ENVIRON

April 8, 2013

Via E Mail and FedEx

Mr. Mostafa Mehran
Arkansas Department of Environmental Quality
5301 Northshore Drive
North Little Rock, AR 72118-5317

Re: Whirlpool Corporation, Fort Smith, Arkansas
Revised Risk Management Plan

Dear Mr. Mehran:

As discussed during our March 19, 2013 meeting in your office, ENVIRON International Corporation (ENVIRON) has prepared the attached Revised Risk Management Plan (RRMP) in accordance with the Letter of Agreement for ADEQ consideration. This further revised RRMP will replace the Risk Management Plan submitted on November 30, 2012. This RRMP takes into account ADEQ written comments and the meeting in ADEQ offices on March 19, 2013 to develop and implement an active site remedy.

The attached RRMP has also incorporated a revised Human Health Risk Assessment (HHRA) as an appendix. As requested by ADEQ during the March 19, 2013 meeting, the potential off-site drinking water pathway is addressed in this revised HHRA.

If you have any questions or comments please contact me at your earliest convenience.

Sincerely,

Tamara R. House-Knight

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cc: Tammie Hynum - ADEQ
Robert Karwowski – Whirlpool Corporation



Revised Risk Management Plan
FT. Smith, Arkansas

Prepared for:
Whirlpool Corporation
Benton Harbor, MI

Prepared by:
ENVIRON International Corporation
Little Rock, Arkansas

Date:
November 2012
Revised April 2013

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Acronyms and Abbreviations

ADEQ:	Arkansas Department of Environmental Quality
CAS:	Corrective Action Strategy
cis-1,2-DCE:	cis-1,2-dichloroethylene
COC:	Constituent of Concern
CSM:	Conceptual Site Model
CVOC:	Chlorinated Volatile Organic Compounds
1,1-DCE:	1,1-dichloroethylene
HHRA:	Human Health Risk Assessment
LOA:	Letter of Agreement
MCL	Maximum Contaminant Level
MIP:	Membrane Interface Probe
PCE:	Tetrachloroethylene
RER:	Risk Evaluation Report
RMP:	Risk Management Plan
RRMP:	Revised Risk Management Plan
TCE:	Trichloroethylene
trans-1,2-DCE:	trans- 1,2-dichloroethylene
UST:	Underground Storage Tank
USEPA:	United States Environmental Protection Agency

1 Introduction

1.1 Background and Objectives

1.1.1 General Site Description

The Whirlpool Fort Smith site is located at 6400 Jenny Lind Road on the south side of Fort Smith, Arkansas (Figure 1). The site manufactured side-by-side household refrigerators and trash compactors. The site had been operated by Whirlpool for over 45 years and ceased production in June 2012.

The property is approximately 153 acres and includes the main manufacturing building (approximately 1.3 million square feet), separate warehouse and administrative offices, and approximately 21 acres of undeveloped land (Figure 2). Additional buildings located on the north side of the property include a water treatment plant and boiler house. The majority of the property surrounding the buildings is covered with concrete or asphalt service roads and parking. Some gravel parking areas are also present.

1.1.2 Site Operations

The manufacturing processes at the Whirlpool-Fort Smith property involved metal fabrication, plastic thermoforming and assembly operations. All storage of hazardous waste containers was limited to 90 days or less, no hazardous waste treatment activities were conducted on-site. Constituents in the soil and groundwater identified during investigations are the result of historical practices prior to 1981, as described below.

Dating back to approximately 1967, a vapor degreasing system utilizing trichloroethylene (TCE) was operated in the former degreaser building located near the northwestern corner of the main manufacturing building, west of the boiler house. The degreasing equipment consisted of a tank and parts rack. The degreasing operations involved placing parts into the parts rack positioned over the tank. The TCE tank was then heated, creating a TCE vapor in the area where the parts were placed. Following degreasing activities, the vapor was condensed and returned to the tank below the parts rack.

The use of TCE was discontinued in 1981. There are no historical records that document any spills or other release incidents from the degreaser building. It is possible that historical leaks from the tank or surface spills in the vicinity of the degreaser building may have occurred, resulting in releases to the soil and groundwater.

A series of soil and groundwater investigations were initiated at the site as part of a project to remove one underground storage tank (UST) previously containing fuel. There was no evidence of a release of petroleum hydrocarbons from the UST, but the analytical data showed the presence of TCE and other solvents in the shallow groundwater. Subsequent investigations, including soil sampling to assess the potential source area have been conducted to delineate affected soil and groundwater. Based on historical process knowledge, and recent analytical data, the primary constituent of concern (COC) is TCE. Tetrachloroethylene (PCE), and TCE daughter products (including cis-1,2-dichloroethylene (cis-1,2-DCE) and trans- 1,2-dichloroethylene (trans-1,2-DCE), 1,1-dichloroethylene (1,1-DCE), and vinyl chloride) resulting from the natural degradation of PCE and TCE have also been periodically detected in monitoring wells.

1.1.3 Summary of Previous Site Assessments and Risk Evaluations

To address the impacts from historical releases, Whirlpool entered into a Letter of Agreement (LOA) with the Arkansas Department of Environmental Quality (ADEQ), dated July 19, 2002. Under the LOA, Whirlpool is following the United States Environmental Protection Agency's (US EPA's) Corrective Action Strategy (CAS) that includes the development of a site conceptual model and other documents describing environmental conditions at the site. To date Whirlpool has completed the following activities and submitted documents as required by Items F and G, of the LOA:

Item F – RMS Corrective Action and Reporting Requirements:

• Notice of Intent (NOI)	August, 2002
• Scoping Meeting	August, 2002
• RMS Work Plan	August, 2002
• Corrective Action Strategy (CAS)	June, 2004
• CAS Work Plan Addendum	August, 2006
• Facility Activities	September, 2006
• Risk Evaluation Report	June, 2007
• Remedy Selection	March, 2008
• Risk Management Plan	March, 2008
• Annual Groundwater Monitoring Report	June, 2012
• Revised Risk Management Plan	November, 30 2012

Item G – Interim/Stabilization Measures:

• Interim Measure Work Plan	March, 2008
• Interim Measure Status Report	February, 2010
• Interim Measure Status Report	July, 2010

Results of the various investigations are included in a series of reports listed below:

- Supplemental Site Investigation, December 2000;
- On-Site ChemOx Pilot Study Report, August, 2002
- Conceptual Site Model (CSM) Report, August 2002;
- CSM Report Addendum, August 2002
- CAS Work Plan, June 2003;
- Off-site Delineation Phase A (installation and sampling of three off-site wells), July 2003;
- Off-site Delineation Phase B (ten Geoprobe™ borings, membrane interface probe (MIP) field screening, and installation and sampling of four off-site wells), November 2003;
- Interim Status Report and Revised CAS Work Plan, June 2004;
- Off-site Delineation Phase C (seven Geoprobe™ borings and installation and sampling of four off-site wells), November 2004;

- Interim Status Report for Off-Site Investigations, March 2005;
- Off-site Delineation Phase D (five Geoprobe™ borings and installation and sampling of four off-site wells), April 2005;
- Interim Status Report for Off-Site Investigations, June 2005;
- Off-site Delineation Phase E (installation and sampling of two off-site monitoring wells), April 2006;

In addition to the above reports, a series of Annual Groundwater Monitoring Reports have been produced since March 2000 documenting the results of semi-annual groundwater sampling events. The last semi-annual groundwater monitoring event was conducted during September 2012.

All of these investigations, reports, and monitoring events were used to create a full understanding of the site background, delineation of COCs in soil and groundwater, potential exposure pathways for evaluated in the risk assessment, and remedial approach, which are all detailed in this Revised Risk Management Plan (RRMP).

1.2 Objectives and Technical Approach

A Risk Management Plan (RMP) for the site was submitted in March of 2008. Since that time, Whirlpool has completed additional investigation activities and implemented two interim measure pilot studies. These activities have provided extensive, valuable data that has led Whirlpool to reevaluate the site strategy and associated final remedy defined in the 2008 RMP. Therefore, at the request of the ADEQ, ENVIRON is preparing this RRMP on Whirlpool's behalf. The intent of the RRMP is to assimilate over 15 years of data, with an emphasis on data collected since 2008, to identify and select a corrective measure that is protective of human health and the environment. The final remedy will take into account the documented site specific conditions identified during the interim measure pilot studies and the results and effectiveness of these activities. As required by the LOA, the remedy selection process has been conducted "in general accordance with the remedy evaluation standards and general decision factors contained in Chapter IV of the EPA guidance document entitled RCRA Corrective Action Plan (Final), May 1994…" (CAP Guidance).

The objective of this RRMP is to present a current CSM, define remedial action criteria, screen and select a corrective measure to meet the remedial action criteria, establish performance monitoring criteria, and present a schedule for implementation. The CSM presented in this RRMP has evolved to incorporate new information available since the CSM presented in the Risk Evaluation Report (RER) (ERM, 2007). Whirlpool did not revise the RER as part of this submittal. However, ENVIRON has completed a Human Health Risk Assessment (HHRA) that incorporates all site data and is consistent with current risk assessment practices and guidance. This HHRA is presented in Appendix A.

2 Remedy Selection

2.1 Introduction and Purpose

The purpose of the remedy selection process is to identify and screen potential remedies for consideration at the site. The RRMP evaluates each potential remedy for its relative appropriateness and practicability to meet a goal that is protective of human health and the environment. As shown on Figures 3 and 4, impacted soil and groundwater are present within the fenced boundary of the Whirlpool site (on-site) and impacted groundwater is present beneath a portion of the residential area north of the site (off-site). Given the nature of the impacted media and differences in land use, there are differences in potentially complete exposure pathways for on-site versus off-site areas. As a result, the RRMP identifies and screens potential remedial technologies separately for on-site versus off-site areas.

2.2 Description of Site Conditions

The CSM characterizes the site conditions and summarizes the basis for the exposure scenarios evaluated. Key components of the CSM include site, land use and exposure, physical, release, ecological, and risk management profiles. A summary of the current site conditions is provided below.

<u>On-Site Current Conditions</u>

The site was operated by Whirlpool for the manufacture of refrigerators and trash compactors until June 2012. Currently, there are no on-site manufacturing operations. In the future, site activities will be restricted to non-residential uses through restrictive covenants to be recorded with the property deed(s). It is presumed all future uses at the site will be non-residential.

Based on the data collected to date, the known area of impacted soil is within the property boundaries and security fencing (Figure 3) and thus entirely on-site. The “source area” is understood to be a localized area near and immediately to the west of the former degreaser building where elevated concentrations of TCE were detected in soil and groundwater. The area of impacted soil is an approximately 50 by 250-foot area west of the former degreaser building. The groundwater plume extends approximately 1,000 feet to the south southwest from the source (Figure 4).

<u>Off-Site Current Conditions</u>

Land use down-gradient (north) of the site is residential. Residential properties to the north include single-family homes and multi-family units. A recreational facility is located over 500 feet northeast of the Whirlpool property boundary, adjacent to the residential area. No agricultural properties are located in the vicinity of the site.

Groundwater with detected concentrations of TCE above drinking water criteria extends into the residential neighborhood north of the site. The recreational facility to the northeast is located over 1,000 feet north of the impacted groundwater area. The extent of the off-site groundwater plume is shown on Figure 4. There are currently no known uses of groundwater within or near the off-site groundwater plume. The highest TCE concentrations in groundwater (i.e., greater than 1 mg/L) are generally limited to a gravel containing portion of the shallow saturated unit. While the aquifer is mostly comprised of clayey material, the gravel containing zone contains some gravel and sandy gravel that varies in thickness from about 6 to 7 feet thick near the source area on-site and thins to be nonexistent immediately north of Jacobs Avenue. Additional details on the site geology and hydrogeology are documented in multiple previous reports and work plans.

2.3 Conceptual Site Model

The site and the surrounding area are connected to the municipal water supply and there are currently no known uses of on- and/or off-site groundwater within or near the impacted groundwater. Currently, there is no ordinance or restriction prohibiting use of groundwater in the impacted area.

Potential Human Exposure Pathways

The scenarios for potential human exposure under current and reasonably expected future conditions at and around the site are summarized in the CSM, Figure 5 and the HHRA (Appendix A: Table 1) and include:

- On-site routine workers who could contact soil during outdoor activities or could inhale soil or groundwater-derived vapors in outdoor or indoor air;
- On-site maintenance workers who could contact soil or groundwater during small-scale construction or maintenance activities;
- On-site construction workers who could contact soil or groundwater during large-scale construction activities;
- Off-site residents or off-site routine workers who could inhale wind-blown vapors and particulates from on-site soil during outdoor activities, or could inhale groundwater-derived vapors in outdoor or indoor air where the groundwater plume has migrated off-site, or could ingest or contact groundwater if water use wells are installed in the area of impacted groundwater; and
- Off-site maintenance or construction workers who could contact groundwater during small-scale construction or maintenance activities that encounter groundwater where the groundwater plume has migrated off-site.

2.4 Corrective Action Objective

The HHRA (Appendix A) quantitatively evaluated risks associated with the identified exposures presented in Section 2.3. Under current land and groundwater use, the HHRA shows that cumulative risk estimates using maximum detected concentrations for all chemicals meeting USEPA's acceptable excess cancer risk and noncancer hazard index (HI) levels for exposure to on-site soil and off-site groundwater. The HHRA shows that cumulative risk estimates calculated using maximum detected concentrations for all chemicals in on-site groundwater are below USEPA's acceptable excess cancer risk level of 10^{-4} and exceed USEPA's noncancer HI level of 1 for the maintenance worker and construction worker via direct contact and the routine worker via vapor intrusion under current on-site land and groundwater use. The HHRA also shows that off-site groundwater concentrations in the area of impacted groundwater would result in unacceptable exposure if water use wells were installed and groundwater with concentrations of TCE above the maximum contaminant level (MCL) is used as a potable source.

Based on the identified exposure pathways that require risk management from the HHRA, the corrective action objectives for the site are as follows:

- Eliminate or reduce the lateral extent or concentration of the groundwater plume both off-site and on-site.
- Eliminate or reduce the potential for unacceptable risk that may result if there are future changes in land or groundwater uses either off-site or on-site.
- Eliminate or reduce to acceptable levels the risk from certain potential on-site groundwater contact exposures identified in the HHRA which could pose an unacceptable risk.

2.5 Remedial Action Criteria

Potential significant exposures are those where the cumulative cancer risk or HI estimates exceed USEPA risk limits of 10^{-4} or 1, respectively, for both soil and groundwater, and off-site areas where groundwater concentrations are above the MCLs and no water well restriction exists, as discussed in the HHRA in Appendix A. As summarized in Section 2.4 and presented in the HHRA (Appendix A), potential exposures to chemicals detected in on-site soil and off-site groundwater under current land and groundwater uses do not present potentially significant risks to on-site and off-site receptors, respectively. Under current on-site land and groundwater uses, potential risks exist for certain on-site contact exposures with groundwater. In the hypothetical scenario in which water use wells are installed in the area of impacted off-site groundwater, exposures could potentially result from use of the groundwater. Therefore, the remedial action criterion for on-site groundwater is to reduce concentrations in groundwater at the source to meet risk limits and reduce or eliminate the source to the off-site groundwater plume which will ultimately reduce the concentrations in off-site groundwater. The remedial action criterion for off-site groundwater is preventing use of groundwater that exceeds the MCLs until concentrations in groundwater decrease in concentration to at or below MCLs.

2.6 Identification and Screening of Corrective Measures

In order to develop a plan to address the impacted soil and groundwater at the site, multiple candidate corrective measures were identified. Each corrective measure was evaluated on a screening-level basis to assess whether the measure should be retained for more detailed consideration.

The potential corrective measures are grouped into one of five categories:

- No Action;
- Containment;

- Removal;
- Treatment; and
- Institutional Controls.

A description of each category and the specific technologies within the categories are presented below along with the discussion of how the corrective measures were screened. Measures eliminated from further consideration are noted, along with the reasons for their elimination. In general, measures which:

- Are not currently available commercially;
- Have not been proven to be effective on similar contaminants of concern (COCs); or
- Are proven to be less effective than other technologies that could achieve the same results, were eliminated from further consideration.

It should be noted that some technologies must be combined with others to address the site conditions. Table 1 summarizes the technologies considered for each of the above general measures that are further discussed in the following sections.

2.6.1 No Action

The No Action measure represents a baseline against which other alternatives are compared. This measure would entail continuation of the current groundwater monitoring program but with no remedial activities to address affected soil or groundwater, either on-site or off-site. This measure would not limit risk posed by COCs.

Screening of the No Action Measure

The No Action measure is screened out from further consideration because it will not address the potential risks associated with affected groundwater if a drinking water well were to be installed, either off-site or on-site. No Action will not reduce concentrations, control mobility, or reduce the extent of impacted media. However, groundwater monitoring will be retained for consideration to be combined with other corrective measures.

2.6.2 Containment

Containment involves placing a physical barrier which impedes movement of COCs, thereby providing a means to reduce or eliminate an exposure pathway. Containment technologies can effectively isolate soil and/or groundwater, and are separated into the following groups:

- Horizontal barriers, and
- Vertical barriers.

Horizontal barrier technologies (i.e., capping) include:

- Topsoil/clay and vegetative covers;
- Asphalt covers;

- Concrete covers; and
- Soil covers with synthetic/geotextile composite liner.

Horizontal barriers prevent contact between impacted surface soil and surface water runoff, thereby reducing the potential for COC migration via infiltration into groundwater. The covers may also be engineered to prevent human exposure to impacted soil and to limit vapor migration.

Much of the on-site area where impacted soil is present is covered by asphalt and concrete which is a very effective horizontal barrier. Continued regular maintenance of the existing cover will reduce the potential for future leaching of COCs from the impacted soil to groundwater. The limited areas where impacted on-site soil is not currently paved (in the northwestern portion of the main building) could be paved to increase the effective surface area of cover. Impacted soil is not present off-site; therefore, applying a horizontal barrier as a corrective measure off-site will have no benefit.

Vertical barrier technologies include:

- Slurry wall;
- Cement-bentonite cutoff wall;
- Grout curtain;
- Sheet pile wall; and
- Interceptor trenches and recovery well systems.

Vertical barriers are typically used to limit or redirect the lateral flow of groundwater from or around an impacted area, to isolate impacted subsurface soil, or to contain an impacted groundwater plume. Such barriers are generally keyed into an existing confining layer. For the Whirlpool site, vertical barriers would be keyed into the lower McAllester Shale at a depth of about 35 feet. Prior to final design, a series of geotechnical soil borings would need to be drilled on 20 to 50 foot intervals along the proposed barrier trench centerline to obtain detailed stratigraphic information and other design data. Depth to water, depth to the “key” layer, soil type, and the potential presence of gravel or flowing sand are important data for barrier design. Compatibility testing may be required to evaluate the impact of COCs on the permeability of the barrier material. Construction of vertical barriers requires a significant working area, typically at least 50-ft wide, along the entire length of the barrier. A material mixing area would also be needed.

<u>Screening of the Containment Measure</u>

A containment-based corrective measure would not remove the impacts from the site but would provide protection of human health and the environment by reducing migration of, or exposure to, COCs in soil and/or groundwater. Containment technologies are proven, commercially available, and readily implemented. Due to the highly intrusive nature of the construction method, residential areas with homes and underground utilities are generally not good candidates for these types of controls. Therefore, containment could be applied on-site and used to control both on-site exposure and the off-site migration of constituents.

Capping of impacted on-site soil was retained as a viable measure to be used in conjunction with other technologies. The use of vertical barriers is screened out from further consideration due to physical space constraints and the extensive design investigative requirements at portions of the target area.

2.6.3 Removal

Removal of impacted soil or groundwater involves excavation or collection of the media for treatment or disposal. Removal technologies must be combined with a treatment or disposal technology to form a complete corrective measure. Treatment technologies will be addressed as part of the design specification if this measure is chosen and will not be discussed as part of this RRMP.

Two proven removal technologies were considered as potentially applicable for the Whirlpool site:

<u>Soil Excavation</u>

Excavation is a proven technology for direct mass removal and is technically feasible for small to moderate soil volumes. Excavation achieves a direct means of reducing the amount of COC mass in the environment which could pose a risk to human health or act as a source to contamination of other media (e.g., groundwater), if such a source were to exist. An alternative to mass excavation is targeted area excavations at areas with higher COC concentrations, if localized high COC concentrations in soil were identified onsite.

<u>Groundwater Extraction</u>

Groundwater extraction is a removal technology that is also sometimes applied as a hydraulic barrier/control technology. Groundwater extraction removes groundwater to prevent down-gradient migration, which results in removal of dissolved and residual mass from the impacted transmissive zone. Groundwater may be extracted using either extraction trenches or extraction wells. It is not generally effective in fully restoring groundwater to residential or industrial cleanup standards, but can provide adequate protection from potential exposure pathways as an independent corrective measure or when coupled with other remedial options.

Groundwater may be extracted using either extraction trenches or extraction wells. An extraction trench is an open trench that is designed to collect and convey liquid discharges by gravity flow in a manner similar to a French drain. The trench could be installed in any of three basic configurations:

1. To intercept a plume down-gradient of the leading edge;
2. In conjunction with a groundwater cutoff barrier to prevent buildup of groundwater up-gradient of the barrier; or
3. As a more active withdrawal system where drain(s) are installed within the groundwater plume perpendicular to the direction of groundwater flow.

Like vertical barriers discussed in previous section of this document, extraction trenches are commonly “keyed” into a confining layer. Extraction trenches are more effective than a line of groundwater wells when used to contain and/or recover impacted liquids in low transmissivity hydrogeological environments. Extraction trenches are considered a feasible technology except where access may be an issue.

Impacted groundwater can also be extracted from the ground by a system of recovery wells designed to control groundwater flow in a specific area and to remove dissolved and residual mass from the impacted transmissive zone. In addition, recovery wells may be used in conjunction with a physical vertical barrier to prevent hydraulic mounding behind the barrier.

Groundwater extraction can reduce dissolved phase concentrations in groundwater.

Screening of the Removal Measure

The removal measure for both soil and groundwater is a proven remedial approach and implemented at other similar sites. On-site, the greatest impact has been identified within the gravelly sand portion termed the transmissive zone, approximately 20 to 30 feet below ground surface. The area that would be targeted for removal is located between multiple buildings which limits the technical practicability of an active removal action. The presence of groundwater at approximately 10 to 12 feet below ground surface also limits the technical practicability of a removal action.

Groundwater pumping and treatment is the USEPA’s presumptive remedy for VOC impacted groundwater. Furthermore, groundwater removal (via pumping and treatment) has the technical ability to reduce COC concentrations within the more transmissive portions of the gravel aquifer, providing near term protection to off-site residents. However subsurface geological, area hydrogeological characteristics, and off-site access in the residential area may limit the ability to install a trench and may also limit the number of recovery wells that could be installed. A pumping test conducted during a previous investigation indicated that the radius of influence of a recovery well and its ability to remove constituent mass in areas outside of the more transmissive portions of the gravel portions aquifer would likely be low. Thus, long term pumping would be required, or additional technologies may be needed to be effective in areas outside the more transmissive portions. In addition, the presence of buried utility lines in the residential area may make installation of a trench unfeasible.

Therefore, only the use of groundwater extraction by recovery wells is retained for further evaluation and use in the development of the final on-site and off-site corrective measure alternatives.

2.6.4 In-Situ Treatment

In-situ treatment technologies rely on the application of treatment methods in the subsurface to reduce constituent mass and concentrations without removing the impacted media. The technologies and options considered for this measure include:

- Biological

  Natural Attenuation

Enhanced Aerobic/Anaerobic Biodegradation

- Physical/Chemical

Vapor Extraction or Sparging

Permeable Treatment Beds

Chemical Oxidation

Soil Flushing

The technologies are described in the following paragraphs.

Biological

Natural Attenuation

The term “natural attenuation” refers to the reliance on natural attenuation processes to control or prevent migration and/or over time achieve site-specific remediation objectives (USEPA, 1989). Natural attenuation processes include a variety of physical, chemical, and biological processes that, under favorable conditions, reduce the mass, toxicity, mobility, volume, or COC concentrations in soil and/or groundwater.

The primary COCs in the off-site plume are TCE and cis-1,2-DCE, and the COCs in the on-site plume are TCE, cis-1,2-DCE, PCE, and vinyl chloride.. These chemicals can be degraded both anaerobically (via reductive dechlorination) or aerobically.

Enhanced Aerobic/Anaerobic Biodegradation

In-situ biological treatment includes the addition of nutrients, oxygen and/or acclimated microbes to enhance the natural degradation processes. Biodegradation in the saturated zone can be used for the remediation of both impacted soil and groundwater. To implement biodegradation in the saturated zone, a series of wells or trenches is used to inject water containing nutrients, microbes and/or oxygen. The treatment occurs as the water flows with the natural or induced gradient and is collected in down-gradient wells or trenches. Additional nutrients, microbes, or oxygen are added to the water and it is recirculated through the soil. Use of this technology may be limited in areas with clayey soil due to limited flow and reduced contact.

Physical/Chemical Treatment

Vapor Extraction or Sparging

Vapor extraction includes application of a vacuum on the subsurface soil to induce volatilization of organic constituents. This is accomplished by pulling a vacuum on a series of vertical or horizontal wells screened in the unsaturated soil zone. Sparging (stripping) of VOCs in groundwater via wells can also be performed to remove vapors. A low permeability cover may be installed above the treatment area to reduce air bypass. This technology works most efficiently in highly permeable, granular soils.

Permeable Treatment Beds

Implementation of permeable treatment beds would include construction of a down-gradient trench filled with a material which would either adsorb or chemically react with constituents in groundwater. As groundwater passes through the bed, COCs would be treated or removed. Treatment beds can include granular zero valent iron, mulch, and other media that create a strong reducing environment to treat dissolved chlorinated hydrocarbons (chlorinated solvents) to nontoxic end products. This technology could potentially be used alone or together with other technologies to control the migration of affected groundwater.

Chemical Oxidation

In-situ chemical oxidation (ISCO) involves decomposition and in-situ destruction using chemical oxidation technologies. In contrast to other remedial technologies, reduction in COCs can be seen in short time frames (e.g. weeks or months). Chemical oxidation technologies are predominantly used to address in-situ groundwater and soil in the source area saturated zone and capillary fringe.

Understanding the site hydrogeologic conditions is important when considering the use of chemical oxidation or reduction technologies because these conditions often determine the extent to which the chemical oxidants or reducing agents may come into contact with the COCs. Soil reactivity with chemical oxidants or reducing agents is also important when considering the costs of chemical oxidation. Excessive loss of a chemical oxidant or reducing agent that is reacting with organics in soil, instead of reacting with the COCs, may preclude the use of the technology as an economically viable approach to site remediation.

Permanganate was evaluated in an on-site field scale test in 2002. This test was conducted in an area where the shallow groundwater is predominately located in a transmissive gravel zone. The results indicated that ISCO was effective in treating the COCs within the treatment zone and over 20 feet outside the treatment zone in the transmissive gravel portion only; however, the subsurface shallow groundwater is predominantly composed of clayey materials. After the test was completed, COC concentrations rebounded to pre-test levels.

Because chemical oxidation requires that the oxidant comes into direct contact with the contaminant, movement of the oxidant throughout the subsurface is extremely important. Although the transmissive gravel zone exists below ground surface near the former greaser building on-site, it does not extend throughout the residential area north of the site. Permanganate was evaluated in off-site tests in April and June of 2009. Specifically, permanganate was applied to 8 injection wells and has been, and is currently being, monitored. As evidence of very slow to no movement of groundwater underneath the residential properties in the area, permanganate was still present in some off-site monitoring wells during the October 2012 groundwater sampling event. This shows that permanganate is not uniformly being distributed throughout the subsurface to treat impacted groundwater. Findings associated with these tests conclude that ISCO is effective in reducing COC concentrations when effectively distributed in the subsurface, which to date has only been achieved at the transmissive zone. In late 2010 and early 2011, a groundwater extraction well was used to better move the permanganate through the subsurface, however this effort was only marginally successful due to the tight clays.

These past tests demonstrate that while chemical oxidation can be effective in localized areas, a different oxidant and/or oxidant delivery method, as well as repeated injections, may be appropriate at this Site.

Soil Flushing

Soil flushing involves the use of a cosolvent or surfactant where an injection or infiltration process moves the cosolvent or surfactant through the impacted soil with the intent of removing COCs from the soil. Extraction fluids would be recovered after moving through the impacted area (i.e., down-gradient of the impacted area). The recovered fluids may need to be treated prior to discharge and/or reinjection.

Screening of the In-Situ Treatment Measure

In-situ treatment technologies are proven remediation methods, readily implemented, and have been used at other similarly impacted sites. Furthermore, in-situ treatment has the technical ability to rapidly reduce groundwater concentrations, providing near term protection to off-site residents. Thus, in-situ treatment via enhanced aerobic/anaerobic biodegradation and chemical oxidation were retained as corrective measures for further consideration at on-site areas where they could be used to rapidly reduce the highest concentration of COCs. This on-site reduction in COCs would then further protect off-site residents.

Natural Attenuation is screened out as an independent corrective measure because it does not appear to be effective in reducing the mass of COCs in a predictable time frame. Based on site data, reductive dechlorination of TCE is occurring given the presence of the breakdown components including vinyl chloride. Natural attenuation may be feasible in combination with some other technology based on the site data.

2.6.5 Institutional Controls

Applying institutional controls as a remedial measure entails the implementation of legally enforceable restrictions on land use or groundwater use to prevent exposure to impacted media. Institutional controls will not directly remediate the site (reduce concentrations and/or limit migration). However, by preventing exposure (ingestion, direct contact, etc.), institutional controls are proven to effectively protect human health on a short and long-term basis. Institutional controls can be applied to both impacted soil and groundwater.

Institutional controls are usually deed recorded wherein a metes and bounds description of impacted media, a description of the impacts (e.g., constituent concentrations and distribution), and all land or groundwater use restrictions are entered into the deed for the impacted property. Institutional controls can be applied via property acquisition, easement or through the use of a legal covenant.

Other institutional controls include Municipal Setting Designations (MSDs) where a city or other municipal entity establishes a prohibition on the installation of groundwater wells and/or the use of groundwater in an area that is impacted. MSDs are often instituted in areas that are fully serviced by municipal water supplies and private groundwater wells are not needed or used.

Screening of Institutional Control Measure

The use of institutional controls has been approved by ADEQ as a remedial measure on other sites and can readily be applied to impacted areas within the limits of Whirlpool's property. Applying institutional controls such as MSDs and/or deed recordation in the off-site area would require the cooperation and approval of residents, property owners, and the City of Fort Smith.

Whirlpool will institute restrictive covenants on its property and options such as MSDs, deed restrictions and restrictive covenants are all feasible options to address off-site issues. For these reasons, the Institutional Control measure is retained as an option to be used in combination with another option.

2.6.6 Summary of Corrective Measures Retained for Further Analysis

Four of the five general corrective measures discussed above were retained, in whole or in part, for potential inclusion in the Whirlpool Revised Risk Management Plan. No Action was completely screened out as a candidate approach. In some cases, a given remedial measure should not be implemented as a "stand alone" remedy or could be applied on a contingency basis, while others could be applied on a broader basis.

To help focus the selection of final corrective measures (presented in Section 3), the retained corrective measures were subjected to a second screening and a "short list" of surviving approaches was identified as summarized in the table below.

Corrective Measures Retained for Further Analysis

General Remedial Measure	Media	Exposure Pathway Applicability	Retained for Potential Inclusion in the RMP?
Containment - Horizontal Barrier	On-Site Soil	Interrupt the soil-to-groundwater pathway by extending the existing asphalt and concrete coverage to reduce infiltration and limit potential leaching from affected on-site soils. Also limits direct contact.	Yes.
Containment – Vertical Barrier	Groundwater	Interrupt the residential groundwater exposure pathway by limiting migration from on-site "source area".	No, implementation constraints (physical and design).
Removal – Excavation	On-Site Soil	Interrupt the soil-to-groundwater exposure pathway by removing constituents from soil.	No, current data indicates higher soil concentrations within the groundwater zone below practical excavation depths.

Corrective Measures Retained for Further Analysis			
General Remedial Measure	**Media**	**Exposure Pathway Applicability**	**Retained for Potential Inclusion in the RMP?**
Removal – Extraction	Groundwater	Interrupt the groundwater exposure pathway by removing constituents from groundwater. Interrupt potential vapor intrusion to indoor air exposure pathway by decreasing concentrations to levels below concern for volatilization.	Yes, for on-site and off-site plume. May also be considered as a contingency action if performance monitoring indicates a need for secondary measures to protect off-site groundwater.
In-situ Treatment – Chemical Oxidation	Groundwater	Interrupt the groundwater exposure pathway by removing constituents from groundwater. Interrupt potential vapor intrusion to indoor air by decreasing concentrations to levels below concern for volatilization.	Yes, for on-site plume.
In-situ Treatment – Permeable Treatment Beds	Groundwater	Interrupt the groundwater exposure pathway by removing constituents from groundwater. Interrupt potential vapor intrusion to indoor air by decreasing concentrations to levels below concern for volatilization.	No, due to implementation constraints.
In-situ Treatment – Enhanced Aerobic/Anaerobic Biodegradation	Groundwater	Interrupt the groundwater exposure pathway by removing constituents from groundwater. Interrupt potential vapor intrusion to indoor air by decreasing concentrations to levels below concern for volatilization.	No, for on-site plume due to limited flow and reduced contact in clayey soil as well as COC levels in on-site soil.

Corrective Measures Retained for Further Analysis			
General Remedial Measure	**Media**	**Exposure Pathway Applicability**	**Retained for Potential Inclusion in the RMP?**
Institutional Controls	On-Site Soil	Interrupt potential for worker direct contact to subsurface soil by restricting access.	Yes.
Institutional Controls	Groundwater	Eliminate groundwater exposure pathway by restricting access.	Yes, for both on-site and off-site.

Based on the second screening performed, the remedial measures retained for potential inclusion in the RRMP are:

- On-Site Soils: Containment via a horizontal barrier and institutional controls;
- On-Site Groundwater: Groundwater extraction, in-situ treatment via chemical oxidation, and institutional controls; and
- Off-Site Groundwater: Groundwater extraction and Institutional controls (including monitored natural attenuation).

3 Risk Management Plan

Grouping different remedial measures into an alternative allows the remedial plan to focus on the specific exposure pathways that pose a potentially significant risk. Based on the environmental setting at the Whirlpool site, two corrective measure alternatives were identified as having a high potential to address the exposure pathways of concern:

- Alternative 1:

  On-Site: Soil Containment, Groundwater Extraction, and Institutional Controls; and

  Off-Site: Groundwater Extraction

- Alternative 2:

  On-Site: Groundwater In-situ Treatment via Chemical Oxidation and Institutional Controls; and

  Off-Site: Monitored Natural Attenuation (MNA) and Institutional Controls

For the first alternative, the direct contact pathway is addressed by adding additional cover to the existing asphalt and concrete in the area where impacted soil is present on-site. Further protection is provided with the first alternative by reducing groundwater concentrations using groundwater extraction. Decreasing groundwater concentrations reduces the potential for future off-site migration. Additionally, applying institutional controls limits on-site access to the impacted soil and groundwater.

The second alternative consists of a combination of in-situ treatment onsite via chemical oxidation coupled with institutional controls. In-situ treatment of on-site groundwater will be conducted via in-situ chemical oxidation (using permanganate or other appropriate oxidant[1]). Institutional controls will be used to limit access to on-site impacted soil and both on-site and off-site groundwater.

3.1 Evaluation of Final Corrective Measure Alternatives

As specified in the CAP guidance, and in accordance with the LOA, the components of the two corrective measures alternatives described above were evaluated against the following performance criteria:

- Protection of human health and the environment;
- Attainment of remedial action criteria;
- Control of the source of releases;
- Compliance with applicable standards for management of waste;
- Short and long-term reliability and effectiveness;
- Reduction in toxicity, mobility, or volume of impacted media;

[1] Oxidant will be determined by a treatability study and/or pilot study.

- Implementability; and
- Cost.

The results of the evaluation are summarized as follows:

Alternative 1	
On-Site: Soil Containment, Groundwater Extraction, and Institutional Controls	
Protection Of Human Health And The Environment	Containment reduces the potential for exposure to impacted soil and limits potential for infiltration through impacted soil and into groundwater Extraction reduces the potential for exposure to impacted groundwater by reducing concentrations Institutional Controls eliminate the potential for exposure to impacted soil and groundwater
Attainment Of Remedial Action Criteria	Containment will not modify concentrations in soil, but can limit the continued migration of COC to groundwater There is a limited potential for extraction to attain MCLs. The tight soil conditions and demonstrated low transmissivity at the site may require long term operation and maintenance of a mechanical system. Institutional Controls will not modify concentrations in soil or groundwater
Control Of The Source Of Releases	Containment creates a physical barrier to isolate the soil source from the environment Extraction controls the plume coming from the source by hydraulic control and may be able to achieve control on-site. The tight soil conditions and demonstrated low transmissivity at the site may require long term operation and maintenance of a mechanical system. Institutional Controls will not physically isolate the source of releases from the environment

Alternative 1	
Compliance With Applicable Standards For Management Of Waste	Containment is not applicable to this criterion since the measure does not involve management of wastes. Extraction can be conducted in a manner consistent with applicable standards. Institutional Controls are not applicable to this criteria since it does not involve management of wastes
Short And Long-Term Reliability And Effectiveness	Containment can be applied in a reasonably short time frame and Institutional controls to ensure the containment is maintained would provide long-term effectiveness. Extraction can be applied in a reasonably short time frame but will be required to be active in the long term to slow groundwater movement. Institutional Controls can be applied in a short time frame and provide long-term effectiveness
Reduction In Toxicity, Mobility, Or Volume Of Impacted Media	Containment will help reduce mobility, but will not affect reductions in toxicity or volume Extraction will help reduce toxicity and volume by direct removal and will reduce mobility by hydraulic control Institutional Controls will not reduce toxicity, mobility, or volume of impacted media
Implementability	Containment is readily implemented Extraction is readily implemented Institutional Controls are readily implemented
Cost	Containment has low to moderate initial and low long term cost Extraction has high initial and moderate to high long term cost Institutional Controls are low cost in the short and long term
Off-Site: Groundwater Extraction	
Protection Of Human Health And The Environment	Extraction may reduce the potential for exposure to impacted groundwater and by reducing concentrations in groundwater may eliminate the vapor intrusion pathway.
Attainment Of Remedial Action Criteria	There is a limited potential for extraction to attain MCLs. The tight soil conditions and demonstrated low transmissivity off-site may result in a substantial system that may require long term operation and maintenance with a low potential for achieving criteria. Access to all applicable off-site areas is unlikely given existing utilities, structures and land uses.
Control Of The Source Of Releases	Extraction controls the plume through hydraulic control; however, achieving control of the off-site groundwater plume may be difficult due to low transmissivity and access issues.

Alternative 1	
Compliance With Applicable Standards For Management Of Waste	Extraction can be conducted in a manner consistent with applicable standards
Short And Long-Term Reliability And Effectiveness	Extraction can be applied in a reasonably short time frame but will be required to be implemented long term to achieve effectiveness due to low transmissive conditions and access issues.
Reduction In Toxicity, Mobility, Or Volume Of Impacted Media	Extraction will help reduce toxicity and volume by direct removal and will reduce mobility by hydraulic control
Implementability	Extraction is readily implemented but may be limited by off-site access issues
Cost	Extraction has high initial and moderate to high long term cost

Alternative 2	
On-Site: In-situ Chemical Oxidation and Institutional Controls	
Protection Of Human Health And The Environment	In-situ chemical oxidation reduces the potential for exposure to impacted groundwater by reducing concentrations Institutional Controls eliminate the potential for exposure to impacted soil and groundwater
Attainment Of Remedial Action Criteria	There is a potential for in-situ chemical oxidation to attain MCLs. Based on subsurface conditions at the Site, repeated injections may be necessary. Institutional Controls will not modify concentrations in soil or groundwater
Control Of The Source Of Releases	In-situ chemical oxidation controls the plume coming from the source by decomposition of contaminants. Institutional Controls will not physically isolate the source of releases from the environment
Compliance With Applicable Standards For Management Of Waste	In-situ chemical oxidation can be conducted in a manner consistent with applicable standards Institutional Controls are not applicable to this criteria since it does not involve management of wastes
Short And Long-Term Reliability And Effectiveness	In-situ chemical oxidation can be applied in a reasonably short time frame but may need to be repeated to ensure long term effectiveness Institutional Controls can be applied in a short time frame and provide long-term effectiveness

Alternative 2	
Reduction In Toxicity, Mobility, Or Volume Of Impacted Media	In-situ chemical oxidation will help reduce toxicity, mobility, and volume by direct removal Institutional Controls will not reduce toxicity, mobility, or volume of impacted media
Implementability	In-situ chemical oxidation is readily implemented Institutional Controls are readily implemented
Cost	In-situ chemical oxidation has moderate initial and low long term cost Institutional Controls are low cost in the short and long term
Off-Site: MNA & Institutional Controls	
Protection Of Human Health And The Environment	MNA reduces the potential for exposure to impacted groundwater by reducing concentrations Institutional Controls eliminate the potential for exposure to impacted soil and groundwater
Attainment Of Remedial Action Criteria	There is a potential for MNA to attain MCLs over time Institutional Controls will not modify concentrations in soil or groundwater
Control Of The Source Of Releases	MNA controls the plume by decomposition of contaminants Institutional Controls will not physically isolate the source of releases from the environment
Compliance With Applicable Standards For Management Of Waste	MNA can be conducted in a manner consistent with applicable standards Institutional Controls are not applicable to this criteria since it does not involve management of wastes
Short And Long-Term Reliability And Effectiveness	MNA will be most effective in the long term Institutional Controls can be applied in a short time frame and provide long-term effectiveness
Reduction In Toxicity, Mobility, Or Volume Of Impacted Media	MNA will reduce toxicity, mobility, and volume of impacted media over time Institutional Controls will not reduce toxicity, mobility, or volume of impacted media
Implementability	MNA is readily implemented Institutional Controls are readily implemented
Cost	MNA is low cost in the short term and depending upon length of monitoring period could be low to moderate in the long term Institutional Controls are low cost in the short and long term

The evaluation of alternatives indicates that both in-situ groundwater treatment and institutional controls could be effective in addressing on-site and off-site groundwater pathways, given that institutional controls can be guaranteed to limit exposure at the off-site areas and in-situ groundwater treatment will help reduce toxicity, mobility, and volume by direct removal. Groundwater recovery is not an action that may be applicable to all off-site areas due to access and transmissivity issues. Years of historical data including the two completed ISCO pilot studies have proven that low transmissivity conditions severely limit the ability of an active corrective action involving extraction/capture of the impacted groundwater. Therefore, the probability that impacted groundwater could be effectively addressed with a groundwater extraction scenario is far less likely than implementation of institutional controls. Coupling a low probability for success with an extraction system, area geology and hydrogeology limitations and off-site access issues with the high initial and long term operating costs suggests this is not an ideal solution.

Institutional controls however will immediately eliminate the potential for exposure to impacted soil and groundwater. Institutional controls also do not have the issue of coverage that groundwater recovery will have due to access and transmissivity issues, because the controls will cover the full area of concern. Institutional controls are also readily implemented, providing faster protection than groundwater recovery.

The evaluation of alternatives illustrates that in-situ groundwater treatment in combination with institutional controls will immediately eliminate the potential for exposure to impacted soil and groundwater and will begin to reduce toxicity, mobility, and volume of the source. This alternative is more cost effectively than the other alternative components in both the immediate, short term, and long term.

3.2 Final Remedy Selection

The Final Remedy Selection is Alternative 2: On-Site Chemical Oxidation, Off-Site MNA, and On-Site and Off-Site Institutional Controls. All the various delineation and interim measure activities undertaken at the site to date have resulted in a well delineated and understood site. Whirlpool has used this knowledge to develop a recommended plan for final corrective measure that can be effectively and efficiently implemented. The Final Remedy Selection will meet the remedial action criteria defined in Section 2.4 of:

- Eliminate or reduce the lateral extent or concentration of the groundwater plume both off-site and on-site.
- Eliminate or reduce the potential for unacceptable risk that may result if there are future changes in land or groundwater uses either off-site or on-site.
- Eliminate or reduce to acceptable levels the risk from certain potential on-site groundwater contact exposures identified in the HHRA which could pose an unacceptable risk.

3.2.1 Final CSM – Exposure Pathways

The selected final remedy will eliminate all exposure pathways associated with impacted on-site and off-site areas (Figure 6). The exposure pathways will be eliminated both on and off-site via the use of institutional controls such as deed restrictions, restrictive covenants, or a City ordinance. Exposure pathways will further be eliminated by demonstrating that off-site vapor intrusion does not pose an unacceptable risk to potential receptors. Lastly, the reduction of source COCs on-site via chemical oxidation and the reduction of off-site COCs via MNA will assist in reducing risks posed by the COCs.

3.2.1.1 On-Site Groundwater

On-site groundwater will be treated in-situ with a chemical oxidant to reduce source area concentrations. This action is also expected to affect the off-site groundwater concentrations by reducing the toxicity and volume of COCs moving off-site.

Use of on-site groundwater will also be restricted via the use of institutional controls within the defined impact area. In addition, institutional controls in the form of deed restrictions will be put into place to prohibit groundwater use on-site, require appropriate health and safety precautions be enforced during construction or maintenance activities that involve excavation into impacted groundwater, and require the future building use comply with OSHA requirements and include CVOCs in impacted groundwater as part of the hazard communication program.

Final Remedy Performance Monitoring Section 3.3.1 includes groundwater and soil vapor monitoring on-site to monitor final remedy effectiveness during the performance monitoring period defined by this RRMP.

3.2.1.2 On-Site Soil

On-site soil will be addressed through Institutional Controls (restrictive covenants) to eliminate access to affected on-site soil. Whirlpool will record restrictive covenants when the property changes ownership. In the interim Whirlpool will continue to operate in accordance with existing site Environmental Health and Safety protocols already in place.

3.2.1.3 Off-Site Groundwater

The selected final remedy includes the use of institutional controls and MNA to control unacceptable risks posed by COCs. These institutional controls may take the form of deed restrictions, restrictive covenants or a City ordinance. MNA will assist in reducing concentrations off-site. In addition to addressing groundwater via institutional controls and MNA, Whirlpool is also proposing to complete an on-site remedial action as discussed in section 3.2.1.2 below.

Potential off-site vapor intrusion exposure to groundwater derived vapors meets USEPA risk limits. See the HHRA, attached as Appendix A.

Final Remedy Performance Monitoring Section 3.3.1 includes groundwater and soil vapor monitoring of off-site areas to monitor final remedy effectiveness during the performance monitoring period defined by this RRMP.

3.3 Performance Criteria

The primary elements of the final remedy include institutional controls that maintain existing on-site soil restriction, off-site and on-site groundwater restriction, source reduction on-site via chemical oxidation, and monitoring off-site for natural recovery. Performance monitoring will be implemented to ensure the primary elements continue to be protective of human health are presented in the following sections.

3.3.1 Performance Monitoring

3.3.1.1 Institutional Controls

In order to meet obligations associated with restrictive covenants, Whirlpool will rely on the future owners of the property to adhere to the recorded restrictive covenants. In the interim Whirlpool will continue to operate in accordance with existing site Environmental Health and Safety protocols already in place. In order to meet obligations associated with the off-site restrictions, Whirlpool will rely on the City of Fort Smith for enforcement.

3.3.1.2 Chemical Oxidation Monitoring

Whirlpool will implement a tiered monitoring program to address chemical reductions completed as part of the on-site in-situ chemical oxidation effort. The final work plan will specify the number of wells to be monitored and frequency of monitoring as these factors are dependent upon the quantity of injectant used, number of injection points and frequency of injection event(s). At a minimum it is expected that monitoring will be completed at the following intervals post injection; one month, three months, six months, and one year.

3.3.1.3 Soil Gas Monitoring

Whirlpool will implement a program of soil gas monitoring for a three-year period on an annual basis to monitor the soil gas concentrations to confirm that groundwater derived vapors are not migrating and that vapor intrusion continues to be an incomplete pathway. The program will use the existing soil gas sampling points augmented with additional soil gas sampling points to be incorporated into the performance monitoring program. The soil gas monitoring will include analysis of CVOCs that have inhalation toxicity values and where the detected concentration in groundwater exceeds the MCL at or near the soil gas sampling point. The additional soil gas sampling locations will be specified in a final work plan.

3.3.1.4 Groundwater Monitoring - MNA

Whirlpool will implement a program of annual groundwater monitoring for a five year period to verify indicators of natural recovery, as well as, plume stability and/or decreasing groundwater impact. A limited number of existing wells will be incorporated into the performance monitoring program. The groundwater monitoring program will include, in addition to MNA indicators, analysis of the key constituents of concern including TCE, PCE, 1,1-DCE, 1,1-DCA, cis-1,2-DCE and vinyl chloride. Specific wells to be incorporated into the performance monitoring system will be specified in the final work plan.

3.4 Contingency Plans

If at the end of five years of monitoring, if the Remedial Action Criteria is not being met, Whirlpool will implement a revised sampling program and determine data impacts to the HHRA that forms the basis for this RRMP. Whirlpool will notify ADEQ within three months of the last annual sampling event of any findings not in accordance with this RRMP.

3.5 Performance Reviews

In accordance with the LOA Whirlpool will complete the following required Performance Reviews.

3.5.1 Quarterly

Whirlpool will prepare quarterly Remedial Action and Operation and Maintenance Status Reports as required in the LOA.

The quarterly status reports will contain the following:

- Description of work completed,
- Summaries of all findings in the reporting period,
- Summaries of problems encountered during the reporting period and actions taken to address problems,
- Deviations from any approved work plans or schedules including justification for any delays with revised projected completion date(s), and
- Projected work for the next reporting period.

3.5.2 Annual Monitoring Report

Whirlpool will prepare annual performance monitoring reports that summarize the results of the annual groundwater and soil gas monitoring activities. The annual monitoring report will contain the following:

- Summaries of the annual groundwater and soil gas monitoring results with comparisons to remedial action criteria;
- Summaries of groundwater level elevation data; and
- Copies of the laboratory analytical reports.

Whirlpool will submit annual monitoring reports with data summaries for current and previous annual submittals. In the event the five year groundwater monitoring program in Section 3.3.1 of this RRMP indicates that the performance criteria have been met, Whirlpool will propose that all performance monitoring cease.

3.5.3 Five Year Review

Consistent with the 2005 Arkansas Groundwater Remediation Level Interim Policy, five years after initiating the Final Remedy Whirlpool will submit a five-year technical review of the status of the Whirlpool site final remedy and assess the need for further actions if necessary.

3.6 Public Involvement Plan

As specified in the LOA, Whirlpool will seek public comment on the Administrative Record (AR) and the proposed corrective measures for the corrective actions to be implemented for the Fort Smith site with ADEQ participation. The public involvement plan will consist of:

- Establishing a local repository for project documents;
- Compiling a copy of the AR for public access at the repository;
- Providing public notice of the availability of the AR and a request for comments on the AR and the proposed corrective measures within 30 days; and
- Completing a Public Meeting for all residents and City Leaders to review the final remedy.

Whirlpool will establish a local document repository where the public will have access to the AR (i.e. the collection of documents forming the basis for the final remedy). The location of the document repository, typically a local library, will be determined in cooperation with the ADEQ.

Whirlpool will provide a copy of relevant site documents to the repository that will provide the public the basis to understand the selection of the final remedy. Whirlpool will then work with ADEQ to place a public notice in a local newspaper advertising the availability of the AR and asking for public comments on the selection of the final corrective measure. The public will be directed to provide comments to the ADEQ. The public comment period will be for a maximum of 30 calendar days. During the 30 day period Whirlpool will complete a public meeting to present the remedy and solicit feedback from invited residents and city leaders. Following receipt of comments and direction from ADEQ, Whirlpool will update the AR, as necessary. Once the AR is complete and fully approved, the RMP will be implemented.

3.7 Proposed Schedule and Completion of CAS Program

The RRMP implementation schedule is presented below and represents Whirlpools current estimate of the timing for completion of each of the outlined tasks. The schedule reinforces Whirlpools commitment to an efficient, expeditious implementation of the final remedy following notification to proceed from the ADEQ.

The schedule will be reviewed on quarterly basis as part of the Performance Plan (Section 3.5). Any schedule revisions will be addressed in the quarterly, annual and five year reports discussed in previous sections of the RRMP.

Activity	Start	End	Comment
Implement Public Involvement Plan	June 1, 2013	September 30, 2013	Includes 30 day comment period, addressing comments with ADEQ, and issuance of RADD
Restricted Covenants / Deed Restrictions developed and Recorded for Whirlpool Property		September 1, 2013 *	* Whirlpool will record restrictive covenants in accordance with Arkansas regulations at the time property(ies) transfer(s) occur.
Prepare and Submit Final Remedy Work Plan To ADEQ	May 1, 2013	August 15, 2013	
Install Additional Soil Gas Sampling Locations	June 1, 2013	August 30, 2013	Assumes ADEQ approval of Work Plan on or before June 30, 2013
Annual Performance (Groundwater / Soil Gas) Monitoring		June 30, 2018 (soil gas will cease in 2016)	Assumes ADEQ approval of Final Remedy Work Plan on or before June 30, 2013
Quarterly Performance Reports		June 1, 2018	
Five Year Review		June 1, 2018	

4 References

Arkansas Department of Environmental Quality. (ADEQ). 2002. “Letter of Agreement to Implement a Risk Management Strategy Between The Arkansas Department of Environmental Quality and Whirlpool Corporation,” July 19.

Environmental Resources Management (ERM). 2007. “Risk Evaluation Report”, June 14.

Environmental Resources Management (ERM). 2008. “Risk Management Plan,” March 27.

ENVIRON International Corporation (ENVIRON). 2012. “Human Health Risk Assessment (HHRA)”, November 30.

United States Environmental Protection Agency (USEPA). 1994. “RCRA Corrective Action Plan (Final)”, May.

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Tables

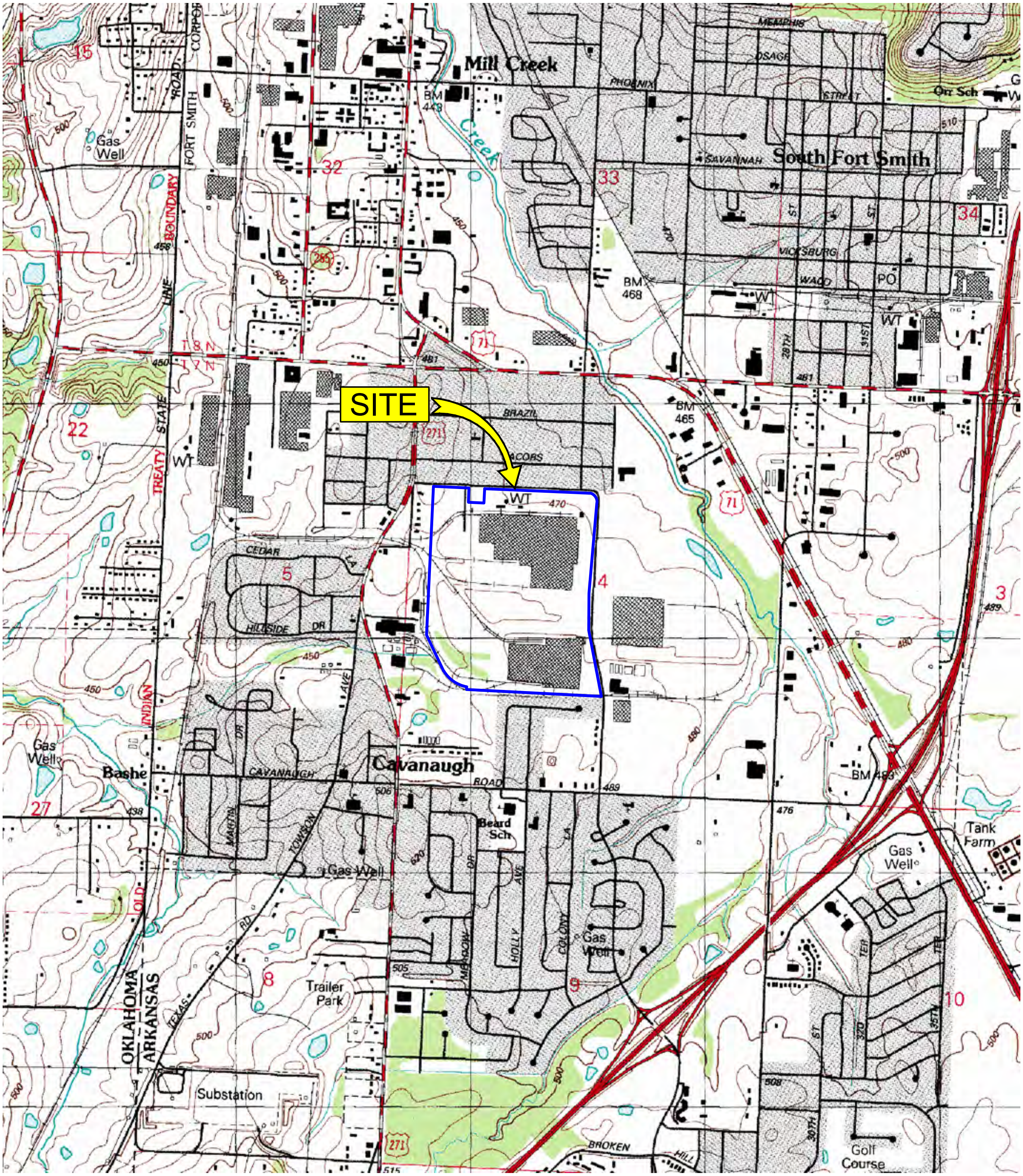
TABLE 1

Corrective Action Measures Summaries

Whirlpool Corporation
Fort Smith, Arkansas

General Corrective Action	Remedial Technology	Process Option	Description
NO ACTION	None	No Action	No action, represents base line conditions. Includes semi-annual ground water monitoring.
CONTAINMENT	Horizontal Barriers	Topsoil/Clay and Vegetation	Placement of topsoil/clay and seeding to vegetate
		Asphalt	Placement of asphalt over affected soil
		Concrete	Mixing and placement of concrete over affected soil
		Engineered Soil Cover w/Synthetic Liner	Construction of combination soil cover and synthetic liner
	Vertical Barriers	Slurry Wall	Installation of trench filled with soil/bentonite slurry
		Cement-Bentonite Wall	Installation of trench filled with cement/bentonite slurry
		Grout Curtain	Injection of clay-cement grout into voids where piles were driven and extracted
		Sheet Pile Wall	Construct of containment wall by driving sheet piling
		Interceptor Trenches	Installation of gravel filled trench used to isolate affected area
REMOVAL	Soil Excavation	Excavation	Excavation - Removing media via backhoe for treatment or disposal
	Ground Water Extraction	Extraction Trenches	Trench, either open or backfilled with porous media, to allow seepage and collection of groundwater and oils
		Extraction Wells	Series of wells to extract impacted groundwater
TREATMENT - In situ	Biological	Enhanced Aerobic/Anaerobic Biodegradation	Addition of bacteria, oxygen and nutrients to promote biodegradation of chemicals
		Natural Attenuation	Long-term monitoring physical, chemical and biological processes that reduce chemicals of concern naturally
	Physical/Chemical	Vapor Extraction	Application of a vacuum on the soil
		Permeable Treatment Beds	Impacted groundwater is intercepted in a downgradient trench filled with materials to treat or absorb the chemicals
		Chemical Oxidation	Saturated soils and groundwater are oxidized by injection of oxidants
		Soil Flushing	A cosolvent or surfactant is used to flood the area
INSTITUTIONAL ACTIONS	Access Restrictions	Deed Recordation	Surveying and filing of deed recordation, restricting groundwater use

Figures



1 1/2 0 1 MILE

2000 0 2000 4000 6000 FEET

CONTOUR INTERVAL 10 FEET

SOURCE: U.S.G.S. 7.5 min□te series (topographic)
So□th Fort Smith, Arkansas □□adrangle, 1997

ARKANSAS

LEGEND

APPROXIMATE PROPERTY BOUNDARY

N

ENVIRON

DRAFTED BY: ELS

DATE: 11/8/12

SITE LOCATION MAP

WHIRLPOOL CORPORATION
6400 SOUTH JENNY LIND ROAD
FORT SMITH, ARKANSAS

FIGURE
1

21-31344A

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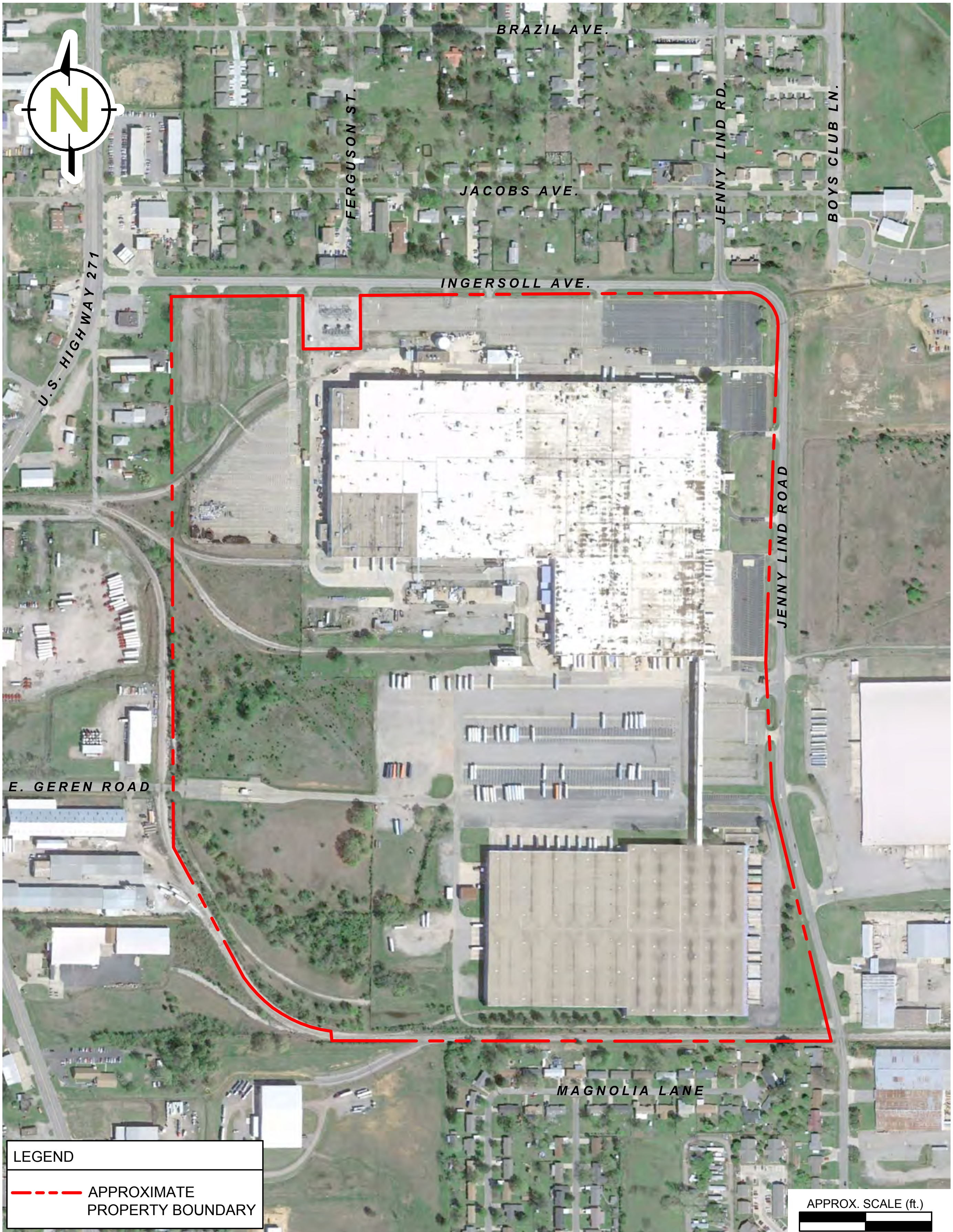

AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO. PHOTO TAKEN MARCH 2012.

ENVIRON

SITE LA□OUT
WHIRLPOOL CORPORATION
6400 JENNY LIND ROAD
FORT SMITH, ARKANSAS

FIGURE
2

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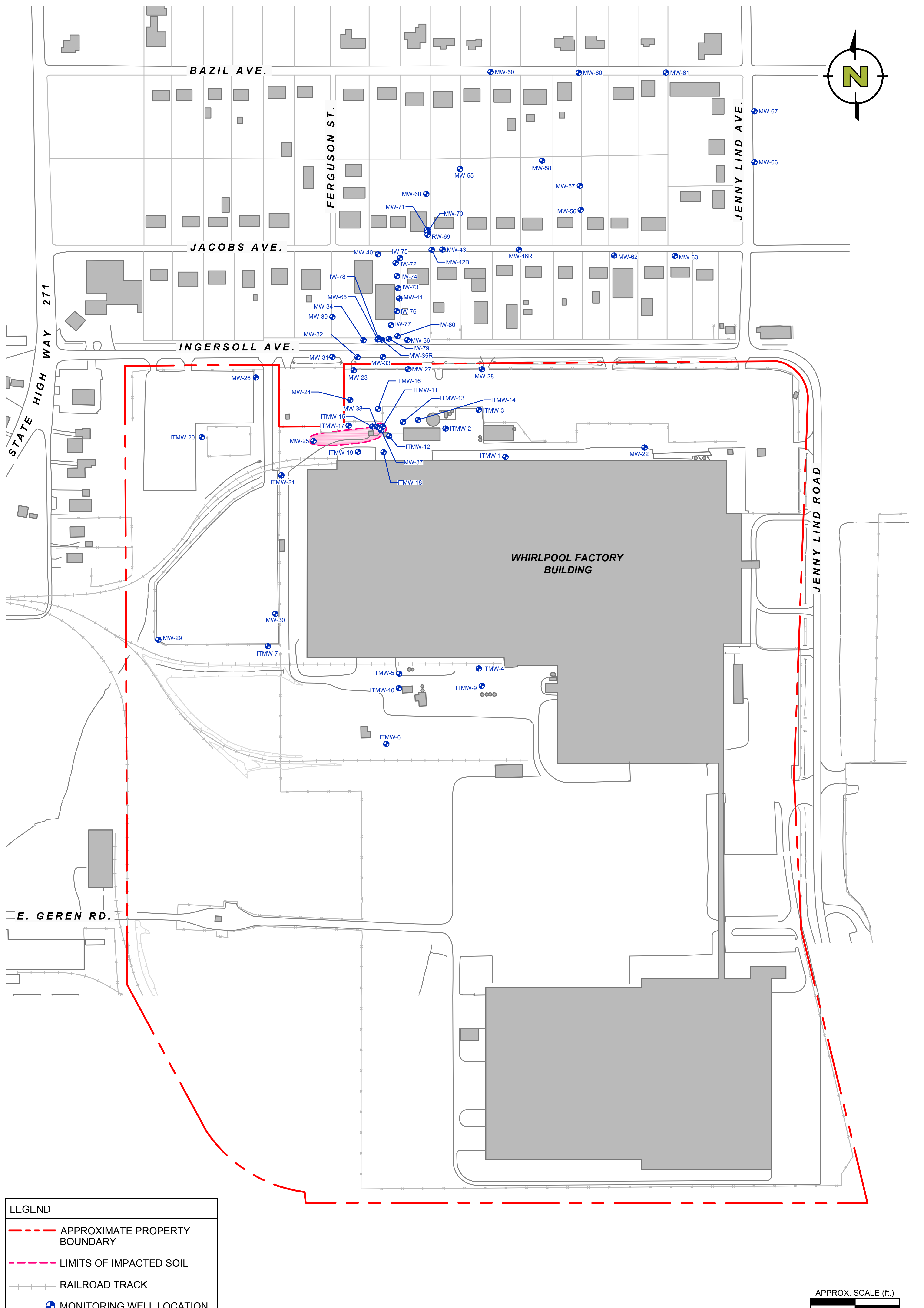

Note: Limits of soil impact were based upon approximation provided by ERM in the 2008 Risk Management Plan.

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DRAFTED BY: ELS/CKN

DATE: 11/27/12

LIMITS OF IMPACTED SOIL

WHIRLPOOL CORPORATION

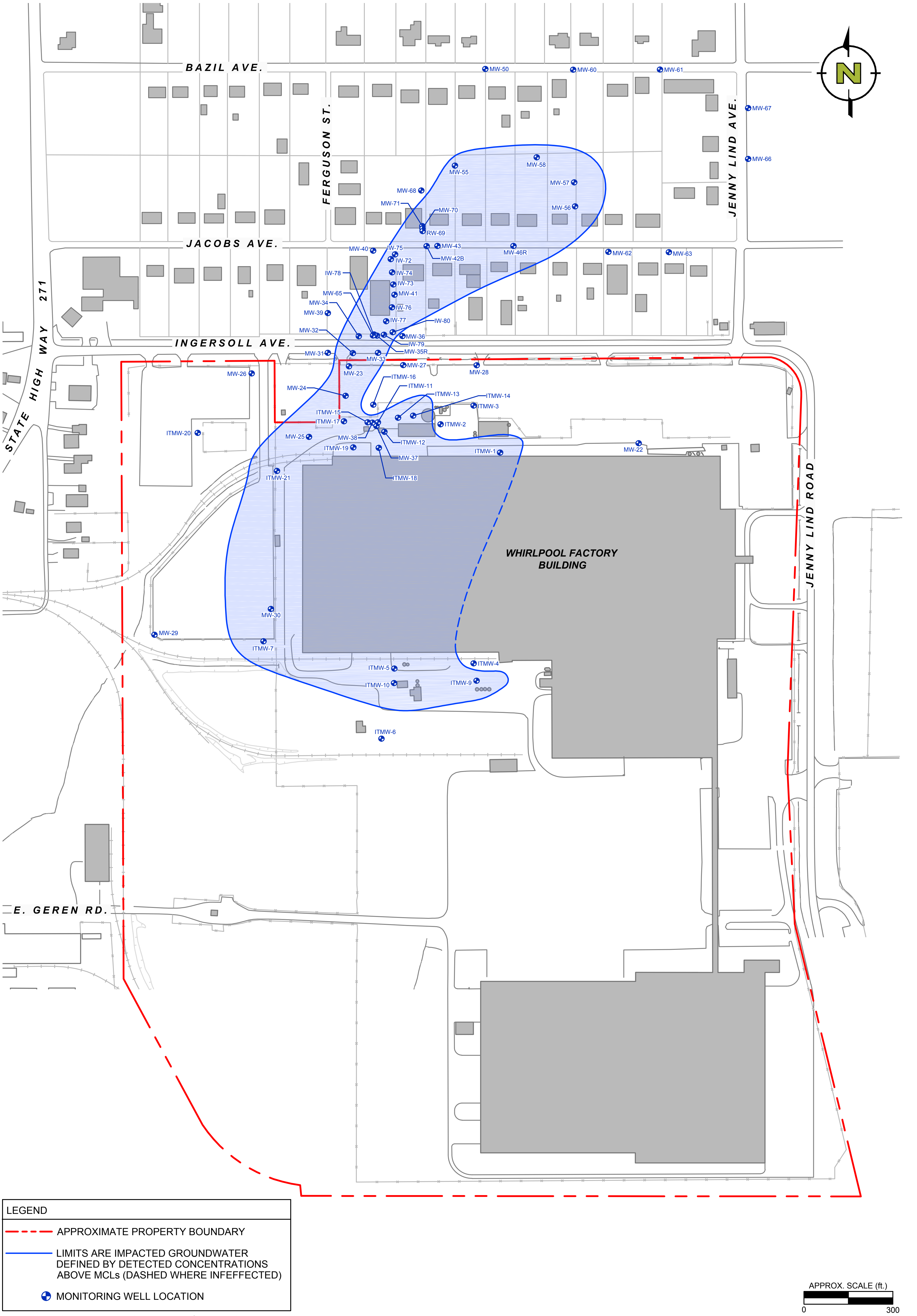
6400 JENNY LIND ROAD

FORT SMITH, ARKANSAS

FIGURE

☐

21-31344A



Note: Soil boring locations were based on Figure 2-13 from the Risk Management Plan (ERM 2008).

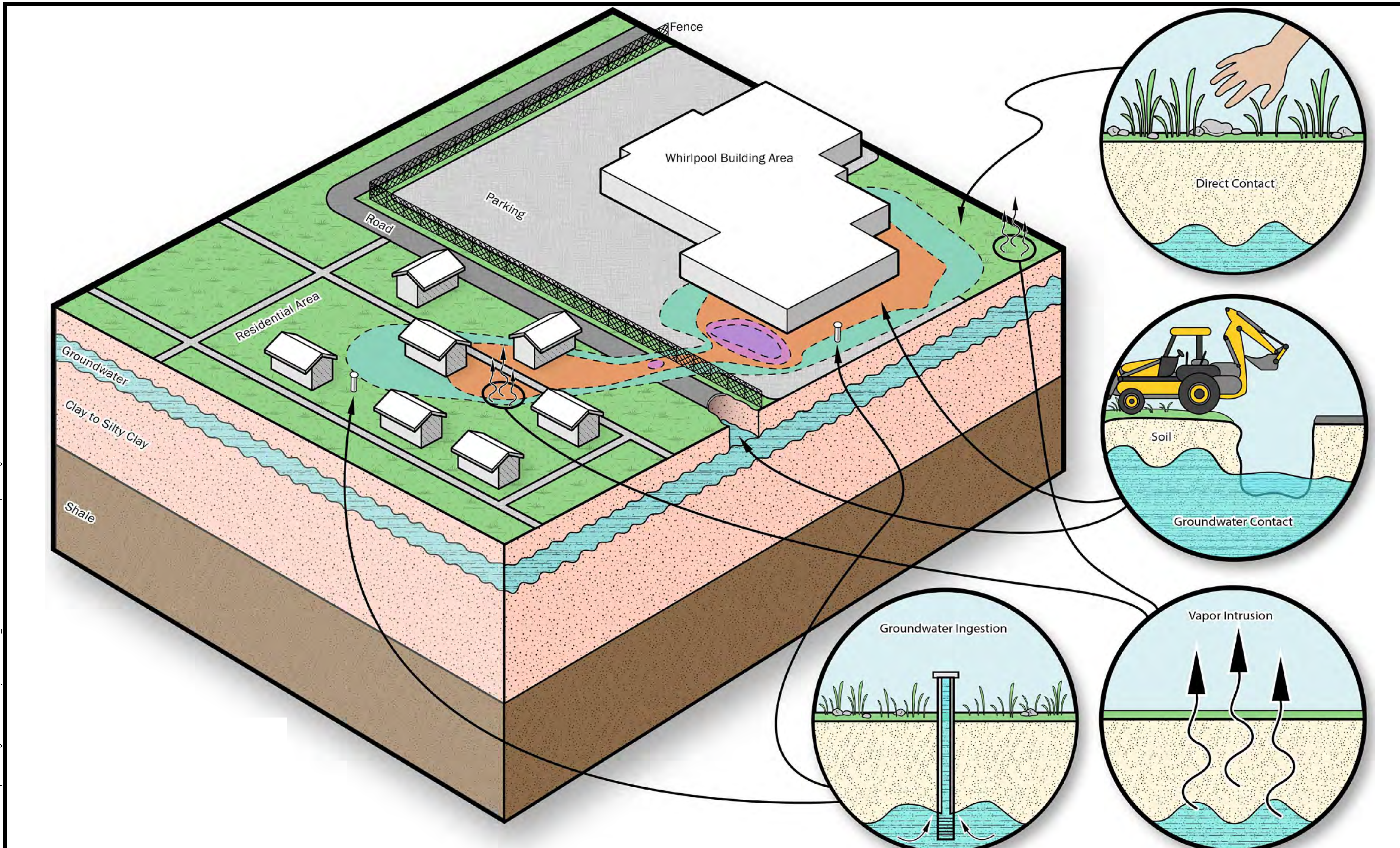
ENVIRON

DRAFTED BY: ELS/CKN | DATE: 4/2/13

LIMITS OF CVOCs IN GROUNDWATER - SPRING 2012
WHIRLPOOL CORPORATION
6400 JENNY LIND ROAD
FORT SMITH, ARKANSAS

FIGURE
4

21-31344A



ENVIRON

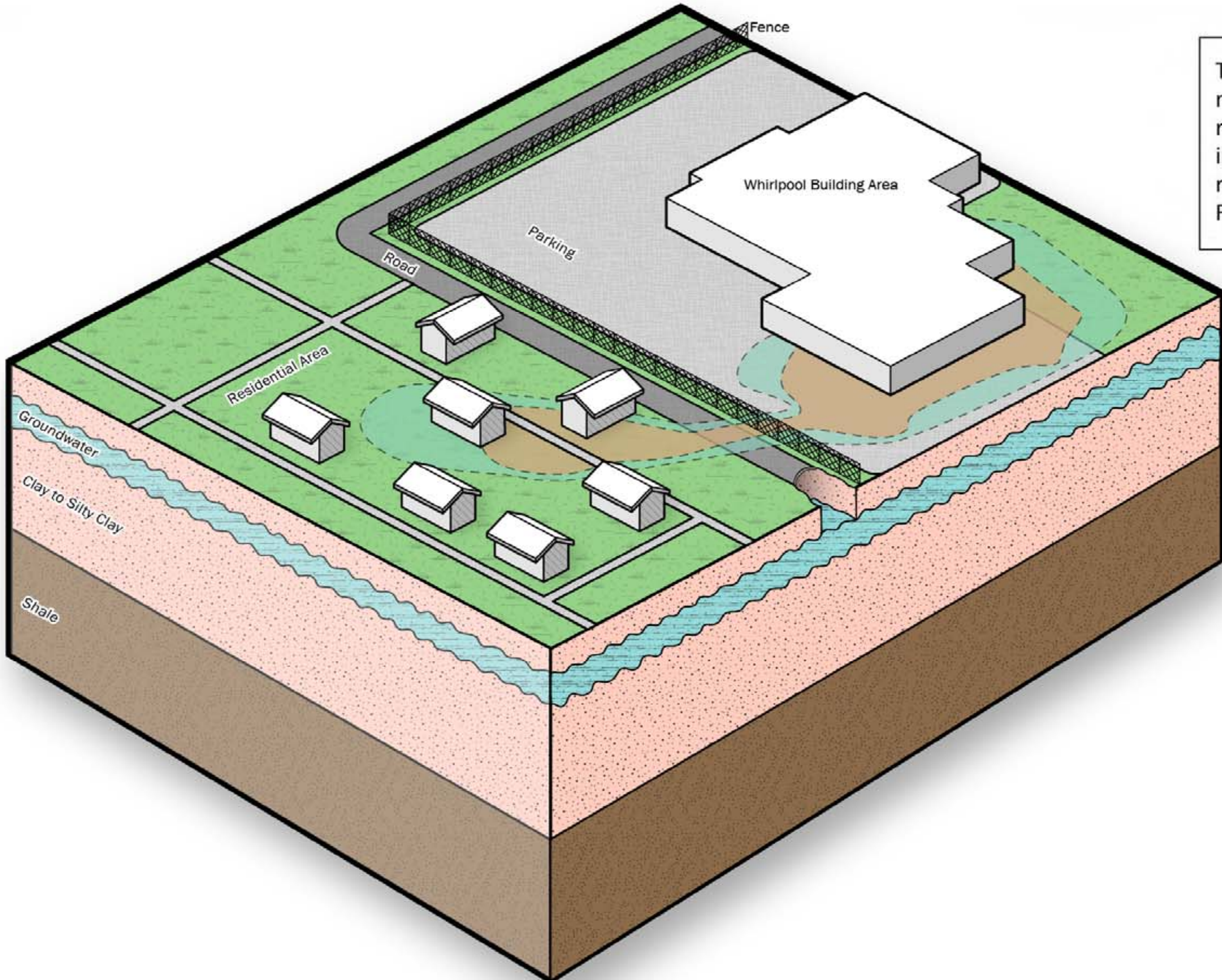
DRAFTED BY: KK/AW/CKN/ELS | DATE: 11/30/12

CSM SCENARIOS FOR POTENTIAL HUMAN EXPOSURE

WHIRLPOOL CORPORATION
6400 JENNY LIND ROAD
FORT SMITH, ARKANSAS

FIGURE

21-31344A



This figure illustrates there are no unacceptable human health risks after successful implementation of the final remedy defined by the Revised Risk Management Plan

ENVIRON

DRAFTED BY: KK/AW/CKN/ELS | DATE: 11/30/12

CSM AFTER REMED□ IMPLEMENTATION
WHIRLPOOL CORPORATION
6400 JENNY LIND ROAD
FORT SMITH, ARKANSAS

FIGURE
6
21-31344A

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Appendix A

Human Health Risk Assessment (HHRA)



Revised Risk Management Plan
Appendix A -
Human Health Risk Assessment

Whirlpool Fort Smith Facility
6400 Jenny Lind Avenue
Fort Smith, Arkansas

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ENVIRON

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1 Introduction

This human health risk assessment evaluates the potential health significance of data for soil, groundwater, and soil gas that were collected at and around the Whirlpool facility in Fort Smith, Arkansas (site) to support remedy selection per the letter of agreement (LOA) with the Arkansas Department of Environmental Quality (ADEQ), dated July 19, 2002. The site and adjacent properties are shown on **Figure 1**. As discussed in the Revised Risk Management Plan (ENVIRON 2012), the risk assessment uses these data to quantify risks from reasonable maximum exposures (RME) to soil, groundwater, and soil gas under current and reasonably expected future land and groundwater use at and the site.

The methods and assumptions used in the risk assessment are consistent with United States Environmental Protection Agency (USEPA) human health risk assessment guidance. The results of the risk assessment are compared to the acceptable risk limits used by Arkansas Department of Environmental Quality (ADEQ 2005) to identify where a release of hazardous substances from the site may cause reasonable maximum exposures to be significant enough to warrant remediation. The scope of the human health risk assessment is summarized in the conceptual site model (CSM) presented in **Table 1**, which is based on current and reasonably anticipated land use at the site. The CSM identifies the potentially exposed populations, the environmental media to which they could be exposed, and the potential routes of exposure. These exposure scenarios are discussed further in Section 3.

The remainder of this report is organized as follows:

- Section 2 discusses the preparation of data used in the risk assessment.
- Section 3 discusses the scenarios for potential human exposure that are evaluated in the risk assessment.
- Section 4 discusses the toxicity values used in the risk calculations.
- Section 5 discusses the physical and chemical parameters used in the risk calculations.
- Section 6 discusses the significance of the risk estimates for the potential exposures discussed in Section 3. Uncertainties associated with the risk estimates are also discussed in this section.
- Section 7 summarizes the findings and conclusions of the risk assessment.

2 Data Collection and Preparation

All valid soil, groundwater, and soil gas data collected at and around the site to support remedy selection were considered for use in the risk assessment. The locations where these data were collected are shown on **Figure 2**.

The following procedures, which are based on USEPA's Risk Assessment Guidance (RAGS) Part A (USEPA 1989), were used to prepare the data for quantitative assessment of RME risks:

- Concentrations qualified as not detected (i.e., U or UJ-qualified data) are evaluated as non-detects.
- The concentrations of 1,3-dichloropropene (total) and xylenes (total) in a sample are the sums of the concentrations of the detected isomers and half the quantitation limits of isomers not detected in the sample but detected in the same matrix at the site. If no isomer is detected in a sample, the chemical is considered to be not detected in the sample.

As a conservative assumption, all concentrations of chemicals are assumed to be site-related. All detected chemicals are included in the risk assessment, regardless of their detection frequency.

3 Exposure Assessment

3.1 Conceptual Site Model

The site is an industrial facility located at 6400 Jenny Lind Avenue, Fort Smith, Arkansas. The site has been operated by Whirlpool for over 35 years to manufacture household appliances. The site is approximately 150 acres and includes the main manufacturing building, adjoining warehouse and administrative offices, manufacturing support buildings, and approximately 20 acres of undeveloped land. The majority of the on-site area surrounding the buildings is covered with concrete, asphalt, or gravel for parking.

The area north of the site is residential and the areas east, south, and west of the site are industrial/commercial. The nearest residence is located to the north, adjacent to the site.

The site and the surrounding area are connected to a municipal water supply and there is no known use of groundwater within or near the area of impacted groundwater. Currently, there is no ordinance or restriction that would prohibit use of groundwater in the impacted area.

The scenarios for potential human exposure under current and potential future conditions at and around the site are summarized in the conceptual site model (CSM) on **Table 1**. The receptors and potential pathways included for quantitative evaluation in the risk assessment are as follows:

- On-Site Routine Workers
  - Soil – incidental ingestion, dermal contact, and inhalation of vapors and particulates during outdoor activities; inhalation of vapors in indoor air
  - Groundwater – inhalation of vapors in outdoor air; inhalation of vapors in indoor air
- On-Site Maintenance Workers
  - Soil – incidental ingestion, dermal contact, and inhalation of vapors and particulates during smaller-scale surface and subsurface maintenance activities
  - Groundwater – incidental ingestion, dermal contact, and inhalation of vapors during smaller-scale subsurface maintenance activities that encounter groundwater

- On-Site Construction Workers
  - Soil – incidental ingestion, dermal contact, and inhalation of vapors and particulates during larger-scale/short-term (i.e., 1 year) construction activities
  - Groundwater – incidental ingestion, dermal contact, and inhalation of vapors during larger-scale/short-term (i.e., 1 year) subsurface construction activities that encounter groundwater
- Off-Site Residents
  - Soil –inhalation of wind-blown vapors and particulates from on-site soil
  - Groundwater – inhalation of vapors in outdoor air; inhalation of vapors in indoor air; and ingestion or dermal contact with groundwater
- Off-Site Routine Workers
  - Soil – inhalation of vapors and particulates from on-site soil during off-site outdoor activities
  - Groundwater – inhalation of vapors in outdoor air; inhalation of vapors in indoor air; and ingestion or dermal contact with groundwater
- Off-Site Maintenance Workers
  - Groundwater – incidental ingestion, dermal contact, and inhalation of vapors during smaller-scale/shorter duration subsurface maintenance activities that encounter groundwater

3.2 Exposure Concentrations

3.2.1 Soil

Risk estimates for RME are conservatively estimated in this risk assessment by first using the maximum detected concentrations at any depth from the available soil data to calculate upper-bound estimates of cumulative cancer and noncancer risks. If these upper-bound estimates of RME risks do not exceed the acceptable risk levels, i.e., cumulative site-related cancer risk of 10^{-4} and noncancer HI of 1, then further calculations such as 95% upper confidence limits (95% UCLs) on the mean are not necessary. The use of maximum detected concentrations, rather than 95% UCLs, for the chemicals evaluated in this risk assessment introduces more conservatism than necessary for RME estimates because it assumes constant, simultaneous worst case exposure to all detected chemicals, when the RME generally would not have all chemicals at worst case concentrations at all times.

3.2.2 Groundwater

To assess potential exposures to groundwater under current and future conditions on- and off-site, the highest detected concentration for each chemical from all monitoring wells sampled since 2008, i.e., the past five (5) years, were used to calculate upper-bound estimates of cumulative cancer and noncancer risks representative of current conditions. On-site and off-site groundwater data from the last ten years of semi-annual groundwater monitoring conducted under the LOA, indicate the plume boundary, defined by concentrations in groundwater that are higher than the Federal maximum contaminant level (MCL), is not expanding and that concentrations of trichloroethene (TCE) in groundwater are not increasing, although some contaminant mass may have been re-distributed following the permanganate injections in 2009. Groundwater data from 2012 show that concentrations of TCE have further decreased by at least a factor of 2.4 from the maximum concentrations detected during the last five years. As discussed above, the use of maximum detected concentrations introduces more conservatism than necessary for RME estimates.

3.2.3 Soil Gas

Soil gas data were collected in May 2012 from two locations that are between 30 and 80 feet away from nearby groundwater wells, as shown on **Figure 2**, to confirm the results of the groundwater vapor intrusion risk calculations discussed in Section 3.3.1. The evaluation of the soil gas data and potential uncertainties in the groundwater vapor intrusion risk estimates are discussed in Section 6.8.2.

3.3 Fate and Transport Models

The following models are used in the risk assessment to estimate exposure concentrations for the exposure scenarios discussed in Section 3.1. These models are used by USEPA and state regulatory agencies for screening level analysis. The following are descriptions of the models.

3.3.1 Soil and Groundwater Vapor Intrusion

Indoor air concentrations resulting from soil or groundwater vapor intrusion into a building are estimated using the following relationships described by Johnson and Ettinger (1991), which USEPA recommends for screening level evaluations (USEPA 2004a):

$$C_{building} = \alpha\, C_{source}$$

where C_{source} is the source vapor concentration, and α is an attenuation coefficient that is given by the following equation:

$$\alpha = \frac{\left[\dfrac{D_T^{eff} A_B}{Q_{building} L_T}\right]\exp\left(\dfrac{Q_{soil} L_{crack}}{D^{crack} A_{crack}}\right)}{\exp\left(\dfrac{Q_{soil} L_{crack}}{D^{crack} A_{crack}}\right) + \left[\dfrac{D_T^{eff} A_B}{Q_{building} L_T}\right] + \left[\dfrac{D_T^{eff} A_B}{Q_{soil} L_T}\right]\left[\exp\left(\dfrac{Q_{soil} L_{crack}}{D^{crack} A_{crack}}\right) - 1\right]}$$

Derivation of this equation and definition of the equation parameters can be found in Johnson and Ettinger's 1991 journal article, and therefore, are not repeated here.

The effective diffusion coefficient term D_T^{eff} in the equation for the attenuation coefficient (α) is calculated based on a "silty clay" soil, the predominant unsaturated soil type at and around the site. The soil-water profile in the vadose zone is estimated using the van Genuchten soil-water retention equation with default water retention parameters appropriate for silty clay (USEPA 2004a).

The distance between on-site groundwater and the foundation of a slab-on-grade building (L_T) is estimated to be approximately 3.5 m, which is the difference between the typical depth to groundwater on-site of 3.7 m (12 ft) and a conservatively assumed building foundation thickness of 15 cm. The cracks in the building foundation are conservatively assumed to be filled with dry sand. The remaining parameters in the equation for the attenuation coefficient (α), which relate to building characteristics, are based on USEPA values for assessing chronic vapor intrusion into residential buildings (USEPA 2004a and 2012a) and default values presented in the Michigan Department of Environmental Quality technical support document for assessing chronic vapor intrusion into commercial buildings (MDEQ 1998)[1]. Residential structures surrounding the Site have not been observed to have basements and as such, evaluation of vapor intrusion into structures with basements was not performed. The rationale for these inputs is discussed in the USEPA guidance and MDEQ guidance, and therefore, is not repeated here.

The source vapor concentration (C_{source}) for a chemical in soil is calculated from the chemical's concentration in soil (C_{soil}), as follows:

$$C_{source} = C_{soil}\left(\frac{K_d}{H} + \frac{\theta_w}{\rho_b H} + \frac{\theta_a}{\rho_b}\right)^{-1}$$

where K_d is the equilibrium-partitioning coefficient, H is the Henry's law constant (adjusted to the estimated subsurface temperature in the Fort Smith, Arkansas area of 16.7 °C (USEPA 2004a)), θ_w is the water-filled soil porosity, ρ_b is the soil bulk density, and θ_a is the air-filled soil porosity.

The soil vapor intrusion risk calculations included a mass balance check to ensure that the assumed mass of a chemical infiltrating into the building over the assumed exposure period does not exceed an upper-bound estimate of the chemical's mass in the vadose zone soil underlying the building. The upper-bound estimate of the chemical's mass in the vadose zone soil was conservatively estimated using the highest concentration of the chemical from any depth in soil at the site and assuming that this concentration represents the concentration in soil from ground surface to the water table. The attenuation coefficient α_{ML} used in the mass balance check is given by the following equation:

$$\alpha_{ML} = \left(\frac{\rho_b \cdot K_d}{H} + \frac{\theta_w}{H} + \theta_a\right)\cdot\left(\frac{A_B \cdot \Delta H}{Q_{building} \cdot ED}\right)$$

where A_B is the area of the building footprint, ΔH is the contaminant thickness (the distance between water table and a building foundation ($L_{T\text{-}gw}$)), and $Q_{building}$ is the air flow rate through the building. These parameters are shown in **Attachment 2** and **Attachment 5**.

The source vapor concentration for a chemical in groundwater is calculated from the chemical's concentration in groundwater (C_{gw}), as follows:

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[1] Factors for assessing this pathway for commercial/industrial buildings, including assumptions regarding building characteristics, are not available from ADEQ or USEPA.

$$C_{source} = C_{gw} \cdot H$$

The computation of the single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 2**. The cumulative risk and HI estimates for vapor intrusion from soil and groundwater are summarized on **Table 2** and **Table 3**, respectively.

In assessing the significance of releases, potential exposure of routine workers to chemicals in soil and groundwater via potential vapor intrusion is also evaluated by dividing the highest estimated concentrations of chemicals in indoor air resulting from vapor intrusion by occupational indoor air standards, and then summing the resulting ratios. This approach is consistent with the approach described in Occupational Safety and Health Administration (OSHA) regulations at 29 CFR 1910.1000(d)(2)(i) for assessing compliance with inhalation exposure limits for a mixture of air contaminants, which uses an equivalent exposure for the mixture (E_m) given by the following:

$$E_m = \sum_i \frac{C_{building,i}}{L_i}$$

where $C_{building,\,i}$ and L_i are the indoor air concentration (calculated as described above) and exposure limit for chemical i, respectively. Exposure is within acceptable limits when E_m does not exceed 1. In applying this approach to assess the significance of contributions from vapor intrusion to indoor air exposures, the contribution to E_m due to vapor intrusion should be much less than 1 (e.g., less than 0.01).

The exposure limits L_i in the above equation are the permissible exposure limits (PELs) established by OSHA (OSHS 2007), threshold limit values (TLVs) recommended by the American Conference of Government Industrial Hygienists (ACGIH 2005) for chemicals without PELs, or NIOSH recommended exposure limits (RELs) for chemicals without a PEL or TLV. The inhalation limits for chemicals evaluated in the risk assessment are shown in **Attachment 1**.

3.3.2 Vapor Emission from Exposed Soil

The potential exposure of outdoor receptors (i.e., routine workers and residents) to vapors that are emitted from soil are assessed based on the normalized average vapor flux J_v of a chemical from unsaturated soil. The average flux is conservatively estimated using an unsteady-state model derived by Jury et al. (1983). This model conservatively assumes that volatile chemicals are present in the soil to a finite depth. The equation for J_v is given by:

$$J_v = \frac{C_{s,0}}{T}\left(2\left(\exp\left(\frac{-Z_1^{\;2}}{4D_E T}\right) - \exp\left(\frac{-Z_2^{\;2}}{4D_E T}\right)\right)\sqrt{\frac{D_E T}{\pi}} - Z_1 erfc\left(\frac{Z_1}{2\sqrt{D_E T}}\right) + Z_2 erfc\left(\frac{Z_2}{2\sqrt{D_E T}}\right)\right)$$

where:

$$D_E = \frac{D_G H + D_L}{\rho_b K_d + \theta_w + \theta_a H}$$

$$D_G = D_{air} \cdot \frac{\theta_a^{10/3}}{n^2}$$

$$D_L = D_{water} \cdot \frac{\theta_w^{10/3}}{n^2}$$

where ρ_b is the soil dry bulk density, D_E is the effective diffusion coefficient in soil, T is the averaging period, D_G is the gas-phase diffusion coefficient, H is the Henry's law constant, D_L is the liquid-phase diffusion coefficient, K_d is the soil-water distribution coefficient, θ_w is water-filled porosity, θ_a is the air-filled porosity, D_{air} is the diffusion coefficient in air, n is the soil porosity, D_{water} is the diffusion coefficient in water and Z_1 and Z_2 are the top and bottom depths of the soil contamination. Derivation of this equation can be found in the Jury et al. 1983 journal article and therefore, is not repeated here. Finite depth volatilization models are also discussed in the Soil Screening Guidance (USEPA 1996). Soil parameters used in this assessment were obtained from USDA's ROSETTA Model V1.0 (1999); parameters for silty clay were selected as representative of the soil observed in the site. The values for chemical-specific parameters and soil parameters for calculating J_V are included in **Attachment 2**.

3.3.3 Groundwater Volatilization into Outdoor Air

Potential exposures to vapor emissions from groundwater that migrate through the vadose zone into outdoor air are assessed using a normalized average vapor flux (J) of a chemical from groundwater, which is calculated by using the steady-state diffusion equation in one-dimension with a constant source concentration and the maximum concentration gradient, as follows:

$$J = D_e \cdot \frac{C_{source}}{L}$$

where D_e is the effective diffusion coefficient of the chemical in the vapor phase, C_{source} is the vapor concentration in equilibrium with the groundwater concentration, and L is the distance from groundwater to the ground surface.

The effective diffusion coefficient for the vapor phase is calculated as follows:

$$D_e = D_v + \frac{D_w}{H}$$

where D_v is the gas phase diffusion coefficient, D_w is the liquid phase diffusion coefficient, and H is the Henry's law constant (adjusted to a subsurface temperature of 16.7°C). The gas and liquid-phase diffusion coefficients are calculated using the Millington-Quirk tortuosity model, as follows:

$$D_v = D_{air} \cdot \frac{\theta_a^{10/3}}{\theta_t^{\,2}}$$

$$D_w = D_{water} \cdot \frac{\theta_w^{10/3}}{\theta_t^{\,2}}$$

where D_{air} is the diffusion coefficient in air, D_{water} is the diffusion coefficient in water, θ_a is the air-filled soil porosity, θ_w is the water-filled soil porosity, and θ_t is the total soil porosity. The values of the porosities used in these calculations are the same as those discussed in Section 3.3.1 for calculating vapor flux from silty clay vadose zone soil.

The normalized vapor flux (J_L) of a chemical from exposed groundwater into outdoor air (e.g., in an excavation) is estimated using an overall mass transfer coefficient (K_L) recommended by USEPA (1995):

$$J_L = K_L = \left(\frac{1}{k_l} + \frac{1}{H\,k_g} \right)^{-1} \left(\frac{m}{10^2\,cm} \right) \left(\frac{10^3\,L}{m^3} \right)$$

where H is the Henry's law constant (adjusted to a subsurface temperature of 16.7°C) and k_l and k_g are the liquid-phase and gas-phase mass transfer coefficients given by the following:

$$k_l = \left(\frac{MW_o}{MW} \right)^{0.5} \left(\frac{T}{298K} \right) k_{l,o}$$

$$k_g = \left(\frac{MW_w}{MW} \right)^{0.335} \left(\frac{T}{298K} \right)^{1.005} k_{g,w}$$

where MW, MW_o, and MW_w are the molecular weights of the chemical, oxygen, and water, T is the absolute temperature of the groundwater, $k_{l,o}$ is the liquid-phase mass transfer coefficient for oxygen, and $k_{g,w}$ is the gas-phase mass transfer coefficient for water vapor.

3.3.4 Dust Emission

Potential exposures to particulate emissions from uncovered soil are assessed using a normalized average particulate flux (J_{10}) of a chemical from surface soil. This particulate flux is conservatively estimated using the "unlimited reservoir" model that USEPA has adapted for screening-level analysis of respirable particulate emissions from soil (USEPA 1996). This model assumes that particulate emissions are created by wind erosion. The equation for J_{10} is given by:

$$J_{10,w} = 0.036 \cdot (1-G) \cdot \left(\frac{u_m}{u_t}\right)^3 \cdot F(x) \frac{g}{m^2 hr} \cdot \frac{hr}{60^2 \sec} \cdot \frac{10^{-3} kg}{g}$$

where G is fraction of ground/vegetative cover, u_m is the mean annual wind speed at the nearest weather station which is located at Fort Smith, Arkansas (NOAA 2010), u_t is the equivalent threshold wind speed at the anemometer height at which u_m was measured, and F(x) is a function dependent on u_m/u_t. The details of this model can be found in USEPA guidance (1996), and are not repeated here. The values for default parameters recommended in the 1996 USEPA guidance are used in conjunction with the wind speed for Fort Smith, Arkansas.

Emission and dispersion modeling were not used to estimate airborne dust concentrations for excavation activities, because such activities are generally required to ensure that dust does not exceed acceptable levels. Emission of respirable soil particulates during maintenance activities is conservatively set at the former annual average National Ambient Air Quality Standard (NAAQS) for PM_{10} of 50 micrograms per cubic meter (ug/m^3). The PM_{10} level of 50 ug/m^3 is based on a time weighted average over an exposure frequency of 30 days per year assuming that maintenance workers spend 5 days per year excavating into the subsurface and 25 days per year conducting other activities that do not involve excavation into the subsurface. In the time-weighted average calculation, the 24-hour average NAAQS for PM_{10} of 150 ug/m^3 was used as the maximum PM_{10} concentration for the time spent excavating into the subsurface and a PM_{10} concentration of 1 ug/m^3 was used for the time spent during activities that do not involve excavation. The PM_{10} concentration during non-excavation activities is expected to be less than 1 ug/m^3. It was conservatively assumed that the PM_{10} concentration would be at these limits every day for the entire assumed periods of exposure.

3.3.5 Air Dispersion

Potential exposure of receptors to vapors and particulates in ambient air are estimated based on emission estimates presented above and using the empirical correlations presented in USEPA's Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002). The normalized air concentration (or air dispersion factor, C/Q) is estimated using the empirical equations presented in USEPA's *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA 2002). The calculations are performed, assuming the source area is the area of the site (approximately 150 acres) for routine workers and residents, and a 15 ft by 15 ft excavation for maintenance and construction workers, and using correlation coefficients for Little Rock, Arkansas, which is the closest city for which correlation coefficients are available. Derivation of the equations and definition of the equation parameters for C/Q can be found in Appendix D of the 2002 USEPA Supplemental Soil Screening Guidance, and therefore, are not repeated here.

3.4 Exposure Factors

Standard default exposure factors recommended by USEPA for estimating reasonable maximum exposures are used where available and appropriate. Where standard default exposure factors are not available or not appropriate for an exposure scenario, the evaluation is conducted using similarly conservative exposure factors based on professional judgment. The exposure factors used in the derivation of the risk estimates are presented in **Attachment 1**.

4 Toxicity Values

According to USEPA (2003), the hierarchy of sources for toxicity values used in quantitative risk computations is:

1. Integrated Risk Information System (IRIS);
2. Provisional Peer Reviewed Toxicity Values (PPRTV); and
3. Other Toxicity Values (e.g., historical HEAST, NCEA provisional values and ATSDR).

When a toxicity value is not available from the first two tiers of the hierarchy, other USEPA and non-USEPA sources of toxicity values can be consulted. Route-to-route extrapolation of toxicity values was made following USEPA guidance (USEPA 2004b, 2009). The toxicity values and their sources used in the risk assessment are summarized in **Attachment 1**. For evaluating construction worker exposures, subchronic noncancer toxicity values are used instead of chronic values, since their exposure duration is one year. The toxicity values in **Attachment 1** are current as of October 2, 2012.

5 Physical and Chemical Parameters

The physical and chemical parameters used in the risk assessment are based on the hierarchy USEPA used in the Soil Screening Guidance (USEPA 1996). The values used in the risk assessment and their sources are presented in **Attachment 1**.

6 Risk Estimation

6.1 Cancer Risk and Noncancer Hazard Index

For the ingestion and dermal exposure routes, estimates of cancer risk and noncancer hazard quotient (HQ) are calculated as follows:

$$Risk = LADD \cdot SF$$

$$HQ = \frac{ADD}{RfD}$$

where LADD is the lifetime average daily dose, SF is the cancer slope factor, ADD is the average daily dose, and RfD is the reference dose.

For the inhalation route, the inhalation cancer risk and noncancer HQ are calculated using the chemical concentration in air (C_{air}), as follows:

$$Risk = C_{air} \cdot URF \cdot \frac{ET \cdot ED \cdot EF}{AT_c}$$

$$HQ = \frac{C_{air}}{RfC} \cdot \frac{ET \cdot ED \cdot EF}{AT_{nc}}$$

where URF is the inhalation unit risk, RfC is the reference concentration, ET is the exposure time, EF is the exposure frequency, ED is the exposure duration, AT_c is the averaging time for carcinogens, and AT_{nc} is the averaging time for non-carcinogens.

The potential cancer risk and noncancer effects that may result from exposure to a combination of chemicals is conservatively estimated according to USEPA guidance (1989), as follows:

$$Cumulative\ Risk = \sum_i Risk_i$$

$$HI = \sum_i HQ_i$$

where HI is the hazard index. For chemicals with different and unrelated noncancer health effects, summing their HQs would overestimate the significance of their combined effects. Where such summation of HQs indicates a potential for unacceptable risk, the HQs may be segregated by target organ and/or critical health effects (USEPA 1989).

6.2 Estimating Risks to On-Site Routine Workers

6.2.1 Contact with Outdoor Soil

On-site routine workers could be exposed to outdoor surface soil via incidental ingestion, dermal contact, and inhalation of vapors and particulates during routine activities. Risk estimates are calculated using the approach discussed in Section 6.1. The receptor specific calculations are discussed below.

The LADDs for soil ingestion ($LADD_{ing}$) and soil dermal contact ($LADD_{derm}$) are calculated as follows, using the exposures factors for routine worker soil contact shown in **Attachment 1**:

$$LADD_{ing} = C_{soil} \cdot \frac{IR \cdot FC \cdot EF \cdot ED}{BW \cdot AT_c}$$

$$LADD_{derm} = C_{soil} \cdot \frac{SA \cdot AF \cdot ABS_{derm} \cdot FC \cdot EF \cdot ED}{BW \cdot AT_c}$$

where C_{soil} is the concentration of chemicals in soil, IR is the incidental soil ingestion rate, FC is the fraction of soil that is contaminated, BW is the body weight, SA is the exposed skin surface area, AF is the soil-to-skin adherence factor recommended by USEPA (2004b), and ABS_{derm} is the chemical-specific dermal absorption factor recommended by USEPA (2004b).

The ADDs for soil ingestion (ADD_{ing}) and soil dermal contact (ADD_{derm}) are calculated as follows:

$$ADD_{ing} = C_{soil} \cdot \frac{IR \cdot FC \cdot EF \cdot ED}{BW \cdot AT_{nc}}$$

$$ADD_{derm} = C_{soil} \cdot \frac{SA \cdot AF \cdot ABS_{derm} \cdot FC \cdot EF \cdot ED}{BW \cdot AT_{nc}}$$

For the inhalation route, the exposure concentration (EC) for cancer and noncancer risk estimates are calculated using the equations shown in Section 6.1.

The air concentrations (C_{air}) of vapor and particulates from soil are calculated as follows:

$$C_{air} = J \cdot C / Q$$

where the product J·C/Q is an air concentration that is normalized to unit concentration in soil. The J term is the normalized, time-average vapor or particulate flux (discussed in Sections 3.3.4 and 3.3.2, respectively). The C/Q term is a dispersion factor, as discussed in Section 3.3.5.

For exposure to the maximum detected concentrations in on-site soil, the upper-bound cumulative cancer risk and noncancer HI estimates for routine workers are 1×10^{-8} and 0.004, respectively, as shown in **Table 2**. These risk estimates for potential routine worker exposures do not exceed ADEQ's risk limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

6.2.2 Soil Volatilization into Indoor Air

The cancer risk and HQ estimates for vapor intrusion from soil are calculated for hypothetical exposure of routine workers via assumed vapor intrusion from soil using the modeling approach and input parameter values discussed in Section 3.3.1, as follows:

$$Risk = C_{building} \cdot URF \cdot \frac{ET \cdot EF \cdot ED}{AT_c}$$

$$HQ = \frac{C_{building}}{RfC} \cdot \frac{ET \cdot EF \cdot ED}{AT_{nc}}$$

As shown in **Table 2**, the routine worker's upper-bound cumulative cancer risk and noncancer HI estimates for soil vapor intrusion based on the maximum detected concentrations in soil among the sampled locations are 3×10^{-7} and 0.1, respectively, which do not exceed USEPA's cancer risk and HI limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

The significance of potential exposure via vapor intrusion is also assessed using occupational inhalation limits. As shown on **Table 2**, the sum of the ratios of the estimated indoor air concentrations via vapor intrusion from soil to the occupational indoor air standards is much lower than 1, which shows that vapor intrusion from soil does not result in unacceptable exposure for workplaces subject to these occupational inhalation limits.

6.2.3 Groundwater Volatilization into Indoor Air

The calculation of cancer risk and HQ estimates for exposure of routine workers via assumed vapor intrusion from groundwater is the same as the soil vapor intrusion calculations discussed above, except using source concentrations from on-site groundwater.

As shown in **Table 3**, the upper-bound cumulative cancer risk and noncancer HI estimates for on-site indoor routine worker's exposure to the maximum detected concentrations in on-site groundwater via vapor intrusion are $1x10^{-5}$ and 3, respectively. The cumulative cancer risk estimate for routine worker exposure to on-site groundwater via inhalation of vapors in indoor air does not exceed ADEQ's risk limit. However, the noncancer HI estimate for routine worker exposure to on-site groundwater via vapor intrusion is above ADEQ's limit. The HI of 3 for potential vapor intrusion from groundwater is largely the result of a TCE concentration of 81 mg/L from a sample collected in 2010. The maximum detected concentration of TCE from on-site monitoring wells in 2012 is 29 mg/L, which corresponds to an HQ of 1.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

The significance of potential exposure via vapor intrusion is also assessed using occupational inhalation limits. As shown on **Table 3**, the sum of the ratios of the estimated indoor air concentrations via vapor intrusion from groundwater using the maximum detected on-site concentrations (calculated as described in Section 3.3.1) to the occupational indoor air standards is much lower than 1, which shows that vapor intrusion from soil does not result in unacceptable exposure for workplaces subject to these occupational inhalation limits.

6.2.4 Groundwater Volatilization into Outdoor Air

On-site routine workers could inhale vapors from groundwater that migrate into outdoor air. The computation of risk and HI for vapor inhalation in outdoor air is analogous to the computations discussed in Section 6.2.1, except the J value is calculated as described in Section 3.3.3.

As shown in **Table 3**, the upper-bound cumulative cancer risk and noncancer HI estimates for outdoor routine worker's exposure to the maximum detected concentrations in on-site groundwater via vapor inhalation are $4x10^{-7}$ and 0.1, respectively, which do not exceed ADEQ's risk limits.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

6.3 Estimating Risks to On-Site Maintenance Workers

6.3.1 Contact with Soil

On-site maintenance workers could contact unsaturated soil via incidental ingestion, dermal contact, and inhalation of vapors and particulates during occasional subsurface activities (e.g., utility maintenance or small scale excavations). The computation of risk and HI for these exposures is analogous to the computations discussed in Section 6.2.1, except exposure factors for maintenance workers are used and the airborne dust concentrations are estimated as discussed in Section 3.3.4. The calculation of the risk and HI for each route of exposure is provided in **Attachment 4**.

For exposure to the maximum detected concentrations in on-site soil, the upper-bound cumulative cancer risk and noncancer HI estimates for maintenance workers are 1×10^{-9} and 0.001 (**Table 2**), respectively, which meet ADEQ's risk limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 3**.

6.3.2 Groundwater Contact

Maintenance workers could contact groundwater via incidental ingestion, dermal contact, and inhalation of vapors during occasional subsurface activities (e.g., utility maintenance or small scale excavations) that extend to the groundwater. The computation of risk and HI for these exposures is analogous to the computations discussed in Section 6.2.1 for routine worker exposures to soil, except the exposure factors are for maintenance workers and the dermal dose, C/Q, and normalized vapor flux are calculated as discussed below.

The LADD and ADD for groundwater dermal contact are calculated as follows:

$$LADD_{derm} = C_{gw} \cdot \frac{SA \cdot EF \cdot ED \cdot FC}{BW \cdot AT_c} \cdot DA$$

$$ADD_{derm} = C_{gw} \cdot \frac{SA \cdot EF \cdot ED \cdot FC}{BW \cdot AT_{nc}} \cdot DA$$

where DA is the chemical-specific dermal absorption dose.

For exposure to the maximum detected concentrations in on-site groundwater, the upper-bound cumulative cancer risk and noncancer HI estimates for maintenance workers are 5×10^{-5} and 30, respectively. The cumulative cancer risk estimate for maintenance worker exposure to on-site groundwater does not exceed ADEQ's risk limits. The noncancer HI estimate for maintenance worker exposure to on-site groundwater is above ADEQ's limit. The HI of 30 for potential inhalation of vapors from exposed groundwater is largely the result of a TCE concentration of 81 mg/L from a sample collected in 2010. The maximum detected concentration of TCE from on-site monitoring wells in 2012 is 29 mg/L at MW-37, which corresponds to a HQ of 10. The detected concentrations of TCE in 2012 from on-site monitoring wells ITMW-17, ITMW-18, ITMW-19, and MW-25 also result in HQs above 1. All other detected concentrations of TCE in 2012 from on-site monitoring wells correspond to HQs less than 1, which meets ADEQ's risk limits.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 3**.

6.4 Estimating Risks to On-Site Construction Workers

6.4.1 Contact with Soil

Construction workers could contact unsaturated soil via incidental ingestion, dermal contact, and inhalation of vapors and particulates during construction activities (e.g., site redevelopment). The computation of risk and HI for these exposures is analogous to the computations discussed in Section 6.3.1, except the exposure factors for construction workers are used and subchronic noncancer toxicity values are used instead of chronic values. The calculation of the risk and HI for each route of exposure is provided in **Attachment 4**.

For exposure to the maximum detected concentrations in on-site soil, the upper-bound cumulative cancer risk and noncancer HI estimates for construction workers are $4x10^{-9}$ and 0.0009 (**Table 2**), respectively, which do not exceed ADEQ's risk limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 3**.

6.4.2 Groundwater Contact

Construction workers could contact groundwater via incidental ingestion, dermal contact, and inhalation of vapors during construction activities (e.g., site redevelopment) that extend to the groundwater. The computation of risk and HI for these exposures is analogous to the computations discussed in Section 6.3.2 for maintenance worker exposures to groundwater, except the exposure factors are for construction workers and subchronic noncancer toxicity values are used instead of chronic values.

For exposure to the maximum detected concentrations in on-site groundwater, the upper-bound cumulative cancer risk and noncancer HI estimates for construction workers are $5x10^{-6}$ and 6, respectively. The cumulative cancer risk estimate for construction worker exposure to on-site groundwater does not exceed ADEQ's risk limit. The noncancer HI estimate for construction worker exposure to on-site groundwater is above ADEQ's limit. The HI of 6 for potential inhalation of vapors from exposed groundwater is largely the result of a TCE concentration of 81 mg/L from a sample collected in 2010. The maximum detected concentration of TCE from on-site monitoring wells in 2012 is 29 mg/L at MW-37, which corresponds to an HQ of 2. The next highest detected concentration of TCE in 2012 from on-site monitoring wells is 18 mg/L, which corresponds to an HQ of 1, which does not exceed ADEQ's risk limits.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 3**.

6.5 Estimating Risks to Off-Site Residents

6.5.1 Inhalation of Soil-Derived Vapors and Particulates

Off-site residents could inhale wind-blown vapors and particulates from on-site unsaturated soil. The computation of risk and HI for these exposures is analogous to the computations discussed in Section 6.2.1 for unsaturated vadose zone soil, except the exposure factors for residents are used.

For carcinogens with a mutagenic mode of action, cancer risk for exposures from 0 to 2 years of age and from 2 to 16 years of age are multiplied by the USEPA-recommended age-dependent adjustment factors (ADAFs), as follows:

$$Inhalation\ Risk = C_{air} \cdot URF \cdot \left(\begin{array}{l} \dfrac{ET \cdot ED_{0-2} \cdot EF}{AT_c} \cdot ADAF_{0-2} + \dfrac{ET \cdot ED_{2-16} \cdot EF}{AT_c} \cdot ADAF_{2-16} \\ + \dfrac{ET \cdot ED_{16-30} \cdot EF}{AT_c} \end{array} \right)$$

where ED is the value for the identified age-group (**Attachment 1**); $ADAF_{0-2}$ is 10; and $ADAF_{2-16}$ is 3 (USEPA 2005). For trichloroethene (TCE) the ADAF is applied only to the portion of the toxicity value representative of kidney effects, as explained in USEPA's IRIS toxicological review (USEPA 2011) and applied in USEPA's Regional Screening Levels (USEPA 2012b).

For exposure to the maximum detected concentrations in on-site soil via vapor and particulate inhalation off-site, the upper-bound cumulative cancer risk and noncancer HI estimates for residents are 6×10^{-8} and 0.01 (**Table 2**), respectively, which meet cancer risk and HI limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 3**.

6.5.2 Groundwater Volatilization into Indoor Air

Off-site residents could inhale vapors from groundwater that migrate into indoor air. The computation of risk and HI for vapor intrusion is analogous to the computations discussed in Section 6.2.3, except the C_{air} value is calculated as described in Section 3.3.1. The assumptions used and the calculation of the risk and HI are provided in **Attachment 3**.

For exposure to the maximum detected concentrations in off-site groundwater via vapor intrusion, the upper-bound cumulative cancer risk and noncancer HI estimates for residents are 6×10^{-6} and 1 (**Table 3**), respectively, which do not exceed cancer risk and HI limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 5**.

6.5.3 Groundwater Volatilization into Outdoor Air

Off-site residents could inhale vapors from groundwater that migrate into outdoor air. The computation of risk and HI for vapor inhalation in outdoor air is analogous to the computations discussed in Section 6.5.1, except the C_{air} value is calculated as described in Section 3.3.3.

For exposure to the maximum detected concentrations in off-site groundwater via inhalation of vapor in outdoor air, the upper-bound cumulative cancer risk and noncancer HI estimates for residents are 5×10^{-8} and 0.01 (**Table 3**), respectively, which meet cancer risk and HI limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 5**.

6.5.4 Groundwater Use

Off-site residents could ingest or contact groundwater if drinking waterwells are installed in the area of impacted groundwater. These hypothetical future uses, which could include potable or nonpotable uses, were conservatively evaluated by comparing detected concentrations in groundwater to Federal MCLs, which are the permissible levels in public water. As shown on **Table 6**, the maximum detected concentrations of TCE and vinyl chloride in off-site monitoring wells exceed the Federal MCLs. As such, use of groundwater from the impacted off-site area, shown on **Figure 4** of the RRMP, could result in potentially significant exposures.

6.6 Estimating Risks to Off-Site Routine Workers

6.6.1 Inhalation of Soil-Derived Vapors and Particulates

Off-site routine workers residents could inhale wind-blown vapors and particulates from on-site unsaturated soil. The computation of risk and HI for these exposures is analogous to the computations discussed in Section 6.2.1 for unsaturated vadose zone soil.

For off-site exposure to the maximum detected concentrations in on-site soil, the upper-bound cumulative cancer risk and noncancer HI estimates for routine workers are 1×10^{-8} and 0.004, respectively, as shown in **Table 2**. These risk estimates for potential routine worker exposures do not exceed ADEQ's risk limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

6.6.2 Groundwater Volatilization into Indoor Air

The cancer risk and HQ estimates for vapor intrusion from groundwater are calculated for exposure of routine workers via assumed vapor intrusion from groundwater as discussed above for on-site groundwater.

As shown in **Table 3**, the upper-bound cumulative cancer risk and noncancer HI estimates for off-site indoor routine worker exposure to the maximum detected concentrations in off-site groundwater via vapor intrusion are 2×10^{-7} and 0.06, respectively, which do not exceed ADEQ's cancer risk and HI limits.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

6.6.3 Groundwater Volatilization into Outdoor Air

Off-site routine workers could inhale vapors from groundwater that migrate into outdoor air. The computation of risk and HI for vapor inhalation in outdoor air is analogous to the computations discussed in Section 6.2.4, except the C_{air} value is calculated as described in Section 3.3.3.

As shown in **Table 3**, the upper-bound cumulative cancer risk and noncancer HI estimates for off-site outdoor routine worker exposure to the maximum detected concentrations in off-site groundwater via vapor inhalation are 7×10^{-9} and 0.002, respectively, which do not exceed ADEQ's cancer risk and HI limits.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

6.6.4 Groundwater Use

Off-site routine workers could ingest or contact groundwater if drinking waterwells are installed in the area of impacted groundwater. These hypothetical future uses would be similar to those evaluated in Section 6.5.4. As shown on **Table 6**, the maximum detected concentrations of TCE and vinyl chloride in off-site monitoring wells exceed the Federal MCLs. As such, use of groundwater from the impacted off-site area, shown on **Figure 4** of the RRMP, could result in potentially significant exposures.

6.7 Estimating Risks to Off-Site Maintenance Workers

6.7.1 Groundwater Contact

Maintenance workers could contact groundwater via incidental ingestion, dermal contact, and inhalation of vapors during occasional subsurface activities (e.g., utility maintenance or small scale excavations) that extend to the groundwater. The computation of risk and HI for these exposures is the same as those discussed in Section 6.3.2.

For exposure to the maximum detected concentrations in off-site groundwater, the upper-bound cumulative cancer risk and noncancer HI estimates for maintenance workers are $9x10^{-7}$ and 0.5 (**Table 3**), respectively, which do not exceed ADEQ's risk limits.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 3**.

6.8 Uncertainty Analysis

6.8.1 Exposure Concentrations

As discussed in Section 3.2.1, all exposure concentrations for soil in this risk assessment are based on the highest concentrations detected at the site; more representative exposure concentrations (i.e., 95% UCLs) are not calculated. This approach streamlines the risk assessment by avoiding calculation of 95% UCLs that would not materially affect risk assessment conclusions. The use of maximum concentrations for all chemicals introduces more conservatism than necessary for RME estimates because it assumes simultaneous worst-case exposure to these chemicals, when the RME generally would not reflect having all chemicals at worst-case concentrations at all times.

Most exposure concentrations that are based on mathematical modeling of chemical transfer from soil or groundwater to air are conservative for the same reasons discussed above, since the model estimates are based on the use of maximum concentrations in soil or groundwater. In addition, the model estimates are conservative because they generally do not account for the reduction of chemical concentrations in the soil or groundwater as chemicals transfer from these media. As a result, risk estimates that are based cross media transfer are more conservative than necessary for RME estimates.

6.8.2 Fate and Transport Models

The groundwater volatilization to indoor air risk estimates for residential exposure are calculated using a central tendency air exchange rate (0.45/hr) identified by USEPA (2012a) and high end inputs for both the groundwater concentration (maximum detected concentration from the last five years) and exposure factors (24 hours of exposure for 350 days/year for 30 years). The combination of these values is believed to give RME risk estimates. The cumulative cancer risk and noncancer HI estimates for residents are $6x10^{-6}$ and 1, respectively, as discussed in Section 6.5.2 (**Table 3**). These risk estimates meet ADEQ and USEPA cancer risk and HI limits. Using the lower air exchange rate of 0.25/hr recommended as a default by USEPA (2004a) would increase the cumulative cancer risk and noncancer HI estimates for residents to $1x10^{-5}$ and 2, respectively, which is slightly higher than the HI limit of 1. However, using an air exchange rate that is lower than the central tendency value of 0.45/hr overestimates the exposure concentration (i.e., the indoor air concentration), which according to USEPA risk assessment guidance is supposed to be an estimate of the average concentration to which receptors are exposed (USEPA 1989). Using the lower air exchange rate is particularly unwarranted because it is combined with the highest detected groundwater concentration over the past five years (which is higher than the most recent data and expected future groundwater concentrations). By overestimating the exposure concentration via a combination of a lower than average air exchange rate and higher than average groundwater concentration, the resulting risk estimates are believed to overestimate RME risks, and as such, are not appropriate for determining whether an unacceptable risk exists.

Further, as discussed in Section 3.2.3, soil gas data were collected to confirm that the results of the volatilization to indoor air calculations, discussed in Section 3.3.1. Specifically, data were collected at two locations that are between 30 and 80 feet from nearby groundwater monitoring wells, as shown on **Figure 2**, and from two different depth intervals at each location. Specifically, soil gas sampling locations SV-01 and SV-02 were located near on-site monitoring well MW-33, which had the highest detected concentration of TCE at the property boundary, and soil gas sampling locations SV-03 and SV-04 were located near off-site monitoring well MW-70, which had the highest detected concentration of TCE off-site where access was readily attainable. The measured concentration of TCE in shallow soil gas collected 7 ft bgs (the sample depth closest to building foundation depths), was conservatively combined with USEPA's 95^{th} percentile subslab soil gas attenuation factor of 0.03 (USEPA 2012a) to estimate the potential for significant vapor intrusion into indoor air. As shown of **Table 4**, the TCE concentrations in shallow soil gas would result in acceptable risk estimates for indoor exposure. These risk estimates are believed to be more conservative than necessary because attenuation in the approximately 7 ft of silty clay soil between the soil gas sample depth and subslab depth was ignored. Accounting for such attenuation, which may be substantial (i.e., a factor of 10 or more based on observed attenuation between the deep and shallow soil gas concentrations), would result in even lower risk estimates than those shown in **Table 4**.

The cancer risk and HQ from groundwater vapor intrusion into a residential building calculated using the most recent concentration of TCE in groundwater at MW-70 (0.33 mg/L) and the approach described in Section 6.5.2 is $1x10^{-6}$ and 0.3, respectively. The single-chemical risk and HQ from soil gas vapor intrusion into a residential building calculated using the measured shallow soil gas concentration at SV-03 and USEPA's default subslab to indoor air attenuation factor of 0.03 are 2 x 10^{-7} and 0.04, respectively. As shown in **Table 4**, the conservatively calculated risks from shallow soil gas are at least 6 times lower than the risks estimated by the groundwater vapor intrusion model. Therefore, the approach described in Section 6.5.2 results in risk estimates that are overly conservative. The degree of model overestimation is particularly large when considering the fact that the risk estimates based on the shallow soil gas data shown in **Table 4** may be 10 times too high because they ignore the soil gas attenuation between the shallow soil gas sample and the slab of the building, as discussed above. As shown in **Table 4**, the same evaluation was performed for on-site locations MW-33 and SV-01, which conservatively assumed groundwater and soil gas concentrations at these locations were to migrate off-site with no attenuation. The results of this evaluation are similar to those discussed above, except the overestimation of residential vapor intrusion risk by the groundwater vapor intrusion model relative to the estimates based on soil gas is even greater.

As discussed in Section 1.1.2 of the Revised Risk Management Plan, TCE is the predominant contaminant at the Site and was detected in groundwater at significantly greater concentrations and frequency than tetrachloroethene (PCE). However, PCE was reported in the deep soil gas sample collected on-site at SV-02. The measured concentration of PCE in deep soil gas collected 15 ft bgs, was conservatively combined with USEPA's 95th percentile subslab soil gas attenuation factor of 0.03 (USEPA 2012a) to estimate the potential for significant vapor intrusion into residential indoor air. As shown on **Table 5**, the PCE concentrations in deep soil gas would result in acceptable risk estimates for residential indoor exposure. These risk estimates are believed to be more conservative than necessary because attenuation in the approximately 15 ft of silty clay soil between the soil gas sample depth and subslab depth was ignored. Accounting for such attenuation, which may be substantial (i.e., a factor of 100 or more based on observed attenuation for TCE), would result in even lower risk estimates than those shown in **Table 5**. These risk estimates are consistent with the groundwater volatilization to indoor air risk estimates that show PCE risks are insignificant compared to those calculated for TCE.

These results indicate that the model used to evaluate the potential for significant vapor intrusion from groundwater is conservative. Measured soil gas concentrations indicate that the modeling approach in Section 6.5.2 over-predicts exposure risks from groundwater.

6.8.3 Exposure Factors

Most of the exposures in the risk assessment were evaluated using factors, presented in **Attachment 1**, that are high-end (i.e., 90th to 95th percentile) estimates of the magnitude, frequency, and duration of potential exposures. When several such high-end factors are multiplied, the resulting estimates of dose will be higher than the 90th percentile of the distribution of exposures in the potentially exposed population and could be higher than the exposure to the maximally exposed individual, particularly when such exposure factors are combined with exposure concentrations that are based on maximum concentrations.

6.8.4 Toxicity Values

RfDs and RfCs used in the risk assessment typically incorporate several safety factors[2] to account for uncertainties in their derivation, which in combination often result in overall uncertainty factors of 1,000 or more. Furthermore, for many chemicals, there is scientific debate about the validity of these RfDs and RfCs, and the association of these doses and concentrations to potential adverse health consequences (USEPA 1995, USEPA 1989). The use of such RfDs and RfCs in the risk evaluation could introduce uncertainty, including overstating, the resultant estimate of noncancer effects.

Oral SFs and URFs used in the risk assessment represent 95% upper confidence bounds on the probability of getting cancer over a lifetime per unit dose. As recognized by USEPA, there is significant scientific evidence that some of the SFs and URFs may be overly conservative and may ignore the potential existence of threshold doses (USEPA 2005a). The use of such SFs and URFs in the risk evaluation could introduce uncertainty, including overstating, the resultant cancer risk estimates.

The dermal toxicity values used in the risk assessment are oral toxicity values that were extrapolated to the dermal route without chemical-specific judgment regarding whether such extrapolation might be appropriate for a particular chemical. This is an appropriately conservative approach, which is also the current state of the practice, to ensure that potential risk via the dermal route is not overlooked (USEPA 2004b). However, some chemicals might exhibit different degrees of toxicity for the dermal route relative to the oral route. For such chemicals, the extrapolation approach used in the risk evaluation could introduce uncertainty to the resultant risk estimates.

The use of surrogate toxicity values was applied conservatively to ensure that potential risk to these detected chemicals is not overlooked. However, some chemicals might exhibit different degrees of toxicity than their surrogate chemicals. For such chemicals, the extrapolation approach used in the risk evaluation could introduce uncertainty to the resultant risk estimates.

6.8.5 Risk Characterization

The summation of cancer risks and HQs for multiple chemicals is based on USEPA guidance (1989) to assume dose additivity, which means that chemicals in a mixture are assumed to have no synergistic or antagonistic interactions and each chemical has the same mode of action and elicits the same health effects. In general, this approach can introduce uncertainty. However, the majority of the cumulative cancer risk and HI estimates in this risk assessment are dominated by contributions from no more than a few chemicals, so that the cumulative risk estimates are nearly the same as those for the few key chemicals.

[2] According to USEPA, safety factors between 3 and 10,000 may be included depending on the source studies (USEPA. *Reference Dose (RfD): Description and Use in Health Risk Assessments, Background Document 1A* March 15, 1993).

7 Summary and Conclusions

The risk assessment evaluated the significance of potential exposure for the following receptors and potential pathways identified for current and potential future land use and groundwater use described in **Table 1**:

- On-Site Routine Workers
  - Soil – incidental ingestion, dermal contact, and inhalation of vapors and particulates during outdoor activities; inhalation of vapors in indoor air
  - Groundwater – inhalation of vapors in outdoor air; inhalation of vapors in indoor air
- On-Site Maintenance Workers
  - Soil – incidental ingestion, dermal contact, and inhalation of vapors and particulates during smaller-scale surface and subsurface maintenance activities
  - Groundwater – incidental ingestion, dermal contact, and inhalation of vapors during smaller-scale subsurface maintenance activities that encounter groundwater
- On-Site Construction Workers
  - Soil – incidental ingestion, dermal contact, and inhalation of vapors and particulates during larger-scale/short-term (i.e., 1 year) construction activities
  - Groundwater – incidental ingestion, dermal contact, and inhalation of vapors during larger-scale/short-term (i.e., 1 year) subsurface construction activities that encounter groundwater
- Off-Site Residents
  - Soil –inhalation of wind-blown vapors and particulates from on-site soil
  - Groundwater – inhalation of vapors in outdoor air; inhalation of vapors in indoor air; and ingestion or contact if water use wells are installed in the area of impacted groundwater
- Off-Site Routine Workers
  - Soil – inhalation of vapors and particulates from on-site soil during off-site outdoor activities
  - Groundwater – inhalation of vapors in outdoor air; inhalation of vapors in indoor air; and ingestion or contact if water use wells are installed in the area of impacted groundwater
- Off-Site Maintenance Workers
  - Groundwater – incidental ingestion, dermal contact, and inhalation of vapors during smaller-scale/shorter duration subsurface maintenance activities that encounter groundwater

The significance of potential exposure to chemicals in soil, groundwater, and soil gas was evaluated for each of these exposures. As discussed in Sections 6.2 to 6.5, the risk estimates using maximum detected concentrations for all chemicals meet cancer risk and noncancer HI levels of $1x10^{-4}$ and 1, respectively, for exposure to on-site soil and off-site groundwater under current land and groundwater uses. Under current on-site land and groundwater uses, the risk estimates using maximum detected concentrations for all chemicals in on-site groundwater meet USEPA's cancer risk level of $1x10^{-4}$ and exceed USEPA's noncancer HI level of 1 for maintenance worker and construction worker contact and routine worker vapor intrusion. In the hypothetical scenario in which drinking water wells are installed in the area of impacted off-site groundwater, potentially significant exposures could result from use of the groundwater.

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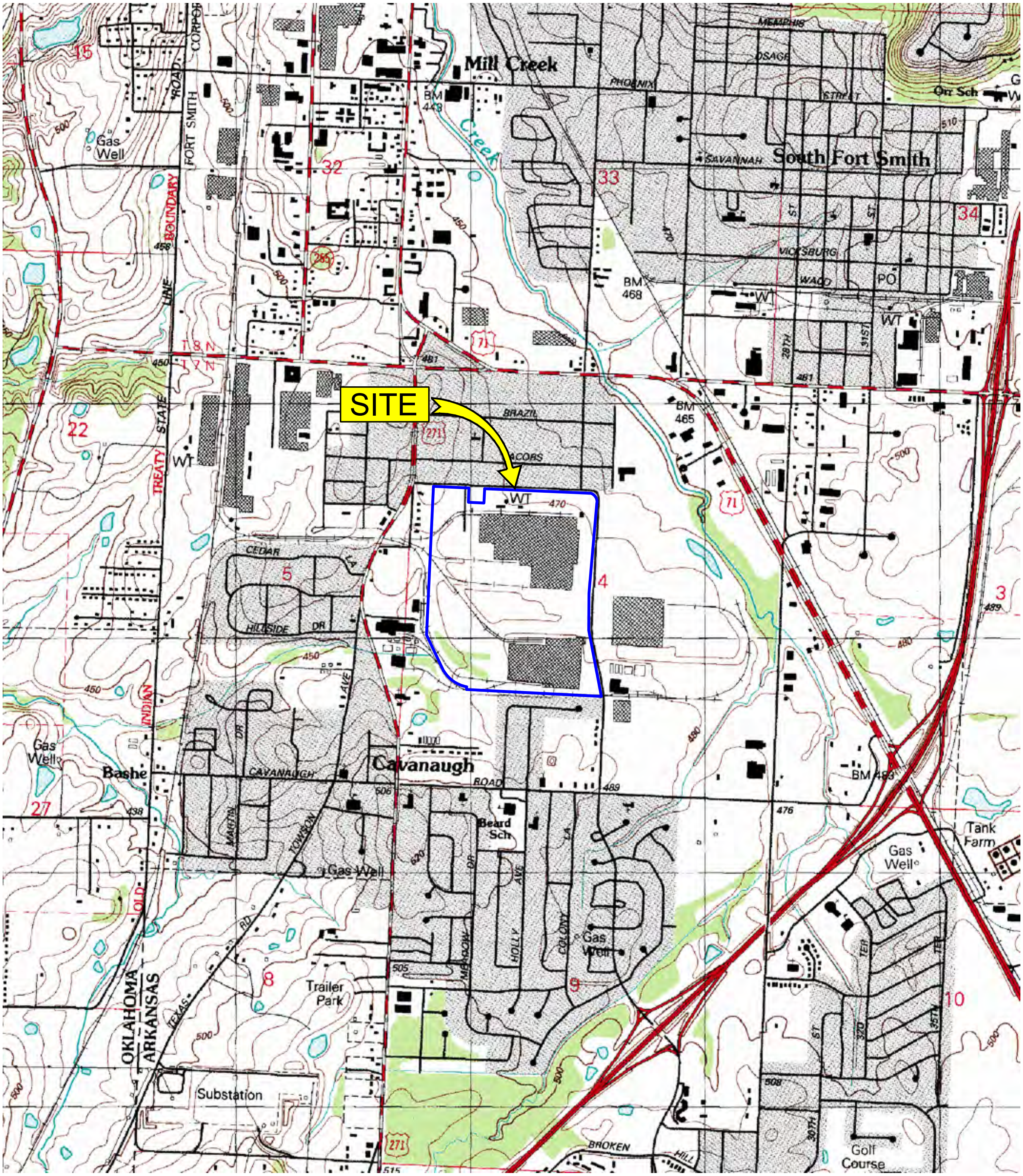
Figures



1 | 1/2 | 0 | 1 MILE

2000 | 0 | 2000 | 4000 | 6000 FEET

CONTOUR INTERVAL 10 FEET

SOURCE: U.S.G.S. 7.5 min□te series (topographic)
So□th Fort Smith, Arkansas □□adrangle, 1997

ARKANSAS

LEGEND

APPROXIMATE PROPERTY BOUNDARY

N

ENVIRON

SITE LOCATION MAP
WHIRLPOOL CORPORATION
6400 SOUTH JENNY LIND ROAD
FORT SMITH, ARKANSAS

FIGURE
1

DRAFTED BY: ELS | DATE: 11/8/12 | 21-31344A

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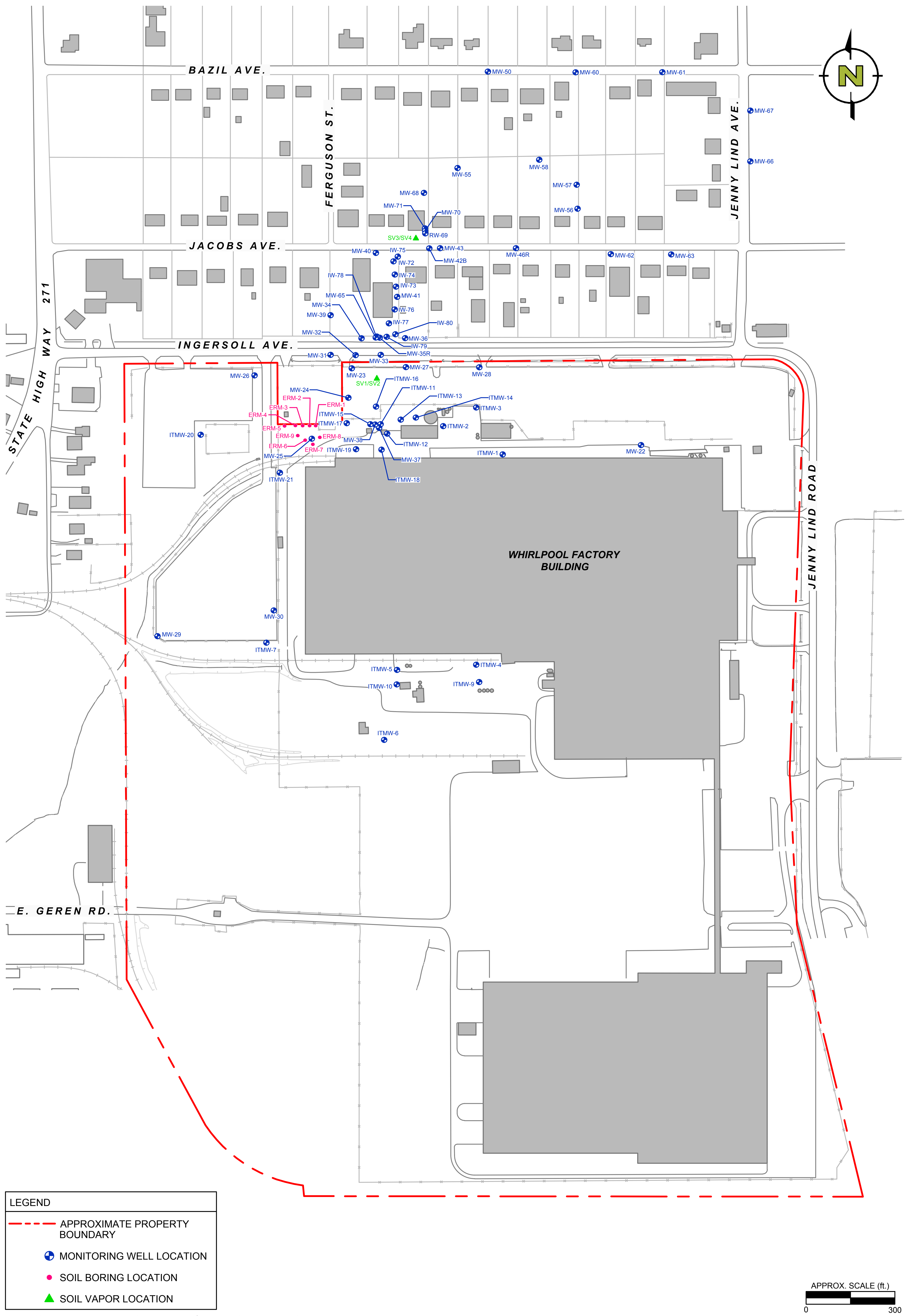


LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- MONITORING WELL LOCATION
- SOIL BORING LOCATION
- SOIL VAPOR LOCATION

Note: Soil boring locations were based on Figure 2-13 from the Risk Management Plan (ERM 2008).

ENVIRON

DRAFTED BY: ELS/CKN | DATE: 11/19/12

SAMPLE LOCATION MAP
WHIRLPOOL CORPORATION
6400 JENNY LIND ROAD
FORT SMITH, ARKANSAS

FIGURE
2
21-31344A

Tables

Table 1: Conceptual Site Model - Scenarios for Potential Human Exposure Whirlpool: Fort Smith Facility, Fort Smith, Arkansas					
Receptor Population	**Exposure Medium**	**Exposure Route**	**Potential Current Exposure?**	**Potential Future Exposure?**	**Comments**
On-Site					
Routine Workers	surface soil	incidental ingestion of and dermal contact with surface soil	Yes	Yes	Exposure to surface soil through incidental ingestion and dermal contact is possible in areas without ground cover or where ground cover may be removed. Exposure through inhalation of vapors from constituents that could volatilize and migrate into indoor or outdoor air is also possible.
		inhalation of soil-derived vapors and airborne particulates (wind erosion) in outdoor air	Yes	Yes	
		inhalation of soil-derived vapors that migrate through building foundations into indoor air	Yes	Yes	
	subsurface soil	inhalation of soil-derived vapors in outdoor air	Yes	Yes	
		inhalation of soil-derived vapors that migrate through building foundations into indoor air	Yes	Yes	
	groundwater	ingestion of and dermal contact with groundwater and inhalation of groundwater-derived vapors during use of groundwater for drinking water	No	No	Potable water in Ft. Smith is obtained from the municipality. There are no production wells currently on Site. Potential exposure of routine workers to groundwater-derived vapors that migrate through cracks in building foundations into indoor air is possible in areas where contaminated groundwater is present.
		incidental ingestion of and dermal contact with groundwater and inhalation of groundwater-derived vapors during use of groundwater for purposes other than drinking water	No	No	
		inhalation of groundwater-derived vapors in outdoor air	Yes	Yes	
		inhalation of groundwater-derived vapors that migrate through building foundations into indoor air	Yes	Yes	
Maintenance Workers	surface and subsurface soil	incidental ingestion of and dermal contact with soil; inhalation of soil-derived vapors and airborne particulates in work-space air	Yes	Yes	Exposure to soil and groundwater during occasional excavations to the depth of existing or planned utilities is possible. The average depth to water at the Site is approximately 12 feet bgs.
	groundwater	incidental ingestion of and dermal contact with exposed groundwater; inhalation of vapors from exposed groundwater in work-space air	Yes	Yes	
Construction Workers	surface and subsurface soil	incidental ingestion of and dermal contact with soil; inhalation of soil-derived vapors and airborne particulates in work-space air	Yes	Yes	Exposure to soil and groundwater is possible where redevelopment of the site could occur.
	groundwater	incidental ingestion of and dermal contact with exposed groundwater; inhalation of vapors from exposed groundwater in work-space air	Yes	Yes	
Residents	various	various	No	No	The Site is zoned for commercial/industrial uses.
Off-Site					
Residents	surface and subsurface soil	inhalation of soil-derived vapors and airborne particulates (wind erosion) in outdoor air	Yes	Yes	Off-Site exposure via inhalation of airborne vapors and dust from exposed on-Site soil is possible.
	groundwater	ingestion of and dermal contact with groundwater and inhalation of groundwater-derived vapors during use of groundwater for drinking water	No	No	Potable water in Fort Smith is obtained from the municipality.
		incidental ingestion of and dermal contact with groundwater and inhalation of groundwater-derived vapors during use of groundwater for purposes other than drinking water	No	No	
		inhalation of groundwater-derived vapors in outdoor air	Yes	Yes	Exposure via inhalation of vapors that could volatilize and migrate into outdoor or indoor air is possible where contaminated groundwater has migrated off-Site.
		inhalation of groundwater-derived vapors that migrate through building foundations into indoor air	Yes	Yes	
Routine Workers	surface and subsurface soil	inhalation of soil-derived vapors and airborne particulates (wind erosion) in outdoor air	Yes	Yes	Off-Site exposure via inhalation of airborne vapors and dust from exposed on-Site soil is possible.
	groundwater	ingestion of and dermal contact with groundwater and inhalation of groundwater-derived vapors during use of groundwater for drinking water	No	No	Potable water in Fort Smith is obtained from the municipality.
		incidental ingestion of and dermal contact with groundwater and inhalation of groundwater-derived vapors during use of groundwater for purposes other than drinking water	No	No	
		inhalation of groundwater-derived vapors in outdoor air	Yes	Yes	Exposure via inhalation of vapors that could volatilize and migrate into outdoor or indoor air is possible where contaminated groundwater has migrated off-Site.
		inhalation of groundwater-derived vapors that migrate through building foundations into indoor air	Yes	Yes	
Maintenance Workers	groundwater	incidental ingestion of and dermal contact with exposed groundwater; inhalation of vapors from exposed groundwater in work-space air	Yes	Yes	Exposure via incidental ingestion, dermal contact, and inhalation of vapors is possible in excavations extending to groundwater in areas where contaminated groundwater has migrated off-site.

Table 2: Upper-Bound Cumulative Risk Estimates for On-Site Soil
Whirlpool, Fort Smith, Arkansas

Receptor	Exposure Type	Risk	HI	Occupational
On-Site Routine Worker	Direct contact	1E-08	4E-03	NA
On-Site Routine Worker	Vapor intrusion to indoor air	3E-07	1E-01	2E-06
On-Site Maintenance Worker	Direct contact	1E-09	1E-03	NA
On-Site Construction Worker	Direct contact	4E-09	9E-04	NA
Off-Site Resident	Vapor and particulate inhalation	6E-08	1E-02	NA
Off-Site Routine Worker	Vapor and particulate inhalation	1E-08	4E-03	NA

Notes:

1. None of the cumulative cancer risk and HI estimates are in excess of ADEQ's risk limits (1E-4 and 1, respectively).
2. Cumulative cancer risk and HI estimates are calculated using the maximum detected concentrations from onsite locations from any depth.
3. NA = Not applicable. Occupational air standards are only applicable for routine worker vapor intrusion exposures.

Table 3: Upper-Bound Cumulative Risk Estimates for Groundwater
Whirlpool, Fort Smith, Arkansas

		On-Site			Off-Site	
Receptor	**Exposure Type**	**Risk**	**HI**	**Occupational**	**Risk**	**HI**
Routine Worker	Vapor intrusion to indoor air	1E-05	**3E+00**	8E-04	2E-07	6E-02
Routine Worker	Vapor inhalation in outdoor air	4E-07	1E-01	NA[4]	7E-09	2E-03
Maintenance Worker	Direct contact	5E-05	**3E+01**	NA[4]	9E-07	5E-01
Construction Worker	Direct contact	5E-06	**6E+00**	NA[4]	NA[4]	NA[4]
Resident	Vapor intrusion to indoor air	NA[3]	NA[3]	NA[4]	6E-06	1E+00
Resident	Vapor inhalation in outdoor air	NA[3]	NA[3]	NA[4]	5E-08	1E-02

Notes:

1. Cumulative cancer risk and HI estimates in excess of ADEQ's risk limits (1E-4 and 1, respectively) are shaded in bold.
2. Cumulative cancer risk and HI estimates are calculated using the maximum detected concentrations from all wells and sample dates.
3. NA = Not applicable. Receptor is not reasonably expected to be present in this area.
4. NA = Not applicable. Occupational air standards are only applicable for routine worker vapor intrusion exposures.

Table 4: Evaluation of TCE in Soil Gas
Whirlpool, Fort Smith, Arkansas

Soil Gas						Groundwater			
Sample Location	**Sample Depth** (ft)	**TCE Concentration** (mg/m^3)	**Risk (2)**	**HQ (2)**		**Nearby Monitoring Well**	**Most Recent TCE Concentration** (mg/L)	**Risk (3)**	**HQ (3)**
SV01	7	ND (4.1E-5)	3E-09	6E-04		MW-33	1.00E+00	4E-06	8E-01
SV02	15	2.27E-01	--[4]	--[4]				--[4]	--[4]
SV03	7	2.90E-03	2E-07	4E-02		MW-70	3.30E-01	1E-06	3E-01
SV04	12	3.98E-02	--[4]	--[4]				--[4]	--[4]

Notes:

1. ND = Non-detect.
2. Residential risk and HQ are calculated using USEPA's default attenuation factor for subslab gas to indoor air of 0.03.
3. Residential risk and HQ are calculated using the approach described in Section 6.5.2 of the report.
4. Risk and HQ estimates are calculated only for concentrations of TCE in shallow soil gas.

Table 5: Evaluation of PCE in Soil Gas
Whirlpool, Fort Smith, Arkansas

Sample Location	**Sample Depth** (ft)	**PCE Concentration** (mg/m^3)	**Risk (1)**	**HQ (1)**
SV02	15	1.1E-01	3E-07	8E-02
Note:				

1. Residential risk and HQ are calculated using USEPA's default attenuation factor for subslab gas to indoor air of 0.03.

Table 6: Groundwater Screening Summary
Whirlpool, Fort Smith, Arkansas

Area	Chem Group	Chemical	CASRN	Meas Basis	Carc Class	Analyzed	Detected	Min Detected (mg/L)	Max Detected (mg/L)	MCL FED (mg/L)	Ratio of Maximum Concentration to MCL
On-Site	VOC	Acetone	67-64-1	T	ID	194	17	2.70E-03	1.99E-01		
On-Site	VOC	Benzene	71-43-2	T	A	194	5	6.60E-04	6.53E-02	5.0E-03	**1.3E+01**
On-Site	VOC	Bromodichloromethane	75-27-4	T	B2	194	3	5.42E-02	6.79E-02	8.0E-02	8.5E-01
On-Site	VOC	Bromoform	75-25-2	T	B2	194	3	4.43E-02	7.67E-02	8.0E-02	9.6E-01
On-Site	VOC	Bromomethane	74-83-9	T	ID	194	3	4.74E-02	6.13E-02		
On-Site	VOC	2-Butanone	78-93-3	T	ID	194	3	9.87E-02	1.06E-01		
On-Site	VOC	Carbon Disulfide	75-15-0	T		194	3	3.59E-02	6.52E-02		
On-Site	VOC	Carbon Tetrachloride	56-23-5	T	LC	194	3	5.89E-02	6.69E-02	5.0E-03	**1.3E+01**
On-Site	VOC	Chlorobenzene	108-90-7	T	D	194	7	1.20E-03	6.86E-02	1.0E-01	6.9E-01
On-Site	VOC	Chloroethane	75-00-3	T	LC	194	3	4.80E-02	7.23E-02		
On-Site	VOC	Chloroform	67-66-3	T	B2	194	33	9.40E-04	6.64E-02	8.0E-02	8.3E-01
On-Site	VOC	Chloromethane	74-87-3	T	D	194	3	4.21E-02	9.00E-02		
On-Site	VOC	Dibromochloromethane	124-48-1	T	C	194	3	4.82E-02	7.13E-02	8.0E-02	8.9E-01
On-Site	VOC	1,1-Dichloroethane	75-34-3	T	SC	194	36	1.60E-03	6.59E-02		
On-Site	VOC	1,2-Dichloroethane	107-06-2	T	B2	194	4	1.20E-03	6.61E-02	5.0E-03	**1.3E+01**
On-Site	VOC	1,1-Dichloroethene	75-35-4	T	C	194	76	2.20E-03	2.50E-01	7.0E-03	**3.6E+01**
On-Site	VOC	1,2-Dichloroethene (total)	540-59-0	T		194	130	1.40E-03	1.00E+01	7.0E-02	**1.4E+02**
On-Site	VOC	cis-1,2-Dichloroethene	156-59-2	T	ID	194	132	1.40E-03	1.00E+01	7.0E-02	**1.4E+02**
On-Site	VOC	trans-1,2-Dichloroethene	156-60-5	T	ID	194	27	8.90E-04	5.99E-02	1.0E-01	6.0E-01
On-Site	VOC	1,2-Dichloropropane	78-87-5	T	B2	194	3	6.03E-02	6.52E-02	5.0E-03	**1.3E+01**
On-Site	VOC	1,3-Dichloropropene (total)	542-75-6	T	B2	194	3	1.05E-01	1.42E-01		
On-Site	VOC	Ethyl Benzene	100-41-4	T	D	194	8	1.50E-03	6.89E-02	7.0E-01	9.8E-02
On-Site	VOC	2-Hexanone	591-78-6	T	ID	194	6	4.80E-03	1.20E-01		
On-Site	VOC	4-Methyl-2-pentanone	108-10-1	T	ID	194	3	1.02E-01	1.20E-01		
On-Site	VOC	Methylene Chloride	75-09-2	T	LC	194	27	2.20E-03	3.10E-01	5.0E-03	**6.2E+01**
On-Site	VOC	Styrene	100-42-5	T		194	4	5.70E-04	6.83E-02	1.0E-01	6.8E-01
On-Site	VOC	1,1,2,2-Tetrachloroethane	79-34-5	T	LC	194	3	5.78E-02	6.40E-02		
On-Site	VOC	Tetrachloroethene	127-18-4	T	LC	194	45	1.20E-03	7.67E-02	5.0E-03	**1.5E+01**
On-Site	VOC	Toluene	108-88-3	T	ID	194	17	1.10E-03	6.54E-02	1.0E+00	6.5E-02
On-Site	VOC	1,1,1-Trichloroethane	71-55-6	T	ID	194	11	5.70E-03	1.10E-01	2.0E-01	5.5E-01
On-Site	VOC	1,1,2-Trichloroethane	79-00-5	T	C	194	12	1.20E-03	6.59E-02	5.0E-03	**1.3E+01**
On-Site	VOC	Trichloroethene	79-01-6	T	HC	194	153	1.60E-03	8.10E+01	5.0E-03	**1.6E+04**
On-Site	VOC	Vinyl Chloride	75-01-4	T	A	194	45	1.00E-03	2.50E+00	2.0E-03	**1.3E+03**
On-Site	VOC	Xylenes (total)	1330-20-7	T	ID	194	8	2.70E-03	1.99E-01	1.0E+01	2.0E-02
Off-Site	VOC	Acetone	67-64-1	T	ID	253	17	4.00E-03	8.50E-02		
Off-Site	VOC	Bromoform	75-25-2	T	B2	253	4	4.40E-03	2.40E-02	8.0E-02	3.0E-01
Off-Site	VOC	2-Butanone	78-93-3	T	ID	253	1	9.50E-02	9.50E-02		
Off-Site	VOC	1,2-Dichloroethane	107-06-2	T	B2	252	1	3.00E-03	3.00E-03	5.0E-03	6.0E-01
Off-Site	VOC	1,1-Dichloroethene	75-35-4	T	C	252	22	1.00E-03	4.20E-03	7.0E-03	6.0E-01
Off-Site	VOC	1,2-Dichloroethene (total)	540-59-0	T		253	111	1.40E-03	4.10E-02	7.0E-02	5.9E-01
Off-Site	VOC	cis-1,2-Dichloroethene	156-59-2	T	ID	253	113	1.40E-03	4.10E-02	7.0E-02	5.9E-01
Off-Site	VOC	4-Methyl-2-pentanone	108-10-1	T	ID	253	1	4.00E-03	4.00E-03		
Off-Site	VOC	Trichloroethene	79-01-6	T	HC	253	166	1.60E-03	1.60E+00	5.0E-03	**3.2E+02**
Off-Site	VOC	Vinyl Chloride	75-01-4	T	A	253	4	1.10E-03	3.00E-03	2.0E-03	**1.5E+00**

Notes:

Summary includes data from all monitoring wells sampled since 2008 (i.e., the past 5 years).

Only constituents detected in each area are shown.

The criteria for 1,2-Dichloroethene (total) are the criteria provided by the agency for cis-1,2-Dichloroethene.

The concentrations for the 1,3-Dichloropropene isomers (cis and trans) were summed before comparing to the criteria for 1,3-Dichloropropene (total).

The concentrations for the Xylene isomers (m/p and o) were summed before comparing to the criteria for Xylenes (total).

Ratios of concentration to the criteria greater than 1 are shaded in bold.

Chem Group - chemical group

Meas Basis - measured basis; T = total, D = dissolved

Carc Class - USEPA Weight-of-Evidence Cancer Classification

Attachment 1

Risk Calculation Inputs

Contents:

- Toxicity Values
- Physical and Chemical Properties
- Occupational Inhalation Limits
- High-End Exposure Factors
- Detected Source Concentrations

Attachment 1: Toxicity Values
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	Cancer Classification		ADAF			SF_{oral} (mg/kg/d)$^{-1}$			SF_{dermal} (mg/kg/d)$^{-1}$			URF (mg/m^3)$^{-1}$			RfD_{oral} (mg/kg/d)			
			Group	Ref	Y/N	f_{ing}	f_{inh}	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	UF	Ref	Notes
VOC	Acetone	67-64-1	ID	1	N												9.0E-01	1,000	1	
VOC	Benzene	71-43-2	A	1	N			5.5E-02	1	68	5.5E-02	125	104	7.8E-03	1	60	4.0E-03	300	1	
VOC	Bromodichloromethane	75-27-4	B2	1	N			6.2E-02	1		6.2E-02	125	104				2.0E-02	1,000	1	
VOC	Bromoform	75-25-2	B2	1	N			7.9E-03	1		7.9E-03	125	104	1.1E-03	1		2.0E-02	1,000	1	
VOC	Bromomethane	74-83-9	ID	126	N												1.4E-03	1,000	1	
VOC	2-Butanone	78-93-3	ID	1	N												6.0E-01	1,000	1	
VOC	Carbon Disulfide	75-15-0			N												1.0E-01	100	1	
VOC	Carbon Tetrachloride	56-23-5	LC	1	N			7.0E-02	1		7.0E-02	125	104	6.0E-03	1		4.0E-03	1,000	1	
VOC	Chlorobenzene	108-90-7	D	1	N												2.0E-02	1,000	1	
VOC	Chloroethane	75-00-3	LC	126	N				126	90		125	104		126	90	1.0E-01	3,000	126	116
VOC	Chloroform	67-66-3	B2	1	N			1.9E-02	135		1.9E-02	125	104	2.3E-02	1		1.0E-02	1,000	1	
VOC	Chloromethane	74-87-3	D	1	N															
VOC	Dibromochloromethane	124-48-1	C	1	N			8.4E-02	1		8.4E-02	125	104				2.0E-02	1,000	1	
VOC	1,1-Dichloroethane	75-34-3	SC	126	N				126	90		125	104		126	90	2.0E-01	3,000	126	
VOC	1,2-Dichloroethane	107-06-2	B2	1	N			9.1E-02	1		9.1E-02	125	104	2.6E-02	1		6.0E-03	10,000	126	114
VOC	1,1-Dichloroethene	75-35-4	C	1	N												5.0E-02	100	1	
VOC	1,2-Dichloroethene (total)	540-59-0			N												2.0E-03	3,000	1	133
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1	N												2.0E-03	3,000	1	
VOC	trans-1,2-Dichloroethene	156-60-5	ID	1	N												2.0E-02	3,000	1	
VOC	1,2-Dichloropropane	78-87-5	B2	2	N			3.6E-02	139		3.6E-02	125	104				9.0E-02	1,000	129	111
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1	N			1.0E-01	1	77	1.0E-01	125	104	4.0E-03	1		3.0E-02	100	1	
VOC	Ethyl Benzene	100-41-4	D	1	N												1.0E-01	1,000	1	
VOC	2-Hexanone	591-78-6	ID	1	N												5.0E-03	1,000	1	
VOC	4-Methyl-2-pentanone	108-10-1	ID	1	N														1	90
VOC	Methylene Chloride	75-09-2	LC	1	Y	1	1	2.0E-03	1	159	2.0E-03	125	104	1.0E-05	1	159	6.0E-03	30	1	
VOC	Styrene	100-42-5			N												2.0E-01	1,000	1	6
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	1	N			2.0E-01	1		2.0E-01	125	104		1	90	2.0E-02	1,000	1	
VOC	Tetrachloroethene	127-18-4	LC	1	N			2.1E-03	1		2.1E-03	125	104	2.6E-04	1		6.0E-03	1,000	1	
VOC	Toluene	108-88-3	ID	1	N												8.0E-02	3,000	1	
VOC	1,1,1-Trichloroethane	71-55-6	ID	1	N												2.0E+00	1,000	1	
VOC	1,1,2-Trichloroethane	79-00-5	C	1	N			5.7E-02	1		5.7E-02	125	104	1.6E-02	1		4.0E-03	1,000	1	
VOC	Trichloroethene	79-01-6	HC	1	Y	0.202	0.2439	4.6E-02	1	159	4.6E-02	125	104	4.1E-03	1	159	5.0E-04	1,000	1	
VOC	Vinyl Chloride	75-01-4	A	1	N			7.2E-01	1	78	7.2E-01	125	104	4.4E-03	1	79	3.0E-03	30	1	
VOC	Xylenes (total)	1330-20-7	ID	1	N												2.0E-01	1,000	1	

Chemical	RfD_{dermal} (mg/kg/d)				RfC (mg/m^3)				$SRfD_{oral}$ (mg/kg/d)				$SRfD_{dermal}$ (mg/kg/d)				SRfC (mg/m^3)			
	Value	UF	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes
Acetone	9.0E-01	1,000	125	104	3.1E+01	100	129	111	2.0E+00	100	129	111	2.0E+00	100	125	104	3.1E+01	100	129	111
Benzene	4.0E-03	300	125	104	3.0E-02	300	1		1.0E-02	100	126		1.0E-02	100	125	104	9.0E-02	100	1	110
Bromodichloromethane	2.0E-02	1,000	125	104			126	90	2.0E-02	1,000	1	62	2.0E-02	1000	125	104	2.0E-02	300	126	
Bromoform	2.0E-02	1,000	125	104			126	90	3.0E-02	100	126		3.0E-02	100	125	104			126	90
Bromomethane	1.4E-03	1,000	125	104	5.0E-03	100	1		5.0E-03	300	126		5.0E-03	300	125	104	1.0E-01	30	126	
2-Butanone	6.0E-01	1,000	125	104	5.0E+00	300	1		2.0E+00	1,000	2		2.0E+00	1000	125	104	5.0E+00	300	1	62
Carbon Disulfide	1.0E-01	100	125	104	7.0E-01	30	1		1.0E-01	100	2	2	1.0E-01	100	125	104	7.0E-01	30	2	2
Carbon Tetrachloride	4.0E-03	1,000	125	104	1.0E-01	100	1		1.0E-02	300	1	110	1.0E-02	300	125	104	1.9E-01	30	129	111
Chlorobenzene	2.0E-02	1,000	125	104	5.0E-02	1,000	126		7.0E-02	300	126		7.0E-02	300	125	104	5.0E-01	100	126	
Chloroethane	1.0E-01	3,000	125	104	1.0E+01	300	1		1.0E-01	3,000	126		1.0E-01	3000	125	104	1.0E+01	300	1	62
Chloroform	1.0E-02	1,000	125	104	5.0E-02	100	117		1.0E-01	100	129	111	1.0E-01	100	125	104	5.0E-02	100	117	
Chloromethane					9.0E-02	1,000	1										4.1E-01	300	129	111
Dibromochloromethane	2.0E-02	1,000	125	104			126	90	7.0E-02	300	126		7.0E-02	300	125	104			126	90
1,1-Dichloroethane	2.0E-01	3,000	125	104	5.0E-01	1,000	2	3	2.0E+00	300	126		2.0E+00	300	125	104	5.0E+00	100	2	3
1,2-Dichloroethane	6.0E-03	10,000	125	104	7.0E-03	3,000	126		2.0E-02	3,000	126		2.0E-02	3000	125	104	7.0E-02	300	126	
1,1-Dichloroethene	5.0E-02	100	125	104	2.0E-01	30	1		5.0E-02	100	1	62	5.0E-02	100	125	104	2.0E-01	30	1	62
1,2-Dichloroethene (total)	2.0E-03	3,000	125	104			1	90, 133	2.0E-02	300	1	110, 133	2.0E-02	300	125	104			126	90, 133
cis-1,2-Dichloroethene	2.0E-03	3,000	125	104			1	90	2.0E-02	300	1	110	2.0E-02	300	125	104			126	90
trans-1,2-Dichloroethene	2.0E-02	3,000	125	104			1	90	2.0E-01	300	1	110	2.0E-01	300	125	104			1	90
1,2-Dichloropropane	9.0E-02	1,000	125	104	4.0E-03	300	1		7.0E-02	1,000	129	111	7.0E-02	1000	125	104	1.3E-02	100	1	110
1,3-Dichloropropene (total)	3.0E-02	100	125	104	2.0E-02	30	1		4.0E-02	100	129	111	4.0E-02	100	125	104	3.6E-02	30	129	111
Ethyl Benzene	1.0E-01	1,000	125	104	1.0E+00	300	1		1.0E-01	1,000	1	62	1.0E-01	1000	125	104	9.0E+00	100	126	
2-Hexanone	5.0E-03	1,000	125	104	3.0E-02	3,000	1		5.0E-03	1,000	1	62	5.0E-03	1000	125	104	3.0E-01	300	1	110
4-Methyl-2-pentanone			125	104	3.0E+00	300	1				1	90, 62			125	104	3.0E+00	300	1	62
Methylene Chloride	6.0E-03	30	125	104	6.0E-01	30	1		6.0E-02	100	2	2	6.0E-02	100	125	104	1.0E+00	90	129	111
Styrene	2.0E-01	1,000	125	104	1.0E+00	30	1		2.0E-01	1,000	1	6, 62	2.0E-01	1000	125	104	3.0E+00	10	2	
1,1,2,2-Tetrachloroethane	2.0E-02	1,000	125	104			1	90	5.0E-02	300	1		5.0E-02	300	125	104			126	90
Tetrachloroethene	6.0E-03	1,000	125	104	4.0E-02	1,000	1		1.0E-01	100	2		1.0E-01	100	125	104	4.0E-02	1,000	1	62
Toluene	8.0E-02	3,000	125	104	5.0E+00	10	1		8.0E-01	300	1	110	8.0E-01	300	125	104	5.0E+00	10	126	
1,1,1-Trichloroethane	2.0E+00	1,000	125	104	5.0E+00	100	1		7.0E+00	300	1		7.0E+00	300	125	104	5.0E+00	100	1	
1,1,2-Trichloroethane	4.0E-03	1,000	125	104	2.0E-04	3,000	126	114	4.0E-03	1,000	126		4.0E-03	1000	125	104	2.0E-03	300	126	114
Trichloroethene	5.0E-04	1,000	125	104	2.0E-03	100	1		5.0E-04	1,000	1	62	5.0E-04	1000	125	104	5.4E-01	300	129	111
Vinyl Chloride	3.0E-03	30	125	104	1.0E-01	30	1		3.0E-03	30	1	62	3.0E-03	30	125	104	1.0E-01	30	1	62
Xylenes (total)	2.0E-01	1,000	125	104	1.0E-01	300	1		2.0E-01	1,000	1	110	2.0E-01	1000	125	104	3.0E-01	100	1	110

References:

1 USEPA. Integrated Risk Information System (IRIS). On-line database.
2 USEPA. 1997. Health Effects Assessment Summary Tables (HEAST). FY-1997 Update. EPA 540/R-97-036. July.
117 USEPA. NCEA. 2003. Risk Assessment Issue Paper for: Derivation of Provisional Subchronic and Chronic RfCs for Chloroform [CASRN 67-66-3]. January 23.
125 USEPA. 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. July.
126 Provisional Peer Reviewed Toxicity Values for Superfund (PPRTV) Database.
129 ATSDR. 2012. Minimal Risk Levels. February.
135 CalEPA. OEHHA. 2009. Technical Support Document for Cancer Potency Factors. Appendix H. May.
139 CalEPA. OEHHA. 1999. Public Health Goal for 1,2-Dichloropropane in Drinking Water. February.

Notes:

2 USEPA adopted chronic value as subchronic value.
3 HEAST Alternate Method.
6 Under review, according to IRIS.
60 IRIS provides a range of 2.2E-6 to 7.8E-6 (ug/m3)-1 as the inhalation URF for Benzene.
62 ENVIRON used chronic value as a surrogate for the subchronic value.
68 IRIS provides a range of 1.5E-2 to 5.5E-2 (mg/kg/d)-1 as the oral Slope Factor for Benzene.
77 IRIS provides an alternate slope factor of 5E-2; however, USEPA does not recommend its use, due to the higher uncertainty in the delivered dose in the supporting study.
78 IRIS presents an oral slope factor for vinyl chloride of 7.2E-1 (mg/kg/d)-1 for continuous lifetime exposure during adulthood and a twofold increase to 1.4 (mg/kg/d)-1 for continuous lifetime exposure from birth.
79 IRIS presents an inhalation URF for vinyl chloride of 4.4E-6 (ug/m3)-1 for continuous lifetime exposure during adulthood and a twofold increase to 8.8E-6 (ug/m3)-1 for continuous lifetime exposure from birth.
90 Inadequate data exist to derive a toxicity value, according to the indicated reference.
104 Dermal toxicity value is extrapolated from oral toxicity value in accordance with the referenced USEPA guidance.
110 The value is based on discussion in the indicated reference regarding the principal study USEPA used in extrapolating from subchronic to chronic.
111 Value as published is an MRL in the indicated reference.
114 The only toxicity value available is from a PPRTV appendix, but EPA advises that such values do not qualify as a source in OSWER Dir. 9285.7-53 and should not be used as a primary basis for site cleanup decisions as they lack sufficient technical support.
116 ENVIRON used subchronic value as a surrogate for the chronic value.
133 ENVIRON used the value for cis-1,2-Dichloroethene [CASRN 156-59-2] from the indicated reference as a surrogate.
159 Because the chemical has a mutagenic mode of action according to USEPA, the SF and URF are adjusted by the following age-dependant adjustment factors (ADAFs) before use: 10 for ages 0 to 2; 3 for ages 2 to 16; and 1 for ages 16 and older (USEPA 2005).

Attachment 1: Physical and Chemical Properties
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	MW (g/mole) Value	MW Ref	MW Notes	K_{ow} (unitless) Value	K_{ow} Ref	K_{ow} Notes	K_{oc} (L/kg) Value	K_{oc} Ref	K_{oc} Notes	H (unitless) Value	H Adjusted*	H Ref	H Notes	s (mg/L) Value	s Ref	s Notes	VP (mm Hg) Value	VP Adjust	VP Ref	VP Notes
VOC	Acetone	67-64-1	5.8E+01	50.1		5.8E-01	44		5.8E-01	44	82	1.6E-03	1.1E-03	44		1.0E+06	44		2.3E+02	1.6E+02	50.1	92
VOC	Benzene	71-43-2	7.8E+01	50.1		1.3E+02	44		5.8E+01	44	111	2.3E-01	1.6E-01	44		1.8E+03	44		9.5E+01	6.4E+01	50.1	92
VOC	Bromodichloromethane	75-27-4	1.6E+02	50.1		1.3E+02	44		5.5E+01	44	111	6.6E-02	4.5E-02	44		6.7E+03	44		5.0E+01	3.3E+01	50.1	92
VOC	Bromoform	75-25-2	2.5E+02	50.1		2.2E+02	44		8.7E+01	44	111	2.2E-02	1.3E-02	44		3.1E+03	44		5.5E+00	3.3E+00	50.1	92
VOC	Bromomethane	74-83-9	9.5E+01	50.1		1.5E+01	44		1.0E+01	44	111	2.6E-01	2.0E-01	44		1.5E+04	44		1.6E+03	1.2E+03	50.1	92
VOC	2-Butanone	78-93-3	7.2E+01	50.1		1.9E+00	69		2.0E+00	69	111	2.3E-03	2.0E-03	50.1	92, 123	2.2E+05	50.2		9.5E+01	6.4E+01	50.1	92
VOC	Carbon Disulfide	75-15-0	7.6E+01	50.1		1.0E+02	44		4.6E+01	44	111	1.2E+00	9.3E-01	44		1.2E+03	44		3.6E+02	2.6E+02	50.1	92
VOC	Carbon Tetrachloride	56-23-5	1.5E+02	50.1		5.4E+02	44		1.7E+02	44	111	1.3E+00	8.8E-01	44		7.9E+02	44		1.2E+02	7.9E+01	50.1	92
VOC	Chlorobenzene	108-90-7	1.1E+02	50.1		7.2E+02	44		2.2E+02	44	111	1.5E-01	9.8E-02	44		4.7E+02	44		1.2E+01	7.5E+00	50.1	92
VOC	Chloroethane	75-00-3	6.5E+01	50.1		2.7E+01	69		1.6E+01	69	111	3.6E-01	3.3E-01	50.1	92, 123	5.7E+03	50.1	92	1.0E+03	7.6E+02	50.1	92
VOC	Chloroform	67-66-3	1.2E+02	50.1		8.3E+01	44		4.0E+01	44	111	1.5E-01	1.1E-01	44		7.9E+03	44		2.0E+02	1.4E+02	50.1	92
VOC	Chloromethane	74-87-3	5.0E+01	50.1		8.3E+01	69		4.0E+01	69	111	3.6E-01	3.3E-01	50.1	92, 123	5.3E+03	50.1	92	4.3E+03	3.4E+03	50.1	92
VOC	Dibromochloromethane	124-48-1	2.1E+02	50.1		1.5E+02	44		6.3E+01	44	111	3.2E-02	2.4E-02	44		2.6E+03	44		4.9E+00	3.5E+00	50.1	92
VOC	1,1-Dichloroethane	75-34-3	9.9E+01	50.1		6.2E+01	44		3.1E+01	44	111	2.3E-01	1.7E-01	44		5.1E+03	44		2.3E+02	1.6E+02	50.1	92
VOC	1,2-Dichloroethane	107-06-2	9.9E+01	50.1		3.0E+01	44		1.7E+01	44	111	4.0E-02	2.7E-02	44		8.5E+03	44		7.9E+01	5.2E+01	50.1	92
VOC	1,1-Dichloroethene	75-35-4	9.7E+01	50.1		1.3E+02	44		5.8E+01	44	111	1.1E+00	8.1E-01	44		2.3E+03	44		6.0E+02	4.4E+02	50.1	92
VOC	1,2-Dichloroethene (total)	540-59-0	9.7E+01	50.1	133	7.2E+01	44	133	3.6E+01	44	133, 111	1.7E-01	1.2E-01	44	133	3.5E+03	44	133	2.0E+02	1.4E+02	50.1	92, 133
VOC	cis-1,2-Dichloroethene	156-59-2	9.7E+01	50.1		7.2E+01	44		3.6E+01	44	111	1.7E-01	1.2E-01	44		3.5E+03	44		2.0E+02	1.4E+02	50.1	92
VOC	trans-1,2-Dichloroethene	156-60-5	9.7E+01	50.1		1.2E+02	44		5.2E+01	44	111	3.9E-01	2.8E-01	44		6.3E+03	44		3.3E+02	2.4E+02	50.1	92
VOC	1,2-Dichloropropane	78-87-5	1.1E+02	50.1		9.3E+01	44		4.3E+01	44	111	1.2E-01	7.8E-02	44		2.8E+03	44		5.2E+01	3.4E+01	50.1	92
VOC	1,3-Dichloropropene (total)	542-75-6	1.1E+02	50.1		1.0E+02	44		4.6E+01	44	111	7.3E-01	4.8E-01	44		2.8E+03	44		3.4E+01	2.2E+01	50.1	92
VOC	Ethyl Benzene	100-41-4	1.1E+02	50.1		1.4E+03	44		3.7E+02	44	111	3.2E-01	2.0E-01	44		1.7E+02	44		9.6E+00	8.1E+00	50.1	92
VOC	2-Hexanone	591-78-6	1.0E+02	50.1		2.4E+01	39		1.5E+01	39	111	3.8E-03	3.2E-03	68		1.8E+04	39		1.2E+01	9.8E+00	50.1	92
VOC	4-Methyl-2-pentanone	108-10-1	1.0E+02	50.1		1.5E+01	62		1.0E+01	62	111	5.6E-03	4.7E-03	50.1	92, 123	1.9E+04	39		2.0E+01	1.2E+01	50.1	92
VOC	Methylene Chloride	75-09-2	8.5E+01	50.1		1.8E+01	44		1.2E+01	44	111	9.0E-02	6.6E-02	44		1.3E+04	44		4.3E+02	3.1E+02	50.1	92
VOC	Styrene	100-42-5	1.0E+02	50.1		8.7E+02	44		7.8E+02	44	82	1.1E-01	7.0E-02	44		3.1E+02	44		6.1E+00	3.7E+00	50.1	92
VOC	1,1,2,2-Tetrachloroethane	79-34-5	1.7E+02	50.1		2.5E+02	44		9.4E+01	44	111	1.4E-02	8.7E-03	44		3.0E+03	44		4.6E+00	2.8E+00	50.1	92
VOC	Tetrachloroethene	127-18-4	1.7E+02	50.1		4.7E+02	44		1.6E+02	44	111	7.5E-01	4.9E-01	44		2.0E+02	44		1.9E+01	1.2E+01	50.1	92
VOC	Toluene	108-88-3	9.2E+01	50.1		5.6E+02	44		1.8E+02	44	111	2.7E-01	1.8E-01	44		5.3E+02	44		2.8E+01	1.8E+01	50.1	92
VOC	1,1,1-Trichloroethane	71-55-6	1.3E+02	50.1		3.0E+02	44		1.1E+02	44	111	7.1E-01	5.0E-01	44		1.3E+03	44		1.2E+02	8.5E+01	50.1	92
VOC	1,1,2-Trichloroethane	79-00-5	1.3E+02	50.1		1.1E+02	44		5.0E+01	44	111	3.7E-02	2.4E-02	44		4.4E+03	44		2.3E+01	1.5E+01	50.1	92
VOC	Trichloroethene	79-01-6	1.3E+02	50.1		5.1E+02	44		1.7E+02	44	111	4.2E-01	2.9E-01	44		1.1E+03	44		7.3E+01	4.9E+01	50.1	92
VOC	Vinyl Chloride	75-01-4	6.3E+01	50.1		3.2E+01	44		1.8E+01	44	111	1.1E+00	9.0E-01	44		2.8E+03	44		3.0E+03	2.4E+03	50.1	92
VOC	Xylenes (total)	1330-20-7	1.1E+02	50.1		1.5E+03	44		3.9E+02	44	111	2.8E-01	1.7E-01	44		1.7E+02	44		8.0E+00	4.9E+00	50.1	92

Chemical	D_{air} (m^2/d) Value	D_{air} Ref	D_{air} Notes	D_{water} (m^2/d) Value	D_{water} Ref	D_{water} Notes	K_p (cm/hr) Value	K_p Ref	K_p Notes	ABS_d (unitless) Value	ABS_d Ref	ABS_d Notes	FA (unitless) Value	FA Ref	FA Notes	$\Delta H_{v,b}$ (cal/mol) Value	$\Delta H_{v,b}$ Ref	$\Delta H_{v,b}$ Notes	T_C (Kelvin) Value	T_C Ref	T_C Notes	T_B (Kelvin) Value	T_B Ref	T_B Notes	HENRY Ref Temp (°C) Value
Acetone	1.1E+00	44		9.8E-05	44		5.2E-04	44	115		62		1.0E+00	62	114	6.96E+03	44	118	5.08E+02	44	118	3.29E+02	44	118	2.5E+01
Benzene	7.6E-01	44		8.5E-05	44		1.5E-02	44	115		62		1.0E+00	62		7.34E+03	44	118	5.62E+02	44	118	3.53E+02	44	118	2.5E+01
Bromodichloromethane	2.6E-01	44		9.2E-05	44		4.7E-03	44	115		62		1.0E+00	62		7.80E+03	44	118	5.86E+02	44	118	3.63E+02	44	118	2.5E+01
Bromoform	1.3E-01	44		8.9E-05	44		2.2E-03	44	115		62		1.0E+00	62		9.48E+03	44	118	6.96E+02	44	118	4.22E+02	44	118	2.5E+01
Bromomethane	6.3E-01	44		1.0E-04	44		2.8E-03	44	115		62		1.0E+00	62		5.71E+03	44	118	4.67E+02	44	118	2.77E+02	44	118	2.5E+01
2-Butanone	7.0E-01	69		8.5E-05	69		9.6E-04	69	115		62		1.0E+00	62		7.48E+03	70		5.37E+02	70		3.53E+02	70		2.0E+01
Carbon Disulfide	9.0E-01	44		8.6E-05	44		1.2E-02	44	115		62		1.0E+00	62		6.39E+03	44	118	5.52E+02	44	118	3.19E+02	44	118	2.5E+01
Carbon Tetrachloride	6.7E-01	44		7.6E-05	44		1.4E-02	44	115		62		1.0E+00	62		7.13E+03	44	118	5.57E+02	44	118	3.50E+02	44	118	2.5E+01
Chlorobenzene	6.3E-01	44		7.5E-05	44		2.9E-02	44	115		62		1.0E+00	62		8.41E+03	44	118	6.32E+02	44	118	4.05E+02	44	118	2.5E+01
Chloroethane	2.3E+00	69		9.9E-05	69		6.1E-03	69	115		62		1.0E+00	62		5.88E+03	70		4.60E+02	70		2.85E+02	70		2.0E+01
Chloroform	9.0E-01	44		8.6E-05	44		6.3E-03	44	115		62		1.0E+00	62		6.99E+03	44	118	5.36E+02	44	118	3.34E+02	44	118	2.5E+01
Chloromethane	1.1E+00	69		5.6E-05	69		1.5E-02	69	115		62		1.0E+00	62		5.11E+03	70		4.16E+02	70		2.49E+02	70		2.0E+01
Dibromochloromethane	1.7E-01	44		9.1E-05	44		2.9E-03	44	115		62		1.0E+00	62		5.90E+03	44	118	6.78E+02	44	118	4.16E+02	44	118	2.5E+01
1,1-Dichloroethane	6.4E-01	44		9.1E-05	44		6.7E-03	44	115		62		1.0E+00	62		6.90E+03	44	118	5.23E+02	44	118	3.31E+02	44	118	2.5E+01
1,2-Dichloroethane	9.0E-01	44		8.6E-05	44		4.1E-03	44	115		62		1.0E+00	62		7.64E+03	44	118	5.61E+02	44	118	3.57E+02	44	118	2.5E+01
1,1-Dichloroethene	7.8E-01	44		9.0E-05	44		1.2E-02	44	115		62		1.0E+00	62		6.25E+03	44	118	5.76E+02	44	118	3.05E+02	44	118	2.5E+01
1,2-Dichloroethene (total)	6.4E-01	44	133	9.8E-05	44	133	7.7E-03	44	133, 115		62		1.0E+00	62	117	7.19E+03	44	118, 133	5.44E+02	44	118, 133	3.34E+02	44	118, 133	2.5E+01
cis-1,2-Dichloroethene	6.4E-01	44		9.8E-05	44		7.7E-03	44	115		62		1.0E+00	62	114	7.19E+03	44	118	5.44E+02	44	118	3.34E+02	44	118	2.5E+01
trans-1,2-Dichloroethene	6.1E-01	44		1.0E-04	44		1.1E-02	44	115		62		1.0E+00	62	114	6.72E+03	44	118	5.17E+02	44	118	3.21E+02	44	118	2.5E+01
1,2-Dichloropropane	6.8E-01	44		7.5E-05	44		7.4E-03	44	115		62		1.0E+00	62		7.59E+03	44	118	5.72E+02	44	118	3.70E+02	44	118	2.5E+01
1,3-Dichloropropene (total)	5.4E-01	44		8.6E-05	44		7.9E-03	44	115		62		1.0E+00	62		7.90E+03	44	118	5.87E+02	44	118	3.81E+02	44	118	2.5E+01
Ethyl Benzene	6.5E-01	44		6.7E-05	44		4.8E-02	44	115		62		1.0E+00	62		8.50E+03	44	118	6.17E+02	44	118	4.09E+02	44	118	2.5E+01
2-Hexanone	7.4E-01	52		7.6E-05	52		3.5E-03	39	115		62		1.0E+00	62	114										2.5E+01
4-Methyl-2-pentanone	6.5E-01	40		6.7E-05	40		2.7E-03	62	115		62		1.0E+00	62		8.24E+03	70		5.71E+02	70		3.90E+02	70		2.0E+01
Methylene Chloride	8.7E-01	44		1.0E-04	44		3.5E-03	44	115		62		1.0E+00	62		6.71E+03	44	118	5.10E+02	44	118	3.13E+02	44	118	2.5E+01
Styrene	6.1E-01	44		6.9E-05	44		3.6E-02	44	115		62		1.0E+00	62		8.74E+03	44	118	6.36E+02	44	118	4.18E+02	44	118	2.5E+01
1,1,2,2-Tetrachloroethane	6.1E-01	44		6.8E-05	44		6.9E-03	44	115		62		1.0E+00	62		9.00E+03	44	118	6.61E+02	44	118	4.20E+02	44	118	2.5E+01
Tetrachloroethene	6.2E-01	44		7.1E-05	44		1.1E-02	44	115		62		1.0E+00	62		8.29E+03	44	118	6.20E+02	44	118	3.94E+02	44	118	2.5E+01
Toluene	7.5E-01	44		7.4E-05	44		3.2E-02	44	115		62		1.0E+00	62		7.93E+03	44	118	5.92E+02	44	118	3.84E+02	44	118	2.5E+01
1,1,1-Trichloroethane	6.7E-01	44		7.6E-05	44		1.2E-02	44	115		62		1.0E+00	62		7.14E+03	44	118	5.45E+02	44	118	3.47E+02	44	118	2.5E+01
1,1,2-Trichloroethane	6.7E-01	44		7.6E-05	44		6.4E-03	44	115		62		1.0E+00	62		8.32E+03	44	118	6.02E+02	44	118	3.86E+02	44	118	2.5E+01
Trichloroethene	6.8E-01	44		7.9E-05	44		1.8E-02	44	115		62		1.0E+00	62		7.51E+03	44	118	5.44E+02	44	118	3.60E+02	44	118	2.5E+01
Vinyl Chloride	9.2E-01	44		1.1E-04	71		6.9E-03	44	115		62		1.0E+00	62		5.25E+03	44	118	4.32E+02	44	118	2.59E+02	44	118	2.5E+01
Xylenes (total)	6.7E-01	44		7.6E-05	44		5.0E-02	44	115		62		1.0E+00	62	114	8.57E+03	44	118	6.21E+02	44	118	4.14E+02	44	118	2.5E+01

References:

39 CHEMFATE data base. Syracuse Research Corporation.

40 Research Triangle Institute, Center for Environmental Analysis. 1995. Supplemental Technical Support Document for Hazardous Waste Identification Rule: Risk Assessment for Human and Ecological Receptors--Volume 1, TABLE A-1. November 1995.

44 USEPA. 1996. Soil Screening Guidance: Technical Background Document and User Guide. Office of Emergency and Remedial Response. EPA/540/R-95/128. May.

50.1 USEPA. 1997. Superfund Chemical Data Matrix (SCDM). Office of Emergency and Remedial Response. September 12.

50.2 USEPA. 2004. Superfund Chemical Data Matrix (SCDM). Office of Emergency and Remedial Response. January.

52 USEPA. 1997. CHEM9 Compound Properties Estimation and Data. Version 1.00. Office of Air Quality Planning and Standards. July.

62 USEPA. 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. July.

68 PHYSPROP data base. Syracuse Research Corporation.

69 USEPA. 2004. WATER9. Version 2.0.0. Office of Air Quality Planning and Standards. July.

70 USEPA. 2003. User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings. June 19.

71 USEPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Office of Solid Waste and Emergency Response. OSWER 9355.4-24. December.

Notes:

* Adjusted Henry's law constant is adjusted from the reference temperature in the indicated source to a groundwater temperature of 16.7 °C for Ft. Smith, Arkansas.

82 ENVIRON used Equation (70) from Reference 44 to calculate Koc value using Log Kow value from indicated reference.

92 Indicated source cites CHEMFATE.

111 ENVIRON used Equation (71) from Reference 44 to calculate Koc value using Log Kow value from indicated reference.

114 A value of 1 is conservatively used because EPA guidance does not provide a default value.

115 ENVIRON calculated Kp value using equation 3.8 (p.3-7) in reference 62 with log Kow from the indicated reference and the MW presented in table.

117 ENVIRON derived the FA based on Exhibit A-4 in the indicated reference.

118 From the 2001 Fact Sheet, "Correcting the Henry's Law Constant for Soil Temperature".

123 Value has been assigned a default reference temperature.

133 ENVIRON used the value for cis-1,2-Dichloroethene [CASRN 156-59-2] from the indicated reference as a surrogate.

Attachment 1: Occupational Inhalation Limits
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	Occupational Inhalation Limits		
			Value (mg/m^3)	Ref	Note
VOC	Acetone	67-64-1	2.4E+03	97	
VOC	Benzene	71-43-2	3.2E+00	97	368
VOC	Bromodichloromethane	75-27-4			
VOC	Bromoform	75-25-2	5.0E+00	97	426
VOC	Bromomethane	74-83-9	3.9E+00	47	
VOC	2-Butanone	78-93-3	5.9E+02	97	
VOC	Carbon Disulfide	75-15-0	6.2E+01	97	
VOC	Carbon Tetrachloride	56-23-5	6.3E+01	97	
VOC	Chlorobenzene	108-90-7	3.5E+02	97	
VOC	Chloroethane	75-00-3	2.6E+03	97	
VOC	Chloroform	67-66-3	4.9E+01	47	
VOC	Chloromethane	74-87-3	2.1E+02	97	
VOC	Dibromochloromethane	124-48-1			
VOC	1,1-Dichloroethane	75-34-3	4.0E+02	97	
VOC	1,2-Dichloroethane	107-06-2	2.0E+02	97	
VOC	1,1-Dichloroethene	75-35-4	2.0E+01	47	
VOC	1,2-Dichloroethene (total)	540-59-0	7.9E+02	97	
VOC	cis-1,2-Dichloroethene	156-59-2	7.9E+02	97	409
VOC	trans-1,2-Dichloroethene	156-60-5	7.9E+02	97	409
VOC	1,2-Dichloropropane	78-87-5	3.5E+02	97	
VOC	1,3-Dichloropropene (total)	542-75-6	4.5E+00	47	
VOC	Ethyl Benzene	100-41-4	4.4E+02	97	
VOC	2-Hexanone	591-78-6	4.1E+02	97	
VOC	4-Methyl-2-pentanone	108-10-1	4.1E+02	97	
VOC	Methylene Chloride	75-09-2	8.7E+01	97	
VOC	Styrene	100-42-5	4.3E+02	97	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	3.5E+01	97	426
VOC	Tetrachloroethene	127-18-4	6.8E+02	97	
VOC	Toluene	108-88-3	7.5E+02	97	
VOC	1,1,1-Trichloroethane	71-55-6	1.9E+03	97	
VOC	1,1,2-Trichloroethane	79-00-5	4.5E+01	97	426
VOC	Trichloroethene	79-01-6	5.4E+02	97	
VOC	Vinyl Chloride	75-01-4	2.6E+00	97	368
VOC	Xylenes (total)	1330-20-7	4.4E+02	97	

References:

47	American Conference of Government Industrial Hygienists. 2012. 2012 TLVs and BEIs. ISBN: 978-1-607260-48-6.
97	Occupational Safety and Health Standards — Toxic and Hazardous Substances, Title 29 Code of Federal Regulations, Pt. 1910 Subpart Z. 2007 ed.

Notes:

368	Complex criterion; source document review required.
409	ENVIRON used 1,2-Dichloroethene (total) [CASRN 540-59-0] value from the indicated reference as a surrogate.
426	Skin Designation assigned; wear appropriate PPE.

Attachment 1: High-End Exposure Factors
Whirlpool, Fort Smith, Arkansas

		Resident Age 0-2	Resident Age 2-6	Resident Age 6-16	Resident Age 16-30		Routine Worker		Maintenance Worker		Construction Worker	
Soil Ingestion												
Ingestion Rate (mg/d)	IR						50	b	100	f	200	f
Conversion Factor (kg/mg)	CF						1E-06		1E-06		1E-06	
Fraction Contacted (unitless)	FC						1.0	f	1.0	f	1.0	f
Exposure Frequency (d/yr)	EF						250	b	30	f	250	b
Exposure Duration (yr)	ED						25	b	10	e	1	f
Body Weight (kg-bw)	BW						70	a	70	a	70	a
Averaging Time, carc (d)	AT_c						25,550	a	25,550	a	25,550	a
Averaging Time, noncarc (d)	AT_{nc}						9,125	a	3,650	a	365	a
Intake, carc (kg-soil/kg-bw per d)							1.75E-07		1.68E-08		2.80E-08	
Soil Dermal Contact												
Adherence Factor (mg/cm^2)	AD						0.2	c	0.2	c	0.2	c
Skin Surface Area (cm^2/d)	SA						3,300	c	3,300	c	3,300	c
Conversion Factor (kg/mg)	CF						1E-06		1E-06		1E-06	
Fraction Contacted (unitless)	FC						1.0	f	1.0	f	1.0	f
Exposure Frequency (d/yr)	EF						250	b	30	f	250	b
Exposure Duration (yr)	ED						25	b	10	e	1	f
Body Weight (kg-bw)	BW						70	a	70	a	70	a
Averaging Time, carc (d)	AT_c						25,550	a	25,550	a	25,550	a
Averaging Time, noncarc (d)	AT_{nc}						9,125	a	3,650	a	365	a
Outdoor Air Inhalation of Vapor and Particulates												
Exposure Time (h/d)	ET	24	24	24	24	d	8	d	8	d	8	d
Exposure Frequency (d/yr)	EF	0	0	0	0	b	250	b	30	f	250	b
Exposure Duration (yr)	ED	0	0	0	0	b	25	b	10	e	1	f
Averaging Time, carc (h)	AT_c	613,200	613,200	613,200	613,200	a	613,200	a	613,200	a	613,200	a
Averaging Time, noncarc (h)	AT_{nc}	0	0	0	0	a	219,000	a	87,600	a	8,760	a
Incidental Groundwater Ingestion												
Drinking Rate (L/hr per event)	DR								0.005	f	0.005	f
Exposure Time (h)	ET								2	f	2	f
Exposure Frequency (d/yr)	EF								5	f	5	f
Exposure Duration (yr)	ED								10	e	1	f
Body Weight (kg-bw)	BW								70	a	70	a
Averaging Time, canc (d)	AT_c								25,550	a	25,550	a
Averaging Time, noncanc (d)	AT_{nc}								3,650	a	365	a
Groundwater Dermal Contact												
Event Time (hr)	t								2	f	2	f
Skin Surface Area (cm^2)	SA								3,300	c	3,300	c
Events per Day (event/d)	EV								1	f	1	f
Exposure Frequency (d/yr)	EF								5	f	5	f
Exposure Duration (yr)	ED								10	e	1	f
Body Weight (kg)	BW								70	a	70	a
Averaging Time, cancer (days)	AT_c								25,550	a	25,550	a
Averaging Time, noncancer (days)	AT_{nc}								3,650	a	365	a
Groundwater Outdoor Vapor Inhalation												
Exposure Time (h/d)	ET	0	0	0	0	d	0	d	8	d	8	d
Exposure Frequency (d/yr)	EF	0	0	0	0	b	0	b	5	f	5	f
Exposure Duration (yr)	ED	2	4	10	14	b	0	b	10	e	1	f
Averaging Time, carc (h)	AT_c	613,200	613,200	613,200	613,200	a	613,200	a	613,200	a	613,200	a
Averaging Time, noncarc (h)	AT_{nc}	262,800	262,800	262,800	262,800	a	0	a	87,600	a	8,760	a
Groundwater Indoor Vapor Inhalation												
Exposure Time (hours/day)	ET	24	24	24	24	d	8	d				
Exposure Frequency (d/yr)	EF	350	350	350	350	b	250	b				
Exposure Duration (yr)	ED	2	4	10	14	b	25	b				
Averaging Time, carc (hours)	AT_c	613,200	613,200	613,200	613,200	a	613,200	a				
Averaging Time, noncarc (hours)	AT_{nc}	262,800	262,800	262,800	262,800	a	219,000	a				
Soil Indoor Vapor Inhalation												
Exposure Time (hours/day)	ET						8	d				
Exposure Frequency (d/yr)	EF						250	b				
Exposure Duration (yr)	ED						25	b				
Averaging Time, carc (hours)	AT_c						613,200	a				
Averaging Time, noncarc (hours)	AT_{nc}						219,000	a				

References:

a. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A) Interim Final (EPA 1989).

b. Standard default exposure factors. OSWER Directive 9285.6-03 (EPA 1991).

c. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual: Part E, Supplemental Guidance for Dermal Risk Assessment (EPA 2004).

d. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual: Part F, Supplemental Guidance for Inhalation Risk Assessment (EPA 2009).

e. The 90th to 95th percentile job tenure for workers in construction (Burmaster 2000).

f. Based on professional judgment and site-specific considerations discussed in the text.

g. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA 2005).

Attachment 1: Detected Source Concentrations
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	Carc Class	Groundwater Concentration (On-Site) (mg/L)	Groundwater Concentration (Off-Site) (mg/L)	Soil Concentration (mg/kg)	SV1 (mg/m^3)	SV2 (mg/m^3)	SV3 (mg/m^3)	SV4 (mg/m^3)
VOC	Acetone	67-64-1	ID	1.99E-01	8.50E-02	ND	NA	NA	NA	NA
VOC	Benzene	71-43-2	A	6.53E-02	ND	ND	NA	NA	NA	NA
VOC	Bromodichloromethane	75-27-4	B2	6.79E-02	ND	ND	NA	NA	NA	NA
VOC	Bromoform	75-25-2	B2	7.67E-02	2.40E-02	ND	NA	NA	NA	NA
VOC	Bromomethane	74-83-9	ID	6.13E-02	ND	ND	NA	NA	NA	NA
VOC	2-Butanone	78-93-3	ID	1.06E-01	9.50E-02	ND	NA	NA	NA	NA
VOC	Carbon Disulfide	75-15-0		6.52E-02	ND	ND	NA	NA	NA	NA
VOC	Carbon Tetrachloride	56-23-5	LC	6.69E-02	ND	ND	NA	NA	NA	NA
VOC	Chlorobenzene	108-90-7	D	6.86E-02	ND	ND	NA	NA	NA	NA
VOC	Chloroethane	75-00-3	LC	7.23E-02	ND	ND	NA	NA	NA	NA
VOC	Chloroform	67-66-3	B2	6.64E-02	ND	ND	NA	NA	NA	NA
VOC	Chloromethane	74-87-3	D	9.00E-02	ND	ND	NA	NA	NA	NA
VOC	Dibromochloromethane	124-48-1	C	7.13E-02	ND	ND	NA	NA	NA	NA
VOC	1,1-Dichloroethane	75-34-3	SC	6.59E-02	ND	ND	NA	NA	NA	NA
VOC	1,2-Dichloroethane	107-06-2	B2	6.61E-02	3.00E-03	ND	NA	NA	NA	NA
VOC	1,1-Dichloroethene	75-35-4	C	2.50E-01	4.20E-03	ND	NA	NA	NA	NA
VOC	1,2-Dichloroethene (total)	540-59-0		1.00E+01	4.10E-02	1.20E-02	NA	NA	NA	NA
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.00E+01	4.10E-02	1.20E-02	NA	NA	NA	NA
VOC	trans-1,2-Dichloroethene	156-60-5	ID	5.99E-02	ND	ND	NA	NA	NA	NA
VOC	1,2-Dichloropropane	78-87-5	B2	6.52E-02	ND	ND	NA	NA	NA	NA
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1.42E-01	ND	ND	NA	NA	NA	NA
VOC	Ethyl Benzene	100-41-4	D	6.89E-02	ND	ND	NA	NA	NA	NA
VOC	2-Hexanone	591-78-6	ID	1.20E-01	ND	ND	NA	NA	NA	NA
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.20E-01	4.00E-03	ND	NA	NA	NA	NA
VOC	Methylene Chloride	75-09-2	LC	3.10E-01	ND	7.00E-03	NA	NA	NA	NA
VOC	Styrene	100-42-5		6.83E-02	ND	ND	NA	NA	NA	NA
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	6.40E-02	ND	ND	NA	NA	NA	NA
VOC	Tetrachloroethene	127-18-4	LC	7.67E-02	ND	ND	NA	1.1E-01	NA	NA
VOC	Toluene	108-88-3	ID	6.54E-02	ND	ND	NA	NA	NA	NA
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.10E-01	ND	ND	NA	NA	NA	NA
VOC	1,1,2-Trichloroethane	79-00-5	C	6.59E-02	ND	ND	NA	NA	NA	NA
VOC	Trichloroethene	79-01-6	HC	8.10E+01	1.60E+00	1.86E-01	ND	2.3E-01	2.9E-03	4.0E-02
VOC	Vinyl Chloride	75-01-4	A	2.50E+00	3.00E-03	ND	NA	NA	NA	NA
VOC	Xylenes (total)	1330-20-7	ID	1.99E-01	ND	ND	NA	NA	NA	NA

Notes:
ND - Not Detected.
NA - Not Analyzed.

Attachment 2

Routine Worker Risk Calculations

Contents:

- Vapor Flux from Soil to Outdoor Air
- Soil PM10 Emission from Wind Erosion
- Cancer Risk Calculations for Exposure of On-Site Routine Workers to On-Site Soil
- Hazard Index Calculations for Exposure of On-Site Routine Workers to On-Site Soil
- Cancer Risk Calculations for Exposure of Off-Site Routine Workers to On-Site Soil
- Hazard Index Calculations for Exposure of Off-Site Routine Workers to On-Site Soil

- Soil Moisture Profile for Comm/Ind Building (Slab-on-Grade)
- Normalized Indoor Air Concentration in a Comm/Ind Building (Slab-on-Grade) due to Vapor Intrusion from Subsurface Soil
- Normalized Indoor Air Concentration in a Comm/Ind Building (Slab-on-Grade) due to Vapor Intrusion from Groundwater
- Cancer Risk and Hazard Index Calculations for On-Site Routine Workers due to Soil Vapor Intrusion into a Comm/Ind Building (Slab-on-Grade)
- Cancer Risk and Hazard Index Calculations for On-Site Routine Workers due to Groundwater Vapor Intrusion into a Comm/Ind Building (Slab-on-Grade)
- Vapor Intrusion Contribution to Occupational Inhalation Exposure Limits Calculations for On-Site Routine Workers Exposure in a Comm/Ind Building (Slab-on-Grade)
- Cancer Risk and Hazard Index Calculations for Off-Site Routine Workers due to Groundwater Vapor Intrusion into a Comm/Ind Building (Slab-on-Grade)

- Vapor Flux to Outdoor Air from Groundwater
- Cancer Risk and Hazard Index Calculations for Exposure of On-Site Routine Workers to Groundwater-derived Vapors in Outdoor Air
- Cancer Risk and Hazard Index Calculations for Exposure of Off-Site Routine Workers to Groundwater-derived Vapors in Outdoor Air

Attachment 2: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	K_{oc} (L/kg)	H (unitless)	D_{air} (m^2/d)	D_{water} (m^2/d)	R_L (unitless)	D_G (m^2/d)	D_L (m^2/d)	D_E (m^2/d)	Infinite J_v (kg/m^2-s)	Finite depth Z1 ERFC term	Finite depth Z2 ERFC term	Finite J_v (kg/m^2-s)	J_v (kg/m^2-s)
VOC	Acetone	67-64-1	5.81E-01	1.14E-03	1.07E+00	9.85E-05	3.17E-01	1.15E-02	9.10E-06	7.01E-05	1.58E-06	0.00E+00	4.48E-03	1.58E-06	1.58E-06
VOC	Benzene	71-43-2	5.82E+01	1.59E-01	7.60E-01	8.47E-05	5.02E-01	8.19E-03	7.82E-06	2.61E-03	9.63E-06	0.00E+00	2.18E+00	5.08E-06	5.08E-06
VOC	Bromodichloromethane	75-27-4	5.51E+01	4.45E-02	2.57E-01	9.16E-05	4.75E-01	2.77E-03	8.46E-06	2.78E-04	3.14E-06	0.00E+00	3.82E-01	2.97E-06	2.97E-06
VOC	Bromoform	75-25-2	8.70E+01	1.34E-02	1.29E-01	8.90E-05	5.58E-01	1.39E-03	8.22E-06	4.80E-05	1.31E-06	0.00E+00	3.38E-04	1.31E-06	1.31E-06
VOC	Bromomethane	74-83-9	1.05E+01	2.01E-01	6.29E-01	1.05E-04	3.78E-01	6.78E-03	9.65E-06	3.63E-03	1.14E-05	0.00E+00	2.39E+00	5.27E-06	5.27E-06
VOC	2-Butanone	78-93-3	2.00E+00	1.96E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.03E-05	1.58E-06	0.00E+00	4.54E-03	1.58E-06	1.58E-06
VOC	Carbon Disulfide	75-15-0	4.59E+01	9.26E-01	8.99E-01	8.64E-05	5.96E-01	9.68E-03	7.98E-06	1.51E-02	2.32E-05	0.00E+00	3.02E+00	5.84E-06	5.84E-06
VOC	Carbon Tetrachloride	56-23-5	1.74E+02	8.82E-01	6.74E-01	7.60E-05	9.41E-01	7.26E-03	7.02E-06	6.81E-03	1.56E-05	0.00E+00	2.72E+00	5.57E-06	5.57E-06
VOC	Chlorobenzene	108-90-7	2.20E+02	9.77E-02	6.31E-01	7.52E-05	9.40E-01	6.79E-03	6.94E-06	7.13E-04	5.04E-06	0.00E+00	1.14E+00	4.01E-06	4.01E-06
VOC	Chloroethane	75-00-3	1.62E+01	3.25E-01	2.34E+00	9.94E-05	4.14E-01	2.52E-02	9.18E-06	1.98E-02	2.66E-05	0.00E+00	3.10E+00	5.91E-06	5.91E-06
VOC	Chloroform	67-66-3	3.97E+01	1.07E-01	8.99E-01	8.64E-05	4.43E-01	9.68E-03	7.98E-06	2.37E-03	9.18E-06	0.00E+00	2.11E+00	5.02E-06	5.02E-06
VOC	Chloromethane	74-87-3	3.97E+01	3.33E-01	1.09E+00	5.62E-05	4.80E-01	1.17E-02	5.19E-06	8.14E-03	1.70E-05	0.00E+00	2.79E+00	5.64E-06	5.64E-06
VOC	Dibromochloromethane	124-48-1	6.26E+01	2.38E-02	1.69E-01	9.07E-05	4.92E-01	1.82E-03	8.38E-06	1.05E-04	1.94E-06	0.00E+00	3.05E-02	1.93E-06	1.93E-06
VOC	1,1-Dichloroethane	75-34-3	3.13E+01	1.66E-01	6.41E-01	9.07E-05	4.29E-01	6.91E-03	8.38E-06	2.68E-03	9.77E-06	0.00E+00	2.20E+00	5.10E-06	5.10E-06
VOC	1,2-Dichloroethane	107-06-2	1.75E+01	2.74E-02	8.99E-01	8.55E-05	3.68E-01	9.68E-03	7.90E-06	7.42E-04	5.14E-06	0.00E+00	1.17E+00	4.05E-06	4.05E-06
VOC	1,1-Dichloroethene	75-35-4	5.82E+01	8.10E-01	7.78E-01	8.99E-05	6.10E-01	8.38E-03	8.30E-06	1.11E-02	1.99E-05	0.00E+00	2.92E+00	5.75E-06	5.75E-06
VOC	1,2-Dichloroethene (total)	540-59-0	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	8.21E-06	0.00E+00	1.95E+00	4.86E-06	4.86E-06
VOC	cis-1,2-Dichloroethene	156-59-2	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	8.21E-06	0.00E+00	1.95E+00	4.86E-06	4.86E-06
VOC	trans-1,2-Dichloroethene	156-60-5	5.22E+01	2.81E-01	6.11E-01	1.03E-04	5.06E-01	6.58E-03	9.49E-06	3.68E-03	1.14E-05	0.00E+00	2.40E+00	5.28E-06	5.28E-06
VOC	1,2-Dichloropropane	78-87-5	4.35E+01	7.82E-02	6.76E-01	7.54E-05	4.48E-01	7.28E-03	6.97E-06	1.28E-03	6.76E-06	0.00E+00	1.65E+00	4.56E-06	4.56E-06
VOC	1,3-Dichloropropene (total)	542-75-6	4.59E+01	4.83E-01	5.41E-01	8.64E-05	5.22E-01	5.83E-03	7.98E-06	5.40E-03	1.39E-05	0.00E+00	2.61E+00	5.47E-06	5.47E-06
VOC	Ethyl Benzene	100-41-4	3.67E+02	2.04E-01	6.48E-01	6.74E-05	1.36E+00	6.98E-03	6.22E-06	1.05E-03	6.11E-06	0.00E+00	1.48E+00	4.38E-06	4.38E-06
VOC	2-Hexanone	591-78-6	1.48E+01	3.23E-03	7.45E-01	7.57E-05	3.57E-01	8.02E-03	6.99E-06	9.23E-05	1.81E-06	0.00E+00	1.76E-02	1.81E-06	1.81E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.05E+01	4.71E-03	6.48E-01	6.74E-05	3.45E-01	6.98E-03	6.22E-06	1.13E-04	2.01E-06	0.00E+00	4.02E-02	2.00E-06	2.00E-06
VOC	Methylene Chloride	75-09-2	1.17E+01	6.60E-02	8.73E-01	1.01E-04	3.59E-01	9.40E-03	9.33E-06	1.76E-03	7.90E-06	0.00E+00	1.90E+00	4.81E-06	4.81E-06
VOC	Styrene	100-42-5	7.77E+02	7.04E-02	6.13E-01	6.91E-05	2.47E+00	6.61E-03	6.38E-06	1.91E-04	2.61E-06	0.00E+00	1.83E-01	2.54E-06	2.54E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	9.35E+01	8.74E-03	6.13E-01	6.83E-05	5.75E-01	6.61E-03	6.30E-06	1.11E-04	1.99E-06	0.00E+00	3.77E-02	1.98E-06	1.98E-06
VOC	Tetrachloroethene	127-18-4	1.56E+02	4.90E-01	6.22E-01	7.08E-05	8.27E-01	6.70E-03	6.54E-06	3.98E-03	1.19E-05	0.00E+00	2.44E+00	5.32E-06	5.32E-06
VOC	Toluene	108-88-3	1.80E+02	1.80E-01	7.52E-01	7.43E-05	8.43E-01	8.10E-03	6.86E-06	1.74E-03	7.87E-06	0.00E+00	1.89E+00	4.80E-06	4.80E-06
VOC	1,1,1-Trichloroethane	71-55-6	1.10E+02	4.97E-01	6.74E-01	7.60E-05	7.02E-01	7.26E-03	7.02E-06	5.15E-03	1.35E-05	0.00E+00	2.58E+00	5.45E-06	5.45E-06
VOC	1,1,2-Trichloroethane	79-00-5	5.03E+01	2.43E-02	6.74E-01	7.60E-05	4.58E-01	7.26E-03	7.02E-06	4.00E-04	3.77E-06	0.00E+00	6.44E-01	3.39E-06	3.39E-06
VOC	Trichloroethene	79-01-6	1.68E+02	2.88E-01	6.83E-01	7.86E-05	8.26E-01	7.35E-03	7.26E-06	2.57E-03	9.57E-06	0.00E+00	2.17E+00	5.07E-06	5.07E-06

Attachment 2: Vapor Flux from Soil to Outdoor Air Whirlpool, Fort Smith, Arkansas															
Chem Group	**Chemical**	**CASRN**	**K_{oc}** (L/kg)	**H** (unitless)	**D_{air}** (m^2/d)	**D_{water}** (m^2/d)	**R_L** (unitless)	**D_G** (m^2/d)	**D_L** (m^2/d)	**D_E** (m^2/d)	**Infinite J_v** (kg/m^2-s)	**Finite depth Z1 ERFC term**	**Finite depth Z2 ERFC term**	**Finite J_v** (kg/m^2-s)	**J_v** (kg/m^2-s)
VOC	Vinyl Chloride	75-01-4	1.85E+01	9.00E-01	9.16E-01	1.06E-04	5.15E-01	9.87E-03	9.81E-06	1.72E-02	2.48E-05	0.00E+00	3.06E+00	5.88E-06	5.88E-06
VOC	Xylenes (total)	1330-20-7	3.86E+02	1.73E-01	6.74E-01	7.56E-05	1.41E+00	7.26E-03	6.98E-06	8.97E-04	5.65E-06	0.00E+00	1.34E+00	4.24E-06	4.24E-06
Notes:	Soil bulk density	kg/L	ρ_b	1.38											
	Soil porosity	L/L-soil	θ	0.48											
	Soil water content	L/L-soil	θ_w	0.32											
	Soil air-filled porosity	L/L-soil	θ_a	0.17											
	Soil organic carbon fraction	unitless	f_{oc}	0.002											
	Averaging period (Exposure Duration)	year	**T**	25											
		days	**T**	9125											
		s	**T**	7.9E+08											
	Molar Gas Constant	L-mmHg/ mole-^{o}K	**R**	62.411											
	Temperature	^{o}C	**Temp**	16.7											
		K	**Temp**	289.7											
	Clean soil above source	m	Z_1	0.00											
	Bottom of source depth	m	Z_2	3.66											

Attachment 2: Soil PM10 Emission from Wind Erosion
Whirlpool, Fort Smith, Arkansas

Unlimited Reservoir Model			
Aerodynamic particle size multiplier			0.036
Ground cover fraction		**G**	0.5
Mode of aggregate size distribution	mm		0.50
Threshold friction velocity	m/s	u'_t	0.50
Correction factor			1.25
Corrected friction velocity	m/s	u^*_t	0.6252
Roughness height	m	z_0	0.005
Anemometer height	m		10.0
Friction velocity at anemometer height	m/s	u_t	11.9
Mean annual wind speed	mph	u_m	7.6
Mean annual wind speed	m/s	u_m	3.40
u_m/u_t			0.286
$x = 0.886\ u_t/u_m$			3.10
F(x)			0.003
Annual average PM_{10} flux	kg-soil/m^2-s	$J_{10,w}$	**3.93E-13**

Attachment 2: Cancer Risk Calculations for Exposure of On-Site Routine Workers to On-Site Soil
Whirlpool, Fort Smith, Arkansas

					Soil Ingestion			Soil Dermal Contact				Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	C_{soil} (mg/kg)	**LADD** (mg/kg/d)	SF_{oral} $(mg/kg/d)^{-1}$	**Risk**	ABS_{derm}	**LADD** (mg/kg/d)	SF_{derm} $(mg/kg/d)^{-1}$	**Risk**	C_{air} (mg/m^3)	**URF** (m^3/mg)	**Risk**	C_{air} (mg/m^3)	**URF** (m^3/mg)	**Risk**	**Risk**
VOC	Acetone	67-64-1	ID															
VOC	Benzene	71-43-2	A			5.5E-02				5.5E-02			7.8E-03			7.8E-03		
VOC	Bromodichloromethane	75-27-4	B2			6.2E-02				6.2E-02								
VOC	Bromoform	75-25-2	B2			7.9E-03				7.9E-03			1.1E-03			1.1E-03		
VOC	Bromomethane	74-83-9	ID															
VOC	2-Butanone	78-93-3	ID															
VOC	Carbon Disulfide	75-15-0																
VOC	Carbon Tetrachloride	56-23-5	LC			7.0E-02				7.0E-02			6.0E-03			6.0E-03		
VOC	Chlorobenzene	108-90-7	D															
VOC	Chloroethane	75-00-3	LC															
VOC	Chloroform	67-66-3	B2			1.9E-02				1.9E-02			2.3E-02			2.3E-02		
VOC	Chloromethane	74-87-3	D															
VOC	Dibromochloromethane	124-48-1	C			8.4E-02				8.4E-02								
VOC	1,1-Dichloroethane	75-34-3	SC															
VOC	1,2-Dichloroethane	107-06-2	B2			9.1E-02				9.1E-02			2.6E-02			2.6E-02		
VOC	1,1-Dichloroethene	75-35-4	C															
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	2.10E-09							1.98E-06			1.60E-13			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	2.10E-09							1.98E-06			1.60E-13			
VOC	trans-1,2-Dichloroethene	156-60-5	ID															
VOC	1,2-Dichloropropane	78-87-5	B2			3.6E-02				3.6E-02								
VOC	1,3-Dichloropropene (total)	542-75-6	B2			1.0E-01				1.0E-01			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4	D															
VOC	2-Hexanone	591-78-6	ID															
VOC	4-Methyl-2-pentanone	108-10-1	ID															
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	1.22E-09	2.0E-03	2.4E-12			2.0E-03		1.14E-06	1.0E-05	9.3E-13	9.35E-14	1.0E-05	7.6E-20	3.4E-12
VOC	Styrene	100-42-5																
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC			2.0E-01				2.0E-01								
VOC	Tetrachloroethene	127-18-4	LC			2.1E-03				2.1E-03			2.6E-04			2.6E-04		
VOC	Toluene	108-88-3	ID															
VOC	1,1,1-Trichloroethane	71-55-6	ID															
VOC	1,1,2-Trichloroethane	79-00-5	C			5.7E-02				5.7E-02			1.6E-02			1.6E-02		
VOC	Trichloroethene	79-01-6	HC	1.86E-01	3.25E-08	4.6E-02	1.5E-09			4.6E-02		3.21E-05	4.1E-03	1.1E-08	2.48E-12	4.1E-03	8.3E-16	1.2E-08
VOC	Vinyl Chloride	75-01-4	A			7.2E-01				7.2E-01			4.4E-03			4.4E-03		
VOC	Xylenes (total)	1330-20-7	ID															
		Cumulative Risk:					**1E-09**							**1E-08**			**8E-16**	**1E-08**

Notes:

The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).

This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.

Attachment 2: Hazard Index Calculations for Exposure of On-Site Routine Workers to On-Site Soil
Whirlpool, Fort Smith, Arkansas

				Soil Ingestion				Soil Dermal Contact				Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	**C_{soil}** (mg/kg)	**ADD** (mg/kg/d)	**RfD_{oral}** (mg/kg/d)	**HQ**	**ABS_{derm}**	**ADD** (mg/kg/d)	**RfD_{derm}** (mg/kg/d)	**HQ**	**C_{air}** (mg/m^3)	**RfC** (mg/m^3)	**HQ**	**C_{air}** (mg/m^3)	**RfC** (mg/m^3)	**HQ**	**HQ**
VOC	Acetone	67-64-1	ID			9.0E-01				9.0E-01			3.1E+01			3.1E+01		
VOC	Benzene	71-43-2	A			4.0E-03				4.0E-03			3.0E-02			3.0E-02		
VOC	Bromodichloromethane	75-27-4	B2			2.0E-02				2.0E-02								
VOC	Bromoform	75-25-2	B2			2.0E-02				2.0E-02								
VOC	Bromomethane	74-83-9	ID			1.4E-03				1.4E-03			5.0E-03			5.0E-03		
VOC	2-Butanone	78-93-3	ID			6.0E-01				6.0E-01			5.0E+00			5.0E+00		
VOC	Carbon Disulfide	75-15-0				1.0E-01				1.0E-01			7.0E-01			7.0E-01		
VOC	Carbon Tetrachloride	56-23-5	LC			4.0E-03				4.0E-03			1.0E-01			1.0E-01		
VOC	Chlorobenzene	108-90-7	D			2.0E-02				2.0E-02			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3	LC			1.0E-01				1.0E-01			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	B2			1.0E-02				1.0E-02			5.0E-02			5.0E-02		
VOC	Chloromethane	74-87-3	D										9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1	C			2.0E-02				2.0E-02								
VOC	1,1-Dichloroethane	75-34-3	SC			2.0E-01				2.0E-01			5.0E-01			5.0E-01		
VOC	1,2-Dichloroethane	107-06-2	B2			6.0E-03				6.0E-03			7.0E-03			7.0E-03		
VOC	1,1-Dichloroethene	75-35-4	C			5.0E-02				5.0E-02			2.0E-01			2.0E-01		
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	5.87E-09	2.0E-03	2.9E-06			2.0E-03		1.98E-06			1.60E-13			2.9E-06
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	5.87E-09	2.0E-03	2.9E-06			2.0E-03		1.98E-06			1.60E-13			2.9E-06
VOC	trans-1,2-Dichloroethene	156-60-5	ID			2.0E-02				2.0E-02								
VOC	1,2-Dichloropropane	78-87-5	B2			9.0E-02				9.0E-02			4.0E-03			4.0E-03		
VOC	1,3-Dichloropropene (total)	542-75-6	B2			3.0E-02				3.0E-02			2.0E-02			2.0E-02		
VOC	Ethyl Benzene	100-41-4	D			1.0E-01				1.0E-01			1.0E+00			1.0E+00		
VOC	2-Hexanone	591-78-6	ID			5.0E-03				5.0E-03			3.0E-02			3.0E-02		
VOC	4-Methyl-2-pentanone	108-10-1	ID										3.0E+00			3.0E+00		
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	3.42E-09	6.0E-03	5.7E-07			6.0E-03		1.14E-06	6.0E-01	4.4E-07	9.35E-14	6.0E-01	3.6E-14	1.0E-06
VOC	Styrene	100-42-5				2.0E-01				2.0E-01			1.0E+00			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC			2.0E-02				2.0E-02								
VOC	Tetrachloroethene	127-18-4	LC			6.0E-03				6.0E-03			4.0E-02			4.0E-02		
VOC	Toluene	108-88-3	ID			8.0E-02				8.0E-02			5.0E+00			5.0E+00		
VOC	1,1,1-Trichloroethane	71-55-6	ID			2.0E+00				2.0E+00			5.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5	C			4.0E-03				4.0E-03			2.0E-04			2.0E-04		
VOC	Trichloroethene	79-01-6	HC	1.86E-01	9.10E-08	5.0E-04	1.8E-04			5.0E-04		3.21E-05	2.0E-03	3.7E-03	2.48E-12	2.0E-03	2.8E-10	3.8E-03
VOC	Vinyl Chloride	75-01-4	A			3.0E-03				3.0E-03			1.0E-01			1.0E-01		
VOC	Xylenes (total)	1330-20-7	ID			2.0E-01				2.0E-01			1.0E-01			1.0E-01		
		Hazard Index:					**2E-04**							**4E-03**			**3E-10**	**4E-03**

Notes:

The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).

This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.

Attachment 2: Cancer Risk Calculations for Exposure of Off-Site Routine Workers to On-Site Soil
Whirlpool, Fort Smith, Arkansas

					Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	**C_{soil} (mg/kg)**	**C_{air} (mg/m^3)**	**URF (m^3/mg)**	**Risk**	**C_{air} (mg/m^3)**	**URF (m^3/mg)**	**Risk**	**Risk**
VOC	Acetone	67-64-1	ID								
VOC	Benzene	71-43-2	A			7.8E-03			7.8E-03		
VOC	Bromodichloromethane	75-27-4	B2								
VOC	Bromoform	75-25-2	B2			1.1E-03			1.1E-03		
VOC	Bromomethane	74-83-9	ID								
VOC	2-Butanone	78-93-3	ID								
VOC	Carbon Disulfide	75-15-0									
VOC	Carbon Tetrachloride	56-23-5	LC			6.0E-03			6.0E-03		
VOC	Chlorobenzene	108-90-7	D								
VOC	Chloroethane	75-00-3	LC								
VOC	Chloroform	67-66-3	B2			2.3E-02			2.3E-02		
VOC	Chloromethane	74-87-3	D								
VOC	Dibromochloromethane	124-48-1	C								
VOC	1,1-Dichloroethane	75-34-3	SC								
VOC	1,2-Dichloroethane	107-06-2	B2			2.6E-02			2.6E-02		
VOC	1,1-Dichloroethene	75-35-4	C								
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	1.98E-06			1.60E-13			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	1.98E-06			1.60E-13			
VOC	trans-1,2-Dichloroethene	156-60-5	ID								
VOC	1,2-Dichloropropane	78-87-5	B2								
VOC	1,3-Dichloropropene (total)	542-75-6	B2			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4	D								
VOC	2-Hexanone	591-78-6	ID								
VOC	4-Methyl-2-pentanone	108-10-1	ID								
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	1.14E-06	1.0E-05	9.3E-13	9.35E-14	1.0E-05	7.6E-20	9.3E-13
VOC	Styrene	100-42-5									
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC								
VOC	Tetrachloroethene	127-18-4	LC			2.6E-04			2.6E-04		
VOC	Toluene	108-88-3	ID								
VOC	1,1,1-Trichloroethane	71-55-6	ID								
VOC	1,1,2-Trichloroethane	79-00-5	C			1.6E-02			1.6E-02		
VOC	Trichloroethene	79-01-6	HC	1.86E-01	3.21E-05	4.1E-03	1.1E-08	2.48E-12	4.1E-03	8.3E-16	1.1E-08
VOC	Vinyl Chloride	75-01-4	A			4.4E-03			4.4E-03		
VOC	Xylenes (total)	1330-20-7	ID								
		Cumulative Risk:					**1E-08**			**8E-16**	**1E-08**

Notes:

The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).

This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.

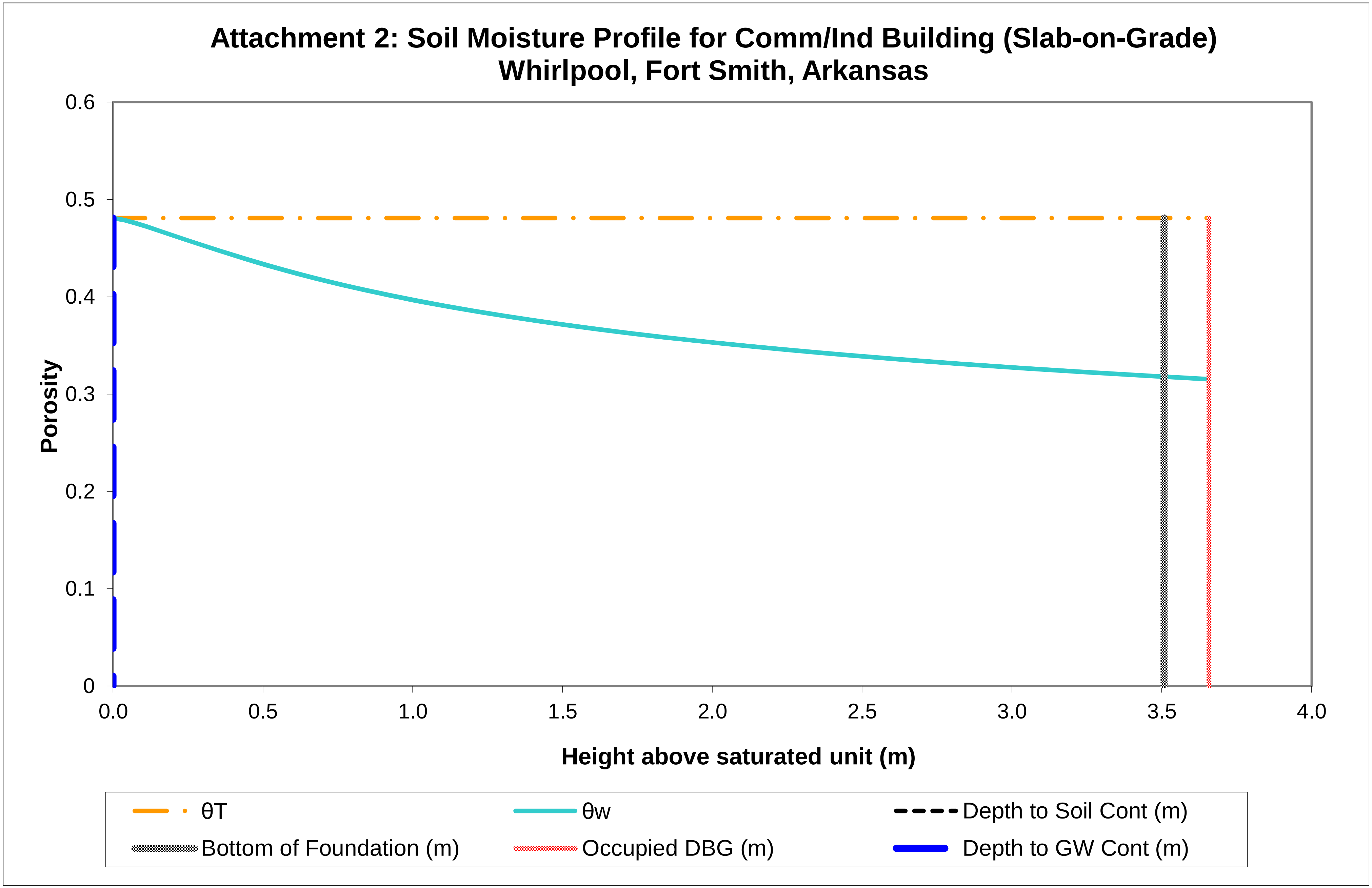
Attachment 2: Hazard Index Calculations for Exposure of Off-Site Routine Workers to On-Site Soil
Whirlpool, Fort Smith, Arkansas

					Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	C_{soil} (mg/kg)	C_{air} (mg/m^3)	**RfC** (mg/m^3)	**HQ**	C_{air} (mg/m^3)	**RfC** (mg/m^3)	**HQ**	**HQ**
VOC	Acetone	67-64-1	ID			3.1E+01			3.1E+01		
VOC	Benzene	71-43-2	A			3.0E-02			3.0E-02		
VOC	Bromodichloromethane	75-27-4	B2								
VOC	Bromoform	75-25-2	B2								
VOC	Bromomethane	74-83-9	ID			5.0E-03			5.0E-03		
VOC	2-Butanone	78-93-3	ID			5.0E+00			5.0E+00		
VOC	Carbon Disulfide	75-15-0				7.0E-01			7.0E-01		
VOC	Carbon Tetrachloride	56-23-5	LC			1.0E-01			1.0E-01		
VOC	Chlorobenzene	108-90-7	D			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3	LC			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	B2			5.0E-02			5.0E-02		
VOC	Chloromethane	74-87-3	D			9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1	C								
VOC	1,1-Dichloroethane	75-34-3	SC			5.0E-01			5.0E-01		
VOC	1,2-Dichloroethane	107-06-2	B2			7.0E-03			7.0E-03		
VOC	1,1-Dichloroethene	75-35-4	C			2.0E-01			2.0E-01		
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	1.98E-06			1.60E-13			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	1.98E-06			1.60E-13			
VOC	trans-1,2-Dichloroethene	156-60-5	ID								
VOC	1,2-Dichloropropane	78-87-5	B2			4.0E-03			4.0E-03		
VOC	1,3-Dichloropropene (total)	542-75-6	B2			2.0E-02			2.0E-02		
VOC	Ethyl Benzene	100-41-4	D			1.0E+00			1.0E+00		
VOC	2-Hexanone	591-78-6	ID			3.0E-02			3.0E-02		
VOC	4-Methyl-2-pentanone	108-10-1	ID			3.0E+00			3.0E+00		
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	1.14E-06	6.0E-01	4.4E-07	9.35E-14	6.0E-01	3.6E-14	4.4E-07
VOC	Styrene	100-42-5				1.0E+00			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC								
VOC	Tetrachloroethene	127-18-4	LC			4.0E-02			4.0E-02		
VOC	Toluene	108-88-3	ID			5.0E+00			5.0E+00		
VOC	1,1,1-Trichloroethane	71-55-6	ID			5.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5	C			2.0E-04			2.0E-04		
VOC	Trichloroethene	79-01-6	HC	1.86E-01	3.21E-05	2.0E-03	3.7E-03	2.48E-12	2.0E-03	2.8E-10	3.7E-03
VOC	Vinyl Chloride	75-01-4	A			1.0E-01			1.0E-01		
VOC	Xylenes (total)	1330-20-7	ID			1.0E-01			1.0E-01		
		Hazard Index:					**4E-03**			**3E-10**	**4E-03**

Notes:

The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).

This C/Q term is estimated using the empirical correlation in USEPA’s Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.


Attachment 2: Soil Moisture Profile for Comm/Ind Building (Slab-on-Grade)
Whirlpool, Fort Smith, Arkansas
Porosity
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Height above saturated unit (m)
θT
θw
Depth to Soil Cont (m)
Bottom of Foundation (m)
Occupied DBG (m)
Depth to GW Cont (m)

Attachment 2: Normalized Indoor Air Concentration in a Comm/Ind Building (Slab-on-Grade) due to Vapor Intrusion from Subsurface Soil
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	D_{air} (m^2/day)	D_{water} (m^2/day)	H (unitless)	D_{crack} (m^2/day)	D_{eff}^T (m^2/day)	α_∞	K_{oc} (L/kg)	K_d (L/kg)	$C_{s, vap}$ (kg-soil/m^3)	α_{ML}	α	C_{bldg} (kg-soil/m^3)
VOC	Acetone	67-64-1	1.07E+00	9.85E-05	1.14E-03	1.72E-01	1.91E-02	8.26E-05	5.81E-01	1.16E-03	4.91E+00	9.22E-04	8.26E-05	4.05E-04
VOC	Benzene	71-43-2	7.60E-01	8.47E-05	1.59E-01	1.22E-01	7.74E-03	8.25E-05	5.82E+01	1.16E-01	4.34E+02	1.04E-05	1.04E-05	4.53E-03
VOC	Bromodichloromethane	75-27-4	2.57E-01	9.16E-05	4.45E-02	4.13E-02	2.80E-03	8.23E-05	5.51E+01	1.10E-01	1.29E+02	3.52E-05	3.52E-05	4.53E-03
VOC	Bromoform	75-25-2	1.29E-01	8.90E-05	1.34E-02	2.07E-02	1.94E-03	8.22E-05	8.70E+01	1.74E-01	3.29E+01	1.38E-04	8.22E-05	2.70E-03
VOC	Bromomethane	74-83-9	6.29E-01	1.05E-04	2.01E-01	1.01E-01	6.41E-03	8.25E-05	1.05E+01	2.10E-02	7.30E+02	6.20E-06	6.20E-06	4.53E-03
VOC	2-Butanone	78-93-3	6.98E-01	8.47E-05	1.96E-03	1.12E-01	1.12E-02	8.25E-05	2.00E+00	3.99E-03	8.35E+00	5.42E-04	8.25E-05	6.89E-04
VOC	Carbon Disulfide	75-15-0	8.99E-01	8.64E-05	9.26E-01	1.44E-01	9.09E-03	8.25E-05	4.59E+01	9.19E-02	2.14E+03	2.11E-06	2.11E-06	4.53E-03
VOC	Carbon Tetrachloride	56-23-5	6.74E-01	7.60E-05	8.82E-01	1.08E-01	6.82E-03	8.25E-05	1.74E+02	3.48E-01	1.29E+03	3.50E-06	3.50E-06	4.53E-03
VOC	Chlorobenzene	108-90-7	6.31E-01	7.52E-05	9.77E-02	1.01E-01	6.45E-03	8.25E-05	2.20E+02	4.41E-01	1.43E+02	3.17E-05	3.17E-05	4.53E-03
VOC	Chloroethane	75-00-3	2.34E+00	9.94E-05	3.25E-01	3.76E-01	2.37E-02	8.26E-05	1.62E+01	3.25E-02	1.08E+03	4.20E-06	4.20E-06	4.53E-03
VOC	Chloroform	67-66-3	8.99E-01	8.64E-05	1.07E-01	1.44E-01	9.16E-03	8.25E-05	3.97E+01	7.94E-02	3.33E+02	1.36E-05	1.36E-05	4.53E-03
VOC	Chloromethane	74-87-3	1.09E+00	5.62E-05	3.33E-01	1.75E-01	1.10E-02	8.25E-05	3.97E+01	7.94E-02	9.52E+02	4.75E-06	4.75E-06	4.53E-03
VOC	Dibromochloromethane	124-48-1	1.69E-01	9.07E-05	2.38E-02	2.72E-02	2.08E-03	8.22E-05	6.26E+01	1.25E-01	6.64E+01	6.82E-05	6.82E-05	4.53E-03
VOC	1,1-Dichloroethane	75-34-3	6.41E-01	9.07E-05	1.66E-01	1.03E-01	6.53E-03	8.25E-05	3.13E+01	6.27E-02	5.29E+02	8.56E-06	8.56E-06	4.53E-03
VOC	1,2-Dichloroethane	107-06-2	8.99E-01	8.55E-05	2.74E-02	1.44E-01	9.38E-03	8.25E-05	1.75E+01	3.50E-02	1.02E+02	4.44E-05	4.44E-05	4.53E-03
VOC	1,1-Dichloroethene	75-35-4	7.78E-01	8.99E-05	8.10E-01	1.25E-01	7.87E-03	8.25E-05	5.82E+01	1.16E-01	1.83E+03	2.47E-06	2.47E-06	4.53E-03
VOC	1,2-Dichloroethene (total)	540-59-0	6.36E-01	9.76E-05	1.19E-01	1.02E-01	6.51E-03	8.25E-05	3.56E+01	7.12E-02	3.75E+02	1.21E-05	1.21E-05	4.53E-03
VOC	cis-1,2-Dichloroethene	156-59-2	6.36E-01	9.76E-05	1.19E-01	1.02E-01	6.51E-03	8.25E-05	3.56E+01	7.12E-02	3.75E+02	1.21E-05	1.21E-05	4.53E-03
VOC	trans-1,2-Dichloroethene	156-60-5	6.11E-01	1.03E-04	2.81E-01	9.80E-02	6.21E-03	8.25E-05	5.22E+01	1.04E-01	7.64E+02	5.93E-06	5.93E-06	4.53E-03
VOC	1,2-Dichloropropane	78-87-5	6.76E-01	7.54E-05	7.82E-02	1.08E-01	6.92E-03	8.25E-05	4.35E+01	8.70E-02	2.39E+02	1.89E-05	1.89E-05	4.53E-03
VOC	1,3-Dichloropropene (total)	542-75-6	5.41E-01	8.64E-05	4.83E-01	8.68E-02	5.49E-03	8.25E-05	4.59E+01	9.19E-02	1.27E+03	3.56E-06	3.56E-06	4.53E-03
VOC	Ethyl Benzene	100-41-4	6.48E-01	6.74E-05	2.04E-01	1.04E-01	6.58E-03	8.25E-05	3.67E+02	7.35E-01	2.06E+02	2.19E-05	2.19E-05	4.53E-03
VOC	2-Hexanone	591-78-6	7.45E-01	7.57E-05	3.23E-03	1.20E-01	9.76E-03	8.25E-05	1.48E+01	2.97E-02	1.24E+01	3.65E-04	8.25E-05	1.02E-03
VOC	4-Methyl-2-pentanone	108-10-1	6.48E-01	6.74E-05	4.71E-03	1.04E-01	7.92E-03	8.25E-05	1.05E+01	2.10E-02	1.87E+01	2.42E-04	8.25E-05	1.54E-03
VOC	Methylene Chloride	75-09-2	8.73E-01	1.01E-04	6.60E-02	1.40E-01	8.97E-03	8.25E-05	1.17E+01	2.34E-02	2.52E+02	1.80E-05	1.80E-05	4.53E-03
VOC	Styrene	100-42-5	6.13E-01	6.91E-05	7.04E-02	9.84E-02	6.30E-03	8.25E-05	7.77E+02	1.55E+00	3.93E+01	1.15E-04	8.25E-05	3.24E-03
VOC	1,1,2,2-Tetrachloroethane	79-34-5	6.13E-01	6.83E-05	8.74E-03	9.84E-02	6.95E-03	8.25E-05	9.35E+01	1.87E-01	2.09E+01	2.17E-04	8.25E-05	1.72E-03
VOC	Tetrachloroethene	127-18-4	6.22E-01	7.08E-05	4.90E-01	9.98E-02	6.30E-03	8.25E-05	1.56E+02	3.12E-01	8.17E+02	5.54E-06	5.54E-06	4.53E-03
VOC	Toluene	108-88-3	7.52E-01	7.43E-05	1.80E-01	1.21E-01	7.64E-03	8.25E-05	1.80E+02	3.61E-01	2.94E+02	1.54E-05	1.54E-05	4.53E-03
VOC	1,1,1-Trichloroethane	71-55-6	6.74E-01	7.60E-05	4.97E-01	1.08E-01	6.83E-03	8.25E-05	1.10E+02	2.20E-01	9.75E+02	4.64E-06	4.64E-06	4.53E-03
VOC	1,1,2-Trichloroethane	79-00-5	6.74E-01	7.60E-05	2.43E-02	1.08E-01	7.11E-03	8.25E-05	5.03E+01	1.01E-01	7.27E+01	6.23E-05	6.23E-05	4.53E-03
VOC	Trichloroethene	79-01-6	6.83E-01	7.86E-05	2.88E-01	1.10E-01	6.93E-03	8.25E-05	1.68E+02	3.35E-01	4.80E+02	9.43E-06	9.43E-06	4.53E-03

Attachment 2: Normalized Indoor Air Concentration in a Comm/Ind Building (Slab-on-Grade) due to Vapor Intrusion from Subsurface Soil
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	D_{air} (m^2/day)	D_{water} (m^2/day)	H (unitless)	D_{crack} (m^2/day)	D_{eff}^{T} (m^2/day)	α_{∞}	K_{oc} (L/kg)	K_d (L/kg)	$C_{s,\,vap}$ (kg-soil/m^3)	α_{ML}	α	C_{bldg} (kg-soil/m^3)
VOC	Vinyl Chloride	75-01-4	9.16E-01	1.06E-04	9.00E-01	1.47E-01	9.27E-03	8.25E-05	1.85E+01	3.69E-02	2.41E+03	1.88E-06	1.88E-06	4.53E-03
VOC	Xylenes (total)	1330-20-7	6.74E-01	7.56E-05	1.73E-01	1.08E-01	6.85E-03	8.25E-05	3.86E+02	7.71E-01	1.69E+02	2.67E-05	2.67E-05	4.53E-03
Notes:	**Soil and Building Characteristics**			**Crack**	**Vadose (below floor to 6")**	**Deep Vadose (6" to bottom of contamin)**								
	SCS Soil texture class			Sand	Silty Clay	Silty Clay								
	Bulk density	kg/L	ρ_b	1.66		1.38								
	Total porosity	L/L-soil	θ_T	0.375	0.481	0.481								
	Water-filled porosity	L/L-soil	θ_w	0.054	0.319	0.319								
	Air-filled porosity	L/L-soil	θ_a	0.321	0.162	0.162								
	Organic carbon fraction	unitless	f_{oc}			0.002								
	Residual saturation	L/L-soil	θ_r	0.053										
	Hydraulic conductivity	cm/s	**K**	7.4E-03										
	Dynamic viscosity of water	g/cm-s	μ_w	0.01307										
	Density of water	g/cm^3	ρ_w	1.0										
	Gravitational acceleration	cm/s^2	**g**	980.7										
	Intrinsic permeability	cm^2	**k**	9.9E-08										
	Relative saturation	unitless	S_e	0.004										
	van Genuchten N	unitless	**N**	1.32										
	van Genuchten M	unitless	**M**	0.243										
	Relative air permeability	unitless	k_{rg}	0.998										
	Permeability to vapor	cm^2	k_v	9.9E-08										
	Distance from building foundation to source	m	$L_{T\text{-}soil}$	0.001										
	Bldg foundation thickness	m	L_{crack}	0.15										
	Bldg foundation length	m		19.29										
	Bldg foundation width	m		19.29										
	Bldg occupied height	m		2.44										
	Bldg occupied volume	m^3		907.93										
	Occupied depth below ground	m		0.0										
	Bldg area for vapor intrusion	m^2	A_B	372.1										
	Ratio of A_{crack} to A_B		η	1E-04										
	Area of cracks	m^2	A_{crack}	3.86E-02										
	Air exchange rate	$hour^{-1}$	**ach**	2.0										
	Building ventilation rate	m^3/day	Q_{bldg}	4.36E+04										
	Pressure difference between outdoors-indoors	kg/m-s^2	ΔP	1.0										
	Viscosity of air	kg/m-s	μ_a	1.8E-05										
	Crack length (bldg perimeter)	m	X_{crack}	77.16										
	Crack depth below ground	m	Z_{crack}	0.15										
	Crack radius	m	r_{crack}	5E-04										
	Soil gas flow rate into bldg	m^3/day	Q_{soil}	3.60E+00										
	Averaging period	d	**T**	9.13E+03										
	Contaminant thickness	m	ΔH	3.5066										

Attachment 2: Normalized Indoor Air Concentration in a Comm/Ind Building (Slab-on-Grade) due to Vapor Intrusion from Groundwater
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	D_{air} (m^2/day)	D_{water} (m^2/day)	H (unitless)	D_{crack} (m^2/day)	D_{eff}^T (m^2/day)	α_{soil}	α_{slab}	α_{∞}	C_{bldg} (L-water/m^3)
VOC	Acetone	67-64-1	1.07E+00	9.85E-05	1.14E-03	1.72E-01	1.87E-02	3.55E-01	8.26E-05	2.93E-05	3.34E-05
VOC	Benzene	71-43-2	7.60E-01	8.47E-05	1.59E-01	1.22E-01	8.00E-04	2.30E-02	8.26E-05	1.90E-06	3.02E-04
VOC	Bromodichloromethane	75-27-4	2.57E-01	9.16E-05	4.45E-02	4.13E-02	1.06E-03	3.02E-02	8.26E-05	2.50E-06	1.11E-04
VOC	Bromoform	75-25-2	1.29E-01	8.90E-05	1.34E-02	2.07E-02	1.64E-03	4.60E-02	8.26E-05	3.80E-06	5.08E-05
VOC	Bromomethane	74-83-9	6.29E-01	1.05E-04	2.01E-01	1.01E-01	7.29E-04	2.10E-02	8.26E-05	1.74E-06	3.49E-04
VOC	2-Butanone	78-93-3	6.98E-01	8.47E-05	1.96E-03	1.12E-01	1.00E-02	2.28E-01	8.26E-05	1.89E-05	3.70E-05
VOC	Carbon Disulfide	75-15-0	8.99E-01	8.64E-05	9.26E-01	1.44E-01	2.87E-04	8.39E-03	8.26E-05	6.93E-07	6.42E-04
VOC	Carbon Tetrachloride	56-23-5	6.74E-01	7.60E-05	8.82E-01	1.08E-01	2.47E-04	7.22E-03	8.26E-05	5.96E-07	5.26E-04
VOC	Chlorobenzene	108-90-7	6.31E-01	7.52E-05	9.77E-02	1.01E-01	9.16E-04	2.63E-02	8.26E-05	2.17E-06	2.12E-04
VOC	Chloroethane	75-00-3	2.34E+00	9.94E-05	3.25E-01	3.76E-01	8.68E-04	2.50E-02	8.26E-05	2.06E-06	6.70E-04
VOC	Chloroform	67-66-3	8.99E-01	8.64E-05	1.07E-01	1.44E-01	1.09E-03	3.11E-02	8.26E-05	2.57E-06	2.76E-04
VOC	Chloromethane	74-87-3	1.09E+00	5.62E-05	3.33E-01	1.75E-01	4.51E-04	1.31E-02	8.26E-05	1.08E-06	3.61E-04
VOC	Dibromochloromethane	124-48-1	1.69E-01	9.07E-05	2.38E-02	2.72E-02	1.26E-03	3.58E-02	8.26E-05	2.96E-06	7.05E-05
VOC	1,1-Dichloroethane	75-34-3	6.41E-01	9.07E-05	1.66E-01	1.03E-01	7.58E-04	2.18E-02	8.26E-05	1.80E-06	2.99E-04
VOC	1,2-Dichloroethane	107-06-2	8.99E-01	8.55E-05	2.74E-02	1.44E-01	2.34E-03	6.44E-02	8.26E-05	5.32E-06	1.46E-04
VOC	1,1-Dichloroethene	75-35-4	7.78E-01	8.99E-05	8.10E-01	1.25E-01	3.06E-04	8.93E-03	8.26E-05	7.37E-07	5.97E-04
VOC	1,2-Dichloroethene (total)	540-59-0	6.36E-01	9.76E-05	1.19E-01	1.02E-01	9.55E-04	2.74E-02	8.26E-05	2.26E-06	2.68E-04
VOC	cis-1,2-Dichloroethene	156-59-2	6.36E-01	9.76E-05	1.19E-01	1.02E-01	9.55E-04	2.74E-02	8.26E-05	2.26E-06	2.68E-04
VOC	trans-1,2-Dichloroethene	156-60-5	6.11E-01	1.03E-04	2.81E-01	9.80E-02	5.85E-04	1.70E-02	8.26E-05	1.40E-06	3.94E-04
VOC	1,2-Dichloropropane	78-87-5	6.76E-01	7.54E-05	7.82E-02	1.08E-01	1.07E-03	3.06E-02	8.26E-05	2.53E-06	1.98E-04
VOC	1,3-Dichloropropene (total)	542-75-6	5.41E-01	8.64E-05	4.83E-01	8.68E-02	3.62E-04	1.06E-02	8.26E-05	8.72E-07	4.21E-04
VOC	Ethyl Benzene	100-41-4	6.48E-01	6.74E-05	2.04E-01	1.04E-01	5.64E-04	1.63E-02	8.26E-05	1.35E-06	2.76E-04
VOC	2-Hexanone	591-78-6	7.45E-01	7.57E-05	3.23E-03	1.20E-01	6.82E-03	1.67E-01	8.26E-05	1.38E-05	4.47E-05
VOC	4-Methyl-2-pentanone	108-10-1	6.48E-01	6.74E-05	4.71E-03	1.04E-01	4.77E-03	1.23E-01	8.26E-05	1.02E-05	4.80E-05
VOC	Methylene Chloride	75-09-2	8.73E-01	1.01E-04	6.60E-02	1.40E-01	1.56E-03	4.39E-02	8.26E-05	3.62E-06	2.39E-04
VOC	Styrene	100-42-5	6.13E-01	6.91E-05	7.04E-02	9.84E-02	1.04E-03	2.97E-02	8.26E-05	2.45E-06	1.73E-04
VOC	1,1,2,2-Tetrachloroethane	79-34-5	6.13E-01	6.83E-05	8.74E-03	9.84E-02	3.27E-03	8.79E-02	8.26E-05	7.26E-06	6.35E-05
VOC	Tetrachloroethene	127-18-4	6.22E-01	7.08E-05	4.90E-01	9.98E-02	3.34E-04	9.74E-03	8.26E-05	8.04E-07	3.95E-04
VOC	Toluene	108-88-3	7.52E-01	7.43E-05	1.80E-01	1.21E-01	6.83E-04	1.97E-02	8.26E-05	1.63E-06	2.94E-04
VOC	1,1,1-Trichloroethane	71-55-6	6.74E-01	7.60E-05	4.97E-01	1.08E-01	3.56E-04	1.04E-02	8.26E-05	8.58E-07	4.27E-04
VOC	1,1,2-Trichloroethane	79-00-5	6.74E-01	7.60E-05	2.43E-02	1.08E-01	2.06E-03	5.71E-02	8.26E-05	4.72E-06	1.15E-04
VOC	Trichloroethene	79-01-6	6.83E-01	7.86E-05	2.88E-01	1.10E-01	5.13E-04	1.49E-02	8.26E-05	1.23E-06	3.54E-04
VOC	Vinyl Chloride	75-01-4	9.16E-01	1.06E-04	9.00E-01	1.47E-01	3.37E-04	9.84E-03	8.26E-05	8.12E-07	7.31E-04

Attachment 2: Normalized Indoor Air Concentration in a Comm/Ind Building (Slab-on-Grade) due to Vapor Intrusion from Groundwater
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	D_{air} (m^2/day)	D_{water} (m^2/day)	H (unitless)	D_{crack} (m^2/day)	D_{eff}^T (m^2/day)	α_{soil}	α_{slab}	α_{∞}	C_{bldg} (L-water/m^3)
VOC	Xylenes (total)	1330-20-7	6.74E-01	7.56E-05	1.73E-01	1.08E-01	6.77E-04	1.95E-02	8.26E-05	1.61E-06	2.80E-04
Notes:	**Crack Soil and Building Characteristics**			**Crack Soil**							
	SCS Soil texture class			Sand							
	Bulk density	kg/L	ρ_b	1.66							
	Total porosity	L/L-soil	θ_T	0.375							
	Water-filled porosity	L/L-soil	θ_w	0.054							
	Air-filled porosity	L/L-soil	θ_a	0.321							
	Residual saturation	L/L-soil	θ_r	0.053							
	Hydraulic conductivity	cm/s	**K**	7.4E-03							
	Dynamic viscosity of water	g/cm-s	μ_w	0.01307							
	Density of water	g/cm^3	ρ_w	1.0							
	Gravitational acceleration	cm/s^2	**g**	980.7							
	Intrinsic permeability	cm^2	**k**	9.9E-08							
	Relative saturation	unitless	S_e	0.004							
	van Genuchten N	unitless	**N**	1.321							
	van Genuchten M	unitless	**M**	0.243							
	Relative air permeability	unitless	k_{rg}	0.998							
	Permeability to vapor	cm^2	k_v	9.89E-08							
	Distance from building foundation	m	$L_{T\text{-}gw}$	3.51							
	Bldg foundation thickness	m	L_{crack}	0.15							
	Bldg foundation length	m		19.29							
	Bldg foundation width	m		19.29							
	Bldg occupied height	m		2.44							
	Bldg occupied volume	m^3		907.93							
	Occupied depth below ground	m		0.0							
	Bldg area for vapor intrusion	m^2	A_B	372.1							
	Ratio of A_{crack} to A_B		η	1E-04							
	Area of cracks	m^2	A_{crack}	4E-02							
	Air exchange rate	$hour^{-1}$	**ach**	2.00							
	Building ventilation rate	m^3/day	Q_{bldg}	4.36E+04							
	Pressure difference between	kg/m-s^2	ΔP	1.0							
	Viscosity of air	kg/m-s	μ_a	1.8E-05							
	Crack length (bldg perimeter)	m	X_{crack}	77.16							
	Crack depth below ground	m	Z_{crack}	0.15							
	Crack radius	m	r_{crack}	5E-04							
	Soil gas flow rate into bldg	m^3/day	Q_{soil}	3.60							

Attachment 2: Cancer Risk and Hazard Index Calculations for On-Site Routine Workers due to Soil Vapor Intrusion into a Comm/Ind Building (Slab-on-Grade)
Whirlpool, Fort Smith, Arkansas

							Cancer		Noncancer	
Chem Group	Chemical	CASRN	Carc Class	C_{soil} (mg/kg)	C_{bldg} (kg-soil/m^3)	C_{air} (mg/m^3)	URF (m^3/mg)	Risk	RfC (mg/m^3)	HQ
VOC	Acetone	67-64-1	ID		4.05E-04				3.1E+01	
VOC	Benzene	71-43-2	A		4.53E-03		7.8E-03		3.0E-02	
VOC	Bromodichloromethane	75-27-4	B2		4.53E-03					
VOC	Bromoform	75-25-2	B2		2.70E-03		1.1E-03			
VOC	Bromomethane	74-83-9	ID		4.53E-03				5.0E-03	
VOC	2-Butanone	78-93-3	ID		6.89E-04				5.0E+00	
VOC	Carbon Disulfide	75-15-0			4.53E-03				7.0E-01	
VOC	Carbon Tetrachloride	56-23-5	LC		4.53E-03		6.0E-03		1.0E-01	
VOC	Chlorobenzene	108-90-7	D		4.53E-03				5.0E-02	
VOC	Chloroethane	75-00-3	LC		4.53E-03				1.0E+01	
VOC	Chloroform	67-66-3	B2		4.53E-03		2.3E-02		5.0E-02	
VOC	Chloromethane	74-87-3	D		4.53E-03				9.0E-02	
VOC	Dibromochloromethane	124-48-1	C		4.53E-03					
VOC	1,1-Dichloroethane	75-34-3	SC		4.53E-03				5.0E-01	
VOC	1,2-Dichloroethane	107-06-2	B2		4.53E-03		2.6E-02		7.0E-03	
VOC	1,1-Dichloroethene	75-35-4	C		4.53E-03				2.0E-01	
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	4.53E-03	5.43E-05				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	4.53E-03	5.43E-05				
VOC	trans-1,2-Dichloroethene	156-60-5	ID		4.53E-03					
VOC	1,2-Dichloropropane	78-87-5	B2		4.53E-03				4.0E-03	
VOC	1,3-Dichloropropene (total)	542-75-6	B2		4.53E-03		4.0E-03		2.0E-02	
VOC	Ethyl Benzene	100-41-4	D		4.53E-03				1.0E+00	
VOC	2-Hexanone	591-78-6	ID		1.02E-03				3.0E-02	
VOC	4-Methyl-2-pentanone	108-10-1	ID		1.54E-03				3.0E+00	
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	4.53E-03	3.17E-05	1.0E-05	2.6E-11	6.0E-01	1.2E-05
VOC	Styrene	100-42-5			3.24E-03				1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC		1.72E-03					
VOC	Tetrachloroethene	127-18-4	LC		4.53E-03		2.6E-04		4.0E-02	
VOC	Toluene	108-88-3	ID		4.53E-03				5.0E+00	
VOC	1,1,1-Trichloroethane	71-55-6	ID		4.53E-03				5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5	C		4.53E-03		1.6E-02		2.0E-04	
VOC	Trichloroethene	79-01-6	HC	1.86E-01	4.53E-03	8.42E-04	4.1E-03	2.8E-07	2.0E-03	9.6E-02
VOC	Vinyl Chloride	75-01-4	A		4.53E-03		4.4E-03		1.0E-01	
VOC	Xylenes (total)	1330-20-7	ID		4.53E-03				1.0E-01	
							Cumulative Risk:	3E-07	**HI:**	1E-01

Attachment 2: Cancer Risk and Hazard Index Calculations for On-Site Routine Workers due to Groundwater Vapor Intrusion into a Comm/Ind Building (Slab-on-Grade)
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	Carc Class	C_{gw} (mg/L)	C_{bldg} (L-water/m^3)	C_{air} (mg/m^3)	Cancer: URF (m^3/mg)	Cancer: Risk	Noncancer: RfC (mg/m^3)	Noncancer: HQ
VOC	Acetone	67-64-1	ID	1.99E-01	3.34E-05	6.65E-06			3.1E+01	4.9E-08
VOC	Benzene	71-43-2	A	6.53E-02	3.02E-04	1.97E-05	7.8E-03	1.3E-08	3.0E-02	1.5E-04
VOC	Bromodichloromethane	75-27-4	B2	6.79E-02	1.11E-04	7.55E-06				
VOC	Bromoform	75-25-2	B2	7.67E-02	5.08E-05	3.89E-06	1.1E-03	3.5E-10		
VOC	Bromomethane	74-83-9	ID	6.13E-02	3.49E-04	2.14E-05			5.0E-03	9.8E-04
VOC	2-Butanone	78-93-3	ID	1.06E-01	3.70E-05	3.92E-06			5.0E+00	1.8E-07
VOC	Carbon Disulfide	75-15-0		6.52E-02	6.42E-04	4.18E-05			7.0E-01	1.4E-05
VOC	Carbon Tetrachloride	56-23-5	LC	6.69E-02	5.26E-04	3.52E-05	6.0E-03	1.7E-08	1.0E-01	8.0E-05
VOC	Chlorobenzene	108-90-7	D	6.86E-02	2.12E-04	1.45E-05			5.0E-02	6.6E-05
VOC	Chloroethane	75-00-3	LC	7.23E-02	6.70E-04	4.85E-05			1.0E+01	1.1E-06
VOC	Chloroform	67-66-3	B2	6.64E-02	2.76E-04	1.84E-05	2.3E-02	3.4E-08	5.0E-02	8.4E-05
VOC	Chloromethane	74-87-3	D	9.00E-02	3.61E-04	3.25E-05			9.0E-02	8.2E-05
VOC	Dibromochloromethane	124-48-1	C	7.13E-02	7.05E-05	5.03E-06				
VOC	1,1-Dichloroethane	75-34-3	SC	6.59E-02	2.99E-04	1.97E-05			5.0E-01	9.0E-06
VOC	1,2-Dichloroethane	107-06-2	B2	6.61E-02	1.46E-04	9.65E-06	2.6E-02	2.0E-08	7.0E-03	3.1E-04
VOC	1,1-Dichloroethene	75-35-4	C	2.50E-01	5.97E-04	1.49E-04			2.0E-01	1.7E-04
VOC	1,2-Dichloroethene (total)	540-59-0		1.00E+01	2.68E-04	2.68E-03				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.00E+01	2.68E-04	2.68E-03				
VOC	trans-1,2-Dichloroethene	156-60-5	ID	5.99E-02	3.94E-04	2.36E-05				
VOC	1,2-Dichloropropane	78-87-5	B2	6.52E-02	1.98E-04	1.29E-05			4.0E-03	7.4E-04
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1.42E-01	4.21E-04	5.99E-05	4.0E-03	2.0E-08	2.0E-02	6.8E-04
VOC	Ethyl Benzene	100-41-4	D	6.89E-02	2.76E-04	1.90E-05			1.0E+00	4.3E-06
VOC	2-Hexanone	591-78-6	ID	1.20E-01	4.47E-05	5.36E-06			3.0E-02	4.1E-05
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.20E-01	4.80E-05	5.75E-06			3.0E+00	4.4E-07
VOC	Methylene Chloride	75-09-2	LC	3.10E-01	2.39E-04	7.41E-05	1.0E-05	6.0E-11	6.0E-01	2.8E-05
VOC	Styrene	100-42-5		6.83E-02	1.73E-04	1.18E-05			1.0E+00	2.7E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	6.40E-02	6.35E-05	4.06E-06				
VOC	Tetrachloroethene	127-18-4	LC	7.67E-02	3.95E-04	3.03E-05	2.6E-04	6.4E-10	4.0E-02	1.7E-04
VOC	Toluene	108-88-3	ID	6.54E-02	2.94E-04	1.92E-05			5.0E+00	8.8E-07
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.10E-01	4.27E-04	4.69E-05			5.0E+00	2.1E-06
VOC	1,1,2-Trichloroethane	79-00-5	C	6.59E-02	1.15E-04	7.56E-06	1.6E-02	9.9E-09	2.0E-04	8.6E-03
VOC	Trichloroethene	79-01-6	HC	8.10E+01	3.54E-04	2.87E-02	4.1E-03	9.6E-06	2.0E-03	3.3E+00
VOC	Vinyl Chloride	75-01-4	A	2.50E+00	7.31E-04	1.83E-03	4.4E-03	6.6E-07	1.0E-01	4.2E-03
VOC	Xylenes (total)	1330-20-7	ID	1.99E-01	2.80E-04	5.58E-05			1.0E-01	1.3E-04
						Cumulative Risk:		1E-05	**HI:**	3E+00

Attachment 2: Vapor Intrusion Contribution to Occupational Inhalation Exposure Limits Calculations for On-Site Routine Workers Exposure in a Comm/Ind Building (Slab-on-Grade)
Whirlpool, Fort Smith, Arkansas

				Soil Indoor Air Vapor Inhalation					Groundwater Indoor Air Vapor Inhalation				
Chem Group	Chemical	CASRN	Carc Class	C_{soil} (mg/kg)	C_{bldg} (kg-soil/m^3)	C_{air} (mg/m^3)	Occupational Inhalation Limit (mg/m^3)	Ratio of Conc To Occ Limits	C_{gw} (mg/l)	C_{bldg} (L-water/m^3)	C_{air} (mg/m^3)	Occupational Inhalation Limit (mg/m^3)	Ratio of Conc To Occ Limits
VOC	Acetone	67-64-1	ID		4.05E-04		2.4E+03		1.99E-01	3.34E-05	6.65E-06	2.4E+03	2.8E-09
VOC	Benzene	71-43-2	A		4.53E-03		3.2E+00		6.53E-02	3.02E-04	1.97E-05	3.2E+00	6.2E-06
VOC	Bromodichloromethane	75-27-4	B2		4.53E-03				6.79E-02	1.11E-04	7.55E-06		
VOC	Bromoform	75-25-2	B2		2.70E-03		5.0E+00		7.67E-02	5.08E-05	3.89E-06	5.0E+00	7.8E-07
VOC	Bromomethane	74-83-9	ID		4.53E-03		3.9E+00		6.13E-02	3.49E-04	2.14E-05	3.9E+00	5.5E-06
VOC	2-Butanone	78-93-3	ID		6.89E-04		5.9E+02		1.06E-01	3.70E-05	3.92E-06	5.9E+02	6.7E-09
VOC	Carbon Disulfide	75-15-0			4.53E-03		6.2E+01		6.52E-02	6.42E-04	4.18E-05	6.2E+01	6.7E-07
VOC	Carbon Tetrachloride	56-23-5	LC		4.53E-03		6.3E+01		6.69E-02	5.26E-04	3.52E-05	6.3E+01	5.6E-07
VOC	Chlorobenzene	108-90-7	D		4.53E-03		3.5E+02		6.86E-02	2.12E-04	1.45E-05	3.5E+02	4.2E-08
VOC	Chloroethane	75-00-3	LC		4.53E-03		2.6E+03		7.23E-02	6.70E-04	4.85E-05	2.6E+03	1.9E-08
VOC	Chloroform	67-66-3	B2		4.53E-03		4.9E+01		6.64E-02	2.76E-04	1.84E-05	4.9E+01	3.8E-07
VOC	Chloromethane	74-87-3	D		4.53E-03		2.1E+02		9.00E-02	3.61E-04	3.25E-05	2.1E+02	1.6E-07
VOC	Dibromochloromethane	124-48-1	C		4.53E-03				7.13E-02	7.05E-05	5.03E-06		
VOC	1,1-Dichloroethane	75-34-3	SC		4.53E-03		4.0E+02		6.59E-02	2.99E-04	1.97E-05	4.0E+02	4.9E-08
VOC	1,2-Dichloroethane	107-06-2	B2		4.53E-03		2.0E+02		6.61E-02	1.46E-04	9.65E-06	2.0E+02	4.8E-08
VOC	1,1-Dichloroethene	75-35-4	C		4.53E-03		2.0E+01		2.50E-01	5.97E-04	1.49E-04	2.0E+01	7.5E-06
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	4.53E-03	5.43E-05	7.9E+02	6.9E-08	1.00E+01	2.68E-04	2.68E-03	7.9E+02	3.4E-06
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	4.53E-03	5.43E-05	7.9E+02	6.9E-08	1.00E+01	2.68E-04	2.68E-03	7.9E+02	3.4E-06
VOC	trans-1,2-Dichloroethene	156-60-5	ID		4.53E-03		7.9E+02		5.99E-02	3.94E-04	2.36E-05	7.9E+02	3.0E-08
VOC	1,2-Dichloropropane	78-87-5	B2		4.53E-03		3.5E+02		6.52E-02	1.98E-04	1.29E-05	3.5E+02	3.7E-08
VOC	1,3-Dichloropropene (total)	542-75-6	B2		4.53E-03		4.5E+00		1.42E-01	4.21E-04	5.99E-05	4.5E+00	1.3E-05
VOC	Ethyl Benzene	100-41-4	D		4.53E-03		4.4E+02		6.89E-02	2.76E-04	1.90E-05	4.4E+02	4.4E-08
VOC	2-Hexanone	591-78-6	ID		1.02E-03		4.1E+02		1.20E-01	4.47E-05	5.36E-06	4.1E+02	1.3E-08
VOC	4-Methyl-2-pentanone	108-10-1	ID		1.54E-03		4.1E+02		1.20E-01	4.80E-05	5.75E-06	4.1E+02	1.4E-08
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	4.53E-03	3.17E-05	8.7E+01	3.6E-07	3.10E-01	2.39E-04	7.41E-05	8.7E+01	8.5E-07
VOC	Styrene	100-42-5			3.24E-03		4.3E+02		6.83E-02	1.73E-04	1.18E-05	4.3E+02	2.8E-08
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC		1.72E-03		3.5E+01		6.40E-02	6.35E-05	4.06E-06	3.5E+01	1.2E-07
VOC	Tetrachloroethene	127-18-4	LC		4.53E-03		6.8E+02		7.67E-02	3.95E-04	3.03E-05	6.8E+02	4.5E-08
VOC	Toluene	108-88-3	ID		4.53E-03		7.5E+02		6.54E-02	2.94E-04	1.92E-05	7.5E+02	2.6E-08
VOC	1,1,1-Trichloroethane	71-55-6	ID		4.53E-03		1.9E+03		1.10E-01	4.27E-04	4.69E-05	1.9E+03	2.5E-08
VOC	1,1,2-Trichloroethane	79-00-5	C		4.53E-03		4.5E+01		6.59E-02	1.15E-04	7.56E-06	4.5E+01	1.7E-07
VOC	Trichloroethene	79-01-6	HC	1.86E-01	4.53E-03	8.42E-04	5.4E+02	1.6E-06	8.10E+01	3.54E-04	2.87E-02	5.4E+02	5.3E-05
VOC	Vinyl Chloride	75-01-4	A		4.53E-03		2.6E+00		2.50E+00	7.31E-04	1.83E-03	2.6E+00	7.2E-04
VOC	Xylenes (total)	1330-20-7	ID		4.53E-03		4.4E+02		1.99E-01	2.80E-04	5.58E-05	4.4E+02	1.3E-07
			Sum of Ratios:					**2E-06**					**8E-04**

Attachment 2: Cancer Risk and Hazard Index Calculations for Off-Site Routine Workers due to Groundwater Vapor Intrusion into a Comm/Ind Building (Slab-on-Grade)
Whirlpool, Fort Smith, Arkansas

							Cancer		Noncancer	
Chem Group	Chemical	CASRN	Carc Class	C_{gw} (mg/L)	C_{bldg} (L-water/m^3)	C_{air} (mg/m^3)	URF (m^3/mg)	Risk	RfC (mg/m^3)	HQ
VOC	Acetone	67-64-1	ID	8.50E-02	3.34E-05	2.84E-06			3.1E+01	2.1E-08
VOC	Benzene	71-43-2	A		3.02E-04		7.8E-03		3.0E-02	
VOC	Bromodichloromethane	75-27-4	B2		1.11E-04					
VOC	Bromoform	75-25-2	B2	2.40E-02	5.08E-05	1.22E-06	1.1E-03	1.1E-10		
VOC	Bromomethane	74-83-9	ID		3.49E-04				5.0E-03	
VOC	2-Butanone	78-93-3	ID	9.50E-02	3.70E-05	3.52E-06			5.0E+00	1.6E-07
VOC	Carbon Disulfide	75-15-0			6.42E-04				7.0E-01	
VOC	Carbon Tetrachloride	56-23-5	LC		5.26E-04		6.0E-03		1.0E-01	
VOC	Chlorobenzene	108-90-7	D		2.12E-04				5.0E-02	
VOC	Chloroethane	75-00-3	LC		6.70E-04				1.0E+01	
VOC	Chloroform	67-66-3	B2		2.76E-04		2.3E-02		5.0E-02	
VOC	Chloromethane	74-87-3	D		3.61E-04				9.0E-02	
VOC	Dibromochloromethane	124-48-1	C		7.05E-05					
VOC	1,1-Dichloroethane	75-34-3	SC		2.99E-04				5.0E-01	
VOC	1,2-Dichloroethane	107-06-2	B2	3.00E-03	1.46E-04	4.38E-07	2.6E-02	9.3E-10	7.0E-03	1.4E-05
VOC	1,1-Dichloroethene	75-35-4	C	4.20E-03	5.97E-04	2.51E-06			2.0E-01	2.9E-06
VOC	1,2-Dichloroethene (total)	540-59-0		4.10E-02	2.68E-04	1.10E-05				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	4.10E-02	2.68E-04	1.10E-05				
VOC	trans-1,2-Dichloroethene	156-60-5	ID		3.94E-04					
VOC	1,2-Dichloropropane	78-87-5	B2		1.98E-04				4.0E-03	
VOC	1,3-Dichloropropene (total)	542-75-6	B2		4.21E-04		4.0E-03		2.0E-02	
VOC	Ethyl Benzene	100-41-4	D		2.76E-04				1.0E+00	
VOC	2-Hexanone	591-78-6	ID		4.47E-05				3.0E-02	
VOC	4-Methyl-2-pentanone	108-10-1	ID	4.00E-03	4.80E-05	1.92E-07			3.0E+00	1.5E-08
VOC	Methylene Chloride	75-09-2	LC		2.39E-04		1.0E-05		6.0E-01	
VOC	Styrene	100-42-5			1.73E-04				1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC		6.35E-05					
VOC	Tetrachloroethene	127-18-4	LC		3.95E-04		2.6E-04		4.0E-02	
VOC	Toluene	108-88-3	ID		2.94E-04				5.0E+00	
VOC	1,1,1-Trichloroethane	71-55-6	ID		4.27E-04				5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5	C		1.15E-04		1.6E-02		2.0E-04	
VOC	Trichloroethene	79-01-6	HC	1.60E+00	3.54E-04	5.67E-04	4.1E-03	1.9E-07	2.0E-03	6.5E-02
VOC	Vinyl Chloride	75-01-4	A	3.00E-03	7.31E-04	2.19E-06	4.4E-03	7.9E-10	1.0E-01	5.0E-06
VOC	Xylenes (total)	1330-20-7	ID		2.80E-04				1.0E-01	
							Cumulative Risk:	2E-07	**HI:**	6E-02

Attachment 2: Vapor Flux to Outdoor Air from Groundwater Whirlpool, Fort Smith, Arkansas						
Chem Group	**Chemical**	**CASRN**	**H** (unitless)	**D_{eff}^{T}** (m^2/day)	**J** (L/m^2-s)	**C_{air}** (L/m^3)
VOC	Acetone	67-64-1	1.14E-03	1.87E-02	6.75E-08	1.78E-06
VOC	Benzene	71-43-2	1.59E-01	8.31E-04	4.18E-07	1.10E-05
VOC	Bromodichloromethane	75-27-4	4.45E-02	1.09E-03	1.53E-07	4.03E-06
VOC	Bromoform	75-25-2	1.34E-02	1.65E-03	6.97E-08	1.84E-06
VOC	Bromomethane	74-83-9	2.01E-01	7.57E-04	4.81E-07	1.27E-05
VOC	2-Butanone	78-93-3	1.96E-03	1.01E-02	6.27E-08	1.65E-06
VOC	Carbon Disulfide	75-15-0	9.26E-01	2.99E-04	8.76E-07	2.31E-05
VOC	Carbon Tetrachloride	56-23-5	8.82E-01	2.57E-04	7.17E-07	1.89E-05
VOC	Chlorobenzene	108-90-7	9.77E-02	9.49E-04	2.93E-07	7.73E-06
VOC	Chloroethane	75-00-3	3.25E-01	9.04E-04	9.30E-07	2.45E-05
VOC	Chloroform	67-66-3	1.07E-01	1.13E-03	3.85E-07	1.01E-05
VOC	Chloromethane	74-87-3	3.33E-01	4.70E-04	4.95E-07	1.30E-05
VOC	Dibromochloromethane	124-48-1	2.38E-02	1.28E-03	9.66E-08	2.55E-06
VOC	1,1-Dichloroethane	75-34-3	1.66E-01	7.86E-04	4.12E-07	1.09E-05
VOC	1,2-Dichloroethane	107-06-2	2.74E-02	2.41E-03	2.09E-07	5.52E-06
VOC	1,1-Dichloroethene	75-35-4	8.10E-01	3.18E-04	8.15E-07	2.15E-05
VOC	1,2-Dichloroethene (total)	540-59-0	1.19E-01	9.89E-04	3.71E-07	9.79E-06
VOC	cis-1,2-Dichloroethene	156-59-2	1.19E-01	9.89E-04	3.71E-07	9.79E-06
VOC	trans-1,2-Dichloroethene	156-60-5	2.81E-01	6.08E-04	5.41E-07	1.43E-05
VOC	1,2-Dichloropropane	78-87-5	7.82E-02	1.11E-03	2.75E-07	7.25E-06
VOC	1,3-Dichloropropene (total)	542-75-6	4.83E-01	3.76E-04	5.75E-07	1.52E-05
VOC	Ethyl Benzene	100-41-4	2.04E-01	5.86E-04	3.78E-07	9.98E-06
VOC	2-Hexanone	591-78-6	3.23E-03	6.91E-03	7.07E-08	1.86E-06
VOC	4-Methyl-2-pentanone	108-10-1	4.71E-03	4.85E-03	7.23E-08	1.91E-06
VOC	Methylene Chloride	75-09-2	6.60E-02	1.61E-03	3.36E-07	8.87E-06
VOC	Styrene	100-42-5	7.04E-02	1.08E-03	2.40E-07	6.32E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	8.74E-03	3.35E-03	9.26E-08	2.44E-06
VOC	Tetrachloroethene	127-18-4	4.90E-01	3.47E-04	5.39E-07	1.42E-05
VOC	Toluene	108-88-3	1.80E-01	7.10E-04	4.05E-07	1.07E-05
VOC	1,1,1-Trichloroethane	71-55-6	4.97E-01	3.71E-04	5.83E-07	1.54E-05
VOC	1,1,2-Trichloroethane	79-00-5	2.43E-02	2.12E-03	1.63E-07	4.29E-06
VOC	Trichloroethene	79-01-6	2.88E-01	5.33E-04	4.86E-07	1.28E-05
VOC	Vinyl Chloride	75-01-4	9.00E-01	3.51E-04	9.99E-07	2.63E-05
VOC	Xylenes (total)	1330-20-7	1.73E-01	7.02E-04	3.85E-07	1.02E-05
	Parameters					
	Depth to groundwater	m	**DTW**	3.66		
	Dispersion coefficient	(kg/m^3) / (kg/m^2/s)	**C/Q**	26.4		

Attachment 2: Cancer Risk and Hazard Index Calculations for Exposure of On-Site Routine Workers to Groundwater-derived Vapors in Outdoor Air
Whirlpool, Fort Smith, Arkansas

							Cancer			Noncancer	
Chem Group	**Chemical**	**CASRN**	**Carc Class**	**C_{GW}** (mg/L)	**C_{air}** (mg/m^3)		**URF** (m^3/mg)	**Risk**		**RfC** (mg/m^3)	**HQ**
VOC	Acetone	67-64-1	ID	1.99E-01	3.54E-07					3.1E+01	2.6E-09
VOC	Benzene	71-43-2	A	6.53E-02	7.19E-07		7.8E-03	4.6E-10		3.0E-02	5.5E-06
VOC	Bromodichloromethane	75-27-4	B2	6.79E-02	2.74E-07						
VOC	Bromoform	75-25-2	B2	7.67E-02	1.41E-07		1.1E-03	1.3E-11			
VOC	Bromomethane	74-83-9	ID	6.13E-02	7.78E-07					5.0E-03	3.6E-05
VOC	2-Butanone	78-93-3	ID	1.06E-01	1.75E-07					5.0E+00	8.0E-09
VOC	Carbon Disulfide	75-15-0		6.52E-02	1.51E-06					7.0E-01	4.9E-07
VOC	Carbon Tetrachloride	56-23-5	LC	6.69E-02	1.26E-06		6.0E-03	6.2E-10		1.0E-01	2.9E-06
VOC	Chlorobenzene	108-90-7	D	6.86E-02	5.30E-07					5.0E-02	2.4E-06
VOC	Chloroethane	75-00-3	LC	7.23E-02	1.77E-06					1.0E+01	4.1E-08
VOC	Chloroform	67-66-3	B2	6.64E-02	6.74E-07		2.3E-02	1.3E-09		5.0E-02	3.1E-06
VOC	Chloromethane	74-87-3	D	9.00E-02	1.17E-06					9.0E-02	3.0E-06
VOC	Dibromochloromethane	124-48-1	C	7.13E-02	1.82E-07						
VOC	1,1-Dichloroethane	75-34-3	SC	6.59E-02	7.16E-07					5.0E-01	3.3E-07
VOC	1,2-Dichloroethane	107-06-2	B2	6.61E-02	3.65E-07		2.6E-02	7.7E-10		7.0E-03	1.2E-05
VOC	1,1-Dichloroethene	75-35-4	C	2.50E-01	5.37E-06					2.0E-01	6.1E-06
VOC	1,2-Dichloroethene (total)	540-59-0		1.00E+01	9.79E-05						
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.00E+01	9.79E-05						
VOC	trans-1,2-Dichloroethene	156-60-5	ID	5.99E-02	8.55E-07						
VOC	1,2-Dichloropropane	78-87-5	B2	6.52E-02	4.73E-07					4.0E-03	2.7E-05
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1.42E-01	2.16E-06		4.0E-03	7.0E-10		2.0E-02	2.5E-05
VOC	Ethyl Benzene	100-41-4	D	6.89E-02	6.88E-07					1.0E+00	1.6E-07
VOC	2-Hexanone	591-78-6	ID	1.20E-01	2.24E-07					3.0E-02	1.7E-06
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.20E-01	2.29E-07					3.0E+00	1.7E-08
VOC	Methylene Chloride	75-09-2	LC	3.10E-01	2.75E-06		1.0E-05	2.2E-12		6.0E-01	1.0E-06
VOC	Styrene	100-42-5		6.83E-02	4.31E-07					1.0E+00	9.9E-08
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	6.40E-02	1.56E-07						
VOC	Tetrachloroethene	127-18-4	LC	7.67E-02	1.09E-06		2.6E-04	2.3E-11		4.0E-02	6.2E-06
VOC	Toluene	108-88-3	ID	6.54E-02	6.99E-07					5.0E+00	3.2E-08
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.10E-01	1.69E-06					5.0E+00	7.7E-08
VOC	1,1,2-Trichloroethane	79-00-5	C	6.59E-02	2.83E-07		1.6E-02	3.7E-10		2.0E-04	3.2E-04
VOC	Trichloroethene	79-01-6	HC	8.10E+01	1.04E-03		4.1E-03	3.5E-07		2.0E-03	1.2E-01
VOC	Vinyl Chloride	75-01-4	A	2.50E+00	6.59E-05		4.4E-03	2.4E-08		1.0E-01	1.5E-04
VOC	Xylenes (total)	1330-20-7	ID	1.99E-01	2.02E-06					1.0E-01	4.6E-06
							Cumulative Risk:	4E-07		**HI:**	1E-01

Note:

The dispersion coefficient to outdoor air (C/Q) is 11.6 (kg/m3) / (kg/m2/s).

Attachment 2: Cancer Risk and Hazard Index Calculations for Exposure of Off-Site Routine Workers to Groundwater-derived Vapors in Outdoor Air
Whirlpool, Fort Smith, Arkansas

							Cancer			Noncancer	
Chem Group	**Chemical**	**CASRN**	**Carc Class**	**C_{GW} (mg/L)**	**C_{air} (mg/m^3)**		**URF (m^3/mg)**	**Risk**		**RfC (mg/m^3)**	**HQ**
VOC	Acetone	67-64-1	ID	8.50E-02	1.51E-07					3.1E+01	1.1E-09
VOC	Benzene	71-43-2	A				7.8E-03			3.0E-02	
VOC	Bromodichloromethane	75-27-4	B2								
VOC	Bromoform	75-25-2	B2	2.40E-02	4.41E-08		1.1E-03	4.0E-12			
VOC	Bromomethane	74-83-9	ID							5.0E-03	
VOC	2-Butanone	78-93-3	ID	9.50E-02	1.57E-07					5.0E+00	7.2E-09
VOC	Carbon Disulfide	75-15-0								7.0E-01	
VOC	Carbon Tetrachloride	56-23-5	LC				6.0E-03			1.0E-01	
VOC	Chlorobenzene	108-90-7	D							5.0E-02	
VOC	Chloroethane	75-00-3	LC							1.0E+01	
VOC	Chloroform	67-66-3	B2				2.3E-02			5.0E-02	
VOC	Chloromethane	74-87-3	D							9.0E-02	
VOC	Dibromochloromethane	124-48-1	C								
VOC	1,1-Dichloroethane	75-34-3	SC							5.0E-01	
VOC	1,2-Dichloroethane	107-06-2	B2	3.00E-03	1.66E-08		2.6E-02	3.5E-11		7.0E-03	5.4E-07
VOC	1,1-Dichloroethene	75-35-4	C	4.20E-03	9.03E-08					2.0E-01	1.0E-07
VOC	1,2-Dichloroethene (total)	540-59-0		4.10E-02	4.01E-07						
VOC	cis-1,2-Dichloroethene	156-59-2	ID	4.10E-02	4.01E-07						
VOC	trans-1,2-Dichloroethene	156-60-5	ID								
VOC	1,2-Dichloropropane	78-87-5	B2							4.0E-03	
VOC	1,3-Dichloropropene (total)	542-75-6	B2				4.0E-03			2.0E-02	
VOC	Ethyl Benzene	100-41-4	D							1.0E+00	
VOC	2-Hexanone	591-78-6	ID							3.0E-02	
VOC	4-Methyl-2-pentanone	108-10-1	ID	4.00E-03	7.63E-09					3.0E+00	5.8E-10
VOC	Methylene Chloride	75-09-2	LC				1.0E-05			6.0E-01	
VOC	Styrene	100-42-5								1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC								
VOC	Tetrachloroethene	127-18-4	LC				2.6E-04			4.0E-02	
VOC	Toluene	108-88-3	ID							5.0E+00	
VOC	1,1,1-Trichloroethane	71-55-6	ID							5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5	C				1.6E-02			2.0E-04	
VOC	Trichloroethene	79-01-6	HC	1.60E+00	2.05E-05		4.1E-03	6.9E-09		2.0E-03	2.3E-03
VOC	Vinyl Chloride	75-01-4	A	3.00E-03	7.90E-08		4.4E-03	2.8E-11		1.0E-01	1.8E-07
VOC	Xylenes (total)	1330-20-7	ID							1.0E-01	
							Cumulative Risk:	7E-09		**HI:**	2E-03

Note:
The dispersion coefficient to outdoor air (C/Q) is 11.6 (kg/m3) / (kg/m2/s).

Attachment 3

Maintenance Worker Risk Calculations

Contents:

- Vapor Flux from Soil to Outdoor Air
- Cancer Risk Calculations for Exposure of On-Site Maintenance Workers to Soil
- Hazard Index Calculations for Exposure of On-Site Maintenance Workers to Soil

- Nonsteady State Dermal Absorption from Water
- Normalized Vapor Flux to Outdoor Air from Exposed Groundwater in Excavations
- Cancer Risk Calculations for Exposure of On-Site Maintenance Workers to Groundwater in Excavations
- Hazard Index Calculations for Exposure of On-Site Maintenance Workers to Groundwater in Excavations
- Cancer Risk Calculations for Exposure of Off-Site Maintenance Workers to Groundwater in Excavations
- Hazard Index Calculations for Exposure of Off-Site Maintenance Workers to Groundwater in Excavations

Attachment 3: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	K_{oc} (L/kg)	H (unitless)	D_{air} (m^2/d)	D_{water} (m^2/d)	R_L (unitless)	D_G (m^2/d)	D_L (m^2/d)	D_E (m^2/d)	Infinite J_v (kg/m^2-s)	Finite depth Z1 ERFC term	Finite depth Z2 ERFC term	Finite J_v (kg/m^2-s)	J_v (kg/m^2-s)
VOC	Acetone	67-64-1	5.81E-01	1.14E-03	1.07E+00	9.85E-05	3.17E-01	1.15E-02	9.10E-06	7.01E-05	2.50E-06	0.00E+00	1.17E-06	2.50E-06	2.50E-06
VOC	Benzene	71-43-2	5.82E+01	1.59E-01	7.60E-01	8.47E-05	5.02E-01	8.19E-03	7.82E-06	2.61E-03	1.52E-05	0.00E+00	1.47E+00	1.09E-05	1.09E-05
VOC	Bromodichloromethane	75-27-4	5.51E+01	4.45E-02	2.57E-01	9.16E-05	4.75E-01	2.77E-03	8.46E-06	2.78E-04	4.97E-06	0.00E+00	3.74E-02	4.95E-06	4.95E-06
VOC	Bromoform	75-25-2	8.70E+01	1.34E-02	1.29E-01	8.90E-05	5.58E-01	1.39E-03	8.22E-06	4.80E-05	2.07E-06	0.00E+00	2.32E-09	2.07E-06	2.07E-06
VOC	Bromomethane	74-83-9	1.05E+01	2.01E-01	6.29E-01	1.05E-04	3.78E-01	6.78E-03	9.65E-06	3.63E-03	1.80E-05	0.00E+00	1.75E+00	1.17E-05	1.17E-05
VOC	2-Butanone	78-93-3	2.00E+00	1.96E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.03E-05	2.50E-06	0.00E+00	1.20E-06	2.50E-06	2.50E-06
VOC	Carbon Disulfide	75-15-0	4.59E+01	9.26E-01	8.99E-01	8.64E-05	5.96E-01	9.68E-03	7.98E-06	1.51E-02	3.66E-05	0.00E+00	2.66E+00	1.38E-05	1.38E-05
VOC	Carbon Tetrachloride	56-23-5	1.74E+02	8.82E-01	6.74E-01	7.60E-05	9.41E-01	7.26E-03	7.02E-06	6.81E-03	2.46E-05	0.00E+00	2.21E+00	1.28E-05	1.28E-05
VOC	Chlorobenzene	108-90-7	2.20E+02	9.77E-02	6.31E-01	7.52E-05	9.40E-01	6.79E-03	6.94E-06	7.13E-04	7.97E-06	0.00E+00	3.99E-01	7.51E-06	7.51E-06
VOC	Chloroethane	75-00-3	1.62E+01	3.25E-01	2.34E+00	9.94E-05	4.14E-01	2.52E-02	9.18E-06	1.98E-02	4.20E-05	0.00E+00	2.78E+00	1.41E-05	1.41E-05
VOC	Chloroform	67-66-3	3.97E+01	1.07E-01	8.99E-01	8.64E-05	4.43E-01	9.68E-03	7.98E-06	2.37E-03	1.45E-05	0.00E+00	1.39E+00	1.07E-05	1.07E-05
VOC	Chloromethane	74-87-3	3.97E+01	3.33E-01	1.09E+00	5.62E-05	4.80E-01	1.17E-02	5.19E-06	8.14E-03	2.69E-05	0.00E+00	2.32E+00	1.30E-05	1.30E-05
VOC	Dibromochloromethane	124-48-1	6.26E+01	2.38E-02	1.69E-01	9.07E-05	4.92E-01	1.82E-03	8.38E-06	1.05E-04	3.06E-06	0.00E+00	1.11E-04	3.06E-06	3.06E-06
VOC	1,1-Dichloroethane	75-34-3	3.13E+01	1.66E-01	6.41E-01	9.07E-05	4.29E-01	6.91E-03	8.38E-06	2.68E-03	1.55E-05	0.00E+00	1.49E+00	1.10E-05	1.10E-05
VOC	1,2-Dichloroethane	107-06-2	1.75E+01	2.74E-02	8.99E-01	8.55E-05	3.68E-01	9.68E-03	7.90E-06	7.42E-04	8.13E-06	0.00E+00	4.25E-01	7.62E-06	7.62E-06
VOC	1,1-Dichloroethene	75-35-4	5.82E+01	8.10E-01	7.78E-01	8.99E-05	6.10E-01	8.38E-03	8.30E-06	1.11E-02	3.15E-05	0.00E+00	2.51E+00	1.34E-05	1.34E-05
VOC	1,2-Dichloroethene (total)	540-59-0	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	1.30E-05	0.00E+00	1.19E+00	1.02E-05	1.02E-05
VOC	cis-1,2-Dichloroethene	156-59-2	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	1.30E-05	0.00E+00	1.19E+00	1.02E-05	1.02E-05
VOC	trans-1,2-Dichloroethene	156-60-5	5.22E+01	2.81E-01	6.11E-01	1.03E-04	5.06E-01	6.58E-03	9.49E-06	3.68E-03	1.81E-05	0.00E+00	1.76E+00	1.17E-05	1.17E-05
VOC	1,2-Dichloropropane	78-87-5	4.35E+01	7.82E-02	6.76E-01	7.54E-05	4.48E-01	7.28E-03	6.97E-06	1.28E-03	1.07E-05	0.00E+00	8.50E-01	9.17E-06	9.17E-06
VOC	1,3-Dichloropropene (total)	542-75-6	4.59E+01	4.83E-01	5.41E-01	8.64E-05	5.22E-01	5.83E-03	7.98E-06	5.40E-03	2.19E-05	0.00E+00	2.05E+00	1.24E-05	1.24E-05
VOC	Ethyl Benzene	100-41-4	3.67E+02	2.04E-01	6.48E-01	6.74E-05	1.36E+00	6.98E-03	6.22E-06	1.05E-03	9.67E-06	0.00E+00	6.82E-01	8.61E-06	8.61E-06
VOC	2-Hexanone	591-78-6	1.48E+01	3.23E-03	7.45E-01	7.57E-05	3.57E-01	8.02E-03	6.99E-06	9.23E-05	2.87E-06	0.00E+00	3.05E-05	2.87E-06	2.87E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.05E+01	4.71E-03	6.48E-01	6.74E-05	3.45E-01	6.98E-03	6.22E-06	1.13E-04	3.18E-06	0.00E+00	2.12E-04	3.18E-06	3.18E-06
VOC	Methylene Chloride	75-09-2	1.17E+01	6.60E-02	8.73E-01	1.01E-04	3.59E-01	9.40E-03	9.33E-06	1.76E-03	1.25E-05	0.00E+00	1.12E+00	9.99E-06	9.99E-06
VOC	Styrene	100-42-5	7.77E+02	7.04E-02	6.13E-01	6.91E-05	2.47E+00	6.61E-03	6.38E-06	1.91E-04	4.12E-06	0.00E+00	7.10E-03	4.12E-06	4.12E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	9.35E+01	8.74E-03	6.13E-01	6.83E-05	5.75E-01	6.61E-03	6.30E-06	1.11E-04	3.15E-06	0.00E+00	1.83E-04	3.15E-06	3.15E-06
VOC	Tetrachloroethene	127-18-4	1.56E+02	4.90E-01	6.22E-01	7.08E-05	8.27E-01	6.70E-03	6.54E-06	3.98E-03	1.88E-05	0.00E+00	1.82E+00	1.18E-05	1.18E-05
VOC	Toluene	108-88-3	1.80E+02	1.80E-01	7.52E-01	7.43E-05	8.43E-01	8.10E-03	6.86E-06	1.74E-03	1.24E-05	0.00E+00	1.12E+00	9.97E-06	9.97E-06
VOC	1,1,1-Trichloroethane	71-55-6	1.10E+02	4.97E-01	6.74E-01	7.60E-05	7.02E-01	7.26E-03	7.02E-06	5.15E-03	2.14E-05	0.00E+00	2.01E+00	1.23E-05	1.23E-05
VOC	1,1,2-Trichloroethane	79-00-5	5.03E+01	2.43E-02	6.74E-01	7.60E-05	4.58E-01	7.26E-03	7.02E-06	4.00E-04	5.97E-06	0.00E+00	1.18E-01	5.88E-06	5.88E-06
VOC	Trichloroethene	79-01-6	1.68E+02	2.88E-01	6.83E-01	7.86E-05	8.26E-01	7.35E-03	7.26E-06	2.57E-03	1.51E-05	0.00E+00	1.46E+00	1.09E-05	1.09E-05
VOC	Vinyl Chloride	75-01-4	1.85E+01	9.00E-01	9.16E-01	1.06E-04	5.15E-01	9.87E-03	9.81E-06	1.72E-02	3.92E-05	0.00E+00	2.72E+00	1.39E-05	1.39E-05
VOC	Xylenes (total)	1330-20-7	3.86E+02	1.73E-01	6.74E-01	7.56E-05	1.41E+00	7.26E-03	6.98E-06	8.97E-04	8.94E-06	0.00E+00	5.60E-01	8.17E-06	8.17E-06
Notes:	Soil bulk density	kg/L	ρ_b	1.38											
	Soil porosity	L/L-soil	θ	0.48											
	Soil water content	L/L-soil	θ_w	0.32											
	Soil air-filled porosity	L/L-soil	θ_a	0.17											
	Soil organic carbon fraction	unitless	f_{oc}	0.002											
	Averaging period (Exposure Duration)	year	**T**	25											
		days	**T**	9125											
		s	**T**	7.9E+08											
	Molar Gas Constant	L-mmHg/mole-^{o}K	**R**	62.411											
	Temperature	^{o}C	**Temp**	16.7											
		K	**Temp**	289.7											
	Clean soil above source	m	Z_1	0.00											
	Bottom of source depth	m	Z_2	3.66											

Attachment 3: Cancer Risk Calculations for Exposure of On-Site Maintenance Workers to Soil
Whirlpool, Fort Smith, Arkansas

					Soil Ingestion			Soil Dermal Contact				Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes
Chem Group	Chemical	CASRN	Cancer Class	C_{soil} (mg/kg)	LADD (mg/kg/d)	SF_{oral} $(mg/kg/d)^{-1}$	Risk	ABS_{derm}	LADD (mg/kg/d)	SF_{derm} $(mg/kg/d)^{-1}$	Risk	C_{air} (mg/m^3)	URF (m^3/mg)	Risk	C_{air} (mg/m^3)	URF (m^3/mg)	Risk	Risk
VOC	Acetone	67-64-1	ID															
VOC	Benzene	71-43-2	A			5.5E-02				5.5E-02			7.8E-03			7.8E-03		
VOC	Bromodichloromethane	75-27-4	B2			6.2E-02				6.2E-02								
VOC	Bromoform	75-25-2	B2			7.9E-03				7.9E-03			1.1E-03			1.1E-03		
VOC	Bromomethane	74-83-9	ID															
VOC	2-Butanone	78-93-3	ID															
VOC	Carbon Disulfide	75-15-0																
VOC	Carbon Tetrachloride	56-23-5	LC			7.0E-02				7.0E-02			6.0E-03			6.0E-03		
VOC	Chlorobenzene	108-90-7	D															
VOC	Chloroethane	75-00-3	LC															
VOC	Chloroform	67-66-3	B2			1.9E-02				1.9E-02			2.3E-02			2.3E-02		
VOC	Chloromethane	74-87-3	D															
VOC	Dibromochloromethane	124-48-1	C			8.4E-02				8.4E-02								
VOC	1,1-Dichloroethane	75-34-3	SC															
VOC	1,2-Dichloroethane	107-06-2	B2			9.1E-02				9.1E-02			2.6E-02			2.6E-02		
VOC	1,1-Dichloroethene	75-35-4	C															
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	2.01E-10							4.15E-06			6.00E-10			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	2.01E-10							4.15E-06			6.00E-10			
VOC	trans-1,2-Dichloroethene	156-60-5	ID															
VOC	1,2-Dichloropropane	78-87-5	B2			3.6E-02				3.6E-02								
VOC	1,3-Dichloropropene (total)	542-75-6	B2			1.0E-01				1.0E-01			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4	D															
VOC	2-Hexanone	591-78-6	ID															
VOC	4-Methyl-2-pentanone	108-10-1	ID															
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	1.17E-10	2.0E-03	2.3E-13			2.0E-03		2.38E-06	1.0E-05	9.3E-14	3.50E-10	1.0E-05	1.4E-17	3.3E-13
VOC	Styrene	100-42-5																
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC			2.0E-01				2.0E-01								
VOC	Tetrachloroethene	127-18-4	LC			2.1E-03				2.1E-03			2.6E-04			2.6E-04		
VOC	Toluene	108-88-3	ID															
VOC	1,1,1-Trichloroethane	71-55-6	ID															
VOC	1,1,2-Trichloroethane	79-00-5	C			5.7E-02				5.7E-02			1.6E-02			1.6E-02		
VOC	Trichloroethene	79-01-6	HC	1.86E-01	3.12E-09	4.6E-02	1.4E-10			4.6E-02		6.90E-05	4.1E-03	1.1E-09	9.30E-09	4.1E-03	1.5E-13	1.3E-09
VOC	Vinyl Chloride	75-01-4	A			7.2E-01				7.2E-01			4.4E-03			4.4E-03		
VOC	Xylenes (total)	1330-20-7	ID															
		Cumulative Risk:					**1E-10**							**1E-09**			**1E-13**	**1E-09**

Notes:

The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).

This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.

The concentration of particulates in the air is assumed to be no more than the former annual National Ambient Air Quality Standards (NAAQS) for PM_{10} of 50 ug/m^3.

Attachment 3: Hazard Index Calculations for Exposure of On-Site Maintenance Workers to Soil
Whirlpool, Fort Smith, Arkansas

					Soil Ingestion			Soil Dermal Contact				Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	**C_{soil}** (mg/kg)	**ADD** (mg/kg/d)	**RfD_{oral}** (mg/kg/d)	**HQ**	**ABS_{derm}**	**ADD** (mg/kg/d)	**RfD_{derm}** (mg/kg/d)	**HQ**	**C_{air}** (mg/m^3)	**RfC** (mg/m^3)	**HQ**	**C_{air}** (mg/m^3)	**RfC** (mg/m^3)	**HQ**	**HQ**
VOC	Acetone	67-64-1	ID			9.0E-01				9.0E-01			3.1E+01			3.1E+01		
VOC	Benzene	71-43-2	A			4.0E-03				4.0E-03			3.0E-02			3.0E-02		
VOC	Bromodichloromethane	75-27-4	B2			2.0E-02				2.0E-02								
VOC	Bromoform	75-25-2	B2			2.0E-02				2.0E-02								
VOC	Bromomethane	74-83-9	ID			1.4E-03				1.4E-03			5.0E-03			5.0E-03		
VOC	2-Butanone	78-93-3	ID			6.0E-01				6.0E-01			5.0E+00			5.0E+00		
VOC	Carbon Disulfide	75-15-0				1.0E-01				1.0E-01			7.0E-01			7.0E-01		
VOC	Carbon Tetrachloride	56-23-5	LC			4.0E-03				4.0E-03			1.0E-01			1.0E-01		
VOC	Chlorobenzene	108-90-7	D			2.0E-02				2.0E-02			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3	LC			1.0E-01				1.0E-01			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	B2			1.0E-02				1.0E-02			5.0E-02			5.0E-02		
VOC	Chloromethane	74-87-3	D										9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1	C			2.0E-02				2.0E-02								
VOC	1,1-Dichloroethane	75-34-3	SC			2.0E-01				2.0E-01			5.0E-01			5.0E-01		
VOC	1,2-Dichloroethane	107-06-2	B2			6.0E-03				6.0E-03			7.0E-03			7.0E-03		
VOC	1,1-Dichloroethene	75-35-4	C			5.0E-02				5.0E-02			2.0E-01			2.0E-01		
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	1.41E-09	2.0E-03	7.0E-07			2.0E-03		4.15E-06			6.00E-10			7.0E-07
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	1.41E-09	2.0E-03	7.0E-07			2.0E-03		4.15E-06			6.00E-10			7.0E-07
VOC	trans-1,2-Dichloroethene	156-60-5	ID			2.0E-02				2.0E-02								
VOC	1,2-Dichloropropane	78-87-5	B2			9.0E-02				9.0E-02			4.0E-03			4.0E-03		
VOC	1,3-Dichloropropene (total)	542-75-6	B2			3.0E-02				3.0E-02			2.0E-02			2.0E-02		
VOC	Ethyl Benzene	100-41-4	D			1.0E-01				1.0E-01			1.0E+00			1.0E+00		
VOC	2-Hexanone	591-78-6	ID			5.0E-03				5.0E-03			3.0E-02			3.0E-02		
VOC	4-Methyl-2-pentanone	108-10-1	ID										3.0E+00			3.0E+00		
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	8.22E-10	6.0E-03	1.4E-07			6.0E-03		2.38E-06	6.0E-01	1.1E-07	3.50E-10	6.0E-01	1.6E-11	2.5E-07
VOC	Styrene	100-42-5				2.0E-01				2.0E-01			1.0E+00			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC			2.0E-02				2.0E-02								
VOC	Tetrachloroethene	127-18-4	LC			6.0E-03				6.0E-03			4.0E-02			4.0E-02		
VOC	Toluene	108-88-3	ID			8.0E-02				8.0E-02			5.0E+00			5.0E+00		
VOC	1,1,1-Trichloroethane	71-55-6	ID			2.0E+00				2.0E+00			5.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5	C			4.0E-03				4.0E-03			2.0E-04			2.0E-04		
VOC	Trichloroethene	79-01-6	HC	1.86E-01	2.18E-08	5.0E-04	4.4E-05			5.0E-04		6.90E-05	2.0E-03	9.5E-04	9.30E-09	2.0E-03	1.3E-07	9.9E-04
VOC	Vinyl Chloride	75-01-4	A			3.0E-03				3.0E-03			1.0E-01			1.0E-01		
VOC	Xylenes (total)	1330-20-7	ID			2.0E-01				2.0E-01			1.0E-01			1.0E-01		
			Hazard Index:				**5E-05**							**9E-04**			**1E-07**	**1E-03**

Notes:

The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).

This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.

The concentration of particulates in the air is assumed to be no more than the former annual National Ambient Air Quality Standards (NAAQS) for PM_{10} of 50 ug/m^3.

Attachment 3: Nonsteady State Dermal Absorption from Water
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	MW (g/mole)	FA (unitless)	K_p (cm/hr)	B (unitless)	τ (hr)	c	b	ts (hr)	DA (L/cm^2-event)
VOC	Acetone	67-64-1	5.8E+01	1.0E+00	5.2E-04	1.5E-03	2.2E-01	3.3E-01	3.0E-01	5.3E-01	1.27E-06
VOC	Benzene	71-43-2	7.8E+01	1.0E+00	1.5E-02	5.0E-02	2.9E-01	3.7E-01	3.3E-01	6.9E-01	3.70E-05
VOC	Bromodichloromethane	75-27-4	1.6E+02	1.0E+00	4.7E-03	2.3E-02	8.7E-01	3.5E-01	3.2E-01	2.1E+00	1.70E-05
VOC	Bromoform	75-25-2	2.5E+02	1.0E+00	2.2E-03	1.3E-02	2.7E+00	3.4E-01	3.1E-01	6.6E+00	1.40E-05
VOC	Bromomethane	74-83-9	9.5E+01	1.0E+00	2.8E-03	1.1E-02	3.6E-01	3.4E-01	3.1E-01	8.6E-01	7.68E-06
VOC	2-Butanone	78-93-3	7.2E+01	1.0E+00	9.6E-04	3.1E-03	2.7E-01	3.4E-01	3.1E-01	6.4E-01	2.42E-06
VOC	Carbon Disulfide	75-15-0	7.6E+01	1.0E+00	1.2E-02	4.2E-02	2.8E-01	3.6E-01	3.3E-01	6.7E-01	3.11E-05
VOC	Carbon Tetrachloride	56-23-5	1.5E+02	1.0E+00	1.4E-02	6.6E-02	7.6E-01	3.8E-01	3.4E-01	1.8E+00	4.84E-05
VOC	Chlorobenzene	108-90-7	1.1E+02	1.0E+00	2.9E-02	1.2E-01	4.5E-01	4.2E-01	3.8E-01	1.1E+00	8.00E-05
VOC	Chloroethane	75-00-3	6.5E+01	1.0E+00	6.1E-03	1.9E-02	2.4E-01	3.5E-01	3.1E-01	5.8E-01	1.49E-05
VOC	Chloroform	67-66-3	1.2E+02	1.0E+00	6.3E-03	2.6E-02	4.9E-01	3.5E-01	3.2E-01	1.2E+00	1.86E-05
VOC	Chloromethane	74-87-3	5.0E+01	1.0E+00	1.5E-02	4.2E-02	2.0E-01	3.6E-01	3.3E-01	4.8E-01	3.58E-05
VOC	Dibromochloromethane	124-48-1	2.1E+02	1.0E+00	2.9E-03	1.6E-02	1.5E+00	3.4E-01	3.1E-01	3.7E+00	1.42E-05
VOC	1,1-Dichloroethane	75-34-3	9.9E+01	1.0E+00	6.7E-03	2.6E-02	3.8E-01	3.5E-01	3.2E-01	9.0E-01	1.83E-05
VOC	1,2-Dichloroethane	107-06-2	9.9E+01	1.0E+00	4.1E-03	1.6E-02	3.8E-01	3.4E-01	3.1E-01	9.0E-01	1.13E-05
VOC	1,1-Dichloroethene	75-35-4	9.7E+01	1.0E+00	1.2E-02	4.4E-02	3.7E-01	3.6E-01	3.3E-01	8.8E-01	3.10E-05
VOC	1,2-Dichloroethene (total)	540-59-0	9.7E+01	1.0E+00	7.7E-03	2.9E-02	3.7E-01	3.5E-01	3.2E-01	8.8E-01	2.07E-05
VOC	cis-1,2-Dichloroethene	156-59-2	9.7E+01	1.0E+00	7.7E-03	2.9E-02	3.7E-01	3.5E-01	3.2E-01	8.8E-01	2.07E-05
VOC	trans-1,2-Dichloroethene	156-60-5	9.7E+01	1.0E+00	1.1E-02	4.0E-02	3.7E-01	3.6E-01	3.3E-01	8.8E-01	2.83E-05
VOC	1,2-Dichloropropane	78-87-5	1.1E+02	1.0E+00	7.4E-03	3.0E-02	4.5E-01	3.5E-01	3.2E-01	1.1E+00	2.12E-05
VOC	1,3-Dichloropropene (total)	542-75-6	1.1E+02	1.0E+00	7.9E-03	3.2E-02	4.4E-01	3.6E-01	3.2E-01	1.1E+00	2.25E-05
VOC	Ethyl Benzene	100-41-4	1.1E+02	1.0E+00	4.8E-02	1.9E-01	4.1E-01	4.7E-01	4.3E-01	9.9E-01	1.27E-04
VOC	2-Hexanone	591-78-6	1.0E+02	1.0E+00	3.5E-03	1.4E-02	3.8E-01	3.4E-01	3.1E-01	9.2E-01	9.75E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.0E+02	1.0E+00	2.7E-03	1.0E-02	3.8E-01	3.4E-01	3.1E-01	9.2E-01	7.32E-06
VOC	Methylene Chloride	75-09-2	8.5E+01	1.0E+00	3.5E-03	1.3E-02	3.1E-01	3.4E-01	3.1E-01	7.5E-01	9.25E-06
VOC	Styrene	100-42-5	1.0E+02	1.0E+00	3.6E-02	1.4E-01	4.0E-01	4.3E-01	4.0E-01	9.7E-01	9.63E-05
VOC	1,1,2,2-Tetrachloroethane	79-34-5	1.7E+02	1.0E+00	6.9E-03	3.4E-02	9.2E-01	3.6E-01	3.2E-01	2.2E+00	2.57E-05
VOC	Tetrachloroethene	127-18-4	1.7E+02	1.0E+00	1.1E-02	5.4E-02	8.9E-01	3.7E-01	3.4E-01	2.1E+00	3.99E-05
VOC	Toluene	108-88-3	9.2E+01	1.0E+00	3.2E-02	1.2E-01	3.5E-01	4.2E-01	3.8E-01	8.3E-01	8.08E-05
VOC	1,1,1-Trichloroethane	71-55-6	1.3E+02	1.0E+00	1.2E-02	5.5E-02	5.9E-01	3.7E-01	3.4E-01	1.4E+00	3.85E-05
VOC	1,1,2-Trichloroethane	79-00-5	1.3E+02	1.0E+00	6.4E-03	2.8E-02	5.9E-01	3.5E-01	3.2E-01	1.4E+00	2.02E-05
VOC	Trichloroethene	79-01-6	1.3E+02	1.0E+00	1.8E-02	7.9E-02	5.7E-01	3.9E-01	3.5E-01	1.4E+00	5.53E-05
VOC	Vinyl Chloride	75-01-4	6.3E+01	1.0E+00	6.9E-03	2.1E-02	2.4E-01	3.5E-01	3.2E-01	5.7E-01	1.69E-05
VOC	Xylenes (total)	1330-20-7	1.1E+02	1.0E+00	5.0E-02	2.0E-01	4.1E-01	4.8E-01	4.4E-01	9.9E-01	1.32E-04
Notes:											
	Event Time	hours	**t**	2							
	K_p capped at 1 cm/hr (USEPA 1992).										

Attachment 3: Normalized Vapor Flux to Outdoor Air from Exposed Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	H (unitless)	MW (g/mol)	k_G (cm/s)	k_L (cm/s)	$1/K_L$ (s/cm)	K_L (cm/s)	J_L (L/m^2-s)
VOC	Acetone	67-64-1	1.1E-03	5.8E+01	5.47E-01	1.44E-03	2.30E+03	4.35E-04	4.35E-03
VOC	Benzene	71-43-2	1.6E-01	7.8E+01	4.95E-01	1.24E-03	8.16E+02	1.23E-03	1.23E-02
VOC	Bromodichloromethane	75-27-4	4.5E-02	1.6E+02	3.86E-01	8.59E-04	1.22E+03	8.18E-04	8.18E-03
VOC	Bromoform	75-25-2	1.3E-02	2.5E+02	3.34E-01	6.92E-04	1.67E+03	5.99E-04	5.99E-03
VOC	Bromomethane	74-83-9	2.0E-01	9.5E+01	4.64E-01	1.13E-03	8.97E+02	1.12E-03	1.12E-02
VOC	2-Butanone	78-93-3	2.0E-03	7.2E+01	5.09E-01	1.30E-03	1.77E+03	5.64E-04	5.64E-03
VOC	Carbon Disulfide	75-15-0	9.3E-01	7.6E+01	4.99E-01	1.26E-03	7.96E+02	1.26E-03	1.26E-02
VOC	Carbon Tetrachloride	56-23-5	8.8E-01	1.5E+02	3.95E-01	8.87E-04	1.13E+03	8.85E-04	8.85E-03
VOC	Chlorobenzene	108-90-7	9.8E-02	1.1E+02	4.38E-01	1.04E-03	9.88E+02	1.01E-03	1.01E-02
VOC	Chloroethane	75-00-3	3.3E-01	6.5E+01	5.28E-01	1.37E-03	7.36E+02	1.36E-03	1.36E-02
VOC	Chloroform	67-66-3	1.1E-01	1.2E+02	4.30E-01	1.01E-03	1.02E+03	9.85E-04	9.85E-03
VOC	Chloromethane	74-87-3	3.3E-01	5.0E+01	5.73E-01	1.55E-03	6.51E+02	1.54E-03	1.54E-02
VOC	Dibromochloromethane	124-48-1	2.4E-02	2.1E+02	3.57E-01	7.62E-04	1.43E+03	6.99E-04	6.99E-03
VOC	1,1-Dichloroethane	75-34-3	1.7E-01	9.9E+01	4.57E-01	1.11E-03	9.18E+02	1.09E-03	1.09E-02
VOC	1,2-Dichloroethane	107-06-2	2.7E-02	9.9E+01	4.57E-01	1.11E-03	9.84E+02	1.02E-03	1.02E-02
VOC	1,1-Dichloroethene	75-35-4	8.1E-01	9.7E+01	4.61E-01	1.12E-03	8.98E+02	1.11E-03	1.11E-02
VOC	1,2-Dichloroethene (total)	540-59-0	1.2E-01	9.7E+01	4.61E-01	1.12E-03	9.13E+02	1.09E-03	1.09E-02
VOC	cis-1,2-Dichloroethene	156-59-2	1.2E-01	9.7E+01	4.61E-01	1.12E-03	9.13E+02	1.09E-03	1.09E-02
VOC	trans-1,2-Dichloroethene	156-60-5	2.8E-01	9.7E+01	4.61E-01	1.12E-03	9.03E+02	1.11E-03	1.11E-02
VOC	1,2-Dichloropropane	78-87-5	7.8E-02	1.1E+02	4.38E-01	1.03E-03	9.96E+02	1.00E-03	1.00E-02
VOC	1,3-Dichloropropene (total)	542-75-6	4.8E-01	1.1E+02	4.40E-01	1.04E-03	9.63E+02	1.04E-03	1.04E-02
VOC	Ethyl Benzene	100-41-4	2.0E-01	1.1E+02	4.47E-01	1.07E-03	9.48E+02	1.06E-03	1.06E-02
VOC	2-Hexanone	591-78-6	3.2E-03	1.0E+02	4.56E-01	1.10E-03	1.59E+03	6.29E-04	6.29E-03
VOC	4-Methyl-2-pentanone	108-10-1	4.7E-03	1.0E+02	4.56E-01	1.10E-03	1.38E+03	7.27E-04	7.27E-03
VOC	Methylene Chloride	75-09-2	6.6E-02	8.5E+01	4.82E-01	1.19E-03	8.69E+02	1.15E-03	1.15E-02
VOC	Styrene	100-42-5	7.0E-02	1.0E+02	4.50E-01	1.08E-03	9.59E+02	1.04E-03	1.04E-02
VOC	1,1,2,2-Tetrachloroethane	79-34-5	8.7E-03	1.7E+02	3.83E-01	8.49E-04	1.48E+03	6.77E-04	6.77E-03
VOC	Tetrachloroethene	127-18-4	4.9E-01	1.7E+02	3.85E-01	8.54E-04	1.18E+03	8.50E-04	8.50E-03
VOC	Toluene	108-88-3	1.8E-01	9.2E+01	4.69E-01	1.15E-03	8.85E+02	1.13E-03	1.13E-02
VOC	1,1,1-Trichloroethane	71-55-6	5.0E-01	1.3E+02	4.14E-01	9.52E-04	1.05E+03	9.48E-04	9.48E-03
VOC	1,1,2-Trichloroethane	79-00-5	2.4E-02	1.3E+02	4.14E-01	9.52E-04	1.15E+03	8.70E-04	8.70E-03
VOC	Trichloroethene	79-01-6	2.9E-01	1.3E+02	4.16E-01	9.60E-04	1.05E+03	9.52E-04	9.52E-03

Attachment 3: Normalized Vapor Flux to Outdoor Air from Exposed Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	H (unitless)	MW (g/mol)	k_G (cm/s)	k_L (cm/s)	$1/K_L$ (s/cm)	K_L (cm/s)	J_L (L/m^2-s)
VOC	Vinyl Chloride	75-01-4	9.0E-01	6.3E+01	5.34E-01	1.39E-03	7.21E+02	1.39E-03	1.39E-02
VOC	Xylenes (total)	1330-20-7	1.7E-01	1.1E+02	4.47E-01	1.07E-03	9.50E+02	1.05E-03	1.05E-02
	Molecular Weight of Oxygen	g/mol	**MW_{02}**	32					
	Molecular Weight of Water	g/mol	**MW_{H20}**	18					
	Temperature	K	**Temp**	289.7					
	Liquid-phase Mass Transfer Coefficient for Oxygen	cm/s	**$k_{L,02}$**	0.002					
	Gas-Phase Mass Transfer Coefficient for Water Vapor at 25 °C	cm/s	**$K_{G,H20}$**	0.833					
	Dispersion coefficient	(kg/m^3) / ($kg/m^2/s$)	**C/Q**	11.6					

Attachment 3: Cancer Risk Calculations for Exposure of On-Site Maintenance Workers to Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas

					Incidental Ingestion			Dermal Contact				Vapor Inhalation				All Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	**C_{gw}** (mg/l)	**LADD** (mg/kg/d)	**SF_{oral}** $(mg/kg/d)^{-1}$	**Risk**	**DA** (L/cm^2-event)	**LADD** (mg/kg/d)	**SF_{derm}** $(mg/kg/d)^{-1}$	**Risk**	**C_{air}** (mg/m^3)	**EC** (mg/m^3)	**URF** (m^3/mg)	**Risk**	**Risk**
VOC	Acetone	67-64-1	ID	1.99E-01	5.56E-08			1.27E-06	2.33E-08			1.01E-02	6.56E-06			
VOC	Benzene	71-43-2	A	6.53E-02	1.83E-08	5.5E-02	1.0E-09	3.70E-05	2.23E-07	5.5E-02	1.2E-08	9.29E-03	6.06E-06	7.8E-03	4.7E-08	6.1E-08
VOC	Bromodichloromethane	75-27-4	B2	6.79E-02	1.90E-08	6.2E-02	1.2E-09	1.70E-05	1.06E-07	6.2E-02	6.6E-09	6.45E-03	4.21E-06			7.8E-09
VOC	Bromoform	75-25-2	B2	7.67E-02	2.14E-08	7.9E-03	1.7E-10	1.40E-05	9.91E-08	7.9E-03	7.8E-10	5.33E-03	3.48E-06	1.1E-03	3.8E-09	4.8E-09
VOC	Bromomethane	74-83-9	ID	6.13E-02	1.71E-08			7.68E-06	4.34E-08			7.94E-03	5.18E-06			
VOC	2-Butanone	78-93-3	ID	1.06E-01	2.96E-08			2.42E-06	2.37E-08			6.94E-03	4.53E-06			
VOC	Carbon Disulfide	75-15-0		6.52E-02	1.82E-08			3.11E-05	1.87E-07			9.51E-03	6.21E-06			
VOC	Carbon Tetrachloride	56-23-5	LC	6.69E-02	1.87E-08	7.0E-02	1.3E-09	4.84E-05	2.99E-07	7.0E-02	2.1E-08	6.87E-03	4.48E-06	6.0E-03	2.7E-08	4.9E-08
VOC	Chlorobenzene	108-90-7	D	6.86E-02	1.92E-08			8.00E-05	5.06E-07			8.06E-03	5.26E-06			
VOC	Chloroethane	75-00-3	LC	7.23E-02	2.02E-08			1.49E-05	9.93E-08			1.14E-02	7.44E-06			
VOC	Chloroform	67-66-3	B2	6.64E-02	1.86E-08	1.9E-02	3.5E-10	1.86E-05	1.14E-07	1.9E-02	2.2E-09	7.59E-03	4.95E-06	2.3E-02	1.1E-07	1.2E-07
VOC	Chloromethane	74-87-3	D	9.00E-02	2.52E-08			3.58E-05	2.97E-07			1.60E-02	1.05E-05			
VOC	Dibromochloromethane	124-48-1	C	7.13E-02	1.99E-08	8.4E-02	1.7E-09	1.42E-05	9.33E-08	8.4E-02	7.8E-09	5.79E-03	3.78E-06			9.5E-09
VOC	1,1-Dichloroethane	75-34-3	SC	6.59E-02	1.84E-08			1.83E-05	1.11E-07			8.34E-03	5.44E-06			
VOC	1,2-Dichloroethane	107-06-2	B2	6.61E-02	1.85E-08	9.1E-02	1.7E-09	1.13E-05	6.89E-08	9.1E-02	6.3E-09	7.80E-03	5.09E-06	2.6E-02	1.3E-07	1.4E-07
VOC	1,1-Dichloroethene	75-35-4	C	2.50E-01	6.99E-08			3.10E-05	7.15E-07			3.23E-02	2.11E-05			
VOC	1,2-Dichloroethene (total)	540-59-0		1.00E+01	2.80E-06			2.07E-05	1.91E-05			1.27E+00	8.29E-04			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.00E+01	2.80E-06			2.07E-05	1.91E-05			1.27E+00	8.29E-04			
VOC	trans-1,2-Dichloroethene	156-60-5	ID	5.99E-02	1.67E-08			2.83E-05	1.57E-07			7.70E-03	5.02E-06			
VOC	1,2-Dichloropropane	78-87-5	B2	6.52E-02	1.82E-08	3.6E-02	6.6E-10	2.12E-05	1.27E-07	3.6E-02	4.6E-09	7.60E-03	4.96E-06			5.2E-09
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1.42E-01	3.98E-08	1.0E-01	4.0E-09	2.25E-05	2.96E-07	1.0E-01	3.0E-08	1.72E-02	1.12E-05	4.0E-03	4.5E-08	7.8E-08
VOC	Ethyl Benzene	100-41-4	D	6.89E-02	1.93E-08			1.27E-04	8.06E-07			8.44E-03	5.50E-06			
VOC	2-Hexanone	591-78-6	ID	1.20E-01	3.35E-08			9.75E-06	1.08E-07			8.77E-03	5.72E-06			
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.20E-01	3.35E-08			7.32E-06	8.10E-08			1.01E-02	6.61E-06			
VOC	Methylene Chloride	75-09-2	LC	3.10E-01	8.67E-08	2.0E-03	1.7E-10	9.25E-06	2.65E-07	2.0E-03	5.3E-10	4.14E-02	2.70E-05	1.0E-05	2.7E-10	9.7E-10
VOC	Styrene	100-42-5		6.83E-02	1.91E-08			9.63E-05	6.07E-07			8.26E-03	5.39E-06			
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	6.40E-02	1.79E-08	2.0E-01	3.6E-09	2.57E-05	1.52E-07	2.0E-01	3.0E-08	5.03E-03	3.28E-06			3.4E-08
VOC	Tetrachloroethene	127-18-4	LC	7.67E-02	2.14E-08	2.1E-03	4.5E-11	3.99E-05	2.82E-07	2.1E-03	5.9E-10	7.57E-03	4.94E-06	2.6E-04	1.3E-09	1.9E-09
VOC	Toluene	108-88-3	ID	6.54E-02	1.83E-08			8.08E-05	4.88E-07			8.58E-03	5.60E-06			
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.10E-01	3.08E-08			3.85E-05	3.91E-07			1.21E-02	7.90E-06			
VOC	1,1,2-Trichloroethane	79-00-5	C	6.59E-02	1.84E-08	5.7E-02	1.1E-09	2.02E-05	1.23E-07	5.7E-02	7.0E-09	6.65E-03	4.34E-06	1.6E-02	6.9E-08	7.7E-08
VOC	Trichloroethene	79-01-6	HC	8.10E+01	2.26E-05	4.6E-02	1.0E-06	5.53E-05	4.13E-04	4.6E-02	1.9E-05	8.95E+00	5.84E-03	4.1E-03	2.4E-05	4.4E-05
VOC	Vinyl Chloride	75-01-4	A	2.50E+00	6.99E-07	7.2E-01	5.0E-07	1.69E-05	3.89E-06	7.2E-01	2.8E-06	4.03E-01	2.63E-04	4.4E-03	1.2E-06	4.5E-06
VOC	Xylenes (total)	1330-20-7	ID	1.99E-01	5.57E-08			1.32E-04	2.42E-06			2.44E-02	1.59E-05			
		Cumulative Risk:					**2E-06**				**2E-05**				**3E-05**	**5E-05**

Notes:

This C/Q term is estimated using USEPA's SCREEN3 air dispersion model (USEPA 1995) to estimate maximum 1-hour concentrations at ground level. The source area for maintenance workers is based on a 15 by 15 foot excavation.

Attachment 3: Hazard Index Calculations for Exposure of On-Site Maintenance Workers to Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas

					Incidental Ingestion			Dermal Contact				Vapor Inhalation			All Routes
Chem Group	Chemical	CASRN	Cancer Class	C_{gw} (mg/L)	ADD (mg/kg/d)	RfD_{oral} (mg/kg/d)	HQ	DA (L/cm^2-event)	ADD (mg/kg/d)	RfD_{derm} (mg/kg/d)	HQ	C_{air} (mg/m^3)	RfC (mg/m^3)	HQ	HQ
VOC	Acetone	67-64-1	ID	1.99E-01	3.89E-07	9.0E-01	4.3E-07	1.27E-06	1.63E-07	9.0E-01	1.8E-07	1.01E-02	3.1E+01	1.5E-06	2.1E-06
VOC	Benzene	71-43-2	A	6.53E-02	1.28E-07	4.0E-03	3.2E-05	3.70E-05	1.56E-06	4.0E-03	3.9E-04	9.29E-03	3.0E-02	1.4E-03	1.8E-03
VOC	Bromodichloromethane	75-27-4	B2	6.79E-02	1.33E-07	2.0E-02	6.6E-06	1.70E-05	7.45E-07	2.0E-02	3.7E-05	6.45E-03			4.4E-05
VOC	Bromoform	75-25-2	B2	7.67E-02	1.50E-07	2.0E-02	7.5E-06	1.40E-05	6.94E-07	2.0E-02	3.5E-05	5.33E-03			4.2E-05
VOC	Bromomethane	74-83-9	ID	6.13E-02	1.20E-07	1.4E-03	8.6E-05	7.68E-06	3.04E-07	1.4E-03	2.2E-04	7.94E-03	5.0E-03	7.2E-03	7.6E-03
VOC	2-Butanone	78-93-3	ID	1.06E-01	2.07E-07	6.0E-01	3.5E-07	2.42E-06	1.66E-07	6.0E-01	2.8E-07	6.94E-03	5.0E+00	6.3E-06	7.0E-06
VOC	Carbon Disulfide	75-15-0		6.52E-02	1.28E-07	1.0E-01	1.3E-06	3.11E-05	1.31E-06	1.0E-01	1.3E-05	9.51E-03	7.0E-01	6.2E-05	7.6E-05
VOC	Carbon Tetrachloride	56-23-5	LC	6.69E-02	1.31E-07	4.0E-03	3.3E-05	4.84E-05	2.09E-06	4.0E-03	5.2E-04	6.87E-03	1.0E-01	3.1E-04	8.7E-04
VOC	Chlorobenzene	108-90-7	D	6.86E-02	1.34E-07	2.0E-02	6.7E-06	8.00E-05	3.55E-06	2.0E-02	1.8E-04	8.06E-03	5.0E-02	7.4E-04	9.2E-04
VOC	Chloroethane	75-00-3	LC	7.23E-02	1.41E-07	1.0E-01	1.4E-06	1.49E-05	6.95E-07	1.0E-01	6.9E-06	1.14E-02	1.0E+01	5.2E-06	1.4E-05
VOC	Chloroform	67-66-3	B2	6.64E-02	1.30E-07	1.0E-02	1.3E-05	1.86E-05	7.97E-07	1.0E-02	8.0E-05	7.59E-03	5.0E-02	6.9E-04	7.9E-04
VOC	Chloromethane	74-87-3	D	9.00E-02	1.76E-07			3.58E-05	2.08E-06			1.60E-02	9.0E-02	8.1E-04	8.1E-04
VOC	Dibromochloromethane	124-48-1	C	7.13E-02	1.40E-07	2.0E-02	7.0E-06	1.42E-05	6.53E-07	2.0E-02	3.3E-05	5.79E-03			4.0E-05
VOC	1,1-Dichloroethane	75-34-3	SC	6.59E-02	1.29E-07	2.0E-01	6.4E-07	1.83E-05	7.78E-07	2.0E-01	3.9E-06	8.34E-03	5.0E-01	7.6E-05	8.1E-05
VOC	1,2-Dichloroethane	107-06-2	B2	6.61E-02	1.29E-07	6.0E-03	2.2E-05	1.13E-05	4.82E-07	6.0E-03	8.0E-05	7.80E-03	7.0E-03	5.1E-03	5.2E-03
VOC	1,1-Dichloroethene	75-35-4	C	2.50E-01	4.89E-07	5.0E-02	9.8E-06	3.10E-05	5.01E-06	5.0E-02	1.0E-04	3.23E-02	2.0E-01	7.4E-04	8.5E-04
VOC	1,2-Dichloroethene (total)	540-59-0		1.00E+01	1.96E-05	2.0E-03	9.8E-03	2.07E-05	1.34E-04	2.0E-03	6.7E-02	1.27E+00			7.7E-02
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.00E+01	1.96E-05	2.0E-03	9.8E-03	2.07E-05	1.34E-04	2.0E-03	6.7E-02	1.27E+00			7.7E-02
VOC	trans-1,2-Dichloroethene	156-60-5	ID	5.99E-02	1.17E-07	2.0E-02	5.9E-06	2.83E-05	1.10E-06	2.0E-02	5.5E-05	7.70E-03			6.1E-05
VOC	1,2-Dichloropropane	78-87-5	B2	6.52E-02	1.28E-07	9.0E-02	1.4E-06	2.12E-05	8.91E-07	9.0E-02	9.9E-06	7.60E-03	4.0E-03	8.7E-03	8.7E-03
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1.42E-01	2.78E-07	3.0E-02	9.3E-06	2.25E-05	2.07E-06	3.0E-02	6.9E-05	1.72E-02	2.0E-02	3.9E-03	4.0E-03
VOC	Ethyl Benzene	100-41-4	D	6.89E-02	1.35E-07	1.0E-01	1.3E-06	1.27E-04	5.64E-06	1.0E-01	5.6E-05	8.44E-03	1.0E+00	3.9E-05	9.6E-05
VOC	2-Hexanone	591-78-6	ID	1.20E-01	2.35E-07	5.0E-03	4.7E-05	9.75E-06	7.56E-07	5.0E-03	1.5E-04	8.77E-03	3.0E-02	1.3E-03	1.5E-03
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.20E-01	2.35E-07			7.32E-06	5.67E-07			1.01E-02	3.0E+00	1.5E-05	1.5E-05
VOC	Methylene Chloride	75-09-2	LC	3.10E-01	6.07E-07	6.0E-03	1.0E-04	9.25E-06	1.85E-06	6.0E-03	3.1E-04	4.14E-02	6.0E-01	3.2E-04	7.2E-04
VOC	Styrene	100-42-5		6.83E-02	1.34E-07	2.0E-01	6.7E-07	9.63E-05	4.25E-06	2.0E-01	2.1E-05	8.26E-03	1.0E+00	3.8E-05	6.0E-05
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	6.40E-02	1.25E-07	2.0E-02	6.3E-06	2.57E-05	1.06E-06	2.0E-02	5.3E-05	5.03E-03			5.9E-05
VOC	Tetrachloroethene	127-18-4	LC	7.67E-02	1.50E-07	6.0E-03	2.5E-05	3.99E-05	1.98E-06	6.0E-03	3.3E-04	7.57E-03	4.0E-02	8.6E-04	1.2E-03
VOC	Toluene	108-88-3	ID	6.54E-02	1.28E-07	8.0E-02	1.6E-06	8.08E-05	3.41E-06	8.0E-02	4.3E-05	8.58E-03	5.0E+00	7.8E-06	5.2E-05
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.10E-01	2.15E-07	2.0E+00	1.1E-07	3.85E-05	2.74E-06	2.0E+00	1.4E-06	1.21E-02	5.0E+00	1.1E-05	1.3E-05
VOC	1,1,2-Trichloroethane	79-00-5	C	6.59E-02	1.29E-07	4.0E-03	3.2E-05	2.02E-05	8.58E-07	4.0E-03	2.1E-04	6.65E-03	2.0E-04	1.5E-01	1.5E-01
VOC	Trichloroethene	79-01-6	HC	8.10E+01	1.59E-04	5.0E-04	3.2E-01	5.53E-05	2.89E-03	5.0E-04	5.8E+00	8.95E+00	2.0E-03	2.0E+01	2.7E+01
VOC	Vinyl Chloride	75-01-4	A	2.50E+00	4.89E-06	3.0E-03	1.6E-03	1.69E-05	2.72E-05	3.0E-03	9.1E-03	4.03E-01	1.0E-01	1.8E-02	2.9E-02
VOC	Xylenes (total)	1330-20-7	ID	1.99E-01	3.90E-07	2.0E-01	2.0E-06	1.32E-04	1.70E-05	2.0E-01	8.5E-05	2.44E-02	1.0E-01	1.1E-03	1.2E-03
		Hazard Index:					**3E-01**				**6E+00**			**2E+01**	**3E+01**

Notes:

This C/Q term is estimated using USEPA's SCREEN3 air dispersion model (USEPA 1995) to estimate maximum 1-hour concentrations at ground level. The source area for maintenance workers is based on a 15 by 15 foot excavation.

Attachment 3: Cancer Risk Calculations for Exposure of Off-Site Maintenance Workers to Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas

					Incidental Ingestion			Dermal Contact				Vapor Inhalation				All Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	**C_{gw}** (mg/l)	**LADD** (mg/kg/d)	**SF_{oral}** $(mg/kg/d)^{-1}$	**Risk**	**DA** (L/cm^2-event)	**LADD** (mg/kg/d)	**SF_{derm}** $(mg/kg/d)^{-1}$	**Risk**	**C_{air}** (mg/m^3)	**EC** (mg/m^3)	**URF** (m^3/mg)	**Risk**	**Risk**
VOC	Acetone	67-64-1	ID	8.50E-02	2.38E-08			1.27E-06	9.97E-09			4.29E-03	2.80E-06			
VOC	Benzene	71-43-2	A			5.5E-02		3.70E-05		5.5E-02				7.8E-03		
VOC	Bromodichloromethane	75-27-4	B2			6.2E-02		1.70E-05		6.2E-02						
VOC	Bromoform	75-25-2	B2	2.40E-02	6.71E-09	7.9E-03	5.3E-11	1.40E-05	3.10E-08	7.9E-03	2.4E-10	1.67E-03	1.09E-06	1.1E-03	1.2E-09	1.5E-09
VOC	Bromomethane	74-83-9	ID					7.68E-06								
VOC	2-Butanone	78-93-3	ID	9.50E-02	2.66E-08			2.42E-06	2.12E-08			6.22E-03	4.06E-06			
VOC	Carbon Disulfide	75-15-0						3.11E-05								
VOC	Carbon Tetrachloride	56-23-5	LC			7.0E-02		4.84E-05		7.0E-02				6.0E-03		
VOC	Chlorobenzene	108-90-7	D					8.00E-05								
VOC	Chloroethane	75-00-3	LC					1.49E-05								
VOC	Chloroform	67-66-3	B2			1.9E-02		1.86E-05		1.9E-02				2.3E-02		
VOC	Chloromethane	74-87-3	D					3.58E-05								
VOC	Dibromochloromethane	124-48-1	C			8.4E-02		1.42E-05		8.4E-02						
VOC	1,1-Dichloroethane	75-34-3	SC					1.83E-05								
VOC	1,2-Dichloroethane	107-06-2	B2	3.00E-03	8.39E-10	9.1E-02	7.6E-11	1.13E-05	3.13E-09	9.1E-02	2.8E-10	3.54E-04	2.31E-07	2.6E-02	6.0E-09	6.4E-09
VOC	1,1-Dichloroethene	75-35-4	C	4.20E-03	1.17E-09			3.10E-05	1.20E-08			5.43E-04	3.54E-07			
VOC	1,2-Dichloroethene (total)	540-59-0		4.10E-02	1.15E-08			2.07E-05	7.83E-08			5.21E-03	3.40E-06			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	4.10E-02	1.15E-08			2.07E-05	7.83E-08			5.21E-03	3.40E-06			
VOC	trans-1,2-Dichloroethene	156-60-5	ID					2.83E-05								
VOC	1,2-Dichloropropane	78-87-5	B2			3.6E-02		2.12E-05		3.6E-02						
VOC	1,3-Dichloropropene (total)	542-75-6	B2			1.0E-01		2.25E-05		1.0E-01				4.0E-03		
VOC	Ethyl Benzene	100-41-4	D					1.27E-04								
VOC	2-Hexanone	591-78-6	ID					9.75E-06								
VOC	4-Methyl-2-pentanone	108-10-1	ID	4.00E-03	1.12E-09			7.32E-06	2.70E-09			3.38E-04	2.20E-07			
VOC	Methylene Chloride	75-09-2	LC			2.0E-03		9.25E-06		2.0E-03				1.0E-05		
VOC	Styrene	100-42-5						9.63E-05								
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC			2.0E-01		2.57E-05		2.0E-01						
VOC	Tetrachloroethene	127-18-4	LC			2.1E-03		3.99E-05		2.1E-03				2.6E-04		
VOC	Toluene	108-88-3	ID					8.08E-05								
VOC	1,1,1-Trichloroethane	71-55-6	ID					3.85E-05								
VOC	1,1,2-Trichloroethane	79-00-5	C			5.7E-02		2.02E-05		5.7E-02				1.6E-02		
VOC	Trichloroethene	79-01-6	HC	1.60E+00	4.47E-07	4.6E-02	2.1E-08	5.53E-05	8.16E-06	4.6E-02	3.8E-07	1.77E-01	1.15E-04	4.1E-03	4.7E-07	8.7E-07
VOC	Vinyl Chloride	75-01-4	A	3.00E-03	8.39E-10	7.2E-01	6.0E-10	1.69E-05	4.67E-09	7.2E-01	3.4E-09	4.83E-04	3.15E-07	4.4E-03	1.4E-09	5.4E-09
VOC	Xylenes (total)	1330-20-7	ID					1.32E-04								
		Cumulative Risk:					**2E-08**				**4E-07**				**5E-07**	**9E-07**

Notes:

This C/Q term is estimated using USEPA's SCREEN3 air dispersion model (USEPA 1995) to estimate maximum 1-hour concentrations at ground level. The source area for maintenance workers is based on a 15 by 15 foot excavation.

Attachment 3: Hazard Index Calculations for Exposure of Off-Site Maintenance Workers to Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas

					Incidental Ingestion			Dermal Contact				Vapor Inhalation			All Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	**C_{gw} (mg/L)**	**ADD (mg/kg/d)**	**RfD_{oral} (mg/kg/d)**	**HQ**	**DA (L/cm^2-event)**	**ADD (mg/kg/d)**	**RfD_{derm} (mg/kg/d)**	**HQ**	**C_{air} (mg/m^3)**	**RfC (mg/m^3)**	**HQ**	**HQ**
VOC	Acetone	67-64-1	ID	8.50E-02	1.66E-07	9.0E-01	1.8E-07	1.27E-06	6.98E-08	9.0E-01	7.8E-08	4.29E-03	3.1E+01	6.4E-07	9.0E-07
VOC	Benzene	71-43-2	A			4.0E-03		3.70E-05		4.0E-03			3.0E-02		
VOC	Bromodichloromethane	75-27-4	B2			2.0E-02		1.70E-05		2.0E-02					
VOC	Bromoform	75-25-2	B2	2.40E-02	4.70E-08	2.0E-02	2.3E-06	1.40E-05	2.17E-07	2.0E-02	1.1E-05	1.67E-03			1.3E-05
VOC	Bromomethane	74-83-9	ID			1.4E-03		7.68E-06		1.4E-03			5.0E-03		
VOC	2-Butanone	78-93-3	ID	9.50E-02	1.86E-07	6.0E-01	3.1E-07	2.42E-06	1.48E-07	6.0E-01	2.5E-07	6.22E-03	5.0E+00	5.7E-06	6.2E-06
VOC	Carbon Disulfide	75-15-0				1.0E-01		3.11E-05		1.0E-01			7.0E-01		
VOC	Carbon Tetrachloride	56-23-5	LC			4.0E-03		4.84E-05		4.0E-03			1.0E-01		
VOC	Chlorobenzene	108-90-7	D			2.0E-02		8.00E-05		2.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3	LC			1.0E-01		1.49E-05		1.0E-01			1.0E+01		
VOC	Chloroform	67-66-3	B2			1.0E-02		1.86E-05		1.0E-02			5.0E-02		
VOC	Chloromethane	74-87-3	D					3.58E-05					9.0E-02		
VOC	Dibromochloromethane	124-48-1	C			2.0E-02		1.42E-05		2.0E-02					
VOC	1,1-Dichloroethane	75-34-3	SC			2.0E-01		1.83E-05		2.0E-01			5.0E-01		
VOC	1,2-Dichloroethane	107-06-2	B2	3.00E-03	5.87E-09	6.0E-03	9.8E-07	1.13E-05	2.19E-08	6.0E-03	3.6E-06	3.54E-04	7.0E-03	2.3E-04	2.4E-04
VOC	1,1-Dichloroethene	75-35-4	C	4.20E-03	8.22E-09	5.0E-02	1.6E-07	3.10E-05	8.41E-08	5.0E-02	1.7E-06	5.43E-04	2.0E-01	1.2E-05	1.4E-05
VOC	1,2-Dichloroethene (total)	540-59-0		4.10E-02	8.02E-08	2.0E-03	4.0E-05	2.07E-05	5.48E-07	2.0E-03	2.7E-04	5.21E-03			3.1E-04
VOC	cis-1,2-Dichloroethene	156-59-2	ID	4.10E-02	8.02E-08	2.0E-03	4.0E-05	2.07E-05	5.48E-07	2.0E-03	2.7E-04	5.21E-03			3.1E-04
VOC	trans-1,2-Dichloroethene	156-60-5	ID			2.0E-02		2.83E-05		2.0E-02					
VOC	1,2-Dichloropropane	78-87-5	B2			9.0E-02		2.12E-05		9.0E-02			4.0E-03		
VOC	1,3-Dichloropropene (total)	542-75-6	B2			3.0E-02		2.25E-05		3.0E-02			2.0E-02		
VOC	Ethyl Benzene	100-41-4	D			1.0E-01		1.27E-04		1.0E-01			1.0E+00		
VOC	2-Hexanone	591-78-6	ID			5.0E-03		9.75E-06		5.0E-03			3.0E-02		
VOC	4-Methyl-2-pentanone	108-10-1	ID	4.00E-03	7.83E-09			7.32E-06	1.89E-08			3.38E-04	3.0E+00	5.1E-07	5.1E-07
VOC	Methylene Chloride	75-09-2	LC			6.0E-03		9.25E-06		6.0E-03			6.0E-01		
VOC	Styrene	100-42-5				2.0E-01		9.63E-05		2.0E-01			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC			2.0E-02		2.57E-05		2.0E-02					
VOC	Tetrachloroethene	127-18-4	LC			6.0E-03		3.99E-05		6.0E-03			4.0E-02		
VOC	Toluene	108-88-3	ID			8.0E-02		8.08E-05		8.0E-02			5.0E+00		
VOC	1,1,1-Trichloroethane	71-55-6	ID			2.0E+00		3.85E-05		2.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5	C			4.0E-03		2.02E-05		4.0E-03			2.0E-04		
VOC	Trichloroethene	79-01-6	HC	1.60E+00	3.13E-06	5.0E-04	6.3E-03	5.53E-05	5.71E-05	5.0E-04	1.1E-01	1.77E-01	2.0E-03	4.0E-01	5.2E-01
VOC	Vinyl Chloride	75-01-4	A	3.00E-03	5.87E-09	3.0E-03	2.0E-06	1.69E-05	3.27E-08	3.0E-03	1.1E-05	4.83E-04	1.0E-01	2.2E-05	3.5E-05
VOC	Xylenes (total)	1330-20-7	ID			2.0E-01		1.32E-04		2.0E-01			1.0E-01		
			Hazard Index:				**6E-03**				**1E-01**			**4E-01**	**5E-01**

Notes:

This C/Q term is estimated using USEPA's SCREEN3 air dispersion model (USEPA 1995) to estimate maximum 1-hour concentrations at ground level. The source area for maintenance workers is based on a 15 by 15 foot excavation.

Attachment 4

Construction Worker Risk Calculations

Contents:

- Vapor Flux from Soil to Outdoor Air
- Cancer Risk Calculations for Exposure of On-Site Construction Workers to Soil
- Hazard Index Calculations for Exposure of On-Site Construction Workers to Soil

- Cancer Risk Calculations for Exposure of On-Site Construction Workers to Groundwater in Excavations
- Hazard Index Calculations for Exposure of On-Site Construction Workers to Groundwater in Excavations

Attachment 4: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	K_{oc} (L/kg)	H (unitless)	D_{air} (m^2/d)	D_{water} (m^2/d)	R_L (unitless)	D_G (m^2/d)	D_L (m^2/d)	D_E (m^2/d)	Infinite J_v (kg/m^2-s)	Finite depth Z1 ERFC term	Finite depth Z2 ERFC term	Finite J_v (kg/m^2-s)	J_v (kg/m^2-s)
VOC	Acetone	67-64-1	5.81E-01	1.14E-03	1.07E+00	9.85E-05	3.17E-01	1.15E-02	9.10E-06	7.01E-05	7.90E-06	0.00E+00	0.00E+00	7.90E-06	7.90E-06
VOC	Benzene	71-43-2	5.82E+01	1.59E-01	7.60E-01	8.47E-05	5.02E-01	8.19E-03	7.82E-06	2.61E-03	4.82E-05	0.00E+00	2.93E-02	4.80E-05	4.80E-05
VOC	Bromodichloromethane	75-27-4	5.51E+01	4.45E-02	2.57E-01	9.16E-05	4.75E-01	2.77E-03	8.46E-06	2.78E-04	1.57E-05	0.00E+00	1.68E-15	1.57E-05	1.57E-05
VOC	Bromoform	75-25-2	8.70E+01	1.34E-02	1.29E-01	8.90E-05	5.58E-01	1.39E-03	8.22E-06	4.80E-05	6.53E-06	0.00E+00	0.00E+00	6.53E-06	6.53E-06
VOC	Bromomethane	74-83-9	1.05E+01	2.01E-01	6.29E-01	1.05E-04	3.78E-01	6.78E-03	9.65E-06	3.63E-03	5.69E-05	0.00E+00	9.03E-02	5.62E-05	5.62E-05
VOC	2-Butanone	78-93-3	2.00E+00	1.96E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.03E-05	7.91E-06	0.00E+00	0.00E+00	7.91E-06	7.91E-06
VOC	Carbon Disulfide	75-15-0	4.59E+01	9.26E-01	8.99E-01	8.64E-05	5.96E-01	9.68E-03	7.98E-06	1.51E-02	1.16E-04	0.00E+00	9.88E-01	9.60E-05	9.60E-05
VOC	Carbon Tetrachloride	56-23-5	1.74E+02	8.82E-01	6.74E-01	7.60E-05	9.41E-01	7.26E-03	7.02E-06	6.81E-03	7.79E-05	0.00E+00	3.69E-01	7.37E-05	7.37E-05
VOC	Chlorobenzene	108-90-7	2.20E+02	9.77E-02	6.31E-01	7.52E-05	9.40E-01	6.79E-03	6.94E-06	7.13E-04	2.52E-05	0.00E+00	1.47E-06	2.52E-05	2.52E-05
VOC	Chloroethane	75-00-3	1.62E+01	3.25E-01	2.34E+00	9.94E-05	4.14E-01	2.52E-02	9.18E-06	1.98E-02	1.33E-04	0.00E+00	1.23E+00	1.03E-04	1.03E-04
VOC	Chloroform	67-66-3	3.97E+01	1.07E-01	8.99E-01	8.64E-05	4.43E-01	9.68E-03	7.98E-06	2.37E-03	4.59E-05	0.00E+00	1.97E-02	4.58E-05	4.58E-05
VOC	Chloromethane	74-87-3	3.97E+01	3.33E-01	1.09E+00	5.62E-05	4.80E-01	1.17E-02	5.19E-06	8.14E-03	8.51E-05	0.00E+00	4.88E-01	7.89E-05	7.89E-05
VOC	Dibromochloromethane	124-48-1	6.26E+01	2.38E-02	1.69E-01	9.07E-05	4.92E-01	1.82E-03	8.38E-06	1.05E-04	9.68E-06	0.00E+00	0.00E+00	9.68E-06	9.68E-06
VOC	1,1-Dichloroethane	75-34-3	3.13E+01	1.66E-01	6.41E-01	9.07E-05	4.29E-01	6.91E-03	8.38E-06	2.68E-03	4.89E-05	0.00E+00	3.28E-02	4.87E-05	4.87E-05
VOC	1,2-Dichloroethane	107-06-2	1.75E+01	2.74E-02	8.99E-01	8.55E-05	3.68E-01	9.68E-03	7.90E-06	7.42E-04	2.57E-05	0.00E+00	2.46E-06	2.57E-05	2.57E-05
VOC	1,1-Dichloroethene	75-35-4	5.82E+01	8.10E-01	7.78E-01	8.99E-05	6.10E-01	8.38E-03	8.30E-06	1.11E-02	9.95E-05	0.00E+00	7.29E-01	8.78E-05	8.78E-05
VOC	1,2-Dichloroethene (total)	540-59-0	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	4.11E-05	0.00E+00	6.86E-03	4.10E-05	4.10E-05
VOC	cis-1,2-Dichloroethene	156-59-2	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	4.11E-05	0.00E+00	6.86E-03	4.10E-05	4.10E-05
VOC	trans-1,2-Dichloroethene	156-60-5	5.22E+01	2.81E-01	6.11E-01	1.03E-04	5.06E-01	6.58E-03	9.49E-06	3.68E-03	5.72E-05	0.00E+00	9.37E-02	5.66E-05	5.66E-05
VOC	1,2-Dichloropropane	78-87-5	4.35E+01	7.82E-02	6.76E-01	7.54E-05	4.48E-01	7.28E-03	6.97E-06	1.28E-03	3.38E-05	0.00E+00	5.82E-04	3.38E-05	3.38E-05
VOC	1,3-Dichloropropene (total)	542-75-6	4.59E+01	4.83E-01	5.41E-01	8.64E-05	5.22E-01	5.83E-03	7.98E-06	5.40E-03	6.93E-05	0.00E+00	2.39E-01	6.71E-05	6.71E-05
VOC	Ethyl Benzene	100-41-4	3.67E+02	2.04E-01	6.48E-01	6.74E-05	1.36E+00	6.98E-03	6.22E-06	1.05E-03	3.06E-05	0.00E+00	1.08E-04	3.06E-05	3.06E-05
VOC	2-Hexanone	591-78-6	1.48E+01	3.23E-03	7.45E-01	7.57E-05	3.57E-01	8.02E-03	6.99E-06	9.23E-05	9.06E-06	0.00E+00	0.00E+00	9.06E-06	9.06E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.05E+01	4.71E-03	6.48E-01	6.74E-05	3.45E-01	6.98E-03	6.22E-06	1.13E-04	1.00E-05	0.00E+00	0.00E+00	1.00E-05	1.00E-05
VOC	Methylene Chloride	75-09-2	1.17E+01	6.60E-02	8.73E-01	1.01E-04	3.59E-01	9.40E-03	9.33E-06	1.76E-03	3.95E-05	0.00E+00	4.51E-03	3.95E-05	3.95E-05
VOC	Styrene	100-42-5	7.77E+02	7.04E-02	6.13E-01	6.91E-05	2.47E+00	6.61E-03	6.38E-06	1.91E-04	1.30E-05	0.00E+00	0.00E+00	1.30E-05	1.30E-05
VOC	1,1,2,2-Tetrachloroethane	79-34-5	9.35E+01	8.74E-03	6.13E-01	6.83E-05	5.75E-01	6.61E-03	6.30E-06	1.11E-04	9.96E-06	0.00E+00	0.00E+00	9.96E-06	9.96E-06
VOC	Tetrachloroethene	127-18-4	1.56E+02	4.90E-01	6.22E-01	7.08E-05	8.27E-01	6.70E-03	6.54E-06	3.98E-03	5.95E-05	0.00E+00	1.17E-01	5.87E-05	5.87E-05
VOC	Toluene	108-88-3	1.80E+02	1.80E-01	7.52E-01	7.43E-05	8.43E-01	8.10E-03	6.86E-06	1.74E-03	3.94E-05	0.00E+00	4.30E-03	3.93E-05	3.93E-05
VOC	1,1,1-Trichloroethane	71-55-6	1.10E+02	4.97E-01	6.74E-01	7.60E-05	7.02E-01	7.26E-03	7.02E-06	5.15E-03	6.77E-05	0.00E+00	2.17E-01	6.58E-05	6.58E-05
VOC	1,1,2-Trichloroethane	79-00-5	5.03E+01	2.43E-02	6.74E-01	7.60E-05	4.58E-01	7.26E-03	7.02E-06	4.00E-04	1.89E-05	0.00E+00	4.84E-11	1.89E-05	1.89E-05
VOC	Trichloroethene	79-01-6	1.68E+02	2.88E-01	6.83E-01	7.86E-05	8.26E-01	7.35E-03	7.26E-06	2.57E-03	4.79E-05	0.00E+00	2.79E-02	4.77E-05	4.77E-05
VOC	Vinyl Chloride	75-01-4	1.85E+01	9.00E-01	9.16E-01	1.06E-04	5.15E-01	9.87E-03	9.81E-06	1.72E-02	1.24E-04	0.00E+00	1.11E+00	9.95E-05	9.95E-05
VOC	Xylenes (total)	1330-20-7	3.86E+02	1.73E-01	6.74E-01	7.56E-05	1.41E+00	7.26E-03	6.98E-06	8.97E-04	2.83E-05	0.00E+00	2.27E-05	2.83E-05	2.83E-05
Notes:	Soil bulk density	kg/L	ρ_b	1.38											
	Soil porosity	L/L-soil	θ	0.48											
	Soil water content	L/L-soil	θ_w	0.32											
	Soil air-filled porosity	L/L-soil	θ_a	0.17											
	Soil organic carbon fraction	unitless	f_{oc}	0.002											
	Averaging period (Exposure Duration)	year	**T**	25											
		days	**T**	9125											
		s	**T**	7.9E+08											
	Molar Gas Constant	L-mmHg/	**R**	62.411											
	Temperature	^oC	**Temp**	16.7											
		K	**Temp**	289.7											
	Clean soil above source	m	Z_1	0.00											
	Bottom of source depth	m	Z_2	3.66											

Attachment 4: Cancer Risk Calculations for Exposure of On-Site Construction Workers to Soil
Whirlpool, Fort Smith, Arkansas

					Soil Ingestion			Soil Dermal Contact				Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes
Chem Group	Chemical	CASRN	Cancer Class	C_{soil} (mg/kg)	LADD (mg/kg/d)	SF_{oral} $(mg/kg/d)^{-1}$	Risk	ABS_{derm}	LADD (mg/kg/d)	SF_{derm} $(mg/kg/d)^{-1}$	Risk	C_{air} (mg/m^3)	URF (m^3/mg)	Risk	C_{air} (mg/m^3)	URF (m^3/mg)	Risk	Risk
VOC	Acetone	67-64-1	ID															
VOC	Benzene	71-43-2	A			5.5E-02				5.5E-02			7.8E-03			7.8E-03		
VOC	Bromodichloromethane	75-27-4	B2			6.2E-02				6.2E-02								
VOC	Bromoform	75-25-2	B2			7.9E-03				7.9E-03			1.1E-03			1.1E-03		
VOC	Bromomethane	74-83-9	ID															
VOC	2-Butanone	78-93-3	ID															
VOC	Carbon Disulfide	75-15-0																
VOC	Carbon Tetrachloride	56-23-5	LC			7.0E-02				7.0E-02			6.0E-03			6.0E-03		
VOC	Chlorobenzene	108-90-7	D															
VOC	Chloroethane	75-00-3	LC															
VOC	Chloroform	67-66-3	B2			1.9E-02				1.9E-02			2.3E-02			2.3E-02		
VOC	Chloromethane	74-87-3	D															
VOC	Dibromochloromethane	124-48-1	C			8.4E-02				8.4E-02								
VOC	1,1-Dichloroethane	75-34-3	SC															
VOC	1,2-Dichloroethane	107-06-2	B2			9.1E-02				9.1E-02			2.6E-02			2.6E-02		
VOC	1,1-Dichloroethene	75-35-4	C															
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	3.35E-10							1.67E-05			6.00E-10			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	3.35E-10							1.67E-05			6.00E-10			
VOC	trans-1,2-Dichloroethene	156-60-5	ID															
VOC	1,2-Dichloropropane	78-87-5	B2			3.6E-02				3.6E-02								
VOC	1,3-Dichloropropene (total)	542-75-6	B2			1.0E-01				1.0E-01			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4	D															
VOC	2-Hexanone	591-78-6	ID															
VOC	4-Methyl-2-pentanone	108-10-1	ID															
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	1.96E-10	2.0E-03	3.9E-13			2.0E-03		9.40E-06	1.0E-05	3.1E-13	3.50E-10	1.0E-05	1.1E-17	7.0E-13
VOC	Styrene	100-42-5																
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC			2.0E-01				2.0E-01								
VOC	Tetrachloroethene	127-18-4	LC			2.1E-03				2.1E-03			2.6E-04			2.6E-04		
VOC	Toluene	108-88-3	ID															
VOC	1,1,1-Trichloroethane	71-55-6	ID															
VOC	1,1,2-Trichloroethane	79-00-5	C			5.7E-02				5.7E-02			1.6E-02			1.6E-02		
VOC	Trichloroethene	79-01-6	HC	1.86E-01	5.20E-09	4.6E-02	2.4E-10			4.6E-02		3.02E-04	4.1E-03	4.0E-09	9.30E-09	4.1E-03	1.2E-13	4.3E-09
VOC	Vinyl Chloride	75-01-4	A			7.2E-01				7.2E-01			4.4E-03			4.4E-03		
VOC	Xylenes (total)	1330-20-7	ID															
		Cumulative Risk:					**2E-10**							**4E-09**			**1E-13**	**4E-09**

Notes:

The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).

This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.

The concentration of particulates in the air is assumed to be no more than the former annual National Ambient Air Quality Standards (NAAQS) for PM_{10} of 50 ug/m^3.

Attachment 4: Hazard Index Calculations for Exposure of On-Site Construction Workers to Soil
Whirlpool, Fort Smith, Arkansas

				Soil Ingestion				Soil Dermal Contact				Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes
Chem Group	Chemical	CASRN	Cancer Class	C_{soil} (mg/kg)	ADD (mg/kg/d)	RfD_{oral} (mg/kg/d)	HQ	ABS_{derm}	ADD (mg/kg/d)	RfD_{derm} (mg/kg/d)	HQ	C_{air} (mg/m^3)	RfC (mg/m^3)	HQ	C_{air} (mg/m^3)	RfC (mg/m^3)	HQ	HQ
VOC	Acetone	67-64-1	ID			2.0E+00				2.0E+00			3.1E+01			3.1E+01		
VOC	Benzene	71-43-2	A			1.0E-02				1.0E-02			9.0E-02			9.0E-02		
VOC	Bromodichloromethane	75-27-4	B2			2.0E-02				2.0E-02			2.0E-02			2.0E-02		
VOC	Bromoform	75-25-2	B2			3.0E-02				3.0E-02								
VOC	Bromomethane	74-83-9	ID			5.0E-03				5.0E-03			1.0E-01			1.0E-01		
VOC	2-Butanone	78-93-3	ID			2.0E+00				2.0E+00			5.0E+00			5.0E+00		
VOC	Carbon Disulfide	75-15-0				1.0E-01				1.0E-01			7.0E-01			7.0E-01		
VOC	Carbon Tetrachloride	56-23-5	LC			1.0E-02				1.0E-02			1.9E-01			1.9E-01		
VOC	Chlorobenzene	108-90-7	D			7.0E-02				7.0E-02			5.0E-01			5.0E-01		
VOC	Chloroethane	75-00-3	LC			1.0E-01				1.0E-01			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	B2			1.0E-01				1.0E-01			5.0E-02			5.0E-02		
VOC	Chloromethane	74-87-3	D										4.1E-01			4.1E-01		
VOC	Dibromochloromethane	124-48-1	C			7.0E-02				7.0E-02								
VOC	1,1-Dichloroethane	75-34-3	SC			2.0E+00				2.0E+00			5.0E+00			5.0E+00		
VOC	1,2-Dichloroethane	107-06-2	B2			2.0E-02				2.0E-02			7.0E-02			7.0E-02		
VOC	1,1-Dichloroethene	75-35-4	C			5.0E-02				5.0E-02			2.0E-01			2.0E-01		
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	2.35E-08	2.0E-02	1.2E-06			2.0E-02		1.67E-05			6.00E-10			1.2E-06
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	2.35E-08	2.0E-02	1.2E-06			2.0E-02		1.67E-05			6.00E-10			1.2E-06
VOC	trans-1,2-Dichloroethene	156-60-5	ID			2.0E-01				2.0E-01								
VOC	1,2-Dichloropropane	78-87-5	B2			7.0E-02				7.0E-02			1.3E-02			1.3E-02		
VOC	1,3-Dichloropropene (total)	542-75-6	B2			4.0E-02				4.0E-02			3.6E-02			3.6E-02		
VOC	Ethyl Benzene	100-41-4	D			1.0E-01				1.0E-01			9.0E+00			9.0E+00		
VOC	2-Hexanone	591-78-6	ID			5.0E-03				5.0E-03			3.0E-01			3.0E-01		
VOC	4-Methyl-2-pentanone	108-10-1	ID										3.0E+00			3.0E+00		
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	1.37E-08	6.0E-02	2.3E-07			6.0E-02		9.40E-06	1.0E+00	2.1E-06	3.50E-10	1.0E+00	7.7E-11	2.3E-06
VOC	Styrene	100-42-5				2.0E-01				2.0E-01			3.0E+00			3.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC			5.0E-02				5.0E-02								
VOC	Tetrachloroethene	127-18-4	LC			1.0E-01				1.0E-01			4.0E-02			4.0E-02		
VOC	Toluene	108-88-3	ID			8.0E-01				8.0E-01			5.0E+00			5.0E+00		
VOC	1,1,1-Trichloroethane	71-55-6	ID			7.0E+00				7.0E+00			5.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5	C			4.0E-03				4.0E-03			2.0E-03			2.0E-03		
VOC	Trichloroethene	79-01-6	HC	1.86E-01	3.64E-07	5.0E-04	7.3E-04			5.0E-04		3.02E-04	5.4E-01	1.3E-04	9.30E-09	5.4E-01	4.0E-09	8.6E-04
VOC	Vinyl Chloride	75-01-4	A			3.0E-03				3.0E-03			1.0E-01			1.0E-01		
VOC	Xylenes (total)	1330-20-7	ID			2.0E-01				2.0E-01			3.0E-01			3.0E-01		
		Hazard Index:					**7E-04**							**1E-04**			**4E-09**	**9E-04**

Notes:

The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).

This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.

The concentration of particulates in the air is assumed to be no more than the former annual National Ambient Air Quality Standards (NAAQS) for PM_{10} of 50 ug/m^3.

Attachment 4: Cancer Risk Calculations for Exposure of On-Site Construction Workers to Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas

					Incidental Ingestion			Dermal Contact				Vapor Inhalation				All Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	**C_{gw}** (mg/l)	**LADD** (mg/kg/d)	**SF_{oral}** $(mg/kg/d)^{-1}$	**Risk**	**DA** (L/cm^2-event)	**LADD** (mg/kg/d)	**SF_{derm}** $(mg/kg/d)^{-1}$	**Risk**	**C_{air}** (mg/m^3)	**EC** (mg/m^3)	**URF** (m^3/mg)	**Risk**	**Risk**
VOC	Acetone	67-64-1	ID	1.99E-01	5.56E-09			1.27E-06	2.33E-09			1.01E-02	6.56E-07			
VOC	Benzene	71-43-2	A	6.53E-02	1.83E-09	5.5E-02	1.0E-10	3.70E-05	2.23E-08	5.5E-02	1.2E-09	9.29E-03	6.06E-07	7.8E-03	4.7E-09	6.1E-09
VOC	Bromodichloromethane	75-27-4	B2	6.79E-02	1.90E-09	6.2E-02	1.2E-10	1.70E-05	1.06E-08	6.2E-02	6.6E-10	6.45E-03	4.21E-07			7.8E-10
VOC	Bromoform	75-25-2	B2	7.67E-02	2.14E-09	7.9E-03	1.7E-11	1.40E-05	9.91E-09	7.9E-03	7.8E-11	5.33E-03	3.48E-07	1.1E-03	3.8E-10	4.8E-10
VOC	Bromomethane	74-83-9	ID	6.13E-02	1.71E-09			7.68E-06	4.34E-09			7.94E-03	5.18E-07			
VOC	2-Butanone	78-93-3	ID	1.06E-01	2.96E-09			2.42E-06	2.37E-09			6.94E-03	4.53E-07			
VOC	Carbon Disulfide	75-15-0		6.52E-02	1.82E-09			3.11E-05	1.87E-08			9.51E-03	6.21E-07			
VOC	Carbon Tetrachloride	56-23-5	LC	6.69E-02	1.87E-09	7.0E-02	1.3E-10	4.84E-05	2.99E-08	7.0E-02	2.1E-09	6.87E-03	4.48E-07	6.0E-03	2.7E-09	4.9E-09
VOC	Chlorobenzene	108-90-7	D	6.86E-02	1.92E-09			8.00E-05	5.06E-08			8.06E-03	5.26E-07			
VOC	Chloroethane	75-00-3	LC	7.23E-02	2.02E-09			1.49E-05	9.93E-09			1.14E-02	7.44E-07			
VOC	Chloroform	67-66-3	B2	6.64E-02	1.86E-09	1.9E-02	3.5E-11	1.86E-05	1.14E-08	1.9E-02	2.2E-10	7.59E-03	4.95E-07	2.3E-02	1.1E-08	1.2E-08
VOC	Chloromethane	74-87-3	D	9.00E-02	2.52E-09			3.58E-05	2.97E-08			1.60E-02	1.05E-06			
VOC	Dibromochloromethane	124-48-1	C	7.13E-02	1.99E-09	8.4E-02	1.7E-10	1.42E-05	9.33E-09	8.4E-02	7.8E-10	5.79E-03	3.78E-07			9.5E-10
VOC	1,1-Dichloroethane	75-34-3	SC	6.59E-02	1.84E-09			1.83E-05	1.11E-08			8.34E-03	5.44E-07			
VOC	1,2-Dichloroethane	107-06-2	B2	6.61E-02	1.85E-09	9.1E-02	1.7E-10	1.13E-05	6.89E-09	9.1E-02	6.3E-10	7.80E-03	5.09E-07	2.6E-02	1.3E-08	1.4E-08
VOC	1,1-Dichloroethene	75-35-4	C	2.50E-01	6.99E-09			3.10E-05	7.15E-08			3.23E-02	2.11E-06			
VOC	1,2-Dichloroethene (total)	540-59-0		1.00E+01	2.80E-07			2.07E-05	1.91E-06			1.27E+00	8.29E-05			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.00E+01	2.80E-07			2.07E-05	1.91E-06			1.27E+00	8.29E-05			
VOC	trans-1,2-Dichloroethene	156-60-5	ID	5.99E-02	1.67E-09			2.83E-05	1.57E-08			7.70E-03	5.02E-07			
VOC	1,2-Dichloropropane	78-87-5	B2	6.52E-02	1.82E-09	3.6E-02	6.6E-11	2.12E-05	1.27E-08	3.6E-02	4.6E-10	7.60E-03	4.96E-07			5.2E-10
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1.42E-01	3.98E-09	1.0E-01	4.0E-10	2.25E-05	2.96E-08	1.0E-01	3.0E-09	1.72E-02	1.12E-06	4.0E-03	4.5E-09	7.8E-09
VOC	Ethyl Benzene	100-41-4	D	6.89E-02	1.93E-09			1.27E-04	8.06E-08			8.44E-03	5.50E-07			
VOC	2-Hexanone	591-78-6	ID	1.20E-01	3.35E-09			9.75E-06	1.08E-08			8.77E-03	5.72E-07			
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.20E-01	3.35E-09			7.32E-06	8.10E-09			1.01E-02	6.61E-07			
VOC	Methylene Chloride	75-09-2	LC	3.10E-01	8.67E-09	2.0E-03	1.7E-11	9.25E-06	2.65E-08	2.0E-03	5.3E-11	4.14E-02	2.70E-06	1.0E-05	2.7E-11	9.7E-11
VOC	Styrene	100-42-5		6.83E-02	1.91E-09			9.63E-05	6.07E-08			8.26E-03	5.39E-07			
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	6.40E-02	1.79E-09	2.0E-01	3.6E-10	2.57E-05	1.52E-08	2.0E-01	3.0E-09	5.03E-03	3.28E-07			3.4E-09
VOC	Tetrachloroethene	127-18-4	LC	7.67E-02	2.14E-09	2.1E-03	4.5E-12	3.99E-05	2.82E-08	2.1E-03	5.9E-11	7.57E-03	4.94E-07	2.6E-04	1.3E-10	1.9E-10
VOC	Toluene	108-88-3	ID	6.54E-02	1.83E-09			8.08E-05	4.88E-08			8.58E-03	5.60E-07			
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.10E-01	3.08E-09			3.85E-05	3.91E-08			1.21E-02	7.90E-07			
VOC	1,1,2-Trichloroethane	79-00-5	C	6.59E-02	1.84E-09	5.7E-02	1.1E-10	2.02E-05	1.23E-08	5.7E-02	7.0E-10	6.65E-03	4.34E-07	1.6E-02	6.9E-09	7.7E-09
VOC	Trichloroethene	79-01-6	HC	8.10E+01	2.26E-06	4.6E-02	1.0E-07	5.53E-05	4.13E-05	4.6E-02	1.9E-06	8.95E+00	5.84E-04	4.1E-03	2.4E-06	4.4E-06
VOC	Vinyl Chloride	75-01-4	A	2.50E+00	6.99E-08	7.2E-01	5.0E-08	1.69E-05	3.89E-07	7.2E-01	2.8E-07	4.03E-01	2.63E-05	4.4E-03	1.2E-07	4.5E-07
VOC	Xylenes (total)	1330-20-7	ID	1.99E-01	5.57E-09			1.32E-04	2.42E-07			2.44E-02	1.59E-06			
		Cumulative Risk:					**2E-07**				**2E-06**				**3E-06**	**5E-06**

Notes:

This C/Q term is estimated using USEPA's SCREEN3 air dispersion model (USEPA 1995) to estimate maximum 1-hour concentrations at ground level. The source area for maintenance workers is based on a 15 by 15 foot excavation.

Attachment 4: Hazard Index Calculations for Exposure of On-Site Construction Workers to Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas

					Incidental Ingestion			Dermal Contact				Vapor Inhalation			All Routes
Chem Group	Chemical	CASRN	Cancer Class	C_{gw} (mg/L)	ADD (mg/kg/d)	RfD_{oral} (mg/kg/d)	HQ	DA (L/cm^2-event)	ADD (mg/kg/d)	RfD_{derm} (mg/kg/d)	HQ	C_{air} (mg/m^3)	RfC (mg/m^3)	HQ	HQ
VOC	Acetone	67-64-1	ID	1.99E-01	3.89E-07	2.0E+00	1.9E-07	1.27E-06	1.63E-07	2.0E+00	8.2E-08	1.01E-02	3.1E+01	1.5E-06	1.8E-06
VOC	Benzene	71-43-2	A	6.53E-02	1.28E-07	1.0E-02	1.3E-05	3.70E-05	1.56E-06	1.0E-02	1.6E-04	9.29E-03	9.0E-02	4.7E-04	6.4E-04
VOC	Bromodichloromethane	75-27-4	B2	6.79E-02	1.33E-07	2.0E-02	6.6E-06	1.70E-05	7.45E-07	2.0E-02	3.7E-05	6.45E-03	2.0E-02	1.5E-03	1.5E-03
VOC	Bromoform	75-25-2	B2	7.67E-02	1.50E-07	3.0E-02	5.0E-06	1.40E-05	6.94E-07	3.0E-02	2.3E-05	5.33E-03			2.8E-05
VOC	Bromomethane	74-83-9	ID	6.13E-02	1.20E-07	5.0E-03	2.4E-05	7.68E-06	3.04E-07	5.0E-03	6.1E-05	7.94E-03	1.0E-01	3.6E-04	4.5E-04
VOC	2-Butanone	78-93-3	ID	1.06E-01	2.07E-07	2.0E+00	1.0E-07	2.42E-06	1.66E-07	2.0E+00	8.3E-08	6.94E-03	5.0E+00	6.3E-06	6.5E-06
VOC	Carbon Disulfide	75-15-0		6.52E-02	1.28E-07	1.0E-01	1.3E-06	3.11E-05	1.31E-06	1.0E-01	1.3E-05	9.51E-03	7.0E-01	6.2E-05	7.6E-05
VOC	Carbon Tetrachloride	56-23-5	LC	6.69E-02	1.31E-07	1.0E-02	1.3E-05	4.84E-05	2.09E-06	1.0E-02	2.1E-04	6.87E-03	1.9E-01	1.7E-04	3.9E-04
VOC	Chlorobenzene	108-90-7	D	6.86E-02	1.34E-07	7.0E-02	1.9E-06	8.00E-05	3.55E-06	7.0E-02	5.1E-05	8.06E-03	5.0E-01	7.4E-05	1.3E-04
VOC	Chloroethane	75-00-3	LC	7.23E-02	1.41E-07	1.0E-01	1.4E-06	1.49E-05	6.95E-07	1.0E-01	6.9E-06	1.14E-02	1.0E+01	5.2E-06	1.4E-05
VOC	Chloroform	67-66-3	B2	6.64E-02	1.30E-07	1.0E-01	1.3E-06	1.86E-05	7.97E-07	1.0E-01	8.0E-06	7.59E-03	5.0E-02	6.9E-04	7.0E-04
VOC	Chloromethane	74-87-3	D	9.00E-02	1.76E-07			3.58E-05	2.08E-06			1.60E-02	4.1E-01	1.8E-04	1.8E-04
VOC	Dibromochloromethane	124-48-1	C	7.13E-02	1.40E-07	7.0E-02	2.0E-06	1.42E-05	6.53E-07	7.0E-02	9.3E-06	5.79E-03			1.1E-05
VOC	1,1-Dichloroethane	75-34-3	SC	6.59E-02	1.29E-07	2.0E+00	6.4E-08	1.83E-05	7.78E-07	2.0E+00	3.9E-07	8.34E-03	5.0E+00	7.6E-06	8.1E-06
VOC	1,2-Dichloroethane	107-06-2	B2	6.61E-02	1.29E-07	2.0E-02	6.5E-06	1.13E-05	4.82E-07	2.0E-02	2.4E-05	7.80E-03	7.0E-02	5.1E-04	5.4E-04
VOC	1,1-Dichloroethene	75-35-4	C	2.50E-01	4.89E-07	5.0E-02	9.8E-06	3.10E-05	5.01E-06	5.0E-02	1.0E-04	3.23E-02	2.0E-01	7.4E-04	8.5E-04
VOC	1,2-Dichloroethene (total)	540-59-0		1.00E+01	1.96E-05	2.0E-02	9.8E-04	2.07E-05	1.34E-04	2.0E-02	6.7E-03	1.27E+00			7.7E-03
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.00E+01	1.96E-05	2.0E-02	9.8E-04	2.07E-05	1.34E-04	2.0E-02	6.7E-03	1.27E+00			7.7E-03
VOC	trans-1,2-Dichloroethene	156-60-5	ID	5.99E-02	1.17E-07	2.0E-01	5.9E-07	2.83E-05	1.10E-06	2.0E-01	5.5E-06	7.70E-03			6.1E-06
VOC	1,2-Dichloropropane	78-87-5	B2	6.52E-02	1.28E-07	7.0E-02	1.8E-06	2.12E-05	8.91E-07	7.0E-02	1.3E-05	7.60E-03	1.3E-02	2.7E-03	2.7E-03
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1.42E-01	2.78E-07	4.0E-02	7.0E-06	2.25E-05	2.07E-06	4.0E-02	5.2E-05	1.72E-02	3.6E-02	2.2E-03	2.2E-03
VOC	Ethyl Benzene	100-41-4	D	6.89E-02	1.35E-07	1.0E-01	1.3E-06	1.27E-04	5.64E-06	1.0E-01	5.6E-05	8.44E-03	9.0E+00	4.3E-06	6.2E-05
VOC	2-Hexanone	591-78-6	ID	1.20E-01	2.35E-07	5.0E-03	4.7E-05	9.75E-06	7.56E-07	5.0E-03	1.5E-04	8.77E-03	3.0E-01	1.3E-04	3.3E-04
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.20E-01	2.35E-07			7.32E-06	5.67E-07			1.01E-02	3.0E+00	1.5E-05	1.5E-05
VOC	Methylene Chloride	75-09-2	LC	3.10E-01	6.07E-07	6.0E-02	1.0E-05	9.25E-06	1.85E-06	6.0E-02	3.1E-05	4.14E-02	1.0E+00	1.8E-04	2.2E-04
VOC	Styrene	100-42-5		6.83E-02	1.34E-07	2.0E-01	6.7E-07	9.63E-05	4.25E-06	2.0E-01	2.1E-05	8.26E-03	3.0E+00	1.3E-05	3.4E-05
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	6.40E-02	1.25E-07	5.0E-02	2.5E-06	2.57E-05	1.06E-06	5.0E-02	2.1E-05	5.03E-03			2.4E-05
VOC	Tetrachloroethene	127-18-4	LC	7.67E-02	1.50E-07	1.0E-01	1.5E-06	3.99E-05	1.98E-06	1.0E-01	2.0E-05	7.57E-03	4.0E-02	8.6E-04	8.9E-04
VOC	Toluene	108-88-3	ID	6.54E-02	1.28E-07	8.0E-01	1.6E-07	8.08E-05	3.41E-06	8.0E-01	4.3E-06	8.58E-03	5.0E+00	7.8E-06	1.2E-05
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.10E-01	2.15E-07	7.0E+00	3.1E-08	3.85E-05	2.74E-06	7.0E+00	3.9E-07	1.21E-02	5.0E+00	1.1E-05	1.1E-05
VOC	1,1,2-Trichloroethane	79-00-5	C	6.59E-02	1.29E-07	4.0E-03	3.2E-05	2.02E-05	8.58E-07	4.0E-03	2.1E-04	6.65E-03	2.0E-03	1.5E-02	1.5E-02
VOC	Trichloroethene	79-01-6	HC	8.10E+01	1.59E-04	5.0E-04	3.2E-01	5.53E-05	2.89E-03	5.0E-04	5.8E+00	8.95E+00	5.4E-01	7.6E-02	6.2E+00
VOC	Vinyl Chloride	75-01-4	A	2.50E+00	4.89E-06	3.0E-03	1.6E-03	1.69E-05	2.72E-05	3.0E-03	9.1E-03	4.03E-01	1.0E-01	1.8E-02	2.9E-02
VOC	Xylenes (total)	1330-20-7	ID	1.99E-01	3.90E-07	2.0E-01	2.0E-06	1.32E-04	1.70E-05	2.0E-01	8.5E-05	2.44E-02	3.0E-01	3.7E-04	4.6E-04
				Hazard Index:			3E-01				6E+00			1E-01	6E+00

Notes:

This C/Q term is estimated using USEPA's SCREEN3 air dispersion model (USEPA 1995) to estimate maximum 1-hour concentrations at ground level. The source area for maintenance workers is based on a 15 by 15 foot excavation.

Attachment 5

Off-Site Resident Risk Calculations

Contents:

- Vapor Flux from On-Site Soil to Outdoor Air
- Soil PM10 Emission from Wind Erosion
- Cancer Risk Calculations for Exposure of Residents to On-Site Soil
- Hazard Index Calculations for Exposure of Residents to On-Site Soil

- Soil Moisture Profile for Residential Building (Slab-on-Grade)
- Normalized Indoor Air Concentration in a Residential Building (Slab-on-Grade) due to Vapor Intrusion from Groundwater
- Cancer Risk and Hazard Index Calculations Residents due to Groundwater Vapor Intrusion into a Residential Building (Slab-on-Grade)

- Vapor Flux to Outdoor Air from Groundwater
- Cancer Risk and Hazard Index Calculations for Exposure of Resident to Groundwater-Derived Vapors in Outdoor Air

Attachment 5: Vapor Flux from On-Site Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	K_{oc} (L/kg)	H (unitless)	D_{air} (m^2/d)	D_{water} (m^2/d)	R_L (unitless)	D_G (m^2/d)	D_L (m^2/d)	D_E (m^2/d)	Infinite J_v (kg/m^2-s)	Finite depth Z1 ERFC term	Finite depth Z2 ERFC term	Finite J_v (kg/m^2-s)	J_v (kg/m^2-s)
VOC	Acetone	67-64-1	5.81E-01	1.14E-03	1.07E+00	9.85E-05	3.17E-01	1.15E-02	9.10E-06	7.01E-05	1.44E-06	0.00E+00	1.16E-02	1.44E-06	1.44E-06
VOC	Benzene	71-43-2	5.82E+01	1.59E-01	7.60E-01	8.47E-05	5.02E-01	8.19E-03	7.82E-06	2.61E-03	8.79E-06	0.00E+00	2.30E+00	4.32E-06	4.32E-06
VOC	Bromodichloromethane	75-27-4	5.51E+01	4.45E-02	2.57E-01	9.16E-05	4.75E-01	2.77E-03	8.46E-06	2.78E-04	2.87E-06	0.00E+00	5.05E-01	2.65E-06	2.65E-06
VOC	Bromoform	75-25-2	8.70E+01	1.34E-02	1.29E-01	8.90E-05	5.58E-01	1.39E-03	8.22E-06	4.80E-05	1.19E-06	0.00E+00	1.31E-03	1.19E-06	1.19E-06
VOC	Bromomethane	74-83-9	1.05E+01	2.01E-01	6.29E-01	1.05E-04	3.78E-01	6.78E-03	9.65E-06	3.63E-03	1.04E-05	0.00E+00	2.49E+00	4.47E-06	4.47E-06
VOC	2-Butanone	78-93-3	2.00E+00	1.96E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.03E-05	1.44E-06	0.00E+00	1.17E-02	1.44E-06	1.44E-06
VOC	Carbon Disulfide	75-15-0	4.59E+01	9.26E-01	8.99E-01	8.64E-05	5.96E-01	9.68E-03	7.98E-06	1.51E-02	2.11E-05	0.00E+00	3.07E+00	4.91E-06	4.91E-06
VOC	Carbon Tetrachloride	56-23-5	1.74E+02	8.82E-01	6.74E-01	7.60E-05	9.41E-01	7.26E-03	7.02E-06	6.81E-03	1.42E-05	0.00E+00	2.80E+00	4.70E-06	4.70E-06
VOC	Chlorobenzene	108-90-7	2.20E+02	9.77E-02	6.31E-01	7.52E-05	9.40E-01	6.79E-03	6.94E-06	7.13E-04	4.60E-06	0.00E+00	1.30E+00	3.49E-06	3.49E-06
VOC	Chloroethane	75-00-3	1.62E+01	3.25E-01	2.34E+00	9.94E-05	4.14E-01	2.52E-02	9.18E-06	1.98E-02	2.43E-05	0.00E+00	3.15E+00	4.96E-06	4.96E-06
VOC	Chloroform	67-66-3	3.97E+01	1.07E-01	8.99E-01	8.64E-05	4.43E-01	9.68E-03	7.98E-06	2.37E-03	8.38E-06	0.00E+00	2.24E+00	4.28E-06	4.28E-06
VOC	Chloromethane	74-87-3	3.97E+01	3.33E-01	1.09E+00	5.62E-05	4.80E-01	1.17E-02	5.19E-06	8.14E-03	1.55E-05	0.00E+00	2.87E+00	4.76E-06	4.76E-06
VOC	Dibromochloromethane	124-48-1	6.26E+01	2.38E-02	1.69E-01	9.07E-05	4.92E-01	1.82E-03	8.38E-06	1.05E-04	1.77E-06	0.00E+00	5.87E-02	1.76E-06	1.76E-06
VOC	1,1-Dichloroethane	75-34-3	3.13E+01	1.66E-01	6.41E-01	9.07E-05	4.29E-01	6.91E-03	8.38E-06	2.68E-03	8.92E-06	0.00E+00	2.32E+00	4.34E-06	4.34E-06
VOC	1,2-Dichloroethane	107-06-2	1.75E+01	2.74E-02	8.99E-01	8.55E-05	3.68E-01	9.68E-03	7.90E-06	7.42E-04	4.69E-06	0.00E+00	1.33E+00	3.53E-06	3.53E-06
VOC	1,1-Dichloroethene	75-35-4	5.82E+01	8.10E-01	7.78E-01	8.99E-05	6.10E-01	8.38E-03	8.30E-06	1.11E-02	1.82E-05	0.00E+00	2.98E+00	4.84E-06	4.84E-06
VOC	1,2-Dichloroethene (total)	540-59-0	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	7.50E-06	0.00E+00	2.09E+00	4.16E-06	4.16E-06
VOC	cis-1,2-Dichloroethene	156-59-2	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	7.50E-06	0.00E+00	2.09E+00	4.16E-06	4.16E-06
VOC	trans-1,2-Dichloroethene	156-60-5	5.22E+01	2.81E-01	6.11E-01	1.03E-04	5.06E-01	6.58E-03	9.49E-06	3.68E-03	1.04E-05	0.00E+00	2.50E+00	4.48E-06	4.48E-06
VOC	1,2-Dichloropropane	78-87-5	4.35E+01	7.82E-02	6.76E-01	7.54E-05	4.48E-01	7.28E-03	6.97E-06	1.28E-03	6.17E-06	0.00E+00	1.79E+00	3.92E-06	3.92E-06
VOC	1,3-Dichloropropene (total)	542-75-6	4.59E+01	4.83E-01	5.41E-01	8.64E-05	5.22E-01	5.83E-03	7.98E-06	5.40E-03	1.27E-05	0.00E+00	2.69E+00	4.63E-06	4.63E-06
VOC	Ethyl Benzene	100-41-4	3.67E+02	2.04E-01	6.48E-01	6.74E-05	1.36E+00	6.98E-03	6.22E-06	1.05E-03	5.58E-06	0.00E+00	1.63E+00	3.79E-06	3.79E-06
VOC	2-Hexanone	591-78-6	1.48E+01	3.23E-03	7.45E-01	7.57E-05	3.57E-01	8.02E-03	6.99E-06	9.23E-05	1.65E-06	0.00E+00	3.69E-02	1.65E-06	1.65E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.05E+01	4.71E-03	6.48E-01	6.74E-05	3.45E-01	6.98E-03	6.22E-06	1.13E-04	1.83E-06	0.00E+00	7.41E-02	1.82E-06	1.82E-06
VOC	Methylene Chloride	75-09-2	1.17E+01	6.60E-02	8.73E-01	1.01E-04	3.59E-01	9.40E-03	9.33E-06	1.76E-03	7.22E-06	0.00E+00	2.03E+00	4.11E-06	4.11E-06
VOC	Styrene	100-42-5	7.77E+02	7.04E-02	6.13E-01	6.91E-05	2.47E+00	6.61E-03	6.38E-06	1.91E-04	2.38E-06	0.00E+00	2.69E-01	2.29E-06	2.29E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	9.35E+01	8.74E-03	6.13E-01	6.83E-05	5.75E-01	6.61E-03	6.30E-06	1.11E-04	1.82E-06	0.00E+00	7.02E-02	1.80E-06	1.80E-06
VOC	Tetrachloroethene	127-18-4	1.56E+02	4.90E-01	6.22E-01	7.08E-05	8.27E-01	6.70E-03	6.54E-06	3.98E-03	1.09E-05	0.00E+00	2.54E+00	4.51E-06	4.51E-06
VOC	Toluene	108-88-3	1.80E+02	1.80E-01	7.52E-01	7.43E-05	8.43E-01	8.10E-03	6.86E-06	1.74E-03	7.19E-06	0.00E+00	2.02E+00	4.11E-06	4.11E-06
VOC	1,1,1-Trichloroethane	71-55-6	1.10E+02	4.97E-01	6.74E-01	7.60E-05	7.02E-01	7.26E-03	7.02E-06	5.15E-03	1.24E-05	0.00E+00	2.67E+00	4.61E-06	4.61E-06
VOC	1,1,2-Trichloroethane	79-00-5	5.03E+01	2.43E-02	6.74E-01	7.60E-05	4.58E-01	7.26E-03	7.02E-06	4.00E-04	3.45E-06	0.00E+00	7.93E-01	3.00E-06	3.00E-06
VOC	Trichloroethene	79-01-6	1.68E+02	2.88E-01	6.83E-01	7.86E-05	8.26E-01	7.35E-03	7.26E-06	2.57E-03	8.74E-06	0.00E+00	2.29E+00	4.32E-06	4.32E-06
VOC	Vinyl Chloride	75-01-4	1.85E+01	9.00E-01	9.16E-01	1.06E-04	5.15E-01	9.87E-03	9.81E-06	1.72E-02	2.26E-05	0.00E+00	3.11E+00	4.94E-06	4.94E-06
VOC	Xylenes (total)	1330-20-7	3.86E+02	1.73E-01	6.74E-01	7.56E-05	1.41E+00	7.26E-03	6.98E-06	8.97E-04	5.16E-06	0.00E+00	1.50E+00	3.67E-06	3.67E-06
Notes:	Soil bulk density	kg/L	ρ_b	1.38											
	Soil porosity	L/L-soil	θ	0.48											
	Soil water content	L/L-soil	θ_w	0.32											
	Soil air-filled porosity	L/L-soil	θ_a	0.17											
	Soil organic carbon fraction	unitless	f_{oc}	0.002											
	Averaging period (Exposure Duration)	year	**T**	25											
		days	**T**	9125											
		s	**T**	7.9E+08											
	Molar Gas Constant	L-mmHg/	**R**	62.411											
	Temperature	^oC	**Temp**	16.7											
		K	**Temp**	289.7											
	Clean soil above source	m	Z_1	0.00											
	Bottom of source depth	m	Z_2	3.66											

Attachment 5: Soil PM10 Emission from Wind Erosion
Whirlpool, Fort Smith, Arkansas

Unlimited Reservoir Model			
Aerodynamic particle size multiplier			0.036
Ground cover fraction		**G**	0.5
Mode of aggregate size distribution	mm		0.50
Threshold friction velocity	m/s	**u'_t**	0.50
Correction factor			1.25
Corrected friction velocity	m/s	**u^*_t**	0.6252
Roughness height	m	**z_0**	0.005
Anemometer height	m		10.0
Friction velocity at anemometer height	m/s	**u_t**	11.9
Mean annual wind speed	mph	**u_m**	7.6
Mean annual wind speed	m/s	**u_m**	3.40
u_m/u_t			0.286
$x = 0.886\ u_t/u_m$			3.10
F(x)			0.003
Annual average PM_{10} flux	kg-soil/m^2-s	**$J_{10,w}$**	**3.93E-13**

Attachment 5: Cancer Risk Calculations for Exposure of Residents to On-Site Soil
Whirlpool, Fort Smith, Arkansas

					Soil Vapor Inhalation				Soil Particulate Inhalation				All Routes
Chem Group	Chemical	CASRN	Cancer Class	C_{soil} (mg/kg)	C_{air} (mg/m^3)	URF (m^3/mg)	f_{inh}	Risk	C_{air} (mg/m^3)	URF (m^3/mg)	f_{inh}	Risk	Risk
VOC	Acetone	67-64-1	ID										
VOC	Benzene	71-43-2	A			7.8E-03				7.8E-03			
VOC	Bromodichloromethane	75-27-4	B2										
VOC	Bromoform	75-25-2	B2			1.1E-03				1.1E-03			
VOC	Bromomethane	74-83-9	ID										
VOC	2-Butanone	78-93-3	ID										
VOC	Carbon Disulfide	75-15-0											
VOC	Carbon Tetrachloride	56-23-5	LC			6.0E-03				6.0E-03			
VOC	Chlorobenzene	108-90-7	D										
VOC	Chloroethane	75-00-3	LC										
VOC	Chloroform	67-66-3	B2			2.3E-02				2.3E-02			
VOC	Chloromethane	74-87-3	D										
VOC	Dibromochloromethane	124-48-1	C										
VOC	1,1-Dichloroethane	75-34-3	SC										
VOC	1,2-Dichloroethane	107-06-2	B2			2.6E-02				2.6E-02			
VOC	1,1-Dichloroethene	75-35-4	C										
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	1.70E-06				1.60E-13				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	1.70E-06				1.60E-13				
VOC	trans-1,2-Dichloroethene	156-60-5	ID										
VOC	1,2-Dichloropropane	78-87-5	B2										
VOC	1,3-Dichloropropene (total)	542-75-6	B2			4.0E-03				4.0E-03			
VOC	Ethyl Benzene	100-41-4	D										
VOC	2-Hexanone	591-78-6	ID										
VOC	4-Methyl-2-pentanone	108-10-1	ID										
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	9.79E-07	1.0E-05	1	1.0E-11	9.35E-14	1.0E-05	1	9.7E-19	1.0E-11
VOC	Styrene	100-42-5											
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC										
VOC	Tetrachloroethene	127-18-4	LC			2.6E-04				2.6E-04			
VOC	Toluene	108-88-3	ID										
VOC	1,1,1-Trichloroethane	71-55-6	ID										
VOC	1,1,2-Trichloroethane	79-00-5	C			1.6E-02				1.6E-02			
VOC	Trichloroethene	79-01-6	HC	1.86E-01	2.73E-05	4.1E-03	0.244	6.3E-08	2.48E-12	4.1E-03	0.244	5.7E-15	6.3E-08
VOC	Vinyl Chloride	75-01-4	A			4.4E-03				4.4E-03			
VOC	Xylenes (total)	1330-20-7	ID										
		Cumulative Risk:						**6E-08**				**6E-15**	**6E-08**

Notes:

The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).

This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.

f_{inh} is the fraction of the inhalation toxicity values that USEPA identified as having a mutagenic mode of action.

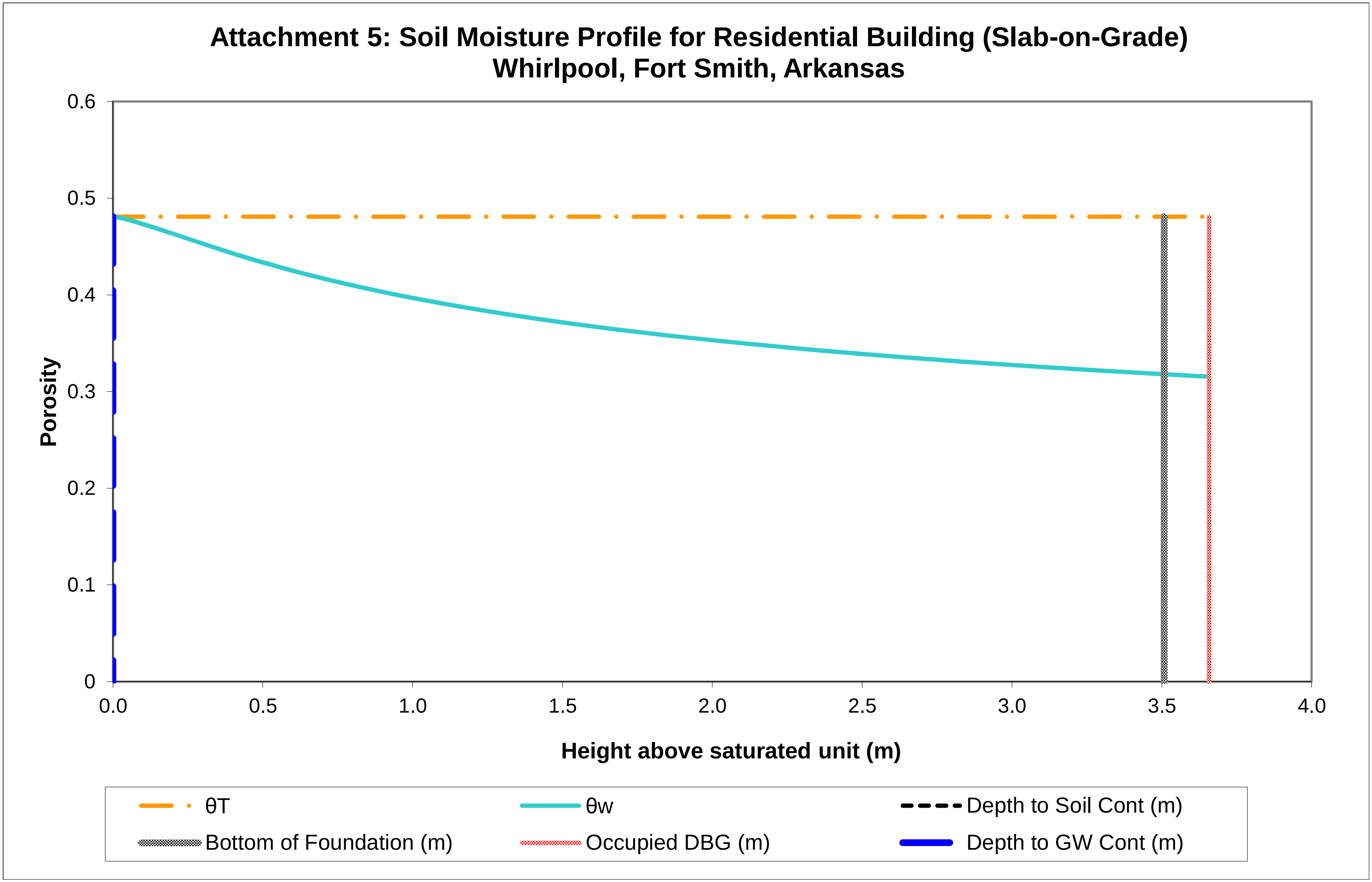
Attachment 5: Hazard Index Calculations for Exposure of Residents to On-Site Soil
Whirlpool, Fort Smith, Arkansas

					Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	C_{soil} (mg/kg)	C_{air} (mg/m^3)	**RfC** (mg/m^3)	**HQ**	C_{air} (mg/m^3)	**RfC** (mg/m^3)	**HQ**	**HQ**
VOC	Acetone	67-64-1	ID			3.1E+01			3.1E+01		
VOC	Benzene	71-43-2	A			3.0E-02			3.0E-02		
VOC	Bromodichloromethane	75-27-4	B2								
VOC	Bromoform	75-25-2	B2								
VOC	Bromomethane	74-83-9	ID			5.0E-03			5.0E-03		
VOC	2-Butanone	78-93-3	ID			5.0E+00			5.0E+00		
VOC	Carbon Disulfide	75-15-0				7.0E-01			7.0E-01		
VOC	Carbon Tetrachloride	56-23-5	LC			1.0E-01			1.0E-01		
VOC	Chlorobenzene	108-90-7	D			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3	LC			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	B2			5.0E-02			5.0E-02		
VOC	Chloromethane	74-87-3	D			9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1	C								
VOC	1,1-Dichloroethane	75-34-3	SC			5.0E-01			5.0E-01		
VOC	1,2-Dichloroethane	107-06-2	B2			7.0E-03			7.0E-03		
VOC	1,1-Dichloroethene	75-35-4	C			2.0E-01			2.0E-01		
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	1.70E-06			1.60E-13			2.2E-05
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	1.70E-06			1.60E-13			2.2E-05
VOC	trans-1,2-Dichloroethene	156-60-5	ID								
VOC	1,2-Dichloropropane	78-87-5	B2			4.0E-03			4.0E-03		
VOC	1,3-Dichloropropene (total)	542-75-6	B2			2.0E-02			2.0E-02		
VOC	Ethyl Benzene	100-41-4	D			1.0E+00			1.0E+00		
VOC	2-Hexanone	591-78-6	ID			3.0E-02			3.0E-02		
VOC	4-Methyl-2-pentanone	108-10-1	ID			3.0E+00			3.0E+00		
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	9.79E-07	6.0E-01	1.6E-06	9.35E-14	6.0E-01	1.5E-13	5.8E-06
VOC	Styrene	100-42-5				1.0E+00			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC								
VOC	Tetrachloroethene	127-18-4	LC			4.0E-02			4.0E-02		
VOC	Toluene	108-88-3	ID			5.0E+00			5.0E+00		
VOC	1,1,1-Trichloroethane	71-55-6	ID			5.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5	C			2.0E-04			2.0E-04		
VOC	Trichloroethene	79-01-6	HC	1.86E-01	2.73E-05	2.0E-03	1.3E-02	2.48E-12	2.0E-03	1.2E-09	1.4E-02
VOC	Vinyl Chloride	75-01-4	A			1.0E-01			1.0E-01		
VOC	Xylenes (total)	1330-20-7	ID			1.0E-01			1.0E-01		
			Hazard Index:				**1E-02**			**1E-09**	**1E-02**

Notes:

The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).

This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of



Attachment 5: Soil Moisture Profile for Residential Building (Slab-on-Grade)
Whirlpool, Fort Smith, Arkansas
Porosity
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Height above saturated unit (m)
θT
θw
Depth to Soil Cont (m)
Bottom of Foundation (m)
Occupied DBG (m)
Depth to GW Cont (m)

Attachment 5: Normalized Indoor Air Concentration in a Residential Building (Slab on Grade) due to Vapor Intrusion from Groundwater
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	D_{air} (m^2/day)	D_{water} (m^2/day)	H (unitless)	D_{crack} (m^2/day)	D_{eff}^{T} (m^2/day)	α_{soil}	α_{slab}	α_{∞}	C_{bldg} (L-water/m^3)
VOC	Acetone	67-64-1	1.07E+00	9.85E-05	1.14E-03	1.72E-01	1.87E-02	6.80E-02	2.73E-03	1.86E-04	2.12E-04
VOC	Benzene	71-43-2	7.60E-01	8.47E-05	1.59E-01	1.22E-01	8.15E-04	3.17E-03	2.73E-03	8.67E-06	1.38E-03
VOC	Bromodichloromethane	75-27-4	2.57E-01	9.16E-05	4.45E-02	4.13E-02	1.07E-03	4.17E-03	2.73E-03	1.14E-05	5.07E-04
VOC	Bromoform	75-25-2	1.29E-01	8.90E-05	1.34E-02	2.07E-02	1.64E-03	6.37E-03	2.73E-03	1.74E-05	2.33E-04
VOC	Bromomethane	74-83-9	6.29E-01	1.05E-04	2.01E-01	1.01E-01	7.43E-04	2.89E-03	2.73E-03	7.90E-06	1.59E-03
VOC	2-Butanone	78-93-3	6.98E-01	8.47E-05	1.96E-03	1.12E-01	1.01E-02	3.78E-02	2.73E-03	1.03E-04	2.03E-04
VOC	Carbon Disulfide	75-15-0	8.99E-01	8.64E-05	9.26E-01	1.44E-01	2.93E-04	1.14E-03	2.73E-03	3.12E-06	2.89E-03
VOC	Carbon Tetrachloride	56-23-5	6.74E-01	7.60E-05	8.82E-01	1.08E-01	2.52E-04	9.82E-04	2.73E-03	2.68E-06	2.37E-03
VOC	Chlorobenzene	108-90-7	6.31E-01	7.52E-05	9.77E-02	1.01E-01	9.32E-04	3.63E-03	2.73E-03	9.91E-06	9.68E-04
VOC	Chloroethane	75-00-3	2.34E+00	9.94E-05	3.25E-01	3.76E-01	8.86E-04	3.45E-03	2.73E-03	9.42E-06	3.06E-03
VOC	Chloroform	67-66-3	8.99E-01	8.64E-05	1.07E-01	1.44E-01	1.11E-03	4.32E-03	2.73E-03	1.18E-05	1.27E-03
VOC	Chloromethane	74-87-3	1.09E+00	5.62E-05	3.33E-01	1.75E-01	4.61E-04	1.80E-03	2.73E-03	4.90E-06	1.63E-03
VOC	Dibromochloromethane	124-48-1	1.69E-01	9.07E-05	2.38E-02	2.72E-02	1.27E-03	4.94E-03	2.73E-03	1.35E-05	3.21E-04
VOC	1,1-Dichloroethane	75-34-3	6.41E-01	9.07E-05	1.66E-01	1.03E-01	7.72E-04	3.00E-03	2.73E-03	8.21E-06	1.36E-03
VOC	1,2-Dichloroethane	107-06-2	8.99E-01	8.55E-05	2.74E-02	1.44E-01	2.37E-03	9.19E-03	2.73E-03	2.51E-05	6.88E-04
VOC	1,1-Dichloroethene	75-35-4	7.78E-01	8.99E-05	8.10E-01	1.25E-01	3.12E-04	1.22E-03	2.73E-03	3.32E-06	2.69E-03
VOC	1,2-Dichloroethene (total)	540-59-0	6.36E-01	9.76E-05	1.19E-01	1.02E-01	9.72E-04	3.78E-03	2.73E-03	1.03E-05	1.22E-03
VOC	cis-1,2-Dichloroethene	156-59-2	6.36E-01	9.76E-05	1.19E-01	1.02E-01	9.72E-04	3.78E-03	2.73E-03	1.03E-05	1.22E-03
VOC	trans-1,2-Dichloroethene	156-60-5	6.11E-01	1.03E-04	2.81E-01	9.81E-02	5.96E-04	2.32E-03	2.73E-03	6.35E-06	1.79E-03
VOC	1,2-Dichloropropane	78-87-5	6.76E-01	7.54E-05	7.82E-02	1.08E-01	1.09E-03	4.24E-03	2.73E-03	1.16E-05	9.07E-04
VOC	1,3-Dichloropropene (total)	542-75-6	5.41E-01	8.64E-05	4.83E-01	8.68E-02	3.69E-04	1.44E-03	2.73E-03	3.93E-06	1.90E-03
VOC	Ethyl Benzene	100-41-4	6.48E-01	6.74E-05	2.04E-01	1.04E-01	5.75E-04	2.24E-03	2.73E-03	6.12E-06	1.25E-03
VOC	2-Hexanone	591-78-6	7.45E-01	7.57E-05	3.23E-03	1.20E-01	6.86E-03	2.61E-02	2.73E-03	7.13E-05	2.31E-04
VOC	4-Methyl-2-pentanone	108-10-1	6.48E-01	6.74E-05	4.71E-03	1.04E-01	4.81E-03	1.84E-02	2.73E-03	5.03E-05	2.37E-04
VOC	Methylene Chloride	75-09-2	8.73E-01	1.01E-04	6.60E-02	1.40E-01	1.58E-03	6.14E-03	2.73E-03	1.68E-05	1.11E-03
VOC	Styrene	100-42-5	6.13E-01	6.91E-05	7.04E-02	9.85E-02	1.06E-03	4.11E-03	2.73E-03	1.12E-05	7.90E-04
VOC	1,1,2,2-Tetrachloroethane	79-34-5	6.13E-01	6.83E-05	8.74E-03	9.85E-02	3.31E-03	1.28E-02	2.73E-03	3.48E-05	3.05E-04
VOC	Tetrachloroethene	127-18-4	6.22E-01	7.08E-05	4.90E-01	9.99E-02	3.40E-04	1.33E-03	2.73E-03	3.63E-06	1.78E-03
VOC	Toluene	108-88-3	7.52E-01	7.43E-05	1.80E-01	1.21E-01	6.97E-04	2.71E-03	2.73E-03	7.41E-06	1.34E-03
VOC	1,1,1-Trichloroethane	71-55-6	6.74E-01	7.60E-05	4.97E-01	1.08E-01	3.64E-04	1.42E-03	2.73E-03	3.87E-06	1.92E-03
VOC	1,1,2-Trichloroethane	79-00-5	6.74E-01	7.60E-05	2.43E-02	1.08E-01	2.09E-03	8.08E-03	2.73E-03	2.21E-05	5.37E-04
VOC	Trichloroethene	79-01-6	6.83E-01	7.86E-05	2.88E-01	1.10E-01	5.23E-04	2.04E-03	2.73E-03	5.57E-06	1.60E-03
VOC	Vinyl Chloride	75-01-4	9.16E-01	1.06E-04	9.00E-01	1.47E-01	3.44E-04	1.34E-03	2.73E-03	3.66E-06	3.30E-03

Attachment 5: Normalized Indoor Air Concentration in a Residential Building (Slab on Grade) due to Vapor Intrusion from Groundwater
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	D_{air} (m^2/day)	D_{water} (m^2/day)	H (unitless)	D_{crack} (m^2/day)	D_{eff}^T (m^2/day)	α_{soil}	α_{slab}	α_{∞}	C_{bldg} (L-water/m^3)
VOC	Xylenes (total)	1330-20-7	6.74E-01	7.56E-05	1.73E-01	1.08E-01	6.90E-04	2.68E-03	2.73E-03	7.34E-06	1.27E-03

Notes:	**Crack Soil and Building Characteristics**			**Crack Soil**
	SCS Soil texture class			Sand
	Bulk density	kg/L	ρ_b	1.66
	Total porosity	L/L-soil	θ_T	0.375
	Water-filled porosity	L/L-soil	θ_w	0.054
	Air-filled porosity	L/L-soil	θ_a	0.321
	Residual saturation	L/L-soil	θ_r	0.053
	Hydraulic conductivity	cm/s	**K**	7.4E-03
	Dynamic viscosity of water	g/cm-s	μ_w	0.01307
	Density of water	g/cm^3	ρ_w	1.0
	Gravitational acceleration	cm/s^2	**g**	980.7
	Intrinsic permeability	cm^2	**k**	9.9E-08
	Relative saturation	unitless	S_e	0.004
	van Genuchten N	unitless	**N**	3.177
	van Genuchten M	unitless	**M**	0.685
	Relative air permeability	unitless	k_{rg}	0.998
	Permeability to vapor	cm^2	k_v	9.89E-08
	Distance from building foundation	m	L_{T-gw}	3.56
	Bldg foundation thickness	m	L_{crack}	0.1
	Bldg foundation length	m		10.00
	Bldg foundation width	m		10.00
	Bldg occupied height	m		2.44
	Bldg occupied volume	m^3		244.00
	Occupied depth below ground	m		0.0
	Bldg area for vapor intrusion	m^2	A_B	100.0
	Ratio of A_{crack} to A_B		η	4E-04
	Area of cracks	m^2	A_{crack}	4E-02
	Air exchange rate	$hour^{-1}$	**ach**	0.45
	Building ventilation rate	m^3/day	Q_{bldg}	2.64E+03
	Pressure difference between	kg/m-s^2	ΔP	1.0
	Viscosity of air	kg/m-s	μ_a	1.8E-05
	Crack length (bldg perimeter)	m	X_{crack}	40
	Crack depth below ground	m	Z_{crack}	0.10
	Crack radius	m	r_{crack}	1E-03
	Soil gas flow rate into bldg	m^3/day	Q_{soil}	7.20

Attachment 5: Cancer Risk and Hazard Index Calculations for Residents due to Groundwater Vapor Intrusion into a Residential Building (Slab-on-Grade)

Whirlpool, Fort Smith, Arkansas

							Cancer			Noncancer	
Chem Group	**Chemical**	**CASRN**	**Carc Class**	C_{gw} (mg/L)	C_{bldg} (L-water/m^3)	C_{air} (mg/m^3)	**URF** (m^3/mg)	f_{inh}	**Risk**	**RfC** (mg/m^3)	**HQ**
VOC	Acetone	67-64-1	ID	8.50E-02	2.12E-04	1.80E-05				3.1E+01	5.6E-07
VOC	Benzene	71-43-2	A		1.38E-03		7.8E-03			3.0E-02	
VOC	Bromodichloromethane	75-27-4	B2		5.07E-04						
VOC	Bromoform	75-25-2	B2	2.40E-02	2.33E-04	5.58E-06	1.1E-03		2.5E-09		
VOC	Bromomethane	74-83-9	ID		1.59E-03					5.0E-03	
VOC	2-Butanone	78-93-3	ID	9.50E-02	2.03E-04	1.93E-05				5.0E+00	3.7E-06
VOC	Carbon Disulfide	75-15-0			2.89E-03					7.0E-01	
VOC	Carbon Tetrachloride	56-23-5	LC		2.37E-03		6.0E-03			1.0E-01	
VOC	Chlorobenzene	108-90-7	D		9.68E-04					5.0E-02	
VOC	Chloroethane	75-00-3	LC		3.06E-03					1.0E+01	
VOC	Chloroform	67-66-3	B2		1.27E-03		2.3E-02			5.0E-02	
VOC	Chloromethane	74-87-3	D		1.63E-03					9.0E-02	
VOC	Dibromochloromethane	124-48-1	C		3.21E-04						
VOC	1,1-Dichloroethane	75-34-3	SC		1.36E-03					5.0E-01	
VOC	1,2-Dichloroethane	107-06-2	B2	3.00E-03	6.88E-04	2.06E-06	2.6E-02		2.2E-08	7.0E-03	2.8E-04
VOC	1,1-Dichloroethene	75-35-4	C	4.20E-03	2.69E-03	1.13E-05				2.0E-01	5.4E-05
VOC	1,2-Dichloroethene (total)	540-59-0		4.10E-02	1.22E-03	5.02E-05					
VOC	cis-1,2-Dichloroethene	156-59-2	ID	4.10E-02	1.22E-03	5.02E-05					
VOC	trans-1,2-Dichloroethene	156-60-5	ID		1.79E-03						
VOC	1,2-Dichloropropane	78-87-5	B2		9.07E-04					4.0E-03	
VOC	1,3-Dichloropropene (total)	542-75-6	B2		1.90E-03		4.0E-03			2.0E-02	
VOC	Ethyl Benzene	100-41-4	D		1.25E-03					1.0E+00	
VOC	2-Hexanone	591-78-6	ID		2.31E-04					3.0E-02	
VOC	4-Methyl-2-pentanone	108-10-1	ID	4.00E-03	2.37E-04	9.49E-07				3.0E+00	3.0E-07
VOC	Methylene Chloride	75-09-2	LC		1.11E-03		1.0E-05	1		6.0E-01	
VOC	Styrene	100-42-5			7.90E-04					1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC		3.05E-04						
VOC	Tetrachloroethene	127-18-4	LC		1.78E-03		2.6E-04			4.0E-02	
VOC	Toluene	108-88-3	ID		1.34E-03					5.0E+00	
VOC	1,1,1-Trichloroethane	71-55-6	ID		1.92E-03					5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5	C		5.37E-04		1.6E-02			2.0E-04	
VOC	Trichloroethene	79-01-6	HC	1.60E+00	1.60E-03	2.57E-03	4.1E-03	0.244	5.9E-06	2.0E-03	1.2E+00
VOC	Vinyl Chloride	75-01-4	A	3.00E-03	3.30E-03	9.89E-06	4.4E-03		6.1E-08	1.0E-01	9.5E-05
VOC	Xylenes (total)	1330-20-7	ID		1.27E-03					1.0E-01	
							Cumulative Risk:		6E-06	**HI:**	1E+00

Note:

f_{inh} is the fraction of the inhalation toxicity value that USEPA identified as having a mutagenic mode of action.

Attachment 5: Vapor Flux to Outdoor Air from Groundwater Whirlpool, Fort Smith, Arkansas						
Chem Group	**Chemical**	**CASRN**	**H** (unitless)	**D_{eff}^T** (m^2/day)	**J** (L/m^2-s)	**C_{air}** (L/m^3)
VOC	Acetone	67-64-1	1.14E-03	1.87E-02	6.75E-08	1.78E-06
VOC	Benzene	71-43-2	1.59E-01	8.31E-04	4.18E-07	1.10E-05
VOC	Bromodichloromethane	75-27-4	4.45E-02	1.09E-03	1.53E-07	4.03E-06
VOC	Bromoform	75-25-2	1.34E-02	1.65E-03	6.97E-08	1.84E-06
VOC	Bromomethane	74-83-9	2.01E-01	7.57E-04	4.81E-07	1.27E-05
VOC	2-Butanone	78-93-3	1.96E-03	1.01E-02	6.27E-08	1.65E-06
VOC	Carbon Disulfide	75-15-0	9.26E-01	2.99E-04	8.76E-07	2.31E-05
VOC	Carbon Tetrachloride	56-23-5	8.82E-01	2.57E-04	7.17E-07	1.89E-05
VOC	Chlorobenzene	108-90-7	9.77E-02	9.49E-04	2.93E-07	7.73E-06
VOC	Chloroethane	75-00-3	3.25E-01	9.04E-04	9.30E-07	2.45E-05
VOC	Chloroform	67-66-3	1.07E-01	1.13E-03	3.85E-07	1.01E-05
VOC	Chloromethane	74-87-3	3.33E-01	4.70E-04	4.95E-07	1.30E-05
VOC	Dibromochloromethane	124-48-1	2.38E-02	1.28E-03	9.66E-08	2.55E-06
VOC	1,1-Dichloroethane	75-34-3	1.66E-01	7.86E-04	4.12E-07	1.09E-05
VOC	1,2-Dichloroethane	107-06-2	2.74E-02	2.41E-03	2.09E-07	5.52E-06
VOC	1,1-Dichloroethene	75-35-4	8.10E-01	3.18E-04	8.15E-07	2.15E-05
VOC	1,2-Dichloroethene (total)	540-59-0	1.19E-01	9.89E-04	3.71E-07	9.79E-06
VOC	cis-1,2-Dichloroethene	156-59-2	1.19E-01	9.89E-04	3.71E-07	9.79E-06
VOC	trans-1,2-Dichloroethene	156-60-5	2.81E-01	6.08E-04	5.41E-07	1.43E-05
VOC	1,2-Dichloropropane	78-87-5	7.82E-02	1.11E-03	2.75E-07	7.25E-06
VOC	1,3-Dichloropropene (total)	542-75-6	4.83E-01	3.76E-04	5.75E-07	1.52E-05
VOC	Ethyl Benzene	100-41-4	2.04E-01	5.86E-04	3.78E-07	9.98E-06
VOC	2-Hexanone	591-78-6	3.23E-03	6.91E-03	7.07E-08	1.86E-06
VOC	4-Methyl-2-pentanone	108-10-1	4.71E-03	4.85E-03	7.23E-08	1.91E-06
VOC	Methylene Chloride	75-09-2	6.60E-02	1.61E-03	3.36E-07	8.87E-06
VOC	Styrene	100-42-5	7.04E-02	1.08E-03	2.40E-07	6.32E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	8.74E-03	3.35E-03	9.26E-08	2.44E-06
VOC	Tetrachloroethene	127-18-4	4.90E-01	3.47E-04	5.39E-07	1.42E-05
VOC	Toluene	108-88-3	1.80E-01	7.10E-04	4.05E-07	1.07E-05
VOC	1,1,1-Trichloroethane	71-55-6	4.97E-01	3.71E-04	5.83E-07	1.54E-05
VOC	1,1,2-Trichloroethane	79-00-5	2.43E-02	2.12E-03	1.63E-07	4.29E-06
VOC	Trichloroethene	79-01-6	2.88E-01	5.33E-04	4.86E-07	1.28E-05
VOC	Vinyl Chloride	75-01-4	9.00E-01	3.51E-04	9.99E-07	2.63E-05
VOC	Xylenes (total)	1330-20-7	1.73E-01	7.02E-04	3.85E-07	1.02E-05
	Parameters					
	Depth to groundwater	m	**DTW**	3.66		
	Dispersion coefficient	(kg/m^3) / (kg/m^2/s)	**C/Q**	26.4		

Attachment 5: Cancer Risk and Hazard Index Calculations for Exposure of Residents to Groundwater-derived Vapors in Outdoor Air
Whirlpool, Fort Smith, Arkansas

							Cancer				Noncancer	
Chem Group	**Chemical**	**CASRN**	**Carc Class**	C_{GW} (mg/L)	C_{air} (mg/m^3)		**URF** (m^3/mg)	f_{inh}	**Risk**		**RfC** (mg/m^3)	**HQ**
VOC	Acetone	67-64-1	ID	8.50E-02	1.51E-07						3.1E+01	4.7E-09
VOC	Benzene	71-43-2	A				7.8E-03				3.0E-02	
VOC	Bromodichloromethane	75-27-4	B2									
VOC	Bromoform	75-25-2	B2	2.40E-02	4.41E-08		1.1E-03		2.0E-11			
VOC	Bromomethane	74-83-9	ID								5.0E-03	
VOC	2-Butanone	78-93-3	ID	9.50E-02	1.57E-07						5.0E+00	3.0E-08
VOC	Carbon Disulfide	75-15-0									7.0E-01	
VOC	Carbon Tetrachloride	56-23-5	LC				6.0E-03				1.0E-01	
VOC	Chlorobenzene	108-90-7	D								5.0E-02	
VOC	Chloroethane	75-00-3	LC								1.0E+01	
VOC	Chloroform	67-66-3	B2				2.3E-02				5.0E-02	
VOC	Chloromethane	74-87-3	D								9.0E-02	
VOC	Dibromochloromethane	124-48-1	C									
VOC	1,1-Dichloroethane	75-34-3	SC								5.0E-01	
VOC	1,2-Dichloroethane	107-06-2	B2	3.00E-03	1.66E-08		2.6E-02		1.8E-10		7.0E-03	2.3E-06
VOC	1,1-Dichloroethene	75-35-4	C	4.20E-03	9.03E-08						2.0E-01	4.3E-07
VOC	1,2-Dichloroethene (total)	540-59-0		4.10E-02	4.01E-07							
VOC	cis-1,2-Dichloroethene	156-59-2	ID	4.10E-02	4.01E-07							
VOC	trans-1,2-Dichloroethene	156-60-5	ID									
VOC	1,2-Dichloropropane	78-87-5	B2								4.0E-03	
VOC	1,3-Dichloropropene (total)	542-75-6	B2				4.0E-03				2.0E-02	
VOC	Ethyl Benzene	100-41-4	D								1.0E+00	
VOC	2-Hexanone	591-78-6	ID								3.0E-02	
VOC	4-Methyl-2-pentanone	108-10-1	ID	4.00E-03	7.63E-09						3.0E+00	2.4E-09
VOC	Methylene Chloride	75-09-2	LC				1.0E-05	1			6.0E-01	
VOC	Styrene	100-42-5									1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC									
VOC	Tetrachloroethene	127-18-4	LC				2.6E-04				4.0E-02	
VOC	Toluene	108-88-3	ID								5.0E+00	
VOC	1,1,1-Trichloroethane	71-55-6	ID								5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5	C				1.6E-02				2.0E-04	
VOC	Trichloroethene	79-01-6	HC	1.60E+00	2.05E-05		4.1E-03	0.244	4.7E-08		2.0E-03	9.8E-03
VOC	Vinyl Chloride	75-01-4	A	3.00E-03	7.90E-08		4.4E-03		4.9E-10		1.0E-01	7.6E-07
VOC	Xylenes (total)	1330-20-7	ID								1.0E-01	
							Cumulative Risk:		5E-08		**HI:**	1E-02

Note:

f_{inh} is the fraction of the inhalation toxicity value that USEPA identified as having a mutagenic mode of action.

The dispersion coefficient to outdoor air (C/Q) is 11.6 (kg/m3) / (kg/m2/s).