Public Health Assessment for

EAST KELLY AIR FORCE BASE
SAN ANTONIO, BEXAR COUNTY, TEXAS
EPA FACILITY ID: TX2571724333
FEBRUARY 27, 2007

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

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

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

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

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PUBLIC HEALTH ASSESSMENT

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Prepared by:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation

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Foreword

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

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment process allows ATSDR scientists and public health assessment cooperative agreement partners flexibility in document format when presenting findings about the public health impact of hazardous waste sites. The flexible format allows health assessors to convey to affected populations important public health messages in a clear and expeditious way.

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

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

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to evaluate possible the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available.

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

Conclusions: The report presents conclusions about the public health threat posed by a site. Ways to stop or reduce exposure will then be recommended in the public health action plan. ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA or other responsible parties. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also recommend health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

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

Letters should be addressed as follows:

Attention: Manager, ATSDR Record Center Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E-60), Atlanta, GA 30333.

List of Acronyms

ADI	Acceptable Daily Intake
AFB	Air Force Base
ATSDR	Agency for Toxic Substances and Disease Registry
CDC	Center for Disease Control and Prevention
CEL	Cancer Effect Level
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CHCl3	Chloroform
cm	centimeter
COC	Chemical of Concern
CREG	Cancer risk evaluation guide
CV	Comparison Value
DHAC	Division of Health Assessment and Consultation
1,2-DCE	1,2-Dichloroethene
1,1-DCE	1,1-Dichloroethane
dL	deciliter
EMEG	Environmental Media Evaluation Guide
IE	Exposure Investigation
EICB	Exposure Investigation Branch
EMEG	Environmental media evaluation guide
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
HAS	Hepatic Angiosarcoma
HEAST	Health Effects Assessment Summary Table
hr	Hour
IRIS	EPA's Integrated Risk Information System
IRP site	Installation Restoration Program site
J&E model	EPA's Johnson & Ettinger model
kg	kilogram
L	Liter
LOAEL	Lowest-observed-adverse-effect level

m^3	cubic meter
mg	milligram
MRL	Minimal risk level
NAAQS	National Ambient Air Quality Standards
NOAEL	No Observed Adverse Effect Level
ND	Not Detected
NPDES	National Pollution Discharge Elimination System
OSHA	Occupational Safety & Health Administration
Pa	Pascal (a unit of pressure)
PAH	Polycyclic Aromatic Hydrocarbon
PCE	Perchloroethylene or Tetrachloroethylene
PEL	Permissible Exposure Limit
PERIS	Program Evaluation Records and Information Services
PHA	Public Health Assessment
PHAGM	ATSDR's Public Health Assessment Guidance Manual
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PRS	Petition Response Section
PVC	Polyvinyl Chloride
RBC	Risk-based concentration
RCRA	Resource Conservation and Recovery Act
RfC	Reference concentration
RfD	Reference dose
RMEG	Reference Dose Media Evaluation Guide
SVOC	Semi-Volatile Organic Compound
TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
TCE	Trichloroethylene
TLV	Threshold limit value
TNRCC	Texas Natural Resource Conservation Commission
TPA	Tetradecanoyl Phorbol Acetate
TWA	Time Weighted Average

µg/m^3	microgram per cubic meter (of air)
USGS	United States Geological Survey
VC	Vinyl Chloride
VOC	Volatile Organic Compound
VSD	Virtually Safe Dose
WHO	World Health Organization

Summary

The late Congressman Frank Tejeda (1945–1997) initially petitioned the Agency for Toxic Substances and Disease Registry (ATSDR) to evaluate the potential public health impact of contaminants released from Kelly Air Force Base. This evaluation request subsequently extended to East Kelly as well. Community members in the East Kelly area are concerned that they may have been exposed to contaminants from the Kelly AFB east annex via stormwater runoff, shallow groundwater, blowing dust, and soil gas. Community members further believe these contaminants could cause various adverse health effects, including cancer, immune system disorders, nervous system disorders, birth defects, liver problems, skin problems, respiratory illnesses, muscular problems, nosebleeds, and headaches.

After reviewing available environmental and health outcome data, ATSDR has determined that the levels of contaminants detected at off-site locations associated with East Kelly Air Force Base are not likely to cause adverse health effects. The agency concludes that the contaminants at East Kelly pose no apparent public health hazard. Data were inconclusive regarding on-site indoor air exposures for other than industrial and limited commercial uses. ATSDR categorizes on-site exposure for uses other than industrial and limited commercial as an indeterminate public health hazard.

Because of community concerns, ATSDR evaluated contaminated surface soil from area S009 within the East Kelly site. The evaluation sought to determine whether chemicals at levels of health concern could migrate off site via stormwater runoff or wind-blown dust. Soil gas samples were evaluated to determine whether residents near East Kelly are currently exposed to volatile organic compounds migrating into their homes from the contaminated shallow groundwater. Data from shallow-aquifer private wells were reviewed to determine whether residents near East Kelly are exposed to contaminated groundwater. The levels of contaminants detected in on-site soil were too low to pose a health threat to potentially exposed residents. Soil gas and indoor air modeling suggest that volatile organic compounds from the shallow groundwater are not migrating into residences at levels of health concern. No private well owners identified near East Kelly are using the contaminated shallow groundwater for drinking water, and in any event the concentrations of contaminants are too low to pose a public health hazard to anyone who might use the shallow groundwater for showering, for irrigation, or for washing cars.

Purpose and Health Issues

Congressman Tejeda initially petitioned the Agency for Toxic Substances and Disease Registry (ATSDR) to evaluate the potential public health impact of contaminants released from Kelly Air Force Base. He later requested[1] that ATSDR extend its evaluation to East Kelly. ATSDR completed a public health assessment for Kelly Air Force Base in 1999. The East Kelly area is an annex east of the main Kelly Air Force Base. It has historically been used for aircraft maintenance and hazardous waste storage and transport. Leakage and spillage of these wastes has occurred throughout East Kelly and contaminated the shallow groundwater and soil with chlorinated solvents. These contaminants have migrated east and southeast into the surrounding community. The surface soil at East Kelly has been contaminated primarily with polyaromatic hydrocarbons (PAHs). Community members suspect contaminants in the shallow groundwater are entering their homes through soil gas and are causing adverse health effects.

The purpose of this public health assessment is to identify community health concerns, to evaluate existing on- and off-site environmental data, to estimate potential human exposures to substances related to the East Kelly site, and to recommend appropriate public health follow-up activities.

Site Background

Commissioned in 1916, Kelly Air Force Base is in Bexar County, Texas—approximately 7 miles southwest of San Antonio. East Kelly (also known as Zone 4) is a storage area comprising about 400 acres along the eastern edge of Kelly Air Force Base. The surrounding community is a mixture of residential, commercial, and light industrial areas (Appendix A, Figures 1 and 6). In 1982, a restoration program eventuated the investigation and clean up of sites contaminated with hazardous substances. The investigation determined that in addition to groundwater contamination from the main Kelly Air Force Base flowing southeast of East Kelly, leaking industrial waste pipe lines in the northern portion of East Kelly were also an environmental contamination source. From the 1940s to the mid-1970s, engine repair facilities at East Kelly used a collection system to transport chemical wastes to a central location for disposal. Over the years, leaks occurred in this network of underground waste collection pipe lines, contaminating shallow groundwater with waste oils, solvents, and paint thinners.[2] Other wastes stored at East Kelly in the past contained herbicides, metals, PAHs, and volatile organic compounds (VOCs).

Community Health Concerns

Specific health concerns expressed by community members pertaining to East Kelly are the release of soil gas into nearby homes from contaminated shallow groundwater and the possibility of contaminated soil found on site (area S009) reaching homes by storm water runoff. Residents are also concerned that contaminants from Kelly Air Force Base are causing a number of illnesses, including cancer, immune system disorders, nervous system disorders, birth defects, liver problems, skin problems, respiratory illnesses, muscular problems, nosebleeds, and headaches. These health concerns were addressed in the 1999 Kelly Air Force Base public health assessment. In this public health assessment, ATSDR evaluates the environmental contamination related to East Kelly to identify any additional impact for these same health concerns.

Demographics

Some 28,336 persons live within a 1-mile radius of East Kelly (Appendix A, Figure 1).[3] This population is 91% Hispanic. Those age 6 or younger comprise 13.1% of the population, and those 65 years and older, 11%. In 2000, about 6,225 females of reproductive age (15–44 years) lived in the area.

Discussion

Methods

Evaluation Methods

The following sections contain an evaluation of the available environmental data for East Kelly. A glossary is contained in Appendix B. In preparing this evaluation, ATSDR used established methodologies for determining how people might be exposed to potential contamination related to East Kelly and what harmful effects, if any, could result from such exposure. Exposure pathways (i.e., routes of physical contact with chemicals) that ATSDR evaluated are ingestion, inhalation, and skin contact (See Appendix F). In its evaluation of environmental data ATSDR uses comparison values (CVs) as screening tools. Comparison values are concentrations of contaminants in environmental media (e.g., water, soil, or air) considered safe under default conditions of exposure during specified time periods (i.e., acute, intermediate, or chronic). Under the specified conditions of exposure, chemicals detected at concentrations below CVs are not likely to represent a health concern. That said, chemicals detected at concentrations above CVs may or may not represent a health concern—a more detailed evaluation of site-specific exposure conditions is required to ascertain the public health implications of exposure to these substances. ATSDR also evaluates the public health implications of exposures to combinations of substances that may be present in one or more environmental media to which populations may be exposed. For a complete discussion of ATSDR's evaluation methods (e.g., quality assurance considerations, human exposure pathway analyses, health-based comparison values, and the methods of selecting contaminants above comparison values), refer to Appendix C.

Extent of Contamination

Area Hydrology

East Kelly lies over a shallow aquifer and a deeper, confined underground waterway known as the Edwards Aquifer. The shallow aquifer is at depths approximately 15 to 30 feet below the surface. The leaking industrial waste lines at East Kelly contaminated the shallow aquifer with VOCs and PAHs.[4] A layer of clay below the shallow aquifer ranges from 50 to 450 feet in thickness. Under the clay layer is about 300 feet of a loose, crumbly rock material known as marl and another 500 feet of limestone and shale. The Edwards aquifer is below about 1000 feet of clay, marl, limestone, and shale layers.[5] Most residences near East Kelly receive drinking water from the Bexar Metropolitan Water District, a municipal facility that obtains its water from the Edwards Aquifer.

Exposure Pathways

ATSDR categorizes identified pathways of site-specific exposure based on the presence of five elements of an exposure pathway:

1. A source of contaminant release,
2. transport process that may carry a contaminant away from its source in a medium such as air, water or soil,
3. a point or area of exposure, i.e., a specific location where people might come into contact with a contaminated medium,
4. an exposure route (e.g., inhalation, ingestion, and/or dermal absorption), and
5. potentially exposed populations.

ATSDR categorizes exposure pathways as completed, potential, or eliminated. A pathway of exposure is considered a "completed" pathway if all five of the aforementioned elements are present. Note that this definition means only that exposure is possible or probable. It does not necessarily mean that exposure is actually known to have occurred. Nor does the existence of a completed pathway of exposure mean that exposure, if it does occur, will necessarily pose a hazard to human health. That determination depends on the route, magnitude, and duration of exposure, as well as the susceptibility of those who are exposed.

If one or more of the elements of an exposure pathway *may* not be present, but information is insufficient to support the elimination of that element, then the pathway is categorized as "potential." Finally, if the known absence of one or more of the aforementioned elements of an exposure pathway makes exposure unlikely, then ATSDR classifies that pathway as "eliminated."

At the East Kelly site, ATSDR identified the following potential human exposure pathways:

- inhalation, ingestion, and dermal contact with off-site private wells that obtain their water supply from the contaminated shallow aquifer,
- biota from the ingestion of produce from off-site vegetable gardens,
- on-site surface soil from accidental ingestion, and
- inhalation of on-site and off-site soil gas from the contaminated shallow groundwater aquifer that migrated into indoor enclosed spaces.

ATSDR identified eliminated the following exposure pathways:

- ingestion of off-site private well water obtained from the shallow groundwater aquifer, and
- accidental ingestion of off-site surface soil.

Please see Appendix F, Exposure Pathways Table.

Private Wells

Residents east of Kelly AFB have had access to municipal water since the 1950s.[6] Three private well surveys conducted in 1988, 1996, and 1998 (Appendix A, Figure 2) identified 22 shallow aquifer private wells within a 1-mile radius of Kelly AFB.[7,8] Most of the identified private wells are constructed in the shallow aquifer and are used for gardening or lawn care. In 1988 one private well on Quintana Road was identified as a drinking water source, but later surveys indicated that the drinking water source for this residence was in fact a municipal water supply. Four private wells were dry or blocked by debris. Water samples from the remaining 18 usable private wells were collected and analyzed for VOCs, semi-volatile organic compounds (SVOCs), metals, and cyanide. Several contaminants were detected in the private well previously thought to have been used for drinking water, but they were not at levels of health concern.[9,10] Several contaminants were also detected in some of the private wells not used for drinking water.[8] Those chemicals are listed in Table 1.

Table 1: Chemicals Detected in Shallow Aquifer Private Wells: 1988, 1996, 1998

Chemical	***EPA Region 6 MSSLs* (ppb)***	***Range of Chemical Concentration (ppb)***	***Number of Private Wells that Chemicals were Detected above Drinking Water Comparison Values****
cis-1,2-Dichloroethene (DCE)	61(n)	ND--190	1
Tetrachloroethene (PCE)	1.1 (c) †	ND---20	8
Trichloroethene (TCE)	1.6 (c)†	ND---82	7
Chloroform	0.16 (c) † [75 (n)] ‡	ND---4.61	3
Lead	15 (EPA's action level)	ND--64.1	1
Thallium	2.9 (n)§	ND--10.7	1
Vinyl Chloride	0.043 (c)†	ND--10	1

* 2000 EPA Region 6 Human Health Medium-Specific Screening Levels for drinking water

† Because ATSDR's RMEGs for PCE, Chloroform & Vinyl chloride are 400, 400, & 2,000 ppb, respectively, none of these substances would have been selected for further study based on non-cancer comparison values, alone. EPA's cancer risk estimate for TCE was withdrawn in 1989 and remains "under review," as has the RfD since 1992.

‡ 2005 Region 6 HHMSSL for chloroform. Using the mechanistic evidence that chloroform is a threshold carcinogen, EPA now considers the RfD to be protective against both cancer and noncancer effects.

§ As a soluble salt. EPA's RfD for thallium contains a 3,000-fold safety (or uncertainty) factor. None of the concentrations detected would be expected to cause adverse health effects in humans who might drink the water.

ND = Not Detected

ppb = parts per billion

Area residents have been notified of the shallow aquifer contamination and have been advised not to use water from their wells for drinking, for showering, or for cooking. The contaminants detected in the private well previously thought to have been used for drinking water in 1988 were not at levels of health concern. This well is currently not used for drinking water.

Irrigation

Although many of the private wells have been plugged, it is possible that some of the private shallow aquifer wells may still be used for irrigating or watering gardens. The contaminants detected in the private wells near East Kelly are mostly VOCs, which quickly volatilize during lawn watering.[11] ATSDR evaluated the irrigation inhalation exposure pathway by comparing the VOC levels in groundwater used for watering lawns and gardens with water used for showering that contained the same levels of VOCs.[12] Because showering occurs in a relatively enclosed space, it would result in much higher exposures than those exposures that might occur while using water outdoors. Showering therefore represents a worst-case scenario for inhalation exposure at this site. (See the calculations presented in Appendix G.) But even in this worst-case scenario, the modeling results show that levels of VOCs in air would not be a health concern.

Plant uptake of VOCs from groundwater or irrigation water into fruits, garden produce, and nuts and the subsequent ingestion (eating) of the product was a concern for the community. In late 2001 samples of peppers, pecans, and various citrus fruits were collected for analysis. Evaluation of the data was conducted by the Environmental Public Health Center. The final results, published by CH2M Hill Consultants in February of 2002, indicate that the consumption of fruit and nuts in the communities surrounding Kelly AFB would pose no hazard to human health. None of the target analytes in any of the 47 samples of fruits, nuts, and vegetables analyzed (e.g., peppers, pecans, limes, grapefruit, lemon, tangerine, bananas, and pears) exceeded the detection limit of 5 ppb (or µg/kg).[13] These results are consistent with the expectation that VOCs will not accumulate in plants because

a. by the time soil water reaches the root zones of off-site plants, the concentration of volatile organic compounds will have been reduced by evaporation, microbial biodegradation, and binding to the soil matrix,

b. only the greatly reduced concentration of VOCs in soil water—rather than the chemicals bound to the soil itself—will be potentially available for uptake by plants, and

c. any VOCs that may remain to be taken up by plants will, for the most part, be transpired, metabolized, or both, rather than accumulated.[14] Therefore, any VOC exposure that might occur as a result of eating locally grown fruits and nuts in the East Kelly area would not be of health concern.

On-site and Off-site Monitoring Wells

East Kelly groundwater sampling data obtained from on and off-site monitoring wells in the shallow aquifer were evaluated. These data were compiled from the 2000 and 2001 Annual Compliance Plans.[15,16] Also evaluated were the groundwater data contained in the Zone 4 RFI Report, which included data from the above Compliance Plans and earlier sampling events.[17] All groundwater data are from monitoring well locations shown in Figure 4 (Appendix A, Site Maps, CH2MHILL Exhibit 4.1) from coordinates 9 through 20 and A through N. The data from approximately 110 groundwater monitoring wells from both the 2000 Semiannual Compliance Plan and the 2001 Semiannual Compliance Plan were evaluated, with the actual number of wells dependent on the type of sampling and the date of the sampling event. In addition, approximately 150 groundwater monitoring well results were evaluated from the Zone 4 RFI Report. These samples were analyzed for metals, VOCs, and semivolatile organic compounds. Some samples were also chosen for polychlorinated biphenyls (PCB) and pesticides analyses. After screening for chemicals of concern, the following chemicals were chosen for further evaluation: 1,2 dichloroethylene (1,2 DCE), tetrachloroethylene (PCE), trichloroethylene (TCE), vinyl chloride (VC) and benzene. Table 2 indicates the range of chemical concentrations found in the monitoring wells located in Figure 4.

Shallow groundwater flow is generally to the east and southeast. PCE, TCE, 1,2 DCE plumes underlay a large portion of East Kelly and the surrounding areas to the east and southeast of East Kelly.[16] A much smaller plume of VC was also found.[16] Human exposure by ingestion of the contaminated groundwater from these wells is not expected to occur, as these are groundwater monitoring wells, not drinking water wells. Nevertheless, a potential human exposure pathway may occur from VOCs in groundwater that volatilize to soil gas. This soil gas may enter the breathing space of basements and slab homes through cracked foundations or cracked slabs that may overlay the contaminated plumes of 1,2 DCE, PCE, TCE, and VC.

Table 2: Chemicals of Concern Found in Shallow Groundwater Monitoring Wells

Chemical	***2000 Compliance Plan– Range of Chemical Concentrations - µg/l***		***2001 Compliance Plan– Range of Chemical Concentrations - µg/l***		***Zone 4 RFI Range of Chemical Concentrations - µg/l***	
	On-site	Off-site	On-site	Off-site	On-site	Off-site
1,2 Dichloroethylene	ND - 790	ND - 480	ND - 665	ND - 199	ND - 794*	ND - 630
Tetrachloroethylene	ND - 140	ND - 160	ND - 168	ND - 112	ND - 260	ND - 230
Trichloroethylene	ND - 320	ND - 100	ND - 100	ND - 87.9	ND - 3698*	ND - 130
Vinyl Chloride	ND - 12	ND - 13	ND - 2.8	ND - 27.3	ND - 12	ND - 13
Benzene	ND -0.5J	ND - 2.0	ND -0.2J	ND -20.5J	ND - 0.2J	ND - 2.0

ND = Not Detected.

µg/l = micrograms per liter.

*1993 sample

J = Estimated.

ATSDR’s conservative computer modeling uses the maximum contaminant levels and the shallowest depth to groundwater found in the monitoring wells off site of East Kelly. This modeling indicates that the gas levels that could be emitted from groundwater and potentially leak into the breathing space of the home would not cause any health hazard to the residents. The off-site estimated levels were not high enough to be a public health hazard for residences.

Vinyl chloride was not found frequently; but when it was found, the levels were generally low. Evidence suggests, however, an off-site VC localized source (27.3 µg/l) to the east of East Kelly at or near monitoring well SS052MW271. The detected levels do not pose a public health hazard, but local authorities should consider reviewing this well data in the future to rule out the possibility of an ongoing local source or rising concentrations.

In one off-site sample, benzene was detected in shallow groundwater at a level of concern. Benzene was not detected in monitoring well SS051MW271 in the January 2000 Semiannual Compliance Report. It was detected at 20.5 µg/l in this well in the January 2001 Semiannual Compliance Report. Benzene was also detected in two on-site samples at levels of concern (784 µg/l at well V25, 11/01/93 and 47 µg/l at well W24, 11/01/93).[18] These two samples were within 200 feet of each other. The water is not used for drinking, but if the highest level of benzene found (784 µg/l) volatilized into soil gas and into indoor confined spaces, it might pose an inhalation hazard. However, this finding appears to be anomalous; the corresponding benzene soil vapor levels for these wells were nondetect (if the groundwater concentration actually was 784 µg/l, one would expect detectable levels of benzene soil vapor). In the future, local authorities should consider reviewing these well data to confirm benzene levels in soil vapor and groundwater and to exclude errors, the possibility of an ongoing source, or a progressive increase in concentrations. On-site soil vapor and data limitations are discussed further in the "On-site Soil Gas—1993 Soil Vapor Sampling on East Kelly" section.

Surface Soil

Nearby residents are concerned that the contaminated surface soil left on site may migrate into residential areas via stormwater runoff or wind-blown dust. ATSDR found no visible evidence that stormwater runoff is affecting the residential areas. Surface soil (less than 1 foot deep) was evaluated to determine whether present contaminant levels exceed screening values. (Contaminated on-site soil deeper than 1 foot is not likely to be carried to residential areas by stormwater runoff or wind.) Samples of on-site soil were collected during remedial investigations throughout the 1990s to determine the extent of soil contamination.[19,20]

Arsenic was detected in surface soil at a former storage yard (site S-7) at concentrations exceeding closure guidelines.[21] In 1997 Kelly AFB removed 1.2 acres of the arsenic-contaminated surface soil and, to attain closure status, disposed of it off site in accordance with Texas Commission on Environmental Quality (TECQ, formerly the Texas Natural Resource Conservation Commission (TNRCC) guidelines. The storage yard is no longer in use, and arsenic concentrations are below background levels.[22] Currently, on-site soils from area S-7 do not pose a public health hazard.

To address further a concern that preremedial soil contamination may have migrated off site into residential yards, ATSDR evaluated the surface water/stormwater drainage system for area S-7. Area S-7 is approximately 1.2 acres and is part of a larger, 33-acre, previously evaluated area. Underlying the 33-acre plot is a series of storm drains designed to divert rainwater runoff into a storm sewer that discharges into Six-Mile Creek. ATSDR does not believe that any substantial contamination would have migrated from area S-7 onto adjacent properties because 1) the extensive storm sewer system across the 33-acre site would have diverted any contaminated surface water into the storm sewer system, and 2) 6 years of postremedial storms and rainwater would have diluted and washed contaminants downstream of Six-Mile Creek. The probability of preremedial contaminated surface water affecting adjacent residential properties is extremely low.

In other areas of East Kelly, the four PAHs listed in Table 3 were detected in on-site surface soil at levels above the corresponding cancer risk-based comparison values developed by EPA Region 6 (Table 3). (Neither EPA nor ATSDR have any comparison values for PAHs based on noncancer effects.) Therefore, these PAHs were selected for further evaluation.[23.]

Table 3. East Kelly Soil Contaminants Detected above Comparison Values

Chemical	*Chemical Type*	*Estimated Risk**	*Risk-Based Comparison Value† (mg/kg)*	*Maximum Concentration (mg/kg)*
Benzo(a)pyrene	PAH	$9.7E^{-05}$	0.062	8.13
Dibenzo(a,h)anthracene	PAH	$2.74E^{-06}$	0.062	0.23
Benzo(a)anthracene	PAH	$1.01E^{-05}$	0.62	8.51
Benzo(b)fluroranthene	PAH	$1.11E^{-05}$	0.62	9.35

* See Appendix D for explanation of scientific notation and cancer risk

† 2000 EPA Region 6 risk-based concentration for residential soil

Appendix D contains the risk analysis for on-site surface soil assumptions. Although the maximum concentrations were detected above health-based screening values, the levels of PAHs in soil—because of their low acute toxicity and their reduced bioavailability in soil—are unlikely to pose a hazard to humans. (See the response to Comment #21 for a more detailed explanation of why PAHs in soil are, as a general rule, unlikely to pose a health hazard to the general public.)

The sum of the maximum hypothetical risks associated with the maximum concentrations of these 4 PAHs add up to 1.2×10^{-4}. Nevertheless, the individual maxima represent the results of extensive sampling over a wide area on site. Thus whether one would ever be exposed to all four maximum concentrations in any single soil sample—let alone every day for an entire lifetime as this estimate assumes—is highly unlikely, if not impossible. Also, due to the low bioavailability of PAHs in soil, actual exposures via soil ingestion and, hence, the associated estimates of hypothetical cancer risk, would be much lower than these maximum concentrations would suggest.[a] In any case, as noted by EPA in that agency's 1986 risk assessment guidelines, such quantitative estimates of cancer risk do not necessarily give a realistic prediction of the risk. In fact, "the true value of the risk is unknown, and may be as low as zero." See Appendix H, response to Public Comment #21, for more discussion on this point.

On-site Soil Gas—1993 Soil Vapor Sampling on East Kelly

From the Zone 4 RFI, approximately 420 on-site soil vapor monitoring wells were installed and monitored on a 200 ft grid of East Kelly—except directly under buildings.[18] Groundwater samples were collected at every other location where soil vapor was collected.

In the worst-case exposure scenario, direct inhalation of the soil vapor, ATSDR found that the soil vapor levels were all below Time Weighted Average (TWA) thresholds, which are permissible exposure limits designed for industrial workers for up to an 8-hour workday during a 40-hour workweek. Because most industrial buildings have concrete floors, it is expected that indoor air levels would be even lower. Chemical concentrations in the breathing zone, in

[a] In the laboratory studies on which CVs for PAHs are based, absorption of the chemicals was maximized either by administering the PAHs orally by gavage, or by painting them onto the skin of mice and covering them with occlusive bandages.

particular, will generally be much lower than those in soil gas. ATSDR considers that the on-site soil vapor intrusion into indoor air space and resultant worker exposure is safe for the majority of commercial/industrial uses.

The levels measured at some locations would not, however, be acceptable for all workers. Some businesses such as daycare centers, schools, nursing homes, and clinics serve more sensitive individuals. In addition, the detection levels in the 1993 data are too high for some of the chemicals (VC, benzene). Therefore, although the data may indicate nondetect, whether levels exist that would preclude certain business uses such as daycare, schools, nursing homes and clinics is unknown. ATSDR did not perform modeling for on-site structures—the model was primarily developed for residential use, and the attenuation factors for industrial use in the model were also unknown. Because conditions in this on-site area are currently changing, ATSDR drew no definitive conclusions with regard to the public health implications of on-site soil gas.

In general, however, the groundwater sampled after 1993 indicates that chemical levels are decreasing and any potential exposures to volatilization from the groundwater would also tend to decrease. No exposures would be expected from ingestion given that these are not drinking water wells.

Off-site Soil Gas

Soil gas consists of vapors within soil space which, given the necessary gradient, can migrate into the air of an enclosed space that is in contact with the soil—a basement, for example. The soil gas can come from soil contaminants or groundwater migrating through these soil spaces. Residents living near East Kelly are concerned that VC and other VOCs from the contaminated shallow aquifer are migrating into their homes. Soil gas samples were taken from the outside of homes identified as having high levels of shallow groundwater contamination; thus these homes have the highest potential for gas migration to indoor air.[24] Five soil gas monitoring wells were installed west and south of East Kelly, and three soil gas monitoring wells were installed east of East Kelly (Appendix A, Figure 3). Soil gas was collected 5 feet below the ground surface and analyzed in March 2000. Although VC was not detected in the soil gas, several other VOCs were detected. The levels of these VOCs in homes are, however, expected to be much lower than levels of VOCs detected directly in the soil gas. After reviewing the relevant toxicity and epidemiologic studies, ATSDR concludes that the VOCs detected in off-site soil gas are not expected to cause adverse health effects.[25, 26, 27, 28, 29, 30, 31, 32] That residents near East Kelly will inhale soil gas directly is unlikely. Workers could be so exposed while digging, but the contaminant levels are sufficiently low that even direct inhalation of the soil gas for short (i.e., subchronic) durations would not be expected to produce any adverse health effects. Furthermore, the levels of VOCs in indoor air due to infiltration of soil gas tend to be much lower than levels directly detected in soil gas. To estimate the indoor air concentration of each VOC detected above screening values in the soil gas, ATSDR used EPA's Johnson and Ettinger model for subsurface vapor intrusion into buildings.[33] We estimate the indoor air concentrations of VOCs to be at least 35,000 times lower than the concentrations detected in soil gas directly (Appendix E), resulting in levels innocuous to humans. Accordingly, in homes located over contaminated shallow groundwater, ATSDR concludes that given the levels of VOCs in the soil gas and the modeling analysis, no adverse health effects are expected to occur from exposure to any VOCs detected in, or estimated to be in, the indoor air. Appendix E details the results of the soil gas sampling results and the modeling.

The locations of soil gas monitoring wells were predominantly south of East Kelly. (See Appendix A, Figure 3). Therefore, ATSDR's modeling for the worst-case indoor VOC levels using soil gas concentrations are associated with the same area. The VOC groundwater plume extends in other areas where no soil gas samples were taken. The groundwater VOC concentrations in these other areas are, however, similar to or lower than those found in the groundwater to the south (where soil gas measurements occurred). Thus indoor air VOC concentrations for these areas are expected to be similar to or lower than those modeled south of East Kelly.

ATSDR Child Health Initiative

Children are at greater risk than are adults from certain kinds of exposure to hazardous substances emitted from waste sites and emergency events. For several reasons children are more likely to be exposed to contaminants in the general environment. Children spend time outdoors more often than do adults, increasing the likelihood children will come into contact with chemicals in the environment. Because they are shorter than adults, children breathe more dust, soil, and heavy vapors close to the ground. Children are also smaller in stature than are adults, resulting in higher doses of chemical exposure per unit of body weight. Moreover, the developing body systems of children can sustain damage if toxic exposures occur during certain growth stages.

Many children live in neighborhoods surrounding East Kelly. Even though children do not have access to the site, during this evaluation ATSDR closely reviewed possible child exposure situations. ATSDR did not identify any chemical contaminants at levels of health concern to children living near East Kelly.

Physical Hazards

East Kelly is entirely surrounded by a fence and guarded 24 hours a day. Therefore, public access is controlled. During the evaluation of the site and the site visit ATSDR did not identify any physical hazards to the public.

Conclusions

Because the estimated levels of residential exposure to contaminants in soil, soil gas, and shallow groundwater were consistently below levels that might produce adverse health effects under conservative (i.e., worse than expected) exposure conditions, ATSDR concludes that the off-site environmental contamination in the East Kelly area poses no apparent public health hazard. Also, because the on-site soil vapor and groundwater data for East Kelly are not sufficient to determine whether the site is safe for other than limited commercial/industrial use, ATSDR has categorized those potential exposure pathways as an "Indeterminate Public Health Hazard."

1. Although the shallow aquifer is contaminated with volatile organic compounds, no one near the East Kelly area drinks water from the shallow aquifer wells. Therefore, due to the absence of direct exposure, the shallow aquifer does not pose a hazard to public health via the ingestion route.

2. To some extent, VOCs will volatilize from groundwater used for irrigation. But the resulting concentrations in air will pose no hazard to public health via the inhalation route.

3. ATSDR expects that plant uptake and accumulation of VOCs from groundwater and subsequent deposition into fruits, nuts, and garden produce will be negligible. VOCs were generally not detected in fruits, nuts, and peppers sampled in 2001.[32]
4. Given the levels of contaminants currently detected, ATSDR concludes that exposure to contaminated soil at East Kelly would pose no threat to public health.
5. Because storm water sewers in Area S-7 transports the intercepted surface water, soil and sediment to Six-Mile Creek, ATSDR considers those drains would have prevented any substantial migration of preremedial contaminants from area S-7 onto residential yards.
6. Given the measured soil gas concentrations and projections using EPA's Johnson and Ettinger model, VOCs are not expected to be present in or around residences at levels that could cause adverse health effects in exposed residents, including sensitive individuals.
7. Evidence suggests a localized source of vinyl chloride to the east of East Kelly (at or near monitoring well SS052MW271).
8. Exposure to on-site soil vapor is safe for most limited commercial and industrial uses. Direct exposure to soil gas from on-site soil gas wells does not exceed TLVs for VOCs of concern, and indoor air levels would be even lower than outdoor levels.
9. Insufficient on-site soil gas and groundwater monitoring data prevented a determination of whether on-site buildings were safe for other than industrial and limited commercial uses.
10. Data suggesting an elevated groundwater benzene level for monitoring wells V25 and V26 are inconclusive; benzene was not detected in soil vapor samples at the same locations.

Recommendations

1. To confirm the absence of an ongoing local source or rising vinyl chloride and benzene levels, local authorities should consider resampling monitoring wells SS052MW271, and to resolve the discrepancy in soil vapor and groundwater levels, local authorities should resample V25 and W24 for benzene.
2. To promote consistency with other "Right to Know" chemical exposure issues, information about the potential for chemical exposures should be posted at each place of business built on site.
3. For those buildings scheduled for conversion to nonindustrial uses, provide subsurface ventilation or sampling to ensure that interior volatile organic chemical levels are safe.
4. EPA has suggested that ongoing, semiannual soil vapor monitoring would provide adequate coverage of changing soil conditions and seasonal variations. (See Comment #12.

Public Health Action Plan

The actions described in this section are designed to ensure that this public health assessment identifies public health hazards and provides a plan of action to mitigate and prevent adverse health effects resulting from exposure to hazardous substances in the environment.

Actions Completed:

1. ATSDR provided technical assistance to Kelly Air Force Base staff on the soil gas sampling plan.
2. ATSDR released the final version of this public health assessment in Spanish, as well as English.

Actions Planned:

The Environmental Public Health Center will investigate and resample monitoring wells SS052MW271 for vinyl chloride and benzene to ensure the absence of an ongoing local source or rising levels, and, to resolve discrepancy in soil vapor and groundwater levels, will investigate and resample V25 and W24 for benzene.

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References

[1] Letter from Petitioner to ATSDR; 1996.

[2] Kelly Air Force Base. Focused feasibility study for site SS051. San Antonio, TX: Contract No. F41650-95-D-2005-5031; 1997 November.

[3] Bureau of the Census. 1990 census of population and housing: summary tape file 1B. Washington DC: US Department of Commerce.

[4] Kelly Air Force Base. Semiannual compliance plan report. Project Documentation CD. San Antonio, TX; January 1999.

[5] Kelly Air Force Base. Kelly Facts. San Antonio, TX: Kelly AFB; 1998 March.

[6] Agency for Toxic Substances and Disease Registry. Record of Official Activity. Conversation between Kimberly Chapman of ATSDR and Nicholas Rodriquez of Bexar Met regarding date of municipal water line installation. Atlanta: US Department of Health and Human Services; 2000 March 14.

[7] Science Applications International Corporation. Kelly AFB/Bexar County, Texas shallow aquifer assessment. Phase III Technical Report. San Antonio, TX; 1998 October.

[8] US Air Force. Installation restoration program, Kelly Air Force Base. Kelly AFB/Bexar County, Texas shallow aquifer assessment. Phase IV. Master well listing. San Antonio, TX; 1999 October.

[9] Ozuna, GB and Stein WG. Quality of the shallow groundwater in southwest Bexar County, TX. San Antonio, TX: US Geological Survey consultation for Kelly AFB; 1990.

[10] Agency for Toxic Substances and Disease Registry. Petitioned public health assessment for Kelly Air Force Base. CERCLIS No. TX2571724333. Atlanta: US Department of Health and Human Services; 1999 August 20.

[11] Agustin RAC. Analysis of the potential for plant uptake of trichloroethylene and an assessment of the relative risk from different crop types. Government Reports Announcements and Index. Issue 01; 1995.

[12] Agency for Toxic Substances and Disease Registry. Health consultation for Lockwood Solvents in Billings, Montana. Atlanta: US Department of Health and Human Services; 2000 May 3.

[13] CH2M Hill, Final Kelly AFB Food Chain Sampling Study, CH2M HILL, Spectrum Building, 613 NW Loop 410, Suite 200, San Antonio, TX: 78216, contract N0. 52826; 2002 February.

[14] Davis JC, Vanderhoof S, Dana J, Selk K, Smith K, Goplen B, Erickson LE. Movement of chlorinated solvents and other volatile organics through plants monitored by Fourier transport infrared (FT-IR) spectrophotometry. J Hazard Subst Res 1998 1(4): 1–26.

[15] US Air Force Installation Restoration Program. January 2000 Semiannual Compliance Plan Report (July - December 1999), Kelly Air Force Base, San Antonio, Texas.

[16] US Air Force Installation Restoration Program. January 2001 Semiannual Compliance Plan Report (July - December 2000), Kelly Air Force Base, San Antonio, Texas.

[17] US Air Force Installation Restoration Program. Final Zone 4 RCRA Facility Investigation Report Zone Overview OU-1/OU-2. Kelly Air Force Base, San Antonio, Texas; 2003 June.

[18] US Air Force Installation Restoration Program. Final Zone 4 Corrective Measures Study. Kelly Air Force Base, San Antonio, Texas; 2004 July.

[19] Federal Facilities Information Management System. Soil contamination: Kelly Air Force Base. Atlanta, GA; 2000.

[20] Agency for Toxic Substances and Disease Registry. Toxicological profile for arsenic. Atlanta: US Department of Health and Human Services; 2000.

[21] US Air Force. Kelly Air Force Base IRP Site SS009 closure report. Final. San Antonio, TX; 1997 September.

[22] Kelly Air Force Base. Frequently asked questions. Available from: http://empub.kelly.af.mil/FAQ.

[23] US EPA. Human health medium-specific screening levels table. Dallas, TX: US Environmental Protection Agency, Region 6; 2000.

[24] CH2MHILL. Kelly Air Force Base informal technical information report: Zone 4 OU-2 and site S-4 soil vapor monitoring. San Antonio, TX: No. 155728; 2000 March.

[25] Agency for Toxic Substances and Disease Registry. Toxicological profile for tetrachloroethylene. Atlanta US Department of Health and Human Services; 1995.

[26] Agency for Toxic Substances and Disease Registry. Toxicological profile for trichloroethylene. Atlanta: US Department of Health and Human Services; 1995.

[27] Agency for Toxic Substances and Disease Registry. Toxicological profile for hexachlorobutadiene. Atlanta: US Department of Health and Human Services; 1994.

[28] Agency for Toxic Substances and Disease Registry. Toxicological profile for 1,2-dichloroethene. Atlanta: US Department of Health and Human Services; 1994.

[29] Agency for Toxic Substances and Disease Registry. Toxicological profile for methylene chloride. Atlanta: US Department of Health and Human Services; 1998.

[30] Agency for Toxic Substances and Disease Registry. Toxicological Profile for Benzene. Atlanta: US Department of Health and Human Services; 1995.

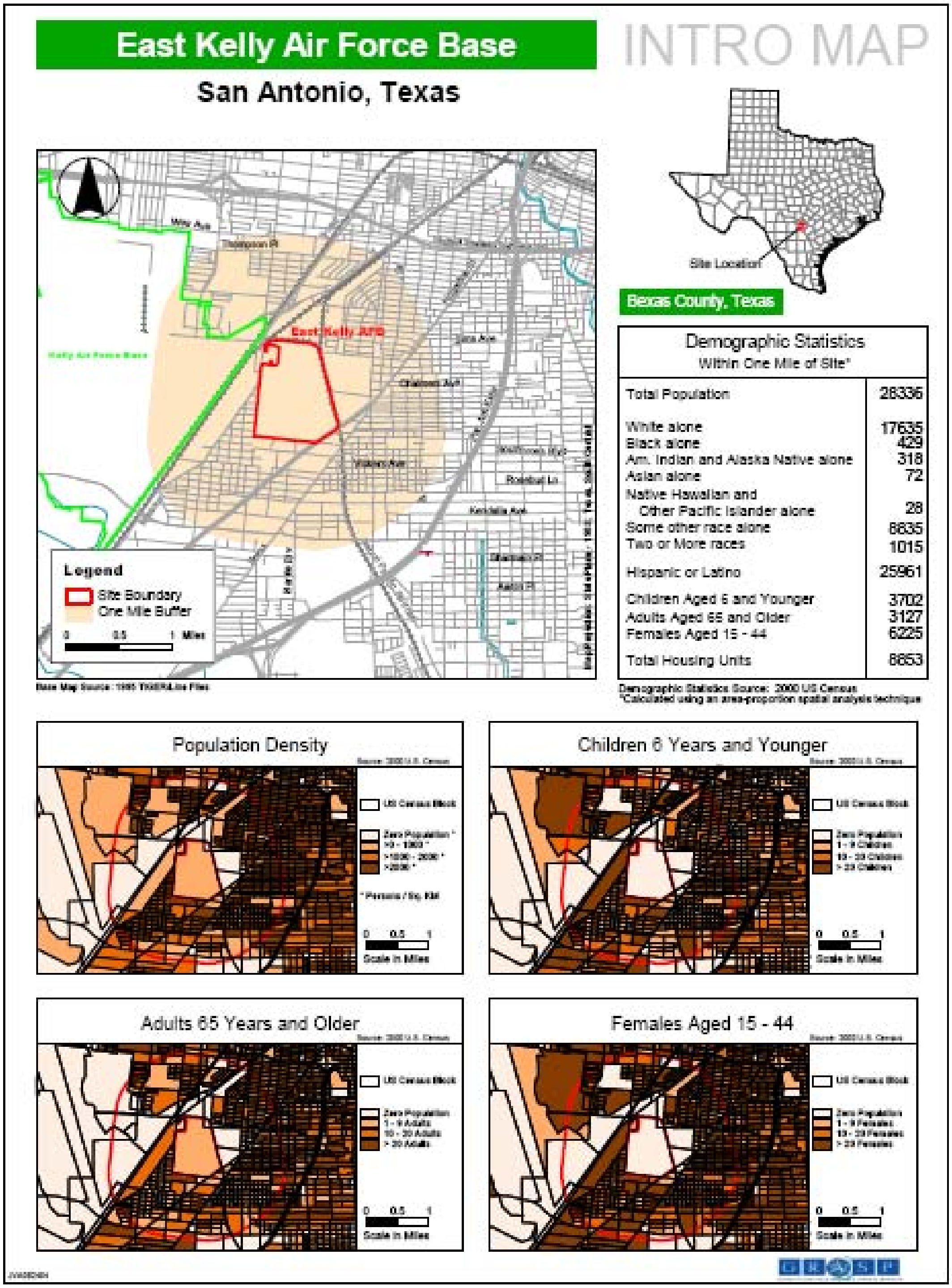
[31] Volkel W, Friedewald M, Lederer E, Pahler A, Parker J, Dekant W. Biotransformation of perchloroethene: dose-dependent excretion of trichloroacetic acid, and N-acetyl-S-(trichlorovinyl)-L-cysteine in rats and humans after inhalation. Toxicol Appl Pharmacol 1998;153;20–7.

32 Pahler A, Parker J, Dekant W. Dose-dependent protein adduct formation in kidney, liver, and blood of rats and in human blood after perchloroethene inhalation. Toxicol Sci 1999;48:5–13.

33 US EPA. The Johnson and Ettinger model for subsurface vapor intrusion into buildings. Washington, DC: US Environmental Protection Agency; 1997.

Appendix A. Site Maps

Figure 1. Site Map



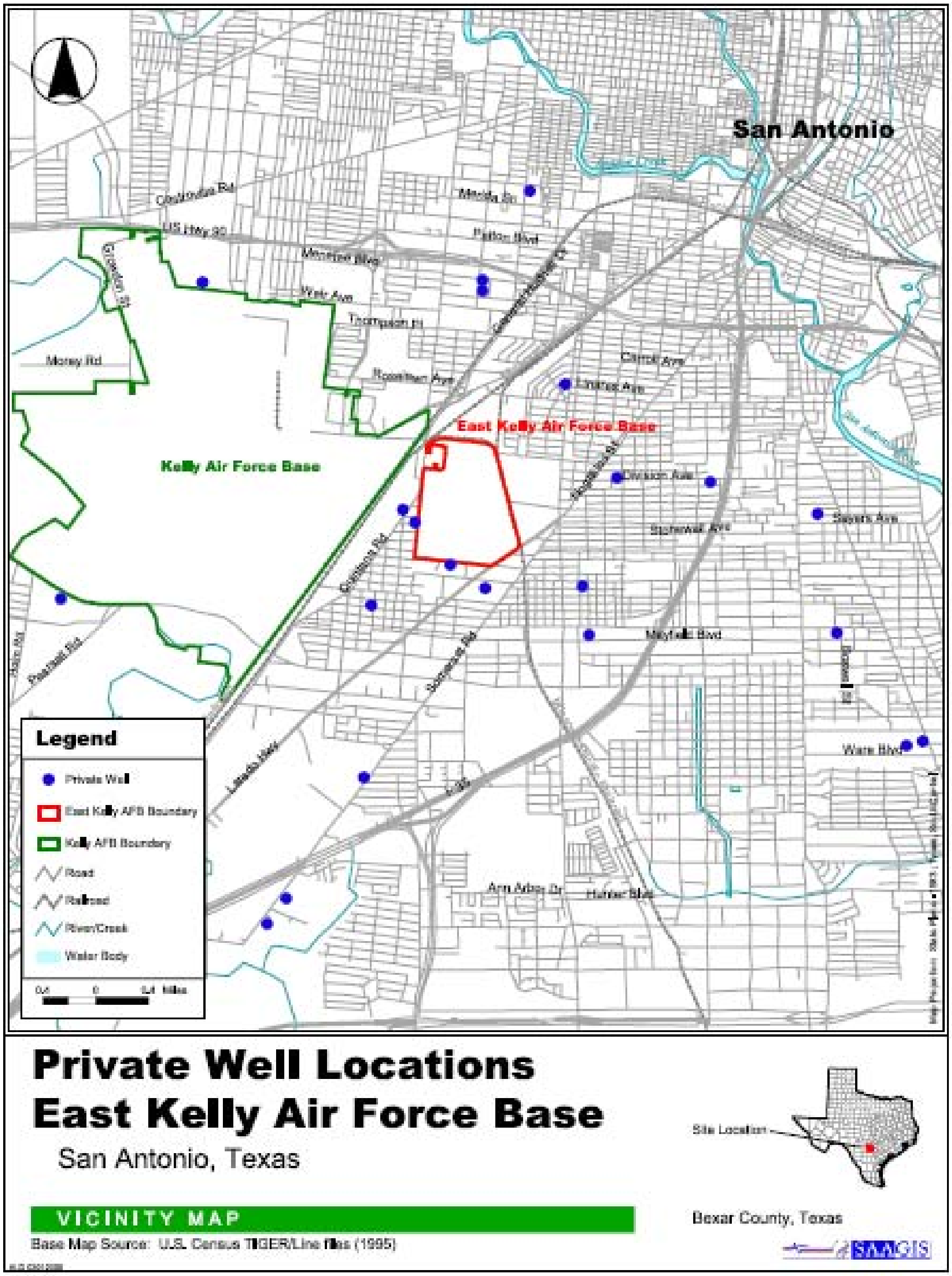


Figure 2

Figure 2. Private Well Locations, East Kelly AFB

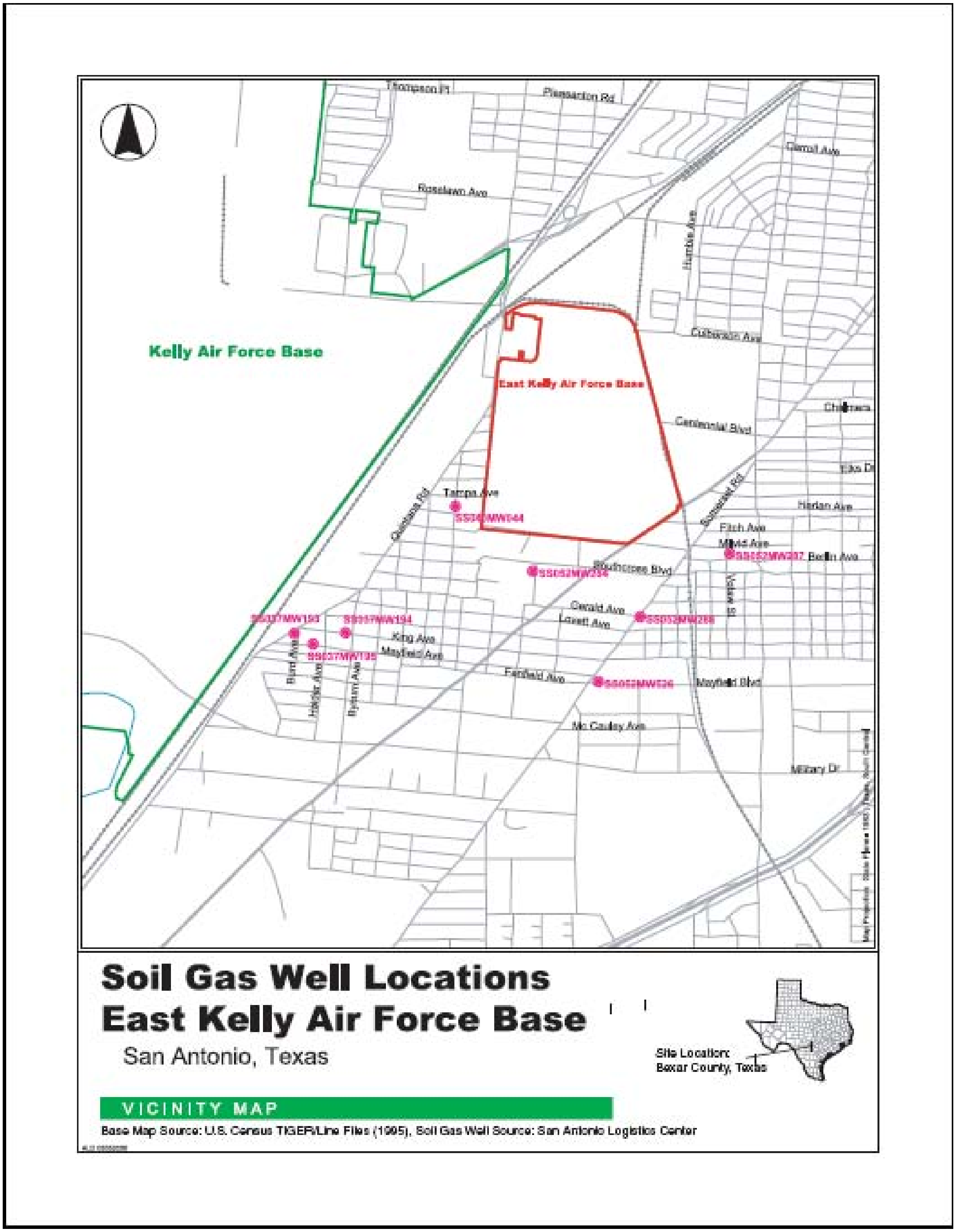
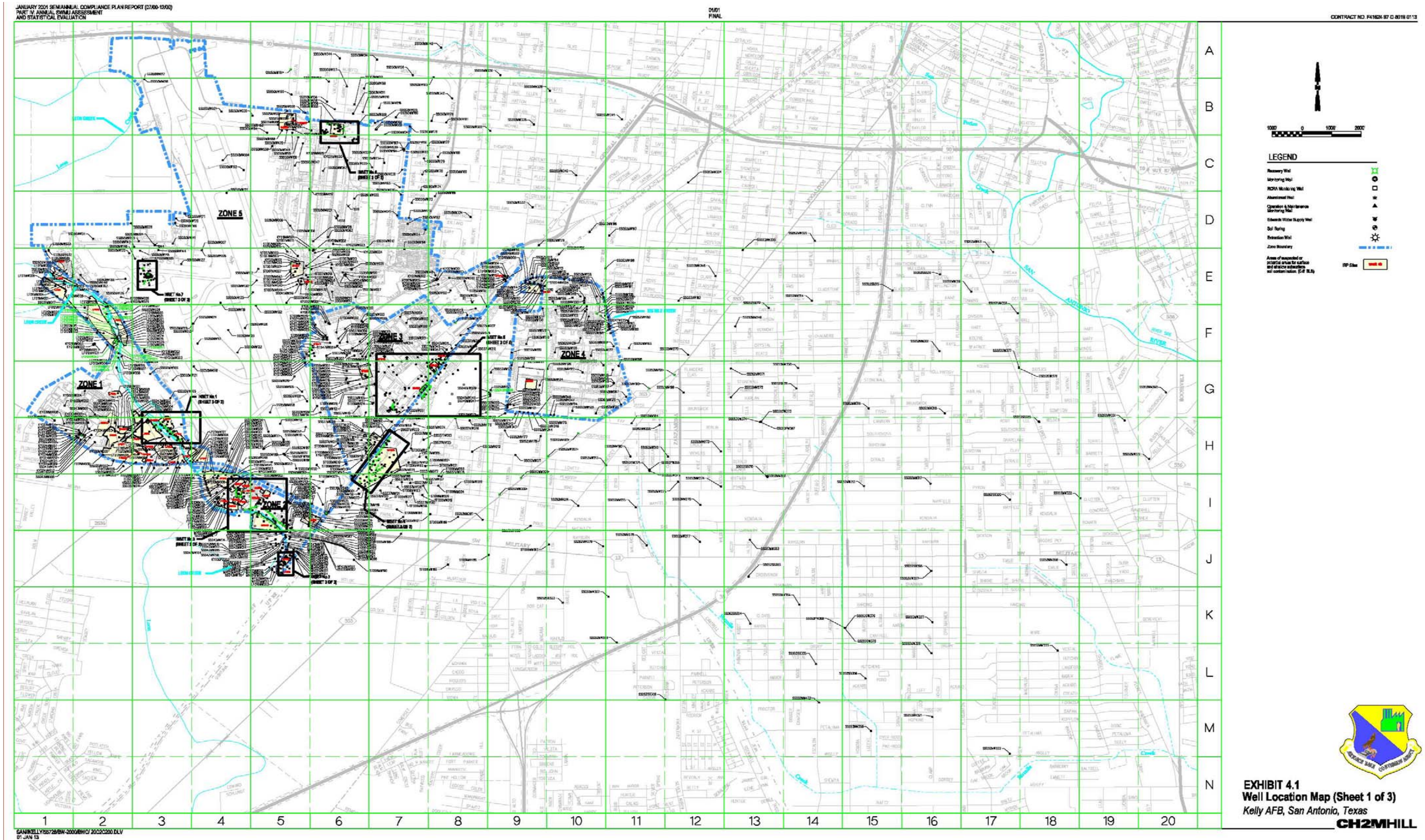


Figure 3. Soil Gas Well Locations, East Kelly AFB

Figure 4. Well Location Map, Kelly AFB



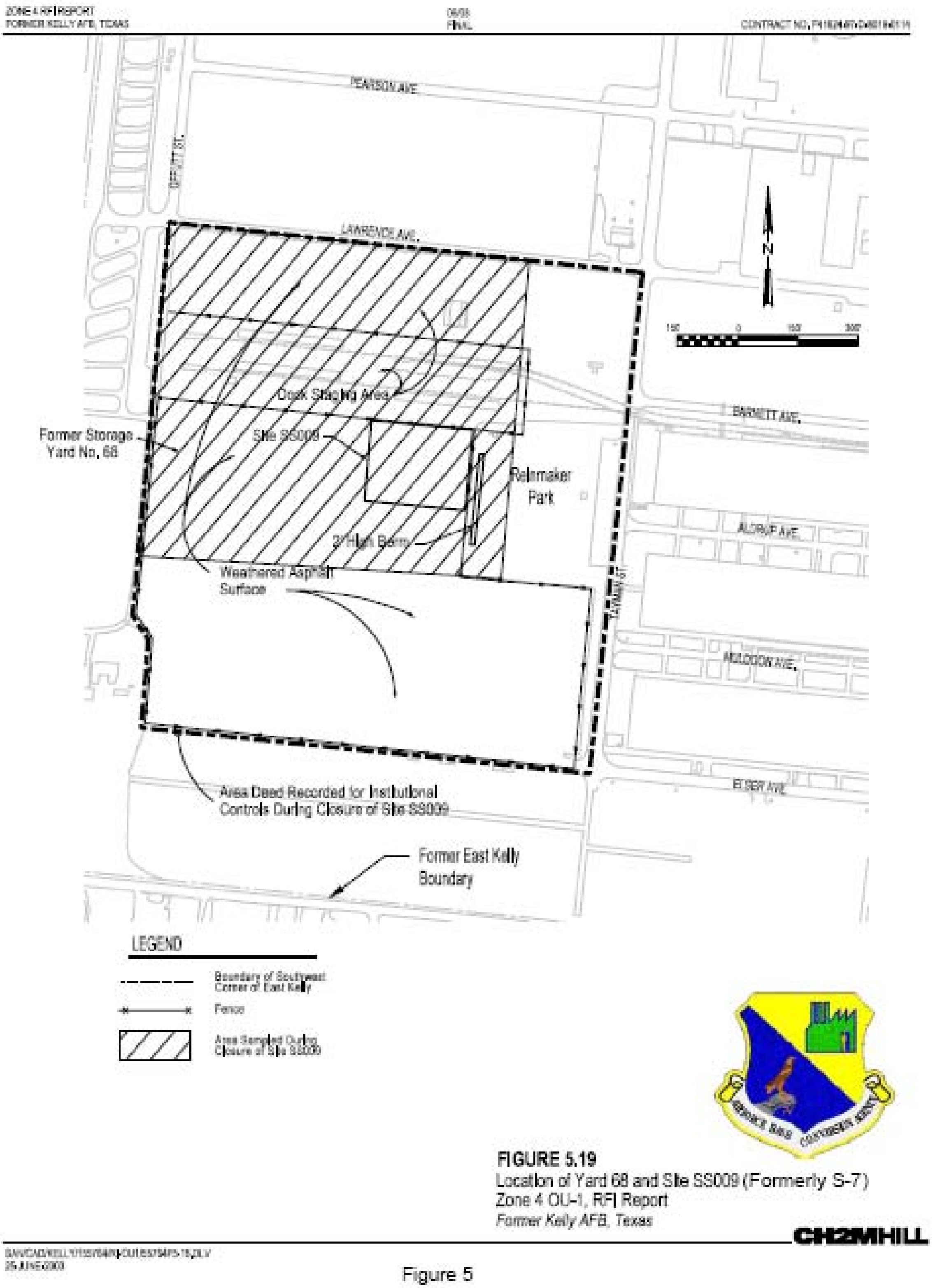


Figure 5. Location of Yard 68 and Ste SS009 (Formerly S-7)

Figure 6. Zone 4 Land Use Map

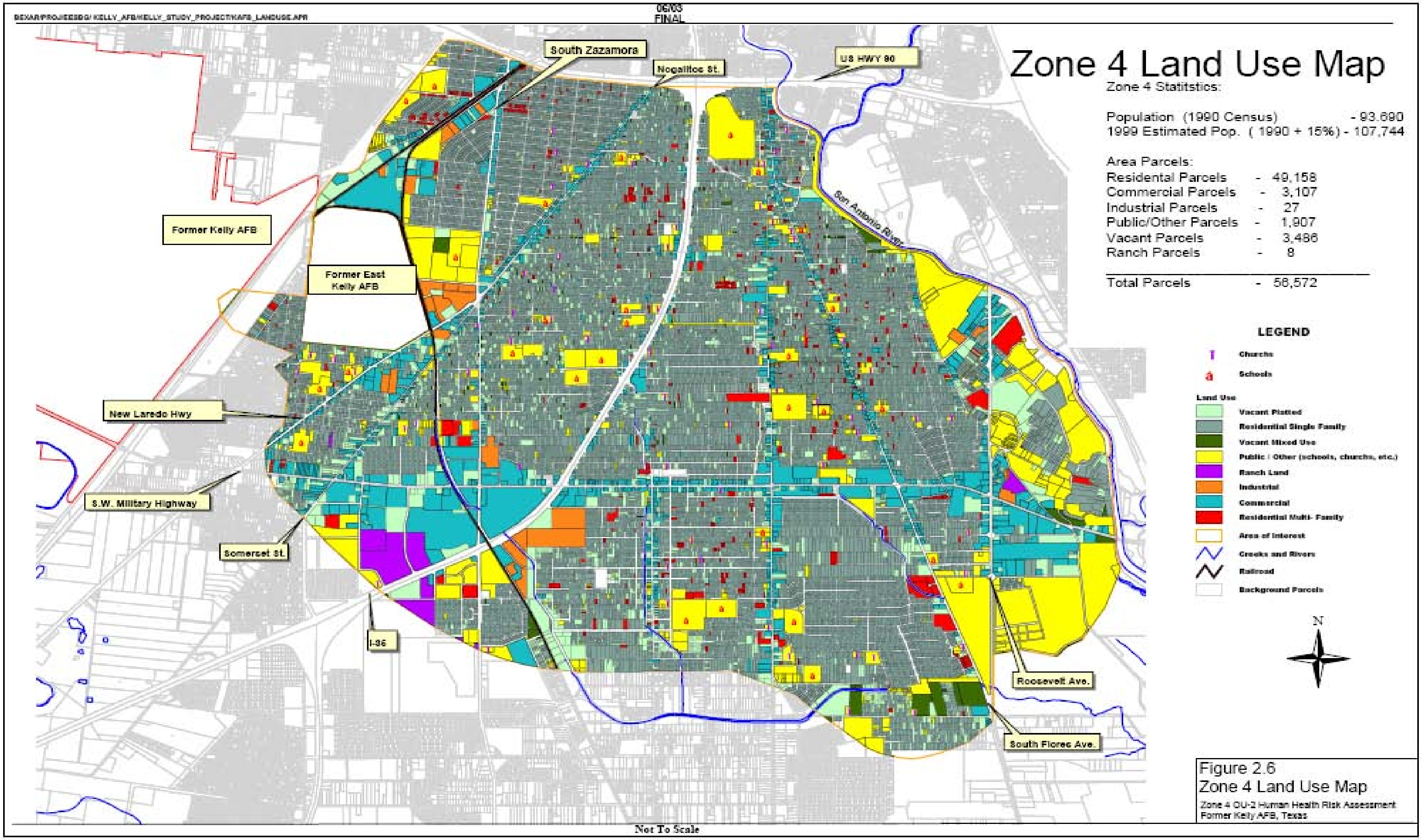


Figure 6

Appendix B. ATSDR Glossary of Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number,
1-888-422-8737.

General Terms

Absorption
The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

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].

Additive effect
A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

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

Aerobic
Requiring oxygen [compare with anaerobic].

Ambient
Surrounding (for example, *ambient* air).

Anaerobic
Requiring the absence of oxygen [compare with aerobic].

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

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

Antagonistic effect
A biologic response to exposure to multiple substances that is **less** than would be expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation
Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study
A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring
Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing
Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP [see Community Assistance Panel.]

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.

Case study
A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number
A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service .

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

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]

Cluster investigation
A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)
A group of people from a community and from health and environmental agencies who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

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. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).

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.

Delayed health effect
A disease or an injury that happens as a result of exposures that might have occurred in the past.

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].

Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.

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

Disease prevention
Measures used to prevent a disease or reduce its severity.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD
United States Department of Defense.

DOE
United States Department of Energy.

Dose (for chemicals that are not radioactive)
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.

Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

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

Environmental media and 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.

EPA
United States Environmental Protection Agency.

Epidemiologic surveillance [see Public health surveillance].

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 assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

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.

Exposure registry
A system of ongoing followup of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

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

Half-life ($t_{½}$)
The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)
The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to evaluate the possible association between the occurrence and exposure to hazardous substances.

Health promotion
The process of enabling people to increase control over, and to improve, their health.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

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].

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Medical monitoring
A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

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

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

mg/cm^2
Milligram per square centimeter (of a surface).

mg/m^3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

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.

Mutagen
A substance that causes mutations (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

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.

National Toxicology Program (NTP)
Part of the Department of Health and Human Services. NTP develops and carries out tests to predict whether a chemical will cause harm to humans.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Physiologically based pharmacokinetic model (PBPK model)
A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

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).

Potentially responsible party (PRP)
A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevalence survey
The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

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

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

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public health action
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

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 [compare with health consultation].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement
The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

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.

Public meeting
A public forum with community members for communication about a site.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA [see Resource Conservation and Recovery Act (1976, 1984)]

Receptor population
People who could come into contact with hazardous substances [see exposure pathway].

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.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD [see reference dose]

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

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].

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

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.

Sample size
The number of units chosen from a population or an environment.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

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.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Substance-specific applied research
A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's toxicological profiles. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

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.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Surveillance [see public health surveillance]

Survey
A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

Synergistic effect
A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

Teratogen
A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

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.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

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
National Library of Medicine (NIH)

For more information on the work of ATSDR, please contact

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Appendix C. Comparison Values and ATSDR Methodology

Comparison Values – Definitions

ATSDR comparison values are media-specific concentrations considered to be safe under default conditions of exposure. They are used as screening values in the preliminary identification of site-specific “contaminants of concern.” This term should not be interpreted to mean “hazard.” As ATSDR uses the phrase, a “contaminant of concern” is a chemical substance detected at the site in question and selected by the health assessor for further evaluation of potential health effects. Generally, a chemical is selected as a “contaminant of concern” because its maximum concentration in air, water, or soil at the site exceeds one of ATSDR’s comparison values.

That said, however, it must be emphasized that comparison values are not thresholds of toxicity. Although concentrations at, or below, the relevant comparison value may reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a comparison value would be expected to produce adverse health effects. The principal purpose behind highly conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health hazards before they become actual public health consequences. Thus, comparison values are designed to be preventive, rather than predictive, of adverse health effects. The probability that such effects will actually occur does not depend on environmental concentrations alone, but on a unique combination of site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure.

Listed and described below are the various comparison values ATSDR uses to select chemicals for further evaluation, as well as other non-ATSDR values that are sometimes used to put environmental concentrations into a meaningful frame of reference.

CREG	=	Cancer Risk Evaluation Guides
MRL	=	Minimal Risk Level
EMEG	=	Environmental Media Evaluation Guides
IEMEG	=	Intermediate Environmental Media Evaluation Guide
RMEG	=	Reference Dose Media Evaluation Guide
RfD	=	Reference Dose
RfC	=	Reference Dose Concentration
RBC	=	Risk-Based Concentration
MCL	=	Maximum Contaminant Level
TLV	=	Threshold Limit Values

Cancer Risk Evaluation Guides (CREGs) are estimated contaminant concentrations expected to cause no more than one excess cancer in a million persons exposed over a lifetime. CREGs are calculated from EPA’s cancer slope factors, or cancer potency factors, using default values for exposure rates. Still, neither CREGs nor cancer slope factors can be used to make realistic predictions of cancer risk. The true risk is always unknown and may be as low as zero.

Minimal Risk Levels (MRL) are estimates of daily human exposure to a chemical (doses expressed in mg/kg/day) that are unlikely to be associated with any appreciable risk of deleterious noncancer effects over a specified duration of exposure. MRLs are calculated using data from human and animal studies and are reported for acute (æ 14 days), intermediate (15–364 days), and chronic (Æ 365 days) exposures. MRLs are published in ATSDR toxicological profiles for specific chemicals.

Environmental Media Evaluation Guides (EMEGs) are concentrations of substances in water, soil, or air that are calculated from ATSDR minimal risk levels for those substances by factoring in default body weights and ingestion rates.

Intermediate Environmental Media Evaluation Guides (IEMEG) are calculated from ATSDR minimal risk levels; they factor in body weight and ingestion rates for intermediate exposures (those occurring for more than 14 days and less than 1 year).

Reference Dose Media Evaluation Guide (RMEG) is the concentration of a contaminant in air, water, or soil that corresponds to EPA's RfD for that contaminant when default values for body weight and intake rates are taken into account.

Reference Dose (RfD) is an estimate of the daily dose of a contaminant that is unlikely to cause noncarcinogenic adverse health effects over a lifetime of chronic exposure. Like ATSDR's MRL, EPA's RfD is a dose expressed in mg/kg/day.

Reference Concentrations (RfC) is a concentration of a substance in air that EPA considers unlikely to cause noncancer adverse health effects over a lifetime of chronic exposure.

Risk-Based Concentrations (RBC) are media-specific concentrations (analogous to ATSDR's EMEGs) derived by Region 6 of the Environmental Protection Agency from RfDs, RfCs, or EPA's cancer slope factors. They represent concentrations of a contaminant in tap water, ambient air, fish, or soil (industrial or residential) that are considered unlikely to cause adverse health effects over a lifetime of chronic exposure. RBCs are based either on cancer ("c") or noncancer ("n") effects.

Maximum Contaminant Levels (MCLs) represent contaminant concentrations in drinking water that EPA deems protective of public health (considering the availability and economics of water treatment technology) over a lifetime (70 years) at an exposure rate of 2 liters of water per day. Unlike other comparison values, MCLs are legally enforceable drinking water standards.

Threshold Limit Values (TLVs) are time-weighted average concentrations for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

Comparison Values - Application

ATSDR assesses a site by evaluating the level of exposure in potential or completed exposure pathways. An exposure pathway describes the way in which chemicals may enter a person's body. It includes all the steps between the release of a chemical and the population exposed; that is, 1) a chemical release source, 2) a chemical movement, 3) a place where people can come into contact with the chemical, 4) a route of human exposure, and 5) a population that could be exposed. In this assessment ATSDR evaluates chemicals in the soil, air, and groundwater that people living in nearby residences could consume or with which they could come into contact.

Comparison values (CVs) are screening tools used to evaluate environmental data relevant to the exposure pathways. Although different agencies like ATSDR and EPA develop their own comparison values for their own purposes, the procedures they follow are essentially the same and, more often than not, the values they arrive at are very similar, as well. Comparison values are concentrations of contaminants considered to be safe levels of exposure. They are derived from available health guidelines, such as ATSDR's minimal risk levels (for noncancer effects) and EPA's cancer slope factors (for cancer effects).

Conservative exposure assumptions are used in the derivation of comparison values to ensure that the latter are much lower than all known levels of effect and, as a result, will be protective of public health in essentially all exposure situations. Thus, if the concentrations in the exposure medium are less than the CV, the exposures are not of potential health concern and no further analysis of the pathway is required. Nevertheless, even if a site-specific concentration exceeds the relevant comparison value, it does not necessarily follow that exposure will necessarily lead to adverse effects. Comparison values generally contain generous margins of safety. And they are based on default, rather than site-specific, conditions of exposure. Site-specific environmental factors and patterns of activity have a major impact on the magnitude and duration of exposure, and they (more than the concentrations alone) will determine whether contaminants that exceed their comparison values might lead to adverse health effects. ATSDR's comparison values are screening tools only**;** they cannot be used to predict the occurrence of adverse health effects. Further analyses utilizing the best medical and toxicological information available are required to determine the public health implications of exposures that exceed state or federal guidelines.

The Cancer Risk Evaluation Guide (CREG) is ATSDR's cancer-based comparison value. It represents the concentration of a potentially carcinogenic substance in a given medium (e.g., air, soil, or water) which, under default conditions of exposure, would yield a "virtually safe dose." EPA defines the virtually safe dose of a carcinogen as one that would correspond to a hypothetical 1-in-a-million lifetime risk level, (i.e., one which would be expected to produce no more than one excess case of cancer in a million persons exposed over a lifetime). EPA and some other governmental agencies often use various multiples of this virtually safe dose as quantitative definitions of different qualitative levels (e.g., "high," "low," "moderate,") of hypothetical risk. Note, however, that neither the values nor the descriptors of these various hypothetical levels of risk are to be taken literally. These numbers are the product of a regulatory methodology designed as a prioritizing tool for risk managers. They cannot be used to predict actual cancer incidence rates in humans. As EPA stated in its 1986 Guidelines for Carcinogen Risk Assessment, "the true value of the risk is unknown and may be as low as zero" (EPA 1986). In its revised guidelines, EPA notes that "the data that support cancer assessments generally are not suitable for numerical calculations of the probability that an agent is a carcinogen" (EPA 2005). Accordingly, ATSDR uses EPA slope factors only as a convenient basis for the derivation of its own conservative cancer-based screening values (CREGs) for water, air, and soil. If further evaluation is necessary, ATSDR guidance provides that the mechanistic relevance of the experimental or epidemiological data to site-specific conditions of exposure should be the primary consideration (ATSDR 2005).

EPA Region 6 cancer-based Risk-Based Concentrations (RBCs) are analogous to ATSDR's CREGs, in that they too are media-specific concentrations that would correspond to hypothetical 10^{-6} levels of lifetime excess cancer risk. Because cancer-based RBCs have been developed for many more substances than CREGs have, ATSDR often uses an RBC when no CREG is available for the substance of interest. This was so often the case with the East Kelly monitoring data that throughout this public health assessment ATSDR chose, for the sake of consistency, to use EPA Region 6 RBCs.

Contaminants of Concern and Public Health Implications

Contaminants of concern (COCs) are the site-specific chemical substances that exceed comparison values and have been subsequently selected by the health assessor for further evaluation. In the first step of the COC selection process, the maximum contaminant concentrations are compared directly to health-based comparison values. ATSDR considers site-specific exposure factors to ensure selection of appropriate health comparison values. (For example, if only adult workers are exposed to soil at a fenced site, an adult soil EMEG would be more appropriate for screening purposes than would a pica child EMEG.) If the maximum concentration reported for a chemical is less than the health comparison value, that chemical is not of public health concern and no further data review is required. If the maximum concentration is greater than the health comparison value, the chemical is selected for additional data review. In addition, any detected chemicals for which no relevant health comparison values exist are automatically selected for additional data review.

The next step of the process requires a more in-depth review of data for each of the contaminants selected to determine the public health implications, if any, of the selected COCs. Having served their purpose in the initial screening process, comparison values are not directly relevant to the toxicological evaluation of public health implications. Conclusions drawn during the latter stage of the analysis are based on the best medical and toxicological information available (ATSDR 1992).

Quality Assurance

In preparing this report ATSDR relied on the information provided in the referenced documents and on contacts with the Texas Natural Resources Conservation Commission, Texas Department of Health, San Antonio Metropolitan Health District, Environmental Protection Agency, United States Geological Survey, community members, and Kelly Air Force Base. ATSDR assumes that adequate quality assurance and control measures were taken during chain-of-custody, laboratory procedures, and data reporting. The validity of the analyses and conclusions drawn in this document are dependent on the availability and reliability of the information.

References

[ATSDR] Agency for Toxic Substances and Disease Registry. 1992. Public Health Assessment Guidance Manual. Atlanta: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2005. Public Health Assessment Guidance Manual (Update). Atlanta: US Department of Health and Human Services.

[EPA] Environmental Protection Agency. 1986. Guidelines for carcinogen risk assessment. FR 51(185):33992–34006.

[EPA] Environmental Protection Agency. 2005. Guidelines for carcinogen risk assessment. Washington DC: EPA/630/P-03/001B, Risk Assessment Forum; March 2005. p. 2–53.

Appendix D. Estimated Exposure Dose and Cancer Risk for On-Site Soil

ATSDR selected an exposure scenario for incidental ingestion of soil at East Kelly that would maximize potential exposure to the contaminants detected in that soil. This exposure scenario is not likely to actually apply to anyone living near this site. ATSDR uses such "worst-case" exposure scenarios in its analysis to assure that the agency does not overlook any plausible hazard to any potentially exposed individual.

ATSDR screened the maximum site-related contaminant concentrations for potential cancer effects by comparing them to the values in EPA's 2000 Region 6 Human Health Medium-Specific Screening Levels Table for residential soil. (These CVs are comparable to ATSDR's CREGs. But unlike ATSDR's CREGs, they were available for all of the contaminants detected in East Kelly soil.) All contaminants that exceeded their respective comparison values were selected for further evaluation. Maximum concentrations were used to calculate an exposure dose. Risk-based screening levels for carcinogens were based on combined childhood and adult exposure. Risk-based screening levels represent hypothetical risks and should not be viewed as predictors of adverse health effects; the actual risk may be zero.

ATSDR used the default ingestion rates recommended for incidental soil ingestion**:** 200 milligrams (mg)/day for children and 100 mg/day for adults. ATSDR used standard body weights for children (15 kg) and adolescents/adults (70 kg).

The exposure frequency was assumed to be constant, and the exposure durations were assumed to be 0–6 years for children and 7–30 years for adolescents/adults.

ATSDR used the following slope factors taken from RBC Tables:

Benzo(a)pyrene:	7.30E+00 risk per mg/kg/day
Dibenzo(a,h)anthracene:	7.30E+00 risk per mg/kg/day
Benzo(a)anthracene:	7.30E-01 risk per mg/kg/day
Benzo(b)fluoranthene:	7.30E-01 risk per mg/kg/day

Slope factors are estimates of the possible carcinogenic potency at low doses of substances that have demonstrated clear carcinogenic potential at much higher doses. They are used to convert doses of a given substance into equivalent levels of hypothetical cancer risk. Those levels of hypothetical risk are expressed as unitless numerical estimates of probability (e.g., 1-in-a-million), usually in scientific notation. Any number can be expressed in scientific notation (i.e., as a factor of some positive or negative power of ten). Positive exponents yield numbers greater than 1; negative exponents yield numbers less than 1. But scientific notation is usually reserved for very large or very small numbers. Thus, a 1-in-a-million chance (0.000001) may be expressed as 10^{-6} , 1×10^{-6}, or 1.00E-06. In the latter form of scientific notation, the letter "E" replaces the "times" symbol and the base 10; the number following the letter "E" is the exponent. Many calculators leave out the base 10 altogether—it is understood to be there—so that 10^{-6}, or 1×10^{-6}, or 1.00E-06 appears in the display as "1. -6."

EPA and other governmental agencies often specify selected levels of such hypothetical risk as quantitative definitions of the qualitative terms (e.g., "high," "low," "moderate") used to describe different levels of potential hazard. Neither the absolute values nor the qualitative descriptors of these hypothetical levels of risk should, however, be taken literally. These numbers are the product of a regulatory methodology designed as a prioritizing tool for risk managers, not as a predictor of actual cancer incidence rates in humans. As EPA stated in its 1986 Guidelines for Carcinogen Risk Assessment, “the true value of the risk is unknown and may be as low as zero” (EPA 1986).

Within the context of the qualitative descriptors mentioned above, the maximum detected concentrations of soil contaminants at East Kelly would pose no apparent increased risk. More importantly, actual toxicological data (as opposed to hypothetical cancer risk estimates) provide no basis for concern about PAHs in soil. In laboratory animals treated orally (i.e., by gavage in oil) no adverse health effects of either a cancerous or noncancerous nature are observed at doses of 1 mg/kg/day or less. Given the reduced bioavailability of PAHs in soil, a 10-kg child would have to eat several pounds of maximally contaminated East Kelly dirt every day to obtain a 1 mg/kg/day dose.

Reference

[EPA] Environmental Protection Agency. 1986. Guidelines for carcinogenic substances. FR 51(185):33992–34006.

Appendix E. Soil Gas and Estimated Risk

Table E-1. East Kelly Soil Gas Sampling Results, Estimated Indoor Air Concentrations, and Cancer Risks

Chemical	*Maximum Soil Gas Concentration µg/m³*	*Maximum Estimated Indoor Air Concentration* µg/m³*	*J&E Estimated Cancer Risk†*
1,1,2-Trichloro-1,1,2-trifluoroethane	275		
cis-1,2-Dichloroethene	344	0.0089	Not classifiable§
1,1,1-Trichloroethane	9.3		
1,1-Dichloroethane	20.6		
Benzene	7.3	0.00019	7.4E-10
Ethylbenzene	10.4		
Methylene Chloride	286	0.0081	2.9E-8
Tetrachloroethene (PCE)	14,230	0.345	8.7E-8
Toluene	165		
Trichloroethene (TCE)	618	0.016	1.2E-8
Xylenes	29.9		
1,2,4-Trichlorobenzene	179		
Hexachlorobutadiene	265	0.0055	5.3E-8
Styrene	8.1		
Vinyl Chloride	ND		

* Indoor air concentrations were derived using EPA's Johnson & Ettinger model for subsurface vapor intrusion into buildings

† Cancer risks were derived using the Unit Risk values incorporated into EPA's Johnson & Ettinger model.

§ Not classifiable as to human carcinogenicity due to absence of data on humans or animals

µg/m³ =micrograms per cubic meter;

ND =Not detected;

Shading indicates that the maximum detected concentration in *soil gas* exceeded the relevant 2000 RBC for ambient air. Note, however, that it is the estimated indoor air concentrations, and not the subterranean soil gas concentrations, that are relevant to human exposure and the potential for adverse health effects, and all of the former were orders of magnitude below these RBCs.

Scientific notation is used in the last column of this table**:** "a E-b" = a x 10^{-b}. Thus, for example, a hypothetical excess lifetime cancer risk of "8.7E-8" equals 8.7×10^{-8} or 0.000000087 or 0.087 per million over background. Current background incidence (i.e., actuarial lifetime risk) of cancer in the United States is roughly 1 in 4 or 0.25 or 2.5×10^{-1}.

Estimating Potential Inhalation Exposure Doses and Cancer Risks
The Johnson and Ettinger Model

Screening tools are not designed to quantify potential health hazards or risks "accurately." They are designed to identify those exposures clearly too low to warrant further investigation. During the screening stage of this investigation, ATSDR used the Johnson & Ettinger Model (J&E Model) to estimate conservatively the 95th percentile indoor air concentrations of VOC contaminants that might result from the migration of subterranean soil vapors into local residences. For potentially carcinogenic contaminants, the model also calculated the cancer risks theoretically associated with continuous lifetime exposure to the corresponding 95th percentile indoor air concentrations, by multiplying the latter by the appropriate, chemical-specific values of Unit Risk (i.e., risk per $\mu g/m^3$).

The J&E Model utilizes a combination of inputs to calculate the ability of the vapors to attenuate as they migrate through the soil and into the home.[1] The model reports each of several individual calculations before calculating the 95th percentile value. The indoor air concentration is mainly dependent on concentration in soil gas and attenuation as the gas migrates through the soil. There are many site-specific properties that govern attenuation. Readily available site-specific properties include chemical-specific properties, depth to the chemical plume, soil type, ground water temperature, building type, and size of foundation crack within the structure. Those less available properties are the vadose-zone-specific parameters, including soil vapor permeability, soil (dry) bulk density, soil porosity, and soil water-filled porosity.

Estimates of VOC Concentrations in Indoor Air

Before soil gas sampling, the Kelly AFB contractor (CH2M Hill) modeled the concentrations found in ground water to predict the indoor air concentrations and identified a few locations with the highest predicted indoor air levels. CH2M Hill did not vary all the site-specific parameters for each house, but only varied the concentration and the depth to groundwater. Therefore, when they identified those locations where indoor levels would be highest, they actually identified locations where the soil gas would be highest.[a] Soil gas samples were then collected in several locations where the maximum soil gas concentrations were likely above the plume, to the south of East Kelly.

ATSDR evaluated the individual toxicity of the highest concentration of each chemical detected in soil gas. The evaluation included estimating potential exposures. The J&E Model is designed to use groundwater values to predict soil gas values, and then to predict indoor air values from those estimated soil gas values. Because, however, the actual concentrations of VOCs in soil gas were known, the first step in which contaminants in soil gas are estimated from those in groundwater was eliminated.

This is important because published concerns about the validity of the J&E Model generally relate to either the calculation of the volatilization of chlorinated compounds from groundwater into the soil gas, or the transmissivity of the soil gas through the soil in areas where there is preferential transport due to the presence of a large bedrock-formations with fissures. Neither of these conditions existed at East Kelly. The soil gas concentrations were measured, not calculated,

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[a] Actual concentrations in indoor air would be changed depending on the presence of a crack or size of the crack in each of the respective foundations (which varies widely).

and there were no outcroppings or large bedrock formations near the soil surface under the homes near East Kelly.

Therefore, soil gas concentrations were input directly into the second stage of the model. The remaining necessary inputs included a 15-cm depth to below grade (no basement), a 200 cm depth to water table, sandy clay soil, and sandy clay loam vadose soil. This created an attenuation factor (α) equal to 1.73E-05.

Use of this attenuation factor greatly overestimated indoor air VOC concentrations, because the actual depth to the water table (20-30 feet or 6600-9900 cm) would create an attenuation factor (α) equal to 1.60E-06 to 7.42E-07. These values are 10-23 times lower than predicted for the worst case. If the local soil contained large amounts of sand (worst case), attenuation could be increased by a factor of 2. If the local soil contained less sand (the more likely situation), attenuation could be 4 times less than the predicted values.

In response to a public comment on the most unlikely attenuation phenomena, ATSDR ignored likely, or even possible, site-specific properties of relevance to soil gas attenuation, and arbitrarily selected a worst-case attenuation factor of (α) equal to 1.0E-04. The worst-case indoor concentrations derived using this attenuation factor were nearly 6 times higher than those previously calculated, but still did not reach levels of concern for either non-cancer or cancer effects. Therefore, ATSDR concluded that indoor air concentrations of VOC contaminants resulting from vapor intrusion would pose no public health hazard at East Kelly.

Note on Estimates of Inhalation Cancer Risks

The old values of Unit Risk that are incorporated into the J&E Model are not always identical to those currently published for the same chemicals. In some cases (e.g., PCE and TCE), current values do not even exist. (The Unit Risk estimates for TCE and PCE were withdrawn many years ago, and are still under review.) This is not a problem, however. Like all screening tools, the J&E Model is intentionally designed to be conservative—rather than accurate—under conditions where accuracy is seldom a practical option, anyway. Consequently, the results generated by the model (which are used only to determine whether further evaluation is justified) are not highly sensitive to relatively small differences in the screening values themselves. For example, a doubling of the unit risk value will only double the estimated risk, while other factors within the model, like attenuation, will create a 10-fold or more increase in the estimated risk. Thus by selecting a sufficiently high attenuation factor, the relative impact of changes in unit risk values for any given chemical becomes negligible.

When considering the potential impact of the variables and corrections on the J&E model results described in this document, the reader should also keep in mind the fact that the cancer “risk” described here is purely hypothetical, regardless of the choice of inputs. Neither the absolute values nor the qualitative descriptors of these hypothetical levels of cancer risk should be taken literally. (See Appendix D of this document.) These numbers, which are used primarily as screening values in this health assessment, are the product of a regulatory methodology designed as a prioritizing tool for risk managers, and not as a predictor of actual cancer incidence rates in humans. As EPA stated in its 1986 Guidelines for Carcinogen Risk Assessment, “the true value of the risk is unknown and may be as low as zero.”[2] Similarly, in its revised 2005 Guidelines, EPA notes that “. . . the data that support cancer assessments generally are not suitable for numerical calculations of the probability that an agent is a carcinogen.”[3] EPA’s revised guidelines are designed to document that agency's decision to replace traditional alphanumeric descriptors of carcinogen classes (e.g., A, B1, B2) with more informative qualitative narratives that include some description of the conditions under which a given chemical exposure might actually cause cancer. This is precisely the kind of perspective that ATSDR attempts to provide in its own qualitative discussions of the likelihood that under site-specific conditions of exposure chemicals will be toxic.[4]

References

1. US Environmental Protection Agency. User's guide for the Johnson and Ettinger (1991) model for subsurface vapor intrusion into buildings. Washington DC; 1997.

2. US Environmental Protection Agency. Guidelines for carcinogenic substances. FR 51:3392–34006; 1986.

3. US Environmental Protection Agency. 2005. Guidelines for Carcinogen Risk Assessment. Washington DC: EPA/630/P-03/001B, Risk Assessment Forum; March 2005. p. 2–53.

4. Agency for Toxic Substances and Disease Registry. Public Health Assessment Guidance Manual (Update). Atlanta: US Department of Health and Human Services; January 2005.

Appendix F. Exposure Pathways Table

Exposure Pathways Table

Pathway Name	***Source***	***Medium***	***Route of Exposure***	***Point of Exposure***	***Receptor Population***	***Time***	***Exposure Activities***	***Chemicals of Concern***
Potential Exposure Pathways								
On-site Soil Gas	Shallow Groundwater	Soil Gas	Inhalation	On-site	Commercial operators, patrons	c, f	Indoor activities	DCE, PCE, TCE, Vinyl Chloride
Off-site Soil Gas	Shallow Groundwater	Soil Gas	Inhalation	Off-site	Residents	p, c, f	Indoor Activities	DCE, PCE, TCE, Vinyl Chloride
Off-site Private Well Water	Shallow Groundwater	Groundwater	Ingestion, Inhalation, Dermal	Off-site	Residents	pre-1988, c, f c, f	Residential Activities	DCE, PCE, TCE, Chloroform, Lead, Thallium, Vinyl Chloride
Biota	Off-site gardens	Vegetables	Ingestion	Off-site	Residents	p, c, f	Residential Activities	DCE, PCE, TCE, Chloroform, Lead, Thallium, Vinyl Chloride
On-site Surface Soil	East Kelly	Surface Soil	Accidental Ingestion	On-site	Trespassers	p, c, f	Trespassing	PAHs, Arsenic
Eliminated Exposure Pathways								
Off-site Private Well Water	Shallow Groundwater	Groundwater	Ingestion	None	Residents	c, f	None	DCE, PCE, TCE, Chloroform, Lead, Thallium, Vinyl Chloride
Off-site Surface Soil	East Kelly	Surface Soil	Ingestion	None	Residents	p, c, f	None	PAHs, Arsenic

KEY: p = past; c = current; f = future

Appendix G. Worst-Case Exposure Scenario: Showering

Estimated Inhalation Exposure during Showering

Equations and default values used:

To assess the potential health impact of inhalation exposures to groundwater-related VOCs at East Kelly, ATSDR used the following equations and highly conservative assumptions to describe the “worst-case” scenario of a resident who showers with VOC-contaminated water from the shallow aquifer. This is a purely hypothetical exposure scenario, because the data available to ATSDR suggest that no one in the East Kelly area is actually showering in water from the shallow aquifer.

The maximum concentration of a VOC in the bathroom air can be estimated by using the following mathematical equation [1] and substituting the indicated values:

$$C_a = \frac{C_w \times f \times F_w \times t}{V_a}$$

where:

C_a	bathroom air concentration (mg/m^3)
C_w	max concentration of contaminant in shallow aquifer water (mg/L)
f	fractional volatilization rate (unitless). Assume 0.9
F_w	shower water flow rate in liters per minute (L/min). Assume 8 L/min.
t	exposure time in minutes (min). Assume 10 min*.
V_a	bathroom volume in cubic meters (m^3). Assume 10 m^3

(* Longer shower times will, of course, result in higher maximum concentrations of VOCs in air. In reality, however, that peak concentration, whatever it might be, will exist for only a short time before and after the water is turned off. Thus, contrary to the assumption made in this worst-case scenario, it will not be a constant concentration to which the bather is exposed throughout the duration of the shower event. Indeed, use of a constant maximal concentration derived from any shower longer than 10 minutes would, arguably, be excessively conservative, even for a worst-case scenario.)

Using the above parameters, the equation reduces to:

$$C_a = \frac{X\ \mu g/L \times 0.9 \times 8\ L/min \times 10\ min}{10\ m^3} = X\ \mu g/L \cdot 7.2\ L/m^3 = Y\ \mu g/m^3$$

Concentrations can be converted between ppb and $\mu g/m^3$ using the following equations:

$$\mu g/m^3 = \frac{ppb \times M.W.}{24.45} \qquad ppb = \frac{\mu g/m^3 \times 24.45}{M.W.}$$

Other assumptions:

(1) a resident would take a 10 minute shower once every day;

(2) the concentration of vinyl chloride in the bathroom throughout the course of all shower-related activities is assumed to be constant and equal to the maximum concentration achieved while the shower water is running;

(3) the rates of volatilization for all VOCs are similar to the rates for chloroform and trichloroethylene [2].

Max Conc in Air During Shower ($\mu g/m^3$) — Max Conc in Air During Shower (ppb)

C_w (µg//L) · 7.2 L/m^3 = C_a (µg/m^3) — C_a (µg/m^3) · 24.45 ÷ M.W. = C_a (ppb)

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cis-1,2-DCE: 190 µg/L X 7.2 L/m^3 = 1368 µg/m^3 — 1368 µg/m^3 X 24.45/96.95 = 345 ppb

(comparison values: OSHA PEL (8-hr TWA) = 790,000 µg/m^3 or 200,000 ppb)

PCE: 20 µg/L X 7.2 L/m^3 = 144 µg/m^3 — 144 µg/m^3 X 24.45/165.80 = 21 ppb

(comparison value: ATSDR's chronic EMEG = 40 ppb)

TCE: 82 µg/L X 7.2 L/m^3 = 590.4 µg/m^3 — 590.4 µg/m^3 X 24.45/131.40 = 110 ppb

(comparison values: ATSDR's intermediate EMEG = 100 ppb)

$CHCl_3$:4.61 µg/L X 7.2 L/m^3 = 33.2 µg/m^3 — 33.2 µg/m^3 X 24.45/119.38 = 7 ppb

(comparison value: chronic EMEG = 20 ppb)

VC: 10 µg/L X 7.2 L/m^3 = 72 µg/m^3 — 72 µg/m^3 X 24.45/62.5 = 28 ppb

(comparison values: RfC = 100 µg/m^3 = 39 ppb; intermediate EMEG = 30 ppb)

U.S. EPA and ATSDR have no current comparison values for cis 1,2-DCE. OSHA's Permissible Exposure Level for 8 hours/day, 5 days/week, indefinitely (200 ppm = 790,000 µg/m^3) is, however, more than 577 times higher than the maximum levels attainable in the shower under these worst-case assumptions.

The maximum attainable level for TCE (110 ppb) exceeds by only 10% ATSDR's iEMEG of 100 ppb—a comparison value which includes a 300-fold safety factor.

The maximum attainable shower concentrations of PCE, chloroform, and vinyl chloride were all *below* the corresponding comparison values for intermediate and chronic duration exposure. The CVs used for PCE, CHCl3, and VC include safety factors of 100, 100, and 300, respectively.

While a shower lasts for just minutes/day or week (and, therefore, constitutes an intermittent, acute exposure), the values used above for comparison assumed durations of exposure ranging from 14 days (ATSDR's intermediate EMEG), to 8 hours per day, 5 days per week, indefinitely (OSHA's PEL), to continuous lifetime exposure (US EPA's RfC and ATSDR's chronic EMEG/MRL). Thus the true margins of safety would be substantially greater than those suggested by the comparisons made in this appendix.

Conclusions

In reality, the maximum concentration would be reached only toward the end of showering and would begin to decline shortly after the shower was turned off. For conservative purposes and ease of calculation, however, it was assumed that the maximum concentration of the VOC attained during the 10-minute shower was sustained throughout the duration of the shower event, including any time spent in the bathroom immediately after the shower (e.g., while toweling off, shaving) Even so, this exposure would still occur for only minutes per day or week. But even if it occurred chronically for 24 hours a day, these (unrealistically high) exposures would still be insufficient, by considerable margins, to produce even minimally adverse health effects. In other words, shower-related exposures to each of these individual VOCs would be well below the corresponding No Observed Adverse Effect Levels (NOAELs).

The latter conclusion has important implications for the potential for combined or interactive effects as well. Studies generally indicate that exposure to a mixture of chemicals is unlikely to produce any adverse health effects as long as the components of that mixture are present at levels well below their respective NOAELs, or below concentrations that would have produced no adverse effects in animals or humans exposed to the component chemicals individually [3–13]. This observation appears to hold whether the component chemicals affect the same [5, 6] or different [7, 8] target organs via different mechanisms. Even chemicals with the same or similar modes of action apparently exhibit no interactive effects, as long as the levels of exposure are well below the respective NOAELs of the component chemicals [9]. These findings, which are relevant to most non-occupational, environmental exposures, appear to apply to inhalation as well as to oral exposures [10–13].

Because no adverse health effects would be associated with this worst-case exposure scenario, ATSDR concludes that no adverse health effects would result from any other, more realistic, off-site exposures to groundwater-related VOCs (e.g., outdoor irrigation), either individually or in combination.

References

1. Andelman JB. Total exposure to volatile organic compounds in potable water. In: Significance and treatment of volatile organic compounds in water supplies; Chapter 20. Chelsea, MI: Lewis Publishers; 1990. p. 485–504.

2. Wan K Jo, Weisel CP, Lioy PJ. Routes of chloroform exposure and body burden from showering with chlorinated tap water. Risk Anal 1990;10(4):575–80.

3. Seed J, Brown, RP Olin SS, Foran JA. .Chemical mixtures: current risk assessment methodologies and future directions. Regul Toxicol Pharmacol 1995;22:76–94.

4. Feron VJ, Jonker D, Groten JP, Horbach GJMJ, Cassee FR, Schoen ED. (). Combination technology: from challenge to reality. Toxicol Trib 1993; 14:1–3.

5. Jonker D, Jones MA, van Bladeren PJ, Woutersen RA, Til HP, Feron VJ . Acute 24 hour toxicity of a combination of four nephrotoxicants in rats compared with the toxicity of the individual compounds. Food Chem Toxicol 1993;31: 45–52.

6. Jonker D, Woutersen RA, van Bladeren PJ, Til HP, Feron VJ. Subacute (4-wk) oral toxicity of a combination of four nephrotoxicants in rats: comparison with the toxicity of the individual compounds. Food Chem Toxicol 1993;31: 45–52.

7. Jonker D, Woutersen RA, van Bladeren PJ, Til HP, Feron VJ . 4-week oral toxicity study of a combination of eight chemicals in rats: comparison with the toxicity of the individual compounds: Food Chem Toxicol 1990;28:623–31.

8. Groton JP, Sinkeldam EJ, Luten JB, van Bladeren PJ. Interaction of dietary calcium, potassium, magnesium, manganese, copper, iron, zinc, and selenium with the accumulation and oral toxicity of cadmium in rats. Food Chem Toxicol 1991;4:249–58.

9. Feron VJ, Groten JP, van Zirge JA, Cassee FR, Jonker D, van Bladeren, PJ. Toxicity studies in rats of simple mixtures of chemicals with the same or different target organs. Toxicol Lett 1995;82–3: 505–12.

10. Groten JP, Schoen ED, van Bladeren PJ, Kuper CF, van Zorge JA, Feron, VJ. Subacute toxicity of a mixture of nine chemicals in rats: detecting interactive effects with a fractionated two-level factorial design. Fundam Appl Toxicol 1997;36:15–29.

11. Cassee FR, Stenuis WH, Groten JP, Feron VP. Toxicity of formaldehyde and acrolein mixtures: in vitro studies using nasal epithelium cells. Exp Toxicol Pathol 1996;48:481–83.

12. Casse FR, Arts LH, Groten JP, Feron VJ. Sensory irritation to mixtures of formaldehyde, acrolein, and acetaldehyde in rats. Arch Toxicol 1996;70:329–37.

13. Bond JA, Leavens TL, Seaton MJ, Medinsky MA. Predicting the toxicity of chemical mixtures based on knowledge of individual components. CIIT Activities 1997;17: 1–7.

Appendix H. Public Comments

ATSDR issued the East Kelly AFB petitioned public health assessment for public comment on June 1, 2001. Below are ATSDR's responses to the comments received. For ease of reference, the comments are italicized and numbered sequentially. The page numbers and paragraph numbers cited refer to locations in the document released on June 1, 2001.

Comment #1: *Page 4, Paragraph 1, Line 3. The practice of waste disposal using landfills historically occurred on Main Kelly but known records do not indicate that this practice of landfilling occurred on East Kelly. Certain sites might be termed as unauthorized landfills under RCRA but these are typically sites of releases.*

Response: ATSDR has removed the term "landfilling"from this paragraph of the public health assessment.

Comment #2: *Page 6, Private Wells. The section states that in 1988 one private well was used for drinking water. Is this well still used for drinking water or are the occupants now using the public drinking water system for drinking water? This section should specifically address this issue.*

Response: The current use of this private well has been clarified. The 1988 USGS survey reported a single private well was being used for drinking water even though municipal water was provided. Later surveys (1996 and 1998) show that municipal water (public water system) is reported as the drinking water source. The section on Private Wells of this public health assessment has been clarified.

Comment #3: *This table presents risk levels in terms of $9.7E^{-05}$, that the average reader will not be able to comprehend. Recommend stating the risk level in terms, such as, 1 in a million, instead of scientific notation. An alternative method is to provide an explanation of the meaning of the scientific notation.*

Response: An explanation of cancer risk numbers has been provided in Appendix C and D, and a reference to that explanation has been added as a footnote to Table 3. Also, an explanatory footnote has been added to the soil gas data table in Appendix E.

Comment #4: *Page 9, Conclusions. This section states the conclusion categories to summarize the ATSDR findings. Recommend ATSDR include descriptions for conclusion categories 1 through 3 and 5 in the Glossary to provide the reader more information to delineate between categories.*

Response: ATSDR has added a description of all conclusion categories in the glossary. (See Appendix B.)

Comment #5: *Page 10. Actions completed numbers 4 and 5 are duplicates.*

Response: Number 5 has been deleted.

Comment #6: *Page 19, Risk Levels. Recommend stating the risk level in terms, such as, 1 in a million, instead of scientific notation. An alternative method is to provide an explanation of the meaning of the scientific notation.*

Response: The risk level terms have been defined in Appendix C and D. Also, an explanatory footnote has been added to the soil gas data table in Appendix E.

Comment #7: *Page 21, Table 3. Recommend stating the risk level in terms, such as, 1 in a million, instead of scientific notation. An alternative method is to provide an explanation of the meaning of the scientific notation.*

Response: The risk level terms have been defined in Appendix C and D. Also, an explanatory footnote has been added to the soil gas data table in Appendix E.

Comment #8: *Page 6, private wells. One private well was identified as a drinking water source through the Kelly AFB Shallow Well Surveys. EPA would support an ATSDR recommendation to properly plug and abandon this well and connect the residents to the area's municipal water system.*

Response: The current use of this private well has been clarified. The 1988 USGS survey reported this private well was being used for drinking water. Later surveys (1996 and 1998) show that municipal water (public water system) is reported as the drinking water source. The section on Private Wells of this public health assessment has been clarified. According to the data presented in this health assessment, neither the levels of groundwater contamination nor the local patterns of water usage are consistent with the existence of a public health hazard. ATSDR agrees that this private well should be abandoned and plugged based solely on prudent public health policy and subject to local ordinance and individual discretion. In any event, the information available to ATSDR is that residences in the vicinity are already connected to municipal water.

Comment #9: *Page 6–7, Irrigation. ATSDR recognizes that while water from wells may not be used for drinking, this water could pose a threat via irrigation. A blanket statement is made that plants don't easily take up volatile organic compounds (VOCs). EPA is not sure that this statement is always true. The premise behind phtyoremediation is that plants do take up VOCs. While plants will uptake VOCs from the groundwater, surface irrigation may indeed volatilize the contaminants. The inhalation evaluation, however, may not be the appropriate comparison for plant uptake concerns.*

Response: ATSDR removed the statement that VOCs "are not easily taken up by plants." The intended point was plant consumption is not a significant route of exposure to VOCs. Site-specific levels of VOC levels, which are already very low, will be even lower (due to volatilization) by the time the irrigation water reaches the plant roots and is (possibly) taken up in solution by the plants. Plant metabolism and transpiration would be expected to reduce further the residual concentration of these VOCs so that little if any would remain in the plants themselves. Whether plant uptake of a soil pollutant actually occurs, it can be of relevance to public health only if the plant actually accumulates the pollutant (as is the case with a few metal-accumulating plants) and people then eat those plants in significant amounts. With VOCs, it will more often be the case that the pollutant, if absorbed, is metabolized (i.e., detoxified), converted to carbon dioxide, or volatilized as the parent compound [1]. In such cases, the pollutant will have been removed from the soil, thereby achieving some degree of "phytoremediation," but will not remain in the plant in appreciable amounts. Site-specific data support this surmise. To address further the community concern regarding this pathway, Southwest Research Institute sampled fruit and nut trees and vegetables in late 2001. The final results, published by CH2M Hill Consultants in February of 2002, indicate that the risk associated with consumption of vegetables, fruits, and nuts in the communities surrounding Kelly AFB is minimal. Only one sample out of 55 was found to contain detectable levels of chlorinated aliphatic hydrocarbons, and this value—less than 5 µg/L of PCE)—was extremely low [2].

Comment #10: *Tables 1 and 2. This table should be based upon Region 6 screening values, not Region 3. Region 3 only looks at ingestion. Region 6 considers dermal, inhalation, and ingestion. For polycyclic aromatic hydrocarbons, Region 6's values are at least an order of magnitude more conservative than Region 3's.*

Response: ATSDR changed Tables 1 and 2 to use Region 6 comparison values instead of Region 3's. These values were used for comparison only and the exposure scenario and risk calculations do not change.

Comment #11: *Page 7, Surface Soil. The sentence "Although the maximum concentrations were detected above health-based comparison values, the levels of these contaminants have not been shown to cause adverse health effects in scientific literature," is confusing. It appears that ATSDR has an alternate set of numbers to compare with site contamination. These numbers should either be used up front or an explanation of why the risk-based values are not applicable to the surface soil should be provided.*

Response: Health-based comparison values (CVs) are not to be confused with thresholds of toxicity; the former contain built-in safety factors which guarantee that they will be much lower than the latter, typically by 1–3 orders of magnitude or more. ATSDR uses its own health-based comparison values (MRLs, EMEGs, RMEGs, and CREGs), and those of other agencies (e.g., EPA RBCs) as screening tools only, and only during the preliminary evaluation of environmental data to select contaminants of concern for further evaluation. Comparison values used in the final version of this document include EPA's Region 6 risk-based concentrations (RBCs). Those based on cancer and noncancer effects are analogous to ATSDR's CREGs and MRL-derived EMEGs, respectively. ATSDR's comparison values correspond to media-specific concentrations of contaminants to which humans might safely be exposed for the indicated durations of exposure (acute, intermediate, or chronic) without any adverse effects being expected. Noncancer-based comparison values are derived by dividing the Lowest-Observed-Adverse-

Effect Levels (LOAELs) or No-Adverse-Effect Levels (NOAELs) for critical effects (the most sensitive effects: i.e., those produced by the lowest doses in a sensitive species) by conservative safety factors which typically range from 10 to 1000 or more. The resulting Minimum Risk Levels (MRLs), expressed in terms of dose (e.g., mg/kg/day), are converted into concentrations in air, water, or soil which, under default conditions of exposure, would yield MRL-equivalent doses. By contrast, ATSDR's cancer-based comparison values (Cancer Risk Evaluation Guides or CREGs) are derived from EPA's cancer slope factors and correspond to a hypothetical 1-in-a-million lifetime excess cancer risk. But whether they are based on cancer or noncancer effects, all comparison values are used for screening purposes only. Site-specific substances exceeding ATSDR's CVs are selected for further evaluation of their potential public health implications. The conclusions drawn from such further evaluation are based solely on "the best medical and toxicologic information available."[3]

Comment #12: *Page 7, Soil Gas. EPA supplied comments on soil gas investigation performed by Kelly AFB. Our concern with the use of these data for the PHA would be in line with our comments on the actual study. The fact that contaminated air was found in the 5-foot vapor monitoring wells is an indication the vapors are migrating. The model may indicate that the concentrations are below risk-based levels in the intermediate step of measured vapor monitoring wells but other numerous variables may be working to potentially create unsatisfactory conditions in the indoor air. The model used in the study does not take into account the various other factors that influence vapor migration, such as preferential flow paths caused by cracks in the soil, root holes, burrowing animal tunnels, subsurface conduits leading into buildings such as sewer and drinking water lines, etc. Actual sampling of indoor air could be justified as it would provide direct results; however, in measuring indoor air there is the problem of interference from household-originating vapors that would need to be addressed. EPA also recommended that soil vapor monitoring be conducted on a continuing schedule to provide better coverage of changing soil conditions and seasonal variation. The sampling for this study took place in the February-March time frame. This monitoring event would not account for conditions which may be present during summer quarter. The EPA recommends that soil vapor monitoring be conducted ongoing, twice yearly, with one of the monitoring events taking place during the summer quarter to take into account the potential for warmer soil temperatures and increased soil vapor movement.*

Response: The flux of vapors is not defined solely by the presence of vapors; an effective gradient is also required. Chemicals partition until they reach an equilibrium with their environment. When chemicals are present in water at levels below the solubility limit, they volatilize slowly (at a rate dependant on the vapor gradient of the air above). All the chemicals that ATSDR investigated are much denser than air (TCE is more than five times as dense). Therefore, either a positive soil-gas pressure is needed to push these vapors upward or lack of a cap (soil cover) is needed to maintain continued diffusion from the source. A soil-gas monitoring well simulates the latter condition. (Sometimes, the soil gas is even collected under negative pressure.) The 5-foot monitoring well is by definition the preferred path that would influence vapor migration. The model used the measurements collected in this "preferred pathway location" and assumed it was directly under the house (when in actuality it was not). The model also assumed that the house was in direct contact with the soil—thus limiting any losses out of the side of a crawl space—and that a foundation crack in the house allowed vapors to enter.

These assumptions represent a highly improbable worst-case scenario that was designed solely to create a conservative, preferred flow path, (i.e., a pathway of exposure to soil gas).

Considering (1) the large margin of safety between measured levels of soil gas and estimated levels of vapor intrusion into homes, and (2) the expectation that in the future, due to remediation efforts, concentrations at the source will be lower rather than higher, ATSDR does not recommend additional monitoring of soil vapor or residential indoor air. Nevertheless, EPA's recommendation of soil vapor monitoring twice a year has been noted in the final release of this public health assessment and in ATSDR's site file.

Comment #13: *Appendix A, Figure 1. There appears to be an error within the demographic statistics box. The total population is listed as 5,021; the breakdown is then listed as 5,021 whites and also 5,021 of Hispanic origin.*

Response: The term "Hispanic" refers to an ethnicity, not a race. Therefore, as noted in a footnote to the Demographic Statistics, a Hispanic may be a member of any race. While ATSDR demographers were reviewing this comment, an error was detected on the total population number as well as other races. This has been corrected and a correct demographic map has been included in this PHA.

Comment #14: *Appendix B - page 16-17. The acronyms CREG and EMEG should be defined.*

Response: These acronyms have been defined.

Comment #15: *Appendix B and C. These appendices use Region 3's 1997 Risk-Based Concentration values for evaluation. Appendix C provides the estimated exposure dose and cancer risk for on-site soil. ATSDR screened site concentrations by comparing these numbers to Region 3's 1997 Risk-Based Concentration Tables for residential soil. EPA, Region 6 does not support this comparison. First of all, the public has no access to the 1997 tables as Region 3's website only has the latest (May 2001) and past versions cannot be obtained from the region. Secondly, Region 3 no longer supports the 1997 tables, and last and most importantly, Kelly Air Force Base is located in Region 6.*

Response: This public health assessment has been modified by using EPA's Region 6 risk-based screening values.

Comment #16: *Johnson and Ettinger Model. People living near Kelly AFB may be exposed to contaminant gases via the following pathway: 1) gases produced by volatile contaminants in groundwater enter the soil above the water table, 2) the gases move upward through the soil and into houses, and 3) people breathe the contaminant gases. ATSDR used the Johnson and Ettinger model to estimate concentrations of contaminant in houses above the contaminant plume near Kelly AFB. However, this model does not account for conditions that are commonly found in the neighborhoods near Kelly AFB.*

The model assumes that all houses are built with cement slab foundations, and the contaminant gases enter the house through a gap between the slab and the wall. However, many houses near Kelly AFB have pier and beam foundations. There is usually a two to three foot space between ground surface and the floor. Floors often consist of only a single layer of planks nailed to cross beams. ATSDR did not address this significant difference between the assumptions incorporated in the model and actual conditions in San Antonio.

During dry periods, networks of large soil cracks appear in the neighborhoods around Kelly AFB. These cracks are often more than a half inch wide at the surface, and five to ten feet long. Crack depths are unknown, but I have probed them to a depth of approximately two feet without reaching bottom. These cracks may serve as preferred pathways for the movement of contaminant gases to the surface. ATSDR should address the effects that these cracks may have on gas concentrations in houses near Kelly AFB.

Response: In using the model, ATSDR assumed that the highest measured vapor concentration in the monitoring wells was located directly underneath the home. In actuality, these groundwater monitoring wells were located far from most of the homes and were believed to contain much higher levels of vapor than the soil gas under the homes. Although the source of the soil gas is believed to be from the groundwater located several feet below the homes, ATSDR assumed for the model that the soil gas immediately below the home was equal to those measured in the monitoring wells. This assumption led to overprediction and conservative (protective) contaminant concentrations.

ATSDR is aware of recent issues regarding underestimating of emissions using the J&E model. One issue was with volatilization of chlorinated solvents from the groundwater into the soil pore spaces. ATSDR bypassed this issue by using the actual soil gas measurements; therefore, no volatilization calculation was needed. Another issue was the potential for the capillary zone in soil to restrict the diffusion of soil vapor into the building. ATSDR assumed that the soil gas concentration was next to the home; therefore, the capillary zone had no influence on the calculations of the model.

Although the restriction caused by the capillary zone was not included in the model (thus leading to a more conservative calculation), ATSDR believes some restriction would occur. Those recent studies that show little or no capillary restriction are limited to those homes built on loose gravel fill that had been placed over fractured bedrock. Currently, no evidence shows any fractured bedrock beneath the community. When proper inputs are used, EPA has validated that the J&E Model works for post and beam construction.

Comment #17: *Johnson and Ettinger Model. According to the Johnson and Ettinger model User's Guide, the model may under-predict concentrations of chlorinated species. Chlorinated species (e.g., PCE, TCE) are common contaminants in the neighborhoods near Kelly AFB. The final Public Health Assessment should state that the model may under-estimate concentrations of chlorinated gases.*

Response

Recently, EPA discovered an error in the J&E model which would underestimate the air concentrations of chlorinated compounds by as much as a factor of two. That error was found to be associated with soil temperature and Henry's Law Coefficient. ATSDR's estimates were not affected by this error because measured soil vapor concentrations were used in the model—not predicted concentrations. The use of actual soil vapor concentrations eliminates the need or use of soil temperature and Henry's Law Coefficient in the model. ATSDR also used other factors to insure the model estimated conservative (protective) contaminant concentrations (as stated above in the previous response).

Comment #18: *Johnson and Ettinger Model. ATSDR used the screening-level version of the Johnson and Ettinger model. This version does not permit the variation of all parameters that affect indoor gas concentrations. For example, the screening-level assumes an enclosed space height of 4.88 m (16 ft). This is the enclosed space height of a typical two story house. However, many of the houses near Kelly AFB are single story houses. Figure 1 shows that changing the enclosed space height to that of a typical single story house increases the calculated risk for tetrachloroethene (PCE) gas by a factor of two. ATSDR should use the tier-2 version of the model. The tier-2 version permits variation of more parameters that affect the risk calculation.*

Response: The model could overestimate contaminant concentrations based on one-story homes at East Kelly. ATSDR's version of the screening model assumed that the first floor was underground, which produced even higher estimates of contaminant concentrations. That said, however, these estimated concentrations from the model were lower than the concentrations found in typical indoor air. Therefore, ATSDR does not believe that further refining of the model is necessary.

Comment #19: *Johnson and Ettinger Model. ATSDR did not evaluate the uncertainty of its results, as recommended on page 2 of the Johnson and Ettinger model User's Guide. I evaluated the uncertainty of ATSDR's estimated cancer risk for PCE gas by varying the tier-2 model parameters as stated below:*

Soil type directly above water table changed from sandy clay to sand.

Enclosed space height changed from 488 cm to 244 cm.

Soil water-filled porosity changed from 0.3 to 0.1.

Soil-building pressure differential changed from 4 Pa to 8 Pa.

Indoor air exchange rate changed from 0.45/hr to 0.20/hr.

Floor-wall seam gap changed from 0.1 to 0.5 cm.

These changes increase the calculated risk for PCE by a factor of more than 30 (5.8E-8 vs. 2.1E-6). Clearly, model results are sensitive to reasonable changes in parameter values. ATSDR should include evaluation of model uncertainty (sensitivity study) in the final version of the Public Health Assessment.

Response: Air is a complex matrix which can cause concentrations to vary by a factor of 10–100. ATSDR used protective factors to allow for this variability. In calculating the model, estimates factors such as biodegradation, capillary resistance and diffusion path length were ignored. By ignoring these factors, the model produced conservative protective) concentration estimates.

As with air measurements, air models have an element of uncertainty. The risk evaluation, however, compensates for this uncertainty variability. Uncertainty was calculated when the risk approached levels that were considered unacceptable. The predicted contaminant levels near the East Kelly homes were found to pose much less risk than contaminant levels normally found indoors in homes—therefore no further analysis was performed.

ATSDR acknowledges the uncertainty associated with J&E model. Although unlikely, if the newly discovered information gained from well-sealed, post and beam constructed homes situated above fractured bedrock were applied to the model, the maximum predictable concentrations could be a factor of about 50 times more than the original predicted value. ATSDR found the modeled vapor concentration still lower than that normally found inside the average home. ATSDR reran the model, selected a scenario that represented a well-sealed home, and used the soil-gas concentrations found in the most contaminated monitoring well. To account for the possibility that the home is built over a fracture, no capillary restriction was assumed in the model with a selected attenuation factor of 10-2. The model produced concentrations that were well below the MRLs and well below other comparison values.

Comment #20: *One issue that needs more clarification is whether water from shallow groundwater wells can be safely used for purposes other than drinking water, such as washing cars and watering lawns and gardens. ATSDR reported that calculations of risk based on exposure from showering with the water indicated an absence of expected health effects, however, it's not clear from this report whether additive effects from all of the VOCs present in the shallow groundwater were accounted for in these risk calculations. This should have included not only the cis-1,2-dichloroethene (DCE), tetrachloroethene (PCE), trichloroethene (TCE) and chloroform, but also the benzene, ethylbenzene, chlorobenzene, toluene, xylenes, styrene and hexachlorobutadiene which are known to be present in the shallow groundwater aquifer from which these wells draw and may have been present in the sampled wells at concentrations below comparison values. The presence of lead and thallium above their respective maximum contaminant level (MCL) concentrations also needs to be considered in calculations of risk from using water from these wells for watering gardens. Unlike VOCs, these metal contaminants do not bind to and accumulate in soils and can be taken up by plants (US EPA, 1986; Kemper and Bertram. 1991). Thus exposure to lead and thallium can occur by ingesting food from gardens or by inhaling soil dispersed from garden areas. Ingestion of soil by young children would also be an exposure route of concern*.

Response: Lead was found in well water at a maximum concentration of 64.1 ppb and thallium at 10.7 ppb. Most lead compounds are relatively insoluble; therefore, natural plant uptake is minimal and should not be a public health concern. Before phytoremediation can be used to treat Pb-contaminated soils, a chelator must be added to mobilize the metal [4]**.**

Until 1972, thallium was used as a rat poison [5]. Although thallium and its oxide are insoluble in water, the chloride, acetate, nitrate, and sulfate of thallium are water-soluble [5]. These soluble salts would be leached out of the soil. The water-insoluble thallium compounds which could accumulate in soil to some extent would have significantly reduced bioavailability relative to soluble thallium compounds and would not be absorbed in appreciable amounts by either plants or geophagic children. Brassica plants (e.g., rutabaga, turnip, cabbage, rape, and mustard) are likely to be the main source of dietary exposure to thallium in food produced on contaminated land [6]. A literature search has turned up no evidence that thallium-related toxicity has ever occurred as a result of eating plants that have naturally accumulated this heavy metal. Cases of thallium poisoning have generally been either accidental or the result of attempted suicides or murders. In a study of 50 cases of thallium poisoning, 23 were accidental, 21 were suicide attempts, and five were homicidal [7]. (The 50th patient was a baby born to a woman who had suffered thallium poisoning during her third trimester.) Thallium poisoning is now rare but still occurs as a result of murder attempts [8]. Although thallium is one of the most toxic heavy metals, its concentration in environmental samples is generally too low to be of concern.

The last part of Appendix G addresses the issue of mixtures in general, and the conclusion stated there is directly applicable to this commenter's expressed concern about the potential effects of various VOCs in combination. As noted in Appendix G,

> "studies generally indicate that exposure to a mixture of chemicals is unlikely to produce any adverse health effects as long as the components of that mixture are present at levels well below their respective NOAELs, which is to say, below concentrations that would have produced no adverse effects in animals or humans exposed to the component chemicals individually (3-13)."

Because none of the VOCs identified in shallow groundwater at East Kelly were present at concentrations that could, individually, produce adverse health effects in exposed persons, the mixture of these same compounds at the same concentrations would not be expected to produce adverse effects, either.

Comment #21: *ATSDR's conclusion that the PAH contaminated soil does not present a likely health hazard is based on an analysis of the four compounds individually, each of which resulted in an estimated risk of less than 1 in 10,000 (10-4). However, since exposure would occur to all four of these carcinogenic compounds at the same time, the estimated risks should be added to obtain an overall risk estimate. In this case, an overall risk of 1.2 x 10-4 is obtained, which according to ATSDR's categories, is a "low increased risk."*

Even this calculated risk is a minimum risk, since exposure can also occur from inhalation of the soil. It is unclear from ATSDR's report why only the ingestion pathway was investigated. Inhalation of dust containing PAH contaminated soil should also have been considered, or a clear explanation of why this pathway was ruled out should have been provided. If PAHs are bound to particles that remain resident in the lungs for extended periods of time, their potential for causing lung cancer would be enhanced.

Response: The air pathway was not included because a hypothetical cancer risk increase of 0.2 in 10,000 or 20 per million was not considered meaningful. Most inhaled dust would be intercepted by nose hair and other upper respiratory structures (e.g., cilia and mucous), and any PAHs bound to such dust would be expelled by the mucociliatory escalator, along with most of the inhaled dust. Any amount of PAH-contaminated dust that might be inhaled and subsequently swallowed would be small in comparison to the default amount of PAH-contaminated, on-site soil that was assumed to be ingested by anyone having access to the site [9]. Comparison values are highly conservative; they typically contain safety factors of 2 or 3 or more orders of magnitude. Therefore, if the major source or pathway of exposure does not significantly exceed the relevant comparison values, then comparatively minor sources or pathways of exposure will not make the difference between a safe and a hazardous exposure.

In addition, the United States is one of the few countries in the world that still bases its cancer CVs (e.g., EPA's cancer-based RBCs and ATSDR's CREGs) on the policy assumption of zero threshold. As a result, those CVs typically contain implicit margins of safety (relative to established thresholds or lowest observed CELs), which commonly exceed the explicit safety factors of comparison values for noncancer effects by several orders of magnitude. Unlike the actuarial risk calculated by, for example, insurance companies, the risk that is "quantified" in quantitative cancer risk assessments is purely hypothetical and does not constitute a realistic prediction of cancer incidence in exposed humans; in fact, "the true value of the risk is unknown and may be as low as zero" [10]. As EPA notes in its 2005 revised cancer risk assessment guidelines, "the data that support cancer assessments generally are not suitable for numerical calculations of the probability that an agent is a carcinogen" in humans [11]. Thus, whenever cancer risk estimates based on zero threshold models are used in site-specific risk assessments (or, less often, in health assessments), the levels of hypothetical risk selected as "safe" will typically span one or more orders of magnitude. The choice of these ranges is relatively arbitrary, being based as they are on value judgments rather than actuarial data. See the last paragraph in this response (number 5).

In the case of PAHs in soil, a number of additional chemical-specific factors support the conclusion that exposures are not likely to constitute any realistic hazard to human health:

1. The animal data are generally of limited relevance to humans because

    a. the PAH exposure protocol in laboratory animals typically involves either massive bolus doses by gavage in oil, or painting PAHs on shaved areas of skin inaccessible to the animal (so that the PAHs cannot be removed), followed by regular, supplemental applications of TPA—a potent promoter substance derived from croton oil [12];

    b. cytochrome P-4501A1, the enzyme principally involved in the metabolic activation of carcinogenic PAHs, is induced in both liver and extrahepatic tissues
    in experimental animals, but is primarily an extrahepatic (especially lung) enzyme in humans, so that oral doses in laboratory animals would result in much higher concentrations of active metabolites (due to the first-pass effect) than they
    would in humans [13]; and

    c. most PAH-induced tumors in gavaged rodents occur in the forestomach—an organ humans do not possess [12].

2. In humans, PAHs are, for the most part, readily metabolized and eliminated and, with the exception of some allergic reactions, few adverse health effects clearly attributable to PAHs have ever been demonstrated [12]. Chronic inhalation of high concentrations of complex PAH mixtures (e.g., cigarette smoke, roofing tar or coal tar pitch volatiles, and coke oven emissions) are associated with increased lung cancer in humans. Additionally,

some individual PAHs are reasonably anticipated to be human carcinogens based on sufficient evidence of carcinogenicity in experimental animals [22], [23], [24] and [25]. Currently, however, no evidence supports a direct association between cancer in humans and either ingestion or dermal exposure to PAHs [12].

3. The total PAH doses that might be associated with ingestion exposure to most moderately contaminated soils (assuming default intake rates) does not exceed the levels that can occur in a normal diet. For example, if an average child consumed 200 mg/day of soil containing the maximum detected concentrations of benzo(a)pyrene (B(a)P), dibenzo(a,h)anthracene, benzo(a)anthracene, and benzo(a)fluorine detected at East Kelly AFB, then that child's total, worst-case, daily intake of soil-associated B(a)P-equivalents (about 2 ug) would be comparable to that obtainable from a single quarter-pound, charcoal-broiled hamburger [14].
4. No adverse effects, either cancerous or noncancerous, are seen in animals chronically exposed to 1 mg B(a)P/kg/day [12]. To receive doses equivalent to this animal NOAEL, a 10-kg child would have to consume daily 1,000,000 mg or 2.2 pounds of maximally contaminated soil at East Kelly containing about 10 ppm B(a)P-equivalents. (Actually, because PAHs in soil are much less bioavailable than PAHs in gavage oil, a child would probably have to consume at least 5 pounds daily of the same soil to receive the same absorbed NOAEL dose that rodents do after an oil gavage dose of 1 mg/kg/day.)
5. Finally, hypothetical population cancer risk estimates derived using regulatory models are not predictive of human health effects; their intended use is in the regulatory ranking of sites for cleanup. Even actuarial population risks (e.g., the statistical odds of dying in an automobile accident) do not predict an individual's risk—that is a factor of individual-specific risk factors, rather than population averages. Due to their hypothetical, assumption-based nature, regulatory cancer risk estimates do not predict real population risks, let alone real individual risks. As stated in EPA's 1986 Carcinogen Risk Assessment Guidelines, "The true risk is unknown, and may be as low as zero." [10]

Comment #22: *ATSDR's calculations of health risks from exposure to soil from East Kelly are based on current concentrations of metals, dibenzodioxins, dibenzofurans and PAHs in soils at East Kelly. Prior to remediation of IRP Site SS009 (a former storage area), however, the soil at this site was contaminated with dioxins, furans and metals at concentrations exceeding background levels. It does not appear that ATSDR considered health risks associated with soil that migrated from this site prior to remediation. According to the IRP closure report for Site SS009 (Kelly Air Force Base, 1997), surface water drainage from this site occurs via storm sewer drains that cross the storage yard. Storm drainage for East Kelly AFB is discharged to Six Mile Creek through National Pollutant Discharge Elimination System NPDES Outfall 004. It is recommended that contamination at the mouth of this outfall should be characterized, particularly if this area of the creek is accessible to and/or frequented by the public. Contaminants in surface water draining from Site 009 prior to remediation could have built up in the creek bed in past years. Even current run off from the site could be of concern, since this site was only cleaned up to meet industrial health criteria.*

Response: Six Mile Creek is basically a sewer, not a creek, with a constant flow of about 500 gallons per minute discharged from a Kelly AFB on-site remediation system. Because the storm water drainage area (approximately 33 acres) for the stormwater system which includes area S-7

(1.2 acres) is quite large, each storm event tends to flush and dilute any contaminated sediment farther downstream. Very large storm events would tend to scour the stormwater sewers of sediment. Because area S-7 has been remediated for at least 6 years, any preremedial contaminated sediment from area S-7 would not have remained near the outfall location, but would have been diluted and carried far downstream.

Comment #23: *The risk analysis performed by ATSDR in this study indicates that VOCs in groundwater do not pose an urgent health hazard to residents living near East Kelly, however, further work is needed to characterize accurately low-level risks from this route of exposure due to limitations in this analysis. Theselimitations include: 1) uncertainties in the prediction of indoor air concentrations using the Johnson and Ettinger model, 2) the inability to access the risk of cancer from 1,1,DCE due to the absence of data, 3) the lack of an assessment of the non-carcinogenic effects of the chemicals of concern, and 4) the limited number of the soil gas monitoring wells.*

Response: ATSDR agrees with several of the specific issues addressed regarding the use of models, including the Johnson and Ettinger model. But for the purposes of addressing the community's public health concerns, uncertainty in the parameters of a model are of potential concern only when that uncertainty could make a difference in the health call. And within the context of an intentionally conservative evaluation like the one in this health assessment, only a relatively few input parameters are, potentially, sensitive enough to alter the agency's conclusions. Therefore, compounding conservative parameters is neither necessary nor appropriate. ATSDR has prioritized the parameters in the models according to their impact on the results. Some parameters affect the predicted concentration by factors of 10 or more (like soil parameters), other parameters affect the concentration by only percentages (e.g., building size). By choosing a high value for the parameter that has the largest effect, we can choose average values for other parameters and still overpredict.

For example, the value ATSDR chose to represent the ability for the soil to transmit soil gas was 100 times higher than we expect. Because this overly conservative value yielded an exposure risk that was 1000 times less than that of other chemicals in our background environment, there was no need to use conservative factors for the parameters that have less influence on exposure calculations.

This conservative approach to modeling allows ATSDR to prioritize those risks that require further investigation. ATSDR appreciates that some residents might still feel that there are chemicals in their homes that need to be monitored. Nevertheless, using this agency's conservative analysis of worst-case exposure scenarios at East Kelly, ATSDR concludes that at the present time concern about soil gas is minimal.

Comment #24: *Models can be very useful tools for providing estimates of health effects of chemicals when data are not available and for guiding the development of better monitoring programs, however, it is important to recognize that models have their limitations and must be applied carefully to different situations. There are a number of factors that could significantly alter the indoor air concentrations that were predicted by the Johnson and Ettinger model in this study. One very important determinant of how well a model predicts reality is whether the data used to run the model are accurate. In this study, single soil gas measurements from each well were used to predict indoor air concentrations. The uncertainty surrounding the accuracy of this* *single measurement at each well is high. Contaminant concentrations can vary significantly in groundwater (and soil gas) depending upon fluctuations in the water table due to rainfall events. Use of an average soil gas concentration, determined from multiple sampling events from the same well over a period of a year (four seasons), would have greatly strengthened this study*.

Response: As previously noted in responses to several similar comments, the estimated indoor air concentrations were so low, despite the many highly conservative (protective) assumptions that were used in the application of the J&E model to soil gas data from this site, no plausible amount of error or inaccuracy could have a substantial impact on resulting conclusions. (See response to Comment #23.)

Comment #25: *Another difficulty with ATSDR's analysis is that there is evidence that the Johnson and Ettinger model is not well suited for predicting the concentrations of chlorinated volatile organic compounds in indoor air from soil gas vapor intrusion and tends to under predict concentrations of these chemicals (Fitzpatrick and Fitzgerald, 1996). Many of the chemicals of concern in the groundwater plume under East Kelly are chlorinated VOCs.*

Response: See response to Comment #17.

Comment #26: *The input parameters used when applying a model to a specific site are also very important in determining the accuracy of the predicted outcomes of the model. In the Johnson and Ettinger model, some of the most critical parameters include the total porosity of the soil, the water-filled porosity, the soil vapor permeability, the soil-building pressure differential, and the depth to groundwater (Kelly Air Force Base, 2000). ATSDR provided no explanation of which parameters they used to obtain the predicted indoor concentrations presented in their assessment. These should be provided in their report. However, if the same parameter were chosen as those used in the Kelly soil vapor monitoring report (Kelly Air Force Base, 2000), then the predicted indoor air concentrations used in the health risk assessment were not overly conservative. For instance, the depth to groundwater in the East Kelly area ranges from 10-30 ft; a 15 ft depth was selected for use in the model. A decrease in the depth parameter to 10 ft would have increased predicted indoor air concentrations of vinyl chloride by 7%. An increase in total soil porosity from 0.3 to 0.4 would have increased predicted concentrations by 85% (Kelly Air force Base, 2000). Such changes in selected parameters would have significant, cumulative effects on the final outcomes of the model.*

Response: See response to Comment #23.

Comment #27: *Building parameters are also important in determining the buildup of soil gas in a home. EPA's parameters for an "average" residence in the U.S. describe a two-story residence with 8 ft ceiling heights with each floor being 1000 square ft. In many cases, this "average residence" is much bigger than those present in the East Kelly area. Thus, soil gas entering the homes would not disperse throughout as large an area, which would again result in higher concentrations than those predicted by the model. Other building parameters of importance include the pressure differential and air exchange rates within a home.*

Response: See response to Comment #23.

Comment #28: *In order to improve the results of this modeling study, site specific input parameters are needed. Once these have been established, the customized model for the East Kelly area should then be validated by measuring indoor air concentrations in homes near the soil gas monitoring wells. If predicted concentrations match those directly measured, then this validated model will be very useful for monitoring the intrusion of soil gas into homes in the future.*

Response: See response to Comment #23.

Comment #29: *There is uncertainty in the health effects evaluated by ATSDR in this report. Maximum soil gas concentrations measured for cis 1,2 dichloroethene (DCE) were almost 10 times EPA's Risk Based Concentration (RBC) criteria for this chemical, and yet ATSDR was not able to calculate an estimated cancer risk for this chemical due to an absence of data. This unknown health effect was not mentioned further in the report. ATSDR should have recommended a need for further investigation of the potential health effects of this chemical.*

Response: Unlike actuarial risks based on actuarial data, the hypothetical lifetime cancer risk estimates inferred from EPA slope factors do not predict actual "health effects" or even the potential for actual, low-exposure health effects. As noted in the responses to several previous comments, "the true value of the risk is unknown and may be as low as zero" [10]. Therefore, by itself, the fact that a measured concentration of a substance exceeds by a factor of 10 the corresponding cancer-based RBC would not necessarily have any real implications for human health. (Statements in Appendices that might have given the contrary impression have been corrected in the final release of this document.) Because of the conservative assumptions and safety factors built into such comparison values, exceeding a noncancer RBC by a factor of 10 would not necessarily imply the existence of a public health hazard, either. Also, whether based on cancer or noncancer effects, RBCs assume a lifetime of continuous exposure.

The maximum detected soil gas concentration of DCE was 344 µg/m^3 as compared to a noncancer RBC of 37 µg/m^3 (Appendix E, Table 1). Because of a general absence of data in humans or animals, ATSDR has not developed any comparison values for cis 1,2-DCE. Nor does EPA list an oral RfD, an inhalation RfC, a slope factor, or any unit risks for this compound. EPA considers cis 1, 2-DCE to be a Class D carcinogen, (i.e., "not classifiable as to human carcinogenicity"—results in mutagenicity assays have been generally nonpositive.) For lack of any other comparison value, the noncancer RBC of 37 µg/m^3 for ambient air was used in this PHA for screening purposes only. The RBC Tables describe the general methodology employed in the derivation of the RBCs, but they do not specify the chemical-specific uncertainty factors used in the derivation of each individual RBC. Assuming, however, that the safety factor used in this case was comparable to the one that ATSDR used to derive its intermediate inhalation MRL for cis-1, 2-dichloroethene (i.e., 1000), an exposure level that exceeds this comparison value or RBC by a factor of 9.3 (i.e., 344/37 µg/m^3) would not be expected to produce any adverse effects in anyone chronically exposed directly to such levels of soil gas. But more to the point, no one will be chronically exposed to the maximum concentration of any contaminant in soil gas anyway.

The most plausible route of exposure to this and other soil-associated VOCs at Kelly AFB would be via inhalation of indoor air contaminated with greatly diluted traces of VOCs derived from this soil gas. For perspective only, the TLV (which is considered a safe worker exposure for 8 hours a day, 40 hours a week, indefinitely) is 200 ppm (200,000 ppb or 793,000 µg/m^3 for all isomers of DCE [15]. This is equivalent to the lowest inhalation exposure to 1,2-DCE that is known to produce even mild effects in rats treated chronically for 16 weeks (equivalent to approximately 10 years in humans) [16]. That TLV is 2,300 times the maximum concentration of 1,2-DCE detected in soil gas at East Kelly (344 µg/m^3), to which no one at East Kelly will be directly exposed on a chronic basis (if at all), anyway.

Comment #30: *Health effects may also have been under estimated in this study because the only health endpoint evaluated by ATSDR for the 15 chemicals present in soil gas was cancer. There was no apparent attempt to assess non-carcinogenic effects, such as reproductive, developmental, immunological and neurological alterations. Evidence from epidemiological studies in humans indicates that chronic exposure to tetrachloroethene can cause memory and concentration impairment and alterations in reaction times (ATSDR, 1997). EPA has not developed an inhalation reference concentration (RfC) for tetrachloroethene, however, acceptable ambient air concentrations have been set by different state agencies for chronic (1 year) exposures. The guideline in Texas for tetrachloroethene is 34 µg/m^3, however, other states have established guideline levels as low as 0.01 µg/m^3 (ATSDR, 1997). The predicted indoor air concentration for tetrachloroethene in homes near East Kelly was 0.23 µg/m^3, which is above the lower guideline values. Because our understanding of the health effects of chronic exposures to low concentrations of VOCs such as tetrachloroethene is limited, especially in young children and the elderly, it would be wise to limit exposure to such chemicals as much as possible. This uncertainty also increases the importance of directly measuring indoor air concentrations of tetrachloroethene to validate the modeled values.*

Response: Direct measurement of the contaminants of concern in the most relevant environmental media are always preferred. In this instance, however, it was possible to determine from existing data, with a substantial margin of safety, the public health implications of exposures at East Kelly.

The fact that Maine uses a comparison value for PCE in air (0.01 µg/m^3, annual average) that is 3400 times lower than the one used in Texas (34 µg/m^3, annual average) does not necessarily mean that the latter value is unsafe. (The TLV is 25,000 ppb or169,530 µg/m^3). Lower comparison values may easily be produced by simply increasing the incorporated margin of safety. All lower no-effect-levels produce, however, the same effect that the highest no-effect-level does (i.e. none). Thus, the fact that the levels of PCE in homes near East Kelly (0.23 µg/m^3) are 148 times lower than the Texas standard, but 23 times higher than the Maine standard, does not alter ATSDR's conclusion that the highest potential exposures to PCE in residential air in the East Kelly area pose no public health hazard to anyone at this site, including young children and the elderly. Nor is our understanding of the effects of low levels of PCE in humans all that limited. PCE has been used in the United States for many decades as a dry-cleaning solvent and as a degreasing/drying agent for metals. No adverse health effects have been observed in humans chronically exposed to 1 ppm (6780 µg/m^3) PCE in air [17]. For homes near East Kelly, one ppm PCE is more than 29,000 times the predicted indoor air concentration for tetrachloroethene.

Comment #31: *According to a meeting summary included in the Kelly AFB soil vapor monitoring report (Kelly Air Force Base, 2000), the locations of the eight soil gas monitoring wells were selected based on the location of the "vinyl chloride plume and not the 1,1 DCE plume." This raises the question as to whether data from the eight monitoring wells are representative of soil gas concentration throughout the East Kelly residential area. Groundwater contamination data should be consulted to determine where additional soil gas monitoring wells should be installed to be sure maximum concentrations of all chemicals of concern have been captured, particularly for the chemical tetrachloroethene (PCE), which is a major contaminant in the shallow groundwater in the entire East Kelly area. Continued monitoring of the present wells, as well as additional wells, is also needed to verify the low concentrations of vinyl chloride measured in the soil gas samples. It is not clear why vinyl chloride concentrations in groundwater samples from wells adjacent to the soil gas wells were below detection limits during the sampling that took place in 2000, when this chemical had been detected in these wells when they were sampled in 1999. Reported concentrations had been as high as 10 ppb. This is particularly strange since these wells sites were chosen to target the vinyl chloride plume. Since vinyl chloride is a breakdown product of TCE and PCE when these chemicals degrade in the environment, it is very important to continue both groundwater and soil monitoring for this potent liver carcinogen.*

Response: ATSDR's concern was to assess the realistic potential for adverse health effects resulting from site-specific exposures. Relative to that potential, none of the suggested changes could have significant cumulative effects on the final outcomes. PCE was a major contaminant in the shallow groundwater in the entire East Kelly area. The maximum detected soil gas concentration (14,230 $\mu g/m^3$) detected in eight soil gas monitoring wells (situated where shallow groundwater contamination was highest) exceeded ATSDR's chronic EMEG of 40 ppb or 271 $\mu g/m^3$ by a factor of about 52. That comparison value contains, however, a built-in safety factor of 100 [17]. In other words, the EMEG is 100 times lower than the minimally adverse health effect on which it was based, (i.e., "increased reaction time" in 60 women occupationally exposed 8 hours a day, 5 days a week, to a median concentration of 15 ppm (101,700 $\mu g/m^3$) for an average of 10 years) [17] [18]. (That median exposure was converted to an equivalent 24-hour/day, 7-day/week exposure of 4 ppm or 27,133 $\mu g/m^3$.) Thus the highest level of PCE detected in soil gas at East Kelly (14,230 $\mu g/m^3$) was still only 14,230 $\mu g/m^3$/27,133 $\mu g/m^3$ = 52% of the chronic adjusted LOAEL for "increased reaction time." And this is based on direct 24-hour/day, 7-day/week exposure to maximally contaminated soil gas itself. Still, residents will not be exposed to soil gas *per se*. Their actual exposures in indoor air (assuming a proportionality factor of at least 35,000) will probably be less than 0.0015% of that LOAEL. Given such a substantial (67,000-fold) margin of (maximum) exposure, no plausible changes in either concentrations of PCE or in model parameters would change ATSDR's conclusion that PCE at East Kelly poses no apparent hazard to public health. Of course, direct measurements of indoor air are always preferable to model projections. In this case, however, model projections would have to be off by a factor of 67,000 for there to be any realistic potential of even minimally adverse effects after long-term, chronic exposure.

Vinyl chloride would not be a "potent liver carcinogen" at the levels detected. Even in those with a history of occupational exposure to monomeric vinyl chloride, the incidence of hepatic angiosarcoma or HAS (the signature cancer produced by vinyl chloride in humans) is quite low. The occupational levels which, in the past, have been associated with HAS were probably well in excess of 100 ppm (100,000 ppb or 256,000 µg/m^3), which was the 8-hr TLV (TWA) for vinyl chloride when occupational cases of HAS were first linked to vinyl chloride exposure in the United States in the early 1970s. As of 1977, only 64 cases had been identified worldwide, the great majority of which occurred in workers who manually cleaned the inside of polymerization tanks where residual concentrations were probably hundreds, if not thousands, of ppm. Through October 1993, 173 deaths had been registered worldwide from HAS, 57 of which occurred in North America [19]. Nonoccupational risk of vinyl chloride-induced HAS was undetectable, if it existed at all. Even in the period 1979–1986, around the time of the peak occurrence of occupational HAS, "there were no confirmed non-occupational cases of angiosarcoma among residents living near a vinyl chloride site in Great Britain" [20]**.**

The epidemiological database supports the conclusion that vinyl chloride-induced hemangiosarcoma is not a plausible health concern at nonoccupational levels of exposure, including the worst-case, potential inhalation exposures at East Kelly [19]. In 2000, vinyl chloride was not detected in 8 soil gas monitoring wells situated where shallow groundwater contamination was highest. And based on modeling results using EPA's Johnson and Ettinger model for subsurface vapor intrusion into buildings, indoor air concentrations of VOCs (including vinyl chloride) would probably be on the order of 35,000 times lower in indoor air than in soil gas. Depending on the method used, detection limits for vinyl chloride in air range from 0.005 to 5.0 ppb [21]. If one assumes 1) the least sensitive method was used to detect vinyl chloride in soil gas (DL= 5 ppb), 2) the true concentration of VC was equal to that detection limit, 3) indoor air contains only 1/35,000 as much vinyl chloride as does soil gas, and 4) 100,000 ppb is the lowest exposure level that might produce HAS in human beings, then the potential indoor air exposures to vinyl chloride at East Kelly will be $(5/35{,}000)/100{,}000 = 1.43 \times 10^{-09}$ ppb or about one-billionth of the lowest level that might produce HAS in humans. Given such an enormous margin of exposure, no plausible differences in groundwater levels or model parameters (e.g., size of average residence, pressure differential, and air exchange rates) would have any effect on ATSDR's conclusion that vinyl chloride at East Kelly poses no apparent hazard to public health.

Comment #32: *As described in this report, children are likely to be more sensitive than adults to certain kinds of chemical exposures due to their smaller size and the fact that they are undergoing rapid growth and development. In addition to these factors, children also have more time to develop chronic diseases when chronic exposure to chemicals begins at an early age. Diseases such as cancer and neurodegenerative diseases develop over extended periods of time; thus chemical insults sustained early in life have a greater chance of developing into symptomatic diseases (Landrigan et al., 1999).*

Of particular relevance to the exposure pathways of concern in this health assessment is the fact that infants breathe more air than adults per pound of body weight. Thus young children living in homes in the East Kelly area would be exposed to twice the dose of chemicals present in indoor air (Landrigan et al., 1999) This needs to be taken into account as this exposure pathway continues to be monitored for both carcinogenic and neurological effects.

Response: Given the margins of exposure for PCE (67,000-fold) and vinyl chloride (almost a billion-fold) described in the previous response, a twofold increase in sensitivity would not meaningfully increase one's probability of suffering adverse health effects due to VOC exposures at East Kelly.

References

1. Karthikeyan R and Kulakow PA. Soil plant microbe interactions in phytoremediation. Adv Biochem Eng Biotechnol 2003: 78: 51–74.

2. CH2M Hill. Final Kelly AFB food chain sampling study. San Antonio, TX: Contract No. 52826; February 2002.

3. Agency for Toxic Substances and Disease Registry. Public health assessment guidance manual. Atlanta: US Department of Health and Human Services; 1992.

4. Barocsi A, Csintalan Z , Kocsanyi L, Dushenkov S, Kuperberg JM. Optimizing phytoremediation of heavy metal-contaminated soil by exploiting plants' stress adaptation. Int J Phytoremed 2003; 5:13–23.

5. Agency for Toxic Substances and Disease Registry. Toxicological profile for thallium. Atlanta: US Department of Health and Human Services; 1992.

6. Sherlock JC and Smart GA. Thallium in foods and the diet. Food Addit Contam 1986; 3:363–70.

7. Rangel-Guerra R, Martinez HR, Villarreal HJ. Thallium poisoning—experience with 50 patients. Gac Med Mex 1990; 126:487–94. [Article in Spanish; English abstract online.]

8. Meggs WJ, Cahill-Morasco R, Shih RD, Goldfrank LR, Hoffman RS. Effects of Prussian blue and n-acetylcysteine on thallium toxicity in mice. J Toxicol Clin Toxicol 1997; 35:163–6.

9. Gough M. Human exposures from dioxin in soil - a meeting report. J Toxicol Environ Health 1991; 32:205–45.

10. US Environmental Protection Agency. Guidelines for carcinogen risk assessment. Federal Register 1986 September 24: 51:51185: 33992–34006. (See p. 33998.); 1986.

11. US Environmental Protection Agency. Guidelines for carcinogen risk assessment. Washington DC: Risk Assessment Forum, EPA/630/P-03/001B; 2005. p. 2–53.

12. Agency for Toxic Substances and Disease Registry. Toxicological profile for polycyclic aromatic hydrocarbons. Atlanta: US Department of Health and Human Services; August 1995.

13. Kawajiri K and Hayashi S-I. The CYP1 family, Chapter 4. In: Cytochromes: metabolic and toxicological aspects. Ioannides C, Ed. New York, NY: CRC Press Inc.; 1996. p 450.

14. Janssen MMT. Nutrients. Chapter 6. In: deVries J, Ed. Food safety and toxicity. New York NY: CRC Press, Inc.; 1996.

15. The American Conference of Governmental Industrial Hygienists. 2003 TLVs and BEIs: threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati OH.; 2003.

16. Agency for Toxic Substances and Disease Registry. Toxicological profile for 1,2-dichloroethene. Atlanta: US Department of Health and Human Services; 1996.

17. Agency for Toxic Substances and Disease Registry. Toxicological profile for tetrachloroethylene. Atlanta: US Department of Health and Human Services; 1997.

18. Ferroni C, Selis L, Mutti A, Folli D , Bergamaschi E, Franchini I. Neurobehavioral and neuroendocrine effects of occupational exposure to perchloroethylene. Neurotoxicol 1992; 13: 243–47.

19. Falk H and Steenland NK. Vinyl chloride and polyvinyl chloride. Chapter 93 In: Rom WN, Ed. Environmental and occupational medicine. 3rd Ed. Philadelphia: Lippincott-Raven Publishers; 1998.

20. Elliot P and Kleinschmidt I. Angiosarcoma of the liver in Great Britain in proximity to vinyl chloride sites. Occup Environ Med 1997; 54:14–18.

21. Agency for Toxic Substances and Disease Registry. Toxicological profile for vinyl chloride. Atlanta: US Department of Health and Human Services; September 1997.

22. IARC 1973. Some polycyclic aromatic hydrocarbons and heterocyclic compounds. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans. vol. 3. Lyon, France: International Agency for Research on Cancer. p. 271.

23. IARC 1983. Polynuclear aromatic compounds. Part 1. Chemical, environmental, and experimental data. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans, vol. 32. Lyon, France: International Agency for Research on Cancer.

24. IARC 1987. Overall evaluations of carcinogenicity. IARC Monographs on the evaluation of carcinogenic risk of chemicals to humans, supplement 7. Lyon, France: International Agency for Research on Cancer. 440 pp.

25. NTP 2004. The Eleventh Report on Carcinogens. Washington DC: US Department of Health and Human Services, Public Health Service, National Toxicology Program.

Appendix I. External Peer Review Comments

In the fall of 2005, ATSDR solicited external peer review comments on the East Kelly AFB petitioned public health assessment. Below are ATSDR's responses to the comments received. For ease of reference, the comments are italicized and numbered sequentially. The page numbers and paragraph numbers cited refer to locations in the document submitted for review in October of 2005.

Comment #1: *The rationale for eliminating the ingestion of water from off-site private wells as a pathway could be made clearer. I understand that these wells are not primary sources of drinking water. If they are used for watering and gardening, they will probably be used for drinking to some extent (albeit, infrequently) by persons outside during warm weather. While the risk associated with this pathway should be trivial, the pathway should be recognized.*

Response: This pathway has is recognized under "Potential Exposure Pathways," and the text has been amended.

Comment #2: *The rationale for eliminating off-site soil as a pathway could also be made clearer. I believe this pathway was rejected based on the assessment made of storm water controls. This could be stated as such in a more explicit manner on page 4.*

Response: Text amended.

Comment #3: *The assessment of storm water appears subjective and not well grounded in data. As with the off-site well water, I believe the off-site soil pathway is probably extremely low risk and there is a low probability that contaminated soils migrated off-site in such quantities as to cause measurable contamination of surficial soils in the surrounding area. Nevertheless, some supporting information could be provided to more carefully document the effectiveness of the storm water control system - e.g., was a surface water analysis conducted? - and to provide more convincing evidence that off-site soils were not contaminated by the site.*

Response: ATSDR concluded that the site-specific storm water drainage controls were adequate and effective to prevent off-site soil contamination from on-site sources.

Comment #4: *The assessment appears thorough and very conservative. Because the assumptions are very conservative, the PHA provides a very safe communication of risks and threats (sic).*

Response: Comment noted.

Comment #5: *Given the uncertainty associated with geo-environmental problems, I recommend that stronger statements be made regarding long-term monitoring. Ground water, soil gas, and conditions within buildings adjacent to the site should be monitored regularly for the foreseeable future. I recommend that a statement be included that all off-site wells within and adjacent to the contaminated area be decommissioned and permanently sealed off, if at all possible.*

Response: The levels of contaminants in off-site groundwater in the surface aquifer were not high enough to warrant such a measure. The community around East Kelly has been notified of the shallow aquifer contamination and has been advised not to drink the water from the shallow aquifer.

Comment #6: *The PHA should be proofread carefully. I noticed a number of typographical errors in the text as well as inconsistent formatting in the tables.*

Response: The document was proofread and corrections were made.

Comment #7: *Reviewer comments must be considered within the context of the information provided. A detailed and independent assessment of the site data, modeling methods, and computations is not being made.*

Response: Comment noted. A technical review was previously conducted.

Comment #8: *It might be useful to explain the difference between hazard and risk to the reader. The document tends to use these terms interchangeably without distinction.*

Response: They *are* used interchangeably in this document because, except where hypothetical cancer risk is being estimated using EPA methodology, the terms "risk" and "hazard" are used, not in their technical sense, but as they are defined in Webster's dictionary to refer to the possibility of, or a possible source of, harm or danger.

Comment #9: *Page 2, 1 paragraph, 3rd line: Replace "Congressman Tejeda later requested ATSDR to evaluate.. ." with "Congressman Tejeda later requested that the ATSDR evaluate..."*

Response: Comment noted.

Comment #10: *While the document notes, rightly, that "the true value of the risk is unknown, and may be as low as zero," the statement is made too often and gives this reviewer the impression that the calculated risks in the document are being marginalized or trivialized.*

Response: Wherever conservative estimates of hypothetical cancer risk are made in this document, "the true value of the risk is unknown, and may be as low as zero" is cited not to trivialize those estimates, but to put them into proper perspective, as EPA did in its 1986 Cancer Risk Assessment Guidelines. If such perspective were not provided everywhere that it was needed in the document, some readers might misinterpret these seemingly precise risk estimates as literal predictions of cancer incidence in exposed humans.

Comment #11: *Concerning the reference to Figure 1 in Appendix A, page 2, 2nd paragraph: The first Figure in the Appendix is not labeled as Figure 1 and it also does not show the surrounding community to East Kelly. The Figure additionally does not show area S009 referenced in the last paragraph on the page and neither do any of the Figures in Appendix A.*

Response: Figure 1 is now labeled as such. Figure 5 has been added to show the location of area S009. Figure 6 (Zone 4 Land Use Map) has been added to show the surrounding community.

Comment #12: *On page 3, 2nd paragraph last line: It is stated "In 1990, about 6225 females of reproductive age (15-44 years) lived in the area." Figure 1, however, references the 2000 census data.*

Response: The 2000 census data was the source of the data presented in both places. The text has been amended.

Comment #13: *On page 3, 3rd paragraph: The text references Appendix F even though only Appendices A and B have been referenced. Consider re-numbering Appendices to follow order of citation.*

Response: comment noted.

Comment #14: *On page 4, 3rd paragraph: The text states "ATSDR identified eliminated exposure pathways from:. . .". Specify why these pathways were eliminated. Also, add parenthesis to text "Please see Appendix F, Exposure Pathways Table" and end paragraph with a ".".*

Response: ATSDR's guidance manual specifies that suspected or possible pathways may be eliminated from consideration if site-specific characteristics make past, current and future exposures extremely unlikely (PHAGM 2005, pg 60-30). Also, the missing period was added.

Comment #15: *On page 4, 4th paragraph: The text states that "residents east of Kelly AFB have had access to municipal water since the 1950s [6]". What about the period from 1916 to l950?*

Response: Unknown. The relevant records were not available for the specified time period.

Comment #16: *On page 5: The 1st sentence states "detected in the private wells near East Kelly are mostly VOC:; which quickly volatilize during watering [11]." What about lead and thallium shown in Table 1.*

Response: Lead & thallium are metals. The levels are, however, too low to produce adverse effects even if occasionally ingested.

Comment #17: *On page 5, Table 1: Show the 2000 EPA Region 6 comparison values in the Table.*

Response: The 2000 EPA Region 6 Human Health Medium-Specific Screening Levels (R6 HHMSSLs) originally used for screening this site have been added to Table 1. In addition, the table has been updated by the inclusion of several footnotes. For example, note that the HHMSSL for chloroform is now 75 ppb, reflecting EPA's recent conclusion that based on the mechanistic evidence that chloroform is a threshold carcinogen, the RfD should protect against cancer as well as noncancer effects. Also, EPA's cancer assessments for TCE and PCE were withdrawn and have been "under review" since 1989 and 1990, respectively. Finally, with the exception of lead, none of the substances listed in Table 1 exceeded ATSDR's health-based comparison values for noncancer effects. The fact that EPA's action level for lead (15 ppb) was exceeded in only one well suggests that Pb levels in that well might have reflected something other than the general condition of the shallow aquifer itself.

Comment #18: *On page 5, last paragraph, 6th line: It is stated that the risk is minimal. What is the risk? It would be useful to quantify it and put it in context. Again, what about lead and thallium?*

Response: The text has been amended to reflect the fact that the consumption of fruits and nuts in the communities surrounding Kelly AFB would pose no hazard to human health as a result of any associated exposure to site-related contaminants, including lead and thallium.

Comment #19: *On page 6, 2nd paragraph: The last line refers to Figure 4, but no such figure was found in the document.*

Response: In this PHA, "Figure 4" is a reference to Exhibit 4.1, a well location map from a January 2001 CH2MHILL report (Semiannual Compliance Plan Report, Part IV; Annual SWMU Assessment, and Statistical Evaluation). A larger, more readable version of that item has replaced the previous version, and it has been labeled as "Figure 4."

Comment #20: *On page 6, 3rd paragraph: The text references PCE, TCE, 1,2 DCE and VC plumes. It would be useful to show these on a Figure and include it in the document.*

Response: Comment noted.

Comment #21: *On pages 5 and 7: Tables 1 and 2 need to include the detection limits used in the analysis for the constituents in the notes below the Table since both Tables have ND and J values.*

Response: The specific values for the detection limits would vary depending upon the source and time period of sampling. Because, however, ATSDR based its toxicological evaluations only on maximum detected concentrations, the absence of such data does not affect ATSDR's conclusions.

Comment #22: *On page 7, Table 2 shows data for 2000 Compliance Plan, 2001 Compliance Plan, and Zone 4 RFI. It is not clear to this reviewer what those are, since they are not explained in the document or shown on a Figure.*

Response: After 2000, shallow groundwater monitoring continued. All updated monitoring data confirmed ATSDR's assessment based on previous data.

Comment #23: *On page 7, numerous references are made to well SS052MW271 and other wells. This reviewer could not locate these on any of the Figures included in the document.*

Response: The original figure 4 (copy of Exhibit 4.1) has been replaced with a larger, more legible version. Well SS052MW271 is located on Figure 4 in grid G-13.

Comment #24: *Page 7, 2nd paragraph, 4th line: It is stated in the text: "Benzene was also detected in two on-site samples at levels of concern (784 µg/L at well V25 etc.)". These concentrations are not within the range of values shown in Table 2 for benzene. Also, while the report indicates that the relatively high concentration of 784 µg/L might pose a health hazard, the report is quick to assume that the value of 784 is an anomaly since the soil gas levels in the wells were non-detect. Were the soil gas levels measured at the same time? Were they measured in the soils in that area in particular or just in the well itself? What would the risk be if the benzene concentrations were used in the risk calculations?*

Response: The outlier value of 784 µg/L benzene in well V25 was not considered to be a valid reflection of aquifer contamination because 1) it far exceeded the concentrations detected in all other wells, and 2) it was not supported by the elevated benzene levels that would have been expected in soil gas, had that result been "real." Nevertheless, ATSDR did call this anomaly to the attention of local officials and recommended the appropriate follow up.

Comment #25: *On page 8, 2nd paragraph, reference is made to site S-7. The site could not be found on any of the Figures and neither could Six Mile Creek.*

Response: Because the original Figure 4 (Exhibit 4.1: Well Location Map from a January 2001 CH2MHILL) was difficult to read, it has been replaced by a larger, more readable version of that figure. Site S-7 is within the boundary of East Kelly in grid # G-9. A new figure, Figure 5 (Figure 5.19 from the CH2MHILL Zone 4 RFI report), has been added, which expands grid G-9 and shows Site SS009 (formerly Site S-7) more clearly. Six Mile Creek is denoted on Figure 4 (Exhibit 4.1) by a labeled, faintly dashed and dotted line that extends from grid H-11 southward to grid N-14, thence eastward to grid N-20.

Comment #26: *On page 8, 2nd paragraph, 4th line, replace "TEQC" with "TCEQ" and spell it out since used for the first time.*

Response: Text amended.

Comment #27: *On page 8, 3rd paragraph, bullet 2 (and the sentence after bullet 2), what is this based on?*

Response: This statement is based on the common observation that storm events generate enormous quantities of runoff water which subsequently scour the sewers and wash contaminants further downstream.

Comment #28: *On page 9, the 4th paragraph ends with a colon. Is there text missing?*

Response: No text is missing. The sentence should have ended with a period and has been amended accordingly.

Comment #29: *On page 8, the last paragraph states: "the levels of PAHs in soil are unlikely to be hazardous to humans because of their low acute toxicity and their reduced bioavailability in soil." The text references Comment #21 for a more detailed explanation. Comment #21 deals with the inhalation pathway and not with the toxicity and bioavailability of PAHs so Comment #21 is not related to the discussion.*

Response: The response continues with another paragraph which begins with: "In the case of PAHs in soil, a number of additional chemical-specific factors support the conclusion that exposures are not likely to constitute any realistic hazard to human health:"

Comment #30: *On page 12, bullet #7: Would the presence of this localized source have any bearing on the risk analysis presented? Provide a comment or explanation.*

Response: No, it would not. The possible presence of another source was mentioned only because the detected concentration of vinyl chloride was not explainable as contamination that had migrated off the East Kelly site.

Comment #31: *On page 12, bullet 5 regarding storm water: what about flooding conditions? Is there a potential for surface overland flow during flooding to reach resident homes?*

Response: Site S-7 has been remediated, and a flash flood of the magnitude suggested by the commenter would only further dilute the remaining contaminants. (See the Figure 5 which has been added to this PHA.)

Comment #32: *On page 33 of Appendix C - Comparison Values and ATSDR Methodology – 2nd paragraph, 4th line - replace "principle" with "principal."*

Response: Correction made.

Comment #33: *On page 36, citations are for (EPA, xxxx), whereas reference list details citations as U.S. Environmental Protection Agency.*

Response: All citations and references have been converted to read "US EPA."

Comment #34: *Page 36 - 3rd paragraph, line 7 - what is a "pica child?*

Response: As used by ATSDR, the term "pica child" refers to a child that exhibits pica behavior which Webster's defines as "a craving for unnatural food, as earth or ashes."

Comment #35: *On page 36: Replace "Texas Natural Resource Conservation Commission" with Texas Commission on Environmental Quality.*

Response: As stated in the text, the Texas Commission on Environmental Quality (TCEQ) was formerly the Texas Natural Resource Conservation Commission (TNRCC).

Comment #36: *On page 41 of Appendix D – "Estimated Exposure Dose and Cancer Risk for On-Site Soil" - bullet number 3, change "[kg]" to "(kg)" for consistency.*

Response: Correction made.

Comment #37: *In Appendix E – "Soil Gas and Estimated Risk" - number the Table as Table 1, since it is referenced as such in Appendix H.*

Response: Correction made.

Comment #38: *In the notes beneath the Table, the notes include a circular reference – "(see Appendix E)" - but the Table is in Appendix E.*

Response: Correction made.

Comment #39: *The unit "**µg**/m^3" needs to be replaced with µg/m^3 throughout the Table. The unit ppbv is not used and should be eliminated from the notes beneath the Table.*

Response: Text amended.

Comment #40: *The notes explain what Shading means but no data are shaded in the Table. Either include the shading if it is missing or eliminate the comment since it would not be applicable.*

Response: Text amended.

Comment #41: *In the last line of notes underneath Table, replace "2.5 x 10-1" with 2.5 x 10^{-1}."*

Response: Text amended.

Comment #42: *On page 46, 3rd line, replace "Eddinger" with "Ettinger." Also, include reference for the model.*

Response: Text amended.

Comment #43: *In Appendix F (Exposure Pathway Table), formatting needs adjustment because column headings are detached and don't line up with the data columns.*

Response: Text amended.

Comment #44: *In Appendix G (Estimated Inhalation Exposure During Showering), when citing references, the reference is enclosed in parenthesis () instead of brackets [ ] as in Appendix H. This is particularly confusing in this Appendix because bullet numbering utilizes numbers enclosed in parentheses as well.*

Response: Text amended.

Comment #45: *On page 55, 1st equation, "f" is defined as "fractional volatilization rate (unitless)." A rate, however, implies a unit of per time and not a unitless variable.*

Response: The key to the meaning of this particular definition is the qualifier "fractional;" a fractional volatilization rate of 0.9 means that 90% of the solute of interest leaves the water and enters the air during the shower.

Comment #46: *On page 61 of Appendix H (Public Comments), Response to Comment #3, change Table 2 to Table 3 because the referenced explanation is actually a footnote to Table 3.*

Response: Text amended.

Comment #47: *Page 62, the word phytoremediation is misspelled.*

Response: Comment noted.

Comment #48: *On the last line of page 62, change 5 ug PCE/L to 5 μg/L of PCE.*

Response: Text amended.

Comment #49: *On the 3rd line of page 67, clarify what the cause of the 50th case of thallium poisoning was.*

Response: The 50th patient was a baby born to a woman who had suffered thallium poisoning during her third trimester. Meggs et al. (1997) is a secondary source. The details of this study ["Thallium poisoning. Experience with 50 patients"] are reported by Rangel-Guerra, Martinez, and Villarreal in the Spanish journal Gac Med Mex. 1990 Nov-Dec; 126(6):487–95. An English translation of the abstract is available on-line at www.pubmed.gov.

Comment #50: *On the 3rd line of the 1st paragraph on page 68, the document is citing a statement from Appendix G. The statement is correctly enclosed in quotations. However, the statement should be preceded with something like: "The conclusion from Appendix G was that. . . .".*

Response: Text amended.

Comment #51: *On page 68, unbold the referenced citation [11].*

Response: Text amended.

Comment #52: *On page 69, 2nd line the text in parenthesis (See last paragraph in this response), does not make sense and this reviewer could not figure out which paragraph is being referenced. If it is referring to item 5) on page 69, then it should just say so.*

Response: Comment noted. The identity of the intended paragraph in that response has been further clarified as follows: "See the last paragraph in this response (Number 5)."

Comment #53: *On page 69, items 1) through 5) should be reformatted to be consistent.*

Response: Text amended.

Comment #54: *On page 70, next to last paragraph, 2nd line - change "Eddigner" to "Ettinger"*

Response: Text amended.

Comment #55: *On page 72, adjust formatting of response to comment #21.*

Response: Text amended.

Comment #56: *On page 72, last paragraph, 2" line - a reference is made to Appendix E, Table 1. While there is a Table on page 45 of Appendix E, it is not labeled as Table 1.*

Response: The indicated table has been labeled.

Comment #57: *On page 76, reference #2, change NO to No.*

Response: Text amended.

Comment #58: *The unit "microgram" in this Appendix is expressed as "µg/L," whereas in previous Appendices,* µ*g/L is used. Be consistent to avoid confusion.*

Response: Changes were made to be consistent.

Comment #59: *It would be helpful to anyone interested in the area if maps showing contaminant concentrations with shading gradients or, better, color were given. This would allow instant assessments.*

Response: Comment noted.

Comment #60: *Appendix F table on Exposure Pathways could use a bit of explanation. Foremost, what does the "Eliminated" category signify?*

Response: Paragraphs have been added to the body of the text (section B: Extent of Contamination, Exposure pathways) explaining ATSDR's definitions of completed, potential, and eliminated pathways.

Comment #61: *The text is adequate.*

Response: Comment noted.

Comment #62: *Based on the statements in the text, the environmental and toxicological data could be the strongest part of the report.*

Response: Comment noted.

Comment #63: *On page 10, the last paragraph, lines 16 and 17, the comment regarding workers digging in the area includes the term "short" duration, which is explained as subchronic. Both are qualitative and should be replaced with assumed hours and days. Digging in the area could be of concern since the VOCs, all heavier than air, would tend to pool in depressions having little air movement.*

Response: The reference to short (i.e., subchronic) durations was not meant to imply that longer exposures might make the workers sick. It was just an acknowledgment of the fact that on-site worker exposures to soil gas, if they occur at all, would be neither chronic nor frequent.

Comment #64: *On page 12, conclusion #8, "…most limited commercial and industrial uses" is vague. What should be excluded? The meaning of the second sentence is not clear. I assume it means that 8 hr daily exposures to levels measured in soil gas wells would not exceed 8-hr TLVs.*

Response: Due to insufficient on-site soil gas and groundwater monitoring data, ATSDR was unable to determine whether or not on-site buildings were safe for uses other than industrial and limited commercial. Additional sampling (e.g., sub-slab borings) should be conducted before sensitive populations (e.g., nurseries or retirement homes) are introduced into the area.

Comment #65: *Conclusion #1 assumes that well water will never be used for drinking. What if that should change? An addition to Recommendation #2 or a 5th recommendation suggesting that wells be posted "Not Potable" could be prudent.*

Response: ATSDR does not consider that such an action is indicated by the data. Because the concentrations of the contaminants in the shallow aquifer ranged from nondetect to 16.4 times higher (for TCE) than the corresponding conservative MCLs for those contaminants, this aquifer could not legally be used as a source of public drinking water. The same regulatory restrictions do not, however, apply to private supplies.

Comment #66: *For perspective, it might be useful to compare this low order contamination with that in EPA superfund sites.*

Response: Comment noted.

Comment #67: *ATSDR's peer review process is clearly not adequate to assess the data collection through recommendation procedures beyond judging the adequacy of the methods cited if properly applied. I expect that is not the intent and that suitable data auditing procedures were followed.*

Response: Comment noted.

Comment #68: *Reasonable assumptions were made to arrive at assessments. The report is above average in clarity.*

Response: Comment noted.

Comment #69: *This document should contain more information on the chronology of this health assessment. It is unclear why a second draft (i.e., the final review draft which followed the June 1, 2001 public comment draft) is being issued and why it has taken five years to produce another document on East Kelly AFB.*

Response: As noted in the Summary and in the Purpose and Issues section, the late Congressman Tejeda originally petitioned ATSDR to evaluate the contaminants in the shallow ground water, soil, and soil gas at East Kelly for their potential to cause adverse health effects in exposed residents. The public comment draft of that assessment was released June 1, 2001. Subsequent to the end of the public comment period, additional data arrived, which ATSDR had to evaluate. Those evaluations then necessitated additional rounds of review and clearance.

Comment #70: *On page 8, paragraph 3, line 9, the opening words, "This finding is an anomaly..."* Should be changed to read "*This finding appears to be an anomaly...*"

Response: The indicated change has been made in the final document.

Comment #71: *It is unclear why ATSDR cites the EPA recommendation to conduct ongoing soil vapor monitoring twice a year and why this would provide better* coverage of changing soil conditions and seasonal variation. Recommendation #4 should be deleted.

Response: See response to Public Comment #12, the last paragraph of which now reads:

"Considering (1) the large margin of safety between measured levels of soil gas and estimated levels of vapor intrusion into homes, and (2) the expectation that, due to remediation efforts, concentrations at the source will be lower, rather than higher, in the future, ATSDR does not recommend additional monitoring of soil vapor or residential indoor air. However, EPA's recommendation of soil vapor monitoring twice a year has been noted in the final release of this public health assessment and in ATSDR's site file."

EPA's recommendation (#4) was a product of EPA policy. If a pathway of exposure exists which creates the potential for an unacceptable long-term risk, EPA automatically recommends further characterization.