ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

CABO ROJO GROUND WATER CONTAMINATION SITE
CABO ROJO, PUERTO RICO
EPA FACILITY ID: PRN000206319
SEPTEMBER 27, 2012

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

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

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

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 90-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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PUBLIC HEALTH ASSESSMENT

CABO ROJO GROUND WATER CONTAMINATION SITE

CABO ROJO, PUERTO RICO

EPA FACILITY ID: PRN000206319

Prepared by:

Eastern Branch
Division of Community Health Investigations
Agency for Toxic Substances and Disease Registry

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Summary

Introduction

The Agency for Toxic Substances and Disease Registry's (ATSDR) top priority is to ensure that the people living in or near Cabo Rojo, Puerto Rico have the best information possible to safeguard their health.

Man-made chemicals called chlorinated volatile organic compounds (VOCs) have been detected at low levels in municipal drinking water supply wells in Cabo Rojo. The source of the contamination has not been identified to date. The U.S. Environmental Protection Agency (EPA) has added the Cabo Rojo Ground Water Contamination site to the National Priorities List (NPL, or "Superfund"). ATSDR is required to conduct public health activities on all sites proposed for the NPL.

The purpose of this Public Health Assessment (PHA) is to determine whether the community is being, has been, or could be harmed by exposure to VOCs in well water and what public health actions need to be taken to reduce harmful exposures. Because of limited data, ATSDR focused its evaluation on exposure to VOCs in municipal well water. Other potential exposure pathways are being evaluated as more data are collected from the site.

Conclusions

ATSDR reached four important conclusions in the PHA:

Conclusion 1

Current exposures to VOCs in municipal water from the Cabo Rojo system are unlikely to harm people's health.

Basis for conclusion 1

None of the public supply wells have exceeded any federal drinking water standards for the various VOCs detected in wells.

Next steps

- The Puerto Rico Sewer and Aqueduct Authority (PRASA) should continue frequent monitoring of the wells' water quality to ensure that the public water supply meets federal standards.

Conclusion 2

In the recent past (the past 10 years or so), exposures to VOCs in municipal water were unlikely to harm people's health. We do not have enough information to make definite conclusions about VOC exposures that may have occurred before that time.

Basis for conclusion 2

All data reviewed indicated that none of the public supply wells have exceeded any federal drinking water standards for the various VOCs

detected in wells. However, data were from limited, recent time periods, and periodic contamination might have occurred in the past.

Next steps

- ATSDR will review any past data made available to the agency.

Conclusion 3

There is a potential for exposures to VOCs in the municipal water to harm public health in the future.

Basis for conclusion 3

The source and extent of the contamination have not been identified. Contaminant concentrations could rise to levels that could result in health effects for people using the water.

Next steps

- EPA should continue its efforts to identify the source, characterize the extent of the contamination, and implement remedial measures to address and prevent groundwater contamination.

Conclusion 4

More information is needed to assess potential exposure pathways including private wells, vapor intrusion and exposure near source areas.

Basis for conclusion 4

The source and extent of the contamination has not been identified to date. VOC concentrations might be higher near source areas and in any area between the source and the affected municipal wells, increasing the potential for exposure.

Recent sampling by EPA to assess vapor intrusion issues showed no harmful VOC levels in indoor air in buildings near potential source areas. However, several buildings had high VOC concentrations beneath the foundation slabs.

Next Steps

- EPA should continue its efforts to identify the source and delineate the areal extent of groundwater contamination at the site. This should include testing of private wells used for domestic purposes.
- EPA should conduct follow-up sampling to verify that indoor levels of VOCs do not increase.
- ATSDR will evaluate additional data collected by EPA and update the findings of this PHA, if necessary.

For More Information

For further information about this public health assessment, please call ATSDR at 1-800-CDC-INFO and ask for information about the “Cabo Rojo Ground Water Contamination Site”. If you have concerns about your health, you should contact your health care provider.

List of Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CREG	Cancer Risk Evaluation Guide
CV	Comparison Value
1,1-DCE	1,1-Dichloroethylene
cis-1,2-DCE	cis-1,2-Dichloroethylene
EMEG	Environmental Media Evaluation Guide
EPA	U.S. Environmental Protection Agency
EQB	Puerto Rico Environmental Quality Board
IARC	International Agency for Research on Cancer
IRIS	Integrated Risk Assessment System
LTHA	Lifetime Health Advisory
MCL	Maximum Contaminant Level
MRL	Minimal Risk Level
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
PCE	Tetrachloroethylene (or Perchloroethylene)
PHA	Public Health Assessment
PRASA	Puerto Rico Aqueduct and Sewer Authority
PRDOH	Puerto Rico Department of Health
RfD	Reference Dose
RSL	Regional Screening Level
RMEG	Reference Media Evaluation Guide
TCE	Trichloroethylene (or Trichloroethene)
µg/L	microgram per liter
VC	Vinyl Chloride
VOC	Volatile Organic Compound

Purpose and Statement of Issues

The Agency for Toxic Substances and Disease Registry (ATSDR) prepared this public health assessment to evaluate, based on the information currently available, potential exposures to contaminants in drinking water from the Cabo Rojo Ground Water Contamination site. The site consists of an area of groundwater contamination in Cabo Rojo, a municipality in southwestern Puerto Rico. Chlorinated volatile organic compounds (VOCs), man-made chemicals, have been detected at low levels in some public water supply wells serving Cabo Rojo. Although the contamination in the wells has not exceeded drinking water standards, the source and extent of the contamination is unknown.

The US Environmental Protection Agency (EPA) proposed the Cabo Rojo Ground Water Contamination site for inclusion on the National Priorities List (NPL) in October 2010; the listing was finalized in March 2011. ATSDR is mandated by Congress to conduct public health activities on all sites proposed for the NPL. Because of limited data, this evaluation focuses only on potential exposures to chlorinated VOCs in the public drinking water supply. We discuss the possibility for adverse health effects to result from other exposures and make recommendations for further sampling that would allow evaluation of such exposures.

Public Comment / Updates to Public Comment PHA

ATSDR released a draft of this PHA for public comment on October 21, 2011. The PHA was available for public review and comment at the Biblioteca Blanca E. Colberg Rodríguez in Cabo Rojo, Puerto Rico. The document was also available for viewing or downloading from the ATSDR web site. The public comment period was open from October 21, 2011 through January 20, 2012. The public comment period was announced to local media outlets. No public comments were received on the PHA.

This PHA has been updated with revised toxicological information on tetrachloroethylene (PCE) and trichloroethylene (TCE) that has become available since the public comment PHA was drafted. The PHA also includes additional historical and recent sample results from public water supply monitoring obtained since the release of the draft PHA. These updates did not change ATSDR's overall findings.

Although this PHA focuses on exposure to VOCs in the public drinking water supply, ATSDR has also been working with EPA since the release of the draft PHA to assess possible vapor intrusion issues in homes, schools, and businesses near potential contamination source areas identified by EPA. For further information, two ATSDR health consultations on these issues are included as Appendices C and D of this PHA.

Background

Introduction and Site Description

Background information on the site is taken from site documents [1,2]. The Cabo Rojo Ground Water Contamination site ("the site") consists of an area of subsurface

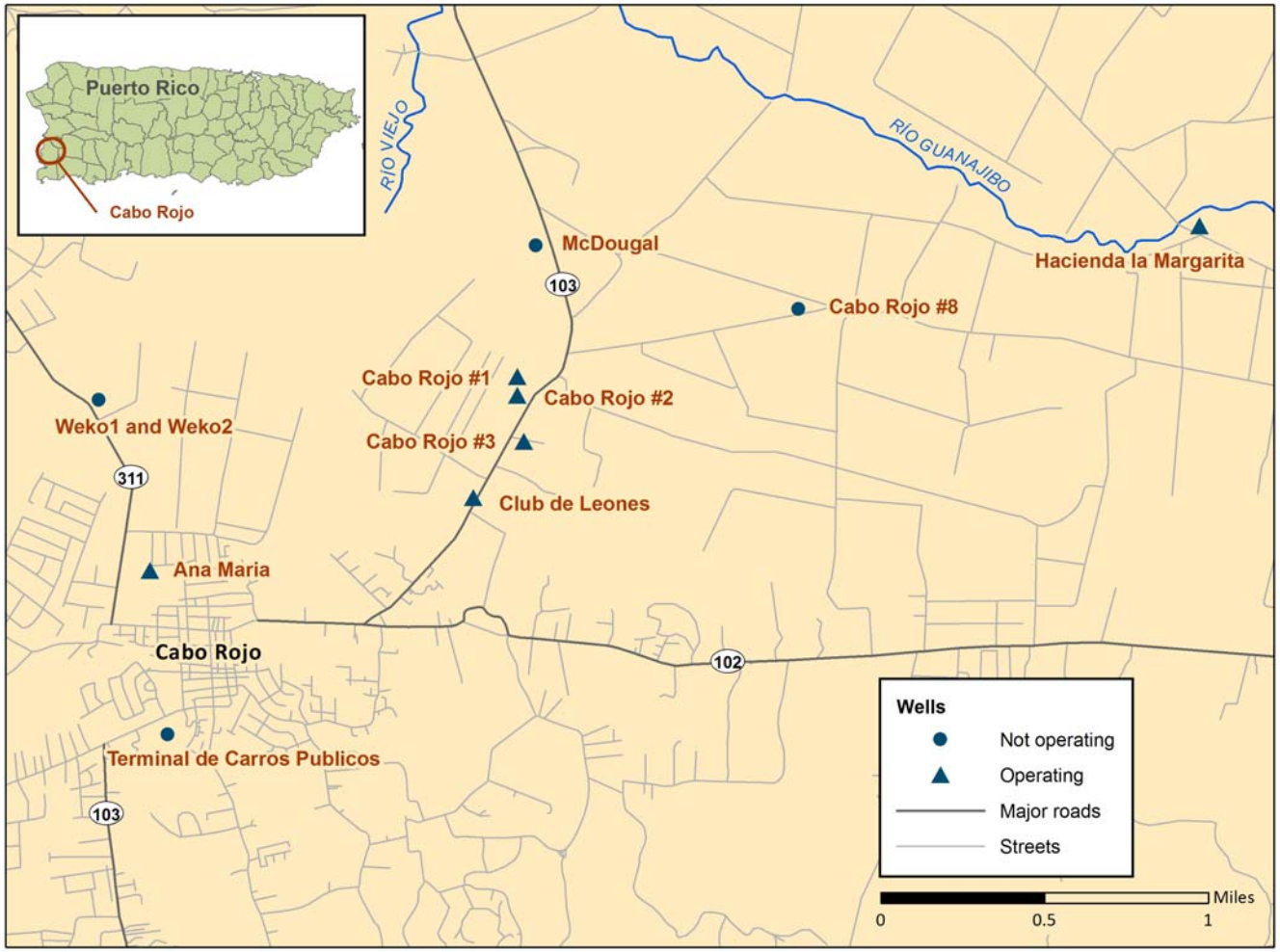
groundwater in Cabo Rojo, Puerto Rico contaminated with chlorinated volatile organic compounds (VOCs). The contamination was identified through routine monitoring of municipal drinking water wells; the source of the groundwater contamination has not been identified at the time of this report. These contaminants are commonly associated with activities such as degreasing, industrial cleaning, and dry cleaning.

The Cabo Rojo Urbano public water system is maintained by the Puerto Rico Aqueduct and Sewer Authority (PRASA) and consists of a surface water intake and six wells serving an estimated population of about 47,000 people (see Figure 1). Several other PRASA wells in and around Cabo Rojo were used in the past but are no longer supplying water for various reasons. Groundwater from the wells is treated by chlorination.

The public water system includes:

- One independently operating well (named Ana Maria) which serves about 1,850 people in the Ana Maria neighborhood of Cabo Rojo [3].
- A surface water intake and filtration plant located more than 4 miles from the supply wells, and an interconnected system of five operating wells (named Cabo Rojo 1, Cabo Rojo 2, Cabo Rojo 3, Club de Leones, and Hacienda la Margarita). Surface water is blended with water from the five active wells, and this combined water supplies about 45,000 people in Cabo Rojo [3].

Figure 1. Cabo Rojo Operating and Non-operating Municipal Well Locations



PRASA conducts monitoring of each of the wells in use. From 2002-2011, the Ana Maria well has shown ongoing low detections of VOCs, including PCE, TCE, and cis-1,2-dichloroethylene (cis-1,2-DCE). Also, the Club de Leones well has shown detections of 1,1-dichloroethylene (1,1-DCE) and vinyl chloride (VC) over the years 2006-2010. A third well, Hacienda la Margarita, had a few low detections of PCE in 2004 and 2005. No data were available for this well from 2006-2008, but recent regular testing has shown no detections since 2009. All of the detections in all of the wells have been below the EPA maximum contaminant levels (MCLs) for the corresponding VOCs.

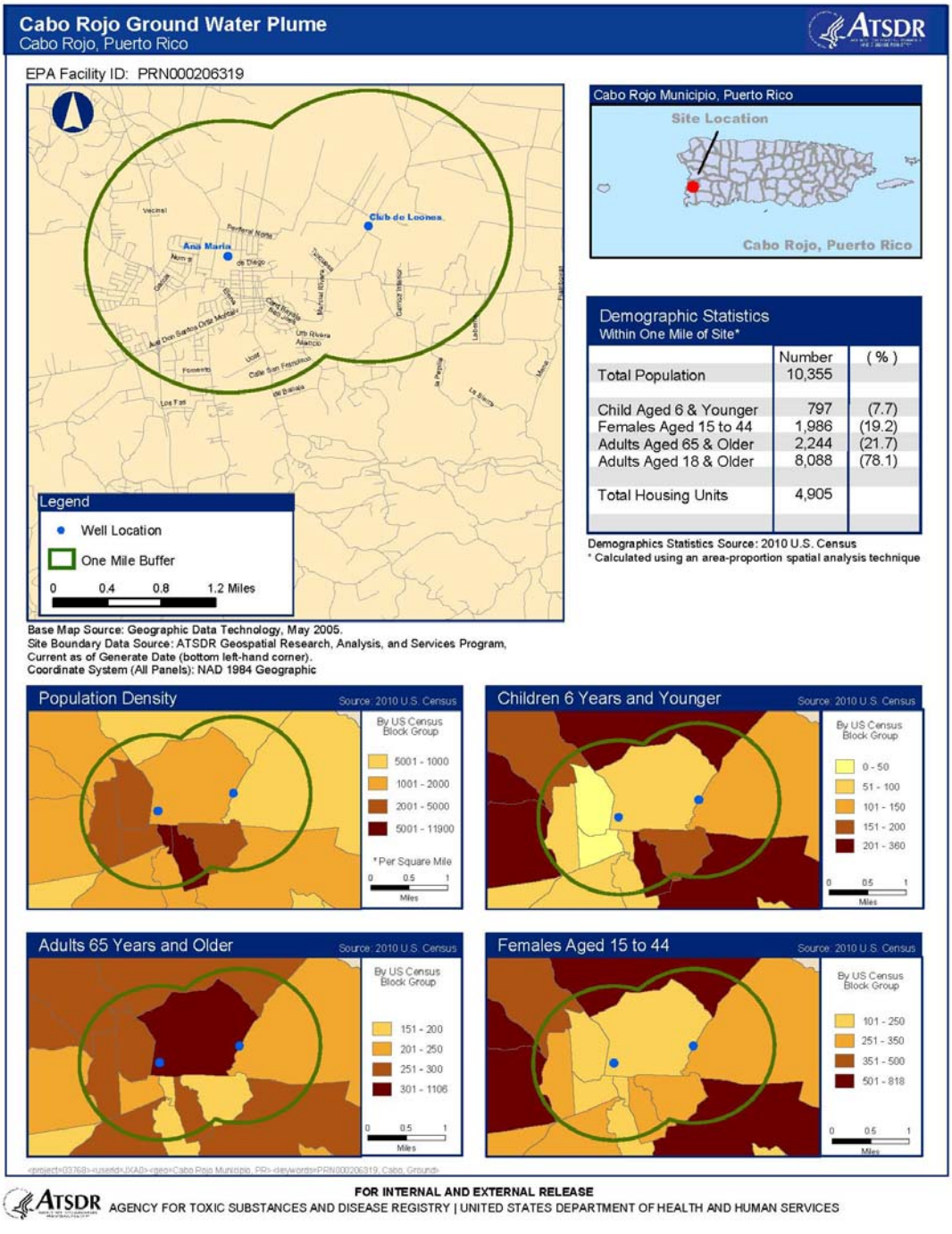
PRASA has implemented more frequent monitoring (every 3 months) of the currently operating wells with detections of VOCs. In addition, EPA has conducted site reconnaissance at multiple facilities in Cabo Rojo to try to locate potential source(s) of the VOC contamination. Though some potential source areas have been identified and preliminarily sampled, the source of the groundwater contamination has not been determined at this time. EPA proposed the site for the NPL in October 2010 as the most viable way to address the ongoing VOC contamination in public supply wells in the area.

Sufficient information does not exist to allow a full assessment of health impacts from all the ways ("exposure pathways") the public may be affected by contaminants at this site. *Therefore, this evaluation will focus on exposure of the public to the VOCs present in municipal water.* This document also recommends appropriate sampling that will allow evaluation of other potentially important exposure pathways.

Demographics

Figure 2 shows a one-mile radius around the two public wells showing VOC contamination at this time. On the basis of Census 2010 data, the estimated population in this area is 10,355. Children aged 6 years or younger make up approximately 7.7% of the population; 21.7% are adults aged 65 years or older; and 19.2% are women aged 15 to 44 years. Total housing units are estimated at 4,905. Almost all of the population is of Hispanic origin.

Figure 2. Site Map and Demographic Information for the Cabo Rojo Ground Water Contamination Site



Land and Natural Resource Use

The Cabo Rojo municipality includes a relatively dense town center surrounded by more rural properties. The wells lie in areas of mixed residential, commercial, and small industrial properties. There is some agricultural and undeveloped land in the area.

The Cabo Rojo Ground Water Contamination site is located in the Guanajibo alluvial valley which consists of bedded sand and gravel alluvium underlain by limestone [4]. The primary source of groundwater is the water-table aquifer, a heterogeneous aquifer composed mainly of limestone and secondary amounts of gravels, sands, and clayey sands [5]. Groundwater recharge comes largely from the Ciénaga de Cuevas, a riverine intermittent wetland in a topographic low northeast of Cabo Rojo. Movement of the groundwater is towards a cone of depression produced by the public water supply well field along Highway PR-103 and towards nearby surface water drainage features: the lower reach of the Río Viejo or the intermittent streams Quebrada Mendoza and Quebrada Pileta, both of which drain to the Río Viejo [5].

Besides the public supply wells, other wells are or have been used in the area. EPA is aware of some non-PRASA wells that are or were used for drinking water [6]. Also, Puerto Rico Department of Natural Resources (PRDNR) and U.S. Geological Survey (USGS) records showed several wells within one mile of the Ana Maria and Club de Leones wells [7,5]. These records list some wells as unused or observation wells, but list others as used for irrigation, stock watering, industrial, or domestic purposes. EPA is currently identifying wells in the area that may be tested for contaminants during the remedial investigation.

Site History and Previous Investigations

PRASA monitoring results from 2002 – 2006 showed low levels of VOCs in the Ana Maria and Hacienda la Margarita wells. In July 2006, EPA collected samples at the public supply wells in Cabo Rojo, some public supply wells in the Mayaguez public system to the north, three private wells in the area, and the Boqueron filtration plant providing surface water to Cabo Rojo. The results confirmed PCE detections in the Ana Maria well and identified the 1,1-DCE detections in the Club de Leones well. VOCs associated with the Cabo Rojo wells were not detected in the other wells tested, including Hacienda la Margarita.

In November and December 2006, EPA surveyed 68 facilities in the municipality of Cabo Rojo area and identified 15 facilities for further investigation as potential sources of the groundwater contamination. These facilities were identified by their observed or suspected use of chlorinated solvents or abandoned facilities with unknown waste sources. In 2007, EPA conducted site investigations at these facilities in an effort to find the source of the contamination in the public supply wells. The results of these investigations are summarized in the HRS Documentation Record [1].

Only 3 of the 15 facilities had chlorinated solvents detected in soil and /or groundwater samples. Of these, only one had detections in both soil and groundwater. This facility, however, is almost 1 mile from the Ana Maria well and further from the Club de Leones

well. Other potential sources are in between this facility and the well. Another facility is close to the Ana Maria well, but only the soil there contained PCE; the groundwater had no chlorinated solvents. A third facility is within a block or two of the Ana Maria well, but while PCE was detected in groundwater beneath the site, it was not detected in soil samples. Based on these results, the contamination in the Ana Maria and Club de Leones wells cannot be attributed to any specific source at this time [1].

In September 2009, EPA collected additional samples from some of the Cabo Rojo public supply wells. The results confirmed the previous detections in the Ana Maria and Club de Leones wells and the previous non-detect findings in other supply wells.

EPA is currently conducting additional sampling to try to better characterize the extent of the contamination and possibly identify the source or sources.

ATSDR Involvement

ATSDR is mandated by Congress to conduct an evaluation of sites proposed for EPA's NPL. This PHA is our evaluation of the Cabo Rojo Ground Water site and its potential health implications. The ATSDR team visited the site in April 2011 to learn from partners and better understand the physical setting of the site and its relationship to the people living and working nearby. ATSDR met with officials from EPA, PRDOH, EQB, and PRASA to learn about past investigations at the site and to collect data and other information. ATSDR staff also met with a local environmental group, an elected official, local educators and medical providers and others to learn about any health concerns related to the site. Along with partner agencies, ATSDR participated in a tour of the public supply wells in the area, including the two wells showing current detections of VOCs.

In early 2012, ATSDR worked with EPA to evaluate, characterize, and address possible vapor intrusion issues at schools, homes, and businesses near potential contamination source areas at the site. ATSDR participated in a series of public meetings in Cabo Rojo to convey information on vapor intrusion to the community in May 2012.

Discussion

Data Used

Required testing of municipal wells is the major source of data evaluated in this report. Partner agencies including PRASA, PRDOH, EQB, and EPA provided these data (covering various wells and time periods) to ATSDR, and we compiled them into one data set. Table 1 summarizes the data ATSDR evaluated by well and year.

Table 1. PRASA Monitoring Data for Cabo Rojo Wells

Well	Dates of PRASA Results Available	Status of Well in 2011
Ana Maria	2002-2011	Operating
Cabo Rojo 1	2007-2012	Operating
Cabo Rojo 2	2005-2011	Operating
Cabo Rojo 3	2007-2012	Operating
Club de Leones	2006-2012	Operating
Hacienda la Margarita	2004-2012	Operating
McDougal	2001-2002	Operates as pumping station for surface water from Mayaguez
Terminal de Carros Públicos	2001-2002	Closed (manganese and iron made water unpalatable)*
Cabo Rojo 8	1998-2001	Closed (unknown reason)*
Weko 1	none	Closed (mercury contamination)*
Weko 2	none	Closed (mercury contamination)*
* Source of listed well closure information is personal communication with PRDOH and EPA during April 2011 site visit. ATSDR attempted to obtain official records of why the wells were closed from PRASA, but to date have not received the information.		

The PRASA data for the above public supply wells were the basis of ATSDR's exposure estimates in this report [8]. Data from EPA sampling of private wells in the area and potential sources could not be used to estimate exposures because only very few samples, generally only a single point in time, were collected (limited sampling did not indicate private wells had the same VOC contamination as municipal wells) [1]. Similarly, only one sample was collected from the surface water source that is blended with the municipal well water. VOC contamination of surface water is unlikely because VOCs tend to evaporate from open water into the air. ATSDR did consider all the available information in making general conclusions and recommendations for further investigation.

The available PRASA data from Cabo Rojo public supply wells covered years from 1998 to 2012, but ATSDR was not provided with data from all wells for all these years – only the dates as indicated in Table 1 were provided. Any well operating as part of the public supply system would have been subject to annual monitoring requirements, and if there were any contaminant detections these should have been reported and triggered more frequent monitoring requirements. However, without documentation we cannot verify whether or not contaminants were detected earlier in the wells. The evaluation of potential health effects assumes that the available data represent the highest contaminant levels in the wells.

Pathway Analysis

ATSDR determines whether people may have come into contact with chemicals from a site by examining exposure pathways. Exposure pathways consist of five elements which must all be present (in the past, now, or in the future) for exposure to occur. The five major elements and their relation to the Cabo Rojo Ground Water site are listed below:

1. A contamination source: yes. Although the source(s) of contamination for this site has not been identified, one or more source is presumed because of the contamination present in groundwater.
2. Transport through an environmental medium: yes. VOC contamination has been measured in the municipal wells and in groundwater beneath some areas in town, so it must be traveling from a source to the wells.
3. An exposure point: yes. People obtain contaminated municipal water from their household taps.
4. An exposure route: yes. People drink and bathe in the water and may breathe in contaminant vapors from the water.
5. An exposed population: yes. People in the area have used and currently use the water.

This analysis indicates that a complete exposure pathway exists at the site. Completed exposure pathways are evaluated further by ATSDR to determine if there are health effects associated with the levels of exposure [9]. For more information on ATSDR's pathway analysis process, please refer to Appendix A.

Evaluation Process

The process by which ATSDR evaluates the possible health impact of contaminants is summarized here and described in more detail in Appendix A.

- When presented with results of comprehensive environmental sampling for chemicals, ATSDR reduces the number of contaminants that need to be evaluated by screening the results for each chemical against *comparison values* (CVs)—concentrations of chemicals in the environment (air, water, or soil) below which no adverse human health effects are expected to occur. If a contaminant is present at a level higher than the corresponding CV, it does not mean that adverse health effects will occur; the contaminant is merely retained for the next step of evaluation. Contaminants are also retained for evaluation if they are classified as human carcinogens and exceed the corresponding CV for cancer (ATSDR's cancer risk evaluation guide).
- The next step of evaluation focuses on identifying which chemicals and exposure situations could be a health hazard. We calculate *exposure doses*—estimated amounts of a contaminant that people come in contact with and get into their bodies, on an equivalent body weight basis—under specified exposure situations, typically starting with "worst case" type assumptions to obtain the highest dose that could be expected. Each calculated exposure dose is compared against the corresponding *health guideline*, typically an ATSDR minimal risk level (MRL) or EPA Reference Dose (RfD), for that chemical. Health guidelines are considered to be not harmful; that is, if

the calculated dose is at or below the health guideline, no adverse health effects would be expected.

- If the "worst case" exposure dose for a chemical is greater than the health guideline, then the exposure dose may be refined to more closely reflect actual exposures that occurred or are occurring at the site. The exposure dose is then compared to known health effect levels (for both cancer and non-cancer effects) identified in ATSDR's toxicological profiles or the scientific literature. *These comparisons are the basis for stating whether or not the exposure presents a health hazard.*

We limited the exposure evaluation of this public health assessment to VOCs detected in the Cabo Rojo municipal wells. The public may have regular exposures from drinking and other uses of this water, and comprehensive data on other potential contaminants of concern and exposure pathways are not available at this time. We summarize the limited available data on other potential exposure pathways and make recommendations for characterizing them further.

Contaminants of Concern

Table 2 summarizes the different VOCs detected in the Cabo Rojo municipal wells. Several VOCs have been detected in supply wells; however, no contaminants have ever been detected that exceeded EPA's drinking water standards (maximum contaminant levels or MCLs) or ATSDR's non-cancer CVs. In the public comment draft of this PHA, the only contaminants that exceeded ATSDR's cancer CVs were PCE and VC. After the development of the draft PHA, EPA updated its oral cancer slope factors for PCE and TCE, and this action changed ATSDR's cancer CVs for these two substances. With the updated CVs, only TCE and VC exceed their cancer CV; however, PCE will be retained herein to maintain consistency with the public comment draft PHA.

Table 2. Summary of Contaminants Detected and Their Comparison Values* (CVs) in Cabo Rojo Municipal Water Supply Wells

Contaminant	# of Wells With Any Detection Above a CV	Highest Concentration Detected in Any Well Sample, µg/L	Non-cancer CV in µg/L	Cancer CV in µg/L; National Toxicology Program Cancer Class	Selected For Further Evaluation?†
Tetrachloroethylene (PCE)	0	4.0	5 – MCL	17 – CREG; Reasonably anticipated to be a carcinogen	**Yes**
Trichloroethylene (TCE)	1	1.6	5 – MCL	0.76 – CREG; Reasonably anticipated to be a carcinogen	**Yes**
cis-1,2-Dichloroethene (cis-1,2-DCE)	0	6.8	20 - RMEG	No cancer CV; Not classified	No
trans-1,2-Dichloroethene (trans-1,2-DCE)	0	0.6	100 – MCL	No cancer CV; Not classified	No
1,1-Dichloroethene (1,1-DCE)	0	1.2	7 – MCL	No cancer CV; Not classified	No
Vinyl Chloride (VC)	1	1.3	2 – MCL	0.02 – CREG; Known human carcinogen	**Yes**
Xylenes	0	1.6	2,000 – EMEG	No cancer CV; Not classified	No

* Please see Appendix A for definitions and additional information about CVs.

CV = comparison value
µg/L = micrograms of contaminant per liter of water
MCL = maximum contaminant level
EMEG = environmental media evaluation guide
RMEG = reference media evaluation guide
CREG = cancer risk evaluation guide

Data sources: as summarized in "Data Used" section beginning on page 7. Data included results from wells no longer operating.

† Contaminants exceeding the lowest CV were selected for further evaluation. PCE also selected to maintain consistency with public comment draft of this PHA.

Evaluation of Exposure from Household Use of Residential Well Water

Exposure to VOCs in water could occur in several ways:

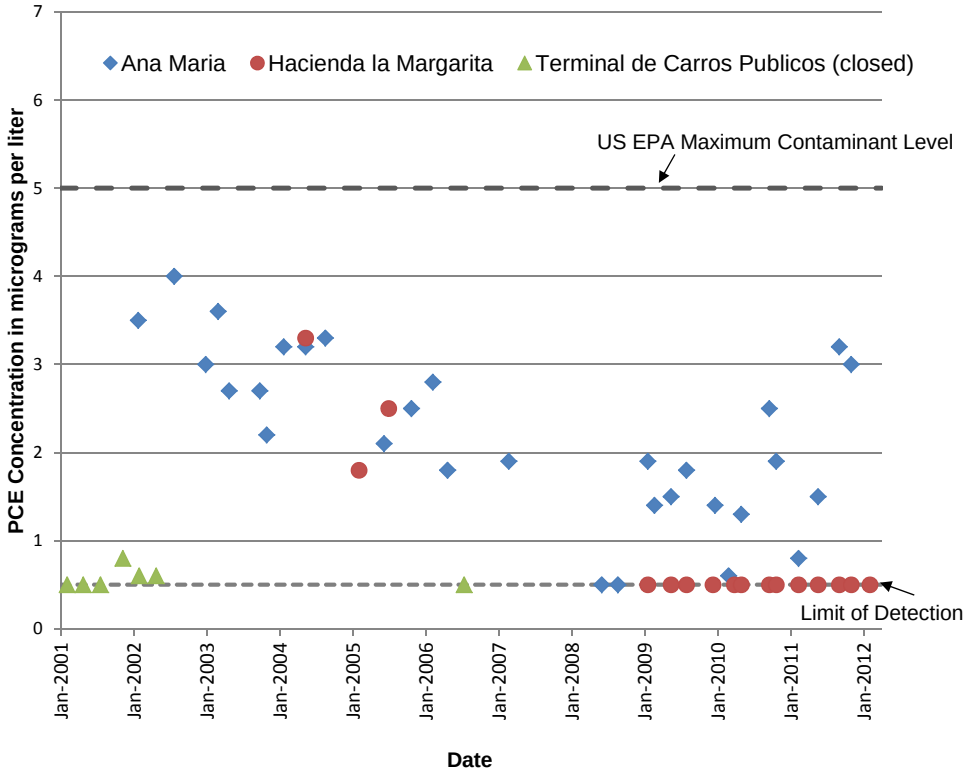
- *Ingestion:* People could drink the water or eat food prepared using the water.
- *Inhalation:* People could breathe in VOCs that volatilize (move into the air) from well water during showering, bathing, or other household use.
- *Dermal Exposure:* People could absorb VOCs through their skin during showering, bathing, or other use.

Often, ingestion exposure is the most significant source of exposure to hazardous substances from a site. In the case of VOC contamination, however, inhalation and dermal exposures can make a significant contribution to the total exposure dose (that is, the total amount of contaminant that enters and can affect a person's body). A precise estimate of these non-ingestion exposures is seldom achievable. A common estimation is that non-ingestion exposures yield a contaminant dose comparable to the ingestion dose [9]. This estimation may underestimate exposures to people who may be exposed to VOCs from shower water for periods of 30 minutes or more per day. However, for the purposes of this general evaluation, we doubled ingestion exposure doses estimated using measured water VOC concentrations and default assumptions for the amount of water consumed per day and other exposure parameters to account for additional exposure from inhalation and dermal exposures.

Potential Health Effects from PCE Exposure

PCE was detected only in the Ana Maria, Hacienda la Margarita, and Terminal de Carros Públicos wells. To get a better understanding of what the PCE concentrations were in these wells, Figure 3 shows the PCE concentrations over time. The only well that has had recent detections of PCE is the Ana Maria well; the Hacienda la Margarita well has not had any detection of PCE since at least early 2009, and the Terminal de Carros Públicos well is closed.

Figure 3. PCE Concentration Over Time in Cabo Rojo Public Supply Wells with Detections



To assess the potential for PCE exposure to cause harmful health effects, an estimate of the exposure dose is needed. To be conservative, we assume that a person is exposed every day throughout life to the highest concentration of PCE detected in any well, 4 µg/L PCE. This concentration was detected in the Ana Maria well, the only well in Cabo Rojo that is not blended with other well water. The following is an example of the dose calculations performed for this evaluation. Multiplying by a factor of 2 to account for additional exposure from breathing in PCE from water and getting it on skin during bathing, the daily dose of PCE in milligrams PCE per kg of body weight per day (mg/kg/day) is estimated for a one-year old as:

$$2 \times \frac{4\frac{\mu g}{L} \times 0.001\frac{mg}{\mu g} \times 1\frac{L}{day}}{10kg} = 0.0008 mg/kg/day$$

The exposure dose changes throughout life as the assumed body weight and ingestion rate changes. Table 3 shows assumptions used to estimate doses for different age ranges and to estimate an average lifetime dose.

Table 3. Exposure Assumptions for Estimating PCE Dose for Cabo Rojo Ground Water Contamination, Based on a Concentration of PCE of 4 μg/L

Ages	0-1	1-6	7-17	18-70
Body Weight in kilograms	10	17	45	70
Ingestion of Drinking Water in Liters per Day	1	1	2	2
Average Dose, mg/kg/day	0.0008	0.0005	0.0004	0.0002
Number of Years	1	6	11	52
Lifetime average dose = Sum of (Average Dose * Number of Years)/Total Number of Years = **0.0003 mg/kg/day**				
mg/kg/day = milligrams of contaminant per kilogram body weight per day. Assumed body weights and ingestion rates from references 9 and 13.				

EPA recently released an updated PCE health risk assessment [10]. EPA determined an oral reference dose (RfD) for PCE of 0.006 milligrams PCE per kilogram body weight per day (mg/kg/day), based on neurological effects in adult humans exposed through their work. The estimated doses in Table 3 are all below EPA's RfD; therefore, non-cancer effects are unlikely to result from exposure to PCE in the municipal supply wells.

The National Toxicology Program (NTP) classifies PCE as reasonably anticipated to be a human carcinogen, and the International Agency for Research on Cancer (IARC) has determined that PCE is a probable human carcinogen [11,12]. These determinations are based on limited human epidemiological studies suggesting elevated risks for esophageal cancer, non-Hodgkin's lymphoma, and cervical cancer and sufficient animal studies showing that PCE induced leukemia in rats and liver cancers in mice [11,12]. EPA considers PCE a likely human carcinogen based on epidemiological evidence showing associations between PCE and bladder cancer, non-Hodgkin's lymphoma, and multiple myeloma [10].

From Table 3, the average estimated lifetime PCE exposure dose is 0.0003 mg/kg/day. To obtain the theoretical increased risk of cancer, this dose is multiplied by the appropriate oral cancer slope factor or oral unit risk in units of $(mg/kg/day)^{-1}$.

EPA's recent updated PCE health risk assessment lists an oral cancer slope factor for PCE of 0.0021 $(mg/kg/day)^{-1}$ [10]. Using this value, the increased risk of cancer is $0.0003 \times 0.0021 = 6.3 \times 10^{-7}$ or less than 1 in a million. This represents a negligible increased risk of cancer for a lifetime of exposure to PCE at the highest concentrations present in the public water supply well.

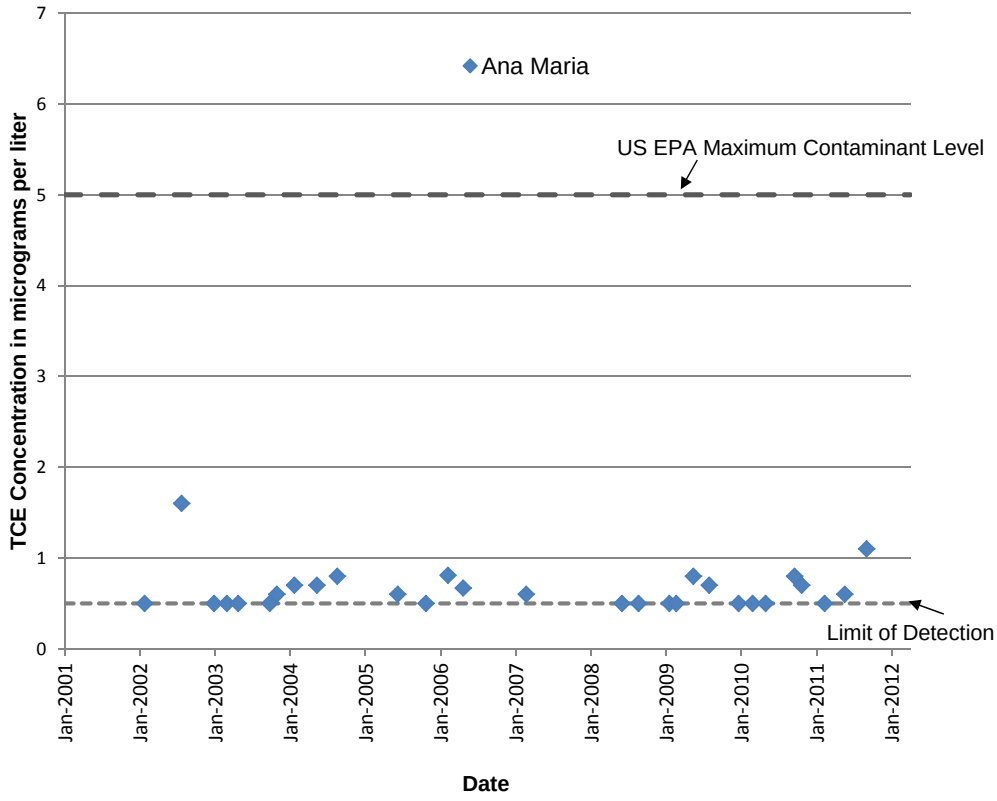
The actual increased risk of cancer is probably even lower than predicted here due to the conservative assumptions used. The above calculations assume exposure is to the highest

concentration detected, and as indicated in Figure 3, most other detections have been lower. The above calculations also assume that PCE levels remain elevated into the future. This could underestimate exposures if sources continue to contribute VOC contamination to the groundwater. However, with EPA's ongoing investigation at the site and development of plans to remediate the contamination, we anticipate that exposures will be reduced.

Potential Health Effects from Trichloroethylene (TCE) Exposure

TCE was detected above the CV only in the Ana Maria well. As shown in Figure 4, the concentrations of TCE detected in the Ana Maria well are generally low, with the maximum concentration detected 1.6 µg/L.

Figure 4. TCE Concentration Over Time in Cabo Rojo Ana Maria Public Supply Well



To assess the potential for TCE exposure to cause harmful health effects, an estimate of the exposure dose was calculated using the same procedure as for the PCE evaluation above. Table 4 below shows estimated exposure doses for various age groups based on continuous exposure to the highest TCE concentration (1.6 µg/L).

Table 4. Exposure Assumptions for Estimating TCE Dose for Cabo Rojo Ground Water Contamination, Based on a Concentration of TCE of 1.6 µg/L

Ages	0-1	1-6	7-17	18-70
Body Weight in kilograms	10	17	45	70
Ingestion of Drinking Water in Liters per Day	1	1	2	2
Average Dose, mg/kg/day	0.0003	0.0002	0.0001	0.00009
Number of Years	1	6	11	52
Lifetime average dose = Sum of (Average Dose * Number of Years)/Total Number of Years = **0.0001 mg/kg/day**				
mg/kg/day = milligrams of contaminant per kilogram body weight per day. Assumed body weights and ingestion rates from references 9 and 13.				

EPA recently released an updated TCE health risk assessment [10]. EPA's updated oral reference dose (RfD) for TCE is 0.0005 mg/kg/day, based on immune effects and cardiac birth defects in animal experiments [10]. The estimated doses in Table 4 are all below the RfD; therefore, non-cancer effects are unlikely from exposure to TCE in the municipal supply wells.

The NTP classifies TCE as reasonably anticipated to be a human carcinogen. In humans, occupational exposure to TCE was associated with excess incidences of several cancers, particularly liver cancer, non-Hodgkin's lymphoma, and kidney cancer [11]. Animal studies showed that TCE exposure caused tumors in mice and rates at several different sites, including liver and kidney, by inhalation or oral exposure [11]. IARC has determined that TCE is a probable human carcinogen based on epidemiological studies showing increased rates of liver cancer and non-Hodgkin's lymphoma, primarily in workers who were exposed to TCE on the job, and animal studies showing increased numbers of liver and kidney tumors upon oral administration [12]. EPA characterizes TCE as carcinogenic to humans by all routes of exposure [10]. This conclusion is based on human epidemiology studies showing associations between human exposure to TCE and kidney cancer, non-Hodgkin's lymphoma, and liver cancer.

EPA's recent updated TCE health risk assessment lists an oral cancer slope factor for TCE of 0.046 $(mg/kg/day)^{-1}$. This oral cancer slope factor represents combined cancer risk of kidney cancer, liver cancer, and non-Hodgkin's lymphoma [10]. Using this value, the theoretical increased risk of cancer is $0.0001 \times 0.046 = 4.6 \times 10^{-6}$ or less than 1 in 100,000. This represents an insignificant increased risk of cancer for a lifetime of exposure to TCE at the highest concentrations present in the public water supply well.

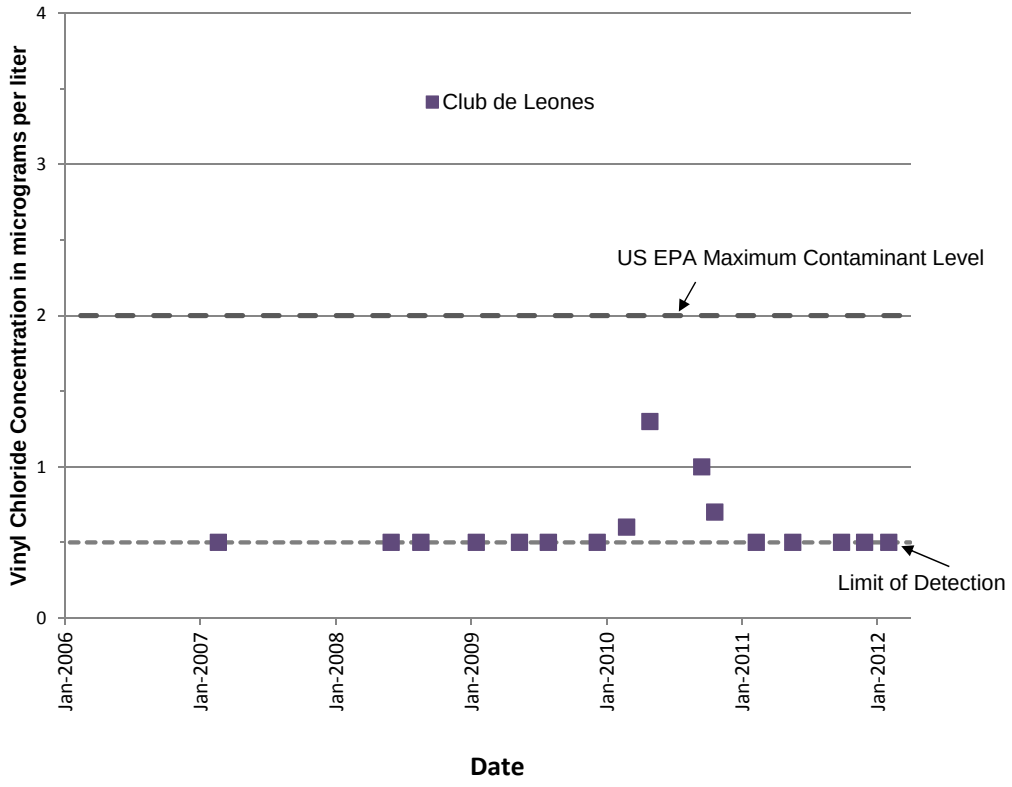
The actual increased risk of cancer from TCE exposure is probably even lower than predicted here due to the conservative assumptions used. The above calculations assume

exposure is to the highest concentration detected, and as indicated in Figure 4, most other detections have been lower. The above calculations also assume that TCE levels remain elevated into the future. This could underestimate exposures if sources continue to contribute VOC contamination to the groundwater. However, with EPA's ongoing investigation at the site and development of plans to remediate the contamination, we anticipate that exposures will be reduced.

Potential Health Effects from Vinyl Chloride (VC) Exposure

The only well that has had any detections of VC is the Club de Leones well. To get a better understanding of what the VC concentrations were in this well, Figure 5 shows the VC concentrations in the Club de Leones well over time.

Figure 5. VC Concentration Over Time in Cabo Rojo Public Supply Wells with Detections



To assess the potential for VC exposure to cause harmful health effects, an estimate of the exposure dose was calculated using the same procedure as for the PCE and TCE evaluations above. Table 5 shows estimated exposure doses for various age groups based on continuous exposure to the highest VC concentration (1.2 μg/L).

Table 5. Exposure Assumptions for Estimating VC Dose for Cabo Rojo Ground Water Contamination, Based on a Concentration of VC of 1.2 μg/L

Ages	0-1	1-6	7-17	18-70
Body Weight in kilograms	10	17	45	70
Ingestion of Drinking Water in Liters per Day	1	1	2	2
Average Dose, mg/kg/day	0.0002	0.0001	0.0001	0.00007
Number of Years	1	6	11	52
Lifetime average dose = Sum of (Average Dose * Number of Years)/Total Number of Years = **0.00008 mg/kg/day**				
mg/kg/day = milligrams of contaminant per kilogram body weight per day. Assumed body weights and ingestion rates from references 9 and 13.				

ATSDR's chronic oral MRL for VC is 0.003 mg/kg/day, based on liver cell changes occurring in animal studies [16]. The estimated doses in Table 4 are all below the MRL; therefore, non-cancer effects are unlikely from exposure to VC in the municipal supply wells.

IARC and NTP have determined that VC is a known human carcinogen based on sufficient human and animal studies [11,15]. VC caused an increased rate of liver cancers in workers who breathed high levels of VC vapors [15]. EPA also considers VC to be a "known human carcinogen by the inhalation route of exposure, based on human epidemiological data, and by analogy the oral route because of positive animal bioassay data as well as pharmacokinetic data allowing dose extrapolation across routes" [10]. EPA also considers VC to be highly likely to be carcinogenic by the dermal route because it is well absorbed and acts systemically [10].

The oral cancer slope factor for VC, based on continuous exposure from birth, is 1.4 $(mg/kg/day)^{-1}$ [10]. Using this value with the average lifetime VC dose listed in Table 5, the theoretical increased risk of cancer is $0.00008 \times 1.4 = 1.1 \times 10^{-4}$ or around 1 in 10,000. This represents a low increased risk of cancer for a lifetime of exposure to VC at the highest concentrations present in the public water supply well. The actual increased risk of cancer is probably even lower than predicted here because we assumed a lifetime of exposure to the highest VC concentration measured and the water from the Club de Leones well is mixed with water from other wells before being supplied for consumption.

Potential Exposure Pathways

Vapor Intrusion

If VOC levels are high enough in groundwater and the groundwater is close enough to the ground surface, sometimes VOCs can move up through the soil above the water table and/or through cracks or gaps in the subsurface. If the travel pathway leads to a building's interior through a basement, crawl space, or cracks in the foundation, it is possible for the contaminant to build up inside. This is known as *vapor intrusion*, and in some cases vapors from contaminants can reach levels indoors that are of health concern. EPA recommends evaluating the potential for vapor intrusion at sites where volatile substances are suspected to be present in soil or groundwater at 100 ft of depth or less near existing or future buildings [17]. Mitigation of the vapor intrusion pathway usually involves improving ventilation of the homes to allow vapors to dissipate.

At ATSDR's request, EPA recently conducted indoor air sampling in homes, schools, and businesses near potential source areas in Cabo Rojo. The results showed that no harmful levels of VOCs were present in indoor air. However, high VOC concentrations were found below some buildings, so further monitoring is warranted. For more information, please consult ATSDR's recent health consultation reports on this subject, attached as Appendix C and Appendix D of this report. ATSDR will continue to work with EPA to ensure that indoor air in buildings in Cabo Rojo is not affected by vapor intrusion from the site.

Incidental Exposure to Surface Soil or Surface Water

Because the source of contamination has not been identified, we cannot determine the conditions of source areas or how people living, working, or playing around them might come in contact with contaminants on those sites. There is no indication that soil or surface water near the municipal wells themselves are contaminated or would pose a hazard to people nearby. ATSDR will continue to evaluate the potential for exposure to contaminated soil, water, or other identified substances at source areas as this information develops throughout the remedial investigation process.

Child Health Considerations

ATSDR recognizes that infants and children might be more vulnerable than adults to exposures in communities with contaminated air, water, soil, or food. This potential vulnerability results from the following factors: 1) children are more likely to play outdoors and bring food into contaminated areas; 2) children are shorter and therefore more likely to contact dust and soil; 3) children's small size results in higher doses of chemical exposure per kg of body weight; and 4) developing body systems 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 the site.

ATSDR's evaluation is protective of young children because comparison values, below which no adverse health effects are expected, are determined for young children. We

included childhood exposure assumptions in calculating lifetime exposure doses for cancer evaluation.

Health Outcome Data

Health outcome data can give a more thorough evaluation of the public health implications of a given exposure. Health outcome data can include mortality information (e.g., the number of people dying from a certain disease) or morbidity information (e.g., the number of people in an area getting a certain disease or illness). The review is most informative when (1) a completed human exposure pathway exists, (2) potential contaminant exposures are high enough to result in measurable health effects, (3) enough people are affected for the health effect to be measured, and (4) a database is available to identify rates of diseases plausibly associated with the exposure for populations of concern.

A review of health outcome data was not performed for this site. Although there is a completed exposure pathway at this site, the exposures taking place are not high enough to result in any expected health effects.

Community Health Concerns Related to the Site

ATSDR team members collected community concerns from community members in Cabo Rojo, including two leaders of a local environmental organization, one elected official, one high school teacher, three employees of a preschool facility, and a local family practice physician. ATSDR also spoke with EPA, EQB, PRDOH, and PRASA officials about concerns they may have heard from the community.

The respondents generally indicated that the community concern related to the groundwater contamination is low. The following concerns are paraphrased from the information collected from all the conversations ATSDR participated in during the April site visit.

Concern: What are the potential health effects from this contamination?

Response: The exposures occurring today and in the past several years are not expected to cause any harm to the public. None of the wells have shown any contaminant concentrations higher than federal drinking water standards, and ATSDR's evaluation showed that no health effects would be expected from exposure to even the highest concentrations detected. We note, however, that these contaminants, at concentrations much higher than those detected in the Cabo Rojo wells, can harm health. Therefore, identifying the source and addressing the contamination are important.

Concern: Should I and my family start drinking bottled water?

Response: The decision to drink bottled water is a personal one. The municipal water in Cabo Rojo meets all federal water quality standards, and the low levels of VOC contamination are not expected to harm health. Drinking bottled water will avoid

exposure to the VOCs in the municipal water, but may increase exposure to other substances[1]. Bottled water is not subject to the same federal standards as municipal water.[2]

Concern: Could this contamination cause kidney problems?

Response: Toxicological studies have shown that exposure to high concentrations of some of the VOCs detected in the municipal wells can cause kidney damage. These VOCs include trichloroethylene (TCE), tetrachloroethylene (PCE), and 1,1-dichloroethene (1,1-DCE). However, the concentrations of these substances in the Cabo Rojo municipal wells were too low to cause the types of effects seen in the toxicological studies.

[1] For more information, please see the 1999 report by the Natural Resources Defense Council, "Bottled Water- Pure Drink or Pure Hype?", available at www.nrdc.org/water/drinking/bw/bwinx.asp.
[2] For more information, please see the Food and Drug Administration's website on bottled water, www.fda.gov/Food/FoodSafety/Product-SpecificInformation/BottledWaterCarbonatedSoftDrinks.

Conclusions and Next Steps

Conclusions

ATSDR reached four important conclusions in the PHA:

Conclusion 1

Current exposures to VOCs in municipal water from the Cabo Rojo system are unlikely to harm people's health.

Basis for conclusion 1

None of the public supply wells have exceeded any federal drinking water standards for the various VOCs detected in wells.

Next steps

- The Puerto Rico Sewer and Aqueduct Authority (PRASA) should continue frequent monitoring of the wells' water quality to ensure that the public water supply meets federal standards.

Conclusion 2

In the recent past (the past 10 years or so), exposures to VOCs in municipal water were unlikely to harm people's health. We do not have enough information to make definite conclusions about VOC exposures that may have occurred before that time.

Basis for conclusion 2

All data reviewed indicated that none of the public supply wells have exceeded any federal drinking water standards for the various VOCs detected in wells. However, data were from limited, recent time periods, and periodic contamination might have occurred in the past.

Next steps

ATSDR will review any past data made available to the agency.

Conclusion 3

There is a potential for exposures to VOCs in the municipal water to harm public health in the future.

Basis for conclusion 3

The source and extent of the contamination have not been identified. Contaminant concentrations could rise to levels that could result in health effects for people using the water.

Next steps

- EPA should continue its efforts to identify the source, characterize the extent of the contamination, and implement remedial measures to address and prevent groundwater contamination.

Conclusion 4

More information is needed to assess potential exposure pathways including private wells, vapor intrusion and exposure near source areas.

Basis for conclusion 4

The source and extent of the contamination has not been identified to date. VOC concentrations might be higher near source areas and in any area between the source and the affected municipal wells, increasing the potential for exposure.

Recent sampling by EPA to assess vapor intrusion issues showed no harmful VOC levels in indoor air in buildings near potential source areas. However, several buildings had high VOC concentrations beneath the foundation slabs.

Next Steps

- EPA should continue its efforts to identify the source and delineate the areal extent of groundwater contamination at the site. Private wells used for domestic purposes should be tested.
- EPA should conduct follow-up sampling to verify that indoor levels of VOCs do not increase.
- ATSDR will evaluate additional data collected by EPA and update the findings of this PHA, if necessary.

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Appendix A. Explanation of Evaluation Process

Screening Process

In evaluating these data, ATSDR used comparison values (CVs) to determine which chemicals to examine more closely. CVs are health-based contaminant concentrations found in a specific media (air, soil, or water) and are used to screen contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water, and soil that someone might inhale or ingest each day.

As health-based thresholds, CVs are set at a concentration below which no known or anticipated adverse human health effects are expected to occur. Different CVs are developed for cancer and non-cancer health effects. Non-cancer levels are based on valid toxicological studies for a chemical, with appropriate safety factors included, and the assumption that small children (22 pounds) and adults are exposed every day. Cancer levels are based on a one-in-a-million excess cancer risk for an adult exposed to contaminated soil or drinking contaminated water every day for 70 years. For chemicals for which both cancer and non-cancer CVs exist, we use the lower level to be protective. Exceeding a CV does not mean that health effects will occur, just that more evaluation is needed.

CVs used in preparing this document are listed below:

Environmental Media Evaluation Guides (EMEGs) are estimated contaminant concentrations in a media where noncarcinogenic health effects are unlikely. EMEGs are derived from the Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk level (MRL).

Cancer Risk Evaluation Guides (CREGs) are estimated contaminant concentrations that would be expected to cause no more than one additional excess cancer in one million persons exposed over a lifetime. CREGs are calculated from U.S. Environmental Protection Agency (EPA) cancer slope factors (CSFs).

Reference Media Evaluation Guides (RMEGs) are estimated contaminant concentrations in a media where noncarcinogenic health effects are unlikely. RMEGs are derived from EPA's reference dose (RfD).

Lifetime Health Advisories (LTHAs) are derived by EPA from a drinking water equivalent level below which no adverse non-cancer health effects are expected to occur over a 70-year lifetime.

Maximum Contaminant Levels (MCLs) are enforceable standards set by EPA for the highest level of a contaminant allowed in drinking water. MCLs are set as close to MCL goals (MCLGs, the level of a contaminant in drinking water below which there is no known or expected risk to health) as feasible using the best available treatment technology and taking cost into consideration.

Some CVs may be based on different durations of exposure. Acute duration is defined as exposure lasting 14 days or less. Intermediate duration exposure lasts between 15 and 364 days, and chronic exposures last 1 year or more. Comparison values based on chronic exposure studies are used whenever available. If an intermediate or acute comparison value is used, it is denoted with a small *i* or *a* before the CV (e.g., iEMEG refers to the intermediate duration EMEG).

Determination of Exposure Pathways

ATSDR identifies human exposure pathways by examining environmental and human components that might lead to contact with contaminants of concern (COCs). A pathway analysis considers five principal elements: a source of contamination, transport through an environmental medium, a point of exposure, a route of human exposure, and an exposed population. Completed exposure pathways are those for which the five elements are evident, and indicate that exposure to a contaminant has occurred in the past, is now occurring, or will occur in the future. Potential exposure pathways are those for which exposure seems possible, but one or more of the elements is not clearly defined. Potential pathways indicate that exposure to a contaminant could have occurred in the past, could be occurring now, or could occur in the future. The identification of an exposure pathway does not imply that health effects will occur. Exposures might be, or might not be, substantive. Therefore, even if exposure has occurred, is now occurring, or is likely to occur in the future, human health effects might not result.

ATSDR reviewed site history, information on site activities, and the available sampling data. On the basis of this review, ATSDR identified household use of municipal well water as the main pathway of concern at the Cabo Rojo Ground Water Contamination site.

Evaluation of Public Health Implications

The next step is to take those contaminants present at levels above the CVs and further identify which chemicals and exposure situations are likely to be a health hazard. Child and adult exposure doses are calculated for the site-specific exposure scenario, using our assumptions of who goes on the site and how often they contact the site contaminants. The exposure dose is the amount of a contaminant that gets into a person's body. Following is a brief explanation of how we calculated the estimated exposure doses for the site.

Ingestion of Groundwater

The overall exposure dose was estimated for young children through adults. Tables 3-5 in the body of the report show the assumptions used for weight and groundwater ingestion for the ages throughout life used to estimate a lifetime exposure dose.

Non-cancer Health Effects

The calculated exposure doses are then compared to an appropriate health guideline for that chemical. Health guideline values are considered safe doses; that is, health effects are unlikely below this level. The health guideline value is based on valid toxicological

studies for a chemical, with appropriate safety factors built in to account for human variation, animal-to-human differences, and/or the use of the lowest study doses that resulted in harmful health effects (rather than the highest dose that did not result in harmful health effects). For non-cancer health effects, the following health guideline values are used.

Minimal Risk Level (MRLs) —Developed by ATSDR
An MRL is an estimate of daily human exposure – by a specified route and length of time – to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects. A list of MRLs can be found at http://www.atsdr.cdc.gov/mrls.html.

Reference Dose (RfD) —Developed by EPA
An RfD is an estimate, with safety factors built in, of the daily, life-time exposure of human populations to a possible hazard that is not likely to cause noncancerous health effects. RfDs can be found at http://www.epa.gov/iris.

If the estimated exposure dose for a chemical is less than the health guideline value, then the exposure is unlikely to cause a noncarcinogenic health effect in that specific situation. If the exposure dose for a chemical is greater than the health guideline, then the exposure dose is compared to known toxicologic values for that chemical and is discussed in more detail in the public health assessment (see Discussion section). These toxicologic values are doses derived from human and animal studies that are summarized in the ATSDR *Toxicological Profiles*. A direct comparison of site-specific exposure and doses to study-derived exposures and doses that cause adverse health effects is the basis for deciding whether health effects are likely or not.

Cancer Health Effects
The estimated risk of developing cancer resulting from exposure to the contaminants was calculated by multiplying the calculated lifetime exposure dose by the appropriate cancer slope factor or oral unit risk. The results estimate the maximum increase in risk of developing cancer after 70 years of exposure to the contaminant.

The actual increased risk of cancer is probably lower than the calculated number, which gives a theoretical worst-case excess cancer risk. The method used to calculate slope factors and unit risks assume that high-dose animal data can be used to estimate the risk for low dose exposures in humans. The methods also assume that no safe level exists for exposure. Little experimental evidence exists to confirm or refute those two assumptions. Lastly, the methods generally compute the upper 95th percent confidence limit for the risk. The actual cancer risk can be lower, perhaps by several orders of magnitude [18].

Because of uncertainties involved in estimating carcinogenic risk, ATSDR employs a weight-of-evidence approach in evaluating all relevant data [19]. Therefore, the carcinogenic risk is described in words (qualitatively) rather than giving a numerical risk estimate only. The numerical risk estimate must be considered in the context of the variables and assumptions involved in their derivation and in the broader context of

biomedical opinion, host factors, and actual exposure conditions. The actual parameters of environmental exposures must be given careful consideration in evaluating the assumptions and variables relating to both toxicity and exposure.

Appendix B. Glossary of Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency in Atlanta, Georgia, with 10 regional offices in the United States. ATSDR serves the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases from toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces laws to protect the environment and human health. This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. For additional questions or comments, call 1-800-CDC-INFO.

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

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

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

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

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

Carcinogen
A substance that causes cancer.

Chronic
Occurring over a long time [compare with acute].

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

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

Completed exposure pathway
[see exposure pathway].

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

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

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

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

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

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

Dose
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An “exposure dose” is how much of a substance is encountered in the environment. An “absorbed dose” is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

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

Epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

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

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

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

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

Health outcome data
Information from private and public institutions on the health status of populations. Health outcome data can include morbidity and mortality statistics, birth statistics, tumor and disease registries, or public health surveillance data.

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

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

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

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

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

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

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

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

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

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

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

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

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

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

Risk
The probability that something will cause injury or harm.

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

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

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

Superfund [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)]

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

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

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

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

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

Other glossaries and dictionaries:
Environmental Protection Agency (http://www.epa.gov/OCEPAterms/) National Library of Medicine (NIH) (http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)

Appendix C. ATSDR Letter Health Consultation, 2/24/2012

Letter Health Consultation

CABO ROJO GROUND WATER CONTAMINATION SITE

CABO ROJO, PUERTO RICO

EPA FACILITY ID: PRN000206319

FEBRUARY 24, 2012

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation 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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or
Visit our Home Page at: http://www.atsdr.cdc.gov

LETTER HEALTH CONSULTATION

CABO ROJO GROUND WATER CONTAMINATION SITE

CABO ROJO, PUERTO RICO

Prepared By:

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

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Agency for Toxic Substances
and Disease Registry
Atlanta, GA 30333

February 24, 2012

Ms. Judith Enck
Administrator, Region 2,
U.S. Environmental Protection Agency (EPA)
290 Broadway
New York, New York 10007-1866

Re: Cabo Rojo Ground Water Contamination site in Cabo Rojo, Puerto Rico

Dear Administrator Enck:

The Agency for Toxic Substances and Disease Registry (ATSDR) reviewed the draft report on the U.S. Environmental Protection Agency's (EPA's) June 2011 soil gas and sub-slab volatile organic compound (VOC) sample results from your investigation of potential source areas for the Cabo Rojo site[1]. This letter health consultation documents our phone conversations and recommendations to collect indoor air samples as soon as possible at locations where results show sub-slab VOCs might be migrating indoors at levels of health concern. The indoor VOC estimates are calculated from their sub-slab concentrations using very conservative assumptions. Nevertheless, prudent public health practice dictates taking prompt action. The Puerto Rico Department of Health has been advised of ATSDR's concern.

Since making these recommendations, we understand that EPA is mobilizing to initiate the following activities:

- additional community involvement activities,
- indoor air sampling and installing a vapor intrusion mitigation system in a Head Start facility (precautionary measure), and
- indoor air sampling at other locations near these potential source areas,

We look forward to working with you to evaluate additional sampling results and convey the findings to the affected community.

Summary of Sampling Results

EPA collected soil gas samples at outdoor and indoor locations underneath the building slab ("sub-slab") and analyzed them in the field for tetrachloroethylene (PCE), trichloroethylene (TCE), and dichloroethylene (DCE, not specified whether 1,1-dichloroethylene or cis- or trans-1,2-dichloroethylene).[2] Laboratory confirmation samples were in agreement with the field sampling

[1] McBurney, J. Memo to J Catanzarita of U.S. Environmental Protection Agency RE: trip report – soil gas investigation, Cabo Rojo site, work assignment no.: SERAS-130, document no. SERAS130-DTR-011312-DRAFT. Edison, NJ: Lockheed Martin SERAS, January 13, 2012.

[2] ATSDR notes that the detection of certain types of dichloroethylene in groundwater is primarily attributable to biodegradation of PCE and/or TCE. When conditions are favorable for biodegradation to occur, the process

results.

VOCs were detected at 4 out of the13 potential source locations investigated. Of these detections, 2 potential source locations had detections in sub-slab indoor samples. One of these was in a building which also contains a Head Start facility where young children are regularly present. A sub-slab sample from inside the Head Start facility was also collected. The Table 1 summarizes the results from indoor sub-slab sampling at the potential source locations, with the results from the Head Start facility shown separately.

Table 1. VOC Detections in Building Sub-Slab Gas Samples, Cabo Rojo Ground Water Contamination Site

Contaminant	Concentration in parts per billion by volume (ppbv) and in micrograms per cubic meter (µg/m^3)		
	Potential Source #1 (4 Samples)	Potential Source #2 (3 Samples)	Head Start Adjoining Potential Source #2 (1 Sample)
PCE	4,870–64,700 ppbv 33,450–444,000 µg/m	103–980 ppbv 707–6,730 µg/m^3	4,970 ppbv 34,133 µg/m^3
TCE	23–113 ppbv 125–615 µg/m^3	ND*–190 ppbv ND*–1,034 µg/m^3	83 ppbv 452 µg/m^3
DCE	Not Detected (ND)* ND*	ND* –1,700 ppbv ND*–6,825 µg/m^3	50 ppbv 201 µg/m^3
*Not Detected (ND) = less than 10 ppbv (less than 54 µg/m^3 for TCE and less than 40 µg/m^3 for DCE) NOTE: Results from other indoor sub-slab locations were not detected for PCE, TCE, and DCE.			

These results for sub-slab concentrations of VOCs are not the same concentrations occupants of the building may be exposed to because concentrations are generally attenuated from the sub-slab to the indoor air. An evaluation of EPA's vapor intrusion database indicates that out of over 1,000 paired indoor air and sub-slab concentration measurements in its vapor intrusion database, the 95th percentile attenuation factor (indoor air concentration divided by sub-slab concentration) is 0.1[3]. ATSDR used this factor to calculate a conservative value for screening purposes and estimate the highest potential indoor air concentrations.

Table 2 shows the potential indoor air concentrations estimated using this conservative screening attenuation factor. Actual indoor air concentrations may be lower. The estimated indoor concentrations are then compared to health-based comparison values (CVs) in Table 2. Comparison values are contaminant concentrations that are not expected to result in any adverse health effects for a given duration of exposure. Exceeding a CV does not mean that adverse health effects are

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also typically involves the generation of vinyl chloride, a known human carcinogen. Vinyl chloride was not summarized in the results ATSDR reviewed.

[3] U.S. Environmental Protection Agency. U.S. EPA's vapor intrusion database: preliminary evaluation of attenuation factors. Draft. Washington, DC: U.S. Environmental Protection Agency, Office of Solid Waste, March 2008.

probable. Rather, it indicates the need for further evaluation to determine the likelihood for adverse health effects. When sub-slab contaminant calculations predict indoor air levels above CVs, indoor air testing is recommended.

Table 2. Highest Estimates of Indoor Air VOC Concentrations Based on the Attenuation of Soil Gas/Sub-Slap Sample Results[+] , Cabo Rojo Ground Water Contamination Site

Contaminant	Highest Indoor Air Estimates in parts per billion by volume (ppbv) and in micrograms per cubic meter (µg/m^3)			Health-Based Comparison Value in ppbv (µg/m^3)
	Potential Source #1	Potential Source #2	Head Start Adjoining Potential Source #2	
PCE	6,470 ppbv 44,434 µg/m	98 ppbv 673 µg/m^3	497 ppbv 3,413 µg/m^3	40 ppbv (300 µg/m^3) – chronic MRL 200 ppbv (1,000 µg/m^3) – acute MRL 0.02 ppbv (0.2 µg/m^3) – CREG
TCE	11.3 ppbv 62 µg/m^3	19 ppbv 103 µg/m^3	8.3 ppbv 45 µg/m^3	0.37 ppbv (2 µg/m^3) – RfC 0.045 ppbv (0.24 µg/m^3) – CREG
DCE	N/A	170 ppbv 683 µg/m^3	5 ppbv 20 µg/m^3	20 ppbv (80 µg/m^3) – intermediate MRL

[+] **Based on an Attenuation Factor of 0.1 (upper 95th percentile)**
Chronic MRL = minimal risk level for non-cancer effects with exposure duration 1 year or longer.
Intermediate MRL = minimal risk level for non-cancer effects for exposure durations from 2 weel to 364 days.
Acute MRL = minimal risk level for non-cancer effects for exposure durations up to 14 days.
RfC = EPA reference concentration not likely to result in adverse health effects for a lifetime of exposure.
CREG = Cancer Risk Evaluation Guide, concentration not likely to increase risk of cancer greater than 1 in a million people exposed over a lifetime.

As indicated in Table 2, some of the estimated potential indoor air concentrations for these VOCs are an order of magnitude or higher than health-based screening levels:

- Calculated PCE air concentration estimates at the Head Start facility and Potential Source #1 exceed the acute minimal risk levels based on neurological effects, and all three locations exceed the chronic MRL, which is based on neurological effects. The estimated PCE concentrations could increase the risk of cancer for children or adults to

unacceptable levels.

- Calculated TCE air concentration estimates at all 3 locations exceed EPA's reference concentration for cardiac and immunologic effects and may increase the risk of cancer (kidney, non-Hodgkin's lymphoma, and liver).
- Calculated DCE air concentration estimates at Potential Source #2 may exceed the intermediate-duration MRL for 1,1-DCE which is based on liver effects. (Since the exact isomer of DCE detected was not specified, we compared to 1,1-DCE which has the lowest (most conservative) comparison values.)

Actual sampling data is needed. These results suggest that a potential exists for harmful inhalation exposures to VOCs from vapor in the buildings tested. Of particular concern is the Head Start facility where young children are regularly present. Assessing the actual concentrations of VOCs in the indoor air is essential to determine the potential risks and prevent potential future harmful exposures from occurring.

Need for Prompt Action

The current rainy season may result in higher vapor intrusion issues because of rain infiltration flushing vapors up from soil into indoor air. Sampling indoor air as soon as possible may capture VOC concentrations that might be missed at dryer times of the year. Immediate sampling will also allow prompt action to be taken to reduce any harmful exposures that may be occurring.

Vapor intrusion is variable. Several rounds of indoor air sampling (best coupled with additional sub-slab and outdoor sampling) may be needed to know the true extent of the problem. If the first round of sampling does not indicate a health concern, we recommend further sampling for confirmation.

Conclusion

Indoor air contaminant estimates calculated from field sub-slab sampling results indicate the potential for harmful indoor air exposures to VOCs through vapor intrusion. One of the buildings includes a Head Start facility where young children are regularly present.

Recommendations

- Conduct indoor air sampling at the affected properties as soon as possible to capture results for the rainy season. Methods should be sensitive enough to detect concentrations at or below the chronic comparison values cited in this letter.
- Conduct indoor air and/or sub-slab sampling at other potentially affected properties, especially if sensitive populations are present.
- ATSDR will evaluate the results of indoor sampling related to this site and assist in conveying the findings to the community.

- If results of winter 2012 sampling do not indicate a health concern, ATSDR recommends that EPA follow up with confirmatory indoor air sampling during another season of the year.

- If indoor air sampling is delayed, precautionary installation of mitigation systems for vapor intrusion in these buildings could prevent potentially harmful exposures.

Thank you for including ATSDR in your site work. Please do not hesitate to contact me if you have any questions or concerns. I can be reached at (770) 488-0768 or by email at JDyken@cdc.gov.

Sincerely,

Christopher J. Portier, Ph.D.
Director, National Center for
Environmental Health, and
Agency for Toxic Substances and
Disease Registry

Appendix D. ATSDR Health Consultation, 5/22/2012

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Agency for Toxic Substances
and Disease Registry
Atlanta, GA 30333

May 22, 2012

Ms. Denise Zeno
Remedial Project Manager
U.S. Environmental Protection Agency (EPA), Region 2
290 Broadway
New York, New York 10007-1866

Re: Evaluation of Indoor Air Sampling at Cabo Rojo Ground Water Contamination site in Cabo Rojo, Puerto Rico

Dear Ms. Zeno:

Thank you for the opportunity for the Agency for Toxic Substances and Disease Registry (ATSDR) to provide public health input related to the U.S. Environmental Protection Agency (EPA)'s investigation of potential source areas for the Cabo Rojo Ground Water Contamination Superfund site ("the Site") in Cabo Rojo, Puerto Rico. ATSDR appreciates the prompt response of EPA to collect indoor air samples at schools and other buildings potentially impacted by vapor intrusion of volatile organic compounds (VOCs) into indoor air from groundwater, as recommended in our letter dated February 24, 2012.

ATSDR has reviewed validated results of EPA's indoor air, sub-slab, and ambient (outdoor) air sampling for VOCs collected the weeks of February 27 and March 19, 2012, in Cabo Rojo, Puerto Rico. The enclosed health consultation documents our evaluation of the results from both phases of sampling and recommendations related to this issue. The focus of the health consultation is on indoor air sample results. Results of sub-slab soil gas and ambient air sampling taken at the same time as the indoor air sampling are discussed as they apply to the indoor air evaluation.

To summarize our conclusions and recommendations:

- No harmful levels of VOCs were found in indoor air of any of the locations in the recent sampling events. However, sub-slab sampling shows continued high VOC concentrations beneath several buildings.

- ATSDR recommends follow-up sampling over time to verify that indoor levels of VOCs do not increase. ATSDR will provide public health input as EPA develops a site-specific sampling strategy.
- Further investigation may be warranted to discover the source or sources of benzene, toluene, ethylbenzene, xylene, and trimethylbenzenes in soil gas beneath one location. These contaminants are not known to be site-related.

We appreciated the opportunity to work with you and Ms. Arlene Anderson, EPA Region 2 On-Scene Coordinator, during community involvement activities held the week of May 14. Thank you for including ATSDR in your site work. Please do not hesitate to contact me if you have any questions or concerns. I can be reached at (770) 488-0768 or by email at JDyken@cdc.gov.

Sincerely,

[signed]

Jill J. Dyken, PhD, PE
Environmental Health Scientist
Eastern Branch
Division of Community Health Investigations (proposed)

Enclosure (1)

cc:
Joe Rotola, EPA R2
Eric Wilson, EPA R2
Angela Carpenter, EPA R2
Mel Hauptman, EPA R2
Arlene Anderson, EPA R2
Iran Rodriguez, ACF R2
Carolyn Baker, ACF R2

Health Consultation

Evaluation of Indoor Air Sampling at Cabo Rojo Ground Water Contamination Site
in Cabo Rojo, Puerto Rico

EPA FACILITY ID: PRN000206319

May 22, 2012

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations (proposed)
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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or
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HEALTH CONSULTATION

Evaluation of Indoor Air Sampling at Cabo Rojo Ground Water Contamination Site
in Cabo Rojo, Puerto Rico

EPA FACILITY ID: PRN000206319

Prepared By:

Eastern Branch
Division of Community Health Investigations (proposed)
Agency for Toxic Substances and Disease Registry

Summary

Introduction

The Agency for Toxic Substances and Disease Registry's (ATSDR) top priority is to ensure that the people living in or near Cabo Rojo, Puerto Rico have the best information possible to safeguard their health.

Man-made chemicals called chlorinated volatile organic compounds (VOCs) have been detected at low levels in municipal drinking water supply wells in Cabo Rojo. The U.S. Environmental Protection Agency (EPA) is investigating potential sources of the contamination and identified high VOCs in the soil and air beneath some buildings where businesses may have used these chemicals in the past.. In February 2012, ATSDR recommended EPA collect indoor air samples to identify any harmful exposures occurring in nearby schools, residences, and businesses.

The purpose of this Health Consultation (HC) is to evaluate results from EPA's sampling of indoor air, sub-slab soil gas, and ambient (outdoor) air in several locations that are potentially affected by VOCs from contaminated groundwater.

Conclusion

No harmful levels of VOCs were found in indoor air of any of the locations in the recent sampling events. However, sub-slab sampling shows continued high VOC concentrations beneath several buildings.

Next steps

- ATSDR recommends follow-up sampling over time to verify that indoor levels of VOCs do not increase. ATSDR will provide public health input as EPA develops a site-specific sampling strategy.
- Further investigation may be warranted to discover the source or sources of benzene, toluene, ethylbenzene, xylene, and trimethylbenzenes in soil gas beneath one location. These contaminants are not known to be site-related.

Background and Statement of Issues

The Agency for Toxic Substances and Disease Registry (ATSDR) has been working with the U.S. Environmental Protection Agency (EPA) to evaluate whether public health might be affected by an area of groundwater contamination in Cabo Rojo, Puerto Rico known as the Cabo Rojo Ground Water Contamination site. Chlorinated volatile organic compounds (VOCs), man-made chemicals, have been detected at low levels in some public water supply wells serving the city. This site was listed on the National Priorities List (NPL) in March 2011.

In August 2011, ATSDR released a draft public health assessment which concluded that the municipal drinking water was unlikely to cause any harm in people drinking and using this water [1]. However, the Agency recommended further evaluation of the potential for contaminants from the groundwater to enter homes through a process known as vapor intrusion, especially near potential sources of the groundwater contamination where concentrations might be higher.

In January 2012, EPA provided ATSDR with results of soil gas and sub-slab (under building foundations) sampling collected in several potential source areas to assess the potential for vapor intrusion in Cabo Rojo [2]. While not conclusive, the results indicated a potential for harmful concentrations of VOCs, particularly tetrachloroethylene (PCE), in indoor air of certain buildings tested, including a Head Start preschool. In a letter health consultation dated February 24, 2012, ATSDR recommended EPA collect indoor air samples so that VOC concentrations could be evaluated [3][1].

EPA collected indoor air samples, sub-slab samples, and ambient (outdoor) samples at several schools, residences, and businesses potentially affected by vapor intrusion in two phases. Phase 1 sampling occurred the week of February 27, 2012; ATSDR received complete results on March 19, 2012 [4]. EPA collected Phase 2 samples at additional properties the week of March 19, 2012, and provided complete results to ATSDR on April 13, 2012. The focus of this health consultation is on indoor air sample results. Results of sub-slab soil gas and ambient air sampling taken at the same time as the indoor air sampling are discussed only as they apply to the indoor air evaluation.

[1] Note: This health consultation uses a cancer screening value for PCE (3.8 µg/m^3) based on updated toxicological information finalized by EPA in February 2012. The February 24, 2012 letter health consultation used a value of 0.2 µg/m^3, based on interim ATSDR guidance to use California EPA PCE information until the EPA update was finalized. This change does not affect ATSDR's prior conclusions or current conclusions regarding PCE potential risk at this site.

Summary of Sampling

In response to ATSDR's February 2012 request for indoor air sampling, EPA conducted further testing in February and March. Samples were collected in 2 phases: Phase 1 testing included schools, businesses, and residences within, immediately adjacent to, or very near the potential sources and was conducted during the week of February 28, 2012. Phase 2 testing included schools, businesses, governmental facilities, and residences located within 100 feet of potential source areas and was conducted the week of March 19, 2012.

Phase 1
EPA investigated all four potential source locations where VOCs were found in sub-slab or soil gas sampling. EPA collected 24-hour indoor, sub-slab, and ambient air samples at each area. Sampling focused on the potential source and schools, businesses, and residences adjacent to and/or near the potential source. Table 1 summarizes the Phase 1 samples.

Table 1. Samples Collected at Potential Sources and Adjoining Properties, Cabo Rojo Ground Water Contamination Site, Phase 1

Potential Source	Location Sampled	# of Indoor Air Samples	# of Sub-Slab Samples*	# of Ambient Samples
Potential Source#1	Potential Source	1	3	1
	Residence	1	0	
Potential Source #2	Potential Source	3	2	5
	Head Start	5	7	
	Adult School	1	1	
Potential Source #3	Potential Source	1	3	3
	Preschool	2	3	
	Residence	1	0	
Potential Source #4[†]	Drug Store	1	2	1
	Vacant Shop	1	3	
	Restaurant	1	0	

*Some residents/occupants did not agree to sub-slab sampling because it would damage flooring.
[†] The building containing Potential Source #4 was demolished several years ago (exact date unknown), and the lot now contains a drug store and a building housing a vacant shop and a restaurant.
NOTE: Samples collected from Potential Source #2 were analyzed for more than 50 VOCs using the standard EPA TO-15 method. Samples from the remaining potential source areas were analyzed for a subset of 8 VOCs related to the Cabo Rojo Ground Water Contamination Site.

Because potential indoor air concerns at the Head Start facility were identified from June 2011 sub-slab sampling, all samples from the area of Potential Source #2 were analyzed for more than 50 VOCs using the EPA TO-15 Method [5]. All other samples from the remaining potential

source areas were analyzed for eight VOCs specific to the Cabo Rojo Site, including PCE, TCE, and six other breakdown products.

Phase 2
In Phase 2, EPA collected 24-hour indoor air, sub-slab, and ambient air samples at schools, businesses, governmental agencies, and residences within 100 feet of the four potential sources tested in Phase 1. No samples associated with Potential Source #4 were collected because there were no properties within 100 feet of the potential source besides those already sampled during Phase 1. Table 2 summarizes the samples collected during Phase 2.

Table 2. Samples Collected at Properties Within 100 Feet of Potential Sources, Cabo Rojo Ground Water Contamination Site, Phase 2

Potential Source	# and Type of Properties Sampled	# of Indoor Air Samples	# of Sub-Slab Samples*	# of Ambient Samples
Potential Source#1	10 Residences	12	10	1
	4 Businesses	4	4	0
Potential Source #2	6 Residences	8	6	1
	1 School	8	7	1
	5 Government Facilities	6	6	1
Potential Source #3	4 Residences	5	4	1
	2 Schools	16	14	2
Potential Source #4	None†	0	0	0

*Some residents/ occupants did not agree to sub-slab sampling because it would damage flooring.
† No additional properties other than those already sampled in Phase 1 were located within 100 feet of potential source.

Summary of Phase 1 Indoor Air Sampling Results

Table 3 summarizes the results of the indoor air sampling, along with health-based comparison values (CVs) used for screening. CVs are contaminant concentrations in air that are not expected to result in any adverse health effects for continuous exposure over different periods of time. Separate CVs exist for noncancer and cancer effects.

If a measured concentration is higher than a CV, it does not mean that adverse health effects will occur. Rather, it indicates the need to further evaluate the potential for adverse health effects. Of the 11 locations with indoor air samples collected, six had one or more detections above a cancer-based CV; only one location had a detection above a non-cancer CV..

The following discussion focuses on evaluation of the indoor air sample results. Results of sub-slab soil gas and ambient air sampling taken at the same time as the indoor air sampling are discussed only as they apply to the indoor air evaluation; table summaries of sub-slab and ambient air results are included in Appendix A for reference.

Evaluation of Indoor Air Exposures at Phase 1 Locations

ATSDR screened the indoor air results to determine which contaminants exceeded CVs; see Tables 3a and 3b for summaries. For contaminants exceeding noncancer CVs, ATSDR compared potential exposures with findings of relevant toxicological studies to determine the likelihood for adverse noncancer health effects. For contaminants exceeding cancer CVs, ATSDR estimated the theoretical increased risk of cancer. This is calculated by multiplying the concentration of a contaminant by its corresponding inhalation unit risk [6]. Because the inhalation unit risk is based on continuous exposure for a lifetime (70 years), this product may be scaled by the fraction of time a person is assumed to be exposed to the contaminant. For this evaluation, we considered three exposure scenarios:

- Schools: ATSDR assumed teachers would be exposed to the highest concentration of each contaminant detected for 50 hours per week, for 30 years. Students at the school were assumed to be exposed to the highest concentration of each contaminant detected for 50 hours per week, for no more than four years. (Typical enrollees for preschools are 3-5 year-olds.)
- Residences: ATSDR assumed residents would be exposed to the highest concentration of each contaminant detected for 24 hours a day, for an assumed lifetime of 70 years. (i.e., no scaling factor was applied to the concentration × inhalation unit risk product.)
- Businesses: ATSDR assumed workers would be exposed to the highest concentration of each contaminant detected for 50 hours per week, for 30 years. (This category was also applied to businesses that may not be currently operating.)

ATSDR compared the estimated theoretical increased cancer risk with EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000. More detailed numerical results from ATSDR cancer estimates are included in Appendix A. The following discussion describes ATSDR's findings from this evaluation for each potential source and nearby properties:

Potential Source #1 – Phase 1 Evaluation

Potential Source #1 is a former business; people reside in a building very close to it. Indoor air samples were collected both in the potential source and the residence. Sub-slab samples were collected in the potential source unit only. An ambient air sample was collected outside of the potential source. The following text evaluates the results from sampling around Potential Source #1:

Indoor Air in Potential Source Unit
PCE was the only VOC detected above CVs in indoor air, and it exceeded only the cancer CV. Assuming a worker's exposure to this concentration of PCE for 50 hours per week for 30 years, the theoretical increased risk of cancer would be 1.6×10^{-7}, or less than 1 in 1,000,000. That is, out of a million workers exposed under this scenario, less than one additional case of cancer would be expected due to the exposure. This is below EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000.

Indoor Air in Residence Near Potential Source #1
A residence adjacent to Potential Source #1 had 1,2-dichloroethane and PCE detected in indoor air above cancer CVs. Assuming a lifetime of exposure to the detected concentrations, the theoretical increased risk of cancer would be 6.6×10^{-5}, or less than 1 in 10,000. That is, out of 10,000 people exposed under this scenario, less than one additional case of cancer would be expected due to the exposure. This is within EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000.

Ambient Air and Sub-Slab Soil Gas at Potential Source #1
One ambient air sample collected from outside the potential source unit detected PCE at a similar concentration as in the indoor air of both the potential source unit and the residence. Sub-slab soil gas sampling performed at the potential source unit at the same time as the indoor sampling detected PCE concentrations in the sub-slab soil gas ranging from 104,000 to 692,000 $\mu g/m^3$, indicating highly elevated PCE concentrations in the soil gas beneath the potential source building.

To summarize, current indoor air exposures at locations near Potential Source #1 are not likely to result in harm to the occupants. However, elevated sub-slab results indicate that ongoing indoor air monitoring is needed. This monitoring will ensure that changing seasons or building/foundation conditions do not increase the likelihood of vapor intrusion at the potential source and adjoining properties.

Potential Source #2 – Phase 1 Evaluation
Potential Source #2 is an operating business. A Head Start preschool and an adult school are adjacent to the business in the same building. Indoor air and sub-slab soil gas samples were collected in each facility. Ambient air samples were collected in several areas around the building. The following text evaluates the results from sampling around Potential Source #2:

Indoor Air in Potential Source Unit
Within the potential source unit, benzene, carbon tetrachloride, chloroform, methylene chloride and PCE in indoor air exceeded their respective cancer CVs. Recent toxicological information indicates that chloroform is unlikely to be carcinogenic at the concentrations

measured in this sampling[2] [6]. Assuming a worker's exposure to the highest concentration of each of the other carcinogenic contaminants for 50 hours per week for 30 years, the theoretical increased risk of cancer would be 1.1×10^{-5}, or less than 1 in 10,000. That is, out of 10,000 workers exposed under this scenario, less than one additional case of cancer would be expected due to the exposure. This is within EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000. Benzene, carbon tetrachloride, chloroform, and methylene chloride are not known to be associated with the groundwater contamination for the Site.

The compounds 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene were detected in the source unit indoor air at a level exceeding EPA's regional screening level for residential air for 1,2,4-trimethylbenzene, based on non-cancer effects. These compounds are not known to be

[2] Chloroform is likely to be carcinogenic only under high-exposure conditions leading to cell death and cell regeneration in susceptible tissues. Exposure to chloroform at the measured concentrations is not high enough to cause these effects.

Table 3a. Summary of Phase 1 Indoor Air Results – Potential Sources #1 and #2

Contaminant	Highest Indoor Air VOC Concentration Detected, in µg/m^3					Health-Based Comparison Values in µg/m^3; NTP Cancer Classification
	Potential Source (PS) #1	Residence Near PS#1	Potential Source (PS) #2	Head Start Near PS #2	Adult School Near PS #2	
Benzene	NA	NA	3	1	2	10 - chronic MRL 0.1 –CREG Known human carcinogen
Carbon Tetrachloride	NA	NA	0.4	0.5	ND	200 - chronic MRL 0.2 – CREG Reasonably anticipated to be a carcinogen
Chloroform	NA	NA	2	16	2	100 - chronic MRL 0.04 – CREG Reasonably anticipated to be a carcinogen
1,2-Dichloroethane	ND	2	ND	ND	1	2000 - chronic MRL 0.04 – CREG Reasonably anticipated to be a carcinogen
cis-1,2-Dichloroethylene	ND	ND	ND	ND	1	None Not classified
Methylene Chloride	NA	NA	600	0.8	1	1000 - chronic MRL 100 – CREG Reasonably anticipated to be a carcinogen
Tetrachloroethylene (PCE)	5	7	48	0.7	ND	270 chronic MRL 3.8 – CREG* Reasonably anticipated to be a carcinogen
Toluene	NA	NA	154	13	814	300 - chronic MRL Not classified
1,2,4-Trimethylbenzene	NA	NA	450	3	102	7.3 – RSL Not classified
1,3,5-Trimethylbenzene	NA	NA	154	1	22	7.3 – RSL for 1,2,4-Trimethylbenzene Not classified

Notes: Results rounded to whole number or one significant figure. Highlights indicate detections above comparison values (CVs).
µg/m^3 = micrograms per cubic meter NTP = National Toxicology Program NA = not analyzed ND = not detected
MRL = minimal risk level CREG = cancer risk evaluation guide RSL = regional screening level
*Note: the CREG for PCE has been updated based on updated toxicological information finalized by EPA in February 2012. The PCE CREG used in ATSDR's February 24, 2012 letter health consultation, 0.2 µg/m^3, was based on interim ATSDR guidance to use California EPA PCE information until the EPA update was finalized. This change does not affect ATSDR's prior conclusions or current conclusions regarding PCE potential risk at this site.

Table 3b. Summary of Phase 1 Indoor Air Results – Potential Sources #3 and #4

Contaminant	Highest Indoor Air VOC Concentration Detected, in µg/m^3						Health-Based Comparison Values in µg/m^3; NTP Cancer Classification
	Potential Source (PS) #3	Preschool Near PS #3	Residence Near PS #3	Drug Store at Former PS #4	Vacant Shop at Former PS #4	Restaurant at Former PS #4	
Benzene	NA	NA	NA	NA	NA	NA	10 - chronic MRL 0.1 –CREG Known human carcinogen
Carbon Tetrachloride	NA	NA	NA	NA	NA	NA	200 - chronic MRL 0.2 – CREG Reasonably anticipated to be a carcinogen
Chloroform	NA	NA	NA	NA	NA	NA	100 - chronic MRL 0.04 – CREG Reasonably anticipated to be a carcinogen
1,2-Dichloroethane	ND	ND	ND	4	ND	ND	2000 - chronic MRL 0.04 – CREG Reasonably anticipated to be a carcinogen
cis-1,2-Dichloroethylene	ND	ND	0.3	ND	ND	ND	None Not classified
Methylene Chloride	NA	NA	NA	NA	NA	NA	1000 - chronic MRL 100 – CREG Reasonably anticipated to be a carcinogen
Tetrachloroethylene (PCE)	3	ND	ND	ND	ND	ND	270 chronic MRL 3.8 – CREG* Reasonably anticipated to be a carcinogen
Toluene	NA	NA	NA	NA	NA	NA	300 - chronic MRL Not classified
1,2,4-Trimethylbenzene	NA	NA	NA	NA	NA	NA	7.3 – RSL Not classified
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	NA	7.3 – RSL for 1,2,4-Trimethylbenzene Not classified

Notes:
Results rounded to whole number or one significant figure. Highlights indicate detections above lowest comparison value.
µg/m^3 = micrograms per cubic meter NTP = National Toxicology Program NA = not analyzed ND = not detected
MRL = minimal risk level CREG = cancer risk evaluation guide RSL = regional screening level
*Note: the CREG for PCE has been updated based on updated toxicological information finalized by EPA in February 2012. The PCE CREG used in ATSDR's February 24, 2012 letter health consultation, 0.2 µg/m^3, was based on interim ATSDR guidance to use California EPA PCE information until the EPA update was finalized. This change does not affect ATSDR's prior conclusions or current conclusions regarding PCE potential risk at this site.

associated with the groundwater contamination for the Site. Few studies exist of the toxicology of these individual compounds. Animal inhalation studies showed that a mixture of compounds containing trimethylbenzenes and other aromatic hydrocarbons caused liver effects at concentrations thousands of times higher than the highest concentration measured at this potential source unit [7]. Health effects are unlikely from exposure to these compounds.

Indoor Air in the Head Start facility Adjacent to Potential Source #2
At the Head Start facility, benzene, carbon tetrachloride, and chloroform in indoor air exceeded the respective cancer CVs (no noncancer CVs were exceeded). Recent toxicological information indicates that chloroform is unlikely to be carcinogenic at the concentrations measured in this sampling [6]. Assuming a teacher's exposure to the highest concentration of each of the other carcinogenic contaminants for 50 hours per week for 30 years, the theoretical increased risk of cancer would be 4.8×10^{-5}, or less than 1 in 10,000. That is, out of 10,000 teachers exposed under this scenario, less than one additional case of cancer would be expected due to the exposure. This is within EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000. Children's risk would be lower because children are only enrolled between the ages of 3 and 5, so their duration of exposure would only be 2-4 years. Benzene, carbon tetrachloride, and chloroform are not known to be associated with the groundwater contamination for the Site. No detections above CVs occurred for PCE, TCE, or DCE (VOCs known to be associated with the Site groundwater contamination) in indoor air.

Indoor Air in Adult School Near Potential Source #2
At the school for adults, toluene was detected in indoor air at 814 $\mu g/m^3$, above the noncancer CV of 300 $\mu g/m^3$. This chronic minimal risk level is based on a human study showing impaired color vision among workers who were exposed during work hours to 35 ppm of toluene, for at least 6 months [8]. The effect level noted in the study, 35 ppm toluene, converts to 142,000 $\mu g/m^3$ toluene. If the detection of 814 $\mu g/m^3$ is representative of average levels of toluene in this school, it is unlikely that adverse health effects would occur from this exposure. However, ATSDR notes that sub-slab soil gas sampling at this location also detected a high concentration of toluene (131,000 $\mu g/m^3$), along with detections of ethylbenzene, xylenes, and trimethylbenzenes. Benzene, toluene, ethylbenzene, and xylenes ("BTEX" compounds) and trimethylbenzenes are not known to be associated with the Site groundwater contamination.

Also at this school, benzene, chloroform, and 1,2-dichloroethane were detected in indoor air above cancer CVs. Recent toxicological information indicates that chloroform is unlikely to be carcinogenic at the concentrations measured in this sampling [6]. Assuming a teacher's exposure to the highest concentration of each of the other carcinogenic contaminants for 50 hours per week for 30 years, the theoretical increased risk of cancer would be 1.2×10^{-5}, or less than 1 in 10,000. That is, out of 10,000 teachers exposed under this scenario, less than one additional case of cancer would be expected due to the exposure. This is within EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000. A student's risk would be lower since they will be enrolled for a shorter time.

Ambient Air and Sub-Slab Soil Gas at Potential Source #2
Five ambient air samples collected from around the building housing both schools and the potential source showed concentrations of benzene, carbon tetrachloride, and chloroform similar to those measured in indoor air. Sub-slab soil gas sampling performed in the Head Start facility at the same time as the indoor sampling detected PCE concentrations in the sub-slab soil gas ranging from 748 to 7,340 µg/m^3, confirming earlier findings. The sub-slab sampling beneath the potential source unit showed PCE concentrations as high as 756,000 µg/m^3, indicating highly elevated PCE concentrations in the soil gas. Sub-slab sampling beneath the source unit and adjoining properties also detected benzene, chloroform, toluene, and trimethylbenzenes.

To summarize, current indoor air exposures at locations near Potential Source #2 are not likely to result in harm. However, elevated sub-slab results indicate that ongoing monitoring of the indoor air is needed. This monitoring will ensure that changing seasons or building/foundation conditions do not increase the likelihood of vapor intrusion into any of these facilities.

Potential Source #3 – Phase 1 Evaluation
Potential Source #3 is a former business. A residence is adjacent to the potential source in the same building, and a preschool is in a separate building very near the potential source. Indoor air samples were collected in each location (business, residence and preschool). Sub-slab soil gas samples were collected from the potential source and preschool. Ambient air samples were collected in several areas around the preschool building. The following text evaluates the results from sampling around Potential Source #3:

Indoor Air in Potential Source Unit
PCE was the only VOC detected in indoor air, and its concentration did not exceed any CV. Indoor air exposures at this unit are not likely to result in any harm.

Indoor Air in Preschool Near Potential Source #3
At the preschool, there were no detections of any VOCs in indoor air. Indoor air exposures at this preschool are not likely to result in any harm.

Indoor Air in Residence Near Potential Source #3
At a nearby residence there were no detections of any VOCs in indoor air. Indoor air exposures at this residence are not likely to result in any harm.

Ambient Air and Sub-Slab Soil Gas at Potential Source #3
Three ambient air samples collected from around the preschool showed no detections of any VOC. Sub-slab sampling at the potential source unit detected relatively high concentrations of PCE, up to 5,780 µg/m^3. The sub-slab sampling at the preschool detected low concentrations of PCE in soil gas, which would not be likely to impact indoor air.

To summarize, current indoor air exposures at locations near Potential Source #3 are not likely to result in harm. However, elevated sub-slab results indicate that ongoing monitoring of the indoor air is needed. This monitoring will ensure that changing seasons or building/foundation conditions do not increase the likelihood of vapor intrusion at the potential source and adjoining properties.

Potential Source #4 – Phase 1 Evaluation

Potential Source #4 was a business, but the business closed and the building was demolished several years ago (exact date unknown). Currently, two buildings are present on the property: a drug store and a building containing a vacant shop and a restaurant. Indoor air samples were collected in all 3 units, and sub-slab samples were collected in the drug store and vacant shop. One ambient air sample was collected in between the two buildings. The following text evaluates the results from sampling around former Potential Source #4:

Indoor Air in Drug Store at Former Potential Source Site

The compound 1,2-dichloroethane was the only VOC detected in indoor air at the drug store. Its concentration exceeded only the cancer CV. Assuming a worker's exposure to this concentration of 1,2-dichloroethane for 50 hours per week for 30 years, the theoretical increased risk of cancer would be 1.3×10^{-5}, or less than 1 in 10,000. That is, out of 10,000 workers exposed under this scenario, less than one additional case of cancer would be expected due to the exposure. This is within EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000.

Indoor Air in Vacant Shop at Former Potential Source Site

No VOCs were detected in indoor air of the vacant shop. Indoor air exposures at this shop are not likely to result in any harm.

Indoor Air in Restaurant at Former Potential Source Site

No VOCs were detected in the restaurant's indoor air.. Indoor air exposures at this restaurant are not likely to result in any harm.

Ambient Air and Sub-Slab Soil Gas at Potential Source #4

One ambient air sample collected in the area of the former Potential Source #4 showed no detections of any VOC. Sub-slab sampling at the drug store detected relatively low concentrations of PCE (49-187 $\mu g/m^3$). The sub-slab sampling at the vacant shop detected even lower concentrations of PCE (1-2 $\mu g/m^3$), which would not be likely to impact indoor air.

To summarize, current indoor air exposures at locations near former Potential Source #4 are not likely to result in harm. However, ongoing monitoring of the indoor air is recommended to ensure that changing seasons or building/foundation conditions do not increase the likelihood of vapor intrusion at properties associated with this former potential source.

Summary of Phase 2 Indoor Air Sampling Results
Data from the Phase 2 sampling (additional properties within 100 feet of the potential source areas) were evaluated similarly as the Phase 1 results. Tables 4a, 4b, and 4c summarize the Phase 2 indoor air results for each potential source area along with applicable health-based CVs. No additional properties were located within 100 feet of Potential Source #4, so no results are shown.

The following discussion focuses on evaluation of the indoor air sample results. Results of sub-slab soil gas and ambient air sampling taken at the same time as the indoor air sampling are discussed only as they apply to the indoor air evaluation; table summaries of sub-slab and ambient air results are attached in Appendix A for reference.

Evaluation of Indoor Air Exposures at Phase 2 Locations

Data from the Phase 2 sampling were evaluated similarly as the Phase 1 data; the general procedure is described in the section beginning on page 7 of this document. Of all the samples collected during Phase 2, no indoor air contaminant levels exceeded a noncancer CV. Some contaminant concentrations exceeded cancer CVs and were evaluated using the same exposure scenarios described previously. For government facilities, the exposure was assumed to be similar to a business exposure scenario.

Potential Source #1 – Phase 2 Evaluation
Indoor air and sub-slab soil gas samples were collected in 4 businesses and 10 residences within 100 feet of potential source #1.One ambient air sample was collected outside of one of the residences. The following text evaluates the results from Phase 2 sampling around Potential Source #1, summarized in Table 4a:

Indoor Air in Residences Near Potential Source #1
1,2-Dichloroethane was the only substance detected above CVs in indoor air in the residential samples. It was detected at only one residence out of 10 residences sampled. A lifetime of exposure to the detected concentration of this compound would result in a theoretical increased risk of 7.5×10^{-6}, or less than 1 in 100,000. That is, out of 100,000 people exposed under this scenario, less than one additional case of cancer would be expected due to the exposure. This is within EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000.

Indoor Air in Businesses Near Potential Source #1
1,2-Dichloroethane and PCE were detected above CVs in indoor air at two of the businesses sampled. Assuming a worker's exposure to the highest concentration of each carcinogenic contaminant for 50 hours per week for 30 years, the theoretical increased risk of cancer would be 1.1×10^{-6}, or less than 1 in 100,000. That is, out of 100,000 workers exposed under this scenario, less than one additional case of cancer would be expected due to the exposures. This is within EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000.

Ambient Air and Sub-Slab Soil Gas from Phase 2 Properties Near Potential Source #1
The ambient air sample detected TCE at 0.3 µg/m^3. The origin of this relatively low detection is not clear, since TCE was not detected in nearby indoor air or sub-slab samples. Sub-slab soil gas sampling performed at the residences and businesses at the same time as the indoor sampling detected low concentrations of PCE and PCE breakdown products in the sub-slab soil gas. PCE concentrations ranged from 0.6 to 12 µg/m^3 in residences and from 3 to 109 µg/m^3 in the businesses.

To summarize, current indoor air exposures at residences and businesses within 100 feet of Potential Source #1 are not likely to result in harm to the occupants.

Table 4a. Summary of Indoor Air Results – Phase 2 Sampling Near Potential Source #1

Contaminant	Highest Indoor Air VOC Concentration Detected, in µg/m^3		Health-Based Comparison Values in µg/m^3; NTP Cancer Classification
	Residences	Businesses	
1,2-Dichloroethane	0.3	0.3	2000 - chronic MRL 0.04 – CREG Reasonably anticipated to be a carcinogen
Tetrachloroethylene (PCE)	ND	0.5	270 chronic MRL 3.8 – CREG* Reasonably anticipated to be a carcinogen

Notes:
Results rounded to whole number or one significant figure.
Highlights indicate detections above comparison values (CVs).
µg/m^3 = micrograms per cubic meter NTP = National Toxicology Program ND = not detected
MRL = minimal risk level CREG = cancer risk evaluation guide
*Note: the CREG for PCE has been updated based on updated toxicological information finalized by EPA in February 2012. The PCE CREG used in ATSDR's February 24, 2012 letter health consultation, 0.2 µg/m^3, was based on interim ATSDR guidance to use California EPA PCE information until the EPA update was finalized. This change does not affect ATSDR's prior conclusions or current conclusions regarding PCE potential risk at this site.

Potential Source #2 – Phase 2 Evaluation

Indoor air and sub-slab soil gas samples were collected in one school, six residences, and five government facilities within 100 feet of potential source #2. Ambient air samples were collected outside of the school, one residence, and one government facility. The following text evaluates the results from Phase 2 sampling around Potential Source #2:

Indoor Air in School Near Potential Source #2

Benzene, chloroform, and 1,2-dichloroethane were the only substances detected above CVs in indoor air in the school samples. Recent toxicological information indicates that chloroform is unlikely to be carcinogenic at the concentrations measured in this sampling [6]. Assuming a teacher's exposure to the highest concentration of each of the other carcinogenic contaminants for 50 hours per week for 30 years, the theoretical increased risk of cancer would be 1.0×10^{-5}, or 1 in 100,000. That is, out of 100,000 teachers exposed under this scenario, one additional case of cancer would be expected due to the exposure. This is within EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000. Children's risk would be lower because children are only enrolled for 2-4 years. Benzene and chloroform are not known to be associated with the groundwater contamination for the Site.

Indoor Air in Residences Near Potential Source #2

Chloroform and 1,2-dichloroethane were the only substances detected above CVs in indoor air in the residential samples. Recent toxicological information indicates that chloroform is unlikely to be carcinogenic at the concentrations measured in this sampling [6]. Assuming a lifetime of exposure to the highest concentration of each of the other carcinogenic contaminants, the theoretical increased risk of cancer would be 1.7×10^{-5}, or less than 1 in 10,000. That is, out of 10,000 people exposed under this scenario, less than one additional case of cancer would be expected due to the exposure. This is within EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000.

Indoor Air in Government Facilities Near Potential Source #2

Chloroform, 1,2-dichloroethane, and TCE were the only substances detected above CVs in indoor air in the government facility samples. Recent toxicological information indicates that chloroform is unlikely to be carcinogenic at the concentrations measured in this sampling [6]. Assuming a worker's exposure to the highest concentration of each of the other carcinogenic contaminants for 50 hours per week for 30 years, the theoretical increased risk of cancer would be 1.1×10^{-5}, or less than 1 in 10,000. That is, out of 10,000 workers exposed under this scenario, less than one additional case of cancer would be expected due to the exposure. This is within EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000. Chloroform is not known to be associated with the groundwater contamination for the Site.

Table 4b. Summary of Indoor Air Results – Phase 2 Sampling Near Potential Source #2

Contaminant	Highest Indoor Air VOC Concentration Detected, in µg/m^3			Health-Based Comparison Values in µg/m^3; NTP Cancer Classification
	School	Residences	Government Facilities	
Benzene	7	ND	ND	10 - chronic MRL 0.1 –CREG Known human carcinogen
Chloroform	0.2	8	3	100 - chronic MRL 0.04 – CREG Reasonably anticipated to be a carcinogen
1,2-Dichloroethane	0.1	0.4	0.4	2000 - chronic MRL 0.04 – CREG Reasonably anticipated to be a carcinogen
Ethylbenzene	8	2	1	300 – chronic MRL Not classified
Methylene Chloride	0.7	0.8	0.5	1000 - chronic MRL 100 – CREG Reasonably anticipated to be a carcinogen
Tetrachloroethylene (PCE)	ND	1	ND	270 chronic MRL 3.8 – CREG* Reasonably anticipated to be a carcinogen
Toluene	39	31	10	300 - chronic MRL Not classified
Trichloroethylene (TCE)	ND	ND	0.6	2 – chronic MRL 0.24 – CREG Reasonably anticipated to be a carcinogen
1,2,4-Trimethylbenzene	7	4	3	7.3 – RSL Not classified

Notes:
Results rounded to whole number or one significant figure.
Highlights indicate detections above comparison values (CVs).
µg/m^3 = micrograms per cubic meter NTP = National Toxicology Program ND = not detected
RSL = EPA Regional Screening Level for resident air MRL = minimal risk level
CREG = cancer risk evaluation guide
*Note: the CREG for PCE has been updated based on updated toxicological information finalized by EPA in February 2012. The PCE CREG used in ATSDR's February 24, 2012 letter health consultation, 0.2 µg/m^3, was based on interim ATSDR guidance to use California EPA PCE information until the EPA update was finalized. This change does not affect ATSDR's prior conclusions or current conclusions regarding PCE potential risk at this site.

Ambient Air and Sub-Slab Soil Gas from Phase 2 Properties Near Potential Source #2
Ambient air samples collected from outside selected Phase 2 locations showed detections of a few VOCs at levels similar to those detected indoors. The VOCs detected were 1,2,4-trimethylbenzene, ethylbenzene, methylene chloride, PCE, and toluene. Sub-slab soil gas

sampling performed at the school, residences, and government facilities at the same time as the indoor sampling detected low concentrations of various VOCs in the sub-slab soil gas, mostly similar in concentration to the indoor air and ambient measurements. PCE sub-slab soil gas concentrations were higher than found in indoor air or ambient samples. Sub slab sample, PCE concentrations ranged from 0.5 to 2 µg/m^3 at the school, 2 to 409 µg/m^3 at residences, and 1 to 7 µg/m^3 at government facilities.

To summarize, current indoor air exposures at schools, residences, and government facilities within 100 feet of Potential Source #2 are not likely to result in harm to the occupants.

Table 4c. Summary of Indoor Air Results – Phase 2 Sampling Near Potential Source #3

Contaminant	Highest Indoor Air VOC Concentration Detected, in µg/m^3		Health-Based Comparison Values in µg/m^3; NTP Cancer Classification
	Schools	Residences	
1,1-Dichloroethylene	ND	0.2	80 – intermediate MRL
1,2-Dichloroethane	0.3	0.2	2000 - chronic MRL 0.04 – CREG Reasonably anticipated to be a carcinogen
cis-1,2-Dichloroethylene	0.2	1	63 – RSL for trans-1,2-dichloroethylene Not classified
trans-1,2-Dichloroethylene	ND	1	63 – RSL Not classified
Tetrachloroethylene (PCE)	0.3	2	270 chronic MRL 3.8 – CREG* Reasonably anticipated to be a carcinogen
Trichloroethylene (TCE)	0.2	0.7	2 – chronic MRL 0.24 – CREG Reasonably anticipated to be a carcinogen

Notes:
Results rounded to whole number or one significant figure.
Highlights indicate detections above comparison values (CVs).
µg/m^3 = micrograms per cubic meter NTP = National Toxicology Program ND = not detected
RSL = EPA Regional Screening Level for resident air MRL = minimal risk level
CREG = cancer risk evaluation guide
*Note: the CREG for PCE has been updated based on updated toxicological information finalized by EPA in February 2012. The PCE CREG used in ATSDR's February 24, 2012 letter health consultation, 0.2 µg/m^3, was based on interim ATSDR guidance to use California EPA PCE information until the EPA update was finalized. This change does not affect ATSDR's prior conclusions or current conclusions regarding PCE potential risk at this site.

Potential Source #3 – Phase 2 Evaluation

Indoor air and sub-slab soil gas samples were collected in two schools and four residences within 100 feet of potential source #3.Ambient air samples were collected outside of the school and one of the residences. The following text evaluates the results from Phase 2 sampling around Potential Source #3:

Indoor Air in Schools Near Potential Source #3

1,2-Dichloroethane was the only substance detected above CVs in indoor air in the school samples. However, assuming a teacher's exposure to the highest concentration detected of this contaminant for 50 hours per week for 30 years, the theoretical increased risk of cancer would be 1.2×10^{-6}, or less than 1 in 100,000. That is, out of 100,000 teachers exposed under this scenario, less than one additional case of cancer would be expected due to the exposure. This is within EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000. Children's risk would be lower because children are only enrolled for 2-4 years.

Indoor Air in Residences Near Potential Source #3

1,2-Dichloroethane and TCE were the only substances detected above CVs in indoor air in the residential samples. A lifetime of exposure to the highest detected concentrations of these compounds would result in a theoretical increased risk of cancer of 8.8×10^{-6}, or less than 1 in 100,000. That is, out of 100,000 people exposed under this scenario, less than one additional case of cancer would be expected due to the exposure. This is within EPA's acceptable risk range for Superfund of 1 in 1,000,000 to 1 in 10,000.

Ambient Air and Sub-Slab Soil Gas from Phase 2 Properties Near Potential Source #3

Ambient air samples showed no detections of VOCs. Sub-slab soil gas sampling performed at the schools and residences at the same time as the indoor sampling detected low concentrations of PCE and one or two detections of its breakdown products. PCE concentrations ranged from 1 to 8 $\mu g/m^3$ at the school and from 2 to 20 $\mu g/m^3$ at the residences.

To summarize, current indoor air exposures at schools and residences within 100 feet of Potential Source #3 are not likely to result in harm.

Conclusions and Recommendations

- No harmful levels of VOCs were found in indoor air of any of the locations in the recent sampling events. However, sub-slab sampling shows continued high VOC concentrations beneath several buildings
- We recommend periodic follow-up sampling to verify that indoor levels of VOCs do not increase. ATSDR will provide public health input as EPA develops a site-specific sampling strategy.
- Further investigation may be warranted to discover the source or sources of benzene, toluene, ethylbenzene, xylene, and trimethylbenzenes in soil gas beneath one location. These contaminants are not known to be site-related.

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Appendix A. Additional Information – Theoretical Cancer Risk Estimate Tables and Ambient and Sub-Slab Sample Summary Tables

Table A1. Details of Cancer Calculations for Potential Sources #1 and #2 – Phase 1 Sampling—Indoor Air

Source Location	Carcinogenic Contaminants Detected Above Cancer CVs											
	Exposure Fraction	Benzene		Carbon Tetrachloride		1,2-Dichloroethane		Methylene Chloride		PCE		Total Theoretical Increased Cancer Risk
		Maximum Detect, in µg/m^3	Inhalation Unit Risk (IUR), per µg/m^3	Maximum Detect, in µg/m^3	IUR, per µg/m^3	Maximum Detect, in µg/m^3	IUR, per µg/m^3	Maximum Detect, in µg/m^3	IUR, per µg/m^3	Maximum Detect, in µg/m^3	IUR, per µg/m^3	
Potential Source #1	0.13	-	-	-		-		-	-	4.85	2.6E-07	1.6E-07
Residence Near PS#1	1.0		-	-	-	2.48	2.6E-05		-	6.77	2.6E-07	6.6E-05
Potential Source #2	0.13	2.93	7.8E-06	0.449	6E-06	-	-	600	1E-08	47.5	2.6E-07	1.1E-05
Head Start Near PS #2	0.13	0.981	7.8E-06	0.519	6E-06		-	-	-	-	-	4.8E-05
Adult School Near PS #2	0.13	2.17	7.8E-06		- - -	1.04	2.6E-05		-	-	-	1.2E-05

Note: Data presented as reported (without rounding for significant figures) to allow reproduction of cancer risk estimate calculations. Chloroform was not included in calculations because the exposures possible at this site are not high enough for chloroform to be considered carcinogenic [6].
Exposure fraction calculated from hours per week exposed and duration of exposure as follows:
- Residences: 168 hours per 168-hour week times 70 years exposure per 70-year lifetime = 1.0
- Schools and Businesses: 50 hours per 168-hour week times 30 years exposure per 70-year lifetime = 50/168 * 30/70 = 0.13

Total Theoretical Cancer Risk equals sum of each maximum detected value times corresponding Inhalation Unit Risk times exposure fraction.

Table A2. Details of Cancer Calculations for Potential Sources #3 and #4 – Phase 1 Sampling—Indoor Air

Source Location	Carcinogenic Contaminants Detected Above Cancer CVs			
	Exposure Fraction	1,2-Dichloroethane		Total Theoretical Increased Cancer Risk
		Maximum Detect, in µg/m^3	Inhalation Unit Risk (IUR), per µg/m^3	
Potential Source #3	0.13		-	-
Preschool Near PS #3	0.13		-	-
Residence Near PS #3	1.0		-	-
Drug Store at Former PS #4	0.13	3.78	2.6E-05	1.3E-05
Vacant Shop at Former PS #4	0.13		-	-
Restaurant at Former PS #4	0.13		-	-

Note: Data presented as reported (without rounding for significant figures) to allow reproduction of cancer risk estimate calculations.
Exposure fraction calculated from hours per week exposed and duration of exposure as follows:
- Residences: 168 hours per 168-hour week times 70 years exposure per 70-year lifetime = 1.0
- Schools and Businesses: 50 hours per 168-hour week times 30 years exposure per 70-year lifetime = 50/168 * 30/70 = 0.13

Total Theoretical Cancer Risk equals sum of each maximum detected value times corresponding Inhalation Unit Risk times exposure fraction.

Table A3. Details of Cancer Calculations for Potential Sources #1 and #2 – Phase 2 Properties—Indoor Air

Source Location	Carcinogenic Contaminants													Total Theoretical Increased Cancer Risk
	Exposure Fraction	Benzene		1,2-Dichloroethane		Ethylbenzene		Methylene Chloride		PCE		TCE		
		Maximum Detect, in µg/m^3	Inhalation Unit Risk (IUR), per µg/m^3	Maximum Detect, in µg/m^3	IUR, per µg/m^3	Maximum Detect, in µg/m^3	IUR, per µg/m^3	Maximum Detect, in µg/m^3	IUR, per µg/m^3	Maximum Detect, in µg/m^3	IUR, per µg/m^3	Maximum Detect, in µg/m^3	IUR, per µg/m^3	
Residences Near PS #1	1.0		-	0.287	2.6E-05	-	-	-		-			-	7.5E-06
Businesses Near PS #1	0.13-		-	0.34	2.6E-05		-	-	-	0.514	2.6E-07		-	1.1E-06
School Near PS #2	0.13 -	6.65	7.8E-06	0.14	2.6E-05 -	7.65	2.5E-06	- 0.659	1E-08	- -	- -		-	1.0E-05
Residences Near PS #2	1.0		-	0.434	2.6E-05	2.13	2.5E-06	0.825	1E-08	1.19	2.6E-07		-	1.7E-05
Government Facilities Near PS #2	0.13-		-	0.418	2.6E-05	1.1	2.5E-06	0.508	1E-08	-	- - -	0.575	4.1E-06	1.1E-05

Note: Data presented as reported (without rounding for significant figures) to allow reproduction of cancer risk estimate calculations. Chloroform was not included in calculations because the exposures possible at this site are not high enough for chloroform to be considered carcinogenic [6].
Exposure fraction calculated from hours per week exposed and duration of exposure as follows:
- Residences: 168 hours per 168-hour week times 70 years exposure per 70-year lifetime = 1.0
- Schools and Businesses: 50 hours per 168-hour week times 30 years exposure per 70-year lifetime = 50/168 * 30/70 = 0.13

Total Theoretical Cancer Risk equals sum of each maximum detected value times corresponding Inhalation Unit Risk times exposure fraction.

Table A4. Details of Cancer Calculations for Potential Source #3 – Phase 2 Properties—Indoor Air

Source Location	Carcinogenic Contaminants							
	Exposure Fraction	1,2-Dichloroethane		PCE		TCE		Total Theoretical Increased Cancer Risk
		Maximum Detect, in µg/m^3	Inhalation Unit Risk (IUR), per µg/m^3	Maximum Detect, in µg/m^3	IUR, per µg/m^3	Maximum Detect, in µg/m^3	IUR, per µg/m^3	
Schools Near PS #3	0.13	0.322	2.6E-05	0.293	2.6E-07	0.242	4.1E-06	1.2E-06
Residences Near PS #3	1.0	0.204	2.6E-05	2.06	2.6E-07	0.73	4.1E-06	8.8E-06

Note: Data presented as reported (without rounding for significant figures) to allow reproduction of cancer risk estimate calculations.
Exposure fraction calculated from hours per week exposed and duration of exposure as follows:
- Residences: 168 hours per 168-hour week times 70 years exposure per 70-year lifetime = 1.0
- Schools and Businesses: 50 hours per 168-hour week times 30 years exposure per 70-year lifetime = 50/168 * 30/70 = 0.13

Total Theoretical Cancer Risk equals sum of each maximum detected value times corresponding Inhalation Unit Risk times exposure fraction.

Table A5. Summary of Ambient Air Sampling Results – Phase 1 Sampling

Source Location	Number of Ambient Air Samples Collected	Contaminant*	Range of Detected Concentrations for Contaminants in µg/m^3	Number of Detections
Potential Source #1	1	PCE	7.99	1
Potential Source #2	5	Benzene	0.788—1.1	5
		Chloroform	0.602—2.4	3
		1,2,4-Trimethylbenzene	0.888—22.4	5
		1,3,5-Trimethylbenzene	0.382—8.77	3
Potential Source #3	3	None Detected	N/A	N/A
Former Potential Source #4	1	None Detected	N/A	N/A
* Only contaminants that exceeded CVs and with detections elevated above detection limit are listed. N/A = Not applicable.				

Table A6. Summary of Sub-Slab Soil Gas Sampling Results – Phase 1 Sampling

Source Location	Number of Sub-Slab Soil Gas Samples Collected	Contaminant*	Range of Detected Concentrations for Contaminants in µg/m^3	Number of Detections
Potential Source (PS) #1	3	PCE	104,000—692,000	3
		TCE	57.1—156	3
Residence Near PS #1	0	N/A	N/A	N/A
Potential Source (PS) #2	2	PCE	561—756,000	2
		TCE	0.654—3370	2
		1,2,4-Trimethylbenzene	0.598—130	2
		1,3,5-Trimethylbenzene	47.7	1
Head Start Near PS #2	7	Benzene	0.223—0.607	5
		Chloroform	0.447—8.69	3
		PCE	748—7340	7
		TCE	0.453—9.41	3
Adult School Near PS #2	1	Chloroform	8.78	1
		Toluene	131,000	1
		1,2,4-Trimethylbenzene	27.8	1
		1,3,5-Trimethylbenzene	8.79	1
Potential Source (PS) #3	3	PCE	332—5,760	3
		TCE	1.58—39.7	3
Preschool Near PS #3	3	PCE	18—26.6	3
Residence Near PS #3	0	N/A	N/A	N/A
Drug Store Near Former PS #4	2	PCE	48.6—187	2
		TCE	1.66	1
Vacant Shop Near PS #4	2	1,1-Dichloroethene	0.334	1
		PCE	1.13—2.29	2
Restaurant Near PS #4	0	N/A	N/A	N/A

* Only contaminants that exceeded CVs and with detections elevated above detection limit are listed.
N/A = Not applicable.

Table A7. Summary of Ambient Air Sampling Results – Phase 2 Sampling

Source Location	Number of Ambient Air Samples Collected	Contaminant*	Range of Detected Concentrations for Contaminants in µg/m^3	Number of Detections
Ambient Samples Near PS #1	1	TCE	0.359	1
Ambient Samples Near PS #2	4	Ethylbenzene	0.82—1.2	3
		Methylene Chloride	0.46—0.576	4
		PCE	0.46—0.558	2
		Toluene	8.68	1
		1,2,4-Trimethylbenzene	1.23—1.61	2
Ambient Samples Near PS #3	3	None Detected	N/A	N/A
* All contaminants with detections are listed. N/A = Not applicable.				

Table A8. Summary of Sub-Slab Soil Gas Sampling Results – Phase 2 Sampling

Source Location	Number of Sub-Slab Soil Gas Samples Collected	Contaminant*	Range of Detected Concentrations for Contaminants in µg/m^3	Number of Detections
Residences Near PS #1	12	1,2-Dichloroethane	1.13	1
		cis-1,2-Dichloroethylene	2.07	1
		trans-1,2-Dichloroethylene	1.46	1
		PCE	0.823—11.9	10
		TCE	0.457—2.68	2
Businesses Near PS #1	4	PCE	3.31—109	3
School Near PS #2	8	Chloroform	0.707	1
Residences Near PS #2	8	Benzene	4.68—5.99	3
		Chloroform	0.58—23.5	5
		PCE	1.7—409	6
		TCE	0.56	1
		1,2,4-Trimethylbenzene	1.64—16.1	5
		Vinyl Chloride	0.186	1
Government Facilities Near PS #2	6	Benzene	2.82—3.01	2
		Chloroform	0.635—15	3
		PCE	1.25—7.25	5
		TCE	0.467—0.497	2
Schools Near PS #3	14	cis-1,2-Dichloroethylene	0.531	1
		PCE	0.663—8.38	10
		TCE	1.76	1
Residences Near PS #3	4	PCE	0.665—20.4	4
		TCE	2.22	1

* Only contaminants that exceeded CVs and with detections elevated above detection limit are listed.
N/A = Not applicable.