Health Consultation

SANFORD DRY CLEANERS SITE

SANFORD, SEMINOLE COUNTY, FLORIDA

EPA FACILITY ID: FLD032728032

Prepared by
Florida Department of Health

DECEMBER 8, 2011

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

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

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

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Foreword

The Florida Department of Health (DOH) evaluates the public health threat of hazardous waste sites through a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR) in Atlanta, Georgia. This health consultation is part of an ongoing effort to evaluate health effects associated with groundwater and soil from the Sanford Dry Cleaners hazardous waste site. The Florida DOH evaluates site-related public health issues through the following processes:

■ Evaluating exposure: Florida DOH scientists begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is on the site, and how human exposures might occur. The United States Environmental Protection Agency (EPA) provided the information for this assessment.

■ Evaluating health effects: If we find evidence that exposures to hazardous substances are occurring or might occur, Florida DOH scientists will determine whether that exposure could be harmful to human health. We focus this report on public health; that is, the health impact on the community as a whole, and base it on existing scientific information.

■ Developing recommendations: In this report, the Florida DOH outlines, in plain language, its conclusions regarding any potential health threat posed by groundwater and soil, and offers recommendations for reducing or eliminating human exposure to contaminants. The role of the Florida DOH in dealing with hazardous waste sites is primarily advisory. For that reason, the evaluation report will typically recommend actions for other agencies, including the EPA and the Florida Department of Environmental Protection (DEP). If, however, an immediate health threat exists or is imminent, Florida DOH will issue a public health advisory warning people of the danger, and will work to resolve the problem.

■ Soliciting community input: The evaluation process is interactive. The Florida DOH starts by soliciting and evaluating information from various government agencies, individuals or organizations responsible for cleaning up the site, and those living in communities near the site. We share any conclusions about the site with the groups and organizations providing the information. Once we prepare an evaluation report, the Florida DOH seeks feedback from the public.

If you have questions or comments about this report, we encourage you to contact us.

Please write to: Bureau of Environmental Public Health Medicine
Florida Department Health
4052 Bald Cypress Way, Bin # A-08
Tallahassee, FL 32399-1712

Or call us at: 850 245-4299 or toll-free in Florida: 1-877-798-2772

Summary

INTRODUCTION	At the Sanford Dry Cleaners (SDC) hazardous waste site, the Florida Department of Health (DOH) and the US Agency for Toxic Substances and Disease Registry's (ATSDR) top priority is to ensure nearby residents have the best information to safeguard their health. The SDC hazardous waste site is at 121 South Palmetto Avenue in Sanford, Florida. The site is currently listed on the Superfund National Priorities List (NPL). Since the 1940s, the owners used dry cleaning solvents at this site. This resulted in groundwater contamination that has spread to the surrounding downtown neighborhood. Nearby residents and businesses use municipal water. One nearby resident has an irrigation well. There is no public access to the property. The dry cleaning operation ceased in 2001 and the property buildings are currently vacant.
CONCLUSION #1	ATSDR and Florida DOH cannot currently conclude whether breathing indoor air in buildings near the former Sanford Dry Cleaners could harm people's health.
BASIS FOR DECISION #1	Groundwater under the SDC hazardous waste site is contaminated with tetrachloroethylene (PCE) and its natural breakdown products. Contaminated groundwater vapors could move up into the air of nearby buildings occupied by workers and residents. The air data we need to make a decision are not available. We are working with the US Environmental Protection Agency (EPA) to gather the needed information.
NEXT STEPS	1) EPA should determine if vapors are entering businesses and homes above the contaminated groundwater. 2) EPA should determine the extent of the groundwater contamination at the SDC hazardous waste site.
CONCLUSION #2	ATSDR and Florida DOH conclude that drinking or showering with municipal water will not harm people's health. The reason for this is that municipal water supplies are not contaminated.

BASIS FOR DECISION #2	The City of Sanford provides businesses and residences near the SDC site with frequently tested, non-contaminated water for drinking and showering.
NEXT STEP	The Florida Department of Environmental Protection (DEP) and the City of Sanford should continue to monitor municipal water systems.
CONCLUSION #3	ATSDR and Florida DOH conclude that exposure to soil contamination at the SDC site is not expected to harm people's health.
BASIS FOR DECISION #3	Most soil on and near the SDC site is covered by asphalt/concrete. Also, dry cleaning solvents tend to evaporate or migrate down to the water table. There is no public access to the site. Windows are shuttered. Doors are locked and a rear fence/gate is chained and locked.
NEXT STEP	EPA should determine the extent of the soil contamination at the SDC hazardous waste site.
CONCLUSION #4	ATSDR and Florida DOH conclude that use of the nearby irrigation well water will not harm people's health.
BASIS FOR DECISION #4	Florida DEP sampled the residential irrigation well 250 feet southeast of the SDC site; it did not contain any site-related contaminants. The irrigation well is reported to be completed to a depth of 200 feet. This well draws water from the Floridan aquifer, below the contaminated surficial aquifer. Groundwater flow in the surficial aquifer is north-northeast toward Lake Monroe.
NEXT STEPS	EPA should periodically sample the irrigation well for site related contaminants.
FOR MORE INFORMATION	If you have concerns about your health or the health of your children, you should contact your health care provider. You may also call the Florida DOH toll-free at 877 798-2772 and ask for information about the SDC hazardous waste site.

Background and Statement of Issues

The purpose of this health consultation report is to assess the public health threat from toxic chemicals in groundwater and soil at the former Sanford Dry Cleaners (SDC) hazardous waste site. The Florida Department of Health (DOH) initiated this assessment when the United States Environmental Protection Agency (EPA) proposed adding this site to their Superfund National Priorities List (NPL) in March 2010. The SDC hazardous waste site is at 121 South Palmetto Avenue in Sanford, Seminole County, Florida, 32771 (Figures 1 and 2).

Health scientists look at what chemicals are present and in what amounts. They compare those amounts to health guidelines. These guidelines are set far below known or suspected levels associated with health effects. Florida DOH uses guidelines developed to protect children. If chemicals are not present at levels high enough to harm children, they would not likely harm adults.

This assessment considers health concerns of nearby residents and explores possible associations with site-related contaminants. This assessment requires the use of assumptions, judgments, and incomplete data. These factors contribute to uncertainty in evaluating the health threat. Assumptions and judgments in this assessment err on the side of protecting public health and may overestimate the risk.

This assessment estimates the health risk for individuals exposed to the highest measured level of contamination. This assessment, however, does not apply equally to all nearby residents. Not all nearby residents were exposed to the highest measured level of contamination. The health risk for most nearby residents is less than the health risk estimated in this report. For those residents whose soil, wells, etc. are not contaminated and were not exposed, the health risk is essentially zero.

Site Description

The SDC site is approximately 1-acre. Figure 1 gives the general location of the SDC site and Figure 2 shows an aerial view of the site. The site is bordered on the south by a former gas station (Thrifty Service Station), on the west by South Palmetto Avenue, on the north by two buildings, and on the east by an asphalt paved alley (Figure 3).

The SDC site contains two buildings that were both part of the SDC operation. On the west side of the site facing South Palmetto Avenue, is a two-story building that housed the storefront for the former SDC. This two-story building is completed to the east on the southern end of the property and abuts a one-story building completing the southeastern property corner. The one-story building on the southeastern corner of the property is where dry cleaning machinery was housed. A door provided access to the eastern alley at the back of the building. The area outside this back door is the main source of contamination.

The southeastern section of the site currently has no public access. This building's doors and windows are covered with plywood and the outside area is secured by an 8-feet high chain link fence with a locked gate. There was evidence of vagrancy in the one-story building before it was secured.

The eastern alley and property to the south is generally covered by asphalt and concrete with a few, small areas of weed covered soil. To the south is a one-story garage and store for the former Thrifty Service Station.

To the north are the 113 and 117 South Palmetto Avenue properties (Figures 2 and 3). They contain two one-story buildings facing South Palmetto Avenue. The 113 and 117 properties were at one time owned concurrently with the 121 property and were part of SDC operations. The current 121 property, specifically near the southeastern corner of 121 is where dry cleaning solvents have been found contaminating soil and groundwater.

The SDC site is in the historic downtown section of Sanford. Since the early 1940s, different entities owned and operated the property as a dry cleaning and laundry business. The dry cleaning business used tetrachloroethylene (PCE) as the cleaning agent. In 1964, the owners expanded to include the adjacent properties at 113 and 117 South Palmetto Avenue. They sold these adjacent properties in the 1970s and continued dry cleaning operations as Sanford Dry Cleaners. The dry cleaning operation ceased in 2001. The current owner of the site is Metro Orlando Affordable Housing, Inc. (MOAH) [DEP 2009].

In January 1993, consultants for the former Thrifty Service Station found dry cleaning solvents in groundwater southeast of the SDC site [DEP 2009]. Subsequent sampling verified dry cleaning solvents in groundwater near the southeastern corner of the SDC site. There has been no cleanup of the SDC site. The responsible parties failed to meet Florida DEP application deadlines to enter the state dry cleaners program. The program provides limited liability of the owner, operator and real property owner of dry cleaning or wholesale supply facilities for cleanup of dry cleaning solvent contamination if the parties meet the eligibility conditions stated in the law. Since the site did not qualify for the state dry cleaners cleanup program, Florida DEP contacted the EPA. EPA proposed the site to the NPL in March of 2010, and EPA added the SDC site to the NPL on September 29, 2010.

On May 19, 2010, the Florida DOH and the Seminole County Health Department (SCHD) staff visited the site. They observed the site and surrounding properties. A residence with an irrigation well is to the southeast, across the alley. There was a small family restaurant and a Goodwill store east across the alley. The site was bordered by the asphalt covered alley to the east. To the south was an asphalt and concrete covered parking area and a building that housed the former Thrifty Service Station. The two buildings immediately north of the site were unoccupied but the third contained a first floor art store and second floor apartments. To the west, across South Palmetto Avenue were a newspaper operation and a wine store (Figure 3). Site access was restricted by plywood boarded windows and doors and an 8-feet high chain link fence with a locked gate. There was evidence of vagrancy in and around adjacent buildings.

Demographics

Florida DOH examines demographic and land use data to identify sensitive populations, such as young children, the elderly, and women of childbearing age, to determine whether these sensitive populations are exposed to any potential health risks. Demographics also provide details on population mobility and residential history in a particular area. This information helps Florida DOH evaluate how long residents might have been exposed to contaminants.

Approximately 5,621 people live within a 1.0 mile radius of the SDC site. Fifty-seven percent (57%) are white, 38% are African-American, 6% are of Hispanic origin, and 2% are of other races/ ethnicities. Approximately nine percent (9%) are less than 5 years old and 76% are older than 18. Seventy percent (74%) have a high school diploma or higher and 17% have at least a bachelor's degree. Ninety-two percent (92%) speak only English and thirty-three percent (33%) have a household income between $25,000 and $50,000 a year [EPA 2011a]. In 2000, the median family income was approximately $41,000 a year in the 32771 zip code [BOC 2000].

Land Use

Land use around the SDC site is mostly commercial with some homes and apartments. Lake Monroe is approximately 0.25 mile to the north.

Community Health Concerns

Florida DOH reviewed previous contamination assessment reports and spoke with county, state, and federal environmental officials. None of the reports or individuals indicated any awareness of health concerns related to the site.

However, in late February 2011, Florida DOH conducted a telephone survey of more than 30 businesses within a half-mile of the site. Florida DOH learned that most respondents (73%) did not know anything about the site or any groundwater or other types of contamination.

One respondent expressed concerns about "contaminated dust" (from an unspecified source). Another felt certain that since the downtown Sanford area is a historic district that it likely has "lots of contamination since it has so many old buildings."

In late April 2011, EPA received one health concern at a public meeting in Sanford. One citizen wanted to know the potential health impacts of 'perc' at the concentrations found at the site. This concern is addressed in the Community Health Concerns Evaluation section below.

Florida DOH solicited public comment on the public comment draft report from July 21, 2011 until September 19, 2011. They did not receive any additional comments or health concerns.

Discussion

Pathway Analyses

Chemical contamination in the environment can harm your health but only if you have contact with those contaminants (exposure). Without contact or exposure, there is no harm to health. If there is contact or exposure, how much of the contaminants you contact (concentration), how often you contact them (frequency), for how long you contact them (duration), and the danger of the contaminant (toxicity) all determine the risk of harm.

Knowing or estimating the frequency with which people could have contact with hazardous substances is essential to assessing the public health importance of these contaminants. To decide if people can contact contaminants at or near a site, Florida DOH looks at human exposure pathways. Exposure pathways have five parts. They are:

1. a source of contamination like a hazardous waste site,
2. an environmental medium like air, water, or soil that can hold or move the contamination,
3. a point where people come into contact with a contaminated medium like water at the tap or soil in the yard,
4. an exposure route like ingesting (contaminated soil or water) or breathing (contaminated air),
5. a population who could be exposed to contamination like nearby residents.

Florida DOH eliminates an exposure pathway if at least one of the five parts referenced above is missing and is very unlikely to be present in the future. Exposure pathways not eliminated are either completed or potential pathways. For completed pathways, all five pathway parts exist and exposure to a contaminant has occurred, is occurring, or will occur. For potential pathways, at least one of the five parts is missing but could exist. Also for potential pathways, exposure to a contaminant could have occurred, could be occurring, or could occur in the future. Contaminant exposure pathways are displayed in Table 1.

The risk from dermal exposure (skin absorption) is commonly less than the risk involved in ingestion (eating/drinking) and inhalation (breathing).

Eliminated Exposure Pathways – The following section lists eliminated human exposure pathways.

Consumption of On-site Groundwater – This exposure pathway was eliminated from consideration because there is no current use or likely future use of groundwater under this site.

Ingestion of On-site Surface Soil – This exposure pathway was eliminated from consideration because there is no public access to the property. As long as site conditions remain the same (restricted access, asphalt cover), the pathway is eliminated. The property is currently abandoned and there is an 8-feet high, chain link fence with a locked gate preventing property access. Most of the site is covered with buildings or pavement. Also, because dry cleaning solvents used at the site tend to either evaporate into the air or sink down to the groundwater, it is unlikely that what little soil is exposed is contaminated.

Ingestion of Off-site Surface Soil – This exposure pathway was eliminated from consideration because access to off-site surface soil near the SDC site is limited to small patches between asphalt and concrete that caps the surrounding area. Also, because dry cleaning solvents used at the site tend to either evaporate into the air or sink down to the groundwater, it is unlikely that nearby surface soil is contaminated.

Ingestion and Inhalation of Off-site Private well water – It is unlikely that nearby (1.0 mile) off-site groundwater will be used in the future for public consumption. Only one private drinking water well was identified within a 1.0 mile radius of the SDC site [Figure 6, DOH 2010]. This well is located approximately 1.0 mile hydraulically up-gradient (southwest) from the SDC site. In 2006, this well (Florida Unique Well ID: AAK9398) was sampled and found to contain low levels of trihalomethanes (79 micrograms per liter, µg/L) that are most typically associated with chlorination treatment and not dry cleaning solvents (Figure 6) [DOH 2010].

The SDC groundwater contamination plume is not completely defined [EPA 2010]. However, it appears to extend less than 0.25 mile off-site northeast and toward Lake Monroe. The current available information shows the groundwater contamination plume no greater than one city block beyond the SDC site [EPA 2010, DEP 2009].

Completed Exposure Pathways – No pathways were identified where human exposure was currently completed for this site.

Potential Exposure Pathways – The following section lists potential human exposure pathways for this site.

Ingestion and Inhalation of City of Sanford Municipal water - Sanford residents near the SDC site are provided drinking water by municipal wells located approximately 3-4 miles southwest, hydraulically upgradient from the SDC site [DOH 2010, EPA 2010, DEP 2009, DEP 2007]. The municipal wells supply water to the downtown city of Sanford residents near and surrounding the SDC site. The municipal wells are hydraulically upgradient from the surficial aquifer measured by groundwater flow at SDC [DEP 2007]. A Florida DOH review of available municipal water sampling records (2004-2009) found no exceedances of health based ATSDR comparison values for any contaminants (Table 3). Because of the distance and intervening uncontaminated wells, low levels of *cis*-1,2-DCE found in 2005 and 2008 in one of the municipal wells (below comparison values) is not likely from the SDC site [DOH 2010].

Exposures to the Off-site Irrigation Well water – There is one residential irrigation well approximately 250 feet southeast of the SDC site. This well is reportedly completed 200 feet below land surface (bls) into the Floridan aquifer. The surficial groundwater flow direction is to the north-northeast toward Lake Monroe. The irrigation well is southeast of the site. In June 2009, consultants for Florida DEP sampled this well and did not detect any site-related contaminants.

Inhalation of VOCs through Groundwater to Indoor Air (Soil Vapor Intrusion) – VOC-contaminated groundwater under nearby homes and businesses may vaporize and migrate up into indoor air. Florida DOH recommends EPA assess the possibility of soil vapor intrusion. There are currently no sub slab or indoor air test data.

Environmental Data

Off-site soil and groundwater sampling

In December 1992, consultants for Florida DEP installed and sampled six monitoring wells (MW) to the south and east of the SDC site (Figure 9). They were investigating potential groundwater contamination from the adjacent former Thrifty Service Station. PCE and TCE were found in the groundwater samples from MW-2 and MW-5 above ATSDR screening guidelines and state drinking water standards (Table 4) [ESSI 1993]. This initial finding of PCE and TCE in groundwater prompted further investigations to identify the contamination's source.

In December 1993, ESSI Omega, Inc. sampled and confirmed PCE and TCE groundwater contamination in MW-5 and reported their findings in a Contamination Assessment Report Addendum (Table 4) [ESSIO 1993].

In 1999, Stillwater Technologies, Inc. conducted a Limited Phase II Environmental Assessment at the SDC site [ST 1999]. Three direct push grab samples (15, 15, and 30 feet) and re-sampling of MW-5 (screened 3-13 feet) identified increased concentrations of PCE (31,000 µg/L) and TCE (8,900 µg/L). Vinyl chloride (VC, 55 µg/L) and cis-1,2-dichloroethylene (cis-1,2-DCE, 180 µg/L) were identified for the first time associated with site groundwater contamination (Table 4). This field work was completed 03/30/1999.

Spanning late 2005 and early 2006, the Florida DEP completed six sampling efforts where they collected soil and groundwater samples from nearby street right-of-ways and analyzed them for VOCs [DEP 2007]. All VOCs were below ATSDR screening guidelines. Florida DEP located the source of solvent contamination at the site's southeastern corner (SDC's back door). Florida DEP installed monitoring wells and sampled from the shallow surficial aquifer (S) at 15 feet below land surface (bls) and deeper surficial aquifer (D) at 35-40 feet bls. They found the highest measured concentrations for VOCs in MW FDEP 3S and MW FDEP 3D (Figure 8, Table 2, and Table 4).

On-site soil and groundwater sampling

In June 2009, consultants for Florida DEP collected two soil samples each from six locations on the SDC site [DEP 2009]. They selected the samples from 0-2 feet and 2-4 feet bls at each boring location (Figure 9, B4-B9). In the 12 on-site soil samples, concentrations of VOCs were all below ATSDR screening guidelines.

Also in June 2009, Florida DEP consultants installed and sampled two on-site monitoring wells (SDC-002S and SDC-003S) approximately 10 feet deep (screened 3-9 feet), where B5 and B7 soil samples had previously been collected, respectively (Figure 9). They analyzed the samples for VOCs [DEP 2009]. In two groundwater samples, the concentrations of PCE (870 µg/L in SDC-003S) and TCE (140 µg/L in SDC-003S) were above ATSDR screening guidelines (Table 4). The concentrations of other VOCs were below ATSDR screening guidelines.

Contamination maps (Figures 10-13) display on-site and off-site historical groundwater sampling results. The analytical results are displayed for health comparison value exceedances for contaminants of concern (PCE, TCE, *cis*-1,2-DCE, *trans*-1,2-DCE and VC, Figures 10, 11, 12). If no health based comparison value exceedances were found in the groundwater, the well is labeled with NE (no exceedances, Figure 13).

Identifying Contaminants of Concern

Florida DOH compares the maximum concentrations of contaminants found at a site to ATSDR and other comparison values. Comparison values are specific for the medium contaminated (soil, water, air, etc.). We screen the environmental data using these comparison values:

- ATSDR Environmental Media Evaluation Guides (EMEGs)
- ATSDR Reference Media Evaluation Guides (RMEGs)
- Florida DEP Soil Cleanup Target Levels (SCTLs)
- EPA Maximum Contaminant Levels (MCLs)

When determining which comparison value to use, Florida DOH follows ATSDR's general hierarchy and uses professional judgment.

We select for further evaluation contaminants with maximum concentrations above a comparison value. Comparison values, however, are not thresholds of toxicity. They are not used to predict health effects or to establish clean-up levels. A concentration above a comparison value does not necessarily mean harm will occur. It does indicate, however, the need for further evaluation.

Maximum contaminant concentrations below comparison values are safe and are not evaluated further.

Comparing the highest measured concentrations in soil to ATSDR and EPA screening guidelines showed no soil contaminants exceeded health guidelines. Comparing the highest measured concentrations in groundwater to ATSDR and EPA screening

guidelines, Florida DOH selected tetrachloroethylene (perchloroethylene or PCE), trichloroethylene (TCE), *cis*-1,2-dichlorethylene (*cis*-1,2-DCE), *trans*-1,2-dichlorethylene (*trans*-1,2-DCE) and vinyl chloride (VC) as contaminants of concern for the purposes of analyzing the potential vapor intrusion pathway. Selection of these contaminants does not necessarily mean there is a public health risk. Rather, Florida DOH selected these contaminants for closer scrutiny. Concentrations of other contaminants are below screening guidelines, are not likely to cause illness, and are not evaluated further.

Public Health Implications

Levels of indoor air contamination are required to assess health hazards. ATSDR recommends using multiple lines of evidence to determine the potential for vapor intrusion into buildings. Actual indoor air sampling is the most important line of evidence. There is a large degree of variation in indoor air levels from vapor intrusion. To assess this variability, multiple sampling events and collection of complimentary data on subslab gas and ambient air levels are required. However, no air sampling has been performed at the Sanford Dry Cleaners site. To estimate exposure from soil vapor intrusion Florida DOH used screening methods based on the highest groundwater concentrations found at or near the SDC hazardous waste site. The screening method is provided within ATSDR guidance documents and relies on groundwater concentrations because there are no current air monitoring data available for comparison [ATSDR 2008, ITRC 2007]. This lack of air data represents a data gap. Screening models can estimate air contaminant concentrations based on groundwater concentrations. Specifically, Florida DOH used the Johnson and Ettinger model as recommended by ATSDR to examine the potential for vapor intrusion [ATSDR 2008].

VOC Air Modeling

Indoor air sampling was not available for the SDC site and surrounding community. Florida DOH applied attenuation factors from the Johnson and Ettinger (1991) model to estimate indoor air concentrations. Groundwater contamination surrounding the SDC site only involves the shallow aquifer at depths less than 45 feet. The majority of contaminants in these groundwater plumes are volatile organic compounds that have the ability to volatilize into vapor. This vapor can, in turn, move from the groundwater, through soil, and eventually seep into buildings and affect the indoor air.

Modeling Approach

Rather than simulating the many complex factors that affect how toxic chemicals disperse in air, Florida DOH evaluated a simple and overestimated exposure situation: *What would be the estimated indoor air concentration of a VOC contaminant for a house or business located directly above a groundwater plume with a VOC concentration equal to the highest groundwater level measured at the SDC site?* Though obviously unrealistic, this scenario provides an upper bound estimate of what the actual ambient air concentrations might be or have been. Florida DOH used the Johnson and Ettinger indoor air model and SDC groundwater data to estimate indoor air concentrations in residences

and businesses in downtown Sanford. This modeling approach is used for screening purposes. The Johnson and Ettinger modeling result is corroborated by modeling based on an upper bound estimate from EPA's database of attenuation factors, though attenuation factors from actual measurements varied by a factor of 100,000 [EPA 2008b].

Johnson and Ettinger Model (1991)

In September 1988, the U.S. Environmental Protection Agency (EPA) developed the Johnson and Ettinger Model to estimate indoor air concentrations and associated health hazards from subsurface vapor intrusion into buildings. This model is a screening-level model that incorporates mechanisms for estimating the transport of contaminated vapors from either subsurface soils or groundwater into the spaces directly above the source of contamination [EQM 2000]. Soil properties, chemical properties of the contaminant, and structural properties of the building are entered into the model. When an initial groundwater concentration is entered into the model an incremental risk is produced. This risk, in turn, can be converted into an air concentration.

The Johnson and Ettinger model is a first-tier screening tool that is based on several assumptions. As a result, it has limitations.

- The model does not consider the effects of multiple contaminants.
- Its calculations do not account for preferential vapor pathways due to soil fractures, vegetation root pathways, utility conduits or the effects of a gravel layer beneath the floor slab.
- The groundwater model does not account for the rise and fall of the water table due to aquifer discharge and recharge.
- The model also assumes that all vapor will enter the building, implying a constant pressure field is generated between the interior spaces and the soil surface.
- It neglects periods of near zero pressure differential.
- Soil properties in the area of contamination are assumed to be identical to those in the area above the contamination.
- For relatively shallow vapor sources (depths less than 15 feet below foundation level), advective vapor transport may result in unattenuated or enhanced vapor intrusion. Very permeable soils located between a relatively shallow source of contamination and a building may serve as a naturally occurring preferential pathway. In highly developed residential areas, extensive networks of subsurface utility conduits could significantly influence the migration of contaminants.
- Deviation from the following default values will result in model inaccuracies: air exchange rate (varies with HVAC system, air tightness of building, etc.), mixing height (complicated by multiple levels), building crack ratio, irregularities in the subsurface media (zones of gravel, silt, debris, perched and irregular quifers, sewage and water lines, cable conduits, etc.), soil porosity and slab thickness.

3-D models show that neighboring buildings and slab surface cover surrounding buildings can have an effect on the subsurface fate and transport of soil gas [Pennell 2009].

All but the most sensitive parameters have been set to either an upper bound value or the median value. As a result, the model is very conservative when predicting indoor air concentrations.

For predicting indoor air contaminant concentrations in buildings at or near SDC, Florida DOH entered the maximum groundwater concentrations for each VOC into the Johnson and Ettinger model. Parameter inputs (as maximum groundwater contaminant concentrations), assumptions and screening output values are available in Appendix C.

Table 5 presents the resultant air screening concentrations for all contaminants of concern. The upper 95th percentile attenuation factor (0.001) from measured data compiled by EPA corroborates the Johnson and Ettinger modeling results (attenuation factor between 0.001 and 0.0015), though measured values from the EPA database varied by a factor of 100,000 [EPA 2008b]. All screening results are greater than their corresponding health based comparison values. *cis*-1,2-DCE does not have a health based comparison value available due to a lack of data for this particular compound. The Johnson and Ettinger model results show that it is possible soil vapor intrusion at or near the SDC site may have significant exceedances of health based values. For an example of the significant exceedances found by the modeling, VC results (557 $\mu g/m^3$) give a screening value 5,570 times the health related guideline (0.1 $\mu g/m^3$). PCE (52,270 $\mu g/m^3$) screening gives a result 174 times the applicable comparison value (300 $\mu g/m^3$). TCE (8,072 $\mu g/m^3$) screening gives a result 16 times the applicable comparison value (500 $\mu g/m^3$) (Table 5). These air concentrations predicted by the screening model are considered high when compared against their health based guideline concentrations. The screening model, with the limitations provided above is only as accurate as the assumptions and parameters used to create the model.

Making health based decisions based on modeling data is not recommended because of the inherent uncertainty and assumptions of modeling. Therefore, the health conclusions regarding indoor air concentrations are indeterminate. Stated another way, ATSDR and Florida DOH cannot conclude there is a public health hazard, but needs air vapor data to provide a basis for decision regarding health. Florida DOH has tabulated the air concentration data (Table 5) and provided health based values for comparison, when available. These health based air concentrations are gathered from animal and human research data and are protective of human health. The lack of soil vapor intrusion contaminant air concentration data is an identified, existing data gap. It is recommended that EPA fill this data gap with future soil vapor intrusion sampling. Florida DOH will review and evaluate this data as it becomes available.

Child Health Considerations

In communities faced with air, water, soil, 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 sometime engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than 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 system 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.

Other susceptible populations may have different or enhanced susceptibilities to chemicals than will most persons exposed to the same levels of that chemical in the environment. Reasons may include genetic makeup, age, health, nutritional status, and exposure to other toxic substances (like cigarette smoke and alcohol). These factors may limit that person's ability to detoxify or excrete harmful chemicals or may increase the effects of damage to their organs or systems.

The developing fetus, children, and especially the developing nervous system may be particularly susceptible to the toxic effects of PCE. Studies in mice suggest that PCE can cross the placenta and that its breakdown metabolite trichloroacetic acid (TCA) concentrates in the fetus. Unmetabolized PCE has been excreted in breast milk and was detected in an exposed infant with liver damage. In addition, possible chemical effects were detected in children in Woburn, Massachusetts. Children in that community may have been exposed to solvent-contaminated drinking water as infants or in the womb, possibly contributing to elevated incidences of acute lymphocytic leukemia or impaired immunity [ATSDR 1997a].

The youngest of the population with immature and developing organs (i.e., premature and newborn infants) will be more vulnerable to toxic substances in general than healthy adults. If the metabolic products are more toxic than the parent compound, an individual with higher metabolic rates (such as children and adolescents) would be expected to have greater toxicity [ATSDR 1997b].

Community Health Concerns Evaluation

PCE is not a health concern in drinking water because the municipal source of drinking water is far removed (more than 2.5 miles) from the site and is not contaminated. Use of the nearby irrigation well will not harm people's health. PCE in soil is not a health concern because there is minimal to no contact with site soils due to concrete and asphalt paving covering the site. PCE in vapors rising into surrounding buildings is a potential source of contamination and exposure. However, no air sampling data is available to determine health impacts, if any. Florida DOH is working with the EPA to gather the needed information.

Conclusions

1. Florida DOH and ATSDR cannot currently conclude whether breathing indoor air near Sanford Dry Cleaners could harm people's health. The information we need to make a decision is not available and represents an identified data gap. We are working with the

US Environmental Protection Agency (EPA) to gather the needed information. The screening vapor intrusion model shows that high levels of VOCs could migrate into nearby residences and businesses that are located over the groundwater plume.

2. Florida DOH and ATSDR conclude that drinking or showering with municipal water will not harm people's health. The reason for this is that municipal water supplies are not contaminated.

3. Florida DOH and ATSDR conclude that exposure to soil contamination at the SDC site is not expected to harm people's health.

4. Florida DOH and ATSDR conclude that use of the nearby irrigation well will not harm people's health.

Recommendations

1. EPA should assess the risk of vapors entering businesses and homes above the contaminated groundwater by collecting air samples in these buildings. Florida DOH and ATSDR will evaluate additional data as it becomes available.

2. EPA should determine the extent of the groundwater contamination at the SDC hazardous waste site. Florida DOH and ATSDR will evaluate additional data as it becomes available.

3. The Florida Department of Environmental Protection (DEP) and the City of Sanford should continue to monitor municipal water systems.

4. EPA should determine the extent of the soil contamination at the SDC hazardous waste site.

5. EPA should periodically sample the irrigation well for site related contaminants.

Public Health Action Plan

Actions Planned

Florida DOH will evaluate new environmental data as it becomes available and summarize them in future reports.

REPORT PREPARATION

This Health Consultation for the Sanford Dry Cleaners Site was prepared by the Florida Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

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Appendix A – Tables

Table 1. Potential and Eliminated Exposure Pathways at the Sanford Dry Cleaners Site

	Exposure Pathway Elements						
Pathway Name	**Pathway Status**	**Source**	**Environmental Medium**	**Point of Exposure**	**Potentially Exposed Population**	**Route of Exposure**	**Time Frame**
Vapor Intrusion	Potential	On-site solvent disposal	Groundwater and Indoor Air	Indoor Air at nearby businesses and homes	Nearby Workers and Residents	Inhalation	Past Present Future
Off-site Groundwater (Private and Municipal Drinking Water Wells)	Potential	On-site solvent disposal	Groundwater	Private and Municipal Drinking Water Wells	Nearby and City Residents	Ingestion and Inhalation	Future
Off-site Irrigation Well	Potential	On-site solvent disposal	Groundwater	Residential Irrigation Well	Nearby residents	Inhalation	Future
On-site Groundwater	Eliminated	On-site solvent disposal	Groundwater	None	None	None	Past, Present, and Future
On-site and off-site Soil	Eliminated	On-site solvent disposal	Soil	None	None	None	Past, Present, and Future

Table 2. History of maximum Comparison Value exceedances in groundwater monitoring wells

Well ID	Location	Sampling depth[Þ] (feet)	Sample date	Contaminant of concern	Contaminant concentration[§]	CV		CV source	EPA MCL*	EPA MCLG[¥]
						child	adult			
MW FDEP-3S	off-site, immediately E of SDC back door	10-15	10/12/05	*cis*-1,2-Dichloroethylene (*cis*-1,2-DCE)	5,900	20	70	RMEG[Ħ]	70	70
MW FDEP-3S	off-site, immediately E of SDC back door	10-15	06/01/09	*trans*-1,2-Dichloroethylene (*trans*-1,2-DCE)	1,300	200	700	RMEG	100	100
MW FDEP-3D	off-site, immediately E of SDC back door	35-40	10/12/05	Tetrachloroethylene (PCE)	75,000	100	400	RMEG	5	0
MW FDEP-3D	off-site, immediately E of SDC back door	35-40	10/12/05	Trichloroethylene (TCE)	19,000	5		EPA MCL	5	0
MW FDEP-3S	off-site, immediately E of SDC back door	10-15	10/12/05	Vinyl Chloride (VC)	400	30	100	ATSDR Chronic EMEG[ε]	2	0

[Þ] below land surface

[§] all concentrations given in micrograms per liter (ug/L)

CV = comparison value

* EPA Maximum Contaminant Level, regulatory level considering health, cost, and technological practicality (enforceable)

[¥] EPA Maximum Contaminant Level Goal, public health cleanup goal (non-enforceable)

[Ħ] RMEG = Reference Dose Media Evaluation Guide

[ε] EMEG = Environmental Media Evaluation Guide

Table 3. Sanford Public Water Supply Wells VOC Sampling History (2004-2009)*

Public Water Supply well ID	System name	Sampling date	VOCs present? Y/N	Contaminant of concern	Concentration[§]	Comparison Value		
						child	adult	source
3590338	ELDER SPRINGS MOBILE HOME PARK	2/23/2004	N					
3594128	ADVANCED EYECARE OF CENTRAL FLORIDA INC	12/17/2004	N					
3590205	SANFORD CITY OF (2 WPS)	6/15/2005	Y	*cis*-1,2-Dichloroethylene (*cis*-1,2-DCE)	0.31	20	70	RMEG[¥]
		3/8/2005	Y	*cis*-1,2-Dichloroethylene (*cis*-1,2-DCE)	0.45	20	70	RMEG
		06/11/2008	Y	*cis*-1,2-Dichloroethylene (*cis*-1,2-DCE)	0.4	20	70	RMEG
3590007	TOWN AND COUNTRY RV RESORT	5/24/2006	N					
		12/31/2009	N					
3590258	CRYSTAL LAKE	3/28/2006	N					
		2/12/2009	N					
3590338	ELDER SPRINGS MOBILE HOME PARK	6/23/2006	N					
		12/1/2009	N					
3590993	PARK RIDGE	3/10/2006	N					
		2/12/2009	N					
3591008	PHILLIPS SECTION	3/10/2006	N					
		2/12/2009	N					
3591061	RAVENNA PARK	3/10/2006	N					
		2/12/2009	N					
3591395	TWELVE OAKS R.V.RESORT	11/29/2006	N					
		6/18/2009	N					

* FDEP drinking water data base, http://www.dep.state.fl.us/water/drinkingwater/download.htm

[§] all concentrations given in micrograms per liter (ug/L)

[¥] RMEG = Reference Dose Media Evaluation Guide

Table 4. History of groundwater Comparison Value exceedances during site investigations

Well or sample ID	Location	Sampling depth[Þ] (feet)	Sample date	Contaminant of concern	Contaminant concentration[§]	Comparison Value		CV source
						child	adult	
MW-2	off-site, SE of SDC across eastern alley	3-13	12/21/92	TCE	19	5		EPA MCL*
MW-5	off-site, just S of SDC SE corner	3-13	12/21/92	TCE	43	5		EPA MCL
			12/07/93	TCE	42	5		EPA MCL
			03/30/99	cis-1,2-DCE	170	20	70	RMEG[Ĥ]
				TCE	13	5		EPA MCL
			03/01/06	cis-1,2-DCE	370	20	70	RMEG
GP-1, DP grab	off-site, NE corner of SDC	15	03/30/99	cis-1,2-DCE	180	20	70	RMEG
				TCE	240	5		EPA MCL
				VC	55	30	100	ATSDR Chronic EMEG[ε]
GP-1, DP grab	off-site, NE corner of SDC	30	03/30/99	PCE	4,800	100	400	RMEG
				TCE	540	5		EPA MCL
GP-2, DP grab	off-site, NE corner of SDC	15	03/30/99	PCE	31,000	100	400	RMEG
				TCE	8,900	5		EPA MCL
MW FDEP-3S	off-site, immediately east of SDC back door	10-15	10/12/05	**cis-1,2-DCE**	**5,900**	**20**	**70**	RMEG
				trans-1,2-DCE	**1,300**	**200**	**700**	RMEG
				PCE	18,000	100	400	RMEG
				TCE	8,200	5		EPA MCL

				VC	**400**	**30**	**100**	ATSDR Chronic EMEG[ε]
			06/01/09	cis-1,2-DCE	3,500	20	70	RMEG
				trans-1,2-DCE	750	200	700	RMEG
				PCE	8,300	100	400	RMEG
				TCE	5,000	5		EPA MCL
				VC	230	30	100	ATSDR Chronic EMEG[ε]
MW FDEP-3S duplicate	off-site, immediately east of SDC back door	10-15	06/01/09	cis-1,2-DCE	3,400	20	70	RMEG
				trans-1,2-DCE	760	200	700	EPA MCL 2010
				PCE	8,900	100	400	RMEG
				TCE	5,100	5		EPA MCL
				VC	230	30	100	ATSDR Chronic EMEG[ε]
MW FDEP-3D	off-site, immediately east of SDC back door	35-40	10/12/05	cis-1,2-DCE	190	20	70	RMEG
				PCE	**75,000**	**100**	**400**	RMEG
				TCE	**19,000**	**5**		EPA MCL
			06/01/09	cis-1,2-DCE	190	20	70	RMEG
				PCE	3,600	100	400	RMEG
				TCE	2,000	5		EPA MCL
MW FDEP-5D	off-site, approximately 50' NE of SDC back door	35-40	10/12/05	cis-1,2-DCE	400	20	70	RMEG
				PCE	18,000	100	400	RMEG

				TCE	5,600	5		EPA MCL
			06/01/09	cis-1,2-DCE	480	20	70	RMEG
				PCE	17,000	100	400	RMEG
				TCE	5,300	5		EPA MCL
MW FDEP-6D	off-site, approximately 75' NE of SDC back door	35-40	10/12/05	TCE	27	5		EPA MCL
MW FDEP-10D	off-site, approximately 100' NE of SDC back door	35-40	01/31/06	TCE	7	5		EPA MCL
MW FDEP-12D	off-site, on E right of way of S Sanford Ave near entrance to Post Office, approximately 150' NE of SDC back door	45-50	06/01/09	cis-1,2-DCE	98	20	70	RMEG
				TCE	40	5		EPA MCL

CV = comparison value

[Þ] below land surface

[§] all concentrations given in micrograms per liter (ug/L)

* EPA Maximum Contaminant Level, regulatory level considering health, cost, and technological practicality (enforceable)

[Ĥ] RMEG = Reference Dose Media Evaluation Guide

[ε] EMEG = Environmental Media Evaluation Guide

GP-1, DP grab = sample from a direct push grab sample

bold denotes maximum exceedance

Table 5. Indoor air screening model results

Contaminant of Concern	Maximum groundwater concentration (µg/L)	Johnson and Ettinger model calculated indoor air screening level (µg/m^3)	EPA 95th percentile attenuation factor model calculated air screening level (µg/m^3)†	Air comparison value (µg/m^3)	Source of air comparison value*
cis-1,2-Dichloroethylene (*cis*-1,2-DCE)	5,900	952	906	None	--
trans-1,2-Dichloroethylene (*trans*-1,2-DCE)	1,300	469	462	800	Intermediate EMEG/MRL
Tetrachloroethylene (PCE)	75,000	52,270	50,900	300	Chronic EMEG/MRL
Trichloroethylene (TCE)	19,000	8,072	7,300	500	Intermediate EMEG/MRL
Vinyl chloride (VC)	400	577	419	0.1	CREG

µg/L = micrograms per liter
µg/m^3 = micrograms per cubic meter
† NOTE: Actual measured values in EPA's database varied by a factor of 100,000 [EPA 2008b]
* Comparison values used to select chemicals for further scrutiny, not for determining the possibility of illness
Sample data from [ESSI 1993], [ESSIO 1993], [ST 1999], [SIS 2007], [FDEP 2009]

Appendix B – Figures

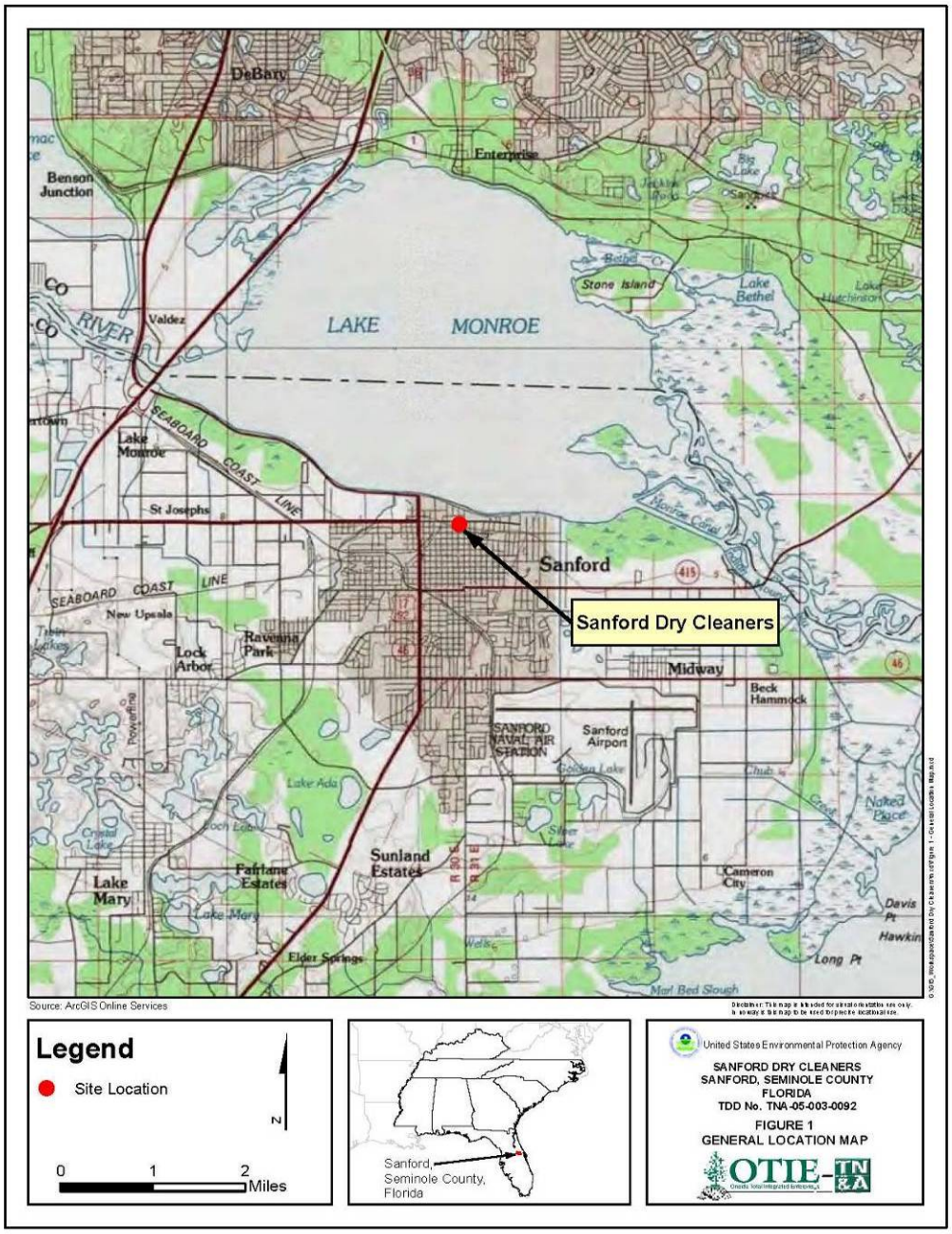


Figure 1. General Location of the Sanford Dry Cleaners Site

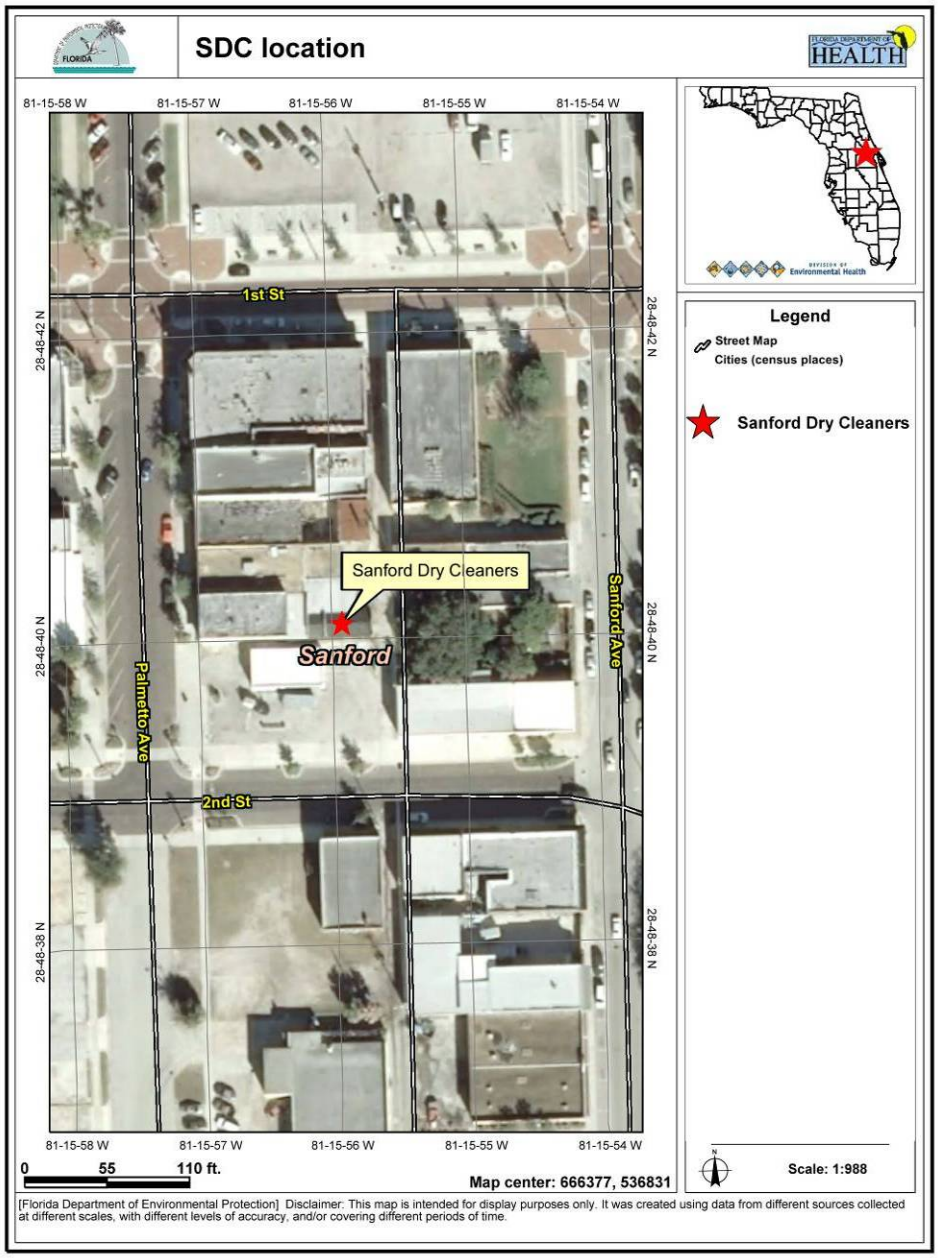


Figure 2. Aerial View of the Sanford Dry Cleaners Site

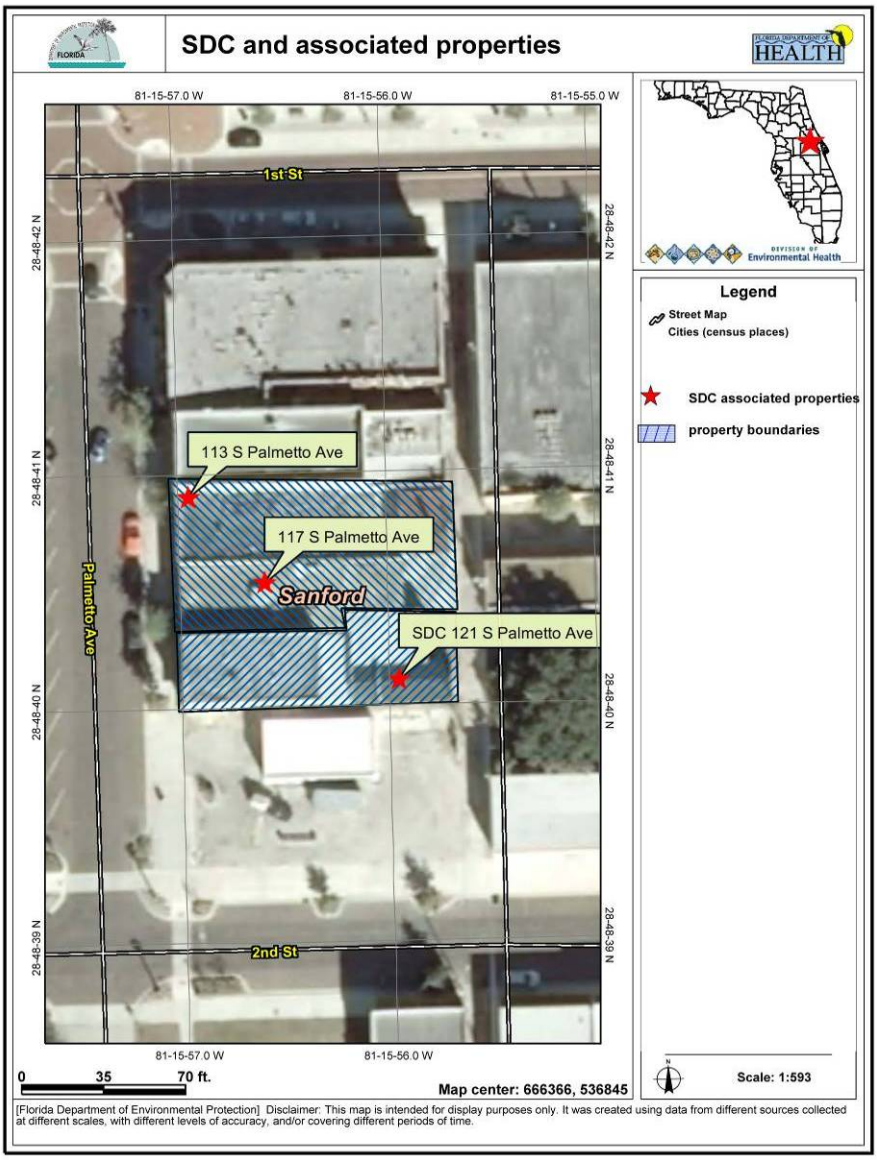


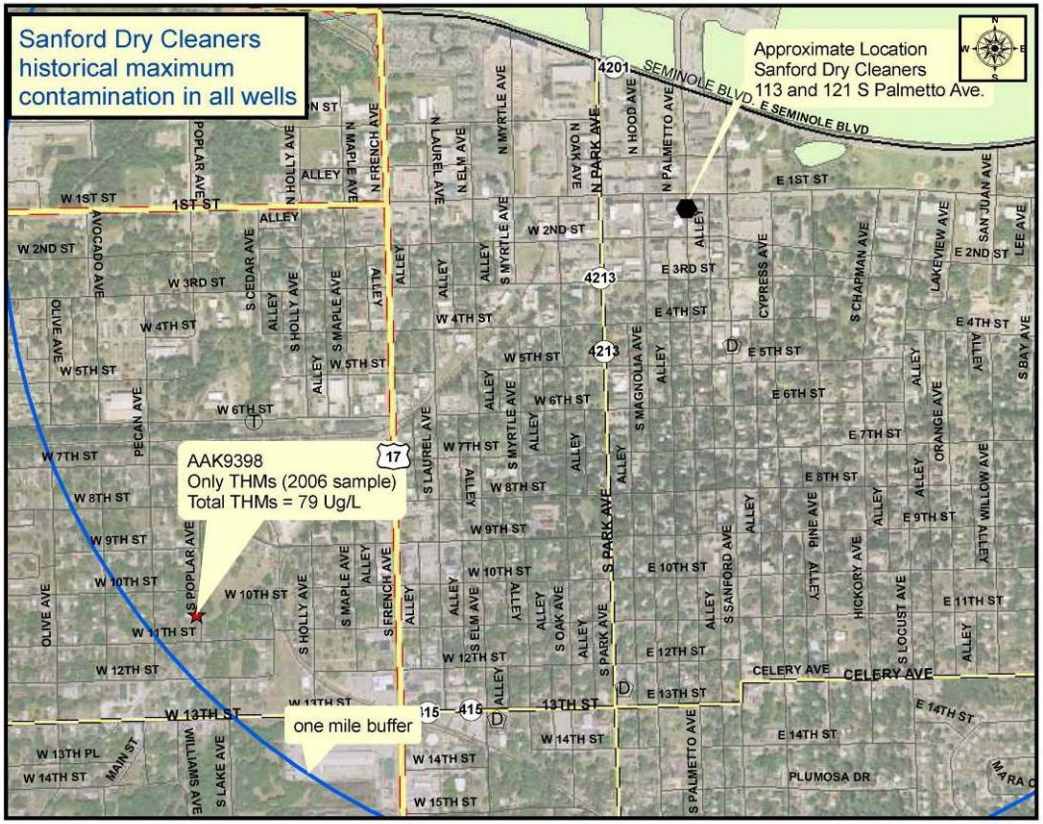
Figure 3. Boundaries of the Sanford Dry Cleaners Site and Nearby Properties

Figure 4. SDC site, rear alley view looking NNW [051910 site visit].

Figure 5. SDC site, view of locked gate at rear of building looking NNW [site visit 051910].

Florida Department of Health
Bureau of Water Programs
Well Surveillance Tracking System

EPA Superfund site, EPA ID: FLD032728032
Sanford Dry Cleaners, 113 and 121 Palmetto Ave.,
Sanford, Fl. Seminole County
ANALYSIS: Dry Cleaning Solvents



aners site, EPA NPL Superfund site, EPA ID: FLD032728032. DOH has only
within 1 mile of this site. Trihalomethanes (THMs) were detected, which are
d are not related to dry cleaner solvents.

Miles
0 0.05 0.1 0.15 0.2 0.25

9/17/2010
EvansMS2

lls located and/or sampled within one mile buffer of SDC site [DOH 2010].

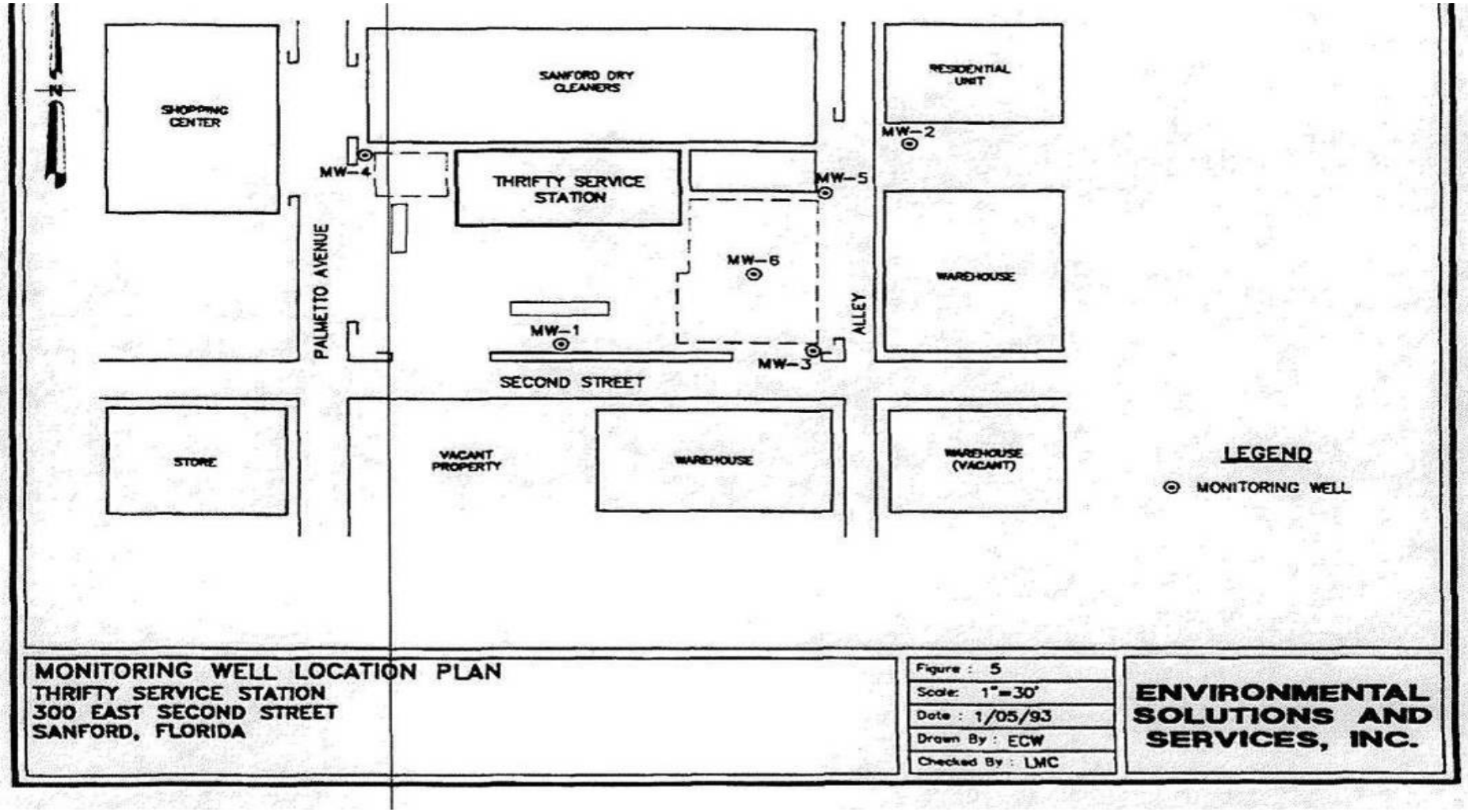


Figure 7. 1992 Off-Site Monitoring Well Locations South and East of the Sanford Dry Cleaners Site [ESSI 1993].

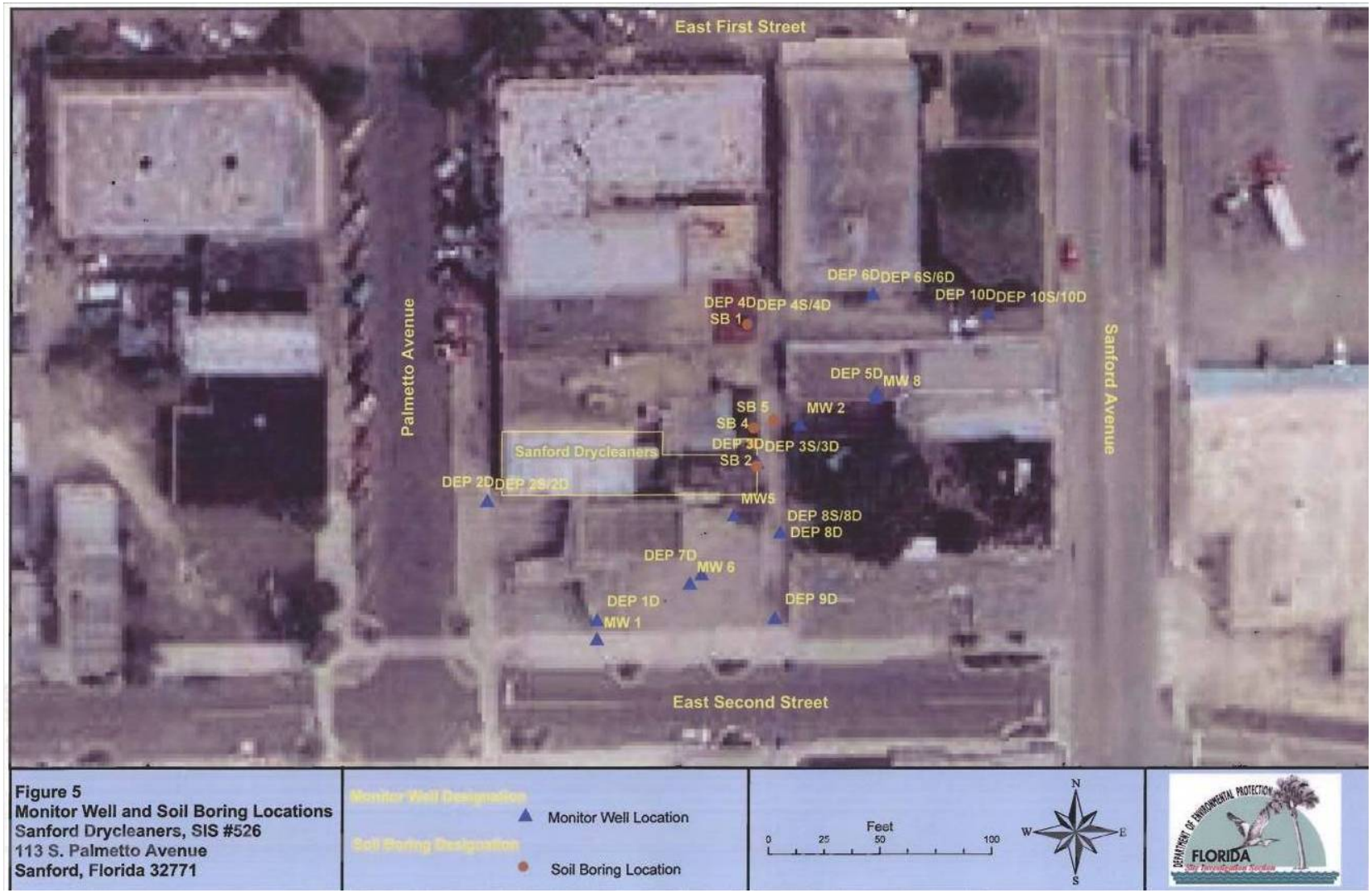


Figure 8. 2005-06 Florida DEP Soil Boring and Monitoring Well Locations [DEP 2007]

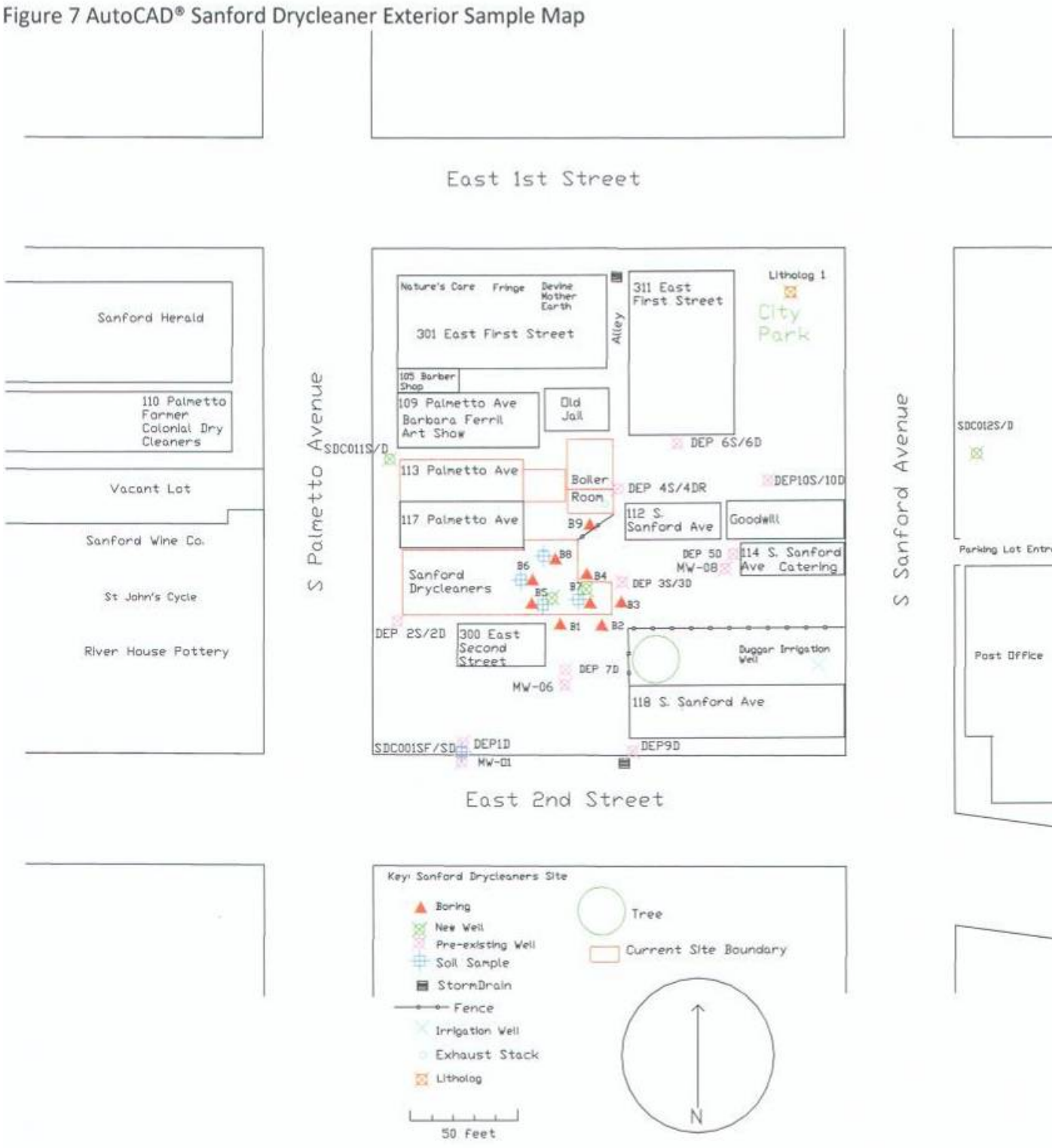
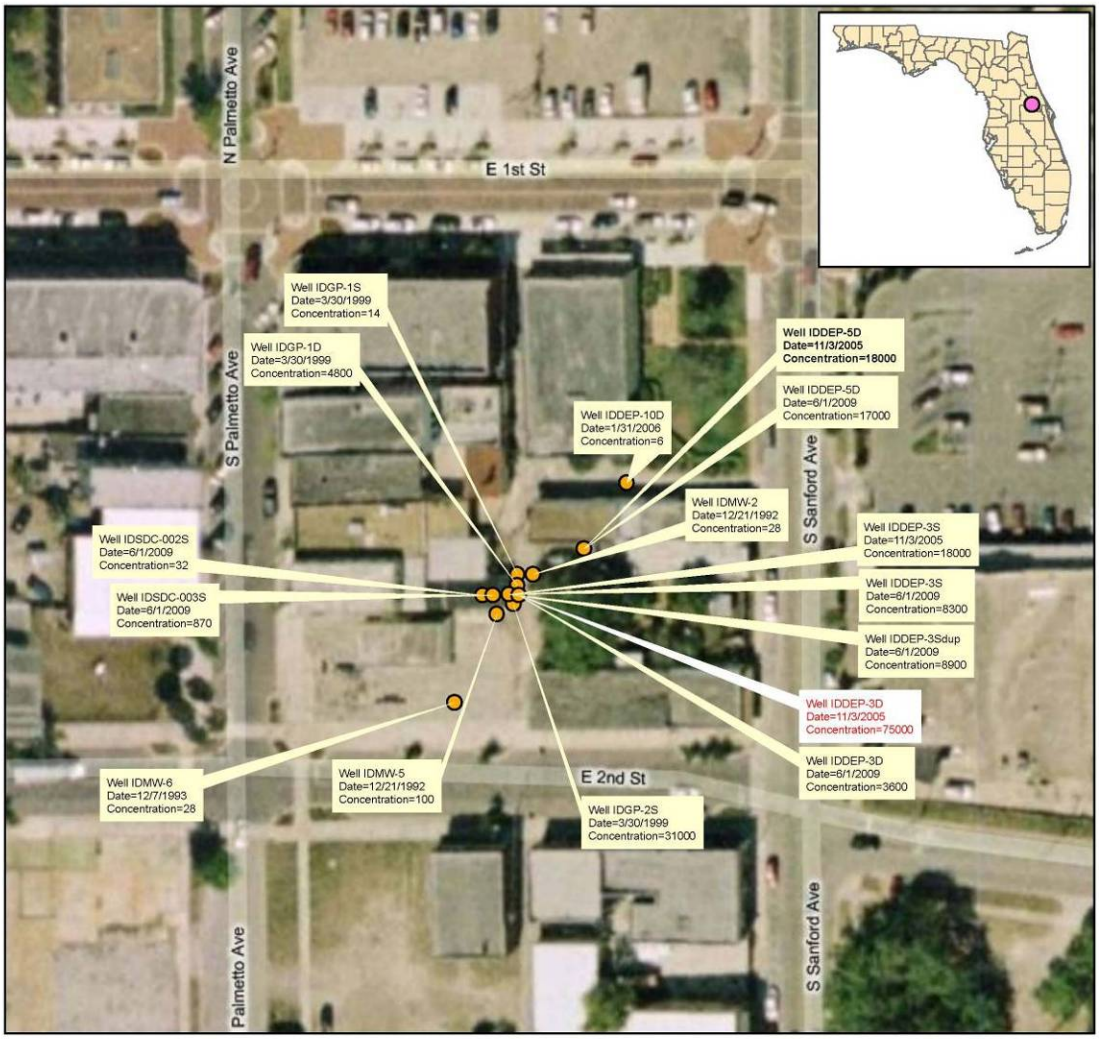


Figure 9. 2009 Florida DEP Soil Boring and Monitor Well Locations [DEP 2009].

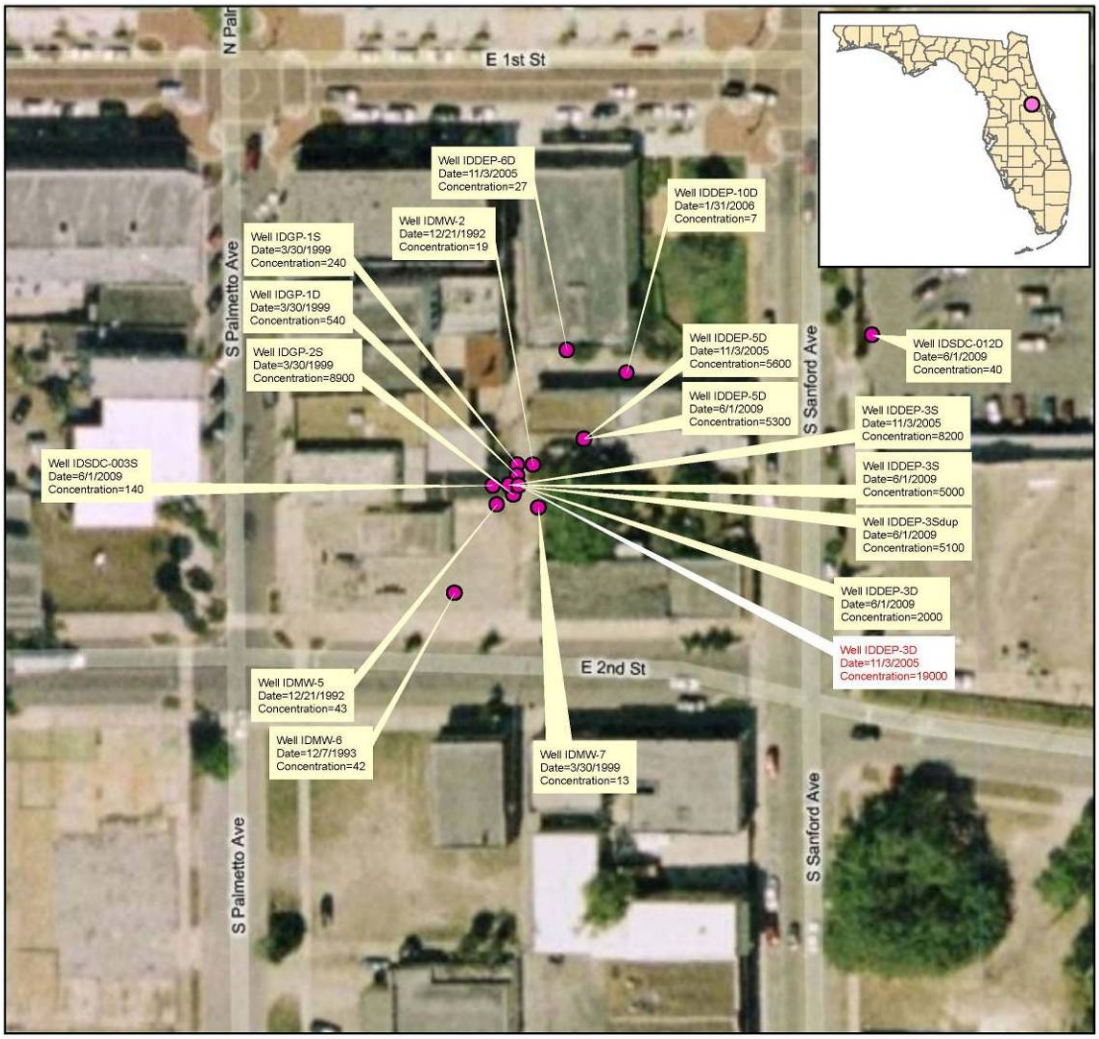


Legend

"CHEMICAL" = 'PCE'

MW = monitoring well
DEP = Department of Environmental Protection
SDC = Sanford Dry Cleaners
S = shallow (10-15')
D = deep (30-50')
GP = direct push grab sample
Concentrations in micrograms per liter (ug/L)
red text denotes maximum exceedance

Figure 10. PCE groundwater comparison value exceedances [ESSI 1993], [ESSIO 1993], [ST 1999], [SIS 2007], [FDEP 2009].

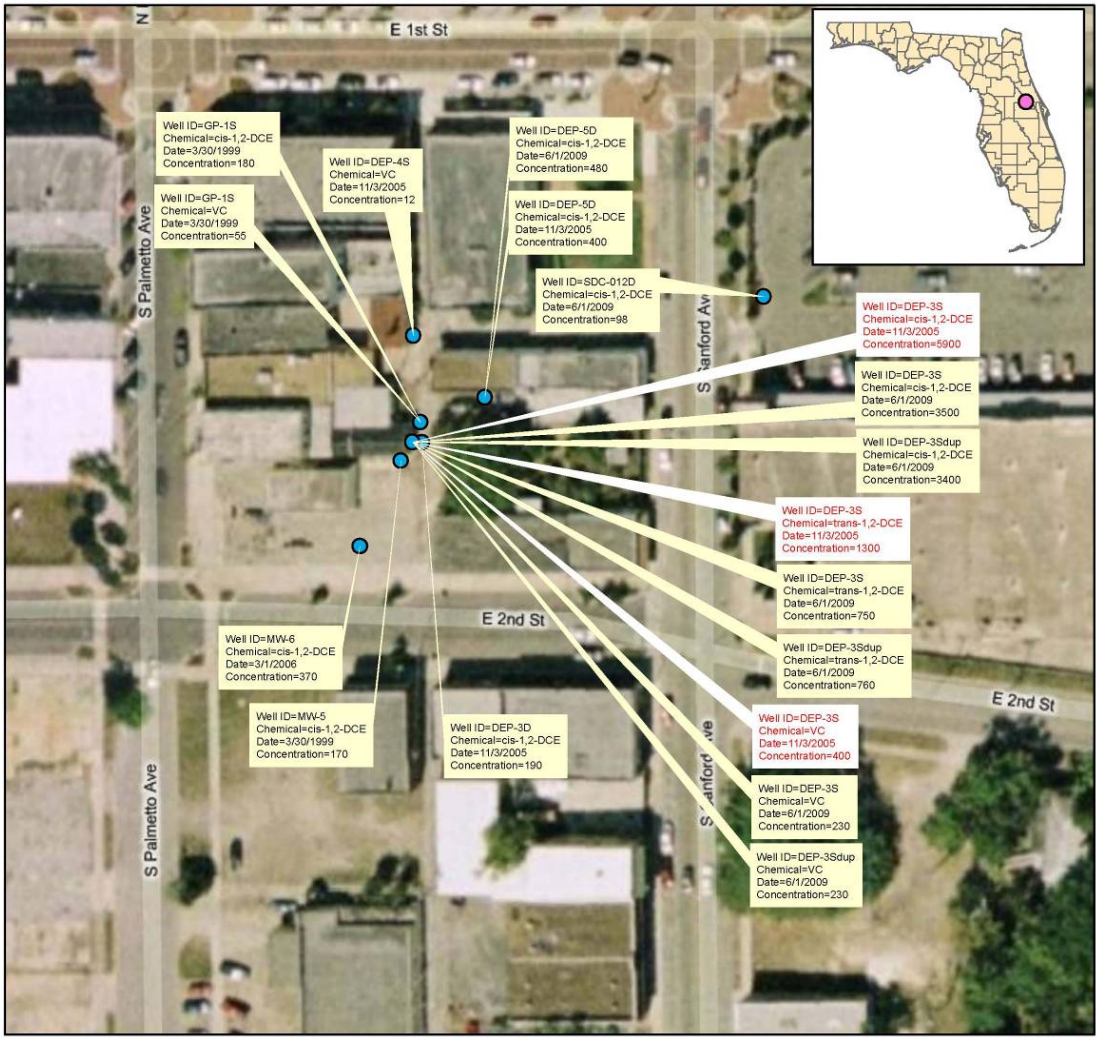


Legend

● "CHEMICAL" = 'TCE'

MW = monitoring well
DEP = Department of Environmental Protection
SDC = Sanford Dry Cleaners
S = shallow (10-15')
D = deep (30-50')
GP = direct push grab sample
Concentrations in micrograms per liter (ug/L)
red text denotes maximum exceedance

Figure 11. TCE groundwater comparison value exceedances [ESSI 1993], [ESSIO 1993], [ST 1999], [SIS 2007], [FDEP 2009].



Legend

"CHEMICAL" = 'Vinyl Chloride, cis-1,2-DCE, or trans-1,2-DCE

VC = vinyl chloride
DCE = dichloroethylene
MW = monitoring well
DEP = Department of Environmental Protection
SDC = Sanford Dry Cleaners
S = shallow (10-15')
D = deep (30-50')
GP = direct push grab sample
Concentrations in micrograms per liter (ug/L)
red text denotes maximum exceedance

Figure 12. VC, *cis*-1,2-DCE, and *trans*-1,2-DCE groundwater comparison value exceedances [ESSI 1993], [ESSIO 1993], [ST 1999], [SIS 2007], [FDEP 2009].

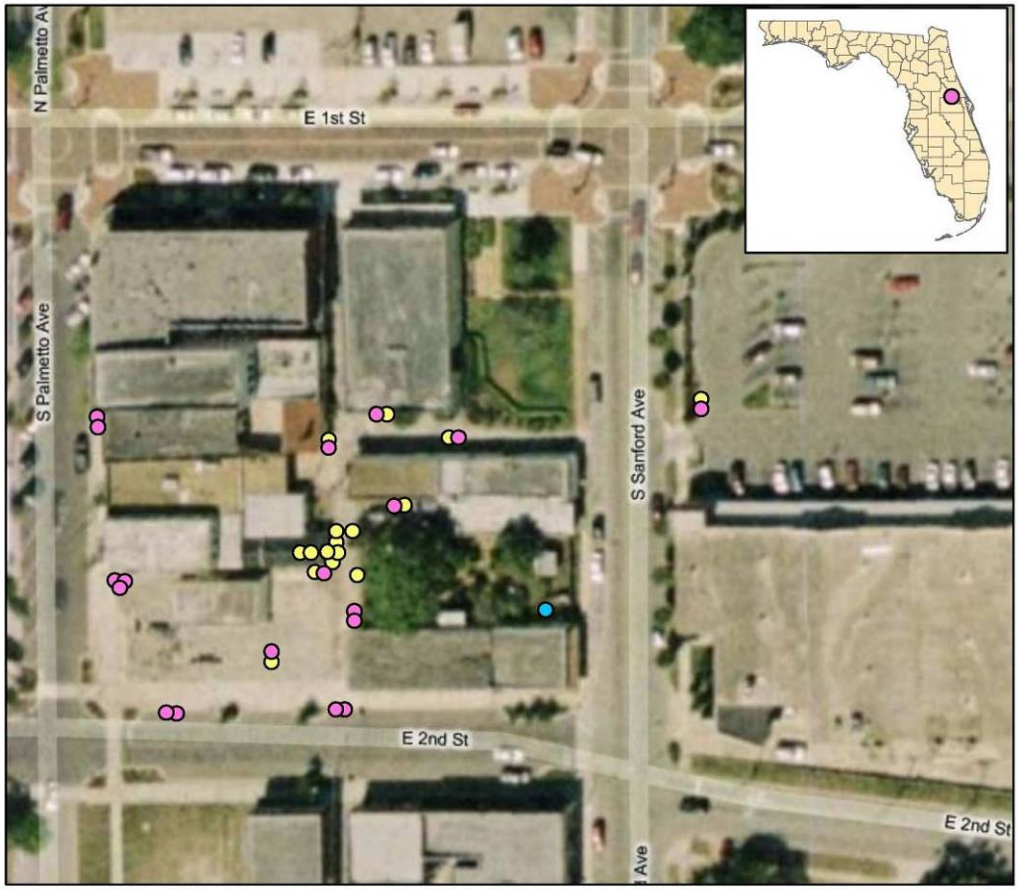


Figure 13. Monitoring well groundwater no exceedances [ESSI 1993], [ESSIO 1993], [ST 1999], [SIS 2007], [FDEP 2009].

Appendix C– Vapor Intrusion Modeling: (1) Johnson and Ettinger Model and (2) EPA 95th Percentile Attenuation Factor

(1) Johnson and Ettinger model assumptions, parameters, and results (as screen shots, two pages per contaminant of concern)

cis-1,2-dichloroethylene (*cis*-1,2-DCE), 5900 µg/L

Enter Site Name (optional):	Sanford Dry Cleaners		
Enter sample concentration, units and media type	5900	µg/L	Ground Water
What is the depth of the soil gas sample or ground water table (for ground water contamination)?(L_T)	5	feet	
This value can change by +/-	0.6	feet	
What is your contaminant of concern (COC)?	cis-1,2-Dichloroethylene		
What type of building are you investigating at your site?	Slab-on-Grade		
What type of soil is beneath the building?	Sand		
What is the average soil/ground water temperature?	23	Celsius	

Chemical Properties				
CAS Number		156592		
Molecular Weight **(MW)**		96.94	[g/mole]	
Henry's Law Constant at ground water temperature **(H)**		0.153583	[unitless]	
Free-Air Diffusion Coefficient **(D_a)**		7.360e-2	[cm²/s]	
Diffusivity in Water **(D_w)**		1.130e-5	[cm²/s]	
Unit Risk Factor **(URF)**		0.	[(µg/m³)⁻¹]	
Reference Concentration **(RfC)**		3.50e-2	[mg/m³]	
Soil Properties				
Total Porosity **(n)**		0.375	[unitless]	
Unsaturated Zone Moisture Content **(θ_w)**	Low 0.0530	Best Estimate 0.0540	High 0.0550	[unitless]
Capillary Zone Moisture Content at Air-Entry Pressure **($\theta_{w,cap}$)**		0.253	[unitless]	
Height of Capillary Zone **(CZ_h)**		0.170	[m]	
Soil-gas Flow Rate Into the Building **(Q_{soil})**		5.00	[L/min]	
Building Properties				
Air Exchange Rate **(E_B)**		0.250	[hr⁻¹]	
Building Mixing Height **(H_B)**		2.44	[m]	
Building Footprint Area **(F_B)**		100.0	[m²]	
Subsurface Foundation Area **(A_B)**		106.0	[m²]	
Building Crack Ratio **(η)**		0.00038	[unitless]	
Building Foundation Slab Thickness **(L_{crack})**		0.100	[m]	

Exposure Parameters

Exposure Duration for Carcinogens **(ED_c)**	30	[years]
Exposure Frequency for Carcinogens **(EF_c)**	350	[days/year]
Averaging Time for Carcinogens **(AT_c)**	70	[years]
Exposure Duration for Non-Carcinogens **(ED_{nc})**	30	[years]
Exposure Frequency for Non-Carcinogens **(EF_{nc})**	365	[days/year]
Averaging Time for Non-Carcinogens **(AT_{nc})**	30	[years]

CALCULATE RESULTS

RESULTS

Unsaturated Zone Effective Diffusion Coefficient **(D_{eff})**	0.01190	[cm^2/s]
Unsaturated + Capillary Zone Effective Diffusion Coefficient **(D^T_{eff})**	0.003257	[cm^2/s]
"A" Parameter	0.001337	Based on parameter analysis: Advection is the dominant mechanism across foundation.
"B" Parameter	173.9	
"C" Parameter	0.004918	
Johnson & Ettinger Attenuation Factor (α)	0.001051	

	INDOOR AIR RESULTS FOR GROUND WATER SAMPLE DATA					
	Low Prediction[1]		Best Estimate		High Prediction[2]	
Indoor Air Concentration	926.5 [µg/m³]	233.8 [ppbv]	952.5 [µg/m³]	240.4 [ppbv]	979.5 [µg/m³]	247.2 [ppbv]
Cancer Risk	0.		0.		0.	
Hazard Quotient	26.47		27.21		27.98	

[1] "Low Prediction" concentration produced with HIGHEST moisture content and DEEPEST depth to contamination.

[2] "High Prediction" concentration produced with LOWEST moisture content and SHALLOWEST depth to contamination.

***trans*-1,2-dichloroethylene (*trans*-1,2-DCE), 1300 µg/L**

Enter Site Name (optional):	Sanford Dry Cleaners		
Enter sample concentration, units and media type	1300	µg/L	Ground Water
What is the depth of the soil gas sample or ground water table (for ground water contamination)?(L_T)	5	feet	
This value can change by +/-	0.6	feet	
What is your contaminant of concern (COC)?	trans-1,2-Dichloroethylene		
What type of building are you investigating at your site?	Slab-on-Grade		
What type of soil is beneath the building?	Sand		
What is the average soil/ground water temperature?	23	Celsius	

Chemical Properties				
CAS Number		156605		
Molecular Weight **(MW)**		96.94	[g/mole]	
Henry's Law Constant at ground water temperature **(H)**		0.355534	[unitless]	
Free-Air Diffusion Coefficient **(D_a)**		7.070e-2	[cm^2/s]	
Diffusivity in Water **(D_w)**		1.190e-5	[cm^2/s]	
Unit Risk Factor **(URF)**		0.	[$(\mu g/m^3)^{-1}$]	
Reference Concentration **(RfC)**		7.00e-2	[mg/m^3]	
Soil Properties				
Total Porosity **(n)**		0.375	[unitless]	
Unsaturated Zone Moisture Content **(θ_w)**	Low 0.0530	Best Estimate 0.0540	High 0.0550	[unitless]
Capillary Zone Moisture Content at Air-Entry Pressure **($\theta_{w,cap}$)**		0.253	[unitless]	
Height of Capillary Zone **(CZ_h)**		0.170	[m]	
Soil-gas Flow Rate Into the Building **(Q_{soil})**		5.00	[L/min]	
Building Properties				
Air Exchange Rate **(E_B)**		0.250	[hr^{-1}]	
Building Mixing Height **(H_B)**		2.44	[m]	
Building Footprint Area **(F_B)**		100.0	[m^2]	
Subsurface Foundation Area **(A_B)**		106.0	[m^2]	
Building Crack Ratio **(η)**		0.00038	[unitless]	
Building Foundation Slab Thickness **(L_{crack})**		0.100	[m]	

Exposure Parameters

Exposure Duration for Carcinogens **(ED_c)**	30	[years]
Exposure Frequency for Carcinogens **(EF_c)**	350	[days/year]
Averaging Time for Carcinogens **(AT_c)**	70	[years]
Exposure Duration for Non-Carcinogens **(ED_{nc})**	30	[years]
Exposure Frequency for Non-Carcinogens **(EF_{nc})**	365	[days/year]
Averaging Time for Non-Carcinogens **(AT_{nc})**	30	[years]

CALCULATE RESULTS

RESULTS

Unsaturated Zone Effective Diffusion Coefficient **(D_{eff})**	0.01143	[cm^2/s]
Unsaturated + Capillary Zone Effective Diffusion Coefficient **(D^T_{eff})**	0.003115	[cm^2/s]
"A" Parameter	0.001278	Based on parameter analysis: Advection is the dominant mechanism across foundation.
"B" Parameter	181.0	
"C" Parameter	0.004918	
Johnson & Ettinger Attenuation Factor (α)	0.001015	

	INDOOR AIR RESULTS FOR GROUND WATER SAMPLE DATA					
	Low Prediction[1]		Best Estimate		High Prediction[2]	
Indoor Air Concentration	456.1 [µg/m³]	115.1 [ppbv]	469.0 [µg/m³]	118.4 [ppbv]	482.3 [µg/m³]	121.7 [ppbv]
Cancer Risk	0.		0.		0.	
Hazard Quotient	6.516		6.700		6.891	

[1] "Low Prediction" concentration produced with HIGHEST moisture content and DEEPEST depth to contamination.

[2] "High Prediction" concentration produced with LOWEST moisture content and SHALLOWEST depth to contamination.

Tetrachlorethylene (PCE), 75000 µg/L

Enter Site Name (optional):	Sanford Dry Cleaners	
Enter sample concentration, units and media type	75000	µg/L	Ground Water
What is the depth of the soil gas sample or ground water table (for ground water contamination)?(L_T)	5	feet
This value can change by +/-	0.6	feet
What is your contaminant of concern (COC)?	Tetrachloroethylene	
What type of building are you investigating at your site?	Slab-on-Grade	
What type of soil is beneath the building?	Sand	
What is the average soil/ground water temperature?	23	Celsius

Chemical Properties

CAS Number			127184	
Molecular Weight **(MW)**			165.83	[g/mole]
Henry's Law Constant at ground water temperature **(H)**			0.678421	[unitless]
Free-Air Diffusion Coefficient **(D_a)**			7.200e-2	[cm^2/s]
Diffusivity in Water **(D_w)**			8.200e-6	[cm^2/s]
Unit Risk Factor **(URF)**			3.00e-6	[$(\mu g/m^3)^{-1}$]
Reference Concentration **(RfC)**			0.	[mg/m^3]

Soil Properties

	Low	Best Estimate	High	
Total Porosity **(n)**		0.375		[unitless]
Unsaturated Zone Moisture Content **(θ_w)**	0.0530	0.0540	0.0550	[unitless]
Capillary Zone Moisture Content at Air-Entry Pressure **($\theta_{w,cap}$)**		0.253		[unitless]
Height of Capillary Zone **(CZ_h)**		0.170		[m]
Soil-gas Flow Rate Into the Building **(Q_{soil})**		5.00		[L/min]

Building Properties

Air Exchange Rate **(E_B)**	0.250	[hr^{-1}]
Building Mixing Height **(H_B)**	2.44	[m]
Building Footprint Area **(F_B)**	100.0	[m^2]
Subsurface Foundation Area **(A_B)**	106.0	[m^2]
Building Crack Ratio **(η)**	0.00038	[unitless]
Building Foundation Slab Thickness **(L_{crack})**	0.100	[m]

Exposure Parameters

Exposure Duration for Carcinogens **(ED_c)**	30	[years]
Exposure Frequency for Carcinogens **(EF_c)**	350	[days/year]
Averaging Time for Carcinogens **(AT_c)**	70	[years]
Exposure Duration for Non-Carcinogens **(ED_{nc})**	30	[years]
Exposure Frequency for Non-Carcinogens **(EF_{nc})**	365	[days/year]
Averaging Time for Non-Carcinogens **(AT_{nc})**	30	[years]

CALCULATE RESULTS

RESULTS

Unsaturated Zone Effective Diffusion Coefficient **(D_{eff})**	0.01164	[cm^2/s]
Unsaturated + Capillary Zone Effective Diffusion Coefficient **(D^T_{eff})**	0.003164	[cm^2/s]
"A" Parameter	0.001299	Based on parameter analysis: Advection is the dominant mechanism across foundation.
"B" Parameter	177.7	
"C" Parameter	0.004918	
Johnson & Ettinger Attenuation Factor (α)	0.001027	

	INDOOR AIR RESULTS FOR GROUND WATER SAMPLE DATA					
	Low Prediction[1]		Best Estimate		High Prediction[2]	
Indoor Air Concentration	5.084e4 [µg/m³]	7.501e3 [ppbv]	5.227e4 [µg/m³]	7.712e3 [ppbv]	5.375e4 [µg/m³]	7.930e3 [ppbv]
Cancer Risk	0.06269		0.06444		0.06627	
Hazard Quotient	0.		0.		0.	

[1] "Low Prediction" concentration produced with HIGHEST moisture content and DEEPEST depth to contamination.

[2] "High Prediction" concentration produced with LOWEST moisture content and SHALLOWEST depth to contamination.

Trichloroethylene, 19000 µg/L

Enter Site Name (optional):	Sanford Dry Cleaners		
Enter sample concentration, units and media type	19000	µg/L	Ground Water
What is the depth of the soil gas sample or ground water table (for ground water contamination)?(L_T)	5	feet	
This value can change by +/-	0.6	feet	
What is your contaminant of concern (COC)?	Trichloroethylene		
What type of building are you investigating at your site?	Slab-on-Grade		
What type of soil is beneath the building?	Sand		
What is the average soil/ground water temperature?	23	Celsius	

Chemical Properties

CAS Number			79016	
Molecular Weight **(MW)**			131.39	[g/mole]
Henry's Law Constant at ground water temperature **(H)**			0.384235	[unitless]
Free-Air Diffusion Coefficient **(D_a)**			7.900e-2	[cm^2/s]
Diffusivity in Water **(D_w)**			9.100e-6	[cm^2/s]
Unit Risk Factor **(URF)**			1.10e-4	[$(\mu g/m^3)^{-1}$]
Reference Concentration **(RfC)**			4.00e-2	[mg/m^3]

Soil Properties

	Low	Best Estimate	High	
Total Porosity **(n)**		0.375		[unitless]
Unsaturated Zone Moisture Content **(θ_w)**	0.0530	0.0540	0.0550	[unitless]
Capillary Zone Moisture Content at Air-Entry Pressure **($\theta_{w,cap}$)**		0.253		[unitless]
Height of Capillary Zone **(CZ_h)**		0.170		[m]
Soil-gas Flow Rate Into the Building **(Q_{soil})**		5.00		[L/min]

Building Properties

Air Exchange Rate **(E_B)**	0.250	[hr^{-1}]
Building Mixing Height **(H_B)**	2.44	[m]
Building Footprint Area **(F_B)**	100.0	[m^2]
Subsurface Foundation Area **(A_B)**	106.0	[m^2]
Building Crack Ratio **(η)**	0.00038	[unitless]
Building Foundation Slab Thickness **(L_{crack})**	0.100	[m]

Exposure Parameters

Exposure Duration for Carcinogens **(ED_c)**	30	[years]
Exposure Frequency for Carcinogens **(EF_c)**	350	[days/year]
Averaging Time for Carcinogens **(AT_c)**	70	[years]
Exposure Duration for Non-Carcinogens **(ED_{nc})**	30	[years]
Exposure Frequency for Non-Carcinogens **(EF_{nc})**	365	[days/year]
Averaging Time for Non-Carcinogens **(AT_{nc})**	30	[years]

CALCULATE RESULTS

RESULTS

Unsaturated Zone Effective Diffusion Coefficient **(D_{eff})**	0.01277	[cm^2/s]
Unsaturated + Capillary Zone Effective Diffusion Coefficient **(D^T_{eff})**	0.003475	[cm^2/s]
"A" Parameter	0.001426	Based on parameter analysis: Advection is the dominant mechanism across foundation.
"B" Parameter	162.0	
"C" Parameter	0.004918	
Johnson & Ettinger Attenuation Factor (α)	0.001106	

	INDOOR AIR RESULTS FOR GROUND WATER SAMPLE DATA					
	Low Prediction[1]		Best Estimate		High Prediction[2]	
Indoor Air Concentration	7.856e3 [µg/m³]	1.463e3 [ppbv]	8.072e3 [µg/m³]	1.503e3 [ppbv]	8.296e3 [µg/m³]	1.545e3 [ppbv]
Cancer Risk	0.3551		0.3649		0.3750	
Hazard Quotient	196.4		201.8		207.4	

[1] "Low Prediction" concentration produced with HIGHEST moisture content and DEEPEST depth to contamination.

[2] "High Prediction" concentration produced with LOWEST moisture content and SHALLOWEST depth to contamination.

Vinyl Chloride, 400 µg/L

Enter Site Name (optional):	Sanford Dry Cleaners		
Enter sample concentration, units and media type	400	µg/L	Ground Water
What is the depth of the soil gas sample or ground water table (for ground water contamination)?(L_T)	5	feet	
This value can change by +/-	0.6	feet	
What is your contaminant of concern (COC)?	Vinyl chloride (chloroethene)		
What type of building are you investigating at your site?	Slab-on-Grade		
What type of soil is beneath the building?	Sand		
What is the average soil/ground water temperature?	23	Celsius	

Chemical Properties					
CAS Number			75014		
Molecular Weight **(MW)**			62.5	[g/mole]	
Henry's Law Constant at ground water temperature **(H)**			1.048724	[unitless]	
Free-Air Diffusion Coefficient **(D_a)**			0.1060	[cm^2/s]	
Diffusivity in Water **(D_w)**			1.230e-5	[cm^2/s]	
Unit Risk Factor **(URF)**			8.80e-6	[$(\mu g/m^3)^{-1}$]	
Reference Concentration **(RfC)**			0.100	[mg/m^3]	
Soil Properties					
Total Porosity **(n)**			0.375	[unitless]	
Unsaturated Zone Moisture Content **(θ_w)**	Low 0.0530	Best Estimate 0.0540	High 0.0550	[unitless]	
Capillary Zone Moisture Content at Air-Entry Pressure **($\theta_{w,cap}$)**			0.253	[unitless]	
Height of Capillary Zone **(CZ_h)**			0.170	[m]	
Soil-gas Flow Rate Into the Building **(Q_{soil})**			5.00	[L/min]	
Building Properties					
Air Exchange Rate **(E_B)**			0.250	[hr^{-1}]	
Building Mixing Height **(H_B)**			2.44	[m]	
Building Footprint Area **(F_B)**			100.0	[m^2]	
Subsurface Foundation Area **(A_B)**			106.0	[m^2]	
Building Crack Ratio **(η)**			0.00038	[unitless]	
Building Foundation Slab Thickness **(L_{crack})**			0.100	[m]	

Exposure Parameters

Exposure Duration for Carcinogens **(ED_c)**	30	[years]
Exposure Frequency for Carcinogens **(EF_c)**	350	[days/year]
Averaging Time for Carcinogens **(AT_c)**	70	[years]
Exposure Duration for Non-Carcinogens **(ED_{nc})**	30	[years]
Exposure Frequency for Non-Carcinogens **(EF_{nc})**	365	[days/year]
Averaging Time for Non-Carcinogens **(AT_{nc})**	30	[years]

CALCULATE RESULTS

RESULTS

Unsaturated Zone Effective Diffusion Coefficient **(D_{eff})**	0.01714	[cm^2/s]
Unsaturated + Capillary Zone Effective Diffusion Coefficient **(D^T_{eff})**	0.004655	[cm^2/s]
"A" Parameter	0.001911	Based on parameter analysis: Advection is the dominant mechanism across foundation.
"B" Parameter	120.7	
"C" Parameter	0.004918	
Johnson & Ettinger Attenuation Factor (α)	0.001376	

	INDOOR AIR RESULTS FOR GROUND WATER SAMPLE DATA					
	Low Prediction[1]		Best Estimate		High Prediction[2]	
Indoor Air Concentration	562.9 [µg/m³]	220.4 [ppbv]	577.3 [µg/m³]	226.0 [ppbv]	592.1 [µg/m³]	231.8 [ppbv]
Cancer Risk	0.002036		0.002088		0.002141	
Hazard Quotient	5.629		5.773		5.921	

[1] "Low Prediction" concentration produced with HIGHEST moisture content and DEEPEST depth to contamination.

[2] "High Prediction" concentration produced with LOWEST moisture content and SHALLOWEST depth to contamination.

(2) EPA's 95th Percentile Attenuation Factor [EPA 2008b]

	C groundwater (µg/L)	Henry's Law Constant (unitless)	C air at groundwater table‡ (µg/m^3)	EPA's attenuation factor	C indoor air† (µg/m^3)
cis-1,2-DCE	5900	0.153583	906139.7	0.001	906.1397
trans-1,2-DCE	1300	0.355534	462194.2	0.001	462.1942
PCE	75000	0.678421	50881575	0.001	50881.58
TCE	19000	0.384235	7300465	0.001	7300.465
VC	400	1.048724	419489.6	0.001	419.4896

‡C air at groundwater table (µg/m^3) = C groundwater (µg/L) * 1000 (L/m^3) * Henry's Law Constant (unitless)

†C indoor air (µg/m^3) = C air at groundwater table (µg/m^3) * EPA's attenuation factor

Glossary

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

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

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

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

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

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

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

Chronic
Occurring over a long time (more than 1 year) [compare with **acute**].

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

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

Completed exposure pathway [see **exposure pathway**].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)

CERCLA, also known as **Superfund**, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

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

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

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

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

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

EPA
United States Environmental Protection Agency.

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

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a **source of contamination** (such as an abandoned business); an **environmental media and transport mechanism** (such as movement through groundwater); a **point of exposure** (such as a private well); a **route of exposure** (eating,

drinking, breathing, or touching), and a **receptor population** (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a **completed exposure pathway**.

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

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

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

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

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

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

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

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

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

Inhalation

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

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

Metabolite
Any product of **metabolism**.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Risk
The probability that something will cause injury or harm.

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

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

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

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

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

Substance
A chemical.

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

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

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

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

µg/m3
Microgram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the

information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a **safety factor**].

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