Health Consultation

Evaluation of Potential Exposures:
Bulk Fuels Facility Groundwater Plume

KIRTLAND AIR FORCE BASE

ALBUQUERQUE, NEW MEXICO

EPA FACILITY ID: NM9570024423

AUGUST 14, 2014

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

Health Consultation: A Note of Explanation

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

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

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Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry (ATSDR)
Division of Community Health Investigations
Central Branch

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List of Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
ATSDR	Agency for Toxic Substances and Disease Registry
AVG	average
AVGAS	aviation gasoline
BFF	bulk fuels facility
bgl	below ground level
bkgd	background
CEL	cancer effect level
CREG	cancer risk evaluation guide
CV	comparison value
EDB	ethylene dibromide (or dibromoethane or 1,2-dibromoethane)
EMEG	environmental media evaluation guide
EPA	U.S. Environmental Protection Agency
JP	jet propellant
KAFB	Kirtland Air Force Base
LNAPL	light non-aqueous phase liquid
LTHA	Lifetime Health Advisory
MCL	maximum contaminant level
mg/L	milligrams per liter
mg/kg/day	milligrams per kilogram per day
MRL	minimal risk level
NIOSH	National Institute for Occupational Safety and Health
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
OSHA	Occupational Safety and Health Administration
PEL	permissible exposure limit
PHC	public health consultation
PHAP	Public Health Action Plan
ppb	parts per billion
ppm	parts per million
REL	recommended exposure limit
RfD	reference dose
RSL	Regional screening level (from USEPA Regional Offices)
SVE	soil vapor extraction
TLV	threshold limit value
µg/L	micrograms per liter (water)
$\mu g/m^3$	micrograms per cubic meter (air)
VA	Veterans Administration
VI	vapor intrusion
VOC	volatile organic compound

Foreword

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

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

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

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

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

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

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

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

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

Letters should be addressed as follows:

Agency for Toxic Substances and Disease Registry
ATTN: Records Center
1600 Clifton Road, NE (Mail Stop F-09)
Atlanta, GA 30333

Summary

The Public Health Issues

Over an approximately 50 year period (circa early 1950's to 1999) aviation gasoline and jet fuels leaked from underground pipes at the bulk fuels facility (BFF) in the northwestern area of the Kirtland Air Force Base, Albuquerque, New Mexico (KAFB). The Air Force has requested ATSDR assistance in evaluating the potential health effects of human exposure to contaminants from the leaked fuels.

Contamination at the BFF is the result of long-term releases of several types of petroleum-based fuels from the underground distribution system. The relatively high vapor pressure and low density of these fuels leads to a portion of the fuel migrating upward as vapors from the subsurface liquid fuels and remainder of the liquid fuels migrating downward until it reaches the underlying groundwater. These physical properties create different pathways of potential exposure: airborne exposure via inhalation to contaminant vapors migrating upward from the subsurface fuel plumes, and ingestion exposure to dissolved (aqueous) contaminants via drinking water wells.

Conclusions

ATSDR has identified four pathways by which people may be exposed to contaminants from fuels that leaked from the BFF area of Kirtland AFB:

1) Based on currently available groundwater monitoring data there are no past or current exposures via groundwater at down-gradient water supply wells. Future exposures, which are possible, will be prevented if ongoing and prospective actions to reduce or prevent exposure are implemented as planned.
2) BFF workers may be exposed to benzene in air via vapor intrusion into buildings. As measured, benzene air concentrations are within the normal range of US residences and below regulated occupational concentrations. These exposures are not expected to harm people's health.
3) Workers and patients at the VA Hospital may be exposed to benzene in air via vapor intrusion into buildings. Based on available data, occupational exposures to workers and short term exposures to patients are not expected to harm people's health. However, due to the limited amount of soil gas and indoor air data available for this location, additional characterization is needed.

4) BFF workers may be exposed to hydrocarbon compounds in air via airborne emissions from the soil vapor extraction (SVE) treatment system. These emissions are treated prior to release and the treatment system is monitored with permit oversight. Assuming the SVE system is operated and maintained per permit conditions, potential exposures are not expected to harm people's health.

Recommendations

1) ATSDR recommends that ongoing and proposed monitoring and actions to prevent or reduce exposure continue as planned.
2) ATSDR recommends that additional characterization of shallow soil gas and/or indoor air at the VA Hospital be conducted.

For More Information

If you have concerns about your health, you should contact your health care provider. For questions or comments related to this Public Health Consultation please call ATSDR at 1-800-CDC-INFO: Bulk Fuels Facility Groundwater Plume, KAFB, Albuquerque, NM.

Statement of Issues and Community Health Concerns

Over an approximately 50 year period (circa early 1950's to 1999) aviation gasoline and jet fuels leaked from underground pipes at the bulk fuels facility (BFF) in the northwestern area of the Kirtland Air Force Base, Albuquerque, New Mexico (KAFB). A leak in the underground piping system was discovered in1999 (CH2M HILL, 2001). Although the exact timing and amount of fuels that leaked into the subsurface are unknown, estimates of the total volume of fuel leaked range from 3 to 24 million gallons (KAFB Fuel Plume Facts, http://www.kirtland.af.mil/shared/media/document/AFD-110822-007.pdf; ABQJournal Online, May 22, 2012; respectively).

The Air Force (and its various contractors) with oversight by the New Mexico Environment Department (NMED) is currently conducting sampling and modeling studies to determine the spatial extent of subsurface vapor and groundwater contamination resulting from the leaked fuel.

The Air Force has requested ATSDR assistance in evaluating the potential health effects of human exposure to contaminants from the leaked fuels. This health consultation is ATSDR's evaluation of:

1) The pathways of exposure by which people may be exposed to BFF-specific contaminants,
2) The measured concentrations and distributions of the specific contaminants included in the complex mixtures of aviation gasoline and jet fuel, and
3) The measured contaminant concentrations relative to the contaminant-specific health comparison values, which are used as screening tools to identify contaminant concentrations of public health concern.

As a starting point for this evaluation of public health issues related to the fuel spill and potential exposure to those contaminants, this section of the health consultation describes the related community health concerns and how this evaluation will address those community concerns. ATSDR has obtained the following community concerns by attending the March 13 and November 27, 2012 public meetings of the KAFB Community Advisory Board, noting concerns expressed in Albuquerque newspaper and television media, and communicating directly (in person or via telephone or e-mail) with representatives from local and state environmental and public health agencies, community groups, and concerned citizens. While the list of concerns (Table 1) may not identify all possible community health concerns, it does include a broad range of issues (from the toxicity of specific contaminants, the ongoing monitoring of subsurface migration, and the proposed processes for preventing or remediating contaminant transport to public drinking water wells).

Table 1 is a summary of the community concerns that have been identified by ATSDR via the above process. While the summarized concerns are grouped into four topics, it seems that the concerns are primarily related to documentation of contaminant migration and remediation and the pace and goals of the remediation process.

Table 1. Community concerns related to BFF groundwater contaminant plume	
Characterization/Remediation Process	• Pace of plume documentation and remedial actions is too slow to prevent plume migration to drinking water wells, • Lack of transparency and communication with community, • Community members would like more access to decision processes.
Sampling/Monitoring Methods/Locations	• Believe that dedicated monitoring well directly adjacent to Ridgecrest #5 Well is necessary, • Contaminant sampling at production wells may lead to misleading results due to dilution from large volume/screen depths.
Remediation Goals and Strategy	• Do not believe that planned vapor extraction procedure will capture or retard migration of LNAPL or EDB plumes, • Believe that construction of water treatment system should be installed on Ridgecrest well(s) to capture and remediate dissolved contaminant plume. Potential shutdown of Ridgecrest well(s) upon contaminant detection will exacerbate down-gradient contaminant migration, • Believe that the prescribed political and regulatory roles of the affected agencies limit their ability to see all issues and would like an independent scientific/technical panel to review problem and develop recommendations.
Evaluation of Potential Exposures	• Believe that groundwater modeling should be conducted to predict when contaminants will reach down-gradient water supply wells, • Concern about airborne releases from vapor extraction/treatment wells.

Most of the identified issues relate to the potential for future exposures via plume migration or the need for more timely actions to prevent future exposures. It is important to note that remedial actions are ongoing and others are in various stages of planning and approval. This consultation will not address the efficacy of the proposed remedial actions on the potential for future exposures to contaminants from contaminated groundwater. Although this consultation cannot evaluate the effectiveness of proposed remedial actions, it will serve as a vehicle for documenting those concerns, and hopefully, initiating community discussion of these issues. The concerns related to "Evaluation of Potential Exposures" are addressed in the **Public Health Implications** section.

A public comment version of this health consultation was released and distributed to the Albuquerque community on July 12, 2013. ATSDR received six sets of comments in response to that release. Note that in response to community requests, an initial 45 day comment period was extended an additional 30 days. The comments and ATSDR's corresponding responses are presented in Appendix A. The comments are summarized to consolidate redundant issues and group similar comments in order to provide a focused response. ATSDR responses indicate how the Consultation was revised or explain why no revision was warranted.

Background

Site History and Physical Setting

Kirtland AFB is located in Bernalillo County in central New Mexico, southeast of and adjacent to the City of Albuquerque and the Albuquerque International SunPort (Figures 1 and 2). Construction of Albuquerque Army Air Base began in January 1941 and was completed in August 1941. In February 1942, Albuquerque Army Air Base was renamed Kirtland Army Air Field.

The BFF area was used for fuel storage and processing as early as 1951 and continues to operate in that capacity. Bulk storage for jet propellant fuels (JP-4; JP-8), diesel fuel, and aviation gasoline (AVGAS) was managed in the eastern portion of the facility. A 250-gallon underground storage tank was located near the Pump House, Building 1033 (CH2M HILL, 2001). The three types of fuel handled by the BFF were AVGAS, jet propellant-4 fuel (JP-4), and JP-8. The use of AVGAS and JP-4 at Kirtland AFB was phased out in 1975 and 1993, respectively. JP-8 was handled through the Former Fuel Offloading Rack (FFOR) until the leak was discovered in 1999.

The BFF is also directly adjacent to the Raymond G. Murphy Veterans Administration Medical Center (VA Hospital) and a city park (USS Bullhead Memorial Park; City of Albuquerque Parks Department; Figure 1). The VA Hospital complex includes a large (217 bed) tertiary care hospital, associated offices and laboratories, and extensive patient and staff parking lots. The USS Bullhead Memorial Park is a 44-acre city park with 2 playgrounds, 7 soccer fields, 4 lit softball fields, barbecue grills and picnic tables and 564 parking spaces (Figure 1).

KAFB lies within the eastern portion of the Albuquerque structural basin, which is filled with mostly unconsolidated deposits of inter-bedded gravel, sand, silt, and clay. The presence of clay has significant implications for bulk hydrocarbon migration in the vadose zone. The thickness of the sand, gravel, silt, and clay in most of the basin exceeds 3,000 feet, though the thickness varies considerably because of the large amount of faulting in the basin (CH2M HILL, 2008). Depths to water (non-pumping wells) measured at the BFF Spill site range from 450 to 544 feet below ground level (bgl; Shaw, 2011). In the BFF area, rainfall (or leaked fuels) initially moves predominately downward until it reaches the water tables at a depth of 450 to 500 feet bgl (Shaw, 2011). At the BFF site, the current groundwater flow direction is north to northeast and is influenced by Water Authority and KAFB pumping wells (Shaw, 2011).

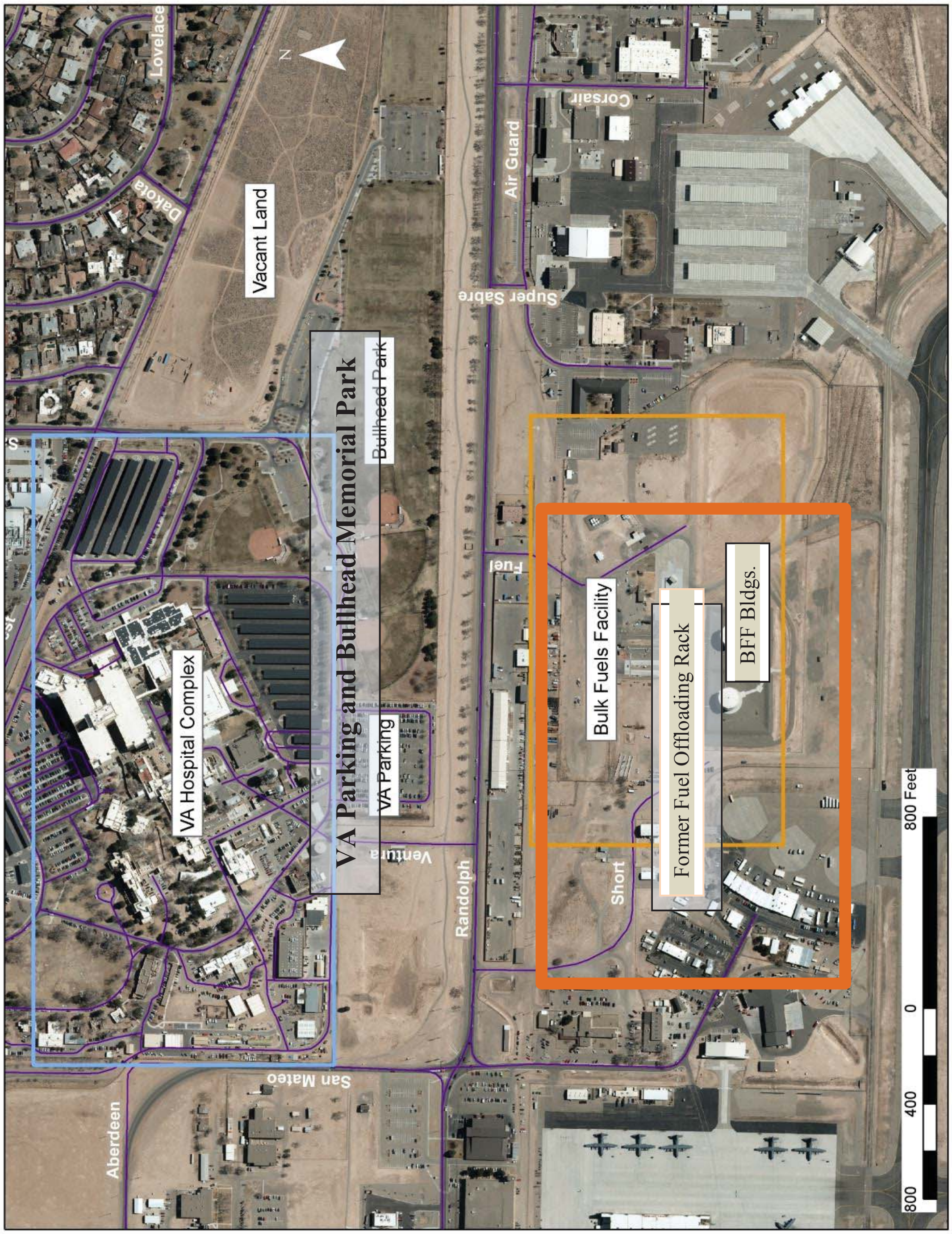

Figure 1. Locations of Bulk Fuels Facility, VA Hospital and Bullhead Park. Boundaries are approximate. Randolph Rd. is the KAFB boundary. BFF outline may not include all portions of former fuel facility.

Pathways of Potential Exposure and Contaminants of Concern

Pathways of Potential Exposure

Contamination at the BFF is the result of long-term releases of several types of petroleum-based fuels from the underground distribution system. The relatively high vapor pressure and low density of these fuels leads to a portion of the fuel migrating upward as vapors from the subsurface liquid fuels and remainder of the liquid fuels migrating downward until it reaches the underlying groundwater. The density and solubility of the liquid fuel compounds relative to groundwater causes the majority of the liquid fuels to float on top of the underlying groundwater.

Thus, most of the leaked fuel is present as a "light non-aqueous phase liquid" (or LNAPL) which is not dissolved in groundwater and the LNAPL migrates down-gradient at a different rate relative to the underlying groundwater. However, fuels such as AVGAS and JP-4/8 are complex mixtures of a variety of hydrocarbon compounds and fuel additives (including benzene, toluene, ethylbenzene, xylenes, hexane, lead, and ethylene dibromide). These compounds have different solubilities in water such that some, such as ethylene dibromide (EDB), may selectively dissolve into and migrate down-gradient with groundwater flow.

These physical properties create different pathways of potential exposure: airborne exposure via inhalation to contaminant vapors migrating upward from the subsurface fuel plumes, and exposure to dissolved (aqueous) contaminants via drinking water wells. These pathways of exposure and the contaminants specific to each pathway are evaluated in the following sections.

In addition to the groundwater and vapor intrusion pathways, exposure to airborne contaminants from the soil vapor extraction (SVE) system is also a possible pathway of exposure. The original SVE system used four internal combustion engines to power pumps at the vapor extraction wells (Shaw, 2011). These engines extracted vapor as fuel, and like an automobile engine, the emissions were treated via catalytic converters (Shaw, 2011). Emissions from these four units operated under a permit from the Albuquerque Environmental Health Department (NMAC Permit Number 1984, April 30, 2009).

The original SVE system has been replaced with a new system incorporating (Shaw, 2012a):

> "…two SVE wells (Kirtland AFB [KAFB]-106161 and [KAFB]-106160, an aboveground piping manifold that runs the vapors to a blower skid, and a catalytic oxidation unit to destroy the hydrocarbon vapors in the air extracted from the wells."
> (https://kirtlandafb.tlisolutions.net/sitedocs/PDFS/20/2004.PDF)

As with the past SVE system, the current system upgrade is also operating under a permit from the Albuquerque Environmental Health Department and will be regularly monitored to ensure permit compliance. Air emissions from both the past and current SVE systems are treated, via catalytic converters, prior to release and the emissions monitored for permit compliance. Consequently, airborne emissions from the SVE system(s) do not represent a completed pathway of exposure (past, present, or future) for this health consultation.

Water Supply Wells (Groundwater) Pathway: Figure 2 shows the locations of the LNAPL and EDB plumes (based on 2011 monitoring data) in relation to nearby public water supply wells. The water supply wells include Albuquerque Bernalillo County Water Utility Authority

(Water Authority) wells (Ridgecrest 3 and 5; and Burton 5), KAFB wells (KAFB 3, 15, and 16) and the Veterans Administration Hospital well (VA Hosp.) Additional Water Authority wells are further down-gradient (north) of the Ridgecrest 3 and 5 wells.

Figure 2 also shows the locations of most of the monitor wells which are the basis for delineation of the contaminant plumes. Additional monitoring wells (not shown) have been recently developed and sampled to further define the northern boundary of the EDB plume. Analytical data from these, and other wells, are discussed in the following section on "Contaminants of Concern".

The water supply wells are drilled to variable depths in order to optimize access to the productive regional aquifer (e.g., 900 feet bgl, KAFB-3; 1,500 feet bgl, VA Hospital Well). Typically, these wells are cased to the top of the water table (depths of 450 to 500 feet bgl) with screen openings from around 100 feet below the water table to well bottom. In contrast, monitoring wells are drilled and open (screened) to sample specific depth zones in order to characterize the distribution of contaminants (such as the vadose zone [ground surface to top of water table], and various aquifer depths below the water table).

Because monitor and water supply wells are open or screened at differing depths, contaminant concentrations in monitoring wells are not a direct indicator of the specific contaminant concentrations people may be exposed by drinking water from the water supply wells. An example of this difference is provided by a recent United States Geological Survey report on contamination in a nearby Water Authority well and adjacent monitoring wells (Bexfield, et.al, 2012). This report indicates that volatile organic compound concentrations in shallower, depth-restricted monitor wells are 40 to 80 times higher than those in an adjacent water supply well (Bexfield, et.al, 2012). This indicates that contaminant concentrations in water supply wells with large vertical screen openings are greatly diluted relative to depth-restricted monitor wells. While the specific dilution from the BFF contaminant plume and down-gradient monitor and water supply wells may be somewhat different, the range of dilution does provide a reference for evaluating future contaminant exposures via water supply wells.

In addition to the difference between contaminant concentrations in monitoring and water supply wells, measured contaminant concentrations from specific water supply wells may not be an accurate indication of the contamination in the water that people drink. Water pumped from multiple sources is typically blended and treated before distribution via the public water system. Ridgecrest 5, however, is a "direct injector" production well, which does not feed into a reservoir system, but is instead sent directly to distribution after chlorination. Some contaminants, such as metals and disinfection by-products, may be introduced via the water treatment, distribution and home plumbing systems. However, in lieu of actual samples from individual faucets, data from the water supply wells, as presented in Table 2, are used to evaluate potential drinking water exposures.

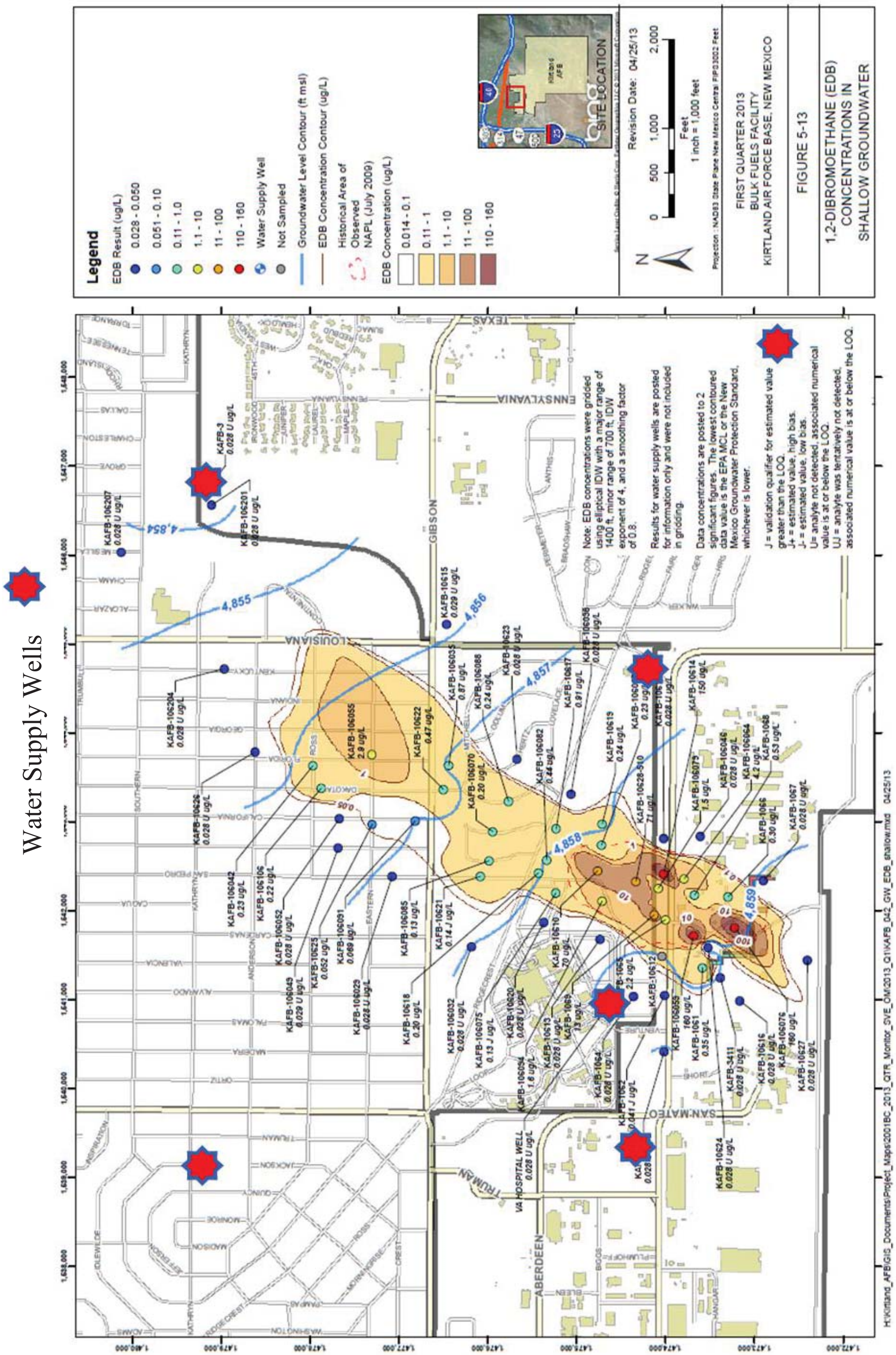

Figure 2. Bulk Fuels Facility Groundwater and NAPL Plumes and Nearby Water Supply Wells (modified from Shaw, 2013).

Table 2. Maximum Concentrations of Groundwater Contaminants in KAFB Monitor and Nearby Water Supply Wells (Adjacent to BFF Area) Detected at Concentrations above Health Comparison Values.

Contaminant	Screening Value (µg/L)	Max. Concentration (µg/L)	
		Monitor Wells	*Water Supply Wells*
Benzene	0.64 CREG/5 MCL	8,460	0.32 J
bis (2-ethylhexyl) phthalate	2.5 CREG/ 6 MCL	1,020	24.8 (3.7 Avg.)*
Dibenzo(a,h)anthracene	NA	1,020	ND
1,2-Dibromoethane (EDB)	0.018 CREG 0.05 MCL	1,000	ND
1,2-Dichloroethane (EDC)	0.38 CREG/5 MCL	565	ND
Ethylbenzene	700 MCL	4,420	ND
Manganese	300 LTHA	5,440	25**
Methylene chloride	5 MCL	675	ND
Napthalene	200 RMEGc	9,640	ND
Tetrachloroethene (PCE)	5 MCL	496	ND
Toluene	200 EMEG Child	19,900	ND
Trichloroethene (TCE)	0.76 CREG	480	ND
Xylenes (total)	2,000 EMEG Child	12,000	ND

- See Appendix B for the derivation and description of the different screening values.
- Contaminant concentrations are from the Quarterly or Semi-Annual Reports (by CH2MHill or Shaw, Inc.; various dates and EXCEL spreadsheets provided by the Water Authority.
- The Water Supply Wells include: KAFB Wells 3, 15, and 16; VA Hospital; and Ridgecrest Wells 3 and 5. Other supply wells that are further down-gradient were not evaluated.
- The sample analyses use different labs, methods, and reporting limits (as described in the section on "Adequacy of Available Data".

*Average concentrations are calculated for the well with the listed maximum concentration and assume a value of ½ the detection limit for non-detection values.

**A manganese detection from the VA Hospital well is listed in Table 3-3 (CH2MHill, 2008) as 3.3 "J" mg/L. Based on other manganese results for this (and other water supply wells) there appears to be inconsistent conversion of µg/L and mg/L units. The estimated "J" manganese detection does not appear valid and is not included in this evaluation.

MCL: maximum contaminant level (EPA).
RMEGc: Media evaluation guide for a child (derived from EPA Reference Dose).
CREG: Cancer risk evaluation guide (ATSDR).
EMEG: Environmental Media Evaluation Guide (ATSDR)
LTHA: Lifetime Health Advisory (EPA)
ND: not detected NA: not available
J = an estimated value that is less than the reporting limit but greater than the minimum detection limit.

Vapor Intrusion Pathway: The vapor intrusion (inhalation) pathway will only occur in buildings where the LNAPL plume is at a relatively shallow depth and the upward migrating vapors can be concentrated in an indoor air space. In unconfined outdoor locations the vapors are rapidly dispersed and do not typically reach concentrations of public health concern (NJDEP, 2013). Figure 3 shows the spatial distribution of the LNAPL benzene plume at various depths below ground level (bgl; shaded area; circa 2011).

It is important to note that the LNAPL plume is at a relatively shallow depth in the immediate vicinity of the BFF where the fuels leaked from the pipes. The LNAPL plume migrates downward until it reaches the water table (at depths of 450 to 480 feet bgl; as documented in quarterly reports, e.g. Figure 3 and Shaw 2012b). Due to the depth and limited lateral migration of the vapor intrusion source (the LNAPL plume), there are relatively few buildings where vapor intrusion could occur and people could be exposed to vapors from the BFF plume. Specifically, those buildings are located at the BFF (KAFB Buildings 1026, 1032, and 1048) and possibly at the VA Hospital. Indoor and outdoor air samples were collected and analyzed for the BFF locations (Shaw, 2012c; 2013b) and measured concentrations are compared to screening values in the following section.

Chronic or long-term exposures to airborne contaminants at BFF buildings are restricted to Air Force personnel working at those locations. Worker exposures are typically evaluated for 8 hour work days and 5 day work weeks rather than the 24/7 exposure periods used to evaluate residential exposures. Although ATSDR does not typically evaluate on-site worker exposures, community members have voiced concerns about potential off-site exposures via vapor intrusion and/or airborne emissions. To address those concerns, this health consultation will evaluate the much higher exposures possible at on-site locations.[1] Consequently, residential screening values are adjusted to reflect a worker exposure scenario as described in the following section and Appendix B.

Figure 3 also shows elevated total VOC vapors in shallow soil (50 feet below ground level; bgl) adjacent to the VA Hospital and in vacant land at the intersection of Ridgecrest and San Pedro Drives. Although there are no direct measurements of either outdoor or indoor air near surface soil gas samples from the VA Hospital buildings, the proximity of the buildings to the SV monitor well with elevated soil gas contaminants (KAFB 106138; location shown in Figure 3) suggests that vapor intrusion is possible at this location.

Measurements of soil gas vapors in the shallow and deeper soil horizons between well KAFB 106138 and the BFF source area SV monitoring wells to the east have not been collected. Therefore, it is not known whether elevated soil gas vapors at the VA Hospital originate from the BFF source or from a past VA Hospital fuel tank leak. According to information provided by the VA, the remediated fuel tank (with NMED oversight and approval) was located about 200 yards from the soil gas sample location (KAFB 106138; Appendix B, Commenter Four). The vapor intrusion pathway at the VA Hospital is considered a pathway of potential exposure.

As there are no buildings on the vacant land at Ridgecrest and San Pedro Drives and buildings (such as restrooms) at Bullhead Memorial Park are not continuously occupied, there is little

[1] The routinely occupied buildings at the BFF consist of small slab on grade structures with offices and storage space. The office spaces are assumed to have ventilation/heating/cooling consistent with those uses, however, the amount of time doors and windows are open is unknown (CH2MHill, 2008).

potential for past or current exposure to site-related contaminants via vapor intrusion. However, if buildings are constructed and occupied in the future at those locations, vapor intrusion could become a pathway of potential exposure. Consequently, soil gas and outdoor air contaminant concentrations at those locations are evaluated in the following section.

Contaminants of Concern

The Air Force (through its contractors) has produced a series of semi-annual or quarterly reports (e.g., Quarterly Pre-Remedy Monitoring and Site Investigation Report for April-June, 2013, Bulk Fuels Facility Spill, Solid Waste Management Units ST-106 and SS-111**;** referenced as CH2MHill or Shaw, various dates) that describe the ongoing monitoring program and present the results of those activities. The monitoring and site characterization data contained in those reports are also maintained in a comprehensive database. These data have been provided to ATSDR in Microsoft ACCESS or EXCEL formats and as publically accessible electronic versions of the monitoring reports (http://www.kirtland.af.mil/environment.asp). Data from Water Authority wells were also provided to ATSDR as EXCEL spreadsheets.

Contaminants in Groundwater: Table 2 lists the groundwater contaminants that have been detected at concentrations exceeding their respective screening values and have a frequency of detection greater than 5 percent (Shaw, 2012b). Shaw (2012b) also includes iron, nitrogen (nitrate as N), phenol, and sulfate (SO_4) as contaminants of concern. However, iron and sulfate have only secondary drinking water standards (based on taste, color, or odor) and do not have primary health-based screening values. While nitrate (nitrogen) and phenol do have health-based screening values (10,000 and 3,000 µg/L, respectively) none of the reported concentrations in monitor or drinking water wells exceeded those values. Shaw (2012b) apparently considers nitrogen (nitrate as N) and phenol to be contaminants of concern based on their use as indicators of bacterial degradation of organic compounds. Iron, nitrogen (nitrate as N), phenol, and sulfate (SO_4) are not considered contaminants of concern in this health consultation.

Of the thirteen groundwater contaminants detected in monitoring wells, only benzene, bis (2-ethylhexyl) phthalate, and manganese have been detected in water supply wells (Table 2). Note that the water supply wells included in this analysis are KAFB-03, KAFB-15, KAFB-16, the VA Hospital well, and Ridgecrest wells 3 and 5, and the Burton 5 well (Figure 2). The single benzene detection occurred in the VA Hospital Well (4/17/2007 sample event), was below the MCL, and has not been replicated in any subsequent sampling events. It should be noted that a single detection of gasoline range organics also occurred in the VA Hospital Well (56 µg/L; 4/1/2011 sample event). There are no drinking water standards for gasoline range organics and there were no prior or subsequent detections.

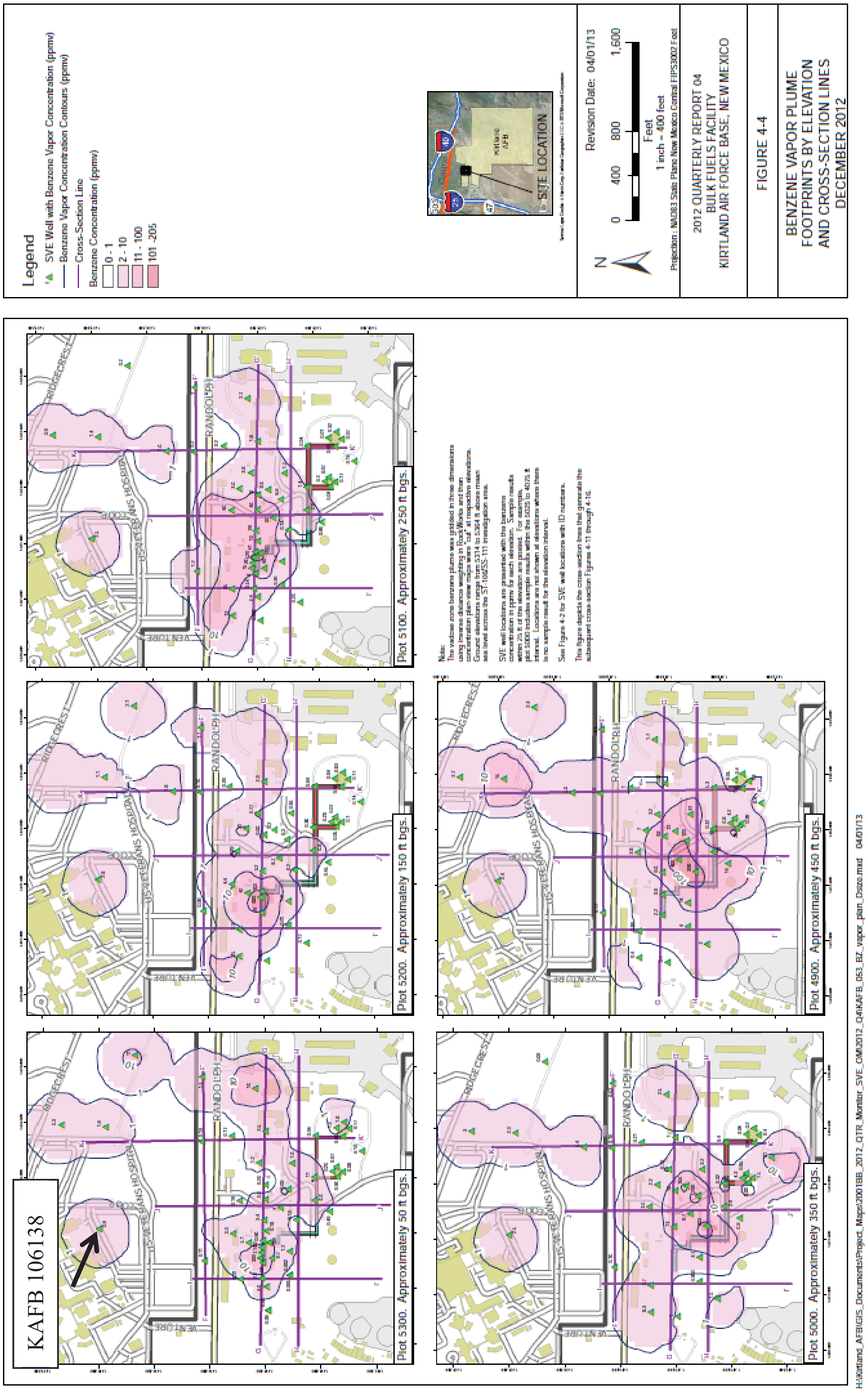

Figure 3. Benzene Vapor Plume Distribution at Various Depths (Figure 4-4 from Shaw, 2012c).

Although most measurements of bis (2-ethylhexyl) phthalate in water supply wells have been non-detections, there have been several results at concentrations above the CREG and MCL (detections of 24.8 µg/L--KAFB-16, 1/29/2009; 6.2 J µg/L-- KAFB-03, 1/27/2009, 16.8 µg/L--KAFB-03, 7/21/2009), and 9 µg/L--VA Hosp.(10/2009). Although high concentrations of bis (2-ethylhexyl) phthalate have been measured in monitor wells (up to 1,020 µg/L; Table 2), this contaminant is also released by plastic pipes and other plastic materials. The sporadic detections in water supply wells suggest that its presence may be due to leaching from pipes or laboratory equipment rather than groundwater migration from the BFF plume. Regardless of the bis (2-ethylhexyl) phthalate source, when the infrequent detections are averaged with non-detections (assuming ½ the detection level for non-detects[2]) for individual water supply wells, the long term average concentration is above the CREG (2.5 µg/L) but below the MCL (6 µg/L; Table 2). Considering that:

1) the CREG assumes continuous daily exposure for 70 years,
2) most bis (2-ethylhexyl) phthalate analyses are non-detections, and
3) water from individual wells is blended before treatment and distribution,

it is very unlikely that long term concentrations of bis (2-ethylhexyl) phthalate ~~in~~ distributed in KAFB or VA Hospital water are above either the CREG or the MCL.

Manganese detections in the water supply wells are generally less than 25 µg/L with frequent non-detections. A manganese detection from the VA Hospital well is listed in CH2MHill (2008) Table 3-3 as 3.3 "J" mg/L (or 3,300 µg/L). Based on other manganese results for this (and other water supply wells) there appears to be inconsistent conversion of µg/L and mg/L units in the database and report tables. The estimated "J" manganese detection does not appear valid and is not included in this evaluation. It should also be noted that manganese analyses are variously presented as "total" or "dissolved" manganese concentrations. Dissolved phase metals analyses are considered non-reproducible and should be measured as "total" metals analyses (EPA, 1988).

An organic manganese compound (methyl manganese tricarbonyl; MMT) was historically used as a fuel additive in AVGAS (ATSDR, 2012). The high manganese concentrations measured in monitor wells (Table 2) suggest a contaminant-related source. Alternatively, the elevated manganese concentrations may not be due to MMT in AVGAS, but rather from microbial degradation of hydrocarbons in the leaked fuels (http://toxics.usgs.gov/pubs/eos-v82-n5-2001-natural/). In either case, with the above noted exception, because manganese concentrations in the water supply wells are below the referenced comparison value, manganese is not a contaminant of concern (Table 2).

The water supply wells that are down-gradient (or adjacent) to the BFF plume are regularly sampled (monthly) for all of the contaminants that have been identified in BFF monitor wells. With very few exceptions (as described above), these contaminants have not been detected in the water supply wells. The infrequent detections in water supply wells (and many non-detections) suggest (but do not prove) that these contaminants are not due to groundwater migration from the

[2] It should be noted that the above substitution procedure for evaluating non-detections is not a recommended procedure (Helsel, 2009; Singh, 2006). However, in this case there are not enough detected samples to use an alternate method of evaluating non-detections.

BFF plume. More importantly, none of the VOCs or fuel-related compounds have been detected in the water supply wells (excepting the previously noted single detections of benzene and gasoline range organics in the VA Hospital well). None of the detected contaminants were present at levels above their respective comparison values (when non-detections are included for bis (2-ethylhexyl) phthalate and manganese; Table 2). Consequently, there are no contaminants of public health concern for past or current exposures in the water supply wells down-gradient (or adjacent) to the BFF plume. The following section on "Public Health Implications" includes additional discussion of the potential for future exposure via water supply wells.

Contaminants in Indoor Air: The list of contaminants for the vapor intrusion (VI) pathway (Table 3) is somewhat different than those for the groundwater pathway because VI contaminants are those that selectively volatize into air (relatively high vapor pressure and low solubility in water; EPA, 2013; http://www.epa.gov/oswer/vaporintrusion/documents/VISL-UsersGuide.pdf .

Table 3 lists the contaminants of concern for the VI pathway, the measured indoor air concentrations of those contaminants at the KAFB buildings 1026, 1032, and 1048, and non-residential inhalation (air) screening levels for each contaminant. The indoor air screening levels are based on the most protective cancer or non-cancer inhalation health comparison values adjusted for worker (as opposed to residential) exposures (see Appendix B). It should be noted that ATSDR does not typically evaluate exposures to on-site workers. Occupational (worker) exposures are usually regulated by the Occupational Safety and Health Administration (OSHA; or the New Mexico Occupational Health and Safety Bureau) or assessed by the National Institute for Occupational Safety and Health (NIOSH). The occupational standards and recommended exposures levels are referenced as a basis of comparison (Table 3).

Of the fifteen contaminants detected in indoor air at the BFF buildings, only benzene was measured at a concentration above its comparison value (Table 3). The highest benzene concentration in indoor air was 23 $\mu g/m^3$ (7/17/12, Bldg. 1026). While this concentration is about 12 times greater than the adjusted, non-residential cancer risk evaluation guide (CREG; 2 $\mu g/m^3$; Table 3), it is only 2.6 times greater than an outdoor (ambient) air sample (8.8 $\mu g/m^3$) collected at the same time. Considering that ambient outdoor benzene air concentrations in US cities ranged from 0.3 to 112 $\mu g/m^3$ (ATSDR, 2007), an indoor air concentration of 23 $\mu g/m^3$ from a building located at a major fuel distribution facility is not significantly elevated and is probably not indicative of increased concentrations via vapor intrusion.

It should also be noted that the NIOSH recommended exposure limit (REL) for occupational exposures to benzene is 266 $\mu g/m^3$ and the OSHA permissible exposure limit (PEL) is 2,660 $\mu g/m^3$ (8 hour time weighted averages).[3] However, NIOSH also recommends that exposure to carcinogens, such as benzene, be as low as feasible (http://www.cdc.gov/niosh/npg/npgd0049.html).

[3] Note that the specific REL is 0.1 part per million (ppm) which is converted to $\mu g/m^3$ using an altitude appropriate conversion factor. The NIOSH-listed conversion factor for benzene is 1ppm = 3.19 mg/m^3. At Albuquerque's altitude (~5200 feet) this conversion becomes 1 ppm= 2.66 mg/m^3 (http://www.ccohs.ca/oshanswers/chemicals/convert.html).

The measured indoor air concentrations of benzene in buildings at the BFF are within the range of typical urban air and indoor residential air (and lower than those of gas stations; ATSDR, 2007; EPA, 2011). Shallow subsurface soil gas benzene concentrations under buildings 1032 and 1048 are essentially the same as the indoor air concentrations (soil gas benzene concentrations ranged from 1.5 to 20.6 μg/m^3; CH2MHill, 2009). Soil gas concentrations are typically much higher than concentrations in overlying buildings due to contaminant reductions from diffusion and dispersion (NJDEP, 2013). This suggests that the benzene present in BFF building indoor air may be due to the ambient air from the fuel facility itself, rather than vapor intrusion from the subsurface plume. Nevertheless, the public health implications of inhalation exposure to benzene are discussed in the following section.

Table 3. Indoor Air Concentrations (BFF Bldgs) and Non-residential Screening Levels.				
Contaminant	**Bldg. 1026 µg/m^3**	**Bldg. 1032 µg/m^3**	**Bldg. 1033 µg/m^3**	**Indoor Air SL µg/m^3**
Acetone	16	22	13	31,000 EMEGc
Benzene	**23**	**6.4**	0.7	**2 CREG$_{adj}$** 266 NIOSH REL 2,660 OSHA PEL
Bromomethane	ND	1.3	0.72	19 EMEGc
2-Butanone (MEK)	4	4	5.9	5,000 RfC
Carbon tetrachloride	0.39 J	0.44	0.46	1.8 CREG$_{adj}$
Chloromethane	0.9	1.3	1	100 EMEGc
Dichlorodifluromethane	2.1	2.2	2.1	260 NJ NR SL
Ethylbenzene	14	1.8	0.2 J	260 EMEGc
Methylene chloride	0.9	4.2	0.3 J	1000 CREG$_{adj}$
Styrene	1	ND	5.4	850 EMEGc
Tetrachloroethylene	ND	0.5 J	ND	3.8 CREG$_{adj}$
Toluene	37	14	0.8 J	300 EMEGc
Trichlorofluoromethane	1.2 J	1.1 J	1.3	1,000 NJ NR SL
1,1,2-Trichloro-1,2,2-trifluoroethane	0.5 J	0.6 J	ND	44,000 NJ NR SL
o-Xylene	13	1.8	0.3 J	220* EMEGc

- Indoor air sampling results are from Shaw (2012c; 2013).
- Bldg 1032 was sampled twice; listed results are the higher values.
- EMEGc -- ATSDR environmental media evaluation guides for continuous, chronic exposure (see Appendix B for more information).
- CREG$_{adj}$ -- ATSDR cancer risk evaluation guides adjusted for occupational exposure (8 hours/day and 20 year exposure duration; see Appendix B for more information).
- NIOSH REL-- National Institute for Occupational Safety and Health Recommended Exposure Limit
- OSHA PEL-- Occupational Safety and Health Administration Permissible Exposure Limit
- NJ NR SL(New Jersey non-residential screening level) use health-based comparison values (NJ DEP Vapor Intrusion Technical Guidance, 2013; Vapor Intrusion Guidance.

* Screening levels are for total xylenes
ND-- not detected.
J = an estimated value that is less than the reporting limit but greater than the minimum detection limit.

Contaminants in Soil Gas and Outdoor Air (VA Hospital and Bullhead Park Areas): Soil vapor monitoring well cluster KAFB 106138 is directly adjacent to VA Hospital Buildings. Table 4 lists the soil gas contaminants detected in the shallowest well (15-25 feet bgl; August 2012 sample event) along with their respective soil gas screening levels. Of the seven soil gas contaminants detected only benzene is present at a concentration greater than its screening value (forty-seven additional VOCs were sampled but not detected).

These soil gas screening values are derived from health-based indoor air comparison values adjusted with an attenuation factor of 0.02 to account for the diffusion and dilution of soil gas vapors into the indoor air of overlying buildings and a 0.1 biodegradation[4] factor for hydrocarbons (NJ DEP Vapor Intrusion Technical Guidance, 2013; http://www.nj.gov/dep/srp/guidance/vaporintrusion/vig_main.pdf). The attenuation factor assumes that the soil gases are measured at a depth of 5 feet bgl. As the soil gases measured at well KAFB 106138 were from a depth of 15-25 feet bgl, the attenuation factor may be high and the resulting screening levels are commensurately health-protective.

EPA's studies on petroleum vapor intrusion sites found that 0.02 was considered a "reasonably conservative attenuation factor" for determining soil vapor concentration thresholds (EPA 2013). EPA indicates that the sub-slab attenuation factor for chlorinated solvents can be applied to petroleum hydrocarbons because little biodegradation is expected between sub-slab and indoor air. Though the EPA studies do not say anything about a biodegradation factor for soil vapor beyond the sub-slab, we know there will be attenuation with distance: groundwater sources deeper than 5 feet and LNAPL sources deeper than 18 feet resulted in soil gas below risk based screening levels. Therefore, a biodegradation factor of 0.1 seems reasonable.

Similar to the VA Hospital area, maximum soil gas concentrations from wells KAFB-106141 and KAFB-106142 (located on vacant land at the intersection of San Pedro and Ridgecrest Drives) are well below applicable screening values with the exception of benzene (Table 4). The highest benzene concentration measured in the vacant land wells is 8,640 $\mu g/m^3$ (from a depth of 15-30 feet bgl). While this concentration is above the residential and non-residential soil gas screening levels (16 and 79 $\mu g/m^3$, respectively; Table 4), the screening values assume a soil gas depth of 5 feet (bgl).

At Bullhead Memorial Park both shallow soil gas and outdoor air samples have been collected and analyzed. In July and August of 2008, representatives from NMED and CH2MHill collected air and soil gas samples (respectively). Soil gas samples are also routinely collected from KAFB 106136 located at Bullhead Park. The results of the air sampling events are presented in a draft memorandum by CH2MHill (2008) with the highest contaminant concentrations listed in Table 4. None the measured air results from Bullhead Memorial Park are above their applicable screening values (Table 3), while soil gas measurements show relatively high concentrations of benzene (Table 4; Shaw, 2012b; Shaw, 2013b). It should also be noted that the outdoor air samples from the park were not elevated above background levels (measured at Wilson Middle School). Although this suggests that vapor intrusion is not contributing measurable amounts of

[4] Biodegradation is the decomposition or breakdown of a substance through the action of microorganisms (bacteria or fungi).

contaminants to outdoor air at the park, such limited sampling may not be representative of all seasonal and atmospheric conditions.

Although there is considerable uncertainty regarding potential inhalation exposures via vapor intrusion at VA Hospital buildings and future exposures on the vacant land, the available data do indicate that potentially harmful concentrations of benzene are present in relatively shallow soil gas at those locations. The potential public health implications of exposure to benzene are presented in the next section.

Table 4. Maximum Measured Soil Gas/Outdoor Air Contaminants from Vacant Land, Bullhead Memorial Park, and VA Hospital

Contaminant	Vacant Land Soil Gas 15-30 ft. bgl µg/m³	Bullhead Memorial Park µg/m³		VA Hospital Soil Gas 15-25 ft. bgl µg/m³	Soil Gas SL (Residential) (5 ft. bgl) µg/m³	Soil Gas SL (non-Res) (5 ft. bgl) µg/m³
		Soil Gas	Outdoor Air			
Benzene	**8,640**	**9,450**	0.6	**48,600**	**16**	**79**
Cyclohexane	680	NM	NM	3,440	310,000	430,000
Ethylbenzene	140	22.8	0.3	660	53,000	74,000
Heptane	560	NM	NM	3,985	NA	NA
Hexane	2,100	NM	NM	945	36,000	51,000
Toluene	3,400	263	2.8	5,320	260,000	360,000
Xylene (total)	1,100	56.8	ND	1,892	5,500	7,700

- Soil gas screening levels (SL) use health-based indoor air comparison values adjusted using an attenuation factor of 0.02 and a biological degradation factor of 0.1 for hydrocarbon compounds (NJ DEP Vapor Intrusion Technical Guidance, 2013; http://www.nj.gov/dep/srp/guidance/vaporintrusion/visl_comparison_table.pdf).
- Note that the soil gas SLs are not applicable to the Bullhead Park outdoor air concentrations.
- Measured soil gas concentrations for KAFB 106138 are for August, 2012 (Shaw, 2012b). Forty-seven additional VOCs were analyzed but not detected.
- Note that the soil gas samples were collected at a depth of 15-25 feet bgl while the soil gas SLs assume a sample depth of 5 feet bgl.
- Ridgecrest/San Pedro vacant land soil gas concentrations based on KAFB 106141/106142 wells (15-30 feet bgl).
- VA Hospital soil gas concentrations based on well KAFB 106138 (15-25 feet bgl).
- Bullhead Memorial Park soil gas concentrations based on highest measured levels at KAFB 106136 (15-25 feet bgl). Outdoor air concentrations are highest measured levels from 3 locations at 12 inches above ground surface (CH2MHill, 2008). Note that soil gas and outdoor air samples were taken at different times and locations within the park.

NA-- screening levels are not available for heptane.
NM—not measured.

Public Health Implications

As presented in the preceding sections, there are several pathways of potential exposure by which people could come into contact with contaminated air or water emanating from the fuels released at the BFF. These pathways, including the contaminant sources, exposure routes and exposed populations, and pathway status and timeframe are summarized in Table 5.

A pathway of exposure is considered complete if people have been (*past*), are (*present*) or are likely to be (*future*) exposed to site-related contaminants. Exposure means that people ingest, inhale, or come into direct skin contact with site-related contaminants. Note that many site-related contaminants are also present at background levels in every environment. Consequently, an exposure pathway also includes a source and process of site-related contaminant migration to some location of exposure. A pathway is incomplete if people are not exposed to site-related contaminants.

There are no past, present, or expected future exposures via the groundwater (down-gradient water supply wells) pathway. BFF-related contaminants have not been detected in the water supply wells. Although it is expected that BFF contaminants would eventually migrate down-gradient to water supply wells in the absence of remedial or contingency actions, such actions are already occurring and will be upgraded in the near future (Shaw, 2012c). An ongoing groundwater monitoring program is also operating in order to determine the efficacy of ongoing and planned remedial actions and provide warning should BFF contaminants approach the drinking water wells.

In addition, the Air Force and the Water Authority have developed a “Memorandum of Agreement” to develop a water supply contingency plan. Components of this plan include: evaluation of new or alternative water supplies, development of a contaminant fate and transport model, a monitoring program to serve as “early warning system”, and an implementation schedule for contingency actions (https://kirtlandafb.tlisolutions.net/sitedocs/PDFS/20/2022.PDF).

The evaluation of future groundwater exposures must acknowledge that ongoing and planned remedial actions are occurring and planned contingency actions will occur. While the overall efficacy of these remedial actions to prevent migration of plume contaminants to down-gradient water supply wells is uncertain, the monitoring program and plans for water treatment or provision of an alternate water supply seem sufficient to ensure that people using KAFB or Water Authority water supply wells will not be exposed to BFF contaminants (above appropriate drinking water health standards) via their drinking water in the future. Consequently, the groundwater pathway is *incomplete* for past, present, and future exposures.

As with groundwater exposures, airborne emissions from the SVE extraction wells and treatment system is an *incomplete* pathway of exposure (past, present, and future; Table 5). Although low concentrations of hydrocarbon compounds are (and will be) released from the SVE system, these emissions are subject to treatment (via catalytic converters) with monitoring (KAFB/contractors) and permit oversight (City of Albuquerque Environmental Health Department). Assuming the SVE treatment and monitoring system is operated and maintained per permit conditions, hydrocarbon compound emissions should not be significantly elevated beyond those expected in urban or fuel facility environments.

Table 5. Pathways of Exposure to Fuels Released from Bulk Fuel Facility, KAFB.

Pathway	Source and Contaminants	Exposure Route and Population	Timeframe and Status
Groundwater: Down-gradient Water Supply Wells (KAFB and Water Authority wells)	Dissolved phase contaminants from plume; e.g. VOCs, EDB. None currently above CVs	Ingestion by KAFB and Water Authority water consumers	**Incomplete for past, present, and future exposure.** Ongoing and planned remedial actions should retard migration and contingency plans are in place to prevent exposure should contaminants reach WSWs.
Indoor air at BFF Buildings	Vapor phase contaminants; volatile hydrocarbon compounds, only benzene is > CV	Inhalation by KAFB workers at buildings 1026, 1032, and 1033.	**Pathway potentially complete,** past/present/future. Benzene air concentrations below occupational limits and 10E-04 risk for occupational exposures. Levels are within background range for indoor air and fuel facility- no indication that benzene is due to VI.
Vapor Intrusion at VA Hospital and vacant land (San Pedro and Ridgecrest Drives)	Unknown, contaminants may be from BFF or VA sources; volatile hydrocarbon compounds, only benzene is > CV	Inhalation by VA Hospital patients and staff; occupants of future bldgs. on currently vacant land	**Pathway is indeterminate for past/present/future exposure.** Subsurface (15-25 ft. bgl) benzene vapor concentration is elevated in these areas. No shallow subsurface (5 ft. bgl) data are available.
Air emissions from SVE treatment system at BFF	Vapor phase contaminants from subsurface fuel plume; volatile hydrocarbon compounds.	Inhalation by workers at BFF (no off-site exposures due to atmospheric dispersion).	**Incomplete for past, present, and future exposure.** Emissions are treated prior to release with appropriate monitoring and permitting.

There is one potentially complete and one indeterminate pathway for air exposures listed in Table 5; both have benzene as the only contaminant measured at levels above health comparison values (Tables 3 and 4). These pathways have different receptor (or potentially exposed) populations; KAFB personnel working at BFF buildings and patients and staff at the VA Hospital (respectively). At the BFF buildings, benzene has been measured in shallow subsurface soil gas (5 ft. bgl; CH2MHill, 2009) and indoor air samples with a maximum indoor air concentration that exceeds the preliminary health comparison value (Table 3).

Indoor air and shallow subsurface soil gas samples have not been collected from the VA Hospital building(s), but a slightly deeper soil gas concentration (15-25 ft. bgl) exceeds the soil gas screening value (based on a 5 foot bgl sample; Table 4). The following section discusses the health implications of inhalation exposures to benzene and presents the measured air concentrations relative to normal background benzene air concentrations.

Health Implications of Benzene Inhalation

The following review of benzene exposure and potential health effects is summarized from the ATSDR Toxicological Profile for Benzene (ATSDR, 2007) with other sources cited as appropriate. Benzene, also known as benzol, is a colorless liquid with a sweet odor. Benzene evaporates into air very quickly and dissolves slightly in water. Benzene is highly flammable. Benzene is found in air, water, and soil.

Benzene comes from both industrial and natural sources. Industrial processes are the main sources of benzene in the environment. Benzene levels in the air can be elevated by emissions from burning coal and oil, benzene waste and storage operations, motor vehicle exhaust, and evaporation from gasoline service stations. Tobacco smoke is another source of benzene in air, particularly indoors. Industrial discharge, disposal of products containing benzene, and leaks from petroleum storage tanks release benzene into water, soil, and air.

Everyone is exposed to a small amount of benzene every day. You are exposed to benzene in the outdoor environment, in the workplace, and in the home. Exposure of the general population to benzene mainly occurs through breathing air that contains benzene. The major sources of benzene exposure are tobacco smoke, automobile service stations, exhaust from motor vehicles, and industrial emissions. Vapors (or gases) from products that contain benzene (such as glues, paints, furniture wax, and detergents) are also a source of exposure. Auto exhaust and industrial emissions account for about 20% of the total national exposure to benzene. About half of the exposure to benzene in the United States results from smoking tobacco or from exposure to tobacco smoke. The average smoker (32 cigarettes per day) takes in about 1.8 milligrams (mg) of benzene per day. This amount is about 10 times the average daily intake of benzene by nonsmokers.

After exposure to benzene, several factors determine whether harmful health effects will occur, as well as the type and severity of such health effects. These factors include the amount of benzene to which you are exposed and the length of time of the exposure. Most information on effects of long-term exposure to benzene is from studies of workers employed in industries that make or use benzene. These workers were exposed to levels of benzene in air far greater than the levels normally encountered by the general population. Current levels of benzene in workplace air are much lower than in the past. Because of this reduction and the availability of protective equipment such as respirators, fewer workers have symptoms of benzene poisoning.

Long-term exposure to benzene can cause cancer of the blood-forming organs (as leukemia). Exposure to benzene has been associated with development of a particular type of leukemia called acute myeloid leukemia (AML). The Department of Health and Human Services has determined that benzene is a known carcinogen (can cause cancer). Both the International Agency for Cancer Research and the EPA have determined that benzene is carcinogenic to humans.

In addition to cancer, exposure to benzene may be harmful to the reproductive organs. Some women workers who breathed high levels of benzene for many months had irregular menstrual periods. When examined, these women showed a decrease in the size of their ovaries. However, exact exposure levels were unknown, and the studies of these women did not prove that benzene caused these effects. It is not known what effects exposure to benzene might have on the developing fetus in pregnant women or on fertility in men. Studies with pregnant animals show that breathing benzene has harmful effects on the developing fetus. These effects include low birth weight, delayed bone formation, and bone marrow damage.

Figure 4 shows the benzene air concentrations associated with cancer effect levels (CELs) from a number of long term occupational health studies (as summarized in ATSDR, 2007). The lowest observed CEL (leukemia) is 1,000 $\mu g/m^3$ (Ott, et.al., 1978; from ATSDR, 2007). In comparison, the NIOSH recommended exposure limit (for an 8 hour time weighted average concentration) is 266 $\mu g/m^3$ and the ATSDR CREG (adjusted for occupational exposure and 1E-04 excess risk) is 200 $\mu g/m^3$ (Figure 4).

The maximum measured indoor air benzene concentration from KAFB Bldg. 1026 (23 $\mu g/m^3$) is above the preliminary CV of 2 $\mu g/m^3$ (1E-06 excess risk CREG adjusted for occupational exposure) but well below the NIOSH REL. The highest measured indoor air concentration is within the range of ambient hourly outdoor air benzene concentrations collected and analyzed from two Albuquerque locations in 2008 (Kavouras, et.al, 2010). Ambient outdoor hourly concentrations of benzene ranged from non-detectable to 41 $\mu g/m^3$ (Table 3-1; (Kavouras, et.al, 2010). These benzene concentrations are also within the range of background indoor air benzene concentrations as summarized by the EPA (range of 95th % indoor air values is 9.9 to 29 $\mu g/m^3$; EPA, 2011a) and the range of outdoor urban air benzene concentrations (0.3 to 112 $\mu g/m^3$; summarized by ATSDR, 2007).

As previously stated, there are no shallow subsurface soil gas (5 ft. bgl) samples from the VA Hospital area. However, applying the previously referenced soil gas attenuation factor of 0.02 and a hydrocarbon degradation factor of 0.1 to the measured 15-25 ft. (bgl) benzene concentration provides a health protective estimate of indoor air benzene concentrations (EPA, 2013; NJDEP, 2013; version 3.1). Using the maximum measured benzene soil gas concentration of 48,600 $\mu g/m^3$ and the above attenuation and biodegradation factors, the maximum estimated indoor air concentration is 97 $\mu g/m^3$ (48,600 x 0.02 x 0.1=97). Because diffusion and dispersion from a depth of 15-25 ft. is likely to be greater than from a depth of 5 ft., the resulting indoor air benzene concentration is probably an overestimate of potential concentrations.

Also, estimated indoor air levels are lower when measured soil vapor concentrations are averaged over a 12 month period. Using the benzene concentrations from soil gas for four 2012 samples (from KAFB 106138; [1,782 $\mu g/m^3$ + 1,242 $\mu g/m^3$ + 48,600 $\mu g/m^3$ + 14,580 $\mu g/m^3$] ÷ 4 = 16,546 $\mu g/m^3$), the estimated annual indoor air benzene concentration is 33 $\mu g/m^3$ (16,546 $\mu g/m^3$ x 0.02 x 0.1 = 33$\mu g/m^3$).

In response to concerns about potential occupational exposures to benzene at the VA Hospital, the VA Engineering Service conducted a benzene worker screening evaluation for four workers representative of employees working adjacent to the soil vapor monitoring location (KAFB 106138; Figure 3; Building 45, Gibson St.#1, USAF Parking Lot #2, and SCI Patio #3). These analyses were conducted using SensorsSafety Products Benzene Personal Monitoring Badges for either 8 hour time weighted averages (TWA; 3 badges) or 15 minute TWA (1 badge) and use NIOSH/OSHA approved analytical procedures.

The results of these screening analyses (which were provided to ATSDR) indicate non-detections at worker protective levels for three of the badges. However, one badge returned an 8 hour TWA benzene concentration of 162 $\mu g/m^3$. While this value is below the NIOSH REL (266 $\mu g/m^3$) and the OSHA PEL (2,660 $\mu g/m^3$) and is consequently protective of worker health, it also confirms the need for additional evaluation of potential benzene vapor intrusion in this area. Note that the specific activities of the person wearing this badge will be reflected in the resulting benzene concentration such that the measured benzene levels may not be related to vapor intrusion. The measured benzene levels could occur if the person is a smoker or gassed up their car over lunch. The VA Industrial Hygienist is currently conducting follow-up queries.

The indoor air comparison value (screening level) for benzene adjusted for occupational exposure and an estimated excess cancer risk of 0.0001 (see Appendix B) is 200 $\mu g/m^3$. While the above estimate of indoor air benzene concentrations at the VA Hospital is speculative (33 or 162 $\mu g/m^3$), potential exposures there are likely to include shorter term exposures to sensitive people such as elderly and/or chronically ill individuals. ATSDR has promulgated Minimal Risk Level (MRLs) health comparison guides for such short term exposures that are explicitly developed to be protective of sensitive individuals (see Appendix B).

The MRL for acute (hours to 14 days) exposure to benzene is 29 $\mu g/m^3$ and for intermediate term exposure (14 to 365 days) is 19 $\mu g/m^3$. It is important to note that the MRLs are developed to be health protective and that exposures at these levels do not necessarily indicate that adverse health effects will occur. The above MRLs are based on lymphocytic effects to mice exposed to benzene at different exposure concentrations and durations (ATSDR, 2007). The health effects in mice occurred at benzene concentrations of 8,080 $\mu g/m^3$ (intermediate exposure) and 5,700 $\mu g/m^3$ (acute exposure; with adjustments for human doses). As the estimated maximum benzene concentrations at the VA Hospital (162 $\mu g/m^3$, 8 hour TWA) is 35 times lower than the concentration on which the acute MRL is based (5,700 $\mu g/m^3$), short term health effects are unlikely for sensitive individuals at the VA Hospital.

Considering that the highest measured and estimated indoor air benzene concentrations in BFF buildings are within the upper end of normal background range of US cities and homes, long-term exposure within those buildings does not present an increase in potential cancer risk relative to that of being in your home for the same period of time. Estimated and measured indoor air benzene concentrations at the VA Hospital Building 45 are higher, but still present a 20 year occupational cancer risk of less than 0.0001.

It is important to understand that the cancer risks calculated above are based on the most conservative assessment model available (NCRP 2001). The dose-response models used to estimate the cancer slope factor (which is the basis for the cancer risk calculation) assume that there is no threshold below which there is no dose-response and actually ignore data which suggest that such a threshold exists (NCRP 2001). It is also important to note that the complete description of cancer risk, as discussed above, is "theoretical excess lifetime cancer risk" and is a statistical concept. Due to the health protective assumptions used in calculating such theoretical risks, the actual potential for site-related cancer health effects may be zero (EPA, 2004).

While the available data indicate that measured and estimated indoor air benzene concentrations at the BFF buildings and VA Hospital (respectively) are within normal indoor air ranges, and consequently do not represent an increased chronic risk, additional data may show higher concentrations. If requested, ATSDR will review future sampling results to ensure that exposures remain as low as possible.

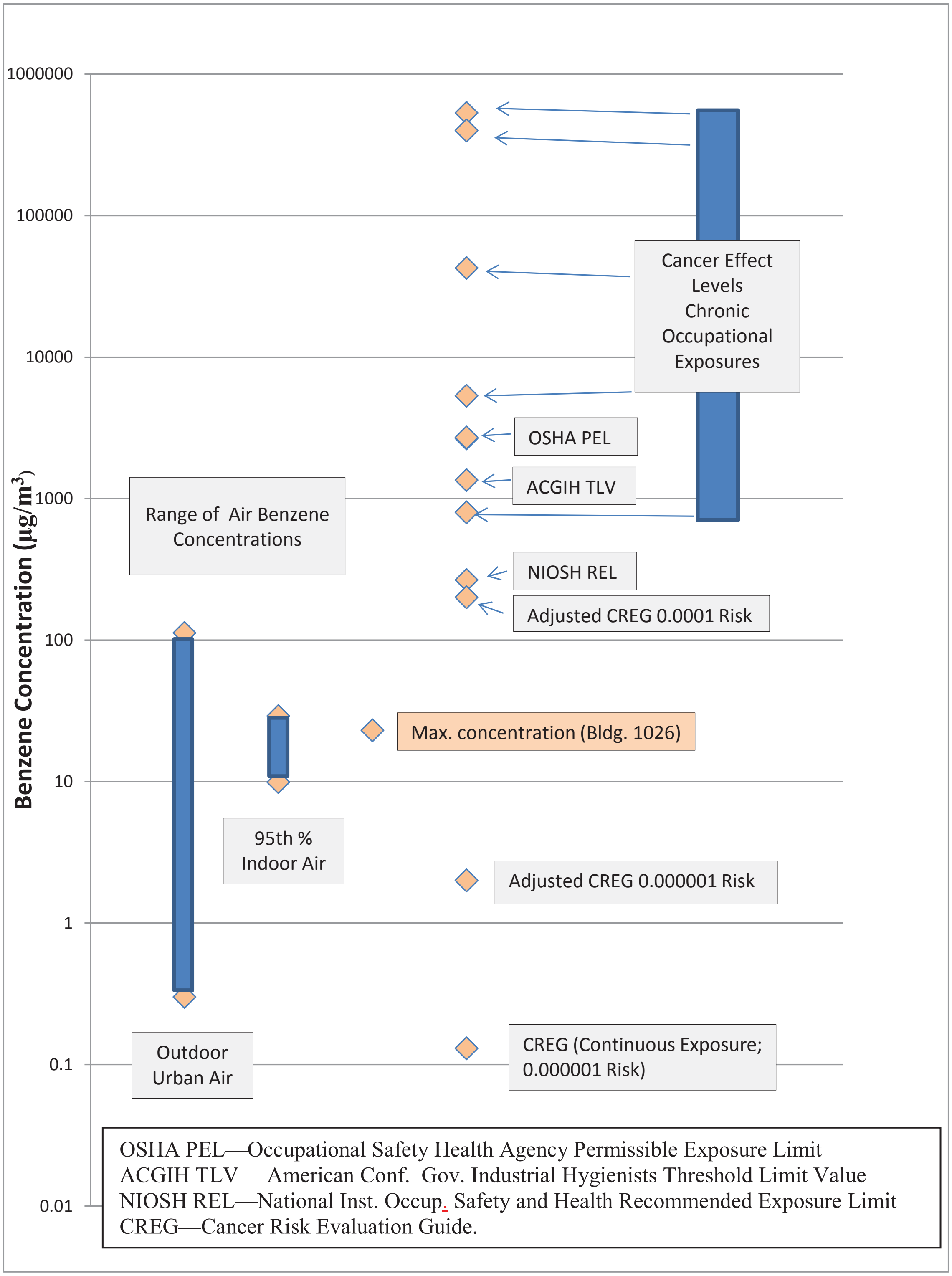

Figure 4. Observed and estimated cancer effect levels for chronic benzene inhalation, the maximum measured air concentration, background air concentrations, and calculated cancer risk levels (adjusted CREG; see Appendix B). Cancer effect levels and outdoor air concentrations are from ATSDR (2007). The 95th % indoor air concentrations are from EPA (2011a).

Adequacy of Available Information

The following public health conclusions are based on the preceding evaluation of environmental data collected by KAFB and its representative contractors with oversight by the NMED, and groundwater monitoring data collected by the Water Authority. Although there are some previously noted deficiencies in data management (i.e., manganese in groundwater), the sampling plans and quality control data indicate that, in general, the available groundwater and air monitoring data provide an adequate basis for the following public health conclusions.

Although most of the available environmental sampling data appear valid and adequate for public health determinations, both NMED and the Water Authority have identified numerous issues related to sample collection and analysis. Examples of these issues are presented in correspondence available on the NMED Hazardous Waste Bureau website (http://www.nmenv.state.nm.us/HWB/kafbperm.htm#KAFBBulkFuelsFacSpill). Specifically, a 9/13/11 letter from R.Shean (ABCWUA) to T. Berardinelli (KAFB; ABCWUA Comments on KAFB BFF Quality Assurance Program) and a 2/1/13 letter from J. Kieling (NMED) to Col. J. Kubinec and J. Pike (KAFB; Disapproval Additional Data Request and Quarterly Pre-Remedy Monitoring and Site Investigation Report for April-June 2012…) identify a number of limitations in ongoing KAFB sampling and data analysis procedures. It is important to note that, in spite of these issues, both NMED and the Water Authority accept the monitoring data used in this Health Consultation (pers. comm. W. Moats, NMED, 4/17/13; and R. Shean, ABCWUA, 4/10/13).

The primary source of uncertainty regarding the groundwater exposure pathway is how long it will take the BFF contaminant plume to reach down-gradient water supply wells (which assumes that it will reach those wells). KAFB has produced a report (Groundwater Travel Time from Bulk Fuels Facility Kirtland Air Force Base, KAFB, New Mexico; KAFB, 2010) that provides an estimate of the contaminant transport velocities and travel times from the BFF to the potentially affected down-gradient wells.

This simple contaminant transport model, based on then available hydrogeological data, indicates a worst-case scenario of 11.3 years (from 2010; based on worst case transport velocity of 0.9 feet/day) for contaminants to reach the nearest down-gradient water supply well. It should be noted that these contaminant transport times and durations are based on regional estimates of hydraulic conductivity rather than any site-specific pump test data from the aquifer zones of interest (KAFB, 2010). While the estimated travel times from this model should be updated with site-specific pump test data, these travel times/durations indicate that there is sufficient time to complete the contingency plan (and provision of alternate water supply, if necessary) contained within the KAFB- Water Authority Memorandum of Agreement (KAFB, 2012). Collectively, a large amount of groundwater monitoring data is available and was reviewed. While potential future exposures to contaminated drinking water would be expected in the absence of explicit remedial or contingency actions, such actions are proposed and if proposed actions are implemented as planned, future exposures are unlikely.

Similarly, while the available air and soil gas monitoring data indicate that benzene exposures are below levels of public health concern, there is some potential for air concentrations to be higher than those measured during a single sample event. It should also be noted that the available air and soil gas monitoring data from BFF buildings are not sufficient to determine if benzene in BFF indoor air samples are the result of VI or simply ambient levels due to the fuel facility. However, from an exposure perspective, the source is irrelevant. However, the collection and analysis of additional air or soil gas samples from the VA Hospital area are needed.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk information.

Exposures to children are accounted for in the development of drinking water standards and health comparison values (as referenced in Table 2 and Appendix B). With this exception, there is very little potential for child-specific exposures to contaminants from the BFF groundwater plume.

Conclusions, Recommendations, and Public Health Action Plan

Conclusions

ATSDR has identified four pathways by which people may be exposed to contaminants from fuels that leaked from the BFF area of Kirtland AFB:

1) Based on currently available groundwater monitoring data there are no past or current exposures via groundwater at down-gradient water supply wells. Future exposures, which are possible, will be prevented if ongoing and prospective actions to reduce or prevent exposure are implemented as planned.
2) BFF workers may be exposed to benzene in air via vapor intrusion into buildings. As measured benzene air concentrations are within the normal range of US residences and below regulated occupational concentrations, these exposures are not expected to harm people's health.
3) Workers and patients at the VA Hospital may be exposed to benzene in air via vapor intrusion into buildings. Based on available data, occupational exposures to workers and short term exposures to patients are not expected to harm people's health. However, due to the limited amount of soil gas and indoor air data available for this location, additional characterization is needed.
4) BFF workers may be exposed to hydrocarbon compounds in air via airborne emissions from the SVE treatment system. These emissions are treated prior to release and the treatment system is monitored with permit oversight. Assuming the SVE system is operated and maintained per permit conditions, potential exposures are not expected to harm people's health.

Recommendations

1) ATSDR recommends that ongoing and proposed monitoring and actions to prevent or reduce exposure continue as planned.
2) ATSDR recommends that additional characterization of shallow soil gas and/or indoor air at the VA Hospital be conducted.

Public Health Action Plan

1) ATSDR is available to evaluate any new environmental data (including planned and recommended indoor air samples) to ensure that potential exposures do not pose a public health hazard.
2) ATSDR presented the results and conclusions of this health consultation to the Albuquerque community and responded to community health concerns as appropriate.

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Appendix A: Public Comments and ATSDR Responses

Commenter One

The ATSDR Evaluation Report for the Kirtland AFB jet fuel spill is filled with conclusions that are not based on data or science. The ATSDR recommendations offer nothing that will result in real solutions. The ATSDR report should be withdrawn in its current form. The ATSDR report should not have been released in its draft form and should not be finalized in its present form. The contradictions, errors, lack of reliable data, poor analyses of remediation and alternatives for Albuquerque for water supply, misinformation about velocity and many other factors described above do not provide a reasonable basis for public discussion of the issues. One wonders why substantial taxpayer funds were spent on such a disingenuous report.

ATSDR Response: The above general comments concerning the Health Consultation are addressed below in relation to issue-specific comments.

1) Groundwater exposure pathway

The ATSDR draws the incorrect conclusion of an “incomplete pathway” for exposure where it has no facts to support any effective ongoing or future remediation. ATSDR fails to inform the public that no plan or technology is in place or even identified for remediation of the EDB plume. ATSDR then states that it is not going to evaluate the “efficacy” of remediation, of which there is none to actually evaluate. The ATSDR report proposes that there is no expected future danger from the contaminated water migrating to Albuquerque water supply wells for residents because 1) remedial action will take place, or 2) the municipal wells can be shut down, or 3) an alternate source of water found
http://www.atsdr.cdc.gov/hac/pha/HCPHA.asp?State=NM

ATSDR offers no assurance that EDB contaminated water will not be delivered to Albuquerque water users at levels that are known to the US Environmental Protection Agency (EPA) to be toxic. EDB is allowed in New Mexico drinking water at levels 5 times higher than allowed in California.

The ATSDR report paves the way for KAFB to try to escape 1) clean up of the EDB plume and 2) reduce financial liability for the largest contamination of an aquifer in US history. The ATSDR assumptions for 1) remediation and 2) availability of alternate water sources are false.

The EDB plume is headed directly toward municipal supply wells at Ridgecrest, KAFB supply well #3 and the Veterans Administration Hospital supply well.

The ATSDR report changes the emphasis of discussion from the main problem of EDB in the aquifer to the hypothetical problem of vapor intrusion of Benzene into buildings without having real data. Shutting down a building that may be too high in benzene vapor is a much different problem than shutting down the most productive portion of Albuquerque’s municipal wells.

ATSDR Response: ATSDR agrees that the contaminated groundwater plume (and the EDB levels) present a significant water resource and remediation problem. However, based on repeated statements from the Water Utility Authority, including the following statement received as a comment on this Health Consultation, contaminants from that plume will not enter the water supply system. Consequently, drinking water exposures to contaminants in the groundwater plume are unlikely to occur and do not present a public health hazard. No changes to the Consultation are necessary.

"Of course the Water Authority accepts that remediation is the key element in the prevention of the groundwater plume reaching the production wells, but the utility will not allow contamination to enter the drinking water supply in any event." Water Authority Comments on the Draft Health Consultation for the Kirtland Air Force Base Bulk Fuels Facility Spill, September 26, 2013, letter (via email) from Rick Shean, Water Quality Hydrologist, Water Authority to Mark Evans, ATSDR.

a) groundwater plume travel time/velocity

The ATSDR analysis of the plume velocity and arrival time at municipal wells in approximately 11 years is based on 2010 statements by KAFB and Shaw (the AF contractor) that are out of date and unreliable…The 2010 travel time report is contradicted by more recent information. As of March 2012, according to NMED, KAFB still underestimates the flow velocity. ATSDR should draw no conclusions whether WUA has sufficient time to meet its goals for contingency planning for the EDB contamination of municipal wells.

The ATSDR Site History disregards the problems with the Bulk Fuels Facility that were known by Kirtland AFB much earlier than 1999. KAFB failed to comply with regulations for pipeline testing and knew the pipelines would fail testing in 1985:

ATSDR Response: While ATSDR did not conduct an analysis of "plume velocity and travel time", it did reference a KAFB report on that issue. The consultation also stated that development of a "contaminant fate and transport model" is planned (under a Memorandum of Agreement between the Air Force and Water Authority) and the consultation also suggested that the model use site-specific pump test data. The above statement from the Water Authority indicates that they believe they have sufficient time to prevent EDB contamination of water supply wells. No changes to the Consultation are necessary.

b) groundwater exposure at VA Hospital

ATSDR fails to describe the groundwater contamination pathway for the Veterans Administration (VA) Hospital. The report only cites the potential for vapor intrusion into VA hospital buildings. The vapor intrusion conclusion is based on inadequate data according to ATSDR. KAFB has not provided the laboratory data for the VA monitoring wells nearest to the VA supply well. The VA monitoring well data was requested under the Freedom of Information Act. VA management has decided to shutdown the VA supply well, switching to city water supplies and the Air Force paying for the water.

ATSDR failed to fully identify contamination at the VA Hospital supply well by only identifying manganese and phthlate. Testing of water at the Veteran's Hospital well in 2011 identified the presence of flourene, and gasoline organic compounds at low levels. Benzo-a-Pyrene was found above the EPA maximum contaminant level. In May 2012, Di(2-ethylhexyl) phthlate was detected. In June 2012 1,2,4-Trichlorobenzene was detected. In September 2012, Pentachloroethane (PCE), also known as Perc, was detected. PCE is very difficult to treat once it reaches groundwater.

ATSDR does not address the concentrations of chemicals found in the groundwater monitoring well KAFB 1064 that is nearest to the VA Hospital 200 ft away in the parking lot. ATSDR did not consider the KAFB 1064 monitoring well, 200 ft distant from the supply well. In 2006 monitoring well KAFB-1064 was constructed in the VA parking lot, 200 ft away, to serve as a "sentinel" monitoring well upgradient of the VA Hospital's production well. TPH-DRO, TPH-GRO, toluene, naphthalene, phenanthrene, nitrate, dissolved iron, and dissolved manganese were detected from the very first groundwater sample. Instead ATSDR relies only on the samples found in the VA supply well. Those samples suffer from the same problems of a long well screen and dilution factor cited above for the sampling of municipal wells. Even with the high dilution factor however, GROs and benzene are showing up in the drinking water for medically compromised veterans and medical staff.

ATSDR Response: Contaminants in the VA Hospital well were evaluated and discussed in several sections of the Consultation. The "Water Supply Wells (Groundwater) Pathway" indicates that the "Veterans Administration Hospital well (VA Hosp.) is included in this pathway. The section on "Contaminants in Groundwater" also discusses contaminant detections (gasoline range organics and benzene) in the VA Hospital well. With regard to the specific contaminants listed above the ACCESS database transmitted to ATSDR contains the following information:

- *1,2,4-Trichlorobenzene—24 analyses, 22 non-detections, 2 detections (4.7 and 5.1 ppb) below the MCL (70 ppb).*
- *Benzo(a)pyrene—40 analyses, no detections (all reported values include U or QU qualifier).*
- *Fluorene—40 analyses, one detection (0.05 ppb) below applicable comparison value (RMEG-child 400 ppb).*
- *Perchloroethylene (PCE)—23 analyses, 2 detections (4.7 and 4.9 ppb) below MCL (5 ppb).*
- *bis(2-ethylhexyl) phthalate—20 analyses, 3 detections (2.2, 2.5, and 9 ppb) with only the 9 ppb value above the CREG (2.5 ppb) and MCL (6 ppb).*

The section on "Contaminants in Groundwater" includes a discussion of bis(2-ethylhexyl) phthalate in KAFB wells. Reference to the VA Hospital well detections has *been added to this section. Also, see response to comment 5 (f) below. No other changes are warranted.*

2) EDB drinking water standards/exposure limits

The allowable exposure to EDB in drinking water in New Mexico is 5 times higher than the State of California**.**

The California Office of Environmental Health Hazard Assessment (OEHHA) establishes a public health goal (PHG) of 0.01 µg/L (0.01 ppb) for ethylene dibromide in drinking water. This PHG is based on the carcinogenic effects observed in an oral study performed by the National Cancer Institute in 1978. The authors reported cancer of the forestomach in rats and mice. (See, PUBLIC HEALTH GOALS FOR CHEMICALS IN DRINKING WATER ETHYLENE DIBROMIDE September 2003 http://oehha.ca.gov/water/phg/pdf/Ph4EDB92603.pdf).

ATSDR Response: While the above responses indicate that exposure to EDB via drinking water is unlikely, the concern that the drinking water standard is not protective of public health warrants a response. As stated, the CA Public Health Goal (PHG) for EDB (1,2-dibromoethane) is 0.01 µg/L. By analogy, the US EPA MCLG for EDB is zero. However, the MCLG and PHG, as drinking water goals, do not necessarily represent contaminant concentrations likely to cause adverse health effects.

The California MCL for EDB is the same as the US EPA and New Mexico drinking water standard (0.05 µg/L; http://www.cdph.ca.gov/certlic/drinkingwater/Documents/DWdocuments/EPAandCDPH-11-28-2008.pdf). In addition to the MCL and PHG, OEHHA has also established a level of "no significant risk" for EDB exposure of 0.2 µg/day (Prop. 65; http://www.oehha.ca.gov/water/phg/pdf/Ph4EDB92603.pdf). Assuming ingestion of 2 liters of water per day, an exposure of "no significant risk" would equal an EDB water intake concentration of 0.1 µg/L, which is higher than both the CA and EPA MCLs. ATSDR has also evaluated the potential health effects of EDB exposure and developed health comparison values that are similar to those of the US EPA and CAL OEHHA (http://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=726&tid=131). Collectively, the above referenced documents indicate that the enforceable drinking water standard for EDB is protective of public health.

3) Data quality

ATSDR relies almost exclusively on the information from the polluter KAFB and Shaw Environmental for its data and conclusions. There is no indication in the report that the ATSDR visited the Kirtland AFB site.

ATSDR disregards:
1) the many years of Notices of Deficiencies and Disapprovals from NMED,

2) the years of failure to comply with the NMED April 2, 2010 order,
3) the findings of the WUA Resolution 12-14 (Attachment 1) and,
4) statements of other scientists for the poor quality of data collected by Kirtland and its contractors.
Available groundwater data for the municipal wells is not adequate to determine exposures. Municipal well screens are several hundred feet long, unlike monitoring wells which have 10 ft long screens. The municipal wells can pump up to 2850 gal. per minute which is an extremely high dilution factor for detection of ethylene Dibromide (EDB) that is measured in parts per trillion. Additionally, the most sensitive testing methodology is not used for the sampling. Due to the low maximum contaminant level (MCL) of EDB (0.05 μg/L) two additional, specialized EPA methods for EDB analysis have been developed. Method 504.1 is a more sensitive indicator than the method 8011 that is used. http://www.epa.gov/oust/cat/Section_3-Properties_and_Methods.pdf.

The ATSDR is accepting compromised groundwater monitoring data. ATSDR makes the statement that there are:
"a number of limitations in ongoing KAFB sampling and data analysis procedures. It is important to note that, in spite of these issues, both NMED and the Water Authority accept the monitoring data used in this Health Consultation."

ATSDR fails to present the personal communications from ABCWUA Rick Shean and NMED William Moats or conduct its own analysis of the "limitations" in the data that ATSDR believes is confirmed in the Health Consultation. (Report, p. 22).

The sampling of soil and groundwater have been conducted inappropriately and resulted in groundwater monitoring data that is not reliable and representative.
Currently, ten (10) shallow groundwater monitoring wells have flooded well screens that cannot provide reliable and representative groundwater samples.
The fact that quarterly sampling often gives such varied results for the presence or non-presence of different GROs and DROs for a long-standing plume of LNAPL contamination is additional evidence that groundwater sampling is incompetent.

ATSDR Response: The various state and federal laws regulating the KAFB groundwater monitoring and remediation activities place responsibility for required environmental monitoring upon the responsible party. These data collection activities are conducted using prescribed sampling and analytical procedures with review and oversight by NMED (and additional review by the Water Authority). Consequently, ATSDR (as well as NMED and the Water Authority) must use data collected by KAFB (or its contractors). As noted in the Consultation, ATSDR also received and evaluated monitoring data collected and analyzed by the Water Authority.

While the available groundwater monitoring data do have some deficiencies (as described in the Consultation), these deficiencies need to be viewed in an appropriate perspective. KAFB has collected thousands of environmental samples and chemical analyses. It is statistically impossible for all of these samples to be collected and analyzed without mistakes. It should be noted that the sampling/analytical deficiencies described above (and referenced in the Health

Consultation) were documented by this review/oversight process, which suggests that this process is working.

While ATSDR has reviewed the quality assurance data associated with the monitoring samples, it has not, and will not, conduct a complete data quality assurance audit of the monitoring data (as this is beyond the scope of the Health Consultation). However, ATSDR has asked NMED and Water Authority representatives if the available data are reliable and representative. The responses (via telephone, referenced as personal communications in the Consultation), were that, with the exceptions noted in the Consultation, the vast majority of monitoring data are reliable and representative. No changes are warranted.

4) Vapor intrusion concerns

ATSDR should provide information for where the expected levels of soil vapor gas will come from. Most of the LNAPL is trapped approximately 500 ft below the water table. No description of how much product remains in the vadose zone is presented. Vapor intrusion became a major focus of the report despite the fact that groundwater contamination is the primary problem.

ATSDR discussion of background exposure seems to be along the lines of “We’re already being exposed, a little more can’t hurt.” A little more can cause damage and there can be legal liability. There is no evidence of "safe threshold levels" when it comes to benzene exposure. Under California law (Thelma L. Rutherford, et al. v. Owens-Illinois, Inc. 1997. 16 Cal. 4th 953), one does not need to prove that exposure to a particular defendants' product actually caused his cancer, but needs only to show defendants' product (in this case, benzene) was a substantial factor in increasing the risk of developing cancer.

Benzene is hematotoxic at levels below 1 ppm. The U.S. EPA Maximum Contaminant Level Goal (MCLG) is zero (0.00) for benzene. Instead, the ATSDR uses occupational guidelines to address exposures that would/should not be present in the workplace but for the negligence of the AF in allowing the leaking to occur for possibly 50 years. The ATSDR does not consider the non-occupational exposures that will be in addition to occupational building exposures. Sensitivities of various persons such as children, asthmatics, the elderly and pregnant women are inadequately considered

Bulk Fuels Facility workers may be women. Exposures to benzene, which is a carcinogen, can be dangerous for pregnant women and the fetus. Epidemiologic studies of adults show clear evidence of causal association between benzene exposure and certain leukemias. http://www.epa.gov/teach/chem_summ/BENZ_summary.pdf

Two studies are available that measured prenatal or early life exposure to benzene. One study measured concentrations of benzene in cord blood in humans as an estimate of placental transfer of benzene; benzene was detected in fetal cord blood at levels equal to or greater than those levels found in maternal blood. Benzene was also detected in breast milk. (Ibid). Prenatal exposures may be linked to miscarriages, lighter birth weight. Childhood leukemia may be associated with paternal benzene exposure. Acute nonlymphocytic leukemia was significantly associated with maternal occupational exposure to benzene during pregnancy.

ATSDR does not consider the potential for increased sensitivity of medically compromised veterans being treated in the VA hospital. The conclusion that no harm is “expected” cannot be made based on the available data that is admittedly “limited” for the vapor intrusion that is possible. Just how limited the data is, is stated by the ATSDR as “no direct measurements of air near the VA hospital;” measurements of soil vapors not being collected from soil vapor monitoring wells, and; unknown levels from past fuel tank leaking at the VA….

The ATSDR does not provide the size of the past VA fuel tank leak, the date of the occurrence, the distance to the VA hospital or the fate and transport.

The ATSDR provides contradictory statements regarding benzene exposure in the buildings. ATSDR states: “The highest benzene concentration in indoor air was 23 µg/m3 (7/17/12, Bldg. 1026). While this concentration is about 16 times greater than the adjusted, non-residential cancer risk evaluation guide (CREG; 1.4 µg/m3; Table 3), it is only 2.6 times greater than an outdoor (ambient) air sample (8.8 µg/m3) collected at the same time.” ATSDR then dismisses the heightened concentration being inhaled by building occupants by stating that “an indoor air concentration of 23 µg/m3 from a building located at a major fuel distribution facility is not significantly elevated and is probably not indicative of increased concentrations via vapor intrusion.”

The Vapor Intrusion information is largely bogus and unsubstantiated. ATSDR has not investigated the volumes of vapor that are available from deep in the groundwater for Vapor Intrusion to be a significant factor. The data used by ATSDR is from boreholes rather than samples actually taken from inside the buildings.

ATSDR Response: As described in the Consultation, the data that underlies the vapor intrusion analysis includes measurements of shallow soil gas contaminant concentrations and where available direct measurements of those same contaminants in indoor (and outdoor ambient) air. The obvious source of subsurface petroleum vapors at the BFF is from the leaked fuels. While most of this leaked fuel migrated down to the water table (at depths of 450-500 ft. bgl), a residual portion will remain as a vapor phase in the shallow vadose zone as evidenced by the elevated soil gas measurements.

As stated in the Consultation, the source of soil gas vapors at the VA Hospital is uncertain. According to Kathy Boyd (NMED-Albuquerque) the VA has permits for 8 petroleum storage tanks with at least 3 currently in use (2—600 gallon; 1—1,000 gallon). A leaking 600 gallon tank was removed and remediated per NMED requirements in the mid-1990's. Alternatively, fuels from the BFF, via subsurface migration, could be the source of elevated soil gas vapors at the soil gas monitoring wells in the VA parking lot. Regardless of source, it is important to determine whether those elevated soil gas levels present a health hazard for people working or visiting the VA Hospital.

As presented in the Consultation, the potential health hazard was evaluated by screening the individual contaminants comprising the petroleum compounds. Of these specific contaminants, only benzene was present in either soil gas or indoor air at concentrations above applicable health screening levels. The evaluation of benzene exposures is complicated by the fact that as a component of gasoline, tobacco smoke, and other household products, measureable concentrations of airborne benzene are essentially everywhere.

Consequently, the evaluation of BFF-specific health hazard from benzene exposure must determine whether site specific exposures exceed normal background exposures. If the site specific levels are not elevated with respect to background levels, as is the case with the measured BFF air concentrations and the estimated VA Hospital air concentrations, there is no increased exposure attributable to the BFF fuel plume.

Regarding the toxicity of benzene, the health consultation specifically addresses exposures to sensitive individuals (such as women of child-bearing age or immuno-compromised individuals). No additional changes are warranted.

It should be noted that this version of the Consultation does include important changes to the sections dealing with vapor intrusion. A recent evaluation of vapor intrusion data for petroleum hydrocarbon compounds by the US EPA includes new findings concerning screening criteria and soil gas-indoor air attenuation factors (EPA, 2013). The primary findings of this report are that the lateral or vertical separation distances between subsurface soil gas and affected indoor air are much lower than previously recommended screening distances. These findings are incorporated in this revised Consultation.

5) Other concerns

a) The Figure 2 map used by ATSDR is from 2011 and out of date.

ATSDR Response: Figure 2 has been revised using more recent information.

b) A plan for a containment well was only partially approved by NMED because it could make the plume travel further toward the northeast where municipal wells are located:

> "NMED staff said that the light non aqueous phase liquid (LNAPL) containment well that was drilled to stop the forward movement of the fuel product floating on the water table have been delayed due to some concerns raised at the NMED that the wells may act to pull the LNAPL plume further downgradient, rather than halt its movement. NMED staff told the board that the three concerns they have for the status of this site is the data gap that exists for the extent of the dissolved phase plume, the existence of ethylene dibromide (EDB) above the drinking water standards at all depths, and the evidence of a "diving" EDB at the farthest reach of the dissolved phase plume.

c) The nature of the Rio Grande aquifer that relies on "mountain front recharge" from precipitation is not addressed. See http://pubs.usgs.gov/ha/ha730/ch_c/C-text4.html

GROUND WATER ATLAS of the UNITED STATES
Arizona, Colorado, New Mexico, Utah HA 730-C, Rio Grande Aquifer

ATSDR Response (5b/5c): Comments noted, no changes warranted.

d) ATSDR incorrectly states that (p. 5):

> "Thus, most of the leaked fuel is present as a 'light non-aqueous phase liquid' (or LNAPL) which is not dissolved in groundwater and the LNAPL migrates down-gradient at a different rate relative to the underlying groundwater."

ATSDR disregards Shaw's quarterly technical reports since at least 2011 that the bulk of the LNAPL has been trapped beneath the water table and is dissolving into the aquifer. The June 2012 Quarterly Report states:

> "NAPL chemical analytical results show that the trapped NAPL will be an ongoing source of dissolved groundwater contamination indefinitely."

ATSDR Response: The above statements are not mutually exclusive. ATSDR is aware of the recent increase in groundwater levels in relation to the LNAPL plume, but that observation does not materially affect potential future groundwater exposures at down-gradient water supply wells. No changes are warranted.

e) ATSDR incorrectly touts the new system replacing the original Soil Vapor Evaporation (SVE) system. ATSDR fails to recognize the inefficiencies of the SVE system and that it cannot remediate the EDB dissolved plume, as described by NMED. (http://www.nmenv.state.nm.us/HWB/documents/KAFB-12-024_5-23-2013_Disapproval_SVE_Treatment_System_WP.pdf).

ATSDR Response: Potential exposure to EDB at down-gradient water supply wells is not dependent on the efficacy of the SVE system. See response to Concern 1 (above). No changes are warranted.

f) ATSDR does not recognize that KAFB reported to NMED that Supply wells 15 and 16 are not functional. ATSDR states that, "The Water Supply Wells include: KAFB Wells 3, 15, and 16." EDB is not being monitored in 15 and 16 because they are shut down. There are no plans for repair or restart of 15 and 16. KAFB 16 is high in arsenic levels and that may be an additional reason along with a $30,000 repair cost factor for not repairing the supply well.

ATSDR should consider whether the high levels of phthalate are nonetheless being presently served up to service personnel and their families. ATSDR waves away the high concentration results for bis (2-ethylhexyl) phthalate in water supply wells that are above the MCL at KAFB supply wells #3, and #16 by claiming that perhaps the results are from leaching from pipes or laboratory equipment. With out knowing the reason for the concentrations, ATSDR concludes that "it is very unlikely" that long term concentrations in the drinking water will be above the MCL. KAFB #3 supply is in the direct pathway of the EDB plume. KAFB #16 is high in arsenic.

ATSDR Response: ATSDR evaluated contaminant exposures in KAFB wells 3, 15, and 16 because these wells were active water supply wells and in the vicinity of the BFF groundwater plume. If KAFB 15/16 are shut down and not re-activated there will be no potential future exposure from those wells.

The Consultation discusses the sporadic, low concentration detections of bis (2-ethylhexyl) phthalate in several of the water supply wells. As discussed, it is uncertain if those detections represent false positives (based on analytical or sampling error) or are indicative of actual levels of groundwater contamination. While the relative infrequency of the detections suggests analytical/sampling error, if real, the long term average concentrations are below the MCL such that bis (2-ethylhexyl) phthalate is not a contaminant of concern per ATSDR screening guidance. No changes are warranted.

g) Data collected in 2004 showed PCE contamination in Kirtland drinking water supply Well #17. Very little data is available for PCE in drinking water on and around Kirtland. (NMED Curry 11/26/08). Is KAFB #17 still operational?

ATSDR Response: KAFB Well 17 is located along the far southwestern boundary of Kirtland AFB (about 7 miles from the BFF) and it is not affected by the BFF groundwater plume. ATSDR has not requested or received any monitoring data from this well and is unaware of its operational status. PCE analyses are conducted as part of the ongoing BFF-related groundwater monitoring program. No PCE detections have occurred in KAFB wells 3, 15, 16 or the VA Hospital well. No changes are warranted.

h) The lack of any data for bio-degradation for EDB in Albuquerque's aquifer was not mentioned by ATSDR. The false representations of KAFB regarding bioremediation of the EDB were not addressed. The possible volume of EDB released over decades from millions of gallons of aviation gasoline and the amount of water that can already be contaminated in the aquifer was not discussed. That amount can be in the range of billions of gallons of contaminated water. ATSDR recognized over a decade ago that EDB degrades "scarcely at all." NMED later informed Kirtland that EDB does not naturally biodegrade. A half teaspoon of EDB can contaminate approximately 9,000,000 gallons of water. A half teaspoon of EDB was in every gallon of aviation gas as an anti-knock agent.

ATSDR Response: Comment noted. Please see the responses to comments 1 and 2 above. No changes are warranted.

i) The map of the former Bulk Fuels Facility (BFF) site Fig. 1 incorrectly describes the location of the former BFF.

ATSDR Response: While Figure 1 makes no reference to the location of the former fuel facility the outlined area does include the source area of historic fuel leakage. However, the Figure 1 caption has been revised to indicate that the referenced BFF area is an approximate location and portions of the former fuel area may be outside the delineated area.

j) ATSDR states:

> "It should be noted that ATSDR does not typically evaluate exposures to on-site workers. Occupational (worker) exposures are usually regulated by the Occupational Safety and Health Administration (OSHA) or assessed by the National Institute for Occupational Safety and Health (NIOSH)."

Why did ATSDR not call on OSHA or NIOSH to perform the exposures to workers? Why did ATSDR not consider the exposures that workers may have already been subjected to in the past at the various building locations.

ATSDR Response: ATSDR forwarded a draft version of the Consultation to NIOSH for review. NIOSH approved the Health Consultation with minor comments concerning references to the NIOSH benzene exposure limit. As measured benzene concentrations were about 10 times lower than applicable OSHA/NIOSH worker exposure limits neither agency is likely to undertake additional actions. No changes are warranted.

Commenter Two

1) …the report also concludes that "future exposures, which are possible, will be prevented if ongoing and prospective remedial actions are implemented as planned." With respect to this we wish to point out that municipal wells would be shut down before contamination entered the drinking water supply, based on sampling from "sentry" wells. To the extent that this is not a "remedial action" we would appreciate it if this point were clarified in future drafts.

ATSDR Response: ATSDR agrees that removing a well from service is not a remedial action. The relevant text has been revised to "…ongoing and prospective actions to reduce or prevent exposure are implemented…"

Commenter Three

1) …for the past four years I have experienced headaches, dizziness and a upset tummy. I understand that this Department is interested in hearing from the Public Sector and I consider myself as a single disabled person/elderly.

I want to know why the City of Albuquerque has not considered to build a Water Plant rather than continue to making the public sick? The reason that I say this is because it is not just the Southeast area that the contamination will flow, it is the entire area of Albuquerque, NM….

ATSDR Response: As discussed in the Consultation, there has been and is no current exposure to contaminated groundwater from the KAFB fuel spill via the public water supply wells. Consequently, any current or past health effects experienced by a resident of Albuquerque are not due to groundwater contamination from the BFF fuel plume. No changes are warranted.

Commenter Four

1) …request deleting Item 3) in the Conclusions on Page v and the Recommendation on Page vi from the report because "Based on the available data mentioned in the report the exposures are not expected to harm people's health"… removing all VA references because there are many inconclusive statements and many contradictions with words used such as may, could, possible, although, suggests, not known, etc…remove the following paragraph on Page 9 because the word "possible" is used and the past VA Hospital Fuel Tank Leak was from a 600-gallon Diesel Tank almost 200 yards away (of which the VA Hospital coordinated with the state of New Mexico it removal and received a clean report)…This report is not taking into consideration many factors that could contribute to elevated levels of benzene such as the Albuquerque National Airport is adjacent to the VA Property along with other Gasoline Sources on site including staff and patient vehicles, etc. and has no real basis that patients and staff are being exposed as a result of the fuel spill.

ATSDR Response: As stated in the Consultation, ATSDR agrees that the potential for exposure to airborne contaminants via vapor intrusion at the VA Hospital is uncertain. However, ATSDR cannot ignore the potential public health implications of the elevated benzene soil gas concentrations from the sampling location in the VA Hospital parking lot. ATSDR also agrees that the source of the measured soil vapor benzene concentrations is unlikely to be a remediated fuel storage tank 200 yards from the sample location. However, this means that the source of the soil vapor is unknown and the subsurface extent of those elevated vapor levels may extend to areas closer to the VA buildings (both laterally and vertically).

In the absence of additional data identifying the source of the soil vapor or confirmation that vapor intrusion is not occurring within VA buildings, the conclusion of an "indeterminate" pathway of exposure is retained along with the recommendation for additional evaluation. Also, the Consultation discusses ambient sources of airborne benzene and specifically addresses such background levels in relation to potential exposures. The information about the remediated fuel tank has been added to the Consultation including the observation that it is unlikely to be the source of the elevated soil vapor levels.

It should also be noted that this version of Consultation also includes reference to recent shallow soil gas benzene levels from the KAFB SVMW 106138 (VA Parking Lot) location that are measured at a concentration of 48,600 $\mu g/m^3$. This concentration is potentially significant from a public health perspective and should be further evaluated.

Commenter Five

Could the soil gas levels at the east end of Bullhead Park be monitored…All the groundhogs are gone…Could the soil gas levels have been toxic to the groundhog colony?

ATSDR Response: As discussed in the Consultation, ATSDR has evaluated the human health implications of measured ambient air contaminant levels in Bullhead Park. While these data are limited in sampling frequency, they are indicative of normal background air concentrations.

However, there are three soil gas monitoring stations in or adjacent to Bullhead Park (KAFB 106136/106141/106142). The shallowest sample depths at these locations are 15 to 20 feet below ground level and recent measured benzene concentrations were 9,450 µg/m^3, 8,640 µg/m^3, and 3,780 µg/m^3 (respectively; August, 2012). ATSDR can make no determination as to the toxicity of those measured benzene levels on groundhogs. As recommendations by ATSDR for additional environmental sampling must be based on potential human health effects, it can offer no support for additional sampling based on potential effects to the groundhog colony.

Commenter Six

1) Reviewed work product lacks info regarding Albuquerque air shed VOCs levels. I have obtained this information from Ken Lienmann of the Albuquerque Air Control Board and attached here.

ATSDR Response: Information and appropriate citation from the above referenced document has been added to the Consultation. Note that according to this document, the measured ambient benzene concentrations at the Albuquerque locations are within the previously referenced national ranges such that substantive changes to the Consultation are not warranted.

2) Health Consult product lacks discussion or material regarding natural attenuation of fuel products and ethylene dibromide.

ATSDR Response: As there is no completed pathway of exposure for ethylene dibromide (EDB) discussion of attenuation is unnecessary. With regard to attenuation of fuel products (such as BTEX compounds), the exposure analysis for BFF locations is based on direct air measurements such that attenuation and discussion thereof is not applicable. Subsurface attenuation (biodegradation) of benzene is significant with respect to the evaluation of potential vapor intrusion at the VA Hospital. As such, a benzene biodegradation factor is incorporated in the soil gas screening levels included in Table 4. A note indicating this provision has been added to the Consultation.

3) Health consult product lack specific information regarding preferentially pathways i.e. things like desiccation cracking and deep rooted plant transport for soil gases to the atmosphere.

ATSDR Response: While such preferential pathways of soil gas migration are conceptually significant to the process of vapor intrusion, the available monitoring data and reports do not include any site specific information that allows for informative discussion of these features. No changes are warranted.

4) The identification of Benzene near the VA hospital has anecdotally been attributed to the closure of a historical Underground Storage Tank (UST) closed in the 1990s. Current BFF investigation has not been able to identify another pathway between the two areas. The recommendation infers that KAFB should do the additional characterization, even though the

source of the benzene could have originated from a non-BFF source. Conclusion #3 indicates, in part, that "due to limited amount of soil gas data available for this location, additional characterization should be conducted." Specific technical issues raised by other Air Force comments question the validity of this conclusion. In addition to these issues, the conclusion is overly broad. It would be more informative if the text identified the objective(s) of additional characterization.

If the recommendation for further sampling is retained, please note that numerous authoritative references have demonstrated that direct measures of indoor air (assuming adequate controlling of background and indoor sources and using multiple lines of evidence) is the superior approach for measuring potential vapor intrusion within a building, especially compared to using soil gas data and highly uncertainty and variable attenuation factors. [For example, see McHugh et al. "Protocol for Tier 2 Evaluation of Vapor Intrusion at Corrective Action Sites." (2012). ER-200707. Environmental Security Technology Certification Program; and McHugh T., et al. ES&T 2012, 46 (9), pp 4792–4799.]

AF disagrees that "However, due to the limited amount of soil gas data available for this location, additional characterization should be conducted." EPA (2013) guidance reminds PVI assessment authors that, 'The soil gas distribution of aerobically biodegradable chemicals (e.g., BTEX) can be significantly different than that of other chemicals that are not biodegradable (i.e., are recalcitrant) in similar settings. Specifically, the vapor concentrations of aerobically biodegradable chemicals exhibit greater attenuation than those of recalcitrant chemicals when the subsurface availability of oxygen is adequate." For this reason, the 0.02 NJ attenuation factor could be overly conservative, and the newer provisions of EPA 2013 PVI guidelines should also be considered.

Spreadsheet from NMED shows 7 USTs at Albuquerque VA Hospital.

This states "Therefore, it is not known whether elevated soil gas vapors at the VA Hospital originate from the BFF source or from a past VA Hospital fuel tank leak." If there is at least one documented VA hospital fuel leak in the area, we should say that, so the public is aware of other potential sources.

For vapor intrusion at VA Hospital and vacant land, Table 5 summarizes the source and contaminants as "vapor phase contaminants from subsurface fuel plume". This is inconsistent with the text on page 15, lines 40-41, which states "it is not known whether elevated soil gas vapors at the VA Hospital originate from the BFF source or from a past VA Hospital fuel tank leak."

ATSDR Response: See above response to Commenter Four. As stated several times in the Consultation, the source of the elevated soil gas concentrations at the VA Hospital is not known (Table 5 has been revised for consistent language). While ATSDR agrees with the above statement that "Current BFF investigation has not been able to identify another pathway *between the two areas…", ATSDR believes that the limited soil vapor sampling locations between the BFF and VA are not sufficient to rule out such a pathway of contaminant migration.*

ATSDR likewise agrees that indoor air sampling is the preferred parameter for assessing potential air exposures. However, there are several ways to further evaluate the elevated soil gas levels and it is outside the scope of this consultation for ATSDR to develop or recommend any specific sampling processes. ATSDR is available to review any prospective sampling plans to ensure that the resulting data provide adequate information for evaluating potential human exposures.

It should be noted that the above referenced EPA (2013) Petroleum Vapor Intrusion Guidance report was released as a draft document for public comment with the specific provision that it not be cited, quoted, or referenced. Consequently, ATSDR will not use or reference the recommendations contained in that draft report until it is released for unrestricted use.

5) This Health Consultation fails to adequately address the potential health risks associated with benzene vapor intrusion and does not follow the state-of-the-science exclusion process that is employed by most states for petroleum hydrocarbon VI screening. Most VI guidance excludes sites based on the lateral or vertical distance from the source of contamination. Additionally, most VI guidance addresses the likelihood of biodegradation of benzene in the soil.

ATSDR Response: The section on "Health Implications of Benzene Inhalation" provides an adequate summary of the potential cancer and non-cancer health effects from benzene exposure. Application of a "state-of-the-science exclusion process for petroleum hydrocarbon VI screening is not pertinent for the BFF fuel spill site. Extensive soil vapor monitoring at the BFF found elevated soil gas concentrations directly adjacent to BFF buildings. Consequently, NMED required KAFB to conduct indoor air sampling at those locations. Detections of several airborne hydrocarbons (specifically benzene) indicate that this is a complete pathway of exposure and ATSDR evaluated the health implications of those exposures.

Alternatively, at the VA Hospital location, the available soil gas data do not allow identification of the specific source or distribution of measured soil gas hydrocarbon levels. Consequently, it would be inappropriate to use any default distance exclusion process as justification for ignoring this potential public health problem. No changes are warranted.

6) This states "BFF workers may be exposed to hydrocarbon compounds in air via airborne emissions from the soil vapor extraction (SVE) treatment system. These emissions are treated prior to release and the treatment system is monitored with permit oversight. Assuming the SVE system is operated and maintained per permit conditions, potential exposures are not expected to harm people's health." Given that the emissions will be treated and the treated emissions will be released into the ambient air outside of buildings, where it will rapidly diffuse, any exposure should be negligible.

ATSDR Response: ATSDR agrees that exposures from this pathway are negligible and therefore considers it to be "incomplete for past, present, and future exposure." Nonetheless, it warrants evaluation as a possible means of exposure to BFF workers. No changes are warranted.

7) This states "This report indicates that volatile organic compound concentrations in a depth-restricted monitor wells are 40 to 80 times higher than those in an adjacent water supply well (Bexfield, et.al, 2012). This indicates that contaminant concentrations in water supply wells with large vertical screen openings are greatly diluted relative to depth-restricted monitor wells.

ATSDR Response: "Shallower" has been added to referenced text.

8) 24 million gallons is an estimate provided by NMED personnel to a local media outlet. To date, no mathematical calculation method has been presented to support this estimate. Current investigation is focusing on measurable concentrations that are central to determining the effects on future remedial efforts.

ATSDR Response: ATSDR agrees that the 24 million gallon estimate may be speculative. It is included in the Consultation because it is a published estimate by an NMED representative and commonly referenced by the Albuquerque community. No changes are warranted.

9) ATSDR's role is as described in of the draft report (essentially to collect, evaluate, and assess potential public health concerns related to contamination at the site subject to study). ATSDR should not use the opportunity of the Public Health Assessment to expand its role into documenting general community concerns, which ATSDR itself describes as primarily related to documenting contaminant migration and remediation and the pace and goals of the remediation process. Air Force would thus urge modification of pages 7-9 so that ATSDR is reporting on health-related concerns and not general concerns associated with remediation. ATSDR should not use the opportunity of the Public Health Assessment to expand its role into documenting general community concerns, which ATSDR itself describes as primarily related to documenting contaminant migration and remediation and the pace and goals of the remediation process. Each of these questions should/will be addressed to some extent in the RCRA Facility Investigation (RFI) Report and subsequent Corrective Measures Evaluation (CME).

ATSDR Response: ATSDR agrees, and the document states, that many of the community concerns relate to remediation of groundwater contaminants. However, the community members believe, and ATSDR concurs, that several of these "remedial" issues have important public health significance in terms of potential future exposures. ATSDR also agrees that many of these issues will be resolved with ongoing investigation and corrective measures. However, that is not a sufficient reason to mute legitimate community concerns. No changes are warranted.

10) Currently the public is supporting ABCWUA's pursuit of 2 new monitoring points at both Ridgecrest #3 & 5.

ATSDR Response: Comment noted.

11) In the table “proscribed” should be “prescribed”.

ATSDR Response: Changed as suggested.

12) The background information does not tell when Kirtland Army Air Field became Kirtland Air Force Base.

ATSDR Response: Comment noted.

13) Add distances from buildings to plume. Compare to other source at VA.

ATSDR Response: All map figures have distance scales and building outlines. The contaminant plume outlines shown in Figures 2 and 3 are interpretations based on available data and change when new data become available (by Shaw, various dates). In Figure 3, the location of the benzene vapor plume area surrounding KAFB 106138 (in the VA Parking lot) is highly speculative as it is based on only a single data point. As the edge of the plume and source are unknown, it would be highly misleading to develop a specific distance measurement to nearby buildings. No changes are warranted.

14) Regarding Figure 2, the information is outdated so KAFB provided an updated edb plume model to ATSDR on 10 July 2013 from the Jan-Mar13 Quarterly Report dated Jun13. It is important to show the most recent information for this project, because it has such a strong public interest.

ATSDR Response: Figure 2 has been replaced with current plume model chart.

15) No figures show the location of “Soil vapor monitoring well cluster KAFB 106138” to determine exactly how close the phrase “is directly adjacent to VA Hospital Buildings” is in linear feet. (The numbers on Figure 3 are of such poor quality as to be illegible: if labeled there, then clarify the Figure 3 text so the point can be located.)

ATSDR Response: A label has been added to Figure 3.

16) Table 2 Title. Consider changing the title of the table. The table only lists chemicals that exceeded screening values. The way it reads the table should have the maximum concentrations of chemicals whether they exceeded the screening levels or not. If this is the case, the maximum concentrations for nitrate and phenol should be in this table. Why include only maximum concentrations that exceeded screening levels for groundwater in Table 2, but include all the chemicals for indoor air and soil gas with chemicals that exceeded screening levels highlighted in Tables 3 and 4?

The paragraph mentions that nitrate and phenol concentrations did not exceed their screening values. This means the chemicals were detected but concentrations were below screening values. However, lines 28-29 says only 13 groundwater chemicals were detected. If phenol and nitrate were detected than more than 13 chemicals were detected.

Also, it can be confusing mentioning chemicals that were detected in the text but are not in the table. Include a heading for the chemicals in the tables.

Nitrogen and phenol presence used as indicators of biodegradation.

ATSDR Response: The table title has been changed to "Maximum Concentrations of Groundwater Contaminants in KAFB Monitor and Nearby Water Supply Wells (Adjacent to BFF Area) Detected at Concentrations above Health Comparison Values." As explained in text, nitrate and phenol were not measured in either monitor or water supply wells above their applicable comparison values and are consequently not listed in Table 2. No other changes are warranted.

17) This information (Shaw, 2012c) only incorporates the summer sample (Jul 2012) and is not the most current information.

ATSDR Response: The review includes data from both the July 2012 and January 2013 sample events. A citation for the January 2013 sample event has been added to the document.

18) Perhaps change "AF personnel" to "AF contract support". The personnel that work in the fuels facility yard are not AF employees, but are contractors. Change "KAFB workers" to BFF contract workers.

ATSDR Response: Comment noted. No change warranted.

19) Recommend deleting the phrase "However, NIOSH also recommends that exposure to carcinogens, such as benzene, be as low as feasible." This represents the NIOSH's "old policy", and is not reflected in their current "New Policy" that states "NIOSH recommended exposure limits (RELs) will be based on risk evaluations using human or animal health effects data, and on an assessment of what levels can be feasibly achieved by engineering controls and measured by analytical techniques." See: http://www.cdc.gov/niosh/npg/nengapdxa.html

ATSDR Response: A previous draft of this consultation had incorporated the new NIOSH policy on carcinogens. In reviewing and approving of this Consultation, NIOSH indicated that they are not planning on updating their benzene RELs per their "New Policy" and suggested reversion to the "old policy".

20) Recommend ATSDR change the CREGadj listed in Table 3 to reflect the 10-4 risk estimate for consistency. Page 30 of Appendix A accurately describes that EPA uses the upper end of their risk range, i.e. a 10-4 risk estimate, if justified, based on site-specific conditions, such as remaining uncertainty on the nature and extent of contamination. The document then states that

"Consequently, a cancer risk of 1.0E-04…is taken as the benchmark for identifying KAFB benzene exposures that constitute an occupational health hazard (140 ug/m3; Figure 4)." This is inconsistent with Table 3 (pg 14) and related text. Changing the CREGadj to 140 ug/m3 would then mean that the highest concentration of benzene in indoor air at 23 ug/m3is safe by all screening levels. It also avoids the confusion of setting a screening level that falls within the middle of US ambient outdoor benzene air concentrations. However, please see comment below regarding incorrect calculation of the CREGadj.

ATSDR Response: As discussed in the Consultation (Appendix B), the ATSDR procedure for screening carcinogens is similar to the risk assessment procedure of the EPA (http://www.epa.gov/oswer/riskassessment/ragsb/index.htm) in that initial screening assumes a target risk level of 1E-06 (ATSDR, 2005) and standard exposure factors. Carcinogens present at concentrations that present a calculated risk of 1E-06 or greater (assuming standard exposure factors) are subject to further analysis. Consequently, benzene air concentrations greater than 2 µg/m3 require further evaluation. No additional changes are warranted.

21) The AF agrees that the attenuation factor of 0.02 is health-protective given that the soil gas measurements were taken at a depth of 15-25 feet bgl. However, it is unclear why ATSDR did not also utilize an attenuation factor to account for benzene biodegradation, as recommended by NJ DEP Vapor Intrusion Technical Guidance Version 3.1 (pg 68).

Nor it is clear why ATSDR did not recommend either developing a site-specific attenuation factor or skipping soil gas measurements altogether in lieu of indoor air samples. See comment below regarding EPA's finalized petroleum VI guidance in April 2013 (released for public comment through June 2013)

Evaluation of EPA (2013) 510-R-13-001 and lessons learned from the EPA petroleum vapor intrusion (PVI) database would suggest that the following statement is unnecessarily conservative: "Although there is considerable uncertainty regarding potential exposures via vapor intrusion at VA Hospital buildings and future exposures on the vacant land, the available data do indicate that potentially harmful concentrations of benzene are present in relatively shallow soil gas at those locations. The potential public health implications of exposure to benzene are presented in the next section."

EPA finalized its petroleum VI (PVI) guidance in April 2013 (released for public comment through June 2013), so EPA guidance may be more or equally relevant for consideration in New Mexico rather than use of New Jersey attenuation factors and 2005 screening levels.

It is unclear why NJ DEP VI Technical Guidance (2012) is used as a basis for attenuation factors for Kirtland AFB, which is in New Mexico.

Link not active; tables were updated March, 2013.

Neither the text nor Table 4 footnotes explain why soil gas at 15-25 ft bgl should be compared to NJ screening levels intended for soil gas collected at 5 ft bgl. EPA (2013) EPA 510-R-13-001 indicates, "there are typically sharp reaction fronts where the PHC vapor concentrations attenuate by orders of magnitude over short distances (e.g., 1 to 5 ft [0.3 to 1.5 m]) and where there is a corresponding decrease in the oxygen concentrations, as observed in several field studies"

ATSDR Response: The NJ DEP Vapor Intrusion Guidance was undergoing revision concurrent with the release of this Consultation and formerly active web links were replaced with a newer version. The revised version of this Consultation references the revised NJ DEP Guidance (NJ DEP, 2013). The revised NJ DEP VIG uses a biological degradation factor of 0.1 for hydrocarbon compounds that is incorporated into the soil gas screening levels. This consultation references those updated soil gas screening levels and also applies the biodegradation factor to estimation of air concentrations from soil gas (for benzene).

While the above referenced EPA Petroleum VI guidance has not yet been released for use, a related EPA report (EPA, 2013) has been released and its findings referenced in this Consultation. That report suggested use of a soil gas to indoor air attenuation factor of 0.02, which is consistent with NJ DEP Guidance and incorporated in this Consultation.

ATSDR did not recommend development of a KAFB-specific attenuation factor because the available data are inadequate for this purpose. As stated in the Consultation, the use of an attenuation factor developed for a soil gas sampling depth of 5 feet bgl is probably conservative for samples from 15 feet bgl. However, this assumes that shallow soil gas levels are lower than deeper measurements. For the VA Hospital sampling location this may not be the case; benzene soil gas concentrations at 15-25 feet are higher than those from 40-50 feet (48,600 $\mu g/m^3$ vs. 35,100 $\mu g/m^3$; August, 2012 sample data; Shaw, 2012c). Considering that the specific source of elevated soil gas concentrations at this location is unknown, it would be inappropriate to assume that 5 foot bgl concentrations are necessarily lower than those from a 15-25 foot depth.

22) The Contingency Plan is already being created. It is due to be finalized by March 2014.

ATSDR Response: Comment noted.

23) ATSDR states that additional data may show "higher concentrations", despite the fact that current data show levels are within normal indoor air ranges. Given that there are ongoing remediation efforts at the source area, and there is likely biodegradation of benzene occurring within the soil, it is unclear under what circumstances additional data would show higher concentrations. This seems to contradict EPA (2013) Petroleum Vapor Intrusion (PVI) guidance out for public comment, along with EPA databases such as EPA 510-R-13-001 (January 2013).

ATSDR Response: ATSDR agrees that the long term potential for vapor intrusion should be declining due to remediation and biodegradation. However, as discussed in the Consultation, the *measured and estimated indoor air benzene levels may be attributable to ambient sources such as normal operations at the BFF or the adjacent airfield/airport rather than from vapor intrusion. If so, normal variations in environmental conditions, such as wind speed and direction, could lead to higher, localized short term benzene air concentrations. No changes are warranted.*

24) It is not clear what the purpose is of identifying NMED and Water Authority issues for the sampling.

ATSDR Response: That section of the Consultation discusses whether the available data provide an adequate basis for the ATSDR's public health decisions. As described, both NMED and the Water Authority, as well as ATSDR, have identified a number of deficiencies in the data provided by KAFB. However, it is the opinion of these reviewing agencies that the described deficiencies should not preclude use of the vast majority of the data for public health or monitoring and remedial decision making.

25) The Public Health Action Plan indicates that ATSDR will evaluate any new environmental data to ensure that potential exposures do not pose a public health hazard. ATSDR should also consider evaluating any proposed sampling plans for the collection of this data. This will help ensure that data collected will meet the criteria need to properly assess potential public health hazards.

The Public Health Action Plan indicates that ATSDR will "present the results and conclusions of this health consultation to the Albuquerque community and respond to community health concerns as appropriate." Is this statement referring to the meeting that occurred 30 July 2013 or is there another meeting planned?

ATSDR Response: ATSDR is available to review any new data or sampling plans that may be related to its public health mission. ATSDR is not currently planning another public meeting related to release of this final version of the Health Consultation. ATSDR will provide a public notice of document availability concerning its completion and availability, distribute this document to all interested respondents, provide copies for local libraries and post electronic versions on the ATSDR web site.

26) The document states that the CREG is based on the EPA established cancer slope factor, however does not site the slope factor, or the equation. The ATSDR continuous CREG does not match the EPA Regional Screening Level (RSL) for residential air. EPA RSLs are based on the EPA IRIS cancer slope factor for benzene and utilize a standard equation. It is undeterminable why the CREG values are different than EPA RSLs.

The CREGadj appears to have been calculated incorrectly. The description of the derivation of this value states: "This is adjusted for occupational exposure by multiplying 0.13 µg/m3 x 8/24 (hours per day) x 250/365 (days per year) x 20/70 (years of exposure). The resulting occupation

CREG for benzene is 1.4 µg/m3."   Not only is this mathematical equation incorrect for adjusting to an occupational exposure scenario, but the resulting answer cannot be reproduced. 0.13 µg/m3 x 8/24 (hours per day) x 250/365 (days per year) x 20/70 (years of exposure) = 0.008, NOT 1.4.

Nonetheless, the correct equation should be: DIVIDING 0.13 µg/m3 by [8/24 (hours per day)] / [250/365 (days per year)] / 20/70 [(years of exposure)], which would equal 1.99 (rounded to 2 ug/m3), for a 10-6 risk level.   Intuitively, if EPA's industrial RSL (25-year exposure) number is 1.6 µg/m3, the ATSDR adjusted (20-year) number should be higher (reflecting less exposure), not lower. Once corrected, please also see comment above regarding the need to portray concentrations up to the 1E-04 risk level (e.g., 200 µg/m3, once corrected) as within the acceptable (risk management) range.

ATSDR Response: As stated above, the CREGadj was calculated incorrectly. The correct equation is:
0.13 µg/m^3 ÷ 8/24 (hours per day) ÷ 250/365 (days per year) ÷ 20/70 (years of exposure
The resulting occupational CREG for benzene is 2 µg/m3. Appropriate changes have been made to all sections of the Consultation.

The ATSDR CREG is calculated using the same equation (and cancer slope factors) as the EPA RSLs except that the CREG assumes a 78 year lifetime exposure period while the EPA RSL assumes exposure for only 30 years. The ATSDR equations for calculating CREGs and other health comparison values are included by reference to the ATSDR Public Health Assessment Guidance Manual (ATSDR, 2005).

As discussed in the Consultation (Appendix B), the ATSDR procedure for screening carcinogens is also similar to the risk assessment procedure of the EPA (http://www.epa.gov/oswer/riskassessment/ragsb/index.htm) in that initial screening assumes a target risk level of 1E-06 (ATSDR, 2005) and standard exposure factors. Carcinogens present at concentrations that present a calculated risk of 1E-06 or greater (assuming standard exposure factors) are subject to further analysis. Consequently, benzene air concentrations greater than 2 µg/m^3 require further evaluation. No additional changes are warranted.

Appendix B: Health Comparison Values and Dose Calculation Procedures

When a hazardous substance is released to the environment, people are not always exposed to it. Exposure happens when people breathe, eat, drink, or make skin contact with a contaminant. Several factors determine the type and severity of health effects associated with exposure to contaminants. Such factors include exposure concentration, frequency and duration of exposure, route of exposure, and cumulative exposures (i.e., the combination of contaminants and routes). Once exposure takes place, individual characteristics—such as age, sex, nutritional status, genetics, lifestyle, and health status—influence how that person absorbs, distributes, metabolizes, and excretes the contaminant. These characteristics, together with the exposure factors discussed above and the specific toxicological effects of the substance, determine the health effects that may result. The following summary of ATSDR's procedure for developing health comparison values and calculating exposure doses is derived from the ATSDR Public Health Assessment Guidance Manual (ATSDR, 2005).

ATSDR considers these physical and biological characteristics when developing health guidelines. Health guidelines provide a basis for evaluating exposures estimated from concentrations of contaminants in different environmental media (soil, air, water, and food) depending on the characteristics of the people who may be exposed and the length of exposure. Health guideline values are in units of dose such as milligrams (of contaminant) per kilogram of body weight per day (mg/kg/day).

ATSDR reviews health and chemical information in documents called toxicological profiles. Each toxicological profile covers a particular substance; it summarizes toxicological and adverse health effects information about that substance and includes health guidelines such as ATSDR's minimal risk level (MRL), EPA's reference dose (RfD) and reference concentration (RfC), and EPA's cancer slope factor (CSF). ATSDR uses these guidelines to determine a person's potential for developing adverse non-cancer health effects and/or cancer from exposure to a hazardous substance.

An MRL is an estimate of daily human exposure to a contaminant that is likely to be without an appreciable risk of adverse non-cancer health effects over a specified duration of exposure for sensitive individuals and children (acute, less than 15 days; intermediate, 15 to 364 days; chronic, 365 days or more). Oral MRLs are expressed in units of milligrams per kilogram per day (mg/kg/day); inhalation MRLs are expressed in micrograms per cubic meter ($\mu g/m^3$). MRLs are not derived for dermal exposure.

RfDs and RfCs are estimates of daily human exposure, including exposure to sensitive subpopulations that are likely to be without appreciable risk of adverse non-cancer health effects during a lifetime (70 years). These guidelines are derived from experimental data and lowest-observed-adverse-effect levels (or no-observed-adverse-effect levels), adjusted downward using uncertainty factors. The uncertainty factors are used to make the guidelines adequately protective for all people, including susceptible individuals. RfDs and RfCs should not be viewed as strict scientific boundaries between what is toxic and what is nontoxic.

For cancer-causing substances, EPA established the cancer slope factor (CSF; http://www.epa.gov/iris/help_ques.htm#cancersf). A CSF is used to estimate the theoretical excess cancer risks expected from maximal exposure for a lifetime. Cancer risk evaluation guides (CREGs) are estimated contaminant concentrations that would be expected to cause an estimated excess theoretical cancer risk less than 1.0E-06 (or 0.000001). The CREGs and CSFs represent statistical estimates of risk and are not indicative of actual health effects. Specifically, a one in a million risk does not mean that one person (out of a million exposed) will get cancer, but rather that one person exposed has a theoretical cancer risk probability of 1.0E-06.

ATSDR CREGs are calculated assuming that exposure is continuous over a person's lifetime (24 hours per day, 365 days per year, for 70 years). Such continuous exposure is not relevant for occupational exposures which only occur during workdays. Consequently, the adjusted CREGs assume exposure for 8 hours per day, 250 days per year, for 20 years. For benzene, the continuous exposure CREG is 0.13 $\mu g/m^3$. This is adjusted for occupational exposure by dividing 0.13 $\mu g/m^3$ ÷ 8/24 (hours per day) ÷ 250/365 (days per year) ÷ 20/70 (years of exposure. The resulting occupational CREG for benzene is 2 µg/m3.

ATSDR CREGs are also calculated using an initial excess risk of 1E-06 (0.000001). However "EPA uses the general 10-4 (1 in 10,000) to 10-6 (1 in 1,000,000) risk range as a "target range" within which the Agency strives to manage risks as part of a Superfund cleanup.… A specific risk estimate around 10-4 may be considered acceptable if justified based on site-specific conditions, including any remaining uncertainties on the nature and extent of contamination and associated risks. Therefore, in certain cases EPA may consider risk estimates slightly greater than 1 x 10-4 to be protective" EPA. 1991. OSWER Directive 9355.0-30. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions.
http://www.epa.gov/oswer/riskassessment/baseline.htm
Consequently, a cancer risk of 1.0E-04 (0.0001; expressed as a theoretical excess 20 year occupational risk) is taken as the benchmark for identifying KAFB benzene exposures that constitute an occupational health hazard (200 $\mu g/m^3$; Figure 4).

Health comparison values (CVs) are estimated contaminant concentrations that are unlikely to cause detectable adverse health outcomes when these concentrations occur in specific media. CVs are used to select site contaminants for further evaluation. CVs are calculated from health guidelines and are presented in media specific units of concentration, such as micrograms/liter (µg/l) or ppm. CVs are calculated using conservative assumptions about daily intake rates by an individual of standard body weight. Because of the conservatism of the assumptions and safety factors, contaminant concentrations that exceed comparison values for an environmental medium do not necessarily indicate a health hazard.

For nonradioactive chemicals, ATSDR uses comparison values like environmental media evaluation guides (EMEGs), cancer risk evaluation guides (CREGs), reference dose (or concentration) media evaluation guides (RMEGs), and others. EMEGs, since they are derived from MRLs, apply only to specific durations of exposure. Also, they depend on the amount of a contaminant ingested or inhaled. Thus, EMEGs are determined separately for children and adults, and also separately for various durations of exposure. A CREG is an estimated concentration of a contaminant that would likely cause, at most, one excess cancer in a million people exposed over a lifetime. CREGs are calculated from CSFs. Reference dose (or concentration) media evaluation guides (RMEGs) are media guides based on EPA's RfDs and RfCs.

EPA's maximum contaminant levels (MCLs) are maximum contaminant concentrations of chemicals allowed in public drinking water systems. MCLs are regulatory standards set as close to health goals as feasible and are based on treatment technologies, costs, and other factors.

Health comparison values, such as EMEGs and MCLs, are derived using standard intake rates for inhalation of air and ingestion of water, soil, and biota. These intake rates are derived from the ATSDR Public Health Assessment Guidance Manual (ATSDR 2005) or from the EPA Exposure Factors Handbook (EPA 2011b). Doses calculated using health protective exposure factors and environmental concentrations are considered "health protective doses" because it is unlikely that any real community exposures are greater than the calculated doses and are most likely to be less than the health protective doses.

After estimating the potential exposure at a site, ATSDR identifies the site's "contaminants of concern" by comparing the exposures of interest with health guidelines, or contaminant concentrations with comparison values. As a general rule, if the guideline or value is exceeded, ATSDR evaluates exposure to determine whether it is of potential health concern. Sometimes additional medical and toxicological information may indicate that these exposures are not of health concern. In other instances, exposures below the guidelines or values could be of health concern because of interactive effects with other chemicals or because of the increased sensitivity of certain individuals. Thus additional analysis is needed to determine whether health effects are likely to occur.

Exposure doses via ingestion are calculated on the basis of the following equation:

Dose (Ingestion) = (Chemical Conc. x IR x EF x ED x ABS) / (BW x AT)

Where:
Chemical Conc. = concentration of each contaminant (in mg/g, µg/g, mg/L, or µg/L; with appropriate unit conversion factors)
IR = ingestion rate (in grams/day or liters/day)
EF = exposure frequency in days per year
ED = exposure duration in years
ABS = a chemical-specific absorption or bioavailability factor (unitless)
BW = body weight in kilograms
AT = averaging time in days