SITE INVESTIGATION REPORT

Casper PCE Plumes Orphan Site

Casper, Wyoming

Prepared by:

EnviroGroup Limited
Centennial, Colorado

Prepared for:

Wyoming Department of Environmental Quality
Cheyenne, Wyoming

May 11, 2012

Project No. WQ-0664

EnviroGroup Limited
The environmental solutions company

SITE INVESTIGATION REPORT

Casper PCE Plumes Orphan Site

Casper, Wyoming

Prepared by:

EnviroGroup Limited
Centennial, Colorado

Prepared for:

Wyoming Department of Environmental Quality
Cheyenne, Wyoming

May 11, 2012

Project No. WQ-0664

M. Litasi Prepared by	5/11/12 Date
P.G. Reviewed by	5/11/12 Date
Approved by	5/11/12 Date

TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 SITE HISTORY 1
1.1.1 North Casper PCE Investigation 1
1.1.2 Downtown Casper PCE Investigation 3
1.1.3 Petitioned Health Consultation, North Casper PCE Plume 4
1.2 GEOLOGIC AND HYDROGEOLOGIC CONDITIONS 5
1.3 ORPHAN PCE PLUME INVESTIGATION PURPOSE AND SCOPE 5
1.4 REPORT ORGANIZATION 7

2 INVESTIGATION LOCATIONS 8

2.1 GROUNDWATER SAMPLING LOCATIONS 8
2.2 SURFACE WATER SAMPLING LOCATIONS 9
2.3 SOIL VAPOR SAMPLING LOCATIONS 9

3 INVESTIGATION PROCEDURES 10

3.1 GROUNDWATER INVESTIGATION 10
3.1.1 Measurements at Existing Wells 10
3.1.2 Monitoring Well Installation 10
3.1.3 Well Development and Groundwater Sampling 13
3.1.4 Grab Groundwater Sample collection 16
3.1.5 Water Table Elevations and Survey 16
3.2 SURFACE WATER INVESTIGATION 17
3.3 SOIL VAPOR INVESTIGATION 18
3.3.1 Soil Vapor Probe Installation 18
3.3.2 Leak Testing 19
3.3.3 Soil Vapor Probe Sampling and Analysis 20
3.4 ECOLOGICAL RISK ASSESSMENT 22
3.5 DECONTAMINATION AND MANAGEMENT OF INVESTIGATIVE DERIVED WASTES 22

4 INVESTIGATION RESULTS 24

4.1 SOIL ANALYTICAL RESULTS 24
4.2 GROUNDWATER INVESTIGATION RESULTS 25
4.2.1 Groundwater Elevations and Flow 25
4.2.2 Groundwater Analytical Results 25
4.3 SURFACE WATER INVESTIGATION RESULTS 26

4.4 SOIL VAPOR INVESTIGATION RESULTS 27
4.4.1 Mobile Laboratory 27
4.4.2 Fixed-Base Laboratory 27
4.4.3 Soil Vapor Sampling Ambient Air Results 28
4.5 DATA VALIDATION 28
4.5.1 Soil Sample QA/QC 28
4.5.2 Groundwater Sample QA/QC 28
4.5.3 Surface Water Sample QA/QC 30
4.5.4 Soil Vapor Sample QA/QC 30
4.6 ECOLOGICAL RISK ASSESSMENT RESULTS 31

5 DATA EVALUATION 32

5.1 DOWNTOWN CASPER AREA 32
5.1.1 Plume #1 32
5.1.2 Plume #2 33
5.1.3 Plume #3 33
5.2 NORTH CASPER AREA 33
5.2.1 North Casper Plume 34
5.2.2 Plume #1 34
5.2.3 Surface Water Evaluation 35
5.3 VAPOR INTRUSION EVALUATION 36

6 CONCLUSIONS 38

6.1 NATURE AND EXTENT OF CONTAMINATION 38
6.1.1 Groundwater 38
6.1.2 Soil Vapor 38
6.2 VAPOR INTRUSION IMPACTS 39

7 RECOMMENDATIONS 40

7.1 AREAS LIKELY TO REQUIRE GROUNDWATER REMEDIAL MEASURES 40
7.2 ECOLOGICAL RISK ASSESSMENT 41

8 STUDY LIMITATIONS 42

9 REFERENCES 43

LIST OF TABLES

Table 1 Borehole Headspace Monitoring
Table 2 Well Completion and Water Level Summary
Table 3 Groundwater Field Water Quality Parameters
Table 4 Surface Water Field Water Quality Parameters
Table 5 Soil Laboratory Analytical Results
Table 6 Groundwater Laboratory Analytical Results
Table 7 Groundwater Laboratory Analytical Results - Grab Samples
Table 8 Surface Water Laboratory Analytical Results
Table 9 Soil Vapor Laboratory Analytical Results

LIST OF FIGURES

Figure 1 Site Location and Previous Investigation PCE Plume Extents
Figure 2A Groundwater Elevation with PCE and TCE Results
Figure 2B Grab Groundwater PCE Results
Figure 3 Soil Vapor PCE and TCE Results
Figure 4 Downtown Casper Plume #1 Groundwater, Surface Water, and Soil Vapor PCE Results
Figure 5 North Casper Plume Groundwater, Surface Water, and Soil Vapor PCE Results
Figure 6 North Casper Plume #1 Groundwater, Surface Water, and Soil Vapor PCE Results

LIST OF APPENDICES

Appendix A Borehole Logs and Well Construction Forms

Appendix B Groundwater Field Water Quality Sampling and Analysis Forms

Appendix C Surface water Field Water Quality Sampling and Analysis Forms

Appendix D Soil Vapor Sampling Logs

Appendix E Ecological Risk Assessment – Ecological Exclusion Assessment

Appendix F Soil Laboratory Results (TestAmerica)

Appendix G Groundwater Laboratory Results (TestAmerica & PACE)

Appendix H Grab Groundwater Laboratory Results (ChemSolutions)

Appendix I Surface Water Laboratory Results (TestAmerica & PACE)

Appendix J Soil Vapor Laboratory Results (Hartman Geosciences Mobile Laboratory, Centek Laboratories, and AirToxics)

1 INTRODUCTION

This report, prepared by EnviroGroup Limited (EnviroGroup) for the Wyoming Department of Environmental Quality (DEQ), presents the results of environmental investigations conducted by EnviroGroup at the Casper Tetrachloroethene (PCE) Plumes Orphan Site (the "Site") from August 2009 to February 2012. The Site is located in the north and downtown areas of Casper, Wyoming, as shown on Figure 1. The following sections present the site history, geologic and hydrogeologic conditions at the site, the purpose and scope of the investigation, and the report organization.

1.1 SITE HISTORY

The current investigation plan was developed based on the results of prior investigations conducted by others between 1994 and 1999, including a North Casper PCE Investigation and Downtown Casper PCE Investigation conducted by Huntingdon Engineering and Environmental, Inc. (Huntingdon, 1994) for DEQ (including summaries of previous investigations conducted by other parties) and a Petitioned Health Consultation, North Casper PCE Plume conducted by the U.S. Department of Health and Human Services (U.S. Department of Health and Human Services, 1999). Results of the previous investigations are summarized in the following sections.

1.1.1 North Casper PCE Investigation

In May and June 1994, Huntingdon conducted an investigation in the North Casper area to evaluate the extent of PCE and related volatile organic compounds (VOCs) in the soil vapor and shallow groundwater. The investigation area was bounded on the east by North Melrose Street, on the west by North Center Street, on the south by Interstate 25, and on the north by the North Platte River. The results of the soil vapor and groundwater investigation are summarized below.

1.1.1.1 Soil Vapor

Soil vapor samples were collected at 97 locations, in conjunction with the groundwater sampling, from approximately nine feet below ground surface (bgs) and analyzed in the field for PCE, trichloroethene (TCE), and 1,1,1-trichloroethane (1,1,1-TCA) using a Photovac 10S70 portable gas chromatograph. PCE and TCE concentrations in the soil vapor samples ranged from <1 part per billion (ppb) to 500,000 ppb and from <1 ppb to

20,320 ppb, respectively. 1,1,1-TCA was not detected above 5 ppb at any sample location. Results of the investigation indicated the presence of two soil vapor plumes which have similar extents to groundwater Plume #1 and the North Casper Plume. Both groundwater plumes are described in the following section.

1.1.1.2 Groundwater

In the investigation area, shallow groundwater was encountered in alluvial materials between approximately eight and 12 feet bgs. Groundwater flow was generally to the north or northeast and consistent with previous investigations, as summarized in Section 2.0 of this report. Groundwater samples were collected from 34 monitoring wells and 17 private wells and were analyzed at Huntingdon's Laboratories in Billings, Montana; St. Louis, Missouri; or at the DEQ Laboratory in Cheyenne, Wyoming for VOCs using Environmental Protection Agency (EPA) Methods 524.2 or 502.2. Additionally, 99 groundwater samples were collected from borehole locations (generally paired with soil vapor samples) and analyzed in the field using a Photovac 10S70 portable gas chromatograph. Laboratory analytical results at some locations indicated the presence of PCE and TCE above the EPA Maximum Contaminant Level (MCL) of 5 micrograms per liter (µg/L). Results of this investigation indicated the presence of two PCE groundwater plumes in North Casper, one of which (Plume #1) appeared to originate from downtown Casper, as described below.

<u>Plume #1</u>

The North Casper extension of Plume #1 appears to consist of two lobes, one aligned with Plume #1A and one aligned with Plume #1B, as shown on Figure 1. The two lobes appear to coalesce into a single narrow plume by East H Street and extend, at relatively low concentrations, in a northeast direction toward the North Platte River. Concentrations of PCE in groundwater appear relatively consistent from downtown to North Casper; however, the PCE concentrations in soil vapor are significantly lower north of I-25.

<u>North Casper Plume</u>

Based on PCE groundwater and soil vapor concentrations reported by Huntingdon, the North Casper Plume appears to originate from a vacant property on the southwest corner of East K Street and North Beech Street. The plume has migrated north under a

community center building and trailer park, then extends in a northeasterly direction toward the North Platte River.

Approximate groundwater PCE plume boundaries are shown on Figure 1.

1.1.2 Downtown Casper PCE Investigation

In September and October 1994, Huntingdon conducted an investigation in Downtown Casper to describe the extent and degree of VOCs including PCE, TCE, and 1,1,1-TCA in shallow groundwater. The investigation area was bounded on the east by McKinley Street, on the west by Poplar Street and the North Platte River, on the south by Collins Drive and East Yellowstone Highway, and on the north by Interstate 25. The results of the soil vapor and groundwater investigation are summarized below.

1.1.2.1 Soil Vapor

Soil vapor samples were collected at 79 locations, in conjunction with groundwater samples, from approximately nine feet bgs and analyzed in the field using a Photovac 10S70 portable gas chromatograph. PCE and TCE concentrations in soil vapor samples ranged from <1 ppb to 425,630 ppb and <1 ppb to 38,080 ppb, respectively. 1,1,1-TCA was not detected above 5 ppb at any sample location. Results of the investigation indicated the presence of two soil vapor plumes which have similar outlines to groundwater Plumes #1 and #2. Both groundwater plumes are described in the following section.

1.1.2.2 Groundwater

In the investigation area, shallow groundwater was encountered in alluvial materials between approximately six and 24 feet bgs. Groundwater flow was generally to the north or northeast and consistent with previous investigations, as summarized in Section 2.0 of this report. Groundwater samples were collected from 67 locations and analyzed in the field using a Photovac 10S70 portable gas chromatograph with duplicate samples from each location analyzed at the DEQ Laboratory in Cheyenne, Wyoming for VOCs using EPA Method 502.2. Laboratory analytical results at some locations indicate the presence of PCE and TCE above the EPA MCL of 5µg/L. Results of this investigation indicated the presence of four PCE groundwater plumes in downtown Casper; one of which (Plume #1) appeared to extend into North Casper, as described below.

Plume #1

Plume #1 was the largest PCE plume identified by Huntingdon, appearing to originate from two potential sources (Plume #1A and Plume #1B) along North Durbin Street, between East 1st and East C Streets. Both groundwater and soil vapor data indicate a similar plume outline, extending northeast toward the Burlington Northern railroad property and continuing north of Interstate 25 into North Casper.

Plume #2

Plume #2 is a relatively small PCE plume that appears to originate near West A Street between North Ash Street and Nichols Avenue, extending north to West B Street. Groundwater flow in this area appears to be northwest toward the North Platte River.

Plume #3

Huntingdon defined "Plume #3" from one elevated PCE (145 µg/L) sample near Industrial Avenue and North David Street. VOCs were not detected in the soil gas samples collected in this area; however, both groundwater and soil vapor data indicate the presence of petroleum hydrocarbons in the vicinity, likely due to a source located approximately one block to the west. Groundwater flows in a northwest direction toward the North Platte River in this area.

Plume #4

Plume #4 is located along South Walnut Street, north of West Yellowstone Highway (not shown on Figure 1), based on two detections of PCE of approximately 23 µg/L. Groundwater in this area flows in a northerly direction, converging with the North Platte River near West 1st Street. Plume #4 does not appear to be related to any of the other PCE plumes described above, based on the northern groundwater flow direction and is not included in this investigation.

Approximate groundwater PCE plume boundaries are shown on Figure 1.

1.1.3 Petitioned Health Consultation, North Casper PCE Plume

The United States Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR) in Atlanta, Georgia, completed a Petitioned Health Consultation for the North Casper PCE Plume on August 26, 1999.

The report summarized previous investigations by consultants including Huntingdon (for DEQ in 1994) in the North Casper area and the EPA indoor air sampling conducted in 1992 at the request of ATSDR. In 1993, an additional petitioned health consultation prompted the DEQ to conduct indoor air sampling in 1994 and 1995 in residences located above the PCE plumes. Results of indoor air testing in homes within the plume boundaries indicated the presence of PCE at concentrations ranging from 3 ppb to 74 ppb. In 1995, ATSDR concluded that PCE levels in some residences may present a public health threat; however, most samples were collected in non-living spaces (e.g., closets) and may not be representative of long-term exposure risks. Periodic air monitoring for PCE was required and additional indoor air samples were collected between 1996 and 1998. ATSDR evaluated the data and concluded that levels of PCE detected in homes were unlikely to cause carcinogenic health effects and that no public health threat was likely. In 1999, ATSDR classified the North Casper PCE Plume Site as "No Apparent Public Health Hazard".

1.2 GEOLOGIC AND HYDROGEOLOGIC CONDITIONS

The land surface at the Site is relatively flat, sloping about two to three feet from southwest to northeast toward the North Platte River. The North Platte alluvial aquifer in the Site area is composed of 30 to 40 feet of unconsolidated braided alluvial deposits (sand and gravel), silts, and clays deposited by the North Platte River atop the late Cretaceous Cody Shale formation. Huntingdon (1994) reported groundwater at depths of approximately eight to 12 feet bgs in the North Casper area and six to 24 feet bgs in the Downtown Casper area. Shallow groundwater generally flows to the north and northeast across the Site, as shown on Figure 2A.

1.3 ORPHAN PCE PLUME INVESTIGATION PURPOSE AND SCOPE

Under the Orphan Site Remediation Program, in the fall of 2009, DEQ contracted with EnviroGroup to:

- evaluate the nature and extent of PCE and TCE in groundwater and soil vapor in four of the five plume areas previously identified by Huntingdon;
- evaluate the potential for vapor intrusion (VI) at the Site due to the presence of chlorinated solvents in the subsurface; and

- evaluate whether VI controls were warranted for Site buildings based on the 2009 DEQ Soil Vapor Screening Levels.

The initial investigation scope of work, described in the Sampling and Analysis Plan (SAP) dated July 24, 2009 and revised September 22, 2009, was approved by the DEQ on September 28, 2009. The first phase of the investigation was implemented between October 2009 and December 2009. Based on the results of the first phase of the investigation, the DEQ identified an area where soil vapor PCE concentrations were above 810 micrograms per cubic meter ($\mu g/m^3$). This area was considered to represent the "worst case" for the potential for VI and the DEQ selected residential and commercial structures for indoor air testing in and around this area to evaluate the extent of VI impacts, if any. Due to the presence of elevated PCE concentrations in soil vapor in a larger area than originally anticipated, a Task Order Amendment was approved by DEQ on March 8, 2010, to increase the number of residences eligible for indoor air testing and VI mitigation.

Additionally, to evaluate soil vapor and groundwater VOC concentrations near locations with elevated results and further delineate the boundaries of the North Casper Plume and Plume #1, as identified during Phase 1 of the investigation, a second investigation phase, was approved by the DEQ on July 9, 2010 and implemented between July 2010 and August 2010. Based on groundwater results from this phase, in October 2010, the DEQ requested the collection of surface water samples from the North Platte River near the discharge area of Plume #1.

To further define the plume boundaries of the North Casper Plume and Plume #1 and to fill potential data gaps, a third phase of the on-going soil vapor and groundwater investigation was approved by the DEQ under Task Order Amendments on November 8, 2010 and December 6, 2010, and implemented in December 2010. The second and third phases of the investigation resulted in an expansion of the indoor air testing area to include 41 additional residences in the spring of 2011 (i.e., the Expanded Testing Area) and indicated the need to further evaluate the nature and extent of PCE in groundwater in the North Casper area.

To further define the northeast plume boundary of Plume #1 and collect groundwater data near the North Platte River, a small follow-up groundwater investigation (i.e., Phase 4), was approved by DEQ on August 9, 2011 and conducted in the North Casper portion of Plume #1 in September 2011. Due to elevated PCE concentrations in wells near the

North Platte River, DEQ requested an additional groundwater investigation of Plume #1, in the North Casper Athletic Complex, to evaluate the presence of VOC pathways near the North Platte River.

The fifth phase was implemented in February 2012 under a Supplemental Sampling and Analysis Plan (EnviroGroup, 2012) and Task Order Amendment approved on February 6, 2012 and included the collection of 49 grab groundwater samples and installation of three monitoring wells.

1.4 REPORT ORGANIZATION

The Site investigation included the sampling of soil, groundwater, surface water, soil vapor, sub-slab vapor, indoor air, and ambient air and the mitigation of buildings impacted by VI. This report includes a discussion and evaluation of the soil, groundwater, surface water, and soil vapor investigation activities including results. The remaining sampling and mitigation activities are discussed in the Vapor Intrusion Evaluation Report (EnviroGroup, 2012).

The following sections of this report discuss investigation locations (Section 2); investigation procedures (Section 3); investigation results including data validation (Section 4); an evaluation of the results (Section 5); conclusions (Section 6); study limitations (Section 7); and references (Section 8.)

2 INVESTIGATION LOCATIONS

The orphan PCE plumes evaluation included:

- installation and sampling of 36 permanent (33 shallow and 3 deep) and 44 temporary groundwater monitoring wells;
- sampling of eight existing monitoring wells and one private water well;
- measurement of water levels in the 33 of the 36 new permanent wells (deep wells were not measured) and in five of eight existing monitoring wells;
- collection of seven surface water samples;
- installation and sampling of 78 shallow soil vapor probes, and
- collection of six ambient (i.e., outdoor) air samples contemporaneous with soil vapor sample collection.

The locations of groundwater, surface water, and soil vapor samples collected during this evaluation are shown on Figures 2A, 2B, and 3. The rationale for the selection of sampling locations is described below.

2.1 GROUNDWATER SAMPLING LOCATIONS

Groundwater sampling locations were selected to further characterize the nature and extent of constituents of interest (COIs) in groundwater, including potential identification of source areas. The COIs are all VOCs (i.e., PCE, TCE and breakdown products) that will tend to partition into the soil vapor phase when present in soil above the water table or dissolved in shallow groundwater (EPA, 2002). Sample locations were selected to evaluate:

- the potential source of Plumes #2 and #3 in the downtown Casper area;
- the potential source near the former dry cleaner at 328/330 North Durbin Street (Plume #1A, Downtown Casper);
- the potential source near East 1st Street between North Wolcott and North Beech Streets (Plume #2B, Downtown Casper);

- groundwater concentrations of VOCs in Plume #1 at the Burlington Railroad Property south of Interstate 25.
- additional potential sources of VOCs contributing to Plumes #1A and #1B north of Interstate 25;
- the vertical extent of VOCs in the potential source areas of Plume #1 in Downtown Casper and north of Interstate 25;
- the potential source near East K Street between North Durbin and North Beech Streets (North Casper Plume);
- potential VOC pathways in the groundwater near the North Platte River; and
- boundaries of the groundwater PCE plumes.

2.2 SURFACE WATER SAMPLING LOCATIONS

Surface water sampling locations were selected to evaluate the impact of PCE in groundwater discharging from the North Casper Plume and North Casper portion of Plume #1 into the North Platte River. Locations were selected based on historic groundwater PCE plume boundaries (Huntingdon, 1994) and groundwater results from new and existing monitoring wells. Sample locations were selected upstream, downstream, and in the estimated discharge zones along the south bank of the North Platte River.

2.3 SOIL VAPOR SAMPLING LOCATIONS

Soil vapor sampling locations were selected to evaluate the nature and extent of dissolved VOC plumes and identify potential source areas. COI concentrations in soil vapor (particularly the spatial distribution and pattern) can indicate source areas in the vadose zone and, more generally, the path of a dissolved plume[1]. Initial locations were selected in the areas of the Site where PCE was identified by Huntingdon (1994) in soil vapor and groundwater. Later phases of the soil vapor investigation expanded the initial testing area to include the North Casper portion of Plume #1 and additional locations were selected to delineate the boundaries of the soil vapor plumes.

[1] Vadose zone soil conditions can independently affect and complicate the spatial pattern of soil vapors above a dissolved plume.

3 INVESTIGATION PROCEDURES

This section of the report summarizes the groundwater, surface water, and soil vapor sampling procedures followed during the sampling program; detailed field procedures are described in the SAP (EnviroGroup, 2009). Field and laboratory procedures were consistent with the procedures recommended in DEQ VRP Fact Sheets and Chapter 11, Part G – Well Construction and Abandonment (WDEQ, 1984).

DEQ selected two principal compounds of concern (COCs), PCE and TCE, as the target analytes for groundwater, surface water, and soil vapor analyses since they are the dominant VOCs historically detected in groundwater and soil vapor samples in the downtown and North Casper areas (Huntingdon, 1994). However, the full list of VOCs was analyzed in all groundwater and surface water samples and selected soil vapor samples in order to evaluate the degradation of PCE and the presence of other potential contaminants in groundwater.

3.1 GROUNDWATER INVESTIGATION

Procedures followed during the groundwater investigation, including monitoring well installation, well development and groundwater sampling, grab groundwater sample collection, and water table elevations including an elevation survey are described below.

3.1.1 Measurements at Existing Wells

Groundwater levels were measured and samples collected at five existing monitoring wells (HC-3, HC-11, HC-12, CG-1, and CG-4A) during the initial site visit on October 9, 2009. One private well (Rizor #1 – used for irrigation) at 925 North Washington Street was sampled on October 8, 2009. Three additional existing wells (MW-2, MW-7A, and MW-1054-2) were sampled on December 1, 2009 with newly installed wells EMW-01 through EMW-07 (discussed in section 3.1.2). Well completion details for existing wells were not available.

3.1.2 Monitoring Well Installation

Prior to drilling activities, EnviroGroup contacted One Call of Wyoming to locate underground utilities at each proposed borehole location. On November 11, 2009 and November 12, 2009, 10 boreholes were advanced by Site Services, Inc., of Golden, Colorado, under the oversight of EnviroGroup personnel, to an approximate depth of 15

to 41 feet bgs using a direct-push rig (i.e., Geoprobe®) for the purpose of soil sample collection and monitor well installation. These wells were located within previously identified plume boundaries of Plumes #1, #2, and #3 (Huntingdon, 1994). Site Services, Inc. advanced boreholes and installed an additional seven shallow (i.e., 10 to 27 feet bgs) wells on July 27 and July 28, 2010 in and around the North Casper Plume and Plume #1 to evaluate groundwater in up-gradient wells and establish plume boundaries. Between December 7, 2010 and December 9, 2010, during the third phase of the groundwater investigation, Site Services, Inc. advanced boreholes and installed thirteen shallow (i.e., 13 to 24 feet bgs) wells. Wells were installed to further define the plume boundaries of the North Casper Plume and Plume #1 and fill existing data gaps.

Soil cores were collected using an acetate sleeve from each borehole from ground surface to the total depth of each borehole and soil lithologies were continuously logged by an experienced EnviroGroup geologist. A miniRAE 2000 organic vapor analyzer (photo-ionization detector (PID)) was used as a field screening tool to measure organic vapor concentrations within each five foot interval at each borehole in December 2009 and July 2010. Each one foot interval of recovered core was split immediately after removing the sleeve and a PID reading was taken at one location immediately above the freshly split surface. If staining was noted, additional PID readings were taken at these locations.

Soil samples were collected on November 12, 2009 from soil cuttings from select boreholes (EMW-04D and EMW-05) with a freshly gloved hand based on visual observation and elevated PID measurements, and are summarized on Table 1. The soil samples ((EMW-04D (15.5-16.0’), EMW-04D (24.0-25.0’), EMW-05 (6.5-7.5’), and EMW-05 (7.5-8.4’)) were packed tightly (to minimize head space) into clean 4 ounce glass jars with Teflon lids (laboratory-supplied), labeled, logged onto chain of custody documents, and stored on ice for submittal to TestAmerica-Denver for VOC analysis using USEPA Method 8260B. The remaining soil core and any samples collected but not submitted to the laboratory were placed into 55 gallon drums and placed at the Casper DEQ building, pending analytical results.

In September 2011, during the fourth phase of the groundwater investigation, three shallow monitoring wells (EMW-28, EMW-29, and EMW-30) were installed in the North Casper area, under the oversight of EnviroGroup personnel, by Tetra Tech, Inc., Of Casper, Wyoming with a CME-55 hollow stem auger (HSA) drill rig to approximately 14 to 15 ft. bgs. Subsurface soil data were obtained utilizing 8.25 inch outer diameter (O.D.)

HSA (4.25 inch inner diameter (I.D.)) and soil cores were collected by continuous or split spoon samplers from ground surface to the total depth of each borehole and were logged lithologically on borehole logs by an experienced geologist.

In February 2012, during the fifth and final phase of the groundwater investigation, three shallow monitoring wells (EMW-31, EMW-32, and EMW-33) were installed in the North Casper area, under the oversight of EnviroGroup personnel by Vista Geosciences (Vista) of Golden, Colorado, to an approximate depth of 13 feet bgs using a direct-push rig (i.e., Geoprobe®). Boreholes were advanced and soil core samples were collected using the same methods as Site Services, Inc. described above.

Additionally, 44 boreholes were advanced by Vista to just below the shallow groundwater surface (approximately 12 to 13 feet bgs) to allow retrieval of groundwater grab samples in the North Casper area to evaluate the northeastern extent of the North Casper portion of Plume #1 and potential groundwater impacts to the North Platte River. No soil cores or soil samples were collected from the temporary boreholes and monitoring wells were not installed. Boreholes were immediately backfilled to ground surface following groundwater sample collection with excavated alluvial materials or hydrated bentonite.

Immediately upon completion of borehole advancement, 33 boreholes were completed as shallow monitoring wells to evaluate current PCE concentrations near the water table. Because PCE is denser than water, it tends to sink and accumulate at the top of a low permeability horizon below the water table. Thus, three boreholes were completed as deeper monitoring wells in the downtown area to evaluate the vertical extent of PCE in groundwater and the potential for higher PCE concentrations at depth.

Monitoring wells were constructed in accordance with applicable DEQ groundwater rules and regulations (WDEQ, 1984). In particular, shallow monitoring wells (EMW-01, EMW-02, EMW-03S, EMW-04S, EMW-05, EMW-06S, and EMW-07 through EMW-33), were constructed with 2 inch I.D., schedule 40 flush joint threaded PVC materials ranging in depth from 10 to 27 feet bgs. Well screens were 5 feet in length (except EMW-15 through EMW-33 which have ten foot screens) with a slot size of 0.020 inch. The filter material (10/20 Colorado Silica Sand) was placed in the annulus of each borehole to a level of approximately two feet above the top of the screen interval. Following installation of the filter material, a bentonite seal (bentonite chips) was placed on top of the filter material to a minimum thickness of two feet. Distilled water was

added to ensure proper hydration of the bentonite. Additional bentonite chips were placed in the annular space to approximately one-half foot bgs in all wells and hydrated. Deeper monitoring wells (EMW-03D, EMW-04D, and EMW-06D), ranging in depth from 30.5 to 41 feet, were constructed similar to shallow monitoring wells, except for the use of 10 foot screens. All monitoring wells were completed with an eight inch diameter flush-mount well vault.

Borehole Logs and Well Completion forms are provided in Appendix A. Well completion information is summarized on Table 2. Monitoring well locations are shown on Figure 2A.

3.1.3 Well Development and Groundwater Sampling

Groundwater samples from new and existing monitoring wells were collected using Low-Flow Purge (LFP) methods. This method relies on the removal of groundwater at a rate similar to the wells rate of recharge (i.e., the groundwater column height during pumping should not vary more than approximately 10 percent from its steady-state condition or by keeping the drawdown at a minimal level (e.g., 0.33 feet); and is documented in the USEPA's Groundwater Sampling Guidelines for Superfund and RCRA Project Managers (Yeskis, D. and Zavala, B, 2002).

Prior to sampling activities, the static water level was measured using an electronic water-sensing probe. A stainless steel submersible pump was placed in the well to a depth determined to be the center of the screened interval. Purge volumes were calculated based on the pump, flow-through cell, and tubing diameters and lengths. Water levels were continuously measured during purging to ensure drawdown did not exceed 0.33 feet. Field water quality parameters (pH, temperature, specific conductance, oxidation-reduction potential, and dissolved oxygen) were measured during purging using a flow-through cell and recorded on field forms. Once three successive readings of two or more field water quality parameters stabilized, samples were collected directly from the discharge port of the pump prior to passing through the flow cell into laboratory-supplied containers. Groundwater samples were labeled, logged onto chain of custody documents, and stored on ice for submittal to TestAmerica–Denver for VOC analysis using USEPA Method 8260B.

To minimize cross contamination of groundwater samples, the submersible pump and cable were cleaned (decontaminated) between sample locations with a solution of

alconox/deionized water (DI) followed by a DI water rinse, and dedicated, disposable polyethylene tubing (did not require decontamination) was used at each well. Purge water was containerized at each well location and temporarily placed into a 150 gallon polyethylene tank mounted in the back of the field vehicle.

All newly installed wells were developed prior to groundwater sampling activities as follows:

- November 2009: Ten new monitoring wells (EMW-01, EMW-02, EMW-03S, EMW-03D, EMW-04S, EMW-04D, EMW-05, EMW-06S, EMW-06D and EMW-07) were developed and two existing monitoring wells (MW-2 and MW-7A) were re-developed between November 16, 2009 and November 18, 2009;
- August 2010: Seven shallow monitoring wells (EMW-08 through EMW-14) installed in July 2010 were developed on August 10, 2010;
- December 2010: Thirteen shallow monitoring wells (EMW-15 through EMW-27) installed in early December 2010 were developed between December 13, 2010 and December 15, 2010;
- September 2011: Three shallow monitoring wells (EMW-28, EMW-29, and EMW-30) installed on September 7, 2011 were developed on September 8, 2011; and
- February 2012: Three shallow monitoring wells (EMW-31, EMW-32, and EMW-33) installed on February 9, 2012 were developed on February 22, 2012.

Wells were developed utilizing a 3 foot weighted slug, 1.5 inch dedicated, disposable polyethylene bailers, and a GeoSub Stainless Steel (SS) submersible pump. Prior to well development, the static water level was measured using an electronic water-sensing probe to allow calculation of the wetted casing volume (i.e., the volume of groundwater standing in the casing under steady-state conditions). The wetted casing volume was calculated based on the static water level, well diameter (2 inch), and well depth. Following recording of initial water levels from each well, the wells were developed by surging the water column with a slug to flush the fine particles from the sand filter surrounding the well screen. Development continued by purging groundwater containing the suspended particulates from the well casing with a submersible pump. Surging and purging continued until a minimum of ten wetted casing volumes were removed. Purge

water was containerized at each well location and temporarily placed into a 150 gallon polyethylene tank mounted in the back of the field vehicle.

Upon completion of monitoring well development activities wells were allowed to rest overnight, at minimum. Following well development:

- On December 1 and December 2, 2009, groundwater samples were collected from monitoring wells EMW-01, EMW-02, EMW-03S, EMW-03D, EMW-04S, EMW-04D, EMW-05, EMW-06S, EMW-06D and EMW-07 and three existing monitoring wells (MW-2, MW-7A, and MW-1054-2). One laboratory prepared trip blank (TB120109), one replicate (MW-2REP) sample, and two duplicate (EMW-05DUP and EMW-06DDUP) samples were collected for quality assurance/quality control (QA/QC) purposes.

- On August 11, 2010, groundwater samples were collected from seven monitoring wells EMW-08 through EMW-14. One laboratory prepared trip blank (TB081110) and one duplicate sample (EMW-08DUP) were collected for QA/QC purposes.

- Between December 15 and December 17, 2010, groundwater samples were collected from 13 monitoring wells EMW-15 through EMW-27. Two laboratory prepared trip blanks (TB121510 and TB121610), two duplicate samples (EMW-18DUP and EMW-21DUP), and two replicate samples (EMW-19REP and EMW-23REP) were collected for QA/QC purposes.

- On September 9, 2011, groundwater samples were collected from three monitoring wells EMW-28, EMW-29, and EMW-30. One laboratory prepared trip blank (TB090911) and one duplicate sample (EMW-29DUP) were collected for QA/QC purposes.

- On February 23, 2012, three groundwater samples were collected from monitoring wells EMW-31, EMW-32, and EMW-33. One laboratory prepared trip blank (TB022312) and one duplicate sample (EMW-31DUP) were collected for QA/QC purposes.

Groundwater field water quality parameters are summarized on Table 3. Groundwater Field Water Quality Sampling and Analysis forms are presented in Appendix B.

3.1.4 Grab Groundwater Sample collection

Grab groundwater samples were collected in February 2012 during the final phase of investigation activities. Samples were collected from 44 temporary boreholes (EBH-01 through EBH-44) using a peristaltic pump with disposable silicon tubing connected to a stainless steel screen. The screen was attached to a hollow rod inserted into the sampling sheath at depth by Vista personnel. The pump was allowed to run for approximately 2-3 minutes while the sampler adjusted and reduced the flow to allow for a complete purge of water through the sample tubing and to minimize agitation during sample collection. Samples were collected directly from the discharge port of the pump into laboratory supplied containers. Grab samples were also collected from 5 existing EnviroGroup monitoring wells (EMW-15, EMW-19, EMW-28, EMW-29, and EMW-30) using a 1.5 inch by 3 foot disposable polyethylene bailer and nylon rope from approximately mid-screen and immediately placed in laboratory supplied containers. Five duplicate samples (EMW-15DUP, EBH-12DUP, EBH-22DUP, EBH-32DUP, and EBH-43DUP) were collected for QA/QC purposes. Grab groundwater samples were labeled, logged onto chain of custody documents, and stored on ice for submittal to ChemSolutions mobile groundwater laboratory (on-Site) for VOC analysis using USEPA Method 8260B. A turn-around time of 1-2 hours was provided by the mobile laboratory to help guide sample collection activities.

To minimize cross contamination of groundwater samples, the stainless steel screen and rods were cleaned (i.e., decontaminated) between sample locations with a solution of alconox/DI followed by a DI water rinse, and dedicated, disposable silicone tubing (did not require decontamination) was used at each well. Purge water was containerized at each well location and temporarily placed into a 150 gallon polyethylene tank mounted in the back of the field vehicle.

Grab groundwater sample locations are shown on Figure 2B.

3.1.5 Water Table Elevations and Survey

The Northing, Easting, ground surface elevation, and top of casing elevation of all sampled wells in October and December 2009 were surveyed and referenced to a consistent site datum by a licensed surveyor, WLC Engineering (WLC) on January 22, 2010. Monitoring wells installed in July 2010 and December 2010, were surveyed by

WLC on October 25, 2010 and January 21, 2011, respectively. Finally, WLC surveyed monitoring wells installed in September 2011 and February 2012 on February 22, 2012.

On February 22 and 23, 2012, water level measurement data was collected from all available shallow monitoring wells in and near Plume #1 and the North Casper Plume. Groundwater elevations were used to develop a representation of the shallow groundwater surface to assess groundwater flow directions.

Water level measurements are summarized in Table 2. Groundwater elevations and approximate flow directions are shown on Figure 2A.

3.2 SURFACE WATER INVESTIGATION

Surface water samples were collected from the south bank of North Platte River near the groundwater discharge zones of Plume #1 and the North Casper Plume. For the North Casper Plume, one upstream sample (ESW-01), one sample in the estimated discharge zone (ESW-02), and one downstream sample (ESW-03) were collected on December 2, 2009 concurrent with groundwater sample collection. One replicate sample (ESW-03 REP) was also collected for QA/QC purposes. On October 13, 2010, two surface water samples (ESW-05 and ESW-06) were collected from the estimated discharge zone of the North Casper portion of Plume #1. One upstream sample (ESW-04) and one downstream sample (ESW-07) were also collected. One trip blank (TB101310) and one duplicate sample (ESW-06DUP) were collected for QA/QC purposes.

All surface water samples were collected using gloved hands and a polyethylene cup within 2 feet of the south riverbank. Samples were collected from approximately 6 inches to 1 foot below the water surface and immediately placed in laboratory supplied containers. Groundwater samples were labeled, logged onto chain of custody documents, and stored on ice for submittal to TestAmerica–Denver for VOC analysis using USEPA Method 8260B. Field water quality parameters (pH, temperature, specific conductance, oxidation-reduction potential, and dissolved oxygen) were measured during sample collection by immersing the field meter in the river.

To minimize cross contamination of surface water samples, the sample cup was cleaned between sample locations with a DI water rinse and allowed to air dry and disposable nitrile gloves (do not require decontamination) were used at each sample location. The sampling cup was rinsed with the surface water at each location minimum of 3 times prior to sample collection.

Surface water field water quality parameters are summarized on Table 4. Surface water Field Water Quality Sampling and Analysis forms are provided in Appendix C.

3.3 SOIL VAPOR INVESTIGATION

Procedures followed during the soil vapor investigation, including soil vapor point installation, sampling, and analysis using a mobile and fixed-base laboratory, are described below.

3.3.1 Soil Vapor Probe Installation

Between November 5, 2009 and November 10, 2009, 40 permanent soil vapor probes (ESV-1 through ESV-40) were installed at the locations shown on Figure 3. The probes were installed at select locations within the PCE soil vapor and groundwater plumes previously identified by Huntingdon (Huntingdon, 1994). Based on elevated soil vapor results identified during the first phase of the investigation, on July 26, 2010 and July 27, 2010, 14 additional soil vapor probes (ESV-41 through ESV-54) were installed at select locations in the North Casper area of Plume #1. Additional locations were selected to fill data gaps in the downtown Casper area and along the North Casper Plume boundary. Between December 6, 2010 and December 8, 2010, 24 soil vapor probes (ESV-55 through ESV-78) were installed primarily in and around the North Casper portion of Plume #1 to identify plume boundaries and evaluate the potential for VI in the overlying structures. Additional locations were selected near the North Casper Plume to fill existing data gaps identified by the second phase of the investigation.

Soil vapor probes were installed under the oversight of EnviroGroup personnel, at locations selected by EnviroGroup, at depths of approximately 5 feet bgs using a direct-push rig (i.e. Geoprobe®). 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 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 depth (e.g., 4 to 5 ft bgs) of the soil vapor sampling zone (typically one foot in length) at the bottom of the borehole 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.

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 bentonite. 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 two 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 ambient air.

3.3.2 Leak Testing

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 12.1% helium (i.e., at least ten times the detection limit of the helium meter). 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) graduated 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% of the shroud concentration, a soil vapor sample was collected for analysis.

During November 2009 soil vapor sampling, the helium meter malfunctioned and shroud testing was not completed on the second day of testing at 13 soil vapor locations. Since tracer test results measured during this investigation indicated minimal tracer gas breakthrough (<1% of the shroud concentration) at the previous 27 sampling locations

(more than 10% of the samples), we believe that all soil vapor probes were properly installed and representative soil vapor samples were collected. Additionally, shroud testing was conducted during the following two investigation phases with no issues and minimal tracer gas breakthrough (i.e., <10% of the shroud concentration). Upon completion of soil vapor sampling activities all soil vapor probes were closed and secured.

3.3.3 Soil Vapor Probe Sampling and Analysis

Soil vapor samples were collected in the field using current state of the art procedures for mobile and fixed-based laboratory methods which are described below.

Sampling and Analysis

To provide information on the nature and extent of PCE and TCE, a mobile laboratory provided by Hartman Environmental Geosciences provided real-time laboratory analysis of PCE and TCE in the soil vapor samples. Duplicate soil vapor samples were collected from approximately 20% of the soil vapor probes for fixed-based laboratory VOC analysis to demonstrate comparability of sample results and to screen for the presence of breakdown products (e.g., cis-1,2-dichloroethene and vinyl chloride) and volatile petroleum compounds (e.g., benzene, toluene, ethylbenzene, and xylenes). Soil vapor sampling was conducted in three phases as follows:

- On November 11, 2009 and November 12, 2009, soil vapor samples including one field duplicate sample (ESV-29DUP) were collected from 40 soil vapor probes for mobile lab analysis. Eight additional duplicate samples (ESV-10DUP, ESV-14DUP, ESV-22DUP, ESV-26DUP, ESV-34DUP, ESV-37DUP, ESV-39DUP, and ESV-40DUP) were collected for fixed-base laboratory analysis.

- On July 27, 2010, 14 soil vapor samples from newly installed probes, one sample from an existing probe (ESV-07), and two field duplicate samples (ESV-43DUP and ESV-49DUP) were collected for mobile lab analysis. Two samples (ESV-43DUP and ESV-52DUP) were collected for fixed-base laboratory analysis.

- On December 8, 2012, 24 soil vapor samples and one field duplicate sample (ESV-75DUP) were collected for mobile lab analysis. Five fixed-based laboratory duplicates (ESV-57DUP, ESV-58DUP, ESV-62DUP, ESV-64DUP, and ESV-78DUP) were also collected. One existing soil vapor probe (ESV-13)

was selected to confirm analytical results from December 2009 sampling; however, due to broken valves on Tedlar bags, the sample could not be collected on two separate occasions.

Each soil vapor probe was not disturbed for a minimum of 24 hours prior to sample collection (other than ESV-46 through ESV-54 which were installed several hours prior to sampling on July 27, 2010 and ESV-76 through ESV-78 which were installed the morning of sampling on December 8, 2010). The same-day installation of the probes described above, as approved by DEQ, did not allow 24 hours between probe installation and sampling as the mobile laboratory was departing the day of installation. Therefore, analytical results for these 12 soil vapor samples may not be fully representative of subsurface soil vapor concentrations and the results may be biased low.

Soil vapor samples for mobile laboratory analysis were collected at flow rates of less than 0.1 liters per minute using 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 10-15 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 in 2009 and July 2010 for the first two sampling events then by Air Toxics Ltd. (Air Toxics), a NELAC certified laboratory, for the December 2010 sampling.

The mobile laboratory used a gas chromatography-mass spectrometry (GC/MS) and completed soil vapor analysis for PCE and TCE only, using USEPA Method 8021 with nominal reporting limits of 7.0 to 15.0 $\mu g/m^3$, respectively. Duplicate samples were shipped to Centek or Air Toxics within nine days of sampling so that no sample exceeded the 30 day holding time for the TO-15 method. Samples were analyzed for VOCs by USEPA Method TO-15 with minimum reporting limits of 1.6 $\mu g/m^3$ or less by Centek, and 10 $\mu g/m^3$ (for most compounds) by Air Toxics. All samples were analyzed within 20 days of collection. Full chain of custody documentation was maintained for all canisters from time of shipping from the laboratory to the time of analysis. Soil vapor sampling logs are provided in Appendix D.

A total of five ambient air samples (two in November 2009, two in July 2010, and one in December 2010) were collected during the three phases of mobile lab soil vapor sampling

to provide information on potential background concentrations of PCE and TCE in ambient air. Samples were collected in an upwind location, approximately five feet above ground surface near the location of the mobile laboratory using clean, 30 mL glass syringes, and analyzed via USEPA Method 8021 by the mobile lab.

3.4 ECOLOGICAL RISK ASSESSMENT

Step 1, the Ecological Exclusion Assessment, of an Ecological Risk Assessment was completed in accordance with DEQ VRP Fact Sheet #14 for the Casper PCE Plumes Orphan Site on September 30, 2010. The results of Step 1, determined that Step 2 was not necessary for this Site in 2010, prior to surface water sampling of the N. Platte River adjacent to Plume #1. The full report is included as Appendix E.

3.5 DECONTAMINATION AND MANAGEMENT OF INVESTIGATIVE DERIVED WASTES

Minimal amounts of investigative derived wastes (IDW) associated with the installation of monitoring wells and soil vapor probes, well development, and groundwater sampling activities were generated during investigation activities. All IDW was stored on-site, at locations selected by DEQ.

All drilling equipment was decontaminated between borehole/monitoring well and soil vapor probe locations. For monitoring well installation, drilling equipment was cleaned using a detergent and potable/distilled/deionized water wash following by a triple-rinse with distilled or deionized water. Decontaminated equipment was then allowed to air dry or appropriately stored for later use. For soil vapor probe installation, drilling equipment was cleaned with a hard bristle brush to remove any soils between boreholes.

Drill cuttings/soil cores were placed into 55 gallon drums, properly labeled with a pending label, and stored on-site pending laboratory analytical results. Decontamination and groundwater purge waters were visually inspected for the presence of non-aqueous phase liquid (NAPL). As no strong odors or sheen were observed, decontamination and groundwater purge waters were placed into 55 gallon drums, properly labeled with pending labels, and stored on-site pending laboratory analytical results.

All other IDW (e.g., disposable gloves, used LFP tubing, bailers and rope, etc.) was bagged, properly labeled with a pending label, and stored on-site, pending characterization and disposal by DEQ.

An inventory of each day's IDW was recorded in a bound field book and/or on appropriate field forms. The inventory references the date and area of generation and was provided to DEQ for its use in the proper management of the IDW. DEQ will remain the sole owner of any IDW generated by investigation activities.

Soil and water placed in drums were characterized by DEQ based upon laboratory analytical results from soil and groundwater samples. Soil drums generated during November 2009 investigation activities were picked-up and transported by Wayne Coleman Construction, Inc. and disposed of by the City of Casper Solid Waste Facility (Casper Landfill). Water drums were also picked-up and transported by Wayne Coleman Construction, Inc., and disposed of locally by the City of Casper Sam Hobbs Regional Wastewater Treatment Plant (Casper WWTP). For IDW generated in 2010 through 2012, soil drums were transported by the drillers to the Casper Landfill and water containerized in the storage tank on the field vehicle was brought to the Casper WWTP for disposal under on-going waste manifests signed by DEQ personnel.

4 INVESTIGATION RESULTS

The results of the soil, groundwater, surface water, and soil vapor investigations, including data validation, and the Ecological Risk Assessment are presented in this section. An evaluation of the data is presented in Section 5.

4.1 SOIL ANALYTICAL RESULTS

Organic vapor borehole headspace monitoring was performed with a PID meter at each borehole location during drilling activities in November 2009 and July 2010. PID measurements were not collected during subsequent drilling activities, with DEQ approval, as soils above the water table were not expected to contain VOCs based on drilling locations. In November 2009, elevated organic vapor concentrations were measured in 7 boreholes located in Plume #1, Plume #2, and Plume #3 in downtown Casper. Elevated PID readings in boreholes EMW-01 and EMW-02 (Plume #1 and Plume #2) are consistent with hydrocarbons present in the soil based on the staining and strong odors noted in lithologic descriptions. The remaining 5 boreholes (EMW-03D, EMW-03S, EMW-04D, EMW-04S, and EMW-05) are within to the Plume #1 historic groundwater PCE plume boundary (Huntingdon, 1994). In July 2010, low PID readings (i.e., <20 parts per million (ppm)) were measured in all seven wells (EMW-08 to EMW-14) located outside the Plume #1 boundary or significantly down-gradient from potential source areas, and no odors or sheens were observed. Organic vapor headspace monitoring results are summarized on Table 1.

During drilling activities, soil samples were collected from soil cuttings from each borehole based on visual observation and elevated PID measurements. Three soil samples (EMW-04D(15.5-16.0’), EMW-04D(24.0-25.0’) and EMW-05(6.5-7.5’)) were collected on November 12, 2009 and submitted for VOC analysis. One soil sample (EMW-05(7.5-8.4’)) was collected as a laboratory QA/QC sample. Although PID readings were higher for soil samples collected from boreholes EMW-01, EMW-02, EMW-03D, and EMW-03S, samples from EMW-04D and EMW-05 were selected for analysis based on higher concurrent soil vapor sample results near these wells. Soil analytical results indicated the presence of PCE at 0.0031 milligrams per kilogram (mg/kg) in sample EMW-04D(15.5-16.0’) exceeding the PCE Migration to Groundwater Cleanup Level of 0.000052 mg/kg (DEQ Voluntary Remediation Program (VRP) Fact Sheet #12, Soil Cleanup Level Look-Up Table, 2009). Acetone, TCE, and total xylenes

were detected in one or more samples below the DEQ cleanup levels. All other compounds were not detected at the reporting limit (RL). Soil analytical results are summarized on Table 5. Complete laboratory data is presented in Appendix F.

4.2 GROUNDWATER INVESTIGATION RESULTS

The following presents a summary of groundwater elevations and flow directions and sample results obtained from monitoring well and grab sample collection.

4.2.1 Groundwater Elevations and Flow

The depth to water was measured in shallow monitoring wells in the North Casper Plume and Plume #1 during sampling activities in February 2012 and results are presented on Table 2. Groundwater elevations were contoured to assess groundwater flow direction. Based on current water levels, shallow groundwater generally appears to flow across downtown and North Casper in a northeasterly direction toward the North Platte River as shown on Figure 2A. Additionally, based on 2009 water level measurements, shallow groundwater in Plume #2 and Plume #3 may flow to the north and northwest into the North Platte River.

4.2.2 Groundwater Analytical Results

The results of groundwater samples collected from permanent and temporary monitor well locations are summarized in the following sections.

4.2.2.1 Monitor Well Sampling

Groundwater samples were collected from 36 new monitoring wells, 8 existing monitor wells, and one private water well between December 2009 and February 2012. Seven laboratory prepared trip blanks seven duplicate samples, and three replicate samples were collected for QA/QC purposes. Field water quality parameters were measured for each well and are summarized on Table 3. A summary of groundwater analytical results is presented on Table 6. PCE and TCE results are shown on Figure 2A. Complete laboratory data is presented in Appendix G.

A summary of laboratory analytical results indicates concentrations of PCE above the EPA MCLs (EPA, 2003) and DEQ Groundwater Cleanup Levels (DEQ GCLs) (DEQ VRP Fact Sheet #13, 2009) of 5 µg/L in 29 of 55 groundwater samples, with

concentrations ranging from 6.0 µg/L to 420 µg/L. TCE and Methylene Chloride concentrations exceeding DEQ GCLs were also detected in sample EMW-04S. All other compounds were reported below DEQ GCLs or were not detected at the RL.

4.2.2.2 Grab Groundwater Samples

Groundwater samples were collected from 44 temporary monitoring wells and 5 existing monitoring wells between February 7, 2012 and February 9, 2012 and analyzed for PCE and TCE only. Five duplicate samples were collected for QA/QC purposes. The mobile laboratory did not require laboratory prepared trip blanks, and field water quality parameters were not measured during grab sampling. A summary of groundwater analytical results is presented on Table 7. PCE results are shown on Figure 2B. Complete laboratory data is presented in Appendix H.

A summary of laboratory analytical results indicates concentrations of PCE above the EPA MCL and DEQ GCL of 5 µg/L in 42 of 54 grab groundwater samples, with concentrations ranging from 5.1 µg/L to 51 µg/L. The highest concentration was detected in monitoring well EMW-15, consistent with previous sampling results. TCE concentrations were reported below the DEQ GCL or were not detected at the RL in all samples.

4.3 SURFACE WATER INVESTIGATION RESULTS

Seven surface water samples were collected on December 2, 2009 and October 13, 2010 from the North Platte River for VOC analysis. Additionally, one replicate and one duplicate sample were collected for QA/QC purposes. Field water quality parameters were measured at each location and are summarized on Table 4. A summary of surface water analytical results is presented in Table 8. PCE and TCE results are shown on Figure 2A. Complete laboratory data is presented in Appendix I.

Surface water analytical results indicated the presence of PCE in samples ESW-02, ESW-03, and ESW-07 well below EPA MCLs and DEQ GCLs. Acetone was also detected at low concentrations below EPA MCLs and DEQ GCLs in six of nine samples. PCE was not detected at the RL at upstream locations ESW-01 and ESW-04 and all other compounds were not detected at the RL in all samples.

4.4 SOIL VAPOR INVESTIGATION RESULTS

Soil vapor samples were collected from 78 permanent soil vapor probe locations between December 2009 and December 2010. Four mobile lab duplicate samples and 15 fixed-laboratory duplicate samples were collected for QA/QC purposes to demonstrate comparability of sample results and to screen for the presence of breakdown products. A summary of soil vapor analytical results is presented on Table 9. Soil vapor PCE and TCE results are shown on Figure 3. Complete laboratory data is presented in Appendix J.

For this Site, PCE results are compared to the 2009 DEQ Soil Vapor Screening Level (DEQ SVSL) of 810 µg/m^3 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 (the ratio of the indoor air concentration to the soil gas concentration) of 0.01. TCE results are compared to the 2009 DEQ SVSL of 90 µg/m^3 based on an estimated 1x10^{-5} risk level target indoor air concentration of 0.9 µg/m^3 (based on considerations of an EPA compilation of background indoor air concentrations by DEQ) with an assumed attenuation factor of 0.01 for shallow soil vapor to indoor air.

4.4.1 Mobile Laboratory

A summary of mobile laboratory analytical results indicate concentrations of PCE above the DEQ SVSL in 19 of 82 mobile laboratory samples, with concentrations ranging from 830 µg/m^3 to >39,000 µg/m^3. TCE concentrations exceeding DEQ GCLs were detected in three samples (ESV-03, ESV-06, and ESV-19) associated with the three highest PCE results. All other PCE and TCE results were reported below DEQ GCLs or were not detected at the RL.

4.4.2 Fixed-Base Laboratory

The fixed-base laboratory duplicate samples generally showed PCE and TCE concentrations lower than those from the mobile laboratory with a few exceptions (ESV-37DUP, ESV-52DUP, and ESV-62DUP). Only one duplicate PCE result was reported above the DEQ SVSL (ESV-40DUP). In addition, the fixed-base laboratory duplicate samples indicated the presence of cis-1,2-dichloroethene in two samples (ESV-14DUP and ESV-43DUP) and 1,1,1-TCA in two samples (ESV-37DUP and ESV-52DUP); however, other breakdown products (i.e., vinyl chloride, trans-1,2-dichloroethene, and 1,1-dichloroethene) were not detected in any of the samples. Acetone (a common

laboratory contaminant) was present in all but one of the samples. Petroleum hydrocarbons (BTEX and associated compounds) and methyl ethyl ketone were also present in most of samples across the Site (although below screening levels). Other VOC compounds were detected at low concentrations in many of the samples, as shown on Table 9.

4.4.3 Soil Vapor Sampling Ambient Air Results

PCE and TCE were not detected in ambient air samples collected in conjunction with the soil vapor sampling at mobile laboratory reporting limits of 7 $\mu g/m^3$ and 15 $\mu g/m^3$, respectively. Ambient Air Results are shown in the mobile laboratory data reports presented in Appendix J

4.5 DATA VALIDATION

All soil, groundwater, surface water, and soil vapor samples were validated by EnviroGroup to verify that they were collected and tested according to the project SAP (EnviroGroup, 2009) and EnviroGroup Standard Operating Procedures. All data were reviewed and validated according to the project QA/QC Project Plan (EnviroGroup, 2009) and results are summarized in the following sections.

4.5.1 Soil Sample QA/QC

Field QA/QC samples (i.e., duplicates, replicates, and trip blanks) were not required for this sampling media. All laboratory QA/QC samples (i.e., method blanks, laboratory control samples, and matrix spikes/duplicates) were within established control limits and no data qualifiers were required. As a result, all soil data were determined usable for data evaluation.

4.5.2 Groundwater Sample QA/QC

Samples collected from monitoring wells were submitted to a fixed-based laboratory (i.e., TestAmerica-Denver or Pace Analytical) and grab groundwater samples were submitted for analysis to a mobile laboratory (i.e., ChemSoultions). QA/QC requirements differed for fixed-based and mobile laboratory analysis and are summarized below.

4.5.2.1 Fixed-based Laboratory

Field QA/QC samples (i.e., duplicates, replicates, and trip blanks) were collected at the required frequency (one in ten samples) unless approved by DEQ prior to sampling. Methylene chloride (a common laboratory contaminant) was detected below the RL in trip blank samples TB120109, TB081110, TB090911, and TB022312, and results were appropriately 'J' flagged by the laboratory.

Where sample and duplicate results were less than 10 times the RL, all sample and duplicate results are +/- the RL with the exception of EMW-29 and EMW-29DUP which are qualified '&' in Table 6. All other sample and duplicate results were less than 20% Relative Percent Difference (RPD) demonstrating samples are precise and representative of the sampling location. Where sample and replicate results were less than 10 times the RL, all sample and replicate results are +/- the RL demonstrating good precision between laboratories. Additionally, all sample and replicate results were less than 20% RPD with the exception of PCE for EMW-23 and EMW-23REP with an RPD of 26.8%. This sample pair was qualified '&' in Table 6.

Low levels of acetone and/or methylene chloride were detected in the laboratory method blanks in TestAmerica data reports D9J120191, D9L030596, 280-20162-1, and 280-25980-1 and are qualified as required by the laboratory. Associated sample results are qualified 'B' to indicate possible lab contamination. All other laboratory QA/QC samples were acceptable and qualified by the laboratory as required.

As a result, all groundwater data were determined usable for data evaluation; however, care should be taken in the interpretation of 'B' qualified results for methylene chloride and acetone.

4.5.2.2 Mobile Laboratory

Field QA/QC samples (i.e., duplicates) were collected at the required frequency (one in ten samples) and trip blanks were not required by the mobile laboratory as samples were submitted for analysis within one or two hours following sample collection. As approved by the DEQ, replicate samples were waived for this sampling event.

Sample and duplicate results less than 10 times the RL, were are +/- the RL, and all other sample and duplicate results were less than 20% RPD demonstrating samples are precise and representative of the sampling location. There were no issues with laboratory

QA/QC samples. As a result, all grab sample groundwater data were determined usable for data evaluation.

4.5.3 Surface Water Sample QA/QC

Field QA/QC samples (i.e., duplicates, replicates, and trip blanks) were collected at the required frequency (one in ten samples) unless approved by DEQ prior to sampling. Methylene chloride was detected below the RL in trip blank sample TB120109 associated with samples ESW-01 through ESW-03 and acetone and methylene chloride were detected in TB101310 associated with samples ESW-04 through ESW-07. Compounds detected in these trip blanks were appropriately 'J' flagged by the laboratory. Field duplicate and replicate samples showed good accuracy, precision, and representativeness between samples.

Low levels of acetone and/or methylene chloride were detected in the laboratory method blanks in data reports D9L030596 and 280-8472-1 and are qualified as required by the laboratory. Associated sample results are qualified 'B' to indicate possible lab contamination. All other laboratory QA/QC samples were acceptable and qualified by the laboratory as required. As a result, all surface water data were determined usable for data evaluation; however, care should be taken in the interpretation of 'B' qualified results for methylene chloride and acetone.

4.5.4 Soil Vapor Sample QA/QC

Trip blanks were not submitted to the fixed base laboratory for the soil vapor sampling program because the laboratory used certified clean Summa canisters. Trip blanks were not considered to be necessary when such cleaning certification was provided and the expected levels in soil vapor are much higher than those in indoor or outdoor air. Field blanks for the mobile laboratory were composed of ambient air samples. No results above the laboratory reporting limits were detected.

Two of the four field duplicates for mobile laboratory analysis yielded good agreement with RPDs of less than 15% at lower concentrations. At higher concentrations, the RPDs range from 39% to 52% RPD.

The results of the fixed base laboratory duplicate analyses compared to the mobile laboratory analyses were typically lower for PCE. Duplicate sample concentrations varied from 2% to 93% lower for all but three samples which were 7% to 60% higher.

Since the mobile laboratory is a screening level analysis and uses a different sample collection and analysis method, this discrepancy for PCE is acceptable as most duplicate sample result RPDs are less than 50%.

Laboratory QA/QC analytical results were reviewed during data validation. Results indicated acceptable accuracy and precision in the analyses from both Centek and Air Toxics. For canisters sent to labs located at sea level, the initial post-test lab vacuum reading should be approximately 4” to 6" Hg higher than the final field (Casper) vacuum reading. Where this is not the case, the canister may have leaked during its return to the lab or the gauge may have been hit. Associated sample results are qualified ‘G’ for three samples (ESV-43DUP, ESV-52DUP, and ESV-62DUP). As a result, all soil vapor data were determined usable for data evaluation.

4.6 ECOLOGICAL RISK ASSESSMENT RESULTS

An ecological exclusion assessment (Step 1 of an Ecological Risk Assessment) was completed for the Site (See Appendix E) in September 2010, prior to surface water sampling of the N. Platte River adjacent to Plume #1. The assessment concluded that groundwater was the only affected media at the Site and that there were no sensitive habitats or species impacted by the plumes.

5 DATA EVALUATION

PCE and TCE were observed in groundwater and soil vapor exceeding DEQ GCLs and SVSLs within two of the four historic groundwater PCE plume boundaries identified by Huntingdon (Huntingdon, 1994). All of the groundwater and soil vapor results exceeding screening levels were within or immediately adjacent to these two historic plume boundaries (North Casper Plume and Plume #1). The following sections discuss the nature and extent of the COIs in groundwater and soil vapor in the downtown Casper and North Casper areas and the potential for vapor intrusion.

5.1 DOWNTOWN CASPER AREA

Three historic groundwater PCE plumes (Huntingdon, 1994) were identified in downtown Casper and were areas of focus in this investigation. The following sections discuss the nature and extent of the PCE plumes and a comparison to historical results. Groundwater and soil vapor PCE results with historic and current plume boundaries are shown on Figure 4.

5.1.1 Plume #1

Groundwater and soil vapor plume outlines were generally consistent with previous investigation results as shown on Figure 4. With the exception of 3 wells (EMW-03S, EMW-04S, and EMW-05) in the downtown area of Plume #1, groundwater PCE concentrations were generally lower than observed in 1994. Results from 1994 in the areas of EMW-03S, EMW-04S, and EMW-05 had lower concentrations of PCE in groundwater than in 2009; however they still exceed the DEQ GCLs. The highest groundwater concentrations were reported in shallow monitoring well EMW-04S (420 µg/L) down-gradient of the former dry cleaner located at 328/330 North Durbin Street. Additionally, elevated PCE concentrations in up-gradient shallow wells EMW-03S and EMW-05 indicate that another PCE source may be located near North Wolcott Street and East 1st Street. Lower concentrations in deeper monitoring wells EMW-03D and EMW-04D indicate a shallow source of PCE in groundwater.

Soil vapor concentrations above the DEQ SVSLs are located inside of the groundwater plume boundary and a general spatial relationship is apparent between shallow groundwater concentrations and nearby soil vapor concentrations of PCE. Structures

within the 810 µg/m^3 PCE plume boundary, as shown on Figure 4, were selected by DEQ for a vapor intrusion evaluation as discussed in Section 5.3.

5.1.2 Plume #2

Huntingdon identified Plume #2 by elevated groundwater and soil vapor PCE results of 27.2 µg/L and 43,500 ppb, respectively, in one borehole on West A Street between N. Ash Street and Nichols Avenue. In 2009, PCE and TCE were not detected in shallow groundwater monitoring well EMW-01 located approximately down-gradient (with an assumed northwest groundwater flow direction) of the 1994 sample location. PCE was detected in soil vapor at all three locations with the highest concentration at ESV-37 (660 µg/m^3); however, concentrations did not exceed the DEQ SVSL. PCE concentrations have decreased in groundwater from 27.2 µg/L to <1 µg/L and in soil vapor from 294,914 µg/m^3 to 660 µg/m^3 or less, indicating natural attenuation is occurring. No additional groundwater or soil vapor investigation was performed in this area; however, a daycare center in the vicinity of ESV-37 was included in the vapor intrusion evaluation as described in Section 5.3.

5.1.3 Plume #3

Plume #3 was identified by Huntingdon in 1994 from elevated groundwater results (145 µg/L) in one borehole near Industrial Avenue and North David Street. In 2009, PCE and TCE were not detected in the soil gas sample collected at ESV-34 or the groundwater sample from EMW-02; however, both groundwater and soil vapor data indicate petroleum contamination in the same general vicinity, likely due to a source located approximately one block to the west. Petroleum contamination may have caused fortuitous biodegradation of PCE in shallow groundwater in the Plume #3 area. No additional groundwater or soil vapor investigation activities were performed in this area in 2010 through Spring 2012.

5.2 NORTH CASPER AREA

Two historic groundwater PCE plumes (Huntingdon, 1994) were identified in North Casper (area north of Interstate 25) and were areas of focus in this investigation. The following sections discuss the nature and extent of the PCE plumes, a comparison to historical results, and potential impacts to the North Platte River. It should be noted that groundwater elevations in North Casper fluctuate seasonally, and PCE concentrations

may vary at different times of the year. This may explain the differences in PCE concentrations between historical and current investigations or summer versus winter sampling results. Groundwater, soil vapor, and surface water PCE results with historic and current plume boundaries are shown on Figures 5 and 6.

5.2.1 North Casper Plume

PCE concentrations in shallow groundwater exceeding DEQ GCLs were observed within the historic groundwater PCE plume boundary identified by Huntingdon and are considerably lower than in 1994. For example, the PCE concentration in CG-4 (or CG-4A) has decreased from 2,280 µg/L to 49 µg/L. Additionally, the current groundwater plume boundary is approximately 50% smaller than in 1994 and the migration of PCE appears to be consistent with groundwater flow to the northeast toward the North Platte River. Unlike in 1994, TCE was not detected in shallow groundwater above DEQ GCLs indicating that it was likely a degradation product and is not present as a source material in the subsurface.

Soil vapor plume outlines were generally consistent with previous investigation results as shown on Figure 5. The highest soil vapor PCE concentrations detected in any Site samples were observed in ESV-06 at >39,000 µg/m^3 and ESV-03 at >27,000 µg/m^3. While very low PCE concentrations (0.37 µg/L, 1.8 µg/L, and 4.4 µg/L) were measured in nearby wells EMW-11, MW-2, and CG-1, the elevated soil vapor results indicate a shallow source of PCE in groundwater. As mentioned by Huntingdon (1994), the potential source of the North Casper Plume appears to be the former dry cleaner located at 1107 North Durbin Street. Structures within the 810 µg/m^3 plume boundary were selected by DEQ for a vapor intrusion evaluation as discussed in Section 5.3.

5.2.2 Plume #1

PCE concentrations in shallow groundwater exceeding DEQ GCLs were observed within the historic plume boundary during the 2009 investigation; however, a PCE concentration of 41 µg/L detected on the edge of the eastern boundary at the Rizor #1 private well (PW-1) resulted in the expansion of the investigation area. Elevated PCE concentrations (65 µg/L and 47 µg/L) in groundwater samples EMW-13 and EMW-14, collected from outside of the original plume boundary in August 2010, indicated the PCE plume had migrated northeast in the direction of groundwater flow. The expanded plume was

further evaluated in February 2012, with the collection of grab groundwater samples along the North Platte River in the North Casper Park.

Plume #1 in the North Casper area is a continuation of the downtown Casper Plume #1 as shallow groundwater flows to the northeast toward the North Platte River (Figure 2A). In downtown Casper, Plume #1 is similar in size to the historic groundwater plume (discussed in Section 5.1.3); however as it extends into North Casper, it almost doubles in size as shown in Figure 6. PCE concentrations appear to have decreased in previously identified areas north of Interstate 25 (similar to downtown Casper), but have increased north of East H Street and east of North Washington Street, consistent with the migration of groundwater to the northeast. Additional PCE sources have not been identified in the North Casper extension of Plume #1 based on the results of this investigation.

A source of PCE is impacting deep (23 to 33 foot) groundwater at EMW-06D, as concentrations of PCE are slightly higher than in shallow groundwater at EMW-06S. This higher concentration of PCE in the deeper alluvial aquifer is not fully understood and requires further evaluation to assess the nature and extent of PCE and whether groundwater remediation is necessary.

Soil vapor plume boundaries were similar to historic results (Figure 6) but demonstrate a spatial relationship with current groundwater PCE concentrations (with the exception of ESV-46). While PCE concentrations were not detected in nearby well EMW-12, the elevated soil vapor results indicate a shallow source of PCE in groundwater. Structures within the 810 $\mu g/m^3$ plume boundary were selected by DEQ for a vapor intrusion evaluation as discussed in Section 5.3.

5.2.3 Surface Water Evaluation

Surface water samples were collected from along the south bank of the North Platte River in locations based on historic plume boundary discharge zones. Very low concentrations (i.e., below RLs) of PCE were detected in groundwater samples (ESW-02, ESW-03, and ESW-07) within the current plume discharge zones. Both sampling events occurred in the fall/winter months when the groundwater elevations were lower than in the spring, and minimal discharge to surface water was anticipated.

During February 2012, grab groundwater samples were also collected along the North Platte River discharge zone of Plume #1 to evaluate potential VOC pathways in

groundwater that may impact surface water. Results indicated the presence of PCE in most of the wells along the riverbank exceeding the DEQ GCL, with the highest concentrations detected in the western-most samples near EMW-31 or by monitoring well EMW-15. Based on the grab groundwater and surface water analytical results, groundwater containing relatively low concentrations of PCE is likely discharging from the North Casper Plume and Plume #1 into the North Platte River; however, PCE concentrations are immediately diluted by the river water.

5.3 VAPOR INTRUSION EVALUATION

Soil vapor analytical results indicated concentrations of PCE and TCE in two plumes (North Casper Plume and Plume #1) exceeding DEQ SVSLs of 810 $\mu g/m^3$ and 90 $\mu g/m^3$, respectively; however, TCE only exceeded the DEQ SVSL in three samples where the PCE results were already very high. Screening levels are generally considered "conservative" and exceedances do not necessarily indicate that the presence of an unacceptable human health risk; however, exceedances indicate the need for further site-specific evaluation. Therefore, EnviroGroup performed a vapor intrusion investigation in downtown and North Casper from 2010 to 2011 in areas where soil vapor VOC concentrations exceeded DEQ SVSLs as identified by DEQ. A complete discussion of sampling procedures, results, and VI controls are presented in the Vapor Intrusion Evaluation Report (EnviroGroup, 2012). Rational for sampling locations is also presented below.

Indoor Air and Sub-Slab Testing Program

DEQ identified areas of concern based on soil vapor PCE concentrations exceeding the 810 $\mu g/m^3$ screening level. Residential structures within these boundaries were considered "worst-case" buildings for the potential for vapor intrusion and were offered indoor air testing and pre-emptive vapor intrusion mitigation. Commercial buildings within the areas exceeding 810 $\mu g/m^3$ in soil vapor were also offered indoor air testing. Sub-slab testing was not conducted within the 810 $\mu g/m^3$ boundary because vapor intrusion was 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 were considered "verification" properties and were offered indoor air and sub-slab vapor testing. Sub-slab vapor testing was conducted (where access was granted) to evaluate the potential for vapor intrusion and provide supporting information for evaluation of background and indoor sources of PCE and TCE. Additionally, the Day Care Center

located above Plume #2 was offered sub-slab vapor and indoor air testing as it appeared to be the most vulnerable building in the area for vapor intrusion impacts based on the elevated PCE soil vapor result of 660 $\mu g/m^3$ at ESV-37 and historic groundwater data from Huntingdon (1994). The Day Care Center (301 West B Street) indoor air results were below residential indoor air screening levels and no additional testing (including sub-slab) was performed in this area.

If any of the buildings tested indicated the potential for vapor intrusion (i.e., indoor air concentrations above DEQ Indoor Air Screening Levels (IASLs)), vapor intrusion mitigation systems were offered and the investigation extended to adjacent buildings (i.e., in a "step out" process) in a sequential manner until analytical results indicated indoor air PCE and TCE concentrations were below the DEQ IASLs of 8.1 $\mu g/m^3$ and 0.9 $\mu g/m^3$, respectively for residential properties and 27.2 $\mu g/m^3$ and 4.2 $\mu g/m^3$, respectively for commercial properties.

During additional groundwater and soil vapor investigation activities, two additional soil vapor locations (ESV-46 and ESV-73), north of the original Study Area, had PCE concentration above 810 $\mu g/m^3$, which initiated additional soil vapor and indoor air sampling to the north and north east (i.e., the Expanded Testing Area) in order to further evaluate the potential for VI.

A total of 86 residential and 17 commercial buildings were tested in the North Casper Plume and Plume #1 north and south of Interstate 25; however, most buildings tested had PCE and TCE indoor air results below DEQ IASLs. All properties that responded to DEQ requests for testing had, at minimum, one indoor air test conducted, and all properties with PCE indoor air results exceeding DEQ IASLs were mitigated. Post-mitigation indoor air testing was conducted in all but one property (due to lack of owner response) and all post-mitigation test results were below DEQ IASLs.

6 CONCLUSIONS

The following presents a summary of conclusions based on our evaluation of the data, as discussed in Section 5.

6.1 NATURE AND EXTENT OF CONTAMINATION

The following sections describe the nature and extent of groundwater and soil vapor contamination at the Site.

6.1.1 Groundwater

The primary groundwater COC at the site is PCE, with low levels of other VOCs. This suggests that the source of contamination was largely PCE, possibly derived from former dry cleaning operations. As shown on Figure 4, the highest PCE concentration (420 µg/L) in shallow groundwater was detected down-gradient of the former dry cleaner located at 328/330 North Durbin Street in Plume #1. A second source area at 1107 North Durbin Street (also a former dry cleaner) was identified in the North Casper Plume but with much lower groundwater PCE concentrations. Additional source areas were not confirmed during this investigation, although data indicate that another source area may exist near North Wolcott Street and East 1st Street (Downtown Plume #1) due to elevated PCE results (e.g., 33 µg/L) in that area. No evidence for the presence of residual NAPL was identified in these three potential source areas. Groundwater contamination (above the MCL) from PCE was not found in Plumes #2 and #3 in downtown Casper.

6.1.2 Soil Vapor

As shown on figure 5, the highest PCE soil vapor concentrations (>39000 µg/m^3 and >27000 µg/m^3) detected were in the North Casper Plume near and down-gradient of the former dry cleaner located at 1107 North Durbin Street. Additionally, elevated soil vapor PCE results were detected in downtown Casper near the 328/330 North Durbin Street former dry cleaner (e.g., 6500 µg/m^3) and down-gradient from the potential source at North Wolcott Street and East 1st Street (e.g., 1030 µg/m^3). The data evaluation (Section 5.0) indicated that elevated concentrations of VOCs in soil vapor correlate well with those detected in the shallow groundwater.

6.2 VAPOR INTRUSION IMPACTS

Results of site investigation activities indicate the presence of elevated concentrations of VOCs, primarily PCE and to a lesser extent TCE, in shallow groundwater and soil vapor above applicable EPA MCLs and DEQ SVSLs, respectively. Investigation activities also indicate the presence of porous soils (i.e., sands) encountered during drilling activities which can increase the potential for sub-surface vapors to migrate into structures and impact indoor air. As a result, EnviroGroup performed a vapor intrusion investigation in downtown and North Casper from 2010 to 2011 in areas where soil vapor VOC concentrations exceeded DEQ SVSLs, as identified by DEQ. Due to PCE results exceeding the DEQ IASL, vapor mitigation systems were installed in two commercial buildings and one residential building in downtown Casper, and three residential houses, one duplex, and one four-plex in the North Casper extension of Plume #1. Additionally, two residential homes in the "worst-case" area of Plume #1 in North Casper opted for vapor mitigation systems with low or no indoor air test results. Out of 15 buildings and one apartment complex tested for VI impacts overlying the North Casper Plume, none required vapor mitigation.

A complete discussion of sampling procedures, results, and VI controls are presented in the Vapor Intrusion Evaluation Report (EnviroGroup, 2012).

7 RECOMMENDATIONS

The following section presents recommendations based on our evaluation of the data and conclusions, as discussed in Sections 5 and 6.

7.1 AREAS LIKELY TO REQUIRE GROUNDWATER REMEDIAL MEASURES

A Remedial Measures Evaluation is required to reduce PCE (and other VOC) concentrations in shallow groundwater at two of the three potential source areas: 1) downtown Casper (near the former dry cleaner at 328/330 North Durbin Street) and 2) North Casper (near the former dry cleaner at 1107 North Durbin Street). The downtown Casper Plume area contains relatively high concentrations of PCE in groundwater and soil vapor and is up-gradient of the areas with VI impacts on indoor air requiring vapor mitigation systems to be installed in ten buildings. The North Casper Plume area also contains relatively high concentrations of PCE in groundwater and soil vapor and groundwater from this source area is potentially discharging into the North Platte River.

Additionally, a source of PCE is impacting deep (23 to 33 foot) groundwater at EMW-06D, as concentrations of PCE are slightly higher than in shallow groundwater at EMW-06S. This higher concentration of PCE in the deeper alluvial aquifer is not fully understood and requires further evaluation to assess the nature and extent of PCE and whether groundwater remediation is necessary.

A Remedial Measures Evaluation is also required for the groundwater to surface water discharge zones of the North Casper Plume and Plume #1 (near the North Casper Park). Elevated concentrations of PCE in most of the monitoring wells and temporary boreholes located near the river in these two plumes exceeded the DEQ GCL. Additionally, analytical results in Plume #1 indicate relatively uniform PCE concentrations across the area with slightly elevated concentrations in monitoring wells EMW-15, EMW-19, and EMW-31. Based on these results and detections of PCE in surface water results, there is indication of a potential VOC pathway and groundwater containing relatively low concentrations of PCE is likely discharging from the North Casper Plume and Plume #1 into the North Platte River; however, PCE concentrations are immediately diluted by the river water.

7.2 ECOLOGICAL RISK ASSESSMENT

As discussed above, groundwater containing relatively low concentrations of PCE is likely discharging from Plume #1 into the North Platte River in the North Casper Park area. The ecological exclusion assessment was completed for the Site (See Appendix E) in September 2010 for the North Casper Plume discharge area and for the 2010 estimated discharge area of Plume #1. Based on February 2012 groundwater sampling results, the current discharge area of Plume #1 may have expanded since 2010 and the ecological exclusion assessment may need to be updated.

8 STUDY LIMITATIONS

EnviroGroup's work presented herein was performed in a manner consistent with the level of care normally exercised by members of our profession practicing in the same geographic area at the time the work is performed. No other warranty is made, expressed or implied, regarding our work. The findings, conclusions, and recommendations presented herein are based on our professional judgment and should not be considered scientific certainties.

This work was performed for DEQ based on our understanding of the environmental issues to be addressed and DEQ's schedule, risk tolerance, and budget for performing this work. Other parties may have different concerns and levels of risk tolerance and, therefore, rely on this report at their own risk.

We have relied on the work of others during this study. We assume that the work performed by others was done correctly, that the information provided is correct, and assume no liability for the errors or omissions of others.

This report presents and evaluates the results of soil, groundwater, surface water, and soil vapor testing conducted at specific locations and specific times. The concentrations of VOCs can vary in time and space; therefore, subsequent tests in the same locations and/or tests in new locations are unlikely to produce the same results. Nevertheless, considering the potential for variations in VOC concentrations in time and space, we believe our conclusions and recommendations are reasonable.

9 REFERENCES

EnviroGroup Limited, 2009. Sampling and Analysis Plan, Casper PCE Plumes Orphan Site, Casper, Wyoming. October 23, 2009.

EnviroGroup Limited, 2009. Quality Assurance/Quality Control Program Plan, Casper PCE Plumes Orphan Site, Casper, Wyoming. October 23, 2009.

EnviroGroup Limited, 2010a. Soil Vapor Investigation Procedures and Results Technical Memorandum, Casper PCE Plumes Orphan Site, Cheyenne, Wyoming. June 10, 2010.

EnviroGroup Limited, 2010b. Soil, Groundwater, and Surface Water Investigation Procedures and Results Technical Memorandum, Casper PCE Plumes Orphan Site, Cheyenne, Wyoming. June 21, 2010.

EnviroGroup Limited, 2012. Supplemental Sampling and Analysis Plan, Casper PCE Plumes Orphan Site, Casper, Wyoming. January 25, 2012.

EnviroGroup Limited, 2012. Vapor Intrusion Evaluation Report, Casper PCE Plumes Orphan Site, Casper, Wyoming. May 2012.

.Freeze, R. A. and J. A. Cherry, 1979, Groundwater, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 604p.

Huntingdon Engineering and Environmental, Inc,1994. Downtown Casper PCE Investigation, Casper, Wyoming. 1994.

Huntingdon Engineering and Environmental, Inc,1994. North Casper PCE Investigation, Casper, Wyoming. August 5, 1994.

United States Environmental Protection Agency, 2002. OSWER Draft Guidance for Evaluation the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), EPA 530-D-02-004, November 2002.

U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, 1999. North Casper PCE Plume, Casper, Natrona County, Wyoming, CERCLIS No. WYD988869764. August 26, 1999.

Wyoming Department of Environmental Quality, 1984. *Water Quality Rules and Regulations, Chapter 11, Design and Construction Standards for Sewerage Systems, Treatment Works, Disposal Systems or Other Facilities Capable of Causing or Contributing to Pollution and Mobile Home Park and Campground Sewerage and Public Water Supply Distribution Systems. Part G, Well Construction Standards*. Wyoming Department of Environmental Quality. Available at: http://deq.state.wy.us/wqd/wqdrules/Chapter_11.pdf

Wyoming Department of Environmental Quality, 2009, DEQ Voluntary Remediation Program (VRP) Fact Sheet #12, Soil Cleanup Level Look-Up Table.

Wyoming Department of Environmental Quality, 2009, DEQ Voluntary Remediation Program (VRP) Fact Sheet #13, Groundwater Cleanup Level Look-Up Table.

Wyoming Department of Environmental Quality, 2007, Voluntary Remediation Program Fact Sheet #14, March 6, 2007.

Yeskis, D. and Zavala, B, Technology Innovative Office, Office of Solid Waste and Emergency Response, United States Environmental Protection Agency, 2002. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers (EPA 542-S-02-001), May.

TABLES

FIGURES

APPENDIX A

BOREHOLE LOGS AND WELL CONSTRUCTION FORMS

APPENDIX B

GROUNDWATER FIELD WATER QUALITY SAMPLING AND ANALYSIS FORMS

APPENDIX C

SURFACE WATER FIELD WATER QUALITY SAMPLING AND ANALYSIS FORMS

APPENDIX D

SOIL VAPOR SAMPLING LOGS

APPENDIX E

ECOLOGICAL RISK ASSESSMENT – ECOLOGICAL EXCLUSION ASSESSMENT

APPENDIX F

SOIL LABORATORY ANALYTICAL RESULTS

APPENDIX G

GROUNDWATER LABORATORY ANALYTICAL RESULTS

APPENDIX H

GROUNDWATER LABORATORY ANALYTICAL RESULTS – GRAB SAMPLES

APPENDIX I

SURFACE WATER LABORATORY ANALYTICAL RESULTS

APPENDIX J

SOIL VAPOR LABORATORY ANALYTICAL RESULTS