EnviroGroup Limited
Vapor Intrusion Solutions

CLIENT MEMO

To: Cherrie Perkins, WDEQ

From: EnviroGroup Limited

Project: Casper PCE Plumes Orphan Site **Date:** June 10, 2010

Subject: **Soil Vapor Investigation Procedures and Results Technical Memo**

cc: WQ-0664

This technical memorandum presents a summary of procedures and results for the soil vapor investigation described in the Sampling and Analysis Plan (SAP) approved by the Wyoming Department of Environmental Quality (DEQ) on September 28, 2009. The first phase of the investigation was implemented from October 2009 to December 2009 by EnviroGroup Limited (EnviroGroup) to evaluate the nature and extent of the tetrachloroethene (PCE) plumes previously identified in Casper, Wyoming and to evaluate the potential for vapor intrusion. This technical memorandum is intended to provide DEQ with interim information prior to completion of the study and final report.

Soil Vapor Investigation Procedures

Between November 4, 2009 and November 10, 2009, 40 permanent soil vapor probes were installed to evaluate the nature and extent of the PCE plumes and evaluate the potential for vapor intrusion. The 40 probes were installed at select locations within four previously identified PCE plumes (i.e., Plume #1, Plume #2, Plume#3, and North Casper Plume) with associated trichloroethene (TCE) in shallow groundwater in Casper, Wyoming as identified by Huntingdon Engineering & Environmental, Inc. (Huntingdon) in 1994.

Soil vapor probes were installed under the oversight of EnviroGroup personnel, at locations selected by EnviroGroup Limited, from ground surface to approximately 5 feet bgs using a direct-push rig (i.e. Geoprobe® or equivalent) throughout investigation areas as shown on Figure 1. Upon completion of drilling activities and using freshly-gloved hands, each soil vapor probe assembly was immediately placed into the borehole by drilling personnel. All soil vapor probes were constructed using 0.25 inch inner diameter (I.D.) by 6 inch long stainless steel screens connected to 0.25 inch outer diameter (O.D.) Nylaflow® tubing. Screens were placed at the desired sampling depth (typically in the middle of the sampling zone, described below) and the tubing extended up the center of the borehole to approximately 6 inches above ground surface and was fitted with an air-tight valve. Screens were placed in the soil vapor sampling zone (typically one foot in length) at the bottom of the borehole.

Each screen was centered within the sampling zone and the annulus surrounding the screen was backfilled with approximately one foot of clean silica sand (i.e., 60 – 120 sieve size) then sealed with a bentonite seal. The granular bentonite seal was installed in nominal 8 inch lifts (with distilled water hydration following each lift) to a height of approximately two feet above the silica sand. The remaining annulus was then backfilled to grade with granular bentonite, installed in one foot lifts (with distilled water hydration between each lift). A five inch diameter flush-mount well vault was concreted around the top of each soil vapor probe to minimize infiltration of water or outdoor air.

Soil Vapor Sampling and Analysis Procedures

Between November 11, 2009 and November 12, 2009, 40 soil vapor samples and one field duplicate sample (ESV-29) were collected from 40 soil vapor probes to provide information on the nature and extent of PCE and TCE. A mobile laboratory provided by Hartman Mobile Geosciences was utilized to provide real-time laboratory analysis of PCE and TCE in the soil vapor samples. Soil vapor samples were also collected from at least 20% of the soil vapor probes as duplicate samples (collected concurrently with mobile lab samples), for fixed-based volatile organic compound (VOC) laboratory analysis to demonstrate comparability of sample results and to screen for the presence of other breakdown products (e.g. vinyl chloride) and BTEX.

Soil vapor samples were collected in the field using current state of the art procedures. Each soil vapor probe was not disturbed for at least 24 hours prior to sampling. During soil vapor sampling activities, a clean, small plastic shroud with two small ports was placed over each soil vapor probe and weighted down. An air-tight seal of foam was placed on the ground surface around the edge of the shroud where it contacted the ground. The soil vapor probe tube, fitted with an air-tight valve, was extended up through the air-tight seal to the exterior side of the shroud.

Each soil vapor tube connected to an air-tight valve, was then connected with a tedlar bag attached to one side of the valve and the glass sampling syringe on the other side of the valve (both outside of the shroud). Prior to purging or sampling activities, helium tracer gas was released via a small diameter tube through a port in the shroud into the enclosure beneath the shroud to a minimum concentration of 19.9%. A sample of the air inside the shroud was measured through the second port using a portable helium detector to determine the concentration of helium within the enclosure beneath the shroud. Three purge volumes (calculated based on the volume of probe tubing and screen) were purged at a flow rate of 0.1 liters per minute, through the shroud into a 60 milliliter (mL) calibrated gas-tight syringe and transferred to a tedlar bag. The tedlar bag was then connected to a portable helium detector to measure for the presence of helium gas in the purged vapor. If high concentrations (>10% of the shroud concentration) of helium were observed in the purge vapor, the soil vapor probe seal was checked and/or enhanced to reduce the infiltration of ambient air into the enclosure and another sample collected. If helium concentrations were less than 10%, a soil vapor sample was collected for analysis. Tracer test results measured prior to malfunctioning of the meter indicated minimal tracer gas breakthrough (<10% of the shroud concentration). Based on this observation, it is assumed that all soil vapor probes were properly

installed and representative soil vapor samples collected. Upon completion of sampling activities all soil vapor probes were closed and secured.

For permanent probes, tracer gas monitoring is recommended for most (with a minimum of 10%), but is typically not required for all, samples collected (e.g., NYSDOH, 2006). Note that the portable helium detector malfunctioned at 14:00 on November 12, 2009 and therefore helium tracer tests could not be completed during sampling of the remaining soil vapor probes (ESV-01 through 07, ESV-10, 13, 14, 16, 17, and 40). Nevertheless, more than 10% of the samples were collected using the helium shroud, confirming that the procedures followed prevented significant cross-contamination of samples with ambient air.

Soil vapor samples collected for mobile laboratory analysis were collected at flow rates of less than 0.1 liters per minute utilizing clean, 30 mL glass syringes supplied and certified clean to reporting limits by Dr. Hartman of Hartman Mobile Geosciences. Fixed-base laboratory duplicate soil vapor samples were collected concurrently with mobile lab samples over approximately a 10 minute time period, utilizing dedicated, laboratory-set regulators and 1 liter Summa® (or equivalent) canisters supplied and certified clean (i.e. batch certification) to reporting limit levels by Centek Laboratories, LLC, (Centek), a National Environmental Laboratory Accreditation Conference (NELAC)-certified laboratory. Each canister had an initial field vacuum reading of at least 26 inches of mercury (Hg) prior to sampling and had a final field vacuum reading of 1 to 7 inches of Hg upon the completion of sample collection according to the vacuum gauges attached to the canisters.

The mobile laboratory utilized a gas chromatography-mass spectrometry (GC/MS) and completed soil vapor analysis for PCE and TCE only utilizing USEPA Method 8021 with nominal reporting limits of 7.0 micrograms per cubic meter ($\mu g/m^3$) and 15.0 $\mu g/m^3$, respectively. Duplicate samples were shipped to Centek within two days of sampling so that no sample exceeded the 30-day holding time for the TO-15 method and analyzed for VOCs by USEPA Method TO-15 with minimum reporting limits of 1.6 $\mu g/m^3$ or less. Full chain of custody documentation was maintained for all canisters from time of shipping from the laboratory to the time of analysis.

Two ambient air samples (1 per day) were collected during the soil vapor sampling to provide information on potential background levels of PCE and TCE due to ambient air. Samples were collected in an upwind location, approximately five feet above ground surface near the location of the mobile laboratory utilizing clean, 30 mL glass syringes, and analyzed by Dr. Hartman.

<u>Soil Vapor Analytical Results</u>

Soil vapor analytical results indicated the presence of PCE in 16 soil vapor samples and one duplicate sample above the DEQ screening level of 810 $\mu g/m^3$. This screening level was calculated based on the $1x10^{-5}$ target indoor air concentration risk level of 8.1 $\mu g/m^3$ from the 2002 EPA OSWER Draft Vapor Intrusion Guidance (EPA, 2002), with an assumed attenuation factor of 0.01 from shallow soil gas to

indoor air. Soil vapor results are summarized on Table 1 and PCE and concentrations are shown on Figure 1.

Six soil vapor probes (i.e., ESV-19, ESV-20, ESV-22, ESV-23, ESV-24, and ESV-27), located in the southern portion (i.e., downtown portion) of Plume #1 south of the Burlington Northern railroad property, contained PCE concentrations exceeding the screening level of 810 µg/m^3 and ranged from 1,030 µg/m^3 to 6,500 µg/m^3. Five soil vapor probes (i.e., ESV-10, ESV-12, ESV-14, ESV-16, and ESV-17), located in the North Casper extension of Plume #1 (i.e., Mid Casper portion), north of the Burlington Northern railroad property, contained PCE concentrations exceeding the screening level of 810 µg/m^3 and ranged from 830 µg/m^3 to 2,600 µg/m^3. PCE was detected below the screening level in all remaining probes. Generally, the highest PCE concentrations were observed within or immediately adjacent to the historic PCE plume boundary identified by Huntingdon (Huntingdon, 1994); however, soil vapor probe ESV-17 which contained a concentration of 1,100 µg/m^3, was collected approximately 200 feet east of the 1994 boundary. Overall, PCE concentrations were generally lower than observed in 1994.

PCE concentrations did not exceed the screening level of 810 µg/m^3 in any soil vapor probe located in Plume #2 or Plume #3; however, PCE was detected in five of the six probes below the screening level.

Five soil vapor probes (i.e., ESV-01, ESV-03, ESV-06, ESV-07, and ESV-40), located in the historic North Casper Plume boundary, contained PCE concentrations exceeding the screening level of 810 µg/m^3 and ranged from 940 µg/m^3 to >39,000 µg/m^3. PCE was detected below the screening level in all remaining probes. Generally, the highest PCE concentrations were observed within the central area of the historic PCE plume boundary identified by Huntingdon (1994). PCE concentrations were generally lower than observed in 1994.

Additionally, soil vapor analytical results also indicate the presence of TCE in three soil vapor samples above the DEQ screening level of 90 µg/m^3. This screening level was calculated based on an indoor air target level of 0.9 µg/m^3 (thirteen times lower than the current EPA 10^{-5} risk level for TCE, based on the 90th percentile of background indoor air concentrations) with an assumed attenuation factor of 0.01 for shallow soil vapor to indoor air. One soil vapor probe (ESV-19) in Plume #1 and two soil vapor probes (i.e., ESV-03 and ESV-06) in the North Casper Plume, contained TCE concentrations from 460 µg/m^3 to 1,900 µg/m^3. TCE was detected well below the screening level in five soil vapor probes and not detected in the remaining soil vapor probes. Soil vapor results are summarized on Table 1 and TCE and concentrations are shown on Figure 1.

PCE and TCE were not detected in ambient air samples (i.e. EAA-01 and EAA-02) at reporting limits of 7 µg/m^3 and 15 µg/m^3, respectively.

Recommendations

Soil vapor analytical results indicate concentrations of PCE and TCE in two plumes exceeding DEQ screening levels of 810 µg/m^3 and 90 µg/m^3, respectively. Screening levels are generally considered "conservative" and exceedances do not necessarily indicate that the presence of an unacceptable human health risk; however, exceedances indicated the need for further site-specific evaluation. Therefore, EnviroGroup recommends that a "focused" indoor air investigation program consistent with the approved SAP be implemented to further assess the vapor intrusion pathway, and additional soil vapor sampling be conducted to further define plume boundaries.

Indoor Air Program

DEQ identified an area of concern based on November 2009 soil vapor PCE concentrations exceeding the 810 µg/m^3 screening level and estimated soil vapor plume contours are presented in Figure 2. Residential structures within these boundaries are considered "worst-case" buildings for the potential for vapor intrusion and will be offered indoor air testing and pre-emptive mitigation. Commercial buildings within the plume boundaries will be offered indoor air testing only at this time. Sub-slab testing will not be conducted within the 810 µg/m^3 boundary because vapor intrusion will be assumed to be the source of PCE in indoor air in these areas. Residential and commercial structures outside and immediately adjacent to the plume boundaries are considered "verification" properties and will be offered indoor air and sub-slab vapor testing. Sub-slab testing should be conducted to determine the potential for vapor intrusion and help determine background and indoor sources of PCE (and TCE). Additionally, the Day Care Center in Plume #2 will be offered sub-slab and indoor air testing as it appears to be the most vulnerable building in the area for vapor intrusion impacts based on the elevated PCE soil vapor result of 660 µg/m^3 at ESV-37.

It is expected that all verification indoor air test results will be below screening levels. However, if any of these buildings indicate the potential for vapor intrusion above screening levels, the investigation should be extended to adjacent buildings (i.e., in a "step out" process) in a sequential manner until analytical results indicate indoor air PCE concentrations are below screening levels.

Due to low turnout at the public meetings, it is anticipated that approximately 65% of residential properties and 50% of commercial properties offered verification air testing will choose to have testing conducted. Depending on response, this may lead to data gaps and additional soil vapor sampling may be required to define the extent of the North Casper Plume and Plume #1 in both the Downtown and mid Casper areas.

Soil Vapor Program

In November 2009, soil vapor sample locations were selected based on historic PCE plume boundaries identified by Huntingdon (1994). All soil vapor results exceeding screening levels were within the historic boundaries with the exception of ESV-17 in Plume #1, north of I-25. Five soil vapor sample

locations in the North Casper Plume (ESV-06, ESV-07, and ESV-03) and Plume #1 south of I-25 (ESV-20 and ESV-23) have results exceeding screening levels and are close to plume boundaries that have not been defined with a result below screening levels. Proposed step-out soil vapor probe locations are presented on Figure 2.

In the North Casper Plume, three soil vapor probe locations are proposed south and east of ESV-06, and two locations are proposed northwest of ESV-03 to further define the plume boundary around the highest soil vapor PCE concentrations measured in November 2009.

Six soil vapor probe locations are proposed to the east and north of ESV-17 and ESV-10 in Plume #1 north of I-25. In October 2009, PCE was detected at 41 µg/L in groundwater sampled from a water well (Rizor #1, 925 N. Washington St.) east of the historic plume boundary identified by Huntington (1994). This result provides evidence that PCE is in the shallow groundwater in the area east of the plume boundary defined in 1994 and presents the potential for vapor intrusion. Soil vapor sampling will provide data to confirm if the soil vapor plume has migrated from the historic plume boundary and help define the eastern extent of the plume.

Plume #1 is well defined south of I-25 (i.e. downtown area) except to the east of ESV-20 and ESV-23. Two soil vapor probe locations are proposed on North Kimball and North Park Streets to evaluate the eastern boundary.

Utilities will be marked prior to soil vapor probe installation by Site Services, Inc. and a mobile laboratory, provided by Dr. Blayne Hartman, will be utilized to provide real-time laboratory analysis of soil vapor samples. Field procedures will be conducted as outlined in the approved SAP. EnviroGroup will provide DEQ with a separate cost estimate for additional investigation activities.

TABLE 1

Soil Vapor Analytical Results - November 2009

Casper PCE Plumes Orphan Site
Casper, WY

Analytical Parameter	WDEQ Soil Vapor Screening Level	Sample ID	ESV-01	ESV-02	ESV-03	ESV-04	ESV-05	ESV-06	ESV-07	ESV-08	ESV-09	ESV-10	ESV-10 DUP	ESV-11	ESV-12	ESV-13	ESV-14	ESV-14 DUP	ESV-15	ESV-16	ESV-17	ESV-18	ESV-19	ESV-20	ESV-21	ESV-22	ESV-22 DUP	ESV-23	ESV-24	ESV-25
		Sample Date	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009
		Units																												
1,1,1-Trichloroethane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.83	---	---	---	---	<0.83	---	---	---	---	---	---	---	---	<0.83	---	---	---
1,1,2,2-Tetrachloroethane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<1	---	---	---	---	<1	---	---	---	---	---	---	---	---	<1	---	---	---
1,1,2-Trichloroethane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.83	---	---	---	---	<0.83	---	---	---	---	---	---	---	---	<0.83	---	---	---
1,1-Dichloroethane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.62	---	---	---	---	<0.62	---	---	---	---	---	---	---	---	<0.62	---	---	---
1,1-Dichloroethene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.6	---	---	---	---	<0.6	---	---	---	---	---	---	---	---	<0.6	---	---	---
1,2,4-Trichlorobenzene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<1.1	---	---	---	---	<1.1	---	---	---	---	---	---	---	---	<1.1	---	---	---
1,2,4-Trimethylbenzene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.75	---	---	---	---	**0.95**	---	---	---	---	---	---	---	---	**2**	---	---	---
1,2-Dibromoethane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<1.2	---	---	---	---	<1.2	---	---	---	---	---	---	---	---	<1.2	---	---	---
1,2-Dichlorobenzene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.92	---	---	---	---	<0.92	---	---	---	---	---	---	---	---	<0.92	---	---	---
1,2-Dichloroethane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.62	---	---	---	---	<0.62	---	---	---	---	---	---	---	---	<0.62	---	---	---
1,2-Dichloropropane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.7	---	---	---	---	<0.7	---	---	---	---	---	---	---	---	<0.7	---	---	---
1,3,5-Trimethylbenzene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.75	---	---	---	---	<0.75	---	---	---	---	---	---	---	---	**0.5** J	---	---	---
1,3-butadiene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.34	---	---	---	---	<0.34	---	---	---	---	---	---	---	---	<0.34	---	---	---
1,3-Dichlorobenzene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.92	---	---	---	---	<0.92	---	---	---	---	---	---	---	---	<0.92	---	---	---
1,4-Dichlorobenzene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.92	---	---	---	---	<0.92	---	---	---	---	---	---	---	---	<0.92	---	---	---
1,4-Dioxane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<1.1	---	---	---	---	<1.1	---	---	---	---	---	---	---	---	<1.1	---	---	---
2,2,4-trimethylpentane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.71	---	---	---	---	<0.71	---	---	---	---	---	---	---	---	<0.71	---	---	---
4-ethyltoluene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.75	---	---	---	---	**0.5** J	---	---	---	---	---	---	---	---	**0.65** J	---	---	---
Acetone	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**8.2**	---	---	---	---	**14**	---	---	---	---	---	---	---	---	**12**	---	---	---
Allyl chloride	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.48	---	---	---	---	<0.48	---	---	---	---	---	---	---	---	<0.48	---	---	---
Benzene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**0.97**	---	---	---	---	**1**	---	---	---	---	---	---	---	---	**0.58**	---	---	---
Benzyl chloride	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.88	---	---	---	---	<0.88	---	---	---	---	---	---	---	---	<0.88	---	---	---
Bromodichloromethane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<1	---	---	---	---	<1	---	---	---	---	---	---	---	---	<1	---	---	---
Bromoform	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<1.6	---	---	---	---	<1.6	---	---	---	---	---	---	---	---	<1.6	---	---	---
Bromomethane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.59	---	---	---	---	<0.59	---	---	---	---	---	---	---	---	<0.59	---	---	---
Carbon disulfide	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**0.51**	---	---	---	---	**0.76**	---	---	---	---	---	---	---	---	<0.47	---	---	---
Carbon tetrachloride	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.96	---	---	---	---	<0.96	---	---	---	---	---	---	---	---	<0.96	---	---	---
Chlorobenzene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.7	---	---	---	---	<0.7	---	---	---	---	---	---	---	---	<0.7	---	---	---
Chloroethane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.4	---	---	---	---	<0.4	---	---	---	---	---	---	---	---	<0.4	---	---	---
Chloroform	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**1.2**	---	---	---	---	<0.74	---	---	---	---	---	---	---	---	<0.74	---	---	---
Chloromethane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**0.23** J	---	---	---	---	**0.63**	---	---	---	---	---	---	---	---	<0.31	---	---	---
cis-1,2-Dichloroethene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.6	---	---	---	---	**1.2**	---	---	---	---	---	---	---	---	<0.6	---	---	---
cis-1,3-Dichloropropene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.69	---	---	---	---	<0.69	---	---	---	---	---	---	---	---	<0.69	---	---	---
Cyclohexane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**8.4**	---	---	---	---	<0.52	---	---	---	---	---	---	---	---	**7.8**	---	---	---
Dibromochloromethane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<1.3	---	---	---	---	<1.3	---	---	---	---	---	---	---	---	<1.3	---	---	---
Ethyl acetate	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.92	---	---	---	---	<0.92	---	---	---	---	---	---	---	---	<0.92	---	---	---
Ethylbenzene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**0.49** J	---	---	---	---	**5.9**	---	---	---	---	---	---	---	---	**1.5**	---	---	---
Freon 11	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**0.97**	---	---	---	---	**1.2**	---	---	---	---	---	---	---	---	**1**	---	---	---
Freon 113	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**0.78** J	---	---	---	---	**0.78** J	---	---	---	---	---	---	---	---	**0.78** J	---	---	---
Freon 114	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<1.1	---	---	---	---	<1.1	---	---	---	---	---	---	---	---	<1.1	---	---	---
Freon 12	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**2**	---	---	---	---	**2.1**	---	---	---	---	---	---	---	---	**2.6**	---	---	---
Heptane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.62	---	---	---	---	<0.62	---	---	---	---	---	---	---	---	**0.75**	---	---	---
Hexachloro-1,3-butadiene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<1.6	---	---	---	---	<1.6	---	---	---	---	---	---	---	---	<1.6	---	---	---
Hexane	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.54	---	---	---	---	**0.79**	---	---	---	---	---	---	---	---	<0.54	---	---	---
Isopropyl alcohol	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**1.6**	---	---	---	---	**2.8**	---	---	---	---	---	---	---	---	**3.5**	---	---	---
m&p-Xylene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**1** J	---	---	---	---	**10** J	---	---	---	---	---	---	---	---	**4.3**	---	---	---
Methyl Butyl Ketone	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<1.2	---	---	---	---	<1.2	---	---	---	---	---	---	---	---	<1.2	---	---	---
Methyl Ethyl Ketone	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**1.7**	---	---	---	---	**1.4**	---	---	---	---	---	---	---	---	**1.2**	---	---	---
Methyl Isobutyl Ketone	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<1.2	---	---	---	---	<1.2	---	---	---	---	---	---	---	---	<1.2	---	---	---
Methyl tert-butyl ether	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.55	---	---	---	---	<0.55	---	---	---	---	---	---	---	---	<0.55	---	---	---
Methylene chloride	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.53	---	---	---	---	**3.8**	---	---	---	---	---	---	---	---	**0.35** J	---	---	---
o-Xylene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.66	---	---	---	---	**8.5**	---	---	---	---	---	---	---	---	**1.5**	---	---	---
Propylene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.26	---	---	---	---	<0.26	---	---	---	---	---	---	---	---	<0.26	---	---	---
Styrene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.65	---	---	---	---	<0.65	---	---	---	---	---	---	---	---	**0.82**	---	---	---
Tetrachloroethylene (PCE)	810	µg/m³	**2660**	**20**	**>27000**	**180**	**51**	**>39000**	**940**	**61**	**505**	**830**	**620**	**550**	**1060**	**260**	**1500**	**160**	**610**	**2600**	**1100**	**11**	**6500**	**1300**	**26**	**1400**	**540**	**1940**	**2120**	**26**
Tetrahydrofuran	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.45	---	---	---	---	<0.45	---	---	---	---	---	---	---	---	<0.45	---	---	---
Toluene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	**1.5**	---	---	---	---	**2.5**	---	---	---	---	---	---	---	---	**5.9**	---	---	---
trans-1,2-Dichloroethene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.6	---	---	---	---	<0.6	---	---	---	---	---	---	---	---	<0.6	---	---	---
trans-1,3-Dichloropropene	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.69	---	---	---	---	<0.69	---	---	---	---	---	---	---	---	<0.69	---	---	---
Trichloroethene (TCE)	90	µg/m³	<15	<15	**620**	<15	<15	**1900**	<15	<15	<15	<15	**0.6** J	<15	<15	<15	<15	**3.4**	<15	<15	<15	<15	**460**	<15	<15	<15	**0.76** J	<15	<15	<15
Vinyl acetate	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.54	---	---	---	---	<0.54	---	---	---	---	---	---	---	---	<0.54	---	---	---
Vinyl Bromide	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.67	---	---	---	---	<0.67	---	---	---	---	---	---	---	---	<0.67	---	---	---
Vinyl chloride	---	µg/m³	---	---	---	---	---	---	---	---	---	---	<0.39	---	---	---	---	<0.39	---	---	---	---	---	---	---	---	<0.39	---	---	---

Notes:
1) WDEQ Soil Vapor Screening Level - PCE screening level was calculated based on the $1x10^{-5}$ target indoor air concentration risk level of 8.1 µg/m³ from the 2002 EPA OSWER Draft Vapor Intrusion Guidance (EPA, 2002), with an assumed attenuation factor of 0.01 from shallow soil gas to indoor air.
TCE screening level was calculated based on an estimated $1x10^{-5}$ target indoor air concentration risk level of 0.9 µg/m³ (thirteen times lower than the current EPA 10^{-5} risk level for TCE) with an assumed attenuation factor of 0.01 for shallow soil vapor to indoor air.
2) µg/m³ - Micrograms per cubic meter.
3) --- - Not available or not analyzed.
4) < - Not detected at the reporting limit (RL).
5) J - Estimate result. Result is less than RL.
6) **Bold** - Detected Result.
7) Yellow Highlight - Result exceeds the WDEQ Soil Vapor Screening Level.
8) Samples analyzed by Hartman Environmental Geoscience Mobile Lab via Method 8021.
9) Duplicate samples (except ESV-29 DUP) analyzed by Centek Laboratories via Method TO-15.

TABLE 1

Soil Vapor Analytical Results - November 2009

Casper PCE Plumes Orphan Site
Casper, WY

Analytical Parameter	WDEQ Soil Vapor Screening Level	Sample ID	ESV-26	ESV-26 DUP	ESV-27	ESV-28	ESV-29	ESV-29 DUP	ESV-30	ESV-31	ESV-32	ESV-33	ESV-34	ESV-34 DUP	ESV-35	ESV-36	ESV-37	ESV-37 DUP	ESV-38	ESV-39	ESV-39 DUP	ESV-40	ESV-40 DUP
		Sample Date	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/11/2009	11/12/2009	11/12/2009	11/12/2009	11/12/2009
		Units																					
1,1,1-Trichloroethane	---	ug/m^3	---	<0.83	---	---	---	---	---	---	---	---	---	<0.83	---	---	---	**0.61** J	---	---	<0.83	---	<0.83
1,1,2,2-Tetrachloroethane	---	ug/m^3	---	<1	---	---	---	---	---	---	---	---	---	<1	---	---	---	<1	---	---	<1	---	<1
1,1,2-Trichloroethane	---	ug/m^3	---	<0.83	---	---	---	---	---	---	---	---	---	<0.83	---	---	---	<0.83	---	---	<0.83	---	<0.83
1,1-Dichloroethane	---	ug/m^3	---	<0.62	---	---	---	---	---	---	---	---	---	<0.62	---	---	---	<0.62	---	---	<0.62	---	<0.62
1,1-Dichloroethene	---	ug/m^3	---	<0.6	---	---	---	---	---	---	---	---	---	<0.6	---	---	---	<0.6	---	---	<0.6	---	<0.6
1,2,4-Trichlorobenzene	---	ug/m^3	---	<1.1	---	---	---	---	---	---	---	---	---	<1.1	---	---	---	<1.1	---	---	<1.1	---	<1.1
1,2,4-Trimethylbenzene	---	ug/m^3	---	<0.75	---	---	---	---	---	---	---	---	---	**0.7** J	---	---	---	**0.6** J	---	---	<0.75	---	<0.75
1,2-Dibromoethane	---	ug/m^3	---	<1.2	---	---	---	---	---	---	---	---	---	<1.2	---	---	---	<1.2	---	---	<1.2	---	<1.2
1,2-Dichlorobenzene	---	ug/m^3	---	<0.92	---	---	---	---	---	---	---	---	---	<0.92	---	---	---	<0.92	---	---	<0.92	---	<0.92
1,2-Dichloroethane	---	ug/m^3	---	<0.62	---	---	---	---	---	---	---	---	---	<0.62	---	---	---	<0.62	---	---	<0.62	---	<0.62
1,2-Dichloropropane	---	ug/m^3	---	<0.7	---	---	---	---	---	---	---	---	---	<0.7	---	---	---	<0.7	---	---	<0.7	---	<0.7
1,3,5-Trimethylbenzene	---	ug/m^3	---	<0.75	---	---	---	---	---	---	---	---	---	<0.75	---	---	---	<0.75	---	---	<0.75	---	<0.75
1,3-butadiene	---	ug/m^3	---	<0.34	---	---	---	---	---	---	---	---	---	<0.34	---	---	---	<0.34	---	---	<0.34	---	<0.34
1,3-Dichlorobenzene	---	ug/m^3	---	<0.92	---	---	---	---	---	---	---	---	---	<0.92	---	---	---	<0.92	---	---	<0.92	---	<0.92
1,4-Dichlorobenzene	---	ug/m^3	---	<0.92	---	---	---	---	---	---	---	---	---	<0.92	---	---	---	<0.92	---	---	<0.92	---	<0.92
1,4-Dioxane	---	ug/m^3	---	<1.1	---	---	---	---	---	---	---	---	---	<1.1	---	---	---	<1.1	---	---	<1.1	---	<1.1
2,2,4-trimethylpentane	---	ug/m^3	---	<0.71	---	---	---	---	---	---	---	---	---	**9**	---	---	---	<0.71	---	---	<0.71	---	<0.71
4-ethyltoluene	---	ug/m^3	---	<0.75	---	---	---	---	---	---	---	---	---	<0.75	---	---	---	<0.75	---	---	<0.75	---	<0.75
Acetone	---	ug/m^3	---	**5.8** J	---	---	---	---	---	---	---	---	---	**12**	---	---	---	**5.2**	---	---	**5.1**	---	**7.2**
Allyl chloride	---	ug/m^3	---	<0.48	---	---	---	---	---	---	---	---	---	<0.48	---	---	---	<0.48	---	---	<0.48	---	<0.48
Benzene	---	ug/m^3	---	<0.49	---	---	---	---	---	---	---	---	---	**0.42** J	---	---	---	<0.49	---	---	<0.49	---	**0.36** J
Benzyl chloride	---	ug/m^3	---	<0.88	---	---	---	---	---	---	---	---	---	<0.88	---	---	---	<0.88	---	---	<0.88	---	<0.88
Bromodichloromethane	---	ug/m^3	---	<1	---	---	---	---	---	---	---	---	---	<1	---	---	---	<1	---	---	<1	---	<1
Bromoform	---	ug/m^3	---	<1.6	---	---	---	---	---	---	---	---	---	<1.6	---	---	---	<1.6	---	---	<1.6	---	<1.6
Bromomethane	---	ug/m^3	---	<0.59	---	---	---	---	---	---	---	---	---	<0.59	---	---	---	<0.59	---	---	<0.59	---	<0.59
Carbon disulfide	---	ug/m^3	---	<0.47	---	---	---	---	---	---	---	---	---	**0.44** J	---	---	---	<0.47	---	---	<0.47	---	<0.47
Carbon tetrachloride	---	ug/m^3	---	<0.96	---	---	---	---	---	---	---	---	---	<0.96	---	---	---	<0.96	---	---	<0.96	---	<0.96
Chlorobenzene	---	ug/m^3	---	<0.7	---	---	---	---	---	---	---	---	---	<0.7	---	---	---	<0.7	---	---	<0.7	---	<0.7
Chloroethane	---	ug/m^3	---	<0.4	---	---	---	---	---	---	---	---	---	<0.4	---	---	---	<0.4	---	---	<0.4	---	<0.4
Chloroform	---	ug/m^3	---	**0.84**	---	---	---	---	---	---	---	---	---	**0.69** J	---	---	---	<0.74	---	---	<0.74	---	<0.74
Chloromethane	---	ug/m^3	---	**0.38**	---	---	---	---	---	---	---	---	---	<0.31	---	---	---	<0.31	---	---	<0.31	---	<0.31
cis-1,2-Dichloroethene	---	ug/m^3	---	<0.6	---	---	---	---	---	---	---	---	---	<0.6	---	---	---	<0.6	---	---	<0.6	---	<0.6
cis-1,3-Dichloropropene	---	ug/m^3	---	<0.69	---	---	---	---	---	---	---	---	---	<0.69	---	---	---	<0.69	---	---	<0.69	---	<0.69
Cyclohexane	---	ug/m^3	---	**3.5**	---	---	---	---	---	---	---	---	---	**24**	---	---	---	**7**	---	---	**10**	---	**7.3**
Dibromochloromethane	---	ug/m^3	---	<1.3	---	---	---	---	---	---	---	---	---	<1.3	---	---	---	<1.3	---	---	<1.3	---	<1.3
Ethyl acetate	---	ug/m^3	---	<0.92	---	---	---	---	---	---	---	---	---	<0.92	---	---	---	<0.92	---	---	<0.92	---	<0.92
Ethylbenzene	---	ug/m^3	---	<0.66	---	---	---	---	---	---	---	---	---	**0.79**	---	---	---	<0.66	---	---	<0.66	---	**0.57** J
Freon 11	---	ug/m^3	---	**0.97**	---	---	---	---	---	---	---	---	---	**1.5**	---	---	---	**2.2**	---	---	**0.91**	---	**1.1**
Freon 113	---	ug/m^3	---	**0.86** J	---	---	---	---	---	---	---	---	---	<1.2	---	---	---	<1.2	---	---	<1.2	---	**0.86** J
Freon 114	---	ug/m^3	---	<1.1	---	---	---	---	---	---	---	---	---	<1.1	---	---	---	<1.1	---	---	<1.1	---	<1.1
Freon 12	---	ug/m^3	---	**2.2**	---	---	---	---	---	---	---	---	---	**2**	---	---	---	**2.5**	---	---	**2**	---	**2.2**
Heptane	---	ug/m^3	---	<0.62	---	---	---	---	---	---	---	---	---	<0.62	---	---	---	<0.62	---	---	<0.62	---	<0.62
Hexachloro-1,3-butadiene	---	ug/m^3	---	<1.6	---	---	---	---	---	---	---	---	---	<1.6	---	---	---	<1.6	---	---	<1.6	---	<1.6
Hexane	---	ug/m^3	---	<0.54	---	---	---	---	---	---	---	---	---	<0.54	---	---	---	<0.54	---	---	<0.54	---	<0.54
Isopropyl alcohol	---	ug/m^3	---	<0.37	---	---	---	---	---	---	---	---	---	<0.37	---	---	---	**1.7**	---	---	**1.4**	---	**1.1**
m&p-Xylene	---	ug/m^3	---	<1.3	---	---	---	---	---	---	---	---	---	**1.8**	---	---	---	<1.3	---	---	<1.3	---	**1.4**
Methyl Butyl Ketone	---	ug/m^3	---	<1.2	---	---	---	---	---	---	---	---	---	<1.2	---	---	---	<1.2	---	---	<1.2	---	<1.2
Methyl Ethyl Ketone	---	ug/m^3	---	**1.1**	---	---	---	---	---	---	---	---	---	**2.9**	---	---	---	**2.4**	---	---	**1.5**	---	**1.4**
Methyl Isobutyl Ketone	---	ug/m^3	---	<1.2	---	---	---	---	---	---	---	---	---	<1.2	---	---	---	<1.2	---	---	<1.2	---	<1.2
Methyl tert-butyl ether	---	ug/m^3	---	<0.55	---	---	---	---	---	---	---	---	---	<0.55	---	---	---	<0.55	---	---	<0.55	---	<0.55
Methylene chloride	---	ug/m^3	---	<0.53	---	---	---	---	---	---	---	---	---	<0.53	---	---	---	<0.53	---	---	<0.53	---	<0.53
o-Xylene	---	ug/m^3	---	<0.66	---	---	---	---	---	---	---	---	---	**0.62** J	---	---	---	<0.66	---	---	<0.66	---	**0.49** J
Propylene	---	ug/m^3	---	<0.26	---	---	---	---	---	---	---	---	---	<0.26	---	---	---	<0.26	---	---	<0.26	---	<0.26
Styrene	---	ug/m^3	---	<0.65	---	---	---	---	---	---	---	---	---	**0.48** J	---	---	---	<0.65	---	---	<0.65	---	<0.65
Tetrachloroethylene (PCE)	810	ug/m^3	**21**	**8.1**	**1030**	**60**	**15**	**16**	**27**	**40**	**8**	**75**	<7	<1	**63**	**450**	**660**	**710**	**36**	**294**	**210**	**4970**	**2000**
Tetrahydrofuran	---	ug/m^3	---	<0.45	---	---	---	---	---	---	---	---	---	<0.45	---	---	---	<0.45	---	---	<0.45	---	<0.45
Toluene	---	ug/m^3	---	**0.65**	---	---	---	---	---	---	---	---	---	**2.8**	---	---	---	**1.2**	---	---	**0.92**	---	**1.1**
trans-1,2-Dichloroethene	---	ug/m^3	---	<0.6	---	---	---	---	---	---	---	---	---	<0.6	---	---	---	<0.6	---	---	<0.6	---	<0.6
trans-1,3-Dichloropropene	---	ug/m^3	---	<0.69	---	---	---	---	---	---	---	---	---	<0.69	---	---	---	<0.69	---	---	<0.69	---	<0.69
Trichloroethene (TCE)	90	ug/m^3	<15	**2.1**	<15	<15	<15	<15	<15	<15	<15	<15	<15	<0.82	<15	<15	<15	<0.82	<15	<15	<0.82	<15	**1.9**
Vinyl acetate	---	ug/m^3	---	<0.54	---	---	---	---	---	---	---	---	---	<0.54	---	---	---	<0.54	---	---	<0.54	---	<0.54
Vinyl Bromide	---	ug/m^3	---	<0.67	---	---	---	---	---	---	---	---	---	<0.67	---	---	---	<0.67	---	---	<0.67	---	<0.67
Vinyl chloride	---	ug/m^3	---	<0.39	---	---	---	---	---	---	---	---	---	<0.39	---	---	---	<0.39	---	---	<0.39	---	<0.39

Notes:
1) WDEQ Soil Vapor Screening Level - PCE screening level was calculated based on the $1x10^{-5}$ target indoor air concentration risk level of 8.1 µg/m^3 from the 2002 EPA OSWER Draft Vapor Intrusion Guidance (EPA, 2002), with an assumed attenuation factor of 0.01 from shallow soil gas to indoor air.
TCE screening level was calculated based on an estimated $1x10^{-5}$ target indoor air concentration risk level of 0.9 µg/m^3 (thirteen times lower than the current EPA 10^{-5} risk level for TCE) with an assumed attenuation factor of 0.01 for shallow soil vapor to indoor air.
2) µg/m^3 - Micrograms per cubic meter.
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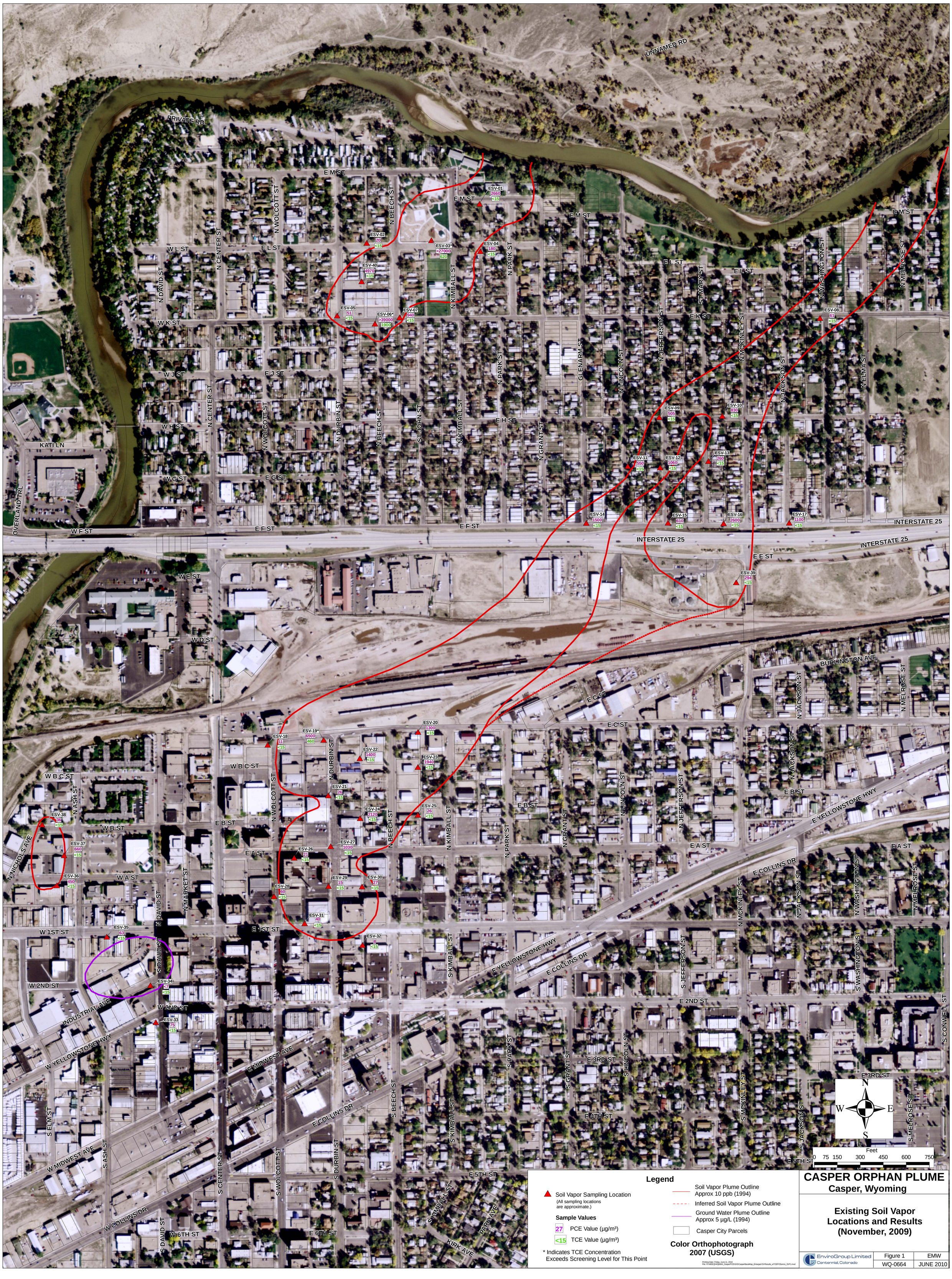
6) **Bold** - Detected Result.
7) Yellow Highlight - Result exceeds the WDEQ Soil Vapor Screening Level.
8) Samples analyzed by Hartman Environmental Geoscience Mobile Lab via Method 8021.
9) Duplicate samples (except ESV-29 DUP) analyzed by Centek Laboratories via Method TO-15.

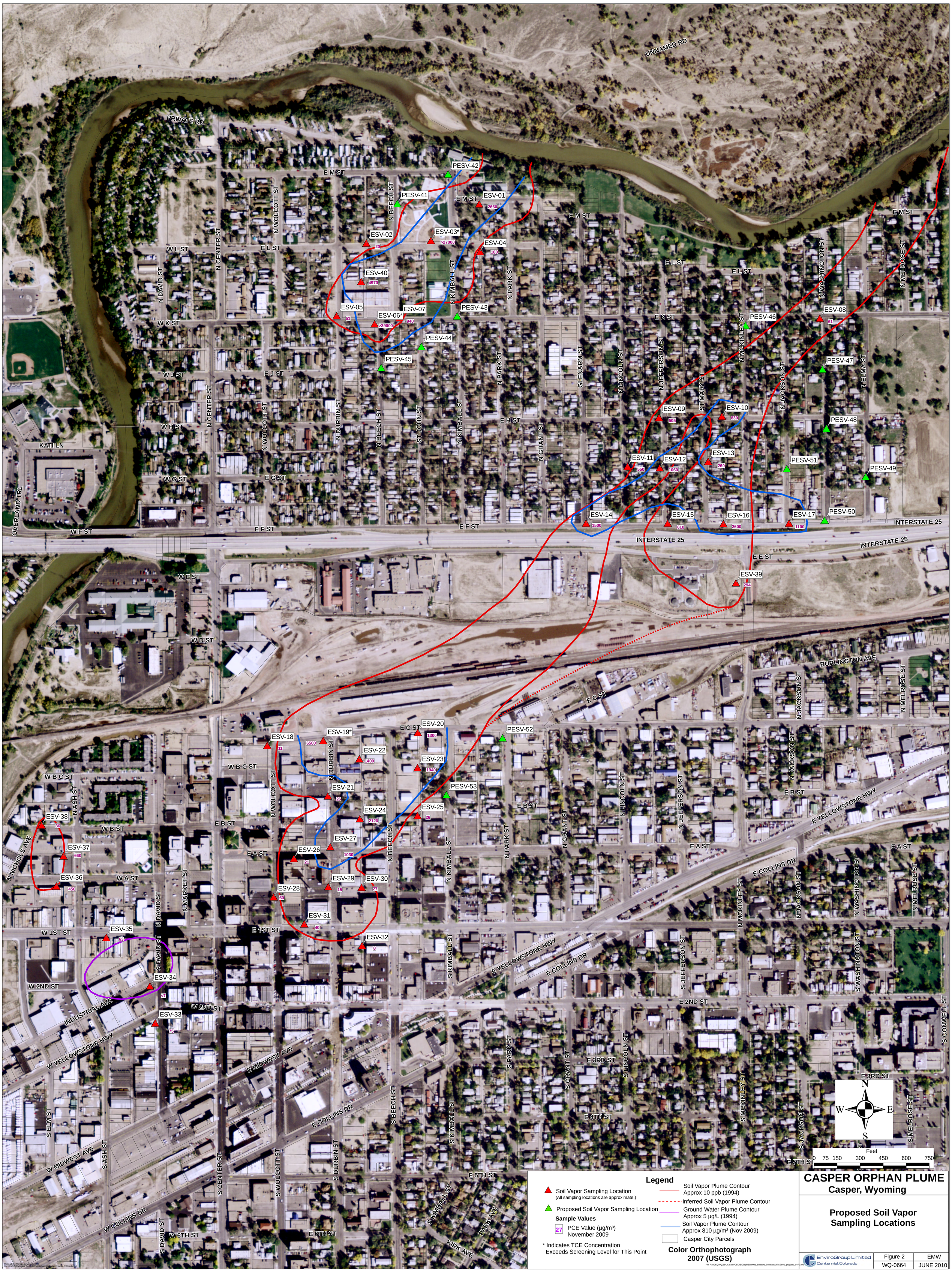


CASPER ORPHAN PLUME
Casper, Wyoming

Existing Soil Vapor Locations and Results (November, 2009)

EnviroGroup Limited
Centennial, Colorado

Figure 1	EMW
WQ-0664	JUNE 2010



Legend

- Soil Vapor Sampling Location (All sampling locations are approximate.)
- Proposed Soil Vapor Sampling Location
- **Sample Values**
  - 27 PCE Value (µg/m³) November 2009
- * Indicates TCE Concentration Exceeds Screening Level for This Point
- Soil Vapor Plume Contour Approx 10 ppb (1994)
- Inferred Soil Vapor Plume Contour
- Ground Water Plume Contour Approx 5 µg/L (1994)
- Soil Vapor Plume Contour Approx 810 µg/m³ (Nov 2009)
- Casper City Parcels

Color Orthophotograph 2007 (USGS)

File: R:\WDE\WQ0664_Casper\PCE\GIS\CasperBaseMap_Enlarged_SVResults_wTCEanno_proposed_SVP.mxd

CASPER ORPHAN PLUME
Casper, Wyoming

Proposed Soil Vapor Sampling Locations

EnviroGroup Limited
Centennial, Colorado

Figure 2	EMW
WQ-0664	JUNE 2010