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Superfund Technical Assessment and Response Team 3 -
Region 8



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Expanded Site Investigation – Field Sampling Plan

PAVILLION AREA GROUNDWATER INVESTIGATION Pavillion, Fremont County, Wyoming

TDD No. 0901-01

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URS
OPERATING SERVICES, INC.

In association with:

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LT Environmental, Inc.
TechLaw, Inc.
Tetra Tech EMI
TN & Associates, Inc.

**FIELD SAMPLING PLAN
For EXPANDED SITE INVESTIGATION**

**PAVILLION AREA GW PLUME
Pavillion, Fremont County, Wyoming**

CERCLIS ID# WYN000802735

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1.0 INTRODUCTION

URS Operating Services, Inc. (UOS) has been tasked by the U.S. Environmental Protection Agency (EPA) Region 8 to conduct an Expanded Site Inspection (ESI) at the Pavillion Area Groundwater (GW) Plume site (EPA ID# WYN000802735) near the town of Pavillion, Fremont County, Wyoming. Field work for this ESI is projected to take place during the week of January 18, 2009. The Wyoming Department of Environmental Quality (WDEQ) and the Wind River Reservation Environmental Group are coordinating and cooperating with the investigation.

This Field Sampling Plan (FSP) is designed to guide field operations during the ESI, and has been prepared in accordance with Technical Direction Document (TDD) 0901-01, the EPA "Guidance for Performing Site Inspections Under CERCLA," Interim Final, September 1992, the "Region 8 Supplement to Guidance for Performing Site Inspections Under CERCLA" and the "UOS Generic Quality Assurance Project Plan" (QAPP) (U.S. Environmental Protection Agency (EPA) 1992a; EPA 1993; URS Operating Services, Inc. (UOS) 2008). The ESI field work will include sampling and non-sampling data collection. Sampling will focus primarily on drinking water wells. Sampling procedures will adhere strictly to those outlined in the UOS Technical Standard Operating Procedures (TSOPs) for field operations at hazardous waste sites (UOS 2005).

Contamination from chemicals of concern in the Pavillion area was originally alleged by local residents when visual and odor parameters for several domestic wells changed. Visual changes included yellow color, increased turbidity, oil sheen, and inclusion of small bubbles/gas. Odor change in the domestic wells can be described as a hydrocarbon odor. Prior screening sampling and analyses indicate chemicals of concern in domestic wells with unknown risks to health and unknown sources. A previous Focused Site Inspection (FSI) performed by EPA narrowed the area of concern to an area in and around 11 wells that possessed detections of methane, Volatile Petroleum Hydrocarbons (VPH), tentatively identified semivolatile organic compounds (SVOCs) and volatile organic compounds (VOCs), nitrate, arsenic, phthalates and caprolactam. These wells are located in Sections 2, 10, 11, 12, 13, 15, 17, 21, and 27 of township 3 north, range 2 east (T3N, R2E) and Section 7 of township 3 North, range 3 east (T3N,R3E) (Section 3.3.2). See section 3.3.2 for a summary of previous work.

Samples may potentially include as many as 20 domestic water well samples (depending on owner consent), 2 municipal well samples, approximately 10 product (liquid and gas phase) and produced water samples, 5 soil samples, 4 groundwater samples, 7 surface water and sediment samples, 10 "opportunity" samples to be collected at the discretion of the field team leader, and 13 field Quality Assurance/Quality Control (QA/QC)

samples (in addition to extra volume for the laboratory matrix spike/matrix spike duplicates (MS/MSD)) (Table 6). The QA/QC samples will follow the requirements of the "Region 8 Supplement to Guidance for Performing Site Inspections under CERCLA" and will include a VOC trip blank per cooler to monitor for volatile contamination during transport and one duplicate or replicate sample per matrix to measure the precision of field collection techniques and laboratory methods.

Samples will be analyzed either through the EPA Contract Laboratories Program (CLP), Routine Analytical Services (RAS), a private commercial laboratory, or sent to the EPA Region 8 Laboratory for non-routine analyses.

2.0 OBJECTIVES

The primary purpose of this ESI is to gather information for the evaluation of this site with regard to potential contamination of domestic water wells.

The specific objectives of this ESI are:

- Quantify levels of chemicals of concern in wells, in order to determine risk(s) to the extent practicable;
- Identify source(s) of chemicals of concern to the extent practicable.

3.0 BACKGROUND INFORMATION

3.1 SITE LOCATION AND DESCRIPTION

The Pavillion Area GW Plume site is located near Pavillion, Wyoming, in Fremont County (Figure 1). The site is a rural community situated southeast of Pavillion in the Wind River Basin, and is centered approximately where several complaints of foul odor and taste in domestic water wells have been levied by residents. The site is centered in the southwest quarter of Section 2, T. 3 N., R. 2 E. The latitude is 43° 15' 37.533" north and the longitude is 108° 36' 59.698" west. Land use surrounding the site is rural, with some residential properties located among fields used for agriculture, and natural gas production.

3.2 SITE CHARACTERISTICS

3.2.1 Physical Geography

The Pavillion Area Groundwater Plume site is located in the Wind River Valley, which is the major regional topographic expression. The valley is located in central Wyoming, and is approximately 200 miles long by 100 miles wide, covering an area of approximately 11,700 square miles (Fox and Dolton 1995). The site is at an elevation of approximately 5,463 feet above mean sea level and the terrain at the site slopes gently to the south (U.S. Geological Survey (USGS) 1958). The site is located in a sparsely populated rural area. The predominant vegetation in the area is a mixture of dryland grasses and shrubs (UOS 2009).

3.2.2 Geology and Hydrogeology

The site is located in the Wind River Basin, a structural and sedimentary basin in central Wyoming resulting from the Larimide Orogeny. The basin is bounded by upfolded and faulted mountain ranges resulting from the Laramide uplifts. These ranges include the Owl Creek and the Bighorn Mountains to the north, the Wind River Range to the west, the Granite Mountains to the south, and the Casper Arch to the east. (USGS 1969; USGS 2006).

Geology at the site may impact the investigation due to its complexity. Groundwater occurrence in the area is also complex and varies with location, elevation, and geologic unit. The U.S. Geological Survey (USGS) reports more than thirty water-bearing formations in the Wind River Basin, including two regional aquifers and one major aquifer (Zelt *et al.* 1999). The Wind River Basin has a complicated structure created by uplifting, folding, and faulting. The Wind River aquifer is the principal source of domestic and stock water at the site.

In the Wind River Basin, the major stratigraphic units exposed at the surface are Cretaceous, Tertiary, and Quaternary in age. The Cretaceous units include the Cody Shale, a dull gray shale, with gray siltstones and fine grained sandstones, and the Mesaverde Formation, a light colored massive to bedded sandstone with gray sandy shale and coals beds present.

Tertiary aged units include the Wind River, Fort Union, and Indian Meadows Formations. The Wind River Formation is the dominant outcrop present in the Wind River Basin and is

exposed over most of the central portion of the basin. This formation is described as a red and white claystone and siltstone unit containing a lenticular coal unit in the center of the formation, and mostly nontuffaceous except near the top (Love and Christiansen 1985). The thickness of the Wind River formation varies from just a few meters at the basin margin, to several thousands of meters thick in the northern part of the area (Seeland 1978). The Indian Meadows Formation is described as a red claystone to sandstone with limestone present; the unit also contains Paleozoic boulders and Mesozoic rocks, probably resulting from glaciations (Love and Christiansen 1985). The Indian Meadow is absent along the southwestern side of the basin, and maybe thousands of meters thick or more in the subsurface along the north side of the basin (Seeland 1978). The Fort Union Formation, the least abundant unit present in the basin, is described as a brown to gray sandstone with gray to black shale and thin coal bed.

Along with the previously mentioned formations, the basin contains various Quaternary deposits including river alluvium, gravel pediment, and fan deposits; and Pleistocene glacial deposits (Love and Christiansen 1985). Along the northern edge of the basin the Fort Union is 2,500 meters thick; along the west and south sides of the basin the formation ranges in thickness from 50 to 350 meters (Seeland 1978).

The Wind River Basin has a complicated structure created by the uplifting, folding, and faulting of the Laramide Orogeny. Various thrust faults run the length of the basin along the north and northeast boundaries. A large amount of faulting is also present in the north central to northeastern part of the basin and in the south part of the basin near the Granite Mountains (Love and Christiansen 1985). The complex geologic structure and rock formations have resulted in many structural and stratigraphic traps for hydrocarbons; consequently, drilling for natural gas and oil is common in the area (Fox and Dolton 1995). Detailed subsurface geology information is not readily available.

In addition to the hydrocarbon production in the basin, uranium deposits occur along the south and southeast basin margins (Seeland 1978, Soister 1968). Many of the lower Eocene aged strata are radioactive in the southeastern part of the basin; however, they only contain uranium minerals in a few localities (Keefer 1965).

Water-yielding, Tertiary aged formations in the basin include the White River, a highly permeable and productive unit, yielding between 1 and 1,100 liters per minute, with a

maximum reported at 3,200 liters per minute; Tepee Trail, which yields small amounts of water and is a confining layer; the Wagon Bed, which yields small amounts of water, but is not considered an aquifer; the Wasatch for which water yield is unknown; and the Wind River, which represents a major aquifer in the basin and yields water between 4 and 11,000 liters per minute. These formations contain local artesian zones, are the principal source of domestic and stock water on the Wind River Reservation, and are the major source of industrial water in the southern part of the basin. The Willwood and Fort Union Formations yield small amounts of water, although the Fort Union is not believed to be suited for domestic use. The Aycross and Indian Meadows Formations represent confining layers within the Tertiary units. A majority of the groundwater used in the region come from the younger aquifers, mostly because of the depth of the aquifers (Zelt *et al.* 1999).

3.2.3 Hydrology

Surface water and runoff generally flow south from the site to Five-Mile Creek, then eastward to the Boysen Reservoir. The annual mean flow of the Five-Mile Creek for the year of 2007 was 120 cubic feet per second (cfs) and the highest flow recorded was 253 cfs in 1999 (USGS 2008).

3.2.4 Meteorology

The climate of Wind River Valley is characterized as semiarid continental, with an annual mean precipitation of approximately 11.5 inches and an annual net precipitation of slightly more than 1 inch (University of Delaware 1986). The two-year 24-hour rainfall event for the area is approximately 1.5 inches (Dunne, Thomas and Luna B. Leopold 1978).

3.3 SITE HISTORY AND BACKGROUND RESEARCH

3.3.1 Site History

Domestic well owners in the Pavillion area have filed complaints with the Wyoming Department of Environmental Quality and USEPA Region 8, and have reported a foul odor and taste in their groundwater. Some domestic well owners suspect the foul odor and taste originates from natural gas well activity in the area.

3.3.2 Previous Work

Previous EPA field activities at the site include a site inspection conducted by UOS in 2009. This site inspection consisted of collecting of 37 residential well water and 2 municipal well water samples in Pavillion, Wyoming. Field activities were conducted from March 2 through 6, 2009, and May 14 and 15, 2009. Samples were analyzed for all or some of the following parameters: VOCs, SVOCs, Target Analyte List (TAL) total metals, pesticides, polychlorinated biphenyls (PCBs), microbiological parameters, anions, and petroleum hydrocarbons including Volatile Petroleum Hydrocarbons (VPH), and Extractable Petroleum Hydrocarbons (EPH). Samples from all 39 properties were analyzed for VOCs, SVOCs, TAL total metals, pesticides, anions, and PCBs via the EPA CLP; samples from 15 properties were analyzed for SVOC Tentatively Identified Compounds (TICs), anions, alkalinity, and methane by the EPA Region 8 Laboratory; samples from 12 properties were analyzed for VPH and EPH by a private commercial laboratory; and samples from 5 properties were analyzed for bacteriological parameters by a private commercial laboratory (UOS 2009).

TICs for SVOC compounds including adamantanes, 2-butoxyethanol phosphate, 2,4-bis(1-phenyl)-phenol, bisphenol-A, terpineol, 5-hydroxymethyltetrahydrofuran, limonene, caprolactam, dimethylphthalate, and bis(2-ethylhexyl)phthalate, were detected in groundwater samples at levels above their respective non-detect values.

Bacterial testing was conducted for five wells. Of those five wells two contained iron reducing bacteria and one contained iron and sulfate reducing bacteria. Heterotrophic plate count testing (a measure of bacterial activity) revealed bacteria at levels between 2 and 130 MPN/mL (Most Probable Number of bacterial colonies per mL).

Arsenic was detected in sample PGDW25 at 31 micrograms per liter ($\mu\text{g/L}$), which exceeds the Maximum Contaminant Level (MCL) of 10 $\mu\text{g/L}$.

VPH were detected in the petroleum analyses for samples PGDW05 and PGDW30 at 26 $\mu\text{g/L}$ and 25 $\mu\text{g/L}$ respectively.

Dissolved methane was detected in 8 domestic wells above the non-detect value.

Nitrate was detected in sample PGDW22 at 43.6 milligrams per liter (mg/L), which exceeds the MCL of 10 mg/L.

Many of the detections (arsenic, methane, adamantanes, 2-butoxyethanol phosphate, phthalates, caprolactam, and VPH) occur in a small number of wells. These wells and the surrounding area are designated as the focus of this ESI (See Figure 2).

4.0 PRELIMINARY PATHWAY ANALYSIS

4.1 SOURCE CHARACTERIZATION

If drinking water wells were being impacted by the release of contaminant(s) to an aquifer, then the pathway from source(s) of contamination to target(s) would likely involve a groundwater plume or conduit pathway. Per the Hazard Ranking System (HRS) when a plume has been identified, but no source has been detected, the plume itself is evaluated as the source. Current HRS policy is:

Occasionally, sites that consist of a plume of contaminated ground water or an area of surface water sediment contamination, with the original source of the contamination unidentified, enter the Superfund process. Before scoring such sites, efforts should be undertaken to identify the original source(s) of contamination. These efforts should be equivalent to those of an expanded SI and should include:

- *Research on site history and regulatory status;*
- *Site reconnaissance;*
- *Consideration of hazardous substances affiliated with industries of potential concern at the site;*
- *Records search and interviews with employees; and*
- *Sampling to eliminate or confirm other possible sources.*

A source should generally not be designated as "unidentified" until sampling has been undertaken in an area and a search for the original sources has been conducted (within the scope of an expanded SI). (EPA 1992b).

Potential sources include oil and natural gas production activities, agricultural sources, industrial chemicals, landowner/well owner management of wells, and well components.

Potential source pathways include:

- Downward infiltration of chemicals of concern from the surface;
- Lateral emplacement of chemicals of concern from offset wells;
- Upward migration of chemicals of concern from underlying sources;
- Direct placement of chemicals of concern in domestic water wells;
- Infiltration from surface water bodies.

4.1.1 Natural Gas Well Drilling and Completion

A potential source of foul groundwater at the site may be the result of natural gas exploration and production in the area since the site contains many natural gas wells that are currently in operation as well as many abandoned wells. Potential contaminants include chemicals used in natural gas well drilling, completion, and work-over activities. Natural gas well drilling, completion, and work-over activities involve the use of a variety of materials, some of which include hazardous compounds (see section 4.1.2).

A typical natural gas well begins with a surface casing hole being drilled. The next stage is the installation of the surface casing, a steel tube, which is placed through upper zones, to isolate drinking water aquifers, stock water aquifers, and sensitive formations, and is sealed on the outside with injected concrete. The surface casing is designed to protect sensitive aquifers from contamination by drilling fluids, fluids used for fracturing well formations, crude oil, etc. The well is then bored to a specific depth in order to reach all geologic formations intended for natural gas production. This is referred to as the “open hole” phase of drilling a well. Once a production target zone is reached, a production casing is installed and cement is once again injected outside the casing pipe and at the bottom to seal the casing. All future work and production is completed inside this casing. The well is then connected to the oil or gas reservoir by perforating the casing. At this point the well is said to be “completed.”

Next, a combination of many techniques may be used to fracture the natural gas production formation, open up the fissures in the matrix surrounding the well and stimulate production. These techniques include, but are not limited to, high pressure, acid injection, sand injection, and cold fracturing using compressed liquid gases. Finally, the production zone is isolated using a series of “packers” and a production tubing is installed. All gas and oil produced by

the well travels through the production tubing. The State of Wyoming Oil and Gas Commission (WYOGC) requires that the surface casing for all natural gas wells extend through and beyond all areas of concern including water wells and coal-bed methane formations. All “work-over water” (water to be injected into the well) must come from a treated municipal source to reduce the possibility of bacterial contamination (WYOGC 2008).

4.1.2 Chemicals Used in Natural Gas Production Activities

According to a list of drilling fluid components assembled by the EPA (EPA 2008), several different types of drilling fluids, containing several hazardous compounds, are used to install gas wells. Techniques for installing wells and their associated chemicals include the following:

Linear gel delivery systems (a polymer based gel which may be used to deliver non-soluble materials into a well) may be used for installation of gas wells and use materials containing diesel with benzene, toluene, ethyl benzene, xylene, 1-methylnaphthalene, 2-methylnaphthalene, dimethylnaphthalenes, trimethylnaphthalenes, fluorenes, phenanthrenes, and other aromatics.

Water sealing agents contain fumaric acid and the linear gel polymer contains fumaric acid and adipic acid. Gelling agents potentially used contain the following: benzene, ethyl benzene, methyl tert-butyl ether, naphthalene, polynuclear aromatic hydrocarbons, polycyclic organic matter, sodium hydroxide, toluene, and xylene.

Several different crosslinkers (chemicals used to bind two or more compounds together) may be used during the installation process. The first type of crosslinker contains boric acid, ethylene glycol, and monoethanolamine. The second type of crosslinker contains sodium tetraborate decahydrate. The third crosslinker contains ammonium chloride, potassium hydroxide, zirconium nitrate and zirconium sulfate.

Foaming agents are also used in the well development process and may contain isopropanol, salt of alkyl amines, diethanolamine, ethanol, 2-butoxyethanol (2-BE), ester salt and polyglycol ether.

Acid treatments may be used and contain either formic acid or hydrochloric acid.

Breaker fluids used may contain diammonium peroxodisulfide or ammonium persulfate, ammonium sulfate, copper compounds, ethylene glycol and glycol ethers. Microbiocide, biocide, and bactericides containing the following are used in conjunction with breaker fluids: 2-bromo-2-nitrol, 3-propanediol, 2,2-dibromo-3-nitrilopropionamide, 2-bromo-3-nitrilopropionamide, polycyclic organic matter, polynuclear aromatic hydrocarbons. Acid corrosion inhibitors are also used in the gas well installation and contain the following compounds: methanol, propargyl alcohol, pyridinium, 1-(phenylmethyl)-ethyl methyl derivative, thiourea, propan-2-ol, polyoxy-1,2-ethanediol-nonylphenyl-hydroxy (EPA 2008).

The Endocrine Disruption Exchange (TEDX) compiled a list of chemicals used in natural gas development in Wyoming (Appendix B). While the TEDX list is comparable to the EPA Study List (Appendix B), it adds several metals that may be found in compounds used in gas well installation and are as follows: aluminum oxide, arsenic, cadmium, copper, iron, lead, mercury, nickel, vanadium and zinc. Hydrogen sulfide may also be contained in drilling fluids (TEDX 2008).

The Superfund Chemical Data Matrix (SCDM) is a list of benchmark values used in the evaluation of National Priorities List (NPL) sites under the HRS. The following chemicals found in the EPA Study List and the TEDX list have a SCDM value associated with them:

TABLE 1
Hazardous Chemicals in Drilling Fluids with a SCDM Value

Chemical Name	SCDM – Drinking Water (1/28/2004) Concentration in µg/L (MCL or RBC)
Benzene	5.0
Toluene	1,000
Ethyl benzene	700
Xylene	10,000
Naphthalene	20
1-Methylnaphthalene	20
2- Methylnaphthalene	150
Fluorenes	1,500
Ethylene glycol	73,000
Formic acid	73,000
Methanol	18,250
Ethylene glycol monobutyl ether	18,000
Aluminum oxide	36,000
Arsenic	0.057
Cadmium	5
Copper	1,300
Hydrogen sulfide	10
Iron	11,000

TABLE 1
Hazardous Chemicals in Drilling Fluids with a SCDM Value

Chemical Name	SCDM – Drinking Water (1/28/2004) Concentration in µg/L (MCL or RBC)
Lead	15
Mercury	0.63
Nickel	730
Vanadium	36
Zinc	11,000

SCDM Superfund Chemical Data Matrix

MCL Maximum Contaminant Level (EPA Drinking Water Regulations)

RBC Risk-Based Concentration (EPA Region 3)

4.1.3 Historical Pesticide and Fungicide Use in Site Area

Two studies conducted in 1998 and 1999 in Fremont County, Wyoming found no pesticides at levels of concern. The quantitative analyte list for the testing that was conducted included 84 pesticides and two pesticide degradation products (USGS 2001).

4.1.3.1 2 – Butoxyethanol Phosphate

2-ButoxyEthanol Phosphate (2-BEP) was detected in three wells in the initial testing performed by EPA. 2-BEP is a potential byproduct of 2-butoxyethanol and phosphates in groundwater.

2-BEP is used as both a plasticizer and a flame retardant and may be found in domestic well components including washers, wiring, PVC pipe, and pumps.

A search of the National Pesticide Information Retrieval System (NPIRS) and the Pesticide Action Network (PAN) pesticides database, indicate while 2-BEP may have been explored as both a fungicide and microbiocide; it is not a current or historical ingredient in any pesticide, rodenticide or fungicide formulated for use in America (NPIRS 2009, PAN 2009).

4.2 GROUNDWATER PATHWAY

There is a potential for groundwater to be contaminated. The surrounding residents obtain drinking water from private domestic wells. The Wyoming State Engineer's Office has records of approximately 83 private domestic wells within the four-mile radius of the site area center. The average number of persons per household in Fremont County, Wyoming, is 2.30 (U.S. Department of the Interior, Bureau of the Census (U.S. Census Bureau) 2000). Assuming that each domestic well serves one household, the total number of residents using groundwater within the four-mile radius of the site can be calculated to be approximately 191 people. The data from the Wyoming State Engineer's Office website does not provide information on the current status of each well within the four-mile radius (Wyoming State Engineer's Office 2008).

There are two domestic primary target wells located within one-half mile of the site that serve five people (UOS 2009). Previous sampling activities at the site indicate the presence of synthetic contaminants in these wells (see section 3.3.2).

The nearest well to the center of the site is outside the one-quarter mile radius of the source and the well is located at 212 Powerline Road. The depth of the domestic well is 210 feet and serves two people.

The town of Pavillion, Wyoming, located approximately five miles northwest of the study area center area has eight municipal wells that supply water to 165 residents in 89 homes (UOS 2009).

Within the two mile radius of the site there are eight stock wells used for ranching purposes (Figure 2).

TABLE 2
Domestic Wells within a Four-Mile Radius

Radius (miles)	Number of Wells	Number of Persons served by Domestic wells
0 - 0.25	0	0
0.25 - 0.50	2	5
0.50 - 1.0	7	16
1.0 - 2.0	15	35
2.0 - 3.0	21	48
3.0 - 4.0	38	87
Total	83	191

4.3 SURFACE WATER PATHWAY

Topography of the site slopes to the south and east. The surface water overland drainage flows off the site mainly in the southeasterly direction 975 feet to the Five-Mile Creek. The annual flow rate of Five-Mile Creek is 120 cfs and the creek is considered a fishery.

Four miles of the fifteen-mile target distance limit along Five-Mile Creek consists of wetlands (Figure 2). The wetlands start approximately one-quarter mile downstream of the site with Palustrine Shrub Scrub and the remainder of the wetlands consists of Palustrine Emergent land with a scattering of Palustrine Scrub Shrub (U.S. Fish and Wildlife Service (USFWS) 1998). No drinking water intakes are documented along the 15-mile target distance limit. No electronic floodplain information could be located at the time of the preparation of this report.

Five-Mile Creek is used for recreational fishing. The following species of fish can be found in Five-Mile Creek: Burbot, Flathead Chubs, Lake Chubs, White Suckers, and Long-nose Dace. The Burbot is a game fish eaten by local residents (Wyoming Game and Fish Department (WGFD) 2009). This creek is classified as a fishery by the State of Wyoming.

Up to seven locations along Five-Mile creek will be sampled to characterize background (upstream) and downstream water quality.

4.4 SOIL EXPOSURE

The potential contamination source would be a plume that is more than two feet below the ground surface and therefore not relevant to the soil exposure pathway. There are 357 natural gas wells located in the study area. The natural gas wells are situated on graveled pads and are unsecured. Since the site includes a residential area, access is not restricted and the site is easily accessible to the public. There are no residents living within 200 feet of the center of the study area. As many as two workers are on site frequently. Approximately 59 residents live within the one-mile radius of the site area center (U.S. Census Bureau 2000).

There are no terrestrial sensitive environments identified within 200 feet of the center of the study area (UOS 2008b).

4.5 AIR PATHWAY

The site is located in a rural area on the Wind River Basin in north central Fremont County. There are 9 residents located within a quarter-mile radius of the site center (UOS 2009), and a total of 161 people within the four-mile radius. The potential contamination source at the site would be a plume that is greater than two feet below the ground surface and therefore not relevant to the air pathway. There are 357 natural gas wells located in the study area. The natural gas wells are situated on graveled pads and are unsecured. Since the site includes a residential area, access is not restricted and easily accessible to the public. The residence nearest to the site is about 975 feet southeast of the site at 212 Powerline Road.

An average of 2.3 people occupies each residence in Fremont County (U.S. Census Bureau 2000). There are sensitive terrestrial environments identified within the four-mile radius of the site. There is a State Wildlife Management Area within the one- to two-mile radius of the site and another State Wildlife Management Area is located within the three- to four-mile radius of the site (WFGD 2008).

There are 1,212 acres of wetlands located within the four-mile radius of the site. More than 1,000 acres of wetlands are part of the Ocean Lake, which is also designated as a State Wildlife Management Area (USFWS 1998).

TABLE 3
Population and Wetlands Within Four Miles of the Site

Distance from Site	Population (# of persons)	Wetlands (acres)
On Site	0	0
0 - ¼ Mile	2	0
>¼ - ½ Mile	9	0
>½ - 1 Mile	7	0
>1 – 2 Miles	39	111
>2 – 3 Miles	51	45
>3 – 4 Miles	53	1,056
Total Within 4 Miles	161	1,212

Source: National Wetlands Inventory (USFWS 1998).

See the table below for a State of Wyoming Game and Fish list of endangered and threatened species found in Fremont County (WGFD 2008).

TABLE 4
Threatened and Endangered Species in Fremont County

Species	Scientific Name	Status
Brown Pelican	<i>Pelecanus occidentalis</i>	Endangered
Wood Stork	<i>Mycteria americana</i>	Endangered
Bald Eagle	<i>Haliaeetus leucocephalus</i>	Threatened
Whooping Crane	<i>Grus americana</i>	Endangered
Piping Plover	<i>Charadrius melodus</i>	Endangered
Least Tern	<i>Sterna antillarum</i>	Endangered
Passenger Pigeon	<i>Ectopistes migartorius</i>	Extinct
Gray Wolf	<i>Canis lupus</i>	Threatened
Grizzly Bear	<i>Ursus arctos</i>	Threatened
Black-footed Ferret	<i>Mustela nigripes</i>	Endangered
Canada Lynx	<i>Lynx canadensis</i>	Threatened

5.0 DATA QUALITY OBJECTIVES PROCESS

The EPA Data Quality Objectives (DQO) Process is a seven-step systematic planning approach to develop acceptance or performance criteria for EPA-funded projects. The seven steps of the DQO process are:

- Step 1 The Problem Statement;
- Step 2 Identifying the Decision;
- Step 3 Identifying the Decision Inputs;
- Step 4 Defining the Investigation Boundaries;
- Step 5 Developing a Decision Rule;
- Step 6 Defining Tolerance Limits on Decision Errors; and
- Step 7 Optimizing the Sample Design.

These DQOs were developed by UOS and EPA based on information provided by research performed in the Preliminary Assessment and sampling results from the Site Inspection.

Based upon the potential risks associated with the potential hazardous substances, the project team identified groundwater as the pathway of potential concern at the site. These risks and possible pathways of concern are presented in the Conceptual Site Model in Figure 3.

Project Objectives

- Quantify levels of chemicals of concern in wells, in order to determine risk(s) to the extent practicable;
- Identify source(s) of chemicals of concern to the extent practicable.

Step 1: Problem Statement

- Contamination due to chemicals of concern in the Pavillion area was originally alleged by local residents when visual and odor parameters for domestic wells changed. Visual changes included color, turbidity, sheen and inclusion of small bubbles/gas. Odor changes can be described as a hydrocarbon odor.
- Through screening sampling and analysis, chemicals of concern have been found in domestic wells with unknown risk to health and unknown sources.
- The previous investigation has narrowed the focus of the area of concern to an area in and around the 11 wells with methane, GRO, and SVOCs found in the dissolved aqueous phase. These wells are located in Sections 2, 10, 11, 12, 13, 15, 17, 21, and 27 of T. 3 N., R. 2 E., and Section 7 of T. 3 N., R. 3 E. (see Section 3.3.2).
- Chemicals of concern discovered in the original investigation include: methane, VPH, tentatively identified SVOCs and VOCs, nitrate, arsenic, phthalates and caprolactam.
- Possible health risks:
 - Arsenic was above the MCL in one well;
 - There exists an uncharacterized risk from SVOCs (caprolactam, dimethylphthalate, bis(2-ethylhexyl)phthalate, and TICs) See section 3.3.2 for a list of TICs;
 - Dissolved methane (explosivity potential); and
 - VPH was detected above 20 parts per million (ppm) in several wells.

Conceptual Site Model (Appendix C)

- The depths of the domestic wells within the area range between 20 and 750 feet below ground surface.
- The principal industries in the area of concern are natural gas production and agriculture.

- Domestic wells show chemicals of concern.

- Potential sources include oil and natural gas production activities, agricultural sources, industrial chemicals, landowner/well owner management of wells, and well components.

- Materials/compounds used within the site area.

- Hydrogeology (depth of freshwater zones used for drinking water, gas production zone depths, vertical and lateral permeability characterization, water chemistry changes with depth).

- Potential source pathway analysis:
 - Downward infiltration of chemicals of concern from the surface;
 - Lateral emplacement of chemicals of concern from offset wells;
 - Upward migration of chemicals of concern from underlying sources; and
 - Direct placement of chemicals of concern in domestic water wells.
 - Infiltration from surface water bodies

Step 2: Identifying the Decision

- The principal investigation questions that must be addressed:
 - What are the levels of chemicals of concern in wells?
 - What are the source(s) of chemicals of concern found in well water?

Step 3: Identifying the Inputs to the Decision

- Types of information that will be gathered:
 - Site Conceptual Model (see above discussion);
 - Determine pathway(s) for chemicals of concern;
 - Chemicals of concern (identify and quantify); and
- Various sources of information that might be used:
 - Natural gas extraction industry: Material Safety Data Sheets (MSDSs), and Product trade names of substances that are put down-hole into production wells or used on their sites;
 - Information from local agricultural businesses regarding pesticide applications;
 - State regulatory agencies (Wyoming Oil and Gas Conservation Commission (WOGCC), WDEQ);

- State and local assistance agencies (Fremont County Health, Agricultural Extension Agencies);
 - Interviews to determine chemical management practices by individuals at or near domestic wells;
 - Federal regulatory agencies (EPA, Bureau of Land Management (BLM), BIA); and
 - Historical sampling and analysis, reports.
- Define the decision values for determining if additional action may be required:
 - MCLs;
 - Integrated Risk Information System (IRIS);
 - Health risk benchmarks from EPA Regional Screening Levels (RSLs); and
 - Risk evaluations for specific compounds by the U.S. Agency for Toxic Substances and Disease Registry.
- Define the evidence to assist with determining the source of chemicals of concern:
 - Chemicals of concern exist in source and well/aquifer; and
 - Chemicals of concern pathway(s) identified.
- Potential Samples (See Table 6):
 - Samples of groundwater and soil from waste pits undergoing voluntary cleanup;
 - 11 wells of concern and adjacent natural gas extraction wells (additional wells may be sampled at the discretion of the Field Team leader);
 - Three to five domestic wells that were not sampled in the SI;
 - 2 Municipal well samples;
 - Up to seven surface water and sediment samples from Five-Mile Creek to assess surface water quality; and
 - One or more natural gas extraction wells (samples to include gas and, if present, liquid phases from both production tubing and bradenhead space).

Test Methods (See Table 10):

- Specific Analyte Testing (to determine human health risk and document release from specific source):
 1. Alcohols, Ketones, 2-Butoxy Ethanol, and Glycols by 8015;
 2. Low-level VOCs and SVOCs (SW-846 8260/8270) by GC/MS (SIM/Full Scan);
 3. Low-level VOCs by Gas Chromatograph/Mass Spectrometer (GC/MS);
 4. 8015 VPH/EPH/OH;
 5. LC TOFF MS;
 6. VOCs, SVOCs, TAL, pesticides, PCBs, and anions, and
 7. Bacteriological testing for iron and sulfur reducing bacteria.

- Hydrocarbon Fingerprinting (to document release from specific source):
 1. Light Gases C1 – C5 nine compounds (identify whether methane is coal or petroleum based);
 2. Polar Fractions (fingerprinting);
 3. Chromatogram Fingerprinting; and
 4. Low level VPH/EPH.

- Stable Isotope Analyses (to document release from specific source):
 1. dD/H, d18O of groundwater (fingerprint groundwater);
 2. dD/H, d13C, d15N, d34S of produced water, condensate, and Bradenhead space (fingerprint hydrocarbons);
 3. 13C/12C of Methane (c1), c2, c3, n-c4, I-c4 or Total c4; (fingerprint methane); and
 4. D/H of c1 (methane), c2, c3, n-c4, I-c4 or total c4 (methane origin: bacterial or petrogenic).
 5. Strontium isotope testing.

- Additional Domestic Water Analyses:

6010 Metals	8260 VOC
6020 Metals	8270 SVOC
8081 Pesticides	300.1 Anions
8082 PCBs	8015 VPH/EPH/OH

Step 4: Defining the Investigation Boundaries

The study area is defined as a four-mile radius loosely centered on the domestic wells that had detections of chemicals of concern in the SI sampling and includes 15-mile section of Five-Mile Creek (see Figure 1). The target population is primarily residents within the study area who use water from domestic wells.

Step 5: Developing a Decision Rule

- Values for determining if additional action may be required:
 - MCLs (See Tables 10 and 11);
 - IRIS;
 - Health risk benchmarks from EPA Regional Screening Levels (See Tables 10 and 11); and
 - Risk evaluations for specific compounds by the U.S. Agency for Toxic Substances and Disease Registry.

Step 6: Defining Tolerance Limits on Decision Errors

Due to limited sources of samples from existing wells and potentially installed monitoring wells, judgmental sampling will be used for this project. Judgmentally based samples can not be analyzed by statistical means. Therefore, error in the data will be controlled by:

- Adhering to the project FSP, TSOPs, and the START QAPP (UOS 2008);
- Validation of data, especially data addressing human health issues; and
- Achieving data quality goals as stated in section 8.0 of the FSP.

Step 7: Optimizing the Sample Design

Additional samples may be collected at the discretion of the EPA Site Assessment Manager based on data obtained during field work. Likewise, some samples may not be collectable during the site visit due to weather, seasonal variations in flow and groundwater levels, etc. Before sampling activities take place, non-sampling data that have been obtained at that point will be used to evaluate options and choose the sampling design that best meets the DQO criteria.

6.0 FIELD PROCEDURES

6.1 CONCEPT OF OPERATIONS

6.1.1 Schedule

Sampling is planned to take place during the week of January 18, 2009, weather permitting.

6.1.2 Safety

All field activities will be conducted in strict accordance with an approved UOS Site Health and Safety Plan, which will be developed before the start of field activities. It is anticipated that all field work can be accomplished in Level D personal protective equipment. Samples collected at natural gas production facilities will be collected in accordance with the UOS Health and Safety Plan, as well as the Health and Safety Plan of the natural gas production facility.

6.1.3 Site Access and Logistics

UOS will obtain site access with the assistance, if necessary, of the EPA Region 8 Site Assessment Manager for this site. UOS will have written consent from all applicable property owners (on site and off-site) prior to the field sampling event.

6.2 SAMPLE LOCATIONS

This ESI involves the collection of approximately 56 field samples (Figure 2) (Tables 6 and 8). These samples will potentially include as many as 20 domestic well water samples (depending on owner consent), 2 municipal well samples, approximately 10 product and produced water samples, 5 soil samples, 4 groundwater samples, 7 surface water and sediment samples, 10 opportunity samples (to be collected at the discretion of the field team leader, and 13 field QA/QC samples (in addition to extra volume for the laboratory MS/MSD) (Table 6). All sample points will be located on a topographic map with a Global Positioning System (GPS) device after sample collection. This procedure will allow documentation of changes in sample locations as they occur in the field due to unanticipated site conditions.

Samples will be collected from domestic water wells in the area.

6.3 SAMPLING METHODS

6.3.1 Groundwater Sampling (Domestic Wells)

Groundwater sampling will be conducted according to the procedures outlined in UOS TSOP 4.12, "Groundwater Sampling." UOS will measure field parameters including pH, temperature and electrical conductivity of each sample collected as described in TSOP 4.14 "Water Sample Field Measurements." All groundwater sampling locations will be photographed and documented in accordance with the procedures outlined in UOS TSOP 4.5, "Sample Location Documentation" (UOS 2005). Additionally, all groundwater sample locations will be located with a GPS unit to record the precise location and elevation of the ground surface where groundwater was acquired.

Samples collected from domestic wells will be collected, handled, stored, and shipped separately from product (liquid and gas phase), produced water, and soil samples. Samples will be collected from domestic wells as close to the well as possible, thus avoiding cross-contamination of samples by household plumbing, pressure systems, treatment systems, leaks, etc. Domestic well purges will exceed the volume of any pressure tank or storage device located in the water line between the well and the sample. Once the purge volume exceeds the holding capacity of the system, water parameters including pH, conductivity, and temperature will be monitored until all three parameters stabilize such that three successive measurements are within 10 percent of each other. After all of these requirements have been satisfied, sampling will begin.

6.3.2 Soil Sampling

Soil samples will be collected using a Geoprobe® truck-mounted direct-push drill rig. A photo ionization detector will be used to screen soil cores and identify potential samples to profile subsurface soil contamination. Sampling procedures will be in accordance with UOS TSOP 4.16, "Surface and Shallow Depth Soil Sampling" and UOS TSOP 4.27 "Basic Geoprobe® Operations." The Macro-Core® open-tube soil core will be used to collect samples starting at ground surface and terminating at groundwater or the evident extent of

contamination. Each soil core is four feet long, and must be extracted after every four-foot “throw” of the Geoprobe® hammer. Soil core descriptions will be logged in the field log book with standard geologic descriptions, sample date and time, and GPS location.

6.3.3 Surface Water and Sediment Sampling

Surface water sampling will be conducted according to UOS TSOP 4.18, “Surface Water Sampling” or by immersing the sample bottles directly into the sample media. UOS will measure field parameters, which include pH, temperature and electrical conductivity of each sample collected as described in TSOP 4.14 “Water Sample Field Measurements.” All data will be recorded on appropriate sample forms. Sampling will be conducted from the farthest downstream location to the farthest upstream location to minimize the potential for cross contamination. All surface water sample locations will be photographed and documented during sampling activities (UOS 2005). If wetlands are observed in the field, they will be assessed to determine if they meet the 40 CFR 230.3 Definition of a Wetland; this information will be entered into the log book. Sediment samples will be collected from the capillary fringe of the water body bank.

6.3.4 Product and Produced Water Sampling

Product and produced water sampling will be conducted according to UOS TSOP 4.21, “Tank Sampling” UOS will measure field parameters, which include pH, temperature and electrical conductivity of each produced water sample collected as described in TSOP 4.14 “Water Sample Field Measurements.” All data will be recorded on appropriate sample forms. Samples will be collected using bailers, bacon bombs, thief samplers, or dippers; if appropriate, samples may be collected from a tank valve. Samples of gas phase product will be collected from the wellhead after the pressure at the sampling point has been recorded.

6.4 CONTROL OF CONTAMINATED MATERIALS

Investigation-derived waste (IDW) generated during the ESI will be handled in accordance with UOS TSOP 4.8, "Investigation Derived Waste Management," and the OERR Directive 9345.3-02, "Management of Investigation Derived Waste During Site Inspections," May 1991 (UOS 2005; EPA 1991).

6.5 ANALYTICAL PARAMETERS

Table 8, the Sample Plan Checklist, lists all sample parameters. All samples will be analyzed by UOS, the EPA CLP RAS, a private laboratory, or the EPA Region 8 Laboratory as shown in Table 10.

6.5.1 Field Analytical Parameters

UOS will measure field parameters including pH, temperature and electrical conductivity of each sample collected as described in TSOP 4.14 "Water Sample Field Measurements."

6.5.2 Laboratory Analytical Parameters

Routine analyses will be performed via the EPA CLP RAS program and will include TICs where applicable.

Non-routine analyses will be performed by the EPA Region 8 Laboratory and private commercial laboratories.

7.0 CHAIN OF CUSTODY

After sample collection and identification, all samples will be handled in strict accordance with the chain-of-custody protocol specified in UOS TSOP 4.3, "Chain of Custody" (UOS 2005).

8.0 MEASUREMENT QUALITY OBJECTIVES

8.1 FIELD QUALITY CONTROL PROCEDURES

All samples will be handled and preserved as described in UOS TSOP 4.2, "Sample Containers, Preservation, and Maximum Holding Times." Calibration of the pH, temperature, and conductivity meters will follow instrument manufacturers' instruction manuals and UOS TSOP 4.14, "Water Sample Field Measurements" (UOS 2005).

All sampling equipment will be decontaminated prior to initial use. All non-disposable sampling equipment will be decontaminated after the collection of each sample in accordance with UOS TSOP 4.11, "Equipment Decontamination." Basic decontamination will consist of washing or brushing gross particulate off sampling equipment with domestic well water and a scrub brush, followed by washing equipment with a solution of Liquinox® and distilled water, rinsing with distilled water, rinsing with methanol and/or nitric acid, and a final rinsing with distilled water. After decontamination, the equipment will be allowed to gravity drain, dry, and then will be wrapped in aluminum foil to minimize potential contamination (UOS 2005).

The following samples will be collected to evaluate quality assurance at the site in accordance with the "Guidance for Performing Site Inspections under CERCLA," Interim Final September 1992, the "Region 8 Supplement to Guidance for Performing Site Inspections under CERCLA," and the UOS Generic QAPP (EPA 1992a; EPA 1993; UOS 2008):

- One trip blank per sample cooler for VOC analyses will be collected for the site;
- One field blank per test for CLP and Region 8 Laboratory tests;
- An equipment rinsate may be obtained, dependent upon the use of non-dedicated sampling equipment;
- A representative duplicate sample will be collected per every 20 samples per matrix; and
- Triple volume samples will be collected at the same frequency as matrix duplicate samples and used for an MS/MSD (the triple volume samples will not be labeled as separate samples).

The UOS Generic QAPP serves as the primary guide for the integration of QA/QC procedures for the START 3 contract (UOS 2008).

8.2 DATA QUALITY INDICATORS

Data quality assessment to determine data quality and usability will include:

- A QA/QC review of field generated data and observations;
- Individual data validation reports for all sample delivery groups;
- Review of the procedures used by the validator to qualify data for reasons related to dilution, reanalysis, and duplicate analysis of samples;
- Evaluation of QC samples such as, trip blanks, equipment rinsates, field replicates, and matrix spike laboratory control samples to assess the quality of the field activities and laboratory procedures;
- Assessment of the quality of data measured and generated in terms of accuracy, precision, and representativeness; and
- Summary of the usability of the data, based upon the assessment of data conducted during the previous steps.

Quality attributes include qualitative and quantitative characteristics of the collected data. The principle qualitative attributes of environmental studies are precision, bias, representativeness, comparability, completeness, and sensitivity. Data quality indicators (DQIs) are specific indicators of quality attributes.

Performance criteria address the collection of samples and acceptance criteria address the use of the data collected (EPA 2002). Performance criteria for each DQI are documented below:

8.2.1 Bias

Bias is systematic or persistent distortion of a measurement process that causes errors in one direction. The extent of bias will be determined by an evaluation of laboratory initial calibration/continuing calibration verification, laboratory control spike/laboratory control spike duplicates, blank spike, MS/MSD, and method blank.

8.2.2 Sensitivity

Sensitivity generally refers to the capability of a method or instrument to discriminate between small differences in analyte concentration. Detection limits and project requirements will be compared in order to select a method with the necessary detection limits to meet the project goals. Data validation will include a review of final reporting limits to determine if matrix issues such as dilution and interferences have affected the end use of the data.

8.2.3 Precision

Precision is the measure of agreement among repeated measurements of the same property under identical, or substantially similar, conditions and is expressed as the relative percent difference (RPD) between the sample pairs. Overall sample precision will be monitored using a duplicate or replicate for each matrix. Acceptance criteria in RPD are: water ± 20 percent, soil ± 30 percent, and sediment ± 35 percent.

8.2.4 Representativeness

Representativeness is the measure of the degree to which data accurately and precisely represents a characteristic of a population parameter, variations at a sampling point, a process condition, or an environmental condition. Representativeness will be achieved by adherence to TSOPs for sampling procedures, field and laboratory QA/QC procedures, appropriateness of sample location, and achieving the acceptance criteria laid out in the FSP.

8.2.5 Completeness

Percent completeness is calculated using the following formula: *Percent Completeness = Number of Valid Measurements/ Number of Measurements Planned X 100*. The actual percentage of completeness is less important than the effect of completeness on the data set. The effect of any non-valid data points on the end use of the data will be evaluated in the analytical results report.

8.2.6 Comparability

Comparability is used to describe how well samples within a data set, as well as two independent data sets, are interchangeable. Comparability will be controlled by collecting all samples in one sampling event adherence to the FSP. The impact to the end use of the data caused by deviations from the FSP or relevant weather events will be discussed in the analytical results report.

9.0 DATA QUALITY ASSESSMENT AND REPORTING

UOS will prepare a Sampling Activities Report (SAR) within 30 days of the conclusion of field activities. An Analytical Results Report (ARR) is scheduled to be submitted within six weeks after the receipt of the validated analytical results. Data validation may be conducted by EPA Region 8 or a UOS contracted validator when appropriate. The SAR and ARR will conform to the “Guidance for Performing Site Inspections under CERCLA,” Interim Final September 1992 and the “Region 8 Supplement to Guidance for Performing Site Inspections under CERCLA” (EPA 1992a; EPA 1993).

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Figure 1 Site Location and Area of Influence Map

Figure 2 Potential Sample Location Map

Figure 3 Pavillion Area Groundwater Plume Site – Conceptual Site Model

TABLE 6
Sample Locations and Rationale

Matrix	Sample #	Location	Rationale
Domestic well water	PGDW03	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW04	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW05	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW10	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW20	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW22	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW23	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW25	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW30	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW32	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW35	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW39	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW40	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW41	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW42	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW43	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW44	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW45	Domestic Well	Identify potential drinking water contaminants.
Municipal Well	PGPW01	Pavillion Municipal Well	Identify potential drinking water contaminants.
Municipal Well	PGPW02	Pavillion Municipal Well	Identify potential drinking water contaminants.
Domestic well water	PGDW46	Domestic Well	Identify potential drinking water contaminants.
Domestic well water	PGDW47	Domestic Well	Identify potential drinking water contaminants.
Product	PGPP01	Natural gas well condensate, gas or produced water	Identify potential source.
Product	PGPP02	Natural gas well condensate, gas or produced water	Identify potential source.
Product	PGPP03	Natural gas well condensate, gas or produced water	Identify potential source.
Product	PGPP04	Natural gas well condensate, gas or produced water	Identify potential source.
Product	PGPP05	Natural gas well condensate, gas or produced water	Identify potential source.
Product	PGPP06	Natural gas well condensate, gas or produced water	Identify potential source.
Soil	PGSO01	Waste Pit 24-3	Identify potential source.
Soil	PGSO02	Waste Pit 14x-11	Identify potential source.
Soil	PGSO03	Waste Pit 42x-11	Identify potential source.
Soil	PGSO04	Waste Pit 33-10	Identify potential source.
Soil	PGSO05	Waste Pit TBD	Identify potential source.
Groundwater	PGMW01	Monitoring Well 24-3#1	Identify potential source.
Groundwater	PGMW02	Monitoring Well 14x-11#6	Identify potential source.
Groundwater	PGMW03	Monitoring Well 42x-11#4	Identify potential source.
Groundwater	PGMW04	Monitoring Well TBD	Identify potential source.

TABLE 6
Sample Locations and Rationale

Matrix	Sample #	Location	Rationale
Surface Water/ Sediment	PGSW01 PGSE01	TBD Five-Mile Creek	Establish Background
Surface Water/ Sediment	PGSW02 PGSE02	TBD Five-Mile Creek	Identify potential source.
Surface Water/ Sediment	PGSW03 PGSE03	TBD Five-Mile Creek	Identify potential source.
Surface Water/ Sediment	PGSW04 PGSE04	TBD Five-Mile Creek	Identify potential source.
Surface Water/ Sediment	PGSW05 PGSE05	TBD Five-Mile Creek	Identify potential source.
Surface Water/ Sediment	PGSW06 PGSE06	TBD Five-Mile Creek	Identify potential source.
Surface Water/ Sediment	PGSW07 PGSE07	TBD Five-Mile Creek	Identify potential source.
QA/QC	PGDW05D	Field duplicate of sample PGDW05	Document the precision of sample collection procedures and laboratory analysis.
QA/QC	PGPP01D	Field duplicate of sample PGPP01	Document the precision of sample collection procedures and laboratory analysis.
QA/QC	PGMW01D	Field duplicate of sample PGMW01	Document the precision of sample collection procedures and laboratory analysis.
QA/QC	PGSW02D	Field duplicate of sample PGSW02	Document the precision of sample collection procedures and laboratory analysis.
QA/QC	PGSO01D	Field duplicate of sample PGSO01	Document the precision of sample collection procedures and laboratory analysis.
QA/QC	PGDW05 MS/MSD	Matrix Spike/ Matrix Spike Duplicate	Document analytical method precision and analyte recovery on native samples.
QA/QC	PGPP01 MS/MSD	Matrix Spike/ Matrix Spike Duplicate	Document analytical method precision and analyte recovery on native samples.
QA/QC	PGMW01 MS/MSD	Matrix Spike/ Matrix Spike Duplicate	Document analytical method precision and analyte recovery on native samples.
QA/QC	PGSW02 MS/MSD	Matrix Spike/ Matrix Spike Duplicate	Document analytical method precision and analyte recovery on native samples.
QA/QC	PGSO01 MS/MSD	Matrix Spike/ Matrix Spike Duplicate	Document analytical method precision and analyte recovery on native samples.
QA/QC	PGFB01	Field Blank	Field Blank
QA/QC	PGRB01	Rinsate Blank	Document decontamination procedures for non- disposable equipment.
QA/QC	PPTB01	VOC Trip Blank (one per cooler)	Document potential for VOC contamination via transport.

Sample designation – PPDW01:

PP = Pavillion Area Groundwater Plume Site

*DW = DW = Drinking Water, PW = Municipal Water, GW = Ground Water, SE =
 Sediment, SW = Surface Water, PP = Product Sample, SO = Soil Sample, TB =
 Trip Blank*

01 = sample number

TABLE 7
Non-Sampling Data Collection Rationale

Data Element	Data Collection Strategy and Rationale
MSDSs, Product Names	Acquire trade names and ingredients of chemicals used in natural gas well activities.
Historical Pesticide Use	Acquire pesticide land application data from federal, state, and local sources.
Historical Data	Acquire relevant data from state regulatory agencies (WOGCC, WDEQ).
Historical Data	Acquire data from local assistance agencies (Fremont Co. Health, Agricultural Extension Agencies (Fremont Co. Health, Agricultural Extension Agencies).
Historical Data	Acquire historical sampling and analysis reports.
Historical Data	Acquire historical data from federal regulatory agencies (EPA, BLM, BIA).

TABLE 8
Sample Plan Checklist

Sample Location	Sample Type	Field Parameters			CLP Analyses	Hydrocarbon Fingerprinting Analyses	Stable Isotope Testing	Specific Analyte Testing	Bacterial Testing	Region 8 Laboratory	Quality Control Samples		
		Temp	pH	Cond							Dup	Spike	Blank
PGDW03 – 47 PGPW01 - 02	Drinking Water Municipal Water	X	X	X	X	(Subset of 5 wells)	(Subset of 5 wells)	X	X	X			
PGPP01 - 06	Product					X	X	X		X			
PGSO01 – 05	Soil	X	X	X	X			X		X			
PGMW01 - 04	Groundwater	X	X	X	X			X	X	X			
PGSW01- 07	Surface Water	X	X	X	X					X			
PGSE01- 07	Sediment				X					X			
PGDW05D	Drinking Water	X	X	X	X	X	X	X		X	X		
PGPP01D	Product					X	X	X		X	X		
PGMW01D	Groundwater	X	X	X	X	X	X	X		X	X		
PGSW02D	Surface Water	X	X	X	X	X	X	X		X	X		
PGSO01D	Soil				X	X	X	X		X	X		
PGDW05 MS/MSD	Drinking Water	X	X	X	X	X	X	X		X		X	
PGPP01 MS/MSD	Product				X	X	X	X		X		X	
PGMW01 MS/MSD	Groundwater	X	X	X	X	X	X	X		X		X	
PGSW02 MS/MSD	Surface Water	X	X	X	X	X	X	X		X		X	
PGSO01 MS/MSD	Soil				X	X	X	X		X		X	
PGRB01	Rinsate Blank				X	X	X	X		X			X
PGFB01	Field Blank				X	X	X	X		X			X
PGTB01	Trip Blank (One per Cooler)				VOCs Only	VOCs Only	VOCs Only	VOCs Only		VOCs Only			X

TABLE 9
Sample Container Types, Volumes, and Sample Preservation

Sample Matrix	Analysis ⁵	Analytical Method Number *	Required Detection Limits ¹	Units	Container Number and Type ²	Required Volume	Preservation ³	Technical Holding Time ⁴
Soil	Total Metals	CLP-SOW ILM05.3/5.4	0.2 - 5,000	µg/L	1 - AGB	8 oz	Cool to 4° C; Nitric Acid to pH <2	6 months
Soil	VOC	CLP-SOW OLC02.1	10 - 20	µg/L	1 - AGB	4 oz	Cool to 4° C; HCl to pH <2	14 Days
Soil	SVOC	CLP-SOW OLC02.1	10 - 25	µg/L	1 - AGB	8 oz	Cool to 4° C	14 Days
Soil	Pest/PCB	CLP-SOW OLC02.1	20-30	µg/L	1 - AGB	8 oz	Cool to 4° C	14 Days
Soil	8015 VPH	EPA 8015	screening	µg/L	1 - AGB	8 oz	Cool to 4° C	14 Days
Soil	8015 EPH	EPA 8015	screening	µg/L	1 - AGB	8 oz	Cool to 4° C	14 Days
Soil	non CLP volatiles	EPA 8260	screening	µg/L	1 - AGB	8 oz	Cool to 4° C	14 Days
Soil	SVOCs by LC/MS-TOF	EPA 8321B	screening	µg/L	1 - AGB	8 oz	Cool to 4° C	14 Days
Soil	non CLP semi-volatiles	EPA 8270	screening	µg/L	1 - AGB	8 oz	Cool to 4° C	14 Days
Soil	LC/MS/MS/MS	SW-846 8330 Mod	30	µg/L	1 - AGB	8 oz	Cool to 4° C	7 Days
Water	Total Metals	CLP-SOW ILM05.3/5.4	0.2 - 5,000	µg/L	2 - HDPE	1 liter	Cool to 4° C; Nitric Acid to pH <2	6 months
Water	VOC	CLP-SOW OLC02.1	1 - 20	µg/L	3 - AGV	40 ml	Cool to 4° C; HCl to pH <2	14 Days
Water	SVOC	CLP-SOW OLC02.1	5 - 25	µg/L	2 - AGB	1 liter	Cool to 4° C	7 Days
Water	Pest/PCB	CLP-SOW OLC02.1	0.5 - 5.0	µg/L	2 - AGB	1 liter	Cool to 4° C	7 Days
Water	8015 EPH	EPA 8015	1	mg/L	2 - AGB	1 liter	Cool to 4° C	7 Days
Water	8015 VPH	EPA 8015	5	µg/L	3 - amber VOA	40mL	Cool to 4° C	14 Days
Water	Inorganic Anions	EPA 300	0.002 – 0.02	mg/L	1 –HDPE 250 mL	At least 50 mL	Cool to 4° C	14 days

TABLE 9
Sample Container Types, Volumes, and Sample Preservation

Sample Matrix	Analysis ⁵	Analytical Method Number *	Required Detection Limits ¹	Units	Container Number and Type ²	Required Volume	Preservation ³	Technical Holding Time ⁴
Water	Alkalinity	EPA 310.1	1	mg/L	1 –HDPE 250 mL	At least 200 mL	Cool to 4° C	14 days
Water	HPC by Simplate	SM9215	1 – 1,000,000	MPN/mL	sterile 125mL plastic container	At least 100mL	Ice (< 10° C without freezing)	30 hours
Water	SRB by BART™ Biodetector	Modified Multiple Tube Method (SM9221)	10 to 1,000,000	MPN/100mL	sterile 125mL plastic container	At least 100mL	Ice (< 10° C without freezing)	30 hours
Water/Product	Stable Isotope	IRMS	1	µg/L	2 - AGB	1 Liter	Cool to 4° C	7 Days
Water/Product	LC/MS/MS/MS	SW-846 8330 Mod	1	µg/L	2 - AGB	1 liter	Cool to 4° C	7 Days
Water/Product	Light Gases	EPA 8260 Mod	1	µg/L	2 - AGV	20 mL	Cool to 4° C	14 Days
Water/Product	SVOCs by LC/MS-TOF	EPA 8321B	screening	µg/L	2 - AGB	1L	Cool to 4° C	7 Days
Water/Product	non CLP semi-volatiles	EPA 8270	screening	µg/L	2 - AGB	1L	Cool to 4° C	7 Days
Water/Product	non CLP volatiles	EPA 8260	screening	µg/L	3 - AGB	40mL	Cool to 4° C	14 Days
Water	pH/Temp/Cond	Field meter	NA	NA	NA	NA	NA	NA

1 Detection limits are presented in this table as ranges. Values are based on method specifications and on project DQOs.

2 Recommended container types: AGV = amber glass vial; HDPE = high density polyethylene bottle and cap; AGB - amber glass bottle.

3 Preserve the samples as soon as they are collected. Add required preservatives to filtered samples following filtration. Completely fill containers used for volatile organic samples, permitting no head space.

4 Technical holding time is the time interval from sample collection until sample analysis (or until sample extraction for semi-volatile compounds). Technical holding times are determined by method and by matrix.

5 Analysis: Volatile Organic Compounds (VOCs); Semi-Volatile Organic Compounds (SVOCs); Pest/PCB = Pesticides and Polychlorinated Biphenyls; Volatile Petroleum Hydrocarbons (VPH); Extractable Petroleum Hydrocarbons (EPH); Contract Laboratory Program (CLP); Heterotrophic Plate Count (HPC); Sulfur Reducing Bacteria (SRB); Liquid Chromatography (LC); Mass Spectrometry (MS); Time of Flight (TOF); Conductivity (Cond);

Table 10
Sample Analyses

Laboratory	Test	Analysis Category	Purpose	Number of Samples
Forensic Geochemistry Lab	Hydrocarbon composition in water	Fingerprint Source	Needed to interpret Isotope work	small subset
Forensic Geochemistry Lab	Strontium Stable Isotope	Fingerprint Source	Fingerprint source	small subset
Forensic Geochemistry Lab	Carbon and hydrogen isotope ratios of methane	Fingerprint Source	Determine methane source (coal, bacteria, natural gas)	small subset
Forensic Geochemistry Lab	C1-C5 hydrocarbons and fixed gas, production gases	Fingerprint Source	Fingerprint of production gas	small subset
Forensic Geochemistry Lab	C3-C10 hydrocarbon composition by GC/MS	Fingerprint Source	Fingerprint of dissolved gases	small subset
Forensic Geochemistry Lab	C10-C40 alkane analysis by GC/FID	Fingerprint Source	Fingerprint of dissolved gases	small subset
Forensic Geochemistry Lab	C3-C44 hydrocarbon composition,	Fingerprint Source/ Human Health	Fingerprint of liquid product	small subset
Commercial Lab	8300 Glycols, Ketones, and Alcohols	Fingerprint Source/ Human Health	Low level analysis for common frac and drilling compounds	all wells
Commercial Lab	8015 GRO/DRO	Fingerprint Source/ Human Health	Hydrocarbon analysis with lower reporting limits	all wells
Commercial Lab	HPC by Simplate	Bacterial	Total heterotrophic bacteria present	Domestic and monitoring wells
Commercial Lab	SRB by BART™ Biodetector	Bacterial	Iron and sulfur reducing bacteria presence	Domestic and monitoring wells
Region 8 Lab	TOF specific analyte Testing	Fingerprint Source/ Human Health	Test for polar compounds	all wells
Region 8 Lab	8260 Low-level VOC	Fingerprint Source/ Human Health	Non-polar compounds (low level)	all wells
Region 8 Lab	8270 Low-level SVOC	Fingerprint Source/ Human Health	Non-polar compounds (low level)	all wells
Region 8 Lab	RSK-175 Light Gases P, M, E, B	Fingerprint Source/ Human Health	Methane source (coal, bacteria, natural gas) all wells	all wells
Region 8 Lab	Anions + Alkalinity	Aquifer Chemistry	Determine how wells and aquifers are interrelated	all wells
EPA CLP Laboratory	CLP Volatiles	Standard Drinking Water Testing	Standard drinking water testing	all wells
EPA CLP Laboratory	CLP Semi-Volatiles	Standard Drinking Water Testing	Standard drinking water testing	all wells
EPA CLP Laboratory	CLP Metals	Standard Drinking Water Testing	Standard drinking water testing	all wells
EPA CLP Laboratory	CLP PCBs + Pesticides	Standard Drinking Water Testing	Standard drinking water testing	all wells

TABLE 11
Inorganic Drinking Water Benchmarks

Substance Name	CLP Reporting Limits (CRQL)		SCDM (Drinking Water) (1/28/2004)			Region 3 RBCs for Tap Water (RSLs) (06/17/2008) (µg/L)		
	ICP-AES /	ICP-MS (CRDL)	MCL/ MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)		MCL	
INORGANIC								
Aluminum	200	Not analyzed				37,000 nc		
Antimony	60	2	6.0	15		15 nc	6.0	
Arsenic	10	1	10	11	0.057	0.045 nc	10	
Barium	200	10	2,000	2,600		7,300 nc	2,000	
Beryllium	5	1	4.0	73		75 ca	4.0	
Cadmium	5	1	5.0	18		18 nc	5.0	
Calcium	5,000	Not analyzed						
Chromium ****	10	2	100	110		55,000 nc		
Cobalt	50	1						
Copper	25	2	1,300			1,500 nc	1,300	
Iron	100	Not analyzed				26,000 nc		
Lead	10	1	15				15	
Magnesium	5,000	Not analyzed						
Manganese †††	15	1		5,100		880 nc		
Mercury	0.2	Not analyzed	2.0	11		0.63 nc	20	
Molybdenum						180 nc		
Nickel	40	1		730		730 nc		
Potassium	5,000	Not analyzed						
Selenium	35	5	50	180		180 nc		
Silver	10	1		180		180 nc		
Sodium	5,000	Not analyzed						
Thallium	25	1	0.50			2.4 nc	2.0	
Vanadium	50	5		260		260 nc		
Zinc	60	2		11,000		11,000 nc		
Cyanide (free cyanide)	10	Not analyzed	200	730				
Asbestos			7 million fibers/L					
Uranium			30			110 nc		
Hydrogen sulfide				1,100		110 nc		
Perchlorate (also CAS number 7601-90-3)				3.7		26 nc		

TABLE 12
Organic Drinking Water Benchmarks

Substance name	CLP Reporting Limits (CRQL)		SCDM (Drinking Water) (1/28/2004)			Region 3 RBCs for Tap Water (RSLs) (06/17/2008) (µg/L)	
	Water (µg/L) (1/2008)	Low Concentration Org. Analytes for Superfund (µg/L) (1/2008)	MCL/MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)	MCL	
VOLATILE ORGANIC COMPOUNDS (VOCs)							
Dichlorodifluoromethane	5.0	0.5				390 nc	
Chloromethane (Methyl chloride)	5.0	0.5				1.8 max	
Bromomethane (Methyl bromide)	5.0	0.5				8.7 nc	
Vinyl Chloride	5.0	0.5	2.0	110	0.057	0.016 nc	
Chloroethane (Ethyl Chloride)	5.0	0.5				21,000 nc	
Trichlorofluoromethane	5.0	0.5		11,000		1,300 nc	
Methylene Chloride (Dichloromethane)	5.0	0.5	5.0	2,200	11	4.8 nc	5.0
Acetone	10	5.0		33,000		22,000 nc	
Carbon Disulfide	5.0	0.5		3,700		1,000 nc	
Methyl Acetate	5.0	0.5					
Dichloroethylene, 1,1- (1,1-Dichloroethene) (1,1-DCE)	5.0	0.5	7.0	1,800		340 nc	7.0
Dichloroethane, 1,1-	5.0	0.5		3,700		2.4 nc	
Trichloro-1,2,2-trifluoroethane, 1,1,2-	5.0	0.5				59,000 nc	
Dichloroethene (total), 1,2- (1,2-Dichloroethylene)				330		330 nc	
Dichloroethene, cis-1,2- (cis-1,2-Dichloroethylene)	5.0	0.5	70	360		370 nc	70
Dichloroethene, trans-1,2- (trans-1,2-Dichloroethylene)	5.0	0.5	100	730		110 nc	100
Methyl tert-Butyl Ether (MTBE)	5.0	0.5				12 nc	
Chloroform	5.0	0.5		360		0.19 max	
Dichloroethane, 1,2- (1,2-DCE) (EDC or DCA) (Ethylene dichloride)	5.0	0.5	5.0		0.94	0.15 nc	5.0
Methyl ethyl ketone (2-Butanone)	10	5.0		22,000		7,100 nc	
Bromochloromethane (Chlorobromomethane)	5.0	0.5					
Trichloroethane, 1,1,1- (1,1,1-TCA)	5.0	0.5	200			9,100 nc	200
Cyclohexane	5.0	0.5				13,000 nc	
Carbon Tetrachloride	5.0	0.5	5.0	26	0.66	0.20 nc	5.0
Bromodichloromethane	5.0	0.5		730	1.4	1.1	
Dichloropropane, 1,2-	5.0	0.5	5.0		1.3	0.39 ca*	
Dichloropropene, 1,3-				1,100	0.85	0.43 ca*	
Dichloropropene, cis-1,3-	5.0	0.5					

TABLE 12
Organic Drinking Water Benchmarks

Substance name	CLP Reporting Limits (CRQL)		SCDM (Drinking Water) (1/28/2004)			Region 3 RBCs for Tap Water (RSLs) (06/17/2008) (µg/L)	
	Water (µg/L) (1/2008)	Low Concentration Org. Analytes for Superfund (µg/L) (1/2008)	MCL/ MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)		MCL
Trichloroethylene (Trichloroethene) (TCE)	5.0	0.5	5.0		7.7	1.7 nc	5.0
Methylcyclohexane	5.0	0.5				6,300 nc	
Dibromochloromethane (THM)	5.0	0.5				0.80 nc	
Trichloroethane, 1,1,2-	5.0	0.5	3.0	150	1.5	0.24 nc	5.0
Benzene	5.0	0.5	5.0	150	1.5	0.41 nc	5.0
Dichloropropene, trans-1,3-	5.0	0.5					
Isopropylbenzene (Cumene)	5.0	0.5		3,700		680 nc	
Tribromomethane (Bromoform)	5.0	0.5				8.5 ca*	
Methyl isobutyl ketone (4-Methyl-2-pentanone)	10	5.0		2,900		2,000 nc	
Hexanone, 2-	10	5.0					
Dibromoethane, 1,2- (EDB) (Ethylene Dibromide)	5.0	0.5			0.0010	0.0065 nc	
Tetrachloroethylene (PCE) (Tetrachloroethene)	5.0	0.5	5.0	360	1.6	0.11 ca	5.0
Tetrachloroethane 1,1,2,2-	5.0	0.5			0.43	0.067 ca	
Toluene	5.0	0.5	1,000	7,300		2,300 nc	1,000
Chlorobenzene	5.0	0.5	100	730		91 nc	100
Ethylbenzene	5.0	0.5	700	3,700		1.5 nc	700
Styrene	5.0	0.5	100	7,300		1,600 nc	100
Xylene (total)	5.0			7,300		200 nc	10,000
Xylene, m-	5.0	0.5	10,000	73,000		1,400 nc	
Xylene, o-	5.0	0.5	10,000	73,000		1,400 nc	
Xylene, p-	5.0	0.5	10,000			1,500 nc	
Dichlorobenzene, 1,3-	5.0	0.5					
Dichlorobenzene, 1,4-	5.0	0.5	75		3.5	0.43 nc	75
Dichlorobenzene, 1,2-	5.0	0.5				370 nc	600
Dibromo-3-chloropropane, 1,2- (DBCP)	5.0	0.5	0.20		0.061	0.00032 nc	0.20
Trichlorobenzene, 1,2,4-	5.0	0.5	70	360		19 ca*	70
Trichlorobenzene, 1,2,3-	5.0	0.5					
Vinyl acetate				37,000		410 nc	
SEMIVOLATILE ORGANIC COMPOUNDS							
Benzaldehyde	5.0	-				3,700 nc	
Phenol	5.0	-		11,000		11,000 nc	

TABLE 12
Organic Drinking Water Benchmarks

Substance name	CLP Reporting Limits (CRQL)		SCDM (Drinking Water) (1/28/2004)			Region 3 RBCs for Tap Water (RSLs) (06/17/2008) (µg/L)	
	Water (µg/L) (1/2008)	Low Concentration Org. Analytes for Superfund (µg/L) (1/2008)	MCL/ MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)		MCL
Bis(2-chloroethyl)ether	5.0	-				0.012 ca	
Chlorophenol, 2-	5.0	-				180 nc	
oxybis, 2,2'- (1-Chloropropane) † (bis (2-chloroisopropyl)ether)	5.0	-				†	
Acetophenone	5.0	-				3,700 nc	
Cresol, o- (Methylphenol, 2-)	5.0	-				1,800 nc	
Bis(2-chloroisopropyl) ether † (also CAS No. 108-60-1)	5.0					0.32 ca	
Cresol, p- (Methylphenol, 4-)	5.0	-		180		180 nc	
N-nitroso-di-n-propylamine (N-nitrosodipropylamine)	5.0	-				0.0096 ca	
Hexachloroethane	5.0	-				4.8 ca**	
Nitrobenzene	5.0	-				3.4 nc	
Isophorone	5.0	-				71 nc	
Nitrophenol, 2- (o-Nitriphenol)	5.0	-					
Dimethylphenol, 2,4-	5.0	-		730		730 nc	
Bis(2-chloroethoxy)methane	5.0	-				110 nc	
Dichlorophenol, 2,4-	5.0	-		110		110 nc	
Naphthalene	5.0	0.10		1,500		6.2 nc	
Chloroaniline, p- (4-Chloroaniline)	5.0	-				150 nc	
Hexachlorobutadiene	5.0	-		7.3	1.1	0.86 ca*	
Caprolactam	5.0	-				18,000 nc	
Chloro-3-methylphenol,4- (p-Chloro-m-Cresol)	5.0	-					
Methylnaphthalene, 2-	5.0	0.10				150 nc	
Hexachlorocyclopentadiene	5.0	-				220 nc	50
Trichlorophenol, 2,4,6-	5.0	-			7.7	6.1 ca**	
Trichlorophenol, 2,4,5-	5.0	-				3,700 nc	
Biphenyl, 1,1'- (Biphenyl)	5.0	-				1,800 nc	
Chloronaphthalene, 2- (beta-Chloronaphthalene)	5.0	-				2,900 nc	
Nitroaniline, 2-	10	-					
Dimethylphthalate	5.0	-					
Acenaphthylene (PAH)	5.0	0.10					
Dinitrotoluene, 2,6-	5.0	-				37 nc	
Nitroaniline, 3-	10	-					

TABLE 12
Organic Drinking Water Benchmarks



Substance name	CLP Reporting Limits (CRQL)		SCDM (Drinking Water) (1/28/2004)			Region 3 RBCs for Tap Water (RSLs) (06/17/2008) (µg/L)	
	Water (µg/L) (1/2008)	Low Concentration Org. Analytes for Superfund (µg/L) (1/2008)	MCL/MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)		MCL
Acenaphthene (PAH)	5.0	0.10		2,200		2,200 nc	
Dinitrophenol, 2,4-	10	-				73 nc	
Nitrophenol, 4-	10	-					
Dinitrobenzene, 1,3-				3.7		3.7 nc	
Dibenzofuran	5.0	-		150			
Dinitrotoluene, 2,4-	5.0	-				73 nc	
Diethylphthalate	5.0	-		29,000		29,000 nc	
Chlorophenyl-phenylether,4-	5.0	-					
Fluorene (PAH)	5.0	0.10		1,500		1,500 nc	
Nitroaniline, 4- (Nitroaniline, p-)	10	-					
Aniline					15	12 ca*	
Dinitro-2-methylephenol, 4,6 (4,6-Dinitro-o-Cresol)	10	-					
Nitrosodiphenylamine, N-	5.0	-			17	14 ca	
Tetrachlorobenzene, 1,2,4,5-	5.0	-		11		11 nc	
Bromophenyl-phenylether, 4- (p-Bromodiphenyl ether)	5.0	-					
Hexachlorobenzene	5.0	-	1.0	29	0.053	0.042 nc	1.0
Atrazine	5.0	-				0.29 nc	3.0
Pentachlorophenol (PCP)	10	0.20	1.0	1,100	0.71	0.56 nc	1.0
Phenanthrene	5.0	0.10					
Anthracene (PAH)	5.0	0.10		11,000		11,000 nc	
Carbazole	5.0				4.3	3.4 ca	
Di-n-butylphthalate (Dibutylphthalate)	5.0	-		3,700		3,700 nc	
Fluoranthene (Benzo(j,k)fluorene) (PAH)	5.0	0.10		1,500		1,500 nc	
Pyrene (PAH)	5.0	0.10		1,100		1,100 nc	
Butylbenzylphthalate	5.0	-		7,300		7,300 nc	
Dichlorobenzidine, 3,3-	5.0	-				0.15 ca	
Benz(a)anthracene (Benzo(a)anthracene) (PAH)	5.0	0.10			0.12	0.029 ca	
Chrysene (PAH)	5.0	0.10			12	2.9 nc	
Bis(2-ethylhexyl)phthalate (DEHP) (PAE) (Di(2-ethylhexyl)phthalate)	5.0		6.0	730	6.1	4.8 ca	6.0
Di-n-octyl phthalate (Dioctylphthalate) (n-Dioctyl Phthalate)	5.0			730			
Benzo(b)fluoranthene (PAH)	5.0	0.10				0.0029 ca	

TABLE 12
Organic Drinking Water Benchmarks

Substance name	CLP Reporting Limits (CRQL)		SCDM (Drinking Water) (1/28/2004)			Region 3 RBCs for Tap Water (RSLs) (06/17/2008) (µg/L)	
	Water (µg/L) (1/2008)	Low Concentration Org. Analytes for Superfund (µg/L) (1/2008)	MCL/MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)		MCL
Benzo(k)fluoranthene (PAH)	5.0	0.10			1.2	0.29 ca	
Benzo(a)pyrene (PAH)	5.0	0.10	0.20		0.012	0.0029 ca	0.20
Indeno(1,2,3-cd)pyrene (PAH)	5.0	0.10			0.12	0.029 ca	
Dibenz(a,h)anthracene (Dibenzo(a,h)anthracene) (PAH)	5.0	0.10			0.012	0.0029 ca	
Benzo(g,h,i)perylene (PAH)	5.0	0.10					
Ethylene glycol monobutylether (EBGE)				18,000		18,000 nc	
Trinitrobenzene 1,3,5- (TNT metabolite)				1,100		1,100 nc	
Acrolein				180		0.042 nc	
PESTICIDES / AROCLORS							
BHC, alpha- (Hexachlorocyclohexane, alpha) (alpha HCH)	0.050				0.014	0.011 ca	
BHC, beta- (Hexachlorocyclohexane, beta) (beta HCH)	0.050				0.047	0.037 ca	
BHC, delta- (Hexachlorocyclohexane, delta)	0.050						
BHC, gamma (Lindane) (gamma BHC) (gamma HCH)	0.050		0.20	11	0.066	0.061 ca	0.20
Heptachlor	0.050		0.40	18	0.019	0.015 nc	0.40
Aldrin	0.050			1.1	0.005	0.0040 nc	
Heptachlor epoxide	0.050		0.20	0.47	0.0094	0.00074 ca*	0.20
Endosulfan I (alpha Endosulfan)	0.050			220			
Dieldrin	0.10			1.8	0.0053	0.0042 nc	
DDE, 4,4'- (p,p'Dichlorodiphenyldichloroethylene)	0.10				0.25	0.20 ca	
Endrin	0.10		2.0	11		11 nc	2.0
Endosulfan II (beta Endosulfan)	0.10			220			
DDD, 4,4'- (p,p'Dichlorodiphenyldichloroethane)	0.10				0.35	0.28 ca	
Endosulfan sulfate	0.10						
DDT, 4,4'- (p,p'Dichlorodiphenyltrichloroethane)	0.10			18	0.25	0.20 ca*	
Methoxychlor	0.50		40	180		180 nc	40
Endrin ketone	0.10						
Endrin aldehyde	0.10						
Chlordane			2	18	0.24	0.19 ca*	2.0
Chlordane, alpha-	0.050			18	0.24		
Chlordane, gamma- (See also CAS No. 5103-74-2)	0.050			18	0.24		
Toxaphene	5.0		3.0		0.077	0.061 ca	3.0

TABLE 12
Organic Drinking Water Benchmarks

Substance name	CLP Reporting Limits (CRQL)		SCDM (Drinking Water) (1/28/2004)			Region 3 RBCs for Tap Water (RSLs) (06/17/2008) (µg/L)	
	Water (µg/L) (1/2008)	Low Concentration Org. Analytes for Superfund (µg/L) (1/2008)	MCL/MCLG (µg/L)	RDSC (µg/L)	CRSC (µg/L)		MCL
Aroclor-1016	1.0					0.096 ca**	
Aroclor-1221	1.0					0.0068 ca	
Aroclor-1232	1.0					0.0068 ca	
Aroclor-1242	1.0					0.034 ca	
Aroclor-1248	1.0					0.034 ca	
Aroclor-1254	1.0					0.034 ca*	
Aroclor-1260	1.0					0.034 ca	
Endosulfan I or II				220		220 nc	
PCBs (Polychlorinated biphenyls)	1.0		0.50	0.73	0.043		
Alachlor			2.0	360	1.1	1.2	2.0
HERBICIDES							
Trifluralin (Treflan)				270	11	8.7 ca*	
DIOXINS / FURANS							
Heptachlorodibenzo-p-dioxin 1,2,3,4,6,7,8- (1,2,3,4,6,7,8-HpCDD)	0.00005				0.00057		
Heptachlorodibenzofuran 1,2,3,4,6,7,8- (1,2,3,4,6,7,8-HpCDF)	0.00005				0.00057		
Heptachlorodibenzofuran 1,2,3,4,7,8,9- (1,2,3,4,7,8,9-HpCDF)	0.00005				0.00057		
Pentachlorodibenzofuran 2,3,4,7,8- (2,3,4,7,8-PeCDF)	0.00005				0.0000057		

- SCDM Superfund Chemical Data Matrix
- RDSC Reference Dose Screening Concentration
- CRSC Cancer Risk Screening Concentration
- MCLG Maximum Contaminant Level Goal. A non-enforceable health goal that is set at a level at which no known or anticipated adverse effect on the health of persons occurs and which allows an adequate margin of safety.
- MCL Maximum contaminant Level. The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLG as feasible using the best available analytical and treatment technologies and taking cost into consideration. MCLs are enforceable standards.
- CRQL Contract Required Quantitation Limit (for organic analytes).
- CRDL Contract Required Detection Limit (for inorganic analytes).
-  Lower than Contract Laboratory Program (CLP) Contract Required Quantitation Limit (CRQL) and below or equal to the CLP Low Concentration CRQL.
-  Lower than the standard CLP CRQL but above the CLP Low Concentration CRQL.
- nc Non cancer
- ca Cancer
- SL Screening level
- ca* Where: nc SL < 100X ca SL
- ca** Where: nc SL < 10X ca SL