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EVALUATION OF HUMAN HEALTH AND SCREENING LEVEL ECOLOGICAL RISK ASSESSMENTS AT AREA OF CONCERN 721 CNC CHARLESTON SC

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ENSAFE INC.

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Evaluation of Human Health and Screening Level Ecological Risk Assessments at Area of Concern 721 at CNC

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Introduction

As a part of the Resource Conservation Recovery Act (RCRA) Facility Investigation (RFI) at Area of Concern 721, human health and screening level ecological risk assessments were completed to evaluate overall risk and formulate a process where risk management decisions can be made. This technical memorandum provides information on the human health and screening level ecological risk assessments for the RFI at AOC 721. It provides a summary of data comparisons to regulatory values and accumulation of risk to specific receptors. The risk assessments are being presented prior to the submittal of the AOC 721 RFI Report to provide technical information during the ongoing wetlands determination at AOC 721.

AOC 721 is located in the northernmost portion of Zone C of the CNC, and is west of Avenue D north and just south of Noisette Creek. The site area consists of made-ground that was constructed in the early 1920s using dredge materials and includes a 650 foot long drainage ditch that discharges into Noisette Creek. A coal storage facility was located within the AOC 721/SWMU 44 area from 1941 until 1996. The existing bulk coal pile and surface soil were removed to a visual standard during an Interim Measure (IM) conducted in 1996.

The original source of contaminants within AOC 721 is assumed to be the coal storage piles. No other known sources of contamination or other waste related activities existed in the area of AOC 721. During the investigation of SWMU 44 (Coal Storage Area) arsenic was the only COPC identified as attributable to the storage activities at the site. Therefore, it was assumed that arsenic would be the primary COPC for the AOC 721 investigation. The potential contaminant migration pathways within AOC 721 include:

- Infiltration through the surface and subsurface soils and into the underlying groundwater. Underlying ground water at AOC 721 has been observed at levels around 6 – 8 inches below ground surface. Shallow groundwater flow directions at AOC 721 are north and north-northwest toward Noisette Creek. The contours show a northern flow trend and perpendicular discharge to Noisette Creek in relation to well 044007.

- Constituents leaching out of the coal storage piles and adhering to the surface soils could travel via overland flow and be deposited in the drainage ditch. Soils deposited in the drainage ditch could then either settle and deposit in the drainage ditch as sediment or travel via surface water flow and deposit in Noisette Creek.

Fate-and-Transport Mechanisms

Chemicals move from sources such as soil and water to exposure points where they may come in contact with potential receptors. The exposure pathways along which they move are defined by four components:

1. A source and chemical mechanism for release to the environment,
2. An environmental transport medium for the released chemicals (e.g., air, water),
3. A potential contact point with the contaminated medium (exposure point), and a exposure route at the exposure point (e.g., inhalation, ingestion, dermal contact).

Screening Level Ecological Risk Assessment

Exposure Pathways

The potential ecological exposure pathways present at AOC 721 include the following:

For terrestrial animals:

- Direct exposure to constituents in surface soils;
- Dermal absorption; and

- Ingestion of contaminated prey species.

For terrestrial plants:

- Root absorption of constituents in soils and near surface groundwater; and
- Leaf absorption of volatile constituents evaporating from the soil or deposited on the leaves.

For aquatic animals:

- Direct contact with contaminated surface water and sediment with gills or integument;
- Ingestion of contaminated prey species; and
- Uptake of constituents via contaminated prey.

For this screening level ecological risk assessment, the assessment endpoints selected are (1) the health of the benthic and terrestrial invertebrate community present in the wetlands within AOC 721, and (2) the health of upper trophic level aquatic and terrestrial receptor populations using the AOC 721 as foraging area. The measurement endpoints used for this screening level risk assessment are (1) a comparison of site concentrations compared to the ecological screening values (US EPA Region 4 soil and sediment screening values) to determine potential adverse effects from constituents identified during the sampling investigation, and (2) a simple food chain model to evaluate exposure to receptors via contaminated prey items. After comparison to ecological screening values, the concentrations present at AOC 721 were compared to CNC wide reference screening values to determine if the concentrations within AOC 721 are similar to other areas within CNC not impacted by the coal piles.

Screening-Level Risk Calculation

To evaluate potential risk from the above listed potential exposure pathways, the maximum concentration of each constituent was compared to the EPA Region 4 ecological screening value (ESV). A hazard quotient (HQ) is calculated for all constituents that had an EPA Region 4 ESV. A constituent who's HQ, using the maximum concentration, is below 1 is assumed to pose no unacceptable level of risk. However if a

constituent generated a HQ greater than or equal to 1 it was included as a COPC and carried forward into baseline problem formulation.

Any COPC known to have the potential to transfer contaminants through the food web was also evaluated using a simple food chain model. Since no site specific biota tissue data is available, some conservative assumptions were made to estimate the potential exposure via food web transfer.

Soil Screening

Soil samples were collected from AOC 721 and analyzed for different parameters based on the contaminants found in samples in the surrounding area and the approved work plan. For a detailed description of what each sample was analyzed for and the rational see Section 6 of the AOC 721 RFI Work Plan. The results of the soil COPC screening are included in Table 1.

After an initial screening of the data to determine potential COPCs, 13 inorganics and 16 organics were identified as COPCs and these constituents were further evaluated using more conservative assumptions (using an average value for exposure estimates and comparing to site specific background) during the COPC Refinement stage. Since all PAHs have similar toxic effects on benthic communities, individual PAH constituents were evaluated as total PAHs during the COPC refinement stage. After comparison to exposure estimates and CNC wide reference concentrations arsenic, selenium and total PAHs remained as primary COPCs.

Arsenic

Arsenic exceeds the EPA Region 4 ESV in 32 of the 33 samples collected during this RFI. The average arsenic concentration is 76.97 mg/kg in AOC 721 soils which generates a HQ of 7.7. Twenty-two sample locations exceeded the CNC wide reference concentration of 39 mg/kg. Arsenic is included as the primary COPC for soil due to the number of exceedences of EPA Region 4 ESV, the reference concentration, and arsenic's historical association with SWMU 44 and the coal storage piles.

Selenium

Selenium exceeded the EPA Region 4 ESV at four of five locations with a screening HQ of 9.4. The HQ calculated using the average concentration also exceeded the ESV (HQ=3.4). The CNC wide reference concentration for selenium (2.8 mg/kg) was exceeded at 4 locations. Since selenium exceeds the ESV and CNC wide screening value it is included as a COPC.

Table 1
AOC 721
Soil COPC Screening

Constituent	Frequency of Detection		Range of Detections (mg/kg)				Range of U Flagged Data		Location of Maximum Detection	EPA Reg. 4 ESV	Det. Exceed. Reg. 4 ESV	S HQ	Ref. Conc.	Mean Conc.	Mean Conc. S HQ
	# det.	# anal.	Min	Q	Max	Q	Min SQL	Max SQL							
Inorganic (mg/kg)															
Aluminum	5	5	2,800		36,600				044SB02501	50	5	732.0	55,500	15156	303.12
Antimony	2	5	0.48	J	1	J	*0.34*	*0.55*	044SS00601	3.5	0	0.3	13	0.43	0.12
Arsenic	33	33	2.8	J	283				044SB03101	10	32	28.3	39	79.56	7.96
Barium	6	6	6.7	J	62				044SS00601	165	0	0.4	193	34.44	0.21
Beryllium	3	6	0.16	J	1.9		*0.35*	*0.65*	044SB02501	1.1	2	1.7	1.7	0.81	0.74
Cadmium	2	6	0.51	J	0.9		*0.03*	*0.11*	044SB00701	1.6	0	0.6	0.98	0.32	NC
Calcium	5	5	3,540		128,000				044SB00701	NA		NC	264,000	34626	NC
Chromium	5	5	7.3		54.3				044SB02501	0.4	5	135.8	114	32.62	81.55
Cobalt	10	10	2.5	J	19.5				721SB00801	20	0	0.98	11.4	8.2	NC
Copper	5	5	4.5	J	69.4				044SS00601	40	3	1.7	126	40.46	1.01
Iron	5	5	3,520		90,500				044SS00601	200	5	452.5	48,700	32496	162.48
Lead	5	5	26.1		64.2				044SB02501	50	1	1.3	310	52.64	1.05
Magnesium	5	5	514	J	5,790	J			044SB02501	NA		NC	7,850	3280.8	NC
Manganese	5	5	37.5		408				044SB02501	100	4	4.1	518	181.1	1.81
Mercury	8	9	0.15		1	J	*0.14*	*0.14*	721SB00301	0.1	8	10.0	1.5	0.29	2.90
Nickel	5	5	11.6		36.9				044SB02501	30	1	1.2	91.8	20.08	0.67
Potassium	5	5	252	J	3,810				044SB02501	NA		NC	3,570	2368.4	NC
Selenium	7	14	0.72	J	7.6		*0.45*	*5.1*	721SB06D01	0.81	6	9.4	2.8	2.75	3.40
Silver	0	6					*0.07*	*0.36*		2	0	0.0	1.7	0.12	0.06
Sodium	4	5	367	J	10,100		*2,880*	*2,880*	044SB02701	NA		NC	6,670	3936.6	NC
Thallium	2	25	3.7		8.3		*0.3*	*4*	044SS00601	1	2	8.3	0.55	0.99	0.99
Tin	1	5	1.3	J	1.3	J	*2.6*	*14.5*	044SB00701	53	0	0.0	12.5	3.45	0.07
Vanadium	5	5	7.1	J	68.5					2	5	34.3	101	40.9	20.45

Table 1
AOC 721
Soil COPC Screening

Zinc	10	10	65.5		279				721SB00801	50	10	5.6	226	137.48	2.75
Organics (ug/kg)															
1,2,4-Trichlorobenzene	0	1					*0.5*	*0.5*		0.01		NC	NA		0.00
1,2-Dichlorobenzene	0	1					*0.5*	*0.5*		0.01		NC	NA		NC
1,3-Dichlorobenzene	0	1					*0.5*	*0.5*		0.01		NC	NA		NC
1,4-Dichlorobenzene	0	1					*0.5*	*0.5*		0.01		NC	NA		NC
2,2' Oxybis (1-chloropropane) [bis(2-Chloroisopropyl)ether]	0	1					*0.5*	*0.5*		NA		NC	NA		NC
2,4,5-Trichlorophenol	0	1					*2.4*	*2.4*		4		NC	NA		NC
2,4,6-Trichlorophenol	0	1					*0.5*	*0.5*		10		NC	NA		NC
2,4-Dichlorophenol	0	1					*0.5*	*0.5*		0.003		NC	NA		NC
2,4-Dimethylphenol	0	1					*0.5*	*0.5*		NA		NC	NA		NC
2,4-Dinitrophenol	0	1					*2.4*	*2.4*		20	0	NC	NA		NC
2,4-Dinitrotoluene	0	1					*0.5*	*0.5*		NA		NC	NA		NC
2,6-Dinitrotoluene	0	1					*0.5*	*0.5*		NA		NC	NA		NC
2-Chloronaphthalene	0	1					*0.5*	*0.5*		1	0	NC	NA		NC
2-Chlorophenol	0	1					*0.5*	*0.5*		0.01	0	NC	NA		NC
2-Methylnaphthalene	5	10	0.27	J	2.5				721SB06C01	NA		NC	NA	0.87	NC
2 Methylphenol(o-Cresol)	0	1					*0.5*	*0.5*		0.5	0	NC	NA		NC
2-Nitroaniline	0	1					*2.4*	*2.4*		NA		NC	NA		NC
2-Nitrophenol	0	1					*0.5*	*0.5*		NA		NC	NA		NC
3&4-Methylphenol (m&p-cresol)										NA		NC	NA		NC
3,3'-Dichlorobenzidine	0	1					*1*	*1*		NA		NC	NA		NC
3-Nitroaniline	0	1					*2.4*	*2.4*		NA		NC	NA		NC
4-Bromophenylphenyl ether	0	1					*0.5*	*0.5*		NA		NC	NA		NC
4-Chloro-3-methylphenol	0	1					*0.5*	*0.5*		NA		NC	NA		NC
4-Chloroaniline	0	1					*0.5*	*0.5*		NA		NC	NA		NC
4-Chlorophenylphenyl ether	0	1					*0.5*	*0.5*		NA		NC	NA		NC

Table 1
AOC 721
Soil COPC Screening

4-Nitroaniline	0	1					*2.4*	*2.4*		NA		NC	NA		NC
4-Nitrophenol	0	1					*2.4*	*2.4*		NA		NC	NA		NC
Acenaphthene	1	1	0.09	J	0.09	J			044SS00601	20	0	0.0	NA	0.09	0.00
Acenaphthylene	0	1					*0.5*	*0.5*		NA		NC	NA		NC
Anthracene	1	1	0.12	J	0.12	J			044SS00601	0.1	1	1.2	NA	0.12	1.20
Benzoic acid	0	1					*0.24*	*0.24*		NA		NC	NA		NC
Benzo(a)anthracene	8	9	0.087	J	0.44	J	*0.48*	*0.48*	044SS00601	NA		NC	NA	0.27	NC
Benzo(a)pyrene	1	1	0.22	J	0.22	J			044SS00601	0.1		2.2	NA	0.22	2.20
Benzo(b)fluoranthene	1	1	0.4	J	0.4	J			044SS00601	NA		NC	NA	0.4	NC
Benzo(g,h,i)perylene	1	1	0.11	J	0.11	J			044SS00601	NA		NC	NA	0.1	NC
Benzo(k)fluoranthene	1	1	0.21	J	0.21	J			044SS00601	NA		NC	NA	0.21	NC
Benzyl alcohol	0	1					*0.5*	*0.5*		NA		NC	NA		NC
Benzyl butyl phthalate	0	1					*0.5*	*0.5*		NA		NC	NA		NC
bis(2 Chloroethoxy)-methane	0	1					*0.5*	*0.5*		NA		NC	NA		NC
bis(2-Chloroethyl)ether	0	1					*0.5*	*0.5*		NA		NC	NA		NC
bis(2- thylhexyl)phthalate	0	1					*0.38*	*0.38*		NA		NC	NA		NC
Chrysene	10	11	0.09	U J	0.94	J			721SB06C01	NA		NC	NA	0.48	NC
Dibenzo(a,h)anthracene	0	1					*0.5*	*0.5*		NA		NC	NA		NC
Dibenzofuran	1	1	0.67		0.67				044SS00601	NA		NC	NA	0.67	NC
Diethylphthalate	0	1					*0.5*	*0.5*		0.1		NC	NA		NC
Dimethylphthalate	0	1					*0.5*	*0.5*		0.1		0.0	NA		0.00
Di-n-butylphthalate	0	1					*0.5*	*0.5*		0.1		0.0	NA		0.00
Di-n-octylphthalate	0	1					*0.5*	*0.5*		0.1		NC	NA		0.00
Fluoranthene	7	8	0.12	J	0.97		*0.48*	*0.48*	721SB06C01	0.10	7.00	9.7	NA	0.47	4.70
Fluorene	1	1	0.063	J	0.063	J			044SS00601	NA		NC	NA	0.063	NC
Hexachlorobenzene	0	1					*0.5*	*0.5*		0.05		NC	NA		0.00
Hexachlorobutadiene	0	1					*0.5*	*0.5*		NA		NC	NA		NC
Hexachlorocyclopentadiene	0	1					*0.5*	*0.5*		NA		NC	NA		NC

Table 1
AOC 721
Soil COPC Screening

Hexachloroethane	0	1					*0.5*	*0.5*		NA		NC	NA		NC
Indeno(1,2,3-cd)pyrene	1	1	0.074	J	0.074	J			044SS00601	NA		NC	NA	0.07	NC
Isophorone	0	1					*0.5*	*0.5*		NA		NC	NA		NC
Naphthalene	13	14	0.055	J	1.2		*0.48*	*0.48*	044SS00601	0.1	11	12.0	NA	0.52	5.20
Nitrobenzene	0	1					*0.5*	*0.5*		40		NC	NA		0.00
n-Nitrosodi-n-propylamine	0	1					*0.5*	*0.5*		NA		NC	NA		NC
N-Nitrosodiphenylamine	0	1					*0.5*	*0.5*		20		NC	NA		0.00
Pentachlorophenol	0	1					*2.4*	*2.4*		0.002		0.0	NA		0.00
Phenanthrene	14	14	0.045	J	2.6				044SS00601	0.1		26.0	NA	0.97	9.70
Phenol	0	1					*0.5*	*0.5*		0.05		0.0	NA		0.00
Pyrene	14	14	0.063	J	0.93	J			721SB01D01	0.1		9.3	NA	0.44	4.40
Total PAHs	15	15	0.108		9.29				721SB06C01	1	12	9.3	NA	3.36	3.36

Notes:
NA = Notes constituents for which no EPA Region 4 ESV or reference concentration is available
NC = Notes contaminants for which there is not sufficient information to calculate a value (primarily used when a constituent was not detected in any sample)
SHQ = Screening HQ
Italicized #'s = Indicates U-flagged data that represents the sample quantitation limits (DL) for each constituent

Total PAHs

Total PAHs exceeded the EPA Region 4 ESV in twelve of the fifteen sample locations (max HQ = 9.3). The average concentration also exceeds the EPA Region 4 ESV (average HQ = 3.4) therefore total PAHs were included as a screening COPC for soil.

Since none of the COPCs identified for soils are thought to transfer via the food web at the levels they were detected, no food chain model is needed to evaluate these COPCs.

Sediment Screening

During the AOC 721 investigation sediment samples were collected from 13 locations along the drainage ditch along the northern edge of AOC 721 (just on the south side of the old perimeter road). For a rational of the analysis at each location see the AOC 721 Work Plan (EnSafe, 2003). The results of the sampling are included in Table 7.2. After an initial screening of the data to determine potential COPCs 20 inorganic constituents and seven PAHs were identified as COPCs. PAHs were further evaluated and discussed based on the total PAH levels for each sediment location.

For refinement of sediments at AOC 721 each constituent that was included as a screening COPC for sediment was evaluated further. One of the typical comparisons made in refinement is to a reference concentration that indicates conditions in sediments not impacted by the site being investigated. No site specific reference concentrations were collected during the AOC 721 investigation; however, reference sediments collected from Rathall Creek during an EPA investigation of another site along the Cooper River were used for comparison. Rathall Creek is a tributary to the Wando River and their confluence is just north of where the Interstate 526 bridge crosses the Wando River. A summary of the inorganic constituents detected in the Rathall Creek samples (n=4) are summarized below:

Parameter	Range			Mean	Reference Concentration
Aluminum	14000	-	26000	20,250	40,500
Arsenic	13	-	21	17	33
Barium	20	-	31	25	49.5
Beryllium	1.2	-	1.3	1.25	2.5

Table 2
Sediment Screening
Charleston Naval Shipyard

Constituent	Frequency of Detection		Range of Detections				Range of U Flagged Data		Location of Maximum Detection	EPA Reg.4 ESV	No. ≥	S HQ	Mean Conc.	Max Conc. S HQ	Ave. Conc. S HQ	Ref. Value	Max Conc. Ref. HQ	Ave. Conc. Ref. HQ	No. ≥ Ref. Value
	# det.	# anal.	Min	Q	Max	Q	Min SQL	Max SQL											
Inorganics (mg/kg)																			
Aluminum	5	5	4,870.00		7,760				044M0001601	NA	NC	NC	6,042.00	NC					
Antimony	2	5	0.53	J	0.97	J	*0.43*	*0.23*	044M001701	12	0	0.1	0.40	0.1	0.03				
Arsenic	18	18	3.5		75.9				721MD00501	7.24	15	10.5	29.16	10.5	4.03	70.00	1.08	0.42	1
Barium	5	5	12.3	J	70.7	J			044M001501	NA	NC	NC	41.20	NC					
Beryllium	7	12	0.46		5.4		*0.32*	*0.47*	721MD00501	NA	NC	NC	1.14	NC					
Cadmium	4	5	0.04		0.84		*0.07*	*0.07*	044M001501	1	0	0.8	0.29	0.8	0.29	9.60	0.09	0.03	0
Calcium	5	5	733		12,600				044M001701	NA	NC		4,525.20						
Chromium	5	5	10.2		23.2				044M001501	52.3	0	0.4	18.02	0.4	0.34	370.00	0.06	0.05	0
Cobalt	18	18	0.77		33.2				721MD00501	NA	NC		6.05						
Copper	5	5	11.9		51.3				044M001701	18.7	4	2.7	30.78	2.7	1.65	270.00	0.19	0.11	0
Iron	5	5	6,730		93,700				044M001501	NA	NC		37,966.00						
Lead	5	5	14		63.6				044M001701	30.2	4	2.1	39.96	2.1	1.32	218.00	0.29	0.18	0
Magnesium	5	5	614	J	1,510				044M001601	NA	NC		1,043.00						
Manganese	4	5	36.9		85.9		*0.06*	*0.06*	044M001701	NA	NC		48.23						
Mercury	18	18	0.04	J	1.6	J			044M001701	0.13	15	12.3	0.47	12.3	3.59	0.71	2.25	0.66	3
Nickel	5	5	3.8	J	26.7	J			044M001701	15.9	1	1.7	8.84	1.7	0.56	51.60	0.52	0.17	0
Potassium	5	5	360	J	8,240	J			044M001501	NA	NC		2,489.80						
Selenium	4	5	0.83	J	9.3	J	*1*	*1*	044M001501	NA	NC		4.51						
Silver	0	5					*0.06*	*0.06*		2	0	0.0	0.05	0.0	0.03	3.70	0.00	0.01	0
Sodium	5	5	798	J	5,860	J			044M001501	NA	NC		2,385.40						
Thallium	5	5	2.1		2.7	J			044M001701	NA	NC		2.04						
Tin	0	5					*0.74*	*2.1*		NA	NC		0.72						
Vanadium	5	5	12.6		33.5				044M001501	NA	NC		23.60						
Zinc	18	18	31.2	J	669	J			721MD01001	124	7	5.4	160.11	5.4	1.29	410.00	1.63	0.39	1
Organics (ug/kg)																			
2-Methylnaphthalene	12	13	0.94		940	J	*890*	*890*	721MD01001	20.23	12	46.5	423.42	46.5	20.93	670.00	1.40	0.63	4
Benzo(a)anthracene	13	13	38	J	1,400				721MD00901	74.8	11	18.7	408.15	18.7	5.46	1,600.00	0.88	0.26	0
Chrysene	13	13	66	J	1,500				721MD00901	108	11	13.9	523.77	13.9	4.85	2,800.00	0.54	0.19	0
Fluoranthene	13	13	5.4		5,400				721MD00901	113	11	47.8	1,275.31	47.8	11.29	5,100.00	1.06	0.25	1
Naphthalene	9	9	81	J	570	J			721MD00901	34.6	9	16.5	329.00	16.5	9.51	2,100.00	0.27	0.16	0
Phenanthrene	13	13	74	J	4,700				721MD01301	86.7	12	54.2	762.08	54.2	8.79	1,500.00	3.13	0.51	1
Pyrene	13	13	76	J	4,200				721MD01301	153	11	27.5	1,077.38	27.5	7.04	2,600.00	1.62	0.41	2
Total PAHs	13	13	640		21,630				721MD01301	1684	11	12.8	5998.6	12.8	3.56	44,792.00	0.48	0.13	0

Notes:

NA = Notes constituents for which no EPA Region 4 ESV, NOAA ERM, or reference concentration is available.
NC = Notes contaminants for which there is not sufficient information to calculate a value.
Italicized #'s = Indicates U-flagged data that represents the sample quantitation limits (DL) for each constituent.
SHQ = screening Hazard Quotient
ESV = Ecological Screening Value

EPA Region 4 ESV = US. EPA 2001. Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment. Originally published November 1995. Website version last updated November 30, 2001. http://www.epa.gov/region4/waste/ots/ecolbul.htm.

Refinement Values (NOAA ERM) Long, E.R., D.D. MacDonald, S.L. Smith and F.D. Calder 1995. "Incidence of Adverse Biological Effects within Ranges of Chemcial Concentrations in Marine and Estuarine Sediments. Environ. Manage. 19:81-97.

Cadmium	0.23	-	0.53	0	0.75
Chromium	34	-	50	42	84
Cobalt	5.6	-	8	6.58	13.15
Copper	12	-	26	22	43.5
Iron	25000	-	30000	27,250	54,500
Lead	12	-	30	23	46
Manganese	230	-	320	267	533.33
Mercury	0.31	-	0.36	0.34	0.67
Nickel	8	-	17	12	23.7
Vanadium	42	-	70	57	113.5
Zinc	45	-	92	73	146.5

Another comparison made during refinement was the NOAA effect range median (ERM) values. The NOAA ERM is the number at which ecological effects are expected to be seen if exceeded. The use of US EPA ESVs and NOAA ERMs help to provide a useful range of potential for effects by calculating HQs as outlined below:

- Average concentration/EPA Region 4 ESV,
- Maximum concentration/NOAA ERM, and
- Average concentration/NOAA ERM.

Risk ranges are presented in Table 2 for those constituents that have EPA Region 4 ESVs and NOAA ERMs. Those constituents that do not have a screening value are compared to the Rathall Creek reference concentration. Arsenic, beryllium, iron, mercury, selenium, thallium, zinc, and total PAHs were identified as final sediment COPCs.

Arsenic

The maximum arsenic HQ (10.5) is located at 721MD001501. Arsenic exceeded the EPA Region 4 ESV at 15 of the 18 sediment sample locations within the boundaries of AOC 721. The average screening HQ for arsenic is 4.03. Six locations exceed the reference concentration. Only one location (721MD001501) exceeds the ERM. Arsenic was a COC at SWMU 44, and is included as a COPC for sediment.

Beryllium

There is no EPA Region 4 ESV or NOAA ERM for beryllium. Beryllium concentrations exceed the reference concentration (2.5 mg/kg) in only one location (721MD00501). Beryllium slightly exceeded the soil reference concentration as well. Beryllium was

identified as a COPC in the SWMU 44 investigation. Beryllium is included as a COPC for sediment.

Iron

There is no EPA Region 4 ESV or NOAA ERM for iron in sediment. The maximum concentration of iron (at location 044M001501) is the only location (of the five sampled) that exceeds the reference concentration. Iron was not identified as a COPC for the SWMU 44 investigation. However, iron did exceed its reference concentration and screening value in soil at AOC 721. Therefore, iron is included as a COPC for sediment.

Mercury

Mercury exceeds both the EPA Region 4 ESV (15 locations) and the NOAA ERM (3 locations). While mercury is present in levels of potential ecological concern, it is not associated with the activities that occurred historically at AOC 721. Mercury is included as a COPC for sediment.

Selenium

There is no EPA Region 4 ESV or NOAA ERM for selenium. However, a value of 3 mg/kg exists as a protective level in the "Guidelines for evaluating selenium data from aquatic monitoring and assessment studies (Lemly 1993)." Three locations (of five) in the AOC 721 ditch exceed this value, with a maximum of 9.3 mg/kg. Selenium was not identified as a COPC in the SWMU 44 investigation. Selenium exceeded its soil reference concentration. Since selenium exceeds the only ecological sediment benchmark found for selenium it is included as a COPC for sediment.

Thallium

There is no EPA Region 4 ESV or NOAA ERM for thallium; however a protective value of 2.6 mg/kg was identified in the literature search (Crommentuijn et. al. 1997). The maximum sediment concentration of thallium detected in AOC 721 is 2.7 mg/kg. Thallium was not identified as a COPC during the SWMU 44 investigation. Thallium is included as a COPC for sediment.

Zinc

Zinc exceeds its EPA Region 4 ESV at 7 of 18 locations and it's NOAA ERM at 1 location. The maximum screening HQ is 5.4 at location 721MD01001 which also has a maximum refinement HQ of 1.6. Average zinc concentrations indicate that exposure to zinc throughout the drainage ditch is just slightly over the EPA Region 4 screening value.

However, there may be a hotspot around location 721MD01001 where some ecological effects may be occurring. The average screening HQ for zinc is 1.3. Zinc is included as a COPC.

Total PAHs

Total PAHs exceed the EPA Region 4 ESV at 11 (of 13) locations with a maximum screening HQ of 12.8 and an average screening HQ of 3.6. No locations in the drainage ditch exceeded the NOAA ERM. Total PAHs were identified as COPCs in the SWMU 44 investigation and were included as soil COPCs in this investigation. Total PAHs are included as a COPC for sediment.

Surface Water Screening

A total of three surface water samples were collected during the AOC 721. The only constituents detected in the surface water were the following inorganics: arsenic (1/3 locations), beryllium (2/3 locations), calcium (3/3 locations), cobalt (1/3 locations), magnesium (3/3 locations), potassium (3/3 locations), sodium (3/3 locations), and thallium (1/3 locations). Of those inorganics detected, none of the constituents with a screening value (arsenic, and thallium) exceeded its value. The inorganics that do not have a screening value that were detected includes: beryllium, calcium, cobalt, magnesium, potassium, and sodium; however these constituents were not evaluated further after the COPC refinement. The results of the surface water screening are included in Table 3.

Table 3
AOC 721
Surface Water COPC Screening
Charleston Naval Shipyard

Constituent	Frequency of Detection		Range of Detections					Range of U Flagged Data		Location of Maximum Detection	EPA Region 4 ESV	Detections Exceeding Region 4 ESV	Screening HQ
	# det.	# analyzed	Min	Q	Max	Q	Mean	Min SQL	Max SQL				
Arsenic	1	3	3.6	J	3.6	J		*2.5*	*2.5*	721WP00101	36	0	0.1
Beryllium	2	3	0.32	J	0.33	J		*0.3*	*0.3*	721WD00101	NL		NC
Calcium	3	3	125,000		169,000					721WD00101	NL		NC
Cobalt	1	3	1.1	J	1.1	J		*1.1*	*1.1*	721WP00101	NL		NC
Magnesium	3	3	331,000		403,000					721WP00101	NL		NC
Mercury	0	3						*0.1*	*0.1*		0.025	0	0.0
Potassium	3	3	126,000		152,000					721WP00101	NL		NC
Selenium	0	3						*2.3*	*2.3*		71	0	0.0
Sodium	3	3	2,340,000	J	2,845,000	J				721WP00101	NL		NC
Thallium	1	3	4.3	J	4.3	J		*3.2*	*3.2*	721WP00101	21.3	0	0.2
Zinc	0	3						*5*	*5*		86	0	0.0

Notes:

NA = Notes constituents for which no EPA Region 4 ESV or reference concentration is available

NC = Notes contaminants for which there is not sufficient information to calculate a value (primarily used when a constituent was not detected in any sample)

Italicized#'s = Indicates U-flagged data that represents the sample quantitation limits (DL) for each constituent

EPA Region 4 ESV: US. EPA 2001. Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment. Originally published November 1995. Website version last updated November 30, 2001. http://www.epa.gov/region4/waste/ots/ecolbul.htm

Groundwater Screening

The shallow groundwater samples collected during the AOC 721 were screened against the EPA Region 4 surface water screening values. This screening is conducted to evaluate if the groundwater – to – surface water pathway may cause surface water concentrations that pose unacceptable levels of risk. The results of this screening are presented in Table 4. The only constituents that generated HQs greater than 1 were:

Arsenic (27/42/13): A screening HQ of 5.7 was calculated using the maximum groundwater concentration (206 µg/L) from location 044GW007, 7th sampling event.

Copper (4/24/3): A screening HQ of 3.0 was calculated using the maximum groundwater concentration (8.8 µg/L) from location 044GW007, first sampling event.

Mercury (1/29/1): A screening HQ of 5.6 was calculated using the maximum groundwater concentration (0.14 µg/L) from location 044GW005, second sampling event.

Nickel (9/24/1): A screening HQ of 1.3 was calculated using the maximum groundwater concentration (10.5 µg/L) from location 044GW006, second sampling event.

Since groundwater discharges to nearby Noisette Creek, it is possible the constituents listed above could discharge at levels exceeding surface water screening levels and become surface water COPCs. However, none of these constituents were present in either the surface water samples collected in Noisette Creek during the 1997 Zone J surface water investigation or during the AOC 721 investigation of site surface waters. Therefore groundwater does not appear to be having a negative impact on surface waters.

Table 4
AOC 721 Groundwater Screening
Charleston Naval Shipyard

Constituent	Frequency of Detection		Range of Detections				Range of U Flagged Data		Location of Maximum Detection	EPA Region 4 ESV	Detections Exceeding Region 4 ESV	Screening HQ	Screening COPC	Reference Concentration Range
	# det.	# analyzed	Min	Q	Max	Q	Min SQL	Max SQL						
Inorganics (ug/L)														
Aluminum	5	15	28.3	J	2,110	J	*8*	*156*	044GW00701	NL	0	NA	Yes	95.7 - 2,110
Antimony	5	35	2.6	J	54.1		*1.6*	*14.4*	044GW00702	NL	0	NA	No	3.1
Arsenic	27	42	2.1	J	206		*2.5*	*3.3*	044GW00711	36	13	5.7	Yes	1.6 - 43
Barium	18	24	22.2		98.1		*8.5*	*35.4*	044GW00707	NL	0	NA	No	13.1 - 147
Beryllium	8	29	0.11	J	0.91	J	*0.1*	*1.3*	044GW00505	NL	0	NA	Yes	0.36 - 4.8
Cadmium	0	24					*0.3*	*0.5*		NL	0	NA	No	
Calcium	24	24	81,400		448,000				044GW00605	NL	0	NA	Yes	60,000 - 720000
Chromium	9	26	1.1	J	4.5	J	*0.5*	*2.9*	044GW00701	50	0	0.1	Yes	0.94 - 128
Cobalt	4	27	0.95	J	5.1		*0.6*	*5.2*	044GW00602	NL	0	NA	Yes	0.97 - 74.6
Copper	4	24	2.6	J	8.8	J	*0.6*	*5.4*	044GW00701	2.9	3	3.0	Yes	0.69-105
Iron	36	40	28	J	8,710		*24.2*	*518*	044GW00701	NL	0	NA	Yes	111-31,900
Lead	3	26	2.2	J	4.9	J	*0.9*	*2.1*	044GW00701	8.5	0	0.6	Yes	1.8-8.5
Magnesium	24	24	22100	J	653,000	J			044GW00501	NL	0	NA	Yes	9,250-1,210,000
Manganese	24	24	173		2580				044GW00602	NL	0	NA	Yes	16.6-4,850
Mercury	1	29	0.14	J	0.14	J	*0.1*	*0.2*	044GW00502	0.025	1	5.6	Yes	0.12-1.1
Nickel	9	24	0.96	J	10.5	J	*0.8*	*13*	044GW00602	8.3	1	1.3	Yes	1.0-55.6
Potassium	24	24	13100		282,000	J			044GW00501	NL	0	NA	Yes	6,400-517,000
Selenium	2	27	4.3	J	5.7	J	*2.3*	*4.4*	044GW00708	71	0	0.1	Yes	26.7
Silver	2	24	1	J	2.2		*0.5*	*2.7*	044GW00703	0.23	2	NA	No	1.4-112
Sodium	24	24	108000		6,590,000				044GW00504	NL	0	NA	Yes	11,300-9,760,000
Thallium	3	29	3.1	J	6	J	*2.3*	*5*	044GW00605	21.3	0	0.3	Yes	2.7-105
Vanadium	22	33	0.94	J	26	J	*0.5*	*9.6*	044GW00604	NL	0	NA	Yes	2.7-12.9
Zinc	4	27	18.1	J	24.7	J	*2.9*	*17.7*	044GW00701	86	0	0.3	Yes	11.3-316
Benzoic acid	1	12	7	J	7	J	*50*	*95*	044GW00503	NL	0		Yes	NA
bis(2-Ethylhexyl)phthalate	1	12	8	J	8	J	*10*	*25*	044GW00601a	NL	0	NA	Yes	NA
Diethylphthalate	1	12	1	J	1	J	*10*	*15*	044GW00503	75.9	0	NA	Yes	NA
Di-n-butylphthalate	1	12	1	J	1	J	*10*	*15*	044GW00503	3.4	0	0.3	Yes	NA

Notes:
NA = Notes constituents for which no EPA Region 4 ESV or reference concentration is available
NC = Notes contaminants for which there is not sufficient information to calculate a value (primarily used when a constituent was not detected in any sample).
Italicized numbers Indicates U-flagged data that represents the sample quantitation limits (DL) for each constituent.

Summary

After comparison to exposure estimates and CNC wide reference concentrations arsenic, selenium and total PAHs remained as primary COPCs for surface soil. During sediment screening, arsenic, beryllium, iron, mercury, selenium, thallium, zinc, and total PAHs were identified as COPCs. Though four inorganic constituents were identified in groundwater to surface water screening pathway of having a screening HQ greater than 1, historical surface water data has shown that groundwater does not appear to be having a negative impact on surface waters.

Human Health Risk Assessment

The human health risk assessment (HHRA) process identifies contaminants and evaluates potential exposure to determine whether the site poses a risk to human health. Although the site is presently in an industrial setting, residential, industrial, and trespasser scenarios were evaluated because land use may change in the future.

The overall methodology of the HHRA was performed in accordance with USEPA Risk Assessment Guidance for Superfund (RAGS), which SCDHEC considers to be acceptable guidance and methodology. This evaluation is based on results from RFI and Corrective Measure Study (CMS) sampling and investigation activities. After potential site-related contaminants were identified, potential risks to human receptors were quantified to evaluate potential impacts to human health. The steps involved in the HHRA include data evaluation, exposure assessment, toxicity assessment, risk characterization, and a risk uncertainty discussion.

Potentially Exposed Populations

Hypothetical future residents, site workers, and trespassers are considered to be potentially exposed populations for AOC 721. On-site residents are possible future human receptors; however, future residential development is unlikely due to nonresidential development re-use plans being discussed for the site.

For this land use scenario, potential receptors include both adult and child. The hypothetical resident is assumed to be exposed to surface soil 350 days per year for duration of 6 and 24 years for the child and adult, respectively.

Hypothetical future site worker exposure to soil and groundwater is assumed to be exposed to surface soil 250 days per year for duration of 25 years. It is not likely that industrial/commercial development will take place at this site.

Hypothetical trespasser exposure to soil and groundwater is assumed to be exposed to surface soil 8 hours per day for 52 days per year for duration of 10 years. This is the likely scenario since the planned re-use of the area is tidal marshland.

Exposure Pathways

Exposure pathways for the hypothetical future residents, site workers and trespassers are incidental ingestion, dermal contact, and inhalation of chemicals in surface soils and incidental ingestion of groundwater for hypothetical future resident, site worker, and trespasser. Tables 5 and 6 present the justification for exposure pathways assessed in HHRA. For both current (site workers) and future (hypothetical residents/future worker) users exposed population scenarios, the incidental ingestion and dermal contact with soil pathways were selected for evaluation and the air pathway for inhalation of chemicals entrained in fugitive dust was selected in the future land use.

The groundwater exposure pathway identified shallow groundwater and the ingestion of contaminants during potable or general use for current land use. For future land use population, the ingestion of contaminants during potable or general use of shallow groundwater was identified for hypothetical residents and hypothetical trespasser/future worker. Though groundwater is not likely to be used as a source of potable or non residential water at this location, this pathway was addressed as a conservative measure.

Table 5
Exposure Pathways Summary
AOC 721
Charleston Naval Complex

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Users (Site Workers)	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	No	This exposure pathway was considered insignificant compared to the other pathways.
	Soil, incidental ingestion	**Yes**	Future site use is considered conservatively representative of current site use.
	Soil, dermal contact	**Yes**	Future site use is considered conservatively representative of current site use.
Future Land Uses			
Hypothetical Residents (Child and Adult), Future Worker	Air, inhalation of gaseous contaminants emanating from soil	No	Fate and transport screening did not identify any COPCs for this indirect exposure pathway.
	Air, inhalation of chemicals entrained in fugitive dust	**Yes**	It is assumed that residents will be exposed to fugitive dusts in surface soil.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	Volatile COPCs were not identified subsequent to risk-based screening comparisons.
	Soil, incidental ingestion	**Yes**	It is assumed that residents will ingest incidental amounts of surface soil.
	Soil, dermal contact	**Yes**	It is assumed that residents will be exposed to surface soil via dermal contact.
	Wild game or domestic animals, Ingestion of tissue impacted by media contamination	No	Hunting/taking of game and/or raising livestock is prohibited within the Charleston, South Carolina city limits.
	Fruits and vegetables, ingestion of plant tissues grown in media	No	The potential for significant exposure via this pathway is low relative to that of other exposure pathways assessed.

Table 6
Groundwater Exposure Pathways Summary
AOC 721
Charleston Naval Complex

Potentially Exposed Population	Medium and Exposure Pathway	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Uses			
Current Users (Site Workers)	Shallow groundwater, ingestion of contaminants during potable or general use	**Yes**	Shallow groundwater is not currently used as a source of potable or nonresidential water at this location.
	Shallow groundwater, inhalation of volatilized shallow groundwater contaminants	No	No volatile COPCs were identified subsequent to risk-based screening comparisons.
Future Land Uses			
Hypothetical Residents (Child and Adult), Future Worker	Shallow groundwater, ingestion of contaminants during potable or general use	**Yes**	Shallow groundwater is not likely to be used as a source of potable or nonresidential water at this location. This pathway was addressed as a conservative measure.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	No volatile COPCs were identified subsequent to risk-based screening comparisons.
Hypothetical Trespasser, Future Worker	Shallow groundwater, ingestion of contaminants during potable or general use	**Yes**	Shallow groundwater is not likely to be used as a source of potable or nonresidential water at this location. This pathway was addressed as a conservative measure.
	Shallow groundwater, Inhalation of volatilized contaminants during domestic use	No	No volatile COPCs were identified subsequent to risk-based screening comparisons.

Carcinogenic Risk

Cancer risks are estimated as a probability. Risks are estimated by calculating incremental lifetime Cancer Risk (CR) as a result of exposure to carcinogens over a lifetime. Results of the cancer risk estimates can be compared to the USEPA target risk range of 1E-06 to 1E-04, or 1 in 1 million to 1 in 10,000. Cancer risk estimates exceeding the USEPA target risk range are considered unacceptable and indicate a need for action.

CR is calculated by multiplying the CDI for each chemical by its upper-bound cancer SF, using Equation 1 below (USEPA, 1989).

Equation 1

$$CR = CDI \times SF$$

where:

CR	=	Cancer risk (unitless)
CDI	=	Chronic daily chemical intake (mg/kg-day)
SF	=	Slope factor $(mg/kg\text{-}day)^{-1}$

The equation above is valid only at low risk. If the calculated risk exceeded 0.01, cancer risk was calculated using Equation 5 below (USEPA, 1989). Its variables are defined as above for Equation 1.

Equation 2

$$CR = 1 \times \exp(-CDI \times SF)$$

Noncarcinogenic Effects

The potential for adverse health effects other than cancer is evaluated as the ratio of the daily intake over the RfD. Noncarcinogenic effects are estimated using the following equation:

Equation 3

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

where:

HQ	=	Hazard quotient (unitless)
CDI	=	Chronic daily chemical intake (mg/kg-day)
RfD	=	Reference dose (mg/kg-day)

HQs for each chemical in each exposure pathway are summed to obtain the hazard index (HI), which allows assessment of the overall potential for noncarcinogenic health effects (USEPA 1989). Adverse health effects can occur when the HI exceed 1.

Chemical of Concern Identification

Chemicals with individual carcinogenic risk estimates greater than 1E-6 were identified as Chemicals of Concern (COCs). Non-carcinogenic COCs were identified in two steps. First, exposure media of concern were identified. An exposure medium was identified as a concern if the cumulative HI for an exposure medium was greater than 1.0. The cumulative HI for an exposure medium was calculated as the sum of the HIs for all exposure pathways in that medium (e.g., the sum of HIs for ingestion, inhalation, and dermal contact for soil).

The second step was to identify individual COCs that contributed to the exposure medium of concern. Chemicals contributing more than 0.1 to the HI of an exposure medium of concern were identified as COCs.

Residential Land Use

Surface Soil

Hypothetical Future Resident: The CRs (based on the adult and child lifetime-weighted average) for soil are 3.08E-04 (ingestion), 2.31E-04 (dermal contact) and 2.63E-07 (inhalation). The cumulative risk for the residential scenario is 5.40E-04. Arsenic was the primary contributor to CR projections for the ingestion and dermal contact. No other COCs were identified based on carcinogenic risk.

Hypothetical Residential Exposure Scenario: Carcinogenic Effects Surface Soil				
Chemical	**Ingestion Risk**	**Dermal Contact Risk**	**Inhalation Risk**	**Sum**

Hypothetical Residential Exposure Scenario: Carcinogenic Effects Surface Soil				
Chemical	**Ingestion Risk**	**Dermal Contact Risk**	**Inhalation Risk**	**Sum**
Arsenic	3.08E-04	2.31E-04	2.63E-07	5.40E-04
Pathway Total	**3.08E-04**	**2.31E-04**	**2.63E-07**	**5.40E-04**

Hazard Estimates Child Residents: The HIs for soil are 9.75E+00 (ingestion) and 7.07E-01 (dermal contact). The HI for the child resident scenario is 1.05E+01. Arsenic and iron were identified as COCs based on HI for the child scenario (ingestion).

Hazard Estimates Adult Residents: The HIs for soil are 1.04E+00 (ingestion) and 2.14E-01 (dermal contact). The HI for the adult resident scenario is 1.26E+00.

Hypothetical Residential Exposure Scenario: Hazard Quotients Surface Soil								
Chemical	**Ingestion Risk**		**Dermal Contact Risk**		**Inhalation Risk**		**Sum**	
	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Arsenic	6.00E-01	**5.60E+00**	1.23E-01	4.06E-01	NA	NA	7.23E-01	**6.00E+00**
Iron	4.13E-01	**3.86E+00**	8.47E-02	2.80E-01	NA	NA	4.98E-01	**4.14E+00**
Thallium	3.12E-02	2.91E-01	6.40E-03	2.11E-02	NA	NA	3.76E-02	3.12E-01
Pathway Total	**1.04E+00**	**9.75E+00**	2.14E-01	7.07E-01	0.0E+00	0.0E+00	**1.26E+00**	**1.05E+01**

Groundwater

Hypothetical Future Resident: The CR (based on the adult and child lifetime-weighted average) for groundwater is 4.60E-03 for ingestion. Arsenic and heptachlor were the primary contributors to CR projections for the ingestion. No other COCs were identified based on carcinogenic risk.

Hypothetical Residential Exposure Scenario: Carcinogenic Effects Groundwater	
Chemical	**Ingestion Risk**
Arsenic	**4.60E-03**
Heptachlor	**5.29E-06**
Acetophenone	NA

Hypothetical Residential Exposure Scenario: Carcinogenic Effects Groundwater	
Chemical	**Ingestion Risk**
Pathway Total	**4.60E-03**

Hazard Estimates Child Residents: The HI for the child resident scenario for groundwater is 4.39E+01 (ingestion). Arsenic was the only significant contributor to the projected HI for the groundwater ingestion pathway.

Hazard Estimates Adult Residents: The HI for the adult resident scenario for groundwater is 1.88E+01 for ingestion. Arsenic was the only significant contributor to the projected HI for the groundwater ingestion pathway.

Hypothetical Residential Exposure Scenario: Hazard Quotients Groundwater		
Chemical	**Ingestion Risk**	
	Adult	Child
Arsenic	**1.88E+01**	**4.39E+01**
Heptachlor	4.33E-03	1.01E-02
Acetophenone	2.75E-04	6.39E-04
Pathway Total	**1.88E+01**	**4.39E+01**

Summary

Arsenic exceeded the cumulative carcinogenic risk threshold of 1E-6 and background at 23 surface soil locations. Therefore, arsenic was identified as a COC. Arsenic and heptachlor exceeded the carcinogenic risk threshold for groundwater at monitoring well 044007.

Arsenic and iron exhibited a HI greater than 1.0 for soil. Therefore, these compounds were identified as COCs based on HI. Arsenic also exceeded the HI for groundwater and was identified as a COC based on HI.

Excess cancer risk and HIs are summarized for this land use scenario below.

Residential Land Use Scenario Summary of HIs and CR AOC 721			
Pathway	**Hazard Index (Adult)**	**Hazard Index (Child)**	**Excess Cancer Risk**
Soil	1.26E+00	1.05E+01	5.40E-04
Groundwater	1.88E+01	4.39E+01	4.60E-03
Total	**2.00E+01**	**5.44E+01**	**5.14E-03**

Commercial/Industrial Land Use

Soil

Hypothetical Site Worker: The CRs for soil are 1.93E-04 (ingestion), 2.63E-04 (dermal contact) and 2.93E-07 (inhalation). The cumulative risk for the site worker scenario is 4.57E-04. Arsenic was the primary contributor to CR projections for the ingestion and dermal contacts. No other COCs were identified based on carcinogenic risk. There were no compounds identified as having a HI greater than 1.

Hypothetical Site Worker Exposure Scenario: Carcinogenic Effects Surface Soil				
Chemical	**Ingestion Risk**	**Dermal Contact Risk**	**Inhalation Risk**	**Sum**
Arsenic	**1.93E-04**	**2.63E-04**	2.93E-07	**4.57E-04**
Pathway Total	**1.93E-04**	**2.63E-04**	2.93E-07	**4.57E-04**

Groundwater

Tables 8.53 to 8.55 present the carcinogenic risks and HIs associated with the incidental ingestion of chemicals in groundwater.

Hypothetical Site Worker: The cumulative risk for the site worker scenario for groundwater is 2.16E-03 for ingestion. Arsenic and heptachlor were the primary contributors to CR projections for the ingestion pathway. No other COCs were identified based on carcinogenic risk.

Hypothetical Site Worker Exposure Scenario: Carcinogenic Effects Groundwater	
Chemical	**Ingestion Risk**

Hypothetical Site Worker Exposure Scenario: Carcinogenic Effects Groundwater	
Chemical	**Ingestion Risk**
Arsenic	**2.16E-03**
Heptachlor	**2.48E-06**
Acetophenone	NA
Pathway Total	**2.16E-03**

Hazard Estimates: The hazard estimate for the future worker is 1.34E+01. Arsenic was the sole contributor to the projected HIs for the groundwater ingestion pathway.

Hypothetical Site Worker Exposure Scenario: Hazard Quotients Groundwater	
Chemical	**Ingestion Risk**
Arsenic	**1.34E+01**
Heptachlor	3.09E-03
Acetophenone	1.93E-04
Pathway Total	**1.34E+01**

Hypothetical Trespasser Scenario

Soil

Hypothetical Trespasser: The CRs for soil are 4.01E-05 (ingestion), 5.48E-05 (dermal contact) and 6.10E-08 (inhalation). The cumulative risk for the trespasser scenario is 9.50E-05. Arsenic was the primary contributor to CR projections for the ingestion and dermal contacts. No other COCs were identified based on carcinogenic risk.

Hypothetical Trespasser Exposure Scenario: Carcinogenic Effects Surface Soil				
Chemical	**Ingestion Risk**	**Dermal Contact Risk**	**Inhalation Risk**	**Sum**
Arsenic	**4.01E-05**	**5.48E-05**	6.10E-08	**9.50E-05**
Pathway Total	**4.01E-05**	**5.48E-05**	6.10E-08	**9.50E-05**

Hypothetical Trespasser: The cumulative risk for the trespasser scenario for groundwater is 1.40E-04 for ingestion. Arsenic was the primary contributors to CR projections for the ingestion pathway; however, heptachlor was also identified.

Hypothetical Trespasser Exposure Scenario: Carcinogenic Effects Groundwater	
Chemical	**Ingestion Risk**
Arsenic	**1.40E-04**
Heptachlor	1.61E-07
Acetophenone	NA
Pathway Total	**1.40E-04**

Hazard Estimates: The hazard estimate for the future trespasser is 2.19E+00. Arsenic was the primary contributor to the projected HIs for the groundwater ingestion pathway.

Hypothetical Trespasser Exposure Scenario: Hazard Quotients Groundwater	
Chemical	**Ingestion Risk**
Arsenic	**2.17E+00**
Heptachlor	5.00E-04
Acetophenone	3.17E-05
Pathway Total	**2.19E+00**

Summary

Arsenic exceeded the cumulative carcinogenic risk threshold of 1E-6 for both the site worker and trespasser scenarios and background at 23 surface soil locations. Therefore, the compound was identified as a COC for this land use scenario. Arsenic and heptachlor exceeded the risk calculations for groundwater at monitoring well 044007 for both the site worker and trespasser scenarios. Therefore, these above compounds were identified as COC for this land use scenario.

Surface soil did not exhibit a HI greater than 1.0; however, arsenic in groundwater exhibited a HI greater than 1.0 for both the site worker and trespasser scenarios. Therefore, arsenic in groundwater was identified based on HI.