RISK ASSESSMENT
ROBINSON TERMINAL – SOUTH
DUKE STREET AND SOUTH UNION STREET
ALEXANDRIA, VIRGINIA

ECS PROJECT NO. 01:21983-E

FOR

EYA

JUNE 1, 2015

June 1, 2015

Mr. Adam Hayes
Sr. Director of Engineering
EYA
4800 Hampden Lane, Suite 300
Bethesda, Maryland 20814

ECS Project No. 01:21983-E

Reference: Risk Assessment, Robinson Terminal – South, Duke Street and South Union Street, Alexandria, Virginia.

Dear Mr. Hayes:

ECS Mid-Atlantic, LLC (ECS) is pleased to provide EYA with the results Risk Assessment (RA) for the above-referenced property. Our services were provided in accordance with ECS Proposal No. 51400-EP dated May 29, 2015. If you have any questions or comments regarding this report, or any other aspect of the project, please contact us at (703) 471-8400.

Respectfully submitted,

ECS MID-ATLANTIC, LLC

David J. Bookbinder, C.P.G.
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Attachments: Figure
Boring Logs
VRP Tables
Laboratory Results

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1.0 BACKGROUND

The subject site is located at 2 Duke Street (Robinson Terminal South) and 226 Strand Street (Alexandria Marine) in Alexandria, Virginia. The site is identified as City of Alexandria Tax Assessment Map Numbers 075.03-04-01 (2 Duke Street) and 075.03-03-14 (226 Strand Street). The 3.35-acre subject site currently occupied with three warehouses, an office building and a free-standing building.

WSP Environment & Energy (WSP) prepared a Phase I Environmental Site Assessment (ESA) for the property in March 2013. WSP identified fill material and historical industrial activities as recognized environmental conditions (RECs) in connection with the property. Based on the findings of the Phase I ESA, WSP conducted a Phase II ESA in April 2013. Five borings were advanced to depths ranging between 10 and 20 feet below surface grade. Saturated conditions were encountered between 3 and 6 feet below surface grade. Two soil samples from each boring and groundwater samples from three of the borings were selected for laboratory analysis. Petroleum contamination was detected the soil samples analyzed from areas where historical petroleum storage and transfer operations were formerly located. Evidence of impact was not detected in borings advanced in areas surrounding other historical operations onsite.

ECS prepared a Phase I ESA for the property in October 2013 (ECS Project No. 21983-C). The following recognized environmental conditions were identified:

- Multiple ASTs are located throughout the site. Staining was observed on the ground around the heating oil tanks. Four oil-water separators were observed inside the service bays of the truck stop, which also showed evidence of staining. A 55-gallon drum of petroleum located outside Alexandria Marine showed significant evidence of leaking on the surrounding gravel. It is possible the subsurface has been impacted from the historical use and storage of petroleum products.
- Alexandria Marine is listed on the UST database as formerly maintaining three 2,000-gallon USTs containing an unknown material. All of the USTs listed are reported to have been “removed from the ground.” ECS considers the presence of former USTs at the site to be a REC because no definitive information is available regarding subsurface conditions in this area and tank closure information was not available for review. A possible vent/fill pipe was observed in the sprinkler room of warehouse #8. It is not known if these pipes are associated with a UST.
- Hydraulic lifts with below ground cylinders were observed in the service bays of warehouses #6, #7 and #8.
- Historically, the southern portion of the site was utilized as a rail spur with a freight house and oil company with multiple petroleum tanks from 1896 to 1921 (Sanborn Maps) and a fertilizer warehouse. It is possible other unknown or undocumented USTs are located beneath the site. The historical industrial use of the site is considered a REC for the site.

ECS conducted a Phase II ESA concurrently with the Phase I ESA (ECS Project No. 21983). A total of 23 borings were advanced across the property (20 on the Robinson Terminal site and 3 on the Alexandria Marine site). Petroleum contamination was detected in 23 of the 33 soil samples submitted for analysis. Volatile organic compounds (VOCs) and pesticides/herbicides were not detected above their respective Virginia Department of Environmental Quality (VDEQ) Tier II risk based level for unrestricted use in the samples analyzed. Several polycyclic aromatic hydrocarbons (PAHs), arsenic and lead were detected above their respective VDEQ Tier II risk based levels. Evidence of petroleum impact was also detected in groundwater samples analyzed from across the property.

We understand that the project consists of the construction of a mixed-use development which will consist of both commercial/retail facilities as well as multi-family residential structures. There will be a total of nine proposed above-grade structures, one proposed below-grade parking garage and one structure that will remain on site from the existing Robinson Terminal facility. The three proposed 5-story commercial/retail buildings and two of the six proposed 4-story residential buildings are expected to be founded on a shared one level below-grade parking garage. The proposed 4-story townhouses located in the northwest portion of the site will be constructed near existing grade. The existing one-story structure to remain onsite located within the northern portion of the site is understood to be founded at-grade.

2.0 SITE-SPECIFIC RISK ASSESSMENT

As noted above, the site consists of the construction of a mixed-use development which will consist of both commercial/retail facilities as well as multi-family residential structures. This risk assessment was performed based on the assumption that the immediate risk associated with the contamination present beneath the property will be to utility/construction workers during redevelopment activities. Utility/construction workers can be exposed to contaminants in soil and groundwater through one of three pathways: dermal contact, ingestion, and inhalation.

Based on the excavation depth (i.e. 12 feet), the majority of the contaminated materials will be removed from the property. Dewatering activities during the excavation will also likely remove the elevated contaminants currently present in the groundwater. Following completion of the redevelopment activities, the property will be covered with buildings, hardscape and/or a clean soil cap at the surface which would close the exposure pathways to future occupants. Additionally, the ventilation system required for the parking garage will remove potential vapors that may remain beneath the structures following the completion of construction activities.

The risk assessment methodology follows the VDEQ Voluntary Remediation Program (VRP) guidance. Risk assessments under the VRP guidance generally follow the methodology described in the EPA's Risk Assessment Guidance for Superfund (RAGS). The steps involved in this risk assessment are as follows:

Section 2.1 - Data Collection,
Section 2.2 - Contaminant Screening,
Section 2.3 - Exposure Assessment,
Section 2.4 - Toxicity Assessment, and
Section 2.5 - Risk Characterization.

2.1 Data Collection and Evaluation

The project consists of the construction of a mixed-use development which will consist of both commercial/retail facilities as well as multi-family residential structures. There will be a total of nine proposed above-grade structures, one proposed below-grade parking garage and one structure that will remain on site from the existing Robinson Terminal facility. The three proposed 5-story commercial/retail buildings and two of the six proposed 4-story residential buildings are expected to be founded on a shared one level below-grade parking garage. The depth of soil excavation for the parking garage is anticipated to be approximately 12 feet below surface grade. The proposed 4-story townhouses located in the northwest portion of the site will be constructed near existing grade. The existing one-story structure to remain onsite located within the northern portion of the site is understood to be founded at-grade. For this risk assessment, ECS compiled the soil and groundwater results from the previous sampling conducted on the property.

2.1.1 Soil Analytical Results

WSP conducted soil sampling on the property in which 10 soil samples were analyzed. Each of the 10 soil samples were analyzed for total petroleum hydrocarbons diesel-range organics (TPH-DRO) and Resource Conservation and Recovery Act (RCRA) metals. Additionally, five of the samples were analyzed for target compound list volatile organic compounds (VOCs), three of the samples were analyzed for semi-volatile organic compounds (SVOCs) where visible staining was observed and three samples were submitted for polychlorinated biphenyls (PCBs). During the sampling event conducted by ECS, 33 soil samples were analyzed for TPH-DRO, total petroleum hydrocarbons gasoline-range organics (TPH-GRO) and VOCs, 26 soil samples were analyzed for RCRA metals and polycyclic aromatic hydrocarbons (PAHs) and 3 soil samples were analyzed for pesticides and herbicides. For metal results that exceeded 20 times their RCRA threshold, a TCLP analysis was conducted for waste characterization purposes.

The table below represents the maximum concentrations detected during the two sampling events compared to the VDEQ Tier III risk based levels for construction workers.

Table 1. Maximum Soil Concentrations Detected
(bold values exceed the VDEQ Tier III Screening Concentration)

RCRA Metals

Date	Media	Contaminant	Concentration	Tier III Screening Level	Units
9/27/13	Soil	Arsenic	**48.1**	**30**	mg/kg
9/26/13	Soil	Barium	235	**22,000**	mg/kg
9/27/13	Soil	Cadmium	10.5	**98**	mg/kg
9/27/13	Soil	Total Chromium	31.8	No listing	mg/kg
9/27/13	Soil	Lead	**1,180**	**800**	mg/kg
9/26/13	Soil	Mercury	1.41	**4.0**	mg/kg
9/27/13	Soil	Silver	7.91	**580**	mg/kg

VOCs

Date	Media	Contaminant	Concentration	Tier III Screening Level	Units
9/27/13	Soil	Acetone	0.21	**67,000**	mg/kg
9/27/13	Soil	2-Butanone	0.047	**19,000**	mg/kg
9/26/13	Soil	Carbon Disulfide	0.011	**350**	mg/kg

VOCs (con't.)

Date	Media	Contaminant	Concentration	Tier III Screening Level	Units
9/27/13	Soil	2-Hexanone	0.38	**130**	mg/kg
4/18/13	Soil	Methylcyclohexane	8.0	**No listing**	mg/kg
9/26/13	Soil	Methylene Chloride	0.015	**320**	mg/kg
9/26/13	Soil	Total Xylenes	0.18	**250**	mg/kg

sVOCs

Date	Media	Contaminant	Concentration	Tier III Screening Level	Units
9/27/13	Soil	Acenaphthene	9.8	**4,500**	mg/kg
9/27/13	Soil	Acenaphthylene	0.084	**2,300**	mg/kg
9/27/13	Soil	Anthracene	18	**23,000**	mg/kg
9/27/13	Soil	Benzo (a) Anthracene	23	**29**	mg/kg
9/27/13	Soil	Benzo (a) Pyrene	**22**	**2.9**	mg/kg
9/27/13	Soil	Benzo (b) Fluoranthene	25	**29**	mg/kg
9/27/13	Soil	Benzo (g,h,i) Perylene	14	**2,300**	mg/kg
9/27/13	Soil	Benzo (k) Fluoranthene	12	**290**	mg/kg
9/27/13	Soil	Chrysene	22	**290**	mg/kg
9/27/13	Soil	Dibenz(a,h)anthracene	2.7	**2.9**	mg/kg
9/27/13	Soil	Fluoranthene	63	**3,000**	mg/kg
9/27/13	Soil	Fluorene	8.7	**3,000**	mg/kg
9/27/13	Soil	Indeno (1,2,3-cd) Pyrene	13	**29**	mg/kg
9/27/13	Soil	Naphthalene	10	**59**	mg/kg
9/27/13	Soil	Phenanthrene	59	**2,300**	mg/kg
9/27/13	Soil	Pyrene	46	**23,000**	mg/kg

Pesticides and Hebicides

Date	Media	Contaminant	Concentration	Tier III Screening Level	Units
9/27/13	Soil	Methoxychlor	**0.0034**	**410**	mg/kg

2.1.2 Groundwater Analytical Results

A total of 14 groundwater samples were analyzed on the property (3 by WSP and 11 by ECS). The three groundwater samples collected by WSP were analyzed for TPH-DRO, VOCs and RCRA metals, and the eleven groundwater samples collected by ECS were analyzed for TPH-DRO, TPH-GRO, VOCs, PAHs and RCRA metals.

The table below represents the maximum concentrations detected during the two sampling events compared to the VDEQ Tier III risk based levels for construction workers.

Table 2. Maximum Ground Water Contaminant Concentrations
(bold values exceed the VDEQ Tier III Screening Concentration)

RCRA-8 Metals

Date Collected	Media	Contaminant	Concentration	Tier III Screening Level Dermal/ Ingestion	Tier III Screening Level Inhalation	Units
9/26/13	Water	Arsenic	0.426	**207**	**No listing**	µg/L
9/26/13	Water	Barium	3.85	**2,140**	**No listing**	µg/L
9/26/13	Water	Cadmium	0.195	**0.84**	**No listing**	µg/L
9/26/13	Water	Total Chromium	0.346	**289**	**No listing**	µg/L
9/26/13	Water	Lead	7.57	**No listing**	**No listing**	µg/L
9/26/13	Water	Mercury	0.0126	**No listing**	**0.0895**	µg/L

VOCs

Date Collected	Media	Contaminant	Concentration	Tier III Screening Level Dermal/ Ingestion	Tier III Screening Level Inhalation	Units
9/26/13	Water	Total Xylenes	1.0	**12,100**	**87.4**	µg/L

sVOCs

Date Collected	Media	Contaminant	Concentration	Tier III Screening Level Dermal/ Ingestion	Tier III Screening Level Inhalation	Units
9/27/13	Water	Acenaphthene	12	**3,120**	**No listing**	µg/L
9/26/13	Water	Acenaphthylene	11	**1,590**	**No listing**	µg/L
9/27/13	Water	Anthracene	26	**8,330**	**No listing**	µg/L
9/27/13	Water	Benzo (a) Anthracene	**53**	**15**	**107**	µg/L

sVOCs (con't.

Date Collected	Media	Contaminant	Concentration	Tier III Screening Level Dermal/ Ingestion	Tier III Screening Level Inhalation	Units
9/27/13	Water	Benzo (a) Pyrene	**47**	**1.01**	**237**	µg/L
9/27/13	Water	Benzo (b) Fluoranthene	**66**	**17**	**1,635**	µg/L
9/27/13	Water	Benzo (g,h,i) Perylene	34	**147**	**No listing**	µg/L
9/27/13	Water	Benzo (k) Fluoranthene	25	**128**	**1,850**	µg/L
9/27/13	Water	Chrysene	52	**1,390**	**2,190**	µg/L
9/27/13	Water	Fluoranthene	120	**330**	**No listing**	µg/L
9/27/13	Water	Fluorene	11	**4,260**	**No listing**	µg/L
9/27/13	Water	Indeno (1,2,3-cd) Pyrene	**31**	**9.71**	**712**	µg/L
9/26/13	Water	Naphthalene	**14**	**606**	**0.722**	µg/L
9/27/13	Water	Phenanthrene	88	**1,560**	**No listing**	µg/L
9/27/13	Water	Pyrene	98	**941**	**No listing**	µg/L

2.2 Contaminant Screening

The purpose of contaminant screening is to compare site-specific contaminant concentrations to one of three VRP sets of screening criteria. The VRP employs a three-tiered approach to screening contaminants. The Tier I screening involves comparing contaminants detected at a site to those from background samples collected from nearby areas that have not been affected by the contaminants of concern. The Tier II screening involves comparing site concentrations to medium-specific values obtained from published sources such as the EPA's Risk-Based Concentrations (RBC) Tables, the EPA's Soil Screening Level (SSL) Guidance, or other action levels established by EPA. The Tier III screening is based upon site-specific analysis that weighs current and potential exposure scenarios for the population(s) based on the contaminants of concern and characteristics of the affected media.

Tier I screening (i.e., background screening) is optional and is normally employed to determine if further screening is necessary. Tier II screening levels are employed for unrestricted sites (i.e., residential or commercial usage) and Tier III screening levels are employed for properties that are in commercial usage and are anticipated to remain in commercial usage as well as potential exposures for utility/construction workers. Because the planned development will involve the excavation of soil to a depth of approximately 12 feet below surface grade, the contaminant concentrations detected in either soil and/or groundwater were compared to the Tier III screening concentrations for risks posed to

utility/construction workers during redevelopment activities. Those chemicals that exceeded the Tier III screening levels were entered into the exposure assessment (Section 2.4).

2.2.1 VRP Tier III Soil Screening

A total of 46 soil samples were collected by ECS and WSP. The contaminants of concern on the site fall into two categories: RCRA metals and SVOCs. For this risk assessment, the highest concentration for all contaminants exceeding their respective Tier III screening level is being utilized for this risk analysis.

Results for all contaminants are presented in VRP Table 2.9 Soil Restricted in Appendix II. Based on the soil sampling results, ECS retained each of the contaminants that exceeded the VRP Tier III screening level due to their actual concentration detected for the dermal, ingestion and inhalation exposure pathways in this risk assessment: arsenic, lead and benzo(a)pyrene.

2.2.2 VRP Tier III Groundwater Screening

A total of 14 groundwater samples were collected during previous sampling events by ECS and WSP. The maximum concentrations were compared to the VRP Tier III screening levels. Results for all contaminants are presented in VRP Table 2.13 Groundwater: Construction Worker in a Trench in Appendix II.

Based on the groundwater sampling results, ECS retained all of the contaminants that exceeded the VRP Tier III screening level due to their actual concentration detected for the dermal and ingestion exposure pathways in this risk assessment: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene and indeno(1,2,3-cd)pyrene. Additionally, naphthalene was retained retained for the inhalation exposure pathway.

2.3 Exposure Assessment

The goals of the exposure assessment are to analyze the contaminant release; to identify exposed populations; to identify potential exposure pathways; and to estimate exposure concentrations and contaminant intakes for each pathway.

As noted in Section 2.1, the site will be developed with at-grade townhouses in the northeast portion of the property and multi-family buildings with one level of below grade parking will be located on the remainder of the property. The majority of the property will be occupied by these structures. This risk assessment was performed assuming that the majority of detected contaminants in soil and groundwater would be removed during redevelopment activities, and construction/utility workers could come into contact with the highest detected

levels in the soil and groundwater. Groundwater was encountered in the borings conducted across the property at depths ranging between 3 and 6 feet below surface grade.

2.3.1 Determining Exposure Point Concentrations

As noted in Section 2.1, the maximum concentrations detected for soil and groundwater were compared to the VRP Tier III screening levels. A quantitative risk assessment was performed on all contaminants that exceeded the screening levels. A listing of the contaminants that are included in this risk assessment for the construction/utility worker population are provided in the table below; the rationale for including these chemicals is discussed in Section 2.2.

Table 3. Contaminants Retained for the Risk Assessment – Soil – Dermal and Ingestion Pathways – Construction/Utility Worker

Contaminant	Maximum Concentration Detected	Maximum Exceeds Tier III Screening Concentration?
Soils – Metals (mg/kg)		
Arsenic	48.1	Yes
Lead	1,180	Yes
Soils – SVOCs (mg/kg)		
Benzo(a)pyrene	22	Yes
Groundwater – SVOCs (ug/L)		
Benzo(a)anthracene	53	Yes
Benzo(a)pyrene	47	Yes
Benzo(b)fluoranthene	66	Yes
Indeno(1,2,3-cd)pyrene	31	Yes

The exposure point concentration for the inhalation pathway was calculated for contaminants exceeding their respective Tier III screening levels. The exposure point concentrations for arsenic and lead in soil were calculated by dividing the concentration employed for the dermal/ingestion pathways by the particulate emission factor provided by VDEQ guidance (3.34×10^9 m^3/kg). The exposure point concentration for benzo(a)pyrene detected in soil above the Tier III screening concentration was calculated by dividing the concentration by its respective volatilization factor. The exposure point concentration for the contaminants detected in groundwater was calculated from VRP Table 3.8 – Exposure Point Concentrations for Construction/Utility Workers in a Trench – Groundwater Less than 15 feet. A listing of the contaminants that are included in this risk assessment are provided in the table below; the rationale for including these chemicals is discussed in Section 2.3.

Table 4. Contaminants Retained for the Risk Assessment – Inhalation Pathway – Construction/ Utility Worker

Contaminant	Exposure Point Concentration (mg/m^3)
Soil – Metals	
Arsenic	1.44E-08
Lead	3.53E-07
Soil – SVOCs	
Benzo(a)pyrene	1.36E-06
Groundwater – SVOCs	
Naphthalene	9.24E-02

2.3.2 Determining Chemical Intakes, Exposure Equations, and Exposure Factors

Chemical intakes for soil and groundwater were calculated using the maximum detected concentrations. The maximum concentrations were also employed to calculate chemical-specific intake levels for each open receptor group and open exposure route. The applicable contaminants for the open exposure pathways for the utility/construction worker are summarized above in tables in Section 2.3.1. For the open soil and groundwater pathways, daily intakes for dermal contact, ingestion and inhalation for each of the applicable contaminants were calculated. The results of the groundwater dermal contact, ingestion and inhalation daily intake calculations are contained in VRP Tables 3.10, 3.11 and 3.12, respectively (Appendix IV). The results of the soil dermal contact, ingestion, and inhalation daily intake calculations are contained in VRP Tables 3.13, 3.14, and 3.15, respectively (Appendix IV). In all of the calculations, conservative VRP default exposure factors were employed.

2.4 Toxicity Assessment

Based on toxicity factors, contaminants are designated as non-carcinogens or carcinogens by the EPA. Some contaminants (arsenic, for example) are evaluated as both non-carcinogens and carcinogens for various exposure pathways, per VRP Guidance. Toxicity designations for the soil and groundwater contaminants identified on the Combined VRP Site are summarized in the tables below.

Lead is classified as a "probable carcinogen". Neither the VDEQ nor the EPA use the RfD approach when evaluating lead; the EPA considers lead to be a special case because of the difficulty in identifying the classic “threshold” needed to develop an RfD.

Table 5. Toxicity Designation for Soil Contaminants Exceeding VRP Tier III Screening Concentrations

Soil	Toxicity Designation		
	Dermal Pathway	Ingestion Pathway	Inhalation Pathway
Metals			
Arsenic	C/NC	C/NC	C/NC
Lead	Note 1	Note 1	Note 1
SVOCs			
Benzo(a)pyrene	C	C	C

C – Carcinogen; **NC** – Non-Carcinogen
Note 1 – No USEPA value established

Table 6. Toxicity Designation for Groundwater Contaminants Exceeding VRP Tier III Screening Concentrations

Groundwater	Toxicity Designation		
	Dermal Pathway	Ingestion Pathway	Inhalation Pathway
SVOCs			
Benzo(a)anthracene	C	C	C
Benzo(a)pyrene	C	C	C
Benzo(b)fluoranthene	C	C	C
Indeno(1,2,3-cd)pyrene	C	C	C
Naphthalene	NC	NC	C/NC

C – Carcinogen
NC – Non-Carcinogen

2.5 Risk Characterization

This step involves calculating appropriate carcinogenic and non-carcinogenic risk factors for chemicals whose concentrations exceed the respective screening levels. Risks are calculated for all on-site and offsite pathways that are considered open. Because risks due to multiple chemicals are assumed to be additive, cumulative cancer risks and hazard quotients are calculated for the risks from various pathways for the different chemicals.

Carcinogenic risk is expressed as the unit probability of a one in a 100,000 chance of cancer occurring. The carcinogenic risk for ingestion and inhalation is calculated by multiplying the chronic daily intake (CDI) times a chemical-specific cancer slope factor. The carcinogenic risk for dermal exposure is calculated by multiplying the Daily Absorbed Dose (DAD) times a chemical-specific cancer slope factor.

For Ingestion or Inhalation Pathways
Carcinogenic Risk = CDI x Cancer Slope Factor

For Dermal Contact Pathway
Carcinogenic Risk = DAD x Cancer Slope Factor

Ingestion CDIs for soil are calculated in VRP Table 3.14. Inhalation CDIs for soil and groundwater are calculated in VRP Tables 3.15 and 3.12, respectively. Lastly, the dermal contact DADs for soil is calculated in VRP Table 3.13. According to the VRP guidance, the risk goal for individual carcinogens is 10^{-5} with a not to exceed cumulative site risk of 10^{-4} for all carcinogens.

Non-carcinogenic risk is expressed as a hazard quotient that is the CDI or the DAD divided by a chemical-specific published reference dose (RfD). Chronic RfDs were employed in the calculations.

For Ingestion or Inhalation Pathways
Non-Carcinogenic Risk = CDI / Chronic RfD

For Dermal Contact Pathway
Non-Carcinogenic Risk = DAD / Chronic RfD

A hazard quotient greater than 1.0 is considered unacceptable; a hazard quotient equal to or less than 1.0 is considered acceptable.

Carcinogenic risk due to exposure to multiple chemicals is considered additive. Therefore, the total carcinogenic risk is calculated by adding the risks from all of the chemicals for all of the open pathways for an exposed population. Risk is calculated for construction/utility workers for all contaminants exceeding VRP Tier III screening levels for the dermal, ingestion and inhalation pathways. The results of the risk assessment are summarized for the utility/construction worker below and the VRP calculations are included in Appendix IV.

ECS employed the default exposure durations for this risk assessment. The following tables summarize risks associated with the construction and utility workers.

Table 7. On-Site Carcinogenic Risk – Construction Worker Pathway

	Dermal	**Ingestion**	**Inhalation**	**Total**
		Soil		
Metals				
Arsenic	5.51E-08	1.06E-06	5.05E-11	1.11E-06
Lead	Note 2	Note 2	Note 2	Note 2
SVOCs				
Benzo(a)pyrene	5.32E-07	2.36E-06	1.22E-09	2.89E-06
Total Cancer Risk - Soil	**5.87E-07**	**3.42E-06**	**1.27E-09**	**4.00E-06**

Table 7. On-Site Carcinogenic Risk – Construction Worker Pathway				
	Dermal	**Ingestion**	**Inhalation**	**Total**
Groundwater				
SVOCs				
Benzo(a)anthracene	2.91E-05	4.73E-08	Note 3	2.91E-05
Benzo(a)pyrene	4.38E-04	4.20E-07	Note 3	4.81E-04
Benzo(b)fluoranthene	6.25E-05	5.89E-08	Note 3	6.25E-05
Indeno(1,2,3-cd)pyrene	3.03E-05	2.77E-08	Note 3	3.04E-05
Naphthalene	Note 3	Note 3	2.56E-06	2.56E-06
Total Cancer Risk - GW	**5.60E-04**	**5.54E-07**	**2.56E-06**	**5.63E-04**
Total Cancer Risk	***5.61E-04***	***3.97E-06***	***2.56E-06***	***5.67E-04***

Note 1 = No cancer slope factor or reference dose is listed for this contaminant
Note 2 = No USEPA value established
Note 3 = Contaminant not evaluated for this pathway

Likewise, non-carcinogenic hazard quotients are also considered additive. Therefore, the total hazard quotient is calculated by adding the quotients from all of the chemicals for all of the open pathways. The quantitative results of the non-carcinogenic hazard quotient assessment for the open pathways are provided in the table below.

Table 8. On-Site Non-Carcinogenic Risk – Construction Worker Pathway				
	Dermal	**Ingestion**	**Inhalation**	**Total**
Soil				
Metals				
Arsenic	8.57E-03	1.65E-01	5.48E-05	1.73E-01
Lead	Note 2	Note 2	Note 2	Note 2
SOVCs				
Benzo(a)pyrene	Note 1	Note 1	Note 1	Note 1
Total Hazard Quotient - Soil	**8.57E-03**	**1.65E-01**	**5.48E-05**	**1.73E-01**
Groundwater				
SVOCs				
Benzo(a)anthracene	Note 1	Note 1	Note 3	Note 1
Benzo(a)pyrene	Note 1	Note 1	Note 3	Note 1
Benzo(b)fluoranthene	Note 1	Note 1	Note 3	Note 1
Indeno(1,2,3-cd)pyrene	Note 1	Note 1	Note 3	Note 1
Naphthalene	Note 3	Note 3	1.76E+00	1.76+00
Total Hazard Quotient - GW	**Note 1**	**Note 1**	**1.76E+00**	**1.76E+00**
Total Hazard Quotient	***8.57E-03***	***1.65E-01***	***1.76E+00***	***1.93E+00***

Note 1 = No cancer slope factor or reference dose is listed for this contaminant
Note 2 = No USEPA value established
Note 3 = Contaminant not evaluated for this pathway

SECTION 3.0

UNCERTAINTY ANALYSIS

The risk assessment conducted for the site was based on the results of sampling conducted by both WSP and ECS. Soil contamination is primarily confined to the fill material which extends to approximately 12-15 feet beneath surface grade. Contaminants in the fill material consist primarily of diesel, SVOCs, arsenic and lead. Sampling was limited due to the presence of the existing buildings on the property. Therefore, the calculations provided in this risk assessment are limited to samples that were collected in accessible areas.

ECS compiled all of the sampling results collected on the property. Overall, a total of 46 soil and 14 groundwater samples have been analyzed across the site. The maximum concentrations detected were utilized in the risk assessment to represent the worst case associated with the highest concentrations detected. Elevated concentrations were not detected in the majority of the borings. Therefore, the maximum concentrations used for this risk assessment likely overestimate the actual risk associated with the subsurface contamination. Additionally, the potential risk was calculated utilizing the default VRP values for duration and exposure time. It is unlikely that a utility/construction worker would be in direct contact with the soil and/or groundwater as part of the redevelopment activities for the entire duration provided in the risk calculations. As a result, the calculated risk likely overestimates the actual risk posed by the contaminant concentrations utilized.

SECTION 4.0

SUMMARY AND RECOMMENDATION

The site consists of two tax parcels comprising approximately 3.35 acres of land. ECS prepared a Phase I ESA for the property in October 2013 (ECS Project No. 21983-C). The following recognized environmental conditions were identified:

- Multiple ASTs are located throughout the site. Staining was observed on the ground around the heating oil tanks. Four oil-water separators were observed inside the service bays of the truck stop, which also showed evidence of staining. A 55-gallon drum of petroleum located outside Alexandria Marine showed significant evidence of leaking on the surrounding gravel. It is possible the subsurface has been impacted from the historical use and storage of petroleum products.
- Alexandria Marine is listed on the UST database as formerly maintaining three 2,000-gallon USTs containing an unknown material. All of the USTs listed are reported to have been "removed from the ground." ECS considers the presence of former USTs at the site to be a REC because no definitive information is available regarding subsurface conditions in this area and tank closure information was not available for review. A possible vent/fill pipe was observed in the sprinkler room of warehouse #8. It is not known if these pipes are associated with a UST.
- Hydraulic lifts with below ground cylinders were observed in the service bays of warehouses #6, #7 and #8.
- Historically, the southern portion of the site was utilized as a rail spur with a freight house and oil company with multiple petroleum tanks from 1896 to 1921 (Sanborn Maps) and a fertilizer warehouse. It is possible other unknown or undocumented USTs are located beneath the site. The historical industrial use of the site is considered a REC for the site.

We understand that the project consists of the construction of a mixed-use development which will consist of both commercial/retail facilities as well as multi-family residential structures. There will be a total of nine proposed above-grade structures, one proposed below-grade parking garage and one structure that will remain on site from the existing Robinson Terminal facility. The three proposed 5-story commercial/retail buildings and two of the six proposed 4-story residential buildings are expected to be founded on a shared one level below-grade parking garage. It is anticipated that the excavation for the parking garage will be to a depth of approximately 12 feet below surface grade. The proposed 4-story townhouses located in the northwest portion of the site will be constructed near existing grade. The existing one-story structure to remain onsite located within the northern portion of the site is understood to be founded at-grade.

Two separate subsurface sampling events were conducted on the property. WSP advanced five borings on the property in April 2013. The samples collected during the April 2013 sampling event were analyzed for TPH-DRO, VOCs, SVOCs, RCRA metals and PCBs. In September 2013, ECS advanced 23 borings across the property. The samples collected

during the September 2013 sampling event were analyzed for TPH-DRO, TPH-GRO, VOCs, PAHs, RCRA metals and pesticides/herbicides. Additionally, a TCLP was conducted on any RCRA metal that exceeded their respective RCRA threshold by 20 times.

A total of 14 groundwater samples were collected during both sampling events (3 by WSP and 11 by ECS). The groundwater samples collected by WSP were analyzed for TPH-DRO, VOCs and RCRA metals. Analysis of TPH-DRO, TPH-GRO, VOCs, PAHs and RCRA metals was conducted on the groundwater samples collected by ECS.

ECS compiled the sampling results conducted during both sampling events. ECS retained the highest concentration of each contaminant detected and compared them to the VRP Tier III screening levels. The maximum concentration of each contaminant that exceeded its respective Tier III screening level was retained for the risk assessment for the utility/construction worker pathway. A risk assessment was performed for the construction/utility worker pathway and the results are as follows.

Table 9. On-Site Construction and Utility Workers Total Carcinogenic Risk and Hazard Quotients from Soil and Groundwater

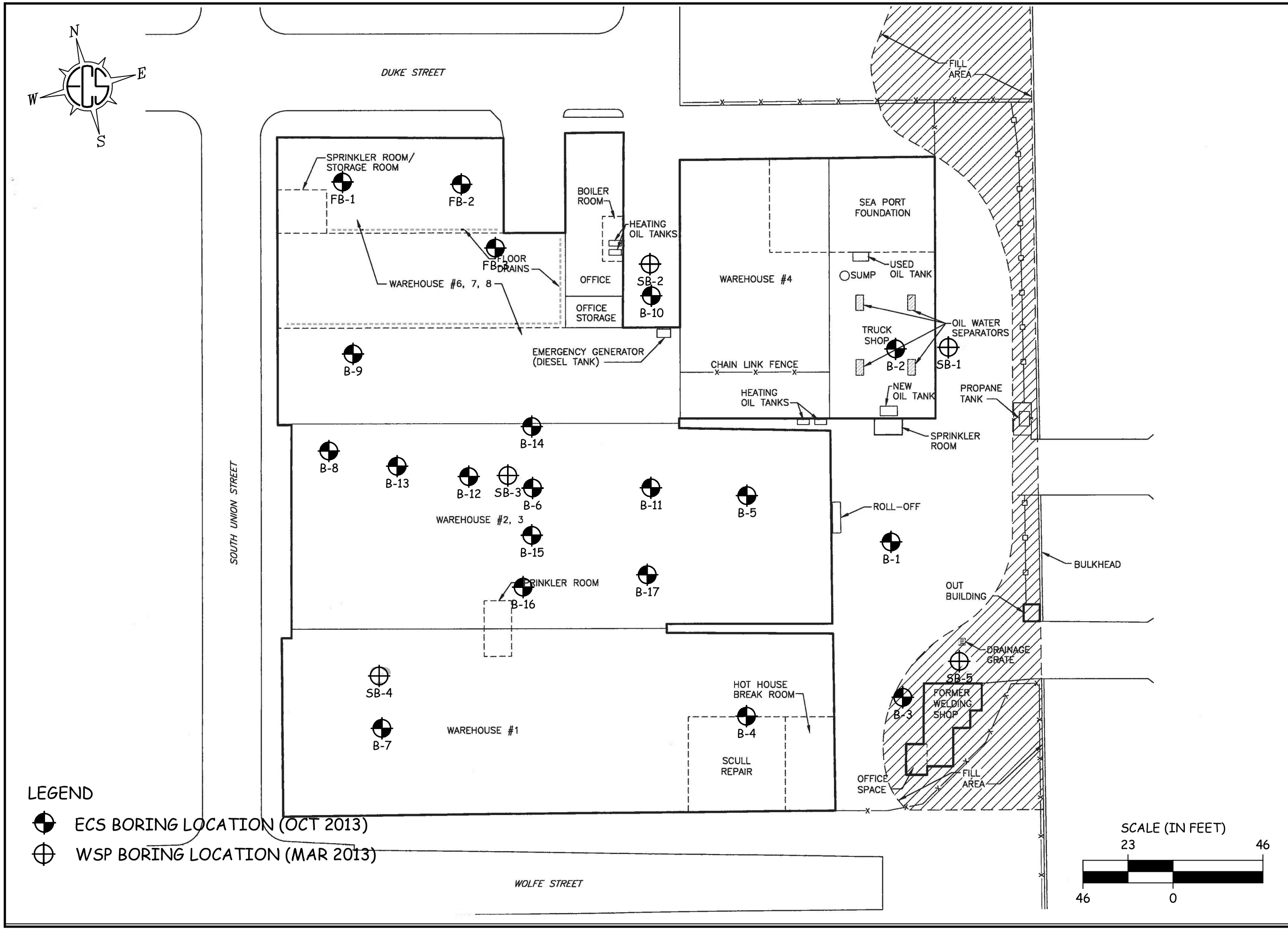
	Dermal	Ingestion	Inhalation	Total
Total Carcinogenic Risk	**5.61E-04**	**3.97E-06**	**2.56E-06**	**5.67E-04**
Total Hazard Quotient	**8.57E-03**	**1.65E-01**	**1.76E+00**	**1.93E+00**

The carcinogenic risk for construction workers exceeds the 1.0×10^{-5} individual risk goal for benzo(a)anthracene, benzo(a)pyrene, benzo(b)flouranthene and indeno(1,2,3-cd)pyrene in groundwater for the dermal pathway. The total cumulative risk for construction workers was above 10^{-4}. The individual hazard quotient for naphthalene for the inhalation pathway for construction workers exceeds the VRP target quotient of one. The total hazard quotient for the utility/construction worker was above 1.0. However, this risk and hazard quotient assumes that a worker will be in direct contact with soil and groundwater for a period of 125 days for a duration of one year, and is based on the highest concentrations detected. Based on the potential risk posed by the concentrations detected, ECS recommends that a site specific health and safety plan be prepared and implemented for any construction or utility line work on the site for protection from exposure to contaminated materials. Additionally, ECS recommends that utility/construction workers who come into direct contact with groundwater or if splashing conditions are present don protective clothing (i.e. gloves, Tyvek suits, etc.) to reduce direct contact with groundwater.

APPENDIX I

FIGURES

Site Characterization Report **Robinson Terminal South Duke Street and Union Street Alexandria, VA 22314**	ECS Mid-Atlantic, LLC 14026 Thunderbolt Place, Suite 100 Chantilly, VA 20151 ECS LLC MID-ATLANTIC	**Figure 1** **Site Location Map** **ECS Project No. 21983-E** **not to scale**



LEGEND

ECS BORING LOCATION (OCT 2013)

WSP BORING LOCATION (MAR 2013)

ROBINSON TERMINAL SOUTH

CITY OF ALEXANDRIA

BORING LOCATION DIAGRAM FIGURE 2

ECS REVISIONS

ENGINEER	DRAFTING
DJB	MJJ

SCALE 1" = 46'

PROJECT NO. 21389-E

SHEET 1 OF 2

DATE 6/1/15

BORING LOCATION DIAGRAM	ECS	**ROBINSON TERMINAL SOUTH**	ENGINEER DJB	SCALE NOT TO SCALE
			DRAFTSMAN MJJ	PROJECT NO. 21983-E
			REVISIONS	SHEET 2 OF 2
FIGURE 3		**CITY OF ALEXANDRIA**		DATE 6/1/15

APPENDIX II

VRP SCREENING TABLES

Revised 7/23/14

Table 2.9 Selection of Contaminants of Concern Soil: Restricted (Commercial/Industrial) **Values changed since last update**	CAS No.	Regional Screening Level (RSL)* Commercial/ Industrial mg/kg		VRP Tier III Screening Concentration mg/kg	Soil Concentration Maximum mg/kg	Contaminant Of Potential Concern?
TAL Inorganics						
Aluminum	7429-90-5	1.10E+05		1.10E+05		
Antimony	7440-36-0	4.70E+01		4.70E+01		
Arsenic	7440-38-2	3.00E+01	*	3.00E+01	4.81E+01	yes
Barium	7440-39-3	2.20E+04		2.20E+04	2.35E+02	
Beryllium	7440-41-7	2.30E+02		2.30E+02		
Cadmium (food, soil)	7440-43-9	9.80E+01	(a)	9.80E+01	1.05E+01	
	7440-43-9					
Calcium	7440-70-2					
Chromium	18540-29-9	6.30E+01		6.30E+01	3.18E+01	
Cobalt	7440-48-4	3.50E+01		3.50E+01		
Copper	7440-50-8	4.70E+03		4.70E+03		
Cyanide	57-12-5	1.30E+01		1.30E+01		
Iron	7439-89-6	8.20E+04		8.20E+04		
Lead	7439-92-1	8.00E+02	(a)	8.00E+02	1.18E+03	yes
Magnesium	7439-95-4					
Manganese (Non-diet)	7439-96-5	2.60E+03	(a)	2.60E+03		
	7439-96-5					
Mercuric Chloride (inorganic salts)	7487-94-7	3.50E+01	(a)	3.50E+01		
Mercury	7439-97-6	4.00E+00	(a)	4.00E+00	1.41E+00	
Methylmercury	22967-92-6	1.20E+01	(a)	1.20E+01		
Nickel	7440-02-0	2.20E+03		2.20E+03		
Potassium	7440-09-7					
Selenium	7782-49-2	5.80E+02		5.80E+02		
Silver	7440-22-4	5.80E+02		5.80E+02	7.91E+00	
Sodium	7440-23-5					
Thallium	7440-28-0	1.20E+00		1.20E+00		
Vanadium (and compounds)	7440-62-2	5.80E+02		5.80E+02		
Zinc	7440-66-6	3.50E+04		3.50E+04		
Other Inorganics						
Perchlorate	14797-73-0	8.20E+01		8.20E+01		
TCL Volatile Organic Compounds (VOCs)						
Acetone	67-64-1	6.70E+04		6.70E+04	2.10E-01	
Benzene	71-43-2	4.20E+01		4.20E+01		
Bromochloromethane	74-97-5	6.30E+01		6.30E+01		
Bromodichloromethane	75-27-4	1.30E+01		1.30E+01		
Bromoform	75-25-2	1.60E+03		1.60E+03		
Bromomethane	74-83-9	3.00E+00		3.00E+00		
2-Butanone (methyl ethyl ketone)	78-93-3	1.90E+04		1.90E+04	4.70E-02	
Carbon disulfide	75-15-0	3.50E+02		3.50E+02	1.10E-02	
Carbon tetrachloride	56-23-5	2.90E+01		2.90E+01		
Chlorobenzene	108-90-7	1.30E+02		1.30E+02		
Chloroethane (Ethyl Chloride)	75-00-3	5.70E+03		5.70E+03		
Chloroform	67-66-3	1.40E+01		1.40E+01		
Chloromethane	74-87-3	4.60E+01		4.60E+01		
Cyclohexane	110-82-7	2.70E+03		2.70E+03		
1,2-Dibromo-3-chloropropane	96-12-8	6.40E-01		6.40E-01		
Dibromochloromethane	124-48-1	3.20E+01		3.20E+01		
1,2-Dibromoethane	106-93-4	1.60E+00		1.60E+00		
1,2-Dichlorobenzene (ortho)	95-50-1	9.30E+02		9.30E+02		
1,3-Dichlorobenzene (meta)	541-73-1	1.10E+02	(a)	1.10E+02		
1,4-Dichlorobenzene (para)	106-46-7	1.10E+02		1.10E+02		
Dichlorodifluoromethane	75-71-8	3.70E+01		3.70E+01		
1,1-Dichloroethane	75-34-3	1.60E+02		1.60E+02		
1,2-Dichloroethane	107-06-2	1.40E+01		1.40E+01		
1,1-Dichloroethene	75-35-4	1.00E+02		1.00E+02		
1,2-Dichloroethane (total)						
cis-1,2-Dichloroethene	156-59-2	2.30E+02		2.30E+02		
trans-1,2-Dichloroethene	156-60-5	2.30E+03		2.30E+03		
1,2-Dichloropropane	78-87-5	6.60E+00		6.60E+00		
1,3-Dichloropropene (total)	542-75-6	3.10E+01		3.10E+01		
cis-1,3-Dichloropropene	10061-01-5	2.30E+03	(a)	2.30E+03		
trans-1,3-Dichloropropene	10061-02-6	2.30E+03	(a)	2.30E+03		
1,4-dioxane	123-91-1	2.30E+02		2.30E+02		
Ethylbenzene	100-41-4	2.50E+02		2.50E+02		
Hexane	110-54-3	2.50E+02		2.50E+02		
2-Hexanone	591-78-6	1.30E+02		1.30E+02	3.80E-01	
Isopropylbenzene	98-82-8	1.10E+03		1.10E+03		
4-Methyl-2-pentanone (methyl isobutyl ketone)	108-10-1	5.60E+03		5.60E+03		
Methyl acetate	79-20-9	1.20E+05		1.20E+05		
Methyl tert-butyl ether	1634-04-4	2.10E+03		2.10E+03		
Methylcyclohexane	108-87-2				8.00E+00	

Revised 7/23/14

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Methylene chloride	75-09-2	3.20E+02		3.20E+02	1.50E-02	
Styrene	100-42-5	3.50E+03		3.50E+03		
1,1,2,2-Tetrachloroethane	79-34-5	2.70E+01		2.70E+01		
Tetrachloroethene	127-18-4	3.90E+01		3.90E+01		
Toluene	108-88-3	4.70E+03		4.70E+03		
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	1.70E+04		1.70E+04		
1,2,3-Trichlorobenzene	87-61-6	6.60E+01		6.60E+01		
1,2,4-Trichlorobenzene	120-82-1	2.60E+01		2.60E+01		
1,1,1-Trichloroethane	71-55-6	3.60E+03		3.60E+03		
1,1,2-Trichloroethane	79-00-5	6.30E-01		6.30E-01		
Trichloroethene	79-01-6	1.90E+00		1.90E+00		
Trichlorofluoromethane	75-69-4	3.10E+02		3.10E+02		
Vinyl Chloride	75-01-4	1.70E+01		1.70E+01		
Total Xylenes	1330-20-7	2.50E+02		2.50E+02	1.80E-01	
Other VOCs						
n-butylbenzene	104-51-8	5.80E+03		5.80E+03		
sec-butylbenzene	135-98-8	1.20E+04		1.20E+04		
tert-butylbenzene	98-06-6	1.20E+04		1.20E+04		
isopropyltoluene	99-87-6					
n-propylbenzene	103-65-1	2.20E+03		2.20E+03		
1,1,1,2-tetrachloroethane	630-20-6	8.80E+01		8.80E+01		
1,2,4-trimethylbenzene	95-63-6	2.40E+01		2.40E+01		
1,3,5-trimethylbenzene	108-67-8	1.20E+03		1.20E+03		
m-xylene	108-38-3	2.40E+02		2.40E+02		
o-xylene	95-47-6	2.80E+02		2.80E+02		
p-xylene	106-42-3	2.40E+02		2.40E+02		
TCL Semivolatile Organic Compounds (SVOCs)						
Acenaphthene	83-32-9	4.50E+03		4.50E+03	9.80E+00	
Acenaphthylene	208-96-8	2.30E+03	(a)	2.30E+03	8.40E-02	
Acetophenone	98-86-2	1.20E+04		1.20E+04		
Anthracene	120-12-7	2.30E+04		2.30E+04	1.80E+01	
Atrazine	1912-24-9	1.00E+02		1.00E+02		
Benzaldehyde	100-52-7	1.20E+04		1.20E+04		
Benzo(a)anthracene	56-55-3	2.90E+01		2.90E+01	2.30E+01	
Benzo(a)pyrene	50-32-8	2.90E+00		2.90E+00	2.20E+01	yes
Benzo(b)fluoranthene	205-99-2	2.90E+01		2.90E+01	2.50E+01	
Benzo(g,h,i)perylene	191-24-2	2.30E+03	(a)	2.30E+03	1.40E+01	
Benzo(k)fluoranthene	207-08-9	2.90E+02		2.90E+02	1.20E+01	
1,1'-Biphenyl	92-52-4	2.00E+01		2.00E+01		
bis(2-Chloroethoxy)methane	111-91-1	2.50E+02		2.50E+02		
bis(2-chloroethyl)ether	111-44-4	1.00E+01		1.00E+01		
bis-(2-Ethylhexyl)phthalate	117-81-7	1.60E+03		1.60E+03		
4-Bromophenyl-phenylether	101-55-3					
Butylbenzylphthalate	85-68-7	1.20E+04		1.20E+04		
Caprolactam	105-60-2	4.00E+04		4.00E+04		
Carbazole	86-74-8					
4-Chloro-3-methylphenol (Cresol p-chloro-m)	59-50-7	8.20E+03		8.20E+03		
Chloroaniline, p-	106-47-8	1.20E+02		1.20E+02		
2-Chloronaphthalene	91-58-7	9.30E+03		9.30E+03		
2-Chlorophenol	95-57-8	5.80E+02		5.80E+02		
4-Chlorophenyl-phenylether	7005-72-3					
Chrysene	218-01-9	2.90E+03		2.90E+03	2.20E+01	
Dibutyl Phthalate	84-74-2	8.20E+03		8.20E+03		
Di-n-octylphthalate	117-84-0	8.20E+02		8.20E+02		
Dibenzo(a,h)anthracene	53-70-3	2.90E+00		2.90E+00	2.70E+00	
Dibenzofuran	132-64-9	1.00E+02		1.00E+02		
3,3'-Dichlorobenzidine	91-94-1	5.10E+01		5.10E+01		
2,4-Dichlorophenol	120-83-2	2.50E+02		2.50E+02		
Diethylphthalate	84-66-2	6.60E+04		6.60E+04		
2,4-Dimethylphenol	105-67-9	1.60E+03		1.60E+03		
Dimethylphthalate	131-11-3					
4,6-Dinitro-2-methylphenol (Dinitro-o-cresol, 4,6-)	534-52-1	6.60E+00		6.60E+00		
2,4-Dinitrophenol	51-28-5	1.60E+02		1.60E+02		
2,4-Dinitrotoluene	121-14-2	7.40E+01		7.40E+01		
2,6-Dinitrotoluene	606-20-2	1.50E+01		1.50E+01		
Fluoranthene	206-44-0	3.00E+03		3.00E+03	6.30E+01	
Fluorene	86-73-7	3.00E+03		3.00E+03	8.70E+00	
Hexachlorobenzene	118-74-1	1.40E+01		1.40E+01		
Hexachlorobutadiene	87-68-3	8.20E+01		8.20E+01		
Hexachlorocyclopentadiene	77-47-4	4.90E+02		4.90E+02		
Hexachloroethane	67-72-1	5.80E+01		5.80E+01		
Indeno(1,2,3-cd)pyrene	193-39-5	2.90E+01		2.90E+01	1.30E+01	

Revised 7/23/14

Table 2.9 Selection of Contaminants of Concern Soil: Restricted (Commercial/Industrial) **Values changed since last update**	CAS No.	Regional Screening Level (RSL)* Commercial/ Industrial mg/kg		VRP Tier III Screening Concentration mg/kg	Soil Concentration Maximum mg/kg	Contaminant Of Potential Concern?
Isophorone	78-59-1	1.60E+04		1.60E+04		
2-Methylnaphthalene	91-57-6	3.00E+02		3.00E+02		
2-Methylphenol (Cresol, o-)	95-48-7	4.10E+03		4.10E+03		
3-Methylphenol (Cresol, m-)	108-39-4	4.10E+03		4.10E+03		
4-Methylphenol (Cresol, p-)	106-44-5	8.20E+03		8.20E+03		
N-Nitroso-di-n-propylamine	621-64-7	3.30E+00		3.30E+00		
N-Nitrosodiphenylamine	86-30-6	4.70E+03		4.70E+03		
Naphthalene	91-20-3	5.90E+01		5.90E+01	1.00E+01	
2-Nitroaniline	88-74-4	8.00E+02		8.00E+02		
3-Nitroaniline	99-09-2					
4-Nitroaniline	100-01-6	3.30E+02		3.30E+02		
Nitrobenzene	98-95-3	1.30E+02		1.30E+02		
2-Nitrophenol	88-75-5					
4-Nitrophenol	100-02-7					
2,2'-Oxybis (Bis(2-chloro-1-methylethyl) ether)	108-60-1	2.20E+02		2.20E+02		
Pentachlorophenol	87-86-5	4.00E+01		4.00E+01		
Phenanthrene	85-01-8	2.30E+03	(a)	2.30E+03	5.90E+01	
Phenol	108-95-2	2.50E+04		2.50E+04		
Pyrene	129-00-0	2.30E+04		2.30E+04	4.60E+01	
1,2,4,5-Tetrachlorobenzene	95-94-3	2.50E+01		2.50E+01		
2,3,4,6-Tetrachlorophenol	58-90-2	2.50E+03		2.50E+03		
2,4,5-Trichlorophenol	95-95-4	8.20E+03		8.20E+03		
2,4,6-Trichlorophenol	88-06-2	8.20E+01		8.20E+01		
Other SVOCs						
Benzoic Acid	65-85-0	3.30E+05		3.30E+05		
TCL Polychlorinated Biphenyls (PCBs)						
Aroclor-1016	12674-11-2	5.20E+00		5.20E+00		
Aroclor-1221	11104-28-2	6.60E+00		6.60E+00		
Aroclor-1232	11141-16-5	6.60E+00		6.60E+00		
Aroclor-1242	53469-21-9	1.00E+01		1.00E+01		
Aroclor-1248	12672-29-6	1.00E+01		1.00E+01		
Aroclor-1254	11097-69-1	1.50E+00		1.50E+00		
Aroclor-1260	11096-82-5	1.00E+01		1.00E+01		
Aroclor-1262	37324-23-5	1.00E+01	(a)	1.00E+01		
Aroclor-1268	11100-14-4	1.00E+01	(a)	1.00E+01		
Total PCBs	1336-36-3	1.00E+01	(a)	1.00E+01		
TCL Pesticides						
Aldrin	309-00-2	1.40E+00		1.40E+00		
alpha-BHC (Hexachlorocyclohexane, Alpha-)	319-84-6	3.70E+00		3.70E+00		
beta-BHC (Hexachlorocyclohexane, Beta-)	319-85-7	1.30E+01		1.30E+01		
delta-BHC	319-86-8	3.70E+00	(a)	3.70E+00		
gamma-BHC (lindane)	58-89-9	2.50E+01		2.50E+01		
Chlordane	12789-03-6	5.00E+01		5.00E+01		
alpha-Chlordane	5103-71-9	5.00E+01	(a)	5.00E+01		
gamma-Chlordane	5103-74-2	5.00E+01	(a)	5.00E+01		
4,4'-DDD	72-54-8	9.60E+01		9.60E+01		
4,4'-DDE	72-55-9	6.80E+01		6.80E+01		
4,4'-DDT	50-29-3	5.20E+01		5.20E+01		
Dieldrin	60-57-1	1.40E+01		1.40E+01		
Endosulfan	115-29-7	4.90E+02		4.90E+02		
Endosulfan I	959-98-8	4.90E+02	(a)	4.90E+02		
Endosulfan II	33213-65-9	4.90E+02	(a)	4.90E+02		
Endosulfan Sulfate	1031-07-8	4.90E+02	(a)	4.90E+02		
Endrin	72-20-8	2.50E+01		2.50E+01		
Endrin Aldehyde	7421-93-4	2.50E+01	(a)	2.50E+01		
Endrin Ketone	53494-70-5	2.50E+01	(a)	2.50E+01		
Heptachlor	76-44-8	5.10E+00		5.10E+00		
Heptachlor epoxide	1024-57-3	1.10E+00		1.10E+00		
Methoxychlor	72-43-5	4.10E+02		4.10E+02	3.40E-03	
Toxaphene	8001-35-2	2.10E+01		2.10E+01		
Chlorinated dioxins/dibenzofurans (CDDs/CDFs)						
2,3,7,8-TCDD	1746-01-6	7.30E-05		7.30E-05		
2,3,7,8-TCDF	51207-31-9					

(a) See Risk-Based Screening Levels Proxy Values

!Noncarcinogenic RSL < Carcinogenic RSL @THQ 0.1

Depth to groundwater in feet 15

Table 2.13 Selection of Contaminants of Concern
Groundwater: Construction Worker in a Trench

Revised 8/12/14

	CAS No.	Water Table Not Contacted	Water Table Contacted					
		Tier III Groundwater Concentration	Dermal Contact & Incidental Ingestion	Inhalation	Tier III Groundwater Concentration		Maximum Groundwater Concentration	Contaminant of Potential Concern?
		ug/L	ug/L	ug/L	ug/L		ug/L	
TAL Inorganics								
Aluminum	7429-90-5		6.9E+05		6.89E+05			
Antimony	7440-36-0		8.30E+01		8.30E+01			
Arsenic	7440-38-2		2.07E+02		2.07E+02		0.426	
Barium	7440-39-3		2.14E+04		2.14E+04		3.85	
Beryllium	7440-41-7		5.83E+01		5.83E+01			
Cadmium (water)	7440-43-9		8.40E-01		5.00E+00	(a)	0.195	
Calcium	7440-70-2							
Chromium	7440-47-3		2.89E+02		2.89E+02		0.346	
Cobalt	7440-48-4		2.74E+03		2.74E+03			
Copper	7440-50-8		2.76E+04		2.76E+04			
Cyanide	57-12-5	1.86E+02	1.38E+04	1.35E-01	2.00E+02	(a)		
Iron	7439-89-6		4.83E+05		4.83E+05			
Lead	7439-92-1						7.56	
Magnesium	7439-95-4							
Manganese (nonfood)	7439-96-5		9.65E+04		9.65E+04			
Mercuric chloride	7487-94-7		2.14E+02		2.14E+02			
Mercury	7439-97-6	5.59E+00		8.95E-02	2.00E+00	(a)	0.0126	
Methylmercury	22967-92-6		6.89E+01		6.89E+01			
Nickel	7440-02-0		5.23E+03		5.23E+03			
Potassium	7440-09-7							
Selenium	7782-49-2		3.45E+03		3.45E+03			
Silver	7440-22-4		5.12E+02		5.12E+02			
Sodium	7440-23-5							
Thallium	7440-28-0		2.76E+01		2.76E+01			
Vanadium	7440-62-2		2.11E+02		2.11E+02			
Zinc	7440-66-6		2.47E+05		2.47E+05			
Other Inorganics								
Perchlorate			4.83E+02		4.83E+02			
TCL Volatile Organic Compounds (VOCs								
Acetone	67-64-1	5.45E+07	7.54E+05	1.41E+04	1.41E+04			
Benzene	71-43-2	1.05E+03	9.41E+02	1.50E+01	1.50E+01			
Bromochloromethane	74-97-5	2.27E+03	3.52E+04	9.91E+00	9.91E+00			
Bromodichloromethane	75-27-4	1.09E+03	1.88E+03	5.51E+00	8.00E+01	(a)		
Bromoform	75-25-2	2.17E+06	7.41E+03	2.32E+03	2.32E+03			
Bromomethane	74-83-9	8.84E+02	1.77E+03	2.06E+01	2.06E+01			
2-Butanone (methyl ethyl ketone	78-93-3	6.26E+06	1.33E+06	1.86E+03	1.86E+03			
Carbon disulfide	75-15-0	2.98E+03	1.20E+04	1.29E+02	1.29E+02			
Carbon tetrachloride	56-23-5	4.13E+02	2.89E+02	2.61E+01	2.61E+01			
Chlorobenzene	108-90-7	1.45E+04	3.49E+03	1.13E+02	1.13E+02			
Chloroethane	75-00-3	2.26E+04		6.78E+02	2.10E+03	(a)		
Chloroform	67-66-3	2.26E+03	1.72E+03	2.28E+01	8.00E+01	(a)		
Chloromethane	74-87-3	1.79E+04		4.51E+02	4.51E+02			
Cyclohexane	110-82-7	9.78E+03		3.42E+03	3.42E+03			
1,2-Dibromo-3-chloropropane	96-12-8	1.61E+03	2.17E+02	5.07E-01	5.07E-01			
Dibromochloromethane	124-48-1	5.89E+04	1.80E+04	8.37E+01	8.37E+01			
1,2-Dibromoethane	106-93-4	2.10E+03	8.71E+02	2.80E+00	2.80E+00			
1,2-Dichlorobenzene (ortho	95-50-1	1.21E+05	2.64E+03	5.23E+02	6.00E+02	(a)		
1,3-Dichlorobenzene (meta)	541-73-1							
1,4-Dichlorobenzene (para)	106-46-7	3.13E+04	2.02E+03	1.66E+02	1.66E+02			
Dichlorodifluoromethane	75-71-8	2.50E+02	6.79E+03	2.31E+02	2.31E+02			
1,1-Dichloroethane	75-34-3	6.07E+04	2.22E+05	9.23E+02	9.23E+02			
1,2-Dichloroethane	107-06-2	4.51E+03	5.28E+03	1.53E+01	1.53E+01			
1,1-Dichloroethene	75-35-4	5.79E+02	5.65E+03	4.14E+01	4.14E+01			
1,2-Dichloroethene (total	540-59-0							
cis-1,2-Dichloroethene	156-59-2		2.37E+03		2.37E+03			
trans-1,2-Dichloroethene	156-60-5	2.68E+01	2.37E+04	1.24E+01	1.00E+02	(a)		
1,2-Dichloropropane	78-87-5	4.10E+02	1.44E+04	2.96E+00	5.00E+00	(a)		
1,3-Dichloropropene (total	542-75-6	1.81E+03	4.67E+03	4.72E+00	4.72E+00			
cis-1,3-Dichloropropene	10061-01-5	1.81E+03	4.71E+02	4.72E+00	4.72E+00			
trans-1,3-Dichloropropene	10061-02-6	1.81E+03	4.71E+02	4.72E+00	4.72E+00			
1,4-dioxane	123-91-1	9.55E+05	3.48E+04	8.00E+01	8.00E+01			
Ethylbenzene	100-41-4	3.38E+04	1.53E+03	6.10E+02	7.00E+02	(a)		
Hexane	110-54-3	8.14E+01	6.11E+03	1.36E+02	1.36E+02			
2-Hexanone	591-78-6	2.98E+04	1.49E+03	1.03E+01	1.03E+01			
Isopropylbenzene	98-82-8	3.45E+03	6.96E+03	9.25E+01	9.25E+01			
4-Methyl-2-pentanone (methyl isobutyl ketone	108-10-1	2.03E+06	2.58E+05	8.99E+02	8.99E+02			
Methyl acetate	79-20-9		7.19E+06		7.19E+06			
Methyl tert-butyl ethe	1634-04-4	4.43E+05	1.69E+06	6.51E+02	6.51E+02			
Methylcyclohexane	108-87-2	6.50E+02		6.24E+02	6.24E+02	(a)		
Methylene chloride	75-09-2	1.47E+03	1.84E+04	5.80E+02	5.80E+02			
Styrene	100-42-5	1.00E+05	7.92E+03	6.56E+02	6.56E+02			
1,1,2,2-Tetrachloroethane	79-34-5	8.81E+02	3.40E+02	3.29E+01	3.29E+01			
Tetrachloroethene	127-18-4	2.92E+02	2.13E+02	1.08E+01	1.08E+01			
Toluene	108-88-3	6.31E+04	3.81E+04	1.02E+03	1.02E+03			
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	9.90E+03	1.76E+05	8.62E+03	8.62E+03			
1,2,3-Trichlorobenzene	87-61-6		1.22E+03		1.22E+03			
1,2,4-Trichlorobenzene	120-82-1	2.32E+03	1.45E+03	5.86E+00	7.00E+01	(a)		
1,1,1-Trichloroethane	71-55-6	2.92E+04	1.95E+05	1.22E+03	1.22E+03			
1,1,2-Trichloroethane	79-00-5	2.37E+02	8.56E+02	5.18E-01	5.00E+00	(a)		
Trichloroethene	79-01-6	1.93E+01	5.27E+01	4.84E-01	5.00E+00	(a)		
Trichlorofluoromethane	75-69-4	1.03E+03	6.69E+04	2.46E+02	2.46E+02			
Vinyl Chloride	75-01-4	2.19E+02	1.53E+03	1.66E+01	1.66E+01			
Total Xylenes	1330-20-7	5.94E+03	1.21E+04	8.74E+01	1.00E+04	(a)	1	
Other VOCs								
n-butylbenzene	104-51-8		7.28E+02		7.28E+02			
sec-butylbenzene	135-98-8		7.48E+02		7.48E+02			
tert-butylbenzene	98-06-6		6.98E+02		6.98E+02			
isopropyltoluene	99-87-6							
n-propylbenzene	103-65-1	1.03E+04	1.64E+03	2.31E+02	2.31E+02			
1,1,1,2-tetrachloroethane	630-20-6	5.12E+04	6.33E+03	2.63E+02	2.63E+02			
1,2,4-trimethylbenzene	95-63-6	1.74E+03		2.32E+01	2.32E+01			
1,3,5-trimethylbenzene	108-67-8	1.23E+02	2.40E+03	2.31E+00	1.20E+01	(a)		
m-xylene	108-38-3	1.33E+03	5.73E+03	2.18E+01	2.18E+01			

Depth to groundwater in feet 15

Table 2.13 Selection of Contaminants of Concern
Groundwater: Construction Worker in a Trench

Revised 8/12/14

	CAS No.	Water Table Not Contacted	Water Table Contacted				
		Tier III Groundwater Concentration	Dermal Contact & Incidental Ingestion	Inhalation	Tier III Groundwater Concentration	Maximum Groundwater Concentration	Contaminant of Potential Concern?
		ug/L	ug/L	ug/L	ug/L	ug/L	
o-xylene	95-47-6	1.83E+03	6.39E+03	2.19E+01	2.19E+01		
p-xylene	106-42-3	1.38E+03	6.13E+03	2.18E+01	2.18E+01		
TCL Semivolatile Organic Compounds (SVOCs							
Acenaphthene	83-32-9		3.12E+03		3.12E+03	12	
Acenaphthylene	208-96-8		1.59E+03		1.59E+03	11	
Acetophenone	98-86-2		2.79E+05		2.79E+05		
Anthracene	120-12-7		8.33E+03		8.33E+03	26	
Atrazine	1912-24-9		4.71E+03		4.71E+03		
Benzaldehyde	100-52-7		2.80E+05		2.80E+05		
Benzo(a)anthracene	56-55-3	6.80E+05	1.50E+01	1.07E+02	1.50E+01	53	yes
Benzo(a)pyrene	50-32-8	1.91E+06	1.01E+00	2.37E+02	1.01E+00	47	yes
Benzo(b)fluoranthene	205-99-2	1.33E+07	1.70E+01	1.65E+03	1.70E+01	66	yes
Benzo(g,h,i)perylene	191-24-2		1.47E+02		1.47E+02	34	
Benzo(k)fluoranthene	207-08-9	1.49E+07	1.28E+02	1.85E+03	1.28E+02	25	
1,1'-Biphenyl	92-52-4	1.80E+03	1.45E+03	1.23E+00	1.23E+00		
bis(2-Chloroethoxy)methane	111-91-1		1.55E+04		1.55E+04		
bis(2-chloroethyl)ethe	111-44-4	1.43E+05	2.82E+03	2.27E+01	2.27E+01		
bis-(2-Ethylhexyl)phthalate	117-81-7	4.06E+09	6.68E+00	2.12E+05	6.68E+00		
4-Bromophenyl-phenylethe	101-55-3						
Butylbenzylphthalate	85-68-7		2.86E+04		2.86E+04		
Caprolactam	105-60-2	8.19E+06	3.16E+05	1.12E+03	1.12E+03		
Carbazole	86-74-8						
4-Chloro-3-methylpheno	59-50-7		4.51E+03		4.51E+03		
4-Chloroaniline	106-47-8		8.77E+02		8.77E+02		
2-Chloronaphthalene	91-58-7		3.27E+03		3.27E+03		
2-Chloropheno	95-57-8		7.35E+03		7.35E+03		
4-Chlorophenyl-phenylethe	7005-72-3						
Chrysene	218-01-9	3.04E+07	1.39E+03	2.19E+03	1.39E+03	52	
Di-n-butylphthalate	84-74-2		1.63E+04		1.63E+04		
Di-n-octylphthalate	117-84-0		1.25E+01		2.00E+01 (a)		
Dibenzo(a,h)anthracene	53-70-3	6.05E+06	1.05E+00	7.23E+02	1.05E+00		
Dibenzofuran	132-64-9		5.12E+01		5.12E+01		
3,3'-Dichlorobenzidine	91-94-1	7.05E+08	8.51E+02	8.66E+04	8.51E+02		
2,4-Dichloropheno	120-83-2		1.13E+03		1.13E+03		
Diethylphthalate	84-66-2		1.64E+06		1.64E+06		
2,4-Dimethylpheno	105-67-9		5.70E+03		5.70E+03		
Dimethylphthalate	131-11-3		4.15E+04		4.15E+04 (a)		
4,6-Dinitro-2-methylpheno	534-52-1		2.01E+02		2.01E+02		
2,4-Dinitropheno	51-28-5		7.72E+03		7.72E+03		
2,4-Dinitrotoluene	121-14-2	2.53E+08	5.44E+02	2.20E+04	5.44E+02		
2,6-Dinitrotoluene	606-20-2		1.34E+02		1.34E+02		
Fluoranthene	206-44-0		3.30E+02		3.30E+02	120	
Fluorene	86-73-7		4.62E+03		4.62E+03	11	
Hexachlorobenzene	118-74-1	2.01E+03	2.62E-02	5.54E+00	1.00E+00 (a)		
Hexachlorobutadiene	87-68-3	7.53E+03	9.52E+00	1.08E+02	9.52E+00		
Hexachlorocyclopentadiene	77-47-4	6.11E+00	4.86E+02	2.43E-01	5.00E+01 (a)		
Hexachloroethane	67-72-1	1.57E+03	1.94E+02	9.81E+00	9.81E+00		
Indeno(1,2,3-cd)pyrene	193-39-5	5.77E+06	9.71E+00	7.12E+02	9.71E+00	31	yes
Isophorone	78-59-1	3.74E+07	5.56E+05	4.64E+03	4.64E+03		
2-Methylnaphthalene	91-57-6		6.15E+01		6.15E+01		
2-Methylpheno	95-48-7	4.48E+07	7.98E+04	6.48E+03	6.48E+03		
3-Methylpheno	108-39-4	6.27E+07	7.88E+04	9.03E+03	9.03E+03		
4-Methylpheno	106-44-5	5.40E+07	1.62E+04	7.75E+03	7.75E+03		
N-Nitroso-di-n-propylamine	621-64-7	1.80E+05	3.34E+02	2.19E+01	2.19E+01		
N-Nitrosodiphenylamine	86-30-6	1.24E+08	7.08E+04	9.17E+03	9.17E+03		
Naphthalene	91-20-3	7.35E+01	6.06E+02	7.22E-01	7.22E-01	14	yes
2-Nitroaniline	88-74-4	1.06E+05	2.33E+03	1.17E+01	1.90E+01 (a)		
3-Nitroaniline	99-09-2		3.51E+02		3.51E+02 (a)		
4-Nitroaniline	100-01-6	1.63E+09	3.89E+03	2.19E+05	3.89E+03		
Nitrobenzene	98-95-3	7.98E+04	1.03E+03	1.57E+01	1.57E+01		
2-Nitrophenol	88-75-5	5.69E+03		8.53E-01	8.53E-01 (a)		
4-Nitrophenol	100-02-7						
2,2'-Oxybis(1-chloropropane	108-60-1	1.54E+06	5.35E+03	3.32E+02	3.32E+02		
Pentachloropheno	87-86-5	1.24E+10	1.03E+02	9.62E+05	1.03E+02		
Phenanthrene	85-01-8		1.56E+03		1.56E+03	88	
Phenol	108-95-2	4.69E+07	9.97E+02	7.32E+03	9.97E+02		
Pyrene	129-00-0		9.41E+02		9.41E+02	98	
1,2,4,5-Tetrachlorobenzene	95-94-3		2.64E-01		2.64E-01		
2,3,4,6-Tetrachloropheno	58-90-2		3.53E+02		3.53E+02		
2,4,5-Trichloropheno	95-95-4		8.33E+03		8.33E+03		
2,4,6-Trichloropheno	88-06-2	1.20E+08	2.90E+01	1.42E+04	2.90E+01		
Other SVOCs							
Benzoic Acid	65-85-0	4.88E+06	7.99E+05	6.95E+02	7.50E+03 (a)		
TCL Polychlorinated Biphenyls (PCBs							
Aroclor-1016	12674-11-2	2.43E+05	1.81E-01	1.48E+02	5.00E-01 (a)		
Aroclor-1221	11104-28-2	1.88E+03	2.14E+01	3.79E+00	3.79E+00		
Aroclor-1232	11141-16-5	1.88E+03	1.94E+01	3.79E+00	3.79E+00		
Aroclor-1242	53469-21-9	9.76E+03	4.81E+00	5.55E+00	4.81E+00		
Aroclor-1248	12672-29-6	4.21E+03	5.01E+00	4.90E+00	4.90E+00		
Aroclor-1254	11097-69-1	7.06E+03	4.31E-02	5.45E+00	5.00E-01 (a)		
Aroclor-1260	11096-82-5	6.76E+03	3.56E+00	5.84E+00	3.56E+00		
Aroclor-1262	37324-23-5	7.79E+02	3.27E+00	5.13E+00	3.27E+00		
Aroclor-1268	11100-14-4	8.03E+02	2.16E+00	5.54E+00	2.16E+00		
Total PCBs	1336-36-3		4.09E+03		4.09E+03		
TCL Pesticides							
Aldrin	309-00-2	5.69E+03	4.90E-02	1.19E+00	4.90E-02		
alpha-BHC	319-84-6	3.45E+02	3.36E+01	1.43E+00	1.43E+00		
beta-BHC	319-85-7	6.05E+05	1.18E+02	5.02E+01	5.02E+01		
delta-BHC	319-86-8						
gamma-BHC (lindane)	58-89-9	6.62E+05	9.07E+01	8.58E+01	8.58E+01		
Chlordane	57-74-9	2.73E+03	2.14E-01	5.83E-01	2.00E+00 (a)		
alpha-Chlordane	5103-71-9	4.36E+03	2.05E-01	5.83E-01	1.00E+00 (a)		
gamma-Chlordane	5103-74-2	4.36E+03	1.07E-01	5.83E-01	1.00E+00 (a)		
4,4'-DDD	72-54-8	2.47E+06	6.92E+01	3.19E+02	6.92E+01		
4,4'-DDE	72-55-9	2.77E+05	2.28E+01	5.86E+01	2.28E+01		
4,4'-DDT	50-29-3	1.49E+06	4.33E-01	1.92E+02	1.00E+00 (a)		

Depth to groundwater in feet 15

Table 2.13 Selection of Contaminants of Concern
Groundwater: Construction Worker in a Trench

Revised 8/12/14

	CAS No.	Water Table Not Contacted	Water Table Contacted				
		Tier III Groundwater Concentration	Dermal Contact & Incidental Ingestion	Inhalation	Tier III Groundwater Concentration	Maximum Groundwater Concentration	Contaminant of Potential Concern?
		ug/L	ug/L	ug/L	ug/L	ug/L	
Dieldrin	60-57-1	4.26E+04	6.11E-01	3.57E+00	6.11E-01		
Endosulfan	115-29-7		6.49E+02		6.49E+02		
Endosulfan I	959-98-8		5.71E+02		5.71E+02		
Endosulfan I	33213-65-9		5.71E+02		5.71E+02		
Endosulfan Sulfate	1031-07-8		8.19E+02		8.19E+02		
Endrin	72-20-8		3.70E-01		2.00E+00 (a)		
Endrin Aldehyde	7421-93-4		1.02E+01		1.02E+01		
Endrin Ketone	53494-70-5						
Heptachlor	76-44-8	5.34E+03	1.47E+00	2.53E+00	1.47E+00		
Heptachlor epoxide	1024-57-3	2.35E+04	2.34E-01	3.61E+00	2.34E-01		
Methoxychlor	72-43-5		5.21E+01		5.21E+01		
Toxaphene	8001-35-2	6.95E+05	3.98E+01	8.19E+01	3.98E+01		
Chlorinated dioxins/dibenzofurans (CDDs/CDFs							
2,3,7,8-TCDD	1746-01-6	1.11E-01	8.16E-07	2.97E-05	3.00E-05 (a)		
2,3,7,8-TCDF	51207-31-9						

(a) The Tier II Screening Level was substituted for the mode
estimate when the model estimate was less than the Tier II leve

Table 3.8 Exposure-point concentration (inhalation) for construction/utility worker in a trench: Groundwater less than 15 feet deep revised 10/5/07	CAS No.	Molecular Weight MWi g/mol	Henry's Law Constant Hi atm-m3/mol	Gas-Phase Mass Transfer Coefficient KiG cm/s	Liquid-Phase Mass Transfer Coefficient KiL cm/s	Overall Mass Transfer Coefficient Ki cm/s	Concentration of Contaminant in Groundwater Cgw ug/L	Volatilization Factor VF L/m3	Concentration of Contaminant in Trench Ctrench ug/m3
TAL Inorganics									
Aluminum	7429-90-5	26.98							
Antimony	7440-36-0	121.76							
Arsenic	7440-38-2	74.92							
Barium	7440-39-3	137.33							
Beryllium	7440-41-7	9.01							
Cadmium (water)	7440-43-9	112.41							
Calcium	7440-70-2	40.08							
Chromium	7440-47-3	52.00							
Cobalt	7440-48-4	58.93							
Copper	7440-50-8	63.55							
Cyanide	57-12-5	26.02							
Iron	7439-89-6	55.85							
Lead	7439-92-1	207.20							
Magnesium	7439-95-4	24.31							
Manganese (nonfood)	7439-96-5	54.94							
Mercuric chloride	7487-94-7	271.50							
Mercury	7439-97-6	200.59	1.14E-02	3.71E-01	7.99E-04	7.95E-04			
Methylmercury	22967-92-6	215.63							
Nickel	7440-02-0	58.69							
Potassium	7440-09-7	39.10							
Selenium	7782-49-2	78.96							
Silver	7440-22-4	107.87							
Sodium	7440-23-5	22.99							
Thallium	7440-28-0	204.38							
Vanadium	7440-62-2	50.94							
Zinc	7440-66-6	65.39							
Other Inorganics									
Perchlorate									
TCL Volatile Organic Compounds (VOCs									
Acetone	67-64-1	58.08	3.88E-05	5.63E-01	1.48E-03	5.58E-04			
Benzene	71-43-2	78.11	5.55E-03	5.09E-01	1.28E-03	1.27E-03			
Bromochloromethane	74-97-5	139.38	1.46E-03	4.20E-01	9.58E-04	9.23E-04			
Bromodichloromethane	75-27-4	163.83	1.60E-03	3.98E-01	8.84E-04	8.55E-04			
Bromoform	75-25-2	252.73	5.35E-04	3.44E-01	7.12E-04	6.50E-04			
Bromomethane	74-83-9	94.94	6.24E-03	4.77E-01	1.16E-03	1.15E-03			
2-Butanone (methyl ethyl ketone	78-93-3	72.11	5.59E-05	5.23E-01	1.33E-03	6.31E-04			
Carbon disulfide	75-15-0	76.14	3.03E-02	5.14E-01	1.30E-03	1.29E-03			
Carbon tetrachloride	56-23-5	153.82	3.04E-02	4.06E-01	9.12E-04	9.11E-04			
Chlorobenzene	108-90-7	112.56	3.70E-03	4.51E-01	1.07E-03	1.05E-03			
Chloroethane	75-00-3	64.51	8.82E-03	5.43E-01	1.41E-03	1.40E-03			
Chloroform	67-66-3	119.38	3.67E-03	4.42E-01	1.04E-03	1.02E-03			
Chloromethane	74-87-3	50.49	8.82E-03	5.90E-01	1.59E-03	1.58E-03			
Cyclohexane	110-82-7	84.16	1.95E-01	4.97E-01	1.23E-03	1.23E-03			
1,2-Dibromo-3-chloropropane	96-12-8	236.33	1.47E-04	3.52E-01	7.36E-04	5.46E-04			
Dibromochloromethane	124-48-1	208.28	7.83E-04	3.67E-01	7.84E-04	7.35E-04			
1,2-Dibromoethane	106-93-4	187.86	7.43E-04	3.80E-01	8.25E-04	7.70E-04			
1,2-Dichlorobenzene (ortho	95-50-1	147.00	1.90E-03	4.12E-01	9.33E-04	9.07E-04			
1,3-Dichlorobenzene (meta)	541-73-1	147.00	3.10E-03	4.12E-01	9.33E-04	9.17E-04			
1,4-Dichlorobenzene (para)	106-46-7	147.00	2.43E-03	4.12E-01	9.33E-04	9.12E-04			
Dichlorodifluoromethane	75-71-8	120.91	3.43E-01	4.40E-01	1.03E-03	1.03E-03			
1,1-Dichloroethane	75-34-3	98.96	5.62E-03	4.71E-01	1.14E-03	1.13E-03			
1,2-Dichloroethane	107-06-2	98.96	9.79E-04	4.71E-01	1.14E-03	1.07E-03			
1,1-Dichloroethene	75-35-4	96.94	2.61E-02	4.74E-01	1.15E-03	1.15E-03			
1,2-Dichloroethene (total	540-59-0	96.94	4.51E-03	4.74E-01	1.15E-03	1.13E-03			
cis-1,2-Dichloroethene	156-59-2	96.94	4.08E-03	4.74E-01	1.15E-03	1.13E-03			
trans-1,2-Dichloroethene	156-60-5	96.94	9.38E-03	4.74E-01	1.15E-03	1.14E-03			
1,2-Dichloropropane	78-87-5	112.99	2.80E-03	4.50E-01	1.06E-03	1.04E-03			
1,3-Dichloropropene (total	542-75-6	110.97	1.77E-02	4.53E-01	1.07E-03	1.07E-03			
cis-1,3-Dichloropropene	10061-01-5	110.97	1.20E-03	4.53E-01	1.07E-03	1.02E-03			
trans-1,3-Dichloropropene	10061-02-6	110.97	8.00E-04	4.53E-01	1.07E-03	1.00E-03			
1,4-dioxane	123-91-1	88.11	4.80E-06	4.89E-01	1.21E-03	8.90E-05			
Ethylbenzene	100-41-4	106.17	7.88E-03	4.60E-01	1.10E-03	1.09E-03			
Hexane	110-54-3	86.18	1.69E+00	4.93E-01	1.22E-03	1.22E-03			
2-Hexanone	591-78-6	100.16	9.32E-05	4.69E-01	1.13E-03	6.93E-04			
Isopropylbenzene	98-82-8	120.19	1.16E+00	4.41E-01	1.03E-03	1.03E-03			
4-Methyl-2-pentanone (methyl isobutyl ketone	108-10-1	100.16	1.38E-04	4.69E-01	1.13E-03	7.92E-04			
Methyl acetate	79-20-9	74.08	1.15E-04	5.19E-01	1.31E-03	8.54E-04			
Methyl tert-butyl ethe	1634-04-4	88.15	5.87E-04	4.89E-01	1.21E-03	1.09E-03			
Methylcyclohexane	108-87-2	98.19	4.30E-01	4.72E-01	1.14E-03	1.14E-03			
Methylene chloride	75-09-2	84.93	2.19E-03	4.95E-01	1.23E-03	1.19E-03			
Styrene	100-42-5	104.15	2.75E-03	4.63E-01	1.11E-03	1.09E-03			
1,1,2,2-Tetrachloroethane	79-34-5	167.85	3.45E-04	3.94E-01	8.73E-04	7.55E-04			
Tetrachloroethene	127-18-4	165.83	1.84E-02	3.96E-01	8.79E-04	8.76E-04			
Toluene	108-88-3	92.14	6.64E-03	4.82E-01	1.18E-03	1.17E-03			
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	187.37	4.81E-01	3.80E-01	8.27E-04	8.26E-04			
1,2,3-Trichlorobenzene	87-61-6	181.45	1.25E-03	3.84E-01	8.40E-04	8.05E-04			
1,2,4-Trichlorobenzene	120-82-1	181.45	1.42E-03	3.84E-01	8.40E-04	8.09E-04			
1,1,1-Trichloroethane	71-55-6	133.40	1.72E-02	4.26E-01	9.80E-04	9.76E-04			
1,1,2-Trichloroethane	79-00-5	133.40	9.13E-04	4.26E-01	9.80E-04	9.23E-04			
Trichloroethene	79-01-6	131.39	1.03E-02	4.28E-01	9.87E-04	9.82E-04			
Trichlorofluoromethane	75-69-4	137.37	9.70E-02	4.22E-01	9.65E-04	9.65E-04			
Vinyl Chloride	75-01-4	62.50	2.70E-02	5.49E-01	1.43E-03	1.43E-03			
Total Xylenes	1330-20-7	106.16	5.18E-03	4.60E-01	1.10E-03	1.09E-03			
Other VOCs									
n-butylbenzene	104-51-8	134.22	1.59E-02	4.25E-01	9.77E-04	9.73E-04			
sec-butylbenzene	135-98-8	134.22	1.76E-02	4.25E-01	9.77E-04	9.73E-04			
tert-butylbenzene	98-06-6	134.22	1.32E-02	4.25E-01	9.77E-04	9.72E-04			
isopropyltoluene	99-87-6	134.22	1.10E-02	4.25E-01	9.77E-04	9.72E-04			
n-propylbenzene	103-65-1	120.19	1.05E-02	4.41E-01	1.03E-03	1.03E-03			
1,1,1,2-tetrachloroethane	630-20-6	167.85	2.42E-03	3.94E-01	8.73E-04	8.54E-04			
1,2,4-trimethylbenzene	95-63-6	120.19	6.16E-03	4.41E-01	1.03E-03	1.02E-03			
1,3,5-trimethylbenzene	108-67-8	120.19	8.77E-03	4.41E-01	1.03E-03	1.03E-03			
m-xylene	108-38-3	106.17	7.34E-03	4.60E-01	1.10E-03	1.09E-03			

Table 3.8 Exposure-point concentration (inhalation) for construction/utility worker in a trench: Groundwater less than 15 feet deep revised 10/5/07	CAS No.	Molecular Weight MWi g/mol	Henry's Law Constant Hi atm-m3/mol	Gas-Phase Mass Transfer Coefficient KiG cm/s	Liquid-Phase Mass Transfer Coefficient KiL cm/s	Overall Mass Transfer Coefficient Ki cm/s	Concentration of Contaminant in Groundwater Cgw ug/L	Volatilization Factor VF L/m3	Concentration of Contaminant in Trench Ctrench ug/m3
o-xylene	95-47-6	106.17	5.19E-03	4.60E-01	1.10E-03	1.09E-03			
p-xylene	106-42-3	106.17	7.66E-03	4.60E-01	1.10E-03	1.09E-03			
TCL Semivolatile Organic Compounds (SVOCs									
Acenaphthene	83-32-9	154.21	1.55E-04	4.06E-01	9.11E-04	6.73E-04			
Acenaphthylene	208-96-8	152.19	1.13E-04	4.07E-01	9.17E-04	6.17E-04			
Acetophenone	98-86-2	120.15	1.07E-05	4.41E-01	1.03E-03	1.63E-04			
Anthracene	120-12-7	178.23	6.50E-05	3.86E-01	8.47E-04	4.65E-04			
Atrazine	1912-24-9	215.68	2.36E-09	3.63E-01	7.70E-04	3.50E-08			
Benzaldehyde	100-52-7	106.12	2.67E-05	4.60E-01	1.10E-03	3.45E-04			
Benzo(a)anthracene	56-55-3	228.29	3.35E-06	3.56E-01	7.49E-04	4.58E-05			
Benzo(a)pyrene	50-32-8	252.31	1.13E-06	3.44E-01	7.12E-04	1.56E-05			
Benzo(b)fluoranthene	205-99-2	252.31	1.11E-04	3.44E-01	7.12E-04	4.89E-04			
Benzo(g,h,i)perylene	191-24-2	276.33	1.41E-07	3.34E-01	6.81E-04	1.92E-06			
Benzo(k)fluoranthene	207-08-9	252.31	8.29E-07	3.44E-01	7.12E-04	1.15E-05			
1,1'-Biphenyl	92-52-4	154.21	3.00E-04	4.06E-01	9.11E-04	7.70E-04			
bis(2-Chloroethoxy)methane	111-91-1	173.04	1.70E-07	3.90E-01	8.60E-04	2.71E-06			
bis(2-chloroethyl)ethe	111-44-4	143.01	1.80E-05	4.16E-01	9.46E-04	2.31E-04			
bis-(2-Ethylhexyl)phthalate	117-81-7	390.56	1.02E-07	2.97E-01	5.72E-04	1.24E-06			
4-Bromophenyl-phenylethe	101-55-3	249.10	1.17E-04	3.45E-01	7.17E-04	5.00E-04			
Butylbenzylphthalate	85-68-7	312.36	1.26E-06	3.20E-01	6.40E-04	1.61E-05			
Caprolactam	105-60-2	113.16	2.53E-08	4.50E-01	1.06E-03	4.66E-07			
Carbazole	86-74-8	167.21	1.54E-08	3.95E-01	8.75E-04	2.49E-07			
4-Chloro-3-methylpheno	59-50-7	142.58	2.45E-06	4.16E-01	9.47E-04	4.00E-05			
4-Chloroaniline	106-47-8	127.57	3.31E-07	4.32E-01	1.00E-03	5.82E-06			
2-Chloronaphthalene	91-58-7	162.62	3.14E-04	3.98E-01	8.87E-04	7.56E-04			
2-Chloropheno	95-57-8	128.56	3.91E-04	4.31E-01	9.98E-04	8.72E-04			
4-Chlorophenyl-phenylethe	7005-72-3	204.65	9.00E-05	3.69E-01	7.91E-04	5.00E-04			
Chrysene	218-01-9	228.29	9.46E-05	3.56E-01	7.49E-04	4.85E-04			
Di-n-butylphthalate	84-74-2	278.34	9.38E-10	3.33E-01	6.78E-04	1.28E-08			
Di-n-octylphthalate	117-84-0	390.56	6.68E-05	2.97E-01	5.72E-04	3.36E-04			
Dibenzo(a,h)anthracene	53-70-3	278.35	1.47E-08	3.33E-01	6.78E-04	2.00E-07			
Dibenzofuran	132-64-9	168.19	1.26E-05	3.94E-01	8.72E-04	1.65E-04			
3,3'-Dichlorobenzidine	91-94-1	253.13	4.00E-09	3.44E-01	7.11E-04	5.62E-08			
2,4-Dichloropheno	120-83-2	163.00	3.16E-06	3.98E-01	8.86E-04	4.87E-05			
Diethylphthalate	84-66-2	222.24	4.50E-07	3.59E-01	7.59E-04	6.55E-06			
2,4-Dimethylpheno	105-67-9	122.16	2.00E-06	4.39E-01	1.02E-03	3.47E-05			
Dimethylphthalate	131-11-3	194.18	1.05E-07	3.76E-01	8.12E-04	1.61E-06			
4,6-Dinitro-2-methylpheno	534-52-1	198.13	4.27E-07	3.73E-01	8.04E-04	6.47E-06			
2,4-Dinitropheno	51-28-5	184.11	4.43E-07	3.82E-01	8.34E-04	6.87E-06			
2,4-Dinitrotoluene	121-14-2	182.13	9.26E-08	3.84E-01	8.38E-04	1.45E-06			
2,6-Dinitrotoluene	606-20-2	182.13	7.47E-07	3.84E-01	8.38E-04	1.16E-05			
Fluoranthene	206-44-0	202.25	1.61E-05	3.70E-01	7.96E-04	1.87E-04			
Fluorene	86-73-7	166.22	6.36E-05	3.96E-01	8.78E-04	4.74E-04			
Hexachlorobenzene	118-74-1	284.78	1.32E-03	3.30E-01	6.70E-04	6.46E-04			
Hexachlorobutadiene	87-68-3	260.76	8.15E-03	3.40E-01	7.01E-04	6.96E-04			
Hexachlorocyclopentadiene	77-47-4	272.77	2.70E-02	3.35E-01	6.85E-04	6.84E-04			
Hexachloroethane	67-72-1	236.74	3.89E-03	3.51E-01	7.35E-04	7.26E-04			
Indeno(1,2,3-cd)pyrene	193-39-5	276.33	1.60E-06	3.34E-01	6.81E-04	2.12E-05			
Isophorone	78-59-1	138.21	6.64E-06	4.21E-01	9.62E-04	1.02E-04			
2-Methylnaphthalene	91-57-6	142.20	5.18E-04	4.17E-01	9.49E-04	8.57E-04			
2-Methylpheno	95-48-7	108.14	1.20E-06	4.57E-01	1.09E-03	2.20E-05			
3-Methylpheno	108-39-4	108.14	8.65E-07	4.57E-01	1.09E-03	1.59E-05			
4-Methylpheno	106-44-5	108.14	7.92E-07	4.57E-01	1.09E-03	1.46E-05			
N-Nitroso-di-n-propylamine	621-64-7	130.19	2.25E-06	4.29E-01	9.92E-04	3.80E-05			
N-Nitrosodiphenylamine	86-30-6	198.22	5.00E-06	3.73E-01	8.04E-04	6.97E-05			
Naphthalene	91-20-3	128.17	4.83E-04	4.32E-01	9.99E-04	8.95E-04	1.40E+01	6.60E+00	9.24E+01
2-Nitroaniline	88-74-4	138.12	1.09E-07	4.21E-01	9.63E-04	1.87E-06			
3-Nitroaniline	99-09-2	138.12	1.44E-07	4.21E-01	9.63E-04	2.47E-06			
4-Nitroaniline	100-01-6	138.12	2.07E-09	4.21E-01	9.63E-04	3.57E-08			
Nitrobenzene	98-95-3	123.11	2.40E-05	4.37E-01	1.02E-03	3.02E-04			
2-Nitrophenol	88-75-5	139.11	9.47E-06	4.20E-01	9.59E-04	1.39E-04			
4-Nitrophenol	100-02-7	139.11	4.15E-10	4.20E-01	9.59E-04	7.13E-09			
2,2'-Oxybis(1-chloropropane	108-60-1	171.06	1.17E-04	3.92E-01	8.65E-04	5.92E-04			
Pentachloropheno	87-86-5	266.34	2.44E-08	3.38E-01	6.93E-04	3.37E-07			
Phenanthrene	85-01-8	178.23	2.33E-05	3.86E-01	8.47E-04	2.57E-04			
Phenol	108-95-2	94.11	3.97E-07	4.79E-01	1.17E-03	7.72E-06			
Pyrene	129-00-0	202.25	1.10E-05	3.70E-01	7.96E-04	1.38E-04			
1,2,4,5-Tetrachlorobenzene	95-94-3	215.89	2.58E-03	3.62E-01	7.70E-04	7.55E-04			
2,3,4,6-Tetrachloropheno	58-90-2	231.89	4.39E-06	3.54E-01	7.43E-04	5.86E-05			
2,4,5-Trichloropheno	95-95-4	197.45	4.33E-06	3.73E-01	8.05E-04	6.11E-05			
2,4,6-Trichloropheno	88-06-2	197.45	7.79E-06	3.73E-01	8.05E-04	1.04E-04			
Other SVOCs									
Benzoic acid	65-85-0	122.12	3.81E-08	4.39E-01	1.02E-03	6.83E-07			
TCL Polychlorinated Biphenyls (PCBs									
Aroclor-1016	12674-11-2	257.90	2.90E-04	3.41E-01	7.04E-04	6.00E-04			
Aroclor-1221	11104-28-2	200.70	3.50E-03	3.71E-01	7.99E-04	7.87E-04			
Aroclor-1232	11141-16-5	232.20	7.36E-04	3.54E-01	7.42E-04	6.94E-04			
Aroclor-1242	53469-21-9	266.50	5.20E-04	3.38E-01	6.93E-04	6.32E-04			
Aroclor-1248	12672-29-6	299.50	2.80E-03	3.25E-01	6.54E-04	6.42E-04			
Aroclor-1254	11097-69-1	328.00	2.00E-03	3.15E-01	6.25E-04	6.10E-04			
Aroclor-1260	11096-82-5	375.70	4.60E-03	3.01E-01	5.84E-04	5.78E-04			
Aroclor-1262	37324-23-5	389.00	4.60E-03	2.98E-01	5.74E-04	5.68E-04			
Aroclor-1268	11100-14-4	453.00	4.60E-03	2.83E-01	5.32E-04	5.26E-04			
Total PCBs	1336-36-3								
TCL Pesticides									
Aldrin	309-00-2	364.91	1.70E-04	3.04E-01	5.92E-04	4.63E-04			
alpha-BHC	319-84-6	290.83	1.06E-05	3.28E-01	6.63E-04	1.17E-04			
beta-BHC	319-85-7	290.83	7.43E-07	3.28E-01	6.63E-04	9.82E-06			
delta-BHC	319-86-8	290.83	4.29E-07	3.28E-01	6.63E-04	5.71E-06			
gamma-BHC (lindane)	58-89-9	290.83	1.40E-05	3.28E-01	6.63E-04	1.46E-04			
Chlordane	57-74-9	409.78	4.86E-05	2.92E-01	5.59E-04	2.85E-04			
alpha-Chlordane	5103-71-9	409.76	4.86E-05	2.92E-01	5.59E-04	2.85E-04			
gamma-Chlordane	5103-74-2	409.76	4.86E-05	2.92E-01	5.59E-04	2.85E-04			
4,4'-DDD	72-54-8	320.04	4.00E-06	3.18E-01	6.32E-04	4.80E-05			
4,4'-DDE	72-55-9	318.02	2.10E-05	3.18E-01	6.34E-04	1.91E-04			
4,4'-DDT	50-29-3	354.48	8.10E-06	3.07E-01	6.01E-04	8.70E-05			

Table 3.8 Exposure-point concentration (inhalation) for construction/utility worker in a trench: Groundwater less than 15 feet deep revised 10/5/07	CAS No.	Molecular Weight MWi g/mol	Henry's Law Constant Hi atm-m3/mol	Gas-Phase Mass Transfer Coefficient KiG cm/s	Liquid-Phase Mass Transfer Coefficient KiL cm/s	Overall Mass Transfer Coefficient Ki cm/s	Concentration of Contaminant in Groundwater Cgw ug/L	Volatilization Factor VF L/m3	Concentration of Contaminant in Trench Ctrench ug/m3
Dieldrin	60-57-1	380.91	1.51E-05	3.00E-01	5.80E-04	1.40E-04			
Endosulfan	115-29-7	406.92	1.12E-05	2.93E-01	5.61E-04	1.08E-04			
Endosulfan I	959-98-8	406.92	6.50E-05	2.93E-01	5.61E-04	3.26E-04			
Endosulfan I	33213-65-9	406.92	6.50E-05	2.93E-01	5.61E-04	3.26E-04			
Endosulfan Sulfate	1031-07-8	422.92	3.25E-07	2.89E-01	5.50E-04	3.82E-06			
Endrin	72-20-8	380.91	7.52E-06	3.00E-01	5.80E-04	7.96E-05			
Endrin Aldehyde	7421-93-4	380.91	4.18E-06	3.00E-01	5.80E-04	4.71E-05			
Endrin Ketone	53494-70-5	380.90	1.25E-05	3.00E-01	5.80E-04	1.21E-04			
Heptachlor	76-44-8	373.32	1.09E-03	3.02E-01	5.86E-04	5.61E-04			
Heptachlor epoxide	1024-57-3	389.32	9.50E-06	2.97E-01	5.73E-04	9.62E-05			
Methoxychlor	72-43-5	345.65	1.58E-05	3.10E-01	6.09E-04	1.51E-04			
Toxaphene	8001-35-2	414.00	6.00E-06	2.91E-01	5.56E-04	6.34E-05			

APPENDIX III

VRP TOXICITY TABLES

Revised 7/29/14 Table 4.1: Noncancer toxicity data Chemical	CAS No.	Chronic/ Subchronic	Oral RfD Value mg/kg-day	Oral to Dermal Adjustment Factor (1)	Oral to Dermal Adjustment Factor Source	Adjusted Dermal RfD mg/kg-day	Primary Target Organ	Source	Chronic/ Subchronic	Inhalation RfC mg/m3	Primary Target Organ	Source
TAL Inorganics												
Arsenic	7440-38-2	Chronic	3.00E-04	1.00E+00	EPA 2001	3.00E-04	skin, vascular	IRIS	Chronic	1.50E-05	developmental, cardiovascular, nervous system	CalEPA
Lead	7439-92-1			1.00E+00	EPA 2001							
TCL Semivolatile Organic Compounds (SVOCs)												
Benzo(a)anthracene	56-55-3			1.00E+00	EPA 2001							
Benzo(a)pyrene	50-32-8			1.00E+00	EPA 2001							
Benzo(b)fluoranthene	205-99-2			1.00E+00	EPA 2001							
Indeno(1,2,3-cd)pyrene	193-39-5			1.00E+00	EPA 2001							
Naphthalene	91-20-3	Chronic	2.00E-02	1.00E+00	EPA 2001	2.00E-02	whole body (decreased weight), kidney, thymus	IRIS	Chronic	3.00E-03	respiratory tract	IRIS

N/A = Not Applicable
(1) Refer to RAGS, Part A, Appendix A

Revised 7/29/14 Table 4.1a: Noncancer toxicity data (Subchronic) Chemical	CAS No.	Chronic/ Subchronic	Oral RfD Value mg/kg-day	Oral to Dermal Adjustment Factor (1)	Oral to Dermal Adjustment Factor Source	Adjusted Dermal RfD mg/kg-day	Primary Target Organ	Source	Chronic/ Subchronic	Inhalation RfC mg/m3	Primary Target Organ	Source
TAL Inorganics												
Arsenic	7440-38-2	Subchronic	3.00E-04	1.00E+00	EPA 2001	3.00E-04	skin	HEAST	Chronic	1.50E-05	developmental, cardiovascular, nervous system	CalEPA
Lead	7439-92-1			1.00E+00	EPA 2001							
Semivolatile Organic Compounds (SVOCs)												
Benzo(a)anthracene	56-55-3			1.00E+00	EPA 2001							
Benzo(a)pyrene	50-32-8			1.00E+00	EPA 2001							
Benzo(b)fluoranthene	205-99-2			1.00E+00	EPA 2001							
Indeno(1,2,3-cd)pyrene	193-39-5			1.00E+00	EPA 2001							
Naphthalene	91-20-3	Chronic	2.00E-02	1.00E+00	EPA 2001	2.00E-02	whole body (decreased weight), kidney, thymus	IRIS	Chronic	3.00E-03	respiratory tract	IRIS

Revised 7/29/14 Table 4.2: Cancer toxicity data Chemical	CAS No.	Oral Cancer Slope Factor 1/(mg/kg-day)	Oral to Dermal Adjustment Factor (1)	Oral to Dermal Adjustment Factor Source	Adjusted Dermal Cancer Slope Factor (1) 1/(mg/kg-day)	Weight of Evidence/ Cancer Guideline Description	Source	Inhalation Unit Risk 1(mg/m3)	Weight of Evidence/ Cancer Guideline Description	Source
TAL Inorganics										
Arsenic	7440-38-2	1.50E+00	1.00E+00	EPA 2001	1.50E+00	A	IRIS	4.30E+00	A	IRIS
Lead	7439-92-1		1.00E+00	EPA 2001		B2	IRIS			
TCL Semivolatile Organic Compounds (SVOCs)										
Benzo(a)anthracene	56-55-3	7.30E-01	1.00E+00	EPA 2001	7.30E-01	B2	SURROGATE	1.10E-01		CalEPA
Benzo(a)pyrene	50-32-8	7.30E+00	1.00E+00	EPA 2001	7.30E+00	B2	IRIS	1.10E+00	B2	CalEPA
Benzo(b)fluoranthene	205-99-2	7.30E-01	1.00E+00	EPA 2001	7.30E-01	B2	SURROGATE	1.10E-01		CalEPA
Indeno(1,2,3-cd)pyrene	193-39-5	7.30E-01	1.00E+00	EPA 2001	7.30E-01	B2	SURROGATE	1.10E-01		CalEPA
Naphthalene	91-20-3		1.00E+00	EPA 2001		C	IRIS	3.40E-02	C	CalEPA

IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables

Mutagenic Mode of Action

EPA Group:
- A - Human carcinogen
- B1 - Probable human carcinogen - indicates that limited human data are available
- B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
- C - Possible human carcinogen
- D - Not classifiable as a human carcinogen
- E - Evidence of noncarcinogenicity
- NA - Weight-of-evidence classification not available

Weight of Evidence:
- Known/Likely
- Cannot be Determined
- Not Likely

APPENDIX IV

VRP EXPOSURE CALCULATIONS

TABLE 3.10
VALUES USED FOR DAILY INTAKE CALCULATIONS
Robinson Terminal - South

Medium:	Groundwater
Exposure Medium:	Groundwater
Receptor Population	**Construction Worker**
Exposure Route:	Dermal
Receptor Age:	**Adult**

Intake Equation:
DAD=DAevent x IF
Intake Factor Equation:
IF=EV x SA x EF x ED x 1/BW x 1/AT

To calculate DAevent, see Guidance, Equations 3-10 to 3-12

Parameter Code	Parameter Definition	Units	VRP Default Value	Rationale/ Reference	User Defined Value	Rationale/ Reference
DAD	Dermally Absorbed Dose	mg/kg-day				
DAevent	Absorbed dose per event	mg/cm^2-event	Chemical specific	EPA, 2001		
EV	Event frequency	events/day	1	EPA, 2001		
SA	Skin Surface Area Available for Contact	cm2	3,470 (1)	EPA, 2011		
EF	Exposure Frequency	days/years	125	EPA, 1991		
ED	Exposure Duration	years	1	EPA, 1991		
BW	Body Weight	kg	80	EPA, 2011		
AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989		
AT-N	Averaging Time (Non-cancer)	days	365	EPA, 1989		
IF-C	Intake Factor (Cancer)	event-cm^2/kg-day	2.12E-01	calculated		
IF-N	Intake Factor (Non-cancer)	event-cm^2/kg-day	1.49E+01	calculated		

DEQ= VRP Staff Professional Judgement
EPA, 1989= Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response. EPA/540/1-89/002.
EPA, 1991= Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. Office of Solid Waste and Emergency Response. OSWER Directive 9285.6-03
EPA, 1992= Dermal Exposure Assessment: Principles and Applications. Office of Health and Environmental Assessment. EPA/600/8-91/011B.
EPA, 1997= Exposure Factors Handbook. Office of Research and Development. EPA/600/P-95/002Fa.
EPA, 2001= RAGS E, Chapter 3
EPA, 2011= EPA Exposure Factors Handbook: 2011 Edition
(1) Represents approximately the head, hands and forearms.
(2) Represents approximately the mean surface area for hands for men and women.

Revised 7/29/14 Chemical of Potential Concern	Cancer Classification	Groundwater Concentration ug/L	Exposure Point Concentration (Dermal) (CW) mg/cm3	Dermally Absorbed Dose (Cancer) (DADc) mg/kg-day	Adjusted Dermal Cancer Slope Factor CSFd 1/(mg/kg-day)	Cancer Risk (DADc*CSFd) unitless	Dermally Absorbed Dose (Non-Cancer) (DADn) mg/kg-day	Adjusted Dermal Reference Dose (chronic) RfDd mg/kg-day	Adjusted Dermal Reference Dose (subchronic) RfDd mg/kg-day	Hazard Quotient (DADn/RfDd) unitless	Absorbed Dose per Event (DAevent) mg/cm2-event	Permeability Coefficient Kp cm/hr	Lag Time Per Event tau hr/event	Time To Reach Steady-State t* hour	Permeability Ratio B	Exposure Time (ET) hours/day	Fraction Absorbed FA
TAL Inorganics																	
Semivolatile Organic Compounds (SVOCs)																	
Benzo(a)anthracene	B2	5.30E+01	5.30E-05	3.99E-05	7.30E-01	2.91E-05					1.88E-04	4.54E-01	1.99E+00	8.33E+00	2.64E+00	4	1.0
Benzo(a)pyrene	B2	4.70E+01	4.70E-05	6.00E-05	7.30E+00	4.38E-04					2.83E-04	6.70E-01	2.64E+00	1.14E+01	4.07E+00	4	1.0
Benzo(b)fluoranthene	B2	6.60E+01	6.60E-05	8.55E-05	7.30E-01	6.25E-05					4.03E-04	6.70E-01	2.72E+00	1.18E+01	4.10E+00	4	1.0
Indeno(1,2,3-cd)pyrene	B2	3.10E+01	3.10E-05	4.16E-05	7.30E-01	3.03E-05					1.96E-04	9.90E-01	3.70E+00	1.64E+01	6.33E+00	4	0.6
Naphthalene	C							2.00E-02	2.00E-02			4.57E-02	5.48E-01	1.32E+00	1.99E-01	4	1.0

TABLE 3.11
VALUES USED FOR DAILY INTAKE CALCULATIONS
Robinson Terminal - South

Medium:	Groundwater
Exposure Medium:	Groundwater
Receptor Population:	**Construction Worker**
Exposure Route:	Ingestion
Receptor Age:	**Adult**

Intake Equation:
CDI=CW x IF
Intake Factor Equation:
IF=IR-W x EF x ED x 1/BW x 1/AT

Parameter Code	Parameter Definition	Units	VRP Default Value	Rationale/ Reference	User Defined Value	Rationale/ Reference
CDI	Chronic Daily Intake	mg/kg-day				
CW	Chemical Concentration in Water	mg/L				
IR-W	Ingestion Rate of Water	liters/day	0.02	EPA, 1991		
EF	Exposure Frequency	days/year	125	EPA, 1991		
ED	Exposure Duration	years	1	EPA, 1991		
BW	Body Weight	kg	80	EPA, 2011		
AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989		
AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989		
IF-C	Intake Factor (Cancer)	liters/kg-day	1.22E-06	calculated		
IF-N	Intake Factor (Non-Cancer)	liters/kg-day	8.56E-05	calculated		

DEQ= VRP Staff Professional Judgement
EPA, 1989= Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response. EPA/540/1-89/002.
EPA, 1991= Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. Office of Solid Waste and Emergency Response. OSWER Directive 9285.6-03
EPA, 2011= EPA Exposure Factors Handbook: 2011 Edition

Revised 7/29/14 Chemical of Potential Concern	Cancer Classification	Groundwater Concentration ug/L	Exposure Point Concentration (Oral) (CW) mg/L	Chronic Daily Intake (Cancer) (CDIc) mg/kg-day	Oral Cancer Slope Factor CSFo 1/(mg/kg-day)	Cancer Risk (CDIc*CSFo) unitless	Chronic Daily Intake (Non-Cancer) (CDIn) mg/kg-day	Oral Reference Dose (chronic) RfDo mg/kg-day	Oral Reference Dose (subchronic) RfDo mg/kg-day	Hazard Quotient (CDIn/RfDo) unitless
TAL Inorganics										
Semivolatile Organic Compounds (SVOCs)		0.00E+00								
Benzo(a)anthracene	B2	5.30E+01	5.30E-02	6.48E-08	7.30E-01	4.73E-08				
Benzo(a)pyrene	B2	4.70E+01	4.70E-02	5.75E-08	7.30E+00	4.20E-07				
Benzo(b)fluoranthene	B2	6.60E+01	6.60E-02	8.07E-08	7.30E-01	5.89E-08				
Indeno(1,2,3-cd)pyrene	B2	3.10E+01	3.10E-02	3.79E-08	7.30E-01	2.77E-08				
Naphthalene	C	0.00E+00						2.00E-02	2.00E-02	

TABLE 3.12
VALUES USED FOR INHALATION EXPOSURE CALCULATIONS
Robinson Terminal - South

Medium:	Groundwater
Exposure Medium:	Air
Receptor Population:	**Construction Worker**
Exposure Route:	Inhalation
Receptor Age:	**Adult**

Exposure Concentration:
EC=(CA x (ET/24hrs/day) x EF x ED)/AT

Parameter Code	Parameter Definition	Units	VRP Default Value	Rationale/ Reference	User Defined Value	Rationale/ Reference
CA	Chemical Concentration in Air	mg/m^3	(1,2)			
EF	Exposure Frequency	days/year	125	DEQ		
ED	Exposure Duration	years	1	DEQ		
ET	Exposure Time (Trench)	hours/day	4	DEQ		
AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989		
AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989		

DEQ= VRP Staff Professional Judgement
EPA, 1989= Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response. EPA/540/1-89/002.
EPA, 1991= Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. Office of Solid Waste and Emergency Response. OSWER Directive 9285.6-03

(1) This exposure route should be evaluated for volatile organic compounds (VOC) and mercury only.
(2) See Section 3.2.2 of the risk assessment guidance.

Revised 7/29/14 Chemical of Potential Concern	Cancer Classification	Groundwater Concentration ug/L	Exposure Point Concentration (Inhalation) (CA) mg/m3	Exposure Concentration EC cancer mg/m3	Inhalation Unit Risk IUR $(mg/m^3)^{-1}$	Cancer Risk (EC*IUR) unitless	Exposure Concentration EC noncancer mg/m3	Inhalation Reference Concentration (chronic) RfCi mg/m^3	Inhalation Reference Concentration (subchronic) RfCi mg/m^3	Hazard Quotient (EC/RfCi) unitless
TAL Inorganics										
Semivolatile Organic Compounds (SVOCs)										
Benzo(a)anthracene		5.30E+01			1.10E-01					
Benzo(a)pyrene	B2	4.70E+01			1.10E+00					
Benzo(b)fluoranthene		6.60E+01			1.10E-01					
Indeno(1,2,3-cd)pyrene		3.10E+01			1.10E-01					
Naphthalene	C	0.00E+00	9.24E-02	7.53E-05	3.40E-02	2.56E-06	5.27E-03	3.00E-03	3.00E-03	1.76E+00

Table 3.13
VALUES USED FOR DAILY INTAKE CALCULATIONS
Robinson Terminal - South

Medium:	Soil
Exposure Medium:	Soil
Receptor Population:	**Construction Worker**
Exposure Route:	Dermal
Receptor Age:	**Adult**

Intake Equation:
DAD=CS x ABS x IF
Intake Factor Equation:
IF=SA x CF x AF x EF x ED x 1/BW x 1/AT

Parameter Code	Parameter Definition	Units	VRP Default Value	Rationale/ Reference	User Defined Value	Rationale/ Reference
DAD	Dermally Absorbed Dose	mg/kg-day				
CS	Chemical Concentration in Soil	mg/kg				
CF	Conversion Factor	kg/mg	1E-06			
AF	Soil to Skin Adherence Factor	mg/cm^2	0.12	EPA, 2011		
ABS	Absorption Factor	unitless	(3) Chemical Specific (1)	EPA, 1995 and EPA, 2001		
SA	Skin Surface Area Available for Contact	cm2/day	3,470 (2)	EPA, 2011 DEQ		
EF	Exposure Frequency	days/years	125	DEQ		
ED	Exposure Duration	years	1	DEQ		
BW	Body Weight	kg	80	EPA, 2011		
AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989		
AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989		
IF-C	Intake Factor (Cancer)	days^-1	2.55E-08	calculated		
IF-N	Intake Factor (Non-cancer)	days^-1	1.78E-06	calculated		

DEQ=	VRP Staff Professional Judgement
EPA, 1989=	Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response. EPA/540/1-89/002.
EPA, 1991=	Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. Office of Solid Waste and Emergency Response. OSWER Directive 9285.6-03
EPA, 1995=	Assessing Dermal Exposure from Soil. Region III. Office of Superfund Programs. EPA/903-K-95-003.
EPA, 2001=	RAGS E, Chapter 3
EPA, 2011=	EPA Exposure Factors Handbook: 2011 Edition

(1) Absorption Factors are listed on VRP Table 3.23
(2) Represents face, hands, and forearms
(3) Based on soil-to-skin adherence data presented in EPA, 2001for a utility worker
Note the following AF s from RAGS E for site specific scenarios:
groundskeeper AF=0.1
construction worker AF=0.3

8/5/2014 Chemical of Potential Concern	Cancer Classification	Exposure Point Concentration (CS) mg/kg	Dermally Absorbed Dose (Cancer) (DADc) mg/kg-day	Adjusted Dermal Cancer Slope Factor CSFd 1/(mg/kg-day)	Cancer Risk (DADc*CSFd) Dermal unitless	Dermally Absorbed Dose (Non-Cancer) (DADn) mg/kg-day	Adjusted Dermal Reference Dose (chronic) RfDd mg/kg-day	Adjusted Dermal Reference Dose (subchronic) RfDd mg/kg-day	Hazard Quotient (DADn/RfDd) Dermal unitless	Absorption Factor (ABS)
TAL Inorganics										
Arsenic	A	4.81E+01	3.67E-08	1.50E+00	5.51E-08	2.57E-06	3.00E-04	3.00E-04	8.57E-03	3.00E-02
Lead	B2	1.18E+03								1.00E-02
Semivolatile Organic Compounds (SVOCs)										
Benzo(a)pyrene	B2	2.20E+01	7.28E-08	7.30E+00	5.32E-07					1.30E-01

Table 3.14
VALUES USED FOR DAILY INTAKE CALCULATIONS
Robinson Terminal - South

Medium:	Soil
Exposure Medium:	Soil
Receptor Population:	**Construction Worker**
Exposure Route:	Ingestion
Receptor Age:	**Adult**

Intake Equation:
CDI = CS x IF
Intake Factor Equation:
IF= IR-S x FI x EF x ED x CF x 1/BW x 1/AT

Parameter Code	Parameter Definition	Units	VRP Default Value	Rationale/ Reference	User Defined Value	Rationale/ Reference
CDI	Chronic Daily Intake	mg/kg-day				
CS	Chemical Concentration in Soil	mg/kg				
CF	Conversion Factor	kg/mg	1E-06			
IR-S	Ingestion Rate - Soil	mg/day	480	EPA,1991		
FI	Fraction Ingested from source	unitless	0.5	DEQ		
EF	Exposure Frequency	days/years	125	DEQ		
ED	Exposure Duration	years	1	DEQ		
BW	Body Weight	kg	80	EPA, 2011		
AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989		
AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989		
IF-C	Intake Factor (Cancer)	days^-1	1.47E-08	calculated		
IF-N	Intake Factor (Non-cancer)	days^-1	1.03E-06	calculated		

DEQ= VRP Staff Professional Judgement
EPA, 1989= Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response. EPA/540/1-89/002.
EPA, 1991= Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. Office of Solid Waste and Emergency Response. OSWER Directive 9285.6-03
EPA, 2001= Draft SSL Guidance, March 2001

EPA, 2011= EPA Exposure Factors Handbook: 2011 Edition

8/5/2014 Chemical of Potential Concern	Cancer Classification	Exposure Point Concentration (Oral) (CS) mg/kg	Chronic Daily Intake (Cancer) (CDIc) mg/kg-day	Oral Cancer Slope Factor CSFo 1/(mg/kg-day)	Cancer Risk (CDIc*CSFo) Oral unitless	Chronic Daily Intake (Non-Cancer) (CDIn) mg/kg-day	Oral Reference Dose (chronic) RfDo mg/kg-day	Oral Reference Dose (subchronic) RfDo mg/kg-day	Hazard Quotient (CDIn/RfDo) Oral unitless
TAL Inorganics									
Arsenic	A	4.81E+01	7.06E-07	1.50E+00	1.06E-06	4.94E-05	3.00E-04	3.00E-04	1.65E-01
Lead	B2	1.18E+03							
Semivolatile Organic Compounds (SVOCs)									
Benzo(a)pyrene	B2	2.20E+01	3.23E-07	7.30E+00	2.36E-06				

Table 3.15
VALUES USED FOR INHALATION EXPOSURE CALCULATIONS
Robinson Terminal - South

Medium:	Soil
Exposure Medium:	Air
Receptor Population:	**Construction Worker**
Exposure Route:	Inhalation
Receptor Age:	**Adult**

Intake Equation:
EC=(CA x (ET/24hrs/day) x EF x ED)/AT

Parameter Code	Parameter Definition	Units	VRP Default Value	Rationale/ Reference	User Defined Value	Rationale/ Reference
CA	Chemical Concentration in Air	mg/m^3	(1)			
EF	Exposure Frequency	days/year	125	DEQ		
ED	Exposure Duration	years	1	DEQ		
ET	Exposure Time	hours/day	4	DEQ		
AT-C	Averaging Time (Cancer)	days	25,550	EPA, 1989		
AT-N	Averaging Time (Non-Cancer)	days	365	EPA, 1989		

DEQ= VRP Staff Professional Judgement
EPA, 1989= Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response. EPA/540/1-89/002.
(1) Ambient air concentrations may be estimated by applying the particulate emission factor (PEF) or volatilization factor (VF) to soil concentrations as described in Soil Screening Guidance: Technical Background Document. U. S. EPA, Office of Solid Waste and Emergency Response. May 1996. (EPA/540/R-95/128) and Soil Screening Guidance: User's Guide. U.S.EPA, Office of Solid Waste and Emergency Response. April 1996. (EPA/540/R-96/018).
as described in Soil Screening Guidance: Technical Background Document. U. S. EPA, Office of Solid Waste

8/5/2014 Chemical of Potential Concern	Cancer Classification	Soil Concentration mg/kg	Exposure Point Concentration (Inhalation) (CA) mg/m3	Exposure Concentration EC cancer mg/m3	Inhalation Unit Risk IUR $(mg/m^3)^{-1}$	Cancer Risk (EC*IUR) unitless	Exposure Concentration EC noncancer mg/m3	Inhalation Reference Concentration (chronic) RfCi mg/m^3	Inhalation Reference Concentration (subchronic) RfCi mg/m^3	Hazard Quotient (EC/RfCi) unitless	Particulate Emission Factor (PEF) m3/kg	Volatilization Factor (VF) m3/kg
TAL Inorganics												
Arsenic	A	4.81E+01	1.44E-08	1.17E-11	4.30E+00	5.05E-11	8.22E-10	1.50E-05	1.50E-05	5.48E-05	3.34E+09	
Lead		1.18E+03	3.53E-07								3.34E+09	
Semivolatile Organic Compounds (SVOCs)												
Benzo(a)pyrene	B2	2.20E+01	1.36E-06	1.11E-09	1.10E+00	1.22E-09					3.34E+09	1.62E+07