WORK PLAN

Residential Vapor Intrusion Survey for AOC-65

Prepared for:

Camp Stanley Storage Activity

Boerne, Texas

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ABBREVIATIONS AND ACRONYMS

ACFM	actual standard cubic feet per minute
AOC	Area of Concern
bgs	below ground surface
CAS	carbon adsorption system
CESWF	U.S. Army Corps of Engineers, Fort Worth District
COC	contaminant of concern
CSSA	Camp Stanley Storage Activity
DCE	dichloroethylene
DQO	Data Quality Objective
DoD	Department of Defense
FD	field duplicate
ft	feet
GC/MS	gas chromatograph/mass spectrometer
IA	Indoor air
IRA	interim removal action
ITRC	Interstate Technology & Regulatory Council
in. H2O vac.	inches of water column vacuum
lb/hr	pounds per hour
lb/yr	pounds per year
LGR	Lower Glen Rose
MCL	maximum contaminant level
MF	manifold
MS	matrix spike
MSD	matrix spike duplicate
OA	Outdoor air
O&M	Operations and Maintenance
OSHA	Occupational Safety and Health Administration
Parsons	Parsons Infrastructure and Technology, Inc.
PBR	permit by rule
PCE	perchloroethylene (tetrachloroethene)
ppbV	parts per billion by volume
QAPP	Quality Assurance Program Plan
RCRA	Resource Conservation and Recovery Act
RRAD	Red River Army Depot
RSL	Regional Screening Level

Acronyms and Abbreviations continued

SIM	selective ion monitoring
SVE	soil vapor extraction
TCE	trichloroethene
TCEQ	Texas Commission on Environmental Quality
tpy	tons per year
µg/L	microgram per liter
UGR	Upper Glen Rose
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VC	vinyl chloride
VEW	vapor extraction well
VI	Vapor intrusion
VIS	Vapor intrusion survey
VMP	vapor monitoring point
VOC	volatile organic compounds

EXECUTIVE SUMMARY

As part of the ongoing investigation associated with the Resource Conservation and Recovery Act (RCRA) 3008(h) Order, Camp Stanley Storage Activity (CSSA) has initiated a Vapor Intrusion Survey (VIS) of off-post residences and businesses west of CSSA to assess potential vapor intrusion (VI) impacts to indoor air (IA) as it relates to Volatile Organic Compounds (VOCs). The area designated as Area of Concern (AOC)-65, located within the Inner Cantonment of CSSA, is a known source area for VOC groundwater contamination. The VOC plume associated with AOC-65 extends west beyond the post boundary beneath both established and newly developed residential areas. The presence of the VOC plume beneath residences may negatively impact IA quality from vapor intrusion (VI).

This work plan provides a description of the activities to be used to conduct a site-specific vapor intrusion pathway evaluation addressing potential chronic exposure within residences that are in the vicinity of the chlorinated solvent plume originating from CSSA. Existing work plans for IA sampling on previous CSSA task orders fulfilled by Parsons are in effect and are available in the CSAA Environmental Encyclopedia, Volume 1, Work Plans. The activities covered by this work plan addendum include the collection of residential IA samples for evaluating potential long term exposure to VOCs due to VI.

The VIS efforts outlined within this document include efforts associated with the collection of IA samples from 8 residences, (including 2 enclosed crawl spaces and one enclosed well), 1 full-time (24/7) occupied military building, and 1 full-time occupied fire station to the north, west, and south of AOC-65. A background outdoor air (OA) samples will be collected concurrently with IA sampling.

Results from the IA sampling effort will be compared with USEPA residential air regional screening levels (RSLs) for PCE and TCE (**Table 3**) to determine if VI is negatively impacting IA quality. Previous VIS efforts to determine VI potential from IA sampling in Building 90 were deemed incomplete by USEPA because sample results were compared with less conservative TCEQ $^{Air}RBEL_{Inh}$s values which are derived differently than the USEPA RSLs.

The $^{Air}RBEL_{Inh}$s and residential air RSLs are calculated using equations with three different inputs; i.e., exposure parameters, toxicity values, and target risk/hazard index. Both TCEQ and USEPA use the same exposure parameters (i.e., they both assume that residents are exposed to contaminants in air 24 hours/day for 350 days/year for 30 years) and both use the same target hazard index (i.e., the "likelihood" of developing adverse noncancer health effects) of 1. However, TCEQ calculates their $^{Air}RBEL_{Inh}$s to be protective of a target risk of 1×10^{-5} (i.e., a risk of one extra case of cancer in a population of 100,000) whereas USEPA calculates their RSLs to be protective of a target risk of 1×10^{-6} (i.e., one extra case of cancer in a population of 1,000,000).

For chemicals like TCE and PCE, screening levels are calculated to be protective of both cancer and noncancer effects for each chemical, with the lesser of the cancer and noncancer-based concentrations used as the final screening level. For TCE, both TCEQ and USEPA use the same toxicity values, so the only difference is in the target risk; i.e., the cancer-based screening level protective of a risk of $1x10^{-6}$ is 0.43 ug/m^3; but when adjusted to be protective of a risk of $1x10^{-5}$, it is 4.3 ug/m^3. Since 4.3 ug/m^3 is greater than the noncancer-based screening level of 2.1

ug/m^3, the noncancer-based value is given as the TCEQ $^{Air}RBEL_{Inh}$. Thus, the TCEQ and USEPA screening levels for TCE in air differ due to the difference in target risks used by the two agencies.

For PCE, USEPA and TCEQ use different toxicity values. TCEQ derived their own toxicity values for PCE in 2008, which assumes that PCE is more carcinogenic than assumed by USEPA (by a factor of 1.5) but also less likely to cause noncancer effects (by a factor of 9). Thus, the PCE screening levels differ between TCEQ and USEPA due to differences in both toxicity values and target risks.

1.0 INTRODUCTION

Parsons is to provide investigations and environmental services at Camp Stanley Storage Activity (CSSA) and this work shall be performed in accordance with requirements of the Resource Conservation and Recovery Act (RCRA) 3008(h) Order in effect for CSSA and in accordance with U.S. Environmental Protection Agency (USEPA) Region 6 and Texas Commission on Environmental Quality (TCEQ) requirements.

This work plan provides a description of the activities to be used to conduct a site-specific VI pathway evaluation addressing potential chronic exposure within residences adjacent to the area of concern (AOC)-65 that are currently in the vicinity a VOC groundwater plume. Existing work plans for IA sampling on previous CSSA task orders fulfilled by Parsons are in effect and are available in the CSAA Environmental Encyclopedia, Volume 1, Work Plans. This work plan sets out project-specific activities directly related to a VIS of residential areas adjacent to CSSA's AOC-65 that have the potential to negatively impact indoor air quality due to vapor intrusion from VOC contaminated groundwater.

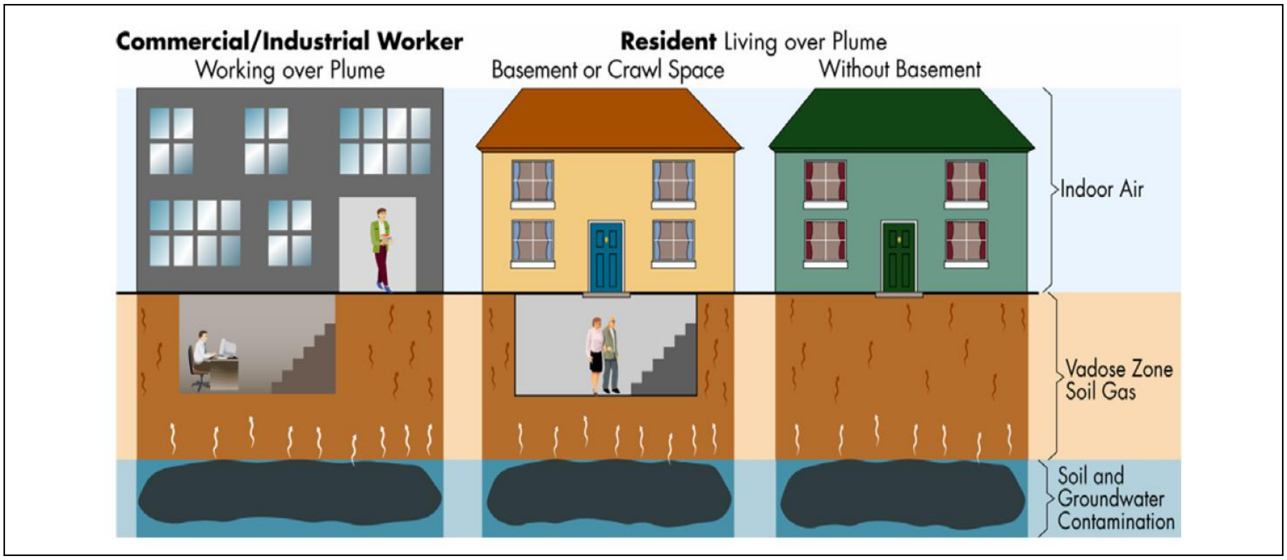
Vapor intrusion is the migration of volatile chemicals from the subsurface into overlying buildings (U.S. Environmental Protection Agency [USEPA] 2002). **Figure 1** schematically depicts a typical vapor intrusion scenario involving both residential and commercial dwellings. Chemicals volatilize from impacted soil and/or groundwater beneath a building and diffuse toward regions of lower chemical concentration (e.g., the atmosphere, conduits, and basements). Soil gas flow into a building can be driven by a number of factors, including barometric pressure changes, wind load, thermal currents, or depressurization from building exhaust fans. The rate of movement of the vapors into the structure is difficult to quantify and depends on soil type, chemical properties, building design and condition, and pressure differential. Upon entry into a structure, soil gas mixes with the existing air through the natural or mechanical ventilation of the building (Interstate Technology & Regulatory Council [ITRC] 2007).

In residential communities, concerns over vapor intrusion are often magnified due to the presence of children, elderly, and other at-risk members of the public who typically reside in those areas as well as the long exposure periods. Additionally, degradation of indoor air quality causes more apprehension and anxiety among building occupants than are typically associated with other environmental problems (ITRC 2007).

Residential structures adjacent to CSSA's AOC-65 contain the three components for a vapor intrusion pathway to be complete, including:

- a source of volatile organic compounds (VOCs) in the subsurface environment (groundwater and/or soil),
- occupied buildings or the potential for future occupied buildings, and
- a migration route to connect them.

Figure 1 Typical Conceptual Model of Vapor Intrusion (ITRC 2007)



The overall approach used to assess the potential risks posed by the vapor intrusion pathway and possible mitigation and remediation options is summarized below (Department of Defense [DoD] 2009).

- ❖ **Evaluate whether exposure to the vapors poses an immediate risk to building occupants:** This can include both acute health risks and the risk of explosion. If such short-term risks are identified due to vapor intrusion, it may be necessary to evacuate the property until the risks are mitigated. If there are no immediate risks, a screening level vapor intrusion evaluation may be conducted.
- ❖ **Conduct a screening level assessment of site contaminants:** This evaluation typically involves comparing site soil gas or groundwater data with conservative risk-based screening values. If site concentrations are below screening levels, it is concluded that the site does not pose a vapor intrusion risk. If exceedances are observed, it may be advisable to re-evaluate the data in a vapor intrusion model using site-specific parameters. In some cases, these site-specific modeling results may be sufficient to determine that the site does not pose a vapor intrusion risk; in other cases, modeling results can become one of the multiple lines of evidence used to evaluate whether there is a significant risk from vapor intrusion.
- ❖ **Conduct a site-specific vapor intrusion pathway evaluation:** This is usually a more data intensive effort and may include collecting near-slab soil gas, sub-slab soil gas, and/or indoor air samples. Multiple lines of evidence may be used to

evaluate the magnitude and extent of vapor intrusion. Depending on the results of the investigation and a human health risk assessment, it may be determined that either no further action is necessary or that mitigation or remediation may be warranted.

- **Evaluate mitigation/remediation options, if necessary:** Mitigation involves using techniques that prevent (or minimize) subsurface vapors from migrating into buildings present above the contamination. Common mitigation measures include installation of sub-slab depressurization or pressurization devices, sealing all cracks, sumps and preferential pathways, and installation of vapor-proof membranes. On active bases, land use (or building use) controls may also be an option to control exposure. Remediation is the treatment and removal of chemicals from contaminated subsurface media, such as soil and groundwater. Common remediation options include soil removal, soil gas extraction, and groundwater treatment. Mitigation and remediation may be performed concurrently or individually, depending on site needs.

Results from a USEPA recommended "phased" approach investigation (further detailed in Section 2) indicate a need for further investigation of the potential for acute and chronic exposures to VOC vapors in residences overlying the VOC groundwater plume emanating from AOC-65. Therefore, USEPA has recommended that a "site-specific" vapor intrusion pathway investigation, including residential IA sampling be performed to evaluate whether potential exposures present significant risk to receptors, as defined by the regulatory agencies (USEPA 2002).

For this work plan, Section 2 describes the background and previous investigations of AOC-65, Section 3 provides a description of work activities planned including data quality objectives (DQOs), and recordkeeping/reporting procedures. References cited can be found in Section 4 of this work plan.

As discussed in Section 2, prior vapor intrusion investigation findings to assess the potential vapor intrusion risks emanating from the AOC-65 source area determined that there was no immediate concern for the CSSA employees located in Building 90 (Red River Army Depot [RRAD] 2002a) and the surrounding area (Parsons 2002). Further investigations assessing vapor intrusion risks along the post boundary where VOC contamination is migrating off-post and within Building 90 itself determined that although no there is no immediate concern for CSSA employees, the potential risk for residential receptors was determined incomplete by USEPA (Parsons 2011). Therefore, the purpose of this project is to complete a site-specific investigation and summarize the potential impacts of VI within the residential area adjacent to AOC-65 and Building 90, if any.

2.0 BACKGROUND

General information regarding the history and environmental setting of CSSA is provided in the CSSA Environmental Encyclopedia (Volume 1-1 Background Information Report). In that report, data regarding the geology, hydrology, and physiography of AOC-65 are also available for reference.

2.1 AOC-65 PREVIOUS INVESTIGATIONS AND FINDINGS

AOC-65 consists of potential VOC source areas believed to be associated with Building 90 and is located approximately 50 feet from CSSA's boundary. One potential source area is a sunken concrete-lined pit on the west side of the building that housed a vat which reportedly utilized tetrachloroethene (PCE) (**Figure 2**). The metal vat (approximately 500 to 750 gallons) was installed prior to 1966 and removed in 1995 when CSSA began using a citrus-based cleaner for operations instead of chlorinated solvents. There were no reported releases of material from the vat made by CSSA personnel. AOC-65 also includes an area extending outside Building 90 that includes abandoned building drain lines and related storm water ditches.

The release of chlorinated solvents to the environment at CSSA resulted in contamination of the Middle Trinity Aquifer, which is the drinking water source for the area. The Middle Trinity Aquifer consists of the Lower Glen Rose (LGR) Limestone, the Bexar Shale (BS) (as a facies of the Hensell Sand), and the Cow Creek (CC) Limestone. Contamination is most widespread within the LGR water-bearing unit, whose depth ranges from about 80 to 300 feet below ground surface. Locally, the BS serves as a confining unit between the water-bearing LGR and CC limestones. Environmental studies demonstrate that most of the contamination resides within the LGR. All three units, the LGR, BS, and CC limestone, dip to the east and southeast and have been regionally fractured, with fracture patterns trending both northwest-southeast and northeast-southwest across the region.

Groundwater contamination potentially originating from Building 90 at AOC-65 was first identified in an off-post well sample in December 1999. The groundwater plume spread southward and westward from the post. The greatest concentrations of solvents are reported at the near subsurface adjacent to the Building 90 source area (64,000 micrograms per liter [μg/L]) within the Upper Trinity Aquifer in the Upper Glen Rose formation (UGR) at CS-AOC65-TSW01. However, within the main LGR aquifer body, solvent concentrations are only present at levels near the maximum contaminant level (MCL) (Pearson and Murphy 2004; Parsons 2010).

Off-post, concentrations in excess of the PCE MCL of 5 μg/L were detected in private and public wells with open borehole completions. Concentrations exceeding 30 μg/L were reported 1,200 feet west-southwest of CSSA. Vertical profiling within that well shows that discrete intervals within uncased upper strata have PCE concentrations over 90 μg/L. Only sporadic, trace concentrations of solvents were detected in Bexar Shale and Cow Creek wells within the plume (Pearson and Murphy 2004).

TCE concentrations above the TCE MCL of 5 μg/L have also been detected in private wells with open borehole completions. Concentrations exceeding 5 μg/L were reported in a wells as far as 1,800 feet west of AOC-65, with concentrations nearing three times the MCL ~15 μg/L as close as 1,200 feet west of AOC-65. Additionally, TCE has a lower derived screening level by both USEPA and TCEQ standards due to a higher toxicity.

Figure 2 Building 90 and AOC-65 Location Map

Following detection of PCE in an off-post well in 1999, two soil samples were collected from a cored area under the vat inside Building 90. Results of these samples confirmed the presence of PCE and TCE in soil at AOC-65. A soil gas survey was conducted at AOC-65 in 2001 to characterize the nature and extent of VOCs in soil gas originating from the contaminated soil and groundwater at Building 90. An interim removal action (IRA) was conducted and a SVE system installed in 2002 to remediate contaminated media, both beneath and surrounding Building 90. Additionally, two industrial hygiene surveys were conducted by the Industrial Hygiene Office at RRAD in 2002 to determine if indoor air concentrations of VOCs at Building 90 posed a health hazard to onsite employees. Results of the surveys indicated no threats to industrial workers within Building 90 (RRAD 2002a and 2002b).

The results related to previous soil gas and indoor air investigations of VOC concentrations are described in greater detail in the paragraphs below.

2.1.1 Soil Gas Survey - January/February 2001

In January and February 2001 a total of 324 soil gas samples were collected from areas inside and surrounding Building 90. Sample depths ranged from 0.5 to 4.5 feet as determined by refusal of the Geoprobe® rig when bedrock was encountered. Analytical results from this investigation are presented in both tabular and figure (Figure 3.2) format in the CSSA Environmental Encyclopedia **(**Volume 1-3, Soil Gas Survey Results).

PCE was detected in 67 soil gas samples at concentrations ranging from 0.08 to 1,590 µg/L. The highest concentration detected in soil gas samples collected outside Building 90 was at sample location BLDG90-15, which was collected in the vicinity of the former solvent vat (shown on Figures 3.3 and 3.4 of Soil Gas Survey Report (Parsons, 2002)). In the soil gas samples collected outside the building, TCE was detected in two areas along the outside of the western wall; i.e., at 1) BLDG90-8 in the northern portion of the building and 2) BLDG90-15, BLDG90-16, BLDG90-17, and BLDG90-37 in the southern portion of the building, as shown on Figure 3.1 of the Soil Gas Survey Report. TCE concentrations ranged from 0.04 µg/L to 8.56 µg/L, with the highest concentration detected in soil gas samples collected outside Building 90 detected in sample BLDG90-15 (Figure 3.2 of Soil Gas Survey Report).

The detection of TCE, *cis-1,2-dichlorethene* (DCE), and *trans-1,2*-DCE during this investigation at significantly lower levels than PCE suggests that some natural degradation of the PCE has already begun near the solvent vat, which appears to be the most likely source area for the VOC contamination. Soil gas VOC concentrations peak inside Building 90 near the vat location, and dissipate immediately outside of, and within a short distance from, the building. PCE levels exceeded 24,000 µg/L in a soil gas sample under the building near the former solvent vat, decreased to 1,590 µg/L in a soil gas sample approximately 25 feet from the building, and were not detected above 5 µg/L in any of the soil gas samples located more than 50 feet from the building. Based on these results, it appears the lateral extent of the PCE plume in soil gas is generally confined to the immediate vicinity of Building 90 (Parsons 2002).

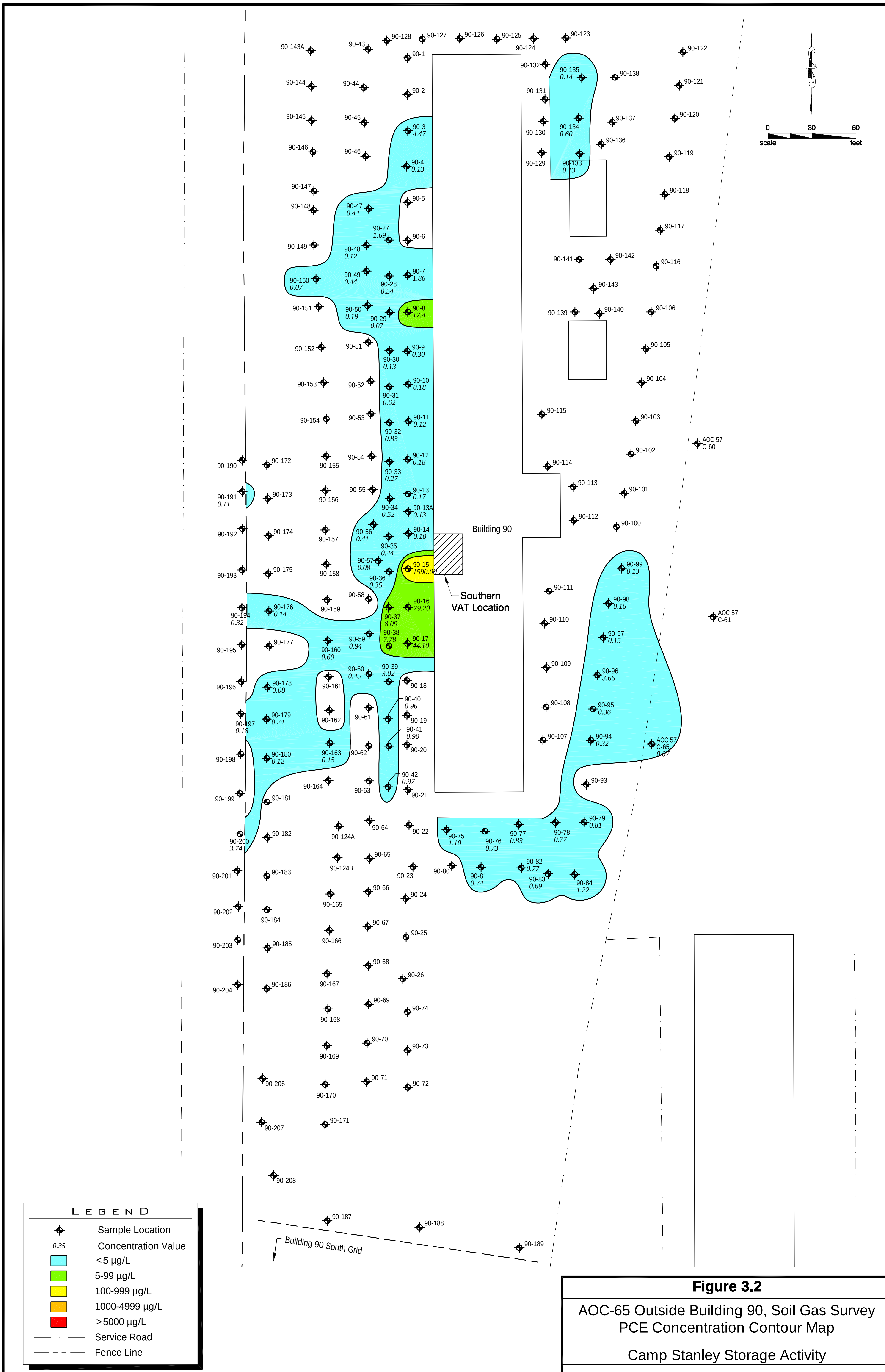


Figure 3.2

AOC-65 Outside Building 90, Soil Gas Survey
PCE Concentration Contour Map

Camp Stanley Storage Activity

PARSONS ENGINEERING SCIENCE, INC.

738290 CSSA–B90–PCE.DWG

2.1.2 Industrial Hygiene Survey Report - April 2002

Six organic vapor monitors were placed within Building 90 in the vicinity of the former solvent vat area. The report concluded that organic vapor measurements in all three monitors were below analytical sensitivity and could not be detected. The report also concluded that airborne concentrations of PCE and other chlorinated hydrocarbon compounds did not exceed the threshold limit value or permissible exposure limit, and respiratory protection was not required in Building 90 (RRAD 2002a).

2.1.3 Industrial Hygiene Survey Report - October/November 2002

A second industrial hygiene study was conducted to assess employee exposures to PCE and TCE vapors due to past activities at Building 90. The survey did not identify any significant concentrations that would pose a health hazard to workers. The maximum PCE concentration detected during the study was 0.03 parts per million (ppm). TCE was not detectable at any sample locations (RRAD 2002b).

2.1.4 Vapor Intrusion Survey - December 2011

In 2010 Parsons conducted a multi-phased VIS along the western border of AOC-65 and within Building 90. Soil gas samples were collected in an area of shallow groundwater and high VOC concentrations close to Building 90 where the most conservative assessment of VI conditions in the neighboring residential areas, adjacent residential areas underlain by contaminated groundwater, could be ascertained on-post. Additionally, indoor air samples were collected from within Building 90.

The VIS efforts were initiated with the collection of eleven soil gas samples collected along the western fenceline of CSSA, adjacent to Building 90, in March 2010. Results indicated that concentrations of PCE in soil gas (as well as benzene, 1,2-dichloroethane, and TCE) were above potential vapor intrusion screening levels. Screening levels for contaminants in soil gas were calculated using May 2010 USEPA regional screening levels (RSLs) for residential air with an applied attenuation factor of 0.85 as noted by USEPA RSL guidance. USEPA calculates their RSLs using equations with three different inputs; i.e., exposure parameters, toxicity values, and target risk/hazard index to be protective of a target risk of 1×10^{-6} (i.e., one extra case of cancer in a population of 1,000,000). The highest concentration of PCE was found in sample AOC65-VIP5 at 1.7 parts per billion volume (ppbv) which is greater than the calculated USEPA soil gas screening level of 0.08 ppbv, but below the calculated soil gas TCEQ residential RBEL for indoor air of 11 ppbv.

Due to the March 2010 soil gas analytical data indicating the presence of PCE in soil gas above the potential vapor intrusion screening levels, indoor air samples were collected from within Building 90 between July and September 2010 (**Figure 4**). Results of samples analyzed by USEPA Method TO-15 SIM for PCE indicate a presence of PCE greater than USEPA's RSL for indoor air (0.06 ppbv, May 2010), but below the TCEQ residential RBEL for indoor air (9.4 ppbv). Analytical results for PCE concentrations collected over a 24-hour period ranged from a high of 0.25 ppbv with the HVAC and the SVE systems off to 0.15 ppbv with the HVAC system off and the SVE system on. Background samples collected during the sampling events were

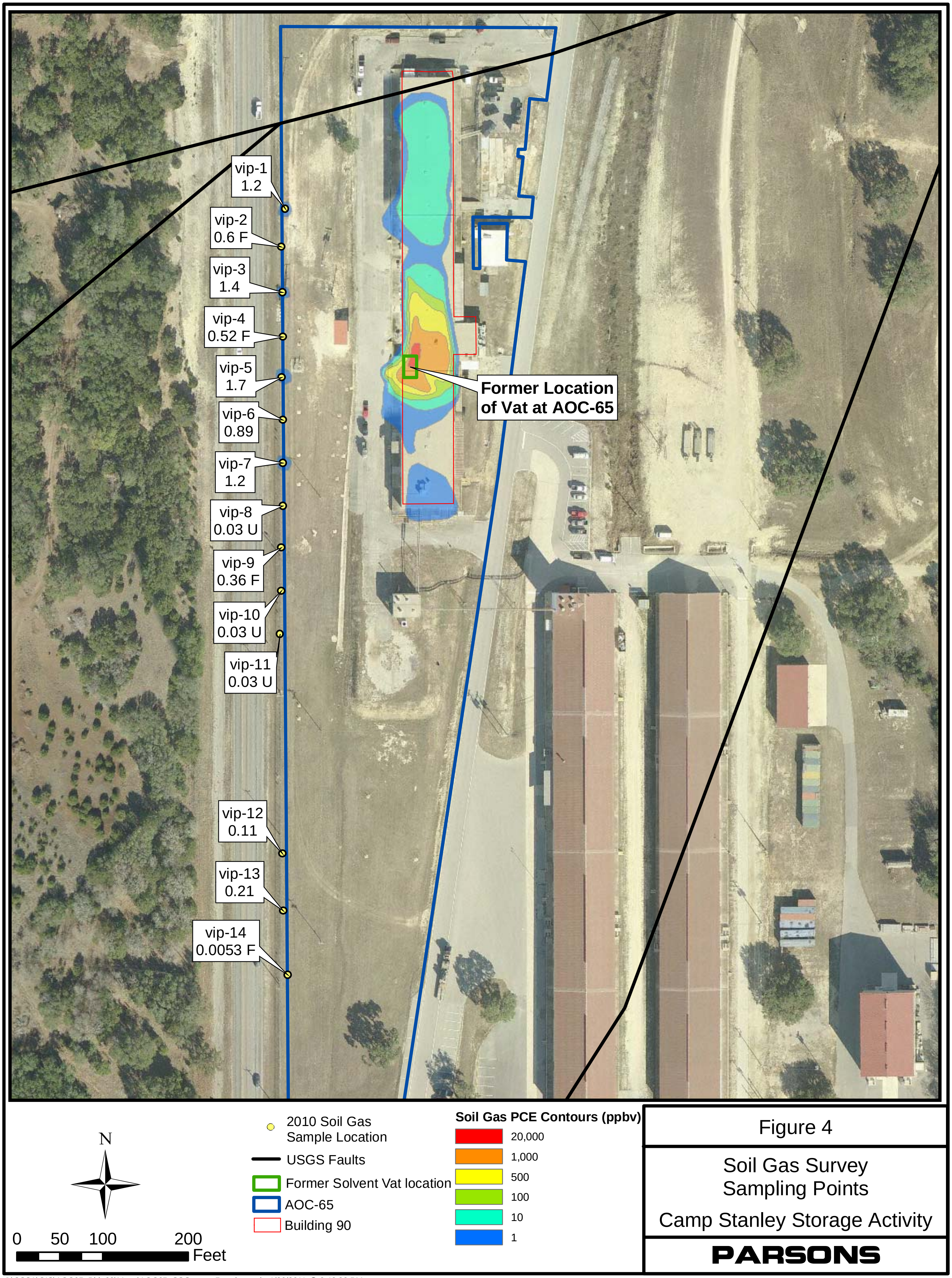


Figure 4

Soil Gas Survey Sampling Points

Camp Stanley Storage Activity

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J:\CSSA\GIS\AOC65_Bldg90\Maps\AOC65_SGSurvey_Results.mxd - 1/20/2011 @ 2:43:38 PM non-detect with the exception of a background sample result of 0.096 ppbv collected during the event with the SVE system on.

Additional soil gas samples were collected southwest of Building 90 in an area that represents more similar groundwater conditions to those found off-post, yet still contain higher VOC concentrations due to the proximity to the Building 90 source. The samples were analyzed for PCE concentrations using the USEPA TO15 SIM procedure and the results indicate that PCE concentrations in soil gas were above the USEPA derived residential indoor air screening level regional screening level (RSL) (0.07 ppbv) at two of the three locations, but were below the TCEQ risk-based exposure limit (RBEL) for PCE (11 ppbv) and TCE (9.6).

The goal of this investigation was to determine the "worst case" scenario for vapor intrusion within residences adjacent to AOC-65 by determining the current vapor intrusion conditions within and around Building 90. Although the data collected does allow some assertions be made regarding residential IA quality, the IA samples collected within Building 90 are not directly comparable due to differences in construction materials and methods. Building 90 is a large industrial building that is not as well insulated, or as air tight as a typical home might be constructed, additionally; Building 90 is equipped with an industrial HVAC system that is designed to exchange a much greater volume of air than a typical residential HVAC system.

2.2 AOC-65 TREATABILITY STUDIES

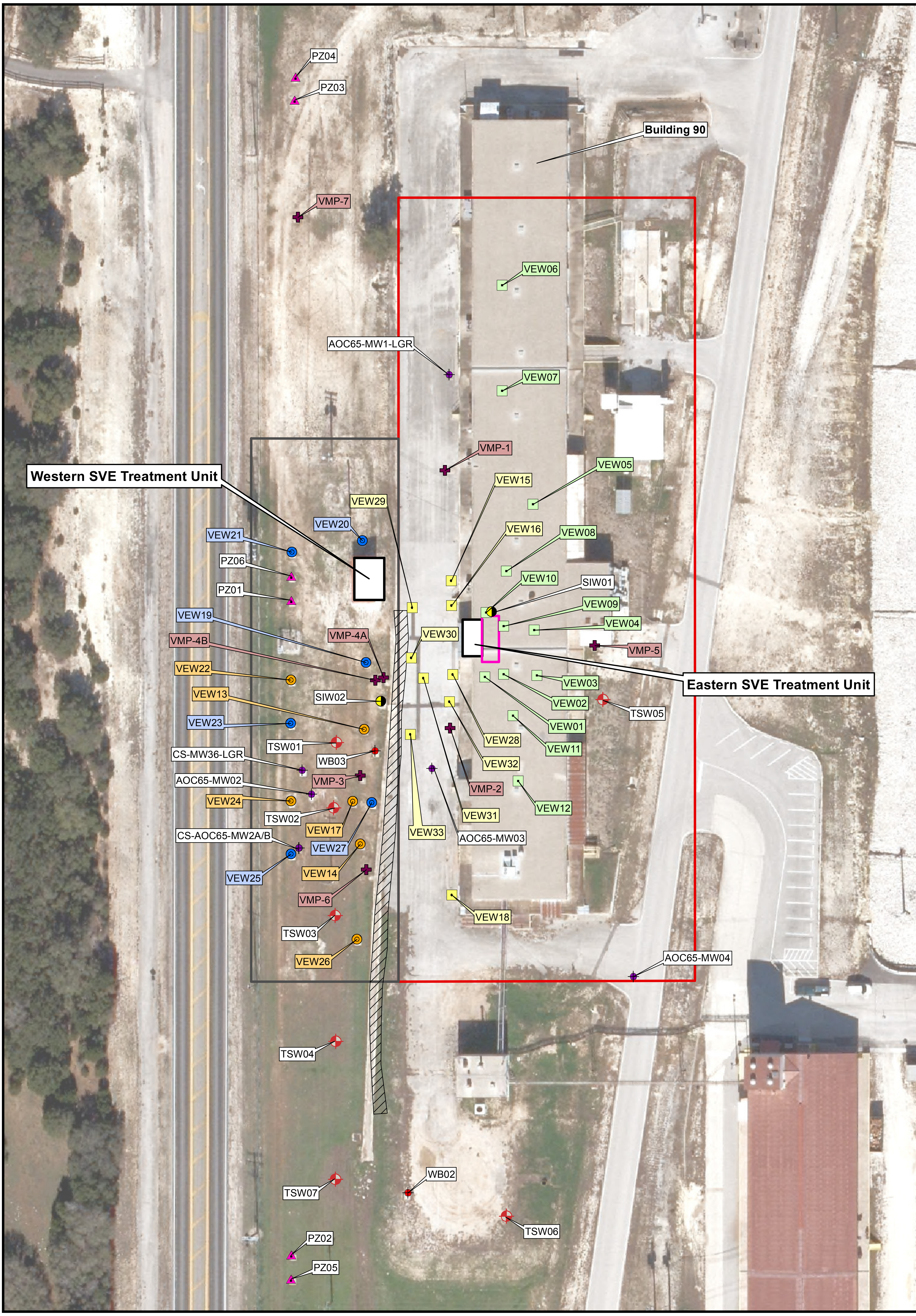
In 2002, Parsons installed seven vapor extraction wells (VEWs) on the west side of Building 90 (VEW 13 - 19) and 12 VEWs beneath Building 90 (VEW 1 - 12) along with the associated piping and equipment for the SVE system as part of an SVE pilot study. Results of this initial study and discussion of system construction and performance are provided in the *AOC-65 SVE Interim Treatability Test Report* (Parsons 2005a). Following the initial study, a 6-month operations and maintenance (O&M) study was conducted and the results are discussed in the *AOC-65 Soil Vapor Extraction Operations and Maintenance Report* (Parsons 2005b). Additionally, a groundwater recharge study and a remedial technology evaluation at AOC-65 was conducted and documented in the *Treatment Evaluation Report for AOC-65 SVE* (Parsons 2005c).

In 2007, Parsons added one deep-nested VEW cluster near the Building 90 west loading dock, four shallow VEWs, and three intermediate-depth VEWs west of the ditch at Building 90 within AOC-65 (Parsons, 2008). The nested VEW cluster consists of two VEWs installed to depths of 125 and 180 feet (ft) below ground surface (bgs). The expanded SVE system at AOC-65 is organized into two separate sub-systems: the Building 90 (or Eastern) system and the Western system. The Eastern - Building 90 system consists of a "sub-slab" blower which services VEWs 1, 2, 8, 9, 10, and 12 and an "exterior" blower which services VEWs 15, 16, 18, 28A, and 28B. The Western system consists of a intermediate-depth or "deep" blower, which services VEWs 13, 14, 17, 22, 24, and 26, and a "shallow" blower which services VEWs 19, 20, 21, 23, 25, and 27. Collectively, the VEWs and blowers are referred to as sub-slab, exterior, deep, or shallow VEWs and blowers.

In 2011, Parsons added two intermediate-depth VEWs, three shallow VEW, and two shallow steam injection wells for a thermally enhanced soil vapor extraction study. The new VEWs are connected to the Building 90 exterior blower. The two steam injection wells (one installed within the concrete-lined pit previously occupied by the solvent vat, the other adjacent to the concrete-lined drainage ditch west of Building 90) provide a means to introduce heat to the formation and increase volatilization of VOCs trapped within fractures and pore spaces thereby increasing the efficiency of the SVE system. Although volatilization of VOCs was increased, the condensate generated when the injected steam cooled negatively impacted system performance. A plan view of the SVE system is shown in **Figure 5**. Monitoring results from operations of the SVE system indicated that approximately 340 pounds (~25 gallons) of PCE has been removed from the underlying limestone at AOC-65 since 2002.

In 2012, Parsons conducted an interim removal action (IRA) of the soils and bedrock beneath the concrete-lined drainage ditch west of Building 90. Approximately 2,000 cubic yards (CY) of contaminated soil and bedrock were removed from the resultant 4-foot wide, 12 to 15-foot deep, and 320-foot long trench. Additionally, the trench was used to facilitate the completion of an *in-situ* chemical oxidation (ISCO) treatability study in which sodium persulfate, activated with base conditions, was injected into the trench and allowed infiltrate through the subsurface via naturally occurring flow paths. Seven treatability study groundwater monitoring wells were installed as part of this study. One of the seven installed monitoring wells, TSW-01, indicated the presence of PCE in groundwater samples in concentrations as high as 64,000 micrograms per liter during the study.

Figure 5 Current plan view of SVE system



N
W E
S

0 25 50 100
Feet

Trench
AOC-65 Vat
AOC 65 Eastern SVE System
AOC 65 Western SVE System
Treatability Study Well
Eastern SVE - Sub-Slab VEW
Eastern SVE - Exterior VEW
Western SVE - Deep VEW
Western SVE - Shallow VEW
Steam Injection Well
Piezometers
Monitoring Well
Westbay Well
VMP

Figure 5

AOC-65 Monitoring Overview Map
Camp Stanley Storage Activity

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3.0 VAPOR INTRUSION SURVEY SCOPE OF WORK

The activities covered by this work plan addendum include the collection of indoor air samples for evaluating potential VI risks to occupants of residences located near the groundwater contamination plume assumed to originate from AOC-65. Additionally, this work plan addendum details the field tasks to be completed as well as the data quality objectives and anticipated reporting requirements. One data collection event is planned to ascertain current IA quality, as it pertains to VOC contamination, within 10 occupied buildings around the PCE/TCE groundwater plume adjacent to CSSA and AOC-65. Data collected during this sampling event will be used to determine if further IA investigations and/or VI mitigation will be required. Decisions regarding the necessity of further investigation and/or mitigation will be made following a review of data garnered by the completion of objectives described in this workplan. These data will be compared to the most conservative screening levels for IA quality available (USEPA RSLs 9.4 $\mu g/m^3$ (1.38 ppbv) for PCE and 0.43 $\mu g/m^3$ (0.08 ppbv) for TCE, (EPA residential indoor air screening level generic table, November 2012) to determine potential VI risk to residential receptors.

1. Phase 1: Identify 10 occupied structures (residential/commercial/military) for participation in the off-post vapor intrusion survey. Candidate structures will represent typical constructions within the area, and are located above or within 0.5 miles of the PCE/TCE plume. The buildings selected will include one and two story residences with differing foundation types and represent examples of structures built using new and old materials and techniques, as well as occupied military or commercial structures.
2. Phase 2: Administer an indoor air building questionnaire to identify indoor VOCs sources (e.g. hobbies, recent dry-cleaning, resident occupation, etc.) that may impact IA sampling results, remove those products and curtail activities prior to and during the IA sampling so results obtained from the study are representative of hazards associated from VI rather than from a secondary source..
3. Phase 3: Collect IA samples at 10 locations in the residential areas west, north, and south of AOC-65 underlain by the PCE/TCE contaminated groundwater plume. Additional sampling may be required if a well completed within the Lower Glen Rose is enclosed within a smaller structure and is located within 100 feet of the residence because the borehole represents a direct pathway for vapors to travel from the contaminated groundwater to the surface.
4. Phase 4: Review of data collected (indoor air samples and indoor air building questionnaire) against USEPA screening levels will provide the basis for recommending either additional IA investigation or no further action.

Existing work plans for soil gas sampling on previous CSSA task orders fulfilled by Parsons are in effect and are available in the CSSA Environmental Encyclopedia, Volume 1, Work Plans. The Quality Assurance Project Plan (QAPP) defines sampling requirements for the field team and analytical laboratory and is also available in CSSA's Environmental Encyclopedia, Volume 1, Work Plans. All field investigation methods will comply with requirements of TCEQ and USEPA Region VI policies.

3.1 SAMPLE LOCATIONS

3.1.1 Procedure

Completion of the objectives provided in this work plan require collecting IA samples within 10 structures on or around the PCE/TCE groundwater contamination plume originating from AOC-65. Samples will be analyzed using USEPA Method TO15 SIM Analysis for PCE and TCE.

Candidate structures are located within one mile of AOC-65; however, residences that are located directly above or adjacent to the groundwater plume are preferred. Additionally, structures currently included in CSSA's groundwater LTMO are preferred given that access agreements are already in place. Locations of candidate structures are provided in **Figure 6**. Also, **Table 1** lists the sample location number, general structure features, approximate distance from AOC-65, foundation type, and associated private or public wells included in CSSA's off-post groundwater monitoring program that have the potential to provide a direct pathway for vapor migration.

Table 1 Candidate Sampling Location Features

Sample Location#	Distance from AOC-65	Well ID (if applicable)	Foundation type
1	0.25 mile	N/A	Slab
2	0.25 mile	RFR-10	Mobile Home / no skirt
3	0.25 mile	On-Post Building	Slab
4	0.5 mile	RFR-10	Slab
5	0.5 mile	LS-7	Slab
6	0.5 mile	RFR-11	Slab
7	0.5 mile	Well Enclosure RFR-11	Dirt
8	0.5 mile	LS-5 / LS-7	Slab
9	0.5 mile	Mobile Home	Mobile Home / with skirt
10	1 mile	Fire Station	Slab
Alternate - 1	0.5 mile	LS-6	Slab
Alternate - 2	1 mile	On-Post Residence	Slab
Alternate - 3	1 mile	On-Post Residence	Slab
Alternate - 4	1 mile	RFR-13	Slab
Alternate - 5	0.25 mile	On-Post Building	Slab
Alternate - 6	0.5 mile	Mobile Home	Mobile Home / with skirt
Alternate - 7	0.5 mile	Mobile Home	Mobile Home / with skirt
Alternate - 8	0.5 mile	RFR-9	Slab

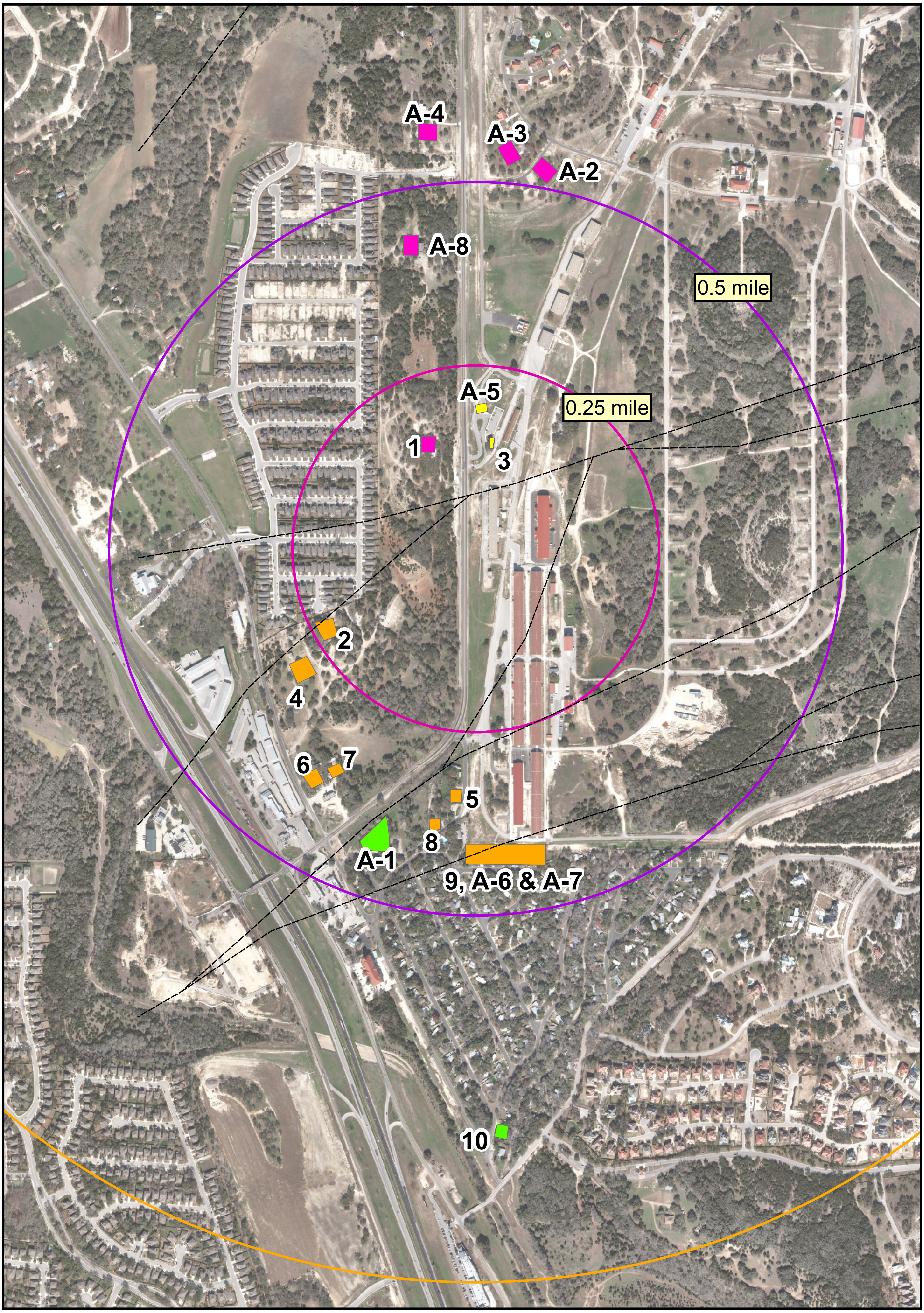

Figure 6

AOC-65
Vapor Monitoring Candidates
Camp Stanley Storage Activity

PARSONS

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3.1.2 Indoor Air Building Survey

Prior to or during collection of IA samples, a building survey will be completed by the sample collection team. Completion of this survey will document building characteristics that may affect vapor intrusion within the occupied space and will determine the number of samples required per structure. Additional samples may be required if either of the following conditions is met: the building is constructed on a pier and beam foundation and the crawl space is enclosed, or the building has a basement. The building survey form is provided in Appendix A.

3.1.3 Indoor Air Occupant Questionnaire

An effort will be made to identify additional sources of indoor air contamination via the completion of a residential questionnaire prior to IA sampling. Questionnaires will be administered to occupants at each residence prior to initiation of IA sampling. If any additional sources of PCE or TCE are identified, these sources will be documented and removed (if possible) from the location. Some background sources will occur on a fairly constant basis and are difficult to eliminate (e.g., volatiles released from stored chemicals or fuels). However, other sources are intermittent and have the potential to skew the data (e.g., cigarette smoke, recently dry-cleaned clothing, etc.). Completing the indoor air building questionnaire will help identify any additional sources of contamination that may affect IA sample results. The questionnaire is provided in Appendix A.

3.2 INDOOR AIR SAMPLING

3.2.1 Procedure

Indoor air sampling and analysis provide the most direct estimate of inhalation exposures. Additionally, results from IA sampling can be directly compared to screening levels provided by the EPA for individual COCs. However, source attribution for the many compounds typically present in indoor air can be challenging. Constituents of indoor air can originate from indoor emission sources, from ambient (outdoor) air contributions, as well as from possible vapor intrusion of contaminated media. Each of these sources can introduce concentrations of volatile chemicals to the indoor environment sufficient to pose an unacceptable health risk. In addition, concentrations of compounds found in indoor air are often subject to temporal and spatial variations, which may complicate estimates of exposure. Some of the potential advantages and limitations of indoor air sampling are summarized in **Table 2**.

IA samples will be collected at 10 locations within the residential areas north, west, and south of AOC-65. For typical single-family residences, one indoor air sample will be collected. Samples will also be collected from two enclosed crawlspaces (mobile homes) and one well enclosure.

An outdoor, or ambient, air sample collected concurrently with IA sampling will be used to provide background values with which to compare to screening levels and IA concentrations. The ambient air sample will be collected on the upwind side of the residence at the #2 sample location (**Figure 6**), and shall be no closer than 15 feet and no farther than 30 feet from the residence.

Summa sampling canister(s) shall be delivered to the field under vacuum and certified clean and leak-free. Sampling will occur at a fixed flow rate over a preset period of time (24 hours) with use of a flow controller calibrated and set in the laboratory. Initial and final vacuums will be recorded for each canister. Canisters will be equipped with dedicated vacuum gauges to facilitate this effort. Canisters will be retrieved prior to being completely filled (with some residual vacuum remaining) to ensure proper collection period. Indoor air and ambient samples will be analyzed using level IV analysis via USEPA Method TO15 Selective Ion Monitoring (SIM) for PCE and TCE.

The sampling canisters will be placed within the normal breathing zone, approximately 3 to 5 feet above the floor or ground for indoor and ambient samples. Indoor air samples shall be collected within a frequently occupied room (e.g. living room). All windows should remain closed with the HVAC system on and running normally for 12 hours prior to and during sampling. Samples collected within enclosed crawlspaces or well houses shall be placed on the ground or slab with skirt reattached or doors and windows closed.

Table 2: Issues Associated with Indoor Air Sampling

Advantages of Indoor Air Sampling	Limitations of Indoor Air Sampling
Provides a direct measurement of indoor air concentrations of the chemicals of concern.	Like any environmental sample, an individual indoor air sample may not be representative of the long term exposure concentration.
Might provide confirmation that the vapor intrusion pathway is complete (or incomplete).	A number of environmental parameters (e.g., water table variations, temperature, soil moisture, atmospheric pressure) may affect vapor intrusion rates, thus indoor air concentrations can have large temporal variability.
Can be used as a validation tool for fate and transport modeling.	Samples at different times of year may be required to account for effects of seasonality on vapor intrusion.
If collected in conjunction with sub-slab samples, indoor air samples can be used to develop empirical, building-specific attenuation factors.	Sampling may be disruptive to building occupants. Normal activities may need to be curtailed to avoid adding volatiles to air. Stored chemicals and cleaning supplies may need to be removed from building.
The direct measurement of indoor air may account for the influence of building-specific parameters that are hard to measure or quantify.	Sampling cannot be used to estimate attenuation of contaminants over time (unless long-term monitoring is undertaken).
Can provide data suitable for either qualitative screening level assessment or a quantitative risk assessment if sufficient data is available.	Sampling cannot be used to predict vapor intrusion impacts to buildings to be built in the future.
Sampling does not require drilling through building foundation and thus does not have the potential to change vapor migration patterns.	Volatile contaminants in groundwater may be released directly to indoor air if groundwater is used in the home.
	Impact from background chemicals may be substantial and must be accounted for (for indoor and outdoor background impacts), sampling design can affect risk assessment.

3.4 DATA QUALITY OBJECTIVES

The investigation of AOC-65 serves as the mechanism for collecting and assessing data that will be used in the decision-making process relating to the potential chronic human health risks from vapor intrusion. During this portion of the overall process, data are collected and assembled to:

1. characterize site-specific conditions at residences and businesses potentially affected by the PCE/TCE plume emanating from AOC-65;
2. determine potential indoor sources of VOCs by administering a residential questionnaire and performing a building survey at residences.
3. summarize and report on vapor intrusion from AOC-65 as to

- requiring additional investigations, or
- warranting no further action.

This investigation provides the mechanism to conduct site-specific screening to assess and evaluate the potential of soil vapor intrusion into specified facilities at CSSA. Ultimately, data developed during this investigation will provide the necessary information for an assessment of potential vapor intrusion impacts from AOC-65 to residential areas potentially impacted by off-post contaminated groundwater. Consequently, collected data must be of sufficient quantity and quality to support defensible decision making.

The USEPA has developed a seven-step process for developing DQOs, which are listed below:

Step 1 – Problem Statements

The overall objective of this SAP Addendum is to generate data needed to determine if VOCs pose a risk to current residential receptors via VI. Previous investigations have successfully identified the major contaminants present in groundwater and soil gas at the site. Specifically, the VOCs present in groundwater and in soil gas include PCE, TCE, DCE and VC.

Based on current uses and residential development of the area surrounding and overlaying contaminated groundwater, there is an immediate need to evaluate the risk these chemicals may pose to current and potential future receptors prior to completion of the remedial facility investigation (RFI). Therefore, data are needed to determine if vapor intrusion is responsible for the presence of contamination in residences that exceed criteria protective of indoor air. The required data will be obtained by performing indoor air testing at selected residences and businesses west of AOC-65. If soil gas concentrations exceed protective criteria, further indoor air investigations and potential indoor air mitigation at individual residences may be required. Additionally, this plan includes the collection of samples from enclosed crawl spaces and well/pump houses within the residential areas west and west southwest of AOC-65 for USEPA TO-15 SIM PCE and TCE Analysis.

Step 2 – Identify the Goal of the Study

The overall data quality goal for this project is to gather sufficient information to determine the potential adverse chronic impacts of vapor intrusion from AOC-65 to the surrounding residential area, if any. Data quality is defined by its representativeness, precision, comparability and completeness. Representativeness of the data is dependent on site selection and the number of samples taken, which are easily addressed in the sampling plan design. The requirements for precision, comparability, and completeness of the data vary between data types but all are enhanced by the use of standardized sampling and analysis protocols and standardized reporting procedures. DQOs are continually being updated as the project progresses and data is generated.

Step 3 – Identify Information Inputs

- Identify the type of information that is needed to resolve the decision statement: Laboratory analysis of indoor air collected from the target areas (Figure 4). Analyses will be for PCE and TCE. Data will be used to evaluate the presence of contamination in the breathing zone.

- Identify the source of information: Laboratory analytical reports from the collected indoor air and background ambient air samples.
- Identify how the Action Level will be determined: The action levels for indoor air samples are the USEPA Regional Indoor Air Screening Level – Residential. These action levels are identified on **Table 3**.
- Identify the appropriate sampling and analytical method: VOCs in indoor and ambient air samples will be analyzed using Method TO-15 SIM for PCE and TCE.

Step 4 – Define the Boundaries of the Study

- Specify the target population: The target population will consist of indoor air, ambient air, crawl space, and well/pump house samples collected at the selected locations. The sample volume will be determined by the analytical laboratory requirements.
- Specify the spatial and temporal boundaries and other practical constraints: The lower vertical boundary for each sample is nominally at ground surface because the objective is to identify soil vapor contamination that has migrated into the breathing zone and poses a potential risk to human health. The temporal constraint for conducting the proposed indoor air sampling is that indoor air data must be collected to determine the existence of a vapor intrusion pathway to residential areas overlying contaminated groundwater.
- Specify the scale of interference for decision making: Individual indoor air sample analytical results are the smallest units used for decision making during this project. Collectively, those data that show concentrations below or above project criteria (Table 3) will define areas that either does not require action or areas that will require further evaluation.

Step 5 – Develop the Analytical Approach

- Specify the action level: indoor air action levels for chemicals of potential concern at the site are identified on **Table 3**.
- Specify the theoretical decision rule: The following decision rules have been developed to address the investigation objectives outlined in Step 2 for the planned activities at AOC-65.
    - IF target VOC concentrations in indoor air samples collected within residences west of the AOC-65 source area are greater than the project action levels (Table 3), THEN additional IA monitoring will be required to determine if VI mitigation should be implemented.
    - IF target VOC concentrations in indoor air samples collected west of the AOC-65 source area are less than the project action levels (Table 3), THEN it will be determined that there is no significant risk to current and potential future receptors and no further action warranted.
    - IF target VOC concentrations in samples collected from crawl spaces or well/pump houses are greater than project action levels AND indoor air samples are below project action levels, THEN it will be determined that

there is no current significant risk to receptors, however additional sampling of indoor air may be required to monitor for changing conditions.

Step 6 – Specify Performance or Acceptance Criteria

The nature of field investigations lends itself to uncertainties, and because data are being collected on a judgmental basis, limits on decision errors cannot be quantified. However, potential errors that may be encountered in the field can be mitigated through the use of established sampling procedures.

One type of decision error, referred to as a false negative error, may arise if sampling or analyses fail to detect contamination that is present at levels of concern. This type of error would result in incorrectly concluding that indoor air contamination does not exist at levels in excess of those that are protective of current and potential future receptors (i.e., project action levels). This type of error will be minimized by optimizing the sampling design such that samples are collected in the area(s) where contamination is most likely to exist, such as above the known groundwater plume at AOC-65, or where a known conduit exists (a well set within the Lower Glen Rose located within the groundwater plume). Additionally, method detection limits will be used that are below the project action levels specified in Table 3.

Incorrectly concluding that contamination is present at levels above the project action level when in fact it is not is another type of potential decision error. This type of error may result if analytical results of IA samples over estimate actual contaminant concentrations, if samples are cross-contaminated, or if contaminants are misidentified. To minimize the potential for this type of error, appropriate sampling and analytical methods will be employed and all laboratory data will undergo validation to identify any problems that could lead to this type of decision error.

Step 7 – Develop the Detailed Plan for Obtaining Data

The purpose of this final step is to define the sampling and analysis program for data collection based on the knowledge gained in the previous six project quality objective steps. The sampling design for the IA investigation implements a judgment-based approach that relies on information gathered during the project and previous investigations to guide further data collection. Each step of data collection will be optimized based on interpretation of results from the previous step. The proposed sample locations are shown on **Figure 6**.

The IA samples will be analyzed by an off-post lab with a gas chromatograph/mass spectrometer (GC/MS) by USEPA method TO-15 SIM using Level IV reporting. Quality assurance/quality control (QA/QC) duplicate samples will be collected at a rate of 10 percent of the IA samples.

3.4.1 Analytical Validation, Verification and Reporting

The data usability of collected indoor air results is a critical consideration when making a determination on the vapor intrusion pathway. The analytical validation and verification task includes issues related to analytical data, including oversight of sample collection and submittal efforts, interaction with the selected laboratory, data verification, data validation, and management of electronic analytical data. Air monitoring and soil gas results from the sampling efforts will be validated in accordance with the CSSA QAPP. All results will be described, analyzed, tabulated, or presented in tables or as figures. Analysis of air monitoring samples will be performed by a laboratory capable of delivering level IV results for Method TO-15 SIM for PCE and TCE.

Parsons will oversee each sampling event, including reviewing each chain-of-custody for accuracy and completeness, verifying that the laboratory sample log-in sheets match the chain-of-custody forms, addressing any sample receipt issues (such as unusable sample containers), and maintaining continuous contact with the laboratory regarding scheduling.

Laboratory data packages will be reviewed by Parsons Chemists for completeness and adherence to the CSSA QAPP and the approved laboratory variances. All associated analytical QA/QC data will be examined, and all exceptions will be noted in both the case narrative and data verification report (DVR). The sample results associated with noncompliant QC performance will be qualified in accordance with the CSSA QAPP.

Following verification of the laboratory data, the data usability as related to the project DQOs will be assessed. Validation will include examination of historical data (if available), laboratory data trends, and the reasons for data collection. Based on the overall assessment of the data, flags may be removed or changed to reflect usability of the data. The basis for such changes will be detailed in the project summary report.

Electronic data submitted by the laboratories will be loaded into the CSSA GIS database, verified for accuracy, and updated to reflect all data qualifier changes incurred through the data verification and validation process.

Table 3: Target Compound List and Residential Screening Levels for Vapor with Laboratory Reporting Levels

	USEPA Regional Indoor Air Screening Level - Residential[1]		**TO-15 SIM Laboratory Reporting Level**		**TO-15 SIM Laboratory Detection Level**	
Analyte	**(µg/m³)**	**(ppbv)**	**(µg/m³)**	**(ppbv)**	**(µg/m³)**	**(ppbv)**
Volatiles						
Tetrachloroethylene (PCE)	9.4	1.39	0.025	0.0037	0.0028	0.00041
Trichloroethylene (TCE)	0.43	0.08	0.025	0.0047	0.0058	0.0011

3.4.2 Recordkeeping and Reporting Procedures

Information gathered during the field activities will be recorded. Field documentation will consist of one or more field logbooks, field forms, sample logs, and labels. Site and field logbooks provide a daily handwritten record of all field activities. The master site logbook is a master record of all activities, and entries are usually made at the end of each workday. Field logbooks are detailed daily records that are kept in real time. The following items will be included in the field logbooks, as appropriate:

- Date and time, weather, names, titles, and organizations of personnel performing the task;
- Name, title, organization, date, time, and purpose of each visitor to the site;
- Brief outline of activities for each day and references to the appropriate logbooks, forms, computer files, and records;
- Record of the number of samples collected at each site by medium, the name of the laboratory(ies) to which samples were shipped, airbill number of each sample shipment, and other pertinent summary information;
- Specific comments on problems that occurred during daily activities, their final resolution, and anticipated impact;
- Record of telephone calls pertaining directly to the decision-making process of the field investigation;
- Description of any field tests and results conducted;
- Description of samples collected and any duplicates or replicates, including sample IDs;
- Equipment used, including serial number, time of calibration, corresponding general comments, and description of any failures or breakdowns; and
- Entries in the master site and field logbooks will be signed by the responsible person at the end of each day.

All results from the indoor air sampling event(s) will be included in a vapor intrusion assessment report summarizing all data collection activities and results. The investigation report will be prepared as both draft and final version, with one round of government comments before issuance of the final report.

4.0 REFERENCES

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Appendix A

Indoor Air Building Survey Form and Questionnaire

Indoor Air Building Survey

Personnel: ___________________________________ Date: ______________________________

Part I - Occupants

Building Address: ____

Property Contact:_____________________________ Owner/Renter/other:________________

Contact's Phone: _____________________________

Number of occupants: Children under age 13 _____ Children 13 - 18 _____ Adults ______

Part II - Resident Characteristics

Residence type: single family / multi-family / apartment / other: _______________________

Describe building: _______________________________________ Year constructed: _________

Number of floors at or above grade: ________

Number of floors below grade: _______ (crawl space (enclosed/open) / slab / basement)

Additional comments: ____

Private well: Yes / No Enclosed well house: Yes / No GAC: Yes / No

Comments:

Indoor Air Building Questionaire

Part III - Outside Contaminant Sources

Distance to AOC-65: ____________

Part IV - Indoor Contaminant Sources

Potential Sources	Location(s)
Paints / thinners / strippers	
Cleaning solvents	
Oven cleaners	
Carpet / upholstery cleaners	
New carpeting / flooring	
Hobbies - glues, paints, etc.	

Part IV - Miscellaneous

Do the occupants have their clothes dry cleaned? Yes / No

If yes, how often? weekly / monthly / 3-4 times per year

Do any of the occupants use solvents at work? Yes / No

If yes, what types of solvents are used? ______________________________________

If yes, are their clothes washed at work? Yes / No