Health Consultation

NATIONAL ENERGY TECHNOLOGY LABORATORY – ALBANY

ALBANY, OREGON

(FORMERLY KNOWN AS: ALBANY RESEARCH CENTER)

UNITED STATES DEPARTMENT OF ENERGY

EPA FACILITY ID: OR2141590008

OCTOBER 25, 2006

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

Health Consultation: A Note of Explanation

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

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

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Prepared by:

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

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Summary and Statement of Issues

Several volatile organic compounds (VOCs) have been detected in groundwater under and adjacent to the Albany Research Center, (NETL-A) Albany Oregon. These VOCs, including carbon tetrachloride, chloroform, tetrachloroethylene, and trichloroethylene (TCE), have been detected in groundwater under the NETL-A facility and the Liberty Elementary School on the east side of the NETL-A facility and in residential drinking water wells on the south and west sides of the site. Extensive soil gas and indoor air monitoring at the school conducted by DOE with Oregon Department of Environmental Quality (DEQ) oversight has determined that there is no past or current public health hazard related to the contaminated groundwater under the school.

In response to the detected VOC contamination at the NETL-A site, the DEQ initiated a survey of private wells adjacent to the NETL-A site and determined that VOCs were present in about ten drinking water wells south and west of the NETL-A site. Residents at these locations have been provided with bottled water and plans to hook up these residences with municipal water were initiated. As a result of these actions, there are unlikely to be any future exposures to VOC-contaminated groundwater of public health significance at these residential locations.

The DEQ has requested that ATSDR conduct a Public Health Consultation of past exposure to VOC-contaminated soil and groundwater to determine if those exposures posed an "unacceptable risk to human health." On the basis of other community concerns about the NETL-A site, DEQ has also requested that the health consultation include an evaluation of the "historical cleanup of radiological materials from an undeveloped portion of the NETL-A property, and about beryllium-contaminated dust found inside NETL-A buildings."

The groundwater and well monitoring data in off-site drinking water wells indicate that at least 10 households have been exposed to VOCs via ingestion of water, direct skin contact with the water, and inhalation of vapors from the water. Comparison of the estimated VOC doses at 9 of the 10 locations with health comparison values and doses associated with adverse health effects in humans and laboratory animals indicates that adverse health effects are unlikely. *Past exposures* to VOCs (including carbon tetrachloride) at these locations are "no apparent public health hazard." This determination means that exposures to site-related contaminants has or may be occurring, but at levels unlikely to create any adverse health effects.

Past exposure to carbon tetrachloride and TCE at one location represents a *public health hazard*. Although the highest estimated doses are below levels that have created adverse health effects in studies of laboratory animals, long term exposure at the residence with the highest concentration could lead to diseases of the liver, kidney, or central nervous system.

The contaminant concentrations on which these dose estimates are based reflect only current or recent groundwater conditions at each location. There is no information available to determine when the contaminants were released into the groundwater or the rate of migration of those contaminants. Based on the provision of bottled water to all affected residences, *current and future* exposures to VOCs via contaminated groundwater are "no apparent public health hazard."

NETL-A conducted metallurgical research involving melting, machining, welding, and alloying of thorium, with limited operations involving separation, purification, and processing of uranium. Radioactive wastes from these activities were treated and buried in the "back forty" area. Estimated radiological doses for occasional walking across or playing in the "back forty"

area are below levels of public health concern. Additional evaluation will be required if there is any change in the use of this property; especially any activities involving excavation.

NETL-A was engaged in beryllium research until the 1980's. In January 2005, small quantities of beryllium were discovered inside buildings at the NETL-A (NETL, 2006). Airborne beryllium monitoring at NETL-A has not detected any beryllium in outdoor perimeter monitors (NETL 2006). There have been occasional beryllium detections in specific buildings and in personal monitors (during sorting of legacy beryl ore samples; NETL, 2006b). Although unlikely, a site visitor may have been in these buildings. No adverse health effects would be expected from such an occasional or intermittent exposure to the detected beryllium concentrations. Potential exposures to beryllium and radiation are no apparent public health hazard.

Background

Site Description and History

The NETL-A site, also known as the Albany Research Center, occupies a 42 acre parcel of land in the western portion of Albany, Oregon (Figure 1). The northern and central portion of the site contain a number of administrative and laboratory buildings while the southern portion (the "back forty") is a vacant, grassy area, formerly used for waste disposal. The NETL-A facility was developed in the mid-1940s as a metallurgical research laboratory operated by the US Bureau of Mines. The NETL-A facility was transferred to the US Department of Energy in 1996 when Congress closed the Bureau of Mines.

Research operations at the NETL-A site have involved various metallurgical operations including melting, machining, welding, and alloying both radioactive and non-radioactive metals. Although several of the operations probably included the use of VOCs as industrial solvents and de-greasers, there has been no documentation of potential historic VOC sources. Consequently, there is no available information on the time frames for potential VOC usage, specific processes or locations of VOC usage, or historic VOC disposal practices.

Routine groundwater monitoring at the NETL-A site was initiated in 2002. In 2005, VOC analyses from a newly installed monitor well detected TCE along the eastern boundary of the NETL-A site. Subsequent soil and soil vapor monitoring at the adjacent Liberty Elementary School indicated that there are no detectable quantities of TCE or related VOCs migrating from groundwater into the school (http://www.netl.doe.gov/about/groundwater/GroundwaterMonitoringHistoryatARC.html).

ODEQ has measured trace concentrations of VOCs in air at various Albany locations, including the Liberty Elementary School. However, these background concentrations are present in all urban areas (ATSDR, 1997) and do not represent a public health hazard. ATSDR concurs with ODEQ that there is no past or current public health hazard related to the contaminated groundwater under the school and that the reported indoor levels of TCE at the school(s) and throughout the Albany area are not expected to result in adverse health effects (cancer or non-cancer).

In May of 2005, a survey of residential wells near the NETL-A site was conducted and subsequent VOC monitoring of those wells indicated that detectable concentrations of several different VOCs were found in 10 drinking water wells (http://www.netl.doe.gov/about/groundwater/airmonitoring.html). Affected residents were provided with bottled water and plans were initiated to provide those residents with city water. At this time, most of the affected residences have been hooked up to the municipal water system and no longer use the wells for drinking or domestic purposes.

From 1948 to 1956, radioactive thorium operations at the NETL-A facility included various melting, machining, welding, and alloying processes (DOE, 1985). Additional research on uranium and thorium alloys was conducted from 1955 to 1978 (DOE, 1985). During these operations, portions of the Biomass Area and Back Forty (Figure 1) were used as waste disposal areas. These areas have been decontaminated and surveyed for residual radioactive contamination several times during the 1948 to 1985 time frame (DOE, 1985).

"In 2004 residual beryllium contamination associated with historic beryllium use at Albany Research Center was identified. The precise origins and dates of beryllium operations have not been determined, though it certainly was already present in 1987" (http://www.eh.doe.gov/advocacy/faclist/showfacility.cfm). NETL-A is currently conducting a beryllium monitoring program which includes both facility/building environmental monitoring and worker surveillance and education activities. Potential exposures to beryllium are evaluated in the following section.

Figure 1. NETL-A facility map and location of on-site monitor wells.

Demographics

Figure 2 shows the location of the NETL-A facility on western margin of the City of Albany, Oregon. This figure also characterizes the population residing within one mile of the facility (based on the 2000 census data). The total (estimated) population within one mile of the NETL-A facility is 6,424 which includes 600 children under age 6, 811 people over age 65, and 1440 women of child-bearing age. Note that about one half of the area adjacent to the NETL-A facility is within the Albany City limits and the other half in unincorporated Benton County. Most residences and other buildings within the City of Albany are hooked into the municipal water system. Many residences in the unincorporated area utilize private wells for drinking water and/or irrigation.

In addition to the residential population adjacent to the NETL-A facility, three schools are also directly adjacent to the NETL-A. These schools utilize municipal water and extensive VOC monitoring has indicated that there is no contamination (above background) at the schools. **(http://www.netl.doe.gov/about/groundwater/GroundwaterMonitoringHistoryatARC.html)**

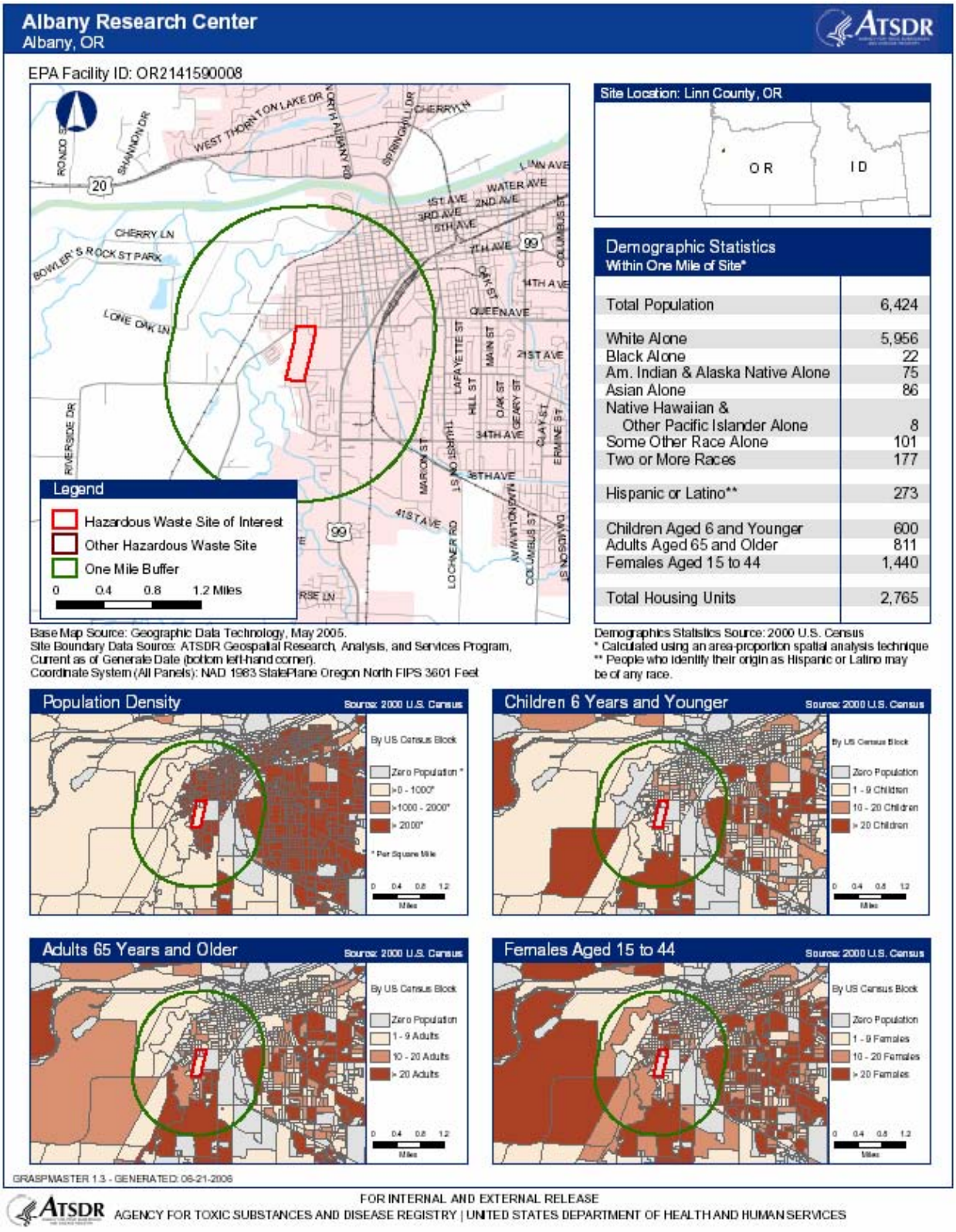

Figure 2. Location of NETL-A facility and demographics of surrounding area, Albany OR.

Community Health Concerns

DEQ has held three public meetings to present and discuss VOC monitoring data collected in the area around the NETL-A site (April 4, 2005; May 17, 2005; and July 28, 2005). The community health concerns presented by area residents to DEQ at these meetings are directly reflected in the issues underlying this health consultation. These issues, as described in the letter requesting an ATSDR health consultation are "concerns about this (VOC) contamination, about the historical cleanup of radiological materials from an undeveloped portion of the NETL-A property, and about beryllium-contaminated dust found inside NETL-A buildings."

As part of its initial visit to the NETL-A site, ATSDR held a public availability session on April, 19, 2006 in order to provide community members an opportunity to discuss their concerns about the NETL-A site with ATSDR representatives. People attending this meeting provided ATSDR with valuable background information about potentially affected wells and groundwater usage in the areas surrounding the NETL-A facility and reiterated the community health concerns obtained by the DEQ. Attendees reiterated the community health concerns presented to the DEQ (listed above), but did not provide any additional health concerns.

Discussion

VOC Exposure

Recent analyses of groundwater samples from residential wells adjacent to the NETL-A site have consistently detected mostly low concentrations of several VOCs. The specific compounds, their measured concentrations, and health comparison values (CV) are listed in Table 1. Carbon tetrachloride, PCE, and TCE were the only compounds detected at concentrations above their respective comparison values. Note that only one well (listed as Well A in Table 1) had VOC concentrations significantly above the comparison values and had the highest concentrations of most of the compounds.

The CVs are calculated concentrations of a substance in air, water, food, or soil that are unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health evaluation process. Exposure to these compounds at concentrations greater than their comparison value does not necessarily mean that someone will get sick. Substances found in amounts greater than their CVs are selected for further evaluation by estimation of the doses that people may be exposed to via drinking or direct absorbtion of the contaminants from water and breathing them in air. These estimated doses are then compared with doses that have resulted in disease or sickness for people or laboratory animals. The health implications for each contaminant are presented in a discussion that relates the potential doses with the specific diseases or health effects caused by each contaminant.

Table 1 shows the three contaminants that had concentrations above their respective comparison values. These contaminants, shown in **bold type**, are carbon tetrachloride, TCE, and vinyl chloride. Estimated doses and cancer risks for these three contaminants are listed in Table 2. The estimated dose in Table 2 are based on measured concentrations of each contaminant in three different wells (listed as A, B, and C). These wells had the highest measured contaminant concentrations, with Well A much higher than all other wells. Other wells had only trace concentrations of VOCs.

Table 2 includes estimated oral doses for both adults and children based on measured VOCs from the three drinking water wells (identified as Wells A, B, and C) with the highest contaminant concentrations. Well A has concentrations of carbon tetrachloride and TCE that are more than 50 times higher than Wells B and C and vinyl chloride concentrations that are approximately equal (all are less than 1 µg/L). According to the owner of the Well A house, this property has been rented to a variety of tenants, who have all lived at this house for three years or less (M. Evans, pers. comm.) Consequently, cancer risk estimates for the Well A location have been adjusted from standard lifetime durations of 30 or 70 years to 5 years (Table 2).

Adult doses are estimated assuming a person drinks 2 liters of water per day (from the household source) and weighs 70 kg (154 pounds). Doses for children assume 1 liter per day water ingestion and a weight of 16 kg (35 pounds). In addition to the oral dose from drinking water, for these VOCs a person may also absorb these compounds directly from contaminated water through the skin (dermal dose) and breathe the compound in the air (inhalation dose).

Studies have shown that exposure to volatile organic compounds (VOCs) from routes other than direct ingestion might be as large as the exposure from ingestion alone. The inhalation dose due to volatization during a shower may equal the ingestion dose from 1.3 liters of water (Wan, et.al., 1990) and that 50—90% of VOCs in water may volatize during showering, laundering, and other activities (Moya et al, 1999; Giardino and Andelman, 1996). Similarly, the dermal dose has been estimated to equal 30% of the ingested dose (Maine DEP/DHS, 1992). Based on the results of these studies, combined VOC exposure doses in Table 2 are summed to include an inhalation dose that is 70% of the ingestion dose, and a dermal contact dose that is 30% of the ingestion dose.

In addition to the estimated oral and combined doses to carbon tetrachloride, TCE, and vinyl chloride, Table 2 also includes several different comparison values for each compound. These comparison values are MRLs, RfDs, and CSFs as defined below:

> **MRL**-- (minimal risk level) is an estimate of the daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during a specified period of exposure (acute—minutes to 14 days; intermediate—14 to 365 days; chronic—more than 1 year);
>
> **RfD**--(Reference Dose) is a daily dose that is likely to be without discernable risk of deleterious effects to human population (including sensitive subgroups) during a lifetime of exposure.
>
> **CSF**--(cancer slope factor) is an estimate of age-averaged lifetime excess cancer incidence rate per unit intake.

A discussion of the estimated doses and possible health effects from exposure to each to these contaminants is presented in the following sections.

Table 1: Concentrations of VOCs in residential wells adjacent to the NETL-A site.

Compound	*Concentration Range: µg/L*	*Well A Max. Conc. µg/L*	*All other Wells Max. Conc. µg/L*	*Comparison Value: µg/L*
Carbon tetrachloride	ND—110	**110**	**2**	0.3 CREG 7 RMEGc
Chloroform	ND—26	26	0.7	100 EMEGcc
1,1-Dichloroethene	ND—12	0.006	12	90 EMEGcc
Cis-1,2-Dichloroethene	ND—1.9	0.012	1.9	70 MCL
Trans-1,2-Dichloroethene	ND—0.15	0.006	0.15	100 MCL
Tetrachloroethene PCE	ND—0.27	0.27	0.25	5 MCL
Trichloroethene TCE	ND—41	**41**	1.6	5 MCL
Vinyl chloride	ND—0.051	**0.039**	**0.051**	0.03 CREG 2 MCL

Note: Measured well concentrations that exceed the comparison value are in **bold type**.

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

CREG: Cancer Risk Evaluation Guide (for 10^{-6} excess cancer risk over a 70 year lifetime).

RMEGc: Reference Dose Media Evaluation Guide; child dose.

EMEGcc: Environmental Media Evaluation Guide (derived by ATSDR); chronic duration; child dose.

MCL: maximum contaminant level for drinking water (derived by EPA).

Table 2: Estimated doses and excess cancer risk from exposure to contaminated groundwater in wells near the NETL-A.

Well A	max conc µg/L	Oral adult dose	Oral child dose	Combined adult dose	Combined child dose	MRL Chronic Oral	RFD-Oral	MRL Inter Oral	MRL acute Oral	oral CSF 1/(mg/kg/day)	Excess risk 30 yr	Excess risk 5 yr
		mg/kg/day										
Carbon tet	110	3.1E-03	6.9E-03	6.3E-03	1.4E-02		7.0E-04	7.0E-03	2.0E-02	1.3E-01	3.5E-04	5.8E-05
TCE	41	1.2E-03	2.6E-03	2.3E-03	5.1E-03				2.0E-01	2.0E-02	2.0E-05	3.3E-06
TCE	41	1.2E-03	2.6E-03	2.3E-03	5.1E-03				2.0E-01	4.0E-01	4.0E-04	6.7E-05
vinyl chloride	0.039	1.1E-06	2.4E-06	2.2E-06	4.9E-06	3.0E-03	3.0E-03			1.4E+00	1.3E-06	2.2E-07
Well B	max conc	Oral adult dose	Oral child dose	Combined adult dose	Combined child dose	MRL Chronic Oral	RFD-Oral	MRL Inter Oral	MRL acute Oral	oral CSF 1/(mg/kg/day)	Excess risk 70 yr	Excess risk 30 yr
Carbon tet	2	5.7E-05	1.3E-04	1.1E-04	2.5E-04		7.0E-04	7.0E-03	2.0E-02	1.3E-01	1.5E-05	6.4E-06
TCE	0.044	1.3E-06	2.8E-06	2.5E-06	5.5E-06				2.0E-01	2.0E-02	5.0E-08	2.2E-08
TCE	0.044	1.3E-06	2.8E-06	2.5E-06	5.5E-06				2.0E-01	4.0E-01	1.0E-06	4.3E-07
vinyl chloride	0.051	1.5E-06	3.2E-06	2.9E-06	6.4E-06	3.0E-03	3.0E-03			1.4E+00	4.1E-06	1.7E-06
Well C	max conc	Oral adult dose	Oral child dose	Combined adult dose	Combined child dose	MRL Chronic Oral	RFD-Oral	MRL Inter Oral	MRL acute Oral	oral CSF 1/(mg/kg/day)	Excess risk 70 yr	Excess risk 30 yr
Carbon tet	ND						7.0E-04	7.0E-03	2.0E-02	1.3E-01		
TCE	1.6	4.6E-05	1.0E-04	9.1E-05	2.0E-04				2.0E-01	2.0E-02	1.8E-06	7.8E-07
TCE	1.6	4.6E-05	1.0E-04	9.1E-05	2.0E-04				2.0E-01	4.0E-01	3.7E-05	1.6E-05
vinyl chloride	0.016	4.6E-07	1.0E-06	9.1E-07	2.0E-06	3.0E-03	3.0E-03			1.4E+00	1.3E-06	5.5E-07

- Adult doses assume: 2 liters per day of water ingested, 70 kg body weight.
- Child doses assume: 1 liter per day of water ingested, 16 kg body weight.
- Combined doses assume that the total dose from ingestion, dermal contact, and inhalation is 2 times the ingestion dose.
- MRL (minimal risk level) is an estimate of the daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during a specified period of exposure (acute—minutes to 14 dayrs; intermediate—14 to 365 days; chronic—more than 1 year).
- RFD (Reference Dose) is a daily dose that is likely to be without discernable risk of deleterious effects to human population (including sensitive subgroups) during a lifetime of exposure.
- CSF (cancer slope factor) is an estimate of possible increases in cancer cases in a human population (expressed in inverse dose units).
- Note that the two TCE entries have different cancer slope factors and different estimates of excess risk.

Carbon Tetrachloride

Based on the available measured carbon tetrachloride concentrations and estimated doses, adverse health effects from past exposure to carbon tetrachloride via contaminated drinking water wells for all but one residence around the NETL-A facility are unlikely to produce any adverse health effects, including cancer. Past exposure at one residence could lead to diseases of the liver, kidney, or central nervous system.

The summary of the properties and potential health effects of exposure to carbon tetrachloride is from the ATSDR Toxicological Profile for Carbon Tetrachloride (ATSDR 1994). Carbon tetrachloride is a clear liquid that evaporates easily and therefore commonly escapes to the environment as a gas. In the past, carbon tetrachloride was used as a cleaning fluid, a degreasing agent, a refrigeration fluid, and an aerosol can propellant. Carbon tetrachloride also destroys ozone in the upper atmosphere such that most uses have been banned or strictly regulated.

As presented in Table 2, carbon tetrachloride was measured in Well A at a maximum concentration of 110 µg/L and in Well B at 2 µg/L. Other wells had only trace or non-detectable concentrations of carbon tetrachloride. The estimated oral dose from drinking water from Well A was 0.003 milligrams (carbon tetrachloride) per kilogram body weight per day (mg/kg/day) for adults and 0.007 mg/kg/day for children. Note that doses for a child are about 2 times the adult dose due to the relative differences in ingestion rates and body weights. Similarly, the estimated combined carbon tetrachloride doses from Well A were 0.006 and 0.014 mg/kg/day for adults and children, respectively.

The primary effects of carbon tetrachloride in humans are on the liver, kidneys, and central nervous system (CNS). Human symptoms of acute (short-term) inhalation and oral exposures to carbon tetrachloride include headache, weakness, lethargy, nausea, and vomiting. Acute exposures to higher levels and chronic (long-term) inhalation or oral exposure to carbon tetrachloride produces liver and kidney damage in humans. Human data on the carcinogenic effects of carbon tetrachloride are limited. Studies in animals have shown that ingestion of carbon tetrachloride increases the risk of liver cancer. EPA has classified carbon tetrachloride as a Group B2, probable human carcinogen (http://www.epa.gov/ttnatw01/hlthef/carbonte.html).

ATSDR has established an intermediate duration (14 to 365 days) minimal risk level (MRL) for ingestion of carbon tetrachloride (Table 2; Figure 2). This MRL is based on a study of the liver effects to carbon tetrachloride (via corn oil gavage) to male rats (Bruckner et al. 1986). Slight changes in liver blood chemistry were observed at doses of 10 mg/kg/day (lowest observed adverse effect level, LOAEL; Figure 3). No adverse effects were observed at doses of 1 mg/kg/day (NOAEL; Figure 2). The intermediate duration MRL of 0.007 mg/kg/day is based on the NOAEL of 1 mg/kg/day and adjusted downward to 0.7 mg/kg/day (to account for intermittent exposure) and further reduced by 100 times to account for interspecies comparisons (use of laboratory rats instead of humans).

The findings of this study are not entirely relevant for evaluating health hazard for NETL-A neighbors exposed to carbon tetrachloride in well water for several reasons. First, gavage doses in the animal study were administered as one large dose per day, while NETL-A neighbors were likely to have been exposed to via drinking water several times a day. (The body handles a single large dose much differently than it does a series of smaller doses.) Second, the total dose entering the body is higher and maintained for a longer time when carbon tetrachloride is dissolved in oil

than when it is dissolved in water. Lastly, exposure to carbon tetrachloride in the animal study lasted only 5 weeks, while maximum exposures to NETL-A neighbors (from the Well A residence) may have occurred over a period of 3 to 5 years.

Figure 3 also shows the estimated, theoretical, doses from lifetime (70 year) exposures to carbon tetrachloride that equate to excess cancer risks of one in ten thousand (10^{-4}), one in one hundred thousand (10^{-5}), and one in a million (10^{-6}). Table 2 shows the estimated excess cancer risk from drinking carbon tetrachloride-contaminated water from Well A for 5 years to be about 6 in one hundred thousand (5.8E-5).

> Note: Because of conservative models used to derive cancer slope factors (CSFs) and inhalation unit risks (IURs), using this approach provides a theoretical estimate of risk; the true or actual risk is unknown and could be as low as zero (EPA, 2003). Although ATSDR recognizes the utility of numerical risk estimates in risk analysis, the Agency considers such estimates in the context of the variables and assumptions involved in their derivation and in the broader context of biomedical opinion, host factors, and actual exposure conditions. The actual parameters of environmental exposures must be given careful consideration in evaluating the assumptions and variables relating to toxicity and exposure (ATSDR 1993; 2005).

The excess cancer risks in Table 2 represent the estimated increase in cancer risk due to exposure to carbon tetrachloride. All of the uncertainties and conservative exposure assumptions associated with the dose calculations are included in the risk estimation as well as the uncertainty in deriving the cancer slope factor (EPA, 2000). The risk estimates in Table 2 cannot be interpreted as evidence that any of the NETL-A neighbors will develop cancer as a result of carbon tetrachloride exposure. *These estimates of excess risk fall within the range of low to no apparent increased risk* (ATSDR, 1991). These low risk estimates combined with the relatively short term exposures (less than 5 years) at the Well A location, indicate that carbon tetrachloride is not likely to create excess cancers. Excess cancer risks at other locations (Wells B and C; Table 2) are much lower and also fall within the range of low to no apparent increased risk.

Also, as the estimated carbon tetrachloride doses are much lower than any doses that have been shown to produce other, non-cancer health effects, such as liver disease (Figure 3), past exposures to carbon tetrachloride, via drinking water wells are unlikely to produce any non-cancer adverse health effects. It must be noted that these determinations are based on the available measured VOC concentrations.

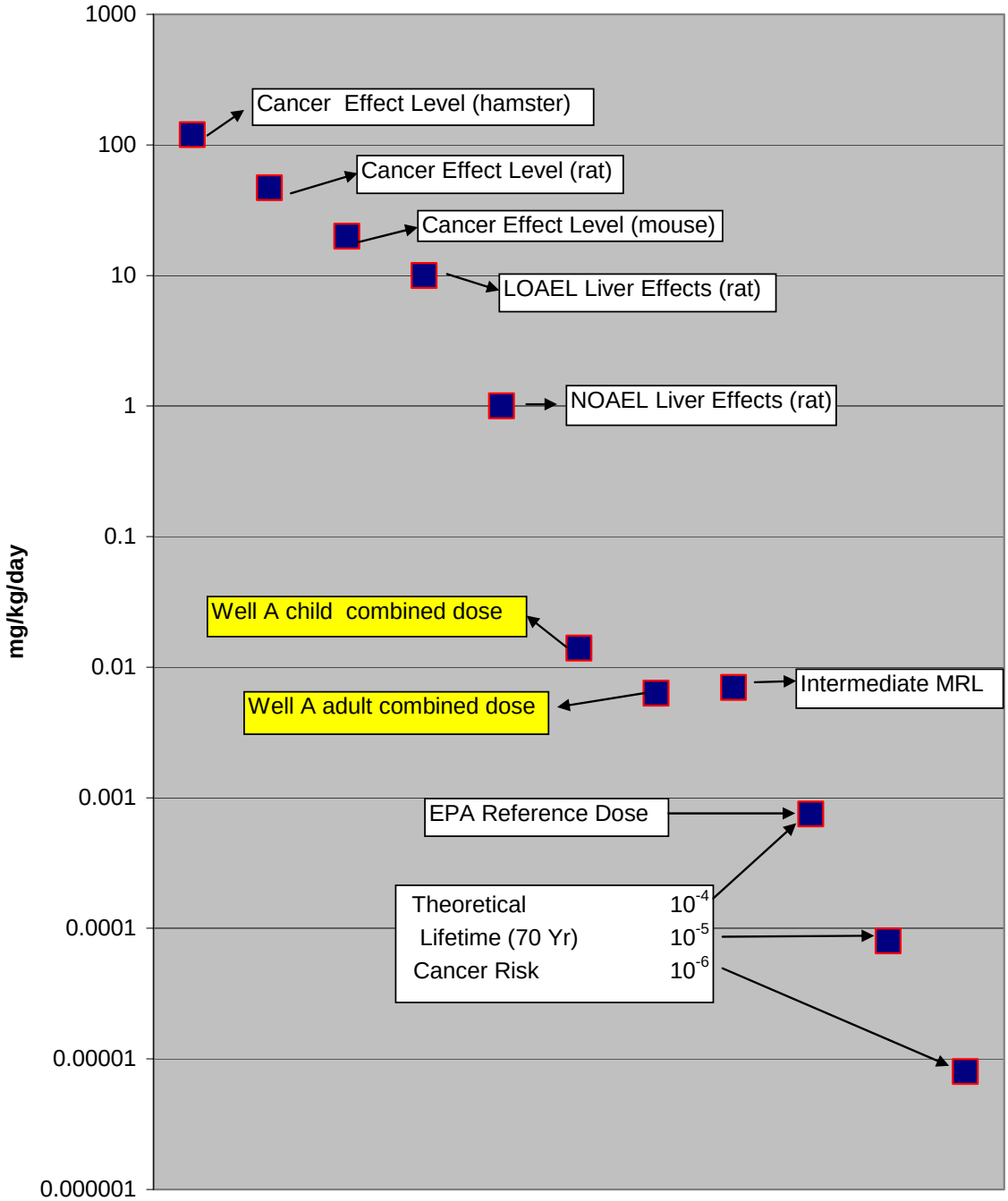

Figure 3. Carbon tetrachloride doses and health effects. Note that the highest estimated doses (Well A) are much lower than any doses associated with adverse health effects in laboratory animals. Although estimated doses are higher than those associated with 70 year cancer risks, five year risk estimates are about 6 in 100,000 (5.8E-5; Table 2). Data are from Table 2 and ATSDR (1994).

Trichloroethylene (TCE or trichloroethene)

Based on the available measured TCE concentrations and estimated doses, adverse health effects from past exposure to TCE via contaminated drinking from most contaminated water wells around the NETL-A facility are unlikely to produce any adverse health effects, including cancer. Past exposure at one residence could lead to diseases of the liver, kidney, or central nervous system.

TCE had a maximum measured concentration of 41 µg/L in Well A, 1.6 µg/L in Well C, and trace or non-detectable concentrations in all other residential wells (Tables 1 and 2). The Well A drinking water concentrations result in estimated combined (ingestion plus inhalation plus dermal contact) TCE doses of 0.0023 mg/kg/day for adults and 0.0051 mg/kg/day for children (Table 2). Estimated doses at other locations are more than 10 times lower than Well A doses (Table 2).

TCE is a nonflammable, oily, colorless liquid that has a sweet odor and a sweet, burning taste. Years ago, TCE was used as an anaesthetic. It is now used as a solvent to remove grease from metal parts and to make other chemicals. It is heavier than water and has low solubility (up to one part TCE per thousand parts of water at room temperature; ATSDR, 1997). These qualities make TCE a troublesome contaminant at hazardous waste sites. When present in groundwater, TCE tends to settle into a layer at the bottom of the aquifer and then continuously dissolves into the groundwater. This may result in high levels of TCE in the aquifer for years after the original release of contamination has ended. This may have happened at NETL-A and may be the reason why there is TCE contamination in private well water.

There are several reports of an increased occurrence of nervous system and developmental effects, and cancer, from ingestion and inhalation of TCE by animals and humans (ATSDR, 1997; 1998). Human health studies *suggest* an increased incidence of cancer of various types (e.g., bladder, lymphoma, kidney, respiratory tract, cervix, skin, liver, and stomach) from exposure to TCE; however, no studies provide clear, unequivocal evidence that exposure is linked to increased cancer risk in humans (ATSDR, 1997; 1998). The available studies suffer from inadequate characterization of exposure, small numbers of subjects, and the fact that subjects were likely exposed to other potentially carcinogenic chemicals. There is, however, sufficient evidence that TCE exposure results in cancer development in animals, although animal studies may not be relevant for evaluating health hazard to humans (ATSDR, 1997).

In 1989, EPA withdrew its cancer assessment for TCE, which was based primarily on animal studies conducted in 1990 and earlier, because more recent pharmacokinetic and mechanistic data for TCE became available (EPA, 2006; Cogliano, 1999). An updated approach to TCE cancer assessment using existing animal data and state-of-the-science papers has been proposed (Cogliano, 1999). The approach, though high-dose animal studies support it, does not appear entirely relevant for evaluating health hazard from human environmental exposure. There are several reasons for this. First, cancer in animals appears to result from species-specific mechanisms that are not entirely relevant to humans (ATSDR, 1997). Second, the animals used in these studies were exposed to very high doses of TCE, several orders of magnitude *higher*

than estimated for NETL-A neighbors, and the overall death rate in the animal studies was high. The surviving animals were not likely to have been in good health and, therefore, would have been more susceptible to adverse effects from TCE exposure (like infections and illnesses) than healthy animals. Third, the overall findings from animal studies are inconsistent: some studies report an increased incidence of cancer, while an equal number do not report an increase at similar levels of exposure (ATSDR, 1997). Fourth, the studies did not evaluate the effect of exposure to stabilizers and impurities in TCE; these things may also be carcinogenic.

ATSDR has also derived a health guideline of 0.2 mg/kg/day for ingestion of TCE based on an acute-duration (less than 14 days) study showing developmental and behavioral changes in mouse pups administered 50 mg/kg/day of TCE (Fredriksson et al., 1993). In this study, the TCE was dissolved in oil and administered by stomach tube (gavage; ATSDR, 1997). The findings of this study are not entirely relevant for evaluating health hazard for NETL-A neighbors exposed to TCE in well water for several reasons. First, gavage doses in the animal study were administered as one large dose per day, while NETL-A neighbors were likely to have been exposed to TCE in drinking water several times a day. (The body handles a single large dose much differently than it does a series of smaller doses.) Second, the total dose entering the body is higher and maintained for a longer time when TCE is dissolved in oil than when it is dissolved in water. Lastly, exposure to TCE in the animal study lasted less than 14 days, while maximum exposures to NETL-A neighbors (from the Well residence) may have occurred over a period of 3 to 5 years. Despite these limitations, the estimated TCE doses for NETL-A neighbors are much lower than any for which adverse health effects have been documented.

ATSDR's TCE Sub-Registry reports an excessive number of children aged 9 years old or younger with speech and hearing deficits (ATSDR, 1994). Although the exposure levels of these children were not well characterized, the findings support the types of outcome seen in animals. Several studies of workers and community residents suggest a possible association between exposure to TCE (and other chemicals) and developmental outcomes (ATSDR, 1998; Fagliano et al., 1990; Bove et al., 1995; MDPH, 1997). However, none of the studies provide conclusive evidence for a causal relationship, largely because information about TCE exposure was incomplete and exposure to other chemicals was likely (ATSDR, 1997). Collectively, the scientific data indicate that the developing nervous system in young animals and humans may be sensitive to the toxic effects of TCE (ATSDR, 1997). Collectively, the scientific data indicate that the developing nervous system of humans may be sensitive to the toxic effects of TCE (ATSDR, 1997), although the dose levels at which these effects occur has not been established. The available TCE measurements indicate that past exposures to TCE by NETL-A neighbors were many orders of magnitude below TCE doses that have been shown to cause neurotoxic effects in animals.

The excess cancer risks in Table 2 represent the expected increase in cancer risk due to exposure to TCE. Note that the TCE cancer risks in Table 2 include estimated excess risk calculated with two different cancer slope factors. The EPA TCE Health Risk Assessment (EPA, 2001) has identified several cancer slope factors, with most between $2x10^{-2}$ and $4x10^{-1}$ per mg/kg-d (Table 2). As there is no scientific consensus on a specific CSF, the EPA recommends using a range of CSFs and presenting a range of estimated excess cancer risks. Consequently, the highest

estimated excess cancer risks due to five years of Well A TCE exposure range from about 7 in 100,000 (6.7E-5) to about 3 in 1,000,000 (3.3E-6; Table 2). Cancer risks at Well B and C locations with lower TCE concentrations are much lower (Table 2).

All of the uncertainties and conservative exposure assumptions associated with the dose calculations are included in the risk estimation as well as the uncertainty in deriving the cancer slope factor (EPA, 2000). The risk estimates in Table 2 cannot be interpreted as evidence that any of the NETL-A neighbors will develop cancer as a result of TCE exposure. *These estimates of excess risk fall within the range of low to no apparent increased risk* (ATSDR, 1991). These low risk estimates combined with the relatively short term exposures (less than 5 years) at the Well A location, indicate that TCE is not likely to create excess cancers. Excess cancer risks at other locations (Wells B and C; Table 2) are much lower and also fall within the range of low to no apparent increased risk.

Also, as the estimated TCE doses are much lower than any doses that have been shown to produce other, non-cancer health effects, such as liver disease (Figure 4), past exposures to TCE, via drinking water wells are unlikely to produce any non-cancer adverse health effects. The highest estimated Well A doses are above the proposed RfD (Figure 4). However, these exposures would not be expected to cause adverse health effects because the proposed RfD has a safety factor of 3,000. It must be noted that these determinations are based on the available measured VOC concentrations.

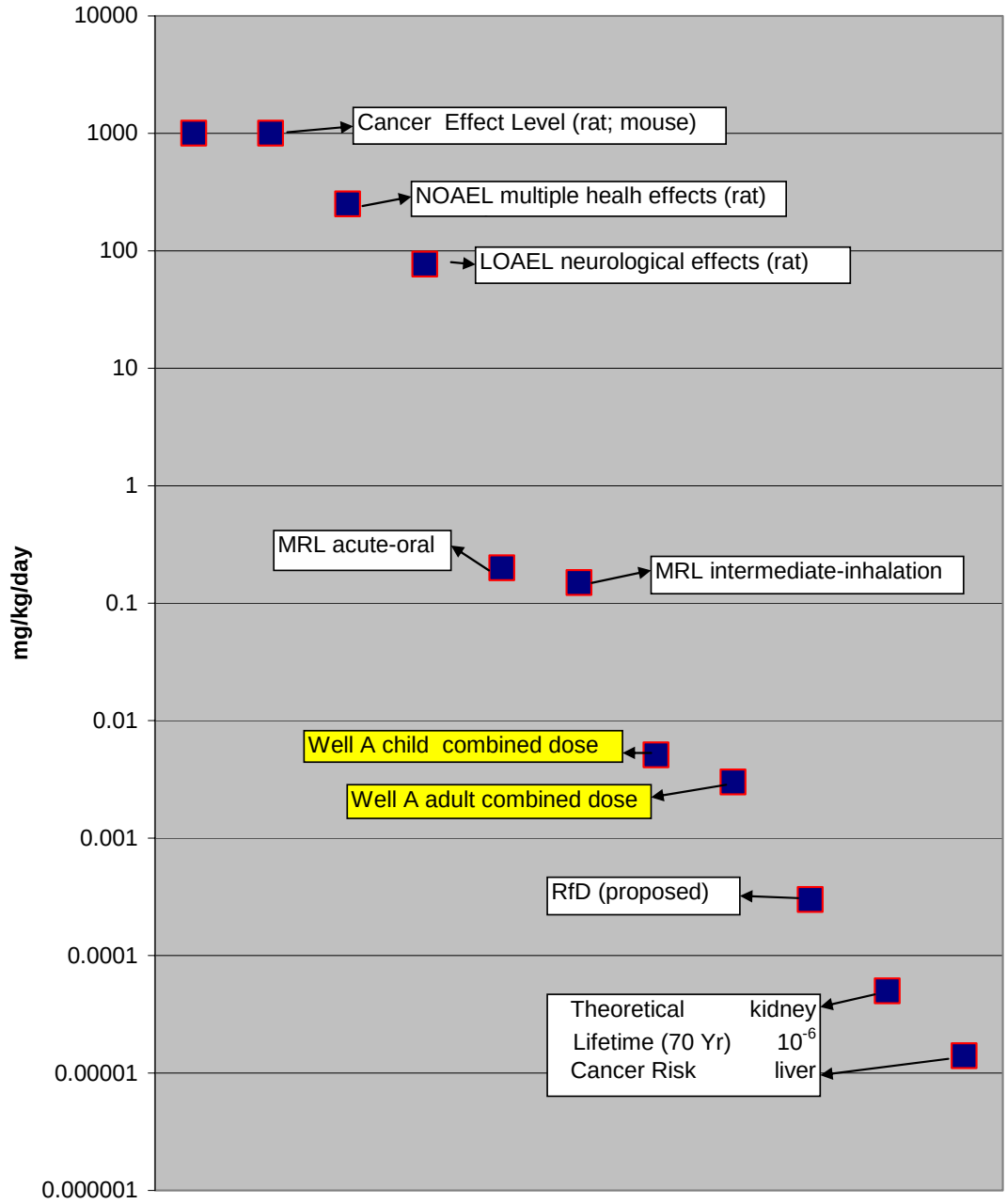

Figure 4. TCE doses and health effects. Note that the highest estimated doses (Well A) are much lower than any doses associated with adverse health effects in laboratory animals. Although estimated doses are higher than those associated with 70 year cancer risks, five year risk estimates range from about 3 in a million to 7 in one hundred thousand (3.3E-6 and 6.7E-5, resp.; depending on the specific cancer slope factor; Table 2). Data are from Table 2, ATSDR (1997), and EPA (2001).

Vinyl Chloride

Based on the available measured vinyl chloride concentrations and estimated doses, adverse health effects from past exposure to vinyl chloride via contaminated drinking water wells around the NETL-A facility are unlikely to produce any adverse health effects, including cancer.

Vinyl chloride is a man-made substance used in the production of polyvinyl chloride (PVC) and other plastic products. It is one of the substances generated when TCE breaks down in groundwater (ATSDR, 1997b). As TCE degrades in groundwater, the resulting vinyl chloride concentration may increase down-gradient, depending on a number of factors, including the chemical characteristics of the soil through which the contaminated groundwater travels and the distance traveled (Cline and Mylavarapu, 1998).

Vinyl chloride has been detected in residential wells at trace concentrations (less than 1 µg/L) in the drinking water wells in the NETL-A area. The maximum concentration of vinyl chloride was 0.05 µg/L in Well B (Table 2). A few other wells had similar, albeit, lower trace concentrations (0.04 and 0.02 µg/L in Wells A and C, respectively). All of these measured concentrations are less than the EPA's Maximum Contaminant Level (MCL) of 2 µg/L for public drinking water supplies. However, these concentrations are greater than the cancer risk evaluation guide (CREG) of 0.03 µg/L (Table 1).

ATSDR's estimated combined doses, assuming exposure to the maximum concentration found in Well B, were 0.000003 mg/kg/day for an adult and 0.000006 mg/kg/day for a child. ATSDR has developed a health guideline (MRL; Table 2) of 0.003 mg/kg/day for chronic ingestion of vinyl chloride (ATSDR, 1997b). This MRL of 0.003 mg/kg/day was based on a NOAEL of 0.17 mg/kg/day for non-cancerous liver effects (i.e., liver cell polymorphism) in rats (Til et al. 1983, 1991) and application of the physiologically based pharmacokinetic (PBPK) model used to derive EPA's reference dose (RfD) (Clewell et al. 2001; EPA 2000). The highest estimated vinyl chloride doses are 500 times lower than the health guideline and more than 28,000 times lower than the doses that produced non-cancerous liver effects in rats (ATSDR, 1997b).

EPA has concluded that sufficient evidence of carcinogenicity exists in humans and animals and has classified vinyl chloride according to its 1986 classification scheme as a Group A or known human carcinogen (EPA 1994). EPA's current weight-of-evidence characterization for vinyl chloride concludes that vinyl chloride is a *known human carcinogen by the inhalation route of exposure*, based on human epidemiological data. By analogy, vinyl chloride is considered a *known human carcinogen by the oral route* because of positive animal bioassay data as well as pharmacokinetic data allowing dose extrapolation across routes. By inference, vinyl chloride is also considered highly *likely to be carcinogenic by the dermal route* because it acts systemically (EPA 2000). Because the epidemiological evidence does not provide sufficient exposure and incidence data to quantify risk based solely on human data, EPA cancer potency factors for inhalation and oral exposure have been calculated based on animal studies.

An oral slope factor for continuous lifetime exposure from birth was estimated by EPA (2000) to be 1.4 per mg/kg/day based on the incidence of liver tumors in rats in a study by Feron et al.

(1981). An oral slope factor of 0.75 per mg/kg/day for continuous lifetime exposure during adulthood was also estimated by EPA (2000). The highest estimated 30 year excess cancer risk is for the Well B location and is about 2 in 1,000,000 (1.7E-6; calculated using the more health protective slope value of 1.4 per mg/kg/day; Table 2). Estimated excess cancer risks at other locations are commensurately lower in relation to the vinyl chloride concentration.

The excess cancer risks in Table 2 represent the expected increase in cancer risk due to exposure to vinyl chloride. All of the uncertainties and conservative exposure assumptions associated with the dose calculations are included in the risk estimation as well as the uncertainty in deriving the cancer slope factor (EPA, 2000). The risk estimates in Table 2 cannot be interpreted as evidence that any of the NETL-A neighbors will develop cancer as a result of TCE exposure. *These estimates of excess risk fall within the range of low to no apparent increased risk* (ATSDR, 1991). These low risk estimates indicate that vinyl chloride is not likely to create excess cancers. Excess cancer risks at other locations are much lower and also fall within the range of low to no apparent increased risk.

Adequacy of available groundwater data for public health determinations

The groundwater and well monitoring data in off-site drinking water wells indicate that at least 10 households have been exposed to VOCs via ingestion of water, direct skin contact with the water, and inhalation of vapors from the water. Maps of maximum concentrations for three different VOCs (carbon tetrachloride, chloroform, and TCE) for the west plume are included in Appendix 1. These maps all show higher on-site concentrations of VOCs that decrease towards the west and are consistent with westerly groundwater flow and contaminant migration. Comparison of the estimated VOC doses at those locations with health comparison values and doses associated with adverse health effects in humans and laboratory animals indicates that adverse health effects are unlikely.

However, the contaminant concentrations on which these dose estimates are based reflect only current or recent groundwater conditions at each location. There is no information available to determine when the contaminants were released into the groundwater or the rate of migration of those contaminants. Also, the limited duration of available monitoring data does not provide an adequate basis for evaluating any temporal trends (e.g., whether contaminant concentrations are increasing or declining over time).

While there is a possibility that contaminant concentrations at the off-site drinking water wells were higher in the past, current carbon tetrachloride and chloroform concentrations have a relatively uniform westerly decrease from on-site wells and soil borings towards the Well A location (Appendix 1). This pattern of VOC concentrations suggests that past off-site concentrations were not any higher as this specific VOC plume migrates towards the west.

For most of the off-site drinking water wells that only have trace concentrations of VOCs, if historic concentrations were 10 times greater than current concentrations, the resulting doses would still be below levels of public health concern. However, if concentrations were 10 times greater at a few of the locations, the resulting VOC exposures could present a public health hazard. Although existing data suggest that past concentrations were not any higher than present, additional data and evaluation of the contaminant sources and distribution of

contaminant concentrations and groundwater flow modeling may be required to address this issue.

Radioactive waste disposal in Biomass and "Back Forty" areas

Between 1948 and 1978, NETL-A conducted metallurgical research for the Atomic Energy Commission (AEC) and the Energy Research and Development Agency (ERDA)—which were predecessor organizations of the U.S. Department of Energy (DOE). This research primarily involved melting, machining, welding, and alloying of thorium, with limited operations involving separation, purification, and processing of uranium. Radioactive wastes from these activities were treated and disposed on site in the Biomass and "Back Forty" areas until 1956 (ORAU, 1989).

Following the completion of AEC/ERDA contract work, the NETL-A facilities used in those operations were surveyed and decontaminated according to the prescribed guidelines in place that time (ANL, 1983a/b). Although the radiological surveys conducted by ANL (1983a/b) determined that there was no radiological hazard associated with NETL-A buildings and property, they recommended additional evaluation of several areas.

Consequently, Bechtel National, Inc. (BNI) conducted additional radiological surveys and decontamination activities of NETL-A facilities and property. The results of those activities are described in several reports (BNI, 1989a/b; as referenced in ORAU, 1989). As an independent verification of those survey/cleanup activities, the Oak Ridge Associated Universities was commissioned to verify the remedial actions (ORAU, 1989). The ORAU report (1989) concluded that, although some areas of residual radioactive contamination were still present in some buildings, the 'remedial actions have been effective in satisfying the established DOE guidelines and the documentation supporting the remedial action process is adequate and accurate."

Currently, access to most of the NETL-A site, including the Biomass Area, is restricted with fences, warning signs, and security guards. Consequently, there is limited potential for public access to potentially contaminated buildings. However, the "back forty" area (Figure 1) is a grassy, vacant area outside the security fence. This area was used for subsurface disposal of radioactive wastes and has surface radiation consistent with those subsurface disposal areas (ANL, 1983a). Soil borings from the "Back Forty" area revealed the highest activities of radium 226, thorium 232, and uranium 238 to be in the top two feet of soil (ANL, 1983b). Note that the uppermost foot of soil in the disposal area was excavated and disposed off-site (ORAU, 1989).

Estimated radiological doses for occasional walking across or playing in the "back forty" area are below levels of public health concern based on several surveys (BNI, 1984; ORAU, 1989). Based on these radiological measurements and estimated doses, a person would have to be at the area of highest concentration/activity for 24 hours per day for 190 days per year to receive a dose exceeding the recommended exposure limit for the general public (BNI, 1984).

There are also five monitor wells in or around the "Back Forty". Water samples from these wells do not indicate any radiologic measurements above the EPA Safe Drinking Water Standards (http://www.epa.gov/safewater/rads/radfr.pdf) which indicates that there is little migration of radiologic contamiants via groundwater. The survey methods, resulting data, and dose

estimation calculations used in the reviewed radiologic survey and monitoring reports are appropriate and protective of public health. Additional evaluation will be required if there is any change in the use of this property; especially any activities involving excavation.

Beryllium dust in NETL-A buildings

NETL-A was engaged in beryllium research until the 1980's. In January 2005, small quantities of beryllium were discovered inside buildings at the NETL-A (NETL, 2006). In response to that discovery and because records concerning historic beryllium clean up operations are not available, NETL-A has initiated a program of beryllium monitoring throughout the facility (NETL, 2006b).

ODEQ has received queries from residents of the surrounding community concerning the potential for beryllium exposure at adjacent properties or incidental exposure during past visits to the NETL-A facility. ODEQ has in turn requested that ATSDR address this issue via this health consultation. Specifically, this health consultation evaluates the potential for beryllium exposure at locations adjacent to the NETL-A facility or incidental exposures to people visiting NETL-A buildings.

The following review of beryllium properties and potential health effects is based on the ATSDR Toxicological Profile for Beryllium (ATSDR, 2002). Beryllium is a naturally-occurring metallic element that is present in rocks, coal, soil, and volcanic dust. Although beryllium is naturally present in air, water, and soil, emissions from combustion of coal and oil may increase concentrations. In air, beryllium is mostly present as fine dust particles that may remain airborne for about 10 days.

Beryllium has many commercial applications and is widely used in the electronic, aircraft, and automobile industries. Beryllium is also chemically similar to aluminum and typically comprises a small percentage of aluminum metal. Pure beryllium metal and ceramics also have numerous nuclear and military applications.

Beryllium dust can be harmful when inhaled, depending on how much and how long you breathe it. When large amounts of soluble beryllium compounds are inhaled (concentrations greater than 1 mg/m^3) it will damage your lungs and resemble pneumonia (reddening and swelling of the lungs; known as acute beryllium disease). Some people may also become sensitive or allergic to beryllium and may develop an immune or inflammatory reaction to beryllium. This condition is called chronic beryllium disease and typically occurs after long term exposures (10-15 years). Exposure levels associated with acute and chronic beryllium disease are more than 100,000 times normal air concentrations of beryllium.

The EPA has established a chronic inhalation reference concentration (RfC) for beryllium of 0.002 micrograms/cubic meter of air ($\mu g/m^3$; EPA 2006). The RfC, based on two human studies of workers and nearby residents at beryllium manufacturing facilities, is calculated to be protective for continuous, lifetime exposure. Airborne beryllium monitoring at NETL-A has not detected any beryllium in outdoor perimeter monitors (NETL 2006). On the basis of these monitoring results, there are no site-related beryllium exposures to people living, working, or attending school adjacent to the NETL-A facility.

In addition to the perimeter or ambient beryllium air monitoring, indoor area and personal monitoring is also conducted (NETL, 2006b). There have been occasional beryllium detections in specific buildings and in personal monitors (during sorting of legacy beryl ore samples; NETL, 2006b). While these detections ranged from 0.0082 $\mu g/m^3$ to 0.015 $\mu g/m^3$, the intermittent times and distributions of the detections indicate that no building or area has persistent airborne beryllium contamination. Although these indoor air samples are greater than the EPA RfC of 0.002 $\mu g/m^3$, the RfC was derived to be protective for continuous, lifetime exposure (24 hr/day for 70 years). Also, the detected concentrations are well below the current and proposed standards designed to protect workers (2.0 $\mu g/m^3$ time weighted average exposure limit current, Occupational Safety and Health Administration; 0.1 $\mu g/m^3$ time weighted average exposure limit proposed, Occupational Safety and Health Administration; NIOSH, 2005).

While NETL-A employees may have occasionally been exposed to low levels of airborne beryllium, these workers have had specific training and medical monitoring to protect their health. Although unlikely, a site visitor may have been in one of these buildings. No adverse health effects would be expected from such an occasional or intermittent exposure to the detected beryllium concentrations. The current beryllium monitoring program provides appropriate information and data to ensure that there is no public health hazard related to beryllium exposures for NETL-A neighbors and visitors.

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 identification. Thus adults need as much information as possible to make informed decisions regarding their children's health.

In this health consultation, doses to children have been estimated using child-specific intake rates and body weights. As the estimated child-specific doses are somewhat greater than adult doses, the resulting public health determinations are based on the doses and potential adverse health effects to children.

Conclusions

Based on the above findings, past operations at the NETL-A have led to releases of several VOCs, including carbon tetrachloride, TCE, and vinyl chloride into groundwater underlying the NETL-A. Off-site migration of these VOCs, via groundwater flow, has caused the contamination of up to 10 residential drinking water wells. People living in those residences

have been exposed to the VOCs by drinking water from the wells, direct skin contact with the VOCs in the household water, and breathing the gaseous VOCs that have escaped into the household air.

This Public Health Consultation provides an estimate of the VOC doses to residents of those houses using the highest measured concentrations of the VOCs. Evaluation of the contaminant distributions and estimated doses, using both children and adult body weights and intake rates for carbon tetrachloride, TCE, and vinyl chloride leads to the following public health determinations;

- Adverse health effects are unlikely for users of most of the contaminated private wells based on recent measured concentrations of VOCs.
- Residences with contaminated wells are currently being provided with bottled water. Current exposure to VOCs at these locations is limited to skin contact with contaminated well water and breathing of gases released into the household air. These exposures are unlikely to create adverse health effects.
- All future exposures to VOCs should be eliminated by providing the affected residences with municipal water and destroying the contaminated wells.
- The available information on the historic use and release of VOCs at NETL-A and patterns of groundwater flow are not adequate to determine how long the residential wells have been contaminated.
- The current distribution of groundwater VOCs suggests that concentrations in residential wells were not higher in the past.
- Based on the above findings, *current and future* exposures to VOCs via contaminated groundwater are "no apparent public health hazard." This determination means that exposures to site-related contaminants has or may be occurring, but at levels unlikely to create any adverse health effects. *Past exposures* at most residences with contaminated wells are "no apparent public health hazard."
- *Past exposure* at one residence is a public health hazard due to exposures to carbon tetrachloride and TCE. Although the estimated doses for this location are below levels that have created adverse health effects in studies of laboratory animals, the measured concentrations are 8 to 15 times greater than applicable health comparison values. Past exposure at this residence could lead to diseases of the liver, kidney, or central nervous system and is considered a *public health hazard*.

In addition to these findings concerning VOC contamination and exposure at residential drinking water wells, this health consultation evaluated the potential for NETL-A neighbors and visitors to be exposed to beryllium dust and radioactive waste materials. The followings finding are based on the available beryllium monitoring and radiological survey data;

- Radioactive waste is present in the subsurface of the "back forty" and contains areas of radiologically-contaminated soil. This area is unfenced and may be accessed by NETL-A neighbors. No adverse health effects are likely from walking across or playing in this area and the potential radiological doses are below levels of public health concern.
- There is no detectable beryllium dust at the NETL-A site perimeter and consequently, no beryllium exposures to the off-site community. Beryllium detections within NETL-A buildings are relatively uncommon and at low concentrations. No adverse health effects are likely from occasional exposures to beryllium levels measured in NETL-A buildings.
- Potential exposures to beryllium and radiation are no apparent public health hazard.

Recommendations

Based on the above conclusions, ATSDR recommends:

- Completion of ongoing activities to provide affected residences with municipal water and closure of affected wells to reduce vertical migration of VOCs.
- Continued monitoring of the groundwater contaminants and additional evaluation of the time and locations of VOC releases to groundwater in order to more completely evaluate historic contaminant concentrations and distributions.
- Initiation of appropriate source remediation or management to control ongoing off-site migration of VOCs.
- Additional radiologic evaluation of the "back forty" should be conducted prior to any changes in use of this property.

Public Health Action Plan

ATSDR will continue to evaluate monitoring data and groundwater information as provided by ODEQ and NETL-A, and revise the public health conclusions of this health consultation as necessary.

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Appendix A: Distribution of Maximum Concentrations of Carbon Tetrachloride, Chloroform, and TCE along the Northwest Boundary of the NETL-A Site

The following maps (Figures A-1, A-2, and A-3, respectively) show the locations of the maximum concentrations of carbon tetrachloride, chloroform, and TCE from groundwater samples collected by DOE and analyzed by either DOE or ODEQ. Note that these maps only include contaminant values for selected locations to illustrate the trend of concentrations along the western boundary of the NETL-A site. The contaminant values shown in these maps are from several different sources and including:

- VOC Investigation Preliminary Data Summary Package, Provided to DEQ by Albany Research Center, October 4, 2005;
- Phase 2B VOC Investigation Preliminary Data Summary Package, Provided to DEQ by NETL-Albany, February 27, 2006;
- Validated Residential Well Data, February 2006, Provided to ATSDR by NETL-A via E-mail on April 12, 2006;
- Groundwater Monitoring Program Periodic Monitoring Well Sampling Data, Individual/Summary Results, Location Map, Exported Data Files (a CD-ROM disk) provided to ATSDR by NETL-A, March 2006;
- Albany Area Residential Groundwater Results June and July 2005 (A printed spreadsheet; X:/Menglish/ARC conc/All Results Summer 2005.xls);
- DEQ Preliminary Residential Sample Results, Albany, Oregon, (A printed map with residential groundwater data, no date.

These data sources include multiple data formats and generally include sample analyses from the 2004 to 2006 timeframe. These data sets are not mutually exclusive and often present redundant results (based on identical results for sample events).

From Figures A-1, A-2, and A-3, the VOC concentrations for the northwest plume appear to be highest at the SB-74 (soil boring location) in the vicinity of Building 2 and apparently migrate to the northwest. Much higher concentrations for each contaminant are present in the center of the facility around Monitor Well 12, however, contaminants from this location are migrating to the east. The diverging groundwater flow pattern is typical of areas located on a groundwater divide and is supported by local topography which shows the NETL-A facility located on a slight ridge which slopes to the west, south, and east.

The potential for groundwater contaminants to flow both westerly and easterly from the NETL-A site is also supported by the pattern of the regional groundwater flow described by the United States Geological Survey (Conlon, et al., 2005) and by NETL-A site specific groundwater elevations contained in the ARC Quarterly Groundwater Monitoring Report (February 2004; ICF, 2004).

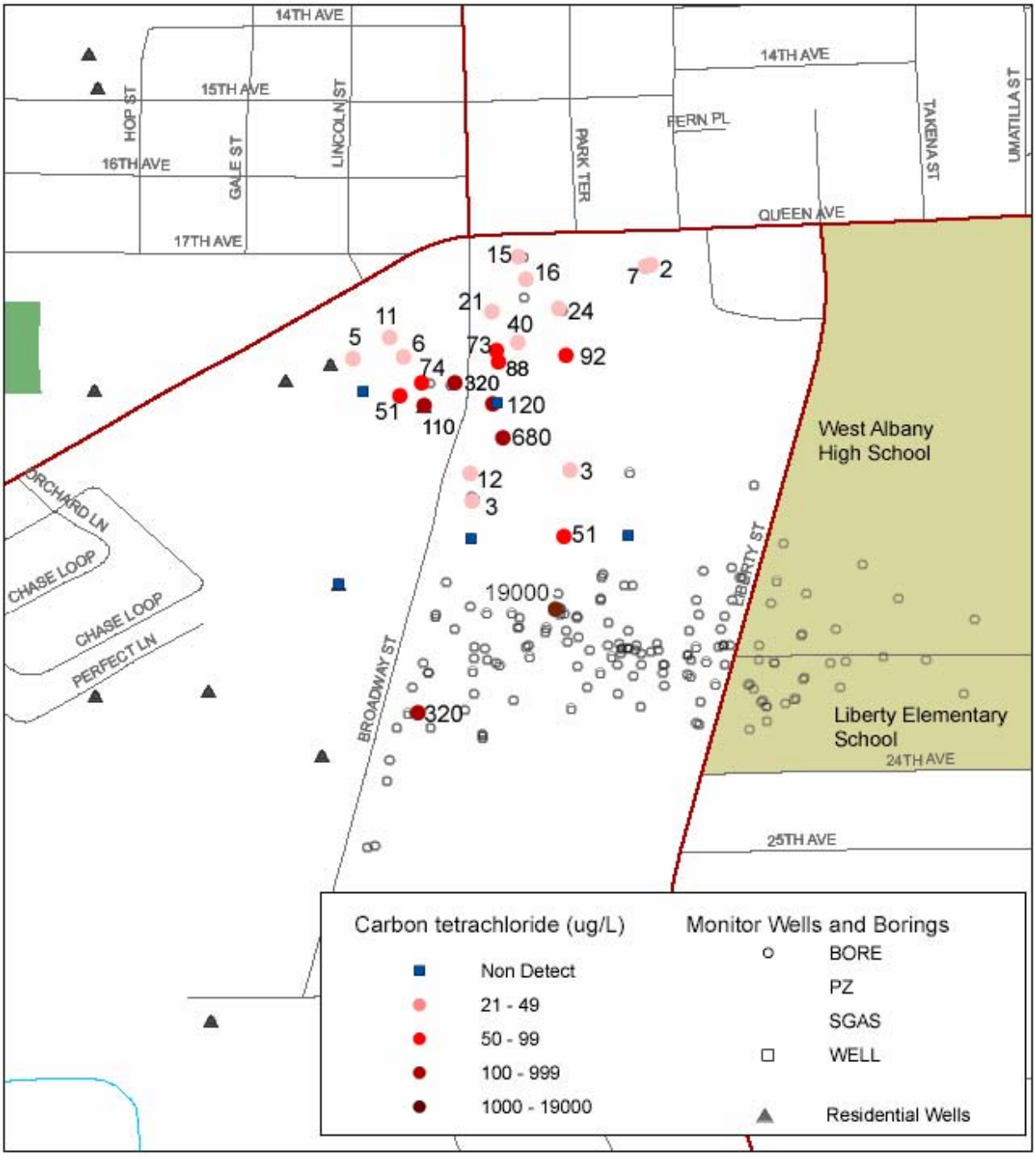

Figure A-1. Distribution of carbon tetrachloride concentrations along northwest boundary of NETL-A. See text for data sources and discussion of concentration trends. Sample concentrations at locations denoted with open circles are not included in this figure and should not be interpreted as non-detections. Concentrations are in micrograms/liter (µg/L).

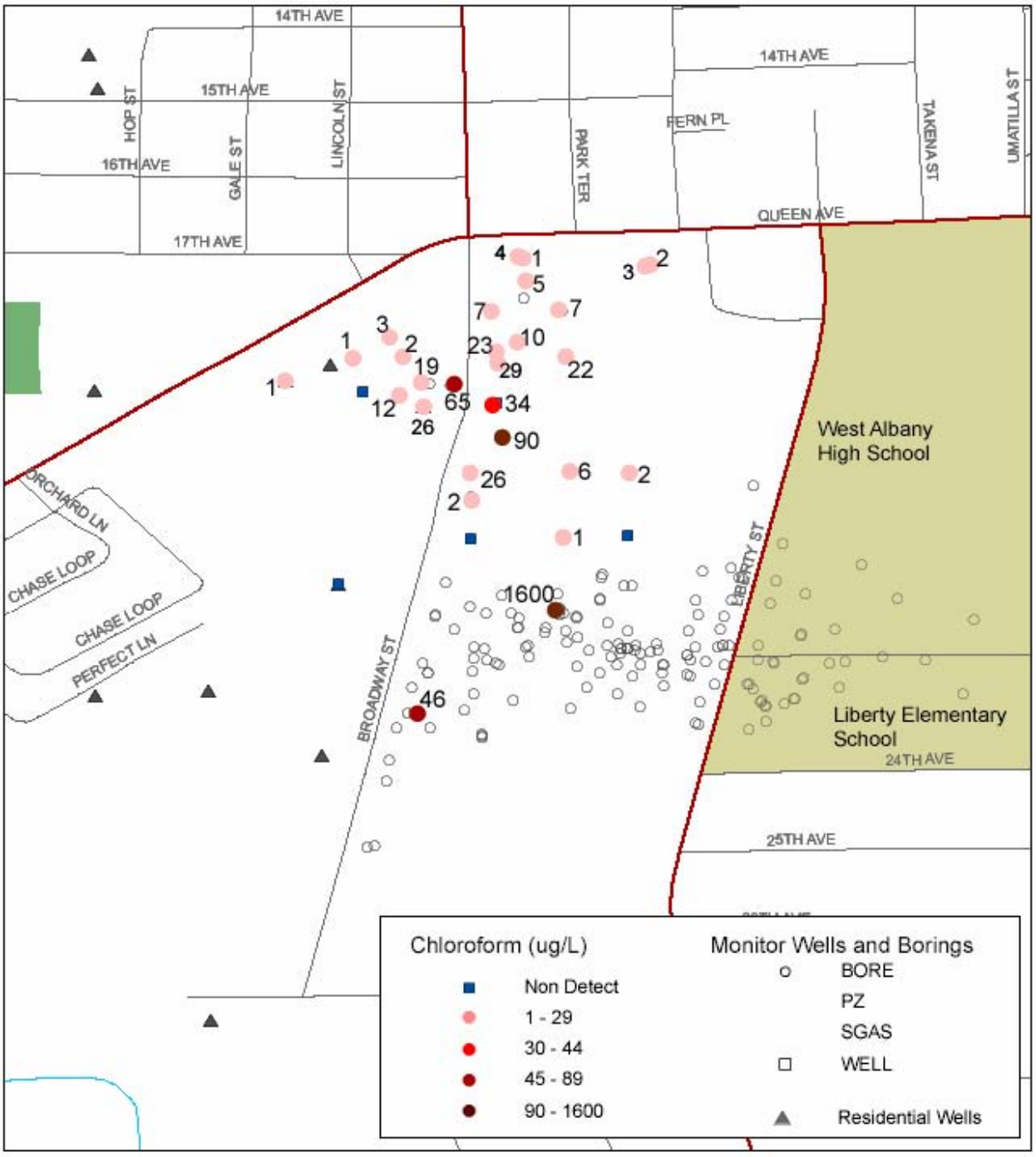

Figure A-2. Distribution of chloroform concentrations along northwest boundary of NETL-A. See text for data sources and discussion of concentration trends. Sample concentrations at locations denoted with open circles are not included in this figure and should not be interpreted as non-detections. Concentrations are in micrograms/liter (µg/L).

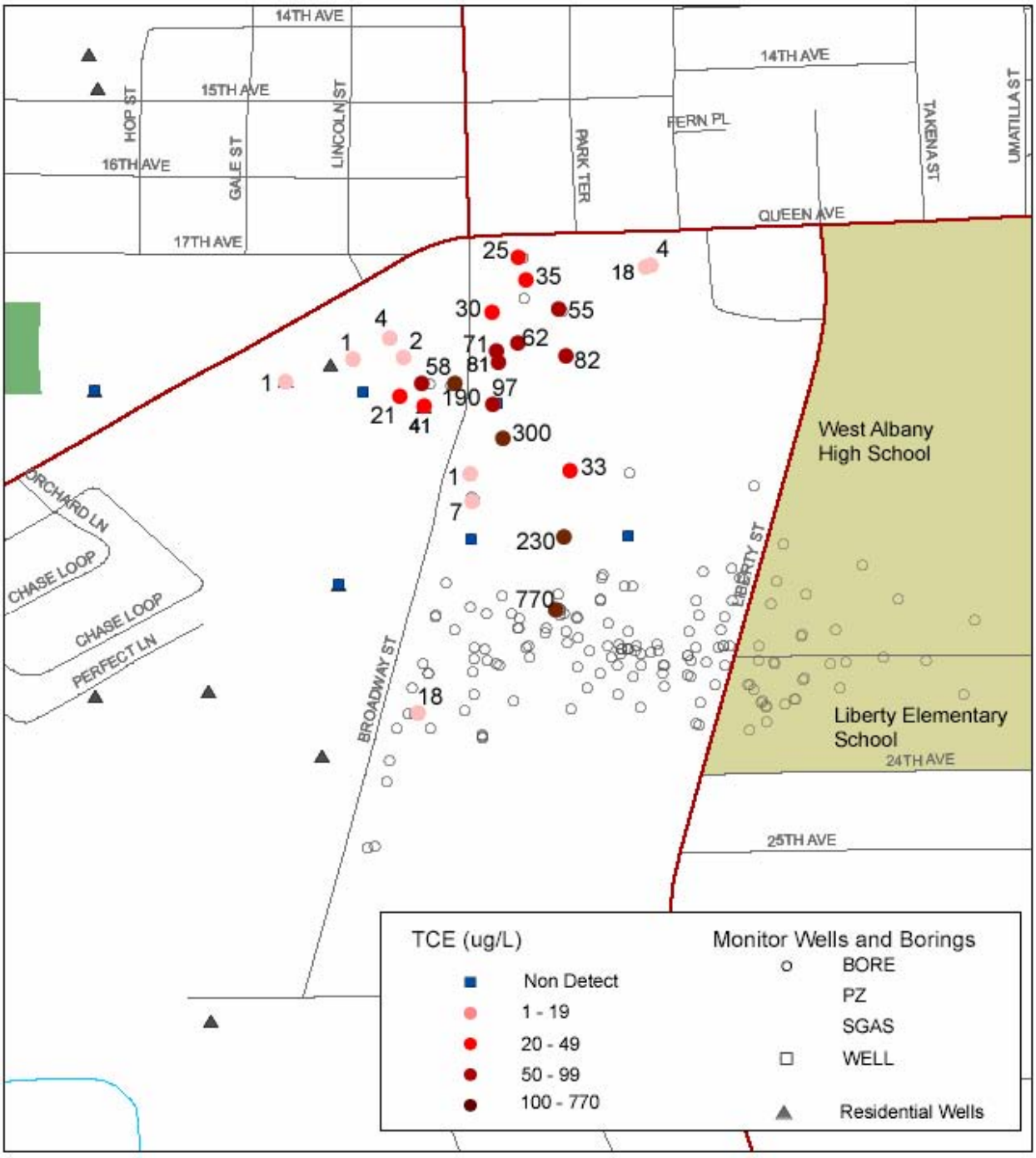

Figure A-3. Distribution of TCE concentrations along northwest boundary of NETL-A. See text for data sources and discussion of concentration trends. Sample concentrations at locations denoted with open circles are not included in this figure and should not be interpreted as non-detections. Concentrations are in micrograms/liter (µg/L).