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& HEALTH

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RE: Whirlpool Corporation - Fort Smith, Arkansas
Updated Human Health Risk Assessment
EPA No. ARD042755389
AFIN No. 66-00048
CAO LIS 13-202

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Dear Mr. Mehran:

Ramboll Environ US Corporation (Ramboll Environ) has prepared the attached updated Human Health Risk Assessment (HHRA) for ADEQ consideration. This HHRA updates the human health risk assessment dated April 2013 for the Whirlpool facility in Fort Smith, Arkansas, and incorporates data collected since the completion of the April 2013 HHRA.

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

Yours sincerely

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FINAL

Human Health Risk Assessment Update

Whirlpool Facility
Fort Smith, Arkansas

Prepared for:
Whirlpool Corporation

Prepared by:
Ramboll Environ US Corporation

Date:
November 2012
Updated April 2013
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1 Introduction

This human health risk assessment (HHRA) updates the human health risk assessment dated April 2013 (ENVIRON 2013) for the Whirlpool facility in Fort Smith, Arkansas (Site) and incorporates data collected since the completion of the April 2013 HHRA, as discussed in Section 3. The HHRA quantifies risks from reasonable maximum exposures (RME) under current and reasonably expected future land and groundwater use at and around the Site. The Site and adjacent properties are shown on **Figure 1**.

The methodologies used in this and previous risk assessments are based on United States Environmental Protection Agency (USEPA) risk assessment guidance, as referenced in this document. The methodologies used in the risk assessment are also consistent with relevant recommendations of the Interstate Technology Regulatory Council (ITRC) on performing and using risk assessments to inform risk-based decisions (ITRC 2015). The results of the risk assessment are intended for use in identifying where a release of hazardous substances from the Site may cause the RME to be significant enough to warrant additional remediation or other protective measures.

The scope of the HHRA is summarized in the conceptual site model (CSM) presented in **Table 1** (See Section 4.1), which is based on current and reasonably anticipated land and groundwater use at and around 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 4.1.

The remainder of this report is organized as follows:

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

2 Environmental Setting

The following summary of information on the Site's environmental setting is referenced from the 2014 *Remedial Action Effectiveness Report* (ENVIRON 2015).

2.1 Site Location and Physiography

The Whirlpool Fort Smith facility is located at 6400 Jenny Lind Road on the south side of Fort Smith, Arkansas (**Figures 1** and **2**). The Site was operated by Whirlpool for nearly 50 years to manufacture household appliances (1966 through 2012). The Site formerly consisted of approximately 153 acres, of which approximately 21 acres on the southwestern portion of the property were undeveloped vegetated areas. The developed portion of the property consists of the inactive former manufacturing facility, a warehouse and ancillary buildings north of the former manufacturing building, including the boiler room and water treatment plant. Concrete driveways and concrete and asphalt parking areas surround the structures. The majority of the onsite area surrounding the buildings is covered with concrete, asphalt, or gravel for parking and the uncovered portions are primarily landscaped areas along roadways. Whirlpool sold the southern portion of the property to Spartan Logistics, which included a warehouse and surrounding property, in September 2014. The site now consists of approximately 93 acres.

2.2 Onsite Land Use

The Site was first developed in 1961 by Norge Corporation as a refrigerator, icemaker and gas/air conditioning manufacturing facility. Whirlpool acquired the facility in 1966. The facility manufactured side-by-side household refrigerators, trash compactors and icemakers during Whirlpool's time of operations. Manufacturing operations ceased in 2012 and the only current onsite activities include occasional building maintenance (i.e. operations equipment is no longer maintained).

2.3 Surrounding Land Use

Residential areas are located to the north of the property beyond Ingersoll Avenue and commercial industrial properties are located to the south, east and west. Undeveloped property used for recreational purposes is also located to the west. As of 2015, the majority of the residential properties north of the Site have groundwater use restrictions in place. The area of existing groundwater use restriction is shown in **Figure 3**.

2.4 Site Geology

The unconsolidated surface materials at the Site consists of stream deposited Quaternary age alluvium that ranges from approximately 25 to 35 feet (ft) in thickness. Underlying the alluvium is the Pennsylvanian Period McAlester Formation which consists primarily of gently dipping dark gray shales and siltstones with thin coal beds and is likely over 500 ft thick in the Fort Smith area (Hendricks 1949).

A review of published geologic literature and data from the Site indicate the unconsolidated alluvium consists primarily of two units; a shallow fine-grained unit (Upper Fine-Grained Unit) and a coarse textured basal unit (Basal Transmissive Zone). The Upper Fine-Grained Unit consists primarily of recent age fine grained alluvial sediment with texture ranging from silt to sandy clay that extends to depths greater than 15 ft below ground surface (bgs). The Basal Transmissive Zone may be equivalent to the Pleistocene age Gerty Sand and consists of unconsolidated river terrace sand and gravel that ranges from 2 to 9 ft in thickness.

2.5 Site Hydrogeology

The primary groundwater zone at the Site is the Basal Transmissive Zone which is under semi-confined conditions. Groundwater under semi-confined conditions is partially confined by overlying soil layers of low permeability.

Evaluation of potentiometric surface maps created from groundwater elevations at the Site indicates that there appear to be three distinct groundwater flow regimes; the northern flow regime, the northeastern flow regime and southern flow regime. The northern and southern flow regimes are separated by a groundwater gradient divide that trends east to west just north of the northwestern portion of former manufacturing building. North of this divide the hydraulic gradient is directed generally to the north/northeast. South of this flat divide, the direction of the hydraulic gradient is primarily to the southeast except for a southwestern gradient in the southwestern quadrant of the property. The northeastern flow regime emanates from the northeastern corner of the former manufacturing building and trends northeasterly as it moves offsite.

There are discontinuous thin zones of greater permeability within the upper fine-grained unit. When present the zones of higher sand content are typically logged as moist or wet indicating the presence of “perched” water. The water present in these zones is perched, as the underlying soil of less permeability impedes its downward migration. It is highly likely that the water content in these zones is seasonal and due to subsurface utilities or other subsurface structures intercepting these shallow permeable zones. Due to the discontinuous nature of these zones or lenses of greater permeability, any groundwater movement would be minimal and localized.

2.6 Groundwater Use

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. As of 2015, all residential properties north of the Site where groundwater impacts have been characterized have groundwater use restrictions in place that eliminate the potential for use of groundwater in the impacted area[1]. The area with restrictions on groundwater use is shown in **Figure 3**.

[1] A deed restriction to preclude future use of groundwater is currently being negotiated with the last property impacted by the groundwater plume that does not already have a deed restriction filed. A letter amending this HHRA will be submitted after this subject deed restriction is filed precluding use of shallow groundwater.

3 Data Collection and Preparation

This HHRA incorporates data collected subsequent to those evaluated in the 2013 HHRA. The data that were subsequently collected, the reason for their collection and their inclusion in this update to the 2013 HHRA are discussed below by matrix.

Soil

Onsite soil data were collected during 2014 in the area of a former drainage trench that is believed to be a primary source of contamination to groundwater. This area is located west of the former degreaser building, as shown on **Figure 4**. The soil data that were collected from above the upper fine-grained unit (i.e. from the unsaturated zone) are evaluated in this update of the HHRA, along with the prior soil data evaluated in the 2013 HHRA (i.e. groundwater data is used for assessment of risks for deeper soil samples that are saturated).

Offsite subsurface soil data were collected during 2014 at certain locations within the neighborhood north of the Site where groundwater monitoring wells or soil vapor sampling points were installed. The subsurface soil data that were collected from above the Upper Fine-Grained Unit (i.e. from the unsaturated zone) are evaluated in this updated HHRA.

Groundwater

Onsite and offsite groundwater data were collected during each quarter to support the onsite and offsite groundwater monitoring, remedy effectiveness and human health risk monitoring. All validated quarterly groundwater monitoring data collected from October 2014 through November 2015 are evaluated in this update of the HHRA. These include groundwater data collected at depths up to 20 ft bgs to provide adequate lateral coverage of the area affected by groundwater from the Site, even though 20 ft is deeper than the depth of typical excavations and the typical top of the shallow groundwater (generally 12 to 15 ft bgs).

Soil Vapor

Onsite and offsite soil vapor data were collected during the quarterly groundwater monitoring events to support the evaluation of the potential for vapor intrusion from groundwater that would pose an increased risk to human health. All valid soil vapor data collected from October 2014 through November 2015 are evaluated in this current HHRA.

Outdoor, Crawl Space and Indoor Air

Outdoor, crawl space and indoor air data were collected in 2015 at Parcel 3 to support previous evaluations of the potential for vapor intrusion from groundwater at this property. These data are included in this update of the HHRA.

The following procedures were used to prepare the data to support quantitative risk assessment. These procedures, which are based on USEPA guidance on human health risk assessment (USEPA 1989), are as follows:

- Concentrations qualified as not detected (i.e. U or UJ-qualified data) are evaluated as non-detects.
- Concentrations qualified as estimated (i.e. J qualified data) were included for quantitative assessment.
- Concentrations in duplicate field samples were averaged to obtain a representative concentration for the sample location. When a constituent was detected in only one sample of a duplicate pair, the average of the detected concentration and one half the quantitation limit was used.
- The concentrations of 1,3-dichloropropene (total) and xylenes (total) are the sums of the concentrations of the isomers that were detected and half the quantitation limits of the isomers there were not detected in the same sample but detected in the same matrix at the site. If no isomer was detected in a sample, the constituent 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. **Attachment A1** presents the exposure point concentrations (EPCs) used in the risk assessment and their sample location IDs. The IDs of the samples included in the risk assessment are listed in **Attachment A2**. The sample locations are shown on **Figures 5, 6** and **7.**

4 Exposure Assessment

This section discusses the potential exposures that are relevant under current and reasonably expected future land use at and around the Site. The exposure setting, potentially exposed populations and exposure pathways are discussed below in Section 0.

Exposures via ingestion and dermal contact are quantified in terms of a dose, as follows:

$$Dose = Concentration \bullet Intake$$

The dose for evaluating cancer risk is averaged over a lifetime and is called the lifetime average daily dose (LADD). For evaluating non-cancer effects, the dose is averaged over the duration of potential exposure and is called the average daily dose (ADD). The concentration term in the dose equation refers to the average chemical concentration in an environmental medium to which a population is exposed over a specified duration. The intake term refers to the intake rate of the contaminated environmental medium, which is a function of the magnitude, frequency and duration of exposure. The methods for estimating the concentration term are discussed in Section 0. The fate and transport models that are used to calculate the concentration of chemicals in the exposure medium (e.g. outdoor dust or air, are discussed in Section 0). The exposure factors that are used to quantify the magnitude, frequency and duration of potential exposures are discussed in Section 0.

Exposures via inhalation are quantified as a time-weighted average concentration in air. The exposure concentration for evaluating cancer risk is averaged over a lifetime. For evaluating non-cancer effects, the exposure concentration is averaged over the period of exposure. The methods for estimating the concentration term are discussed in Section 0.

4.1 Potential Human Exposures

As discussed in Sections 0 and 0, the Site is an industrial property that is located in a mixed industrial/commercial, residential and recreational (parks) area where future land and groundwater uses onsite and offsite are expected to remain unchanged. The potentially exposed populations at and in the vicinity of the Site based on the current and expected future land and groundwater uses are summarized in the CSM in **Table 1**.

Table 1: Conceptual Site Model – Scenarios for Potential Human Exposure

Source Media		On-Site				Off-Site		
		Routine Workers	Utility Maintenance Workers	Redevelopment Construction Workers	Trespassers	Residents	Routine Workers	Utility Maintenance Workers
Soil	Incidental Ingestion	●	●	●	●	○	○	●
	Dermal Contact	●	●	●	●	○	○	●
	Inhalation of Vapor	●	●	●	●	●	●	●
	Inhalation of Particulates	●	●	●	●	○	○	●
	Vapor Intrusion	●	○	○	○	●	●	○
Groundwater	Incidental Ingestion	○	●	●	○	○	○	●
	Dermal Contact	○	●	●	○	○	○	●
	Inhalation of Vapor	●	●	●	●	●	●	●
	Vapor Intrusion	●	○	○	○	●	●	○
	Potable Water Use	○	○	○	○	○	○	○

● = Potentially complete pathway
○ = Pathway is not complete

Note: The Site's current health & safety procedures ensure that maintenance worker and construction worker exposures remain within acceptable exposure levels.

As part of the corrective measures at the Site, Whirlpool has filed a deed restriction for the Site to maintain commercial/industrial land use. As such, workers comprise the main receptor population at the Site under both current and reasonably expected future land use.

As discussed in Section 0, manufacturing operations ceased onsite in 2012. Thus, under current conditions, the only populations with potentially significant current onsite exposures include occasional maintenance workers and trespassers. Under reasonably expected future conditions, the only populations with potentially significant onsite exposures are routine workers, maintenance workers and redevelopment construction workers. Any subsurface maintenance or construction work will be conducted in accordance with current or future Site Health and Safety Plan, which contains provisions for preventing significant exposures to contaminated environmental media. Public access to the Site is limited by fencing and on-site security is provided daily from 10 pm to 6 am, but trespassing is plausible.

The areas around the Site consist of a mixture of commercial/industrial, residential and recreational land use. As discussed in Section 0, the properties within or near the northern offsite groundwater plume have groundwater use restrictions. Current zoning for these areas is expected to remain unchanged, as discussed in Section 0. As such, the largest potentially exposed populations around the Site are residents and workers.

The following summarizes the receptors and exposure pathways evaluated in this update of the HHRA.

4.1.1 Onsite

Routine Workers

Currently, there are no routine workers onsite as manufacturing operations ceased in 2012, as discussed in Section 0. Future routine workers would likely be engaged in commercial/industrial activities that generally take place indoors. During limited time outdoors, these future workers could be exposed to soil (typically from the surface to a depth of 2 ft) in areas where concrete or asphalt pavement may be removed. Potential routes of exposure to surface soil would include incidental ingestion, dermal contact and inhalation of soil vapor and airborne particulates in outdoor air. As discussed in Section 0, the majority of the outdoor area of the Site is covered in concrete, asphalt or gravel and the uncovered portions are primarily landscaped areas along roadways.

These workers could be exposed via inhalation of constituents from the subsurface soil and groundwater if constituents were to volatilize and migrate to outdoor air or migrate through cracks in the building foundation into indoor air.

Utility Maintenance Workers

Currently, the Site is inactive. However, it is possible for workers to be involved in occasional utility maintenance activities at the Site. All workers who are involved with maintenance activities at the Site will follow existing health and safety procedures designed to prevent unacceptable exposure in all areas of the Site. Notwithstanding such procedures, the risk assessment evaluates potential exposures under a hypothetical future scenario in which maintenance workers do not necessarily follow health and safety procedures. As such, workers conducting occasional subsurface maintenance or construction activities under this hypothetical scenario could be exposed to surface and subsurface soil in paved and unpaved areas of the Site. Maintenance worker exposure involving subsurface activities is expected to include installation or repair of underground utilities, or removal and/or repair of pavement. These activities are also expected to be of limited duration. Potential routes of exposure to surface and subsurface soil during such activities would include incidental ingestion, dermal contact and inhalation of soil vapor and airborne particulates.

Maintenance workers could encounter groundwater during excavations at the Site where groundwater is shallower than about 10 to 15 ft bgs, the depth to which workers are reasonably assumed to excavate at and around the Site. Potential routes of exposure to groundwater would include incidental ingestion, dermal contact and inhalation of vapor.

Redevelopment Construction Workers

There are no construction projects currently active at the Site. Workers involved with potential future construction and/or redevelopment activities at the Site would follow health and safety procedures employed to prevent unacceptable exposure. However, the risk assessment evaluates potential exposures under a hypothetical future scenario in which construction workers do not necessarily follow health and safety procedures. As such, workers conducting subsurface construction activities under this hypothetical scenario could be exposed to surface and subsurface soil in paved and unpaved areas of the Site. Potential routes of exposure to surface and subsurface soil during such activities would include incidental ingestion, dermal contact and inhalation of soil vapor and airborne particulates.

Construction workers could encounter groundwater during excavations. Potential routes of exposure to groundwater would include incidental ingestion, dermal contact and inhalation of vapors.

Trespassers

Trespasser contact with onsite soil was not previously evaluated because onsite production activities had only recently ceased and fencing, security and decommissioning activities limited the opportunity for trespassing. However, since the cessation of manufacturing activities at the Site, potential exposure of trespassers is plausible, although fencing controls access to the Site and onsite security is present daily from 10 pm to 6 am. Fencing makes trespassing unlikely and would limit the frequency of any unauthorized access as well as the types of activities while onsite. While onsite, trespassers could be exposed to soil in areas without ground cover. As discussed in Section 0, the majority of the outdoor area of the Site is covered in concrete, asphalt or gravel and the uncovered portions are primarily landscaped areas along roadways. Potential routes of exposure to surface soil would include incidental ingestion, dermal contact and inhalation of soil vapor and airborne particulates.

Trespassers also could be exposed via inhalation of constituents from the subsurface soil and groundwater if the constituents were to volatilize and migrate to outdoor air.

4.1.2 Offsite

Residents

Residential exposure to offsite soil was not evaluated in the prior risk assessment because no offsite soil data had been collected prior to 2012. In 2014, subsurface soil data were collected at offsite locations. Therefore, this update of the HHRA evaluates residential exposure to constituents detected in these subsurface soil samples via outdoor inhalation of soil-derived vapors.

Residents could be exposed via indoor inhalation of constituents from the offsite subsurface soil and groundwater if constituents were to volatilize and migrate through cracks in the building foundation into indoor air.

Additionally, residents could be exposed via outdoor inhalation of constituents from onsite soil and groundwater if constituents in these media were to volatilize to outdoor air and migrate offsite.

Routine Workers

Offsite routine workers could be exposed to the same media and via the same routes of exposure as the offsite residents discussed above.

Utility Maintenance Workers

Offsite maintenance workers could be exposed to the same media and via the same routes of exposure as the onsite maintenance workers discussed above. However, per the Cooperation and Reimbursement Agreement between Whirlpool and the City of Fort Smith, workers involved with potential future maintenance activities offsite will follow procedures designed to prevent unacceptable exposure.

The risk assessment evaluates potential exposures under a hypothetical future scenario in which maintenance workers do not necessarily follow these procedures to assist in determining what procedures may be necessary for potential contact with soil or groundwater.

4.2 Exposure Concentrations

Attachment A1 presents the EPCs used in the risk assessment and their sample location IDs. The IDs of the samples included in the risk assessment are listed in **Attachment A2**.

4.2.1 Soil

Risk estimates for RME are estimated in this risk assessment using upper-bound estimates that are based on the maximum detected concentrations at any depth in the unsaturated zone (i.e. collected above the shallow groundwater bearing unit) (as discussed in Section 3). The use of maximum detected concentrations, rather than 95% UCLs, for the chemicals evaluated in this risk assessment introduces conservatism 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.

4.2.2 Groundwater

To assess potential exposures to groundwater under current and future conditions on- and offsite, the highest detected concentration collected since October 2014 for each chemical from all monitoring wells screened near the top of the shallow groundwater bearing unit (i.e. where the top of screen is shallower than 20 ft bgs) (as discussed in Section 3), were used to calculate

upper-bound estimates of cumulative cancer and non-cancer risks representative of current conditions. As discussed above, the use of maximum detected concentrations introduces more conservatism than necessary for RME estimates.

4.2.3 Perched Water

Perched water was collected at onsite and offsite locations where vapor points either filled with water after installation or where water was present in borings intended as vapor point locations, which were then completed as shallow monitoring wells. Because soil vapor could not be collected from these locations, perched water was instead collected to provide an additional line of evidence in the evaluation of the potential for vapor intrusion from groundwater into offsite residential buildings. To assess potential vapor intrusion exposures to constituents in perched water under current and future conditions on- and offsite, the highest detected concentration for each chemical from all locations with such data since October 2014 were used. These concentrations are also used to calculate potential risks for maintenance worker and construction worker exposure in excavations. As discussed above, the use of maximum detected concentrations introduces more conservatism than necessary for RME estimates.

4.2.4 Soil Vapor

Soil vapor was collected at offsite locations and at the Site boundary to provide an additional line of evidence in the evaluation of the potential for vapor intrusion from groundwater into offsite residential buildings. To assess potential vapor intrusion exposures to constituents in soil vapor under current and future conditions, the highest detected concentration for each chemical from all soil vapor monitoring points sampled since October 2014 were used. As discussed above, the use of maximum detected concentrations introduces more conservatism than necessary for RME estimates.

4.2.5 Outdoor, Crawl Space and Indoor Air

Outdoor, crawl space and indoor air data were collected at Parcel 3 to provide additional lines of evidence in the evaluation of the potential for vapor intrusion. These data were evaluated to determine whether the concentrations detected in these media are associated with the groundwater conditions related to the Site.

4.3 Fate and Transport Models

The following models were used in this update of the HHRA to estimate exposure concentrations for the exposure scenarios discussed in Section 0. These models are used by USEPA and state regulatory agencies for screening level analysis (i.e. they tend to overestimate concentrations and are consistent with the models used in the 2013 HHRA, except where noted). The following are brief descriptions of the models. Further details of these models are provided in Appendix B.

4.3.1 Vapor Intrusion into Buildings

Indoor air concentrations resulting from migration of vapors from soil and groundwater into a building are estimated using the model described by Johnson and Ettinger (1991), which USEPA recommends for screening level evaluations (USEPA 2004a, 2015) and which was used in the human health risk assessment included in the Revised Risk Management Plan (RRMP) (ENVIRON 2013). The calculations in this update of the HHRA use generic soil properties recommended by USEPA (2004a) that are representative of the soil types at the Site. The commercial/industrial building characteristics used are based on the currently recommended values for deriving the State of Michigan Part 201 generic vapor intrusion criteria for commercial/industrial sites (CSAG 2014), because neither USEPA nor ADEQ provide default values for non-residential buildings. The building characteristics are considered conservative for the evaluation of current conditions because the buildings currently at the Site are much larger in size than the commercial building assumed in the Michigan criteria. The residential building characteristics are based on USEPA values for assessing chronic vapor intrusion into residential buildings (USEPA 2004a and 2015). 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 commercial/industrial and residential building characteristics are the same as those used in the 2013 HHRA, except the air exchange rate was reduced from two to one per hour for commercial/industrial buildings and from 0.45 to 0.25 per hour for residential buildings. The higher air exchange rates used in the prior risk assessment were intended to minimize compounding of the highly conservative decision to evaluate all historical groundwater data, including those collected prior to the start of groundwater remediation and were believed to be high-biased with respect to the then current conditions. Lower air exchange rates are used in this assessment because this risk assessment uses groundwater data that are more representative of current conditions (i.e. data from the past year). A discussion of the model and the input parameters used in the assessment is provided in Appendix B.

As discussed in Sections 0 and 0, perched groundwater and soil vapor data were collected to provide an additional line of evidence in the evaluation of the potential for vapor intrusion from groundwater into offsite residential buildings. The evaluation of the potential for vapors from perched groundwater to migrate into indoor air was conducted using the approach described above for evaluating potential vapor intrusion from groundwater.

Consistent with the 2013 HHRA, the evaluation of the potential for soil vapor to migrate into indoor air uses USEPA's 95th percentile subslab soil gas attenuation factor of 0.03 (USEPA 2012a, 2015) to estimate the potential for significant vapor intrusion into indoor air. This approach is believed to be conservative because attenuation in the approximately 5.5 ft or greater of silty clay soil between the soil vapor sample depth and subslab depth is ignored. Accounting for such attenuation, which may be substantial, would justify using an even lower attenuation factor than USEPA's default subslab attenuation factor.

4.3.2 Vapor Emission from Exposed Water

The model for estimating vapor emissions from exposed water surfaces in excavations is based on mass transfer coefficients recommended in USEPA guidance (USEPA 1995a) and is the same model used in the 2013 HHRA. A discussion of the model and the input parameters, which are the same as those used in the 2013 HHRA, used in the calculation is provided in Appendix B.

4.3.3 Vapor Emission from Exposed Soil

Vapor emissions from exposed soil are estimated using the Jury model (Jury et al. 1983), based on depletion over time of soil initially contaminated from ground surface to a finite depth. A discussion of the model, which is the same as the model used in the 2013 HHRA, is provided in Appendix B.

4.3.4 Dust Emission

Emission of respirable soil particulates (PM_{10}) for routine worker and resident exposures to outdoor soil are calculated using the wind erosion model recommended by USEPA (1996) with USEPA default soil parameters. The wind speed and anemometer height are from the weather station nearest the Site with an extensive data record, which is located in Fort Smith, Arkansas [National Oceanic and Atmospheric Administration (NOAA) 2012]. The model and inputs are the same as those used in the 2013 HHRA.

During maintenance activities, the PM_{10} level is set at 50 micrograms per cubic meter (µg/m^3). This PM_{10} level is based on a time weighted average assuming maintenance workers spend 1/3 of their exposure period excavating into the subsurface and 2/3 of their exposure period conducting maintenance activities that do not involve excavation into the subsurface. In the time weighted average calculation, the 24 hour average National Ambient Air Quality Standard (NAAQS) for PM_{10} of 150 µg/m^3 is used as the maximum PM_{10} concentration for the time spent excavating into the subsurface during maintenance activities and a PM_{10} concentration of 1 µg/m^3 is used for the time spent during maintenance activities that do not involve excavation. The PM_{10} concentration during non-excavation maintenance activities is expected to be less than 1 µg/m^3, based on the wind erosion model recommended by USEPA (1996) using site-specific wind speed from Fort Smith, Arkansas (NOAA 2012).

During construction activities, the PM_{10} level is set at 50 µg/m^3, which is the former annual average NAAQS for PM_{10}, since construction workers are assumed to be performing excavations for a working year. It is conservatively assumed that the PM_{10} concentration would be at this limit every day for the entire period of construction worker exposure[2].

[2] This approach is believed to be more practical and has less uncertainty than using particulate emission/dispersion modeling to estimate air concentrations from different dust generating activities associated with construction projects. Since total dust emissions for which PM_{10} concentration are likely to exceed 50 µg/m^3 would be visible, PM_{10} levels less than 50 µg/m^3 would be easily achievable at the Site.

4.3.5 Air Dispersion

The annual average outdoor air concentrations were estimated in the 2013 HHRA using the empirical correlations presented in USEPA's Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002), assuming a square source area, correlation coefficients for the Little Rock, Arkansas meteorological area and a mean wind speed for Fort Smith of 7.6 miles per hour. The calculation of these outdoor air concentrations are updated as discussed below.

For Emission from Groundwater in an Excavation

The calculations for this scenario are the same as those in the 2013 HHRA. The source area is still based on an assumed 15 ft by 15 ft excavation and the maximum 1 hour air concentration at the ground surface is converted to a maximum 24 hour average air concentration using a conversion factor of 0.4 (USEPA 1995b).

For Emission from Groundwater Through Vadose Zone

The only change in the calculations is the assumed size of the source area. Based on the more recent groundwater characterization data, the size of the groundwater plume is now estimated to be 34 acres, based on the area of the groundwater plume onsite and offsite as shown on Figures 2A and 2B of the 2015 Fourth Quarter Groundwater Report.

For Emissions From Offsite Soil

The source area [linear drainage feature encompassing approximately 2,500 square feet (ft^2)] is assumed to be USEPA's default 0.5 acre area (USEPA 2002) because the concentrations in offsite soil data are not believed to be associated with the groundwater plume.

For Emission From Onsite Soil

The methodology for estimating the annual average outdoor air concentrations was changed to provide conservative and plausible concentrations. Specifically, this update of the 2013 HHRA does not use the assumption that onsite and offsite receptors both breathe air at ground surface within the source area, as was assumed in using USEPA's empirical correlations in the 2013 HHRA.

Instead, air concentrations are estimated using USEPA's SCREEN3 program (USEPA 1995) to account for the receptor's breathing height and distance from the following two onsite soil source areas: the former linear drainage feature; and the rest of the Site. Emission and dispersion are modeled separately for these areas because the soil TCE concentrations in the linear drainage feature are up to approximately 100 times higher than those at the rest of the Site and as such, are not representative of the emission and dispersion of TCE from the rest of the Site.

In applying SCREEN3, all receptors are conservatively assumed to be always downwind from the source areas even though a receptor is expected to be downwind for only a fraction of the exposure period due to changes in wind direction.

Onsite receptors are assumed to be simultaneously at the downwind edge of the former linear drainage feature (2,500 ft^2) and the remaining area of the 93 acre Site (source areas). These receptors are assumed to be standing just beyond the edge of the source areas, where air concentrations at the assumed receptor height are highest.

Offsite receptors were assumed to be 315 ft downwind of the former linear drainage feature source area and 46 ft downwind of the Site boundary, which are the shortest distances from each source area to offsite properties across Ingersoll Avenue.

The air concentrations from both source areas are summed to calculate outdoor air inhalation risk estimates. The output from SCREEN3 is included in Attachments B1.5 and B1.6.

4.4 Exposure Factors

The exposure factors for evaluating the exposure scenarios summarized in the CSM are discussed in this section. In this update of the HHRA, standard default exposure factors recommended by USEPA for estimating RME are used where available and appropriate. Where standard default exposure factors are not available or appropriate for an exposure scenario, the risk assessment uses similarly conservative exposure factors that are based on Site-specific considerations and professional judgment, as discussed below.

The exposure factors are the same as those used in the 2013 HHRA, except certain exposure factors such as adult body weight and skin surface area were updated to be consistent with USEPA's current recommendations (USEPA 2014).

4.4.1 Routine Workers

In the 2013 HHRA and this update of the HHRA, potential exposure of onsite routine workers is conservatively evaluated using the standard default exposure factors that USEPA (1991a, 2014) recommends for estimating RME. Quantitative evaluation of offsite routine workers is unnecessary because the exposure factors for the offsite routine workers are lower than the offsite residents discussed in Section 0. According to USEPA, the standard default exposure factors are conservative assumptions about the magnitude, frequency and duration of exposures, which in combination, are intended to provide estimates of exposures that are higher than actual exposures to a large portion (90% to 99%) of a potentially exposed population.

<u>Soil Ingestion Rate</u>

An incidental soil ingestion rate of 50 milligrams (mg) per day is used for routine workers. USEPA has recommended the use of this value for evaluating high end routine worker hand to mouth exposures to soil (USEPA 1991a).

Soil Dermal Contact Rate and Absorption

The dermal contact rate is the product of the exposed skin surface area and the soil-to-skin adherence factor. The exposed skin area of 3,527 square centimeters (cm^2) and the soil-to-skin adherence factor of 0.12 mg/cm^2 are the USEPA recommended skin area and adherence factor for evaluating high end contact with soil by workers in industrial settings (USEPA 2014). The absorbed dose from dermal contact with soil is estimated by multiplying the dermal contact rate by USEPA recommended absorption factors for absorption from soil (USEPA 2004b).

Exposure Time

Routine workers are assumed to be at the Site and inhale vapors and particulates from site-related sources for eight hours per day, which is the USEPA recommended value for full time workers (USEPA 2009, 2014).

Exposure Frequency and Duration

Routine workers are assumed to be at the Site for 250 days per year for 25 years. This combination of exposure frequency and exposure duration is expected to be conservative for the amount of time that workers are actually exposed to soil during outdoor activities, as routine workers in many industrial settings typically spend the majority of their time indoors. USEPA has recommended the use of these values for evaluating high end routine worker exposures (USEPA 1991a, 2014).

Body Weight

The body weight of 80 kilograms (kg) is the standard USEPA recommended body weight for assessing exposure to adults (USEPA 2014).

Averaging Time

The averaging time for evaluating cancer risk is equal to a lifetime of 70 years and the averaging time for evaluating non-cancer risk is equal to the exposure duration (USEPA 1989, 2014).

Although it is recognized that the use of the default exposure factors, rather than site-specific factors (e.g. a site-specific exposure frequency or a fraction contacted term <1), results in overestimation of RME risks at the Site, this approach streamlines this update of the HHRA.

4.4.2 Utility Maintenance Workers

The exposure factors used for evaluating potential exposure of utility maintenance workers to soil and groundwater, which are consistent with those in the 2013 HHRA, except where USEPA has revised its recommendations, are as follows:

Soil Ingestion Rate

An incidental soil ingestion rate of 100 mg per day is used for workers performing occasional maintenance work that involves excavation into the soil. This soil ingestion rate is based on the time weighted average over an exposure frequency of 30 days per year, assuming that a maintenance worker spends 10 days per year excavating into the subsurface and 20 days per year conducting maintenance activities that do not involve excavation into the subsurface. An ingestion rate of 200 mg per day is used as the ingestion rate during excavation into the subsurface and an ingestion rate of 50 mg per day is used as the ingestion rate during activities that do not involve excavation into the subsurface. The ingestion rate of 200 mg per day during excavation is consistent with the soil to hand adherence data for the construction-related activities in the 1997 Exposure Factors Handbook (USEPA 1997) and the ingestion rate of 50 mg per day during activities not involving construction is USEPA's recommended value for evaluating high end routine worker exposures to soil (USEPA 1991a).

Soil Dermal Contact Rate and Absorption

The dermal contact rate is the product of the exposed skin surface area and the soil-to-skin adherence factor. The exposed skin area of 3,527 cm^2 and the soil-to-skin adherence factor of 0.12 mg/cm^2 are the USEPA recommended skin area and adherence factor for evaluating high end contact with soil by workers in industrial settings (USEPA 2014). The absorbed dose from dermal contact with soil was estimated by multiplying the dermal contact rate by USEPA recommended absorption factors for absorption from soil (USEPA 2004b).

Groundwater Ingestion Rate

A rate of 0.005 liters (L) per hour is used for incidental ingestion of groundwater during maintenance work in excavations that extend into groundwater. This rate is 10% of the rate that USEPA (1989) recommends for ingestion while swimming and represents a conservative estimate of incidental groundwater ingestion that could occur while workers are in an excavation pit containing impacted groundwater.

Groundwater Dermal Contact

The exposed skin surface area of 3,527 cm^2 is based on the USEPA recommended exposed skin surface area for evaluating high end contact with soil by workers in industrial settings (USEPA 2014). Workers are conservatively assumed to be covered with groundwater over this exposed skin surface area for 2 hours per event. The absorbed dose for organic chemicals is estimated using an unsteady state approach (USEPA 2004b), which is more conservative than the steady state approach (USEPA 1989), particularly for hydrophobic chemicals. The permeability coefficient (K_p) for dermal absorption from groundwater is estimated following USEPA guidance (USEPA 1992 and 2004b).

Exposure Time

Maintenance workers are assumed to be at the Site and inhale vapors and particulates from site-related sources for 8 hours per day, which is the USEPA recommended value for full-time workers (USEPA 2009, 2014).

Soil and Groundwater Exposure Frequency

An exposure frequency of 30 days per year is used for workers performing occasional maintenance work that involves excavation into the soil. The number of days workers perform occasional maintenance that involves actual excavation into groundwater is assumed to be five days per year. The assumption of five days per year can represent the excavation time for a few small repairs per year or one larger repair. These exposure frequencies are expected to be conservative for the amount of time that workers are actually exposed to soil or groundwater (as opposed to the total time for maintenance, which typically includes time not associated with excavation).

Exposure Duration

An exposure duration of 10 years is used for maintenance worker exposure to soil or groundwater. The exposure duration of 10 years is supported by the analysis of Burmaster (2000), using data from the Bureau of Labor Statistics through February 1996, which indicated that the 95th and 90th percentile job tenure of workers in construction is approximately 12.48 years and 7.7 years, respectively. The duration of 10 years is longer than the length of time that workers typically work at one location (USEPA 1997, 2011).

Body Weight

The body weight of 80 kg is the standard USEPA recommended body weight for assessing exposure to adults (USEPA 2014).

Averaging Time

The averaging time for evaluating cancer risk is equal to a lifetime of 70 years and the averaging time for evaluating non-cancer risk is equal to the exposure duration (USEPA 1989, 2014).

4.4.3 Redevelopment Construction Workers

The exposure factors used for evaluating potential exposure of redevelopment construction workers to soil are the same as those in the 2013 HHRA. These exposure factors are the same as those for utility maintenance workers discussed in Section 0, except as follows:

Soil Ingestion Rate

An incidental soil ingestion rate of 200 mg per day, consistent with the soil to hand adherence data for the construction related activities in the 1997 Exposure Factors Handbook (USEPA 1997) is used for the construction worker.

More recently, USEPA guidance (USEPA 2002) recommended an ingestion rate of 330 mg per day that is an estimated 95th percentile from a single soil ingestion study that involved 10 adults (Stanek et al. 1997). This ingestion rate is not used in the risk calculations because it is based on very limited data that might not be appropriate for representing actual exposure. However, the effects of using the somewhat higher ingestion rate of 330 mg per day are evaluated in Section 0. In addition, the estimated 90th percentile ingestion rate from the same study was approximately 200 mg per day.

Exposure Frequency and Duration

Redevelopment construction workers are assumed to contact soil for up to 250 days for 1 year. This exposure frequency is expected to be conservative for the amount of time that workers are actually exposed to soil in excavations (as opposed to the total time for construction, which typically includes time not associated with excavation).

Potential exposure of construction workers to groundwater is conservatively evaluated using the risk estimates for maintenance workers, based on the exposure factors discussed in Section 0. The frequency of construction worker contact with groundwater is expected to be no more than the 5 days per year assumed for the maintenance worker.

4.4.4 Adolescent Trespassers

The following exposure factors for trespassers conservatively assume trespassers to be adolescents from 6 to 16 years old. As discussed in Section 4.1.1, trespasser contact with onsite soil was not previously evaluated because onsite production activities had only recently ceased and fencing, security and decommissioning activities limited the opportunity for trespassing at that time.

Soil Ingestion Rate

A soil ingestion rate of 100 mg per day is conservatively used for adolescent trespassers. USEPA has recommended the use of this value for evaluating high-end exposures of adolescent residents to soil for an entire day (USEPA 1991a, 2014). Use of this value for trespassers at the Site is highly conservative because trespassers are only assumed to be onsite for 2 hours of their 16 waking hours, as discussed below.

Soil Dermal Contact Rate and Absorption

The exposed skin area of 4,400 cm^2 is calculated for the forearms, lower legs, hands and head of adolescents using the mean values for body surface area from USEPA (2011). The soil-to-skin adherence factor of 0.12 mg per cm^2 is the adherence factor for routine workers recommended by USEPA (2014) and is conservatively used for trespassers. The absorbed dose from dermal contact with soil is estimated by multiplying the dermal contact rate by USEPA-recommended absorption factors for chemical absorption from soil (2004b).

Exposure Time

Trespassers were assumed to be at the Site and inhale vapors and particulates from site-related sources for two hours per day while trespassing.

Exposure Frequency and Duration

The exposure frequency of 100 days per year for contact with soil is based on a conservative assumption that trespassers visit the Site two days per week and 50 weeks per year.

The exposure duration of 10 years is based on the assumed age range of the trespassers.

Body Weight

The body weight of 44.3 kg is the mean body weight of 6 to 16 year olds (USEPA 2011).

Averaging Time

The averaging time for evaluating cancer risk is equal to a lifetime of 70 years and the averaging time for evaluating non-cancer risk is equal to the exposure duration (USEPA 1989, 2014).

4.4.5 Residents

The exposure factors used for evaluating potential exposure of offsite residents, which are consistent with those in the 2013 HHRA, except where USEPA has revised its recommendations, are as follows:

Exposure Time

Residents are assumed to be at home and inhale vapors and particulates from site-related sources for 24 hours per day, the USEPA recommended value for residents (USEPA 2009, 2014).

Exposure Frequency and Duration

Residents are assumed to be at home for 350 days per year for 26 years (six years as children and 20 years as adults). This combination of exposure frequency and exposure duration is expected to be conservative for the amount of time that residents could actually be exposed while at home. USEPA has recommended the use of these values for evaluating high end residential exposures (USEPA 2014).

Averaging Time

The averaging time for evaluating cancer risk is equal to a lifetime of 70 years and the averaging time for evaluating non-cancer risk is equal to the exposure duration (USEPA 1989, 2014).

Uncertainties associated with the exposure factors used in estimating chemical intakes are discussed in Section 0.

5 Toxicity Values

A toxicity assessment identifies potential adverse health effects that are associated with exposure to chemicals and determines the dose response relationship between exposure and the occurrence of adverse effects. The toxicity values used in this update of the HHRA were compiled from USEPA's hierarchy of sources, which is consistent with the hierarchy in the 2013 HHRA, as follows:

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 was not available from the first two tiers of the hierarchy, other USEPA and non-USEPA sources [e.g. Agency for Toxic Substances and Disease Registry (ATSDR)] of toxicity values were consulted. The toxicity values used in the risk assessment and their sources are summarized in Appendix B and are discussed below. The toxicity values used in this risk assessment are current as of September 2015.

5.1 Cancer Toxicity Values

For chemicals that USEPA assessed prior to the 2005 Guidelines for Carcinogen Risk Assessment (USEPA 2005a), USEPA considers chemicals belonging to the following cancer weight of evidence groups as human carcinogens:

- Group A, Known Human Carcinogen: Sufficient evidence of carcinogenicity in humans;
- Group B1, Probable Human Carcinogen: Limited evidence of carcinogenicity in humans;
- Group B2, Probable Human Carcinogen: Sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans; and
- Group C, Possible Human Carcinogen: Limited evidence of carcinogenicity in animals and inadequate or lack of evidence in humans.

As shown in Appendix B, USEPA has designated some of the constituents identified at the Site as Group B2 or Group C, which means that USEPA acknowledges that there is either inadequate evidence or a lack of evidence that these constituents actually cause cancer in humans. Therefore, evaluating these constituents as human carcinogens in the risk assessment is conservative.

For chemicals that USEPA assessed after the 2005 Guidelines for Carcinogen Risk Assessment (USEPA 2005a), USEPA uses the following cancer weight of evidence groups:

- Carcinogenic to Humans;
- Likely to be Carcinogenic to Humans;
- Suggestive Evidence of Carcinogenic Potential; and
- Inadequate Information to Assess Carcinogenic Potential.

USEPA derived cancer slope factors (SFs) and inhalation unit risk factors (URFs) used in the risk assessment and their sources are shown in Appendix B. The oral SFs and URFs 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. Nonetheless, they are used here as conservative assessment tools. In addition, as recommended by USEPA (2005b), ADAFs are used to adjust toxicity values for carcinogens with a mutagenic mode of action to assess potential exposures of children and adolescents.

5.2 Non-cancer Toxicity Values

Constituents designated by USEPA as belonging to the cancer weight of evidence Group D (Not Classifiable as to Human Carcinogenicity) are considered non-carcinogens. Constituents not designated as belonging to any cancer group are also treated as non-carcinogens. Chronic and subchronic reference doses (RfDs) and inhalation reference concentrations (RfCs) used in the risk assessment and their sources are shown in Appendix B.

The oral RfDs and inhalation RfCs represent conservative estimates of the daily exposure to the human population, including sensitive subpopulations (e.g. children), which are likely to be without an appreciable risk of deleterious effects. These RfDs and RfCs typically incorporate several safety factors to account for uncertainties in their derivation, which in combination often result in overall uncertainty factors of 1,000 or more. Furthermore, for many constituents, there is significant scientific debate about the validity of these RfDs and RfCs and the association of these doses and concentrations to potential adverse health consequences. Nonetheless, the RfDs and RfCs are used here as conservative assessment tools.

5.3 Extrapolation of Toxicity Values

The USEPA sources of toxicity values discussed above do not provide dermal toxicity values for any of the constituents. Therefore, oral toxicity values (i.e. oral SFs and RfDs) are used as dermal toxicity values in this risk assessment. Adjustments to the oral toxicity values, where appropriate, are made in this route-to-route extrapolation following USEPA guidance (USEPA 2004b).

The USEPA sources of toxicity values discussed above do not provide inhalation toxicity values (URFs and RfCs) for all of the constituents. Route-to-route extrapolation from oral toxicity values was not performed to obtain inhalation toxicity values for these constituents, consistent with USEPA guidance on performing inhalation risk assessments (USEPA 2009).

Uncertainties introduced by using extrapolated toxicity values are discussed in Section 0.

5.4 Occupational Inhalation Limits

While operational, the Site was subject to by OSHA regulation and future uses of the Site could likewise be subject to OSHA regulation. Because these scenarios involve the use of

occupational exposure limits (OELs), this update of the HHRA includes an evaluation of worker inhalation exposures relative to OELs, similar to the evaluation in the 2013 HHRA. The OELs in this update of the HHRA are based on the lowest occupational inhalation limits from the following sources: Permissible exposure limits (PELs) established by OSHA (29 CFR 1910), threshold limit values (TLVs) recommended by the American Conference of Government Industrial Hygienists (ACGIH) (ACGIH 2015), the recommended exposure limits (RELs) established by National Institute for Occupational Safety and Health (NIOSH) (NIOSH 2007) and California OSHA PELs (CalOSHA 2015). Using the lowest value from these sources, while not enforceable by OSHA, is consistent with OSHA's current recommendations. This approach is more conservative than the approach in the 2013 HHRA, where a hierarchy of sources was used. These inhalation limits for constituents evaluated in the risk assessment are shown in Appendix B.

6 Risk Characterization

The health significance of the potential exposures described in Section 4 is discussed in the following subsections. Section 0 describes the methods for quantifying cancer risks and non-cancer HIs. Sections 0 and 0 discuss each receptor's risk estimates for the media to which they are assumed to be exposed. Uncertainties in this update of the HHRA are discussed in Section 0.

6.1 Cancer Risk and Non-cancer Hazard Index

The cancer risk associated with potential exposure to a chemical via ingestion and dermal contact is calculated by multiplying an estimate of the LADD for a particular exposure scenario by the cancer SF for the chemical, as follows:

$$Risk = LADD \cdot SF$$

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

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

where ET is exposure time, EF is exposure frequency, ED is exposure duration and AT_c is the averaging time for cancer risks.

The non-cancer hazard quotient (HQ) associated with potential exposure to a chemical via ingestion and dermal contact is calculated by dividing an estimate of the ADD for a particular exposure scenario by the RfD for the chemical, as follows:

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

For the inhalation route, the HQ is calculated using C_{air} and the RfC, as follows:

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

where AT_{nc} is the averaging time for non-cancer risks.

The media-specific cumulative cancer risk and non-cancer effects that may result from exposure to the combination of constituents at an area are estimated following USEPA guidance (USEPA 1989), as follows:

$$Cumulative\ Risk = \sum_i Risk_i$$

$$Hazard\ Index = \sum_i HQ_i$$

where:

$Risk_i$ = estimated cancer risk for the ith constituent

HQ_i = hazard quotient for the ith constituent

This approach may result in estimates of media-specific cumulative cancer risk and non-cancer HI that are more conservative than necessary. For example, different chemicals may cause different and unrelated non-cancer health effects, so summing the HQs for their individual effects would overestimate the significance of their combined effects. Nonetheless, this approach is used here as a conservative assessment tool.

The media-specific cumulative cancer risk and HI estimates for each receptor population are compared with ADEQ's and USEPA's cancer risk limit of 10^{-4} and HI limit of 1, respectively for determining whether Corrective Measures are warranted (ADEQ 2005, 61 FR 19432, May 1, 1996; USEPA 1991b). The risk estimates and results of the comparison to the USEPA and ADEQ limits are discussed in the following sections.

The details of the cumulative cancer risk and non-cancer HI calculations are presented in Appendix B.

6.2 Risk Characterization for Onsite Receptors

6.2.1 Estimating Risks to Onsite Routine Workers

As discussed in Section 0, routine workers are conservatively assumed to be exposed to constituents in surface and subsurface soil anywhere at the Site. The risk assessment evaluates the potential exposure of routine workers to constituents in soil conservatively assuming two alternate hypothetical cases at each area: (1) all soil is outdoors and workers are exposed to the outdoor soil for the entire work day; and (2) all soil is under an occupied building and workers are exposed to constituents in the soil via assumed vapor intrusion for the entire work day.

The upper-bound risk estimates, which are a conservative estimate of the RME risks, for these exposures are summarized in **Table 2**. Appendix B provides the risk estimates by chemical and route of exposure.

Table 2: Upper-Bound Cumulative Cancer Risks and Non-cancer HIs for Onsite Routine Workers

Soil	Outdoor		VI		
	Risk	**HI**	**Risk**	**HI**	**Occ**
	3E-06	4E-01	**7E-04**	**2E+02**	5E-02

Groundwater	Outdoor Inhalation		VI		
	Risk	**HI**	**Risk**	**HI**	**Occ**
	8E-07	3E-01	4E-05	**1E+01**	2E-03

Notes:
Cumulative cancer risk and HI estimates in excess of ADEQ's and USEPA's RME risk limits (1E-4 and 1, respectively) are shaded in bold.

Table 2 shows that the upper-bound risks for onsite routine worker exposure to soil and groundwater via vapor intrusion exceed ADEQ's and USEPA's cancer risk and/or HI limits of 10^{-4} and 1, respectively, for RME risks. All potential exposures for future onsite workers, will be managed via engineering and institutional controls as well as monitoring and the use of best practices (e.g. personal protective equipment, where appropriate) to ensure onsite exposures to soil, groundwater or vapors from soil or groundwater remain within acceptable exposure levels. The conservative use of maximum soil and groundwater concentrations resulting in the respective receptor's risk estimates in Table 2 is summarized below.

The estimates of unacceptable risk from soil in **Table 2** are primarily due to potential vapor intrusion from soil-derived vapors at the maximum detected concentration of trichloroethene (TCE) of 270 mg/kg. This concentration was detected in the soil sample at location DP-07, which was collected from approximately 5 ft bgs[3]. This location is in the paved former linear drainage feature outside of the northwest corner of the manufacturing building. Because this area is outdoors, there would be no potential for significant vapor intrusion exposure from this soil under current conditions, if the building were occupied.

Additionally, the upper-bound non-cancer risk for onsite routine worker exposure to groundwater via vapor intrusion exceeds ADEQ's and USEPA's HI limit of 1 for RME risks. This HI estimate is consistent with those from the 2013 HHRA and are primarily because of the maximum detected concentration of TCE in groundwater of 169 mg/L, which was detected at location MW-86. This location is outside the manufacturing building and within Area 1. The TCE concentrations at this location have ranged from 46.7 mg/L in April 2015 to 169 mg/L and was 131 mg/L during the most recent quarterly sampling event used in this risk assessment.

As discussed in Section 0, while operational the Site was subject to OSHA regulation and future uses of the Site could likewise be subject to OSHA regulation. Therefore, the significance of

[3] A removal action was performed immediately adjacent to DP-07 in 2014; and therefore, TCE impacts in this area are assumed to have been significantly reduced or eliminated, which enhances the conservatism of the evaluation of risks for the site.

potential exposure via vapor intrusion is also assessed using occupational inhalation limits. The assessment of vapor intrusion risk using occupational inhalation limits was conducted by dividing each constituent's predicted indoor air concentration due to vapor intrusion by its occupational inhalation limit and then summing the quotients (or ratios) for all constituents detected in the soil or groundwater. This approach is equivalent to 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). Consistent with the 2013 HHRA, the sum of the ratios is much lower than 1, as shown on **Table 2**. Therefore, vapor intrusion from subsurface soil or groundwater would not affect OSHA compliance.

As discussed in Section 0, manufacturing operations have ceased on Site and the only workers onsite are covered by Site Health and Safety Protocols (HASP). In potential future scenarios, not governed by Site HASP or OSHA, there could be exposures that exceed ADEQ's and USEPA risk limits as shown above.

6.2.2 Estimating Risks to Onsite Utility Maintenance Workers

As discussed in Section 0, utility maintenance workers are assumed to be exposed to surface and subsurface soil as well as shallow groundwater, including perched water, during subsurface maintenance activities anywhere at the Site. The upper-bound risk estimates for these exposures are summarized in **Table 3**. Appendix B provides the risk estimates by chemical and route of exposure.

Table 3: Upper-Bound Cumulative Cancer Risks and Non-cancer HIs for Onsite Utility Maintenance Workers

	Outdoor	
Soil	Risk	HI
	3E-07	9E-02

	Risk	HI
Groundwater	1E-04	**5E+01**

Table 3 shows that the upper-bound risk estimates for onsite utility maintenance worker exposure to soil meets ADEQ's and USEPA's cancer and non-cancer risk and HI limits for RME risks. These risk estimates are higher than those in the 2013 HHRA and are primarily due to potential exposure to the maximum detected concentration of TCE discussed in Section 0. All potential exposures for future onsite maintenance workers will be managed via engineering and institutional controls as well as monitoring and the use of best practices (e.g. personal protective equipment, where appropriate) to ensure onsite exposures to soil, groundwater or vapors from soil or groundwater remain within acceptable exposure levels. The conservative use of maximum soil and groundwater concentrations resulting in the respective receptor's risk estimates in Table 3 is summarized below.

This table also shows that the upper-bound non-cancer HI for onsite utility maintenance worker exposure to groundwater, which includes detected concentrations in the perched water, exceeds ADEQ's and USEPA's non-cancer HI limit of 1 for RME risks, which is consistent with the conclusions in the 2013 HHRA. The risk estimates for potential exposure to groundwater are primarily due to the maximum detected concentration of TCE of 169 mg/L at location MW-86, as discussed in Section 0. The groundwater at and around this location is approximately 20 ft bgs, which is deeper than workers are reasonably expected to excavate, as discussed in Section **Error! Reference source not found.**. Maintenance workers could, however, encounter perched groundwater during excavations at the Site. The maximum detected concentration of TCE in the perched water onsite was 0.0593 mg/L. The HI estimate for utility maintenance worker contact with perched water based on this concentration would meet ADEQ's and USEPA's HI limit of 1.

As discussed in Section 0, manufacturing operations have ceased on Site and the only workers onsite are covered by Site HASP. In potential future scenarios, not governed by Site HASP, there could be exposures that exceed ADEQ's and USEPA's RME risk limits for potential exposure to shallow groundwater, as shown above.

6.2.3 Estimating Risks to Onsite Redevelopment Construction Workers

As discussed in Section 0, redevelopment construction workers are assumed to be exposed to surface and subsurface soil as well as shallow groundwater, which could include perched water, during construction activities. The upper-bound risk estimates for these exposures are summarized in **Table 4**. Appendix B provides the risk estimates by chemical and route of exposure.

Table 4: Upper-Bound Cumulative Cancer Risks and Non-cancer HIs for Onsite Redevelopment Construction Workers

	Outdoor	
Soil	Risk	HI
	5E-07	**2E+00**

Groundwater	Risk	HI
	1E-05	**5E+01**

Table 4 shows that the upper-bound risk estimates for onsite redevelopment construction worker exposure to soil exceeds ADEQ's and USEPA's non-cancer HI limit of 1 for RME risks. These risk estimates are higher than those in the 2013 HHRA and are primarily due to potential exposure to the maximum detected concentration of TCE discussed in Section 0. All potential exposures for future onsite construction workers will be managed via engineering and institutional controls as well as monitoring and the use of best practices (e.g. personal protective equipment, where appropriate) to ensure onsite exposures to soil, groundwater or vapors from soil or groundwater remain within acceptable exposure levels. The conservative use of

maximum soil and groundwater concentrations resulting in the respective receptor's risk estimates in Table 4 is summarized below.

This table also shows that the upper-bound non-cancer HI for onsite redevelopment construction worker exposure to groundwater, which includes detected concentrations in the perched water, exceeds ADEQ's and USEPA's non-cancer HI limit of 1 for RME risks which is consistent with the conclusions in the 2013 HHRA. The risk estimates for potential exposure to groundwater are primarily because of the maximum detected concentration of TCE of 169 mg/L at location MW-86, as discussed in Section 0. The groundwater at and around this location is approximately 20 ft bgs, which is deeper than workers are reasonably expected to excavate, as discussed in Section **Error! Reference source not found.**. Construction workers could, however, encounter perched groundwater during excavations at the Site. The maximum detected concentration of TCE in the perched water onsite was 0.0593mg/L. The HI estimates for redevelopment construction worker contact with perched water based on this concentration would meet ADEQ's and USEPA's HI limit of 1.

As discussed in Section 0, manufacturing operations have ceased onsite and the only workers onsite are covered by Site HASP. In potential future scenarios, not governed by Site HASP, there could be exposures that exceed ADEQ's and USEPA's RME risk limits for potential exposure to shallow groundwater, as shown above.

6.2.4 Estimating Risks to Trespassers

As discussed in Section 0, trespassers are conservatively assumed to be exposed to surface soil anywhere at the Site (though most of the Site is paved) and outdoor air (assuming no pavement). The upper-bound risk estimates for these exposures are summarized in **Table 5**.

Table 5: Upper-Bound Cumulative Cancer Risks and Non-cancer HIs for Onsite Trespassers

	Outdoor	
Soil	Risk	HI
	3E-07	7E-02

	Outdoor Inhalation	
Groundwater	Risk	HI
	5E-08	3E-02

Notes:
Cumulative cancer risk and HI estimates in excess of ADEQ's and USEPA's RME risk limits (1E-4 and 1, respectively) are shaded in bold.

Table 5 shows that the upper-bound risk estimates for trespasser exposures to soil and groundwater meet ADEQ's and USEPA's cancer risk and HI limits of 10^{-4} and 1 for RME risks.

6.3 Risk Characterization for Offsite Receptors

6.3.1 Estimating Risks to Offsite Residents

As discussed in Section 0, offsite residents are conservatively assumed to be exposed to constituents in offsite subsurface soil via inhalation of soil vapors outdoors and indoors. Residents could also be exposed to constituents in onsite soil that volatilize to outdoor air and migration offsite. Additionally, offsite residents could be exposed to constituents in offsite groundwater that volatilize to outdoor or indoor air. The upper-bound risk estimates for these exposures are summarized in **Table 6a**.

As discussed in Section 0, soil vapor was collected at offsite locations and at the Site boundary to provide an additional line of evidence regarding the potential for significant vapor intrusion from groundwater into offsite residential buildings. Some soil vapor sampling points filled with water and it was not possible to collect soil vapor. Because soil vapor could not be collected from these locations, perched water was instead collected to provide an additional line of evidence in the evaluation of the potential for vapor intrusion from groundwater into offsite residential building, as discussed in Section 0. These upper-bound risk estimates are summarized in **Table 6b**.

Outdoor, crawl space and indoor air data were collected at a residential property exhibiting the highest soil vapor concentrations in April and November 2015 and are evaluated below to determine whether the detected concentrations in these media are associated with the groundwater conditions related to the Site.

Appendix B provides the risk estimates by chemical and route of exposure.

Table 6a: Upper-Bound Cumulative Cancer Risks and Non-cancer HIs for Offsite Residents

	Outdoor Inhalation		VI	
Off-Site Soil	Risk	HI	Risk	HI
	2E-09	7E-04	1E-06	3E-01

	Outdoor Inhalation		VI	
On-Site Soil	Risk	HI	Risk	HI
	5E-07	2E-01	NA	NA

	Outdoor Inhalation		VI	
Off-Site Groundwater	Risk	HI	Risk	HI
	2E-08	5E-03	5E-06	1E+00

Notes:
Cumulative cancer risk and HI estimates in excess of ADEQ's and USEPA's RME risk limits (1E-4 and 1, respectively) are shaded in bold.
NA -- Not Applicable.

Table 6a shows that the upper-bound risks for offsite residential exposure to offsite and onsite soil and groundwater meet ADEQ's and USEPA's cancer risk and HI limits for RME risks, which is consistent with the conclusions in the 2013 HHRA.

As discussed above, perched groundwater and soil vapor were evaluated to provide additional lines of evidence to determine where there is a potential for significant vapor intrusion from groundwater to occur at offsite residences. Perched groundwater and soil vapor samples from above perched groundwater were used to calculate estimates of the cumulative cancer risk and non-cancer HI. As discussed in Section 0, the perched groundwater was evaluated using an attenuation factor calculated using the approach used for shallow groundwater. The risk estimates for soil vapor conservatively used USEPA's generic default residential subslab attenuation factor of 0.03 which does not account for attenuation through at least 5 ft of clay prior to reaching a building.

The HI of 20 shown on **Table 6b** is based on the soil vapor TCE concentration of 1,200 ug/m^3 (collected on November 4, 2015) from VP-9 at Parcel 3, where the vapor intrusion pathway is incomplete based on the crawl space air data (Table 6c). The HI from soil vapor samples collected at soil vapor sampling locations other than VP-9 is no higher than 0.07.

Table 6b: Additional Lines of Evidence for Upper-Bound Cumulative Cancer Risks and Non-cancer HIs for Offsite Resident Vapor Intrusion

	VI	
Perched Water	Risk	HI
	4E-06	9E-01

	VI	
Soil Vapor *	Risk	HI
	8E-05	**2E+01**

Notes:
Cumulative cancer risk and HI estimates in excess of ADEQ's and USEPA's RME risk limits (1E-4 and 1, respectively) are shaded in bold.
* See text in preceeding paragraph.

Table 6b shows that the RME risk estimates for residential exposure to vapors from perched groundwater meet ADEQ's and USEPA's cancer risk and HI limits. As discussed above, the RME risk estimates for residential exposure to soil vapor exceeds the HI limit at Parcel 3, which is further evaluated below. The RME risk estimates for potential exposure to soil vapor for the remaining residential parcels meet ADEQ's and USEPA's cancer risk and HI limits.

The upper-bound risk estimates for soil vapor are higher than the risk estimates based on the perched groundwater data. As discussed in the quarterly reports, these higher risk estimates should not be interpreted as an indication that the risk estimates from the perched groundwater data are not adequately conservative. Rather, the interpretation should be that the risk estimates based on the soil vapor data are extreme upper-bound rather than reasonable worst-case and thus, are more conservative than necessary. As discussed in Section 0, these risk estimates for soil vapor ignore the attenuation due to the approximately 5 ft of silty clay between the soil vapor sample depth and the assumed subslab depth, which is likely to be substantial. Accounting for such attenuation would result in soil vapor risk estimates that are lower than those for perched groundwater.

As discussed above, outdoor, crawl space and indoor air data were also collected from a residence (Parcel 3) in the neighborhood north of the Site in April and November 2015[4]. As shown on **Table 6c**, only two chemicals [1,2-dichloroethane (1,2-DCA) and tetrachloroethene (PCE)] were detected in the crawl space air sample. Neither 1,2-DCA or PCE are believed to be related to contamination in the offsite groundwater because neither chemical was detected in groundwater at Parcel 3 nor detected elsewhere in offsite groundwater at concentrations that

[4] Risk calculations are based upon the soil vapor data from November 2015.

exceed the drinking water standard[5]. These were also the only two VOCs detected in the outdoor air. The concentrations in the crawl space air sample are nearly the same as those in the outdoor air, which is consistent with the fact that the crawl space has openings to outdoor air and that these concentrations are unrelated to contamination in offsite groundwater. The absence of detectable plume-related concentrations in the crawl space air data indicates an incomplete vapor intrusion pathway from the groundwater plume.

The concentrations of 1,2-DCA and TCE in the indoor air appear to be related to an indoor source (or sources) because the indoor air concentration of 1,2-DCA is approximately 35 times higher than the concentrations in the outdoor air and crawl space air and TCE was not detected in crawl space or outdoor air samples. The concentration of PCE in indoor air appears to be related to outdoor sources because it is nearly the same as the PCE concentrations in the outdoor air and crawl space air.

Because the detected concentrations in outdoor, crawl space and indoor air samples are not associated with the groundwater conditions related to the Site, the calculation of risk estimates is unnecessary to evaluate the degree of potential for vapor intrusion from groundwater.

Table 6c: Outdoor Air, Crawl Space Air and Indoor Air Concentrations at Parcel 3

Chemical	Outdoor Air	Crawl Space Air	Indoor Air
1,2-Dichloroethane	0.06	0.066	2.1
Tetrachloroethene	0.080	0.077	0.081
Trichloroethene	ND	ND	0.062

Notes:
All concentrations are in ug/m^3.
ND -- Not detected.

Using multiple lines of evidence, these results confirm that vapor intrusion from groundwater does not pose an unacceptable risk via vapor intrusion to offsite residences.

6.3.2 Estimating Risks to Offsite Routine Workers

As discussed in Section 0, offsite routine workers are conservatively assumed to be exposed to the same media and via the same routes of exposure as residents. These exposures for offsite routine workers are evaluated indirectly in this risk assessment using exposure estimates for offsite residents, as explained in Section 0. This streamlines the risk assessment and is conservative because offsite routine worker exposures would be lower than offsite residential exposures. Therefore, the cumulative cancer risk and HI for offsite routine worker exposure to

[5] 1,2-DCA was only detected offsite in groundwater at MW-31 (2008) at a concentration of 3 micrograms per liter (µg/L). MW-31 is more than 600 ft from Parcel 3. PCE was detected offsite in groundwater at MW-33/33R (2014/2015), MW-41 (2014), MW-43 (2006), MW-46R (2015) and MW-58 (2014) and MW-176 (2015) at concentrations ranging from 0.11 µg/L to 0.91 µg/L. MW-176 is located on Parcel 3 and the highest detected concentration of PCE was 0.14 µg/L, which is below the maximum contaminant level (MCL) of 5 µg/L.

soil and groundwater are expected to be no higher than the estimates discussed in Section 0, which meet ADEQ's and USEPA's cancer risk and HI limits for RME risks. These conclusions are consistent with those in the 2013 HHRA.

6.3.3 Estimating Risks to Offsite Utility Maintenance Workers

As discussed in Section 0, utility maintenance workers are assumed to be exposed to surface and subsurface soil as well as shallow groundwater, including perched water, during subsurface maintenance activities offsite. The upper-bound risk estimates for these exposures are summarized in **Table 7**. Appendix B provides the risk estimates by chemical and route of exposure.

Table 7: Upper-Bound Cumulative Cancer Risks and Non-cancer HIs for Offsite Utility Maintenance Workers

	Outdoor	
Soil	Risk	HI
	8E-11	7E-05

	Risk	HI
Groundwater	4E-07	2E-01

Notes:
Cumulative cancer risk and HI estimates in excess of ADEQ's and USEPA's RME risk limits (1E-4 and 1, respectively) are shaded in bold.

Table 7 shows that the upper-bound risk estimates for offsite utility maintenance worker exposure to soil and groundwater meet ADEQ's and USEPA's cancer and non-cancer risk and HI limits for RME risks. These conclusions are consistent with those in the 2013 HHRA.

6.4 Uncertainty Analysis

6.4.1 Exposure Concentrations

As discussed in Section 4.2.1, exposure concentrations for soil in this risk assessment are based on the highest concentrations detected in soil on- and offsite and concentrations more representative of the RME (e.g. 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 regarding the need for corrective measures.

However, this approach inflates the media specific cumulative cancer risk and HI estimates, since these estimates are entirely based on maximum detected concentrations. The use of maximum detected concentrations for all constituents introduces more conservatism than necessary for RME estimates because it assumes simultaneous worst case exposure to all

constituents constantly, when the RME generally would not have all constituents at worst case concentrations at all times.

The above discussion regarding soil exposure concentrations also applies to groundwater exposure concentrations for excavation scenarios, since maintenance workers and construction workers would not be expected to be exposed to groundwater with the maximum detected concentrations of every constituent during every excavation.

For the groundwater and soil vapor intrusion scenarios, the use of maximum detected concentrations also overstates the RME risk. This is because the groundwater under an individual building is unlikely to have the maximum detected concentrations of all constituents. However, these upper bound estimates can be useful for identifying constituents for which significant risk is possible, so that risk-based concentration limits for such constituents can be used to identify specific locations where significant exposures might occur.

Most exposure concentrations that are based on mathematical modeling of constituent 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 detected concentrations in soil or groundwater. In addition, the model estimates are conservative because they generally do not account for the reduction of constituent concentrations in the soil or groundwater as constituents transfer from these media. As a result, risk estimates that are based on the sum of risk estimates for multiple media are more conservative than necessary for RME estimates. These include many of the risk estimates discussed in Sections 6.2 and 6.3.

6.4.2 Exposure Factors

As discussed in Section 0, most of the exposure factors used in the risk assessment 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 detected concentrations (as discussed above).

Also, the use of generic default exposure factors for evaluation of potential exposure of workers to soil is more conservative than necessary for RME estimates, which allow the use of site-specific considerations (USEPA 1989). For example, the "fraction contacted" terms used in this evaluation assume that routine workers are exposed to soil for an entire work day at each area, but workers at commercial/industrial sites generally spend only a part of the work day at a particular part of the Site.

The ingestion rate for estimating exposure of construction workers to soil in this update of the HHRA is 200 mg per day. As noted in Section 0, this ingestion rate is based on USEPA-compiled soil-to-hand adherence data for construction-related activities (USEPA 1997) and is believed to be plausible, conservative and consistent with the expectation that incidental soil

ingestion is associated primarily with hand-to-mouth contact. More recently, USEPA guidance (2003) recommends an ingestion rate of 330 mg per day that is based on the variability in the data from a single soil ingestion study that involved a very small number of individuals. This ingestion rate was not used in the risk calculations discussed in Section 0 because it is based on very limited data that might not be appropriate for representing actual exposure. However, using the somewhat higher ingestion rate of 330 mg per day would not alter the conclusions of the risk assessment.

6.4.3 Extrapolated Toxicity Values

As discussed in Section 0, the dermal toxicity values used in this update of the HHRA 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 a conservative approach to ensure that potential risk via the dermal route is not overlooked. However, some constituents might exhibit different degrees of toxicity for the dermal route relative to the oral route. For such constituents, the extrapolation approach used in the risk evaluation could introduce uncertainty.

6.4.4 Risk Characterization

The summation of cancer risks and HQs for multiple constituents, as described in Section 0, is based on USEPA guidance (USEPA 1989) to assume dose additivity, which means that constituents in a mixture are assumed to have no synergistic or antagonistic interactions and each constituent has the same mode of action and elicits the same health effects. In general, this approach can introduce significant uncertainty. However, the majority of the cumulative cancer risk and HI estimates in this update of the HHRA are dominated by contributions from no more than a few constituents, so that the media specific cumulative risk estimates are nearly the same as those for the few key constituents.

7 Summary and Conclusions

This HHRA evaluated the potential health significance of data for soil, groundwater, soil gas, outdoor air, crawl space air and indoor air that were collected at and around the Site. The risk assessment used these data to derive upper-bound risks as conservative estimates of RME risks under current and reasonably expected future land and groundwater use at and around the Site. The evaluation used the data that are discussed in Section 3 and methods that are consistent with USEPA risk assessment guidance and ITRC recommendations on performing and using risk assessments to inform risk-based decisions. Estimates of cumulative cancer risks and non-cancer HIs were calculated and compared with ADEQ's and USEPA's cancer risk limit of 10^{-4} and a HI limit of 1, respectively, for RME risks, which ADEQ and USEPA have established as triggers for Corrective Measures under RCRA Corrective Action (ADEQ 2005, USEPA 1991b).

Based on consideration of current and reasonably expected land use at and around the Site, the potentially exposed populations evaluated in the risk assessment are:

- Onsite:
  - Routine workers
  - Utility Maintenance workers
  - Redevelopment Construction workers
  - Trespassers
- Offsite:
  - Residents
  - Routine workers
  - Utility Maintenance workers

The potential exposures evaluated for these receptors are summarized in the CSM presented in **Table 1**. Results of the risk assessment are summarized below and on **Table 2** to **Table 7** for these onsite and offsite receptors.

7.1 Onsite

Currently, there are no unacceptable exposures onsite.

In the future, there could be exposures that would result in risk estimates that exceed ADEQ's and USEPA's risk limits of 10^{-4} and 1, respectively. The calculated unacceptable risks are primarily due to potential exposure to maximum detected concentrations of TCE in soil and groundwater. All potential exposures for future onsite workers, maintenance workers or construction workers will be managed via engineering and institutional controls as well as monitoring and the use of best practices (e.g. personal protective equipment, where appropriate) to ensure onsite exposures to soil, groundwater or vapors from soil or groundwater remain within acceptable exposure levels.

7.2 Offsite

Currently, there are no unacceptable exposures offsite.

In the future, there could be exposures that may result in risk estimates that exceed ADEQ's and USEPA's risk limits of 10^{-4} and 1, respectively, if offsite soil vapors at Parcel 3 migrate into indoor air. Periodic monitoring will be completed to ensure that potential risk from vapor intrusion into offsite properties remain within acceptable exposure levels.

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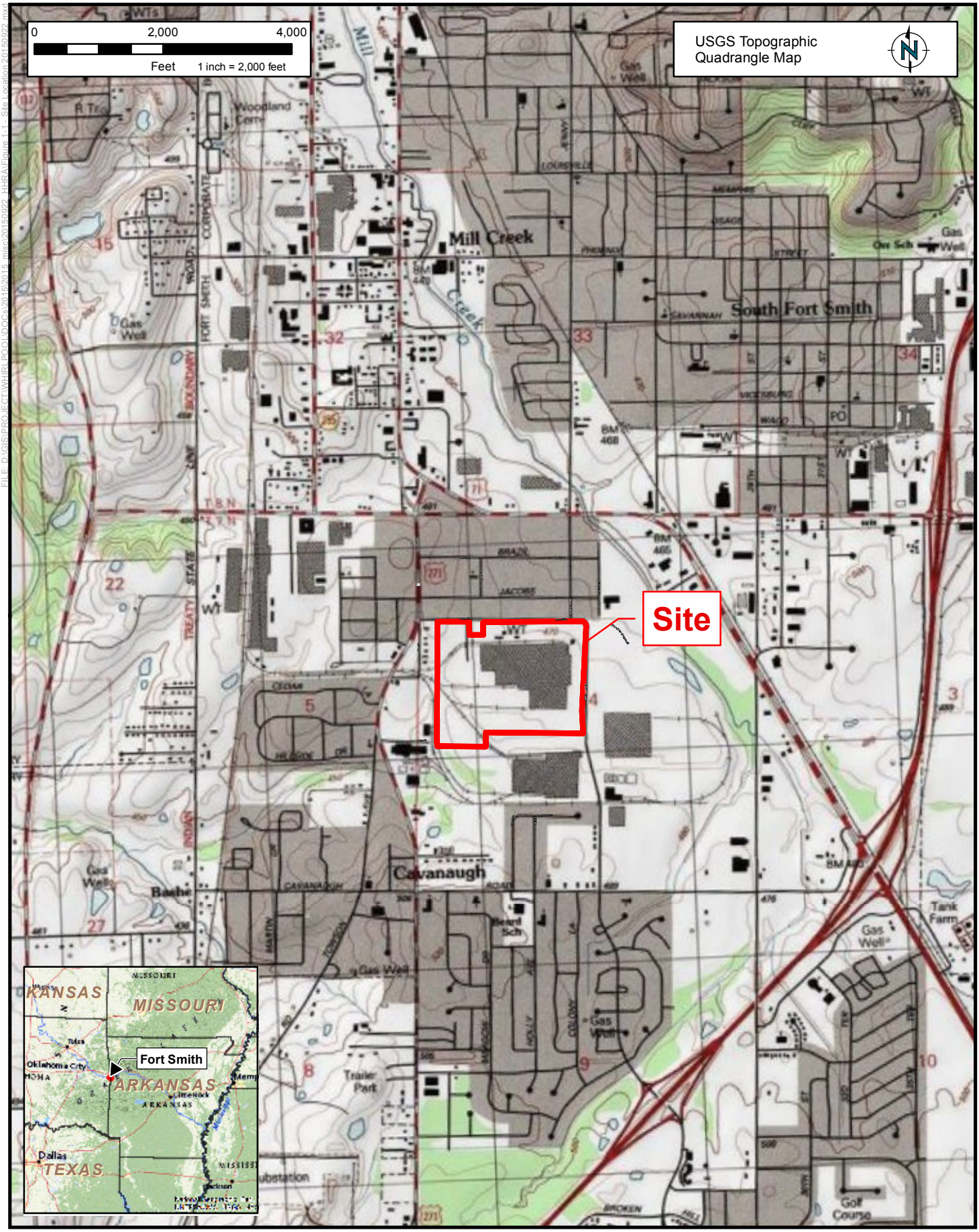
Figures



RAMBOLL ENVIRON

DRAFTED BY: KTS

DATE: 09/22/2015

SITE LOCATION

Whirlpool Facility - Fort Smith, Arkansas

Figure 1.1

PROJECT: 2131344B

RAMBOLL ENVIRON

DRAFTED BY: KTS

DATE: 09/22/2015

SITE LAYOUT

Whirlpool Facility - Fort Smith, Arkansas

Figure 1.2

PROJECT: 2131344B

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RAMBOLL ENVIRON

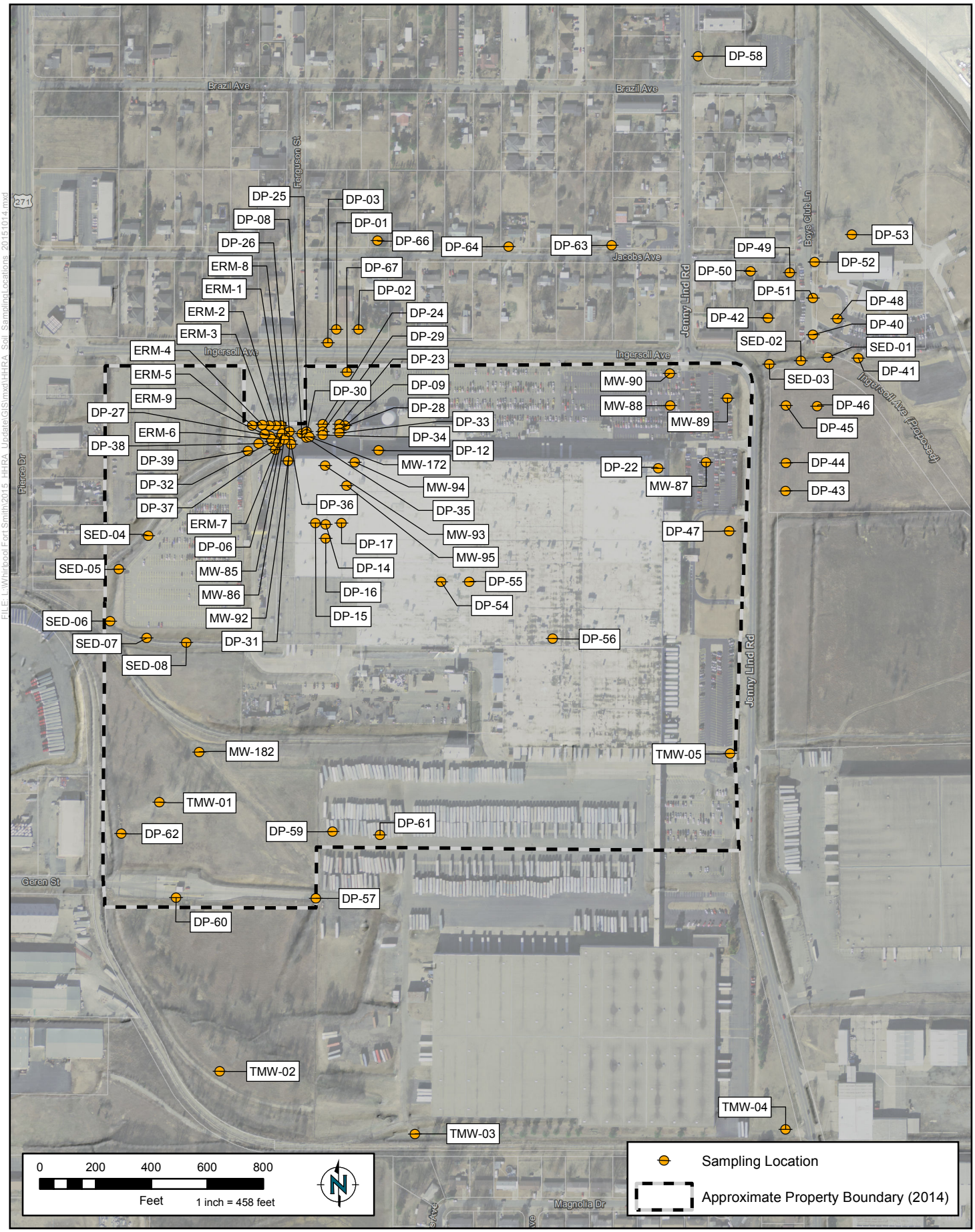
DRAFTED BY: KTS | DATE: 10/28/2015

LOCATION OF FORMER DRAINAGE TRENCH

Whirlpool Facility - Fort Smith, Arkansas

Figure 1.3

PROJECT: 3436269



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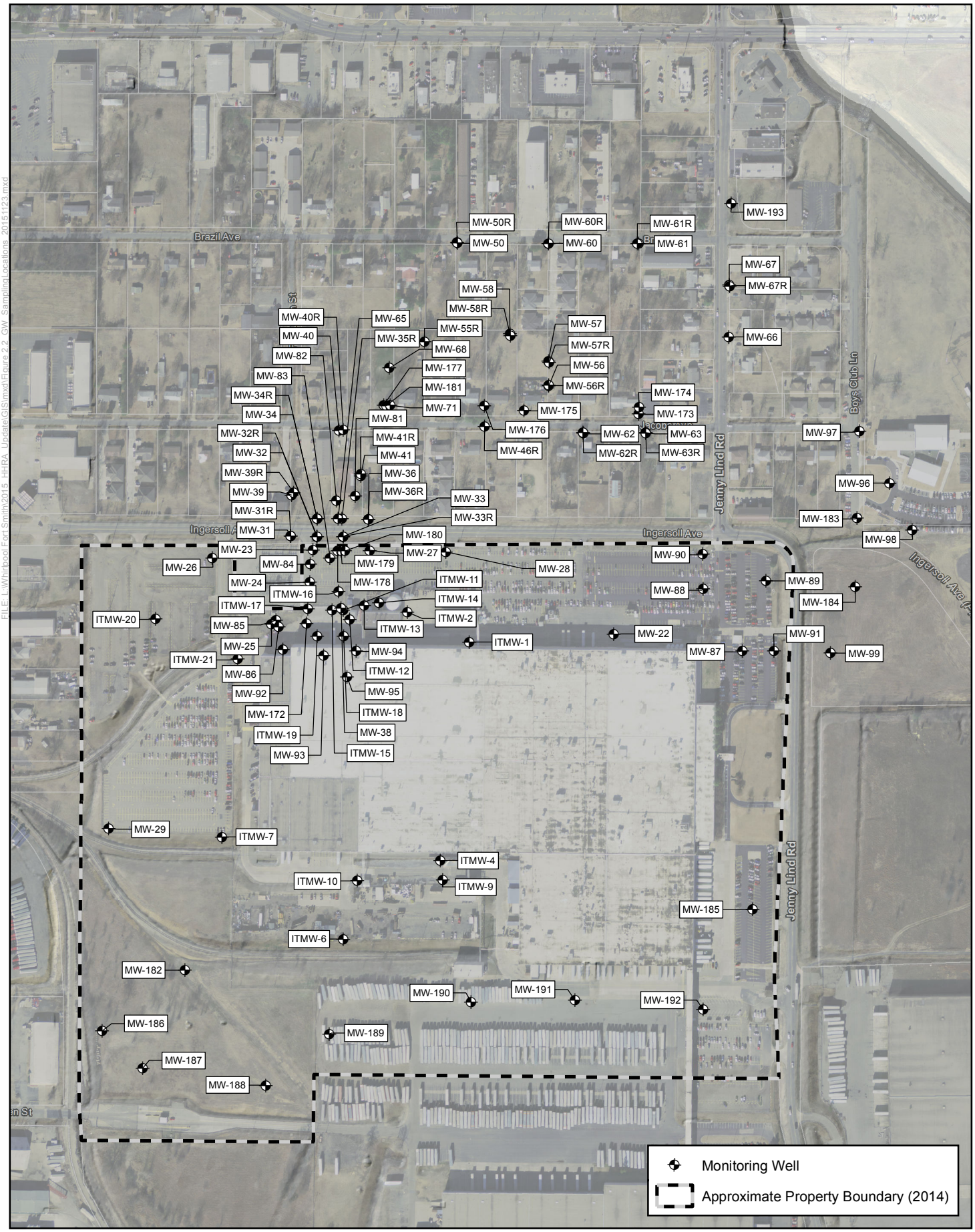
RAMBOLL ENVIRON

SOIL SAMPLING LOCATIONS

Whirlpool Facility - Fort Smith, Arkansas

Figure 2.1

DRAFTED BY: FK | DATE: 10/15/2015 | PROJECT: 3437500E



RAMBOLL ENVIRON

GROUNDWATER SAMPLING LOCATIONS (SINCE OCTOBER 2014)

Whirlpool Facility - Fort Smith, Arkansas

Figure 2.2

DRAFTED BY: FK | DATE: 11/24/2015 | PROJECT: 3437500E

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RAMBOLL ENVIRON

SOIL VAPOR, OUTDOOR AIR, CRAWL SPACE, AND INDOOR AIR SAMPLING LOCATIONS (SINCE OCTOBER 2014)

Whirlpool Facility - Fort Smith, Arkansas

Figure 2.3

DRAFTED BY: FK | DATE: 10/16/2015 | PROJECT: 3437500E

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RAMBOLL ENVIRON

DRAFTED BY: KTS

DATE: 10/09/2015

GROUNDWATER USE RESTRICTION MAP

Whirlpool Facility - Fort Smith, Arkansas

Figure 3

PROJECT: 3437500A

Appendix A

Samples Used in the Risk Assessment and Data Summaries

Attachment A1: Exposure Point Concentrations
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	On-Site Soil						Off-Site Soil		On-Site Groundwater		Off-Site Groundwater		Off-Site Perched Water		Off-Site Soil Vapor	
			Former Drainage Trench Soil		Remaining Site Soil		Total Site Soil											
			Conc (mg/kg)	Location	Conc (mg/kg)	Location	Conc (mg/kg)	Location	Conc (mg/kg)	Location	Conc (mg/kg)	Location	Conc (mg/kg)	Location	Conc (mg/kg)	Location	Conc (mg/kg)	Location
VOC	Acetone	67-64-1	5.86E-02	MW-172	5.16E-02	DP-59	5.86E-02	MW-172	6.23E-02	DP-58	3.99E-01	MW-86	6.36E-01	TMW-11	1.69E-01	VP-8		
VOC	Benzene	71-43-2	6.30E-04	DP-06			6.30E-04	DP-06			2.00E-03	MW-38	5.70E-04	MW-173	1.50E-03	VP-15		
VOC	Bromodichloromethane	75-27-4	2.60E-03	DP-29			2.60E-03	DP-29			5.30E-03	MW-25						
VOC	Bromoform	75-25-2			6.10E-03	MW-95	6.10E-03	MW-95			3.55E-02	MW-24	1.12E-02	MW-81				
VOC	Bromomethane	74-83-9	2.44E-01	MW-85			2.44E-01	MW-85	9.30E-03	DP-52	8.43E-02	MW-24	5.16E-02	MW-36R	4.80E-03	VP-5		
VOC	2-Butanone	78-93-3	2.50E-01	MW-86			2.50E-01	MW-86	6.30E-03	DP-53	1.43E-01	MW-86	8.10E-01	TMW-11	3.39E-02	VP-5		
VOC	Carbon Disulfide	75-15-0	2.80E-03	DP-30	7.40E-03	MW-92	7.40E-03	MW-92	9.10E-04	DP-01	1.08E-02	MW-86	6.20E-03	MW-173	8.60E-04	VP-6		
VOC	Carbon Tetrachloride	56-23-5	5.20E-03	DP-29			5.20E-03	DP-29			1.44E-02	MW-86						
VOC	Chlorobenzene	108-90-7									7.00E-03	MW-29			2.20E-04	VP-5		
VOC	Chloroethane	75-00-3									2.20E-03	MW-25	8.20E-04	MW-36R	9.60E-04	VP-5		
VOC	Chloroform	67-66-3	5.70E-02	DP-07	5.20E-03	DP-55	5.70E-02	DP-07			4.06E+00	MW-86	7.60E-03	MW-62R	1.05E-02	VP-10		
VOC	Chloromethane	74-87-3									1.10E-01	MW-25	4.87E-02	MW-36R	1.50E-03	VP-6		
VOC	Dibromochloromethane	124-48-1									3.50E-03	MW-25	2.20E-04	MW-81				
VOC	1,1-Dichloroethane	75-34-3	8.80E-03	DP-28			8.80E-03	DP-28			4.42E-02	MW-86					1.40E-02	VP-9
VOC	1,2-Dichloroethane	107-06-2	1.81E-01	MW-86	7.20E-03	MW-95	1.81E-01	MW-86			2.50E-03	MW-33R	1.60E-04	MW-36R			5.40E-03	VP-9
VOC	1,1-Dichloroethene	75-35-4	1.60E-01	DP-07	1.10E-03	DP-16	1.60E-01	DP-07			2.95E-01	MW-86	3.50E-03	MW-176	2.80E-03	VP-10	3.00E-02	VP-9
VOC	1,2-Dichloroethene (total)	540-59-0	5.20E+00	DP-08	4.90E-01	DP-16	5.20E+00	DP-08										
VOC	cis-1,2-Dichloroethene	156-59-2	1.85E+01	DP-29	4.90E-01	DP-16	1.85E+01	DP-29			2.87E+00	MW-25	1.11E-01	MW-176	1.88E-02	VP-10	5.40E-03	VP-9
VOC	trans-1,2-Dichloroethene	156-60-5	2.40E-01	DP-29			2.40E-01	DP-29			7.04E-01	MW-25	2.50E-03	MW-176	9.20E-04	VP-10	7.80E-04	VP-7
VOC	1,2-Dichloropropane	78-87-5									2.00E-03	MW-33R	2.50E-04	MW-181				
VOC	Ethyl Benzene	100-41-4	1.40E-03	DP-08			1.40E-03	DP-08							5.10E-04	VP-9		
VOC	2-Hexanone	591-78-6	7.30E-02	DP-07	5.90E-02	MW-95	7.30E-02	DP-07			5.80E-03	MW-86	3.60E-03	MW-173	1.20E-02	VP-5		
VOC	4-Methyl-2-pentanone	108-10-1	1.75E-02	DP-23			1.75E-02	DP-23			3.00E-03	MW-86	4.00E-03	TMW-11	2.50E-03	VP-5		
VOC	Methylene Chloride	75-09-2	3.14E+00	DP-23	7.00E-03	ERM-5	3.14E+00	DP-23	3.30E-03	DP-43	5.05E-02	MW-86	4.65E-03	MW-41R	1.50E-03	VP-5		
VOC	Styrene	100-42-5													1.60E-04	VP-8		
VOC	1,1,2,2-Tetrachloroethane	79-34-5									1.71E+00	MW-86						
VOC	Tetrachloroethene	127-18-4	1.70E-01	DP-07	4.40E-03	DP-14	1.70E-01	DP-07			4.40E-02	MW-86	8.90E-04	MW-46R	2.60E-04	VP-9	1.50E-03	VP-9
VOC	Toluene	108-88-3	7.03E-02	DP-28	1.60E-03	DP-16	7.03E-02	DP-28	1.20E-03	DP-03	1.04E-02	MW-86	3.80E-03	MW-176	1.50E-03	VP-10		
VOC	1,1,1-Trichloroethane	71-55-6	3.20E-02	DP-07			3.20E-02	DP-07			1.31E+00	MW-86					4.50E-05	VP-9
VOC	1,1,2-Trichloroethane	79-00-5	3.50E-02	DP-07			3.50E-02	DP-07			1.07E-02	MW-86						
VOC	Trichloroethene	79-01-6	2.70E+02	DP-07	1.70E+00	DP-16	2.70E+02	DP-07	1.60E-02	DP-01	1.69E+02	MW-86	7.20E-01	MW-176	6.36E-01	VP-10	1.20E+00	VP-9
VOC	Vinyl Chloride	75-01-4	4.43E+00	DP-23	3.80E-02	DP-16	4.43E+00	DP-23			5.40E-01	MW-25	1.50E-03	MW-58	6.10E-04	VP-10	1.90E-02	VP-9
VOC	Xylenes (total)	1330-20-7	8.90E-03	DP-08	1.06E-03	DP-14	8.90E-03	DP-08	3.60E-03	DP-03								
INORG	Iron	7439-89-6									1.43E+01	MW-184	7.40E+01	MW-61R				
INORG	Manganese	7439-96-5									1.28E+01	MW-33R	2.00E+01	MW-61R				

Attachment A2: Samples Used in the Risk Assessment Whirlpool, Fort Smith, Arkansas				
On/Off-Site	**Matrix**	**Location**	**Sample Date**	**Sample Name**
On-Site	Groundwater	ITMW-1	10/15/2014	ITMW-1-201410
On-Site	Groundwater	ITMW-1	1/14/2015	ITMW-1-201501
On-Site	Groundwater	ITMW-1	4/15/2015	ITMW-1-201504
On-Site	Groundwater	ITMW-1	7/22/2015	ITMW-1-201507
On-Site	Groundwater	ITMW-1	10/7/2015	ITMW-1-201510
On-Site	Groundwater	ITMW-11	10/15/2014	ITMW-11-201410
On-Site	Groundwater	ITMW-11	12/4/2014	ITMW-11-20141204
On-Site	Groundwater	ITMW-11	1/15/2015	ITMW-11-201501
On-Site	Groundwater	ITMW-11	4/15/2015	ITMW-11-201504
On-Site	Groundwater	ITMW-11	7/22/2015	ITMW-11-201507
On-Site	Groundwater	ITMW-11	10/7/2015	ITMW-11-201510
On-Site	Groundwater	ITMW-12	10/15/2014	DUP-04-201410
On-Site	Groundwater	ITMW-12	10/15/2014	ITMW-12-201410
On-Site	Groundwater	ITMW-12	12/4/2014	ITMW-12-20141204
On-Site	Groundwater	ITMW-12	1/15/2015	DUP-04-201501
On-Site	Groundwater	ITMW-12	1/15/2015	ITMW-12-201501
On-Site	Groundwater	ITMW-12	4/15/2015	ITMW-12-201504
On-Site	Groundwater	ITMW-12	7/23/2015	ITMW-12-201507
On-Site	Groundwater	ITMW-12	10/7/2015	ITMW-12-201510
On-Site	Groundwater	ITMW-13	10/15/2014	ITMW-13-201410
On-Site	Groundwater	ITMW-13	1/14/2015	ITMW-13-201501
On-Site	Groundwater	ITMW-13	4/15/2015	ITMW-13-201504
On-Site	Groundwater	ITMW-13	4/15/2015	DUP-03-201504
On-Site	Groundwater	ITMW-13	4/15/2015	ITMW-13-201504
On-Site	Groundwater	ITMW-13	7/22/2015	ITMW-13-201507
On-Site	Groundwater	ITMW-13	7/22/2015	DUP-02-201507
On-Site	Groundwater	ITMW-13	7/22/2015	ITMW-13-201507
On-Site	Groundwater	ITMW-13	10/7/2015	DUP-01-201510
On-Site	Groundwater	ITMW-13	10/7/2015	ITMW-13-201510
On-Site	Groundwater	ITMW-14	10/15/2014	ITMW-14-201410
On-Site	Groundwater	ITMW-14	1/14/2015	ITMW-14-201501
On-Site	Groundwater	ITMW-14	4/15/2015	ITMW-14-201504
On-Site	Groundwater	ITMW-14	7/22/2015	ITMW-14-201507
On-Site	Groundwater	ITMW-14	10/7/2015	ITMW-14-201510
On-Site	Groundwater	ITMW-15	10/16/2014	DUP-05-201410
On-Site	Groundwater	ITMW-15	10/16/2014	ITMW-15-201410
On-Site	Groundwater	ITMW-15	12/5/2014	ITMW-15-20141205
On-Site	Groundwater	ITMW-15	1/15/2015	DUP-05-201501
On-Site	Groundwater	ITMW-15	1/15/2015	ITMW-15-201501
On-Site	Groundwater	ITMW-15	4/15/2015	ITMW-15-201504
On-Site	Groundwater	ITMW-15	7/22/2015	ITMW-15-201507
On-Site	Groundwater	ITMW-15	10/8/2015	ITMW-15-201510
On-Site	Groundwater	ITMW-15	10/21/2015	ITMW-15-201510
On-Site	Groundwater	ITMW-16	10/15/2014	ITMW-16-201410
On-Site	Groundwater	ITMW-16	1/14/2015	ITMW-16-201501
On-Site	Groundwater	ITMW-16	4/14/2015	ITMW-16-201504
On-Site	Groundwater	ITMW-16	7/22/2015	ITMW-16-201507
On-Site	Groundwater	ITMW-16	7/22/2015	ITMW-16-201507
On-Site	Groundwater	ITMW-16	10/7/2015	ITMW-16-201510
On-Site	Groundwater	ITMW-17	10/16/2014	ITMW-17-201410
On-Site	Groundwater	ITMW-17	12/5/2014	ITMW-17-20141205
On-Site	Groundwater	ITMW-17	1/15/2015	ITMW-17-201501

Attachment A2: Samples Used in the Risk Assessment Whirlpool, Fort Smith, Arkansas				
On/Off-Site	**Matrix**	**Location**	**Sample Date**	**Sample Name**
On-Site	Groundwater	ITMW-17	4/15/2015	ITMW-17-201504
On-Site	Groundwater	ITMW-17	7/22/2015	ITMW-17-201507
On-Site	Groundwater	ITMW-17	7/22/2015	ITMW-17-201507
On-Site	Groundwater	ITMW-17	10/8/2015	ITMW-17-201510
On-Site	Groundwater	ITMW-18	10/15/2014	ITMW-18-201410
On-Site	Groundwater	ITMW-18	12/4/2014	ITMW-18-20141204
On-Site	Groundwater	ITMW-18	1/15/2015	ITMW-18-201501
On-Site	Groundwater	ITMW-18	4/16/2015	DUP-04-201504
On-Site	Groundwater	ITMW-18	4/16/2015	ITMW-18-201504
On-Site	Groundwater	ITMW-18	7/22/2015	ITMW-18-201507
On-Site	Groundwater	ITMW-18	7/23/2015	DUP-07-201507
On-Site	Groundwater	ITMW-18	7/23/2015	ITMW-18-201507
On-Site	Groundwater	ITMW-18	10/8/2015	DUP-06-201510
On-Site	Groundwater	ITMW-18	10/8/2015	ITMW-18-201510
On-Site	Groundwater	ITMW-18	10/21/2015	ITMW-18-201510
On-Site	Groundwater	ITMW-19	10/16/2014	ITMW-19-201410
On-Site	Groundwater	ITMW-19	12/5/2014	ITMW-19-20141205
On-Site	Groundwater	ITMW-19	1/15/2015	ITMW-19-201501
On-Site	Groundwater	ITMW-19	4/15/2015	ITMW-19-201504
On-Site	Groundwater	ITMW-19	7/22/2015	ITMW-19-201507
On-Site	Groundwater	ITMW-19	7/23/2015	ITMW-19-201507
On-Site	Groundwater	ITMW-19	10/8/2015	ITMW-19-201510
On-Site	Groundwater	ITMW-19	10/21/2015	ITMW-19-201510
On-Site	Groundwater	ITMW-2	10/15/2014	ITMW-2-201410
On-Site	Groundwater	ITMW-2	1/13/2015	ITMW-2-201501
On-Site	Groundwater	ITMW-2	4/15/2015	ITMW-2-201504
On-Site	Groundwater	ITMW-2	7/22/2015	ITMW-2-201507
On-Site	Groundwater	ITMW-2	10/6/2015	ITMW-2-201510
On-Site	Groundwater	ITMW-20	10/15/2014	ITMW-20-201410
On-Site	Groundwater	ITMW-20	1/12/2015	ITMW-20-201501
On-Site	Groundwater	ITMW-20	4/13/2015	ITMW-20-201504
On-Site	Groundwater	ITMW-20	7/22/2015	ITMW-20-201507
On-Site	Groundwater	ITMW-20	10/7/2015	ITMW-20-201510
On-Site	Groundwater	ITMW-21	10/15/2014	ITMW-21-201410
On-Site	Groundwater	ITMW-21	1/14/2015	ITMW-21-201501
On-Site	Groundwater	ITMW-21	4/14/2015	ITMW-21-201504
On-Site	Groundwater	ITMW-21	7/22/2015	ITMW-21-201507
On-Site	Groundwater	ITMW-21	10/8/2015	ITMW-21-201510
On-Site	Groundwater	ITMW-4	10/16/2014	ITMW-4-201410
On-Site	Groundwater	ITMW-4	1/13/2015	ITMW-4-201501
On-Site	Groundwater	ITMW-4	4/14/2015	ITMW-4-201504
On-Site	Groundwater	ITMW-4	7/22/2015	ITMW-4-201507
On-Site	Groundwater	ITMW-4	10/7/2015	ITMW-4-201510
On-Site	Groundwater	ITMW-9	10/15/2014	DUP-02-201410
On-Site	Groundwater	ITMW-9	10/15/2014	ITMW-9-201410
On-Site	Groundwater	ITMW-9	1/13/2015	DUP-02-201501
On-Site	Groundwater	ITMW-9	1/13/2015	ITMW-9-201501
On-Site	Groundwater	ITMW-9	4/15/2015	ITMW-9-201504
On-Site	Groundwater	ITMW-9	7/21/2015	ITMW-9-201507
On-Site	Groundwater	ITMW-9	10/7/2015	DUP-09-201510
On-Site	Groundwater	ITMW-9	10/7/2015	ITMW-9-201510
On-Site	Groundwater	MW-172	10/22/2014	MW-172-20141022

Attachment A2: Samples Used in the Risk Assessment Whirlpool, Fort Smith, Arkansas				
On/Off-Site	**Matrix**	**Location**	**Sample Date**	**Sample Name**
On-Site	Groundwater	MW-172	12/5/2014	MW-172-20141205
On-Site	Groundwater	MW-172	1/15/2015	MW-172-201501
On-Site	Groundwater	MW-172	4/16/2015	MW-172-201504
On-Site	Groundwater	MW-172	7/23/2015	MW-172-201507
On-Site	Groundwater	MW-172	10/8/2015	MW-172-201510
On-Site	Groundwater	MW-172	10/22/2015	MW-172-201510
On-Site	Groundwater	MW-177	4/14/2015	MW-177-201504
On-Site	Groundwater	MW-177	10/6/2015	MW-177-201510
On-Site	Groundwater	MW-177	1/21/2015	MW-177-GW-20150121
On-Site	Groundwater	MW-178	4/16/2015	MW-178-201504
On-Site	Groundwater	MW-178	7/22/2015	MW-178-201507
On-Site	Groundwater	MW-178	10/7/2015	MW-178-201510
On-Site	Groundwater	MW-178	1/18/2015	MW-178-GW-20150118
On-Site	Groundwater	MW-179	4/16/2015	MW-179-201504
On-Site	Groundwater	MW-179	7/22/2015	MW-179-201507
On-Site	Groundwater	MW-183	10/6/2015	MW-183-201510
On-Site	Groundwater	MW-184	10/5/2015	MW-184-201510
On-Site	Groundwater	MW-185	9/16/2015	MW-185-GW-091615
On-Site	Groundwater	MW-185	10/5/2015	MW-185-201510
On-Site	Groundwater	MW-186	9/14/2015	MW-186-GW-091415
On-Site	Groundwater	MW-186	10/5/2015	MW-186-201510
On-Site	Groundwater	MW-187	9/14/2015	MW-187-GW-091415
On-Site	Groundwater	MW-187	10/5/2015	MW-187-201510
On-Site	Groundwater	MW-188	9/17/2015	MW-188A-GW-091715
On-Site	Groundwater	MW-188	10/5/2015	MW-188-201510
On-Site	Groundwater	MW-189	9/17/2015	MW-189A-GW-091715
On-Site	Groundwater	MW-189	10/5/2015	MW-189-201510
On-Site	Groundwater	MW-190	9/14/2015	MW-190-GW-091415
On-Site	Groundwater	MW-190	10/5/2015	MW-190-201510
On-Site	Groundwater	MW-191	9/15/2015	MW-191-GW-091515
On-Site	Groundwater	MW-191	10/5/2015	MW-191-201510
On-Site	Groundwater	MW-191	10/5/2015	MW-191-201510
On-Site	Groundwater	MW-192	9/16/2015	MW-192-GW-091615
On-Site	Groundwater	MW-192	10/5/2015	MW-192-201510
On-Site	Groundwater	MW-193	10/6/2015	MW-193-201510
On-Site	Groundwater	MW-22	10/15/2014	MW-22-201410
On-Site	Groundwater	MW-22	1/13/2015	MW-22-201501
On-Site	Groundwater	MW-22	4/13/2015	MW-22-201504
On-Site	Groundwater	MW-22	7/22/2015	MW-22-201507
On-Site	Groundwater	MW-22	10/7/2015	MW-22-201510
On-Site	Groundwater	MW-23	10/23/2014	MW-23-20141023
On-Site	Groundwater	MW-23	1/15/2015	MW-23-201501
On-Site	Groundwater	MW-23	4/14/2015	MW-23-201504
On-Site	Groundwater	MW-23	7/23/2015	MW-23-201507
On-Site	Groundwater	MW-23	10/8/2015	MW-23-201510
On-Site	Groundwater	MW-23	10/21/2015	MW-23-201510
On-Site	Groundwater	MW-23	11/5/2015	MW-23-201511
On-Site	Groundwater	MW-24	10/23/2014	MW-24-20141023
On-Site	Groundwater	MW-24	1/15/2015	MW-24-201501
On-Site	Groundwater	MW-24	4/16/2015	MW-24-201504
On-Site	Groundwater	MW-24	7/23/2015	MW-24-201507
On-Site	Groundwater	MW-24	10/8/2015	MW-24-201510

Attachment A2: Samples Used in the Risk Assessment Whirlpool, Fort Smith, Arkansas				
On/Off-Site	**Matrix**	**Location**	**Sample Date**	**Sample Name**
On-Site	Groundwater	MW-24	10/21/2015	MW-24-201510
On-Site	Groundwater	MW-24	11/5/2015	MW-24-201511
On-Site	Groundwater	MW-25	10/16/2014	MW-25-201410
On-Site	Groundwater	MW-25	10/24/2014	MW-25-20141024
On-Site	Groundwater	MW-25	12/5/2014	MW-25-20141205
On-Site	Groundwater	MW-25	1/15/2015	MW-25-201501
On-Site	Groundwater	MW-25	4/16/2015	MW-25-201504
On-Site	Groundwater	MW-25	7/22/2015	MW-25-201507
On-Site	Groundwater	MW-25	7/23/2015	MW-25-201507
On-Site	Groundwater	MW-25	10/8/2015	MW-25-201510
On-Site	Groundwater	MW-26	10/14/2014	MW-26-201410
On-Site	Groundwater	MW-26	10/14/2014	MW-26-201410
On-Site	Groundwater	MW-26	1/14/2015	MW-26-201501
On-Site	Groundwater	MW-26	1/14/2015	MW-26-201501
On-Site	Groundwater	MW-26	4/13/2015	MW-26-201504
On-Site	Groundwater	MW-26	7/22/2015	MW-26-201507
On-Site	Groundwater	MW-26	10/7/2015	MW-26-201510
On-Site	Groundwater	MW-27	10/14/2014	MW-27-201410
On-Site	Groundwater	MW-27	1/14/2015	MW-27-201501
On-Site	Groundwater	MW-27	4/13/2015	MW-27-201504
On-Site	Groundwater	MW-27	7/22/2015	MW-27-201507
On-Site	Groundwater	MW-27	10/7/2015	MW-27-201510
On-Site	Groundwater	MW-28	10/14/2014	MW-28-201410
On-Site	Groundwater	MW-28	1/14/2015	MW-28-201501
On-Site	Groundwater	MW-28	4/13/2015	MW-28-201504
On-Site	Groundwater	MW-28	7/22/2015	MW-28-201507
On-Site	Groundwater	MW-28	10/7/2015	MW-28-201510
On-Site	Groundwater	MW-29	10/15/2014	MW-29-201410
On-Site	Groundwater	MW-29	1/13/2015	MW-29-201501
On-Site	Groundwater	MW-29	4/14/2015	MW-29-201504
On-Site	Groundwater	MW-29	7/22/2015	MW-29-201507
On-Site	Groundwater	MW-29	10/7/2015	MW-29-201510
On-Site	Groundwater	MW-31	10/14/2014	MW-31-201410
On-Site	Groundwater	MW-31	1/12/2015	MW-31-201501
On-Site	Groundwater	MW-31R	1/19/2015	MW-31R-GW-20150119
On-Site	Groundwater	MW-31R	4/14/2015	MW-31R-201504
On-Site	Groundwater	MW-31R	7/21/2015	MW-31R-201507
On-Site	Groundwater	MW-31R	10/6/2015	MW-31R-201510
On-Site	Groundwater	MW-32	10/14/2014	MW-32-201410
On-Site	Groundwater	MW-32	1/14/2015	MW-32-201501
On-Site	Groundwater	MW-33	10/15/2014	MW-33-201410
On-Site	Groundwater	MW-33	1/14/2015	MW-33-201501
On-Site	Groundwater	MW-33R	1/18/2015	MW-33R-GW-20150118
On-Site	Groundwater	MW-33R	4/15/2015	DUP-01-201504
On-Site	Groundwater	MW-33R	4/15/2015	MW-33R-201504
On-Site	Groundwater	MW-33R	7/22/2015	DUP-04-201507
On-Site	Groundwater	MW-33R	7/22/2015	MW-33R-201507
On-Site	Groundwater	MW-33R	10/8/2015	DUP-05-201510
On-Site	Groundwater	MW-33R	10/8/2015	MW-33R-201510
On-Site	Groundwater	MW-33R	10/22/2015	MW-33R-201510
On-Site	Groundwater	MW-33R	11/5/2015	MW-33R-201511
On-Site	Groundwater	MW-38	10/16/2014	DUP-06-201410

Attachment A2: Samples Used in the Risk Assessment Whirlpool, Fort Smith, Arkansas				
On/Off-Site	**Matrix**	**Location**	**Sample Date**	**Sample Name**
On-Site	Groundwater	MW-38	10/16/2014	MW-38-201410
On-Site	Groundwater	MW-38	12/4/2014	MW-38-20141204
On-Site	Groundwater	MW-38	1/15/2015	DUP-06-201501
On-Site	Groundwater	MW-38	1/15/2015	MW-38-201501
On-Site	Groundwater	MW-38	4/16/2015	MW-38-201504
On-Site	Groundwater	MW-38	7/22/2015	MW-38-201507
On-Site	Groundwater	MW-38	7/23/2015	MW-38-201507
On-Site	Groundwater	MW-38	10/8/2015	MW-38-201510
On-Site	Groundwater	MW-38	10/21/2015	MW-38-201510
On-Site	Groundwater	MW-86	12/5/2014	MW-86-20141205
On-Site	Groundwater	MW-86	1/15/2015	MW-86-201501
On-Site	Groundwater	MW-86	4/16/2015	MW-86-201504
On-Site	Groundwater	MW-86	7/23/2015	MW-86-201507
On-Site	Groundwater	MW-86	10/8/2015	MW-86-201510
On-Site	Groundwater	MW-87	10/16/2014	MW-87-201410
On-Site	Groundwater	MW-87	1/14/2015	MW-87-201501
On-Site	Groundwater	MW-87	4/16/2015	MW-87-201504
On-Site	Groundwater	MW-87	7/23/2015	MW-87-201507
On-Site	Groundwater	MW-87	10/7/2015	MW-87-201510
On-Site	Groundwater	MW-87	10/7/2015	MW-87-201510
On-Site	Groundwater	MW-88	10/16/2014	MW-88-201410
On-Site	Groundwater	MW-88	1/13/2015	MW-88-201501
On-Site	Groundwater	MW-88	4/16/2015	MW-88-201504
On-Site	Groundwater	MW-88	7/23/2015	MW-88-201507
On-Site	Groundwater	MW-88	10/7/2015	MW-88-201510
On-Site	Groundwater	MW-89	10/15/2014	MW-89-201410
On-Site	Groundwater	MW-89	1/13/2015	MW-89-201501
On-Site	Groundwater	MW-89	4/16/2015	MW-89-201504
On-Site	Groundwater	MW-89	7/23/2015	MW-89-201507
On-Site	Groundwater	MW-89	10/7/2015	MW-89-201510
On-Site	Groundwater	MW-90	10/16/2014	MW-90-201410
On-Site	Groundwater	MW-90	1/12/2015	MW-90-201501
On-Site	Groundwater	MW-90	4/15/2015	MW-90-201504
On-Site	Groundwater	MW-90	7/22/2015	MW-90-201507
On-Site	Groundwater	MW-90	10/7/2015	MW-90-201510
On-Site	Groundwater	MW-91	10/16/2014	MW-91-201410
On-Site	Groundwater	MW-91	1/13/2015	DUP-07-201501
On-Site	Groundwater	MW-91	1/13/2015	MW-91-201501
On-Site	Groundwater	MW-91	4/16/2015	MW-91-201504
On-Site	Groundwater	MW-91	7/23/2015	MW-91-201507
On-Site	Groundwater	MW-91	10/7/2015	DUP-08-201510
On-Site	Groundwater	MW-91	10/7/2015	MW-91-201510
On-Site	Groundwater	MW-92	10/22/2014	MW-92-20141022
On-Site	Groundwater	MW-92	12/4/2014	MW-92-20141204
On-Site	Groundwater	MW-92	1/15/2015	MW-92-201501
On-Site	Groundwater	MW-92	4/16/2015	MW-92-201504
On-Site	Groundwater	MW-92	7/23/2015	MW-92-201507
On-Site	Groundwater	MW-92	10/8/2015	MW-92-201510
On-Site	Perched Water	VP-12	4/22/2015	VP-12-20150422
On-Site	Perched Water	VP-12	7/30/2015	VP-12-201507
On-Site	Perched Water	VP-12	10/7/2015	VP-12-201510
On-Site	Perched Water	VP-12	1/21/2015	VP-12-GW-20150121

Attachment A2: Samples Used in the Risk Assessment Whirlpool, Fort Smith, Arkansas				
On/Off-Site	**Matrix**	**Location**	**Sample Date**	**Sample Name**
On-Site	Perched Water	VP-14	7/30/2015	VP-14-201507
On-Site	Perched Water	VP-14	10/7/2015	VP-14-201510
On-Site	Perched Water	VP-2D	10/15/2014	VP-2-DEEP-201410
On-Site	Perched Water	VP-2S	10/15/2014	VP-2-SHALLOW-201410
On-Site	Soil	DP-38	8/5/2014	DP-38 (5.0 FT) - 082014
On-Site	Soil	DP-38	8/5/2014	DP-38 (14.5 FT) - 082014
On-Site	Soil	DP-38	8/5/2014	DP-38 (18.0 FT) - 082014
On-Site	Soil	DP-38	8/5/2014	DP-38 (22.0 FT) - 082014
On-Site	Soil	DP-38	8/5/2014	DP-38 (25.0 FT) - 082014
On-Site	Soil	DP-39	8/6/2014	DP-39 (4.0 FT) - 082014
On-Site	Soil	DP-39	8/6/2014	DP-39 (7.0 FT) - 082014
On-Site	Soil	DP-39	8/6/2014	DP-39 (7.0 FT) - 082014-DUP
On-Site	Soil	DP-39	8/6/2014	DP-39 (16.5 FT) - 082014
On-Site	Soil	DP-39	8/6/2014	DP-39 (23.5 FT) - 082014
On-Site	Soil	DP-39	8/6/2014	DP-39 (28.0 FT) - 082014
On-Site	Soil	DP-47	8/12/2014	DP-47-SL (5.0 FT) - 20140812
On-Site	Soil	DP-47	8/12/2014	DP-47-SL (22.0 FT) - 20140812
On-Site	Soil	DP-54	8/19/2014	DP-54-SL (3.0 FT) - 20140819
On-Site	Soil	DP-54	8/19/2014	DP-54-SL (13.0 FT) - 20140819
On-Site	Soil	DP-55	8/19/2014	DP-55-SL (4.0 FT) - 20140819
On-Site	Soil	DP-55	8/19/2014	DP-55-SL (8.0 FT) - 20140819
On-Site	Soil	DP-55	8/19/2014	DP-55-SL (13.0 FT) - 20140819
On-Site	Soil	DP-55	8/19/2014	DP-55-SL (27.0 FT) - 20140819
On-Site	Soil	DP-55	8/19/2014	DP-55-SL (31.0 FT) - 20140819
On-Site	Soil	DP-56	8/19/2014	DP-56-SL (3.0 FT) - 20140819
On-Site	Soil	DP-56	8/19/2014	DP-56-SL (11.0 FT) - 20140819
On-Site	Soil	DP-57	8/25/2014	DP-57-SL (1.0 FT) - 20140825
On-Site	Soil	DP-57	8/25/2014	DP-57-SL (20.5 FT) - 20140825
On-Site	Soil	DP-57	8/25/2014	DP-57-SL (28.0 FT) - 20140825
On-Site	Soil	DP-59	8/25/2014	DP-59-SL (1.0 FT) - 20140825
On-Site	Soil	DP-59	8/25/2014	DP-59-SL (37.0 FT) - 20140825
On-Site	Soil	DP-60	8/26/2014	DP-60-SL (1.0 FT) - 20140826
On-Site	Soil	DP-60	8/26/2014	DP-60-SL (11.0 FT) - 20140826
On-Site	Soil	DP-60	8/26/2014	DP-60-SL (26.0 FT) - 20140826
On-Site	Soil	DP-61	8/26/2014	DP-61-SL (1.0 FT) - 20140826
On-Site	Soil	DP-61	8/26/2014	DP-61-SL (4.0 FT) - 20140826
On-Site	Soil	DP-61	8/26/2014	DP-61-SL (23.0 FT) - 20140826
On-Site	Soil	DP-62	8/26/2014	DP-62-SL (1.0 FT) - 20140826
On-Site	Soil	DP-62	8/26/2014	DP-62-SL (24.5 FT) - 20140826
On-Site	Soil	SED-04	8/20/2014	SED-04-SL-20140820
On-Site	Soil	SED-05	8/20/2014	SED-05-SL-20140820
On-Site	Soil	SED-06	8/20/2014	SED-06-SL-20140820
On-Site	Soil	SED-07	8/20/2014	SED-07-SL-20140820
On-Site	Soil	SED-08	8/20/2014	SED-08-SL-20140820
Off-Site	Ambient Air	AA-P3-Crawl Space	4/22/2015	Crawl Space-AA-20150422
Off-Site	Ambient Air	AA-P3-Crawl Space	11/5/2015	Crawl Space-201511
Off-Site	Ambient Air	AA-P3-Indoor	4/23/2015	Indoor-AA-20150423
Off-Site	Ambient Air	AA-P3-Indoor	11/5/2015	Indoor Air-201511
Off-Site	Ambient Air	AA-P3-Outdoor	4/22/2015	Outdoor-AA-20150422
Off-Site	Ambient Air	AA-P3-Outdoor	11/5/2015	Outdoor Air-201511
Off-Site	Groundwater	MW-173	4/15/2015	MW-173-201504
Off-Site	Groundwater	MW-173	7/22/2015	MW-173-201507

Attachment A2: Samples Used in the Risk Assessment Whirlpool, Fort Smith, Arkansas				
On/Off-Site	**Matrix**	**Location**	**Sample Date**	**Sample Name**
Off-Site	Groundwater	MW-173	10/6/2015	MW-173-201510
Off-Site	Groundwater	MW-174	4/14/2015	MW-174-201504
Off-Site	Groundwater	MW-174	7/21/2015	MW-174-201507
Off-Site	Groundwater	MW-174	10/6/2015	MW-174-201510
Off-Site	Groundwater	MW-174	1/20/2015	MW-174-GW-20150120
Off-Site	Groundwater	MW-175	4/15/2015	MW-175-201504
Off-Site	Groundwater	MW-175	7/21/2015	MW-175-201507
Off-Site	Groundwater	MW-175	10/7/2015	MW-175-201510
Off-Site	Groundwater	MW-175	1/20/2015	MW-175-GW-20150120
Off-Site	Groundwater	MW-176	4/14/2015	MW-176-201504
Off-Site	Groundwater	MW-176	7/21/2015	MW-176-201507
Off-Site	Groundwater	MW-176	10/6/2015	MW-176-201510
Off-Site	Groundwater	MW-176	1/20/2015	MW-176-GW-20150120
Off-Site	Groundwater	MW-180	4/16/2015	MW-180-201504
Off-Site	Groundwater	MW-180	7/22/2015	MW-180-201507
Off-Site	Groundwater	MW-180	10/7/2015	MW-180-201510
Off-Site	Groundwater	MW-180	1/19/2015	MW-180-GW-20150119
Off-Site	Groundwater	MW-181	4/14/2015	MW-181-201504
Off-Site	Groundwater	MW-181	7/21/2015	MW-181-201507
Off-Site	Groundwater	MW-181	1/21/2015	MW-181-GW-20150121
Off-Site	Groundwater	MW-34	10/15/2014	MW-34-201410
Off-Site	Groundwater	MW-34	1/13/2015	MW-34-201501
Off-Site	Groundwater	MW-34	4/14/2015	MW-34-201504
Off-Site	Groundwater	MW-35R	10/14/2014	MW-35R-201410
Off-Site	Groundwater	MW-35R	1/13/2015	MW-35R-201501
Off-Site	Groundwater	MW-35R	4/14/2015	MW-35R-201504
Off-Site	Groundwater	MW-35R	7/21/2015	MW-35R-201507
Off-Site	Groundwater	MW-35R	10/7/2015	MW-35R-201510
Off-Site	Groundwater	MW-35R	11/4/2015	MW-35R-201511
Off-Site	Groundwater	MW-36	10/14/2014	MW-36-201410
Off-Site	Groundwater	MW-36	1/12/2015	MW-36-201501
Off-Site	Groundwater	MW-36	4/14/2015	MW-36-201504
Off-Site	Groundwater	MW-36R	7/20/2015	MW-36R-201507
Off-Site	Groundwater	MW-36R	10/6/2015	MW-36R-201510
Off-Site	Groundwater	MW-39	10/13/2014	MW-39-201410
Off-Site	Groundwater	MW-39	1/12/2015	MW-39-201501
Off-Site	Groundwater	MW-39	1/12/2015	MW-39-201501
Off-Site	Groundwater	MW-39	4/14/2015	MW-39-201504
Off-Site	Groundwater	MW-40	10/13/2014	MW-40-201410
Off-Site	Groundwater	MW-40	1/12/2015	MW-40-201501
Off-Site	Groundwater	MW-40	4/14/2015	MW-40-201504
Off-Site	Groundwater	MW-40R	7/20/2015	MW-40R-201507
Off-Site	Groundwater	MW-40R	10/6/2015	DUP-03-201510
Off-Site	Groundwater	MW-40R	10/6/2015	MW-40R-201510
Off-Site	Groundwater	MW-41	10/15/2014	MW-41-201410
Off-Site	Groundwater	MW-41	1/14/2015	MW-41-201501
Off-Site	Groundwater	MW-41	4/15/2015	DUP-02-201504
Off-Site	Groundwater	MW-41	4/15/2015	MW-41-201504
Off-Site	Groundwater	MW-41R	7/21/2015	DUP-03-201507
Off-Site	Groundwater	MW-41R	7/21/2015	MW-41R-201507
Off-Site	Groundwater	MW-41R	10/6/2015	DUP-07-201510
Off-Site	Groundwater	MW-41R	10/6/2015	MW-41R-201510

Attachment A2: Samples Used in the Risk Assessment Whirlpool, Fort Smith, Arkansas				
On/Off-Site	**Matrix**	**Location**	**Sample Date**	**Sample Name**
Off-Site	Groundwater	MW-46R	10/16/2014	DUP-03-201410
Off-Site	Groundwater	MW-46R	10/16/2014	MW-46R-201410
Off-Site	Groundwater	MW-46R	1/13/2015	DUP-03-201501
Off-Site	Groundwater	MW-46R	1/13/2015	MW-46R-201501
Off-Site	Groundwater	MW-46R	4/14/2015	DUP-07-201504
Off-Site	Groundwater	MW-46R	4/14/2015	MW-46R-201504
Off-Site	Groundwater	MW-46R	7/21/2015	DUP-05-201507
Off-Site	Groundwater	MW-46R	7/21/2015	MW-46R-201507
Off-Site	Groundwater	MW-46R	10/7/2015	MW-46R-201510
Off-Site	Groundwater	MW-50	10/14/2014	MW-50-201410
Off-Site	Groundwater	MW-50	1/13/2015	MW-50-201501
Off-Site	Groundwater	MW-50	4/14/2015	MW-50-201504
Off-Site	Groundwater	MW-50R	7/21/2015	MW-50R-201507
Off-Site	Groundwater	MW-50R	10/6/2015	MW-50R-201510
Off-Site	Groundwater	MW-55R	7/20/2015	MW-55R-201507
Off-Site	Groundwater	MW-55R	10/6/2015	MW-55R-201510
Off-Site	Groundwater	MW-56	10/15/2014	MW-56-201410
Off-Site	Groundwater	MW-56	10/15/2014	MW-56-201410
Off-Site	Groundwater	MW-56	1/13/2015	MW-56-201501
Off-Site	Groundwater	MW-56	4/16/2015	MW-56-201504
Off-Site	Groundwater	MW-56R	7/20/2015	MW-56R-201507
Off-Site	Groundwater	MW-56R	10/6/2015	MW-56R-201510
Off-Site	Groundwater	MW-57	10/15/2014	MW-57-201410
Off-Site	Groundwater	MW-57	10/16/2014	MW-57-201410
Off-Site	Groundwater	MW-57	1/13/2015	MW-57-201501
Off-Site	Groundwater	MW-57	4/16/2015	MW-57-201504
Off-Site	Groundwater	MW-57R	7/20/2015	MW-57R-201507
Off-Site	Groundwater	MW-57R	10/6/2015	MW-57R-201510
Off-Site	Groundwater	MW-58	10/15/2014	MW-58-201410
Off-Site	Groundwater	MW-58	1/14/2015	MW-58-201501
Off-Site	Groundwater	MW-58	4/16/2015	MW-58-201504
Off-Site	Groundwater	MW-58R	7/21/2015	MW-58R-201507
Off-Site	Groundwater	MW-58R	10/8/2015	MW-58R-201510
Off-Site	Groundwater	MW-58R	10/22/2015	MW-58R-201510
Off-Site	Groundwater	MW-60	10/14/2014	MW-60-201410
Off-Site	Groundwater	MW-60	1/13/2015	MW-60-201501
Off-Site	Groundwater	MW-60	4/14/2015	MW-60-201504
Off-Site	Groundwater	MW-60R	7/21/2015	MW-60R-201507
Off-Site	Groundwater	MW-60R	10/6/2015	MW-60R-201510
Off-Site	Groundwater	MW-61	10/14/2014	MW-61-201410
Off-Site	Groundwater	MW-61	1/13/2015	MW-61-201501
Off-Site	Groundwater	MW-61	4/14/2015	MW-61-201504
Off-Site	Groundwater	MW-61R	7/21/2015	MW-61R-201507
Off-Site	Groundwater	MW-61R	9/18/2015	MW-61R-GW-091815
Off-Site	Groundwater	MW-61R	10/8/2015	DUP-02-201510
Off-Site	Groundwater	MW-61R	10/8/2015	MW-61R-201510
Off-Site	Groundwater	MW-61R	10/22/2015	MW-61R-201510
Off-Site	Groundwater	MW-61R	11/4/2015	MW-61R-201511
Off-Site	Groundwater	MW-62	10/14/2014	MW-62-201410
Off-Site	Groundwater	MW-62	1/13/2015	MW-62-201501
Off-Site	Groundwater	MW-62	4/14/2015	MW-62-201504
Off-Site	Groundwater	MW-62R	7/21/2015	MW-62R-201507

Attachment A2: Samples Used in the Risk Assessment Whirlpool, Fort Smith, Arkansas				
On/Off-Site	**Matrix**	**Location**	**Sample Date**	**Sample Name**
Off-Site	Groundwater	MW-62R	10/6/2015	MW-62R-201510
Off-Site	Groundwater	MW-63	10/14/2014	MW-63-201410
Off-Site	Groundwater	MW-63	1/13/2015	MW-63-201501
Off-Site	Groundwater	MW-63	1/14/2015	MW-63-201501
Off-Site	Groundwater	MW-63	4/14/2015	MW-63-201504
Off-Site	Groundwater	MW-63R	7/21/2015	MW-63R-201507
Off-Site	Groundwater	MW-63R	10/8/2015	MW-63R-201510
Off-Site	Groundwater	MW-63R	10/22/2015	MW-63R-201510
Off-Site	Groundwater	MW-65	10/14/2014	MW-65-201410
Off-Site	Groundwater	MW-65	1/13/2015	MW-65-201501
Off-Site	Groundwater	MW-65	4/15/2015	MW-65-201504
Off-Site	Groundwater	MW-65	7/20/2015	MW-65-201507
Off-Site	Groundwater	MW-65	7/20/2015	MW-65-201507
Off-Site	Groundwater	MW-65	10/7/2015	MW-65-201510
Off-Site	Groundwater	MW-65	11/4/2015	MW-65-201511
Off-Site	Groundwater	MW-66	10/13/2014	MW-66-201410
Off-Site	Groundwater	MW-66	1/14/2015	MW-66-201501
Off-Site	Groundwater	MW-66	4/15/2015	MW-66-201504
Off-Site	Groundwater	MW-66	7/20/2015	MW-66-201507
Off-Site	Groundwater	MW-66	10/6/2015	MW-66-201510
Off-Site	Groundwater	MW-67	10/13/2014	MW-67-201410
Off-Site	Groundwater	MW-67	1/12/2015	MW-67-201501
Off-Site	Groundwater	MW-67	4/15/2015	MW-67-201504
Off-Site	Groundwater	MW-67R	7/20/2015	MW-67R-201507
Off-Site	Groundwater	MW-67R	10/6/2015	MW-67R-201510
Off-Site	Groundwater	MW-68	10/14/2014	MW-68-201410
Off-Site	Groundwater	MW-68	1/12/2015	MW-68-201501
Off-Site	Groundwater	MW-68	4/13/2015	MW-68-201504
Off-Site	Groundwater	MW-68	7/20/2015	MW-68-201507
Off-Site	Groundwater	MW-68	10/6/2015	MW-68-201510
Off-Site	Groundwater	MW-68	10/6/2015	MW-68-201510
Off-Site	Groundwater	MW-71	10/14/2014	MW-71-201410
Off-Site	Groundwater	MW-71	10/14/2014	MW-71-201410
Off-Site	Groundwater	MW-71	1/14/2015	MW-71-201501
Off-Site	Groundwater	MW-71	4/14/2015	MW-71-201504
Off-Site	Groundwater	MW-71	7/20/2015	MW-71-201507
Off-Site	Groundwater	MW-71	10/6/2015	MW-71-201510
Off-Site	Groundwater	MW-81	1/13/2015	MW-81-201501
Off-Site	Groundwater	MW-81	1/13/2015	MW-81-201501
Off-Site	Groundwater	MW-81	4/15/2015	MW-81-201504
Off-Site	Groundwater	MW-81	7/22/2015	MW-81-201507
Off-Site	Groundwater	MW-81	10/8/2015	MW-81-201510
Off-Site	Groundwater	MW-81	11/5/2015	MW-81-201511
Off-Site	Groundwater	MW-96	10/22/2014	MW-96-20141022
Off-Site	Groundwater	MW-96	1/15/2015	MW-96-201501
Off-Site	Groundwater	MW-96	4/16/2015	DUP-06-201504
Off-Site	Groundwater	MW-96	4/16/2015	MW-96-201504
Off-Site	Groundwater	MW-96	7/23/2015	DUP-06-201507
Off-Site	Groundwater	MW-96	7/23/2015	MW-96-201507
Off-Site	Groundwater	MW-96	10/7/2015	MW-96-201510
Off-Site	Groundwater	MW-97	10/22/2014	MW-97-20141022
Off-Site	Groundwater	MW-97	1/15/2015	MW-97-201501

Attachment A2: Samples Used in the Risk Assessment Whirlpool, Fort Smith, Arkansas				
On/Off-Site	**Matrix**	**Location**	**Sample Date**	**Sample Name**
Off-Site	Groundwater	MW-97	4/16/2015	MW-97-201504
Off-Site	Groundwater	MW-97	7/23/2015	MW-97-201507
Off-Site	Groundwater	MW-97	10/7/2015	MW-97-201510
Off-Site	Groundwater	MW-98	10/29/2014	MW-98-GW-2014 1029
Off-Site	Groundwater	MW-98	1/15/2015	MW-98-201501
Off-Site	Groundwater	MW-98	4/16/2015	MW-98-201504
Off-Site	Groundwater	MW-98	7/23/2015	MW-98-201507
Off-Site	Groundwater	MW-98	10/6/2015	MW-98-201510
Off-Site	Groundwater	MW-99	10/22/2014	MW-99-20141022
Off-Site	Groundwater	MW-99	1/15/2015	MW-99-201501
Off-Site	Groundwater	MW-99	4/16/2015	MW-99-201504
Off-Site	Groundwater	MW-99	7/23/2015	MW-99-201507
Off-Site	Groundwater	MW-99	10/6/2015	MW-99-201510
Off-Site	Groundwater	TMW-10	9/18/2015	TMW-10-GW-091815
Off-Site	Groundwater	TMW-10	10/8/2015	TMW-10-201510
Off-Site	Groundwater	TMW-10	11/4/2015	TMW-10-201511
Off-Site	Groundwater	TMW-11	9/18/2015	TMW-11-GW-091815
Off-Site	Groundwater	TMW-11	10/8/2015	TMW-11-201510
Off-Site	Groundwater	TMW-11	11/4/2015	TMW-11-201511
Off-Site	Perched Water	VP-10	4/22/2015	VP-10-20150422
Off-Site	Perched Water	VP-10	7/30/2015	VP-10-201507
Off-Site	Perched Water	VP-10	10/6/2015	VP-10-201510
Off-Site	Perched Water	VP-10	1/20/2015	VP-10-GW-20150120
Off-Site	Perched Water	VP-15	10/7/2015	VP-15-201510
Off-Site	Perched Water	VP-15	7/1/2015	VP-15-GW-20150701
Off-Site	Perched Water	VP-1S	10/15/2014	VP-1-SHALLOW-201410
Off-Site	Perched Water	VP-5	4/22/2015	VP-05-20150422
Off-Site	Perched Water	VP-5	7/30/2015	VP-05-201507
Off-Site	Perched Water	VP-5	10/6/2015	VP-05-201510
Off-Site	Perched Water	VP-6	4/22/2015	VP-06-20150422
Off-Site	Perched Water	VP-6	7/30/2015	VP-06-201507
Off-Site	Perched Water	VP-6	10/6/2015	VP-06-201510
Off-Site	Perched Water	VP-6	1/20/2015	VP-06-GW-20150120
Off-Site	Perched Water	VP-8	4/22/2015	VP-08-20150422
Off-Site	Perched Water	VP-8	7/30/2015	VP-08-201507
Off-Site	Perched Water	VP-8	10/7/2015	VP-08-201510
Off-Site	Perched Water	VP-9	7/30/2015	VP-09-201507
Off-Site	Soil	DP-40	8/7/2014	DP-40 (4.0 FT) - 082014
Off-Site	Soil	DP-40	8/7/2014	DP-40 (11.0 FT) - 082014
Off-Site	Soil	DP-40	8/7/2014	DP-40 (14.5 FT) - 082014
Off-Site	Soil	DP-41	8/8/2014	DP-41 (4.0 FT) - 082014
Off-Site	Soil	DP-41	8/8/2014	DP-41 (10.0 FT) - 082014
Off-Site	Soil	DP-41	8/8/2014	DP-41 (14.0 FT) - 082014
Off-Site	Soil	DP-42	8/8/2014	DP-42 (4.0 FT) - 082014
Off-Site	Soil	DP-42	8/8/2014	DP-42 (8-0 FT) - 082014
Off-Site	Soil	DP-42	8/8/2014	DP-42 (12.0 FT) - 082014
Off-Site	Soil	DP-43	8/11/2014	DP-43-SL (4.0 FT) - 20140811
Off-Site	Soil	DP-43	8/11/2014	DP-43-SL (10.0 FT) - 20140811
Off-Site	Soil	DP-43	8/11/2014	DP-43-SL (19.0 FT) - 20140811
Off-Site	Soil	DP-44	8/11/2014	DP-44-SL (4.0 FT) - 20140811
Off-Site	Soil	DP-44	8/11/2014	DP-44-SL (11.0 FT) - 20140811
Off-Site	Soil	DP-44	8/11/2014	DP-44-SL (18.0 FT) - 20140811

Attachment A2: Samples Used in the Risk Assessment Whirlpool, Fort Smith, Arkansas				
On/Off-Site	**Matrix**	**Location**	**Sample Date**	**Sample Name**
Off-Site	Soil	DP-44	8/11/2014	DP-44-SL (21.5 FT) - 20140811
Off-Site	Soil	DP-45	8/11/2014	DP-45-SL (4.0 FT) - 20140811
Off-Site	Soil	DP-45	8/11/2014	DP-45-SL (12.0 FT) - 20140811
Off-Site	Soil	DP-45	8/11/2014	DP-45-SL (18.0 FT) - 20140811
Off-Site	Soil	DP-46	8/12/2014	DP-46-SL (4.5 FT) - 20140812
Off-Site	Soil	DP-46	8/12/2014	DP-46-SL (13.5 FT) - 20140812
Off-Site	Soil	DP-46	8/12/2014	DP-46-SL (18.0 FT) - 20140812
Off-Site	Soil	DP-48	8/14/2014	DP-48-SL (4.0 FT)-20140814
Off-Site	Soil	DP-48	8/14/2014	DP-48-SL (11.5 FT)-20140814
Off-Site	Soil	DP-49	8/14/2014	DP-49-SL (4.0 FT)-20140814
Off-Site	Soil	DP-49	8/14/2014	DP-49-SL (10.0 FT)-20140814
Off-Site	Soil	DP-49	8/14/2014	DP-49-SL (13.0 FT)-20140814
Off-Site	Soil	DP-50	8/14/2014	DP-50-SL (4.0 FT)-20140814
Off-Site	Soil	DP-50	8/14/2014	DP-50-SL (10.0 FT)-20140814
Off-Site	Soil	DP-51	8/18/2014	DP-51-SL (1.0 FT) - 20140818
Off-Site	Soil	DP-51	8/18/2014	DP-51-SL (14.0 FT) - 20140818
Off-Site	Soil	DP-52	8/18/2014	DP-52-SL (4.0 FT) - 20140818
Off-Site	Soil	DP-52	8/18/2014	DP-52-SL (11.0 FT) - 20140818
Off-Site	Soil	DP-53	8/18/2014	DP-53-SL (1.0 FT) - 20140818
Off-Site	Soil	DP-53	8/18/2014	DP-53-SL (8.5 FT) - 20140818
Off-Site	Soil	DP-58	8/25/2014	DP-58-SL (1.0 FT) - 20140825
Off-Site	Soil	DP-58	8/25/2014	DP-58-SL (8.0 FT) - 20140825
Off-Site	Soil	SED-01	8/20/2014	SED-01-SL-20140820
Off-Site	Soil	SED-02	8/20/2014	SED-02-SL-20140820
Off-Site	Soil	SED-03	8/20/2014	SED-03-SL-20140820
Off-Site	Soil Vapor	VP-5	1/16/2015	VP-05-201501
Off-Site	Soil Vapor	VP-7	4/23/2015	VP-07-20150423
Off-Site	Soil Vapor	VP-7	7/30/2015	VP-07-201507
Off-Site	Soil Vapor	VP-7	10/7/2015	VP-07-201510
Off-Site	Soil Vapor	VP-7	1/19/2015	VP-7-201501
Off-Site	Soil Vapor	VP-9	4/23/2015	VP-09-20150423
Off-Site	Soil Vapor	VP-9	10/9/2015	VP-09-201510
Off-Site	Soil Vapor	VP-9	11/4/2015	VP-09-201511
Off-Site	Soil Vapor	VP-9	1/19/2015	VP-9-201501

Appendix B

Human Health Risk Assessment Supporting Calculations and Information

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List of Attachments

Attachment B1: Toxicity Values, Physical and Chemical Properties, Occupational Air Standards, High-End Exposure Factors, and Exposure Point Concentrations
Attachment B2: Routine Worker Risk Calculations
Attachment B3: Onsite Utility Maintenance Worker Risk Calculations
Attachment B4: Redevelopment Construction Worker Risk Calculations
Attachment B5: Residential Risk Calculations
Attachment B6: Offsite Utility Maintenance Worker Risk Calculations
Attachment B7: Trespasser Risk Calculations

B1 Introduction

This appendix to the updated human health risk assessment (HHRA) for the Whirlpool facility in Fort Smith, Arkansas (Site) provides information and calculations that support the discussion of the HHRA. The methods used in the risk assessment are based on United States Environmental Protection Agency (USEPA) risk assessment guidance. The methods are also consistent with recommendations of the Interstate Technology Regulatory Council (ITRC) on performing and using risk assessments to inform risk-based decisions (ITRC 2015).

The information in this appendix is organized in sections that correspond to the following potentially exposed populations discussed in Section 4.1 of the HHRA and summarized in Table 1:

- Onsite
  - Routine Workers
  - Utility Maintenance Workers
  - Redevelopment Construction Workers
  - Trespassers
- Offsite
  - Residents
  - Routine Workers
  - Utility Maintenance Workers

The toxicity values used in the human health risk assessment were compiled from USEPA's hierarchy of sources (USEPA 2003). Route-to-route extrapolation of toxicity values was made following USEPA guidance (USEPA 2004b, 2009). The toxicity values and physical and chemical properties used in the risk calculations are provided in this appendix as **Attachments B1.1** and **B1.2**. The toxicity values used in this risk assessment are current as of September 2015.

B2 Risk Estimation Methodology

For the ingestion and dermal exposure routes, estimates of cancer risk and non-cancer 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}), which is either the outdoor or indoor air concentration, as follows:

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

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

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 exposure factors used in the risk calculations and their bases are provided in **Attachment B1.4**.

Concentrations used to calculate the risk estimates for each media are shown in **Attachment A1**.

The media-specific cumulative cancer risk and noncancer hazard index (HI) for exposure to a combination of chemicals are conservatively estimated according to USEPA guidance (1989), as follows:

$$Cumulative\ Risk = \sum_i Risk_i$$

$$HI = \sum_i HQ_i$$

where:

$Risk_i$ = Estimated cancer risk for the ith constituent
HQ_i = Hazard quotient for the ith constituent

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).

B3 Routine Workers

The computation of risk estimates for exposure to soil during outdoor activities is discussed in Section B1.1. The computation of risk estimates for exposure to soil and groundwater constituents via volatilization into indoor air and outdoor air is discussed in Section B1.2 and Section B1.3.

B3.1 Exposure to Soil during Outdoor Activities

As discussed in Section 4.1.1 of the HHRA, routine workers could be exposed to surface soil via incidental ingestion, dermal contact, and inhalation of vapors and particulates during routine outdoor activities. Risk estimates for these activities are calculated using the methodology discussed in Section 0 and the receptor-specific equations discussed in this section.

The LADDs for soil ingestion ($LADD_{ing}$) and soil dermal contact ($LADD_{derm}$) are calculated as follows, using the exposure factors for routine worker soil contact shown in **Attachment B1.4** of this appendix:

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

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

where C_{soil} is the constituent concentration in soil, *IR* is the ingestion rate, *FC* is the fraction contacted, *SA* is the exposed skin surface area, *AF* is the soil-to-skin adherence factor, and ABS_{derm} is the chemical-specific dermal absorption factor.

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 outdoor air concentrations of vapors and particulates from soil are calculated as follows:

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

The *J* term is the normalized average vapor (J_v) or particulate flux ($J_{10,w}$), the *C/Q* term is the air concentration normalized to a unit flux, and C_{source} is the source vapor concentration that is given by the following equation.

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

where K_d is the equilibrium-partitioning coefficient, H is the Henry's law constant, θ_w is the water-filled soil porosity, ρ_b is the soil bulk density, and θ_a is the air-filled soil porosity. For this risk assessment, the Henry's law constant is adjusted to a subsurface temperature of 16.7°C, which is the approximate average groundwater temperature of Fort Smith (USEPA 2004a, Figure 8).

The normalized average vapor flux J_v of a constituent from unsaturated soil is conservatively estimated using an unsteady-state model derived by Jury et al. (1983). This model conservatively assumes that volatile constituents are present in the soil to a finite depth. The equation for J_v is given by:

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

where T is the averaging period (equivalent to ED), Z_1 is the depth to the top of the contamination (zero), Z_2 is the maximum bottom depth (conservatively assumed to be the depth to groundwater), and D_E is the effective diffusivity calculated as follows:

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

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

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

Derivation of this equation and definition of the equation parameters can be found in the Jury et al. 1983 journal article and in USEPA guidance (1996), and therefore, are not repeated here. The calculation of J_v is performed using values for chemical-specific parameters and default soil parameters recommended in USEPA guidance (2004a), using a soil type of silty clay, which is the predominant vadose zone soil type at the Site. The calculation of J_v is shown in **Attachment B2.1**.

The normalized average particulate flux $J_{10,w}$ of a constituent from soil is conservatively estimated using the "unlimited reservoir" model that USEPA has adapted for screening-level analysis of particulate emissions from soil (USEPA 1996). This model assumes that particulate emissions are created by wind erosion. The equation for $J_{10,w}$ 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 in Fort Smith, Arkansas (NOAA 2012), 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 default parameter values recommended in the 1996 USEPA guidance are used with site-specific wind speed and anemometer height in calculating $J_{10,w}$, as shown in **Attachment B2.2**.

As discussed in Section 4.3.5 of the HHRA, estimates of air emission and dispersion were calculated from the following two onsite soil source areas: the former trench area; and the rest of the Site. The *C/Q* and inputs used to calculate this value, i.e., the SCREEN3 output for both soil source areas are presented in **Attachments B1.5** and **B1.6**. The maximum 1 hour air concentration from SCREEN 3 is converted to an annual average air concentration using a conversion factor of 0.19 (USEPA 1995b).

The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for incidental ingestion of and dermal contact with soil during outdoor activities across the entire Site are shown in **Attachments B2.7** and **B2.8** of this appendix. The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for inhalation exposure to soil during outdoor activities at the former drainage trench and the remaining area of the Site, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachments B2.3**, **B2.4**, **B2.5**, and **B2.6** of this appendix.

B3.2 Volatilization Into Indoor Air

Vapor intrusion exposures are evaluated relative to both occupational inhalation limits and cumulative cancer risk and noncancer HQ estimates.

B3.2.1 Soil

For the vapor intrusion exposure pathway, estimates of cancer risk and noncancer HQ are calculated as presented in Section 0, using the concentration in indoor air ($C_{building}$). For assessing routine worker exposures, chronic *RfCs* are used. The indoor air concentration is based on the modeling approach and input parameter values discussed below.

The indoor air concentrations are estimated using the following relationships described by Johnson and Ettinger (1991):

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

where α is an attenuation coefficient and C_{source} is the source vapor concentration described in Section B1.1.

The attenuation coefficient, assuming that constituents are present in the soil at constant concentrations, is given by the following equation:

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

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 using a soil-water profile that was estimated using a soil type of silty clay, which is the predominant soil type at 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). These parameters and the resulting soil-water profile in the vadose zone are shown in **Attachment B2.9** and **B2.10** of this appendix.

The remaining parameters in the equation for the attenuation coefficient α, which relate to building characteristics, are based on the currently recommended values for deriving the Michigan Part 201 generic vapor intrusion criteria for commercial/industrial sites (CSAG 2014), because neither USEPA nor ADEQ provides default values for non-residential buildings. The building characteristics are considered conservative for the evaluation of current conditions because the building currently at the Site is much larger in size than the commercial building assumed in the Michigan criteria. The values used in the calculations are shown in **Attachment B2.10** of this appendix and their bases are discussed in the Criteria Stakeholder Advisory Group Report (CSAG 2014).

The indoor air concentrations resulting from soil volatilizing and migrating into indoor air are calculated with a mass balance check. The mass balance check ensures that the assumed mass of a constituent infiltrating into the building over the assumed exposure period does not exceed an upper-bound estimate of the constituent's mass in the vadose zone underlying the building. The upper-bound estimate of the constituent's mass in the vadose zone is conservatively estimated using the highest concentration of the constituent from any depth at the location and assuming that this concentration represents the soil concentration from the slab to the water table. The normalized indoor air concentration calculated using this mass balance check is given by the following equation:

$$C_{b,ML} = \rho_b \cdot \left(\frac{\Delta H}{ach \cdot H_b \cdot ED}\right)$$

where ΔH is the contaminant thickness (the distance between groundwater and a building foundation), *ach* is the air exchange rate, and H_b is the building occupied height. These parameters are shown in **Attachment B2.10** of this appendix.The computation of upper-bound single-chemical cancer risk and noncancer HQfor soil-derived vapors into indoor air, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachment B2.12** of this appendix.

B3.2.2 Groundwater

The chemical-specific cancer risk and noncancer HQ estimates for vapor intrusion from groundwater, which includes perched water, are calculated in a manner analogous to the approach discussed in **Section B1.2.1**, except for the calculation of source vapor concentration.

The source vapor concentration for a constituent in groundwater is calculated from the constituent's concentration in groundwater C_{gw} using Henry's law as follows:

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

The attenuation coefficient and associated soil-water profile in the vadose zone are the same as those discussed in Section B1.2.1 and are shown in **Attachments B2.9** and **B2.11**.

The computation of upper-bound single-chemical cancer risk and noncancer HQ for groundwater-derived vapors into indoor air, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachment B2.13** of this appendix.

B3.2.3 Occupational Inhalation Limits

Potential exposure of onsite routine workers to constituents in soil and groundwater via vapor intrusion is evaluated by dividing each constituent's predicted indoor air concentration due to vapor intrusion (discussed in Sections B1.2.1 and B1.2.2) by its occupational inhalation limit, and then summing the quotients (or ratios) for all constituents detected in the soil or groundwater. This approach is equivalent to 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 and occupational 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 OELs are discussed in Section 5.4 of the HHRA and summarized in

Attachment B2. The E_m estimates for soil-derived vapors into indoor air are shown in **Attachment B2.12** of this appendix.

B3.3 Exposure to Groundwater via Volatilization into Outdoor Air

The concentration (C_{air}) of constituents from groundwater that migrate through the Vadose Zone to outdoor air is calculated as follows:

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

where J is the vapor flux, C/Q is the normalized annual-average air concentration at ground level, and C_{source} is the source vapor concentration that is given by the equation in Section B1.2.2. The C/Q term is estimated as discussed in Section 3.4.1 of the HHRA. The C/Q and inputs used to calculate this value are presented in **Attachment B2.15**. The vapor flux J is calculated by using the steady-state diffusion equation in one-dimension with a constant source concentration and the maximum concentration gradient, as follows:

$$J = D_e \cdot \frac{C_v}{L}$$

where D_e is the effective diffusion coefficient of the chemical in the vapor phase, C_v is the vapor concentration in equilibrium with the groundwater concentration, and L is the distance from groundwater to the ground surface. The equilibrium vapor concentration in the above equations is related to the groundwater concentration using Henry's law as discussed in Section B1.2.2.

The effective diffusion coefficient for the vapor phase is calculated in a manner analogous to the approach discussed in Section B1.2.1. The distance between the groundwater and the ground surface is based on the depth to groundwater at the Site. The parameters used to calculate the vapor flux and the effective diffusion coefficient are shown in **Attachment B2.14**. The estimated outdoor air concentrations are used in the inhalation risk equations discussed in Section 0 to calculate inhalation cancer risk and HQ.

The computation of the upper-bound single-chemical cancer risk and HQ estimates for groundwater-derived vapors in outdoor air onsite, which are summed to estimate the cumulative cancer risk and HI, are shown in **Attachment B2.16** of this appendix.

B4 Utility Maintenance Workers

Risk estimates for utility maintenance workers are calculated for potential exposures to soil and groundwater. The computation of these risk estimates are discussed in Sections B1.4 and B1.5, respectively.

B4.1 Exposure to Soil during Utility Maintenance Activities

The computation of risk estimates for worker exposure to soil via incidental ingestion, dermal contact, and inhalation of soil vapor and airborne particulates during maintenance activities is analogous to the computations discussed in Section B1.1 for routine workers, except the soil exposure factors for utility maintenance workers are used, as presented in **Attachment B1.4** of this appendix, and the airborne dust concentrations are estimated as discussed in Section 4.3.4 of the HHRA for soil exposures.

The calculation of J_v is shown in **Attachment B3.1**. The air concentration of respirable soil particulates during maintenance activities is shown in **Attachment B3.2**. The *C/Q* values from SCREEN3 and inputs used to calculate these values are presented in **Attachments B1.5** and **B1.6**. The maximum 1 hour air concentrations from SCREEN 3 are converted to an annual average air concentration using a conversion factor of 0.19 (USEPA 1995b).

The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for incidental ingestion of and direct contact with soil during outdoor activities across the entire Site are shown in **Attachments B3.7** and **B3.8** of this appendix. The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for inhalation exposure to soil during outdoor activities at the former drainage trench and the remaining area of the Site, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachments B3.3**, **B3.4**, **B3.5**, and **B3.6** of this appendix.

B4.1 Exposure to Groundwater during Utility Maintenance Activities

As discussed in Section 4.1 of the HHRA, utility maintenance workers could be exposed to groundwater and perched water via incidental ingestion, dermal contact, and inhalation of vapors during excavations that extend to the groundwater. The cancer risk and noncancer HQ estimates for the ingestion and dermal exposure routes are calculated in a manner analogous to the method discussed in Section B1.1, except: the exposure factors for utility maintenance workers are used, as presented in **Attachment B1.4** of this appendix; the calculation of the *LADD* and *ADD* for the dermal route of exposure; and, the vapor flux, which are discussed below.

The *LADD* and *ADD* for groundwater dermal contact are calculated as follows, using the exposure factors for utility maintenance worker groundwater contact shown in **Attachment B1.4** of this appendix:

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

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

where C_{gw} is the constituent concentration in groundwater, DA_{event} is the absorbed dose per event, *SA* is the exposed skin surface area, and *EV* is the event frequency.

The *DA* for organic chemicals is estimated using an unsteady-state approach (USEPA 2004b, Equations 3.2 and 3.3), which is more conservative than the steady-state approach (USEPA 1989), particularly for hydrophobic chemicals. The *DA* for inorganic chemicals is estimated using a steady-state approach (USEPA 2004b, Equation 3.4). The details of the calculation of *DA* for organic and inorganic chemicals are provided by USEPA (USEPA 2004b) and not repeated here. The dermal absorbed dose for groundwater is calculated in **Attachment B3.9** of this appendix. The calculation of the C/Q is presented in **Attachment B3.10**.

The normalized vapor flux *J* of a chemical from groundwater is estimated using an overall mass transfer coefficient that is recommended by USEPA (1995):

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

where 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 (0.002 cm/s), and $k_{g,w}$ is the gas-phase mass transfer coefficient for water vapor (0.833 cm/s). The calculation of the normalized vapor flux is shown in **Attachment B3.11**.

The computation of the single-chemical cancer risk and noncancer HQ estimates for exposure to groundwater during maintenance activities onsite, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachment B3.12** and **B3.13** of this appendix.

B5 Redevelopment Construction Workers

Risk estimates for redevelopment construction workers are calculated for potential exposures to soil and groundwater. The computation of these risk estimates are discussed in Sections B1.6 and B1.7, respectively

B5.1 Exposure to Soil during Redevelopment Construction Activities

The computation of risk estimates for worker exposure to soil via incidental ingestion, dermal contact, and inhalation of vapors and particulates during redevelopment construction activities is analogous to the computations discussed in Section B1.1 for routine workers, except: the soil exposure factors for redevelopment construction workers are used, as presented in **Attachment B1.4** of this appendix; subchronic noncancer toxicity values are used instead of chronic values; and the airborne dust concentrations are estimated as discussed in Section 4.3.4 of the HHRA.

The calculation of J_v is shown in **Attachment B4.1**. The PM_{10} level for redevelopment construction activities is shown in **Attachment B4.2**. The *C/Q* values from SCREEN3 and inputs used to calculate these values are presented in **Attachments B1.5** and **B1.6**. The maximum 1 hour air concentrations from SCREEN 3 are converted to an annual average air concentration using a conversion factor of 0.19 (USEPA 1995b).

The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for incidental ingestion of and direct contact with soil during outdoor activities across the entire Site are shown in **Attachments B4.7** and **B4.8** of this appendix. The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for inhalation exposure to soil during outdoor activities at the former drainage trench and the remaining area of the Site, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachments B4.3**, **B4.4**, **B4.5**, and **B4.6** of this appendix.

B5.2 Exposure to Groundwater during Redevelopment Construction Activities

The computation of risk estimates for worker exposure to groundwater via incidental ingestion, dermal contact, and inhalation of vapors during redevelopment construction activities is analogous to the computations discussed in Section B1.5 for utility maintenance workers, except the groundwater exposure factors for redevelopment construction workers are used, as presented in **Attachment B1.4** of this appendix and subchronic noncancer toxicity values are used instead of chronic values.

The dermal absorbed dose for groundwater is calculated in **Attachment B4.9**. The calculation of the C/Q is presented in **Attachment B4.10**. The calculation of the normalized vapor flux is shown in **Attachment B4.11**.

The computation of the single-chemical cancer risk and noncancer HQ estimates for exposure to groundwater during redevelopment construction activities onsite, which are summed to

estimate the cumulative cancer risk and noncancer HI, are shown in **Attachments B4.12** and **4.13,** respectively, of this appendix.

B6 Trespassers

Risk estimates for trespassers are calculated for potential exposures to soil and groundwater. The computation of these risk estimates are discussed in **Sections B1.8** and **B1.9**, respectively.

B6.1 Exposure to Soil during Outdoor Activities

The computation of risk estimates for trespassers exposure to soil is analogous to the computations discussed in **Section B1.1**, except age-dependent adjustment factors (ADAFs) are used as discussed below and the soil exposure factors for trespassers are used, as presented in **Attachment B1.4** of this appendix.

For carcinogens with a mutagenic mode of action for which USEPA guidance (USEPA 2005) recommends the use of ADAFs, cancer risk estimates for exposures from 0 to 2 years of age and from 2 to 16 years of age are multiplied by the USEPA-recommended ADAFs before summation. For trespasser exposures from ages 6 to 16 years of age, the ADAFs are applies as follows:

$$Ingestion\ Risk = C_{soil} \cdot SF \cdot \left(\frac{IR \cdot FC \cdot EF \cdot ED}{BW \cdot AT_c} \cdot ADAF_{2-16} \right)$$

$$Dermal\ Risk = C_{soil} \cdot SF \cdot \left(\frac{SA \cdot AF \cdot ABS_{derm} \cdot FC \cdot EF \cdot ED}{BW \cdot AT_c} \cdot ADAF_{2-16} \right)$$

$$Inhalation\ Risk = C_{air} \cdot URF \cdot \left(\frac{ET \cdot EF \cdot ED}{AT_c} \cdot ADAF_{2-16} \right)$$

where IR, ED, BW, SA and AF are provided in **Attachment B1.4** and $ADAF_{2\text{-}16}$ is 3 (USEPA 2005). The calculation of J_v is shown in **Attachment B5.1**. The calculation of $J_{10,w}$ is shown in **Attachment B5.2**. The calculation of the C/Q is presented in **Attachment B5.3**.

The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for incidental ingestion of and dermal contact with soil during trespassing activities across the entire Site are shown in **Attachments B5.7** and **B5.8** of this appendix. The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for inhalation exposure to soil during outdoor activities at the former drainage trench and the remaining area of the Site, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachments B5.3**, **B5.4**, **B5.5**, and **B5.6** of this appendix.

B6.2 Exposure to Groundwater via Volatilization into Outdoor Air

The computation of risk estimates for trespasser exposure to onsite groundwater is analogous to the computations discussed in Section B1.3, except ADAFs are used as discussed in Section

B1.10 and the exposure factors for trespassers are used, as presented in **Attachment B1.4** of this appendix.

The calculation of the C/Q is presented in **Attachment B5.10**. The parameters used to calculate the vapor flux and the effective diffusion coefficient are shown in **Attachment B5.9**.

The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for exposure to groundwater-derived vapors in outdoor air onsite, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachment B5.11** of this appendix.

B7 Offsite Residents

The computation of risk estimates for exposure to soil during outdoor activities is discussed in Section B1.10. The computation of risk estimates for exposure to soil, groundwater, and soil vapor constituents via volatilization into indoor air is discussed in Section B1.11. The computation of risk estimates for exposure to groundwater constituents via volatilization to outdoor air is discussed in Section B1.12.

B7.1 Exposure to Soil during Outdoor Activities

B7.1.1 Exposure to Offsite Soil via Inhalation

The chemical-specific cancer risk and noncancer HQ estimates for evaluating offsite residential inhalation exposures to offsite soil is analogous to the computations discussed in **Sections B1.1** except the exposure factors and ADAFs for residents are used, as presented in **Attachment B1.4** of this appendix. Additionally, the C/Q is calculated as described in Section B1.3 using a source area is 0.5 acre, as discussed in Section 4.3.5 of the HHRA.

Cancer risk estimates for exposures from 0 to 2 years of age and from 2 to 16 years of age are multiplied by the USEPA-recommended ADAFs before summation, as follows:

$$Inhalation\ Risk = C_{air} \cdot URF \cdot \left(\frac{ET \cdot EF \cdot ED_{0-2}}{AT_c} \cdot ADAF_{0-2} + \frac{ET \cdot EF \cdot ED_{2-16}}{AT_c} \cdot ADAF_{2-16} + \frac{ET \cdot EF \cdot ED_{16-26}}{AT_c} \right)$$

where ED_{0-2}, ED_{2-16}, and ED_{16-26} are 2, 14, and 10 years respectively, $ADAF_{0-2}$ is 10, and $ADAF_{2-16}$ is 3 (USEPA 2005). The calculation of J_v is shown in **Attachment B6.1**. The calculation of $J_{10,w}$ is shown in **Attachment B6.2**. The calculation of the C/Q is presented in **Attachment B6.3**.

The computation of the single-chemical cancer risk and noncancer HQ estimates for exposure to soil during outdoor activities offsite, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachments B6.4** and **B6.5** of this appendix.

B7.1.2 Exposure to Onsite Soil via Inhalation

Offsite residents could be exposed via inhalation of constituents from onsite soil-derived vapors and particulates from uncovered areas at the Site, if these emissions were to migrate offsite. The computation of risk estimates for offsite residential exposure to constituents in onsite soil via inhalation is analogous to the computations discussed in Sections B1.1, except the exposure factors for residents are used, as presented in **Attachment B1.4** of this appendix. The calculation of J_v is shown in **Attachment B6.1**. The calculation of $J_{10,w}$ is shown in **Attachment B6.2**. The *C/Q* and inputs used to calculate this value, i.e., the SCREEN3 output for both soil source areas are presented in **Attachments B1.5** and **B1.6**. The maximum 1 hour air

concentration from SCREEN 3 is converted to an annual average air concentration using a conversion factor of 0.19 (USEPA 1995b).

The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for inhalation exposure to soil during outdoor activities at the former drainage trench and the remaining area of the Site, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachments B6.3**, **B6.4**, **B6.5**, and **B6.6** of this appendix.

B7.2 Volatilization into Indoor Air

B7.2.1 Soil

The chemical-specific cancer risk and noncancer HQ estimates for evaluating intrusion of chemicals from offsite soil into indoor air were calculated in a manner analogous to the approach discussed in Section B1.2.1 for inhalation exposure, except the exposure factors and ADAFs for residents are used, as presented in **Attachment B1.4** of this appendix, and the building parameters for residential buildings are used, based on USEPA values for assessing chronic vapor intrusion into residential buildings (USEPA 2004a and 2015), as presented in **Attachment B6.10** and **B6.11**.

The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for soil-derived vapors in indoor air, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachment B6.13** of this appendix.

B7.2.2 Groundwater and Perched Water

The chemical-specific cancer risk and noncancer HQ estimates for vapor intrusion from groundwater and perched water are calculated in a manner analogous to the approach discussed in Section B1.2.2, except the exposure factors and ADAFs for residents are used, as presented in **Attachment B1.4** of this appendix, the building parameters for residential buildings are used, based on USEPA values for assessing chronic vapor intrusion into residential buildings (USEPA 2004a and 2015), as presented in **Attachment B6.12**.

The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for groundwater and perched water-derived vapors in indoor air, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachments B6.14** and **B6.15**, respectively, of this appendix.

B7.2.3 Soil Vapor

The chemical-specific cancer risk and noncancer HQ estimates for vapor intrusion from soil vapor are calculated in a manner analogous to the approach discussed in Section B1.2.1, except the exposure factors and ADAFs for residents are used, as presented in **Attachment B1.4** of this appendix, and using USEPA's empirically-derived 95th percentile subslab soil gas attenuation factor of 0.03 (USEPA 2012, 2015).

The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for soil vapor that migrates to indoor air, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachment B6.16** of this appendix.

B7.3 Exposure to Groundwater via Volatilization into Outdoor Air

The computation of risk estimates for offsite exposure to offsite groundwater is analogous to the computations discussed in Section B1.3, except the exposure factors and ADAFs for residents are used, as presented in **Attachment B1.4** of this appendix.

The calculation of the C/Q is presented in **Attachment B6.18**. The parameters used to calculate the vapor flux and the effective diffusion coefficient are shown in **Attachment B6.17**.

The computation of the single-chemical cancer risk and noncancer HQ estimates for groundwater-derived vapors in offsite outdoor air, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachment B6.19** of this appendix.

B8 Offsite Utility Maintenance Workers

Risk estimates for offsite utility maintenance workers are calculated for potential exposures to soil and groundwater. The computation of these risk estimates are discussed in Sections B1.13 and B1.14, respectively.

B8.1 Exposure to Soil during Utility Maintenance Activities

The computation of risk estimates for offsite utility maintenance worker exposure to offsite soil is analogous to the computations discussed in Section B1.4 except C/Q is calculated as described in Section B1.3 and using a source area of 0.5 acre, as discussed in Section 4.3.5 of the HHRA.

The calculation of J_v is shown in **Attachment B7.1**. The air concentration of respirable soil particulates during utility maintenance activities is shown in **Attachment B7.2**. The calculation of the *C/Q* is presented in **Attachment B7.3**.

The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for exposure to soil during utility maintenance activities offsite, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachments B7.4** and **B7.5** of this appendix.

B8.2 Exposure to Groundwater during Utility Maintenance Activities

The computation of risk estimates for offsite utility maintenance worker exposure to offsite groundwater is analogous to the computations discussed in Section 0.

The dermal absorbed dose for groundwater is calculated in **Attachment B7.6**. The calculation of the C/Q is presented in **Attachment B7.7**. The calculation of the normalized vapor flux is shown in **Attachment B7.8**.

The computation of upper-bound single-chemical cancer risk and noncancer HQ estimates for exposure to groundwater during utility maintenance activities offsite, which are summed to estimate the cumulative cancer risk and noncancer HI, are shown in **Attachments B7.9** and **B7.10** of this appendix.

B9 References

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Attachment B1

Toxicity Values, Physical and Chemical Properties, Occupational Air Standards, High-End Exposure Factors, and Exposure Point Concentrations

Attachments

B1.1 Toxicity Values

B1.2 Physical and Chemical Properties

B1.3 Occupational Air Standards

B1.4 High-End Exposure Factors

B1.5 SCREEN3 Output for Source Area Corresponding to the Former Drainage Trench

B1.6 SCREEN3 Output for Source Area Corresponding to the Remaining Area of the 93-acre Site

Attachment B1.1: 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)				RfD_{dermal} (mg/kg/d)				RfC (mg/m^3)				$SRfD_{oral}$ (mg/kg/d)				$SRfD_{dermal}$ (mg/kg/d)				SRfC (mg/m^3)			
			Group	Ref	Y/N	f_{oral}	f_{inh}	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes
VOC	Acetone	67-64-1	ID	1	N												9.0E-01	1,000	1		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
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		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
VOC	Bromodichloromethane	75-27-4	B2	1	N			6.2E-02	1		6.2E-02	125	104				2.0E-02	1,000	1		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	
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		2.0E-02	1,000	125	104			126	90	3.0E-02	100	126		3.0E-02	100	125	104			126	90
VOC	Bromomethane	74-83-9	ID	126	N												1.4E-03	1,000	1		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	
VOC	2-Butanone	78-93-3	ID	1	N												6.0E-01	1,000	1		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
VOC	Carbon Disulfide	75-15-0			N												1.0E-01	100	1		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
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		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
VOC	Chlorobenzene	108-90-7	D	1	N												2.0E-02	1,000	1		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	
VOC	Chloroethane	75-00-3	LC	126	N				126	90		125	104		126	90	1.0E-01	3,000	126	116	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
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		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	
VOC	Chloromethane	74-87-3	D	1	N																				9.0E-02	1,000	1										4.1E-01	300	129	111
VOC	Dibromochloromethane	124-48-1	C	1	N			8.4E-02	1		8.4E-02	125	104				2.0E-02	1,000	1		2.0E-02	1,000	125	104			126	90	7.0E-02	300	126		7.0E-02	300	125	104			126	90
VOC	1,1-Dichloroethane	75-34-3	SC	126	N				126	90		125	104		126	90	2.0E-01	3,000	126		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
VOC	1,2-Dichloroethane	107-06-2	B2	1	N			9.1E-02	1		9.1E-02	125	104	2.6E-02	1		2.0E-02	3,000	126	116	2.0E-02	3,000	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	
VOC	1,1-Dichloroethene	75-35-4	C	1	N												5.0E-02	100	1		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
VOC	1,2-Dichloroethene (total)	540-59-0			N												2.0E-03	3,000	1	133	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
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1	N												2.0E-03	3,000	1		2.0E-03	3,000	125	104			1	90	2.0E-02	300	1	110	2.0E-02	300	125	104			126	90
VOC	trans-1,2-Dichloroethene	156-60-5	ID	1	N												2.0E-02	3,000	1		2.0E-02	3,000	125	104			1	90	2.0E-01	300	1	110	2.0E-01	300	125	104			1	90
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	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
VOC	Ethyl Benzene	100-41-4	D	1	N												1.0E-01	1,000	1		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	
VOC	2-Hexanone	591-78-6	ID	1	N												5.0E-03	1,000	1		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
VOC	4-Methyl-2-pentanone	108-10-1	ID	1	N														1	90			125	104	3.0E+00	300	1				1	90, 62			125	104	3.0E+00	300	1	62
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		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
VOC	Styrene	100-42-5			N												2.0E-01	1,000	1	6	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	
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		2.0E-02	1,000	125	104			1	90	5.0E-02	300	1		5.0E-02	300	125	104			1	90, 62
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		6.0E-03	1,000	125	104	4.0E-02	1,000	1		8.0E-03	300	129	111, 86	8.0E-03	300	125	104	4.1E-02	300	129	111, 86
VOC	Toluene	108-88-3	ID	1	N												8.0E-02	3,000	1		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	
VOC	1,1,1-Trichloroethane	71-55-6	ID	1	N												2.0E+00	1,000	1		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	
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		4.0E-03	1,000	125	104					4.0E-03	1,000	126		4.0E-03	1000	125	104				
VOC	Trichloroethene	79-01-6	HC	1	Y	0.202	0.244	4.6E-02	1	159	4.6E-02	125	104	4.1E-03	1	159	5.0E-04	1,000	1		5.0E-04	1,000	125	104	2.0E-03	100	1		5.0E-04	10	129	111, 86	5.0E-04	10	125	104	2.1E-03	10	129	111, 86
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		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
VOC	Xylenes (total)	1330-20-7	ID	1	N												2.0E-01	1,000	1		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
INORG	Iron	7439-89-6	D	91	N				91	90		125	104		91	90	7.0E-01	2	126		7.0E-01	2	125	104			92	90	7.0E-01	2	126		7.0E-01	1.5	125	104			92	90, 62
INORG	Manganese	7439-96-5	D	1	N												1.4E-01	1	1		8.4E-03	1	125	104	5.0E-05	1,000	1		1.4E-01	1	1	62	8.4E-03	1	125	104	5.0E-05	1,000	1	62

References

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2 USEPA. 1997. Health Effects Assessment Summary Tables (HEAST). FY-1997 Update. EPA 540/R-97-036. July.
91 USEPA. NCEA. 2001. Evaluation of Carcinogenicity of Iron [CASRN 7439-89-6] and Compounds. November 14.
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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. 2014. Minimal Risk Levels. December
135 CalEPA. OEHHA. 2009. Technical Support Document for Cancer Potency Factors. Appendix H. May.
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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 Ramboll 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.
78 For evaluating partial lifetime exposures that include early-life exposure, the slope factor is also used in risk calculations that do not prorate the early-life exposure, per USEPA's May 2000 Toxicological Review.
79 For evaluating partial lifetime exposures that include early-life exposure, the unit risk factor is also used in risk calculations that do not prorate the early-life exposure, per USEPA's May 2000 Toxicological Review.
86 This is a DRAFT toxicity value.
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.
116 Ramboll Environ used subchronic value as a surrogate for the chronic value.
133 Ramboll 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-dependent 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 B1.2: Physical and Chemical Properties
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	MW (g/mole)		K_{ow} (unitless)			K_{oc} (L/kg)			K_d (L/kg)		H (unitless)					s (mg/L)			VP (mm Hg)				D_{air} (m^2/d)			D_{water} (m^2/d)			K_p (cm/hr)			ABS_d (unitless)		FA (unitless)			$\Delta H_{v,b}$ (cal/mol)			T_C (Kelvin)			T_B (Kelvin)			HENRY Ref Temp (°C)	VP Ref Temp (°C)
			Value	Ref	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Value	Adjust	Ref	Notes	Value	Ref	Notes	Value	Adjust	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Value
VOC	Acetone	67-64-1	5.8E+01	50.3	5.8E-01	44		5.8E-01	44	82			1.6E-03	1.1E-03	44		1.0E+06	44		2.3E+02	2.0E+02	50.3		1.1E+00	44		9.8E-05	44		5.2E-04	44	115	0.0E+00	62	1.0E+00	62	114	6.96E+03	44	118	5.08E+02	44	118	3.29E+02	44	118	2.5E+01	
VOC	Benzene	71-43-2	7.8E+01	50.3	1.3E+02	44		5.8E+01	44	111			2.3E-01	1.6E-01	44		1.8E+03	44		9.5E+01	8.0E+01	50.3		7.6E-01	44		8.5E-05	44		1.5E-02	44	115	0.0E+00	62	1.0E+00	62		7.34E+03	44	118	5.62E+02	44	118	3.53E+02	44	118	2.5E+01	
VOC	Bromodichloromethane	75-27-4	1.6E+02	50.3	1.3E+02	44		5.5E+01	44	111			6.6E-02	4.5E-02	44		6.7E+03	44		5.0E+01	4.2E+01	50.3		2.6E-01	44		9.2E-05	44		4.7E-03	44	115	0.0E+00	62	1.0E+00	62		7.80E+03	44	118	5.86E+02	44	118	3.63E+02	44	118	2.5E+01	
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	1.3E-01	44		8.9E-05	44		2.2E-03	44	115	0.0E+00	62	1.0E+00	62		9.48E+03	44	118	6.96E+02	44	118	4.22E+02	44	118	2.5E+01	2.5E+01
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	6.3E-01	44		1.0E-04	44		2.8E-03	44	115	0.0E+00	62	1.0E+00	62		5.71E+03	44	118	4.67E+02	44	118	2.77E+02	44	118	2.5E+01	2.5E+01
VOC	2-Butanone	78-93-3	7.2E+01	50.3	1.9E+00	69		2.0E+00	69	111			2.3E-03	2.0E-03	50.3	123	2.2E+05	50.3		9.1E+01	7.7E+01	50.3		7.0E-01	69		8.5E-05	69		9.6E-04	69	115	0.0E+00	62	1.0E+00	62		7.48E+03	70		5.37E+02	70		3.53E+02	70		2.0E+01	
VOC	Carbon Disulfide	75-15-0	7.6E+01	50.3	1.0E+02	44		4.6E+01	44	111			1.2E+00	9.3E-01	44		1.2E+03	44		3.6E+02	3.0E+02	50.3		9.0E-01	44		8.6E-05	44		1.2E-02	44	115	0.0E+00	62	1.0E+00	62		6.39E+03	44	118	5.52E+02	44	118	3.19E+02	44	118	2.5E+01	
VOC	Carbon Tetrachloride	56-23-5	1.5E+02	50.3	5.4E+02	44		1.7E+02	44	111			1.3E+00	8.8E-01	44		7.9E+02	44		1.2E+02	9.7E+01	50.3		6.7E-01	44		7.6E-05	44		1.4E-02	44	115	0.0E+00	62	1.0E+00	62		7.13E+03	44	118	5.57E+02	44	118	3.50E+02	44	118	2.5E+01	
VOC	Chlorobenzene	108-90-7	1.1E+02	50.3	7.2E+02	44		2.2E+02	44	111			1.5E-01	9.8E-02	44		4.7E+02	44		1.2E+01	1.0E+01	50.3		6.3E-01	44		7.5E-05	44		2.9E-02	44	115	0.0E+00	62	1.0E+00	62		8.41E+03	44	118	6.32E+02	44	118	4.05E+02	44	118	2.5E+01	
VOC	Chloroethane	75-00-3	6.5E+01	50.3	2.7E+01	69		1.6E+01	69	111			4.5E-01	4.1E-01	50.3	123	6.7E+03	50.3		1.0E+03	8.6E+02	50.3		2.3E+00	69		9.9E-05	69		6.1E-03	69	115	0.0E+00	62	1.0E+00	62		5.88E+03	70		4.60E+02	70		2.85E+02	70		2.0E+01	
VOC	Chloroform	67-66-3	1.2E+02	50.3	8.3E+01	44		4.0E+01	44	111			1.5E-01	1.1E-01	44		7.9E+03	44		2.0E+02	1.7E+02	50.3		9.0E-01	44		8.6E-05	44		6.3E-03	44	115	0.0E+00	62	1.0E+00	62		6.99E+03	44	118	5.36E+02	44	118	3.34E+02	44	118	2.5E+01	
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	1.1E+00	69		5.6E-05	69		1.5E-02	69	115	0.0E+00	62	1.0E+00	62		5.11E+03	70		4.16E+02	70		2.49E+02	70		2.0E+01	2.5E+01
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	1.7E-01	44		9.1E-05	44		2.9E-03	44	115	0.0E+00	62	1.0E+00	62		5.90E+03	44	118	6.78E+02	44	118	4.16E+02	44	118	2.5E+01	2.5E+01
VOC	1,1-Dichloroethane	75-34-3	9.9E+01	50.3	6.2E+01	44		3.1E+01	44	111			2.3E-01	1.7E-01	44		5.1E+03	44		2.3E+02	1.9E+02	50.3		6.4E-01	44		9.1E-05	44		6.7E-03	44	115	0.0E+00	62	1.0E+00	62		6.90E+03	44	118	5.23E+02	44	118	3.31E+02	44	118	2.5E+01	
VOC	1,2-Dichloroethane	107-06-2	9.9E+01	50.3	3.0E+01	44		1.7E+01	44	111			4.0E-02	2.7E-02	44		8.5E+03	44		7.9E+01	6.7E+01	50.3		9.0E-01	44		8.6E-05	44		4.1E-03	44	115	0.0E+00	62	1.0E+00	62		7.64E+03	44	118	5.61E+02	44	118	3.57E+02	44	118	2.5E+01	
VOC	1,1-Dichloroethene	75-35-4	9.7E+01	50.3	1.3E+02	44		5.8E+01	44	111			1.1E+00	8.1E-01	44		2.3E+03	44		6.0E+02	5.1E+02	50.3		7.8E-01	44		9.0E-05	44		1.2E-02	44	115	0.0E+00	62	1.0E+00	62		6.25E+03	44	118	5.76E+02	44	118	3.05E+02	44	118	2.5E+01	
VOC	1,2-Dichloroethene (total)	540-59-0	9.7E+01	50.3	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	1.7E+02	50.3		6.4E-01	44	133	9.8E-05	44	133	7.7E-03	44	133, 115	0.0E+00	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	
VOC	cis-1,2-Dichloroethene	156-59-2	9.7E+01	50.3	7.2E+01	44		3.6E+01	44	111			1.7E-01	1.2E-01	44		3.5E+03	44		2.0E+02	1.7E+02	50.3		6.4E-01	44		9.8E-05	44		7.7E-03	44	115	0.0E+00	62	1.0E+00	62	114	7.19E+03	44	118	5.44E+02	44	118	3.34E+02	44	118	2.5E+01	
VOC	trans-1,2-Dichloroethene	156-60-5	9.7E+01	50.3	1.2E+02	44		5.2E+01	44	111			3.9E-01	2.8E-01	44		6.3E+03	44		3.3E+02	2.8E+02	50.3		6.1E-01	44		1.0E-04	44		1.1E-02	44	115	0.0E+00	62	1.0E+00	62	114	6.72E+03	44	118	5.17E+02	44	118	3.21E+02	44	118	2.5E+01	
VOC	1,2-Dichloropropane	78-87-5	1.1E+02	50.3	9.3E+01	44		4.3E+01	44	111			1.2E-01	7.8E-02	44		2.8E+03	44		5.3E+01	4.5E+01	50.3		6.8E-01	44		7.5E-05	44		7.4E-03	44	115	0.0E+00	62	1.0E+00	62		7.59E+03	44	118	5.72E+02	44	118	3.70E+02	44	118	2.5E+01	
VOC	Ethyl Benzene	100-41-4	1.1E+02	50.3	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	50.3		6.5E-01	44		6.7E-05	44		4.8E-02	44	115	0.0E+00	62	1.0E+00	62		8.50E+03	44	118	6.17E+02	44	118	4.09E+02	44	118	2.5E+01	
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	7.4E-01	52		7.6E-05	52		3.5E-03	39	115	0.0E+00	62	1.0E+00	62	114											2.5E+01	
VOC	4-Methyl-2-pentanone	108-10-1	1.0E+02	50.3	1.5E+01	62		1.0E+01	62	111			5.6E-03	4.7E-03	50.3	123	1.9E+04	39		2.0E+01	1.7E+01	50.3		6.5E-01	40		6.7E-05	40		2.7E-03	62	115	0.0E+00	62	1.0E+00	62		8.24E+03	70		5.71E+02	70		3.90E+02	70		2.0E+01	
VOC	Methylene Chloride	75-09-2	8.5E+01	50.3	1.8E+01	44		1.2E+01	44	111			9.0E-02	6.6E-02	44		1.3E+04	44		4.4E+02	3.7E+02	50.3		8.7E-01	44		1.0E-04	44		3.5E-03	44	115	0.0E+00	62	1.0E+00	62		6.71E+03	44	118	5.10E+02	44	118	3.13E+02	44	118	2.5E+01	
VOC	Styrene	100-42-5	1.0E+02	50.3	8.7E+02	44		7.8E+02	44	82			1.1E-01	7.0E-02	44		3.1E+02	44		6.4E+00	5.4E+00	50.3		6.1E-01	44		6.9E-05	44		3.6E-02	44	115	0.0E+00	62	1.0E+00	62		8.74E+03	44	118	6.36E+02	44	118	4.18E+02	44	118	2.5E+01	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	1.7E+02	50.3	2.5E+02	44		9.4E+01	44	111			1.4E-02	8.7E-03	44		3.0E+03	44		4.6E+00	3.9E+00	50.3		6.1E-01	44		6.8E-05	44		6.9E-03	44	115	0.0E+00	62	1.0E+00	62		9.00E+03	44	118	6.61E+02	44	118	4.20E+02	44	118	2.5E+01	
VOC	Tetrachloroethene	127-18-4	1.7E+02	50.3	4.7E+02	44		1.6E+02	44	111			7.5E-01	4.9E-01	44		2.0E+02	44		1.9E+01	1.6E+01	50.3		6.2E-01	44		7.1E-05	44		1.1E-02	44	115	0.0E+00	62	1.0E+00	62		8.29E+03	44	118	6.20E+02	44	118	3.94E+02	44	118	2.5E+01	
VOC	Toluene	108-88-3	9.2E+01	50.3	5.6E+02	44		1.8E+02	44	111			2.7E-01	1.8E-01	44		5.3E+02	44		2.8E+01	2.4E+01	50.3		7.5E-01	44		7.4E-05	44		3.2E-02	44	115	0.0E+00	62	1.0E+00	62		7.93E+03	44	118	5.92E+02	44	118	3.84E+02	44	118	2.5E+01	
VOC	1,1,1-Trichloroethane	71-55-6	1.3E+02	50.3	3.0E+02	44		1.1E+02	44	111			7.1E-01	5.0E-01	44		1.3E+03	44		1.2E+02	1.1E+02	50.3		6.7E-01	44		7.6E-05	44		1.2E-02	44	115	0.0E+00	62	1.0E+00	62		7.14E+03	44	118	5.45E+02	44	118	3.47E+02	44	118	2.5E+01	
VOC	1,1,2-Trichloroethane	79-00-5	1.3E+02	50.3	1.1E+02	44		5.0E+01	44	111			3.7E-02	2.4E-02	44		4.4E+03	44		2.3E+01	1.9E+01	50.3		6.7E-01	44		7.6E-05	44		6.4E-03	44	115	0.0E+00	62	1.0E+00	62		8.32E+03	44	118	6.02E+02	44	118	3.86E+02	44	118	2.5E+01	
VOC	Trichloroethene	79-01-6	1.3E+02	50.3	5.1E+02	44		1.7E+02	44	111			4.2E-01	2.9E-01	44		1.1E+03	44		6.9E+01	5.8E+01	50.3		6.8E-01	44		7.9E-05	44		1.8E-02	44	115	0.0E+00	62	1.0E+00	62		7.51E+03	44	118	5.44E+02	44	118	3.60E+02	44	118	2.5E+01	
VOC	Vinyl Chloride	75-01-4	6.3E+01	50.3	3.2E+01	44		1.8E+01	44	111			1.1E+00	9.0E-01	44		2.8E+03	44		3.0E+03	2.5E+03	50.3		9.2E-01	44		1.1E-04	71		6.9E-03	44	115	0.0E+00	62	1.0E+00	62		5.25E+03	44	118	4.32E+02	44	118	2.59E+02	44	118	2.5E+01	
VOC	Xylenes (total)	1330-20-7	1.1E+02	50.3	1.5E+03	44		3.9E+02	44	111	5.7E+01	50.3	2.8E-01	1.7E-01	44		1.7E+02	44		7.9E+00	6.7E+00	50.3		6.7E-01	44		7.6E-05	44		5.0E-02	44	115	0.0E+00	62	1.0E+00	62	114	8.57E+03	44	118	6.21E+02	44	118	4.14E+02	44	118	2.5E+01	
INORG	Iron	7439-89-6	5.6E+01	50.3							2.5E+01	35																				1.0E-03	62		0.0E+00	62													
INORG	Manganese	7439-96-5	5.5E+01	50.3							6.5E+01	35																				1.0E-03	62		0.0E+00	62													

References:

35 Baes III, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Released Radionuclides through Agriculture (AD-89-T-2-A-106) (formerly EPA078-D-X0304), Oak Ridge National Laboratory, ORNL-5786.

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.

50.3 USEPA. 20014. Superfund Chemical Data Matrix (SCDM). Office of Superfund Remediation and Technology Innovation. June 20, 2014.

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:

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

92 Indicated source cites CHEMFATE.

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

Attachment B1.3: Occupational Air Standards
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	Cal OSHA PEL (mg/m^3)			PEL (mg/m^3)			TLV-TWA (mg/m^3)			REL (mg/m^3)		
			Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes
VOC	Acetone	67-64-1	1.2E+03	168		2.4E+03	97		5.9E+02	47		5.9E+02	46	
VOC	Benzene	71-43-2	3.2E+00	168		3.2E+00	97	368	1.6E+00	47		3.2E-01	46	657
VOC	Bromodichloromethane	75-27-4												
VOC	Bromoform	75-25-2	5.0E+00	168		5.0E+00	97	426	5.2E+00	47		5.0E+00	46	426
VOC	Bromomethane	74-83-9	3.9E+00	168		8.0E+01	97		3.9E+00	47				
VOC	2-Butanone	78-93-3	5.9E+02	168		5.9E+02	97		5.9E+02	47		5.9E+02	46	
VOC	Carbon Disulfide	75-15-0	3.0E+00	168		6.2E+01	97		3.1E+00	47		3.0E+00	46	
VOC	Carbon Tetrachloride	56-23-5	1.3E+01	168		6.3E+01	97		3.1E+01	47		1.3E+01	46	439, 657
VOC	Chlorobenzene	108-90-7	4.6E+01	168		3.5E+02	97		4.6E+01	47				
VOC	Chloroethane	75-00-3	2.6E+02	168		2.6E+03	97		2.6E+02	47				
VOC	Chloroform	67-66-3	9.8E+00	168		2.4E+02	97	360	4.9E+01	47		9.8E+00	46	439, 657
VOC	Chloromethane	74-87-3	1.1E+02	168		2.1E+02	97		1.0E+02	47				
VOC	Dibromochloromethane	124-48-1												
VOC	1,1-Dichloroethane	75-34-3	4.0E+02	168		4.0E+02	97		4.0E+02	47		4.0E+02	46	
VOC	1,2-Dichloroethane	107-06-2	4.0E+00	168		2.0E+02	97		4.0E+01	47		4.0E+00	46	657
VOC	1,1-Dichloroethene	75-35-4	4.0E+00	168					2.0E+01	47				
VOC	1,2-Dichloroethene (total)	540-59-0	7.9E+02	168		7.9E+02	97		7.9E+02	47		7.9E+02	46	
VOC	cis-1,2-Dichloroethene	156-59-2				7.9E+02	97	409	7.9E+02	47		7.9E+02	46	409
VOC	trans-1,2-Dichloroethene	156-60-5				7.9E+02	97	409	7.9E+02	47		7.9E+02	46	409
VOC	1,2-Dichloropropane	78-87-5	3.5E+02	168		3.5E+02	97		4.6E+01	47				
VOC	Ethyl Benzene	100-41-4	2.2E+01	168		4.4E+02	97		8.7E+01	47		4.4E+02	46	
VOC	2-Hexanone	591-78-6	4.0E+00	168		4.1E+02	97		2.0E+01	47		4.0E+00	46	
VOC	4-Methyl-2-pentanone	108-10-1	2.1E+02	168		4.1E+02	97		8.2E+01	47		2.1E+02	46	
VOC	Methylene Chloride	75-09-2	8.7E+01	168		8.7E+01	97		1.7E+02	47				
VOC	Styrene	100-42-5	2.2E+02	168		4.3E+02	97		8.5E+01	47		2.2E+02	46	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	7.0E+00	168		3.5E+01	97	426	6.9E+00	47		7.0E+00	46	426, 657
VOC	Tetrachloroethene	127-18-4	1.7E+02	168		6.8E+02	97		1.7E+02	47				
VOC	Toluene	108-88-3	3.7E+01	168		7.5E+02	97		7.5E+01	47		3.8E+02	46	
VOC	1,1,1-Trichloroethane	71-55-6	1.9E+03	168		1.9E+03	97		1.9E+03	47		1.9E+03	46	
VOC	1,1,2-Trichloroethane	79-00-5	4.5E+01	168		4.5E+01	97	426	5.5E+01	47		4.5E+01	46	426, 657
VOC	Trichloroethene	79-01-6	1.4E+02	168		5.4E+02	97		5.4E+01	47		1.3E+02	46	657, 661
VOC	Vinyl Chloride	75-01-4	2.6E+00	168		2.6E+00	97	368	2.6E+00	47				
VOC	Xylenes (total)	1330-20-7	4.4E+02	168		4.4E+02	97		4.3E+02	47				
INORG	Iron	7439-89-6												
INORG	Manganese	7439-96-5	2.0E-01	168		5.0E+00	97	360	2.0E-02	47	418	1.0E+00	46	

References:

46 National Institute for Occupational Safety and Health (NIOSH). 2007. NIOSH Pocket Guide to Chemical Hazards. DHHS. 2005-149. August.

47 American Conference of Government Industrial Hygienists. 2015. 2015 TLVs and BEIs. ISBN: 978-1-607260-59-2.

97 Occupational Safety and Health Standards — Toxic and Hazardous Substances, Title 29 Code of Federal Regulations, Pt. 1910 Subpart Z. 2007 ed.

168 State of California. Department of Industrial Relations. Table AC1 - Permissible Exposure Limits For Chemical Contaminants.

Notes:

360 Criteria are ceiling levels.

368 Complex criterion; source document review required.

409 Ramboll Environ used 1,2-Dichloroethene (total) [CASRN 540-59-0] value from the indicated reference as a surrogate.

418 Respirable Fraction criterion.

426 Skin Designation assigned; wear appropriate PPE.

439 The value was for a 60-minute TWA exposure.

657 Potential occupational carcinogen

661 Supplementary exposure limit for all exposures found in Appendix C.

Attachment B1.4: High-End Exposure Factors
Whirlpool, Fort Smith, Arkansas

			Resident Age 0-2	Resident Age 2-6	Resident Age 6-16	Resident Age 16-26		Routine Worker		Maintenance Worker		Construction Worker		Adolescent Trespasser (6-16)	
Soil Ingestion															
Ingestion Rate (mg/d)	IR							50	b	100	f	200	f	100	f
Conversion Factor (kg/mg)	CF							1E-06		1E-06		1E-06		1E-06	
Fraction Contacted (unitless)	FC							1.0	f	1.0	f	1.0	f	0.1	f
Exposure Frequency (d/yr)	EF							250	i	30	f	250	i	100	f
Exposure Duration (yr)	ED							25	i	10	e	1	f	10	f
Body Weight (kg-bw)	BW							80	i	80	i	80	i	44.3	j
Averaging Time, carc (d)	AT_c							25,550	a	25,550	a	25,550	a	25,550	a
Averaging Time, noncarc (d)	AT_{nc}							9,125	a	3,650	a	365	a	3,650	a
Soil Dermal Contact															
Adherence Factor (mg/cm^2)	AD							0.12	i	0.12	i	0.12	i	0.12	f
Skin Surface Area (cm^2/d)	SA							3,527	i	3,527	i	3,527	i	4,400	j
Conversion Factor (kg/mg)	CF							1E-06		1E-06		1E-06		1E-06	
Fraction Contacted (unitless)	FC							1.0	f	1.0	f	1.0	f	0.1	f
Exposure Frequency (d/yr)	EF							250	i	30	f	250	i	100	f
Exposure Duration (yr)	ED							25	i	10	e	1	f	10	f
Body Weight (kg-bw)	BW							80	i	80	i	80	i	44.3	j
Averaging Time, carc (d)	AT_c							25,550	a	25,550	a	25,550	a	25,550	a
Averaging Time, noncarc (d)	AT_{nc}							9,125	a	3,650	a	365	a	3,650	a
Outdoor Air Inhalation of Soil Vapor and/or Particulates															
Exposure Time (h/d)	ET		24	24	24	24	d, i	8	d, i	8	d, i	8	d, i	2	d
Exposure Frequency (d/yr)	EF		350	350	350	350	i	250	i	30	f	250	i	100	f
Exposure Duration (yr)	ED		2	4	10	10	i	25	i	10	e	1	f	10	f
Averaging Time, carc (h)	AT_c		613,200	613,200	613,200	613,200	a, d	613,200	a, d	613,200	a, d	613,200	a, d	613,200	a
Averaging Time, noncarc (h)	AT_{nc}		227,760	227,760	227,760	227,760	a, d	219,000	a, d	87,600	a, d	8,760	a, d	87,600	a
Incidental Groundwater Ingestion															
Ingestion Rate (L/hr)	DR									0.005	f	0.005	f		
Exposure Time (h/d)	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									80	i	80	i		
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									3,527	i	3,527	i		
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									80	i	80	i		
Averaging Time, cancer (days)	AT_c									25,550	a	25,550	a		
Averaging Time, noncancer (days)	AT_{nc}									3,650	a	365	a		
Outdoor Groundwater Vapor Inhalation															
Exposure Time (h/d)	ET		24	24	24	24	d, i	8	d, i	8	d, i	8	d, i	2	d
Exposure Frequency (d/yr)	EF		350	350	350	350	i	250	i	5	f	5	f	100	f
Exposure Duration (yr)	ED		2	4	10	10	i	25	i	10	e	1	f	10	f
Averaging Time, carc (h)	AT_c		613,200	613,200	613,200	613,200	a, d	613,200	a, d	613,200	a, d	613,200	a, d	613,200	a
Averaging Time, noncarc (h)	AT_{nc}		227,760	227,760	227,760	227,760	a, d	219,000	a, d	87,600	a, d	8,760	a, d	87,600	a
Indoor Soil and/or Groundwater Vapor Inhalation															
Exposure Time (h/d)	ET		24	24	24	24	d, i	8	d, i						
Exposure Frequency (d/yr)	EF		350	350	350	350	i	250	i						
Exposure Duration (yr)	ED		2	4	10	10	i	25	i						
Averaging Time, carc (h)	AT_c		613,200	613,200	613,200	613,200	a, d	613,200	a, d						
Averaging Time, noncarc (h)	AT_{nc}		227,760	227,760	227,760	227,760	a, d	219,000	a, d						

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).
h. Exposure Factors Handbook (EPA 1997).
i. Standard default exposure factors. OSWER Directive 9200.1-120 (EPA 2014).
j. Exposure Factors Handbook (EPA 2011).

RAMBOLL ENVIRON

Attachment B1.6: SCREEN3 Output for Source Area Corresponding to the Former Drainage Trench

```
***  SCREEN3 MODEL RUN  ***
  *** VERSION DATED 96043 ***

 Off-Site Trench

 SIMPLE TERRAIN INPUTS:
    SOURCE TYPE                =         AREA
    EMISSION RATE (G/(S-M**2)) =      1.00000
    SOURCE HEIGHT (M)          =        .0000
    LENGTH OF LARGER SIDE (M)  =      76.2000
    LENGTH OF SMALLER SIDE (M) =       7.6200
    RECEPTOR HEIGHT (M)        =       1.5000
    URBAN/RURAL OPTION         =        RURAL
 THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
 THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

    MODEL ESTIMATES DIRECTION TO MAX CONCENTRATION


 BUOY. FLUX =     .000 M**4/S**3;  MOM. FLUX =     .000 M**4/S**2.

 *** STABILITY CLASS  4 ONLY ***
 *** ANEMOMETER HEIGHT WIND SPEED OF   3.40 M/S ONLY ***

 **********************************
 *** SCREEN AUTOMATED DISTANCES ***
 **********************************

 *** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING
DISTANCES ***

   DIST     CONC             U10M   USTK  MIX HT   PLUME  MAX DIR
    (M)   (UG/M**3)   STAB  (M/S)  (M/S)    (M)   HT (M)   (DEG)
 -------  ----------  ----  -----  -----  ------  ------  -------
      1.   .2129E+07    4     3.4    3.4  1088.0     .00      0.
    100.   .1446E+07    4     3.4    3.4  1088.0     .00      0.
    200.   .4121E+06    4     3.4    3.4  1088.0     .00      0.

 MAXIMUM 1-HR CONCENTRATION AT OR BEYOND     1. M:
     48.   .3883E+07    4     3.4    3.4  1088.0     .00      0.
```

```
**********************************
*** SCREEN DISCRETE DISTANCES ***
**********************************

*** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING
DISTANCES ***

   DIST     CONC             U10M   USTK  MIX HT   PLUME  MAX DIR
    (M)   (UG/M**3)   STAB  (M/S)  (M/S)    (M)   HT (M)   (DEG)
 -------  ----------  ----  -----  -----  ------  ------  -------
     96.   .1556E+07    4     3.4    3.4  1088.0     .00      0.

      ****************************************
      *** SUMMARY OF SCREEN MODEL RESULTS ***
      ****************************************

  CALCULATION        MAX CONC    DIST TO   TERRAIN
   PROCEDURE        (UG/M**3)    MAX (M)    HT (M)
 --------------    -----------   -------   -------
 SIMPLE TERRAIN      .3883E+07       48.        0.


 ****************************************************
 ** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
 ****************************************************
```

Attachment B1.6: SCREEN3 Output for Source Area Corresponding to the Remaining Area of the 93-acre Site

```
  ***  SCREEN3 MODEL RUN  ***
  *** VERSION DATED 96043 ***


 SIMPLE TERRAIN INPUTS:
    SOURCE TYPE                =         AREA
    EMISSION RATE (G/(S-M**2)) =      1.00000
    SOURCE HEIGHT (M)          =        .0000
    LENGTH OF LARGER SIDE (M)  =     613.0000
    LENGTH OF SMALLER SIDE (M) =     613.0000
    RECEPTOR HEIGHT (M)        =       1.5000
    URBAN/RURAL OPTION         =        RURAL
 THE REGULATORY (DEFAULT) MIXING HEIGHT OPTION WAS SELECTED.
 THE REGULATORY (DEFAULT) ANEMOMETER HEIGHT OF 10.0 METERS WAS ENTERED.

    MODEL ESTIMATES DIRECTION TO MAX CONCENTRATION


 BUOY. FLUX =     .000 M**4/S**3;  MOM. FLUX =     .000 M**4/S**2.

 *** STABILITY CLASS  4 ONLY ***
 *** ANEMOMETER HEIGHT WIND SPEED OF   3.40 M/S ONLY ***

 **********************************
 *** SCREEN AUTOMATED DISTANCES ***
 **********************************

 *** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING
DISTANCES ***

   DIST     CONC             U10M   USTK  MIX HT   PLUME  MAX DIR
    (M)   (UG/M**3)   STAB  (M/S)  (M/S)    (M)   HT (M)   (DEG)
 -------  ----------  ----  -----  -----  ------  ------  -------
      1.   .1402E+08    4     3.4    3.4  1088.0     .00     45.
    100.   .1528E+08    4     3.4    3.4  1088.0     .00     45.
    200.   .1666E+08    4     3.4    3.4  1088.0     .00     45.
    300.   .1777E+08    4     3.4    3.4  1088.0     .00     45.
    400.   .1875E+08    4     3.4    3.4  1088.0     .00     45.
    500.   .1434E+08    4     3.4    3.4  1088.0     .00     45.

 MAXIMUM 1-HR CONCENTRATION AT OR BEYOND     1. M:
    400.   .1875E+08    4     3.4    3.4  1088.0     .00     45.
```

```
*********************************
 *** SCREEN DISCRETE DISTANCES ***
 *********************************

 *** TERRAIN HEIGHT OF    0. M ABOVE STACK BASE USED FOR FOLLOWING
DISTANCES ***

   DIST     CONC             U10M   USTK  MIX HT   PLUME  MAX DIR
    (M)   (UG/M**3)   STAB  (M/S)  (M/S)    (M)   HT (M)   (DEG)
 -------  ----------  ----  -----  -----  ------  ------  -------
    447.   .1832E+08    4     3.4    3.4  1088.0     .00     45.

      ***************************************
      *** SUMMARY OF SCREEN MODEL RESULTS ***
      ***************************************

  CALCULATION        MAX CONC    DIST TO   TERRAIN
   PROCEDURE        (UG/M**3)    MAX (M)    HT (M)
 --------------    -----------   -------   -------
 SIMPLE TERRAIN      .1875E+08      400.        0.


 ****************************************************
 ** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **
 ****************************************************
```

Attachment B2

Routine Worker Risk Calculations

Attachments

B2.1 Vapor Flux from Soil to Outdoor Air

B2.2 Soil PM_{10} Emission from Wind Erosion

B2.3 Cancer Risk Calculations for Inhalation Exposure of Routine Workers to Former Drainage Trench Soil

B2.4 Hazard Index Calculations for Inhalation Exposure of Routine Workers to Former Drainage Trench Soil

B2.5 Cancer Risk Calculations for Inhalation Exposure of Routine Workers to Remaining Site Soil

B2.6 Hazard Index Calculations for Inhalation Exposure of Routine Workers to Remaining Site Soil

B2.7 Cancer Risk Calculations for Contact Exposure of Routine Workers to Total Site Soil

B2.8 Hazard Index Calculations for Contact Exposure of Routine Workers to Total Site Soil

B2.9 Soil Moisture Profile for a Generic Comm/Ind Building (Slab-on-Grade)

B2.10 Normalized Indoor Air Concentration in a Generic Comm/Ind Building (Slab-on-Grade) due to Soil-derived Vapor Intrusion

B2.11 Normalized Indoor Air Concentration in a Generic Comm/Ind Building (Slab-on-Grade) due to Groundwater-derived Vapor Intrusion

B2.12 Cancer Risk and Hazard Index Calculations for Soil-derived Vapor Intrusion into a Generic Comm/Ind Building (Slab-on-Grade)

B2.13 Cancer Risk and Hazard Index Calculations for Groundwater-derived Vapor Intrusion into a Generic Comm/Ind Building (Slab-on-Grade)

B2.14 Normalized Vapor Flux to Outdoor Air from Groundwater

B2.15 Dispersion Factor for Groundwater to Outdoor Air

B2.16 Cancer Risk and Hazard Index Calculations for Exposure of Routine Workers to Groundwater-derived Vapors in Outdoor Air

Attachment B2.1: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	K_{oc} (L/kg)	K_d (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		2.00E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.11E-05	1.59E-06	0.00E+00	4.84E-03	1.59E-06	1.59E-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		4.09E-01	2.34E+00	9.94E-05	4.28E-01	2.52E-02	9.18E-06	2.41E-02	2.93E-05	0.00E+00	3.15E+00	5.96E-06	5.96E-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	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	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
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	5.74E+01	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
INORG	Iron	7439-89-6		2.50E+01	0.00E+00							0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INORG	Manganese	7439-96-5		6.50E+01	0.00E+00							0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
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-^oK	**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												

RAMBOLL ENVIRON

Attachment B2.2: 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	$\mathbf{u'_t}$	0.50
Correction factor			1.25
Corrected friction velocity	m/s	$\mathbf{u^*_t}$	0.6252
Roughness height	m	$\mathbf{z_0}$	0.005
Anemometer height	m		10.0
Friction velocity at anemometer height	m/s	$\mathbf{u_t}$	11.9
Mean annual wind speed	mph	$\mathbf{u_m}$	7.6
Mean annual wind speed	m/s	$\mathbf{u_m}$	3.39750
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	$\mathbf{J_{10,w}}$	**3.93E-13**

RAMBOLL ENVIRON

Attachment B2.3: Cancer Risk Calculations for Inhalation Exposure of Routine Workers to Former Drainage Trench Soil Whirlpool, Fort Smith, Arkansas

					Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation 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	5.86E-02	6.83E-08			1.70E-14			
VOC	Benzene	71-43-2	A	6.30E-04	2.36E-09	7.8E-03	1.5E-12	1.83E-16	7.8E-03	1.2E-19	1.5E-12
VOC	Bromodichloromethane	75-27-4	B2	2.60E-03	5.70E-09			7.54E-16			
VOC	Bromoform	75-25-2	B2			1.1E-03			1.1E-03		
VOC	Bromomethane	74-83-9	ID	2.44E-01	9.49E-07			7.07E-14			
VOC	2-Butanone	78-93-3	ID	2.50E-01	2.93E-07			7.25E-14			
VOC	Carbon Disulfide	75-15-0		2.80E-03	1.21E-08			8.12E-16			
VOC	Carbon Tetrachloride	56-23-5	LC	5.20E-03	2.14E-08	6.0E-03	1.0E-11	1.51E-15	6.0E-03	7.4E-19	1.0E-11
VOC	Chlorobenzene	108-90-7	D								
VOC	Chloroethane	75-00-3	LC								
VOC	Chloroform	67-66-3	B2	5.70E-02	2.11E-07	2.3E-02	4.0E-10	1.65E-14	2.3E-02	3.1E-17	4.0E-10
VOC	Chloromethane	74-87-3	D								
VOC	Dibromochloromethane	124-48-1	C								
VOC	1,1-Dichloroethane	75-34-3	SC	8.80E-03	3.31E-08			2.55E-15			
VOC	1,2-Dichloroethane	107-06-2	B2	1.81E-01	5.41E-07	2.6E-02	1.1E-09	5.25E-14	2.6E-02	1.1E-16	1.1E-09
VOC	1,1-Dichloroethene	75-35-4	C	1.60E-01	6.79E-07			4.64E-14			
VOC	1,2-Dichloroethene (total)	540-59-0		5.20E+00	1.87E-05			1.51E-12			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.85E+01	6.64E-05			5.36E-12			
VOC	trans-1,2-Dichloroethene	156-60-5	ID	2.40E-01	9.35E-07			6.96E-14			
VOC	1,2-Dichloropropane	78-87-5	B2								
VOC	Ethyl Benzene	100-41-4	D	1.40E-03	4.53E-09			4.06E-16			
VOC	2-Hexanone	591-78-6	ID	7.30E-02	9.74E-08			2.12E-14			
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.75E-02	2.58E-08			5.07E-15			
VOC	Methylene Chloride	75-09-2	LC	3.14E+00	1.11E-05	1.0E-05	9.1E-12	9.10E-13	1.0E-05	7.4E-19	9.1E-12
VOC	Styrene	100-42-5									
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC								
VOC	Tetrachloroethene	127-18-4	LC	1.70E-01	6.68E-07	2.6E-04	1.4E-11	4.93E-14	2.6E-04	1.0E-18	1.4E-11
VOC	Toluene	108-88-3	ID	7.03E-02	2.49E-07			2.04E-14			
VOC	1,1,1-Trichloroethane	71-55-6	ID	3.20E-02	1.29E-07			9.27E-15			
VOC	1,1,2-Trichloroethane	79-00-5	C	3.50E-02	8.75E-08	1.6E-02	1.1E-10	1.01E-14	1.6E-02	1.3E-17	1.1E-10
VOC	Trichloroethene	79-01-6	HC	2.70E+02	1.01E-03	4.1E-03	3.4E-07	7.83E-11	4.1E-03	2.6E-14	3.4E-07
VOC	Vinyl Chloride	75-01-4	A	4.43E+00	1.92E-05	4.4E-03	6.9E-09	1.28E-12	4.4E-03	4.6E-16	6.9E-09
VOC	Xylenes (total)	1330-20-7	ID	8.90E-03	2.78E-08			2.58E-15			
INORG	Iron	7439-89-6	D								
INORG	Manganese	7439-96-5	D								
		Cumulative Risk:					**3E-07**			**3E-14**	**3E-07**
Notes:											
The annual maximum dispersion coefficient to outdoor air (C/Q) is 0.7 (kg/m³) / (kg/m²/s).											

RAMBOLL ENVIRON

Attachment B2.4: Hazard Index Calculations for Inhalation Exposure of Routine Workers to Former Drainage Trench Soil
Whirlpool, Fort Smith, Arkansas

				Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**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	5.86E-02	6.83E-08	3.1E+01	5.1E-10	1.70E-14	3.1E+01	1.3E-16	5.1E-10
VOC	Benzene	71-43-2	6.30E-04	2.36E-09	3.0E-02	1.8E-08	1.83E-16	3.0E-02	1.4E-15	1.8E-08
VOC	Bromodichloromethane	75-27-4	2.60E-03	5.70E-09			7.54E-16			
VOC	Bromoform	75-25-2								
VOC	Bromomethane	74-83-9	2.44E-01	9.49E-07	5.0E-03	4.3E-05	7.07E-14	5.0E-03	3.2E-12	4.3E-05
VOC	2-Butanone	78-93-3	2.50E-01	2.93E-07	5.0E+00	1.3E-08	7.25E-14	5.0E+00	3.3E-15	1.3E-08
VOC	Carbon Disulfide	75-15-0	2.80E-03	1.21E-08	7.0E-01	3.9E-09	8.12E-16	7.0E-01	2.6E-16	3.9E-09
VOC	Carbon Tetrachloride	56-23-5	5.20E-03	2.14E-08	1.0E-01	4.9E-08	1.51E-15	1.0E-01	3.4E-15	4.9E-08
VOC	Chlorobenzene	108-90-7			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	5.70E-02	2.11E-07	5.0E-02	9.6E-07	1.65E-14	5.0E-02	7.5E-14	9.6E-07
VOC	Chloromethane	74-87-3			9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1								
VOC	1,1-Dichloroethane	75-34-3	8.80E-03	3.31E-08	5.0E-01	1.5E-08	2.55E-15	5.0E-01	1.2E-15	1.5E-08
VOC	1,2-Dichloroethane	107-06-2	1.81E-01	5.41E-07	7.0E-03	1.8E-05	5.25E-14	7.0E-03	1.7E-12	1.8E-05
VOC	1,1-Dichloroethene	75-35-4	1.60E-01	6.79E-07	2.0E-01	7.7E-07	4.64E-14	2.0E-01	5.3E-14	7.7E-07
VOC	1,2-Dichloroethene (total)	540-59-0	5.20E+00	1.87E-05			1.51E-12			
VOC	cis-1,2-Dichloroethene	156-59-2	1.85E+01	6.64E-05			5.36E-12			
VOC	trans-1,2-Dichloroethene	156-60-5	2.40E-01	9.35E-07			6.96E-14			
VOC	1,2-Dichloropropane	78-87-5			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4	1.40E-03	4.53E-09	1.0E+00	1.0E-09	4.06E-16	1.0E+00	9.3E-17	1.0E-09
VOC	2-Hexanone	591-78-6	7.30E-02	9.74E-08	3.0E-02	7.4E-07	2.12E-14	3.0E-02	1.6E-13	7.4E-07
VOC	4-Methyl-2-pentanone	108-10-1	1.75E-02	2.58E-08	3.0E+00	2.0E-09	5.07E-15	3.0E+00	3.9E-16	2.0E-09
VOC	Methylene Chloride	75-09-2	3.14E+00	1.11E-05	6.0E-01	4.2E-06	9.10E-13	6.0E-01	3.5E-13	4.2E-06
VOC	Styrene	100-42-5			1.0E+00			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5								
VOC	Tetrachloroethene	127-18-4	1.70E-01	6.68E-07	4.0E-02	3.8E-06	4.93E-14	4.0E-02	2.8E-13	3.8E-06
VOC	Toluene	108-88-3	7.03E-02	2.49E-07	5.0E+00	1.1E-08	2.04E-14	5.0E+00	9.3E-16	1.1E-08
VOC	1,1,1-Trichloroethane	71-55-6	3.20E-02	1.29E-07	5.0E+00	5.9E-09	9.27E-15	5.0E+00	4.2E-16	5.9E-09
VOC	1,1,2-Trichloroethane	79-00-5	3.50E-02	8.75E-08			1.01E-14			
VOC	Trichloroethene	79-01-6	2.70E+02	1.01E-03	2.0E-03	1.2E-01	7.83E-11	2.0E-03	8.9E-09	1.2E-01
VOC	Vinyl Chloride	75-01-4	4.43E+00	1.92E-05	1.0E-01	4.4E-05	1.28E-12	1.0E-01	2.9E-12	4.4E-05
VOC	Xylenes (total)	1330-20-7	8.90E-03	2.78E-08	1.0E-01	6.4E-08	2.58E-15	1.0E-01	5.9E-15	6.4E-08
INORG	Iron	7439-89-6								
INORG	Manganese	7439-96-5			5.0E-05			5.0E-05		
	Hazard Index:					**1E-01**			**9E-09**	**1E-01**
Notes:										
The annual maximum dispersion coefficient to outdoor air (C/Q) is 0.7 (kg/m³) / (kg/m²/s).										

RAMBOLL ENVIRON

Attachment B2.5: Cancer Risk Calculations for Inhalation Exposure of Routine Workers to Remaining Site Soil
Whirlpool, Fort Smith, Arkansas

					Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation 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	5.16E-02	2.90E-07			7.22E-14			
VOC	Benzene	71-43-2	A			7.8E-03			7.8E-03		
VOC	Bromodichloromethane	75-27-4	B2								
VOC	Bromoform	75-25-2	B2	6.10E-03	2.84E-08	1.1E-03	2.5E-12	8.54E-15	1.1E-03	7.7E-19	2.5E-12
VOC	Bromomethane	74-83-9	ID								
VOC	2-Butanone	78-93-3	ID								
VOC	Carbon Disulfide	75-15-0		7.40E-03	1.54E-07			1.04E-14			
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	5.20E-03	9.29E-08	2.3E-02	1.7E-10	7.28E-15	2.3E-02	1.4E-17	1.7E-10
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	7.20E-03	1.04E-07	2.6E-02	2.2E-10	1.01E-14	2.6E-02	2.1E-17	2.2E-10
VOC	1,1-Dichloroethene	75-35-4	C	1.10E-03	2.25E-08			1.54E-15			
VOC	1,2-Dichloroethene (total)	540-59-0		4.90E-01	8.49E-06			6.86E-13			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	4.90E-01	8.49E-06			6.86E-13			
VOC	trans-1,2-Dichloroethene	156-60-5	ID								
VOC	1,2-Dichloropropane	78-87-5	B2								
VOC	Ethyl Benzene	100-41-4	D								
VOC	2-Hexanone	591-78-6	ID	5.90E-02	3.80E-07			8.26E-14			
VOC	4-Methyl-2-pentanone	108-10-1	ID								
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	1.20E-07	1.0E-05	9.8E-14	9.80E-15	1.0E-05	8.0E-21	9.8E-14
VOC	Styrene	100-42-5									
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC								
VOC	Tetrachloroethene	127-18-4	LC	4.40E-03	8.34E-08	2.6E-04	1.8E-12	6.16E-15	2.6E-04	1.3E-19	1.8E-12
VOC	Toluene	108-88-3	ID	1.60E-03	2.74E-08			2.24E-15			
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	1.70E+00	3.07E-05	4.1E-03	1.0E-08	2.38E-12	4.1E-03	8.0E-16	1.0E-08
VOC	Vinyl Chloride	75-01-4	A	3.80E-02	7.96E-07	4.4E-03	2.9E-10	5.32E-14	4.4E-03	1.9E-17	2.9E-10
VOC	Xylenes (total)	1330-20-7	ID								
INORG	Iron	7439-89-6	D								
INORG	Manganese	7439-96-5	D								
		Cumulative Risk:					**1E-08**			**9E-16**	**1E-08**
Notes:											
The annual maximum dispersion coefficient to outdoor air (C/Q) is 3.6 (kg/m³) / (kg/m²/s).											

RAMBOLL ENVIRON

Attachment B2.6: Hazard Index Calculations for Inhalation Exposure of Routine Workers to Remaining Site Soil
Whirlpool, Fort Smith, Arkansas

				Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**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	5.16E-02	2.90E-07	3.1E+01	2.1E-09	7.22E-14	3.1E+01	5.3E-16	2.1E-09
VOC	Benzene	71-43-2			3.0E-02			3.0E-02		
VOC	Bromodichloromethane	75-27-4								
VOC	Bromoform	75-25-2	6.10E-03	2.84E-08			8.54E-15			
VOC	Bromomethane	74-83-9			5.0E-03			5.0E-03		
VOC	2-Butanone	78-93-3			5.0E+00			5.0E+00		
VOC	Carbon Disulfide	75-15-0	7.40E-03	1.54E-07	7.0E-01	5.0E-08	1.04E-14	7.0E-01	3.4E-15	5.0E-08
VOC	Carbon Tetrachloride	56-23-5			1.0E-01			1.0E-01		
VOC	Chlorobenzene	108-90-7			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	5.20E-03	9.29E-08	5.0E-02	4.2E-07	7.28E-15	5.0E-02	3.3E-14	4.2E-07
VOC	Chloromethane	74-87-3			9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1								
VOC	1,1-Dichloroethane	75-34-3			5.0E-01			5.0E-01		
VOC	1,2-Dichloroethane	107-06-2	7.20E-03	1.04E-07	7.0E-03	3.4E-06	1.01E-14	7.0E-03	3.3E-13	3.4E-06
VOC	1,1-Dichloroethene	75-35-4	1.10E-03	2.25E-08	2.0E-01	2.6E-08	1.54E-15	2.0E-01	1.8E-15	2.6E-08
VOC	1,2-Dichloroethene (total)	540-59-0	4.90E-01	8.49E-06			6.86E-13			
VOC	cis-1,2-Dichloroethene	156-59-2	4.90E-01	8.49E-06			6.86E-13			
VOC	trans-1,2-Dichloroethene	156-60-5								
VOC	1,2-Dichloropropane	78-87-5			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4			1.0E+00			1.0E+00		
VOC	2-Hexanone	591-78-6	5.90E-02	3.80E-07	3.0E-02	2.9E-06	8.26E-14	3.0E-02	6.3E-13	2.9E-06
VOC	4-Methyl-2-pentanone	108-10-1			3.0E+00			3.0E+00		
VOC	Methylene Chloride	75-09-2	7.00E-03	1.20E-07	6.0E-01	4.6E-08	9.80E-15	6.0E-01	3.7E-15	4.6E-08
VOC	Styrene	100-42-5			1.0E+00			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5								
VOC	Tetrachloroethene	127-18-4	4.40E-03	8.34E-08	4.0E-02	4.8E-07	6.16E-15	4.0E-02	3.5E-14	4.8E-07
VOC	Toluene	108-88-3	1.60E-03	2.74E-08	5.0E+00	1.2E-09	2.24E-15	5.0E+00	1.0E-16	1.2E-09
VOC	1,1,1-Trichloroethane	71-55-6			5.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5								
VOC	Trichloroethene	79-01-6	1.70E+00	3.07E-05	2.0E-03	3.5E-03	2.38E-12	2.0E-03	2.7E-10	3.5E-03
VOC	Vinyl Chloride	75-01-4	3.80E-02	7.96E-07	1.0E-01	1.8E-06	5.32E-14	1.0E-01	1.2E-13	1.8E-06
VOC	Xylenes (total)	1330-20-7			1.0E-01			1.0E-01		
INORG	Iron	7439-89-6								
INORG	Manganese	7439-96-5			5.0E-05			5.0E-05		
	Hazard Index:					**4E-03**			**3E-10**	**4E-03**
Notes:										
The annual maximum dispersion coefficient to outdoor air (C/Q) is 3.6 (kg/m³) / (kg/m²/s).										

RAMBOLL ENVIRON

Attachment B2.7: Cancer Risk Calculations for Contact Exposure of Routine Workers to Total Site Soil
Whirlpool, Fort Smith, Arkansas

					Soil Ingestion			Soil Dermal Contact				Contact 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	Risk
VOC	Acetone	67-64-1	ID	5.86E-02	8.96E-09							
VOC	Benzene	71-43-2	A	6.30E-04	9.63E-11	5.5E-02	5.3E-12			5.5E-02		5.3E-12
VOC	Bromodichloromethane	75-27-4	B2	2.60E-03	3.98E-10	6.2E-02	2.5E-11			6.2E-02		2.5E-11
VOC	Bromoform	75-25-2	B2	6.10E-03	9.33E-10	7.9E-03	7.4E-12			7.9E-03		7.4E-12
VOC	Bromomethane	74-83-9	ID	2.44E-01	3.73E-08							
VOC	2-Butanone	78-93-3	ID	2.50E-01	3.82E-08							
VOC	Carbon Disulfide	75-15-0		7.40E-03	1.13E-09							
VOC	Carbon Tetrachloride	56-23-5	LC	5.20E-03	7.95E-10	7.0E-02	5.6E-11			7.0E-02		5.6E-11
VOC	Chlorobenzene	108-90-7	D									
VOC	Chloroethane	75-00-3	LC									
VOC	Chloroform	67-66-3	B2	5.70E-02	8.71E-09	1.9E-02	1.7E-10			1.9E-02		1.7E-10
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	8.80E-03	1.35E-09							
VOC	1,2-Dichloroethane	107-06-2	B2	1.81E-01	2.77E-08	9.1E-02	2.5E-09			9.1E-02		2.5E-09
VOC	1,1-Dichloroethene	75-35-4	C	1.60E-01	2.45E-08							
VOC	1,2-Dichloroethene (total)	540-59-0		5.20E+00	7.95E-07							
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.85E+01	2.83E-06							
VOC	trans-1,2-Dichloroethene	156-60-5	ID	2.40E-01	3.67E-08							
VOC	1,2-Dichloropropane	78-87-5	B2			3.6E-02				3.6E-02		
VOC	Ethyl Benzene	100-41-4	D	1.40E-03	2.14E-10							
VOC	2-Hexanone	591-78-6	ID	7.30E-02	1.12E-08							
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.75E-02	2.68E-09							
VOC	Methylene Chloride	75-09-2	LC	3.14E+00	4.80E-07	2.0E-03	9.6E-10			2.0E-03		9.6E-10
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	1.70E-01	2.60E-08	2.1E-03	5.5E-11			2.1E-03		5.5E-11
VOC	Toluene	108-88-3	ID	7.03E-02	1.07E-08							
VOC	1,1,1-Trichloroethane	71-55-6	ID	3.20E-02	4.89E-09							
VOC	1,1,2-Trichloroethane	79-00-5	C	3.50E-02	5.35E-09	5.7E-02	3.1E-10			5.7E-02		3.1E-10
VOC	Trichloroethene	79-01-6	HC	2.70E+02	4.13E-05	4.6E-02	1.9E-06			4.6E-02		1.9E-06
VOC	Vinyl Chloride	75-01-4	A	4.43E+00	6.77E-07	7.2E-01	4.9E-07			7.2E-01		4.9E-07
VOC	Xylenes (total)	1330-20-7	ID	8.90E-03	1.36E-09							
INORG	Iron	7439-89-6	D									
INORG	Manganese	7439-96-5	D									
		Cumulative Risk:					**2E-06**					**2E-06**

RAMBOLL ENVIRON

Attachment B2.8: Hazard Index Calculations for Contact Exposure of Routine Workers to Total Site Soil
Whirlpool, Fort Smith, Arkansas

				Soil Ingestion			Soil Dermal Contact				Contact Routes
Chem Group	Chemical	CASRN	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	HQ
VOC	Acetone	67-64-1	5.86E-02	2.51E-08	9.0E-01	2.8E-08			9.0E-01		2.8E-08
VOC	Benzene	71-43-2	6.30E-04	2.70E-10	4.0E-03	6.7E-08			4.0E-03		6.7E-08
VOC	Bromodichloromethane	75-27-4	2.60E-03	1.11E-09	2.0E-02	5.6E-08			2.0E-02		5.6E-08
VOC	Bromoform	75-25-2	6.10E-03	2.61E-09	2.0E-02	1.3E-07			2.0E-02		1.3E-07
VOC	Bromomethane	74-83-9	2.44E-01	1.04E-07	1.4E-03	7.5E-05			1.4E-03		7.5E-05
VOC	2-Butanone	78-93-3	2.50E-01	1.07E-07	6.0E-01	1.8E-07			6.0E-01		1.8E-07
VOC	Carbon Disulfide	75-15-0	7.40E-03	3.17E-09	1.0E-01	3.2E-08			1.0E-01		3.2E-08
VOC	Carbon Tetrachloride	56-23-5	5.20E-03	2.23E-09	4.0E-03	5.6E-07			4.0E-03		5.6E-07
VOC	Chlorobenzene	108-90-7			2.0E-02				2.0E-02		
VOC	Chloroethane	75-00-3			1.0E-01				1.0E-01		
VOC	Chloroform	67-66-3	5.70E-02	2.44E-08	1.0E-02	2.4E-06			1.0E-02		2.4E-06
VOC	Chloromethane	74-87-3									
VOC	Dibromochloromethane	124-48-1			2.0E-02				2.0E-02		
VOC	1,1-Dichloroethane	75-34-3	8.80E-03	3.77E-09	2.0E-01	1.9E-08			2.0E-01		1.9E-08
VOC	1,2-Dichloroethane	107-06-2	1.81E-01	7.75E-08	2.0E-02	3.9E-06			2.0E-02		3.9E-06
VOC	1,1-Dichloroethene	75-35-4	1.60E-01	6.85E-08	5.0E-02	1.4E-06			5.0E-02		1.4E-06
VOC	1,2-Dichloroethene (total)	540-59-0	5.20E+00	2.23E-06	2.0E-03	1.1E-03			2.0E-03		1.1E-03
VOC	cis-1,2-Dichloroethene	156-59-2	1.85E+01	7.92E-06	2.0E-03	4.0E-03			2.0E-03		4.0E-03
VOC	trans-1,2-Dichloroethene	156-60-5	2.40E-01	1.03E-07	2.0E-02	5.1E-06			2.0E-02		5.1E-06
VOC	1,2-Dichloropropane	78-87-5			9.0E-02				9.0E-02		
VOC	Ethyl Benzene	100-41-4	1.40E-03	5.99E-10	1.0E-01	6.0E-09			1.0E-01		6.0E-09
VOC	2-Hexanone	591-78-6	7.30E-02	3.13E-08	5.0E-03	6.3E-06			5.0E-03		6.3E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.75E-02	7.49E-09							
VOC	Methylene Chloride	75-09-2	3.14E+00	1.34E-06	6.0E-03	2.2E-04			6.0E-03		2.2E-04
VOC	Styrene	100-42-5			2.0E-01				2.0E-01		
VOC	1,1,2,2-Tetrachloroethane	79-34-5			2.0E-02				2.0E-02		
VOC	Tetrachloroethene	127-18-4	1.70E-01	7.28E-08	6.0E-03	1.2E-05			6.0E-03		1.2E-05
VOC	Toluene	108-88-3	7.03E-02	3.01E-08	8.0E-02	3.8E-07			8.0E-02		3.8E-07
VOC	1,1,1-Trichloroethane	71-55-6	3.20E-02	1.37E-08	2.0E+00	6.8E-09			2.0E+00		6.8E-09
VOC	1,1,2-Trichloroethane	79-00-5	3.50E-02	1.50E-08	4.0E-03	3.7E-06			4.0E-03		3.7E-06
VOC	Trichloroethene	79-01-6	2.70E+02	1.16E-04	5.0E-04	2.3E-01			5.0E-04		2.3E-01
VOC	Vinyl Chloride	75-01-4	4.43E+00	1.90E-06	3.0E-03	6.3E-04			3.0E-03		6.3E-04
VOC	Xylenes (total)	1330-20-7	8.90E-03	3.81E-09	2.0E-01	1.9E-08			2.0E-01		1.9E-08
INORG	Iron	7439-89-6			7.0E-01				7.0E-01		
INORG	Manganese	7439-96-5			1.4E-01				8.4E-03		
		Hazard Index:				**2E-01**					**2E-01**

RAMBOLL ENVIRON

Attachment B2.9: Soil Moisture Profile for a Generic 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)
Vadose Zone Soil: ρb = 1.38 θr = 0.111 α = 0.016 N = 1.321
θT
θw
Bottom of Foundation (m)
Occupied DBG (m)

Attachment B2.10: Normalized Indoor Air Concentration in a Generic Comm/Ind Building (Slab-on-Grade) due to Soil-derived Vapor Intrusion
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)		$C_{b,\infty}$ (kg-soil/m^3)	$C_{b,\ norm}$ (kg-soil/m^3)
VOC	Acetone	67-64-1	1.07E+00	9.85E-05	1.14E-03	1.72E-01	1.91E-02	1.43E-04	5.81E-01	1.16E-03	4.91E+00		7.02E-04	7.02E-04
VOC	Benzene	71-43-2	7.60E-01	8.47E-05	1.59E-01	1.22E-01	7.74E-03	1.43E-04	5.82E+01	1.16E-01	4.34E+02		6.20E-02	7.25E-03
VOC	Bromodichloromethane	75-27-4	2.57E-01	9.16E-05	4.45E-02	4.13E-02	2.80E-03	1.42E-04	5.51E+01	1.10E-01	1.29E+02		1.83E-02	7.25E-03
VOC	Bromoform	75-25-2	1.29E-01	8.90E-05	1.34E-02	2.07E-02	1.94E-03	1.42E-04	8.70E+01	1.74E-01	3.29E+01		4.68E-03	4.68E-03
VOC	Bromomethane	74-83-9	6.29E-01	1.05E-04	2.01E-01	1.01E-01	6.41E-03	1.43E-04	1.05E+01	2.10E-02	7.30E+02		1.04E-01	7.25E-03
VOC	2-Butanone	78-93-3	6.98E-01	8.47E-05	2.00E-03	1.12E-01	1.11E-02	1.43E-04	2.00E+00	3.99E-03	8.50E+00		1.21E-03	1.21E-03
VOC	Carbon Disulfide	75-15-0	8.99E-01	8.64E-05	9.26E-01	1.44E-01	9.09E-03	1.43E-04	4.59E+01	9.19E-02	2.14E+03		3.06E-01	7.25E-03
VOC	Carbon Tetrachloride	56-23-5	6.74E-01	7.60E-05	8.82E-01	1.08E-01	6.82E-03	1.43E-04	1.74E+02	3.48E-01	1.29E+03		1.85E-01	7.25E-03
VOC	Chlorobenzene	108-90-7	6.31E-01	7.52E-05	9.77E-02	1.01E-01	6.45E-03	1.43E-04	2.20E+02	4.41E-01	1.43E+02		2.04E-02	7.25E-03
VOC	Chloroethane	75-00-3	2.34E+00	9.94E-05	4.09E-01	3.76E-01	2.37E-02	1.43E-04	1.62E+01	3.25E-02	1.31E+03		1.88E-01	7.25E-03
VOC	Chloroform	67-66-3	8.99E-01	8.64E-05	1.07E-01	1.44E-01	9.16E-03	1.43E-04	3.97E+01	7.94E-02	3.33E+02		4.75E-02	7.25E-03
VOC	Chloromethane	74-87-3	1.09E+00	5.62E-05	3.33E-01	1.75E-01	1.10E-02	1.43E-04	3.97E+01	7.94E-02	9.52E+02		1.36E-01	7.25E-03
VOC	Dibromochloromethane	124-48-1	1.69E-01	9.07E-05	2.38E-02	2.72E-02	2.08E-03	1.42E-04	6.26E+01	1.25E-01	6.64E+01		9.45E-03	7.25E-03
VOC	1,1-Dichloroethane	75-34-3	6.41E-01	9.07E-05	1.66E-01	1.03E-01	6.53E-03	1.43E-04	3.13E+01	6.27E-02	5.29E+02		7.55E-02	7.25E-03
VOC	1,2-Dichloroethane	107-06-2	8.99E-01	8.55E-05	2.74E-02	1.44E-01	9.38E-03	1.43E-04	1.75E+01	3.50E-02	1.02E+02		1.46E-02	7.25E-03
VOC	1,1-Dichloroethene	75-35-4	7.78E-01	8.99E-05	8.10E-01	1.25E-01	7.87E-03	1.43E-04	5.82E+01	1.16E-01	1.83E+03		2.61E-01	7.25E-03
VOC	1,2-Dichloroethene (total)	540-59-0	6.36E-01	9.76E-05	1.19E-01	1.02E-01	6.51E-03	1.43E-04	3.56E+01	7.12E-02	3.75E+02		5.36E-02	7.25E-03
VOC	cis-1,2-Dichloroethene	156-59-2	6.36E-01	9.76E-05	1.19E-01	1.02E-01	6.51E-03	1.43E-04	3.56E+01	7.12E-02	3.75E+02		5.36E-02	7.25E-03
VOC	trans-1,2-Dichloroethene	156-60-5	6.11E-01	1.03E-04	2.81E-01	9.80E-02	6.21E-03	1.43E-04	5.22E+01	1.04E-01	7.64E+02		1.09E-01	7.25E-03
VOC	1,2-Dichloropropane	78-87-5	6.76E-01	7.54E-05	7.82E-02	1.08E-01	6.92E-03	1.43E-04	4.35E+01	8.70E-02	2.39E+02		3.41E-02	7.25E-03
VOC	Ethyl Benzene	100-41-4	6.48E-01	6.74E-05	2.04E-01	1.04E-01	6.58E-03	1.43E-04	3.67E+02	7.35E-01	2.06E+02		2.95E-02	7.25E-03
VOC	2-Hexanone	591-78-6	7.45E-01	7.57E-05	3.23E-03	1.20E-01	9.76E-03	1.43E-04	1.48E+01	2.97E-02	1.24E+01		1.77E-03	1.77E-03
VOC	4-Methyl-2-pentanone	108-10-1	6.48E-01	6.74E-05	4.71E-03	1.04E-01	7.92E-03	1.43E-04	1.05E+01	2.10E-02	1.87E+01		2.67E-03	2.67E-03
VOC	Methylene Chloride	75-09-2	8.73E-01	1.01E-04	6.60E-02	1.40E-01	8.97E-03	1.43E-04	1.17E+01	2.34E-02	2.52E+02		3.60E-02	7.25E-03
VOC	Styrene	100-42-5	6.13E-01	6.91E-05	7.04E-02	9.84E-02	6.30E-03	1.43E-04	7.77E+02	1.55E+00	3.93E+01		5.61E-03	5.61E-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	1.43E-04	9.35E+01	1.87E-01	2.09E+01		2.98E-03	2.98E-03
VOC	Tetrachloroethene	127-18-4	6.22E-01	7.08E-05	4.90E-01	9.98E-02	6.30E-03	1.43E-04	1.56E+02	3.12E-01	8.17E+02		1.17E-01	7.25E-03
VOC	Toluene	108-88-3	7.52E-01	7.43E-05	1.80E-01	1.21E-01	7.64E-03	1.43E-04	1.80E+02	3.61E-01	2.94E+02		4.20E-02	7.25E-03
VOC	1,1,1-Trichloroethane	71-55-6	6.74E-01	7.60E-05	4.97E-01	1.08E-01	6.83E-03	1.43E-04	1.10E+02	2.20E-01	9.75E+02		1.39E-01	7.25E-03
VOC	1,1,2-Trichloroethane	79-00-5	6.74E-01	7.60E-05	2.43E-02	1.08E-01	7.11E-03	1.43E-04	5.03E+01	1.01E-01	7.27E+01		1.04E-02	7.25E-03
VOC	Trichloroethene	79-01-6	6.83E-01	7.86E-05	2.88E-01	1.10E-01	6.93E-03	1.43E-04	1.68E+02	3.35E-01	4.80E+02		6.86E-02	7.25E-03
VOC	Vinyl Chloride	75-01-4	9.16E-01	1.06E-04	9.00E-01	1.47E-01	9.27E-03	1.43E-04	1.85E+01	3.69E-02	2.41E+03		3.44E-01	7.25E-03
VOC	Xylenes (total)	1330-20-7	6.74E-01	7.56E-05	1.73E-01	1.08E-01	6.85E-03	1.43E-04	3.86E+02	7.71E-01	1.69E+02		2.42E-02	7.25E-03
INORG	Iron	7439-89-6								2.50E+01				
INORG	Manganese	7439-96-5								6.50E+01				
Notes:	**Soil and Building Characteristics**			**Crack Soil**		**Source Soil**								
	SCS Soil texture class			Sand		Silty Clay								
	Bulk density	kg/L	ρ_b	1.66		1.38								
	Total porosity	L/L-soil	θ_T	0.375		0.481								
	Water-filled porosity	L/L-soil	θ_w	0.054		0.319								
	Air-filled porosity	L/L-soil	θ_a	0.321		0.162								
	Organic carbon fraction	unitless	f_{oc}	NA		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	3.18										
	van Genuchten M	unitless	M	0.685										
	Relative air permeability	unitless	k_{rg}	0.997										
	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		20.00										
	Bldg foundation width	m		20.00										
	Bldg occupied height	m		3.05										
	Bldg occupied volume	m^3		1219.20										
	Occupied depth below ground	m		0.0										
	Bldg area for vapor intrusion	m^2	A_B	400.0										
	Ratio of A_{crack} to A_B		η	2E-04										
	Area of cracks	m^2	A_{crack}	8.00E-02										
	Air exchange rate	$hour^{-1}$	ach	1.0										
	Building ventilation rate	m^3/day	Q_{bldg}	2.93E+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}	80										
	Crack depth below ground	m	Z_{crack}	0.15										
	Crack radius	m	r_{crack}	1E-03										
	Soil gas flow rate into bldg	m^3/day	Q_{soil}	4.18E+00										
	Averaging period	d	ED	9.13E+03										
	Contaminant thickness	m	ΔH	3.5066										
	Indoor air conc by mass balance	kg-soil/m^3	$C_{b,ML}$	7.25E-03										
	Molar Gas Constant	mmHg-m^3/mole-^oK	R	6.24E-02										
	Temperature	^oC	T	16.7										
		K	T	289.85										

RAMBOLL ENVIRON

Attachment B2.11: Normalized Indoor Air Concentration in a Generic Comm/Ind Building (Slab-on-Grade) due to Groundwater-derived Vapor Intrusion
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_∞	$C_{b,\,norm}$ (L-water/m^3)
VOC	Acetone	67-64-1	1.07E+00	9.85E-05	1.14E-03	1.72E-01	1.87E-02	3.38E-01	1.43E-04	4.83E-05	5.50E-05
VOC	Benzene	71-43-2	7.60E-01	8.47E-05	1.59E-01	1.22E-01	8.00E-04	2.13E-02	1.43E-04	3.05E-06	4.85E-04
VOC	Bromodichloromethane	75-27-4	2.57E-01	9.16E-05	4.45E-02	4.13E-02	1.06E-03	2.80E-02	1.43E-04	4.01E-06	1.78E-04
VOC	Bromoform	75-25-2	1.29E-01	8.90E-05	1.34E-02	2.07E-02	1.64E-03	4.27E-02	1.43E-04	6.11E-06	8.16E-05
VOC	Bromomethane	74-83-9	6.29E-01	1.05E-04	2.01E-01	1.01E-01	7.29E-04	1.95E-02	1.43E-04	2.79E-06	5.60E-04
VOC	2-Butanone	78-93-3	6.98E-01	8.47E-05	2.00E-03	1.12E-01	9.92E-03	2.13E-01	1.43E-04	3.04E-05	6.08E-05
VOC	Carbon Disulfide	75-15-0	8.99E-01	8.64E-05	9.26E-01	1.44E-01	2.87E-04	7.77E-03	1.43E-04	1.11E-06	1.03E-03
VOC	Carbon Tetrachloride	56-23-5	6.74E-01	7.60E-05	8.82E-01	1.08E-01	2.47E-04	6.68E-03	1.43E-04	9.55E-07	8.43E-04
VOC	Chlorobenzene	108-90-7	6.31E-01	7.52E-05	9.77E-02	1.01E-01	9.16E-04	2.43E-02	1.43E-04	3.48E-06	3.40E-04
VOC	Chloroethane	75-00-3	2.34E+00	9.94E-05	4.09E-01	3.76E-01	7.47E-04	2.00E-02	1.43E-04	2.85E-06	1.17E-03
VOC	Chloroform	67-66-3	8.99E-01	8.64E-05	1.07E-01	1.44E-01	1.09E-03	2.89E-02	1.43E-04	4.13E-06	4.44E-04
VOC	Chloromethane	74-87-3	1.09E+00	5.62E-05	3.33E-01	1.75E-01	4.51E-04	1.22E-02	1.43E-04	1.74E-06	5.78E-04
VOC	Dibromochloromethane	124-48-1	1.69E-01	9.07E-05	2.38E-02	2.72E-02	1.26E-03	3.32E-02	1.43E-04	4.75E-06	1.13E-04
VOC	1,1-Dichloroethane	75-34-3	6.41E-01	9.07E-05	1.66E-01	1.03E-01	7.58E-04	2.02E-02	1.43E-04	2.89E-06	4.79E-04
VOC	1,2-Dichloroethane	107-06-2	8.99E-01	8.55E-05	2.74E-02	1.44E-01	2.34E-03	5.99E-02	1.43E-04	8.56E-06	2.35E-04
VOC	1,1-Dichloroethene	75-35-4	7.78E-01	8.99E-05	8.10E-01	1.25E-01	3.06E-04	8.26E-03	1.43E-04	1.18E-06	9.57E-04
VOC	1,2-Dichloroethene (total)	540-59-0	6.36E-01	9.76E-05	1.19E-01	1.02E-01	9.55E-04	2.54E-02	1.43E-04	3.63E-06	4.30E-04
VOC	cis-1,2-Dichloroethene	156-59-2	6.36E-01	9.76E-05	1.19E-01	1.02E-01	9.55E-04	2.54E-02	1.43E-04	3.63E-06	4.30E-04
VOC	trans-1,2-Dichloroethene	156-60-5	6.11E-01	1.03E-04	2.81E-01	9.80E-02	5.85E-04	1.57E-02	1.43E-04	2.24E-06	6.32E-04
VOC	1,2-Dichloropropane	78-87-5	6.76E-01	7.54E-05	7.82E-02	1.08E-01	1.07E-03	2.84E-02	1.43E-04	4.06E-06	3.18E-04
VOC	Ethyl Benzene	100-41-4	6.48E-01	6.74E-05	2.04E-01	1.04E-01	5.64E-04	1.51E-02	1.43E-04	2.16E-06	4.42E-04
VOC	2-Hexanone	591-78-6	7.45E-01	7.57E-05	3.23E-03	1.20E-01	6.82E-03	1.57E-01	1.43E-04	2.24E-05	7.25E-05
VOC	4-Methyl-2-pentanone	108-10-1	6.48E-01	6.74E-05	4.71E-03	1.04E-01	4.77E-03	1.15E-01	1.43E-04	1.64E-05	7.75E-05
VOC	Methylene Chloride	75-09-2	8.73E-01	1.01E-04	6.60E-02	1.40E-01	1.56E-03	4.07E-02	1.43E-04	5.82E-06	3.84E-04
VOC	Styrene	100-42-5	6.13E-01	6.91E-05	7.04E-02	9.84E-02	1.04E-03	2.75E-02	1.43E-04	3.94E-06	2.77E-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	8.19E-02	1.43E-04	1.17E-05	1.02E-04
VOC	Tetrachloroethene	127-18-4	6.22E-01	7.08E-05	4.90E-01	9.98E-02	3.34E-04	9.02E-03	1.43E-04	1.29E-06	6.32E-04
VOC	Toluene	108-88-3	7.52E-01	7.43E-05	1.80E-01	1.21E-01	6.83E-04	1.83E-02	1.43E-04	2.61E-06	4.72E-04
VOC	1,1,1-Trichloroethane	71-55-6	6.74E-01	7.60E-05	4.97E-01	1.08E-01	3.56E-04	9.62E-03	1.43E-04	1.38E-06	6.84E-04
VOC	1,1,2-Trichloroethane	79-00-5	6.74E-01	7.60E-05	2.43E-02	1.08E-01	2.06E-03	5.30E-02	1.43E-04	7.58E-06	1.84E-04
VOC	Trichloroethene	79-01-6	6.83E-01	7.86E-05	2.88E-01	1.10E-01	5.13E-04	1.38E-02	1.43E-04	1.97E-06	5.68E-04
VOC	Vinyl Chloride	75-01-4	9.16E-01	1.06E-04	9.00E-01	1.47E-01	3.37E-04	9.10E-03	1.43E-04	1.30E-06	1.17E-03
VOC	Xylenes (total)	1330-20-7	6.74E-01	7.56E-05	1.73E-01	1.08E-01	6.77E-04	1.81E-02	1.43E-04	2.59E-06	4.48E-04
INORG	Iron	7439-89-6									
INORG	Manganese	7439-96-5									

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}	0.997
	Permeability to vapor	cm^2	k_v	9.89E-08
	Distance from building foundation to source	m	$L_{T\text{-}gw}$	3.51
	Bldg foundation thickness	m	L_{crack}	0.15
	Bldg foundation length	m		20.00
	Bldg foundation width	m		20.00
	Bldg occupied height	m		3.05
	Bldg occupied volume	m^3		1219.20
	Occupied depth below ground	m		0.0
	Bldg area for vapor intrusion	m^2	A_B	400.0
	Ratio of A_{crack} to A_B		η	2E-04
	Area of cracks	m^2	A_{crack}	8E-02
	Air exchange rate	$hour^{-1}$	ach	1.00
	Building ventilation rate	m^3/day	Q_{bldg}	2.93E+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}	80
	Crack depth below ground	m	Z_{crack}	0.15
	Crack radius	m	r_{crack}	1E-03
	Soil gas flow rate into bldg	m^3/day	Q_{soil}	4.18

RAMBOLL ENVIRON

Attachment B2.12: Cancer Risk and Hazard Index Calculations for Soil-derived Vapor Intrusion into a Generic Comm/Ind Building (Slab-on-Grade)
Whirlpool, Fort Smith, Arkansas

						Cancer		Noncancer		Occupational	
Chem Group	**Chemical**	**CASRN**	**Carc Class**	**C_{soil}** (mg/kg)	**C_{air}** (mg/m^3)	**URF** (m^3/mg)	**Risk**	**RfC** (mg/m^3)	**HQ**	**Occupational Air Standard** (mg/m^3)	**Ratio of C_{air} to Occ Air Standard**
VOC	Acetone	67-64-1	ID	5.86E-02	4.11E-05			3.1E+01	3.0E-07	5.9E+02	7.0E-08
VOC	Benzene	71-43-2	A	6.30E-04	4.57E-06	7.8E-03	2.9E-09	3.0E-02	3.5E-05	3.2E-01	1.4E-05
VOC	Bromodichloromethane	75-27-4	B2	2.60E-03	1.88E-05						
VOC	Bromoform	75-25-2	B2	6.10E-03	2.85E-05	1.1E-03	2.6E-09			5.0E+00	5.7E-06
VOC	Bromomethane	74-83-9	ID	2.44E-01	1.77E-03			5.0E-03	8.1E-02	3.9E+00	4.6E-04
VOC	2-Butanone	78-93-3	ID	2.50E-01	3.04E-04			5.0E+00	1.4E-05	5.9E+02	5.2E-07
VOC	Carbon Disulfide	75-15-0		7.40E-03	5.36E-05			7.0E-01	1.7E-05	3.0E+00	1.8E-05
VOC	Carbon Tetrachloride	56-23-5	LC	5.20E-03	3.77E-05	6.0E-03	1.8E-08	1.0E-01	8.6E-05	1.3E+01	3.0E-06
VOC	Chlorobenzene	108-90-7	D					5.0E-02		4.6E+01	
VOC	Chloroethane	75-00-3	LC					1.0E+01		2.6E+02	
VOC	Chloroform	67-66-3	B2	5.70E-02	4.13E-04	2.3E-02	7.7E-07	5.0E-02	1.9E-03	9.8E+00	4.2E-05
VOC	Chloromethane	74-87-3	D					9.0E-02		1.0E+02	
VOC	Dibromochloromethane	124-48-1	C								
VOC	1,1-Dichloroethane	75-34-3	SC	8.80E-03	6.38E-05			5.0E-01	2.9E-05	4.0E+02	1.6E-07
VOC	1,2-Dichloroethane	107-06-2	B2	1.81E-01	1.31E-03	2.6E-02	2.8E-06	7.0E-03	4.3E-02	4.0E+00	3.3E-04
VOC	1,1-Dichloroethene	75-35-4	C	1.60E-01	1.16E-03			2.0E-01	1.3E-03	4.0E+00	2.9E-04
VOC	1,2-Dichloroethene (total)	540-59-0		5.20E+00	3.77E-02					7.9E+02	4.8E-05
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.85E+01	1.34E-01						
VOC	trans-1,2-Dichloroethene	156-60-5	ID	2.40E-01	1.74E-03						
VOC	1,2-Dichloropropane	78-87-5	B2					4.0E-03		4.6E+01	
VOC	Ethyl Benzene	100-41-4	D	1.40E-03	1.01E-05			1.0E+00	2.3E-06	2.2E+01	4.6E-07
VOC	2-Hexanone	591-78-6	ID	7.30E-02	1.29E-04			3.0E-02	9.8E-04	4.0E+00	3.2E-05
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.75E-02	4.67E-05			3.0E+00	3.6E-06	8.2E+01	5.7E-07
VOC	Methylene Chloride	75-09-2	LC	3.14E+00	2.28E-02	1.0E-05	1.9E-08	6.0E-01	8.7E-03	8.7E+01	2.6E-04
VOC	Styrene	100-42-5						1.0E+00		8.5E+01	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC							6.9E+00	
VOC	Tetrachloroethene	127-18-4	LC	1.70E-01	1.23E-03	2.6E-04	2.6E-08	4.0E-02	7.0E-03	1.7E+02	7.3E-06
VOC	Toluene	108-88-3	ID	7.03E-02	5.10E-04			5.0E+00	2.3E-05	3.7E+01	1.4E-05
VOC	1,1,1-Trichloroethane	71-55-6	ID	3.20E-02	2.32E-04			5.0E+00	1.1E-05	1.9E+03	1.2E-07
VOC	1,1,2-Trichloroethane	79-00-5	C	3.50E-02	2.54E-04	1.6E-02	3.3E-07			4.5E+01	5.6E-06
VOC	Trichloroethene	79-01-6	HC	2.70E+02	1.96E+00	4.1E-03	6.5E-04	2.0E-03	2.2E+02	5.4E+01	3.6E-02
VOC	Vinyl Chloride	75-01-4	A	4.43E+00	3.21E-02	4.4E-03	1.2E-05	1.0E-01	7.3E-02	2.6E+00	1.3E-02
VOC	Xylenes (total)	1330-20-7	ID	8.90E-03	6.45E-05			1.0E-01	1.5E-04	4.3E+02	1.5E-07
INORG	Iron	7439-89-6	D								
INORG	Manganese	7439-96-5	D					5.0E-05		2.0E-02	
					Cumulative Risk:		7E-04	**HI:**	2E+02	**E_m:**	5E-02

Note:

E_m is the equivalent exposure for the mixture, ie., the sum of the ratios of the indoor air concentration to the occupational standard.

RAMBOLL ENVIRON

Attachment B2.13: Cancer Risk and Hazard Index Calculations for Perched Water-derived Vapor Intrusion into a Generic Comm/Ind Building (Slab-on-Grade)
Whirlpool, Fort Smith, Arkansas

						Cancer		Noncancer		Occupational	
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**	**Occupational Air Standard** (mg/m^3)	**Ratio of C_{air} to Occ Air Standard**
VOC	Acetone	67-64-1	ID	3.99E-01	2.19E-05			3.1E+01	1.6E-07	5.9E+02	3.7E-08
VOC	Benzene	71-43-2	A	2.00E-03	9.70E-07	7.8E-03	6.2E-10	3.0E-02	7.4E-06	3.2E-01	3.0E-06
VOC	Bromodichloromethane	75-27-4	B2	5.30E-03	9.46E-07						
VOC	Bromoform	75-25-2	B2	3.55E-02	2.90E-06	1.1E-03	2.6E-10			5.0E+00	5.8E-07
VOC	Bromomethane	74-83-9	ID	8.43E-02	4.72E-05			5.0E-03	2.2E-03	3.9E+00	1.2E-05
VOC	2-Butanone	78-93-3	ID	1.43E-01	8.69E-06			5.0E+00	4.0E-07	5.9E+02	1.5E-08
VOC	Carbon Disulfide	75-15-0		1.08E-02	1.11E-05			7.0E-01	3.6E-06	3.0E+00	3.7E-06
VOC	Carbon Tetrachloride	56-23-5	LC	1.44E-02	1.21E-05	6.0E-03	5.9E-09	1.0E-01	2.8E-05	1.3E+01	9.6E-07
VOC	Chlorobenzene	108-90-7	D	7.00E-03	2.38E-06			5.0E-02	1.1E-05	4.6E+01	5.2E-08
VOC	Chloroethane	75-00-3	LC	2.20E-03	2.57E-06			1.0E+01	5.9E-08	2.6E+02	9.7E-09
VOC	Chloroform	67-66-3	B2	4.06E+00	1.80E-03	2.3E-02	3.4E-06	5.0E-02	8.2E-03	9.8E+00	1.8E-04
VOC	Chloromethane	74-87-3	D	1.10E-01	6.36E-05			9.0E-02	1.6E-04	1.0E+02	6.2E-07
VOC	Dibromochloromethane	124-48-1	C	3.50E-03	3.96E-07						
VOC	1,1-Dichloroethane	75-34-3	SC	4.42E-02	2.12E-05			5.0E-01	9.7E-06	4.0E+02	5.3E-08
VOC	1,2-Dichloroethane	107-06-2	B2	2.50E-03	5.87E-07	2.6E-02	1.2E-09	7.0E-03	1.9E-05	4.0E+00	1.5E-07
VOC	1,1-Dichloroethene	75-35-4	C	2.95E-01	2.82E-04			2.0E-01	3.2E-04	4.0E+00	7.1E-05
VOC	1,2-Dichloroethene (total)	540-59-0								7.9E+02	
VOC	cis-1,2-Dichloroethene	156-59-2	ID	2.87E+00	1.23E-03						
VOC	trans-1,2-Dichloroethene	156-60-5	ID	7.04E-01	4.45E-04						
VOC	1,2-Dichloropropane	78-87-5	B2	2.00E-03	6.35E-07			4.0E-03	3.6E-05	4.6E+01	1.4E-08
VOC	Ethyl Benzene	100-41-4	D					1.0E+00		2.2E+01	
VOC	2-Hexanone	591-78-6	ID	5.80E-03	4.20E-07			3.0E-02	3.2E-06	4.0E+00	1.1E-07
VOC	4-Methyl-2-pentanone	108-10-1	ID	3.00E-03	2.33E-07			3.0E+00	1.8E-08	8.2E+01	2.8E-09
VOC	Methylene Chloride	75-09-2	LC	5.05E-02	1.94E-05	1.0E-05	1.6E-11	6.0E-01	7.4E-06	8.7E+01	2.2E-07
VOC	Styrene	100-42-5						1.0E+00		8.5E+01	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	1.71E+00	1.75E-04					6.9E+00	2.6E-05
VOC	Tetrachloroethene	127-18-4	LC	4.40E-02	2.78E-05	2.6E-04	5.9E-10	4.0E-02	1.6E-04	1.7E+02	1.6E-07
VOC	Toluene	108-88-3	ID	1.04E-02	4.91E-06			5.0E+00	2.2E-07	3.7E+01	1.3E-07
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.31E+00	8.96E-04			5.0E+00	4.1E-05	1.9E+03	4.7E-07
VOC	1,1,2-Trichloroethane	79-00-5	C	1.07E-02	1.97E-06	1.6E-02	2.6E-09			4.5E+01	4.4E-08
VOC	Trichloroethene	79-01-6	HC	1.69E+02	9.60E-02	4.1E-03	3.2E-05	2.0E-03	1.1E+01	5.4E+01	1.8E-03
VOC	Vinyl Chloride	75-01-4	A	5.40E-01	6.33E-04	4.4E-03	2.3E-07	1.0E-01	1.4E-03	2.6E+00	2.5E-04
VOC	Xylenes (total)	1330-20-7	ID					1.0E-01		4.3E+02	
INORG	Iron	7439-89-6	D	1.43E+01							
INORG	Manganese	7439-96-5	D	1.28E+01				5.0E-05		2.0E-02	
					Cumulative Risk:		4E-05	**HI:**	1E+01	**E_m:**	2E-03

Note:

E_m is the equivalent exposure for the mixture, ie., the sum of the ratios of the indoor air concentration to the occupational standard

RAMBOLL ENVIRON

Attachment B2.14: Normalized 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	1.87E-06
VOC	Benzene	71-43-2	1.59E-01	8.31E-04	4.18E-07	1.16E-05
VOC	Bromodichloromethane	75-27-4	4.45E-02	1.09E-03	1.53E-07	4.25E-06
VOC	Bromoform	75-25-2	1.34E-02	1.65E-03	6.97E-08	1.93E-06
VOC	Bromomethane	74-83-9	2.01E-01	7.57E-04	4.81E-07	1.34E-05
VOC	2-Butanone	78-93-3	2.00E-03	9.96E-03	6.30E-08	1.75E-06
VOC	Carbon Disulfide	75-15-0	9.26E-01	2.99E-04	8.76E-07	2.43E-05
VOC	Carbon Tetrachloride	56-23-5	8.82E-01	2.57E-04	7.17E-07	1.99E-05
VOC	Chlorobenzene	108-90-7	9.77E-02	9.49E-04	2.93E-07	8.14E-06
VOC	Chloroethane	75-00-3	4.09E-01	7.78E-04	1.01E-06	2.80E-05
VOC	Chloroform	67-66-3	1.07E-01	1.13E-03	3.85E-07	1.07E-05
VOC	Chloromethane	74-87-3	3.33E-01	4.70E-04	4.95E-07	1.37E-05
VOC	Dibromochloromethane	124-48-1	2.38E-02	1.28E-03	9.66E-08	2.68E-06
VOC	1,1-Dichloroethane	75-34-3	1.66E-01	7.86E-04	4.12E-07	1.14E-05
VOC	1,2-Dichloroethane	107-06-2	2.74E-02	2.41E-03	2.09E-07	5.81E-06
VOC	1,1-Dichloroethene	75-35-4	8.10E-01	3.18E-04	8.15E-07	2.26E-05
VOC	1,2-Dichloroethene (total)	540-59-0	1.19E-01	9.89E-04	3.71E-07	1.03E-05
VOC	cis-1,2-Dichloroethene	156-59-2	1.19E-01	9.89E-04	3.71E-07	1.03E-05
VOC	trans-1,2-Dichloroethene	156-60-5	2.81E-01	6.08E-04	5.41E-07	1.50E-05
VOC	1,2-Dichloropropane	78-87-5	7.82E-02	1.11E-03	2.75E-07	7.63E-06
VOC	Ethyl Benzene	100-41-4	2.04E-01	5.86E-04	3.78E-07	1.05E-05
VOC	2-Hexanone	591-78-6	3.23E-03	6.91E-03	7.07E-08	1.96E-06
VOC	4-Methyl-2-pentanone	108-10-1	4.71E-03	4.85E-03	7.23E-08	2.01E-06
VOC	Methylene Chloride	75-09-2	6.60E-02	1.61E-03	3.36E-07	9.33E-06
VOC	Styrene	100-42-5	7.04E-02	1.08E-03	2.40E-07	6.65E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	8.74E-03	3.35E-03	9.26E-08	2.57E-06
VOC	Tetrachloroethene	127-18-4	4.90E-01	3.47E-04	5.39E-07	1.49E-05
VOC	Toluene	108-88-3	1.80E-01	7.10E-04	4.05E-07	1.12E-05
VOC	1,1,1-Trichloroethane	71-55-6	4.97E-01	3.71E-04	5.83E-07	1.62E-05
VOC	1,1,2-Trichloroethane	79-00-5	2.43E-02	2.12E-03	1.63E-07	4.52E-06
VOC	Trichloroethene	79-01-6	2.88E-01	5.33E-04	4.86E-07	1.35E-05
VOC	Vinyl Chloride	75-01-4	9.00E-01	3.51E-04	9.99E-07	2.77E-05
VOC	Xylenes (total)	1330-20-7	1.73E-01	7.02E-04	3.85E-07	1.07E-05
INORG	Iron	7439-89-6				
INORG	Manganese	7439-96-5				
	Parameters					
	Depth to groundwater	m	**DTW**	3.66		
	Dispersion coefficient	(kg/m^3) / (kg/m^2/s)	**C/Q**	27.7		

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Attachment B2.15: Dispersion Factor for Groundwater to Outdoor Air Whirlpool, Fort Smith, Arkansas		
Parameter	**Units**	**Value**
Correlation coefficient city		Little Rock
Correlation coefficient A		12.4964
Correlation coefficient B		18.4476
Correlation coefficient C		210.2128
Groundwater source area	acres	34.00
Groundwater averaging time for C/Q		Annual Max
Conversion factor from 1-Hr Max for groundwater		0.19
C/Q for Groundwater	$(kg/m^3)/(kg/m^2/s)$	**27.75**
Note:		
C/Q is estimated using the empirical correlation in USEPA's Supplemental SSG (2002).		

Attachment B2.16: Cancer Risk and Hazard Index Calculations for Exposure of 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	3.99E-01	7.47E-07				3.1E+01	5.5E-09
VOC	Benzene	71-43-2	A	2.00E-03	2.32E-08	7.8E-03	1.5E-11		3.0E-02	1.8E-07
VOC	Bromodichloromethane	75-27-4	B2	5.30E-03	2.25E-08					
VOC	Bromoform	75-25-2	B2	3.55E-02	6.86E-08	1.1E-03	6.2E-12			
VOC	Bromomethane	74-83-9	ID	8.43E-02	1.13E-06				5.0E-03	5.1E-05
VOC	2-Butanone	78-93-3	ID	1.43E-01	2.50E-07				5.0E+00	1.1E-08
VOC	Carbon Disulfide	75-15-0		1.08E-02	2.62E-07				7.0E-01	8.6E-08
VOC	Carbon Tetrachloride	56-23-5	LC	1.44E-02	2.87E-07	6.0E-03	1.4E-10		1.0E-01	6.5E-07
VOC	Chlorobenzene	108-90-7	D	7.00E-03	5.70E-08				5.0E-02	2.6E-07
VOC	Chloroethane	75-00-3	LC	2.20E-03	6.15E-08				1.0E+01	1.4E-09
VOC	Chloroform	67-66-3	B2	4.06E+00	4.34E-05	2.3E-02	8.1E-08		5.0E-02	2.0E-04
VOC	Chloromethane	74-87-3	D	1.10E-01	1.51E-06				9.0E-02	3.8E-06
VOC	Dibromochloromethane	124-48-1	C	3.50E-03	9.39E-09					
VOC	1,1-Dichloroethane	75-34-3	SC	4.42E-02	5.05E-07				5.0E-01	2.3E-07
VOC	1,2-Dichloroethane	107-06-2	B2	2.50E-03	1.45E-08	2.6E-02	3.1E-11		7.0E-03	4.7E-07
VOC	1,1-Dichloroethene	75-35-4	C	2.95E-01	6.67E-06				2.0E-01	7.6E-06
VOC	1,2-Dichloroethene (total)	540-59-0								
VOC	cis-1,2-Dichloroethene	156-59-2	ID	2.87E+00	2.96E-05					
VOC	trans-1,2-Dichloroethene	156-60-5	ID	7.04E-01	1.06E-05					
VOC	1,2-Dichloropropane	78-87-5	B2	2.00E-03	1.53E-08				4.0E-03	8.7E-07
VOC	Ethyl Benzene	100-41-4	D						1.0E+00	
VOC	2-Hexanone	591-78-6	ID	5.80E-03	1.14E-08				3.0E-02	8.7E-08
VOC	4-Methyl-2-pentanone	108-10-1	ID	3.00E-03	6.02E-09				3.0E+00	4.6E-10
VOC	Methylene Chloride	75-09-2	LC	5.05E-02	4.71E-07	1.0E-05	3.8E-13		6.0E-01	1.8E-07
VOC	Styrene	100-42-5							1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	1.71E+00	4.39E-06					
VOC	Tetrachloroethene	127-18-4	LC	4.40E-02	6.58E-07	2.6E-04	1.4E-11		4.0E-02	3.8E-06
VOC	Toluene	108-88-3	ID	1.04E-02	1.17E-07				5.0E+00	5.3E-09
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.31E+00	2.12E-05				5.0E+00	9.7E-07
VOC	1,1,2-Trichloroethane	79-00-5	C	1.07E-02	4.83E-08	1.6E-02	6.3E-11			
VOC	Trichloroethene	79-01-6	HC	1.69E+02	2.28E-03	4.1E-03	7.6E-07		2.0E-03	2.6E-01
VOC	Vinyl Chloride	75-01-4	A	5.40E-01	1.50E-05	4.4E-03	5.4E-09		1.0E-01	3.4E-05
VOC	Xylenes (total)	1330-20-7	ID						1.0E-01	
INORG	Iron	7439-89-6	D	1.43E+01						
INORG	Manganese	7439-96-5	D	1.28E+01					5.0E-05	
					Cumulative Risk:		8E-07		**HI:**	3E-01

RAMBOLL ENVIRON

Attachment B3

Onsite Utility Maintenance Worker Risk Calculations

Attachments

B3.1 Vapor Flux from Soil to Outdoor Air

B3.2 Soil PM_{10} Emission from Wind Erosion

B3.3 Cancer Risk Calculations for Inhalation Exposure of On-Site Utility Maintenance Workers to Former Drainage Trench Soil

B3.4 Hazard Index Calculations for Inhalation Exposure of On-Site Utility Maintenance Workers to Former Drainage Trench Soil

B3.5 Cancer Risk Calculations for Inhalation Exposure of On-Site Utility Maintenance Workers to Remaining Area Soil

B3.6 Hazard Index Calculations for Inhalation Exposure of On-Site Utility Maintenance Workers to Remaining Area Soil

B3.7 Cancer Risk Calculations for Contact Exposure of On-Site Utility Maintenance Workers to Total Site Soil

B3.8 Hazard Index Calculations for Contact Exposure of On-Site Utility Maintenance Workers to Total Site Soil

B3.9 Dermal Absorbed Dose for Groundwater

B3.10 Dispersion Factor for Groundwater in Excavations to Outdoor Air

B3.11 Normalized Vapor Flux to Outdoor Air from Exposed Groundwater in Excavations

B3.12 Cancer Risk Calculations for Exposure of On-Site Utility Maintenance Workers to Groundwater in Excavations

B3.13 Hazard Index Risk Calculations for Exposure of On-Site Utility Maintenance Workers to Groundwater in Excavations

Attachment B3.1: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	K_{oc} (L/kg)	K_d (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		2.00E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.11E-05	2.52E-06	0.00E+00	1.41E-06	2.52E-06	2.52E-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		4.09E-01	2.34E+00	9.94E-05	4.28E-01	2.52E-02	9.18E-06	2.41E-02	4.64E-05	0.00E+00	2.86E+00	1.43E-05	1.43E-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	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	5.74E+01	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
INORG	Iron	7439-89-6		2.50E+01	0.00E+00							0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INORG	Manganese	7439-96-5		6.50E+01	0.00E+00							0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
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**	10												
		days	**T**	3650												
		s	**T**	3.2E+08												
	Molar Gas Constant	L-mmHg/ mole-^oK	**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												

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Attachment B3.2: Soil PM10 Emission from Wind Erosion Whirlpool, Fort Smith, Arkansas		
Annual average PM_{10} concentration	$(mg/m^3)/(mg/kg)$	**5.00E-08**
Note:		
The concentration of particulates in the air is assumed to be no more than the former annual National Ambient Air Quality Standards (NAAQS).		

Attachment B3.3: Cancer Risk Calculations for Inhalation Exposure of On-Site Utility Maintenance Workers to Former Drainage Trench Soil
Whirlpool, Fort Smith, Arkansas

					Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation 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	5.86E-02	1.08E-07			2.93E-09			
VOC	Benzene	71-43-2	A	6.30E-04	5.09E-09	7.8E-03	1.6E-13	3.15E-11	7.8E-03	9.6E-16	1.6E-13
VOC	Bromodichloromethane	75-27-4	B2	2.60E-03	9.50E-09			1.30E-10			
VOC	Bromoform	75-25-2	B2			1.1E-03			1.1E-03		
VOC	Bromomethane	74-83-9	ID	2.44E-01	2.10E-06			1.22E-08			
VOC	2-Butanone	78-93-3	ID	2.50E-01	4.64E-07			1.25E-08			
VOC	Carbon Disulfide	75-15-0		2.80E-03	2.85E-08			1.40E-10			
VOC	Carbon Tetrachloride	56-23-5	LC	5.20E-03	4.90E-08	6.0E-03	1.2E-12	2.60E-10	6.0E-03	6.1E-15	1.2E-12
VOC	Chlorobenzene	108-90-7	D								
VOC	Chloroethane	75-00-3	LC								
VOC	Chloroform	67-66-3	B2	5.70E-02	4.51E-07	2.3E-02	4.1E-11	2.85E-09	2.3E-02	2.6E-13	4.1E-11
VOC	Chloromethane	74-87-3	D								
VOC	Dibromochloromethane	124-48-1	C								
VOC	1,1-Dichloroethane	75-34-3	SC	8.80E-03	7.15E-08			4.40E-10			
VOC	1,2-Dichloroethane	107-06-2	B2	1.81E-01	1.02E-06	2.6E-02	1.0E-10	9.05E-09	2.6E-02	9.2E-13	1.0E-10
VOC	1,1-Dichloroethene	75-35-4	C	1.60E-01	1.59E-06			8.00E-09			
VOC	1,2-Dichloroethene (total)	540-59-0		5.20E+00	3.91E-05			2.60E-07			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.85E+01	1.39E-04			9.25E-07			
VOC	trans-1,2-Dichloroethene	156-60-5	ID	2.40E-01	2.07E-06			1.20E-08			
VOC	1,2-Dichloropropane	78-87-5	B2								
VOC	Ethyl Benzene	100-41-4	D	1.40E-03	8.90E-09			7.00E-11			
VOC	2-Hexanone	591-78-6	ID	7.30E-02	1.54E-07			3.65E-09			
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.75E-02	4.10E-08			8.75E-10			
VOC	Methylene Chloride	75-09-2	LC	3.14E+00	2.32E-05	1.0E-05	9.1E-13	1.57E-07	1.0E-05	6.1E-15	9.1E-13
VOC	Styrene	100-42-5									
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC								
VOC	Tetrachloroethene	127-18-4	LC	1.70E-01	1.48E-06	2.6E-04	1.5E-12	8.50E-09	2.6E-04	8.6E-15	1.5E-12
VOC	Toluene	108-88-3	ID	7.03E-02	5.17E-07			3.52E-09			
VOC	1,1,1-Trichloroethane	71-55-6	ID	3.20E-02	2.91E-07			1.60E-09			
VOC	1,1,2-Trichloroethane	79-00-5	C	3.50E-02	1.52E-07	1.6E-02	9.5E-12	1.75E-09	1.6E-02	1.1E-13	9.6E-12
VOC	Trichloroethene	79-01-6	HC	2.70E+02	2.17E-03	4.1E-03	3.5E-08	1.35E-05	4.1E-03	2.2E-10	3.5E-08
VOC	Vinyl Chloride	75-01-4	A	4.43E+00	4.56E-05	4.4E-03	7.8E-10	2.22E-07	4.4E-03	3.8E-12	7.9E-10
VOC	Xylenes (total)	1330-20-7	ID	8.90E-03	5.36E-08			4.45E-10			
INORG	Iron	7439-89-6	D								
INORG	Manganese	7439-96-5	D								
		Cumulative Risk:					**4E-08**			**2E-10**	**4E-08**
Notes:											
The annual maximum dispersion coefficient to outdoor air (C/Q) is 0.7 (kg/m³) / (kg/m²/s).											

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Attachment B3.4: Hazard Index Calculations for Inhalation Exposure of On-Site Utility Maintenance Workers to Former Drainage Trench Soil
Whirlpool, Fort Smith, Arkansas

				Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**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	5.86E-02	1.08E-07	3.1E+01	9.6E-11	2.93E-09	3.1E+01	2.6E-12	9.8E-11
VOC	Benzene	71-43-2	6.30E-04	5.09E-09	3.0E-02	4.6E-09	3.15E-11	3.0E-02	2.9E-11	4.7E-09
VOC	Bromodichloromethane	75-27-4	2.60E-03	9.50E-09			1.30E-10			
VOC	Bromoform	75-25-2								
VOC	Bromomethane	74-83-9	2.44E-01	2.10E-06	5.0E-03	1.1E-05	1.22E-08	5.0E-03	6.7E-08	1.2E-05
VOC	2-Butanone	78-93-3	2.50E-01	4.64E-07	5.0E+00	2.5E-09	1.25E-08	5.0E+00	6.8E-11	2.6E-09
VOC	Carbon Disulfide	75-15-0	2.80E-03	2.85E-08	7.0E-01	1.1E-09	1.40E-10	7.0E-01	5.5E-12	1.1E-09
VOC	Carbon Tetrachloride	56-23-5	5.20E-03	4.90E-08	1.0E-01	1.3E-08	2.60E-10	1.0E-01	7.1E-11	1.3E-08
VOC	Chlorobenzene	108-90-7			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	5.70E-02	4.51E-07	5.0E-02	2.5E-07	2.85E-09	5.0E-02	1.6E-09	2.5E-07
VOC	Chloromethane	74-87-3			9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1								
VOC	1,1-Dichloroethane	75-34-3	8.80E-03	7.15E-08	5.0E-01	3.9E-09	4.40E-10	5.0E-01	2.4E-11	3.9E-09
VOC	1,2-Dichloroethane	107-06-2	1.81E-01	1.02E-06	7.0E-03	4.0E-06	9.05E-09	7.0E-03	3.5E-08	4.0E-06
VOC	1,1-Dichloroethene	75-35-4	1.60E-01	1.59E-06	2.0E-01	2.2E-07	8.00E-09	2.0E-01	1.1E-09	2.2E-07
VOC	1,2-Dichloroethene (total)	540-59-0	5.20E+00	3.91E-05			2.60E-07			
VOC	cis-1,2-Dichloroethene	156-59-2	1.85E+01	1.39E-04			9.25E-07			
VOC	trans-1,2-Dichloroethene	156-60-5	2.40E-01	2.07E-06			1.20E-08			
VOC	1,2-Dichloropropane	78-87-5			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4	1.40E-03	8.90E-09	1.0E+00	2.4E-10	7.00E-11	1.0E+00	1.9E-12	2.5E-10
VOC	2-Hexanone	591-78-6	7.30E-02	1.54E-07	3.0E-02	1.4E-07	3.65E-09	3.0E-02	3.3E-09	1.4E-07
VOC	4-Methyl-2-pentanone	108-10-1	1.75E-02	4.10E-08	3.0E+00	3.7E-10	8.75E-10	3.0E+00	8.0E-12	3.8E-10
VOC	Methylene Chloride	75-09-2	3.14E+00	2.32E-05	6.0E-01	1.1E-06	1.57E-07	6.0E-01	7.2E-09	1.1E-06
VOC	Styrene	100-42-5			1.0E+00			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5								
VOC	Tetrachloroethene	127-18-4	1.70E-01	1.48E-06	4.0E-02	1.0E-06	8.50E-09	4.0E-02	5.8E-09	1.0E-06
VOC	Toluene	108-88-3	7.03E-02	5.17E-07	5.0E+00	2.8E-09	3.52E-09	5.0E+00	1.9E-11	2.9E-09
VOC	1,1,1-Trichloroethane	71-55-6	3.20E-02	2.91E-07	5.0E+00	1.6E-09	1.60E-09	5.0E+00	8.8E-12	1.6E-09
VOC	1,1,2-Trichloroethane	79-00-5	3.50E-02	1.52E-07			1.75E-09			
VOC	Trichloroethene	79-01-6	2.70E+02	2.17E-03	2.0E-03	3.0E-02	1.35E-05	2.0E-03	1.8E-04	3.0E-02
VOC	Vinyl Chloride	75-01-4	4.43E+00	4.56E-05	1.0E-01	1.2E-05	2.22E-07	1.0E-01	6.1E-08	1.3E-05
VOC	Xylenes (total)	1330-20-7	8.90E-03	5.36E-08	1.0E-01	1.5E-08	4.45E-10	1.0E-01	1.2E-10	1.5E-08
INORG	Iron	7439-89-6								
INORG	Manganese	7439-96-5			5.0E-05			5.0E-05		
	Hazard Index:					**3E-02**			**2E-04**	**3E-02**

Notes:

The annual maximum dispersion coefficient to outdoor air (C/Q) is 0.7 (kg/m³) / (kg/m²/s).

RAMBOLL ENVIRON

Attachment B3.5: Cancer Risk Calculations for Inhalation Exposure of On-Site Utility Maintenance Workers to Remaining Site Soil
Whirlpool, Fort Smith, Arkansas

					Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation 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	5.16E-02	4.59E-07			2.58E-09			
VOC	Benzene	71-43-2	A			7.8E-03			7.8E-03		
VOC	Bromodichloromethane	75-27-4	B2								
VOC	Bromoform	75-25-2	B2	6.10E-03	4.49E-08	1.1E-03	1.9E-13	3.05E-10	1.1E-03	1.3E-15	1.9E-13
VOC	Bromomethane	74-83-9	ID								
VOC	2-Butanone	78-93-3	ID								
VOC	Carbon Disulfide	75-15-0		7.40E-03	3.64E-07			3.70E-10			
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	5.20E-03	1.99E-07	2.3E-02	1.8E-11	2.60E-10	2.3E-02	2.3E-14	1.8E-11
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	7.20E-03	1.95E-07	2.6E-02	2.0E-11	3.60E-10	2.6E-02	3.7E-14	2.0E-11
VOC	1,1-Dichloroethene	75-35-4	C	1.10E-03	5.27E-08			5.50E-11			
VOC	1,2-Dichloroethene (total)	540-59-0		4.90E-01	1.78E-05			2.45E-08			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	4.90E-01	1.78E-05			2.45E-08			
VOC	trans-1,2-Dichloroethene	156-60-5	ID								
VOC	1,2-Dichloropropane	78-87-5	B2								
VOC	Ethyl Benzene	100-41-4	D								
VOC	2-Hexanone	591-78-6	ID	5.90E-02	6.02E-07			2.95E-09			
VOC	4-Methyl-2-pentanone	108-10-1	ID								
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	2.49E-07	1.0E-05	9.8E-15	3.50E-10	1.0E-05	1.4E-17	9.8E-15
VOC	Styrene	100-42-5									
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC								
VOC	Tetrachloroethene	127-18-4	LC	4.40E-03	1.85E-07	2.6E-04	1.9E-13	2.20E-10	2.6E-04	2.2E-16	1.9E-13
VOC	Toluene	108-88-3	ID	1.60E-03	5.68E-08			8.00E-11			
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	1.70E+00	6.61E-05	4.1E-03	1.1E-09	8.50E-08	4.1E-03	1.4E-12	1.1E-09
VOC	Vinyl Chloride	75-01-4	A	3.80E-02	1.89E-06	4.4E-03	3.3E-11	1.90E-09	4.4E-03	3.3E-14	3.3E-11
VOC	Xylenes (total)	1330-20-7	ID								
INORG	Iron	7439-89-6	D								
INORG	Manganese	7439-96-5	D								
		Cumulative Risk:					**1E-09**			**1E-12**	**1E-09**
Notes:											
The annual maximum dispersion coefficient to outdoor air (C/Q) is 3.6 (kg/m³) / (kg/m²/s).											

RAMBOLL ENVIRON

Attachment B3.6: Hazard Index Calculations for Inhalation Exposure of On-Site Utility Maintenance Workers to Remaining Site Soil
Whirlpool, Fort Smith, Arkansas

				Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**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	5.16E-02	4.59E-07	3.1E+01	4.1E-10	2.58E-09	3.1E+01	2.3E-12	4.1E-10
VOC	Benzene	71-43-2			3.0E-02			3.0E-02		
VOC	Bromodichloromethane	75-27-4								
VOC	Bromoform	75-25-2	6.10E-03	4.49E-08			3.05E-10			
VOC	Bromomethane	74-83-9			5.0E-03			5.0E-03		
VOC	2-Butanone	78-93-3			5.0E+00			5.0E+00		
VOC	Carbon Disulfide	75-15-0	7.40E-03	3.64E-07	7.0E-01	1.4E-08	3.70E-10	7.0E-01	1.4E-11	1.4E-08
VOC	Carbon Tetrachloride	56-23-5			1.0E-01			1.0E-01		
VOC	Chlorobenzene	108-90-7			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	5.20E-03	1.99E-07	5.0E-02	1.1E-07	2.60E-10	5.0E-02	1.4E-10	1.1E-07
VOC	Chloromethane	74-87-3			9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1								
VOC	1,1-Dichloroethane	75-34-3			5.0E-01			5.0E-01		
VOC	1,2-Dichloroethane	107-06-2	7.20E-03	1.95E-07	7.0E-03	7.7E-07	3.60E-10	7.0E-03	1.4E-09	7.7E-07
VOC	1,1-Dichloroethene	75-35-4	1.10E-03	5.27E-08	2.0E-01	7.2E-09	5.50E-11	2.0E-01	7.5E-12	7.2E-09
VOC	1,2-Dichloroethene (total)	540-59-0	4.90E-01	1.78E-05			2.45E-08			
VOC	cis-1,2-Dichloroethene	156-59-2	4.90E-01	1.78E-05			2.45E-08			
VOC	trans-1,2-Dichloroethene	156-60-5								
VOC	1,2-Dichloropropane	78-87-5			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4			1.0E+00			1.0E+00		
VOC	2-Hexanone	591-78-6	5.90E-02	6.02E-07	3.0E-02	5.5E-07	2.95E-09	3.0E-02	2.7E-09	5.5E-07
VOC	4-Methyl-2-pentanone	108-10-1			3.0E+00			3.0E+00		
VOC	Methylene Chloride	75-09-2	7.00E-03	2.49E-07	6.0E-01	1.1E-08	3.50E-10	6.0E-01	1.6E-11	1.1E-08
VOC	Styrene	100-42-5			1.0E+00			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5								
VOC	Tetrachloroethene	127-18-4	4.40E-03	1.85E-07	4.0E-02	1.3E-07	2.20E-10	4.0E-02	1.5E-10	1.3E-07
VOC	Toluene	108-88-3	1.60E-03	5.68E-08	5.0E+00	3.1E-10	8.00E-11	5.0E+00	4.4E-13	3.1E-10
VOC	1,1,1-Trichloroethane	71-55-6			5.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5								
VOC	Trichloroethene	79-01-6	1.70E+00	6.61E-05	2.0E-03	9.1E-04	8.50E-08	2.0E-03	1.2E-06	9.1E-04
VOC	Vinyl Chloride	75-01-4	3.80E-02	1.89E-06	1.0E-01	5.2E-07	1.90E-09	1.0E-01	5.2E-10	5.2E-07
VOC	Xylenes (total)	1330-20-7			1.0E-01			1.0E-01		
INORG	Iron	7439-89-6								
INORG	Manganese	7439-96-5			5.0E-05			5.0E-05		
	Hazard Index:					**9E-04**			**1E-06**	**9E-04**

Notes:

The annual maximum dispersion coefficient to outdoor air (C/Q) is 3.6 (kg/m³) / (kg/m²/s).

RAMBOLL ENVIRON

Attachment B3.7: Cancer Risk Calculations for Contact Exposure of Off-Site Utility Maintenance Workers to Total Site Soil
Whirlpool, Fort Smith, Arkansas

					Soil Ingestion			Soil Dermal Contact				Contact 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	Risk
VOC	Acetone	67-64-1	ID	5.86E-02	8.60E-10							
VOC	Benzene	71-43-2	A	6.30E-04	9.25E-12	5.5E-02	5.1E-13			5.5E-02		5.1E-13
VOC	Bromodichloromethane	75-27-4	B2	2.60E-03	3.82E-11	6.2E-02	2.4E-12			6.2E-02		2.4E-12
VOC	Bromoform	75-25-2	B2	6.10E-03	8.95E-11	7.9E-03	7.1E-13			7.9E-03		7.1E-13
VOC	Bromomethane	74-83-9	ID	2.44E-01	3.58E-09							
VOC	2-Butanone	78-93-3	ID	2.50E-01	3.67E-09							
VOC	Carbon Disulfide	75-15-0		7.40E-03	1.09E-10							
VOC	Carbon Tetrachloride	56-23-5	LC	5.20E-03	7.63E-11	7.0E-02	5.3E-12			7.0E-02		5.3E-12
VOC	Chlorobenzene	108-90-7	D									
VOC	Chloroethane	75-00-3	LC									
VOC	Chloroform	67-66-3	B2	5.70E-02	8.37E-10	1.9E-02	1.6E-11			1.9E-02		1.6E-11
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	8.80E-03	1.29E-10							
VOC	1,2-Dichloroethane	107-06-2	B2	1.81E-01	2.66E-09	9.1E-02	2.4E-10			9.1E-02		2.4E-10
VOC	1,1-Dichloroethene	75-35-4	C	1.60E-01	2.35E-09							
VOC	1,2-Dichloroethene (total)	540-59-0		5.20E+00	7.63E-08							
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.85E+01	2.72E-07							
VOC	trans-1,2-Dichloroethene	156-60-5	ID	2.40E-01	3.52E-09							
VOC	1,2-Dichloropropane	78-87-5	B2			3.6E-02				3.6E-02		
VOC	Ethyl Benzene	100-41-4	D	1.40E-03	2.05E-11							
VOC	2-Hexanone	591-78-6	ID	7.30E-02	1.07E-09							
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.75E-02	2.57E-10							
VOC	Methylene Chloride	75-09-2	LC	3.14E+00	4.61E-08	2.0E-03	9.2E-11			2.0E-03		9.2E-11
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	1.70E-01	2.50E-09	2.1E-03	5.2E-12			2.1E-03		5.2E-12
VOC	Toluene	108-88-3	ID	7.03E-02	1.03E-09							
VOC	1,1,1-Trichloroethane	71-55-6	ID	3.20E-02	4.70E-10							
VOC	1,1,2-Trichloroethane	79-00-5	C	3.50E-02	5.14E-10	5.7E-02	2.9E-11			5.7E-02		2.9E-11
VOC	Trichloroethene	79-01-6	HC	2.70E+02	3.96E-06	4.6E-02	1.8E-07			4.6E-02		1.8E-07
VOC	Vinyl Chloride	75-01-4	A	4.43E+00	6.50E-08	7.2E-01	4.7E-08			7.2E-01		4.7E-08
VOC	Xylenes (total)	1330-20-7	ID	8.90E-03	1.31E-10							
INORG	Iron	7439-89-6	D									
INORG	Manganese	7439-96-5	D									
		Cumulative Risk:					**2E-07**					**2E-07**

RAMBOLL ENVIRON

Attachment B3.8: Hazard Index Calculations for Contact Exposure of On-Site Utility Maintenance Workers to Total Site Soil
Whirlpool, Fort Smith, Arkansas

				Soil Ingestion			Soil Dermal Contact				Contact Routes
Chem Group	Chemical	CASRN	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	HQ
VOC	Acetone	67-64-1	5.86E-02	6.02E-09	9.0E-01	6.7E-09			9.0E-01		6.7E-09
VOC	Benzene	71-43-2	6.30E-04	6.47E-11	4.0E-03	1.6E-08			4.0E-03		1.6E-08
VOC	Bromodichloromethane	75-27-4	2.60E-03	2.67E-10	2.0E-02	1.3E-08			2.0E-02		1.3E-08
VOC	Bromoform	75-25-2	6.10E-03	6.27E-10	2.0E-02	3.1E-08			2.0E-02		3.1E-08
VOC	Bromomethane	74-83-9	2.44E-01	2.51E-08	1.4E-03	1.8E-05			1.4E-03		1.8E-05
VOC	2-Butanone	78-93-3	2.50E-01	2.57E-08	6.0E-01	4.3E-08			6.0E-01		4.3E-08
VOC	Carbon Disulfide	75-15-0	7.40E-03	7.60E-10	1.0E-01	7.6E-09			1.0E-01		7.6E-09
VOC	Carbon Tetrachloride	56-23-5	5.20E-03	5.34E-10	4.0E-03	1.3E-07			4.0E-03		1.3E-07
VOC	Chlorobenzene	108-90-7			2.0E-02				2.0E-02		
VOC	Chloroethane	75-00-3			1.0E-01				1.0E-01		
VOC	Chloroform	67-66-3	5.70E-02	5.86E-09	1.0E-02	5.9E-07			1.0E-02		5.9E-07
VOC	Chloromethane	74-87-3									
VOC	Dibromochloromethane	124-48-1			2.0E-02				2.0E-02		
VOC	1,1-Dichloroethane	75-34-3	8.80E-03	9.04E-10	2.0E-01	4.5E-09			2.0E-01		4.5E-09
VOC	1,2-Dichloroethane	107-06-2	1.81E-01	1.86E-08	2.0E-02	9.3E-07			2.0E-02		9.3E-07
VOC	1,1-Dichloroethene	75-35-4	1.60E-01	1.64E-08	5.0E-02	3.3E-07			5.0E-02		3.3E-07
VOC	1,2-Dichloroethene (total)	540-59-0	5.20E+00	5.34E-07	2.0E-03	2.7E-04			2.0E-03		2.7E-04
VOC	cis-1,2-Dichloroethene	156-59-2	1.85E+01	1.90E-06	2.0E-03	9.5E-04			2.0E-03		9.5E-04
VOC	trans-1,2-Dichloroethene	156-60-5	2.40E-01	2.47E-08	2.0E-02	1.2E-06			2.0E-02		1.2E-06
VOC	1,2-Dichloropropane	78-87-5			9.0E-02				9.0E-02		
VOC	Ethyl Benzene	100-41-4	1.40E-03	1.44E-10	1.0E-01	1.4E-09			1.0E-01		1.4E-09
VOC	2-Hexanone	591-78-6	7.30E-02	7.50E-09	5.0E-03	1.5E-06			5.0E-03		1.5E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.75E-02	1.80E-09							
VOC	Methylene Chloride	75-09-2	3.14E+00	3.23E-07	6.0E-03	5.4E-05			6.0E-03		5.4E-05
VOC	Styrene	100-42-5			2.0E-01				2.0E-01		
VOC	1,1,2,2-Tetrachloroethane	79-34-5			2.0E-02				2.0E-02		
VOC	Tetrachloroethene	127-18-4	1.70E-01	1.75E-08	6.0E-03	2.9E-06			6.0E-03		2.9E-06
VOC	Toluene	108-88-3	7.03E-02	7.22E-09	8.0E-02	9.0E-08			8.0E-02		9.0E-08
VOC	1,1,1-Trichloroethane	71-55-6	3.20E-02	3.29E-09	2.0E+00	1.6E-09			2.0E+00		1.6E-09
VOC	1,1,2-Trichloroethane	79-00-5	3.50E-02	3.60E-09	4.0E-03	9.0E-07			4.0E-03		9.0E-07
VOC	Trichloroethene	79-01-6	2.70E+02	2.77E-05	5.0E-04	5.5E-02			5.0E-04		5.5E-02
VOC	Vinyl Chloride	75-01-4	4.43E+00	4.55E-07	3.0E-03	1.5E-04			3.0E-03		1.5E-04
VOC	Xylenes (total)	1330-20-7	8.90E-03	9.14E-10	2.0E-01	4.6E-09			2.0E-01		4.6E-09
INORG	Iron	7439-89-6			7.0E-01				7.0E-01		
INORG	Manganese	7439-96-5			1.4E-01				8.4E-03		
		Hazard Index:				**6E-02**					**6E-02**

RAMBOLL ENVIRON

Attachment B3.9: Dermal Absorbed Dose for Groundwater
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	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
INORG	Iron	7439-89-6	5.6E+01		1.0E-03	0.0E+00	2.2E-01	3.3E-01	3.0E-01	5.2E-01	2.00E-06
INORG	Manganese	7439-96-5	5.5E+01		1.0E-03	0.0E+00	2.1E-01	3.3E-01	3.0E-01	5.1E-01	2.00E-06
Notes:											
	Event Time	hours	**t**	2							
	K_p capped at 1 cm/hr (USEPA 1992).										

RAMBOLL ENVIRON

Attachment B3.10: Dispersion Factor for Groundwater in Excavations to Outdoor Air Whirlpool, Fort Smith, Arkansas		
Parameter	**Units**	**Value**
Correlation coefficient city		Little Rock
Correlation coefficient A		12.4964
Correlation coefficient B		18.4476
Correlation coefficient C		210.2128
Groundwater source area	acres	0.0052
Groundwater averaging time for C/Q		24-Hour Max
Conversion factor from 1-Hr Max for groundwater		0.40
C/Q for Groundwater	$(kg/m^3)/(kg/m^2/s)$	**11.61**
Note:		
C/Q is estimated using the empirical correlation in USEPA's Supplemental SSG (2002).		

Attachment B3.11: 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	1.76E+03	5.70E-04	5.70E-03
VOC	Carbon Disulfide	75-15-0	9.3E-01	7.6E+01	4.99E-01	1.26E-03	7.95E+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	4.1E-01	6.5E+01	5.28E-01	1.37E-03	7.35E+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	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	1.06E+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
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
INORG	Iron	7439-89-6	0.0E+00	5.6E+01	5.54E-01	1.47E-03			
INORG	Manganese	7439-96-5	0.0E+00	5.5E+01	5.57E-01	1.48E-03			
	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					

RAMBOLL ENVIRON

Attachment B3.12: Cancer Risk Calculations for Exposure of On-Site Utility 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	3.99E-01	9.76E-08			1.27E-06	4.38E-08			2.02E-02	1.32E-05			
VOC	Benzene	71-43-2	A	2.00E-03	4.89E-10	5.5E-02	2.7E-11	3.70E-05	6.38E-09	5.5E-02	3.5E-10	2.84E-04	1.86E-07	7.8E-03	1.4E-09	1.8E-09
VOC	Bromodichloromethane	75-27-4	B2	5.30E-03	1.30E-09	6.2E-02	8.0E-11	1.70E-05	7.77E-09	6.2E-02	4.8E-10	5.04E-04	3.28E-07			5.6E-10
VOC	Bromoform	75-25-2	B2	3.55E-02	8.68E-09	7.9E-03	6.9E-11	1.40E-05	4.29E-08	7.9E-03	3.4E-10	2.47E-03	1.61E-06	1.1E-03	1.8E-09	2.2E-09
VOC	Bromomethane	74-83-9	ID	8.43E-02	2.06E-08			7.68E-06	5.59E-08			1.09E-02	7.12E-06			
VOC	2-Butanone	78-93-3	ID	1.43E-01	3.50E-08			2.42E-06	2.99E-08			9.45E-03	6.17E-06			
VOC	Carbon Disulfide	75-15-0		1.08E-02	2.64E-09			3.11E-05	2.90E-08			1.58E-03	1.03E-06			
VOC	Carbon Tetrachloride	56-23-5	LC	1.44E-02	3.52E-09	7.0E-02	2.5E-10	4.84E-05	6.02E-08	7.0E-02	4.2E-09	1.48E-03	9.65E-07	6.0E-03	5.8E-09	1.0E-08
VOC	Chlorobenzene	108-90-7	D	7.00E-03	1.71E-09			8.00E-05	4.83E-08			8.22E-04	5.37E-07			
VOC	Chloroethane	75-00-3	LC	2.20E-03	5.38E-10			1.49E-05	2.82E-09			3.47E-04	2.27E-07			
VOC	Chloroform	67-66-3	B2	4.06E+00	9.93E-07	1.9E-02	1.9E-08	1.86E-05	6.51E-06	1.9E-02	1.2E-07	4.64E-01	3.03E-04	2.3E-02	7.0E-06	7.1E-06
VOC	Chloromethane	74-87-3	D	1.10E-01	2.69E-08			3.58E-05	3.40E-07			1.96E-02	1.28E-05			
VOC	Dibromochloromethane	124-48-1	C	3.50E-03	8.56E-10	8.4E-02	7.2E-11	1.42E-05	4.28E-09	8.4E-02	3.6E-10	2.84E-04	1.85E-07			4.3E-10
VOC	1,1-Dichloroethane	75-34-3	SC	4.42E-02	1.08E-08			1.83E-05	6.97E-08			5.59E-03	3.65E-06			
VOC	1,2-Dichloroethane	107-06-2	B2	2.50E-03	6.12E-10	9.1E-02	5.6E-11	1.13E-05	2.44E-09	9.1E-02	2.2E-10	2.95E-04	1.92E-07	2.6E-02	5.0E-09	5.3E-09
VOC	1,1-Dichloroethene	75-35-4	C	2.95E-01	7.22E-08			3.10E-05	7.89E-07			3.81E-02	2.49E-05			
VOC	1,2-Dichloroethene (total)	540-59-0						2.07E-05								
VOC	cis-1,2-Dichloroethene	156-59-2	ID	2.87E+00	7.02E-07			2.07E-05	5.13E-06			3.65E-01	2.38E-04			
VOC	trans-1,2-Dichloroethene	156-60-5	ID	7.04E-01	1.72E-07			2.83E-05	1.72E-06			9.05E-02	5.90E-05			
VOC	1,2-Dichloropropane	78-87-5	B2	2.00E-03	4.89E-10	3.6E-02	1.8E-11	2.12E-05	3.65E-09	3.6E-02	1.3E-10	2.33E-04	1.52E-07			1.5E-10
VOC	Ethyl Benzene	100-41-4	D					1.27E-04								
VOC	2-Hexanone	591-78-6	ID	5.80E-03	1.42E-09			9.75E-06	4.88E-09			4.24E-04	2.76E-07			
VOC	4-Methyl-2-pentanone	108-10-1	ID	3.00E-03	7.34E-10			7.32E-06	1.89E-09			2.53E-04	1.65E-07			
VOC	Methylene Chloride	75-09-2	LC	5.05E-02	1.24E-08	2.0E-03	2.5E-11	9.25E-06	4.03E-08	2.0E-03	8.1E-11	6.74E-03	4.40E-06	1.0E-05	4.4E-11	1.5E-10
VOC	Styrene	100-42-5						9.63E-05								
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	1.71E+00	4.18E-07	2.0E-01	8.4E-08	2.57E-05	3.80E-06	2.0E-01	7.6E-07	1.34E-01	8.77E-05			8.4E-07
VOC	Tetrachloroethene	127-18-4	LC	4.40E-02	1.08E-08	2.1E-03	2.3E-11	3.99E-05	1.51E-07	2.1E-03	3.2E-10	4.34E-03	2.83E-06	2.6E-04	7.4E-10	1.1E-09
VOC	Toluene	108-88-3	ID	1.04E-02	2.54E-09			8.08E-05	7.25E-08			1.36E-03	8.90E-07			
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.31E+00	3.20E-07			3.85E-05	4.36E-06			1.44E-01	9.40E-05			
VOC	1,1,2-Trichloroethane	79-00-5	C	1.07E-02	2.62E-09	5.7E-02	1.5E-10	2.02E-05	1.86E-08	5.7E-02	1.1E-09	1.08E-03	7.05E-07	1.6E-02	1.1E-08	1.2E-08
VOC	Trichloroethene	79-01-6	HC	1.69E+02	4.13E-05	4.6E-02	1.9E-06	5.53E-05	8.06E-04	4.6E-02	3.7E-05	1.87E+01	1.22E-02	4.1E-03	5.0E-05	8.9E-05
VOC	Vinyl Chloride	75-01-4	A	5.40E-01	1.32E-07	7.2E-01	9.5E-08	1.69E-05	7.86E-07	7.2E-01	5.7E-07	8.70E-02	5.67E-05	4.4E-03	2.5E-07	9.1E-07
VOC	Xylenes (total)	1330-20-7	ID					1.32E-04								
INORG	Iron	7439-89-6	D	1.43E+01	3.50E-06			2.00E-06	2.47E-06							
INORG	Manganese	7439-96-5	D	1.28E+01	3.13E-06			2.00E-06	2.21E-06							
		Cumulative Risk:					**2E-06**				**4E-05**				**6E-05**	**1E-04**

RAMBOLL ENVIRON

Attachment B3.13: Hazard Index Calculations for Exposure of On-Site Utility Maintenance Workers to Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas

				Incidental Ingestion			Dermal Contact				Vapor Inhalation			All Routes
Chem Group	Chemical	CASRN	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	3.99E-01	6.83E-07	9.0E-01	7.6E-07	1.27E-06	3.06E-07	9.0E-01	3.4E-07	2.02E-02	3.1E+01	3.0E-06	4.1E-06
VOC	Benzene	71-43-2	2.00E-03	3.42E-09	4.0E-03	8.6E-07	3.70E-05	4.47E-08	4.0E-03	1.1E-05	2.84E-04	3.0E-02	4.3E-05	5.5E-05
VOC	Bromodichloromethane	75-27-4	5.30E-03	9.08E-09	2.0E-02	4.5E-07	1.70E-05	5.44E-08	2.0E-02	2.7E-06	5.04E-04			3.2E-06
VOC	Bromoform	75-25-2	3.55E-02	6.08E-08	2.0E-02	3.0E-06	1.40E-05	3.00E-07	2.0E-02	1.5E-05	2.47E-03			1.8E-05
VOC	Bromomethane	74-83-9	8.43E-02	1.44E-07	1.4E-03	1.0E-04	7.68E-06	3.91E-07	1.4E-03	2.8E-04	1.09E-02	5.0E-03	1.0E-02	1.0E-02
VOC	2-Butanone	78-93-3	1.43E-01	2.45E-07	6.0E-01	4.1E-07	2.42E-06	2.09E-07	6.0E-01	3.5E-07	9.45E-03	5.0E+00	8.6E-06	9.4E-06
VOC	Carbon Disulfide	75-15-0	1.08E-02	1.85E-08	1.0E-01	1.8E-07	3.11E-05	2.03E-07	1.0E-01	2.0E-06	1.58E-03	7.0E-01	1.0E-05	1.2E-05
VOC	Carbon Tetrachloride	56-23-5	1.44E-02	2.47E-08	4.0E-03	6.2E-06	4.84E-05	4.21E-07	4.0E-03	1.1E-04	1.48E-03	1.0E-01	6.8E-05	1.8E-04
VOC	Chlorobenzene	108-90-7	7.00E-03	1.20E-08	2.0E-02	6.0E-07	8.00E-05	3.38E-07	2.0E-02	1.7E-05	8.22E-04	5.0E-02	7.5E-05	9.3E-05
VOC	Chloroethane	75-00-3	2.20E-03	3.77E-09	1.0E-01	3.8E-08	1.49E-05	1.98E-08	1.0E-01	2.0E-07	3.47E-04	1.0E+01	1.6E-07	3.9E-07
VOC	Chloroform	67-66-3	4.06E+00	6.95E-06	1.0E-02	7.0E-04	1.86E-05	4.56E-05	1.0E-02	4.6E-03	4.64E-01	5.0E-02	4.2E-02	4.8E-02
VOC	Chloromethane	74-87-3	1.10E-01	1.88E-07			3.58E-05	2.38E-06			1.96E-02	9.0E-02	9.9E-04	9.9E-04
VOC	Dibromochloromethane	124-48-1	3.50E-03	5.99E-09	2.0E-02	3.0E-07	1.42E-05	3.00E-08	2.0E-02	1.5E-06	2.84E-04			1.8E-06
VOC	1,1-Dichloroethane	75-34-3	4.42E-02	7.57E-08	2.0E-01	3.8E-07	1.83E-05	4.88E-07	2.0E-01	2.4E-06	5.59E-03	5.0E-01	5.1E-05	5.4E-05
VOC	1,2-Dichloroethane	107-06-2	2.50E-03	4.28E-09	2.0E-02	2.1E-07	1.13E-05	1.71E-08	2.0E-02	8.5E-07	2.95E-04	7.0E-03	1.9E-04	1.9E-04
VOC	1,1-Dichloroethene	75-35-4	2.95E-01	5.05E-07	5.0E-02	1.0E-05	3.10E-05	5.52E-06	5.0E-02	1.1E-04	3.81E-02	2.0E-01	8.7E-04	9.9E-04
VOC	1,2-Dichloroethene (total)	540-59-0			2.0E-03		2.07E-05		2.0E-03					
VOC	cis-1,2-Dichloroethene	156-59-2	2.87E+00	4.91E-06	2.0E-03	2.5E-03	2.07E-05	3.59E-05	2.0E-03	1.8E-02	3.65E-01			2.0E-02
VOC	trans-1,2-Dichloroethene	156-60-5	7.04E-01	1.21E-06	2.0E-02	6.0E-05	2.83E-05	1.21E-05	2.0E-02	6.0E-04	9.05E-02			6.6E-04
VOC	1,2-Dichloropropane	78-87-5	2.00E-03	3.42E-09	9.0E-02	3.8E-08	2.12E-05	2.56E-08	9.0E-02	2.8E-07	2.33E-04	4.0E-03	2.7E-04	2.7E-04
VOC	Ethyl Benzene	100-41-4			1.0E-01		1.27E-04		1.0E-01			1.0E+00		
VOC	2-Hexanone	591-78-6	5.80E-03	9.93E-09	5.0E-03	2.0E-06	9.75E-06	3.42E-08	5.0E-03	6.8E-06	4.24E-04	3.0E-02	6.5E-05	7.3E-05
VOC	4-Methyl-2-pentanone	108-10-1	3.00E-03	5.14E-09			7.32E-06	1.33E-08			2.53E-04	3.0E+00	3.9E-07	3.9E-07
VOC	Methylene Chloride	75-09-2	5.05E-02	8.65E-08	6.0E-03	1.4E-05	9.25E-06	2.82E-07	6.0E-03	4.7E-05	6.74E-03	6.0E-01	5.1E-05	1.1E-04
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	1.71E+00	2.93E-06	2.0E-02	1.5E-04	2.57E-05	2.66E-05	2.0E-02	1.3E-03	1.34E-01			1.5E-03
VOC	Tetrachloroethene	127-18-4	4.40E-02	7.53E-08	6.0E-03	1.3E-05	3.99E-05	1.06E-06	6.0E-03	1.8E-04	4.34E-03	4.0E-02	5.0E-04	6.8E-04
VOC	Toluene	108-88-3	1.04E-02	1.78E-08	8.0E-02	2.2E-07	8.08E-05	5.07E-07	8.0E-02	6.3E-06	1.36E-03	5.0E+00	1.2E-06	7.8E-06
VOC	1,1,1-Trichloroethane	71-55-6	1.31E+00	2.24E-06	2.0E+00	1.1E-06	3.85E-05	3.05E-05	2.0E+00	1.5E-05	1.44E-01	5.0E+00	1.3E-04	1.5E-04
VOC	1,1,2-Trichloroethane	79-00-5	1.07E-02	1.83E-08	4.0E-03	4.6E-06	2.02E-05	1.30E-07	4.0E-03	3.3E-05	1.08E-03			3.7E-05
VOC	Trichloroethene	79-01-6	1.69E+02	2.89E-04	5.0E-04	5.8E-01	5.53E-05	5.64E-03	5.0E-04	1.1E+01	1.87E+01	2.0E-03	4.3E+01	5.4E+01
VOC	Vinyl Chloride	75-01-4	5.40E-01	9.25E-07	3.0E-03	3.1E-04	1.69E-05	5.50E-06	3.0E-03	1.8E-03	8.70E-02	1.0E-01	4.0E-03	6.1E-03
VOC	Xylenes (total)	1330-20-7			2.0E-01		1.32E-04		2.0E-01			1.0E-01		
INORG	Iron	7439-89-6	1.43E+01	2.45E-05	7.0E-01	3.5E-05	2.00E-06	1.73E-05	7.0E-01	2.5E-05				6.0E-05
INORG	Manganese	7439-96-5	1.28E+01	2.19E-05	1.4E-01	1.6E-04	2.00E-06	1.55E-05	8.4E-03	1.8E-03		5.0E-05		2.0E-03
		Hazard Index:				**6E-01**				**1E+01**			**4E+01**	**5E+01**

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Attachment B4

Redevelopment Construction Worker Risk Calculations

Attachments

B4.1 Vapor Flux from Soil to Outdoor Air

B4.2 Soil PM_{10} Emission from Wind Erosion

B4.3 Cancer Risk Calculations for Inhalation Exposure of Redevelopment Construction Workers to Former Drainage Trench Soil

B4.4 Hazard Index Calculations for Inhalation Exposure of Redevelopment Construction Workers to Former Drainage Trench Soil

B4.5 Cancer Risk Calculations for Inhalation Exposure of Redevelopment Construction Workers to Remaining Site Soil

B4.6 Hazard Index Calculations for Inhalation Exposure of Redevelopment Construction Workers to Remaining Site Soil

B4.7 Cancer Risk Calculations for Contact Exposure of Redevelopment Construction Workers to Total Site Soil

B4.8 Hazard Index Calculations for Contact Exposure of Redevelopment Construction Workers to Total Site Soil

B4.9 Dermal Absorbed Dose for Groundwater

B4.10 Dispersion Factor for Groundwater in Excavations to Outdoor Air

B4.11 Normalized Vapor Flux to Outdoor Air from Exposed Groundwater in Excavations

B4.12 Cancer Risk Calculations for Exposure of Redevelopment Construction Workers to Groundwater in Excavations

B4.13 Hazard Index Calculations for Exposure of Redevelopment Construction Workers to Groundwater in Excavations

Attachment B4.1: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	K_{oc} (L/kg)	K_d (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		2.00E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.11E-05	7.96E-06	0.00E+00	0.00E+00	7.96E-06	7.96E-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		4.09E-01	2.34E+00	9.94E-05	4.28E-01	2.52E-02	9.18E-06	2.41E-02	1.47E-04	0.00E+00	1.40E+00	1.08E-04	1.08E-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	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	5.74E+01	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
INORG	Iron	7439-89-6		2.50E+01	0.00E+00							0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INORG	Manganese	7439-96-5		6.50E+01	0.00E+00							0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
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**	1												
		days	**T**	365												
		s	**T**	3.2E+07												
	Molar Gas Constant	L-mmHg/ mole-^oK	**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												

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Attachment B4.2: Soil PM10 Emission from Wind Erosion Whirlpool, Fort Smith, Arkansas		
Annual average PM_{10} concentration	$(mg/m^3)/(mg/kg)$	**5.00E-08**
Note:		
The concentration of particulates in the air is assumed to be no more than the former annual National Ambient Air Quality Standards (NAAQS).		

Attachment B4.3: Cancer Risk Calculations for Inhalation Exposure of Redevelopment Construction Workers to Former Drainage Trench Soil
Whirlpool, Fort Smith, Arkansas

					Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation 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	5.86E-02	3.42E-07			2.93E-09			
VOC	Benzene	71-43-2	A	6.30E-04	2.23E-08	7.8E-03	5.7E-13	3.15E-11	7.8E-03	8.0E-16	5.7E-13
VOC	Bromodichloromethane	75-27-4	B2	2.60E-03	3.02E-08			1.30E-10			
VOC	Bromoform	75-25-2	B2			1.1E-03			1.1E-03		
VOC	Bromomethane	74-83-9	ID	2.44E-01	1.01E-05			1.22E-08			
VOC	2-Butanone	78-93-3	ID	2.50E-01	1.47E-06			1.25E-08			
VOC	Carbon Disulfide	75-15-0		2.80E-03	1.98E-07			1.40E-10			
VOC	Carbon Tetrachloride	56-23-5	LC	5.20E-03	2.83E-07	6.0E-03	5.5E-12	2.60E-10	6.0E-03	5.1E-15	5.5E-12
VOC	Chlorobenzene	108-90-7	D								
VOC	Chloroethane	75-00-3	LC								
VOC	Chloroform	67-66-3	B2	5.70E-02	1.93E-06	2.3E-02	1.4E-10	2.85E-09	2.3E-02	2.1E-13	1.4E-10
VOC	Chloromethane	74-87-3	D								
VOC	Dibromochloromethane	124-48-1	C								
VOC	1,1-Dichloroethane	75-34-3	SC	8.80E-03	3.16E-07			4.40E-10			
VOC	1,2-Dichloroethane	107-06-2	B2	1.81E-01	3.43E-06	2.6E-02	2.9E-10	9.05E-09	2.6E-02	7.7E-13	2.9E-10
VOC	1,1-Dichloroethene	75-35-4	C	1.60E-01	1.04E-05			8.00E-09			
VOC	1,2-Dichloroethene (total)	540-59-0		5.20E+00	1.57E-04			2.60E-07			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.85E+01	5.60E-04			9.25E-07			
VOC	trans-1,2-Dichloroethene	156-60-5	ID	2.40E-01	1.00E-05			1.20E-08			
VOC	1,2-Dichloropropane	78-87-5	B2								
VOC	Ethyl Benzene	100-41-4	D	1.40E-03	3.16E-08			7.00E-11			
VOC	2-Hexanone	591-78-6	ID	7.30E-02	4.88E-07			3.65E-09			
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.75E-02	1.30E-07			8.75E-10			
VOC	Methylene Chloride	75-09-2	LC	3.14E+00	9.15E-05	1.0E-05	3.0E-12	1.57E-07	1.0E-05	5.1E-15	3.0E-12
VOC	Styrene	100-42-5									
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC								
VOC	Tetrachloroethene	127-18-4	LC	1.70E-01	7.36E-06	2.6E-04	6.2E-12	8.50E-09	2.6E-04	7.2E-15	6.2E-12
VOC	Toluene	108-88-3	ID	7.03E-02	2.04E-06			3.52E-09			
VOC	1,1,1-Trichloroethane	71-55-6	ID	3.20E-02	1.55E-06			1.60E-09			
VOC	1,1,2-Trichloroethane	79-00-5	C	3.50E-02	4.87E-07	1.6E-02	2.5E-11	1.75E-09	1.6E-02	9.1E-14	2.6E-11
VOC	Trichloroethene	79-01-6	HC	2.70E+02	9.51E-03	4.1E-03	1.3E-07	1.35E-05	4.1E-03	1.8E-10	1.3E-07
VOC	Vinyl Chloride	75-01-4	A	4.43E+00	3.25E-04	4.4E-03	4.7E-09	2.22E-07	4.4E-03	3.2E-12	4.7E-09
VOC	Xylenes (total)	1330-20-7	ID	8.90E-03	1.86E-07			4.45E-10			
INORG	Iron	7439-89-6	D								
INORG	Manganese	7439-96-5	D								
		Cumulative Risk:					**1E-07**			**2E-10**	**1E-07**

Notes:

The annual maximum dispersion coefficient to outdoor air (C/Q) is 0.7 (kg/m³) / (kg/m²/s).

Attachment B4.4: Hazard Index Calculations for Inhalation Exposure of Redevelopment Construction Workers to Former Drainage Trench Soil
Whirlpool, Fort Smith, Arkansas

				Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**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	5.86E-02	3.42E-07	3.1E+01	2.5E-09	2.93E-09	3.1E+01	2.2E-11	2.5E-09
VOC	Benzene	71-43-2	6.30E-04	2.23E-08	9.0E-02	5.7E-08	3.15E-11	9.0E-02	8.0E-11	5.7E-08
VOC	Bromodichloromethane	75-27-4	2.60E-03	3.02E-08	2.0E-02	3.4E-07	1.30E-10	2.0E-02	1.5E-09	3.5E-07
VOC	Bromoform	75-25-2								
VOC	Bromomethane	74-83-9	2.44E-01	1.01E-05	1.0E-01	2.3E-05	1.22E-08	1.0E-01	2.8E-08	2.3E-05
VOC	2-Butanone	78-93-3	2.50E-01	1.47E-06	5.0E+00	6.7E-08	1.25E-08	5.0E+00	5.7E-10	6.8E-08
VOC	Carbon Disulfide	75-15-0	2.80E-03	1.98E-07	7.0E-01	6.5E-08	1.40E-10	7.0E-01	4.6E-11	6.5E-08
VOC	Carbon Tetrachloride	56-23-5	5.20E-03	2.83E-07	1.9E-01	3.4E-07	2.60E-10	1.9E-01	3.1E-10	3.4E-07
VOC	Chlorobenzene	108-90-7			5.0E-01			5.0E-01		
VOC	Chloroethane	75-00-3			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	5.70E-02	1.93E-06	5.0E-02	8.8E-06	2.85E-09	5.0E-02	1.3E-08	8.8E-06
VOC	Chloromethane	74-87-3			4.1E-01			4.1E-01		
VOC	Dibromochloromethane	124-48-1								
VOC	1,1-Dichloroethane	75-34-3	8.80E-03	3.16E-07	5.0E+00	1.4E-08	4.40E-10	5.0E+00	2.0E-11	1.4E-08
VOC	1,2-Dichloroethane	107-06-2	1.81E-01	3.43E-06	7.0E-02	1.1E-05	9.05E-09	7.0E-02	3.0E-08	1.1E-05
VOC	1,1-Dichloroethene	75-35-4	1.60E-01	1.04E-05	2.0E-01	1.2E-05	8.00E-09	2.0E-01	9.1E-09	1.2E-05
VOC	1,2-Dichloroethene (total)	540-59-0	5.20E+00	1.57E-04			2.60E-07			
VOC	cis-1,2-Dichloroethene	156-59-2	1.85E+01	5.60E-04			9.25E-07			
VOC	trans-1,2-Dichloroethene	156-60-5	2.40E-01	1.00E-05			1.20E-08			
VOC	1,2-Dichloropropane	78-87-5			1.3E-02			1.3E-02		
VOC	Ethyl Benzene	100-41-4	1.40E-03	3.16E-08	9.0E+00	8.0E-10	7.00E-11	9.0E+00	1.8E-12	8.0E-10
VOC	2-Hexanone	591-78-6	7.30E-02	4.88E-07	3.0E-01	3.7E-07	3.65E-09	3.0E-01	2.8E-09	3.7E-07
VOC	4-Methyl-2-pentanone	108-10-1	1.75E-02	1.30E-07	3.0E+00	9.9E-09	8.75E-10	3.0E+00	6.7E-11	9.9E-09
VOC	Methylene Chloride	75-09-2	3.14E+00	9.15E-05	1.0E+00	2.0E-05	1.57E-07	1.0E+00	3.4E-08	2.0E-05
VOC	Styrene	100-42-5			3.0E+00			3.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5								
VOC	Tetrachloroethene	127-18-4	1.70E-01	7.36E-06	4.1E-02	4.1E-05	8.50E-09	4.1E-02	4.8E-08	4.1E-05
VOC	Toluene	108-88-3	7.03E-02	2.04E-06	5.0E+00	9.3E-08	3.52E-09	5.0E+00	1.6E-10	9.3E-08
VOC	1,1,1-Trichloroethane	71-55-6	3.20E-02	1.55E-06	5.0E+00	7.1E-08	1.60E-09	5.0E+00	7.3E-11	7.1E-08
VOC	1,1,2-Trichloroethane	79-00-5	3.50E-02	4.87E-07			1.75E-09			
VOC	Trichloroethene	79-01-6	2.70E+02	9.51E-03	2.1E-03	1.0E+00	1.35E-05	2.1E-03	1.4E-03	1.0E+00
VOC	Vinyl Chloride	75-01-4	4.43E+00	3.25E-04	1.0E-01	7.4E-04	2.22E-07	1.0E-01	5.1E-07	7.4E-04
VOC	Xylenes (total)	1330-20-7	8.90E-03	1.86E-07	3.0E-01	1.4E-07	4.45E-10	3.0E-01	3.4E-10	1.4E-07
INORG	Iron	7439-89-6								
INORG	Manganese	7439-96-5			5.0E-05			5.0E-05		
	Hazard Index:					**1E+00**			**1E-03**	**1E+00**
Notes:										
The annual maximum dispersion coefficient to outdoor air (C/Q) is 0.7 (kg/m³) / (kg/m²/s).										

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Attachment B4.5: Cancer Risk Calculations for Inhalation Exposure of Redevelopment Construction Workers to Remaining Site Soil
Whirlpool, Fort Smith, Arkansas

					Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation 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	5.16E-02	1.45E-06			2.58E-09			
VOC	Benzene	71-43-2	A			7.8E-03			7.8E-03		
VOC	Bromodichloromethane	75-27-4	B2								
VOC	Bromoform	75-25-2	B2	6.10E-03	1.42E-07	1.1E-03	5.1E-13	3.05E-10	1.1E-03	1.1E-15	5.1E-13
VOC	Bromomethane	74-83-9	ID								
VOC	2-Butanone	78-93-3	ID								
VOC	Carbon Disulfide	75-15-0		7.40E-03	2.53E-06			3.70E-10			
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	5.20E-03	8.48E-07	2.3E-02	6.4E-11	2.60E-10	2.3E-02	2.0E-14	6.4E-11
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	7.20E-03	6.59E-07	2.6E-02	5.6E-11	3.60E-10	2.6E-02	3.1E-14	5.6E-11
VOC	1,1-Dichloroethene	75-35-4	C	1.10E-03	3.44E-07			5.50E-11			
VOC	1,2-Dichloroethene (total)	540-59-0		4.90E-01	7.16E-05			2.45E-08			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	4.90E-01	7.16E-05			2.45E-08			
VOC	trans-1,2-Dichloroethene	156-60-5	ID								
VOC	1,2-Dichloropropane	78-87-5	B2								
VOC	Ethyl Benzene	100-41-4	D								
VOC	2-Hexanone	591-78-6	ID	5.90E-02	1.90E-06			2.95E-09			
VOC	4-Methyl-2-pentanone	108-10-1	ID								
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	9.85E-07	1.0E-05	3.2E-14	3.50E-10	1.0E-05	1.1E-17	3.2E-14
VOC	Styrene	100-42-5									
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC								
VOC	Tetrachloroethene	127-18-4	LC	4.40E-03	9.20E-07	2.6E-04	7.8E-13	2.20E-10	2.6E-04	1.9E-16	7.8E-13
VOC	Toluene	108-88-3	ID	1.60E-03	2.24E-07			8.00E-11			
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	1.70E+00	2.89E-04	4.1E-03	3.9E-09	8.50E-08	4.1E-03	1.1E-12	3.9E-09
VOC	Vinyl Chloride	75-01-4	A	3.80E-02	1.35E-05	4.4E-03	1.9E-10	1.90E-09	4.4E-03	2.7E-14	1.9E-10
VOC	Xylenes (total)	1330-20-7	ID								
INORG	Iron	7439-89-6	D								
INORG	Manganese	7439-96-5	D								
		Cumulative Risk:					**4E-09**			**1E-12**	**4E-09**
Notes:											
The annual maximum dispersion coefficient to outdoor air (C/Q) is 3.6 (kg/m³) / (kg/m²/s).											

RAMBOLL ENVIRON

Attachment B4.6: Hazard Index Calculations for Inhalation Exposure of Redevelopment Construction Workers to Remaining Site Soil
Whirlpool, Fort Smith, Arkansas

				Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**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	5.16E-02	1.45E-06	3.1E+01	1.1E-08	2.58E-09	3.1E+01	1.9E-11	1.1E-08
VOC	Benzene	71-43-2			9.0E-02			9.0E-02		
VOC	Bromodichloromethane	75-27-4			2.0E-02			2.0E-02		
VOC	Bromoform	75-25-2	6.10E-03	1.42E-07			3.05E-10			
VOC	Bromomethane	74-83-9			1.0E-01			1.0E-01		
VOC	2-Butanone	78-93-3			5.0E+00			5.0E+00		
VOC	Carbon Disulfide	75-15-0	7.40E-03	2.53E-06	7.0E-01	8.3E-07	3.70E-10	7.0E-01	1.2E-10	8.3E-07
VOC	Carbon Tetrachloride	56-23-5			1.9E-01			1.9E-01		
VOC	Chlorobenzene	108-90-7			5.0E-01			5.0E-01		
VOC	Chloroethane	75-00-3			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	5.20E-03	8.48E-07	5.0E-02	3.9E-06	2.60E-10	5.0E-02	1.2E-09	3.9E-06
VOC	Chloromethane	74-87-3			4.1E-01			4.1E-01		
VOC	Dibromochloromethane	124-48-1								
VOC	1,1-Dichloroethane	75-34-3			5.0E+00			5.0E+00		
VOC	1,2-Dichloroethane	107-06-2	7.20E-03	6.59E-07	7.0E-02	2.2E-06	3.60E-10	7.0E-02	1.2E-09	2.2E-06
VOC	1,1-Dichloroethene	75-35-4	1.10E-03	3.44E-07	2.0E-01	3.9E-07	5.50E-11	2.0E-01	6.3E-11	3.9E-07
VOC	1,2-Dichloroethene (total)	540-59-0	4.90E-01	7.16E-05			2.45E-08			
VOC	cis-1,2-Dichloroethene	156-59-2	4.90E-01	7.16E-05			2.45E-08			
VOC	trans-1,2-Dichloroethene	156-60-5								
VOC	1,2-Dichloropropane	78-87-5			1.3E-02			1.3E-02		
VOC	Ethyl Benzene	100-41-4			9.0E+00			9.0E+00		
VOC	2-Hexanone	591-78-6	5.90E-02	1.90E-06	3.0E-01	1.4E-06	2.95E-09	3.0E-01	2.2E-09	1.5E-06
VOC	4-Methyl-2-pentanone	108-10-1			3.0E+00			3.0E+00		
VOC	Methylene Chloride	75-09-2	7.00E-03	9.85E-07	1.0E+00	2.2E-07	3.50E-10	1.0E+00	7.7E-11	2.2E-07
VOC	Styrene	100-42-5			3.0E+00			3.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5								
VOC	Tetrachloroethene	127-18-4	4.40E-03	9.20E-07	4.1E-02	5.2E-06	2.20E-10	4.1E-02	1.2E-09	5.2E-06
VOC	Toluene	108-88-3	1.60E-03	2.24E-07	5.0E+00	1.0E-08	8.00E-11	5.0E+00	3.7E-12	1.0E-08
VOC	1,1,1-Trichloroethane	71-55-6			5.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5								
VOC	Trichloroethene	79-01-6	1.70E+00	2.89E-04	2.1E-03	3.1E-02	8.50E-08	2.1E-03	9.0E-06	3.1E-02
VOC	Vinyl Chloride	75-01-4	3.80E-02	1.35E-05	1.0E-01	3.1E-05	1.90E-09	1.0E-01	4.3E-09	3.1E-05
VOC	Xylenes (total)	1330-20-7			3.0E-01			3.0E-01		
INORG	Iron	7439-89-6								
INORG	Manganese	7439-96-5			5.0E-05			5.0E-05		
	Hazard Index:					**3E-02**			**9E-06**	**3E-02**

Notes:

The annual maximum dispersion coefficient to outdoor air (C/Q) is 3.6 (kg/m³) / (kg/m²/s).

RAMBOLL ENVIRON

Attachment B4.7: Cancer Risk Calculations for Contact Exposure of Redevelopment Construction Workers to Total Site Soil
Whirlpool, Fort Smith, Arkansas

					Soil Ingestion			Soil Dermal Contact				Contact 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	Risk
VOC	Acetone	67-64-1	ID	5.86E-02	1.43E-09							
VOC	Benzene	71-43-2	A	6.30E-04	1.54E-11	5.5E-02	8.5E-13			5.5E-02		8.5E-13
VOC	Bromodichloromethane	75-27-4	B2	2.60E-03	6.36E-11	6.2E-02	3.9E-12			6.2E-02		3.9E-12
VOC	Bromoform	75-25-2	B2	6.10E-03	1.49E-10	7.9E-03	1.2E-12			7.9E-03		1.2E-12
VOC	Bromomethane	74-83-9	ID	2.44E-01	5.97E-09							
VOC	2-Butanone	78-93-3	ID	2.50E-01	6.12E-09							
VOC	Carbon Disulfide	75-15-0		7.40E-03	1.81E-10							
VOC	Carbon Tetrachloride	56-23-5	LC	5.20E-03	1.27E-10	7.0E-02	8.9E-12			7.0E-02		8.9E-12
VOC	Chlorobenzene	108-90-7	D									
VOC	Chloroethane	75-00-3	LC									
VOC	Chloroform	67-66-3	B2	5.70E-02	1.39E-09	1.9E-02	2.6E-11			1.9E-02		2.6E-11
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	8.80E-03	2.15E-10							
VOC	1,2-Dichloroethane	107-06-2	B2	1.81E-01	4.43E-09	9.1E-02	4.0E-10			9.1E-02		4.0E-10
VOC	1,1-Dichloroethene	75-35-4	C	1.60E-01	3.91E-09							
VOC	1,2-Dichloroethene (total)	540-59-0		5.20E+00	1.27E-07							
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.85E+01	4.53E-07							
VOC	trans-1,2-Dichloroethene	156-60-5	ID	2.40E-01	5.87E-09							
VOC	1,2-Dichloropropane	78-87-5	B2			3.6E-02				3.6E-02		
VOC	Ethyl Benzene	100-41-4	D	1.40E-03	3.42E-11							
VOC	2-Hexanone	591-78-6	ID	7.30E-02	1.79E-09							
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.75E-02	4.28E-10							
VOC	Methylene Chloride	75-09-2	LC	3.14E+00	7.68E-08	2.0E-03	1.5E-10			2.0E-03		1.5E-10
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	1.70E-01	4.16E-09	2.1E-03	8.7E-12			2.1E-03		8.7E-12
VOC	Toluene	108-88-3	ID	7.03E-02	1.72E-09							
VOC	1,1,1-Trichloroethane	71-55-6	ID	3.20E-02	7.83E-10							
VOC	1,1,2-Trichloroethane	79-00-5	C	3.50E-02	8.56E-10	5.7E-02	4.9E-11			5.7E-02		4.9E-11
VOC	Trichloroethene	79-01-6	HC	2.70E+02	6.60E-06	4.6E-02	3.0E-07			4.6E-02		3.0E-07
VOC	Vinyl Chloride	75-01-4	A	4.43E+00	1.08E-07	7.2E-01	7.8E-08			7.2E-01		7.8E-08
VOC	Xylenes (total)	1330-20-7	ID	8.90E-03	2.18E-10							
INORG	Iron	7439-89-6	D									
INORG	Manganese	7439-96-5	D									
		Cumulative Risk:					**4E-07**					**4E-07**

RAMBOLL ENVIRON

Attachment B4.8: Hazard Index Calculations for Contact Exposure of Redevelopment Construction Workers to Total Site Soil
Whirlpool, Fort Smith, Arkansas

				Soil Ingestion			Soil Dermal Contact				Contact Routes
Chem Group	Chemical	CASRN	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	HQ
VOC	Acetone	67-64-1	5.86E-02	1.00E-07	2.0E+00	5.0E-08			2.0E+00		5.0E-08
VOC	Benzene	71-43-2	6.30E-04	1.08E-09	1.0E-02	1.1E-07			1.0E-02		1.1E-07
VOC	Bromodichloromethane	75-27-4	2.60E-03	4.45E-09	2.0E-02	2.2E-07			2.0E-02		2.2E-07
VOC	Bromoform	75-25-2	6.10E-03	1.04E-08	3.0E-02	3.5E-07			3.0E-02		3.5E-07
VOC	Bromomethane	74-83-9	2.44E-01	4.18E-07	5.0E-03	8.4E-05			5.0E-03		8.4E-05
VOC	2-Butanone	78-93-3	2.50E-01	4.28E-07	2.0E+00	2.1E-07			2.0E+00		2.1E-07
VOC	Carbon Disulfide	75-15-0	7.40E-03	1.27E-08	1.0E-01	1.3E-07			1.0E-01		1.3E-07
VOC	Carbon Tetrachloride	56-23-5	5.20E-03	8.90E-09	1.0E-02	8.9E-07			1.0E-02		8.9E-07
VOC	Chlorobenzene	108-90-7			7.0E-02				7.0E-02		
VOC	Chloroethane	75-00-3			1.0E-01				1.0E-01		
VOC	Chloroform	67-66-3	5.70E-02	9.76E-08	1.0E-01	9.8E-07			1.0E-01		9.8E-07
VOC	Chloromethane	74-87-3									
VOC	Dibromochloromethane	124-48-1			7.0E-02				7.0E-02		
VOC	1,1-Dichloroethane	75-34-3	8.80E-03	1.51E-08	2.0E+00	7.5E-09			2.0E+00		7.5E-09
VOC	1,2-Dichloroethane	107-06-2	1.81E-01	3.10E-07	2.0E-02	1.5E-05			2.0E-02		1.5E-05
VOC	1,1-Dichloroethene	75-35-4	1.60E-01	2.74E-07	5.0E-02	5.5E-06			5.0E-02		5.5E-06
VOC	1,2-Dichloroethene (total)	540-59-0	5.20E+00	8.90E-06	2.0E-02	4.5E-04			2.0E-02		4.5E-04
VOC	cis-1,2-Dichloroethene	156-59-2	1.85E+01	3.17E-05	2.0E-02	1.6E-03			2.0E-02		1.6E-03
VOC	trans-1,2-Dichloroethene	156-60-5	2.40E-01	4.11E-07	2.0E-01	2.1E-06			2.0E-01		2.1E-06
VOC	1,2-Dichloropropane	78-87-5			7.0E-02				7.0E-02		
VOC	Ethyl Benzene	100-41-4	1.40E-03	2.40E-09	1.0E-01	2.4E-08			1.0E-01		2.4E-08
VOC	2-Hexanone	591-78-6	7.30E-02	1.25E-07	5.0E-03	2.5E-05			5.0E-03		2.5E-05
VOC	4-Methyl-2-pentanone	108-10-1	1.75E-02	3.00E-08							
VOC	Methylene Chloride	75-09-2	3.14E+00	5.38E-06	6.0E-02	9.0E-05			6.0E-02		9.0E-05
VOC	Styrene	100-42-5			2.0E-01				2.0E-01		
VOC	1,1,2,2-Tetrachloroethane	79-34-5			5.0E-02				5.0E-02		
VOC	Tetrachloroethene	127-18-4	1.70E-01	2.91E-07	8.0E-03	3.6E-05			8.0E-03		3.6E-05
VOC	Toluene	108-88-3	7.03E-02	1.20E-07	8.0E-01	1.5E-07			8.0E-01		1.5E-07
VOC	1,1,1-Trichloroethane	71-55-6	3.20E-02	5.48E-08	7.0E+00	7.8E-09			7.0E+00		7.8E-09
VOC	1,1,2-Trichloroethane	79-00-5	3.50E-02	5.99E-08	4.0E-03	1.5E-05			4.0E-03		1.5E-05
VOC	Trichloroethene	79-01-6	2.70E+02	4.62E-04	5.0E-04	9.2E-01			5.0E-04		9.2E-01
VOC	Vinyl Chloride	75-01-4	4.43E+00	7.59E-06	3.0E-03	2.5E-03			3.0E-03		2.5E-03
VOC	Xylenes (total)	1330-20-7	8.90E-03	1.52E-08	2.0E-01	7.6E-08			2.0E-01		7.6E-08
INORG	Iron	7439-89-6			7.0E-01				7.0E-01		
INORG	Manganese	7439-96-5			1.4E-01				8.4E-03		
		Hazard Index:				**9E-01**					**9E-01**

RAMBOLL ENVIRON

Attachment B4.9: Dermal Absorbed Dose for Groundwater
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	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
INORG	Iron	7439-89-6	5.6E+01		1.0E-03	0.0E+00	2.2E-01	3.3E-01	3.0E-01	5.2E-01	2.00E-06
INORG	Manganese	7439-96-5	5.5E+01		1.0E-03	0.0E+00	2.1E-01	3.3E-01	3.0E-01	5.1E-01	2.00E-06
Notes:											
	Event Time	hours	**t**	2							
	K_p capped at 1 cm/hr (USEPA 1992).										

RAMBOLL ENVIRON

Attachment B4.10: Dispersion Factor for Groundwater in Excavations to Outdoor Air Whirlpool, Fort Smith, Arkansas		
Parameter	**Units**	**Value**
Correlation coefficient city		Little Rock
Correlation coefficient A		12.4964
Correlation coefficient B		18.4476
Correlation coefficient C		210.2128
Groundwater source area	acres	0.0052
Groundwater averaging time for C/Q		24-Hour Max
Conversion factor from 1-Hr Max for groundwater		0.40
C/Q for Groundwater	$(kg/m^3)/(kg/m^2/s)$	**11.61**
Note:		
C/Q is estimated using the empirical correlation in USEPA's Supplemental SSG (2002).		

Attachment B4.11: 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	1.76E+03	5.70E-04	5.70E-03
VOC	Carbon Disulfide	75-15-0	9.3E-01	7.6E+01	4.99E-01	1.26E-03	7.95E+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	4.1E-01	6.5E+01	5.28E-01	1.37E-03	7.35E+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	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	1.06E+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
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
INORG	Iron	7439-89-6	0.0E+00	5.6E+01	5.54E-01	1.47E-03			
INORG	Manganese	7439-96-5	0.0E+00	5.5E+01	5.57E-01	1.48E-03			
	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					

RAMBOLL ENVIRON

Attachment B4.12: Cancer Risk Calculations for Exposure of Redevelopment 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	3.99E-01	9.76E-09			1.27E-06	4.38E-09			2.02E-02	1.32E-06			
VOC	Benzene	71-43-2	A	2.00E-03	4.89E-11	5.5E-02	2.7E-12	3.70E-05	6.38E-10	5.5E-02	3.5E-11	2.84E-04	1.86E-08	7.8E-03	1.4E-10	1.8E-10
VOC	Bromodichloromethane	75-27-4	B2	5.30E-03	1.30E-10	6.2E-02	8.0E-12	1.70E-05	7.77E-10	6.2E-02	4.8E-11	5.04E-04	3.28E-08			5.6E-11
VOC	Bromoform	75-25-2	B2	3.55E-02	8.68E-10	7.9E-03	6.9E-12	1.40E-05	4.29E-09	7.9E-03	3.4E-11	2.47E-03	1.61E-07	1.1E-03	1.8E-10	2.2E-10
VOC	Bromomethane	74-83-9	ID	8.43E-02	2.06E-09			7.68E-06	5.59E-09			1.09E-02	7.12E-07			
VOC	2-Butanone	78-93-3	ID	1.43E-01	3.50E-09			2.42E-06	2.99E-09			9.45E-03	6.17E-07			
VOC	Carbon Disulfide	75-15-0		1.08E-02	2.64E-10			3.11E-05	2.90E-09			1.58E-03	1.03E-07			
VOC	Carbon Tetrachloride	56-23-5	LC	1.44E-02	3.52E-10	7.0E-02	2.5E-11	4.84E-05	6.02E-09	7.0E-02	4.2E-10	1.48E-03	9.65E-08	6.0E-03	5.8E-10	1.0E-09
VOC	Chlorobenzene	108-90-7	D	7.00E-03	1.71E-10			8.00E-05	4.83E-09			8.22E-04	5.37E-08			
VOC	Chloroethane	75-00-3	LC	2.20E-03	5.38E-11			1.49E-05	2.82E-10			3.47E-04	2.27E-08			
VOC	Chloroform	67-66-3	B2	4.06E+00	9.93E-08	1.9E-02	1.9E-09	1.86E-05	6.51E-07	1.9E-02	1.2E-08	4.64E-01	3.03E-05	2.3E-02	7.0E-07	7.1E-07
VOC	Chloromethane	74-87-3	D	1.10E-01	2.69E-09			3.58E-05	3.40E-08			1.96E-02	1.28E-06			
VOC	Dibromochloromethane	124-48-1	C	3.50E-03	8.56E-11	8.4E-02	7.2E-12	1.42E-05	4.28E-10	8.4E-02	3.6E-11	2.84E-04	1.85E-08			4.3E-11
VOC	1,1-Dichloroethane	75-34-3	SC	4.42E-02	1.08E-09			1.83E-05	6.97E-09			5.59E-03	3.65E-07			
VOC	1,2-Dichloroethane	107-06-2	B2	2.50E-03	6.12E-11	9.1E-02	5.6E-12	1.13E-05	2.44E-10	9.1E-02	2.2E-11	2.95E-04	1.92E-08	2.6E-02	5.0E-10	5.3E-10
VOC	1,1-Dichloroethene	75-35-4	C	2.95E-01	7.22E-09			3.10E-05	7.89E-08			3.81E-02	2.49E-06			
VOC	1,2-Dichloroethene (total)	540-59-0						2.07E-05								
VOC	cis-1,2-Dichloroethene	156-59-2	ID	2.87E+00	7.02E-08			2.07E-05	5.13E-07			3.65E-01	2.38E-05			
VOC	trans-1,2-Dichloroethene	156-60-5	ID	7.04E-01	1.72E-08			2.83E-05	1.72E-07			9.05E-02	5.90E-06			
VOC	1,2-Dichloropropane	78-87-5	B2	2.00E-03	4.89E-11	3.6E-02	1.8E-12	2.12E-05	3.65E-10	3.6E-02	1.3E-11	2.33E-04	1.52E-08			1.5E-11
VOC	Ethyl Benzene	100-41-4	D					1.27E-04								
VOC	2-Hexanone	591-78-6	ID	5.80E-03	1.42E-10			9.75E-06	4.88E-10			4.24E-04	2.76E-08			
VOC	4-Methyl-2-pentanone	108-10-1	ID	3.00E-03	7.34E-11			7.32E-06	1.89E-10			2.53E-04	1.65E-08			
VOC	Methylene Chloride	75-09-2	LC	5.05E-02	1.24E-09	2.0E-03	2.5E-12	9.25E-06	4.03E-09	2.0E-03	8.1E-12	6.74E-03	4.40E-07	1.0E-05	4.4E-12	1.5E-11
VOC	Styrene	100-42-5						9.63E-05								
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	1.71E+00	4.18E-08	2.0E-01	8.4E-09	2.57E-05	3.80E-07	2.0E-01	7.6E-08	1.34E-01	8.77E-06			8.4E-08
VOC	Tetrachloroethene	127-18-4	LC	4.40E-02	1.08E-09	2.1E-03	2.3E-12	3.99E-05	1.51E-08	2.1E-03	3.2E-11	4.34E-03	2.83E-07	2.6E-04	7.4E-11	1.1E-10
VOC	Toluene	108-88-3	ID	1.04E-02	2.54E-10			8.08E-05	7.25E-09			1.36E-03	8.90E-08			
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.31E+00	3.20E-08			3.85E-05	4.36E-07			1.44E-01	9.40E-06			
VOC	1,1,2-Trichloroethane	79-00-5	C	1.07E-02	2.62E-10	5.7E-02	1.5E-11	2.02E-05	1.86E-09	5.7E-02	1.1E-10	1.08E-03	7.05E-08	1.6E-02	1.1E-09	1.2E-09
VOC	Trichloroethene	79-01-6	HC	1.69E+02	4.13E-06	4.6E-02	1.9E-07	5.53E-05	8.06E-05	4.6E-02	3.7E-06	1.87E+01	1.22E-03	4.1E-03	5.0E-06	8.9E-06
VOC	Vinyl Chloride	75-01-4	A	5.40E-01	1.32E-08	7.2E-01	9.5E-09	1.69E-05	7.86E-08	7.2E-01	5.7E-08	8.70E-02	5.67E-06	4.4E-03	2.5E-08	9.1E-08
VOC	Xylenes (total)	1330-20-7	ID					1.32E-04								
INORG	Iron	7439-89-6	D	1.43E+01	3.50E-07			2.00E-06	2.47E-07							
INORG	Manganese	7439-96-5	D	1.28E+01	3.13E-07			2.00E-06	2.21E-07							
		Cumulative Risk:					**2E-07**				**4E-06**				**6E-06**	**1E-05**

RAMBOLL ENVIRON

Attachment B4.13: Hazard Index Calculations for Exposure of Redevelopment Construction Workers to Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas

				Incidental Ingestion			Dermal Contact				Vapor Inhalation			All Routes
Chem Group	Chemical	CASRN	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	3.99E-01	6.83E-07	2.0E+00	3.4E-07	1.27E-06	3.06E-07	2.0E+00	1.5E-07	2.02E-02	3.1E+01	3.0E-06	3.5E-06
VOC	Benzene	71-43-2	2.00E-03	3.42E-09	1.0E-02	3.4E-07	3.70E-05	4.47E-08	1.0E-02	4.5E-06	2.84E-04	9.0E-02	1.4E-05	1.9E-05
VOC	Bromodichloromethane	75-27-4	5.30E-03	9.08E-09	2.0E-02	4.5E-07	1.70E-05	5.44E-08	2.0E-02	2.7E-06	5.04E-04	2.0E-02	1.1E-04	1.2E-04
VOC	Bromoform	75-25-2	3.55E-02	6.08E-08	3.0E-02	2.0E-06	1.40E-05	3.00E-07	3.0E-02	1.0E-05	2.47E-03			1.2E-05
VOC	Bromomethane	74-83-9	8.43E-02	1.44E-07	5.0E-03	2.9E-05	7.68E-06	3.91E-07	5.0E-03	7.8E-05	1.09E-02	1.0E-01	5.0E-04	6.1E-04
VOC	2-Butanone	78-93-3	1.43E-01	2.45E-07	2.0E+00	1.2E-07	2.42E-06	2.09E-07	2.0E+00	1.0E-07	9.45E-03	5.0E+00	8.6E-06	8.9E-06
VOC	Carbon Disulfide	75-15-0	1.08E-02	1.85E-08	1.0E-01	1.8E-07	3.11E-05	2.03E-07	1.0E-01	2.0E-06	1.58E-03	7.0E-01	1.0E-05	1.2E-05
VOC	Carbon Tetrachloride	56-23-5	1.44E-02	2.47E-08	1.0E-02	2.5E-06	4.84E-05	4.21E-07	1.0E-02	4.2E-05	1.48E-03	1.9E-01	3.6E-05	8.0E-05
VOC	Chlorobenzene	108-90-7	7.00E-03	1.20E-08	7.0E-02	1.7E-07	8.00E-05	3.38E-07	7.0E-02	4.8E-06	8.22E-04	5.0E-01	7.5E-06	1.3E-05
VOC	Chloroethane	75-00-3	2.20E-03	3.77E-09	1.0E-01	3.8E-08	1.49E-05	1.98E-08	1.0E-01	2.0E-07	3.47E-04	1.0E+01	1.6E-07	3.9E-07
VOC	Chloroform	67-66-3	4.06E+00	6.95E-06	1.0E-01	7.0E-05	1.86E-05	4.56E-05	1.0E-01	4.6E-04	4.64E-01	5.0E-02	4.2E-02	4.3E-02
VOC	Chloromethane	74-87-3	1.10E-01	1.88E-07			3.58E-05	2.38E-06			1.96E-02	4.1E-01	2.2E-04	2.2E-04
VOC	Dibromochloromethane	124-48-1	3.50E-03	5.99E-09	7.0E-02	8.6E-08	1.42E-05	3.00E-08	7.0E-02	4.3E-07	2.84E-04			5.1E-07
VOC	1,1-Dichloroethane	75-34-3	4.42E-02	7.57E-08	2.0E+00	3.8E-08	1.83E-05	4.88E-07	2.0E+00	2.4E-07	5.59E-03	5.0E+00	5.1E-06	5.4E-06
VOC	1,2-Dichloroethane	107-06-2	2.50E-03	4.28E-09	2.0E-02	2.1E-07	1.13E-05	1.71E-08	2.0E-02	8.5E-07	2.95E-04	7.0E-02	1.9E-05	2.0E-05
VOC	1,1-Dichloroethene	75-35-4	2.95E-01	5.05E-07	5.0E-02	1.0E-05	3.10E-05	5.52E-06	5.0E-02	1.1E-04	3.81E-02	2.0E-01	8.7E-04	9.9E-04
VOC	1,2-Dichloroethene (total)	540-59-0			2.0E-02		2.07E-05		2.0E-02					
VOC	cis-1,2-Dichloroethene	156-59-2	2.87E+00	4.91E-06	2.0E-02	2.5E-04	2.07E-05	3.59E-05	2.0E-02	1.8E-03	3.65E-01			2.0E-03
VOC	trans-1,2-Dichloroethene	156-60-5	7.04E-01	1.21E-06	2.0E-01	6.0E-06	2.83E-05	1.21E-05	2.0E-01	6.0E-05	9.05E-02			6.6E-05
VOC	1,2-Dichloropropane	78-87-5	2.00E-03	3.42E-09	7.0E-02	4.9E-08	2.12E-05	2.56E-08	7.0E-02	3.7E-07	2.33E-04	1.3E-02	8.2E-05	8.2E-05
VOC	Ethyl Benzene	100-41-4			1.0E-01		1.27E-04		1.0E-01			9.0E+00		
VOC	2-Hexanone	591-78-6	5.80E-03	9.93E-09	5.0E-03	2.0E-06	9.75E-06	3.42E-08	5.0E-03	6.8E-06	4.24E-04	3.0E-01	6.5E-06	1.5E-05
VOC	4-Methyl-2-pentanone	108-10-1	3.00E-03	5.14E-09			7.32E-06	1.33E-08			2.53E-04	3.0E+00	3.9E-07	3.9E-07
VOC	Methylene Chloride	75-09-2	5.05E-02	8.65E-08	6.0E-02	1.4E-06	9.25E-06	2.82E-07	6.0E-02	4.7E-06	6.74E-03	1.0E+00	3.0E-05	3.6E-05
VOC	Styrene	100-42-5			2.0E-01		9.63E-05		2.0E-01			3.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5	1.71E+00	2.93E-06	5.0E-02	5.9E-05	2.57E-05	2.66E-05	5.0E-02	5.3E-04	1.34E-01			5.9E-04
VOC	Tetrachloroethene	127-18-4	4.40E-02	7.53E-08	8.0E-03	9.4E-06	3.99E-05	1.06E-06	8.0E-03	1.3E-04	4.34E-03	4.1E-02	4.9E-04	6.3E-04
VOC	Toluene	108-88-3	1.04E-02	1.78E-08	8.0E-01	2.2E-08	8.08E-05	5.07E-07	8.0E-01	6.3E-07	1.36E-03	5.0E+00	1.2E-06	1.9E-06
VOC	1,1,1-Trichloroethane	71-55-6	1.31E+00	2.24E-06	7.0E+00	3.2E-07	3.85E-05	3.05E-05	7.0E+00	4.4E-06	1.44E-01	5.0E+00	1.3E-04	1.4E-04
VOC	1,1,2-Trichloroethane	79-00-5	1.07E-02	1.83E-08	4.0E-03	4.6E-06	2.02E-05	1.30E-07	4.0E-03	3.3E-05	1.08E-03			3.7E-05
VOC	Trichloroethene	79-01-6	1.69E+02	2.89E-04	5.0E-04	5.8E-01	5.53E-05	5.64E-03	5.0E-04	1.1E+01	1.87E+01	2.1E-03	4.0E+01	5.2E+01
VOC	Vinyl Chloride	75-01-4	5.40E-01	9.25E-07	3.0E-03	3.1E-04	1.69E-05	5.50E-06	3.0E-03	1.8E-03	8.70E-02	1.0E-01	4.0E-03	6.1E-03
VOC	Xylenes (total)	1330-20-7			2.0E-01		1.32E-04		2.0E-01			3.0E-01		
INORG	Iron	7439-89-6	1.43E+01	2.45E-05	7.0E-01	3.5E-05	2.00E-06	1.73E-05	7.0E-01	2.5E-05				6.0E-05
INORG	Manganese	7439-96-5	1.28E+01	2.19E-05	1.4E-01	1.6E-04	2.00E-06	1.55E-05	8.4E-03	1.8E-03		5.0E-05		2.0E-03
		Hazard Index:				**6E-01**				**1E+01**			**4E+01**	**5E+01**

RAMBOLL ENVIRON

Attachment B5

Residential Risk Calculations

Attachments

B5.1 Vapor Flux from Soil to Outdoor Air

B5.2 Soil PM_{10} Emission from Wind Erosion

B5.3 Dispersion Factor for Off-Site Soil to Outdoor Air

B5.4 Cancer Risk Calculations for Exposure of Residents to Off-Site Soil

B5.5 Hazard Index Calculations for Exposure of Residents to Off-Site Soil

B5.6 Cancer Risk Calculations for Inhalation Exposure of Residents to Former Drainage Trench Soil

B5.7 Hazard Index Calculations for Inhalation Exposure of Residents to Former Drainage Trench Soil

B5.8 Cancer Risk Calculations for Inhalation Exposure of Residents to Remaining Site Soil

B5.9 Hazard Index Calculations for Inhalation Exposure of Residents to Remaining Site Soil

B5.10 Soil Moisture Profile for a Default Residential Building without a Basement

B5.11 Normalized Indoor Air Concentration in a Default Residential Building without a Basement due to Soil-derived Vapor Intrusion

B5.12 Normalized Indoor Air Concentration in a Default Residential Building without a Basement due to Groundwater-derived Vapor Intrusion

B5.13 Cancer Risk and Hazard Index Calculations for Soil-derived Vapor Intrusion into a Default Residential Building without a Basement

B5.14 Cancer Risk and Hazard Index Calculations for Groundwater-derived Vapor Intrusion into a Default Residential Building without a Basement

B5.15 Cancer Risk and Hazard Index Calculations for Perched Water-derived Vapor Intrusion into a Default Residential Building without a Basement

B5.16 Cancer Risk and Hazard Index Calculations for Soil Vapor-derived Vapor Intrusion into a Default Residential Building without a Basement

B5.17 Normalized Vapor Flux to Outdoor Air from Groundwater

B5.18 Dispersion Factor for Groundwater to Outdoor Air

B5.19 Cancer Risk and Hazard Quotient Calculations for Exposure of Residents to Groundwater-derived Vapors in Outdoor Air

Attachment B5.1: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	K_{oc} (L/kg)	K_d (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	1.55E-06	0.00E+00	5.57E-03	1.55E-06	1.55E-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	9.44E-06	0.00E+00	2.21E+00	4.91E-06	4.91E-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	3.08E-06	0.00E+00	4.07E-01	2.90E-06	2.90E-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	1.28E-06	0.00E+00	4.61E-04	1.28E-06	1.28E-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	1.12E-05	0.00E+00	2.41E+00	5.09E-06	5.09E-06
VOC	2-Butanone	78-93-3	2.00E+00		2.00E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.11E-05	1.56E-06	0.00E+00	6.01E-03	1.56E-06	1.56E-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	2.27E-05	0.00E+00	3.03E+00	5.63E-06	5.63E-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	1.53E-05	0.00E+00	2.73E+00	5.37E-06	5.37E-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	4.94E-06	0.00E+00	1.17E+00	3.90E-06	3.90E-06
VOC	Chloroethane	75-00-3	1.62E+01		4.09E-01	2.34E+00	9.94E-05	4.28E-01	2.52E-02	9.18E-06	2.41E-02	2.87E-05	0.00E+00	3.16E+00	5.74E-06	5.74E-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	9.00E-06	0.00E+00	2.14E+00	4.85E-06	4.85E-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	1.67E-05	0.00E+00	2.81E+00	5.44E-06	5.44E-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	1.90E-06	0.00E+00	3.55E-02	1.89E-06	1.89E-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	9.58E-06	0.00E+00	2.22E+00	4.92E-06	4.92E-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	5.04E-06	0.00E+00	1.21E+00	3.94E-06	3.94E-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	1.95E-05	0.00E+00	2.93E+00	5.54E-06	5.54E-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	8.05E-06	0.00E+00	1.98E+00	4.70E-06	4.70E-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	8.05E-06	0.00E+00	1.98E+00	4.70E-06	4.70E-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	1.12E-05	0.00E+00	2.42E+00	5.10E-06	5.10E-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	6.63E-06	0.00E+00	1.68E+00	4.42E-06	4.42E-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	6.00E-06	0.00E+00	1.51E+00	4.25E-06	4.25E-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	1.78E-06	0.00E+00	2.09E-02	1.77E-06	1.77E-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	1.97E-06	0.00E+00	4.62E-02	1.96E-06	1.96E-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	7.75E-06	0.00E+00	1.92E+00	4.65E-06	4.65E-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	2.56E-06	0.00E+00	2.00E-01	2.49E-06	2.49E-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	1.95E-06	0.00E+00	4.35E-02	1.94E-06	1.94E-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	1.17E-05	0.00E+00	2.47E+00	5.14E-06	5.14E-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	7.72E-06	0.00E+00	1.92E+00	4.64E-06	4.64E-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	1.33E-05	0.00E+00	2.60E+00	5.26E-06	5.26E-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	3.70E-06	0.00E+00	6.75E-01	3.30E-06	3.30E-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	9.39E-06	0.00E+00	2.20E+00	4.90E-06	4.90E-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	2.43E-05	0.00E+00	3.07E+00	5.66E-06	5.66E-06
VOC	Xylenes (total)	1330-20-7	3.86E+02	5.74E+01	1.73E-01	6.74E-01	7.56E-05	1.41E+00	7.26E-03	6.98E-06	8.97E-04	5.54E-06	0.00E+00	1.37E+00	4.11E-06	4.11E-06
INORG	Iron	7439-89-6		2.50E+01	0.00E+00							0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INORG	Manganese	7439-96-5		6.50E+01	0.00E+00							0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
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**	26												
		days	**T**	9490												
		s	**T**	8.2E+08												
	Molar Gas Constant	L-mmHg/ mole-^oK	**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												

RAMBOLL ENVIRON

Attachment B5.2: 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	$\mathbf{u'_t}$	0.50
Correction factor			1.25
Corrected friction velocity	m/s	$\mathbf{u^*_t}$	0.6252
Roughness height	m	$\mathbf{z_0}$	0.005
Anemometer height	m		10.0
Friction velocity at anemometer height	m/s	$\mathbf{u_t}$	11.9
Mean annual wind speed	mph	$\mathbf{u_m}$	7.6
Mean annual wind speed	m/s	$\mathbf{u_m}$	3.39750
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	$\mathbf{J_{10,w}}$	**3.93E-13**

RAMBOLL ENVIRON

Attachment B5.3: Dispersion Factor for Off-Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas

Parameter	Units	Value
Correlation coefficient city		Little Rock
Correlation coefficient A		12.4964
Correlation coefficient B		18.4476
Correlation coefficient C		210.2128
Off-Site Soil source area	acres	0.5
Soil C/Q averaging time		Annual Max
Conversion factor from 1-Hr Max for soil		0.19
C/Q for off-site soil	$(kg/m^3)/(kg/m^2/s)$	**14.01**
Note:		
C/Q is estimated using the empirical correlation in USEPA's Supplemental SSG (2002).		

RAMBOLL ENVIRON

Attachment B5.4: Cancer Risk Calculations for Exposure of Residents to Off-Site Soil
Whirlpool, Fort Smith, Arkansas

						Soil Vapor Inhalation			
Chem Group	**Chemical**	**CASRN**	**Cancer Class**		**C_{soil}** (mg/kg)	**C_{air}** (mg/m^3)	**URF** (m^3/mg)	**f_{inh}**	**Risk**
VOC	Acetone	67-64-1	ID		6.23E-02	1.40E-06			
VOC	Benzene	71-43-2	A				7.8E-03		
VOC	Bromodichloromethane	75-27-4	B2						
VOC	Bromoform	75-25-2	B2				1.1E-03		
VOC	Bromomethane	74-83-9	ID		9.30E-03	6.88E-07			
VOC	2-Butanone	78-93-3	ID		6.30E-03	1.43E-07			
VOC	Carbon Disulfide	75-15-0			9.10E-04	7.44E-08			
VOC	Carbon Tetrachloride	56-23-5	LC				6.0E-03		
VOC	Chlorobenzene	108-90-7	D						
VOC	Chloroethane	75-00-3	LC						
VOC	Chloroform	67-66-3	B2				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		
VOC	1,1-Dichloroethene	75-35-4	C						
VOC	1,2-Dichloroethene (total)	540-59-0							
VOC	cis-1,2-Dichloroethene	156-59-2	ID						
VOC	trans-1,2-Dichloroethene	156-60-5	ID						
VOC	1,2-Dichloropropane	78-87-5	B2						
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		3.30E-03	2.23E-07	1.0E-05	1	2.2E-12
VOC	Styrene	100-42-5							
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC						
VOC	Tetrachloroethene	127-18-4	LC				2.6E-04		
VOC	Toluene	108-88-3	ID		1.20E-03	8.10E-08			
VOC	1,1,1-Trichloroethane	71-55-6	ID						
VOC	1,1,2-Trichloroethane	79-00-5	C				1.6E-02		
VOC	Trichloroethene	79-01-6	HC		1.60E-02	1.14E-06	4.1E-03	0.244	2.4E-09
VOC	Vinyl Chloride	75-01-4	A				4.4E-03		
VOC	Xylenes (total)	1330-20-7	ID		3.60E-03	2.15E-07			
INORG	Iron	7439-89-6	D						
INORG	Manganese	7439-96-5	D						
		Cumulative Risk:							**2E-09**

Notes:

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

RAMBOLL ENVIRON

Attachment B5.5: Hazard Index Calculations for Exposure of Residents to Off-Site Soil
Whirlpool, Fort Smith, Arkansas

					Soil Vapor Inhalation		
Chem Group	**Chemical**	**CASRN**		**C_{soil}** (mg/kg)	**C_{air}** (mg/m^3)	**RfC** (mg/m^3)	**HQ**
VOC	Acetone	67-64-1		6.23E-02	1.40E-06	3.1E+01	4.4E-08
VOC	Benzene	71-43-2				3.0E-02	
VOC	Bromodichloromethane	75-27-4					
VOC	Bromoform	75-25-2					
VOC	Bromomethane	74-83-9		9.30E-03	6.88E-07	5.0E-03	1.3E-04
VOC	2-Butanone	78-93-3		6.30E-03	1.43E-07	5.0E+00	2.7E-08
VOC	Carbon Disulfide	75-15-0		9.10E-04	7.44E-08	7.0E-01	1.0E-07
VOC	Carbon Tetrachloride	56-23-5				1.0E-01	
VOC	Chlorobenzene	108-90-7				5.0E-02	
VOC	Chloroethane	75-00-3				1.0E+01	
VOC	Chloroform	67-66-3				5.0E-02	
VOC	Chloromethane	74-87-3				9.0E-02	
VOC	Dibromochloromethane	124-48-1					
VOC	1,1-Dichloroethane	75-34-3				5.0E-01	
VOC	1,2-Dichloroethane	107-06-2				7.0E-03	
VOC	1,1-Dichloroethene	75-35-4				2.0E-01	
VOC	1,2-Dichloroethene (total)	540-59-0					
VOC	cis-1,2-Dichloroethene	156-59-2					
VOC	trans-1,2-Dichloroethene	156-60-5					
VOC	1,2-Dichloropropane	78-87-5				4.0E-03	
VOC	Ethyl Benzene	100-41-4				1.0E+00	
VOC	2-Hexanone	591-78-6				3.0E-02	
VOC	4-Methyl-2-pentanone	108-10-1				3.0E+00	
VOC	Methylene Chloride	75-09-2		3.30E-03	2.23E-07	6.0E-01	3.6E-07
VOC	Styrene	100-42-5				1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5					
VOC	Tetrachloroethene	127-18-4				4.0E-02	
VOC	Toluene	108-88-3		1.20E-03	8.10E-08	5.0E+00	1.6E-08
VOC	1,1,1-Trichloroethane	71-55-6				5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5					
VOC	Trichloroethene	79-01-6		1.60E-02	1.14E-06	2.0E-03	5.5E-04
VOC	Vinyl Chloride	75-01-4				1.0E-01	
VOC	Xylenes (total)	1330-20-7		3.60E-03	2.15E-07	1.0E-01	2.1E-06
INORG	Iron	7439-89-6					
INORG	Manganese	7439-96-5				5.0E-05	
		Hazard Index:					**7E-04**

RAMBOLL ENVIRON

Attachment B5.6: Cancer Risk Calculations for Inhalation Exposure of Residents to Former Drainage Trench Soil Whirlpool, Fort Smith, Arkansas

						Soil Vapor Inhalation				Soil Particulate Inhalation				Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	**ADAF**	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	N	5.86E-02	2.68E-08				6.81E-15				
VOC	Benzene	71-43-2	A	N	6.30E-04	9.14E-10	7.8E-03		2.5E-12	7.32E-17	7.8E-03		2.0E-19	2.5E-12
VOC	Bromodichloromethane	75-27-4	B2	N	2.60E-03	2.23E-09				3.02E-16				
VOC	Bromoform	75-25-2	B2	N			1.1E-03				1.1E-03			
VOC	Bromomethane	74-83-9	ID	N	2.44E-01	3.67E-07				2.83E-14				
VOC	2-Butanone	78-93-3	ID	N	2.50E-01	1.15E-07				2.90E-14				
VOC	Carbon Disulfide	75-15-0		N	2.80E-03	4.66E-09				3.25E-16				
VOC	Carbon Tetrachloride	56-23-5	LC	N	5.20E-03	8.26E-09	6.0E-03		1.8E-11	6.04E-16	6.0E-03		1.3E-18	1.8E-11
VOC	Chlorobenzene	108-90-7	D	N										
VOC	Chloroethane	75-00-3	LC	N										
VOC	Chloroform	67-66-3	B2	N	5.70E-02	8.17E-08	2.3E-02		6.7E-10	6.62E-15	2.3E-02		5.4E-17	6.7E-10
VOC	Chloromethane	74-87-3	D	N										
VOC	Dibromochloromethane	124-48-1	C	N										
VOC	1,1-Dichloroethane	75-34-3	SC	N	8.80E-03	1.28E-08				1.02E-15				
VOC	1,2-Dichloroethane	107-06-2	B2	N	1.81E-01	2.11E-07	2.6E-02		2.0E-09	2.10E-14	2.6E-02		1.9E-16	2.0E-09
VOC	1,1-Dichloroethene	75-35-4	C	N	1.60E-01	2.62E-07				1.86E-14				
VOC	1,2-Dichloroethene (total)	540-59-0		N	5.20E+00	7.23E-06				6.04E-13				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	N	1.85E+01	2.57E-05				2.15E-12				
VOC	trans-1,2-Dichloroethene	156-60-5	ID	N	2.40E-01	3.62E-07				2.79E-14				
VOC	1,2-Dichloropropane	78-87-5	B2	N										
VOC	Ethyl Benzene	100-41-4	D	N	1.40E-03	1.76E-09				1.63E-16				
VOC	2-Hexanone	591-78-6	ID	N	7.30E-02	3.83E-08				8.48E-15				
VOC	4-Methyl-2-pentanone	108-10-1	ID	N	1.75E-02	1.01E-08				2.03E-15				
VOC	Methylene Chloride	75-09-2	LC	Y	3.14E+00	4.32E-06	1.0E-05	1		3.65E-13	1.0E-05	1		
VOC	Styrene	100-42-5		N										
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	N										
VOC	Tetrachloroethene	127-18-4	LC	N	1.70E-01	2.58E-07	2.6E-04		2.4E-11	1.97E-14	2.6E-04		1.8E-18	2.4E-11
VOC	Toluene	108-88-3	ID	N	7.03E-02	9.65E-08				8.16E-15				
VOC	1,1,1-Trichloroethane	71-55-6	ID	N	3.20E-02	4.97E-08				3.72E-15				
VOC	1,1,2-Trichloroethane	79-00-5	C	N	3.50E-02	3.42E-08	1.6E-02		1.9E-10	4.06E-15	1.6E-02		2.3E-17	1.9E-10
VOC	Trichloroethene	79-01-6	HC	Y	2.70E+02	3.91E-04	4.1E-03	0.244	4.3E-07	3.14E-11	4.1E-03	0.244	3.5E-14	4.3E-07
VOC	Vinyl Chloride	75-01-4	A	N	4.43E+00	7.41E-06	4.4E-03		4.4E-08	5.15E-13	4.4E-03		3.1E-15	4.4E-08
VOC	Xylenes (total)	1330-20-7	ID	N	8.90E-03	1.08E-08				1.03E-15				
INORG	Iron	7439-89-6	D	N										
INORG	Manganese	7439-96-5	D	N										
		Cumulative Risk:							**5E-07**				**4E-14**	**5E-07**

Notes:

The annual maximum dispersion coefficient to outdoor air (C/Q) is 0.3 (kg/m³) / (kg/m²/s).

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

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Attachment B5.7: Hazard Index Calculations for Inhalation Exposure of Residents to Former Drainage Trench Soil Whirlpool, Fort Smith, Arkansas

				Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**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	5.86E-02	2.68E-08	3.1E+01	8.3E-10	6.81E-15	3.1E+01	2.1E-16	8.3E-10
VOC	Benzene	71-43-2	6.30E-04	9.14E-10	3.0E-02	2.9E-08	7.32E-17	3.0E-02	2.3E-15	2.9E-08
VOC	Bromodichloromethane	75-27-4	2.60E-03	2.23E-09			3.02E-16			
VOC	Bromoform	75-25-2								
VOC	Bromomethane	74-83-9	2.44E-01	3.67E-07	5.0E-03	7.0E-05	2.83E-14	5.0E-03	5.4E-12	7.0E-05
VOC	2-Butanone	78-93-3	2.50E-01	1.15E-07	5.0E+00	2.2E-08	2.90E-14	5.0E+00	5.6E-15	2.2E-08
VOC	Carbon Disulfide	75-15-0	2.80E-03	4.66E-09	7.0E-01	6.4E-09	3.25E-16	7.0E-01	4.5E-16	6.4E-09
VOC	Carbon Tetrachloride	56-23-5	5.20E-03	8.26E-09	1.0E-01	7.9E-08	6.04E-16	1.0E-01	5.8E-15	7.9E-08
VOC	Chlorobenzene	108-90-7			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	5.70E-02	8.17E-08	5.0E-02	1.6E-06	6.62E-15	5.0E-02	1.3E-13	1.6E-06
VOC	Chloromethane	74-87-3			9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1								
VOC	1,1-Dichloroethane	75-34-3	8.80E-03	1.28E-08	5.0E-01	2.5E-08	1.02E-15	5.0E-01	2.0E-15	2.5E-08
VOC	1,2-Dichloroethane	107-06-2	1.81E-01	2.11E-07	7.0E-03	2.9E-05	2.10E-14	7.0E-03	2.9E-12	2.9E-05
VOC	1,1-Dichloroethene	75-35-4	1.60E-01	2.62E-07	2.0E-01	1.3E-06	1.86E-14	2.0E-01	8.9E-14	1.3E-06
VOC	1,2-Dichloroethene (total)	540-59-0	5.20E+00	7.23E-06			6.04E-13			
VOC	cis-1,2-Dichloroethene	156-59-2	1.85E+01	2.57E-05			2.15E-12			
VOC	trans-1,2-Dichloroethene	156-60-5	2.40E-01	3.62E-07			2.79E-14			
VOC	1,2-Dichloropropane	78-87-5			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4	1.40E-03	1.76E-09	1.0E+00	1.7E-09	1.63E-16	1.0E+00	1.6E-16	1.7E-09
VOC	2-Hexanone	591-78-6	7.30E-02	3.83E-08	3.0E-02	1.2E-06	8.48E-15	3.0E-02	2.7E-13	1.2E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.75E-02	1.01E-08	3.0E+00	3.2E-09	2.03E-15	3.0E+00	6.5E-16	3.2E-09
VOC	Methylene Chloride	75-09-2	3.14E+00	4.32E-06	6.0E-01	6.9E-06	3.65E-13	6.0E-01	5.8E-13	6.9E-06
VOC	Styrene	100-42-5			1.0E+00			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5								
VOC	Tetrachloroethene	127-18-4	1.70E-01	2.58E-07	4.0E-02	6.2E-06	1.97E-14	4.0E-02	4.7E-13	6.2E-06
VOC	Toluene	108-88-3	7.03E-02	9.65E-08	5.0E+00	1.9E-08	8.16E-15	5.0E+00	1.6E-15	1.9E-08
VOC	1,1,1-Trichloroethane	71-55-6	3.20E-02	4.97E-08	5.0E+00	9.5E-09	3.72E-15	5.0E+00	7.1E-16	9.5E-09
VOC	1,1,2-Trichloroethane	79-00-5	3.50E-02	3.42E-08			4.06E-15			
VOC	Trichloroethene	79-01-6	2.70E+02	3.91E-04	2.0E-03	1.9E-01	3.14E-11	2.0E-03	1.5E-08	1.9E-01
VOC	Vinyl Chloride	75-01-4	4.43E+00	7.41E-06	1.0E-01	7.1E-05	5.15E-13	1.0E-01	4.9E-12	7.1E-05
VOC	Xylenes (total)	1330-20-7	8.90E-03	1.08E-08	1.0E-01	1.0E-07	1.03E-15	1.0E-01	9.9E-15	1.0E-07
INORG	Iron	7439-89-6								
INORG	Manganese	7439-96-5			5.0E-05			5.0E-05		
		Hazard Index:				**2E-01**			**2E-08**	**2E-01**
Notes:										
The annual maximum dispersion coefficient to outdoor air (C/Q) is 0.3 (kg/m³) / (kg/m²/s).										

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Attachment B5.8: Cancer Risk Calculations for Inhalation Exposure of Residents to Remaining Site Soil
Whirlpool, Fort Smith, Arkansas

						Soil Vapor Inhalation				Soil Particulate Inhalation				Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	**ADAF**	**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	N	5.16E-02	2.78E-07				7.06E-14				
VOC	Benzene	71-43-2	A	N			7.8E-03				7.8E-03			
VOC	Bromodichloromethane	75-27-4	B2	N										
VOC	Bromoform	75-25-2	B2	N	6.10E-03	2.72E-08	1.1E-03		1.1E-11	8.34E-15	1.1E-03		3.3E-18	1.1E-11
VOC	Bromomethane	74-83-9	ID	N										
VOC	2-Butanone	78-93-3	ID	N										
VOC	Carbon Disulfide	75-15-0		N	7.40E-03	1.45E-07				1.01E-14				
VOC	Carbon Tetrachloride	56-23-5	LC	N			6.0E-03				6.0E-03			
VOC	Chlorobenzene	108-90-7	D	N										
VOC	Chloroethane	75-00-3	LC	N										
VOC	Chloroform	67-66-3	B2	N	5.20E-03	8.78E-08	2.3E-02		7.2E-10	7.11E-15	2.3E-02		5.8E-17	7.2E-10
VOC	Chloromethane	74-87-3	D	N										
VOC	Dibromochloromethane	124-48-1	C	N										
VOC	1,1-Dichloroethane	75-34-3	SC	N										
VOC	1,2-Dichloroethane	107-06-2	B2	N	7.20E-03	9.86E-08	2.6E-02		9.1E-10	9.85E-15	2.6E-02		9.1E-17	9.1E-10
VOC	1,1-Dichloroethene	75-35-4	C	N	1.10E-03	2.12E-08				1.50E-15				
VOC	1,2-Dichloroethene (total)	540-59-0		N	4.90E-01	8.02E-06				6.70E-13				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	N	4.90E-01	8.02E-06				6.70E-13				
VOC	trans-1,2-Dichloroethene	156-60-5	ID	N										
VOC	1,2-Dichloropropane	78-87-5	B2	N										
VOC	Ethyl Benzene	100-41-4	D	N										
VOC	2-Hexanone	591-78-6	ID	N	5.90E-02	3.64E-07				8.07E-14				
VOC	4-Methyl-2-pentanone	108-10-1	ID	N										
VOC	Methylene Chloride	75-09-2	LC	Y	7.00E-03	1.13E-07	1.0E-05	1		9.57E-15	1.0E-05	1		
VOC	Styrene	100-42-5		N										
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	N										
VOC	Tetrachloroethene	127-18-4	LC	N	4.40E-03	7.87E-08	2.6E-04		7.3E-12	6.02E-15	2.6E-04		5.6E-19	7.3E-12
VOC	Toluene	108-88-3	ID	N	1.60E-03	2.59E-08				2.19E-15				
VOC	1,1,1-Trichloroethane	71-55-6	ID	N										
VOC	1,1,2-Trichloroethane	79-00-5	C	N			1.6E-02				1.6E-02			
VOC	Trichloroethene	79-01-6	HC	Y	1.70E+00	2.90E-05	4.1E-03	0.244	3.2E-08	2.32E-12	4.1E-03	0.244	2.6E-15	3.2E-08
VOC	Vinyl Chloride	75-01-4	A	N	3.80E-02	7.49E-07	4.4E-03		4.5E-09	5.20E-14	4.4E-03		3.1E-16	4.5E-09
VOC	Xylenes (total)	1330-20-7	ID	N										
INORG	Iron	7439-89-6	D	N										
INORG	Manganese	7439-96-5	D	N										
		Cumulative Risk:							**4E-08**				**3E-15**	**4E-08**

Notes:

The annual maximum dispersion coefficient to outdoor air (C/Q) is 3.5 (kg/m³) / (kg/m²/s).

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

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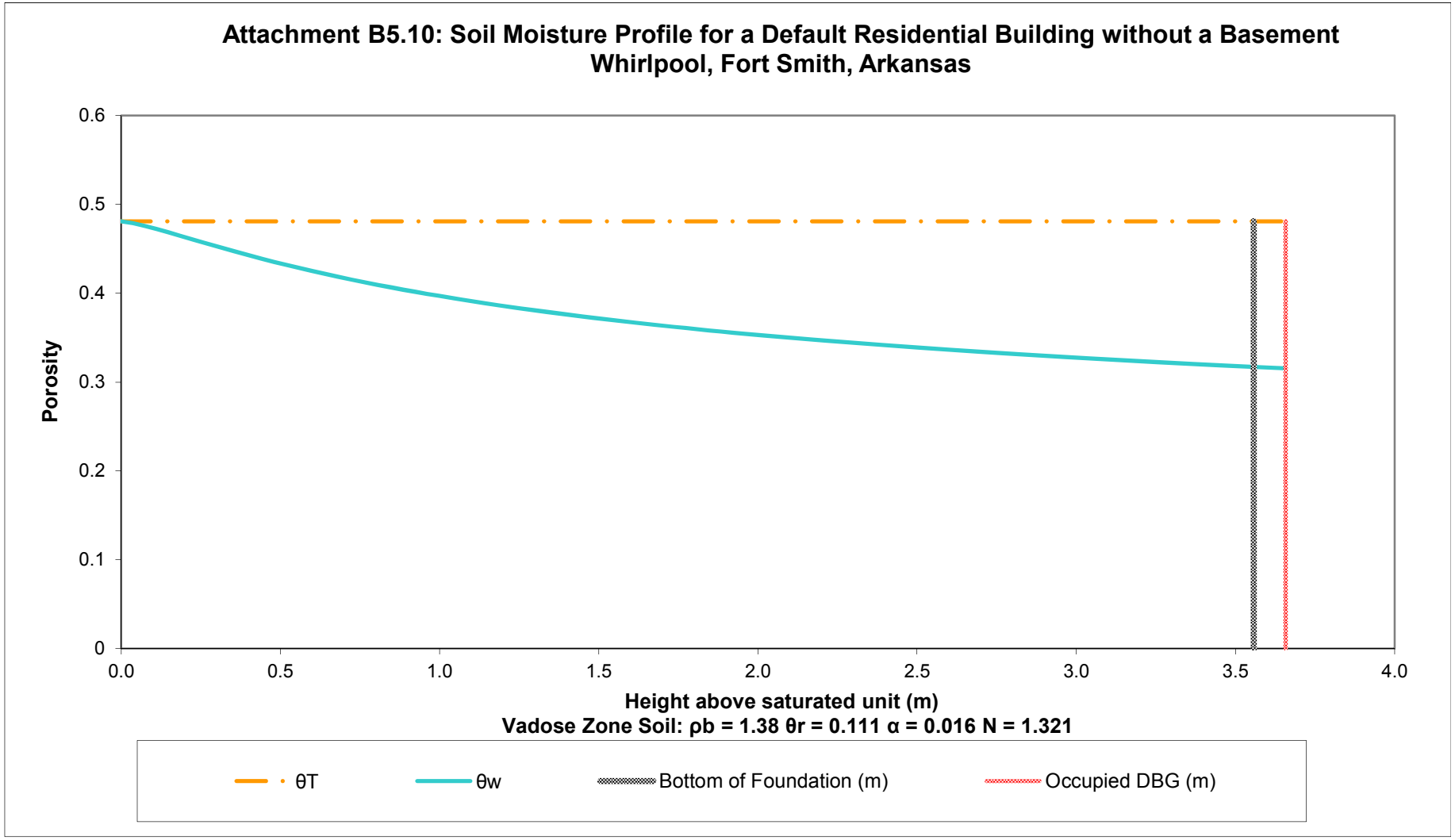
Attachment B5.9: Hazard Index Calculations for Inhalation Exposure of Residents to Remaining Site Soil
Whirlpool, Fort Smith, Arkansas

				Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**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	5.16E-02	2.78E-07	3.1E+01	8.6E-09	7.06E-14	3.1E+01	2.2E-15	8.6E-09
VOC	Benzene	71-43-2			3.0E-02			3.0E-02		
VOC	Bromodichloromethane	75-27-4								
VOC	Bromoform	75-25-2	6.10E-03	2.72E-08			8.34E-15			
VOC	Bromomethane	74-83-9			5.0E-03			5.0E-03		
VOC	2-Butanone	78-93-3			5.0E+00			5.0E+00		
VOC	Carbon Disulfide	75-15-0	7.40E-03	1.45E-07	7.0E-01	2.0E-07	1.01E-14	7.0E-01	1.4E-14	2.0E-07
VOC	Carbon Tetrachloride	56-23-5			1.0E-01			1.0E-01		
VOC	Chlorobenzene	108-90-7			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	5.20E-03	8.78E-08	5.0E-02	1.7E-06	7.11E-15	5.0E-02	1.4E-13	1.7E-06
VOC	Chloromethane	74-87-3			9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1								
VOC	1,1-Dichloroethane	75-34-3			5.0E-01			5.0E-01		
VOC	1,2-Dichloroethane	107-06-2	7.20E-03	9.86E-08	7.0E-03	1.4E-05	9.85E-15	7.0E-03	1.3E-12	1.4E-05
VOC	1,1-Dichloroethene	75-35-4	1.10E-03	2.12E-08	2.0E-01	1.0E-07	1.50E-15	2.0E-01	7.2E-15	1.0E-07
VOC	1,2-Dichloroethene (total)	540-59-0	4.90E-01	8.02E-06			6.70E-13			
VOC	cis-1,2-Dichloroethene	156-59-2	4.90E-01	8.02E-06			6.70E-13			
VOC	trans-1,2-Dichloroethene	156-60-5								
VOC	1,2-Dichloropropane	78-87-5			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4			1.0E+00			1.0E+00		
VOC	2-Hexanone	591-78-6	5.90E-02	3.64E-07	3.0E-02	1.2E-05	8.07E-14	3.0E-02	2.6E-12	1.2E-05
VOC	4-Methyl-2-pentanone	108-10-1			3.0E+00			3.0E+00		
VOC	Methylene Chloride	75-09-2	7.00E-03	1.13E-07	6.0E-01	1.8E-07	9.57E-15	6.0E-01	1.5E-14	1.8E-07
VOC	Styrene	100-42-5			1.0E+00			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5								
VOC	Tetrachloroethene	127-18-4	4.40E-03	7.87E-08	4.0E-02	1.9E-06	6.02E-15	4.0E-02	1.4E-13	1.9E-06
VOC	Toluene	108-88-3	1.60E-03	2.59E-08	5.0E+00	5.0E-09	2.19E-15	5.0E+00	4.2E-16	5.0E-09
VOC	1,1,1-Trichloroethane	71-55-6			5.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5								
VOC	Trichloroethene	79-01-6	1.70E+00	2.90E-05	2.0E-03	1.4E-02	2.32E-12	2.0E-03	1.1E-09	1.4E-02
VOC	Vinyl Chloride	75-01-4	3.80E-02	7.49E-07	1.0E-01	7.2E-06	5.20E-14	1.0E-01	5.0E-13	7.2E-06
VOC	Xylenes (total)	1330-20-7			1.0E-01			1.0E-01		
INORG	Iron	7439-89-6								
INORG	Manganese	7439-96-5			5.0E-05			5.0E-05		
	Hazard Index:					**1E-02**			**1E-09**	**1E-02**
Notes:										
The annual maximum dispersion coefficient to outdoor air (C/Q) is 3.5 (kg/m³) / (kg/m²/s).										

RAMBOLL ENVIRON


Attachment B5.10: Soil Moisture Profile for a Default Residential Building without a Basement
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)
Vadose Zone Soil: ρb = 1.38 θr = 0.111 α = 0.016 N = 1.321
θT
θw
Bottom of Foundation (m)
Occupied DBG (m)

Attachment B5.11: Normalized Indoor Air Concentration in a Default Residential Building without a Basement due to Soil-derived Vapor Intrusion
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)	$C_{b,\infty}$ (kg-soil/m^3)	$C_{b,\,norm}$ (kg-soil/m^3)
VOC	Acetone	67-64-1	1.07E+00	9.85E-05	1.14E-03	1.72E-01	1.93E-02	6.12E-03	5.81E-01	1.16E-03	4.93E+00	3.02E-02	3.02E-02
VOC	Benzene	71-43-2	7.60E-01	8.47E-05	1.59E-01	1.22E-01	7.94E-03	6.08E-03	5.82E+01	1.16E-01	4.35E+02	2.65E+00	3.53E-02
VOC	Bromodichloromethane	75-27-4	2.57E-01	9.16E-05	4.45E-02	4.13E-02	2.87E-03	5.97E-03	5.51E+01	1.10E-01	1.29E+02	7.69E-01	3.53E-02
VOC	Bromoform	75-25-2	1.29E-01	8.90E-05	1.34E-02	2.07E-02	1.96E-03	5.88E-03	8.70E+01	1.74E-01	3.29E+01	1.94E-01	3.53E-02
VOC	Bromomethane	74-83-9	6.29E-01	1.05E-04	2.01E-01	1.01E-01	6.58E-03	6.07E-03	1.05E+01	2.10E-02	7.32E+02	4.44E+00	3.53E-02
VOC	2-Butanone	78-93-3	6.98E-01	8.47E-05	2.00E-03	1.12E-01	1.12E-02	6.10E-03	2.00E+00	3.99E-03	8.53E+00	5.21E-02	3.53E-02
VOC	Carbon Disulfide	75-15-0	8.99E-01	8.64E-05	9.26E-01	1.44E-01	9.33E-03	6.09E-03	4.59E+01	9.19E-02	2.14E+03	1.31E+01	3.53E-02
VOC	Carbon Tetrachloride	56-23-5	6.74E-01	7.60E-05	8.82E-01	1.08E-01	7.00E-03	6.08E-03	1.74E+02	3.48E-01	1.29E+03	7.86E+00	3.53E-02
VOC	Chlorobenzene	108-90-7	6.31E-01	7.52E-05	9.77E-02	1.01E-01	6.62E-03	6.07E-03	2.20E+02	4.41E-01	1.43E+02	8.69E-01	3.53E-02
VOC	Chloroethane	75-00-3	2.34E+00	9.94E-05	4.09E-01	3.76E-01	2.43E-02	6.13E-03	1.62E+01	3.25E-02	1.32E+03	8.07E+00	3.53E-02
VOC	Chloroform	67-66-3	8.99E-01	8.64E-05	1.07E-01	1.44E-01	9.40E-03	6.10E-03	3.97E+01	7.94E-02	3.34E+02	2.03E+00	3.53E-02
VOC	Chloromethane	74-87-3	1.09E+00	5.62E-05	3.33E-01	1.75E-01	1.13E-02	6.10E-03	3.97E+01	7.94E-02	9.54E+02	5.82E+00	3.53E-02
VOC	Dibromochloromethane	124-48-1	1.69E-01	9.07E-05	2.38E-02	2.72E-02	2.12E-03	5.90E-03	6.26E+01	1.25E-01	6.66E+01	3.93E-01	3.53E-02
VOC	1,1-Dichloroethane	75-34-3	6.41E-01	9.07E-05	1.66E-01	1.03E-01	6.70E-03	6.07E-03	3.13E+01	6.27E-02	5.31E+02	3.22E+00	3.53E-02
VOC	1,2-Dichloroethane	107-06-2	8.99E-01	8.55E-05	2.74E-02	1.44E-01	9.62E-03	6.10E-03	1.75E+01	3.50E-02	1.02E+02	6.23E-01	3.53E-02
VOC	1,1-Dichloroethene	75-35-4	7.78E-01	8.99E-05	8.10E-01	1.25E-01	8.08E-03	6.09E-03	5.82E+01	1.16E-01	1.83E+03	1.11E+01	3.53E-02
VOC	1,2-Dichloroethene (total)	540-59-0	6.36E-01	9.76E-05	1.19E-01	1.02E-01	6.68E-03	6.07E-03	3.56E+01	7.12E-02	3.76E+02	2.28E+00	3.53E-02
VOC	cis-1,2-Dichloroethene	156-59-2	6.36E-01	9.76E-05	1.19E-01	1.02E-01	6.68E-03	6.07E-03	3.56E+01	7.12E-02	3.76E+02	2.28E+00	3.53E-02
VOC	trans-1,2-Dichloroethene	156-60-5	6.11E-01	1.03E-04	2.81E-01	9.81E-02	6.37E-03	6.07E-03	5.22E+01	1.04E-01	7.65E+02	4.64E+00	3.53E-02
VOC	1,2-Dichloropropane	78-87-5	6.76E-01	7.54E-05	7.82E-02	1.08E-01	7.10E-03	6.08E-03	4.35E+01	8.70E-02	2.40E+02	1.46E+00	3.53E-02
VOC	Ethyl Benzene	100-41-4	6.48E-01	6.74E-05	2.04E-01	1.04E-01	6.75E-03	6.07E-03	3.67E+02	7.35E-01	2.06E+02	1.25E+00	3.53E-02
VOC	2-Hexanone	591-78-6	7.45E-01	7.57E-05	3.23E-03	1.20E-01	9.93E-03	6.10E-03	1.48E+01	2.97E-02	1.24E+01	7.59E-02	3.53E-02
VOC	4-Methyl-2-pentanone	108-10-1	6.48E-01	6.74E-05	4.71E-03	1.04E-01	8.07E-03	6.09E-03	1.05E+01	2.10E-02	1.87E+01	1.14E-01	3.53E-02
VOC	Methylene Chloride	75-09-2	8.73E-01	1.01E-04	6.60E-02	1.40E-01	9.20E-03	6.09E-03	1.17E+01	2.34E-02	2.53E+02	1.54E+00	3.53E-02
VOC	Styrene	100-42-5	6.13E-01	6.91E-05	7.04E-02	9.85E-02	6.46E-03	6.07E-03	7.77E+02	1.55E+00	3.93E+01	2.38E-01	3.53E-02
VOC	1,1,2,2-Tetrachloroethane	79-34-5	6.13E-01	6.83E-05	8.74E-03	9.85E-02	7.10E-03	6.08E-03	9.35E+01	1.87E-01	2.09E+01	1.27E-01	3.53E-02
VOC	Tetrachloroethene	127-18-4	6.22E-01	7.08E-05	4.90E-01	9.99E-02	6.47E-03	6.07E-03	1.56E+02	3.12E-01	8.18E+02	4.96E+00	3.53E-02
VOC	Toluene	108-88-3	7.52E-01	7.43E-05	1.80E-01	1.21E-01	7.84E-03	6.08E-03	1.80E+02	3.61E-01	2.95E+02	1.79E+00	3.53E-02
VOC	1,1,1-Trichloroethane	71-55-6	6.74E-01	7.60E-05	4.97E-01	1.08E-01	7.01E-03	6.08E-03	1.10E+02	2.20E-01	9.76E+02	5.93E+00	3.53E-02
VOC	1,1,2-Trichloroethane	79-00-5	6.74E-01	7.60E-05	2.43E-02	1.08E-01	7.29E-03	6.08E-03	5.03E+01	1.01E-01	7.29E+01	4.43E-01	3.53E-02
VOC	Trichloroethene	79-01-6	6.83E-01	7.86E-05	2.88E-01	1.10E-01	7.11E-03	6.08E-03	1.68E+02	3.35E-01	4.81E+02	2.92E+00	3.53E-02
VOC	Vinyl Chloride	75-01-4	9.16E-01	1.06E-04	9.00E-01	1.47E-01	9.51E-03	6.10E-03	1.85E+01	3.69E-02	2.41E+03	1.47E+01	3.53E-02
VOC	Xylenes (total)	1330-20-7	6.74E-01	7.56E-05	1.73E-01	1.08E-01	7.03E-03	6.08E-03	3.86E+02	7.71E-01	1.70E+02	1.03E+00	3.53E-02
INORG	Iron	7439-89-6								2.50E+01			
INORG	Manganese	7439-96-5								6.50E+01			

Notes:	Soil and Building Characteristics			Crack Soil		Source Soil
	SCS Soil texture class			Sand		Silty Clay
	Bulk density	kg/L	ρ_b	1.66		1.38
	Total porosity	L/L-soil	θ_T	0.375		0.481
	Water-filled porosity	L/L-soil	θ_w	0.054		0.317
	Air-filled porosity	L/L-soil	θ_a	0.321		0.164
	Organic carbon fraction	unitless	f_{oc}	NA		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	3.18		
	van Genuchten M	unitless	M	0.685		
	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}	0.1		
	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}	4.00E-02		
	Air exchange rate	$hour^{-1}$	ach	0.3		
	Building ventilation rate	m^3/day	Q_{bldg}	1.46E+03		
	Pressure difference between outdoors-indoors	kg/m-s^2	ΔP	4.0		
	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}	0.1		
	Crack radius	m	r_{crack}	1E-03		
	Soil gas flow rate into bldg	m^3/day	Q_{soil}	9.01E+00		
	Averaging period	d	ED	9.49E+03		
	Contaminant thickness	m	ΔH	3.5566		
	Indoor air conc by mass balance	kg-soil/m^3	$C_{b,ML}$	3.53E-02		
	Molar Gas Constant	mmHg-m^3/mole-^oK	R	6.24E-02		
	Temperature	^oC	T	16.7		
		K	T	289.85		

RAMBOLL ENVIRON

Attachment B5.12: Normalized Indoor Air Concentration in a Default Residential Building without a Basement due to Groundwater-derived Vapor Intrusion
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_∞	$C_{b,\,norm}$ (L-water/m^3)
VOC	Acetone	67-64-1	1.07E+00	9.85E-05	1.14E-03	1.72E-01	1.87E-02	5.51E-02	6.15E-03	3.39E-04	3.87E-04
VOC	Benzene	71-43-2	7.60E-01	8.47E-05	1.59E-01	1.22E-01	8.15E-04	2.54E-03	6.15E-03	1.56E-05	2.48E-03
VOC	Bromodichloromethane	75-27-4	2.57E-01	9.16E-05	4.45E-02	4.13E-02	1.07E-03	3.33E-03	6.15E-03	2.05E-05	9.13E-04
VOC	Bromoform	75-25-2	1.29E-01	8.90E-05	1.34E-02	2.07E-02	1.64E-03	5.10E-03	6.15E-03	3.14E-05	4.19E-04
VOC	Bromomethane	74-83-9	6.29E-01	1.05E-04	2.01E-01	1.01E-01	7.43E-04	2.31E-03	6.15E-03	1.42E-05	2.86E-03
VOC	2-Butanone	78-93-3	6.98E-01	8.47E-05	2.00E-03	1.12E-01	9.94E-03	3.01E-02	6.15E-03	1.85E-04	3.70E-04
VOC	Carbon Disulfide	75-15-0	8.99E-01	8.64E-05	9.26E-01	1.44E-01	2.93E-04	9.13E-04	6.15E-03	5.62E-06	5.20E-03
VOC	Carbon Tetrachloride	56-23-5	6.74E-01	7.60E-05	8.82E-01	1.08E-01	2.52E-04	7.85E-04	6.15E-03	4.83E-06	4.26E-03
VOC	Chlorobenzene	108-90-7	6.31E-01	7.52E-05	9.77E-02	1.01E-01	9.32E-04	2.90E-03	6.15E-03	1.78E-05	1.74E-03
VOC	Chloroethane	75-00-3	2.34E+00	9.94E-05	4.09E-01	3.76E-01	7.62E-04	2.37E-03	6.15E-03	1.46E-05	5.98E-03
VOC	Chloroform	67-66-3	8.99E-01	8.64E-05	1.07E-01	1.44E-01	1.11E-03	3.46E-03	6.15E-03	2.13E-05	2.29E-03
VOC	Chloromethane	74-87-3	1.09E+00	5.62E-05	3.33E-01	1.75E-01	4.61E-04	1.44E-03	6.15E-03	8.83E-06	2.94E-03
VOC	Dibromochloromethane	124-48-1	1.69E-01	9.07E-05	2.38E-02	2.72E-02	1.27E-03	3.95E-03	6.15E-03	2.43E-05	5.79E-04
VOC	1,1-Dichloroethane	75-34-3	6.41E-01	9.07E-05	1.66E-01	1.03E-01	7.72E-04	2.40E-03	6.15E-03	1.48E-05	2.45E-03
VOC	1,2-Dichloroethane	107-06-2	8.99E-01	8.55E-05	2.74E-02	1.44E-01	2.37E-03	7.35E-03	6.15E-03	4.53E-05	1.24E-03
VOC	1,1-Dichloroethene	75-35-4	7.78E-01	8.99E-05	8.10E-01	1.25E-01	3.12E-04	9.72E-04	6.15E-03	5.98E-06	4.84E-03
VOC	1,2-Dichloroethene (total)	540-59-0	6.36E-01	9.76E-05	1.19E-01	1.02E-01	9.72E-04	3.02E-03	6.15E-03	1.86E-05	2.21E-03
VOC	cis-1,2-Dichloroethene	156-59-2	6.36E-01	9.76E-05	1.19E-01	1.02E-01	9.72E-04	3.02E-03	6.15E-03	1.86E-05	2.21E-03
VOC	trans-1,2-Dichloroethene	156-60-5	6.11E-01	1.03E-04	2.81E-01	9.81E-02	5.96E-04	1.86E-03	6.15E-03	1.14E-05	3.22E-03
VOC	1,2-Dichloropropane	78-87-5	6.76E-01	7.54E-05	7.82E-02	1.08E-01	1.09E-03	3.39E-03	6.15E-03	2.09E-05	1.63E-03
VOC	Ethyl Benzene	100-41-4	6.48E-01	6.74E-05	2.04E-01	1.04E-01	5.75E-04	1.79E-03	6.15E-03	1.10E-05	2.25E-03
VOC	2-Hexanone	591-78-6	7.45E-01	7.57E-05	3.23E-03	1.20E-01	6.86E-03	2.10E-02	6.15E-03	1.29E-04	4.17E-04
VOC	4-Methyl-2-pentanone	108-10-1	6.48E-01	6.74E-05	4.71E-03	1.04E-01	4.81E-03	1.48E-02	6.15E-03	9.10E-05	4.29E-04
VOC	Methylene Chloride	75-09-2	8.73E-01	1.01E-04	6.60E-02	1.40E-01	1.58E-03	4.92E-03	6.15E-03	3.03E-05	2.00E-03
VOC	Styrene	100-42-5	6.13E-01	6.91E-05	7.04E-02	9.85E-02	1.06E-03	3.29E-03	6.15E-03	2.02E-05	1.42E-03
VOC	1,1,2,2-Tetrachloroethane	79-34-5	6.13E-01	6.83E-05	8.74E-03	9.85E-02	3.31E-03	1.02E-02	6.15E-03	6.29E-05	5.50E-04
VOC	Tetrachloroethene	127-18-4	6.22E-01	7.08E-05	4.90E-01	9.99E-02	3.40E-04	1.06E-03	6.15E-03	6.53E-06	3.20E-03
VOC	Toluene	108-88-3	7.52E-01	7.43E-05	1.80E-01	1.21E-01	6.97E-04	2.17E-03	6.15E-03	1.33E-05	2.41E-03
VOC	1,1,1-Trichloroethane	71-55-6	6.74E-01	7.60E-05	4.97E-01	1.08E-01	3.64E-04	1.13E-03	6.15E-03	6.97E-06	3.47E-03
VOC	1,1,2-Trichloroethane	79-00-5	6.74E-01	7.60E-05	2.43E-02	1.08E-01	2.09E-03	6.47E-03	6.15E-03	3.98E-05	9.67E-04
VOC	Trichloroethene	79-01-6	6.83E-01	7.86E-05	2.88E-01	1.10E-01	5.23E-04	1.63E-03	6.15E-03	1.00E-05	2.89E-03
VOC	Vinyl Chloride	75-01-4	9.16E-01	1.06E-04	9.00E-01	1.47E-01	3.44E-04	1.07E-03	6.15E-03	6.60E-06	5.94E-03
VOC	Xylenes (total)	1330-20-7	6.74E-01	7.56E-05	1.73E-01	1.08E-01	6.90E-04	2.15E-03	6.15E-03	1.32E-05	2.29E-03
INORG	Iron	7439-89-6									
INORG	Manganese	7439-96-5									
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 to source	m	$L_{T\text{-}gw}$	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	0.25							
	Building ventilation rate	m^3/day	Q_{bldg}	1.46E+03							
	Pressure difference between outdoors-indoors	kg/m-s^2	ΔP	4.0							
	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}	9.01							

RAMBOLL ENVIRON

Attachment B5.13: Cancer Risk and Hazard Index Calculations for Soil-derived Vapor Intrusion into a Default Residential Building without a Basement
Whirlpool, Fort Smith, Arkansas

							Cancer				Noncancer	
Chem Group	**Chemical**	**CASRN**	**Carc Class**	**ADAF**	**C_{soil}** (mg/kg)	**C_{air}** (mg/m^3)	**URF** (m^3/mg)	**f_{inh}**	**Risk**		**RfC** (mg/m^3)	**HQ**
VOC	Acetone	67-64-1	ID	N	6.23E-02	1.88E-03					3.1E+01	5.8E-05
VOC	Benzene	71-43-2	A	N			7.8E-03				3.0E-02	
VOC	Bromodichloromethane	75-27-4	B2	N								
VOC	Bromoform	75-25-2	B2	N			1.1E-03					
VOC	Bromomethane	74-83-9	ID	N	9.30E-03	3.29E-04					5.0E-03	6.3E-02
VOC	2-Butanone	78-93-3	ID	N	6.30E-03	2.23E-04					5.0E+00	4.3E-05
VOC	Carbon Disulfide	75-15-0		N	9.10E-04	3.21E-05					7.0E-01	4.4E-05
VOC	Carbon Tetrachloride	56-23-5	LC	N			6.0E-03				1.0E-01	
VOC	Chlorobenzene	108-90-7	D	N							5.0E-02	
VOC	Chloroethane	75-00-3	LC	N							1.0E+01	
VOC	Chloroform	67-66-3	B2	N			2.3E-02				5.0E-02	
VOC	Chloromethane	74-87-3	D	N							9.0E-02	
VOC	Dibromochloromethane	124-48-1	C	N								
VOC	1,1-Dichloroethane	75-34-3	SC	N							5.0E-01	
VOC	1,2-Dichloroethane	107-06-2	B2	N			2.6E-02				7.0E-03	
VOC	1,1-Dichloroethene	75-35-4	C	N							2.0E-01	
VOC	1,2-Dichloroethene (total)	540-59-0		N								
VOC	cis-1,2-Dichloroethene	156-59-2	ID	N								
VOC	trans-1,2-Dichloroethene	156-60-5	ID	N								
VOC	1,2-Dichloropropane	78-87-5	B2	N							4.0E-03	
VOC	Ethyl Benzene	100-41-4	D	N							1.0E+00	
VOC	2-Hexanone	591-78-6	ID	N							3.0E-02	
VOC	4-Methyl-2-pentanone	108-10-1	ID	N							3.0E+00	
VOC	Methylene Chloride	75-09-2	LC	Y	3.30E-03	1.17E-04	1.0E-05	1	1.1E-09		6.0E-01	1.9E-04
VOC	Styrene	100-42-5		N							1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	N								
VOC	Tetrachloroethene	127-18-4	LC	N			2.6E-04				4.0E-02	
VOC	Toluene	108-88-3	ID	N	1.20E-03	4.24E-05					5.0E+00	8.1E-06
VOC	1,1,1-Trichloroethane	71-55-6	ID	N							5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5	C	N			1.6E-02					
VOC	Trichloroethene	79-01-6	HC	Y	1.60E-02	5.65E-04	4.1E-03	0.2439	1.2E-06		2.0E-03	2.7E-01
VOC	Vinyl Chloride	75-01-4	A	N			4.4E-03				1.0E-01	
VOC	Xylenes (total)	1330-20-7	ID	N	3.60E-03	1.27E-04					1.0E-01	1.2E-03
INORG	Iron	7439-89-6	D	N								
INORG	Manganese	7439-96-5	D	N							5.0E-05	
						Cumulative Risk:			1E-06		**HI:**	3E-01

Note:

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

RAMBOLL ENVIRON

Attachment B5.14: Cancer Risk and Hazard Index Calculations for Groundwater-derived Vapor Intrusion into a Default Residential Building without a Basement
Whirlpool, Fort Smith, Arkansas

							Cancer				Noncancer	
Chem Group	**Chemical**	**CASRN**	**Carc Class**	**ADAF**	**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	N	6.36E-01	2.46E-04					3.1E+01	7.6E-06
VOC	Benzene	71-43-2	A	N	5.70E-04	1.41E-06	7.8E-03		3.9E-09		3.0E-02	4.5E-05
VOC	Bromodichloromethane	75-27-4	B2	N								
VOC	Bromoform	75-25-2	B2	N	1.12E-02	4.69E-06	1.1E-03		1.8E-09			
VOC	Bromomethane	74-83-9	ID	N	5.16E-02	1.48E-04					5.0E-03	2.8E-02
VOC	2-Butanone	78-93-3	ID	N	8.10E-01	3.00E-04					5.0E+00	5.7E-05
VOC	Carbon Disulfide	75-15-0		N	6.20E-03	3.23E-05					7.0E-01	4.4E-05
VOC	Carbon Tetrachloride	56-23-5	LC	N			6.0E-03				1.0E-01	
VOC	Chlorobenzene	108-90-7	D	N							5.0E-02	
VOC	Chloroethane	75-00-3	LC	N	8.20E-04	4.90E-06					1.0E+01	4.7E-07
VOC	Chloroform	67-66-3	B2	N	7.60E-03	1.74E-05	2.3E-02		1.4E-07		5.0E-02	3.3E-04
VOC	Chloromethane	74-87-3	D	N	4.87E-02	1.43E-04					9.0E-02	1.5E-03
VOC	Dibromochloromethane	124-48-1	C	N	2.20E-04	1.27E-07						
VOC	1,1-Dichloroethane	75-34-3	SC	N							5.0E-01	
VOC	1,2-Dichloroethane	107-06-2	B2	N	1.60E-04	1.99E-07	2.6E-02		1.8E-09		7.0E-03	2.7E-05
VOC	1,1-Dichloroethene	75-35-4	C	N	3.50E-03	1.70E-05					2.0E-01	8.1E-05
VOC	1,2-Dichloroethene (total)	540-59-0		N								
VOC	cis-1,2-Dichloroethene	156-59-2	ID	N	1.11E-01	2.45E-04						
VOC	trans-1,2-Dichloroethene	156-60-5	ID	N	2.50E-03	8.04E-06						
VOC	1,2-Dichloropropane	78-87-5	B2	N	2.50E-04	4.08E-07					4.0E-03	9.8E-05
VOC	Ethyl Benzene	100-41-4	D	N							1.0E+00	
VOC	2-Hexanone	591-78-6	ID	N	3.60E-03	1.50E-06					3.0E-02	4.8E-05
VOC	4-Methyl-2-pentanone	108-10-1	ID	N	4.00E-03	1.71E-06					3.0E+00	5.5E-07
VOC	Methylene Chloride	75-09-2	LC	Y	4.65E-03	9.28E-06	1.0E-05	1	9.2E-11		6.0E-01	1.5E-05
VOC	Styrene	100-42-5		N							1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	N								
VOC	Tetrachloroethene	127-18-4	LC	N	8.90E-04	2.85E-06	2.6E-04		2.6E-10		4.0E-02	6.8E-05
VOC	Toluene	108-88-3	ID	N	3.80E-03	9.15E-06					5.0E+00	1.8E-06
VOC	1,1,1-Trichloroethane	71-55-6	ID	N							5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5	C	N			1.6E-02					
VOC	Trichloroethene	79-01-6	HC	Y	7.20E-01	2.08E-03	4.1E-03	0.244	4.3E-06		2.0E-03	1.0E+00
VOC	Vinyl Chloride	75-01-4	A	N	1.50E-03	8.91E-06	4.4E-03		5.3E-08		1.0E-01	8.5E-05
VOC	Xylenes (total)	1330-20-7	ID	N							1.0E-01	
INORG	Iron	7439-89-6	D	N	7.40E+01							
INORG	Manganese	7439-96-5	D	N	2.00E+01						5.0E-05	
						Cumulative Risk:			5E-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.

RAMBOLL ENVIRON

Attachment B5.15: Cancer Risk and Hazard Index Calculations for Perched Water-derived Vapor Intrusion into a Default Residential Building without a Basement
Whirlpool, Fort Smith, Arkansas

							Cancer				Noncancer	
Chem Group	**Chemical**	**CASRN**	**Carc Class**	**ADAF**	**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	N	1.69E-01	6.53E-05					3.1E+01	2.0E-06
VOC	Benzene	71-43-2	A	N	1.50E-03	3.72E-06	7.8E-03		1.0E-08		3.0E-02	1.2E-04
VOC	Bromodichloromethane	75-27-4	B2	N								
VOC	Bromoform	75-25-2	B2	N			1.1E-03					
VOC	Bromomethane	74-83-9	ID	N	4.80E-03	1.37E-05					5.0E-03	2.6E-03
VOC	2-Butanone	78-93-3	ID	N	3.39E-02	1.25E-05					5.0E+00	2.4E-06
VOC	Carbon Disulfide	75-15-0		N	8.60E-04	4.48E-06					7.0E-01	6.1E-06
VOC	Carbon Tetrachloride	56-23-5	LC	N			6.0E-03				1.0E-01	
VOC	Chlorobenzene	108-90-7	D	N	2.20E-04	3.83E-07					5.0E-02	7.4E-06
VOC	Chloroethane	75-00-3	LC	N	9.60E-04	5.74E-06					1.0E+01	5.5E-07
VOC	Chloroform	67-66-3	B2	N	1.05E-02	2.40E-05	2.3E-02		2.0E-07		5.0E-02	4.6E-04
VOC	Chloromethane	74-87-3	D	N	1.50E-03	4.41E-06					9.0E-02	4.7E-05
VOC	Dibromochloromethane	124-48-1	C	N								
VOC	1,1-Dichloroethane	75-34-3	SC	N							5.0E-01	
VOC	1,2-Dichloroethane	107-06-2	B2	N			2.6E-02				7.0E-03	
VOC	1,1-Dichloroethene	75-35-4	C	N	2.80E-03	1.36E-05					2.0E-01	6.5E-05
VOC	1,2-Dichloroethene (total)	540-59-0		N								
VOC	cis-1,2-Dichloroethene	156-59-2	ID	N	1.88E-02	4.15E-05						
VOC	trans-1,2-Dichloroethene	156-60-5	ID	N	9.20E-04	2.96E-06						
VOC	1,2-Dichloropropane	78-87-5	B2	N							4.0E-03	
VOC	Ethyl Benzene	100-41-4	D	N	5.10E-04	1.15E-06					1.0E+00	1.1E-06
VOC	2-Hexanone	591-78-6	ID	N	1.20E-02	5.01E-06					3.0E-02	1.6E-04
VOC	4-Methyl-2-pentanone	108-10-1	ID	N	2.50E-03	1.07E-06					3.0E+00	3.4E-07
VOC	Methylene Chloride	75-09-2	LC	Y	1.50E-03	2.99E-06	1.0E-05	1	3.0E-11		6.0E-01	4.8E-06
VOC	Styrene	100-42-5		N	1.60E-04	2.28E-07					1.0E+00	2.2E-07
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	N								
VOC	Tetrachloroethene	127-18-4	LC	N	2.60E-04	8.33E-07	2.6E-04		7.7E-11		4.0E-02	2.0E-05
VOC	Toluene	108-88-3	ID	N	1.50E-03	3.61E-06					5.0E+00	6.9E-07
VOC	1,1,1-Trichloroethane	71-55-6	ID	N							5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5	C	N			1.6E-02					
VOC	Trichloroethene	79-01-6	HC	Y	6.36E-01	1.84E-03	4.1E-03	0.244	3.8E-06		2.0E-03	8.8E-01
VOC	Vinyl Chloride	75-01-4	A	N	6.10E-04	3.62E-06	4.4E-03		2.2E-08		1.0E-01	3.5E-05
VOC	Xylenes (total)	1330-20-7	ID	N							1.0E-01	
INORG	Iron	7439-89-6	D	N								
INORG	Manganese	7439-96-5	D	N							5.0E-05	
						Cumulative Risk:			4E-06		**HI:**	9E-01
Note:												
f_{inh} is the fraction of the inhalation toxicity value that USEPA identified as having a mutagenic mode of action.												

RAMBOLL ENVIRON

Attachment B5.16: Cancer Risk and Hazard Index Calculations for Soil Vapor-derived Vapor Intrusion into a Default Residential Building without a Basement
Whirlpool, Fort Smith, Arkansas

							Cancer				Noncancer	
Chem Group	**Chemical**	**CASRN**	**Carc Class**	**ADAF**	**C_{sv}** (mg/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	N							3.1E+01	
VOC	Benzene	71-43-2	A	N			7.8E-03				3.0E-02	
VOC	Bromodichloromethane	75-27-4	B2	N								
VOC	Bromoform	75-25-2	B2	N			1.1E-03					
VOC	Bromomethane	74-83-9	ID	N							5.0E-03	
VOC	2-Butanone	78-93-3	ID	N							5.0E+00	
VOC	Carbon Disulfide	75-15-0		N							7.0E-01	
VOC	Carbon Tetrachloride	56-23-5	LC	N			6.0E-03				1.0E-01	
VOC	Chlorobenzene	108-90-7	D	N							5.0E-02	
VOC	Chloroethane	75-00-3	LC	N							1.0E+01	
VOC	Chloroform	67-66-3	B2	N			2.3E-02				5.0E-02	
VOC	Chloromethane	74-87-3	D	N							9.0E-02	
VOC	Dibromochloromethane	124-48-1	C	N								
VOC	1,1-Dichloroethane	75-34-3	SC	N	1.40E-02	4.20E-04					5.0E-01	8.1E-04
VOC	1,2-Dichloroethane	107-06-2	B2	N	5.40E-03	1.62E-04	2.6E-02		1.5E-06		7.0E-03	2.2E-02
VOC	1,1-Dichloroethene	75-35-4	C	N	3.00E-02	9.00E-04					2.0E-01	4.3E-03
VOC	1,2-Dichloroethene (total)	540-59-0		N								
VOC	cis-1,2-Dichloroethene	156-59-2	ID	N	5.40E-03	1.62E-04						
VOC	trans-1,2-Dichloroethene	156-60-5	ID	N	7.80E-04	2.34E-05						
VOC	1,2-Dichloropropane	78-87-5	B2	N							4.0E-03	
VOC	Ethyl Benzene	100-41-4	D	N							1.0E+00	
VOC	2-Hexanone	591-78-6	ID	N							3.0E-02	
VOC	4-Methyl-2-pentanone	108-10-1	ID	N							3.0E+00	
VOC	Methylene Chloride	75-09-2	LC	Y			1.0E-05	1			6.0E-01	
VOC	Styrene	100-42-5		N							1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	N								
VOC	Tetrachloroethene	127-18-4	LC	N	1.50E-03	4.50E-05	2.6E-04		4.2E-09		4.0E-02	1.1E-03
VOC	Toluene	108-88-3	ID	N							5.0E+00	
VOC	1,1,1-Trichloroethane	71-55-6	ID	N	4.50E-05	1.35E-06					5.0E+00	2.6E-07
VOC	1,1,2-Trichloroethane	79-00-5	C	N			1.6E-02					
VOC	Trichloroethene	79-01-6	HC	Y	1.20E+00	3.60E-02	4.1E-03	0.244	7.5E-05		2.0E-03	1.7E+01
VOC	Vinyl Chloride	75-01-4	A	N	1.90E-02	5.70E-04	4.4E-03		3.4E-06		1.0E-01	5.5E-03
VOC	Xylenes (total)	1330-20-7	ID	N							1.0E-01	
INORG	Iron	7439-89-6	D	N								
INORG	Manganese	7439-96-5	D	N							5.0E-05	
						Cumulative Risk:			8E-05		**HI:**	2E+01
Note:												
f_{inh} is the fraction of the inhalation toxicity value that USEPA identified as having a mutagenic mode of action.												

RAMBOLL ENVIRON

Attachment B5.17: Normalized 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	1.87E-06
VOC	Benzene	71-43-2	1.59E-01	8.31E-04	4.18E-07	1.16E-05
VOC	Bromodichloromethane	75-27-4	4.45E-02	1.09E-03	1.53E-07	4.25E-06
VOC	Bromoform	75-25-2	1.34E-02	1.65E-03	6.97E-08	1.93E-06
VOC	Bromomethane	74-83-9	2.01E-01	7.57E-04	4.81E-07	1.34E-05
VOC	2-Butanone	78-93-3	2.00E-03	9.96E-03	6.30E-08	1.75E-06
VOC	Carbon Disulfide	75-15-0	9.26E-01	2.99E-04	8.76E-07	2.43E-05
VOC	Carbon Tetrachloride	56-23-5	8.82E-01	2.57E-04	7.17E-07	1.99E-05
VOC	Chlorobenzene	108-90-7	9.77E-02	9.49E-04	2.93E-07	8.14E-06
VOC	Chloroethane	75-00-3	4.09E-01	7.78E-04	1.01E-06	2.80E-05
VOC	Chloroform	67-66-3	1.07E-01	1.13E-03	3.85E-07	1.07E-05
VOC	Chloromethane	74-87-3	3.33E-01	4.70E-04	4.95E-07	1.37E-05
VOC	Dibromochloromethane	124-48-1	2.38E-02	1.28E-03	9.66E-08	2.68E-06
VOC	1,1-Dichloroethane	75-34-3	1.66E-01	7.86E-04	4.12E-07	1.14E-05
VOC	1,2-Dichloroethane	107-06-2	2.74E-02	2.41E-03	2.09E-07	5.81E-06
VOC	1,1-Dichloroethene	75-35-4	8.10E-01	3.18E-04	8.15E-07	2.26E-05
VOC	1,2-Dichloroethene (total)	540-59-0	1.19E-01	9.89E-04	3.71E-07	1.03E-05
VOC	cis-1,2-Dichloroethene	156-59-2	1.19E-01	9.89E-04	3.71E-07	1.03E-05
VOC	trans-1,2-Dichloroethene	156-60-5	2.81E-01	6.08E-04	5.41E-07	1.50E-05
VOC	1,2-Dichloropropane	78-87-5	7.82E-02	1.11E-03	2.75E-07	7.63E-06
VOC	Ethyl Benzene	100-41-4	2.04E-01	5.86E-04	3.78E-07	1.05E-05
VOC	2-Hexanone	591-78-6	3.23E-03	6.91E-03	7.07E-08	1.96E-06
VOC	4-Methyl-2-pentanone	108-10-1	4.71E-03	4.85E-03	7.23E-08	2.01E-06
VOC	Methylene Chloride	75-09-2	6.60E-02	1.61E-03	3.36E-07	9.33E-06
VOC	Styrene	100-42-5	7.04E-02	1.08E-03	2.40E-07	6.65E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	8.74E-03	3.35E-03	9.26E-08	2.57E-06
VOC	Tetrachloroethene	127-18-4	4.90E-01	3.47E-04	5.39E-07	1.49E-05
VOC	Toluene	108-88-3	1.80E-01	7.10E-04	4.05E-07	1.12E-05
VOC	1,1,1-Trichloroethane	71-55-6	4.97E-01	3.71E-04	5.83E-07	1.62E-05
VOC	1,1,2-Trichloroethane	79-00-5	2.43E-02	2.12E-03	1.63E-07	4.52E-06
VOC	Trichloroethene	79-01-6	2.88E-01	5.33E-04	4.86E-07	1.35E-05
VOC	Vinyl Chloride	75-01-4	9.00E-01	3.51E-04	9.99E-07	2.77E-05
VOC	Xylenes (total)	1330-20-7	1.73E-01	7.02E-04	3.85E-07	1.07E-05
INORG	Iron	7439-89-6				
INORG	Manganese	7439-96-5				
	Parameters					
	Depth to groundwater	m	**DTW**	3.66		
	Dispersion coefficient	(kg/m^3) / (kg/m^2/s)	**C/Q**	27.7		

RAMBOLL ENVIRON

Attachment B5.18: Dispersion Factor for Groundwater to Outdoor Air Whirlpool, Fort Smith, Arkansas		
Parameter	**Units**	**Value**
Correlation coefficient city		Little Rock
Correlation coefficient A		12.4964
Correlation coefficient B		18.4476
Correlation coefficient C		210.2128
Groundwater source area	acres	34.00
Groundwater averaging time for C/Q		Annual Max
Conversion factor from 1-Hr Max for groundwater		0.19
C/Q for Groundwater	$(kg/m^3)/(kg/m^2/s)$	**27.75**
Note:		
C/Q is estimated using the empirical correlation in USEPA's Supplemental SSG (2002).		

RAMBOLL ENVIRON

Attachment B5.19: 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**	**ADAF**	**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	N	6.36E-01	1.19E-06					3.1E+01	3.7E-08
VOC	Benzene	71-43-2	A	N	5.70E-04	6.61E-09	7.8E-03		1.8E-11		3.0E-02	2.1E-07
VOC	Bromodichloromethane	75-27-4	B2	N								
VOC	Bromoform	75-25-2	B2	N	1.12E-02	2.17E-08	1.1E-03		8.5E-12			
VOC	Bromomethane	74-83-9	ID	N	5.16E-02	6.89E-07					5.0E-03	1.3E-04
VOC	2-Butanone	78-93-3	ID	N	8.10E-01	1.42E-06					5.0E+00	2.7E-07
VOC	Carbon Disulfide	75-15-0		N	6.20E-03	1.51E-07					7.0E-01	2.1E-07
VOC	Carbon Tetrachloride	56-23-5	LC	N			6.0E-03				1.0E-01	
VOC	Chlorobenzene	108-90-7	D	N							5.0E-02	
VOC	Chloroethane	75-00-3	LC	N	8.20E-04	2.29E-08					1.0E+01	2.2E-09
VOC	Chloroform	67-66-3	B2	N	7.60E-03	8.12E-08	2.3E-02		6.6E-10		5.0E-02	1.6E-06
VOC	Chloromethane	74-87-3	D	N	4.87E-02	6.69E-07					9.0E-02	7.1E-06
VOC	Dibromochloromethane	124-48-1	C	N	2.20E-04	5.90E-10						
VOC	1,1-Dichloroethane	75-34-3	SC	N							5.0E-01	
VOC	1,2-Dichloroethane	107-06-2	B2	N	1.60E-04	9.29E-10	2.6E-02		8.6E-12		7.0E-03	1.3E-07
VOC	1,1-Dichloroethene	75-35-4	C	N	3.50E-03	7.92E-08					2.0E-01	3.8E-07
VOC	1,2-Dichloroethene (total)	540-59-0		N								
VOC	cis-1,2-Dichloroethene	156-59-2	ID	N	1.11E-01	1.14E-06						
VOC	trans-1,2-Dichloroethene	156-60-5	ID	N	2.50E-03	3.75E-08						
VOC	1,2-Dichloropropane	78-87-5	B2	N	2.50E-04	1.91E-09					4.0E-03	4.6E-07
VOC	Ethyl Benzene	100-41-4	D	N							1.0E+00	
VOC	2-Hexanone	591-78-6	ID	N	3.60E-03	7.06E-09					3.0E-02	2.3E-07
VOC	4-Methyl-2-pentanone	108-10-1	ID	N	4.00E-03	8.03E-09					3.0E+00	2.6E-09
VOC	Methylene Chloride	75-09-2	LC	Y	4.65E-03	4.34E-08	1.0E-05	1	4.3E-13		6.0E-01	6.9E-08
VOC	Styrene	100-42-5		N							1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	N								
VOC	Tetrachloroethene	127-18-4	LC	N	8.90E-04	1.33E-08	2.6E-04		1.2E-12		4.0E-02	3.2E-07
VOC	Toluene	108-88-3	ID	N	3.80E-03	4.27E-08					5.0E+00	8.2E-09
VOC	1,1,1-Trichloroethane	71-55-6	ID	N							5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5	C	N			1.6E-02					
VOC	Trichloroethene	79-01-6	HC	Y	7.20E-01	9.71E-06	4.1E-03	0.244	2.0E-08		2.0E-03	4.7E-03
VOC	Vinyl Chloride	75-01-4	A	N	1.50E-03	4.16E-08	4.4E-03		2.5E-10		1.0E-01	4.0E-07
VOC	Xylenes (total)	1330-20-7	ID	N							1.0E-01	
INORG	Iron	7439-89-6	D	N	7.40E+01							
INORG	Manganese	7439-96-5	D	N	2.00E+01						5.0E-05	
						Cumulative Risk:			2E-08		**HI:**	5E-03

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

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Attachment B6

Offsite Utility Maintenance Worker Risk Calculations

Attachments

B6.1 Vapor Flux from Soil to Outdoor Air

B6.2 Soil PM_{10} Emission from Wind Erosion

B6.3 Dispersion Factor for Soil to Outdoor Air

B6.4 Cancer Risk Calculations for Exposure of Off-Site Utility Maintenance Workers to Soil

B6.5 Hazard Index Calculations for Exposure of Off-Site Utility Maintenance Workers to Soil

B6.6 Dermal Absorbed Dose for Groundwater

B6.7 Dispersion Factor for Groundwater in Excavations to Outdoor Air

B6.8 Normalized Vapor Flux to Outdoor Air from Exposed Groundwater in Excavations

B6.9 Cancer Risk Calculations for Exposure of Off-Site Utility Maintenance Workers to Groundwater in Excavations

B6.10 Hazard Index Calculations for Exposure of Off-Site Utility Maintenance Workers to Groundwater in Excavations

Attachment B6.1: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	K_{oc} (L/kg)	K_d (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		2.00E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.11E-05	2.52E-06	0.00E+00	1.41E-06	2.52E-06	2.52E-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		4.09E-01	2.34E+00	9.94E-05	4.28E-01	2.52E-02	9.18E-06	2.41E-02	4.64E-05	0.00E+00	2.86E+00	1.43E-05	1.43E-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	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	5.74E+01	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
INORG	Iron	7439-89-6		2.50E+01	0.00E+00							0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INORG	Manganese	7439-96-5		6.50E+01	0.00E+00							0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
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**	10												
		days	**T**	3650												
		s	**T**	3.2E+08												
	Molar Gas Constant	L-mmHg/ mole-^oK	**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												

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Attachment B6.2: Soil PM10 Emission from Wind Erosion Whirlpool, Fort Smith, Arkansas		
Annual average PM_{10} concentration	$(mg/m^3)/(mg/kg)$	**5.00E-08**
Note:		
The concentration of particulates in the air is assumed to be no more than the former annual National Ambient Air Quality Standards (NAAQS).		

Attachment B6.3: Dispersion Factor for Off-Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas

Parameter	Units	Value
Correlation coefficient city		Little Rock
Correlation coefficient A		12.4964
Correlation coefficient B		18.4476
Correlation coefficient C		210.2128
Off-Site Soil source area	acres	0.5
Soil C/Q averaging time		Annual Max
Conversion factor from 1-Hr Max for soil		0.19
C/Q for off-site soil	$(kg/m^3)/(kg/m^2/s)$	**14.01**
Note:		
C/Q is estimated using the empirical correlation in USEPA's Supplemental SSG (2002).		

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Attachment B6.4: Cancer Risk Calculations for Exposure of Off-Site Utility Maintenance Workers to Off-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	6.23E-02	9.14E-10							2.18E-06			3.12E-09			
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	9.30E-03	1.36E-10							1.52E-06			4.65E-10			
VOC	2-Butanone	78-93-3	ID	6.30E-03	9.25E-11							2.22E-07			3.15E-10			
VOC	Carbon Disulfide	75-15-0		9.10E-04	1.34E-11							1.76E-07			4.55E-11			
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																
VOC	cis-1,2-Dichloroethene	156-59-2	ID															
VOC	trans-1,2-Dichloroethene	156-60-5	ID															
VOC	1,2-Dichloropropane	78-87-5	B2			3.6E-02				3.6E-02								
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	3.30E-03	4.84E-11	2.0E-03	9.7E-14			2.0E-03		4.62E-07	1.0E-05	1.8E-14	1.65E-10	1.0E-05	6.5E-18	1.1E-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	1.20E-03	1.76E-11							1.68E-07			6.00E-11			
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	1.60E-02	2.35E-10	4.6E-02	1.1E-11			4.6E-02		2.45E-06	4.1E-03	3.9E-11	8.00E-10	4.1E-03	1.3E-14	5.0E-11
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	3.60E-03	5.28E-11							4.11E-07			1.80E-10			
INORG	Iron	7439-89-6	D															
INORG	Manganese	7439-96-5	D															
		Cumulative Risk:					**1E-11**							**4E-11**			**1E-14**	**5E-11**

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Attachment B6.5: Hazard Index Calculations for Exposure of Off-Site Utility Maintenance Workers to Off-Site Soil
Whirlpool, Fort Smith, Arkansas

				Soil Ingestion			Soil Dermal Contact				Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes
Chem Group	**Chemical**	**CASRN**	**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	6.23E-02	6.40E-09	9.0E-01	7.1E-09			9.0E-01		2.18E-06	3.1E+01	1.9E-09	3.12E-09	3.1E+01	2.8E-12	9.1E-09
VOC	Benzene	71-43-2			4.0E-03				4.0E-03			3.0E-02			3.0E-02		
VOC	Bromodichloromethane	75-27-4			2.0E-02				2.0E-02								
VOC	Bromoform	75-25-2			2.0E-02				2.0E-02								
VOC	Bromomethane	74-83-9	9.30E-03	9.55E-10	1.4E-03	6.8E-07			1.4E-03		1.52E-06	5.0E-03	8.3E-06	4.65E-10	5.0E-03	2.5E-09	9.0E-06
VOC	2-Butanone	78-93-3	6.30E-03	6.47E-10	6.0E-01	1.1E-09			6.0E-01		2.22E-07	5.0E+00	1.2E-09	3.15E-10	5.0E+00	1.7E-12	2.3E-09
VOC	Carbon Disulfide	75-15-0	9.10E-04	9.35E-11	1.0E-01	9.3E-10			1.0E-01		1.76E-07	7.0E-01	6.9E-09	4.55E-11	7.0E-01	1.8E-12	7.8E-09
VOC	Carbon Tetrachloride	56-23-5			4.0E-03				4.0E-03			1.0E-01			1.0E-01		
VOC	Chlorobenzene	108-90-7			2.0E-02				2.0E-02			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3			1.0E-01				1.0E-01			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3			1.0E-02				1.0E-02			5.0E-02			5.0E-02		
VOC	Chloromethane	74-87-3										9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1			2.0E-02				2.0E-02								
VOC	1,1-Dichloroethane	75-34-3			2.0E-01				2.0E-01			5.0E-01			5.0E-01		
VOC	1,2-Dichloroethane	107-06-2			2.0E-02				2.0E-02			7.0E-03			7.0E-03		
VOC	1,1-Dichloroethene	75-35-4			5.0E-02				5.0E-02			2.0E-01			2.0E-01		
VOC	1,2-Dichloroethene (total)	540-59-0			2.0E-03				2.0E-03								
VOC	cis-1,2-Dichloroethene	156-59-2			2.0E-03				2.0E-03								
VOC	trans-1,2-Dichloroethene	156-60-5			2.0E-02				2.0E-02								
VOC	1,2-Dichloropropane	78-87-5			9.0E-02				9.0E-02			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4			1.0E-01				1.0E-01			1.0E+00			1.0E+00		
VOC	2-Hexanone	591-78-6			5.0E-03				5.0E-03			3.0E-02			3.0E-02		
VOC	4-Methyl-2-pentanone	108-10-1										3.0E+00			3.0E+00		
VOC	Methylene Chloride	75-09-2	3.30E-03	3.39E-10	6.0E-03	5.7E-08			6.0E-03		4.62E-07	6.0E-01	2.1E-08	1.65E-10	6.0E-01	7.5E-12	7.8E-08
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			2.0E-02				2.0E-02								
VOC	Tetrachloroethene	127-18-4			6.0E-03				6.0E-03			4.0E-02			4.0E-02		
VOC	Toluene	108-88-3	1.20E-03	1.23E-10	8.0E-02	1.5E-09			8.0E-02		1.68E-07	5.0E+00	9.2E-10	6.00E-11	5.0E+00	3.3E-13	2.5E-09
VOC	1,1,1-Trichloroethane	71-55-6			2.0E+00				2.0E+00			5.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5			4.0E-03				4.0E-03								
VOC	Trichloroethene	79-01-6	1.60E-02	1.64E-09	5.0E-04	3.3E-06			5.0E-04		2.45E-06	2.0E-03	3.4E-05	8.00E-10	2.0E-03	1.1E-08	3.7E-05
VOC	Vinyl Chloride	75-01-4			3.0E-03				3.0E-03			1.0E-01			1.0E-01		
VOC	Xylenes (total)	1330-20-7	3.60E-03	3.69E-10	2.0E-01	1.8E-09			2.0E-01		4.11E-07	1.0E-01	1.1E-07	1.80E-10	1.0E-01	4.9E-11	1.1E-07
INORG	Iron	7439-89-6			7.0E-01				7.0E-01								
INORG	Manganese	7439-96-5			1.4E-01				8.4E-03			5.0E-05			5.0E-05		
	Hazard Index:					**4E-06**							**4E-05**			**1E-08**	**5E-05**

RAMBOLL ENVIRON

Attachment B6.6: Dermal Absorbed Dose for Groundwater
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	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
INORG	Iron	7439-89-6	5.6E+01		1.0E-03	0.0E+00	2.2E-01	3.3E-01	3.0E-01	5.2E-01	2.00E-06
INORG	Manganese	7439-96-5	5.5E+01		1.0E-03	0.0E+00	2.1E-01	3.3E-01	3.0E-01	5.1E-01	2.00E-06
Notes:											
	Event Time	hours	**t**	2							
	K_p capped at 1 cm/hr (USEPA 1992).										

RAMBOLL ENVIRON

Attachment B6.7: Dispersion Factor for Groundwater in Excavations to Outdoor Air Whirlpool, Fort Smith, Arkansas		
Parameter	**Units**	**Value**
Correlation coefficient city		Little Rock
Correlation coefficient A		12.4964
Correlation coefficient B		18.4476
Correlation coefficient C		210.2128
Groundwater source area	acres	0.0052
Groundwater averaging time for C/Q		24-Hour Max
Conversion factor from 1-Hr Max for groundwater		0.40
C/Q for Groundwater	$(kg/m^3)/(kg/m^2/s)$	**11.61**
Note:		
C/Q is estimated using the empirical correlation in USEPA's Supplemental SSG (2002).		

Attachment B6.8: 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	1.76E+03	5.70E-04	5.70E-03
VOC	Carbon Disulfide	75-15-0	9.3E-01	7.6E+01	4.99E-01	1.26E-03	7.95E+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	4.1E-01	6.5E+01	5.28E-01	1.37E-03	7.35E+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	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	1.06E+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
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
INORG	Iron	7439-89-6	0.0E+00	5.6E+01	5.54E-01	1.47E-03			
INORG	Manganese	7439-96-5	0.0E+00	5.5E+01	5.57E-01	1.48E-03			
	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					

RAMBOLL ENVIRON

Attachment B6.9: Cancer Risk Calculations for Exposure of Off-Site Utility 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	6.36E-01	1.56E-07			1.27E-06	6.97E-08			3.21E-02	2.10E-05			
VOC	Benzene	71-43-2	A	5.70E-04	1.39E-10	5.5E-02	7.7E-12	3.70E-05	1.82E-09	5.5E-02	1.0E-10	8.11E-05	5.29E-08	7.8E-03	4.1E-10	5.2E-10
VOC	Bromodichloromethane	75-27-4	B2			6.2E-02		1.70E-05		6.2E-02						
VOC	Bromoform	75-25-2	B2	1.12E-02	2.74E-09	7.9E-03	2.2E-11	1.40E-05	1.35E-08	7.9E-03	1.1E-10	7.79E-04	5.08E-07	1.1E-03	5.6E-10	6.9E-10
VOC	Bromomethane	74-83-9	ID	5.16E-02	1.26E-08			7.68E-06	3.42E-08			6.68E-03	4.36E-06			
VOC	2-Butanone	78-93-3	ID	8.10E-01	1.98E-07			2.42E-06	1.69E-07			5.35E-02	3.49E-05			
VOC	Carbon Disulfide	75-15-0		6.20E-03	1.52E-09			3.11E-05	1.66E-08			9.05E-04	5.90E-07			
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	8.20E-04	2.01E-10			1.49E-05	1.05E-09			1.30E-04	8.45E-08			
VOC	Chloroform	67-66-3	B2	7.60E-03	1.86E-09	1.9E-02	3.5E-11	1.86E-05	1.22E-08	1.9E-02	2.3E-10	8.69E-04	5.67E-07	2.3E-02	1.3E-08	1.3E-08
VOC	Chloromethane	74-87-3	D	4.87E-02	1.19E-08			3.58E-05	1.50E-07			8.68E-03	5.66E-06			
VOC	Dibromochloromethane	124-48-1	C	2.20E-04	5.38E-11	8.4E-02	4.5E-12	1.42E-05	2.69E-10	8.4E-02	2.3E-11	1.79E-05	1.17E-08			2.7E-11
VOC	1,1-Dichloroethane	75-34-3	SC					1.83E-05								
VOC	1,2-Dichloroethane	107-06-2	B2	1.60E-04	3.91E-11	9.1E-02	3.6E-12	1.13E-05	1.56E-10	9.1E-02	1.4E-11	1.89E-05	1.23E-08	2.6E-02	3.2E-10	3.4E-10
VOC	1,1-Dichloroethene	75-35-4	C	3.50E-03	8.56E-10			3.10E-05	9.36E-09			4.53E-04	2.95E-07			
VOC	1,2-Dichloroethene (total)	540-59-0						2.07E-05								
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.11E-01	2.72E-08			2.07E-05	1.98E-07			1.41E-02	9.20E-06			
VOC	trans-1,2-Dichloroethene	156-60-5	ID	2.50E-03	6.12E-10			2.83E-05	6.11E-09			3.21E-04	2.10E-07			
VOC	1,2-Dichloropropane	78-87-5	B2	2.50E-04	6.12E-11	3.6E-02	2.2E-12	2.12E-05	4.56E-10	3.6E-02	1.6E-11	2.91E-05	1.90E-08			1.9E-11
VOC	Ethyl Benzene	100-41-4	D					1.27E-04								
VOC	2-Hexanone	591-78-6	ID	3.60E-03	8.81E-10			9.75E-06	3.03E-09			2.63E-04	1.72E-07			
VOC	4-Methyl-2-pentanone	108-10-1	ID	4.00E-03	9.78E-10			7.32E-06	2.52E-09			3.38E-04	2.20E-07			
VOC	Methylene Chloride	75-09-2	LC	4.65E-03	1.14E-09	2.0E-03	2.3E-12	9.25E-06	3.71E-09	2.0E-03	7.4E-12	6.21E-04	4.05E-07	1.0E-05	4.1E-12	1.4E-11
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	8.90E-04	2.18E-10	2.1E-03	4.6E-13	3.99E-05	3.06E-09	2.1E-03	6.4E-12	8.78E-05	5.73E-08	2.6E-04	1.5E-11	2.2E-11
VOC	Toluene	108-88-3	ID	3.80E-03	9.30E-10			8.08E-05	2.65E-08			4.99E-04	3.25E-07			
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	7.20E-01	1.76E-07	4.6E-02	8.1E-09	5.53E-05	3.43E-06	4.6E-02	1.6E-07	7.96E-02	5.19E-05	4.1E-03	2.1E-07	3.8E-07
VOC	Vinyl Chloride	75-01-4	A	1.50E-03	3.67E-10	7.2E-01	2.6E-10	1.69E-05	2.18E-09	7.2E-01	1.6E-09	2.42E-04	1.58E-07	4.4E-03	6.9E-10	2.5E-09
VOC	Xylenes (total)	1330-20-7	ID					1.32E-04								
INORG	Iron	7439-89-6	D	7.40E+01	1.81E-05			2.00E-06	1.28E-05							
INORG	Manganese	7439-96-5	D	2.00E+01	4.89E-06			2.00E-06	3.45E-06							
		Cumulative Risk:					**8E-09**				**2E-07**				**2E-07**	**4E-07**

RAMBOLL ENVIRON

Attachment B6.10: Hazard Index Calculations for Exposure of Off-Site Utility Maintenance Workers to Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas

				Incidental Ingestion			Dermal Contact				Vapor Inhalation			All Routes
Chem Group	Chemical	CASRN	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	6.36E-01	1.09E-06	9.0E-01	1.2E-06	1.27E-06	4.88E-07	9.0E-01	5.4E-07	3.21E-02	3.1E+01	4.8E-06	6.5E-06
VOC	Benzene	71-43-2	5.70E-04	9.76E-10	4.0E-03	2.4E-07	3.70E-05	1.27E-08	4.0E-03	3.2E-06	8.11E-05	3.0E-02	1.2E-05	1.6E-05
VOC	Bromodichloromethane	75-27-4			2.0E-02		1.70E-05		2.0E-02					
VOC	Bromoform	75-25-2	1.12E-02	1.92E-08	2.0E-02	9.6E-07	1.40E-05	9.47E-08	2.0E-02	4.7E-06	7.79E-04			5.7E-06
VOC	Bromomethane	74-83-9	5.16E-02	8.84E-08	1.4E-03	6.3E-05	7.68E-06	2.39E-07	1.4E-03	1.7E-04	6.68E-03	5.0E-03	6.1E-03	6.3E-03
VOC	2-Butanone	78-93-3	8.10E-01	1.39E-06	6.0E-01	2.3E-06	2.42E-06	1.18E-06	6.0E-01	2.0E-06	5.35E-02	5.0E+00	4.9E-05	5.3E-05
VOC	Carbon Disulfide	75-15-0	6.20E-03	1.06E-08	1.0E-01	1.1E-07	3.11E-05	1.16E-07	1.0E-01	1.2E-06	9.05E-04	7.0E-01	5.9E-06	7.2E-06
VOC	Carbon Tetrachloride	56-23-5			4.0E-03		4.84E-05		4.0E-03			1.0E-01		
VOC	Chlorobenzene	108-90-7			2.0E-02		8.00E-05		2.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3	8.20E-04	1.40E-09	1.0E-01	1.4E-08	1.49E-05	7.37E-09	1.0E-01	7.4E-08	1.30E-04	1.0E+01	5.9E-08	1.5E-07
VOC	Chloroform	67-66-3	7.60E-03	1.30E-08	1.0E-02	1.3E-06	1.86E-05	8.53E-08	1.0E-02	8.5E-06	8.69E-04	5.0E-02	7.9E-05	8.9E-05
VOC	Chloromethane	74-87-3	4.87E-02	8.34E-08			3.58E-05	1.05E-06			8.68E-03	9.0E-02	4.4E-04	4.4E-04
VOC	Dibromochloromethane	124-48-1	2.20E-04	3.77E-10	2.0E-02	1.9E-08	1.42E-05	1.89E-09	2.0E-02	9.4E-08	1.79E-05			1.1E-07
VOC	1,1-Dichloroethane	75-34-3			2.0E-01		1.83E-05		2.0E-01			5.0E-01		
VOC	1,2-Dichloroethane	107-06-2	1.60E-04	2.74E-10	2.0E-02	1.4E-08	1.13E-05	1.09E-09	2.0E-02	5.5E-08	1.89E-05	7.0E-03	1.2E-05	1.2E-05
VOC	1,1-Dichloroethene	75-35-4	3.50E-03	5.99E-09	5.0E-02	1.2E-07	3.10E-05	6.55E-08	5.0E-02	1.3E-06	4.53E-04	2.0E-01	1.0E-05	1.2E-05
VOC	1,2-Dichloroethene (total)	540-59-0			2.0E-03		2.07E-05		2.0E-03					
VOC	cis-1,2-Dichloroethene	156-59-2	1.11E-01	1.90E-07	2.0E-03	9.5E-05	2.07E-05	1.39E-06	2.0E-03	6.9E-04	1.41E-02			7.9E-04
VOC	trans-1,2-Dichloroethene	156-60-5	2.50E-03	4.28E-09	2.0E-02	2.1E-07	2.83E-05	4.28E-08	2.0E-02	2.1E-06	3.21E-04			2.4E-06
VOC	1,2-Dichloropropane	78-87-5	2.50E-04	4.28E-10	9.0E-02	4.8E-09	2.12E-05	3.20E-09	9.0E-02	3.6E-08	2.91E-05	4.0E-03	3.3E-05	3.3E-05
VOC	Ethyl Benzene	100-41-4			1.0E-01		1.27E-04		1.0E-01			1.0E+00		
VOC	2-Hexanone	591-78-6	3.60E-03	6.16E-09	5.0E-03	1.2E-06	9.75E-06	2.12E-08	5.0E-03	4.2E-06	2.63E-04	3.0E-02	4.0E-05	4.6E-05
VOC	4-Methyl-2-pentanone	108-10-1	4.00E-03	6.85E-09			7.32E-06	1.77E-08			3.38E-04	3.0E+00	5.1E-07	5.1E-07
VOC	Methylene Chloride	75-09-2	4.65E-03	7.96E-09	6.0E-03	1.3E-06	9.25E-06	2.60E-08	6.0E-03	4.3E-06	6.21E-04	6.0E-01	4.7E-06	1.0E-05
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			2.0E-02		2.57E-05		2.0E-02					
VOC	Tetrachloroethene	127-18-4	8.90E-04	1.52E-09	6.0E-03	2.5E-07	3.99E-05	2.14E-08	6.0E-03	3.6E-06	8.78E-05	4.0E-02	1.0E-05	1.4E-05
VOC	Toluene	108-88-3	3.80E-03	6.51E-09	8.0E-02	8.1E-08	8.08E-05	1.85E-07	8.0E-02	2.3E-06	4.99E-04	5.0E+00	4.6E-07	2.9E-06
VOC	1,1,1-Trichloroethane	71-55-6			2.0E+00		3.85E-05		2.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5			4.0E-03		2.02E-05		4.0E-03					
VOC	Trichloroethene	79-01-6	7.20E-01	1.23E-06	5.0E-04	2.5E-03	5.53E-05	2.40E-05	5.0E-04	4.8E-02	7.96E-02	2.0E-03	1.8E-01	2.3E-01
VOC	Vinyl Chloride	75-01-4	1.50E-03	2.57E-09	3.0E-03	8.6E-07	1.69E-05	1.53E-08	3.0E-03	5.1E-06	2.42E-04	1.0E-01	1.1E-05	1.7E-05
VOC	Xylenes (total)	1330-20-7			2.0E-01		1.32E-04		2.0E-01			1.0E-01		
INORG	Iron	7439-89-6	7.40E+01	1.27E-04	7.0E-01	1.8E-04	2.00E-06	8.94E-05	7.0E-01	1.3E-04				3.1E-04
INORG	Manganese	7439-96-5	2.00E+01	3.42E-05	1.4E-01	2.4E-04	2.00E-06	2.42E-05	8.4E-03	2.9E-03		5.0E-05		3.1E-03
		Hazard Index:				**3E-03**				**5E-02**			**2E-01**	**2E-01**

RAMBOLL ENVIRON

Attachment B7

Trespasser Risk Calculations

Attachments

B7.1 Vapor Flux from Soil to Outdoor Air

B7.2 Soil PM_{10} Emission from Wind Erosion

B7.3 Cancer Risk Calculations for Inhalation Exposure of Trespassers to Former Drainage Trench Soil

B7.4 Hazard Index Calculations for Inhalation Exposure of Trespassers to Former Drainage Trench Soil

B7.5 Cancer Risk Calculations for Inhalation Exposure of Trespassers to Remaining Site Soil

B7.6 Hazard Index Calculations for Inhalation Exposure of Trespassers to Remaining Site Soil

B7.7 Cancer Risk Calculations for Contact Exposure of Trespassers to Total Site Soil

B7.8 Hazard Index Calculations for Contact Exposure of Trespassers to Total Site Soil

B7.9 Normalized Vapor Flux to Outdoor Air from Groundwater

B7.10 Dispersion Factor for Groundwater to Outdoor Air

B7.11 Cancer Risk and Hazard Quotient Calculations for Exposure of Trespassers to Groundwater-derived Vapors in Outdoor Air

Attachment B7.1: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	K_{oc} (L/kg)	K_d (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		2.00E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.11E-05	2.52E-06	0.00E+00	1.41E-06	2.52E-06	2.52E-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		4.09E-01	2.34E+00	9.94E-05	4.28E-01	2.52E-02	9.18E-06	2.41E-02	4.64E-05	0.00E+00	2.86E+00	1.43E-05	1.43E-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	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	5.74E+01	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
INORG	Iron	7439-89-6		2.50E+01	0.00E+00							0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INORG	Manganese	7439-96-5		6.50E+01	0.00E+00							0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
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**	10												
		days	**T**	3650												
		s	**T**	3.2E+08												
	Molar Gas Constant	L-mmHg/ mole-^oK	**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												

RAMBOLL ENVIRON

Attachment B7.2: 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	$\mathbf{u'_t}$	0.50
Correction factor			1.25
Corrected friction velocity	m/s	$\mathbf{u^*_t}$	0.6252
Roughness height	m	$\mathbf{z_0}$	0.005
Anemometer height	m		10.0
Friction velocity at anemometer height	m/s	$\mathbf{u_t}$	11.9
Mean annual wind speed	mph	$\mathbf{u_m}$	7.6
Mean annual wind speed	m/s	$\mathbf{u_m}$	3.39750
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	$\mathbf{J_{10,w}}$	**3.93E-13**

RAMBOLL ENVIRON

Attachment B7.3: Cancer Risk Calculations for Inhalation Exposure of Trespassers to Former Drainage Trench Soil Whirlpool, Fort Smith, Arkansas

						Soil Vapor Inhalation				Soil Particulate Inhalation				Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	**ADAF**	**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	N	5.86E-02	1.08E-07				1.70E-14				
VOC	Benzene	71-43-2	A	N	6.30E-04	5.09E-09	7.8E-03		1.3E-13	1.83E-16	7.8E-03		4.6E-21	1.3E-13
VOC	Bromodichloromethane	75-27-4	B2	N	2.60E-03	9.50E-09				7.54E-16				
VOC	Bromoform	75-25-2	B2	N			1.1E-03				1.1E-03			
VOC	Bromomethane	74-83-9	ID	N	2.44E-01	2.10E-06				7.07E-14				
VOC	2-Butanone	78-93-3	ID	N	2.50E-01	4.64E-07				7.25E-14				
VOC	Carbon Disulfide	75-15-0		N	2.80E-03	2.85E-08				8.12E-16				
VOC	Carbon Tetrachloride	56-23-5	LC	N	5.20E-03	4.90E-08	6.0E-03		9.6E-13	1.51E-15	6.0E-03		2.9E-20	9.6E-13
VOC	Chlorobenzene	108-90-7	D	N										
VOC	Chloroethane	75-00-3	LC	N										
VOC	Chloroform	67-66-3	B2	N	5.70E-02	4.51E-07	2.3E-02		3.4E-11	1.65E-14	2.3E-02		1.2E-18	3.4E-11
VOC	Chloromethane	74-87-3	D	N										
VOC	Dibromochloromethane	124-48-1	C	N										
VOC	1,1-Dichloroethane	75-34-3	SC	N	8.80E-03	7.15E-08				2.55E-15				
VOC	1,2-Dichloroethane	107-06-2	B2	N	1.81E-01	1.02E-06	2.6E-02		8.6E-11	5.25E-14	2.6E-02		4.4E-18	8.6E-11
VOC	1,1-Dichloroethene	75-35-4	C	N	1.60E-01	1.59E-06				4.64E-14				
VOC	1,2-Dichloroethene (total)	540-59-0		N	5.20E+00	3.91E-05				1.51E-12				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	N	1.85E+01	1.39E-04				5.36E-12				
VOC	trans-1,2-Dichloroethene	156-60-5	ID	N	2.40E-01	2.07E-06				6.96E-14				
VOC	1,2-Dichloropropane	78-87-5	B2	N										
VOC	Ethyl Benzene	100-41-4	D	N	1.40E-03	8.90E-09				4.06E-16				
VOC	2-Hexanone	591-78-6	ID	N	7.30E-02	1.54E-07				2.12E-14				
VOC	4-Methyl-2-pentanone	108-10-1	ID	N	1.75E-02	4.10E-08				5.07E-15				
VOC	Methylene Chloride	75-09-2	LC	Y	3.14E+00	2.32E-05	1.0E-05	1	2.3E-12	9.10E-13	1.0E-05	1	8.9E-20	2.3E-12
VOC	Styrene	100-42-5		N										
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	N										
VOC	Tetrachloroethene	127-18-4	LC	N	1.70E-01	1.48E-06	2.6E-04		1.3E-12	4.93E-14	2.6E-04		4.2E-20	1.3E-12
VOC	Toluene	108-88-3	ID	N	7.03E-02	5.17E-07				2.04E-14				
VOC	1,1,1-Trichloroethane	71-55-6	ID	N	3.20E-02	2.91E-07				9.27E-15				
VOC	1,1,2-Trichloroethane	79-00-5	C	N	3.50E-02	1.52E-07	1.6E-02		7.9E-12	1.01E-14	1.6E-02		5.3E-19	7.9E-12
VOC	Trichloroethene	79-01-6	HC	Y	2.70E+02	2.17E-03	4.1E-03	0.244	4.3E-08	7.83E-11	4.1E-03	0.244	1.6E-15	4.3E-08
VOC	Vinyl Chloride	75-01-4	A	N	4.43E+00	4.56E-05	4.4E-03		6.5E-10	1.28E-12	4.4E-03		1.8E-17	6.5E-10
VOC	Xylenes (total)	1330-20-7	ID	N	8.90E-03	5.36E-08				2.58E-15				
INORG	Iron	7439-89-6	D	N										
INORG	Manganese	7439-96-5	D	N										
		Cumulative Risk:							**4E-08**				**2E-15**	**4E-08**

Notes:

The annual maximum dispersion coefficient to outdoor air (C/Q) is 0.7 (kg/m³) / (kg/m²/s).

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

RAMBOLL ENVIRON

Attachment B7.4: Hazard Index Calculations for Inhalation Exposure of Trespassers to Former Drainage Trench Soil
Whirlpool, Fort Smith, Arkansas

				Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**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	5.86E-02	1.08E-07	3.1E+01	8.0E-11	1.70E-14	3.1E+01	1.3E-17	8.0E-11
VOC	Benzene	71-43-2	6.30E-04	5.09E-09	3.0E-02	3.9E-09	1.83E-16	3.0E-02	1.4E-16	3.9E-09
VOC	Bromodichloromethane	75-27-4	2.60E-03	9.50E-09			7.54E-16			
VOC	Bromoform	75-25-2								
VOC	Bromomethane	74-83-9	2.44E-01	2.10E-06	5.0E-03	9.6E-06	7.07E-14	5.0E-03	3.2E-13	9.6E-06
VOC	2-Butanone	78-93-3	2.50E-01	4.64E-07	5.0E+00	2.1E-09	7.25E-14	5.0E+00	3.3E-16	2.1E-09
VOC	Carbon Disulfide	75-15-0	2.80E-03	2.85E-08	7.0E-01	9.3E-10	8.12E-16	7.0E-01	2.6E-17	9.3E-10
VOC	Carbon Tetrachloride	56-23-5	5.20E-03	4.90E-08	1.0E-01	1.1E-08	1.51E-15	1.0E-01	3.4E-16	1.1E-08
VOC	Chlorobenzene	108-90-7			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	5.70E-02	4.51E-07	5.0E-02	2.1E-07	1.65E-14	5.0E-02	7.5E-15	2.1E-07
VOC	Chloromethane	74-87-3			9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1								
VOC	1,1-Dichloroethane	75-34-3	8.80E-03	7.15E-08	5.0E-01	3.3E-09	2.55E-15	5.0E-01	1.2E-16	3.3E-09
VOC	1,2-Dichloroethane	107-06-2	1.81E-01	1.02E-06	7.0E-03	3.3E-06	5.25E-14	7.0E-03	1.7E-13	3.3E-06
VOC	1,1-Dichloroethene	75-35-4	1.60E-01	1.59E-06	2.0E-01	1.8E-07	4.64E-14	2.0E-01	5.3E-15	1.8E-07
VOC	1,2-Dichloroethene (total)	540-59-0	5.20E+00	3.91E-05			1.51E-12			
VOC	cis-1,2-Dichloroethene	156-59-2	1.85E+01	1.39E-04			5.36E-12			
VOC	trans-1,2-Dichloroethene	156-60-5	2.40E-01	2.07E-06			6.96E-14			
VOC	1,2-Dichloropropane	78-87-5			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4	1.40E-03	8.90E-09	1.0E+00	2.0E-10	4.06E-16	1.0E+00	9.3E-18	2.0E-10
VOC	2-Hexanone	591-78-6	7.30E-02	1.54E-07	3.0E-02	1.2E-07	2.12E-14	3.0E-02	1.6E-14	1.2E-07
VOC	4-Methyl-2-pentanone	108-10-1	1.75E-02	4.10E-08	3.0E+00	3.1E-10	5.07E-15	3.0E+00	3.9E-17	3.1E-10
VOC	Methylene Chloride	75-09-2	3.14E+00	2.32E-05	6.0E-01	8.8E-07	9.10E-13	6.0E-01	3.5E-14	8.8E-07
VOC	Styrene	100-42-5			1.0E+00			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5								
VOC	Tetrachloroethene	127-18-4	1.70E-01	1.48E-06	4.0E-02	8.5E-07	4.93E-14	4.0E-02	2.8E-14	8.5E-07
VOC	Toluene	108-88-3	7.03E-02	5.17E-07	5.0E+00	2.4E-09	2.04E-14	5.0E+00	9.3E-17	2.4E-09
VOC	1,1,1-Trichloroethane	71-55-6	3.20E-02	2.91E-07	5.0E+00	1.3E-09	9.27E-15	5.0E+00	4.2E-17	1.3E-09
VOC	1,1,2-Trichloroethane	79-00-5	3.50E-02	1.52E-07			1.01E-14			
VOC	Trichloroethene	79-01-6	2.70E+02	2.17E-03	2.0E-03	2.5E-02	7.83E-11	2.0E-03	8.9E-10	2.5E-02
VOC	Vinyl Chloride	75-01-4	4.43E+00	4.56E-05	1.0E-01	1.0E-05	1.28E-12	1.0E-01	2.9E-13	1.0E-05
VOC	Xylenes (total)	1330-20-7	8.90E-03	5.36E-08	1.0E-01	1.2E-08	2.58E-15	1.0E-01	5.9E-16	1.2E-08
INORG	Iron	7439-89-6								
INORG	Manganese	7439-96-5			5.0E-05			5.0E-05		
		Hazard Index:				**2E-02**			**9E-10**	**2E-02**
Notes:										
The annual maximum dispersion coefficient to outdoor air (C/Q) is 0.7 (kg/m³) / (kg/m²/s).										

RAMBOLL ENVIRON

Attachment B7.5: Cancer Risk Calculations for Inhalation Exposure of Trespassers to Remaining Site Soil
Whirlpool, Fort Smith, Arkansas

						Soil Vapor Inhalation				Soil Particulate Inhalation				Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	**ADAF**	**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	N	5.16E-02	4.59E-07				7.22E-14				
VOC	Benzene	71-43-2	A	N			7.8E-03				7.8E-03			
VOC	Bromodichloromethane	75-27-4	B2	N										
VOC	Bromoform	75-25-2	B2	N	6.10E-03	4.49E-08	1.1E-03		1.6E-13	8.54E-15	1.1E-03		3.1E-20	1.6E-13
VOC	Bromomethane	74-83-9	ID	N										
VOC	2-Butanone	78-93-3	ID	N										
VOC	Carbon Disulfide	75-15-0		N	7.40E-03	3.64E-07				1.04E-14				
VOC	Carbon Tetrachloride	56-23-5	LC	N			6.0E-03				6.0E-03			
VOC	Chlorobenzene	108-90-7	D	N										
VOC	Chloroethane	75-00-3	LC	N										
VOC	Chloroform	67-66-3	B2	N	5.20E-03	1.99E-07	2.3E-02		1.5E-11	7.28E-15	2.3E-02		5.5E-19	1.5E-11
VOC	Chloromethane	74-87-3	D	N										
VOC	Dibromochloromethane	124-48-1	C	N										
VOC	1,1-Dichloroethane	75-34-3	SC	N										
VOC	1,2-Dichloroethane	107-06-2	B2	N	7.20E-03	1.95E-07	2.6E-02		1.7E-11	1.01E-14	2.6E-02		8.5E-19	1.7E-11
VOC	1,1-Dichloroethene	75-35-4	C	N	1.10E-03	5.27E-08				1.54E-15				
VOC	1,2-Dichloroethene (total)	540-59-0		N	4.90E-01	1.78E-05				6.86E-13				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	N	4.90E-01	1.78E-05				6.86E-13				
VOC	trans-1,2-Dichloroethene	156-60-5	ID	N										
VOC	1,2-Dichloropropane	78-87-5	B2	N										
VOC	Ethyl Benzene	100-41-4	D	N										
VOC	2-Hexanone	591-78-6	ID	N	5.90E-02	6.02E-07				8.26E-14				
VOC	4-Methyl-2-pentanone	108-10-1	ID	N										
VOC	Methylene Chloride	75-09-2	LC	Y	7.00E-03	2.49E-07	1.0E-05	1	2.4E-14	9.80E-15	1.0E-05	1	9.6E-22	2.4E-14
VOC	Styrene	100-42-5		N										
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	N										
VOC	Tetrachloroethene	127-18-4	LC	N	4.40E-03	1.85E-07	2.6E-04		1.6E-13	6.16E-15	2.6E-04		5.2E-21	1.6E-13
VOC	Toluene	108-88-3	ID	N	1.60E-03	5.68E-08				2.24E-15				
VOC	1,1,1-Trichloroethane	71-55-6	ID	N										
VOC	1,1,2-Trichloroethane	79-00-5	C	N			1.6E-02				1.6E-02			
VOC	Trichloroethene	79-01-6	HC	Y	1.70E+00	6.61E-05	4.1E-03	0.244	1.3E-09	2.38E-12	4.1E-03	0.244	4.7E-17	1.3E-09
VOC	Vinyl Chloride	75-01-4	A	N	3.80E-02	1.89E-06	4.4E-03		2.7E-11	5.32E-14	4.4E-03		7.6E-19	2.7E-11
VOC	Xylenes (total)	1330-20-7	ID	N										
INORG	Iron	7439-89-6	D	N										
INORG	Manganese	7439-96-5	D	N										
		Cumulative Risk:							**1E-09**				**5E-17**	**1E-09**

Notes:

The annual maximum dispersion coefficient to outdoor air (C/Q) is 3.6 (kg/m³) / (kg/m²/s).

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

RAMBOLL ENVIRON

Attachment B7.6: Hazard Index Calculations for Inhalation Exposure of Trespassers to Former Drainage Trench Soil Whirlpool, Fort Smith, Arkansas

				Soil Vapor Inhalation			Soil Particulate Inhalation			Inhalation Routes
Chem Group	**Chemical**	**CASRN**	**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	5.16E-02	4.59E-07	3.1E+01	3.4E-10	7.22E-14	3.1E+01	5.3E-17	3.4E-10
VOC	Benzene	71-43-2			3.0E-02			3.0E-02		
VOC	Bromodichloromethane	75-27-4								
VOC	Bromoform	75-25-2	6.10E-03	4.49E-08			8.54E-15			
VOC	Bromomethane	74-83-9			5.0E-03			5.0E-03		
VOC	2-Butanone	78-93-3			5.0E+00			5.0E+00		
VOC	Carbon Disulfide	75-15-0	7.40E-03	3.64E-07	7.0E-01	1.2E-08	1.04E-14	7.0E-01	3.4E-16	1.2E-08
VOC	Carbon Tetrachloride	56-23-5			1.0E-01			1.0E-01		
VOC	Chlorobenzene	108-90-7			5.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3			1.0E+01			1.0E+01		
VOC	Chloroform	67-66-3	5.20E-03	1.99E-07	5.0E-02	9.1E-08	7.28E-15	5.0E-02	3.3E-15	9.1E-08
VOC	Chloromethane	74-87-3			9.0E-02			9.0E-02		
VOC	Dibromochloromethane	124-48-1								
VOC	1,1-Dichloroethane	75-34-3			5.0E-01			5.0E-01		
VOC	1,2-Dichloroethane	107-06-2	7.20E-03	1.95E-07	7.0E-03	6.4E-07	1.01E-14	7.0E-03	3.3E-14	6.4E-07
VOC	1,1-Dichloroethene	75-35-4	1.10E-03	5.27E-08	2.0E-01	6.0E-09	1.54E-15	2.0E-01	1.8E-16	6.0E-09
VOC	1,2-Dichloroethene (total)	540-59-0	4.90E-01	1.78E-05			6.86E-13			
VOC	cis-1,2-Dichloroethene	156-59-2	4.90E-01	1.78E-05			6.86E-13			
VOC	trans-1,2-Dichloroethene	156-60-5								
VOC	1,2-Dichloropropane	78-87-5			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4			1.0E+00			1.0E+00		
VOC	2-Hexanone	591-78-6	5.90E-02	6.02E-07	3.0E-02	4.6E-07	8.26E-14	3.0E-02	6.3E-14	4.6E-07
VOC	4-Methyl-2-pentanone	108-10-1			3.0E+00			3.0E+00		
VOC	Methylene Chloride	75-09-2	7.00E-03	2.49E-07	6.0E-01	9.5E-09	9.80E-15	6.0E-01	3.7E-16	9.5E-09
VOC	Styrene	100-42-5			1.0E+00			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5								
VOC	Tetrachloroethene	127-18-4	4.40E-03	1.85E-07	4.0E-02	1.1E-07	6.16E-15	4.0E-02	3.5E-15	1.1E-07
VOC	Toluene	108-88-3	1.60E-03	5.68E-08	5.0E+00	2.6E-10	2.24E-15	5.0E+00	1.0E-17	2.6E-10
VOC	1,1,1-Trichloroethane	71-55-6			5.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5								
VOC	Trichloroethene	79-01-6	1.70E+00	6.61E-05	2.0E-03	7.5E-04	2.38E-12	2.0E-03	2.7E-11	7.5E-04
VOC	Vinyl Chloride	75-01-4	3.80E-02	1.89E-06	1.0E-01	4.3E-07	5.32E-14	1.0E-01	1.2E-14	4.3E-07
VOC	Xylenes (total)	1330-20-7			1.0E-01			1.0E-01		
INORG	Iron	7439-89-6								
INORG	Manganese	7439-96-5			5.0E-05			5.0E-05		
	Hazard Index:					**8E-04**			**3E-11**	**8E-04**
Notes:										
The annual maximum dispersion coefficient to outdoor air (C/Q) is 3.6 (kg/m³) / (kg/m²/s).										

RAMBOLL ENVIRON

Attachment B7.7: Cancer Risk Calculations for Contact Exposure of Trespassers to Total Site Soil
Whirlpool, Fort Smith, Arkansas

						Soil Ingestion				Soil Dermal Contact					Contact Routes
Chem Group	**Chemical**	**CASRN**	**Cancer Class**	**ADAF**	C_{soil} (mg/kg)	**LADD** (mg/kg/d)	SF_{oral} $(mg/kg/d)^{-1}$	f_{oral}	**Risk**	ABS_{derm}	**LADD** (mg/kg/d)	SF_{derm} $(mg/kg/d)^{-1}$	f_{oral}	**Risk**	**Risk**
VOC	Acetone	67-64-1	ID	N	5.86E-02	6.47E-10									
VOC	Benzene	71-43-2	A	N	6.30E-04	6.96E-12	5.5E-02		3.8E-13			5.5E-02			3.8E-13
VOC	Bromodichloromethane	75-27-4	B2	N	2.60E-03	2.87E-11	6.2E-02		1.8E-12			6.2E-02			1.8E-12
VOC	Bromoform	75-25-2	B2	N	6.10E-03	6.74E-11	7.9E-03		5.3E-13			7.9E-03			5.3E-13
VOC	Bromomethane	74-83-9	ID	N	2.44E-01	2.69E-09									
VOC	2-Butanone	78-93-3	ID	N	2.50E-01	2.76E-09									
VOC	Carbon Disulfide	75-15-0		N	7.40E-03	8.17E-11									
VOC	Carbon Tetrachloride	56-23-5	LC	N	5.20E-03	5.74E-11	7.0E-02		4.0E-12			7.0E-02			4.0E-12
VOC	Chlorobenzene	108-90-7	D	N											
VOC	Chloroethane	75-00-3	LC	N											
VOC	Chloroform	67-66-3	B2	N	5.70E-02	6.29E-10	1.9E-02		1.2E-11			1.9E-02			1.2E-11
VOC	Chloromethane	74-87-3	D	N											
VOC	Dibromochloromethane	124-48-1	C	N			8.4E-02					8.4E-02			
VOC	1,1-Dichloroethane	75-34-3	SC	N	8.80E-03	9.72E-11									
VOC	1,2-Dichloroethane	107-06-2	B2	N	1.81E-01	2.00E-09	9.1E-02		1.8E-10			9.1E-02			1.8E-10
VOC	1,1-Dichloroethene	75-35-4	C	N	1.60E-01	1.77E-09									
VOC	1,2-Dichloroethene (total)	540-59-0		N	5.20E+00	5.74E-08									
VOC	cis-1,2-Dichloroethene	156-59-2	ID	N	1.85E+01	2.04E-07									
VOC	trans-1,2-Dichloroethene	156-60-5	ID	N	2.40E-01	2.65E-09									
VOC	1,2-Dichloropropane	78-87-5	B2	N			3.6E-02					3.6E-02			
VOC	Ethyl Benzene	100-41-4	D	N	1.40E-03	1.55E-11									
VOC	2-Hexanone	591-78-6	ID	N	7.30E-02	8.06E-10									
VOC	4-Methyl-2-pentanone	108-10-1	ID	N	1.75E-02	1.93E-10									
VOC	Methylene Chloride	75-09-2	LC	Y	3.14E+00	3.47E-08	2.0E-03	1	2.1E-10			2.0E-03	1		2.1E-10
VOC	Styrene	100-42-5		N											
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	N			2.0E-01					2.0E-01			
VOC	Tetrachloroethene	127-18-4	LC	N	1.70E-01	1.88E-09	2.1E-03		3.9E-12			2.1E-03			3.9E-12
VOC	Toluene	108-88-3	ID	N	7.03E-02	7.76E-10									
VOC	1,1,1-Trichloroethane	71-55-6	ID	N	3.20E-02	3.53E-10									
VOC	1,1,2-Trichloroethane	79-00-5	C	N	3.50E-02	3.87E-10	5.7E-02		2.2E-11			5.7E-02			2.2E-11
VOC	Trichloroethene	79-01-6	HC	Y	2.70E+02	2.98E-06	4.6E-02	0.202	1.9E-07			4.6E-02	0.202		1.9E-07
VOC	Vinyl Chloride	75-01-4	A	N	4.43E+00	4.89E-08	7.2E-01		3.5E-08			7.2E-01			3.5E-08
VOC	Xylenes (total)	1330-20-7	ID	N	8.90E-03	9.83E-11									
INORG	Iron	7439-89-6	D	N											
INORG	Manganese	7439-96-5	D	N											
		Cumulative Risk:							**2E-07**						**2E-07**

Notes:

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

RAMBOLL ENVIRON

Attachment B7.8: Hazard Index Calculations for Contact Exposure of Trespassers to Total Site Soil
Whirlpool, Fort Smith, Arkansas

				Soil Ingestion			Soil Dermal Contact				Contact Routes
Chem Group	Chemical	CASRN	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	HQ
VOC	Acetone	67-64-1	5.86E-02	4.53E-09	9.0E-01	5.0E-09			9.0E-01		5.0E-09
VOC	Benzene	71-43-2	6.30E-04	4.87E-11	4.0E-03	1.2E-08			4.0E-03		1.2E-08
VOC	Bromodichloromethane	75-27-4	2.60E-03	2.01E-10	2.0E-02	1.0E-08			2.0E-02		1.0E-08
VOC	Bromoform	75-25-2	6.10E-03	4.72E-10	2.0E-02	2.4E-08			2.0E-02		2.4E-08
VOC	Bromomethane	74-83-9	2.44E-01	1.89E-08	1.4E-03	1.3E-05			1.4E-03		1.3E-05
VOC	2-Butanone	78-93-3	2.50E-01	1.93E-08	6.0E-01	3.2E-08			6.0E-01		3.2E-08
VOC	Carbon Disulfide	75-15-0	7.40E-03	5.72E-10	1.0E-01	5.7E-09			1.0E-01		5.7E-09
VOC	Carbon Tetrachloride	56-23-5	5.20E-03	4.02E-10	4.0E-03	1.0E-07			4.0E-03		1.0E-07
VOC	Chlorobenzene	108-90-7			2.0E-02				2.0E-02		
VOC	Chloroethane	75-00-3			1.0E-01				1.0E-01		
VOC	Chloroform	67-66-3	5.70E-02	4.41E-09	1.0E-02	4.4E-07			1.0E-02		4.4E-07
VOC	Chloromethane	74-87-3									
VOC	Dibromochloromethane	124-48-1			2.0E-02				2.0E-02		
VOC	1,1-Dichloroethane	75-34-3	8.80E-03	6.80E-10	2.0E-01	3.4E-09			2.0E-01		3.4E-09
VOC	1,2-Dichloroethane	107-06-2	1.81E-01	1.40E-08	2.0E-02	7.0E-07			2.0E-02		7.0E-07
VOC	1,1-Dichloroethene	75-35-4	1.60E-01	1.24E-08	5.0E-02	2.5E-07			5.0E-02		2.5E-07
VOC	1,2-Dichloroethene (total)	540-59-0	5.20E+00	4.02E-07	2.0E-03	2.0E-04			2.0E-03		2.0E-04
VOC	cis-1,2-Dichloroethene	156-59-2	1.85E+01	1.43E-06	2.0E-03	7.2E-04			2.0E-03		7.2E-04
VOC	trans-1,2-Dichloroethene	156-60-5	2.40E-01	1.86E-08	2.0E-02	9.3E-07			2.0E-02		9.3E-07
VOC	1,2-Dichloropropane	78-87-5			9.0E-02				9.0E-02		
VOC	Ethyl Benzene	100-41-4	1.40E-03	1.08E-10	1.0E-01	1.1E-09			1.0E-01		1.1E-09
VOC	2-Hexanone	591-78-6	7.30E-02	5.64E-09	5.0E-03	1.1E-06			5.0E-03		1.1E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.75E-02	1.35E-09							
VOC	Methylene Chloride	75-09-2	3.14E+00	2.43E-07	6.0E-03	4.0E-05			6.0E-03		4.0E-05
VOC	Styrene	100-42-5			2.0E-01				2.0E-01		
VOC	1,1,2,2-Tetrachloroethane	79-34-5			2.0E-02				2.0E-02		
VOC	Tetrachloroethene	127-18-4	1.70E-01	1.31E-08	6.0E-03	2.2E-06			6.0E-03		2.2E-06
VOC	Toluene	108-88-3	7.03E-02	5.43E-09	8.0E-02	6.8E-08			8.0E-02		6.8E-08
VOC	1,1,1-Trichloroethane	71-55-6	3.20E-02	2.47E-09	2.0E+00	1.2E-09			2.0E+00		1.2E-09
VOC	1,1,2-Trichloroethane	79-00-5	3.50E-02	2.71E-09	4.0E-03	6.8E-07			4.0E-03		6.8E-07
VOC	Trichloroethene	79-01-6	2.70E+02	2.09E-05	5.0E-04	4.2E-02			5.0E-04		4.2E-02
VOC	Vinyl Chloride	75-01-4	4.43E+00	3.42E-07	3.0E-03	1.1E-04			3.0E-03		1.1E-04
VOC	Xylenes (total)	1330-20-7	8.90E-03	6.88E-10	2.0E-01	3.4E-09			2.0E-01		3.4E-09
INORG	Iron	7439-89-6			7.0E-01				7.0E-01		
INORG	Manganese	7439-96-5			1.4E-01				8.4E-03		
		Hazard Index:				**4E-02**					**4E-02**

RAMBOLL ENVIRON

Attachment B7.9: Normalized 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	1.87E-06
VOC	Benzene	71-43-2	1.59E-01	8.31E-04	4.18E-07	1.16E-05
VOC	Bromodichloromethane	75-27-4	4.45E-02	1.09E-03	1.53E-07	4.25E-06
VOC	Bromoform	75-25-2	1.34E-02	1.65E-03	6.97E-08	1.93E-06
VOC	Bromomethane	74-83-9	2.01E-01	7.57E-04	4.81E-07	1.34E-05
VOC	2-Butanone	78-93-3	2.00E-03	9.96E-03	6.30E-08	1.75E-06
VOC	Carbon Disulfide	75-15-0	9.26E-01	2.99E-04	8.76E-07	2.43E-05
VOC	Carbon Tetrachloride	56-23-5	8.82E-01	2.57E-04	7.17E-07	1.99E-05
VOC	Chlorobenzene	108-90-7	9.77E-02	9.49E-04	2.93E-07	8.14E-06
VOC	Chloroethane	75-00-3	4.09E-01	7.78E-04	1.01E-06	2.80E-05
VOC	Chloroform	67-66-3	1.07E-01	1.13E-03	3.85E-07	1.07E-05
VOC	Chloromethane	74-87-3	3.33E-01	4.70E-04	4.95E-07	1.37E-05
VOC	Dibromochloromethane	124-48-1	2.38E-02	1.28E-03	9.66E-08	2.68E-06
VOC	1,1-Dichloroethane	75-34-3	1.66E-01	7.86E-04	4.12E-07	1.14E-05
VOC	1,2-Dichloroethane	107-06-2	2.74E-02	2.41E-03	2.09E-07	5.81E-06
VOC	1,1-Dichloroethene	75-35-4	8.10E-01	3.18E-04	8.15E-07	2.26E-05
VOC	1,2-Dichloroethene (total)	540-59-0	1.19E-01	9.89E-04	3.71E-07	1.03E-05
VOC	cis-1,2-Dichloroethene	156-59-2	1.19E-01	9.89E-04	3.71E-07	1.03E-05
VOC	trans-1,2-Dichloroethene	156-60-5	2.81E-01	6.08E-04	5.41E-07	1.50E-05
VOC	1,2-Dichloropropane	78-87-5	7.82E-02	1.11E-03	2.75E-07	7.63E-06
VOC	Ethyl Benzene	100-41-4	2.04E-01	5.86E-04	3.78E-07	1.05E-05
VOC	2-Hexanone	591-78-6	3.23E-03	6.91E-03	7.07E-08	1.96E-06
VOC	4-Methyl-2-pentanone	108-10-1	4.71E-03	4.85E-03	7.23E-08	2.01E-06
VOC	Methylene Chloride	75-09-2	6.60E-02	1.61E-03	3.36E-07	9.33E-06
VOC	Styrene	100-42-5	7.04E-02	1.08E-03	2.40E-07	6.65E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	8.74E-03	3.35E-03	9.26E-08	2.57E-06
VOC	Tetrachloroethene	127-18-4	4.90E-01	3.47E-04	5.39E-07	1.49E-05
VOC	Toluene	108-88-3	1.80E-01	7.10E-04	4.05E-07	1.12E-05
VOC	1,1,1-Trichloroethane	71-55-6	4.97E-01	3.71E-04	5.83E-07	1.62E-05
VOC	1,1,2-Trichloroethane	79-00-5	2.43E-02	2.12E-03	1.63E-07	4.52E-06
VOC	Trichloroethene	79-01-6	2.88E-01	5.33E-04	4.86E-07	1.35E-05
VOC	Vinyl Chloride	75-01-4	9.00E-01	3.51E-04	9.99E-07	2.77E-05
VOC	Xylenes (total)	1330-20-7	1.73E-01	7.02E-04	3.85E-07	1.07E-05
INORG	Iron	7439-89-6				
INORG	Manganese	7439-96-5				
	Parameters					
	Depth to groundwater	m	**DTW**	3.66		
	Dispersion coefficient	(kg/m^3) / (kg/m^2/s)	**C/Q**	27.7		

RAMBOLL ENVIRON

Attachment B7.10: Dispersion Factor for Groundwater to Outdoor Air Whirlpool, Fort Smith, Arkansas		
Parameter	**Units**	**Value**
Correlation coefficient city		Little Rock
Correlation coefficient A		12.4964
Correlation coefficient B		18.4476
Correlation coefficient C		210.2128
Groundwater source area	acres	34.00
Groundwater averaging time for C/Q		Annual Max
Conversion factor from 1-Hr Max for groundwater		0.19
C/Q for Groundwater	$(kg/m^3)/(kg/m^2/s)$	**27.75**
Note:		
C/Q is estimated using the empirical correlation in USEPA's Supplemental SSG (2002).		

Attachment B7.11: Cancer Risk and Hazard Index Calculations for Exposure of Trespassers to Groundwater-derived Vapors in Outdoor Air
Whirlpool, Fort Smith, Arkansas

							Cancer				Noncancer	
Chem Group	**Chemical**	**CASRN**	**Carc Class**	**ADAF**	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	N	3.99E-01	7.47E-07					3.1E+01	5.5E-10
VOC	Benzene	71-43-2	A	N	2.00E-03	2.32E-08	7.8E-03		5.9E-13		3.0E-02	1.8E-08
VOC	Bromodichloromethane	75-27-4	B2	N	5.30E-03	2.25E-08						
VOC	Bromoform	75-25-2	B2	N	3.55E-02	6.86E-08	1.1E-03		2.5E-13			
VOC	Bromomethane	74-83-9	ID	N	8.43E-02	1.13E-06					5.0E-03	5.1E-06
VOC	2-Butanone	78-93-3	ID	N	1.43E-01	2.50E-07					5.0E+00	1.1E-09
VOC	Carbon Disulfide	75-15-0		N	1.08E-02	2.62E-07					7.0E-01	8.6E-09
VOC	Carbon Tetrachloride	56-23-5	LC	N	1.44E-02	2.87E-07	6.0E-03		5.6E-12		1.0E-01	6.5E-08
VOC	Chlorobenzene	108-90-7	D	N	7.00E-03	5.70E-08					5.0E-02	2.6E-08
VOC	Chloroethane	75-00-3	LC	N	2.20E-03	6.15E-08					1.0E+01	1.4E-10
VOC	Chloroform	67-66-3	B2	N	4.06E+00	4.34E-05	2.3E-02		3.3E-09		5.0E-02	2.0E-05
VOC	Chloromethane	74-87-3	D	N	1.10E-01	1.51E-06					9.0E-02	3.8E-07
VOC	Dibromochloromethane	124-48-1	C	N	3.50E-03	9.39E-09						
VOC	1,1-Dichloroethane	75-34-3	SC	N	4.42E-02	5.05E-07					5.0E-01	2.3E-08
VOC	1,2-Dichloroethane	107-06-2	B2	N	2.50E-03	1.45E-08	2.6E-02		1.2E-12		7.0E-03	4.7E-08
VOC	1,1-Dichloroethene	75-35-4	C	N	2.95E-01	6.67E-06					2.0E-01	7.6E-07
VOC	1,2-Dichloroethene (total)	540-59-0		N								
VOC	cis-1,2-Dichloroethene	156-59-2	ID	N	2.87E+00	2.96E-05						
VOC	trans-1,2-Dichloroethene	156-60-5	ID	N	7.04E-01	1.06E-05						
VOC	1,2-Dichloropropane	78-87-5	B2	N	2.00E-03	1.53E-08					4.0E-03	8.7E-08
VOC	Ethyl Benzene	100-41-4	D	N							1.0E+00	
VOC	2-Hexanone	591-78-6	ID	N	5.80E-03	1.14E-08					3.0E-02	8.7E-09
VOC	4-Methyl-2-pentanone	108-10-1	ID	N	3.00E-03	6.02E-09					3.0E+00	4.6E-11
VOC	Methylene Chloride	75-09-2	LC	Y	5.05E-02	4.71E-07	1.0E-05	1	4.6E-14		6.0E-01	1.8E-08
VOC	Styrene	100-42-5		N							1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	N	1.71E+00	4.39E-06						
VOC	Tetrachloroethene	127-18-4	LC	N	4.40E-02	6.58E-07	2.6E-04		5.6E-13		4.0E-02	3.8E-07
VOC	Toluene	108-88-3	ID	N	1.04E-02	1.17E-07					5.0E+00	5.3E-10
VOC	1,1,1-Trichloroethane	71-55-6	ID	N	1.31E+00	2.12E-05					5.0E+00	9.7E-08
VOC	1,1,2-Trichloroethane	79-00-5	C	N	1.07E-02	4.83E-08	1.6E-02		2.5E-12			
VOC	Trichloroethene	79-01-6	HC	Y	1.69E+02	2.28E-03	4.1E-03	0.244	4.5E-08		2.0E-03	2.6E-02
VOC	Vinyl Chloride	75-01-4	A	N	5.40E-01	1.50E-05	4.4E-03		2.1E-10		1.0E-01	3.4E-06
VOC	Xylenes (total)	1330-20-7	ID	N							1.0E-01	
INORG	Iron	7439-89-6	D	N	1.43E+01							
INORG	Manganese	7439-96-5	D	N	1.28E+01						5.0E-05	
						Cumulative Risk:			5E-08		**HI:**	3E-02
Note:												
f_{inh} is the fraction of the inhalation toxicity value that USEPA identified as having a mutagenic mode of action.												

RAMBOLL ENVIRON