Public H
Assessment
for

JET PROPULSION LABORATORY (NASA)
PASADENA, LOS ANGELES COUNTY, CALIFORNIA
CERCLIS NO. CA9800013030
AUGUST 5, 1999

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

PUBLIC HEALTH ASSESSMENT

JET PROPULSION LABORATORY (NASA)

PASADENA, LOS ANGELES COUNTY, CALIFORNIA

CERCLIS NO. CA9800013030

Prepared by:

Federal Facilities Assessment Branch
Division of Health Assessment and Consultation
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, full-scale 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 (E-56), Atlanta, GA 30333.

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LIST OF ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
CDHS	California Department of Health Services
CTC	carbon tetrachloride
CV	comparison value
DCA	1,1- or 1,2-dichloroethane
1,2-DCE	1,2-dichloroethene
EPA	United States Environmental Protection Agency
FS	feasibility study
JPL	Jet Propulsion Laboratory
MCL	EPA's maximum contaminant level
MRL	ATSDR's minimal risk level
MWDSC	Metropolitan Water District of Southern California
NASA	National Aeronautics and Space Administration
nd	nondetectable
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
OU	operable unit
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
PHA	Public Health Assessment
PHAP	public health action plan
ppb	parts per billion
RfD	reference dose
RMEG	reference dose media evaluation guide
RI	remedial investigation
SVOC	semivolatile organic compound
1,1,1-TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TSH	thyroid stimulating hormone
VOC	volatile organic compound

SUMMARY

The National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) is located in Pasadena, California, northeast of Interstate 210. Established before World War II, the facility has been under the jurisdiction of NASA since 1958. Activities at JPL currently focus on automated exploration of the solar system and deep space. Under a contract with NASA, the California Institute of Technology operates JPL and maintains the facility. As a result of former site activities, chemicals, primarily volatile organic compounds (VOC) and perchlorate (a component of solid rocket fuel), used at JPL have been released to soil and groundwater.

The Agency for Toxic Substances and Disease Registry (ATSDR) conducted site visits in 1997 to assess the potential for public health hazards. During these visits, ATSDR identified two pathways where people could potentially be exposed to site-related contaminants: 1) exposure to contaminated groundwater and 2) exposure to contaminated soil. ATSDR also identified the following primary community concerns: 1) future groundwater and drinking water quality and 2) increased incidence of Hodgkin's disease. The evaluation of these potential pathways and community concerns is the focus of this Public Health Assessment.

Following a careful evaluation of available data, ATSDR determined that VOC-contaminated groundwater does not present a past, present, or future public health to JPL employees or nearby residents. On-site groundwater has never been used as a source of drinking water and area water purveyors, who are aware of the contamination problem in the water basin, regularly monitor their municipal water and take steps (e.g., well water blending, VOC treatment, or well closure) to ensure that the drinking water distributed to consumers is safe.

Since a new sensitive test for measuring perchlorate has become available, elevated levels have been detected in groundwater and in raw, unprocessed well water. As with the VOC, current sampling and well water blending procedures used by area water purveyors likely prevent harmful exposures to perchlorate. Insufficient data are available to estimate potential exposure to perchlorate in groundwater before 1997. However, based on the 1997-1999 perchlorate data, as well as data on groundwater flow, the migration patterns observed for other contaminants, and the protective measures taken by local water purveyors to ensure that VOC contaminants did not reach unsafe levels in finished drinking water, it is unlikely that perchlorate in groundwater posed a past public health hazard.

ATSDR also determined that exposure, if any, to contaminated soils associated with the JPL site and in the Arroyo Secco near the JPL boundary is unlikely to cause either short-term or long-term

adverse health effects to employees and the public due to low contaminant levels, the depth of contamination, and/or infrequent or unlikely exposure.

Based on a review of the available information on groundwater and soil contamination, ATSDR concludes that JPL should be assigned to the *No Apparent Public Health Hazard* category for past, present, and potential future human exposure to VOC-contaminated groundwater processed for drinking water and surface soils or soil gasses. Even though it is unlikely that past human exposure to perchlorate in drinking water posed a public health threat, because the past levels of human exposure to perchlorate are unknown, ATSDR concludes that the site should be assigned to the *Indeterminate Public Health Hazard* category for potential past human exposures to perchlorate in drinking water.

BACKGROUND

Site Description and History

The National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) is located in Pasadena, California, northeast of Interstate 210. JPL consists of approximately 155 buildings on a 176-acre campus situated on a foothill ridge of the San Gabriel Mountains (see Figure 1). The facility is located within the boundaries of the cities of Pasadena and La Cañada-Flintridge; residential areas of these cities and the community of Altadena are within 1 to 3 miles of JPL. JPL is bordered to the north by the Angeles National Forest; to the east by the Arroyo Secco (an intermittent stream bed) and spreading grounds (a series of man-made basins used to percolate runoff water to replenish the aquifer); to the west by a residential neighborhood; and to the south by an equestrian club, a fire station, a U.S. Forest Service Ranger Station, and the Hahamonga Community Watershed Park (formerly known at Oak Grove Park). Also located south of the facility are several schools and the Devil's Gate Reservoir.

In 1936, a group of researchers began experimenting with rocket fuels in Pasadena's Arroyo Secco area. The group was soon enlisted to conduct research for the U.S. military, and in 1945 the group was designated the Jet Propulsion Laboratory, under the jurisdiction of the U.S. Army. In 1958, the facility was transferred to NASA and assigned a mission of research and development in aeronautics, space technology, and space transportation (JPL, 1991b).

The California Institute of Technology is currently under contract with NASA to perform research and development at JPL, as well as to manage the facilities. NASA maintains a presence at the facility in a supervisory role only. Primary activities at JPL currently include automated exploration of the solar system and deep space (including the Mars Pathfinder mission) and design and operation of the Deep Space Network that tracks spacecraft.

In performing these tasks, support facilities and research and development laboratories at JPL have used a variety of chemicals, including chlorinated solvents, solid rocket fuel propellants, cooling tower chemicals, sulfuric acid, Freon, mercury, and various laboratory chemicals. From 1945 to 1960, JPL disposed of liquid and solid wastes, including chemical wastes, in over 40 seepage pits and waste pits on the facility grounds (JPL, 1991a). It is believed that the seepage pits were backfilled between 1960 and 1963, when JPL installed a sewer system (Ebasco, 1990a, 1993). Since there is very little undeveloped land on the facility grounds, these disposal areas are now located under buildings, retaining walls, parking lots, roads, and flower planters. JPL now transports all of its hazardous wastes off site for destruction, disposal, or recycling.

Remedial and Regulatory History

In 1980, the city of Pasadena detected volatile organic compounds (VOCs)—carbon tetrachloride (CTC) and trichloroethylene (TCE)—in municipal wells located in and east of the Arroyo Secco spreading grounds southeast of JPL. VOCs were also detected at around the same time in two drinking water wells operated by the Lincoln Avenue Water Company, which primarily supplies the community of Altadena. Although the detected VOC concentrations initially did not exceed California drinking water standards (5 parts per billion [ppb] for CTC and TCE) the contaminant levels gradually rose so that the contamination in these wells was eventually above state standards (JPL, 1997a, 1994). These elevated contaminant concentrations forced the temporary closure of two Pasadena municipal wells in 1985, followed by the temporary closure of the two Lincoln Avenue wells in 1987, and finally the remaining two Pasadena wells in 1989 (JPL, 1994).

Because JPL is the major industrial establishment near these wells, it was suspected to be the source of the groundwater contamination. JPL and the city of Pasadena conducted preliminary assessment (PA) activities in 1982, 1984, 1986, and 1987 to identify the source(s) of contamination (JPL, 1991a).

In 1990, NASA funded the construction of a water treatment plant for the four contaminated Pasadena municipal wells. This allowed the city of Pasadena to resume production of drinking water from these wells. Also in 1990, JPL removed a suspected contaminant source area consisting of a storm drain and 160 cubic yards of soil and sludge (JPL, 1994). The Lincoln Avenue Water Company built a water treatment system in 1992, which allowed them to reopen the two closed drinking water wells.

In 1992, following an expanded site inspection (ESI) that identified CTC, TCE, and 1,1-dichloroethane (DCA), and to a lesser extent tetrachloroethylene (PCE), above drinking water standards in on-site groundwater (Ebasco, 1990a), JPL was placed on the U.S. Environmental Protection Agency's (EPA's) National Priorities List (NPL). Later that year (December 1992), EPA, the state of California, and JPL negotiated a Federal Facilities Agreement specifying how investigation and cleanup work at the site would be conducted.

During the site investigation process, JPL was divided into three operable units (OUs) to facilitate characterization of the sources, nature, and extent of contamination at and around the installation and to enable the proper design of cleanup measures. At each OU, JPL is conducting both a remedial investigation (RI) to identify and characterize the contamination and a feasibility study (FS) to determine the best methods of remediation. For OUs 1 and 3, JPL anticipates completing an RI report in early 1999, to be followed by an FS report. For OU2, JPL recently completed a draft RI (February 1999) and they continue to study treatment technologies for removing VOC vapors from soil (JPL, 1997a, 1998; Foster Wheeler, 1999). The following are descriptions of the OUs at JPL.

- *OU 1: On-site groundwater.* This OU addresses contaminated groundwater directly beneath the JPL site and the adjacent Arroyo Secco. RI/FS activities have included installation of 19 groundwater monitoring wells on JPL grounds and in the arroyo (Foster Wheeler, 1998a). By periodically monitoring the presence of contaminants in these wells, and performing computer modeling of groundwater movement, investigators will determine possible remedial actions. Current information about on-site groundwater contamination is summarized in Table 1.

- *OU 2: On-site contamination sources.* This OU encompasses all potential contaminant sources in soil at JPL. The majority of these sources are seepage pits where JPL allegedly disposed of liquid hazardous wastes before installing a sewer system in the early 1960s (connected to the Pasadena/Los Angeles sanitary sewer system). Other source areas include waste pits, stormwater discharge points, and chemical spill areas. Figure 2 is a three-dimensional model of JPL which shows the relationship of the contamination sources to nearby city of Pasadena drinking water wells. RI/FS activities at OU 2 have included soil-vapor probes, soil sampling, and/or installation of soil-vapor wells at suspected source areas. These activities help investigators characterize soil contamination and evaluate clean-up strategies. Current information about these on-site contamination sources is summarized in Table 1.

- *OU 3: Off-site groundwater.* This OU addresses any potential groundwater contamination detected in communities east of the Arroyo Secco. RI/FS activities have included installation of five groundwater monitoring wells in nearby Altadena and Pasadena (Foster Wheeler, 1998a). Monitoring these wells will help indicate whether contaminants have moved off site and determine the direction of movement and extent of contamination. Current information about all drinking water wells in the vicinity of JPL is summarized in Table 1.

In the summer of 1997, perchlorate, a chemical used in solid rocket fuel, was detected in monitoring wells at JPL and in some municipal wells near JPL. Perchlorate has become a contaminant of concern only recently, because until 1997 there was no laboratory test to detect low levels of perchlorate in water. Although there is a good deal of information about the health effects from short-term exposure to perchlorate, relatively little is currently known about the effects from long-term exposure (CDHS, 1997).

NASA, JPL, and other federal agencies are cooperating fully in joint industry, government, and academic efforts to develop a better understanding of the human health issues associated with perchlorate. In May 1997, a peer review panel of experts associated with the Toxicology Excellence for Risk Assessment convened to recommend and prioritize a set of studies to develop a better understanding of the long-term human health and ecological risks of perchlorate, address key data gaps, and reduce uncertainties in EPA's guidance levels. EPA's National Center for Environmental Assessment reviewed the data from these studies, and in September 1998, released its findings in an external review draft health risk assessment titled "Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization Based on Emerging Information." The document, along with all new data and the study protocols, was subjected to an external expert peer review early in 1999 (EPA, 1999).

Until new information about perchlorate becomes available, the Agency for Toxic Substances and Disease Registry (ATSDR) is unable to *fully* evaluate any potential public health hazards related to perchlorate at JPL. ATSDR will evaluate these new data as they become available, and will use any and all new information to further assess the perchlorate contamination at JPL. A summary of current information about perchlorate and its occurrence at JPL is presented in Appendix C.

Demographics

JPL has a work force of approximately 8,000 people (6,000 employees and 2,000 contractors). Approximately 30 percent of JPL employees come from Pasadena, 7 percent from Altadena, and 7 percent from La Cañada- Flintridge (JPL, 1994). There are no residents on the JPL property.

Population data, housing data, and a census tract map of the JPL area are presented in Appendix D. The total population residing in the vicinity of JPL includes:

- 9,500 people within 1 mile of the site
- 17,000 people within 2 miles of the site
- 20,000 people within 3 miles of the site

The city of Pasadena borders JPL to the south and southeast and has primarily residential, office, retail, and service areas. From 1980 to 1990, the population of Pasadena grew 9.7 percent to 131,591 (JPL, 1994).

Altadena borders JPL to the east. Altadena has residential as well as office, retail, and service areas, but Altadena residents are generally employed outside their home community. From 1980 to 1990, Altadena's population rose 3.9 percent to 42,658 (JPL, 1994).

Bordering JPL to the west is La Cañada-Flintridge. Most residents commute outside of La Cañada-Flintridge to work. From 1980 to 1990, the population declined 2.9 percent to 19,578 (JPL, 1994).

Land Use and Natural Resources

JPL is an active research and development facility that performs light industrial activities. The perimeter of the facility is surrounded by an 8-foot high chain link fence with motion detectors; access to the facility is controlled at all times (JPL, 1994). Adjacent areas to the east and west of the facility, except for Arroyo Secco, are primarily residential; the adjacent Arroyo Secco area to the east and south includes a reservoir, park, ranger station, fire station, and equestrian club; directly north of the facility are the San Gabriel Mountains and the Angeles National Forest.

Groundwater beneath JPL has never been pumped for use as drinking water (JPL, 1997e). Employees at JPL receive public drinking water from the city of Pasadena. Pasadena currently pumps groundwater from three Raymond Basin wells, blends and treats the "raw"water from the wells at the Devils Gate Groundwater Treatment Facility, and then sends the water to the Windsor Reservoir before delivering the "finished" — treated and blended—drinking water to area customers.[1] In addition to groundwater sources, about 60 percent of the city of Pasadena's water supply comes from the Metropolitan Water District of Southern California (MWDSC). The MWDSC's imported water supplies are from northern California via the California Water Project and its supply from the Colorado River (Raymond Basin, 1998b).

JPL is situated on an alluvial fan formed by sediments that washed down from higher ground in the San Gabriel Mountains. The facility is located in the Monk Hill Sub-Basin of the Raymond

[1] The city of Pasadena has four wells located near JPL, but only three are currently operating since the Arroyo well's closure in June/July 1997 (City of Pasadena, 1999).

Basin, an aquifer covering approximately 40 square miles which is replenished by water flows from the San Gabriel Mountains, including the Arroyo. The Raymond Basin is an important source of drinking water for many communities in the area including Alhambra, Altadena, Arcadia, La Cañada-Flintridge, Pasadena, San Marino, and Sierra Madre. Sixteen water purveyors, who are each allowed to pump a certain amount of water per year, supply groundwater from the Raymond Basin to the public. In 1944 the Superior Court of California approved the Raymond Basin Judgement, which adjudicated the rights to groundwater production to preserve the safe yield of the groundwater basin (Raymond Basin, 1998b). Under authority of a 1984 court order, the Raymond Basin Management Board, made up of representatives of the water purveyors, oversees the management and protection of the Raymond Basin (Raymond Basin, 1997a, 1997b). A total of six Raymond Basin water purveyors operate wells within 4 miles of JPL. The closest—within 2,500 feet of JPL—are four drinking water wells, directly east of the Arroyo Secco, that are operated by the city of Pasadena. Other nearby municipal wells are located in Altadena, La Cañada-Flintridge, and Pasadena (locations of nearby drinking water wells and monitoring wells are shown in Figure 3).

The climate in Pasadena is semiarid and is characterized by hot, dry summers and mild winters with intermittent rain. The average annual precipitation in the area is 22.5 inches. The local aquifer is recharged by both natural infiltration of precipitation and artificial recharge from spreading grounds located on the eastern edge of the Arroyo Secco. The spreading basins and the Arroyo Secco are used for flood control during rainy months (December to March), when the intermittent stream running through the arroyo reaches its highest levels. The arroyo drains into the Devil's Gate Reservoir located 1 mile south of JPL. The reservoir is formed by the Devil's Gate Dam, which is situated at the southern edge of the reservoir by Interstate 210. The level of the reservoir fluctuates during the year, with little or no standing water present during dry seasons. During major floods, water has risen over portions of Hahamonga Community Watershed Park to the west and the spreading basins to the east. The Devil's Gate Dam and Reservoir has undergone renovations that should result in a several-acre-large permanent pond. The level of this pond will be raised and lowered throughout the year to maintain proper flow downstream of the dam. There are no other lakes, ponds, or wetlands in the vicinity of JPL.

ATSDR Involvement

ATSDR conducted initial site visits at JPL on August 12 and August 20, 1997, to meet with JPL environmental personnel and state public health and environmental officials and to gather information pertinent to the preparation of a public health assessment (PHA) for this site. On December 2 and 3, 1997, ATSDR conducted another site visit to collect further information for the PHA and held four public availability sessions near JPL to provide community members an opportunity to ask questions and voice their concerns regarding public health issues at JPL. Those public availability sessions were announced in a November 19, 1997 ATSDR-issued press release. sent to major and local news media of the Los Angeles-Pasadena area. Eleven community members attended and expressed concerns. ATSDR addresses their concerns in the "Community Health Concerns" section of this PHA.

On August 4, 1998 ATSDR release the Jet Propulsion Laboratory Public Health Assessment (PHA) for public review and comment. That public comment period ended September 20, 1998. During that period ATSDR received comments or questions from six individuals and two organizations or agencies. Subsequently, ATSDR met with two individuals to obtain clarification on their concerns.

Quality Assurance and Quality Control

In preparing this public health assessment (PHA), ATSDR relied on the information provided in the referenced documents and from the referenced contacts. ATSDR assumes that adequate quality assurance and control measures were followed with chain-of-custody, laboratory procedures, and data reporting. The validity of the analyses and conclusions drawn in this document are dependent on the availability and reliability of the referenced information.

EVALUATION OF POTENTIAL PATHWAYS OF EXPOSURE

Introduction

In this section, ATSDR evaluates whether a public health hazard exists for people who live near or access the JPL site. In evaluating health hazards, ATSDR first tries to establish whether individuals could have been (past), are (present), or could be (future) exposed to chemicals originating from the JPL site. ATSDR does this by carefully evaluating the elements of an *exposure pathway* that might lead to human exposure. These elements, include a source of contamination, an environmental medium (such as soil, water, or air) in which contaminants may be present, a point of human exposure, a route of human exposure (such as ingestion, inhalation, or skin contact), and a receptor population (such as nearby residents). Figure 4 explains the exposure evaluation process in more detail.

ATSDR identifies exposure pathways as completed or potential. A completed exposure pathway exists in the past, present, or future if all elements of the exposure pathway are present and if the receptor population has been, is, or will be exposed to the contaminants in sufficient concentration and/or duration that adverse health effects could result. Potential pathways, however, are defined as situations in which at least one of the pathway elements is missing, but could exist.

If exposure was or is possible, ATSDR considers whether chemicals were or are present at levels that might be harmful to people. ATSDR does this by screening the concentrations of contaminants in an environmental medium against health-based comparison values. Comparison values are chemical concentrations that health scientists have determined are not likely to cause adverse effects, even when assuming very conservative exposure scenarios designed to be protective of public health. Because comparison values are not thresholds of toxicity, environmental levels of contaminants that exceed comparison values would not necessarily produce adverse health effects. If a chemical is found in the environment at levels exceeding its corresponding comparison value, ATSDR examines the duration of potential exposure variables and the toxicology of the contaminant. Through examination of both the level and duration of exposure to contaminants ATSDR makes a determination on the potential public health hazard that may arise from exposure to contaminated environmental media.

ATSDR's evaluation of potential public health hazards associated with areas of concern at JPL is summarized in Table 1. Except for the completed and potential exposure pathways for groundwater and soil, other pathways are not associated with any known public health hazards because: 1) no site-related contamination is present, 2) contaminant concentrations detected are too low to pose health hazards, and/or 3) exposure to the general public has been prevented. ATSDR summarizes its evaluation of the completed and/or potential groundwater and soil exposure pathways in Table 2 and describes it in more detail in the discussion that follows. To acquaint readers with terminology used in this report, a glossary and comparison values list are included in Appendices A and B, respectively.

Evaluation of Groundwater/Drinking Water Exposure Pathway

Has groundwater contamination from the JPL site resulted in municipal drinking water that is unsafe for local residents or JPL employees to drink?

Conclusions

- Groundwater at JPL has not affected the health of facility employees because on-site groundwater has never been used for drinking water.

- Off-site groundwater with VOC contamination does not pose a past or present public health hazard. Although VOCs were found in groundwater monitoring wells and in raw water of nearby public supply wells, area water purveyors have taken and continue to take measures (e.g., well water blending, water treatment, or well closure) that improve the quality of finished drinking water delivered to the public. Furthermore, as required by the California Department of Health Services, water purveyors regularly monitor drinking water for VOCs to ensure that it meets safe drinking water standards.

- Off-site groundwater with VOC contamination is not expected to pose a future public health hazard. Area water purveyors are aware of the contamination in the water basin and will continue to monitor, blend, and treat water to safe levels. If contaminant levels continue to rise in the water basin, however, water purveyors may need to take additional measures to preserve the quality of drinking water, including closing more wells, building more treatment systems, increasing their treatment capacities, and/or buying imported water.

- Perchlorate contamination in off-site groundwater presents no apparent present or future public health hazard. The current sampling and well water blending procedures used by the drinking water purveyors near JPL help to prevent any potential present or future public health hazards posed by perchlorate in groundwater. Past exposures to perchlorate contamination present an indeterminate public health hazard because there are no data on perchlorate levels before 1997. Based on the available data, however, it is unlikely that past perchlorate levels in groundwater posed a public health hazard.

Discussion

Hydrogeology

As discussed in "Land Uses and Natural Resources," JPL is situated in the Raymond Basin aquifer, which is a significant source of drinking water for many nearby communities. Groundwater has been encountered in monitoring wells at JPL at depths of 100 to 240 feet below ground surface. Groundwater flows predominantly south and southeast from JPL toward the

Arroyo Secco, *although the direction can change, and even reverse for short periods of time*, depending on seasonal variations, pumping rates of the various supply wells in the area, and the quantity of infiltration of surface runoff water in the Arroyo Secco basins (Ebasco, 1993). Groundwater elevations at JPL are generally lower between July and December and higher between January and June.

Thrust faults in the vicinity of JPL include the Mount Lukens Thrust Fault, the south branch of the San Gabriel Thrust Fault, and the JPL Thrust Fault. These faults comprise part of the Sierra Madre Fault system that separates the San Gabriel Mountains from the Raymond Basin. The JPL Thrust Fault runs along the hillside at the uphill edge of the JPL campus, and creates an uplifted, or perched, aquifer that is separate from the larger regional aquifer (Ebasco, 1993).

Groundwater Quality and Sources of Contamination

Through the RI and previous investigations, JPL has installed a total of 19 monitoring wells on site and in the adjacent Arroyo Secco to characterize contaminant concentrations in groundwater beneath source areas of the site, and to track contaminant movement (see Figure 3). There are a number of suspected contaminant source areas at JPL. Some of the source areas include seepage pits, waste pits, stormwater discharge points, and spill areas where hazardous waste may have been released indirectly to groundwater through the soil.

Many of these monitoring wells have screens at several different depths in the aquifer to provide information about the three-dimensional distribution of contaminants beneath JPL. Since August 1996, JPL has sampled its monitoring wells quarterly and analyzed the samples for VOCs and metals; JPL now analyzes these quarterly samples for perchlorate, as well (Foster Wheeler, 1997a, 1997b).

As part of the RI/FS, JPL has also installed five off-site monitoring wells to the south and east of the facility, in Altadena, Pasadena, and the Hahamonga Community Watershed Park (see Figure 3). These wells will help identify groundwater contamination that may have migrated from JPL and determine the horizontal and vertical extent of contamination. JPL also samples these wells quarterly.

The available data indicate that JPL is a source of VOC and perchlorate contamination in both on-site and off-site groundwater. Of the contaminants detected on site, TCE, CTC, 1,2-DCA, and perchlorate were detected most frequently and at concentrations above California maximum contaminant levels (MCLs) or action levels. The highest concentrations of these chemicals were found in the north-central portion of the site, just downgradient from the Liquid and Solid Propellant Laboratory and the Assembly Handling and Equipment and Shipping Facility.

Much lower concentrations of VOCs and perchlorate have migrated off site. Following the current direction of groundwater flow (southeastward), CTC, TCE, and perchlorate plumes have migrated approximately 2,500 feet downgradient toward the city of Pasadena and Lincoln Avenue Company production wells. (1,2-DCA has not been observed at any off-site well over the course of the RI groundwater monitoring.) While the highest levels of these VOCs were largely found in the upper layer of the aquifer, lower levels (0.5 to 5 ppb) had extended vertically to the deeper aquifer and laterally to the city of Pasadena wells. Concentrations and direction of contaminant flow can fluctuate in response to pumping of wells and seasonal variations in groundwater elevations. *Since 1996, however, the shapes of the plumes have stayed relatively stable, suggesting that widespread or higher levels of contaminants are not traveling further downgradient and in the direction of public water supply wells* (Foster Wheeler, 1998a).

Groundwater investigations performed by JPL indicate that VOC concentrations beneath JPL vary seasonally and may indicate the presence of an off-site sources in addition to on-site sources (JPL, 1997b). One such potential source of contamination is associated with the use of septic systems in La Cañada-Flintridge, an area without sewers. According to JPL and the Valley Water Company, citizens in these areas have often cleaned their plumbing pipes by pouring solvent down their drains (JPL, 1997a; Raymond Basin, 1997a).

The groundwater investigation conducted by JPL of Operable Units 1 and 3: on-site and off-site groundwater (Foster Wheeler, 1999) developed additional information on the configuration of the contaminated groundwater plumes and the distribution of contaminants within those plumes. Although not conclusive, the evidence gathered strongly suggests that potential additional sources of groundwater contamination lie upgradient to the west, in the direction of the Valley Water Company wells. Because VOCs are used in a wide variety of commercial application, many potential sources exist upgradient for those compounds. The injection of imported Colorado River water for aquifer recharge by Valley Water Company may be the source of additional perchlorate contamination detected in local municipal wells. The source of the perchlorate contamination (recently detected at levels as high as 16 ppb) in the water of the Colorado River may be traced to two sites near Henderson, Nevada associated with the manufacture of ammonium perchlorate.

Drinking Water Use and Quality

Located within 4 miles of JPL are drinking water wells operated by six water purveyors (municipal wells are shown in Figure 4). To the west there are four wells operated by the Valley Water Company and one well operated by the La Cañada Irrigation District. To the east and southeast there are four wells owned by the city of Pasadena, of which three are currently used; two wells operated by the Lincoln Avenue Water Company; two wells operated by the Rubio Canyon Land and Water Company; and one well operated by the Los Flores Water Company. Table 3 summarizes raw well water monitoring data for chemicals that exceed comparison values for each of these drinking water sources. It should be noted that raw water is pretreated and unblended water in the municipal wells. Raw water is processed before it is delivered to area consumers as finished water for drinking and other domestic uses. By such processes as blending with other water sources and effectively treating the water, area water purveyors are able to dilute and/or remove chemicals that may have been present in raw water.

The following discussion describes water quality information maintained by water purveyors about their systems.

Volatile Organic Compounds

VOC contamination has been detected in the raw water of wells belonging to three water purveyors located adjacent to JPL: the city of Pasadena and the Lincoln Avenue Water Company, to the east of JPL; and Valley Water Company, to the west. At various times the concentrations of TCE and CTC in the raw water drawn from some of these wells have exceeded drinking water standards and the purveyors have temporarily shut down some drinking water wells. As Table 3 indicates, some of the highest levels of CTC and TCE were found in raw water from the city of Pasadena's Arroyo well, located about 2,500 feet downgradient from and the closest to the site. The Arroyo well has been closed since June/July 1997 (City of Pasadena, 1999). PCE is also present in Valley Water Company wells (JPL, 1997d; Raymond Basin, 1997a), but the small amounts of PCE found at JPL makes it an unlikely source of the well water contamination. It should be noted that VOCs have not been detected or have not exceeded standards in raw water in municipal wells located farther away from JPL (La Cañada Irrigation District, Rubio Canyon Land and Water Company, and Los Flores Water Company) (JPL, 1997d; La Cañada, 1998; Rubio Canyon, 1998; Los Flores, 1998).

The California Department of Health Services (CDHS) sets and oversees sampling schedules for water purveyors in the area and throughout California to ensure that VOCs (and other chemicals) are adequately monitored. Through its Domestic Water Quality and Monitoring Regulations (Chapter 15, Title 22, California Code of Regulations), CDHS specifically requires a water purveyor to perform VOC sampling of raw water and submit the results to CDHS (Raymond Basin, 1998a). A water purveyor may need to adjust the water monitoring schedule as VOC concentrations in the wells change. The scheduled sampling for VOCs is as follows:

- Sample before beginning water distribution operations.

- Sample every three years unless or until VOCs are detected.

- Sample quarterly once VOCs have been detected, unless or until the contaminant concentrations exceed the drinking water standard. The water purveyor is required to take steps to reduce the contaminant concentration or shut down the contaminated well. If this occurs the water purveyor must also inform its customers about the detected contamination.

- On a case-by-case basis, sample finished water if detections in raw water exceed drinking water standards. This sampling is usually required monthly.

Area water purveyors are aware of the contamination problem in the water basin, but they have taken several measures to help safeguard against unacceptable levels passing through the system and reaching area consumers. These measures include:

- *Treat water to remove VOCs.* Each of the water purveyors now operates some type of water treatment system (e.g., air stripping or activated carbon filtering) to remove VOCs.

- *Blend water from all wells.* Since the VOC levels vary among their drinking water wells, some water purveyors are often able to blend well water from different wells to reduce the overall VOC concentrations to below drinking water standards. (Table 4 summaries the wells used by each of the area water purveyors.) For example, Pasadena has pooled raw water from the Arroyo well (1930) with water from the Windsor well (1918) and the Ventura well (1924), and later with Well 52 (1977). Water from these other wells has historically shown lower levels of contaminants, if any, than raw water drawn from the Arroyo well.

- *Blend well water with imported water.* The purveyors also have the option of blending their well water with imported water to augment their drinking water supplies. Table 4 presents information on the percent of imported water used by each water purveyor. As the table indicates, the city of Pasadena draws as much as 60 percent, the Lincoln Avenue Water Company draws as much as 20 percent, and the Valley Water Company draws as much as 75 percent from imported water sources.[2] Blending well water with imported water enables the water purveyors to dilute chemicals, if present, and deliver safe drinking water to their customers. For example, by blending well water containing PCE (even up to 17 ppb) with water imported from the MWDSC, the Valley Water Company has met safe drinking water standards.

Together these processes would be expected to greatly dilute VOC concentrations measured in raw water. Additional reduction of VOCs in the water is likely to occur when VOCs are released or volatilized—that is, converted from a liquid into a vapor—as the water flows through the distribution system.

Perchlorate

The presence of perchlorate in groundwater did not become a concern until a sensitive test to detect perchlorate was introduced in early 1997. Since then, CDHS has recommended that water purveyors and responsible parties at hazardous waste sites analyze groundwater for perchlorate using the new test method. CDHS has set a conservative provisional drinking water standard (called an "action level") of 18 ppb. Perchlorate has been detected above the action level in the Pasadena drinking water well located closest to JPL (the Arroyo Well, shown in Figure 3). Perchlorate has been detected at much higher levels (maximum detection=1,230 ppb) in monitoring wells at JPL (Foster Wheeler, 1997b; Foster Wheeler, 1998a). The city of Pasadena closed the affected drinking water well as a result of the perchlorate detection. Perchlorate levels subsequently rose above the action level in the next Pasadena well downgradient to JPL (Well No. 52, see Figure 3). By blending the water from this well with water from the remaining drinking water wells, Pasadena has been able to avoid shutting down Well No. 52 while still providing finished water that is below the action level for perchlorate (City of Pasadena, 1998). Perchlorate has been detected below the action level in the other two Pasadena drinking water wells and in the wells of other nearby water purveyors. (See Table 3 and Appendix C for a summary of available information on perchlorate and its occurrence at and near JPL.)

Perchlorate levels in and around JPL before 1997 are unknown. Several factors suggest, however, that high levels of contamination may have never reached residential taps.

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[2] Local purveyors prefer not to import water because the cost of imported water is generally much higher than the costs of treatment (Raymond Basin, 1997a).

- The hydrogeologic and contaminant data given in the groundwater RI (Foster Wheeler, 1999b) and the results of the quarterly groundwater monitoring indicate that the operation of the Arroyo well has exerted considerable influence on groundwater flow in the area; drawing contaminants towards that well and limiting the spread of contaminants elsewhere.

- The rise in perchlorate levels in nearby Pasadena Well #52 began after pumping of the Arroyo well had ceased, suggesting that perchlorate levels were actually lower in other Pasadena of Lincoln Water wells in the past.

- The Arroyo well had perchlorate levels above the action level when perchlorate analysis began, but since the other three Pasadena wells did not, blended water from all four wells probably did not exceed the action level. The Arroyo well has not been used since June/July 1997.

- The action level for perchlorate is considerably lower than levels shown to cause harmful effects in available studies of communities, workers, and laboratory animals.

Exposure Pathway Evaluation

Past Exposures

VOCs and perchlorate have been detected in groundwater monitoring wells on and near JPL and in raw water of nearby drinking water wells operated by Pasadena, Lincoln Avenue Water Company, Valley Water Company, Rubio Canyon, and Los Flores, but it is unlikely that people were exposed to harmful levels of contaminants when they drank water. Even though water testing data are not available for all years to fully evaluate the likelihood of past exposure, several factors suggest that unsafe levels of chemicals never reached finished drinking water supplies. First, no drinking water wells exist at the JPL facility where the highest levels of contamination exist, and employees have received their drinking water from public water sources. Second, when contaminants have been detected during periodic sampling of the raw groundwater supply, that water has been treated and tested to ensure its safety as drinking water before it is distributed to area customers.

Some people who lived near the JPL facility continue to be concerned about health problems and their relation to contaminants detected in raw well water. To determine if potential health hazards could have existed, ATSDR conservatively estimated exposure doses for an adult and a child assuming that they drank raw water from the affected public wells. Note that this is a highly conservative and unlikely scenario that greatly overestimates possible health risks associated with drinking finished water because no one drinks the raw, untreated or blended groundwater. Actual concentrations, if any, in the finished drinking water would have been much lower than the maximum detected concentrations noted in raw water. This maximum-exposure, hypothetical example is intended to determine whether adverse health effects might arise if exposure occurred at these high levels.

In estimating exposure, ATSDR derived human exposure doses using conservative assumptions about the frequency and duration of potential exposure. ATSDR assumed that a typical adult drank 2 liters of water each day and weighed 70 kilograms and that a child drank 1 liter of water each day and weighed 16 kilograms. Because it is not known when migrating chemicals first reached the wells, ATSDR used an exposure period of 50 years for adults (to consider the years roughly between JPL start up [1945] and well closure [1985 to 1987]) and 6 years for children to calculate a maximum exposure dose. ATSDR also assumed that the drinking water contained the maximum concentrations of VOCs or perchlorate detected at any one well before the well was closed. Furthermore, ATSDR assumed that 100 percent of the water used for drinking came from the raw water of the affected well. These are conservative assumptions about exposure, since most consumers probably drank water from other sources and were probably exposed to much lower concentrations, if any, over the course of a life time.

ATSDR compared the estimated doses with available health guidelines (such as ATSDR's minimal risk levels and EPA's reference doses), cancer guidelines, and with data from available toxicologic studies. (The health guidelines provide a conservative estimate of daily exposures to a chemical that are not likely to result in adverse effects, even for the most sensitive members of a community [e.g., pregnant women, children]). In its analysis, ATSDR found that, even when assuming an individual drank the raw water containing the highest chemical concentrations, the estimated doses are less than or just slightly above the corresponding health guidelines and often many times lower than adverse effect levels reported in medical literature for daily lifetime ingestion of these chemicals. For this reason, ATSDR finds that drinking water in the past, or using it in the home, probably did not harm consumers' health, or increase their risk of cancer. However, because there is no information on past perchlorate levels, ATSDR has assigned past exposures to perchlorate in off-site groundwater as an indeterminate public health hazard.

<u>Current and Future Exposures</u>

No exposure to harmful levels of contaminants found in groundwater is occurring now nor is likely to occur in the future. As mentioned above, the groundwater beneath the site is not used for drinking water and water purveyors continue to monitor, blend, and treat well water to remove contamination from raw water, if present, before distributing the finished drinking water to the consumer. If contamination is routinely detected in wells in the future, the water purveyor is required to close the well.

Perchlorate has been detected above the CDHS action level in two Pasadena drinking water wells. By closing one well, the Arroyo well, and blending water from the second well with the remaining drinking water wells, Pasadena is producing finished water that is below the action level for perchlorate (City of Pasadena, 1998). Perchlorate has been detected below the action level in numerous other drinking water wells near JPL. CDHS requires regular sampling of drinking water wells where perchlorate concentrations are of potential concern. This regular sampling, together with water blending or well closures (when necessary), now ensures that all water distributed to consumers meets California's action level for perchlorate. ATSDR believes that these actions will continue to eliminate any potential public health hazard posed by exposure to perchlorate in groundwater near JPL.

Evaluation of Soil Exposure Pathway

Could exposure to soil contamination at JPL result in adverse human health effects?

Conclusion

No public health hazards are associated with exposure to contaminated soils at JPL. Contaminants in on- and off-site (in the Arroyo Secco near the JPL boundary) soils were detected at levels that pose no public health hazard and were inaccessible to JPL workers or the public because of their depth below the ground's surface or were located where exposure was infrequent or unlikely. VOC vapors were detected in relatively shallow soil in the area of Building 107, but indoor air quality sampling in this building detected no VOC vapors.

Discussion

Extent and Sources of Soil Contamination

The pre-RI and RI activities for OU 2 have involved measurement of soil gas through probes and wells and collection of subsurface soil samples from over 40 suspected contaminant source areas at JPL and nearby in the Arroyo Secco (Ebasco, 1993; Foster Wheeler, 1997c). Information on these sources is summarized in Table 1. Samples of surface soil (0 to 6 inches deep) generally were not collected at JPL, because most of the suspected source areas are buried beneath pavement, buildings, retaining walls, or flower planters (Foster Wheeler, 1998b). At areas that are exposed at the surface (e.g., the stormwater discharge points), soil sampling began at depths of 1 foot or more. For these areas, ATSDR considered the shallowest samples to be representative of surface soil. Subsurface soil sampling has detected no contamination at levels above health-based comparison values (CVs). Soil-gas sampling has detected areas of soil contamination:

- VOC vapors were detected above CVs for air in numerous soil-vapor probes and monitoring wells at JPL. Most of the detections that exceeded CVs were at depths of 80 to 200 feet below ground surface. CTC was detected above its CV at depths of 11 to 13 feet in soil-vapor probes 31 and 33, which were taken at two locations near Building 107.

Exposure Pathway Evaluation

The majority of suspected contaminant source areas at JPL are located beneath pavement, buildings, retaining walls, and flower planters and are not accessible to JPL employees (the types of cover over each source area are specified in Table 1). In addition, soil sampling has detected no contaminants at concentrations above CVs, although soil-gas sampling has detected VOC vapors above CVs. Although workers could be exposed to currently inaccessible subsurface soils during future excavation, demolition, or construction work, ATSDR assumes that these workers will wear proper protective equipment in accordance with the Occupational Safety and Health Administration (OSHA) regulations.

VOCs were detected above CVs for air in numerous soil-vapor probes and soil-vapor well samples. The majority of these detections were at depths of 80 to 200 feet and are not expected to pose a public health hazard to JPL workers. CTC vapors were detected above CVs at depths of 11 to 13 feet in soil-vapor probes 31 and 33, located directly south of Building 107. VOC vapors in soil at relatively shallow depths have the potential to collect in the lower levels of buildings, where they can pose a public health hazard. Soil-vapor measurements from soil-vapor probes are not necessarily indicative of VOC concentrations in the air at a nearby building, but they can indicate areas where indoor air sampling might be required. In response to ATSDR concerns about potential VOC vapors in indoor air, JPL performed indoor air quality sampling at Building 107. This sampling indicated that VOC vapors were not present in the building.

COMMUNITY HEALTH CONCERNS

Community health concerns have been brought to ATSDR's attention through the PHA process at the JPL site. In 1994, JPL prepared a Superfund Community Relations Plan that details community concerns and develops goals and objectives to better understand the needs of the surrounding community. The plan summarizes the results of two rounds of interviews, conducted in 1991 and 1993, with a total of 43 members of the surrounding communities. Through these interviews, JPL found that overall awareness of environmental problems at the facility was low (JPL, 1994). Nevertheless, interviewees did express concerns regarding groundwater and drinking water quality, current hazardous waste disposal practices. Since these interviews, JPL has conducted remedial investigation activities at the facility and the surrounding communities that address these health and environmental concerns. ATSDR has thoroughly reviewed all available documents from these activities and addresses the communities concerns in the "Evaluation of Potential Pathways of Exposure" section of this PHA.

As previously mentioned, ATSDR conducted four public availability sessions between December 2 and 3, 1997. The following are other specific concerns expressed by community members at these meetings regarding contamination and health effects associated with the JPL site.

- *Concern about future groundwater and drinking water quality.*

Water purveyors surrounding JPL are aware of the contamination problem in their water basin. Currently, they are able to provide, through treatment and well water blending, drinking water that meets regulatory standards. ATSDR acknowledges, however, that with a rise in contaminant levels (especially for perchlorate), purveyors might need costly treatment systems, system upgrades, or drinking water well closures to continue to provide safe water to their customers. They may also need to then replace their lost groundwater capacity with imported water.

If contaminant levels continue to rise appropriate remedial measures may be required to maintain safe drinking water sources. JPL is currently considering remedial options that would reduce or remove contamination from the area groundwater. Under consideration is a laboratory bench scale study of removing perchlorate via ion exchange. Until more is known about the human toxicology of perchlorate (e.g., from the expert peer review) and until such time effective technologies or strategies are identified, however, ATSDR suggests that the best approach to ensuring the availability of a safe source of water is through frequent monitoring of any potentially affected well.

- *Concern about a perceived increase incidence of Hodgkin's disease in communities surrounding JPL.*

ATSDR is not aware of any studies that suggest an elevated rate of Hodgkins' disease exists in the community around JPL. Information available about Hodgkin's disease suggests that it is an uncommon malignancy of the lymphoreticular system that occurs most frequently in young adults (Rothman and Freed, 1989). Most researchers agree that the likely cause of Hodgkin's disease is an infectious agent—a virus in particular; however, neither the virus, nor the cell of origin of the disease have been identified (Michels, 1995).[3] The Epstein-Barr virus has been found at higher levels in individuals with Hodgkin's disease, and is a suspected agent (Herbst et al., 1990; Mueller et al., 1989); however, research suggests that the virus is probably a co-factor and not the single causative agent (Michels, 1995).

While the origin of the disease is likely infectious, socioeconomic and genetic factors also play a role (Rothman and Freed, 1989). The higher the socioeconomic status, the higher the risk of Hodgkin's disease in young adults. Socioeconomic factors (e.g., high maternal education, single facility housing and small family size have been associated with HD in young adults (15 to 39 years), but not in older patients (Gutensohn et al., 1982; Glaser, 1987; Bonelli et al., 1990; Chen et al., 1997). In addition, Hodgkin's disease patients generally had fewer childhood infectious diseases, or had them later in life (Grufferman and Delzell, 1984). Ethnic variation in the disease suggests that a genetic predisposition plays a role (Stiller, 1998). There is a familial link to the disease; however, while siblings of younger adults are at higher risk of contracting Hodgkin's disease, siblings of older adults are not. This suggests an interaction between "environment" and genetic factors (Grufferman and Delzell, 1984).

Although medical researchers suspect that environmental factors may influence whether an individual contracts Hodgkin's disease, no specific environmental agents have been linked to the disease. Some studies have noted a higher than average rate of Hodgkin's disease in worker populations exposed to organic solvents; however, researchers were not able to identify which particular solvent may have been linked to the increased rate of disease (Hardell et al., 1981; Olsson and Brandt, 1980; Swaen et al., 1996). This is because workers are often exposed to multiple chemicals over the course of their work experience. Perchlorate has been potentially associated with cancer of the follicular thyroid cells (EPA, 1999), but it has not been associated with Hodgkin's disease. Similarly, no studies have associated TCE with Hodgkin's disease.

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[3] The cell of origin is the particular cells in the body that the virus attacks, and thus initiates the disease process.

ATSDR CHILD HEALTH INITIATIVE

ATSDR recognizes that infants and children may be more sensitive to exposures than adults in communities with contamination of their water, soil, air, or food. This sensitivity is a result of the following factors: Children are more likely to be exposed to soil or surface water contamination because they play outdoors and often bring food into contaminated areas. For example, children may come into contact with and ingest soil particles at higher rates than do adults; also, some children with a behavior trait known as "pica" are more likely than others to ingest soil and other nonfood items. Children are shorter than adults, which means they can breathe dust, soil, and any vapors close to the ground. Also, they are smaller, resulting in higher doses of chemical exposure per body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Because children depend completely on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at sites such as JPL.

ATSDR has attempted to identify populations of children in the vicinity of JPL and any completed exposure pathways to these children. Children are not regularly or normally present at JPL, although children of JPL employees may visit JPL on occasion. JPL offers a day care service for its employees at a facility located southeast of JPL near La Cañada High School. The following schools are located within one mile southeast of JPL: Flintridge School for Boys, St. Bede School, St. Francis High School, Oak Grove School, and La Cañada High School. Located within one mile east or southeast of JPL are Mt. Lowe Academy, Audubon School, Sacred Heart School, Franklin School, and Five Acres School. These schools are shown in Figure 1. Roughly 1,500 children under the age of ten are estimated to live within 1 mile of JPL. ATSDR did not identify any completed exposure pathways from JPL that are specific to children at nearby schools or residential areas. Like all other people living or working in the vicinity of JPL, children ingest drinking water—supplied by local water purveyors—that has, at least in part, been pumped from aquifers near JPL. This potential groundwater exposure pathway is discussed extensively in "Environmental Contamination and Potential Pathways of Exposure."

CONCLUSIONS

Based on an evaluation of available environmental information, ATSDR has reached the following conclusions:

- On-site groundwater at JPL does not present a past, present, or future public health hazard because on-site groundwater has never been used for drinking and there are no plans to use this groundwater in the future.

- VOC contamination in off-site groundwater does not present a past, present, or future public health hazard because water purveyors, under the supervision of CDHS, have regularly monitored drinking water wells and taken steps (e.g., water blending, water treatment, or well closure) to ensure that the "finished" drinking water distributed to consumers is safe. These actions will continue to prevent exposures to contaminated groundwater in the future.

- Perchlorate contamination in off-site groundwater presents no apparent present or future public health hazard. The current sampling and well water blending procedures used by the drinking water purveyors near JPL are expected to prevent any potential present or future public health hazards posed by perchlorate in groundwater. Past exposures to perchlorate contamination present an indeterminate public health hazard because there are no data on perchlorate levels before 1997. Based on the available data, however, it is unlikely that past perchlorate levels in groundwater have posed a public health hazard.

- Further degradation of groundwater quality could force water purveyors to build new treatment systems, increase their treatment capacities, and/or buy imported water.

- No public health hazards are associated with exposure to contaminated soils at JPL. Contaminants in on- and off-site (in the Arroyo Secco near the JPL boundary) soils were detected at levels that pose no public health hazard and were inaccessible to JPL workers or the public because of their depth below the ground's surface or were located where exposure was infrequent or unlikely. VOC vapors were detected in relatively shallow soil in the area of Building 107, but indoor air quality sampling in this building detected no VOC vapors.

- Community members expressed concern about a perceived increased incidence of Hodgkin's disease in communities surrounding JPL. Most researchers agree that the likely cause of Hodgkin's disease is an infectious agent. No studies to date have associated perchlorate or TCE with Hodgkin's disease, two primary contaminants of concern at JPL.

PUBLIC HEALTH ACTION PLAN

The public health action plan (PHAP) for JPL contains a description of actions taken and those to be taken by ATSDR, JPL, EPA, and CDHS at and in the vicinity of JPL after the completion of this PHA. The purpose of the PHAP is to ensure that this PHA not only identifies ongoing and potential public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The public health actions that are completed, being implemented, planned, or recommended are as follows:

Completed Actions

- JPL and the city of Pasadena installed a treatment system in 1990 to remove VOCs from groundwater detected in Pasadena drinking water wells located east/southeast of JPL.

- All water purveyors in the vicinity of JPL, under the supervision of CDHS, have taken steps (e.g., sampling, well water blending, water treatment, well closure) to ensure that all drinking water supplied to consumers meets drinking water standards.

- JPL performed indoor air quality sampling to ensure that VOC vapors detected in shallow soil near Building 107 are not collecting inside the building.

- In June 1999 JPL released a Draft Final RI report for OUs 1 and 3.

- In February 1999 JPL has released a draft RI report for OU 2.

Ongoing and Planned Actions

- When sufficient information on the toxicological effects of perchlorate become available, ATSDR will review the available information on perchlorate in nearby drinking water wells and further evaluate any potential public health hazards that may have been posed by exposure to perchlorate in groundwater.

- JPL is considering remedial options that would reduce or remove contamination from the groundwater. Currently, they have conducted a study of ion exchange resins for removing perchlorate and are currently evaluating other approaches and technologies. Until a feasible treatment technology or strategy is selected, ATSDR feels that the best approach to ensuring the availability of a safe source of water is through frequent monitoring of any potentially affected well.

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; also known as Superfund), as amended, requires ATSDR to conduct needed follow-up health actions in communities living near hazardous waste sites. To identify appropriate action, ATSDR created the Health Activities Recommendation Panel (HARP). HARP has evaluated the data and information contained in the JPL Public Health Assessment for appropriate public health actions. It has been determined that the Division of Toxicology, ATSDR will prepare a Toxicological Profile for perchlorates.

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REFERENCES

Bonelli, L., Vitals, V., Bistolfi, F., Landucci, M., and P. Bruzzi. 1990. Hodgkin's disease in adults: Association with social factors and age at tonsillectomy. A case study. Int. J. Cancer. 45:423-427.

Bookman-Edmonston. 1997. Draft Raymond Groundwater Basin Perchlorate Contamination Problem Work Plan. Prepared by Bookman-Edmonston Engineering for the Raymond Basin Management Board. September 1997.

California Department of Health Services. *See* CDHS.

CDHS. 1997. Perchlorate in Drinking Water. Fact Sheet. California Department of Health Services. May 1997.

Chen Y.T., Zheng, T., Chou, M-C, P. Boyle. 1997. The increase of Hodgkin's disease incidence among young adults. Cancer. 79(11):2209-2218.

City of Pasadena. 1998. Personal communication with Brad Bowman, Principal Engineer, City of Pasadena Water and Power Department. February 19, 1998.

City of Pasadena. 1999. Personal communication with Farid Niknam, Engineer, City of Pasadena Water and Power Department. March 1999.

Ebasco. 1990a. Expanded Site Inspection Report, NASA-Jet Propulsion Laboratory. Prepared by Ebasco Environmental for NASA-JPL, Pasadena, CA. May 1990.

Ebasco. 1990b. Supplemental Information to the Expanded Site Inspection Report, NASA-Jet Propulsion Laboratory: Hazard Ranking System Documentation. Prepared by Ebasco Environmental for NASA-JPL, Pasadena, CA. November 1990.

Ebasco. 1993. Work Plan for performing a Remedial Investigation/Feasibility study, NASA-Jet Propulsion Laboratory. Prepared by Ebasco Environmental for NASA-JPL, Pasadena, CA. December 1993.

EPA. 1999. U.S. Environmental Protection Agency Office of Water. Overview of perchlorate issues. http://www.epa.gov/ncea/perch/htm

Foster Wheeler. 1997a. Report: Quarterly Groundwater Monitoring Results, February-March 1997. Prepared by Foster Wheeler Environmental Corporation for NASA-JPL, Pasadena, CA. April 1997.

Foster Wheeler. 1997b. Report: Quarterly Groundwater Monitoring Results, June-July 1997. Prepared by Foster Wheeler Environmental Corporation for NASA-JPL, Pasadena, CA. September 1997.

Foster Wheeler. 1997c. Soil-vapor probe, soil-vapor well, and soil boring data collected during RI activities for OU 2. Presented by Foster Wheeler Environmental Corporation to ATSDR on December 5, 1997.

Foster Wheeler. 1998a. Draft remedial investigation report for operable units 1 and 3: On-site and offsite groundwater. Prepared by Foster Wheeler Environmental Corporation for NASA-JPL, Pasadena, CA. September 1998.

Foster Wheeler. 1998b. Personal communication with B.G. Randolph, Foster Wheeler Environmental Corporation. February 27, 1998.

Foster Wheeler. 1999a. Draft remedial investigation report for operable unit 2: Potential on-site contaminant source areas. Prepared by Foster Wheeler Environmental Corporation for NASA-JPL, Pasadena, CA. February 1999.

Foster Wheeler. 1999b. Draft final remedial investigation for operable units 1 and 3: on-site and off-site groundwater. Prepared by Foster Wheeler Environmental Corporation for NASA-JPL, Pasadena, CA. June 1999.

Glaser, S.L. 1987. Regional variation in Hodgkin's disease incidence by histologic subtype in the US. Cancer. 60(11):2841-2847.

Grufferman, S. and E. Delzell. 1984. Epidemiology of Hodgkin's disease. Epidemiol. Rev. 6:76-106.

Gutensohn, N.M. and D.S. Shapiro. 1982. Social class risk factors among children with Hodgkin's disease. Int. J. Cancer. 30:433-435.

Hardell, L., Eriksson, M., Lenner, P., and E. Lundgreen. 1981. Malignant lymphoma and exposure to chemicals especially organic solvents, chlorophenols and phenoxy acids: A case-control study. Br. J. Cancer 43: 169-176.

Hebrst, H., Niedobitek, G., Kneda, M., Hummel, M. et al. 1990. High incidence of Epstein-Barr virus genomes in Hodgkin's disease. American Journal of Pathology. 136(1):13-18.

Jet Propulsion Lab. *See* JPL

JPL. 1991a. Environmental Cleanup Review Fact Sheet No. 1. April 1991.

JPL. 1991b. Jet Propulsion Laboratory Closeup. September 1991.

JPL. 1994. Superfund Community Relations Plan for National Aeronautics and Space Administration Jet Propulsion Laboratory. January 1994.

JPL. 1997a. Personal communication with Charles Buril, Manager, JPL Environmental Affairs Office. November 13, 1997.

JPL. 1997b. Superfund Project packet. Prepared for ATSDR. August 1997.

JPL. 1997c. Interoffice memorandum: Perchlorate in Drinking Water. Results from July 16, 1997 perchlorate sampling. August 15, 1997.

JPL. 1997d. Water sampling data from area water purveyors. Provided to ATSDR December 3, 1997 and June 24, 1998.

JPL. 1997e. Personal communication with Charles Buril, Manager, JPL Environmental Affairs Office. August 20, 1997.

JPL. 1998. Personal communication with Charles Buril, Manager, JPL Environmental Affairs Office. February 18, 1998.

JPL. 1999. Personal communication with Charles Buril, Manager, JPL Environmental Affairs Office. March 24, 1999.

La Cañada. 1998. Personal communication with Doug Laister, Engineer, La Cañada Irrigation District. February 19, 1998.

Lincoln Avenue. 1998a. Personal communication with Bob Heyward, Engineer, Lincoln Avenue Water Company. February 19, 1998.

Lincoln Avenue. 1998b. Personal communication with Bob Heyward, Engineer, Lincoln Avenue Water Company. December 3, 1998.

Los Flores. 1998. Personal communication with Ken Vader, Engineer, Los Flores Water Company. March 3, 1998.

Michels, K.B. 1995. The origins of Hodgkin's disease. Eur. J. Cancer. 4(5):379-388.

Mueller, N., Evans, A., Harris, N., Comstock, G., et al. 1989. Hodgkin's disease and Epstein-Barr. The New England Journal of Medicine. 320(11):689-695.

Olsson, H. and L. Brandt. 1980. Occupational exposure to organic solvents and Hodgkin's disease in men. A case-referent study. Scand. J. Work Environ. Health. 6(4):302-305.

Raymond Basin. 1997a. Personal communication with members of Raymond Basin Management Board. December 3, 1997.

Raymond Basin. 1997b. Watermaster Service in the Raymond Basin. July 1, 1996–June 30, 1997. September 1997.

Raymond Basin. 1998a. Personal communication with Ronald Palmer, Executive Officer, Raymond Basin Management Board. February 10, 1998.

Raymond Basin. 1998b. Comments on the Draft Public Health Assessment for the Jet Propulsion Laboratory. May 14, 1998.

Rothman, H. and N. Freed. 1989. Epidemiology of Hodgkin's disease. JAOA. 89(6):783-785.

Rubio Canyon. 1998. Personal communication with Wally Weaver, Engineer, Rubio Canyon Land and Water Company. March 5, 1998.

Stiller, C.A. 1998. What causes Hodgkin's disease in children ? Eur. J. Cancer. 34(4):523-528.

Swaen, G.M., Slangen, J.M., Ott, M.G., Kusters, E., et al. 1996. Investigation of a cluster of ten cases of Hodgkin's disease in an occupational setting. Int. Archives Occup. Environ. Health. 68(4):224-228.

Valley Water. 1998a. Personal communication with Andy Boytim, Engineer, Valley Water Company. February 19, 1998a.

Valley Water. 1998b. Personal communication with Andy Boytim, Engineer, Valley Water Company. RE: Water quality data. November 1998.

Valley Water. 1999. Personal communication with Andy Boytim, Engineer, Valley Water Company. February 26, 1999.

U.S. Environmental Protection Agency. *See* EPA.

TABLES

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
OU 1: On-site Groundwater				
Groundwater	Carbon tetrachloride (CTC), tetrachloroethylene (PCE), and trichloroethylene(TCE) were discovered in on-site groundwater in 1990. Perchlorate was discovered in 1997.	Since long-term on-site groundwater monitoring began in June/July 1994, CTC (nondetectable (nd)-310 ppb) has been detected above maximum contaminant levels (MCLs) in 12 wells; TCE (nd-73 ppb) has been detected above MCLs in eight wells; and dichloroethane (DCA) (nd-8.9 ppb) has been detected above MCLs in four wells. Perchlorate analysis in January/February 1998 indicated concentrations (nd-1,230 ppb) above California's action level in five wells.	Quarterly groundwater monitoring continues to track contaminant movement. No treatment is currently being performed. The remedial investigation/feasibility study (RI/FS) is ongoing and is scheduled for completion in early 1999. JPL is considering an interim removal action, using soil-vapor extraction, to begin removing volatile organic compound (VOC) vapors in soil that may be contaminating groundwater on site.	No public health hazard is associated with groundwater at JPL because there is no known exposure to groundwater on site.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
OU 2: On-site Contamination Sources				
The following seepage pits and waste pits were used between 1940 and 1960 for disposal of liquid hazardous wastes.				
Seepage Pits 1, 2, 3, 4, and 35	Seepage Pits 1, 2, and 35 are located beneath a paved parking lot north of Building 11, and Seepage Pits 3 and 4 are located beneath flower planters west and north of Building 11, respectively; these sites are inaccessible to JPL employees. Seepage Pits 1 and 2 are located in the area with the longest history of use at JPL. Seepage Pits 3 and 4 apparently were connected to Building 11, where solvents may have been used for plumbing and electrical work. Seepage Pit 35 was connected to former Building 81, which housed workshops, storage rooms, and offices.	Seepage Pit 4 was inaccessible to soil boring. Sampling at Seepage Pits 1 and 35 was performed during a pre-RI investigation. **Soil gas:** Chloroform, CTC, dichloroethene (DCE), and 1,1,1-trichloroethane (TCA) were detected in one or more of these seepage pits. **Subsurface soil[1]:** One semivolatile organic compound (SVOC) was detected below comparison values (CVs) in one sample. No metals were detected above CVs.	No treatment is currently being performed on any OU 2 sites. The draft RI report for OU 2 was completed in February 1999, and will be followed by the FS report. JPL is evaluating an interim removal action, using soil-vapor extraction to begin removing VOC vapors from soil.	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pit 5	This site is located beneath a lawn and concrete sidewalls east of Building 277. Seepage Pit 5 was associated with former Buildings 68, 71, and 127, which may have been used to store solvents used in mixing and developing propellants.	**Soil gas:** CTC, Freon, and TCE were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard. This seepage pit is believed to be buried and is unlikely to have contaminated the surface soil of the lawn.
Seepage Pit 6	This seepage pit is located beneath Mariner Road just south of Building 277 and is inaccessible to JPL employees. This seepage pit may have been associated with the same contaminant sources as Seepage Pits 1, 2, 3, 4, and 5.	**Soil gas:** CTC, Freon, and TCE were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pits 7, 7A, and 7B	Seepage Pit 7 is located beneath Building 103, and Seepage Pits 7A and 7B are located beneath an electrical substation south of Building 103; these sites are inaccessible to JPL employees. Building 103 housed machine, fabrication, and metal shops; solvents and other liquids were allegedly dumped in a drain hole in the floor (Seepage Pit 7).	**Soil gas:** CTC and TCE were detected. **Subsurface soil:** One SVOC was detected below CVs in one soil sample. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pits 8, 9, 13, and 13A	Seepage Pits 8, 13, and 13A are located beneath Building 302 and are inaccessible to JPL employees. Seepage Pit 9 is also suspected to be located under Building 302, but its exact location is unknown. Seepage Pit 8 is a dry well the drained liquids from a testing machine. Seepage Pit 9 may have been connected to a small workshop at former Building 13 or to the credit union at former Building 44. Seepage Pits 13 and 13A may have been connected to a materials and/or chemistry laboratory, and drained to Seepage Pit 8.	Seepage Pits 8, 13, and 13A were inaccessible to soil probing or boring. **Soil gas:** No VOCs were detected at Seepage Pit 9.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pits 10 and 12	Seepage Pit 10 is located beneath pavement, a retaining wall foundation, and bank of nitrogen tanks east of Building 78. Seepage Pit 12 is located beneath a flower bed and pavement south of Building 78. These sites are inaccessible to JPL employees. Building 78 reportedly housed a hydraulics laboratory and chemical test cell; solvents used for cleaning and degreasing were reportedly dumped into drains.	Seepage Pit 10 was inaccessible to soil boring. **Soil gas:** Chloroform, CTC, Freon, PCE, and/or TCE were detected at these sites. **Subsurface soil:** One SVOC was detected below CVs in one sample from Seepage Pit 12. No metals were detected above CVs in Seepage Pit 12.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pit 11	Seepage Pit 11 is located beneath a planted slope and a retaining wall foundation north of Building 113. Seepage Pit 11 was associated with former Building 104, which collected sanitary waste, and Building 101, which may have collected solvent and hydrocarbon wastes.	Seepage Pit 11 was inaccessible to soil boring. **Soil gas:** CTC was detected at this site.	See Seepage Pit 1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard. Seepage Pit 11 is believed to be buried and is unlikely to have contaminated the surface soil of the planted slope it is partially beneath.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pit 14	This site is located beneath the paved patio entryway to Building 302 and is inaccessible to JPL employees. This seepage pit is associated with the same contamination sources as Seepage Pits 10 and 12.	**Soil gas:** Chloroform, CTC, Freon, and TCE were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pit 15 and 16	Seepage Pit 15 is located beneath the foundation of Building 300, and Seepage Pit 16 is located beneath the north end of the paved patio on the east side of Building 303; these sites are inaccessible to JPL employees. Seepage Pit 15 was associated with old test cell buildings and a liquid testing facility where small spills of solvents reportedly occurred over the years. Seepage Pit 16 may have been used for disposal of paint solvents.	**Soil gas:** CTC, Freon, and TCE were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pit 17	This site is located beneath a planted slope located near Building 280. The seepage pit was associated with former Building 55, a solid propellant mixing facility where solvents were reportedly disposed of in sumps.	**Soil gas:** CTC, DCE, and Freon were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard. Seepage Pit 17 is believed to be buried and is unlikely to have contaminated the surface soil of the planted slope it is beneath.
Seepage Pits 18, 19, and 30	Seepage Pit 18 is located beneath Pioneer Road, and Seepage Pit 30 is located beneath a paved parking area off Pioneer road south of Building 117; these sites are inaccessible to JPL employees. Seepage Pit 19 is located beneath Pioneer Road and a planted slope. These seepage pits were associated with a solid propellant test cell where tubs of solvent (e.g., CTC and acetone) were reportedly disposed of in sumps and drains.	Sampling at Seepage Pit 18 was performed during a pre-RI investigation. **Soil gas:** Freon and DCE were detected at Seepage Pit 19 and Freon and TCE were detected at Seepage Pit 30. No VOCs were detected at these sites. **Subsurface soil:** No VOCs were detected in Seepage Pit 18. No SVOCs were detected at Seepage Pits 19 or 30. No metals were detected above CVs in Seepage Pits 18, 19, or 30.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard. Seepage Pit 19 is believed to be buried and is unlikely to have contaminated the surface soil of the planted slope it is partially beneath.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pits 20 and 21	These sites are located beneath or behind retaining wall foundations and are inaccessible to JPL employees. These seepage pits were associated with compressors and a maintenance shop where solvents were used.	These seepage pits were sampled through a single boring. **Soil gas:** Chloroform, CTC, DCE, Freon, and TCE were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pit 22	This site is located beneath office trailers and is inaccessible to JPL employees. This seepage pit is associated with the former wind tunnel building, which had no history of solvent or chemical use.	No sampling has been performed at this site.	See Seepage Pit 1	No public health hazard is associated with this site because there is no evidence that the site ever contained hazardous materials.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pits 23, 24, and 25	Seepage Pits 23 and 24 are located beneath the paved parking area along Explorer Road south of Building 67, and Seepage Pit 25 is located beneath a paved walkway southeast of Building 67; these sites are inaccessible to JPL employees. Although Building 67 has been used primarily as an office building, at one time it did contain small laboratories that may have been connected to seepage pits.	Seepage Pit 25 was inaccessible to soil boring. **Soil gas:** CTC, DCE, Freon, and TCE were detected at Seepage Pits 23 and 24. **Subsurface soil:** One SVOC was detected below CVs in one sample from Seepage Pits 23 and 24. No metals were detected above CVs in Seepage Pits 23 or 24.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pit 26 and 28	Seepage Pit 26 is located beneath Building 299, and Seepage Pit 28 is located beneath a flower planter and Pioneer Road, south of Building 299; these sites are inaccessible to JPL employees. These seepage pits are associated with Building 299, which housed an experimental chemistry laboratory, fluorine propellant test cell, and acid-neutralizing pit. Numerous chemicals were reportedly disposed of in sumps near the building.	Seepage Pit 28 was inaccessible to soil boring. Sampling at Seepage Pit 26 was performed during a pre-RI investigation. **Soil gas:** DCE and 1,1,1-TCA were detected at Seepage Pit 26. **Subsurface soil:** No VOCs or SVOCs were detected at Seepage Pit 26.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pit 27	This site is located beneath the paved parking lot southeast of Building 246 and is inaccessible to JPL employees. This seepage pit was connected to a soils test laboratory which had no history of solvent or chemical usage.	This site was investigated during the pre-RI investigation. The site was ruled out as suspected contamination source area.	See Seepage Pit 1	No public health hazard is associated with this site because there is no evidence that the site ever contained hazardous materials.
Seepage Pits 29 and 31	Seepage Pits 29 and 31 are located beneath paved parking/driveway areas off of Explorer Road and are inaccessible to JPL employees. These seepage pits were associated with solid and liquid propellant test cells where solvents were used.	Sampling at Seepage Pit 31 was performed during a pre-RI investigation. **Soil gas:** High levels of CTC, as well as chloroform and TCE, were detected at Seepage Pit 31. CTC, Freon, and TCE were detected at Seepage Pit 29. **Subsurface soil:** No VOCs were detected at Seepage Pit 31. No SVOCs were detected at these seepage pits. No metals were detected above CVs at these seepage pits.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Seepage Pits 32 and 34	Seepage Pit 32 is located beneath a paved walkway south of Building 86, and Seepage Pit 34 is located beneath the paved driveway northeast of Building 98; these sites are inaccessible to JPL employees. These seepage pit were located at the eastern end of a solid propellant preparation area and were reportedly used to dispose of solvents and other chemicals.	Seepage Pit 32 was inaccessible to soil boring. **Soil gas:** Benzene, toluene, ethylbenzene, and xylene, chloroform, Freon, DCA, DCE, PCE, and 1,1,1-TCA were detected at Seepage Pit 34. **Subsurface soil:** No SVOCs were detected at Seepage Pit 34. No metals were detected above CVs in Seepage Pit 34.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Seepage Pit 33	This site is located beneath a paved driveway west of Building 97 and is inaccessible to JPL employees. This seepage was associated with a development laboratory for solid propellant chemistry experimentation where solvents were used to clean hardware. All liquids reportedly were drained to the seepage pit.	**Soil gas:** No VOCs were detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
OU 2: Contamination Sources (continued)				
The following waste pits were used for disposal of municipal wastes and solid and liquid hazardous wastes.				
Seepage Pits 36 and 37	Seepage Pit 36 is located beneath a paved driveway, and Seepage Pit 37 is located beneath Explorer Road; these sites are inaccessible to JPL employees. Seepage Pit 36 was associated with test cells and shops along Jato Road. Seepage Pit 37 was a dry well for a former building with an unknown use.	**Soil gas:** Soil-vapor probe detected chloroform and CTC. Soil-vapor well detected CTC, chloroform, TCE, and PCE. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	See Seepage Pit 1	No public health hazard is associated with these sites because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.
Waste Pits WP-1, WP-2, and WP-5	These sites are located along the eastern property boundary just south of Arroyo Road. WP-1 and WP-2 cross over the property boundary into the Arroyo Seco.	A soil-vapor probe or monitoring well has not been installed at WP-5. **Soil gas:** No VOCs were detected at these waste pits. **Subsurface soil:** No SVOCs were detected at WP-1 or WP-2. No metals were detected above CVs at WP-2. No contaminants were detected above CVs at WP-5.	No treatment is currently being performed on any OU 2 sites. The RI report for OU 2 is under review by regulators, and will be followed by the FS report. JPL is considering an interim removal action, using soil-vapor extraction, to begin removing VOC vapors from soil.	No public health hazard is associated with these sites because contaminants were detected at levels that do not pose a health hazard. Although JPL employees and recreational users (hikers, horseback riders) could access this area, contamination was not detected at levels that pose a public health hazard.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Waste Pit WP-3	This site is located underneath a paved area along Pioneer Road southwest of Building 248 and is inaccessible to JPL employees.	**Soil gas:** Chloroform, CTC, Freon, DCE, and TCE were detected. **Subsurface soil:** One SVOC was detected below CVs in one sample. No metals were detected above CVs.	See Waste Pit WP-1	No public health hazard is associated with this site because subsurface soils are inaccessible and contaminants were detected at levels that do not pose a health hazard.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
OU 2: Contamination Sources (continued)				
The following discharge points received stormwater runoff that may have contained hazardous materials.				
Waste Pit WP-4	This site is located along the eastern property boundary just south of Arroyo Road.	**Soil gas:** Soil-vapor well detected no VOCs. **Subsurface soil:** Polycyclic aromatic hydrocarbons (PAHs) were detected below CVs in one sample. No metals were detected above CVs.	See Waste Pit WP-1	No public health hazard is associated with this site because contaminants were detected at levels that do not pose a health hazard. Although JPL employees and recreational users (hikers, horseback riders) could access this area, contamination was not detected at levels that pose a public health hazard.
Discharge Point DP-1	DP-1 is located approximately 50 feet beyond the eastern property boundary, in the Arroyo Seco.	**Soil gas:** No VOCs were detected. **Subsurface soil:** A dioxin, PAHs, polychlorinated biphenyls (PCBs), and SVOCs were detected below CVs.	No treatment is currently being performed on any OU 2 sites. JPL is considering an interim removal action, using soil-vapor extraction, to begin removing VOC vapors from soil.	No public health hazard is associated with this site because contaminants were detected at levels that do not pose a health hazard. Although JPL employees and recreational users (hikers, horseback riders) could access this area, contamination was not detected at levels that pose a public health hazard.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Discharge Points DP-2, DP-3, and DP-4	DP-2 and DP-4 are located near the eastern property boundary, while DP-3 is located approximately 150 feet beyond the eastern property boundary, in the Arroyo Seco.	Soil boring was performed on DP-2, while test pitting was performed on DP-3 and DP-4. **Soil gas:** No VOCs were detected at DP-2. **Subsurface soil:** PAHs were detected below CVs at DP-3. No metals were detected above CVs at DP-3 or DP-4.	See DP-1	No public health hazard is associated with these sites because contaminants were detected at levels that do not pose a health hazard. Although JPL employees and recreational users (hikers, horseback riders) could access these areas, contamination was not detected at levels that pose a public health hazard.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
OU 2: Contamination Sources (continued)				
The following OU 2 sites are locations of miscellaneous suspected chemical releases.				
Building 197	This building was suspected to have VOC contamination as a result of wind tunnel and propellant operations.	**Soil gas:** Freon was detected. **Subsurface soil:** No SVOCs were detected. No metals were detected above CVs.	No treatment is currently being performed on any OU 2 sites. JPL is considering an interim removal action, using soil-vapor extraction, to begin removing VOC vapors from soil.	No public health hazard is associated with this site because no contamination was detected except for low levels of Freon at depth.
Building 302	A contamination source was suspected to be located beneath Building 302, the Micro Devices Building.	Building 302 was inaccessible to soil boring. JPL attempted to investigate this source area by performing soil gas probes around the edge of the building. **Soil gas:** Soil-vapor probe detected no VOCs.	See Building 197.	No public health hazard is associated with this site because there is no completed exposure pathway to the suspected contamination source area. Sampling around the building did not detect contamination, and any contamination located beneath the building is not accessible to JPL employees.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/Waste Disposal History	Investigation Results/Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Building 306	During excavation of the foundation for this building, JPL discovered an old landfill. This landfill is believed to predate JPL. Soil in the landfill was contaminated with oil which apparently had been used as a dust suppressor.	**Soil gas:** CTC, Freon, 1,1,1-TCA, and TCE were detected. **Subsurface soil:** Subsurface soil samples detected no SVOCs. No metals were detected above CVs.	JPL removed approximately 20,000 cubic yards of contaminated soil. Post-excavation sampling confirmed that the contaminated soil had been removed.	No public health hazard is associated with this site because the petroleum-contaminated soil was removed.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
OU 3: Off-site Groundwater				
City of Pasadena drinking water wells	Four drinking water wells are located within 2,500 feet southeast of JPL, just east of the Arroyo Seco. This water source, in combination with imported water, serves approximately 133,000 people in Pasadena.	Monitoring of wells in 1980 revealed low concentrations of CTC and TCE that gradually increased over time. Low levels of PCE and other VOCs have also been detected periodically. Perchlorate has been detected above California's action level in two drinking water wells and has been detected below the action level in the two other wells.	Two wells were closed in 1985, and two more were closed in 1989 when contaminants exceeded drinking water standards. In 1990, JPL and the city of Pasadena constructed a water treatment plant to remove VOCs from the water and allow the wells to be reopened. The Arroyo Well was closed again in 1997 due to perchlorate contamination.	No public health hazard is associated with VOC contamination in these wells. VOCs have been present above drinking water standards in raw water from some of these wells but, due to treatment and blending, the finished water does not contain VOCs above drinking water standards. Since water purveyors sample their groundwater for VOCs periodically rather than continuously, for short periods of time in the past finished drinking water may have contained VOCs above drinking water standards. However, VOCs in these wells have been at low levels that would not have caused adverse health effects to consumers over short periods of exposure.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
City of Pasadena drinking water wells (continued)		CTC, perchlorate, and TCE have been detected above the MCL/action level in raw water from one or more of these supply wells. The ranges of contaminant concentrations detected above the MCL/action level are as follows: **Cont.** / **Range** / **MCL** **CTC** 5.1 - 13.0 ppb 5 ppb **Perchlorate** 90 - 145 ppb 18 ppb **TCE** 5.0 - 32.0 ppb 5 ppb	Perchlorate has more recently been detected above the action level in Well No. 52. By blending water from this well with water from the remaining wells, Pasadena is reducing the overall perchlorate concentration of its finished water to below the action level. Pasadena performs monthly sampling at each well for VOCs and perchlorate and performs weekly sampling of its finished water for VOCs and perchlorate. The California Department of Health Services (CDHS) reviews these sampling data.	Perchlorate contamination presents an indeterminate past public health hazard because groundwater was not analyzed for perchlorate until 1997. Perchlorate levels may have been lower in the past, because perchlorate levels rose throughout 1997 in the Pasadena wells. Although one Pasadena well had perchlorate levels above the action level when perchlorate analysis began, the other three wells did not exceed the action level, so the blended finished water probably did not exceed the action level. Through regular sampling and well water blending, Pasadena is currently able to keep the perchlorate concentration below the action level in its finished water.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Lincoln Avenue Water Company drinking water wells	Two drinking water wells are located within 3,500 feet southeast of JPL, in Altadena. This water source serves approximately 8,000 people, primarily in Altadena.	Monitoring of wells revealed CTC, PCE, and TCE in both drinking water wells in the early 1980s that gradually increased over time. Perchlorate has been detected below California's action level in these wells. PCE and TCE have been detected above the MCL in raw water from one or more of these supply wells. The ranges of contaminant concentrations detected above the MCL are as follows: **Cont.** / **Range** / **MCL** **PCE** 6.9 ppb* 5 ppb **TCE** 5.9 - 92 ppb 5 ppb * Only one detection was above the MCL.	These two wells were shut down in 1987 when concentrations of TCE exceeded drinking water standards. In 1992, Lincoln Avenue installed a granular activated carbon treatment system and was able to reopen its wells. Through a combination of treatment, blending, and the addition of imported water, Lincoln Avenue has kept its finished water within regulatory standards. Lincoln Avenue performs weekly sampling of its raw and finished water for VOCs and perchlorate. CDHS reviews these sampling data.	No public health hazard is associated with VOC contamination in these wells. VOCs have been present above drinking water standards in raw water from some of these wells but, due to treatment and blending, the finished water does not contain VOCs above drinking water standards. Since water purveyors sample their groundwater for VOCs periodically rather than continuously, for short periods of time in the past finished drinking water may have contained VOCs above drinking water standards. However, VOCs in these wells have been at low levels that would not have caused adverse health effects to consumers over short periods of exposure.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Lincoln Avenue Water Company drinking water wells (continued)				* Perchlorate contamination presents an indeterminate past public health hazard because groundwater was not analyzed for perchlorate until 1997. In light of the current low levels of perchlorate in these wells, however, it is unlikely that past exposure to perchlorate presents a public health hazard.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Valley Water Company drinking water wells	Four drinking water wells are located within 2,500 feet west of JPL. This water source, in combination with imported water, serves approximately 10,500 people in La Cañada-Flintridge. Valley Water uses groundwater only from May through September; for the rest of the year the company relies on imported water. Although JPL is generally downgradient to the wells, increased rainfall and groundwater mounding in the Arroyo Seco can reverse groundwater flow from JPL towards these wells for short periods of time.	PCE and TCE were discovered above drinking water standards through monitoring in the 1985. Perchlorate has been detected below California's action level in these wells. PCE and TCE have been detected above the MCL in raw water from one or more of these supply wells. The ranges of contaminant concentrations detected above the MCL are as follows: **Cont.** / **Range** / **MCL** **PCE** 52 - 110.0 ppb 5 ppb **TCE** 5.9 ppb* 5 ppb * Only one detection was above the MCL.	Valley Water installed an air stripper system in 1993 to treat VOCs. Through a combination of treatment, blending, and the addition of imported water, Valley Water has kept its finished water within regulatory standards. During its groundwater pumping season, Valley Water performs monthly sampling of raw water for VOCs and perchlorate and performs weekly sampling of its finished water for VOCs. CDHS reviews these sampling data.	No public health hazard is associated with VOC contamination in these wells. VOCs have been present above drinking water standards in raw water from some of these wells but, due to treatment and blending, the finished water does not contain VOCs above drinking water standards. Since water purveyors sample their groundwater for VOCs periodically rather than continuously, for short periods of time in the past finished drinking water may have contained VOCs above drinking water standards. However, VOCs in these wells have been at low levels that would not have caused adverse health effects to consumers over short periods of exposure. * See Lincoln Avenue Water Company.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
La Cañada Irrigation District drinking Water wells	Two drinking water wells are located within 3,000 feet west of JPL. This water source, in combination with imported water, has in the past served approximately 8,500 people in La Cañada-Flintridge. These wells had been inactive for some time but were reopened in 1997. Although JPL is generally downgradient to these wells, increased rainfall and mounding in the Arroyo Seco can reverse groundwater flow from JPL towards these wells for short periods of time.	Perchlorate has been detected at concentrations below California's action level. With one exception, any VOCs detected in these wells have been at concentrations below drinking water standards; VOCs temporarily exceeded water standards in one sampling round, but subsequent samples showed contamination had fallen back to below the standards. Nitrate levels have been elevated but below drinking water standards.	La Cañada currently performs yearly sampling of its raw water for VOCs and quarterly sampling for nitrates. CDHS reviews these sampling data. La Cañada has also performed some perchlorate sampling. Because the samples of raw water have met water quality standards, CDHS does not require La Cañada to sample its finished water. As La Cañada begins its injection/recovery program and becomes a larger water producer, CDHS may require a different sampling schedule.	No public health hazard is associated with these drinking water wells. No contaminants have been detected in water from these wells at levels above drinking water standards. * See Lincoln Avenue Water Company.
Rubio Canyon Land and Water Company drinking water wells	Two drinking water wells are located approximately 1 mile southeast of JPL, in Pasadena. This water source, in combination with imported water, serves approximately 7,350 people.	Perchlorate has been detected at concentrations below California's action level. Organic contaminants were detected below drinking water standards in one well in 1989 but have not been detected in later samples.	Rubio Canyon conducts yearly sampling of its raw water for VOCs, and perchlorate sampling when requested by CDHS. CDHS reviews these sampling data. Because no contaminants have been detected above drinking water standards in raw water samples, CDHS does not require Rubio Canyon to sample its finished water.	No public health hazard is associated with these drinking water wells. No contaminants have been detected in water from these wells at levels above drinking water standards. * See Lincoln Avenue Water Company.

Table 1. Evaluation of Potential Public Health Hazards at the Jet Propulsion Laboratory (continued)

Site	Site Description/ Waste Disposal History	Investigation Results/ Environmental Monitoring Results	Corrective Activities and/or Current Status	Evaluation of Public Health Hazard
Los Flores Water Company drinking water wells	One drinking water well is located over 1 mile southeast of JPL, in Pasadena. This water source, in combination with imported water, serves approximately 2,800 people. Los Flores imports water throughout the year, and pumps groundwater only during months of peak demand (usually May to November).	PCE has recently been detected (4.7 ppb) near the federal MCL in the drinking water well. The source of the PCE has not yet been determined. Perchlorate has been detected below the action level.	Due to the recent detection of PCE, Los Flores plans to perform quarterly sampling of its raw water for VOCs (CDHS has not yet assigned Los Flores an updated sampling schedule.) During well operations, Los Flores will also take monthly or bimonthly perchlorate samples, although CDHS has not required this sampling. Because the samples of raw water have met water quality standards, CDHS has not required Los Flores to sample its finished water. Due to the recent PCE detection, however, Los Flores may voluntarily sample its finished water during the next pumping season.	No public health hazard is associated with these drinking water wells. No contaminants have been detected in water from these wells at levels above drinking water standards. * See Lincoln Avenue Water Company.

[1] Samples of surface soil (0 to 6 inches deep) generally were not collected at JPL because most of the suspected source areas are buried beneath pavement, buildings, retaining walls, or flower planters. At areas that are exposed at the surface (e.g., the stormwater discharge points), soil sampling began at depths of 1 foot or more. For these areas, ATSDR considered the shallowest samples to be representative of surface soil.

Sources (OU 1): Foster Wheeler, 1997a, 1997b., 1999b

Sources (OU 2): Ebasco, 1990a, 1993; Foster Wheeler, 1997c, 1998a.

Sources (OU 3): City of Pasadena, 1998; JPL, 1997d; La Cañada, 1998; Lincoln Avenue, 1998; Los Flores, 1998; Raymond Basin, 1997a, 1997b; Rubio Canyon, 1998; Valley Water, 1998; Foster Wheeler, 1999b.

Table 2. Exposure Pathways

Pathway Name	Exposure Pathway Elements						Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Time of Exposure	Exposed Population	
Completed Exposure Pathways							
Off-site groundwater: Perchlorate contamination	Contaminated soil and groundwater at JPL.	Groundwater	Drinking water pumped from aquifers near JPL.	Ingestion Dermal contact Inhal-ation	**Past:** Perchlorate in groundwater was not analyzed before 1997. **Present and future:** Perchlorate has been detected at low levels in most of the drinking water wells in the vicinity of JPL. Perchlorate levels exceed California's action level in some wells, which have been either closed down or blended with water from other wells.	Customers of drinking water purveyors located in the vicinity of JPL.	Perchlorate contamination in off-site groundwater presents no apparent present or future public health hazard. The current sampling and blending procedures used by the drinking water purveyors near JPL are expected to prevent any potential present or future public health hazards posed by perchlorate in groundwater. Past exposures to perchlorate contamination present an indeterminate public health hazard because there are no data on perchlorate levels before 1997. Based on the available data, however, it is unlikely that past perchlorate levels in groundwater have posed a public health hazard.

Table 2. Exposure Pathways (continued)

Pathway Name	Exposure Pathway Elements: Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Time of Exposure	Exposed Population	Comments
Potential Exposure Pathways							
Off-site groundwater: VOCs contamination	Contaminated soil and groundwater at JPL; other off-site sources may also exist.	Groundwater	Drinking water pumped from aquifers near JPL.	Ingestion Dermal contact Inhal-ation	**Past, present, and future:** VOCs have been detected in various drinking water wells since the early 1980s.	Customers of water purveyors located in the vicinity of JPL.	VOC contamination in off-site groundwater does not present a past, present, or future public health hazard because water purveyors, under the supervision of CDHS, have regularly monitored drinking water wells and taken steps (e.g., water blending, water treatment, or well closure) to ensure that the water distributed to consumers is safe. For all purveyors VOCs have been at low levels that would not have caused adverse health effects to consumers over short periods of exposure.

Table 2. Exposure Pathways (continued)

Pathway Name	Exposure Pathway Elements						Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Time of Exposure	Exposed Population	
Potential Exposure Pathways (continued)							
On-site soil	Historical disposal of hazardous wastes to on-site seepage pits, waste pits, and stormwater discharge points; miscellaneous spills and chemical releases.	Surface and subsurface soil	Surface soils beneath grass and other vegetation; subsurface soils exposed through const-ruction.	Ingestion Dermal contact	**Past:** Source areas now covered by pavement, buildings, etc. may have been accessible in the past. **Present and future:** Several seepage pits are located in areas covered with grass or other vegetation. The depths of these seepage pits beneath the surface are not known in all cases, but it is unlikely that any of them are located at the surface.	JPL employees and construction workers	Contaminated soils at JPL do not present a public health hazard because these soils do not contain contaminants at levels that pose a public health hazard and/or they are inaccessible to JPL workers. Although workers could be exposed to currently inaccessible subsurface soils during future excavation, demolition, or construction work, ATSDR assumes that these workers will wear proper protective equipment in accordance with OSHA regulations.

Table 2. Exposure Pathways (continued)

Pathway Name	Exposure Pathway Elements						Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Time of Exposure	Exposed Population	
Potential Exposure Pathways (continued)							
On-site VOC vapors	Historical disposal of VOCs to on-site seepage pits.	Indoor air	Basements/ lower levels of buildings near contaminated soil.	Inhalation	**Past:** VOC vapors were detected at relatively shallow depths in soil-vapor probes 31 and 33, located near Building 107. There are no data on past indoor air quality in this building. **Present and future:** Air quality samples taken in May 1998 showed that there were no VOC vapors in Building 107.	JPL employees in affected buildings.	No public health hazard is associated with indoor VOC vapors because recent sampling indicated that VOC vapors are not present in Building 107.

Table 2. Exposure Pathways (continued)

Pathway Name	Exposure Pathway Elements						Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Time of Exposure	Exposed Population	
Off-site soil	Historical disposal of hazardous wastes to waste pits and stormwater discharge points.	Surface and subsurface soil	Waste pits (WP-1, WP-2, and WP-4) that extend over the property boundary into the Arroyo Seco; off-site stormwater discharge points (DP-1 and DP-3) in the Arroyo Seco.	Ingestion Dermal contact	**Past, present, and future:** Any exposure to contaminated soil through recreational use at these sites is likely to be infrequent and of short duration.	Hikers, horseback riders, and others who use the Arroyo Seco for recreation.	No public health hazard is associated with off-site soil because contaminants were detected at levels that do not pose a health hazard. Although JPL employees and recreational users (hikers, horseback riders) could access these areas, contamination was not detected at levels that pose a public health hazard.

Table 3. Summary of Raw Water Data from Water Purveyors in the Vicinity of JPL

Contaminant	Range of Detections by Well (ppb)[1]				Date of First Detection	Comparison Values (ppb)	Comparison Value Reference
City of Pasadena (Data from 1/80 - 6/93, 10/96-9/97)							
Chemical	*Well No.52*	*Arroyo*	*Ventura*	*Windsor*			
CTC	0.4 - 2.7	0.6 - 13	0.1 - 1.0	0.4 - 5.1	5.1 (6/89)	5 7	MCL child RMEG
TCE	0.3 - 5.6	1.2 - 32	0.1 - 1.0	0.9 - 3.6	1.4 (6/89)	5	MCL
Perchlorate	10	90 - 130	4.0 - 5.0	nd	90 (8/97)	18	CDHS Action Level (AL)
Lincoln Avenue Water Company (Data from 1/80 - 11/96)							
	Well 3	*Well 5*					
PCE	0.1 - 4.1	0.67 - 6.9			0.67 (7/81)	5 100	MCL childRMEG
TCE	0.2 - 72	3.8 - 92			10.1 (1/80)	5	MCL
CTC	0.3 - 2.0	0.6 - 1.9			2.0 (12/90)	5 7	MCL childRMEG
Perchlorate	7.0 - 17	6.0 - 7.0			7.0 (6/97)	18	CDHS AL
Valley Water Company (Data from 12/81 - 9/84, 6/85 - 3/94)							
	Well 1	*Well 2*	*Well 4*	*Well 3*			
PCE	2.5 - 63.8	32	6.2 - 110	0.9 - 2.0	32 (6/85)	5 100	MCL childRMEG
TCE	0.6 - 5.9	1.0	0.6 - 4.6		5.9 (6/85)	5	MCL
Perchlorate	5.0	3.1 - 4.0	5.0	3.2 -4.4	5.0 (6/97)	18	CDHS AL
Rubio Canyon Land and Water Co. (Data from Foster Wheeler, 1999b)							
	Well #4	*Well #7*					
Perchlorate	5.0 - 6.0	4.0			06/97	18	CDHS AL

Las Flores Water Co, (Data from Foster Wheeler, 1999b)							
	Well # 2						
Perchlorate	5.0 - 7.0				06/97	18	CDHS AL

Source: City of Pasadena, 1998; Lincoln Avenue, 1998a; Valley Water, 1998a, 1998b, Foster Wheeler, 1999b.

[1] All sampling data are of **raw water** (before water treatment) from the wellhead, where a contaminant exceeded a comparison value, except for a few Pasadena samples of blended water.

Key: MCL = EPA's maximum contaminant level; RMEG= ATSDR's reference dose media evaluation guide; CDHS=California Department of Health Services.

Table 4. Sources of Drinking Water for Water Purveyors in the Vicinity of JPL

Water Purveyor	Public Drinking Water Wells Near JPL	Date of Operations	Well Water Blending	Water Treatment	% of Local Groundwater / % of Imported Water	Source of Imported Water	Year Imported Water First Used
City of Pasadena	Windsor	1918 - present [1]	Water from four wells is blended in a reservoir before use.	Water treatment plant since September 1990.	40%/ 60%	MWDSC (50% from Colorado River and 50% from Northern California)	1954
	Ventura	1924 - present [1]					
	Arroyo	1930 - 1997					
	Well 52	1977 - present [1]					
Lincoln Avenue Water Company	Well 3	1920 - present [2]	Well water is not blended because wells are operated one at a time.	Water treatment plant since 1992.	80%/ 20%	same	same
	Well 5	1971- present [2]					
Valley Water Company	Well 1	1914 - present	Well water, which is used only during the summer months, is not blended routinely because wells are operated one at a time.	Air stripping unit since 1994.	25-30%/ 70-75%	same	same
	Well 2	1921 - present					
	Well 4	1971 - present					

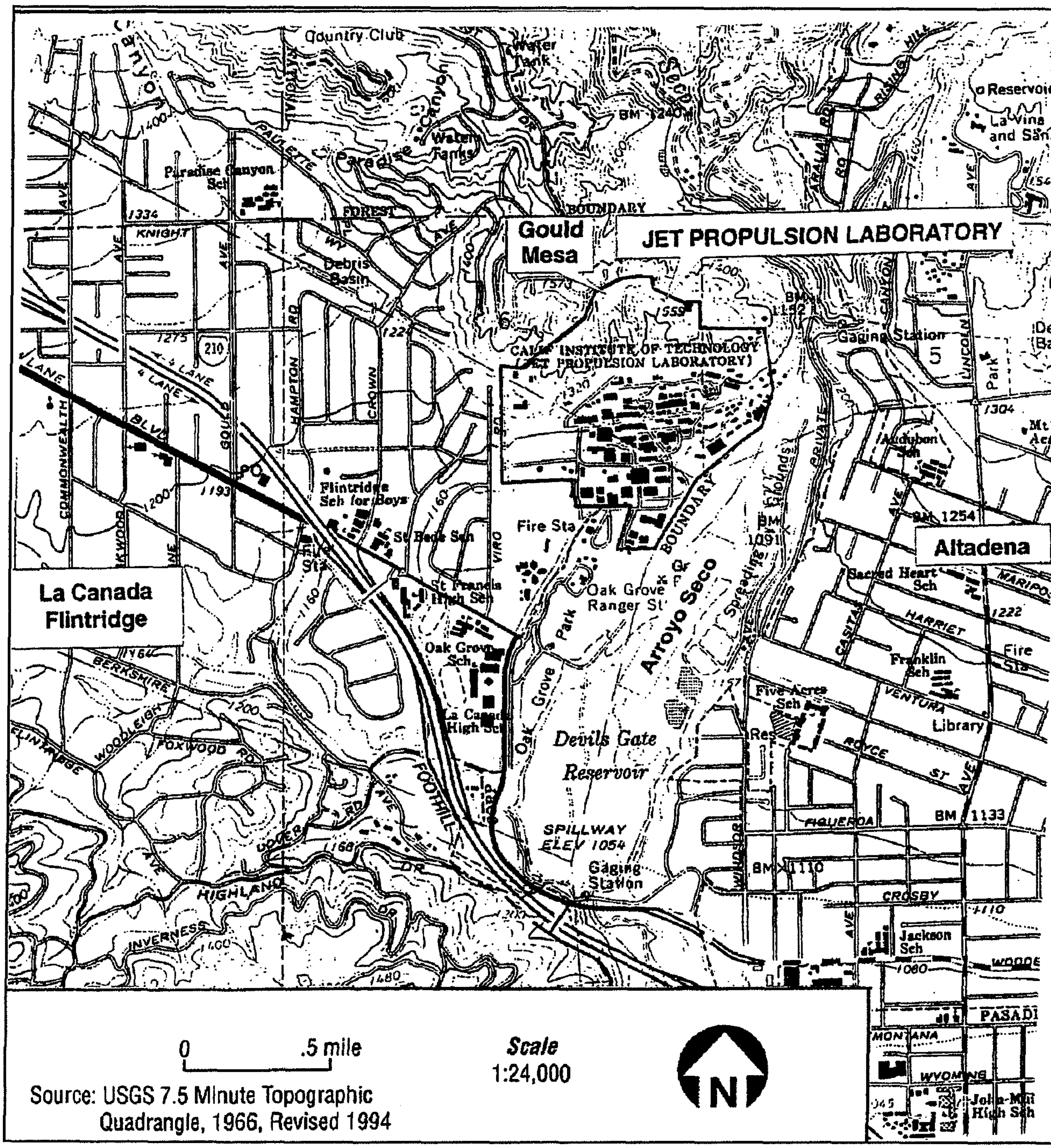
Sources: Lincoln Avenue, 1998b; JPL, 1994; Valley Water, 1999.

[1] Elevated contaminant concentrations forced the temporary closure of two Pasadena municipal wells in 1985, followed by the temporary closure of the remaining two Pasadena wells in 1989. All four wells reopened in 1990 following the start up of the water treatment plant.

Lincoln Avenue Water Company closed their two wells in 1987 due to contamination, but they reopened the wells in 1992 when the water treatment plant went on line.

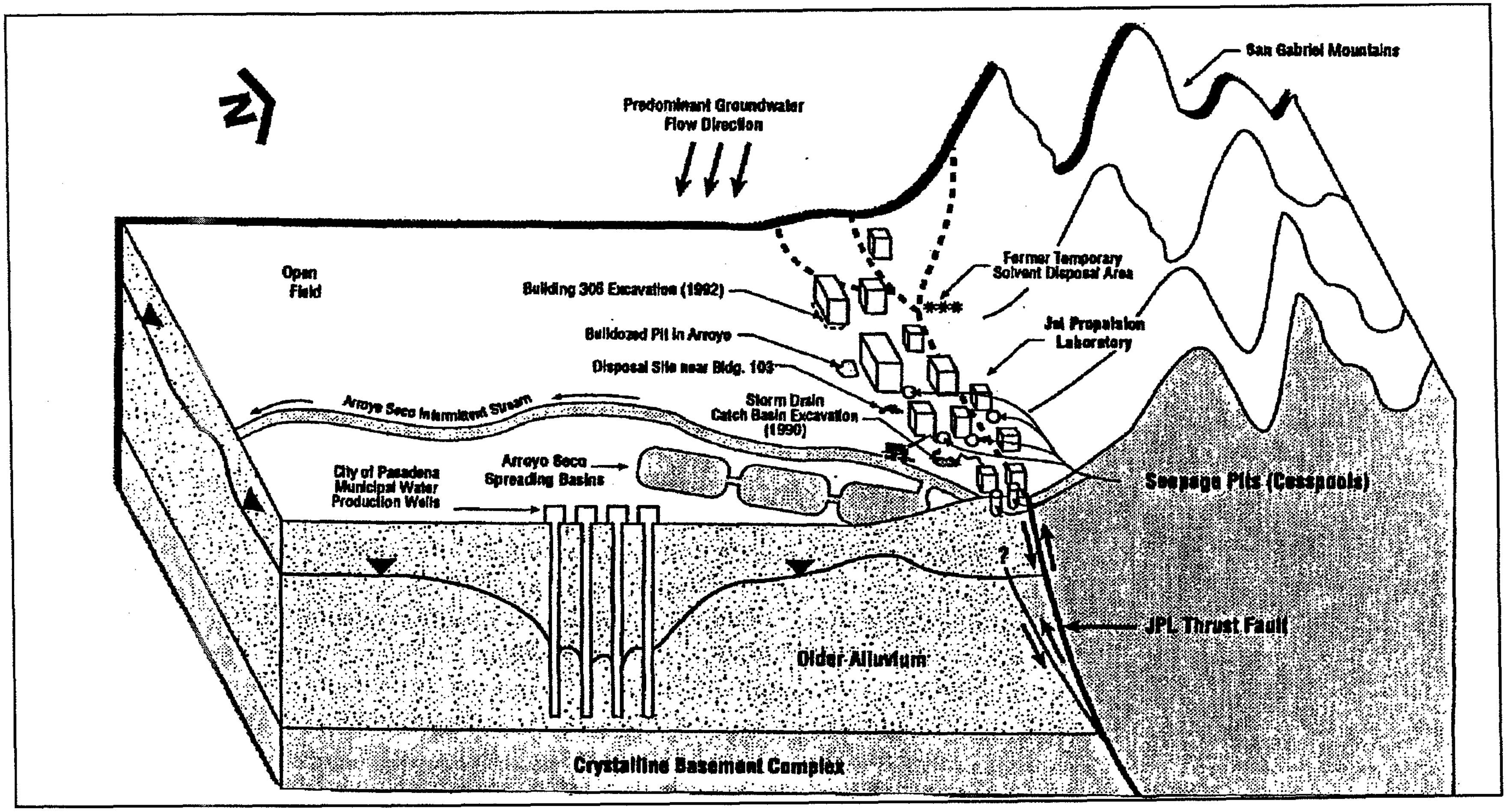
FIGURES

Figure 1. Site Location Map



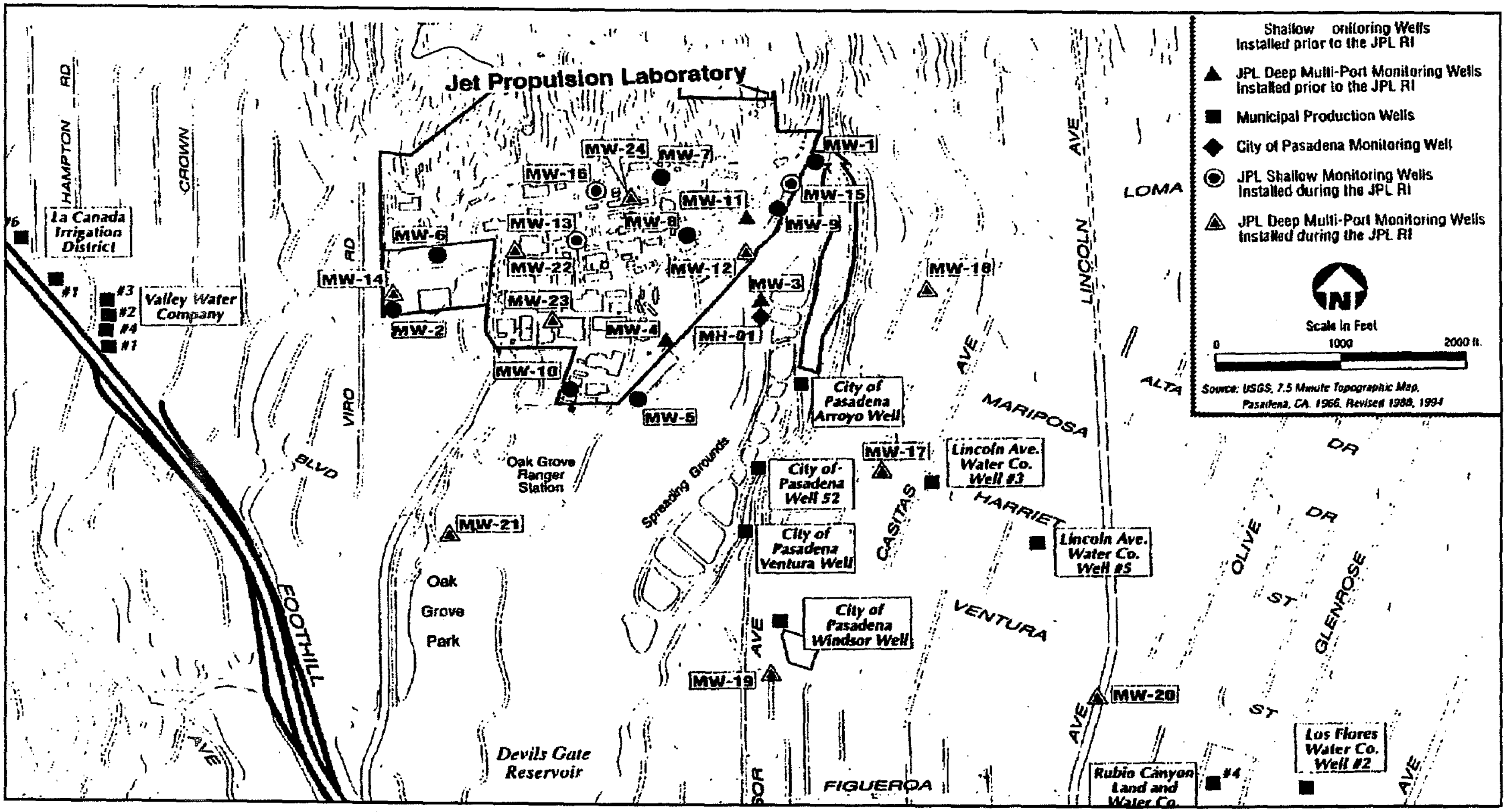
Source: Foster Wheeler, 1998a

Figure 2. Conceptual Model Illustration for the Jet Propulsion Laboratory



Source: Ebasco, 1993

Figure 3. Locations for JPL Groundwater Monitoring Wells and Nearby Municipal Production Wells



Source: Foster Wheeler, 1998a

FIGURE 4. ATSDR's Exposure Evaluation Process

REMEMBER: For a public health threat to exist, the following three conditions must all be met:

- People must come into contact with areas that have potential contamination
- Contaminants must exist in the environment
- The amount of contamination must be sufficient to affect people's health

Are People Exposed To Areas With Potentially Contaminated Media?

For exposure to occur, contaminants must be in locations where people can contact them.

People may contact contaminants by any of the following three exposure routes:

Inhalation
Ingestion
Dermal absorption

→

Are the Environmental Media Contaminated?

ATSDR considers:

Soil
Ground water
Surface water and sediment
Air
Food sources

→

For Each Completed Exposure Pathway, Will the Contamination Affect Public Health?

ATSDR will evaluate existing data on contaminant concentration and exposure duration and frequency.

ATSDR will also consider individual characteristics (such as age, gender, and lifestyle) of the exposed population that may influence the public health effects of contamination.

APPENDICES

APPENDIX A. Glossary

Acute

Occurring over a short time, usually a few minutes or hours. An *acute* exposure can result in short-term or long-term health effects. An *acute* effect happens a short time (up to 1 year) after exposure.

Ambient

Surrounding. For example, *ambient* air is usually outdoor air (as opposed to indoor air).

Analyte

A chemical component of a sample to be determined or measured. For example, if the *analyte* is mercury, the laboratory test will determine the amount of mercury in the sample.

Background Level

A typical or average level of a chemical in the environment. *Background* often refers to naturally occurring or uncontaminated levels.

Carcinogen

Any substance that may produce cancer.

CERCLA

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980, also known as Superfund. This is the legislation that created ATSDR.

Chronic

Occurring over a long period of time (more than 1 year).

Comparison Values

Estimated contaminant concentrations in specific media that are not likely to cause adverse health effects, given a standard daily ingestion rate and standard body weight. The *comparison values* are calculated from the scientific literature available on exposure and health effects.

Concentration

The amount of one substance dissolved or contained in a given amount of another. For example, sea water contains a higher concentration of salt than fresh water.

Contaminant

Any substance or material that enters a system (the environment, human body, food, etc.) where it is not normally found.

Dermal

Referring to the skin. *Dermal* absorption means absorption through the skin.

Dose

The amount of substance to which a person is exposed. *Dose* often takes body weight into account.

Environmental contamination

The presence of hazardous substances in the environment. From the public health perspective, *environmental contamination* is addressed when it potentially affects the health and quality of life of people living and working near the contamination.

Exposure

Contact with a chemical by swallowing, by breathing, or by direct contact (such as through the skin or eyes). *Exposure* may be short term (acute) or long term (chronic).

Exposure Investigation

The collection and analysis of site-specific information to determine if human populations have been exposed to hazardous substances. The site-specific information may include environmental sampling, exposure-dose reconstruction, biologic or biomedical testing, and evaluation of medical information. The information from an *exposure investigation* is included in public health assessments, health consultations, and public health advisories.

Finished Water

Water that has been filtered, blended with water from other source(s), or treated with other chemical or physical processes to produce water that is suitable for human consumption.

Hazard

A source of risk that does not necessarily imply potential for occurrence. A hazard produces risk only if an exposure pathway exists, and if exposures create the possibility of adverse consequences.

Health Investigation

Any investigation of a defined population, using epidemiologic methods, which would assist in determining exposures or possible public health impact by defining health problems requiring further investigation through epidemiologic studies, environmental monitoring or sampling, and surveillance.

Health Consultation

A response to a specific question or request for information pertaining to a hazardous substance or facility (which includes waste sites). It often contains a time-critical element that necessitates a rapid response; therefore, it is a more limited response than an assessment.

Health Outcome Data

A major source of data for public health assessments. The identification, review, and evaluation of health outcome parameters are interactive processes involving the health assessors, data source generators, and the local community. *Health outcome data* are community specific and may be derived from databases at the local, state, and national levels, as well as from data collected by private health care organizations and professional institutions and associations. Databases to be considered include morbidity and mortality data, birth statistics, medical records, tumor and disease registries, surveillance data, and previously conducted health studies.

Ingestion

Swallowing (such as eating or drinking). Chemicals can get in or on food, drink, utensils, cigarettes, or hands where they can be ingested. After *ingestion*, chemicals can be absorbed into the blood and distributed throughout the body.

Inhalation

Breathing. Exposure may occur from inhaling contaminants because they can be deposited in the lungs, taken into the blood, or both.

Media

Soil, water, air, plants, animals, or any other parts of the environment that can contain contaminants.

Minimal Risk Level (MRL)

An *MRL* is defined as an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse effects (noncancer) over a specified duration of exposure. *MRLs* are derived when reliable and sufficient data exist to identify the target organ(s) of effect or the most sensitive health effect(s) for a specific duration via a given route of exposure. *MRLs* are based on noncancer health effects only. *MRLs* can be derived for acute, intermediate, and chronic duration exposures by the inhalation and oral routes.

National Priorities List (NPL)

The Environmental Protection Agency's (EPA) listing of sites that have undergone preliminary assessment and site inspection to determine which locations pose immediate threat to persons living or working near the release. These sites are most in need of cleanup.

No Apparent Public Health Hazard

Sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.

No Public Health Hazard

Sites for which data indicate no current or past exposure or no potential for exposure and therefore no health hazard.

Plume

An area of chemicals in a particular medium, such as air or groundwater, moving away from its source in a long band or column. A *plume* can be a column of smoke from a chimney or chemicals moving with groundwater.

Potential/Indeterminate Public Health Hazard

Sites for which no conclusions about public health hazard can be made because data are lacking.

Potentially Exposed

The condition where valid information, usually analytical environmental data, indicates the presence of contaminant(s) of a public health concern in one or more environmental media contacting humans (i.e., air, drinking water, soil, food chain, surface water), and there is evidence that some of those persons have an identified route(s) of exposure (i.e., drinking contaminated water, breathing contaminated air, having contact with contaminated soil, or eating contaminated food).

Public Availability Session

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

Public Comment

An opportunity for the general public to comment on Agency findings or proposed activities. The public health assessment process, for example, includes the opportunity for public comment as the last step in the draft phase. The purposes of this activity are to 1) provide the public, particularly the community associated with a site, the opportunity to comment on the public health findings contained in the public health assessment, 2) evaluate whether the community health concerns have been adequately addressed, and 3) provide ATSDR with additional information.

Public Health Action

Designed to prevent exposures and/or to mitigate or prevent adverse health effects in populations living near hazardous waste sites or releases. Public health actions can be identified from information developed in public health advisories, public health assessments, and health consultations. These actions include recommending the dissociation (separation) of individuals from exposures (for example, by providing an alternative water supply), conducting biologic indicators of exposure studies to assess exposure, and providing health education for health care providers and community members.

Public Health Advisory

A statement by ATSDR containing a finding that a release of hazardous substances poses a significant risk to human health and recommending measures to be taken to reduce exposure and eliminate or substantially mitigate the significant risk to human health.

Public Health Assessment

The evaluation of data and information on the release of hazardous substances into the environment in order to assess any current or future impact on public health, develop health advisories or other recommendations, and identify studies or actions needed to evaluate and mitigate or prevent human health effects; also, the document resulting from that evaluation.

Public Health Hazard

Sites that pose a public health hazard as the result of long-term exposures to hazardous substances.

Raw Water

A term, when used in reference to a water supply intended for treatment for a public water supply, describes the water extracted directly from groundwater or surface water, prior to filtration, blending with water from other sources, or other chemical of physical treatment processes.

Risk

In risk assessment, the probability that something will cause injury, combined with the potential severity of that injury.

Risk Communication

Activities to ensure that messages and strategies designed to prevent exposure, adverse human health effects, and diminished quality of life are effectively communicated to the public. As part of a broader prevention strategy, risk communication supports education efforts by promoting public awareness, increasing knowledge, and motivating individuals to take action to reduce their exposure to hazardous substances.

Route of Exposure

The way in which a person may contact a chemical substance. For example, drinking (ingestion) and bathing (skin contact) are two different *routes of exposure* to contaminants that may be found in water.

Significant Health Risk

Circumstances where people are being or could be exposed to hazardous substances at levels that pose an urgent public health hazard or a public health hazard; public health advisories are generally issued when urgent public health hazards have been identified.

Superfund

Another name for the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), which created ATSDR.

Superfund Amendments and Reauthorization Act (SARA)

The 1986 legislation that broadened ATSDR's responsibilities in the areas of public health assessments, establishment and maintenance of toxicologic databases, information dissemination, and medical education.

Toxicological Profile

A document about a specific substance in which ATSDR scientists interpret all known information on the substance and specify the levels at which people may be harmed if exposed. The *toxicological profile* also identifies significant gaps in knowledge on the substance, and serves to initiate further research, where needed.

Volatile organic compounds (VOCs)

Substances containing carbon and different proportions of other elements such as hydrogen, oxygen, fluorine, chlorine, bromine, sulfur, or nitrogen; these substances easily become vapors or gases. A significant number of the *VOCs* are commonly used as solvents (paint thinners, lacquer thinner, degreasers, and dry cleaning fluids).

APPENDIX B. Comparison Values

The conclusion that a contaminant exceeds the comparison value does not mean that it will cause adverse health effects. Comparison values represent media-specific contaminant concentrations that are used to select contaminants for further evaluation to determine the possibility of adverse public health effects.

Cancer Risk Evaluation Guides (CREGs)

CREGs are estimated contaminant concentrations that would be expected to cause no more than once excess cancer in a million (10^{-6}) persons exposed over a lifetime. ATSDR's CREGs are calculated from EPA's cancer potency factors.

Environmental Media Evaluation Guides (EMEGs)

EMEGs are based on ATSDR minimal risk levels (MRLs) and factors in body weight and ingestion rates. An EMEG is an estimate of daily human exposure to a chemical (in mg/kg/day) that is likely to be without noncarcinogenic health effects over a specified duration of exposure.

Maximum Contaminant Level (MCL)

The MCL is the drinking water standard established by EPA. It is the maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet. MCLs are considered protective of public health over a lifetime (70 years) for people consuming 2 liters of water per day.

Reference Media Evaluation Guides (RMEGs)

ATSDR derives RMEGs from EPA's oral reference doses. The RMEG represents the concentration in water or soil at which daily human exposure is unlikely to result in adverse noncarcinogenic effects.

APPENDIX B. Comparison Values

The conclusion that a contaminant exceeds the comparison value does not mean that it will cause adverse health effects. Comparison values represent media-specific contaminant concentrations that are used to select contaminants for further evaluation to determine the possibility of adverse public health effects.

Action Level (AL)

Action Levels are based upon a mode-of-action approach that harmonized noncancer and cancer approaches to derive a single oral risk benchmark (RfD). The contaminant concentration expressed in terms of mg/kg/day when applied to the standard default body weight (70 kg) and water consumption (2 L/day) results in an action level expressed as the chemical concentration expressed as parts per billion (ppb). An Action Level is a regulatory level recommended by the EPA or a state health department warrant or trigger a response action under Superfund.

Cancer Risk Evaluation Guides (CREGs)

CREGs are estimated contaminant concentrations that would be expected to cause no more than once excess cancer in a million (10^{-6}) persons exposed over a lifetime. ATSDR's CREGs are calculated from EPA's cancer potency factors.

Environmental Media Evaluation Guides (EMEGs)

EMEGs are based on ATSDR minimal risk levels (MRLs) and factors in body weight and ingestion rates. An EMEG is an estimate of daily human exposure to a chemical (in mg/kg/day) that is likely to be without noncarcinogenic health effects over a specified duration of exposure.

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The MCL is the drinking water standard established by EPA. It is the maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet. MCLs are considered protective of public health over a lifetime (70 years) for people consuming 2 liters of water per day.

Reference Media Evaluation Guides (RMEGs)

ATSDR derives RMEGs from EPA's oral reference doses. The RMEG represents the concentration in water or soil at which daily human exposure is unlikely to result in adverse noncarcinogenic effects.

APPENDIX C. Perchlorate in Groundwater at Jet Propulsion Laboratory

Background

The perchlorate ion (ClO_4^-) is often used by chemists to promote crystallization of compounds. Perchlorate is soluble in water and is a strong oxidant. Ammonium perchlorate (NH_4ClO_4), in particular, is used in the manufacture of solid rocket fuel, fireworks, and explosive devices.

Although perchlorate has been known as an environmental contaminant at some hazardous waste sites, no standardized methods exist for detecting perchlorate in water, and, until recently, perchlorate could not be detected at concentrations below 400 ppb. In 1997, Aerojet Corporation—a company responsible for a Superfund site in southern California where perchlorate has been a contaminant of concern—developed a new analytical method to detect perchlorate concentrations as low as 4 ppb. CDHS subsequently began urging California water purveyors and responsible parties at hazardous waste sites to analyze groundwater for perchlorate using the new test method. Since sampling began in the summer of 1997, perchlorate has been detected at low levels in wells throughout southern California, and at higher levels in some areas. As a result, regulatory agencies, water purveyors, and the public are becoming more aware of perchlorate as a potential contaminant in drinking water and are especially interested in the potential health effects of this contaminant.

Health Effects

In 1992 and again in 1995, EPA evaluated the body of toxicological information on perchlorate and determined that, although there is considerable information about the health effects from short-term exposure to perchlorate, there is not enough information about the effects from long-term exposure (CDHS, 1997). At high levels, perchlorate can interfere with production of thyroid hormones and lead to below-normal levels of thyroid hormones in the blood. This condition, called hypothyroidism, can cause the body to increase its production of thyroid stimulating hormone (TSH). Increased levels of TSH may cause enlargement of the thyroid and a person to feel sluggish, depressed, cold, or tired. Because perchlorate can reduce the body's level of thyroid hormone, in the past doctors used high doses of potassium perchlorate ($KClO_4$) as a drug treatment for people with hyperthyroidism, a condition in which the thyroid produces an above-normal amount of hormones (this condition is often caused by Grave's Disease). Perchlorate treatments were discontinued when some patients developed blood or immune system disorders. However, it is unknown if perchlorate caused these problems (CDHS, 1997). As the interest in perchlorate contamination has grown, EPA and other researchers have begun new studies on the toxicological effects of perchlorate. ATSDR will analyze all new data on perchlorate as they become available, and will use any and all new information to further evaluate the perchlorate contamination at JPL.

Safe Drinking Water Levels

Based on the existing toxicological studies of perchlorate, EPA derived a provisional reference dose (RfD) for perchlorate. An RfD is a dose of chemical to which a person could be exposed over a long period of time without an increased risk of adverse, non-cancer health effects. Using the available toxicological information, EPA estimated that a perchlorate dose of 0.14 mg/kg/day (i.e., a mg of perchlorate absorbed per kilogram of a person's body weight per day) would not be expected to adversely affect a person's thyroid. By applying a safety margin of 300 to 1,000 to this value to account for any uncertainties in the toxicological data, EPA derived an RfD of 1 to 5 x 10^{-4} mg/kg/day. CDHS used the upper limit of this range (0.0005 mg/kg/day) to determine a provisional drinking water standard (called an "action level") of 18 ppb for California. Subsequent review of the toxicology of perchlorate has resulted in a proposed oral benchmark of 0.0009 mg.kg/day (see EPA, 1999). This higher dose would give an action level of about 32 ppb, but formal action or adoption of these values has not yet occurred

Because of the 300-fold margin of safety, the current California action level of 18 ppb would translate to a perchlorate dose that is 300 times less than the lowest dose of perchlorate at which no adverse health affects have been observed. For example, although the action level is 18 ppb, a person could drink 8 cups (approximately 2 liters) of water contaminated with 540 ppb perchlorate and still be ingesting 10 times less perchlorate than the lowest amount at which no health effect has been observed in toxicological studies.

Monitoring Drinking Water for Perchlorate

Since CDHS initiated sampling in 1997, perchlorate has been detected in numerous monitoring and drinking water wells in the Monk Hill Sub-basin and elsewhere in the Raymond Basin. CDHS schedules sampling for the various water purveyors in the area to ensure that perchlorate levels are adequately monitored. CDHS regularly reviews the sampling data from all water purveyors, and adjusts the required sampling schedules as contaminant concentrations in the wells change. If perchlorate concentrations rise above the action level in drinking water wells, CDHS requires the water purveyor to shut down the contaminated well or take other steps (e.g., blending the groundwater with imported water or water from other wells) to ensure that the finished drinking water distributed to consumers meets the action level. If a water purveyor is unable to take these steps, it is required to inform its customers about the contaminated drinking water. In addition to the samples mandated by CDHS, many water purveyors perform more frequent sampling to ensure their compliance with water quality standards. Current sampling schedules of the water purveyors closest to JPL are listed in Table 1.

Perchlorate at JPL

In the summer of 1997, sampling showed the presence of perchlorate in JPL monitoring wells and in Pasadena municipal wells located east/southeast of JPL. Perchlorate concentrations above the CDHS action level forced the closure of the Pasadena drinking water well located closest to JPL (the Arroyo Well—see Figure 3). Perchlorate levels have recently risen above the action level in the next Pasadena well downgradient to JPL, Well No. 52. By blending the water from this well with water from the remaining drinking water wells, Pasadena has been able to avoid shutting down Well No. 52 while still providing finished water that is below the action level for perchlorate (City of Pasadena, 1998). In 1997, JPL sampled tap water from several locations at the facility and did not detect perchlorate above the action level (JPL, 1997c). The current sampling and blending procedures used at the drinking water wells near JPL are expected to prevent any potential present or future public health hazards posed by perchlorate in groundwater.

Perchlorate in groundwater was not analyzed before 1997, so it is unknown what the perchlorate levels in the Pasadena drinking water wells or other nearby wells were in the past. The rise in perchlorate levels observed during 1997 in the Pasadena wells may indicate that perchlorate levels were lower in these wells in the past. Although the Arroyo Well had perchlorate levels above the action level when perchlorate analysis began, the other three wells did not exceed the action level, so the blended water from these four wells probably did not exceed the action level. Even if finished water from these wells did exceed the action level in the past, this action level is very conservative. In fact, the maximum perchlorate concentration detected at JPL to date (615 ppb, in monitoring well MW-16), if present in drinking water, would still translate to a dose of perchlorate that is about eight times less than the lowest dose at which no health effect has been observed in toxicological studies. Based on the available data from JPL, it is unlikely that past perchlorate levels in groundwater have posed a public health hazard. Because there is no information on past perchlorate levels, however, ATSDR considers past exposures to perchlorate in off-site groundwater at JPL to be an indeterminate public health hazard.

Cleaning Up Perchlorate

Previous to the current investigations to determine feasible methodologies to remove the perchlorate anion from drinking water, the only known method of removing low levels of perchlorate from water was a reverse osmosis membrane technique that is very expensive (Bookman-Edmonston, 1997) and has not been implemented on a large scale for drinking water. EPA, the Department of Defense, responsible parties at hazardous waste sites, environmental technology companies, and university researchers are studying potential perchlorate cleanup technologies. JPL and its environmental contractors are currently looking at a number of possible cleanup strategies, including ion-exchange resins and hydrogenation (JPL, 1998). Very promising results have been obtained after conducting a series of large scale tests and a feasible cleanup system may heve been identified for use at JPL (JPL, 1999). The Raymond Basin Management Board has organized a Perchlorate Task Force—made up of water purveyors, state and federal regulators, and other interested parties—to look at ways to prevent, minimize, and clean up perchlorate contamination in the groundwater of the Raymond Basin. ATSDR will evaluate any developments in perchlorate treatment to assess their potential effect on environmental conditions and public health at JPL.

Conclusions

Regular sampling for perchlorate, together with water blending or well closures (when necessary) now ensures that all water distributed to consumers meets California's action level for perchlorate. ATSDR believes these actions will continue to eliminate any potential public health hazard posed by exposure to perchlorate in groundwater near JPL. The presence of perchlorate contamination in groundwater is not without consequences, however. Until an effective treatment is identified, there is no practical way to remove perchlorate from water if perchlorate levels continue to rise in the groundwater near JPL. Therefore, water purveyors may need to close down more of their drinking water wells to prevent contamination. If these water purveyors are forced to replace their groundwater with much more expensive imported water, the increased cost could have a large economic impact on the communities that depend on these water purveyors to supply their drinking water. In addition, the availability of imported water in California can vary dramatically from year to year, depending on a host of conditions throughout the southwestern United States including rainfall, water demand, and ecological conditions. The conservation, preservation, and remediation of groundwater supplies is therefore vitally important to the people of southern California.

APPENDIX D. Population and Housing Data; Census Tract Map

POPULATION DATA TABLE
NASA Jet Propulsion Laboratory, Los Angeles County

	La Cañada-Flintridge[1]	La Cañada - Flintridge[2]	Altadena[3]	Altadena[4]
Total persons	5,294	4,245	4,200	6,006
Total area, square miles	2.92	1.00	0.50	0.7
Persons per square mile	1,815	4,250	8,329	8,528
% Male	49.7	48.6	48.8	49.9
% Female	50.3	51.4	51.2	50.1
% White	83.1	85.3	19.5	18.5
% Black	0.2	0.0	67.3	59.8
% American Indian, Eskimo, or Aleut	0.2	0.0	0.3	0.5
% Asian or Pacific Islander	15.4	13.5	2.9	4.2
% Other races	1.2	1.2	10.0	17.0
% Hispanic origin	3.8	4.8	16.0	27.4
% Under age 10	12.7	14.3	17.3	19.2
% Age 65 and older	12.1	13.8	10.1	8.7

Source: Census of Population and Housing, 1990: Summary Tape File 1A (California) [machine-readable data files]. Prepared by the Bureau of the Census. Washington, DC: The Bureau [producer and distributor], 1991.

[1] Tract 4605.01 (see census tract map); [2] Tract 4505.02 (see census tract map);[3] Tract 4603.02 (see census tract map); and [4] Tract 4610.00 (see census tract map)

HOUSING DATA TABLE

NASA Jet Propulsion Laboratory, Los Angeles County

	La Cañada-Flintridge[1]	La Cañada - Flintridge[2]	Altadena[3]	Altadena[4]
Households*	1,331	1,785	1,469	1,713
Persons per household	3.11	2.97	2.89	3.44
% Households owner-occupied	75.5	94.5	90.5	67.4
% Households renter-occupied	24.5	5.5	9.5	32.6
% Households mobile homes	0.2	0.0	0.0	0.1
% Persons in group quarters	1.5	0.0	0.0	1.8
Median value, owner-occupied households, $	167,800	500,001	467,900	157,700
Median rent paid, renter-occupied households, $	572	1,001	969	549

Source: Census of Population and Housing, 1990: Summary Tape File 1A (California) [machine-readable data files]. Prepared by the Bureau of the Census. Washington, DC: The Bureau [producer and distributor], 1991.

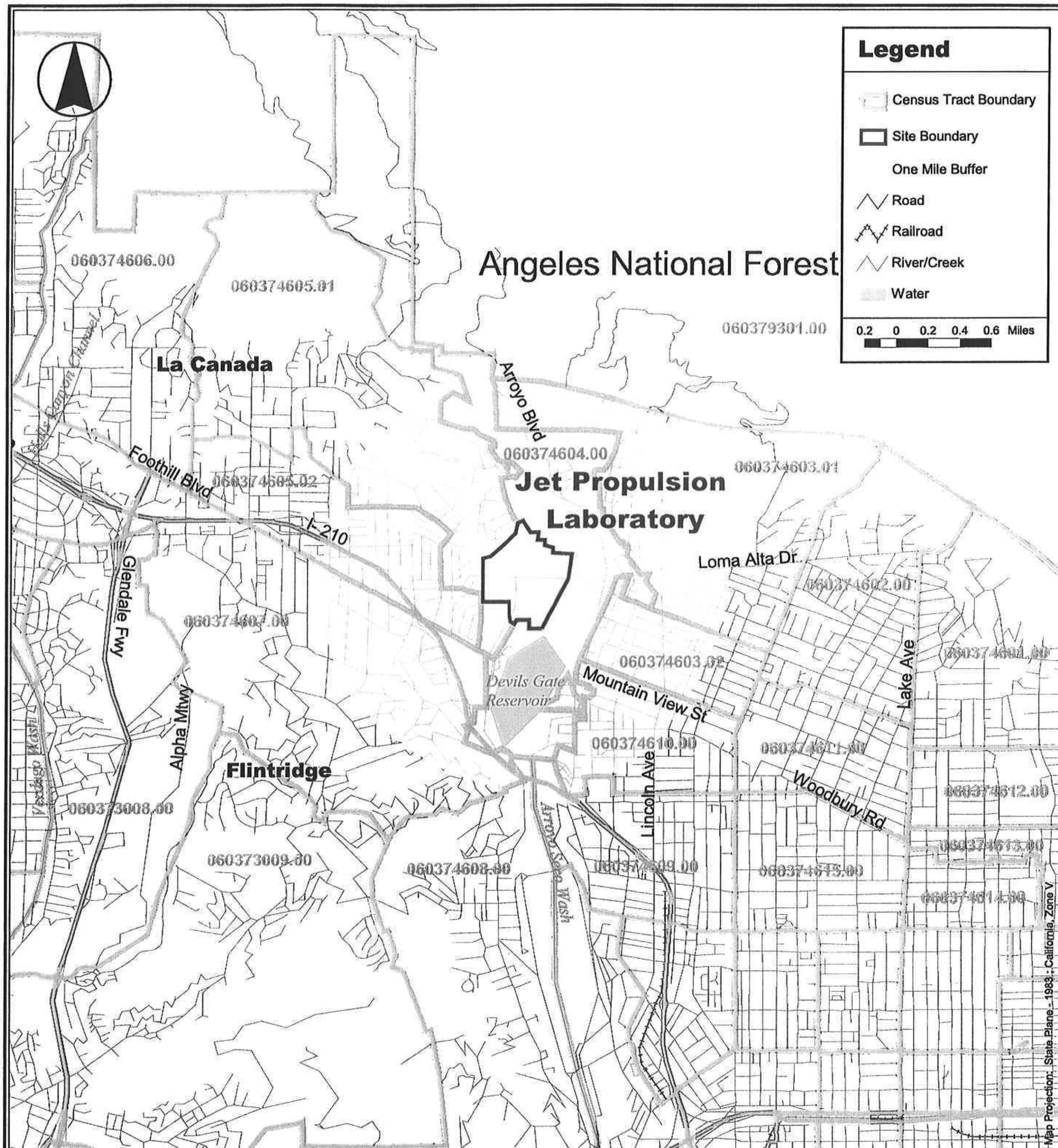
* A household is an occupied housing unit, but does not include group quarters such as military barracks, prisons, and college dormitories.

[1] Tract 4605.01 (see census tract map)

[2] Tract 4505.02 (see census tract map)

[3] Tract 4603.02 (see census tract map)

[4] Tract 4610.00 (see census tract map)



U.S. Census Tracts
Jet Propulsion Laboratory

Pasadena, California

CERCLIS No. CA9800013030

VICINITY MAP

Base Map Source: 1995 TIGER/Line Files

ALD 06241998

Site Location

Los Angeles County, California

ATSDR GIS Spatial Analysis Activity

APPENDIX E. Responses to Public Comments

The Agency for Toxic Substances and Disease Registry (ATSDR) released the Jet Propulsion Laboratory (JPL) Public Health Assessment (PHA) on August 4, 1998 for public review and comments. That public comment period ended September 20, 1998. During that period ATSDR received the following comments/questions from six individuals and two organizations or agencies.

Some of the comments received were very similar and those comments were grouped and summarized or, if possible, one exemplary comment was selected to state the issue. For comments that questioned the validity of statements made in the PHA, ATSDR verified or corrected the statements. ATSDR has not addressed requests for information to be included in the PHA, unless the party who filed the request provided the supporting documentation. The list of comments does not include editorial comments concerning such things as word spelling or sentence syntax.

Potential Past Exposure Comments

Several public comments were received that questioned various aspects of the ATSDR evaluation of the potential for human exposure to contaminants in the past. For the convenience of the reader we have grouped those comments and our responses together.

1. **Comment:** One commenter wrote: "The Public Health Assessment for JPL does not contain enough scientific facts to support its conclusions that there are no health hazards from completed pathways of volatile organic compound (VOC) toxins at this site. It relies upon only current levels of toxins in the water to state that there was, is, and will be no health risk. It totally neglects to give correct data on past levels of toxins and any subsequent health hazards."

   Response: In the preparation of this public health assessment, as with all others, much more information and data are reviewed in the analysis phase than are incorporated in the document. Because of the concerns expressed about our evaluation of the potential for past exposure to contaminants from JPL, we decided to incorporate more historical data in the "Evaluation of Potential Exposure Pathways" sections and in Tables 3 and 4 on the levels of contaminants detected in the drinking water wells near JPL.

Please keep in mind that these data we have been included in the assessment are from raw water samples prior to any treatment or blending with water obtained from other wells or water sources. Depending upon the level that contaminants are detected and many other specific circumstances, the detection of contaminants in the well may trigger a range of response actions, including the need for additional or more frequent sampling, the need to cease production of water from that well, or the need to treat or blend that water to ensure that the quality of the finished water meets safe drinking water standards.

It must be emphasized, as we discussed in the public comment draft of this PHA, our review of the implications of groundwater contamination at JPL indicates there is *no evidence of past human exposure to VOC-contaminated drinking water at levels know to result in adverse human health effects.*

2. **Comment**: One commenter wrote: "Contaminants are found at high levels in groundwater monitoring wells proving that human exposure has occurred."

Response: ATSDR emphasizes that regardless of the presence or extent of contamination detected in groundwater monitoring wells located at or near the JPL site, exposures are only possible if people drink or otherwise come in contact with the groundwater. Monitoring wells characterize the contamination in the groundwater, but as we discuss in the PHA, no one uses groundwater drawn from beneath or immediately near the JPL site, where the highest levels of contamination. Therefore, no one has been exposed to the most contaminated groundwater. Rather, area residents receive drinking water from water purveyors, who are required by law to test and ensure that the drinking water they deliver to their customers meets federal and state standards. For a more detailed discussion on elements of an exposure pathway that might lead to human exposure, please see the "Evaluation of Potential Exposure Pathways" section of the PHA.

Additionally, it is important to understand that *monitoring wells* are constructed to draw samples of groundwater from specific depth intervals, whereas *drinking water wells* are usually constructed to extract groundwater over a much thicker section of the saturated aquifer. Thus, while a *monitoring well* permits contaminant sampling of very narrow interval(s) of the aquifer to permit evaluation of plume characteristics, *drinking water wells* blend water from many levels of the aquifer and, therefore, typically show lower contaminant values than nearby monitoring wells.

3. **Comment:** Some comments asserted that JPL has been contaminating drinking water for 50 to 60 years and that is a "long period of exposure"

Response: ATSDR is not aware of any evidence to suggest that area's drinking water supplies have been contaminated for 50 to 60 years, or that people could have been exposed to contaminated drinking water for that duration. A number of factors suggest that it is highly unlikely that customers ever received finished drinking water containing harmful levels of contaminants originating from JPL. First, and most importantly, we know that since testing began in the 1980s, finished drinking water delivered to area customers has safely met drinking water standards. Second, water purveyors have blended raw well water with other well water over the course of their history and/or with imported sources since the 1950s. By blending raw well water with other sources, chemical concentrations, if any were present in the wells at the time, have been greatly diluted and reduced to safe levels. Third, it is unlikely that the contaminants have been in the public wells (or raw water) for 50 to 60 years, or since JPL started operations in 1945. Although information is not available to tell us when contaminants first reached some of the area public water supply wells, we know that it could take many years for the contaminants to infiltrate through the soils and alluvium from source areas at JPL to the groundwater and then migrate to the public drinking water supply wells.

4. **Comment:** One commenter wrote: "The report acknowledges that there is no information on the level or presence of perchlorate prior to approximately 1996. In view of the absence of information on the presence and distribution of perchlorate in the drinking water, how is it possible to reach a conclusion that this has not been harmful?" Another commenter is also concerned that "ATSDR simply ignores the fact that JPL likely had the capability of doing this work, and perhaps has records which have not been provided to it."

Response: Because the technology for accurately measuring perchlorate was not available until 1997, we do not have any data, nor does JPL, on what levels of perchlorate, if any, might have been present in drinking water supplies prior to that time. Without these data, it is difficult to determine with certainty when perchlorate first reached these area drinking water wells (e.g., city of Pasadena, Lincoln Water). In light of these uncertainties, we used our knowledge of the nature of groundwater and contaminant migration beneath JPL and our best professional judgement to draw conclusions regarding the likelihood of potential exposure to harmful levels of perchlorate. We must remind the reader that perchlorate was detected at elevated levels in the samples of *untreated* and *unblended* raw well water. ATSDR emphasizes that the treatment and blending processes, which have been practiced for many years, would have greatly diluted any perchlorate, if present, in well water before reaching the customer.

5. **Comment:** One commenter was concerned that "Since water flows downhill and would clearly flow under the JPL site and into the Arroyo Secco spreading ponds, it is difficult to understand how a conclusion was reached that no toxic substances reach the drinking water."

   Response: ATSDR has stated in its environmental pathways discussion that trichloroethylene (TCE), tetrachloroethylene (PCE), carbon tetrachloride, and perchlorate have been detected above ATSDR's comparison values, EPA's MCLs, and/or CDHS action levels in the groundwater and raw water drawn from municipal drinking water wells operated the city of Pasadena, the Lincoln Avenue Water Company, and the Valley Water Company. With the exception of PCE, these chemicals are believed to have originated from the JPL site. As stated above, the reader should remember that the "raw" water containing the elevated levels of these chemicals is treated and blended with other well water or imported water before it is delivered to the customer. These routine measures dilute and/or remove the contaminants, if present, in the drinking water before it reaches residential taps. Local water purveyors must also conduct scheduled testing of the finished water quality to ensure it meets the state's drinking water standards.

6. **Comment:** Several commenters expressed concerns about the extent of the discussion in the PHA on hazardous waste at the JPL site. They wrote: "There is no discussion of the nature of the buried material which ATSDR acknowledges is to be found on the site." and "ATSDR acknowledges that the use and disposal of chemical substances at JPL was done in a manner likely to penetrate into the groundwater and reach the soil and air. However, there is no review of the nature of the materials."

   Response: In evaluating potential public health hazards, ATSDR thoroughly reviews the available environmental data for any and all suspected releases. However, because it would be a duplication of effort to present every piece of environmental data in our document, we strive to present only the most relevant material for the *exposure pathways* of greatest concern. For a more detailed discussion on buried material at the site, please refer to JPL documents cited in the "Reference" section of this PHA.

7. **Comment:** One commenter wrote: "ATSDR is silent on the question of monitoring of the use and disposal of material and migration of contaminants on and off site from 1936 to 1979."

Response: Prior to the late 1970s, little if any environmental monitoring occurred, owing largely to the absence of federal, state, or local environmental requirements. It should be noted that this problem is not specific to JPL, but is a common concern at many other National Priorities List (NPL) sites and hazardous releases. One of the challenges we face is to evaluate public health hazards that may have occurred in the past, given the absence of adequate environmental monitoring. Where no historical data exist, we review available environmental and contaminant fate data and make assumptions about past exposure using our best professional judgement.

8. **Comment:** One commenter wrote: "There is no acknowledgment of changes in standards which would have created a false sense of security since water standards have progressively fallen over the last 50 years. Although JPL may have been in compliance, and drinking water resources may have been in compliance with standards in the past, those standards were unlikely to be protective in the light of today's toxicologic knowledge."

Response: In the 1980s, the federal EPA established mandatory water quality guidelines (standards) for key chemical contaminants, including TCE and carbon tetrachloride—the primary contaminants detected in groundwater at JPL. These standards set limits on the amount of a chemical that can be contained in drinking water supplies. Since that time, EPA and CA EPA have developed more standards and has changed some standards to reflect the current understanding of a chemical's toxicology. In 1997, the CDHS set a provisional water quality standard for perchlorate, another contaminant of concern at the site. However, there have been no changes in the MCLs for TCE, carbon tetrachloride, and the action level for perchlorate since they were developed.

9. **Comment:** One commenter is concerned that "ATSDR's report assumes that the regional water purveyors were properly monitoring, treating, and blending drinking water to keep the finished water within standards. No data to support this is offered."

Response: We based our discussions on information provided to us by the Raymond Basin Management Board and area water purveyors. The Raymond Groundwater Basin was adjudicated in 1943-44 and regulated under direction of the state of California. Since

1984, the Raymond Basin Management Board, under the California Department of Health Services requirements, has coordinated routine sampling, analysis, and monitoring programs throughout the basin to ensure that drinking water meets standards set by local, state, and federal regulatory agencies. ATSDR feels confident that, since these programs have been in place, and subject to state oversight and regulatory review, the state and area water purveyors have taken and continue to take appropriate measures to ensure that water is safe to drink.

Because of the lack of demonstrated need, the absence of extensive regulatory requirements, and the limitations in the analytical methods applied to the testing of drinking water, limited groundwater monitoring occurred prior to the 1980s for the chemicals of concern identified at the site. It should be noted, however, that "raw", untreated well water has been blended either with imported water since the 1950s or with other well water. Therefore, if any low-level contamination from any source reached any potentially affected, nearby wells during the 1950s or later, the cumulative effects of blending of water from multiple sources, treatment, pumping to and holding in storage tanks resulted in not only a significant dilution of VOC content but also a significant reduction in the VOC content due to the volatilization and extractive effects of water processing before delivery to the customer's tap at their residence.

Other Comments:

1. **Comment:** Please clarify the difference between on-site and off-site groundwater if all groundwater belongs to the Raymond Basin.

   Response: The Raymond Basin covers approximately 40 square miles and includes groundwater beneath the JPL site and in its vicinity. During environmental investigations of the JPL site, groundwater samples were taken both from on-site wells (located within the JPL site boundaries) and from off-site wells (located beyond the JPL site boundaries). ATSDR reviews on-site groundwater data to determine whether chemicals used or stored at a site have entered the groundwater beneath or near suspected sources. Because groundwater is constantly moving under the site, ATSDR also reviews off-site groundwater monitoring data to help determine whether contaminants have traveled with groundwater beyond a site's boundaries, and to what extent. This is important because we want to know if contaminants have reached drinking water sources, or if they have the potential to in the future.

2. **Comment:** One commenter wrote: "According to the information provided by ATSDR, the remedial investigation will not be completed until 1999, and the ATSDR did its site visit and data collection in 1997. Clearly, the report is based on incomplete data and any conclusion seems premature."

   Response: The conclusions and recommendations in the JPL PHA are based on environmental data and exposure information available at the time the document was prepared. ATSDR reviewed the draft RI reports for operable units 1, 2, and 3 (Foster Wheeler, 1990a, 1999b) prior to the release of this version of the PHA

   Sometimes site characterization and/or remediation continues for years after releases have first been suspected and after ATSDR's involvement begins. In such cases, a PHA may not be a single fixed document but will likely reflect the dynamic, iterative process of collection and evaluation of new information regarding the site. Therefore, if new data are collected or additional information compiled that suggests the public health may be adversely affected, ATSDR will modify or add to the document to reflect the public health implications of the additional data.

3. **Comment:** One commenter wrote: "There is no characterization of plume movement or content."

   Response: A description of the groundwater contaminant plumes has been added to the PHA. Please see pages 11 - 13.

4. **Comment:** One commenter asked why the well water is blended with imported water.

   Response: The available groundwater supply in the area around JPL is inadequate to serve all the needs of the rapidly expanding population. To ensure that their communities have sufficient supplies to meet increasing demands, many water purveyors augment their water supplies with imported surface water. Today, some communities import as much as 75 percent of their water supply from surface water sources.

5. **Comment:** One commenter wrote: "The PHA cites that future increases in levels of contamination can be handled by water purveyors. If, however, contamination increases to the point that multiple wells must be closed, it is not certain that adequate supplies of additional imported water will be available to solve the problem."

Response: ATSDR acknowledges that contamination can severely restrict the use wells and, in turn, of the groundwater resource of the basin and force area purveyors to import more water at a greater unit-cost. ATSDR also recognizes that ultimately there is a finite supply of water available in the combined resources of an adjudicated groundwater basin and the imported water supply. ATSDR did not intend to imply that the blending of water should in any way serve as a long-term solution to water quality problems in the basin. While blending has diluted the level of contaminants in the finished water and ensured the safety of the water delivered to customers, ATSDR agrees with the purveyors that the best approach to ensuring the availability of a safe source of water is to treat the contamination in the aquifer or, if necessary, at the point of use. But until effective remediation technologies are identified, ATSDR recommends that monitoring continue. ATSDR has added a recommendation to the "Public Health Action Plan" section of this PHA that addresses this concern.

6. **Comment:** One individual expressed concern that the groundwater was blended with surface water from the Colorado River, which also contains perchlorate.

Response: Several water purveyors, including the city of Pasadena, the Lincoln Avenue Water Company, and the Valley Water Company import surface water from the Metropolitan Water District of Southern California (MWDSC) to augment their drinking water supplies. The MWDSC obtains water from the Colorado River and from northern California. The MWDSC routinely checks the quality of water before delivering it to the purveyors. Since the methodology to test for perchlorate at low detection levels, the level of perchlorate in the water imported from the Colorado River has ranged from ND to about 7 ppb with a reported high of 16 ppb (see Foster Wheeler, 1999b) Thus, the safety of that source of drinking water is ensured through monitoring, as is the safety of the resultant blended water supplied by the water purveyors to their customers.

7. **Comment:** One commenter wrote: "ATSDR has not calculated delivered doses or dose equivalents for any of the materials which have been identified in the drinking water. Thus, even volatile hydrocarbon distribution and dosage have not been calculated for which hydraulic models and pharmacokinetically based dose models are available."

Response: ATSDR developed conservative estimates of exposure based on "raw" water. ATSDR assumed that every day an adult (154 pounds) and a child (22 pounds) drank "raw" water containing the highest detected concentrations of TCE, PCE, carbon tetrachloride, and perchlorate. (ATSDR considers this a highly conservative and unlikely exposure scenario.) ATSDR then compared these estimated doses to their respective minimal risk levels (MRLs) or reference doses (RfDs). In all cases, the calculated values were within an order of magnitude of the guidance levels. Because the calculated values were derived using contaminant concentrations in "raw" water rather than in " finished" water (finished drinking water has been blended and treated to meet safe drinking water standards) and because the guidance levels for the contaminants of concern are set many times lower (300 to 1,000 fold for perchlorate, see Appendix B) than the level shown in toxicologic studies to result in adverse health effects, ATSDR does not expect that drinking finished public water, or using that water as it is delivered to the tap at the home, will harm residents' health. ATSDR has added an expanded discussion on exposure to the "Exposure Pathway Evaluation" section.

8. **Comment:** One commenter wrote: "ATSDR states that Hodgkin's disease has no reported association with any chemical exposure. This is not correct."

Response: We have added a discussion on Hodgkin's disease (HD) to the "Community Health Concern" section of this PHA. As the discussion states, most researchers today agree that the likely cause of HD is an infectious agent. Although medical researchers suspect that environmental factors may influence whether an individual contracts HD, no specific environmental agents have been linked to the disease. Some studies have noted a higher than average rate of HD in workers exposed to organic solvents. Because workers are often exposed to multiple chemicals over the course of their work, researchers were not able to identify which particular solvent may have been linked to the increased rate of the disease. Furthermore, ATSDR found no studies that associate HD with either perchlorate or TCE, two chemicals of particular concern to the community.

9. **Comment:** A commenter expressed concern that "ATSDR dismisses the reported increase in incidence of HD without investigation which is inappropriate." They asked ATSDR to "Explain why an epidemiological study has not been done to assess whether any HD disease or other health effects have occurred."

Response: In assessing threats to the public's health, ATSDR first examines the potential exposure pathways related to a site. If ATSDR determines that a completed exposure pathway to environmental contaminants poses a potential public health threat, ATSDR may gather health outcome data to complement the environmental and exposure data. In evaluating available data from the JPL site, ATSDR has not found a completed exposure pathway posing a potential public health hazard. Based on the data available for review, ATSDR does not believe that contaminants from the JPL site are responsible for health problems such as Hodgkin's disease or cancer.

10. **Comment:** What kinds of cancers were found in the community, how many cases, and what are the chances that a large number of similar cancers is coincidental.

Response: The CDHS monitors cancer incidence in California communities. Community members with specific concerns about cancer rates in the area surrounding the JPL site should express their concerns to the CDHS's Cancer Surveillance at 510-540-2711.

11. **Comment**: One commenter asked ATSDR to explain how we conclude that no adverse health effects are expected while assigning an intermediate public health hazard to the site.

Response: Based on a review of the available information on groundwater and soil contamination, ATSDR concludes that JPL should be assigned to the *No Apparent Public Health Hazard* category for past, present, and potential future human exposure to VOC-contaminated groundwater processed for drinking water and surface soils or soil gasses. Even though it is unlikely that past human exposure to perchlorate in drinking water posed a public health threat, because the past levels of human exposure to perchlorate are unknown, ATSDR concludes that the site should be assigned to the *Indeterminate Public Health Hazard* category for potential past human exposures to perchlorate in drinking water.

12. **Comment**: A commenter is concerned that the community is not being informed about information sessions about the site. They asked ATSDR to explain how the public is being informed about meetings as well as availability of remedial investigation reports.

Response: At the outset and as an integral part of the public health assessment process, ATSDR issued a press release on November 19, 1997 to the major and local are news media of the Los Angeles-Pasadena area announcing a series of four public availability sessions to be held in the Pasadena Holiday Inn on December 2, 1997 and at the La Canada-Flintridge Library, La Canada, CA on December 3, 1997. Those sessions were attended by a total of eleven community members. Follow-up press coverage appeared in the Pasadena Star News and JPL's newspaper, The Universe.

With the release of the Public Comment Draft of the JPL Public Health Assessment, ATSDR developed a two-sided fact sheet summarizing the assessment process and the findings of the assessment. Copies of that assessment draft and fact sheet were distributed to a total of 30 individuals and/or organizations and made available in the official document repositories established for the JPL site: the Pasadena Central Library, the La Cañada-Flintridge Public Library, the Altadena Public Library, and the JPL Library. In addition, multiple copies of the fact sheet were distributed to the libraries and to a La Cañada-Flintridge woman's group.

JPL has sponsored several community activities to inform the public about environmental conditions at JPL and about the progress of any remediation activities. Many of these community activities are required by the U.S. Environmental Protection Agency's Superfund regulation. To assist in community relation activities, JPL has prepared a community relations plan that details community concerns (gathered from 43 interviews), develops a process to further investigate the needs of the public, and presents a plan to keep community members informed about actions at the site. This plan as well as other information about the site is kept at the Pasadena Central, Altadena Public, and the La Cañada-Flintridge Public Libraries.

In addition, JPL has provided site information and public meeting schedules in the regional and local newspapers (e.g., Los Angeles Times, Pasadena Star-News), in informational fact sheets, and a news letter. JPL representatives have held meetings to inform members of the communities and public officials surrounding JPL of JPL activities, answer questions, and clear up differing perceptions and understandings. Any community member interested in obtaining information about the site should contact the Public Services Office at JPL.

13. **Comment**: Several commenters suggested providing clearer, more legible figures.

Response: The figures have been replaced as suggested.