D	Dec-92	<0.01	PG&E, 1994a
36-35	Mar-93	<0.01	PG&E, 1994a
36-35	Jun-93	<0.01	PG&E, 1994a
36-35	Sep-93	<0.01	PG&E, 1994a
36-35	Nov-93	<0.01	PG&E, 1994a
36-35	Feb-94	<0.01	Alisto, 1998
36-35	May-94	<0.01	Alisto, 1998 (8)
36-35	Aug-94	<0.01	Alisto, 1998
36-35	Oct-94	<0.01	Alisto, 1998
36-35	Feb-95	<0.01	Alisto, 1998
36-35	Apr-95	<0.01	Alisto, 1998
36-35	Aug-95	<0.01	Alisto, 1998
36-35	Oct-95	<0.01	Alisto, 1998
36-35	Feb-96	<0.01	Alisto, 1998
36-35	Apr-96	<0.01	Alisto, 1998
36-35	Jul-96	<0.01	PG&E, 1996b
36-35	Jul-96	<0.01	Alisto, 1998
36-35 D	Jul-96	<0.01	Alisto, 1998
36-35	Oct-96	<0.01	Alisto, 1998
36-35	Feb-97	<0.01	Alisto, 1998
36-35	Apr-97	<0.01	Alisto, 1998
36-35	Jul-97	<0.01	Alisto, 1998
36-35	Mar-98	—	Alisto, 2000
36-35	May-98	—	Alisto, 2000
36-35	Aug-98	—	Alisto, 2000
36-35	Nov-98	<0.01	Alisto, 2000
36-35	Feb-99	—	Alisto, 2000

Notes:
(1) D -duplicate sample
(2) Result from routine monitoring sent to resident on request via June 8, 1993 correspondence from Glen Riddle (PG&E) to Barbara Whitson 35633 Fairview Road Hinkley, CA 92347.
(3) Result from routine monitoring sent to resident on request via August 7, 1996 correspondence from Glen Riddle (PG&E) to Barbara Whitson 35633 Fairview Road Hinkley, CA 92347.
(4) Result from routine monitoring sent to resident on request via May 5, 1995 correspondence from Glen Riddle (PG&E) to Nancy Kurth 23124 Santa Fe Road Hinkley, CA 92347.
(5) Result from routine monitoring sent to resident on request via July 8, 1994 correspondence from Glen Riddle (PG&E) to Robert Stiles 36401 Summerset Road. This letter erroneously states that sampling was done in June, 1994.
(6) Result from routine monitoring sent to resident on request via May 4, 1995 correspondence from Glen Riddle (PG&E) to Kevin Smith 36401 Summerset Road.
(7) Result from routine monitoring sent to resident on request via May 19, 1995 correspondence from Glen Riddle (PG&E) to Kevin Smith 36401 Summerset Road.
(8) Result from routine monitoring sent to resident on request via July 8, 1994 correspondence from Glen Riddle (PG&E) to Dwane Watrous 36359 Summerset Road. This letter erroneously states that sampling was done in June, 1994.

PG&E, 1994a. Report of Activities PG&E Hinkley Compressor Station Groundwate Remediation Project, 1993 Annual/Semi-Annual Report.
PG&E, 1994b. March 1, 1994 correspondence from Glen Riddle (PG&E) to Linda Parker, 23112 Highway 58 Hinkley, CA 92347.
PG&E, 1994c. July 11, 1994 Correspondence from Glen Riddle (PG&E) to Jim Blackwood, 23146 Highway 58 Hinkley, CA 92347.
PG&E, 1994d. July 11, 1994 correspondence from Glen Riddle (PG&E) to Geno Gallardo, 23058 Highway 58 Hinkley, CA 92347.
PG&E, 1995. March 30, 1995 correspondence from Glen Riddle (PG&E) to Barbar Whitson 35633 Fairview Road Hinkley, CA 92347.
PG&E, 1996a. August 7, 1996 correspondence from Glen Riddle (PG&E) to Kevin Smith. 36401 Summerset Road Hinkley, CA 92347.
PG&E, 1996b. August 7, 1996 correspondence from Glen Riddle (PG&E) to Dwan Watrous 36359 Summerset Road Hinkley, CA 92347.
Alisto, 1998. Semiannual Report Groundwater Remediation Project July 1 to December 31, 1997.
Alisto, 2000. Annual and Semiannual Report Groundwater Remediation Project July 1 to December 31, 1999

Table 8: Elements of Completed Exposure Pathways

Source	Environmental Medium	Contaminant	Point of Exposure	Route of Exposure	Exposed Populations	Time Frame
Hinkley Site	Groundwater	Total Chromium and Hexavalent Chromium	Residents located above the chromium contaminated groundwater plume	Skin absorption, ingestion, inhalation	Residents	Past
Hinkley Site	Groundwater	Hexavalent Chromium	Residents located near the chromium contaminated groundwater plume	Skin absorption, ingestion, inhalation	Residents	Current

Table 9: Elements of Potential Exposure Pathways

Source	Environmental Medium	Contaminant	Point of Exposure	Route of Exposure	Exposed Populations	Time Frame
Hinkley Site	Ambient air	Total Chromium	Residents in the vicinity of the Hinkley site	Skin absorption, incidental ingestion, inhalation	Residents	Past
Hinkley Site	Soil, Waste Water, Ambient Air, & Groundwater	Total Chromium	Workers on-site at the former evaporation & percolation ponds and the cooling tower; off-site at the Land Treatment Field (north of the Hinkley site); and/or Mojave Dairy	Skin absorption, incidental ingestion, inhalation	PG&E workers; Mojave Dairy workers; and/or near-by residents	Past
Hinkley Site	Ambient air	Total Chromium	Site Characterization Field Activities & Mojave Dairy Irrigation Operations	Skin absorption, incidental ingestion, inhalation	PG&E workers, Mojave Dairy workers, & near-by residents	Past
Hinkley Site	Ambient air	Total Chromium	Land Treatment Fields	Skin absorption, incidental ingestion, inhalation	PG&E workers & near-by residents	Current and Future

Table 10: Elements of Eliminated Exposure Pathways

Source	Environmental Medium	Point of Exposure	Route of Exposure	Exposed Populations	Time Frame
Hinkley Site	Soil	Residents living in the vicinity of the Hinkley site	Skin absorption, incidental ingestion, inhalation	Residents	Current and future
Hinkley Site	Soil	Off-site Land Treatment Fields (north of the Hinkley site & north of Hwy 58)	Skin absorption, incidental ingestion, inhalation	PG&E Workers	Current and future
Hinkley Site	Groundwater	Residents in the vicinity of the Hinkley site	Skin absorption, ingestion, and inhalation	Residents	Current and future
Hinkley Site	Groundwater	Residents and PG&E employees that used the on-site swimming pool	Skin absorption, ingestion, and inhalation	Residents and PG&E employees	Past, current, and future
Hinkley Site	Ambient air	PG&E employees in the vicinity of the cooling towers and Residents living in the vicinity of the Hinkley site	Skin absorption, incidental ingestion, inhalation	PG&E workers and nearby residents	Past (post-1966), current, and future
Hinkley Site	Milk, meat, and/or organs from dairy cows	Consumers who may have consumed meat, milk, and/or milk from dairy cows fed alfalfa irrigated with chromium contaminated groundwater	Ingestion	Consumers	Past, current, and future

Table 11: Cancer Risks via the Ingestion and Inhalation Exposure Pathways

	Quantitative Cancer Risk Estimate[a]	Qualitative Cancer Risk Estimate[a]
Site Characterization Field Activities - Inhalation of Hexavalent Chromium in the Ambient Air	3.3×10^{-8}	no apparent increased risk
Mojave Dairy Irrigation Operations - Inhalation of Hexavalent Chromium in the Ambient Air	2.9×10^{-5}	very low increased risk
Residents Who Lived Above the Chromium Contaminated Groundwater Plume (pre-1988) - Ingestion of Hexavalent Chromium in the Groundwater	2.6×10^{-3}	moderate increased risk
Residents Who Lived Above the Chromium Contaminated Groundwater Plume (post-1988) - Ingestion of Hexavalent Chromium in the Groundwater	5.2×10^{-5}	very low increased risk
a = Cancer risks via the inhalation and ingestion pathways may be an over-estimation. For an in-depth explanation, please refer to the section under "Toxicology and Chemistry of Chromium".		

Table 11: Cancer Risks via the Ingestion and Inhalation Exposure Pathways

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Residents Who Lived Above the Chromium Contaminated Groundwater Plume (post-1988) - Ingestion of Hexavalent Chromium in the Groundwater	5.2×10^{-5}	very low increased risk
a = Cancer risks via the inhalation and ingestion pathways may be an over-estimation. For an in-depth explanation, please refer to the section under "Toxicology and Chemistry of Chromium".		

APPENDIX C - FIGURES

Figure 1: Location of Pacific Gas and Electric Hinkley Compressor Station [1]

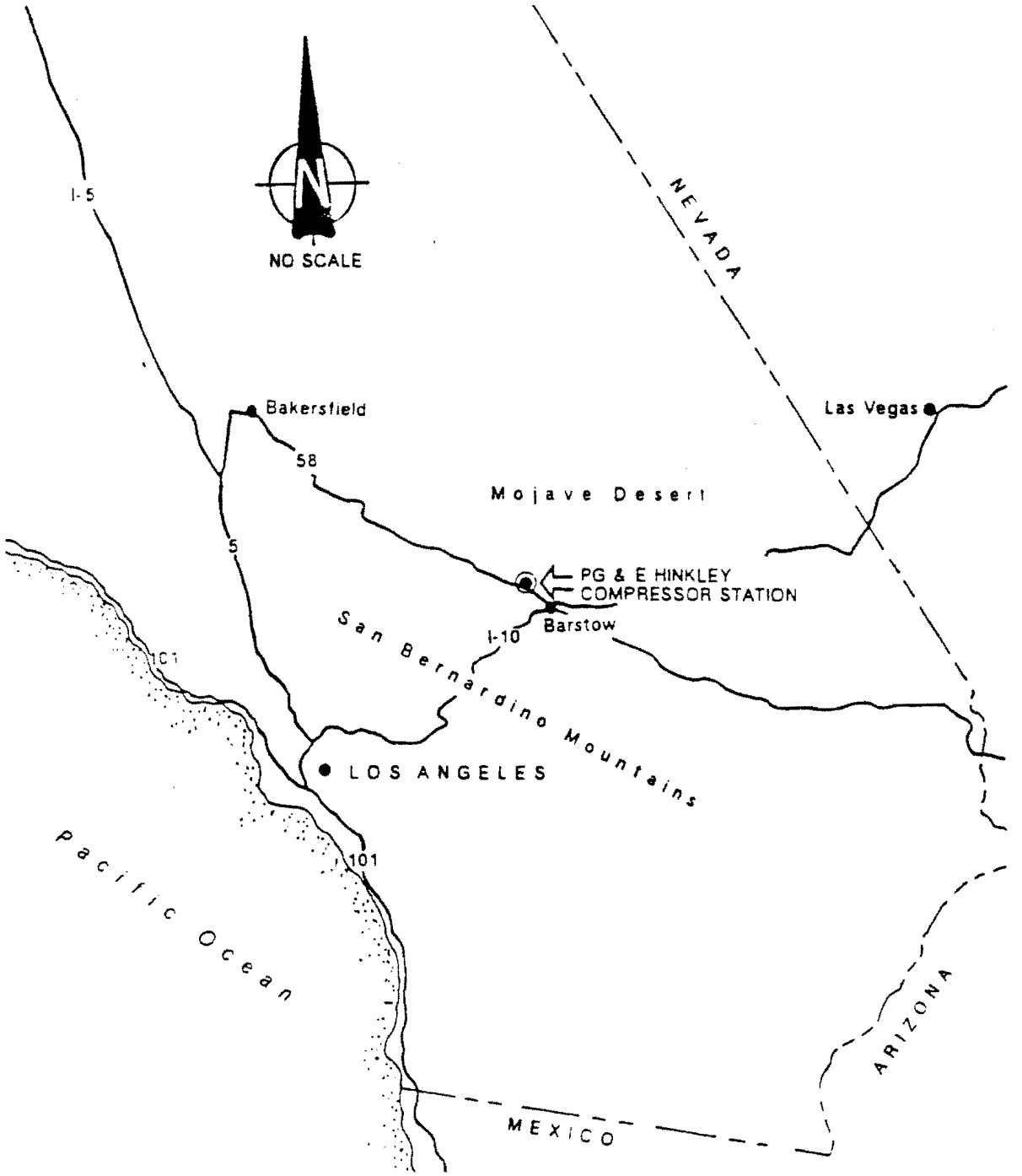


Figure 2: Approximate Location of Residences/Private Wells near the Chromium Contaminated Plume (as of 1998) in the Vicinity of the Hinkley Site [21]

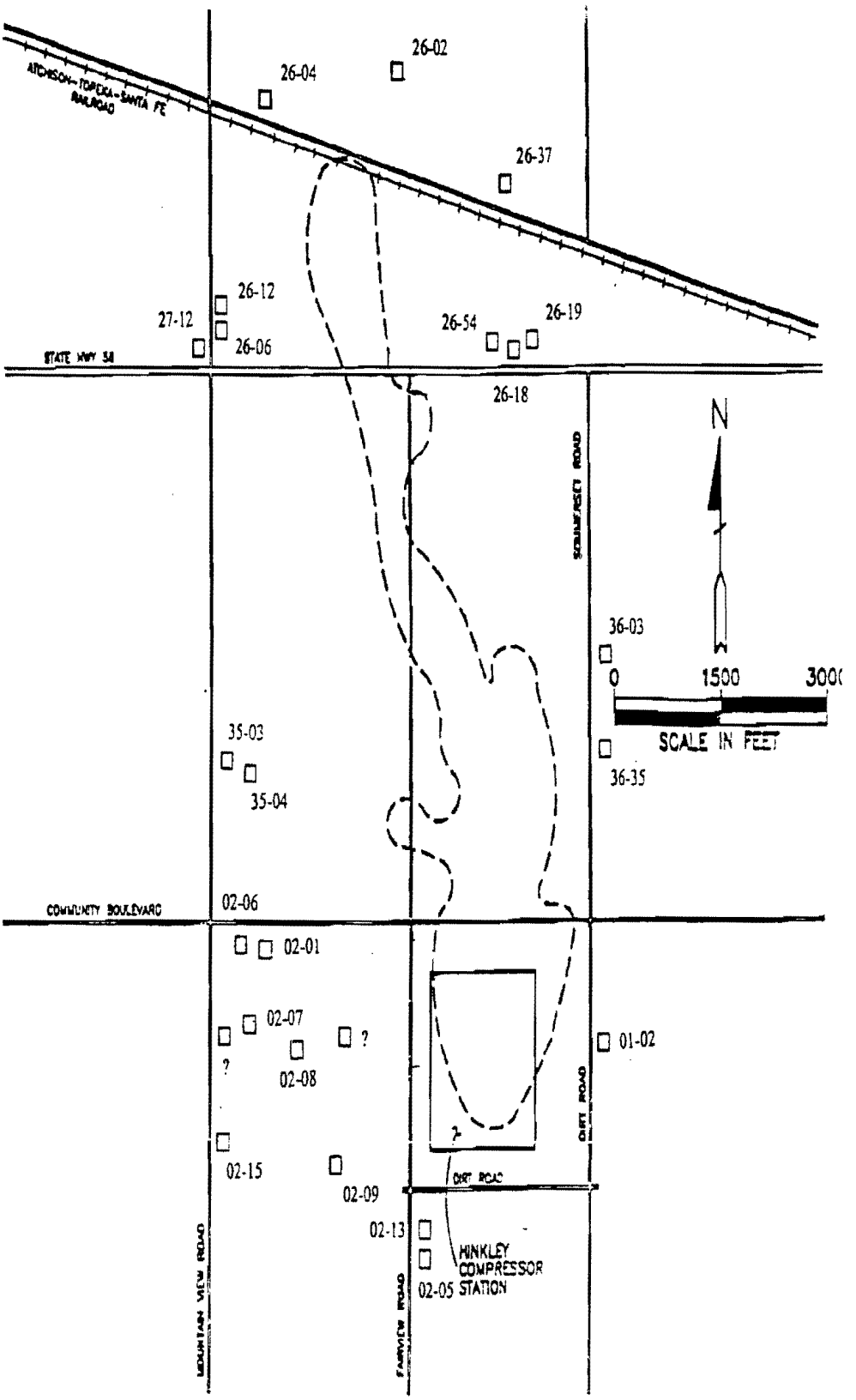


Figure 3: Locations of Areas A, B, and C at the Hinkley Site [2]

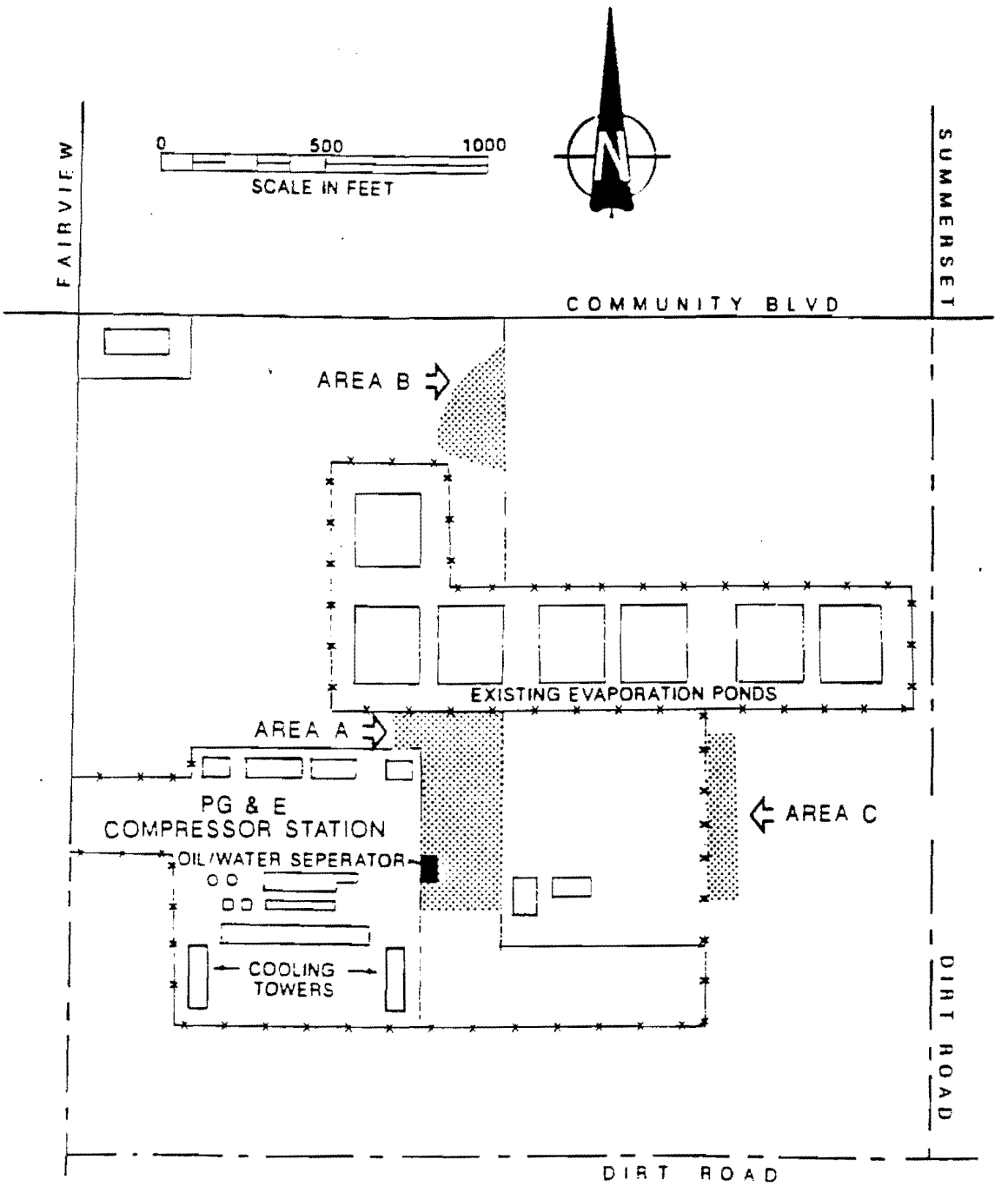


Figure 4: Area A - Locations of Trenches A, B, and C and the Soil Borings [2]

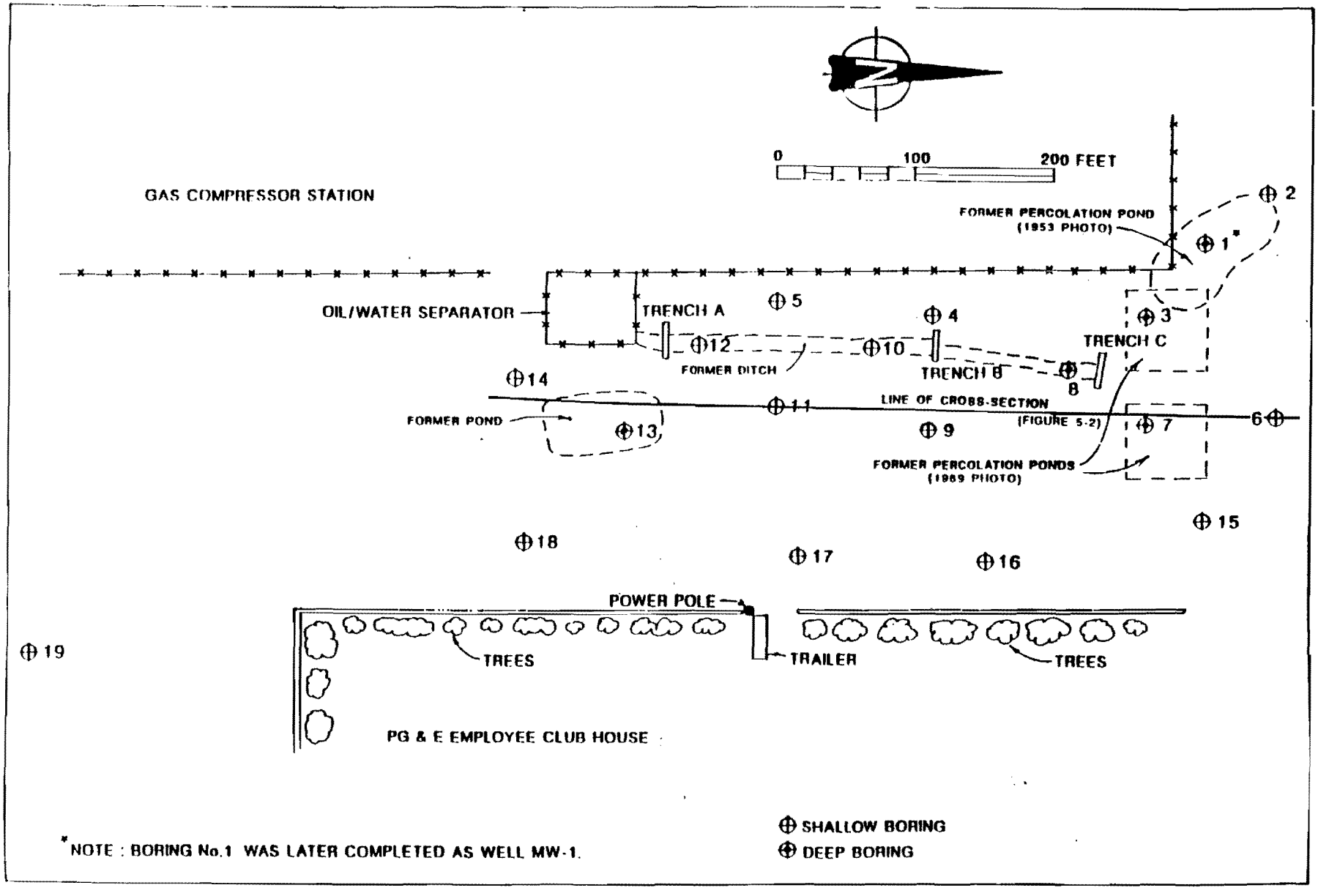


Figure 5: Area B - Locations of the Soil Boreholes [2]

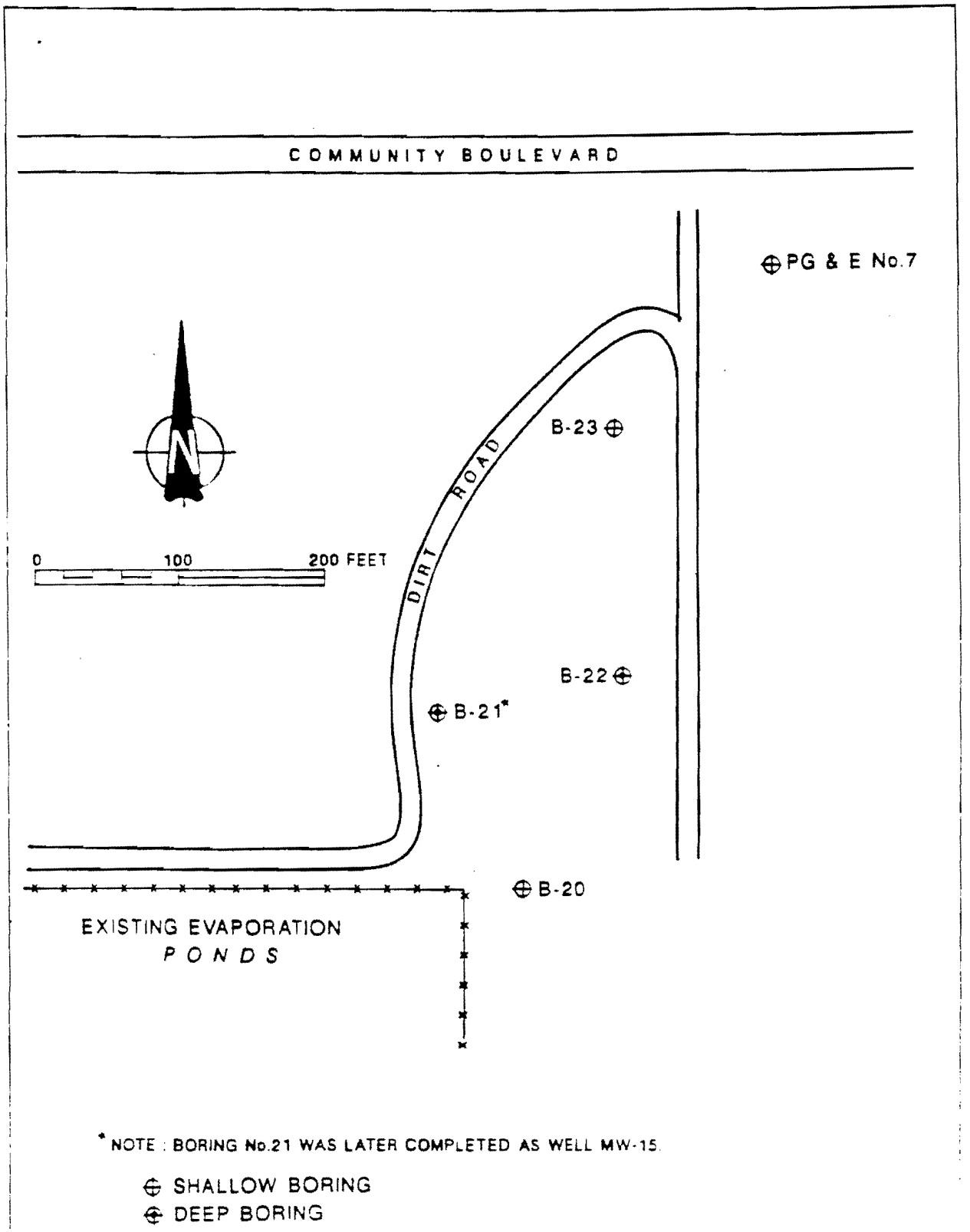


Figure 6: Area C - Location of the Soil Boreholes [2]

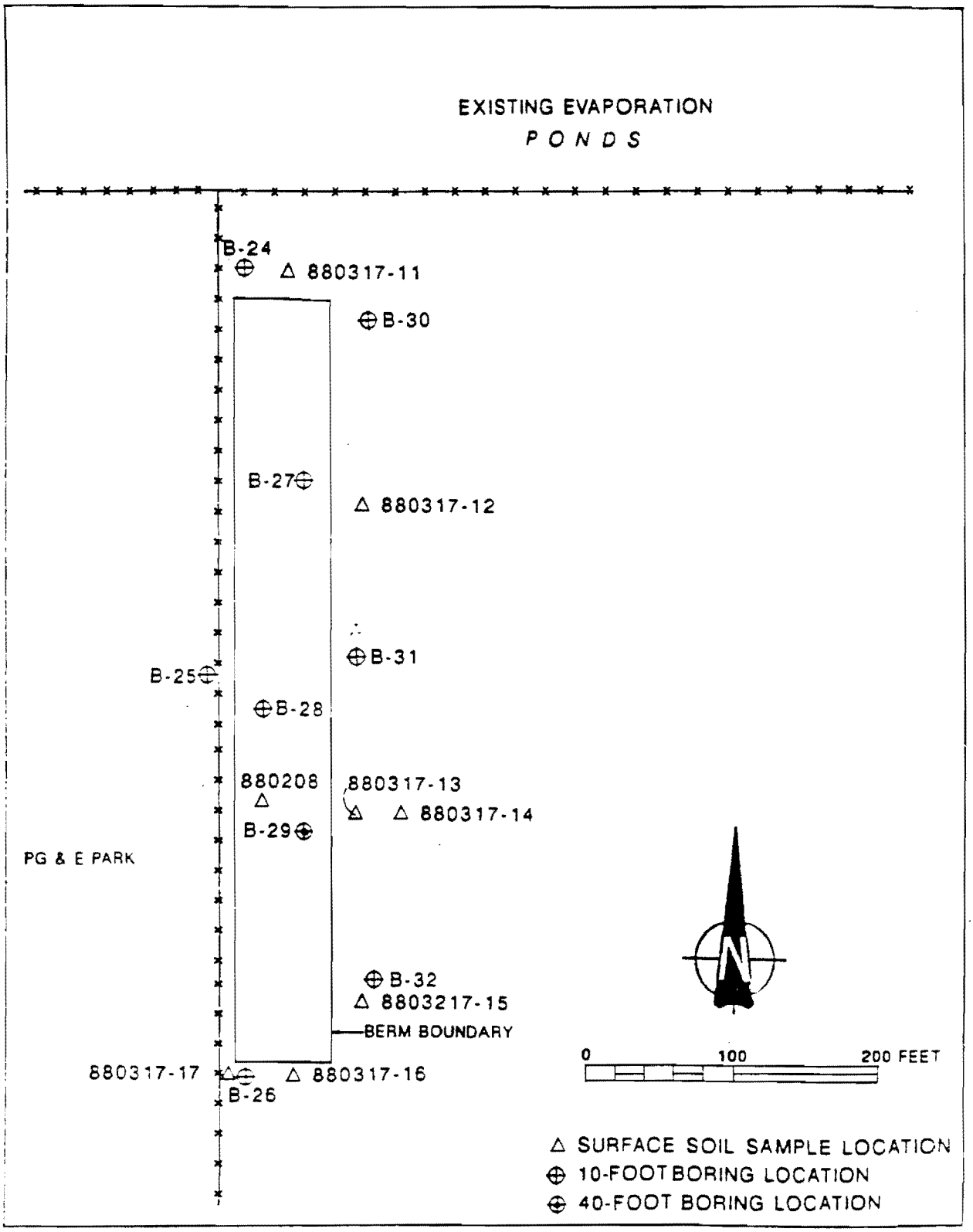


Figure 7: Locations of the Surface Soil Samples Collected in the Vicinity of the Hinkley Site and at the Hinkley Site [2]

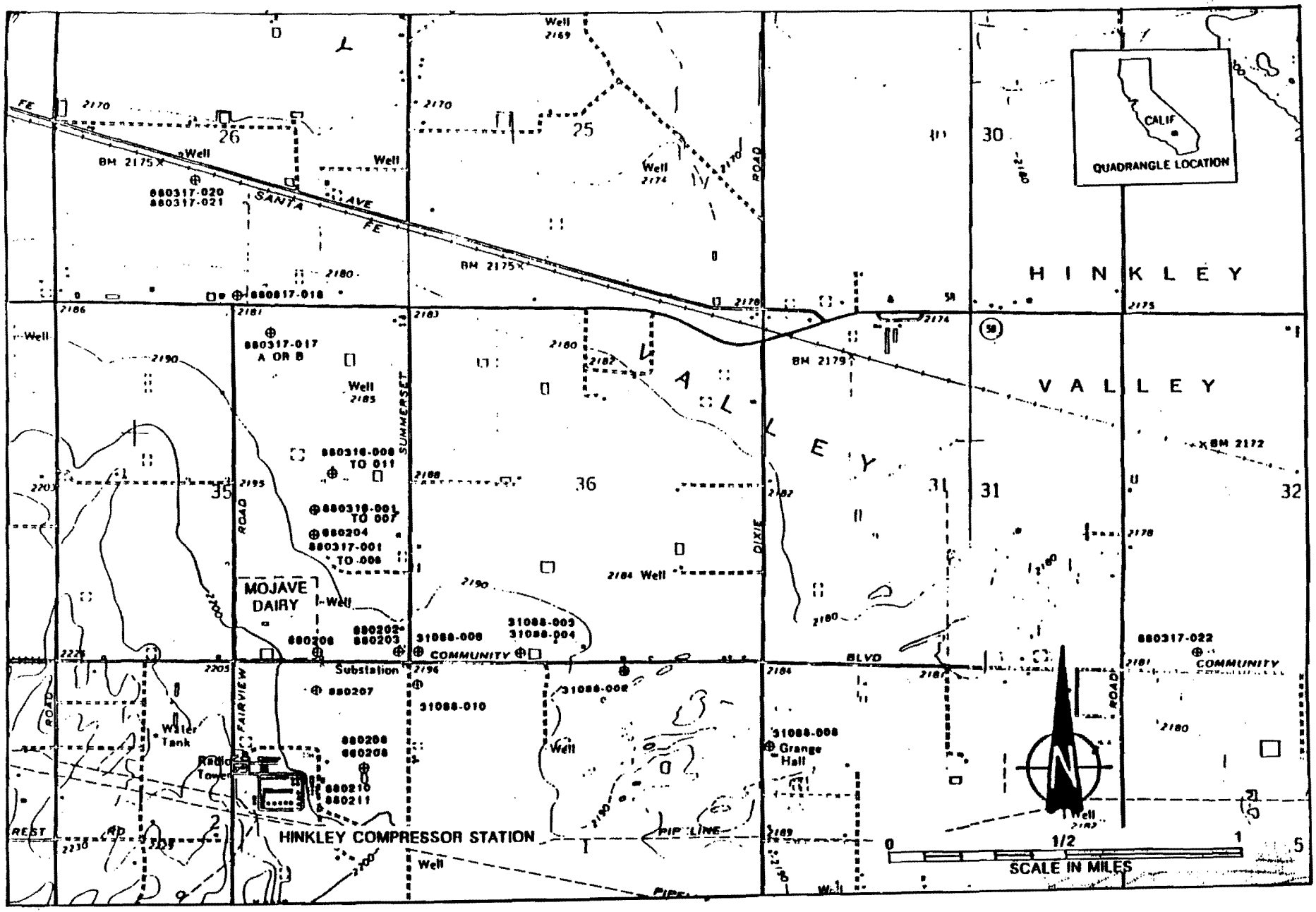


Figure 8: Lysimeter Locations at the Land Treatment Field Located North of the Hinkley Site [4]

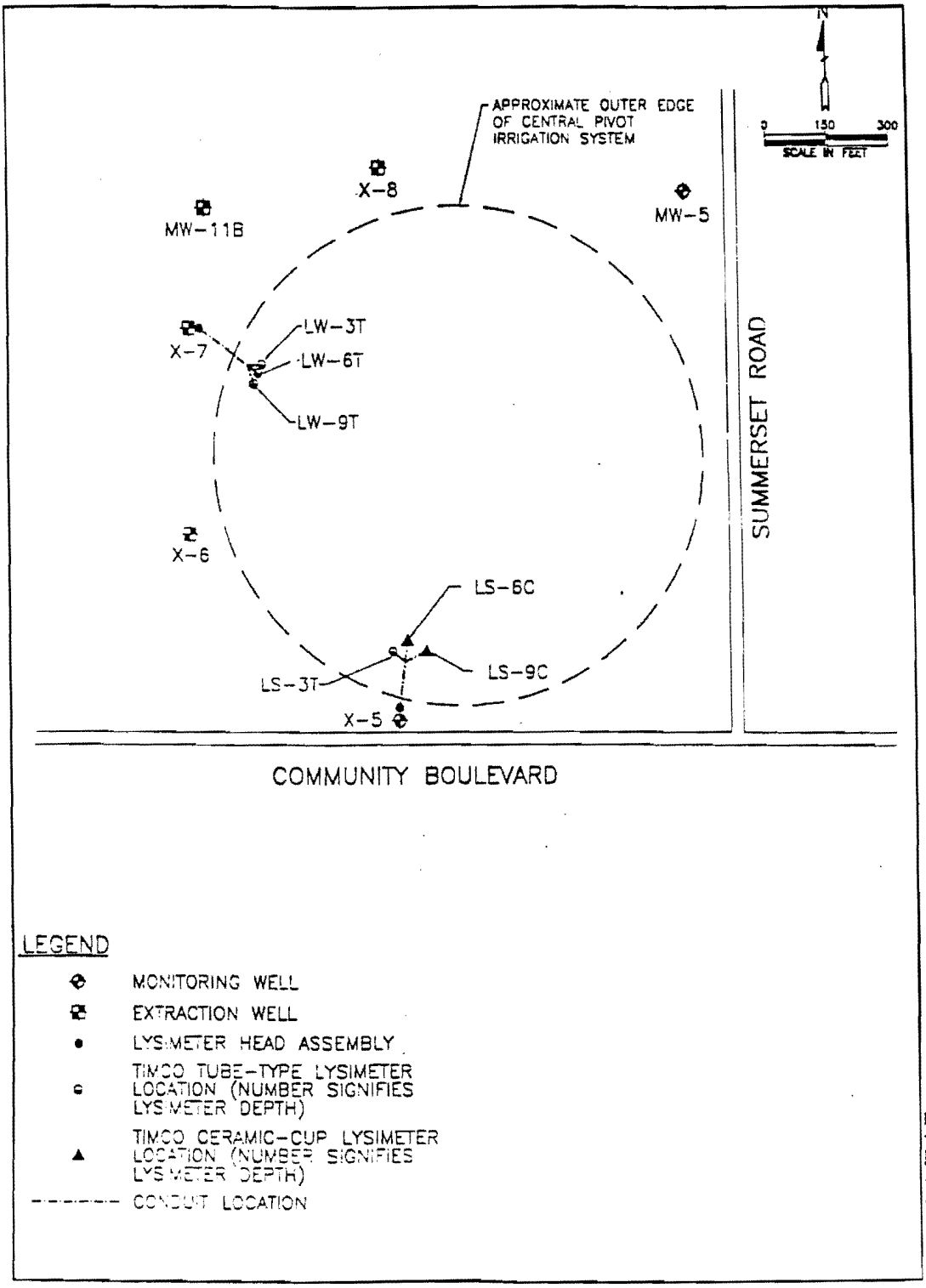


Figure 9: Diagram of the Total Chromium Groundwater Plume Concentrations (in mg/l) as of May 1988 [2]

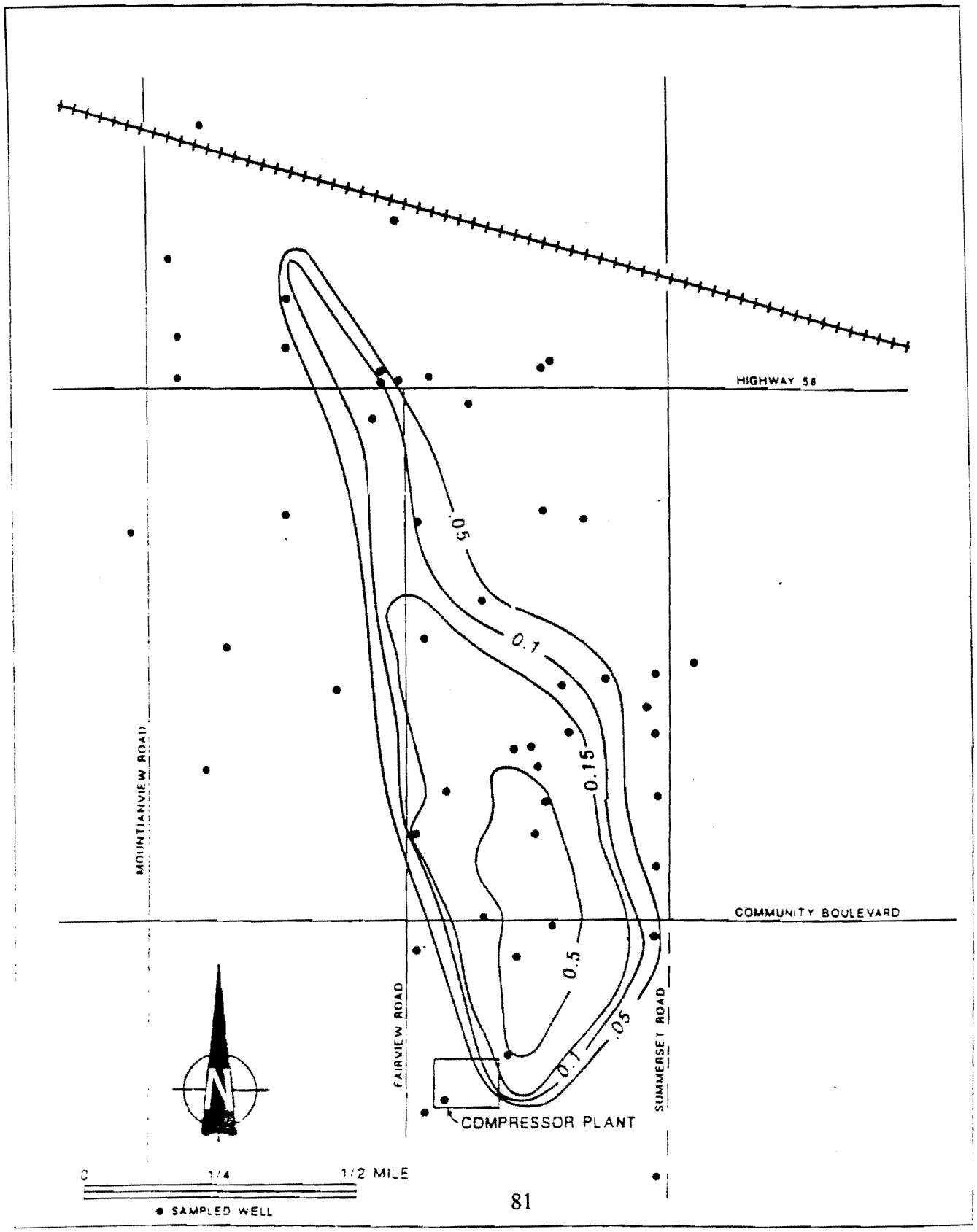


Figure 10: Locations of Monitoring Wells [2]

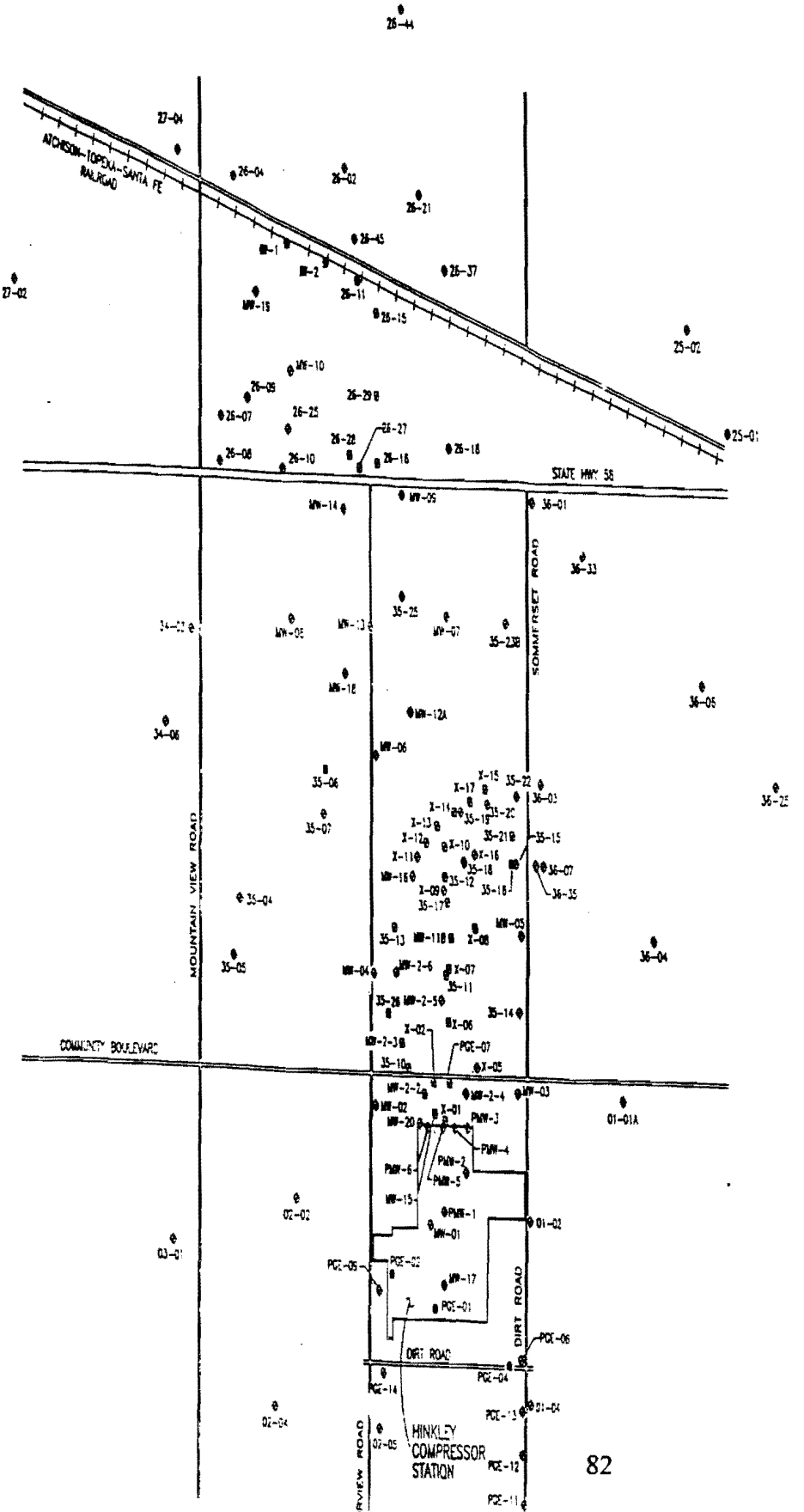
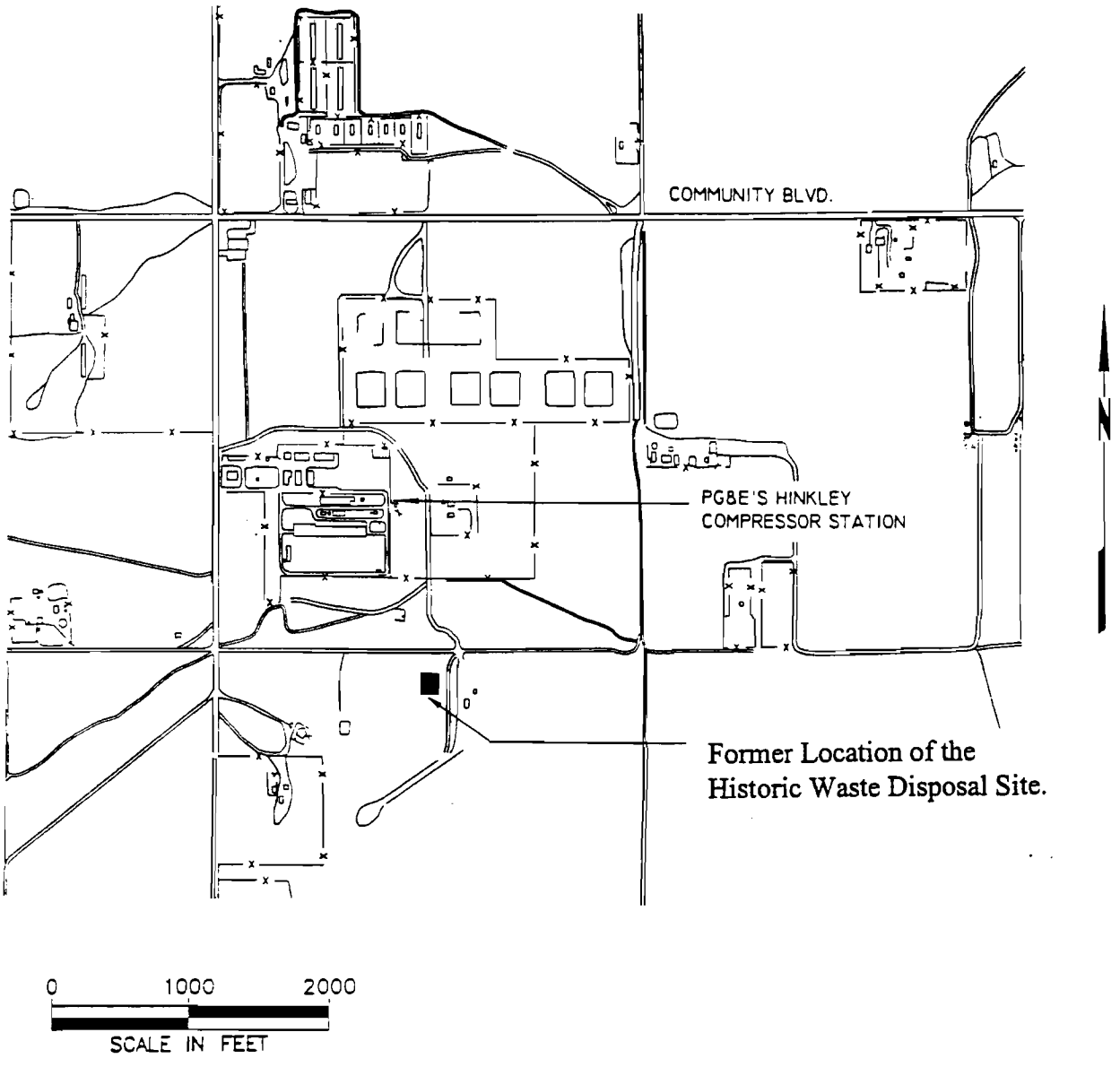


Figure 11: Location of the Historic Waste Disposal Site [17]



APPENDIX D - RESPONSE TO PUBLIC COMMENTS

On January 4, 1999, a copy of this document, *Public Health Assessment (PHA), Pacific Gas and Electric Company—Hinkley Site*, was placed at the United States Post Office (located at 37476 Hinkley Road, Hinkley, CA) for all interested parties to review. Also, additional copies were sent to individuals who requested this document. On January 11, 1999 at the Hinkley Senior Center (located on Mountain View Road and Community Boulevard), the CDHS staff presented the major points of the PHA at a community meeting, heard the concerns from the community (see attached meeting notes) and encouraged the attendees to respond during the public comment period.

The original four weeks' (January 4th to February 1st) time allotted for the public to respond to the PHA was extended until March 1st at the request of several community members.

RESPONSE TO PUBLIC COMMENTS

This appendix contains CDHS' responses to the comments received from four community members and PG&E. We tried to answer most of the questions by clarifying information provided in the PHA. Occasionally, there were questions that were unanswerable in the context of the PHA. Several sections of the PHA have been updated to include information provided to us during the community meeting and public comment period.

Written comments received from community members:

1. Comment: "On page 29 of the PG&E Draft, I find that the statement of no apparent past health hazard not accurate because you have no information before 1988. You do not know what levels were in the air, water, or soil."

CDHS's Response: CDHS acknowledges that the community has been extremely upset by the statement of "no apparent past health hazard,"since data prior to 1988 were not available. In the Draft PHA (dated March 10, 1999) , when we referred to the "past," we meant the time period between 1988 to 1999.

For this updated PHA, we need to clearly define the past time period. For past exposure, the time period is pre-1988. CDHS has determined that, for residents, there is one completed exposure pathway (i.e., ingestion of contaminated groundwater pumped from the ten private domestic wells serving fourteen homes contained chromium at levels greater than EPA's drinking water standard or MCL of 0.05 mg/l) and one potential inhalation pathway (i.e., residents may have been exposed to ambient air levels of hexavalent chromium that "drifted" off the Hinkley site from the cooling tower). Also, CDHS has identified four potential past exposure pathway (viz., soil, waste-water, ambient air, and groundwater) that may have impacted PG&E employees at the Hinkley site and at the Land Treatment Fields. Thus, according to the limited past information reviewed, the Hinkley site posed a past public health hazard.

2. Comment: "I purchased property located at 22122 Riverview Road, Hinkley, CA in 1984. After this time, I developed heart failure, lung disease, and kidney and liver problems (organs almost non-functioning.) I can't say for sure what caused my medical problems but they can be verified by doctors. I'm 58 years old and dying."

CDHS's Response: Several community members have told CDHS their concerns and frustrations about the poor status of their health. The focus of the PHA is to determine if exposure to chromium (used in the past by PG&E) has potentially impacted the community. Without such exposure information, it would be difficult to determine if these health concerns (i.e., heart failure, lung disease, kidney and liver problems) were related to past activities at the Hinkley site. The four health conditions may be caused by many other factors..

The health problems described by the commenters are often the result of multiple genetic, lifestyle and environmental factors rather than a single cause. For example, "heart failure" may be related to rheumatic heart disease caused by past infection, coronary artery disease resulting from cigarette smoking, high cholesterol intake, diabetes, high blood pressure, or other factors. Some health problems may be interrelated, as heart failure often results in multiple organ dysfunction (including kidney, liver and lung) due to abnormalities of blood flow to other organs.

What we know about the health effects of exposure to hexavalent chromium is from studies in occupational settings, animal studies, and a few studies of health effects in communities with high levels of chromium in the environment. Below is a summary of the findings of those studies:

Cancer:

The relationship of hexavalent chromium inhalation exposure to respiratory cancers (lung, bronchial, nasal) among workers is well established. These exposures were to high levels of chromic acid, welding fumes, or lead and zinc containing chrome pigments. Some studies have shown a possible relationship to stomach cancer, but others have not. Studies in animals have confirmed the relationship between lung cancer and inhaled chromium compounds. A Swedish study of people living near a chromium plant found no evidence of increased lung cancer. A study of a chromium-contaminated area in China initially found increased lung and stomach cancer rates. Follow-up studies showed that areas with the highest cancer rates had the lowest exposures to chromium, suggesting that the cancers may have been related to something other than chromium exposure. Hinkley residents with wells affected by the chromium plume may have inhaled aerosolized chromium while showering or other activities involving spraying. It is unlikely that levels of exposure from these sources would have been high enough to contribute to an increased risk of cancer. As we have no information on levels of exposure (if any) to workers at the PG&E site or local dairies, we cannot speculate on the relationship of chromium exposure and lung cancers in this group. There is no evidence that other types of cancer besides respiratory or stomach cancers are related to chromium exposure.

Heart Disease:

Studies in workers, animal studies, and a community exposure study from Tokyo have all shown no evidence of heart disease related to chromium exposure. Most heart disease is caused by blockage of the arteries and thought to be related to diet, exercise, and cigarette smoking. Heart disease can also be due to high blood pressure, diabetes, inherited diseases, infections (such as rheumatic fever), or the aging process.

Respiration:

There is no evidence that oral exposure to chromium is related to respiratory symptoms. A Tokyo study showed an increased number of complaints of nasal irritation among residents near a chromium-contaminated site, but there was no evidence of changes in lung function. Worker studies have shown respiratory effects, including asthma and bronchitis, in those exposed to inhaled chromium, but many of the studies did not have information on exposure levels or other contributing factors such as smoking and exposure to other chemicals. No significant respiratory effects have been seen in workers with intermediate or chronic exposures to hexavalent chromium levels lower than 0.001 mg /m^3. This level is approximately 2,000 times higher than levels measured in the ambient air sampling investigations at the Mojave Dairy and during the Site Characterization Field Activities.

Kidney or Bladder Disease:

Studies in workers exposed to chromium by inhalation have shown no evidence of an increase in rates of kidney or bladder disease. Some studies, using urine tests for early kidney damage, have shown evidence of an effect on kidney function by inhaled chromium, while others have not. People who have ingested large doses of chromium by accident or in suicide attempts have developed kidney failure. Studies in animals have shown kidney damage with high oral doses. For hexavalent chromium, long term exposure studies in rats showed no effects at levels below 3.6mg/kg/day (equivalent to eating or drinking 252 mg/day for a 150 lb adult and 72 mg/day for a 44 lb child.). The ingestion doses estimated for adults and for children living above the contaminated groundwater plume and ingesting chromium-contaminated groundwater were below this level (approximately 60 to 100 times lower, respectively). Community studies in Tokyo and New Jersey of people living near chromium-contaminated areas showed no evidence of kidney disease. Other causes of kidney and bladder disease include infections, genetic abnormalities, atherosclerosis (hardening of the arteries), cigarette smoking, exposures to other industrial chemicals, and overuse of pain relievers (aspirin, ibuprofen). Urinary infections are caused by introduction of bacteria or obstruction of flow in the urinary system and are unrelated to chromium exposure.

Liver:

Some worker studies have shown evidence of liver damage from inhaling high levels of hexavalent chromium. Ingestion of large amounts (7.5 mg/kg potassium dichromate) in poisoning

cases has also caused liver damage. Animal studies have shown no evidence of liver disease due to inhalation. Studies in animals showed no toxic liver effects of drinking or eating less than 3.6 mg/kg/day for 1 year. The Tokyo study of people exposed to chromium from a nearby construction site showed no increased incidence of liver disease. It is unlikely that Hinkley residents would have been exposed to levels of chromium high enough to result in liver disease. Other factors that may contribute to liver disease include viruses (hepatitis), genetic diseases, exposure to industrial chemicals (carbon tetrachloride, carbon disulfide, solvents), overdoses of drugs (acetaminophen, aspirin), and excessive alcohol intake.

Eyesight:

A direct splash of liquid containing extremely high amounts of chromium may cause a burn of the outer layer of the eye. Exposure to aerosolized chromium can cause eye irritation. There is no evidence that chromium exposure is related to vision loss. Common causes of vision loss include cataracts, glaucoma, age-related degeneration of the retina, and damage of the retina from diabetes or atherosclerosis.

Arthritis:

There are no studies of an effect of chromium on the musculoskeletal system. The most common cause of arthritis, osteoarthritis, is thought to be due to the aging process and "wear and tear" on joints and ligaments. Contributing factors may include injuries, overuse, and excess weight. The cause of rheumatoid arthritis is unknown. It is thought to be due to an abnormality of the immune system related to genetic factors and responses to infections. Neither of these conditions is likely to be due to chromium exposure.

3. Comment: "I am writing in regards to the PG&E report your office received furnished by the PG&E company, as I understand it. The contents MAY pertain to the current status of the water purity (or lack thereof), but I certainly take exception to the statement of page 29 that the Hinkley site posed no apparent past health hazard. I cannot judge regarding the present and future. I know only that people who have lived here for varying periods of time have definitely been affected, and the closer to the PG&E plant, the worse the exposure. I see nothing in the report that cites the residents, who lived on Summerset, or the residents, whose swimming pool was destroyed by filling it with soil (done through PG&E direction) after they sold to them and moved to Arizona. A resident died from a heart attack just days after moving into their new home, which they had built. Almost every house which used to stand on Summerset has been destroyed or left unoccupied, also some on Highway 58, and on Community Blvd. And also on Fairview Rd.. Why did PG&E have this done, after buying them from the owners if there was no contamination? My husband and myself have not been affected to the same extent as those who lived closer, or worked at the plant, yet we have health problems we did not have anywhere we lived in the past, and which did not become evident until we had lived at our present location for several years. I fully believe PG&E personnel are not any more truthful now than they have been in the past. I only hope your department will investigate all sources of

information, not just the candy-coated words of this company and their hired "experts". Talk with the first families who were involved in it. Some of them are no longer alive. Talk with the attorneys who investigated this matter and brought suit against PG&E. Talk with the former PG&E employees. The prosecuting attorneys, if they are legally able, investigate fully! I had a Hinkley resident make the comment to me just today, that the Health Department should have conducted a full investigation when this all first started, and he doesn't expect your department to do anything now. I am still optimistic enough to expect our public officers to act in the public interests. May you pursue this matter with scrupulous honesty. The Spanish speaking people here, mostly dairy workers, need extra assistance due to the language difficulty. They need a spokesperson!!"

CDHS's Response: It is common practice at most hazardous waste sites for the responsible parties to carry out, with agency oversight, site investigation and clean-up activities. Most of the time, responsible parties hire environmental consultants to conduct these activities. However, CDHS believes that additional environmental sampling with input from the community might help the community to better understand current and future exposure to chromium. We are now working with several governmental agencies to obtain additional independent environmental sampling.

It was very informative for us to hear all the community comments at the January 11th meeting, and CDHS will remain available to those community members who are interested in discussing potential health impacts due to living in the vicinity of the Hinkley site. Please see Comment # 1—CDHS's response to the questions concerning health problems in the community. Concerned community members are encouraged to contact our health educators, Judy Lewis or Tivo Rojas (who are bilingual-Spanish/English), at 510-622-4500. Collect calls will be accepted.

We do not know why PG&E demolished all the homes located above the chromium-contaminated groundwater plume. For questions concerning PG&E activities, please contact PG&E at 925-974-4082.

4. Comment: "My home is at Mt. View [in] Hinkley, CA where I have lived since 1958. It is [on] the southwest corner of HWY 58 located [to the] right of land so contaminated [that] PG&E purchased and destroyed 2 very nice homes [one with] a built-in swimming pool and paid numerous people who resided there. Our land was flood irrigated from [the] same wells in the 1970's. We were asked about [whether] we have had health problems. I, myself, have had cancer and urinary infections and complications. I have had to have a pacemaker since 1982. I am losing my eyesight. All these things [may] now be caused by [hexavalent] chromium. Plus, [in] 1988, my land [which is] a dairy site was appraised for a million [dollar], now [I] can not sell or even rent [the land] as a dairy site. We have not been reimbursed for anything by PG&E. All we get is hot air about [the] water being o.k. We were in [Colorado?] in 1989 for a time. We buy water to drink, but we use the well water for everything. My concern [is] does this [chromium] build up in your body by constant contact? Even if the water has smaller about now, does it build up in [the] body?

My arthritis and bladder problems are worse and [my] eyesight and heart, all continue to get worse, why? And my respiration is getting bad, why?

CDHS's Response: CDHS acknowledges that several community members have expressed their concerns and frustrations about the poor status of their health. Please see CDHS's response to Comment # 1. For questions concerning PG&E's past and present activities, please contact PG&E at 925-974-4082.

The following is a response to the question about the potential accumulation of chromium in the body. Chromium can enter your body when you breathe air, eat food, or drink water containing chromium (18). If your skin comes into contact with chromium, very little will enter your body, unless your skin is damaged (18). Within a few days, the chromium that entered your body is eliminated in your urine or feces.

Written comments received from PG&E concerning statements made in the PHA:

1. Text (page 5, paragraph 4, sentence 3): "Groundwater above the blue clay is unconfined or semi-confined, which means that it has the potential to migrate downwards."

PG&E's Comment: "This characteristic doesn't have anything to do with its potential to migrate downward, it means it is close to or slightly higher than atmospheric pressure."

CDHS's Response: We have made the changes in the text to reflect this comment.

2. Text (page 8, paragraph 4, sentence 7 & 8): "The majority of the groundwater pumped from the site were below EPA's PRG of 450 mg/kg for total chromium in industrial soil, with the exception of one sample...." "Because one soil sample was above EPA's PRG of 450 mg/kg for total chromium in industrial soil, further investigation is warranted."

PG&E's Comment: [It is] not clear which sample this is.

CDHSs' Response: The sample identification number is PG8802-02. It was collected from the Land Treatment Field (north of the Hinkley site).

3. Text (page 8, paragraph 4, sentence 7 & 8; page 9, last sentences in paragraphs 1 & 2): "PG&E excavated all soil that exceeded 500 mg/kg of total chromium, however, the levels of total chromium detected in the remediated trench soil still exceeded EPA's PRG of 450 mg/kg for industrial soil, thus, further evaluation is warranted."

PG&E's Comment: [These statements are] not accurate. For both Areas A & C, the cleanup soil confirmation showed all soil samples well below 450 mg/kg. See attached draft table. Thus, [further evaluation] is not needed.

CDHS's Response: At the time the PHA was written, PG&E had not provided this information to us. During the public comment period, PG&E's representative provided us with an additional report (i.e., Draft: Soil Remediation Project Confirmation Sampling and Analysis Report). The results in this report were incorporated into the PHA.

4. Text (page 12 paragraph 1, sentence 4 & 5): "The soil sample containing total chromium at 514 mg/kg was collected in an agricultural pond used to remediate the chromium contaminated groundwater, thus, it was compared and determined to be above USEPA's PRG of 450 mg/kg for industrial soil." and "Therefore, further investigation is warranted."

PG&E's Comment : This pond was not used to remediate chromium.

CDHS's Response: The appropriate change was made in the PHA.