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PROPOSED RISK BASED ACTION LEVELS CNC CHARLESTON SC
9/8/1992
ENSAFE/ ALLEN AND HOSHALL



**COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION
CHARLESTON NAVAL SHIPYARD
CHARLESTON, SOUTH CAROLINA**

**PROPOSED RISK-BASED ACTION LEVELS
CHARLESTON NAVAL SHIPYARD**

Prepared for:

**Department of the Navy
Southern Division
Naval Facilities Engineering Command
Washington, DC**

**SOUTHDIV Contract Number:
N62467-89-D-0318**



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September 8, 1992

RISK-BASED ACTION LEVELS FOR RCRA FACILITY INVESTIGATION

CHARLESTON NAVAL SHIP YARD CHARLESTON, SOUTH CAROLINA

INTRODUCTION

In December 1984 the Charleston Naval Shipyard, Charleston, South Carolina submitted a closure plan for each interim Status facility. A new hazardous waste container storage and transfer facility was to begin construction in 1985. As a consequence of construction of the new facility, all interim status facilities were to be closed in accordance with 40 CFR 265 Subpart G standards.

The original closure of the interim status facilities involved the determination of the presence and/or extent of contamination with respect to the corresponding facility. Under RCRA closure standards, closure and post closure has been based on a quantified reference. However, during closure of the facilities at the shipyard anomalous levels of analytes were observed in samples collected. Since soil materials can not be assumed to be native, comparison to native soils is inappropriate.

During closure of these facilities South Carolina Department of Health and Environment (SCDHEC) has been receptive to the use of health based risk criteria. In March 1987, USEPA published proposed rules for "alternate clean closure" which would permit residual contaminant levels above background if the operator demonstrates through a risk assessment that no human health or environmental threat results. Due to the high degree of heterogeneity identified under previous studies, corrective measures may be based on health based risk. Preliminary remediation goals have been generated from data. Final remediation goals will be based on current data generated during the RCRA Facility Investigation.

PRELIMINARY REMEDIATION GOALS

Conservative preliminary remediation goals (or Action Levels) for soil and groundwater at the Charleston Naval Ship Yard may be established through the use of formulae presented in US EPA's 'Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Volume I, Parts A & B' (RAGS Part A & B). In order to establish a point of reference for scoping of RFI activities, remediation goals under residential exposure scenarios will be calculated. These goals will serve as indicators of when additional investigations are not necessary to delineate the extent of contamination. Cessation of investigative activities will be dictated by identification of media samples having contaminant concentrations at or below the calculated Action Levels. As part of subsequent Corrective Measures Studies (CMS), additional media sampling may be required for engineering design purposes, but may be scaled to meet specific engineering/design data requirements.

The most conservative residential exposure assumptions were applied (i.e. maximum exposure durations; uniform, chronic exposure to contaminated media; etc.). Tables 1 through 8 provide

TABLE 1-GROUNDWATER RISK-(HAZARD INDEX) BASED ACTION LEVELS
 VOLATILE COMPOUNDS
 CHARLESTON NAVAL SHIPYARD
 CHARLESTON, SOUTH CAROLINA

PARAMETER	SLOPE	SLOPE	REFERENCE	REFERENCE	CANCER	HAZARD
	FACTOR ORAL (MG/KG/DAY) ⁻¹	FACTOR INHALATION (MG/KG/DAY) ⁻¹	DOSE ORAL (MG/KG/DAY)	DOSE INHALATION (MG/KG/DAY)	RISK-BASED ACTION LEVEL (MG/L)	INDEX-BASED ACTION LEVEL (MG/L)
BENZENE	2.90E-02	2.90E-02	0.00E+00	0.00E+00	6.18E-04	ERR
CARBON TETRACHLORIDE	1.30E-01	5.30E-02	7.00E-04	0.00E+00	2.59E-04	2.56E-02
CHLOROBENZENE	0.00E+00	0.00E+00	2.00E-02	6.00E-03	ERR	5.41E-02
CHLOROFORM	6.10E-03	8.10E-02	1.00E-02	0.00E+00	2.75E-04	3.65E-01
DIBROMOCHLOROMETHANE	8.40E-02	0.00E+00	2.00E-02	0.00E+00	1.01E-03	7.30E-01
DICHLOROFLUOROMETHANE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ERR	ERR
DIETHYL ETHER	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ERR	ERR
ETHYLBENZENE	0.00E+00	0.00E+00	1.00E-01	2.80E-01	ERR	1.56E+00
ETHYLENE DICHLORIDE	0.00E+00	9.10E-02	0.00E+00	0.00E+00	2.50E-04	ERR
ETHYLENE OXIDE	1.02E+00	3.50E-01	0.00E+00	0.00E+00	3.65E-05	ERR
FORMALDEHYDE	0.00E+00	4.50E-02	2.00E-01	0.00E+00	5.05E-04	7.30E+00
METHYLENE CHLORIDE	7.50E-03	1.00E-10	6.00E-02	6.40E-01	1.14E-02	1.62E+00
METHYLETHYL KETONE	0.00E+00	0.00E+00	5.00E-02	0.00E+00	ERR	1.83E+00
METHYLISOBUTYL KETONE	0.00E+00	0.00E+00	5.00E-02	0.00E+00	ERR	1.83E+00
1,1,2,2-TETRACHLOROETHANE	2.00E-01	2.00E-01	0.00E+00	0.00E+00	8.96E-05	ERR
TETRACHLOROETHENE	5.00E-02	2.00E-03	1.00E-02	0.00E+00	1.48E-03	3.65E-01
TOLUENE	0.00E+00	0.00E+00	2.00E-01	1.20E-01	ERR	1.01E+00
1,1,1-TRICHLOROETHANE	0.00E+00	0.00E+00	9.00E-02	0.00E+00	ERR	3.29E+00
TRICHLOROETHYLENE	1.10E-02	6.00E-03	0.00E+00	0.00E+00	2.54E-03	ERR
TRICHLOROFLUOROETHANE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ERR	ERR
TRICHLOROFLUOROMETHANE	0.00E+00	0.00E+00	3.00E-01	2.00E-01	ERR	1.65E+00

NOTE: RfD and Slope Factor (a.k.a. Cancer Potency Factor) values obtained from IRIS and/or HEAST 1992
 Inhalation exposure is not a factor for these parameters.

TABLE 2-GROUNDWATER RISK-(HAZARD INDEX) BASED ACTION LEVELS
SEMI-VOLATILE COMPOUNDS
CHARLESTON NAVAL SHIPYARD
CHARLESTON, SOUTH CAROLINA

PARAMETER	SLOPE	SLOPE	REFERENCE	REFERENCE	CANCER	HAZARD
	FACTOR ORAL (MG/KG/DAY) ⁻¹	FACTOR INHALATION (MG/KG/DAY) ⁻¹	DOSE ORAL (MG/KG/DAY)	DOSE INHALATION (MG/KG/DAY)	RISK-BASED ACTION LEVEL (MG/L)	INDEX-BASED ACTION LEVEL (MG/L)
ACENAPHTHENE	0.00E+00	NA	6.00E-02	NA	ERR	5.11E+00
ACENAPHTHYLENE	0.00E+00	NA	0.00E+00	NA	ERR	0.00E+00
AMINOPYRIDINE	0.00E+00	NA	2.00E-05	NA	ERR	1.70E-03
ANTHRACENE	0.00E+00	NA	0.00E+00	NA	ERR	0.00E+00
BENZO(A)ANTHRACENE	4.30E-01	NA	0.00E+00	NA	1.98E-04	0.00E+00
BENZO(B)FLUORANTHENE	4.30E-01	NA	0.00E+00	NA	1.98E-04	0.00E+00
BENZO(K)FLUORANTHENE	4.30E-01	NA	0.00E+00	NA	1.98E-04	0.00E+00
BENZO(A)PYRENE	5.80E+00	NA	0.00E+00	NA	1.47E-05	0.00E+00
bis(2-ETHYLHEXYL)PHTHALATE	1.40E-02	NA	2.00E-02	NA	6.08E-03	1.70E+00
BUTYLBENZYLPHthalATE	0.00E+00	NA	2.00E-01	NA	ERR	1.70E+01
CHRYSENE	4.30E-01	NA	0.00E+00	NA	1.98E-04	0.00E+00
CRESOL	0.00E+00	NA	5.00E-02	NA	ERR	4.26E+00
p-DICHLOROBENZENE	2.40E-02	NA	2.00E-01	NA	3.55E-03	1.70E+01
DICHLORODIMETHYLHYDRANTOIN	0.00E+00	NA	0.00E+00	NA	ERR	0.00E+00
DICHLOROPHENOL	0.00E+00	NA	0.00E+00	NA	ERR	0.00E+00
DIETHYLENE TRIAMINE	0.00E+00	NA	0.00E+00	NA	ERR	0.00E+00
DIETHYL PHTHALATE	0.00E+00	NA	8.00E-01	NA	ERR	6.81E+01
4,6-DINITRO-o-CRESOL	0.00E+00	NA	0.00E+00	NA	ERR	0.00E+00
2,4-DINITROTOLUENE	6.80E-01	NA	2.00E-03	NA	1.25E-04	1.70E-01
FLUORANTHENE	0.00E+00	NA	4.00E-02	NA	ERR	3.41E+00
FLUORENE	0.00E+00	NA	4.00E-02	NA	ERR	3.41E+00
METHYL CELLOSOLVE	0.00E+00	NA	0.00E+00	NA	ERR	0.00E+00
HYDRAZINE	3.00E+00	NA	0.00E+00	NA	2.84E-05	0.00E+00
INDENO(1,2,3-cd)PYRENE	0.00E+00	NA	0.00E+00	NA	ERR	0.00E+00
1-METHYLNAPHTHALENE	0.00E+00	NA	0.00E+00	NA	ERR	0.00E+00
2-METHYLNAPHTHALENE	4.90E-03	NA	0.00E+00	NA	1.74E-02	0.00E+00
NAPHTHALENE	0.00E+00	NA	4.00E-02	NA	ERR	3.41E+00
n-NITROSODIPHENYLAMINE	4.90E-03	NA	0.00E+00	NA	1.74E-02	0.00E+00
PENTACHLOROPHENOL	1.20E-01	NA	3.00E-02	NA	7.10E-04	2.56E+00
PHENANTHRENE	0.00E+00	NA	0.00E+00	NA	ERR	0.00E+00
PHENOL	0.00E+00	NA	6.00E-01	NA	ERR	5.11E+01
PYRENE	0.00E+00	NA	3.00E-02	NA	ERR	2.56E+00
2,4,6-TRICHLOROPHENOL	1.10E-02	NA	0.00E+00	NA	7.74E-03	0.00E+00

NOTE: RfD and Slope Factor (a.k.a. Cancer Potency Factor) values obtained from IRIS and/or HEAST 1992
Inhalation exposure is not a factor for these parameters; inhalation exposure pathway risk is not considered appropriate due to the non-volatile nature of these contaminants

TABLE 3-GROUNDWATER RISK-(HAZARD INDEX) BASED ACTION LEVELS
PESTICIDE/PCB COMPOUNDS
CHARLESTON NAVAL SHIPYARD
CHARLESTON, SOUTH CAROLINA

PARAMETER	SLOPE	SLOPE	REFERENCE	REFERENCE	CANCER	HAZARD
	FACTOR ORAL (MG/KG/DAY) ⁻¹	FACTOR INHALATION (MG/KG/DAY) ⁻¹	DOSE ORAL (MG/KG/DAY)	DOSE INHALATION (MG/KG/DAY)	RISK-BASED ACTION LEVEL (MG/L)	INDEX-BASED ACTION LEVEL (MG/L)
alpha-BHC	6.3	NA	0	NA	1.35E-05	0.00E+00
beta-BHC	1.8	NA	0	NA	4.73E-05	0.00E+00
delta-BHC	0	NA	0	NA	ERR	0.00E+00
gamma-BHC	1.3	NA	0.0003	NA	6.55E-05	2.55E-02
4,4'-DDT	0.34	NA	0.0005	NA	2.50E-04	4.26E-02
4,4'-DDD	0.24	NA	0	NA	3.55E-04	0.00E+00
4,4'-DDE	0.34	NA	0	NA	2.50E-04	0.00E+00
HEPTACHLOR	4.5	NA	0.0005	NA	1.89E-05	4.26E-02
AROCHLOR 1260	7.7	NA	0	NA	1.11E-05	0.00E+00

NOTE: RfD and Slope Factor (a.k.a. Cancer Potency Factor) values obtained from IRIS and/or HEAST 1992
Inhalation exposure is not a factor for these parameters; inhalation exposure pathway risk is not considered

TABLE 4-GROUNDWATER RISK-(HAZARD INDEX) BASED ACTION LEVELS
 INORGANIC COMPOUNDS
 CHARLESTON NAVAL SHIPYARD
 CHARLESTON, SOUTH CAROLINA

PARAMETER	SLOPE FACTOR ORAL (MG/KG/DAY) ⁻¹	SLOPE FACTOR INHALATION (MG/KG/DAY) ⁻¹	REFERENCE DOSE ORAL (MG/KG/DAY)	REFERENCE DOSE INHALATION (MG/KG/DAY)	CANCER RISK-BASED ACTION LEVEL (MG/L)	HAZARD INDEX-BASED ACTION LEVEL (MG/L)
ANTIMONY	0	NA	0.0004	NA	ERR	3.41E-02
ARSENIC	0.00	NA	0.00	NA	ERR	2.55E-02
BARIUM	0	NA	0.07	NA	ERR	5.96E+00
BERYLLIUM	4.3	NA	0.005	NA	1.98E-05	4.26E-01
CADMIUM	0	NA	0.001	NA	ERR	8.52E-02
CHROMIUM	0	NA	0.005	NA	ERR	4.26E-01
COPPER	0	NA	0.037	NA	ERR	3.15E+00
LEAD	0	NA	0.0014	NA	ERR	1.19E-01
MERCURY	0	NA	0.0004	NA	ERR	3.41E-02
NICKEL	0	NA	0.02	NA	ERR	1.70E+00
SELENIUM	0	NA	0.005	NA	ERR	4.26E-01
SILVER	0	NA	0.005	NA	ERR	4.26E-01
ZINC	0	NA	0.2	NA	ERR	1.70E+01

NOTE: RfD and Slope Factor (a.k.a. Cancer Potency Factor) values obtained from IRIS and/or HEAST 1992

Lead has been shown to be non-bioavailable at soil concentrations below 200 mg/kg (personal communication with Dr. Harlal Choudhury, USEPA/ECAO, June 1991)

TABLE 5-SOIL RISK-(HAZARD INDEX) BASED ACTION LEVELS
 VOLATILE COMPOUNDS
 CHARLESTON NAVAL SHIPYARD
 CHARLESTON, SOUTH CAROLINA

PARAMETER	SLOPE FACTOR ORAL (MG/KG/DAY) ⁻¹	REFERENCE DOSE ORAL (MG/KG/DAY)	CANCER RISK-BASED ACTION LEVEL (MG/KG)	HAZARD INDEX-BASED ACTION LEVEL (MG/KG)
BENZENE	2.90E-02	0.00E+00	1.69E+01	0.00E+00
CARBON TETRACHLORIDE	1.30E-01	7.00E-04	3.76E+00	1.47E+02
CHLOROBENZENE	0.00E+00	2.00E-02	ERR	4.19E+03
CHLOROFORM	6.10E-03	1.00E-02	8.02E+01	2.10E+03
DIBROMOCHLOROMETHANE	8.40E-02	2.00E-02	5.82E+00	4.19E+03
DICHLOROFLUOROMETHANE	0.00E+00	0.00E+00	ERR	0.00E+00
DIETHYL ETHER	0.00E+00	0.00E+00	ERR	0.00E+00
ETHYLBENZENE	0.00E+00	1.00E-01	ERR	2.10E+04
ETHYLENE DICHLORIDE	0.00E+00	9.10E-02	ERR	1.91E+04
ETHYLENE OXIDE	1.02E+00	0.00E+00	4.80E-01	0.00E+00
FORMALDEHYDE	0.00E+00	2.00E-01	ERR	4.19E+04
METHYLENE CHLORIDE	7.50E-03	6.00E-02	6.52E+01	1.26E+04
METHYLETHYL KETONE	0.00E+00	5.00E-02	ERR	1.05E+04
METHYLISOBUTYL KETONE	0.00E+00	5.00E-02	ERR	1.05E+04
1,1,2,2-TETRACHLOROETHANE	2.00E-01	0.00E+00	2.45E+00	0.00E+00
TETRACHLOROETHENE	5.00E-02	1.00E-02	9.79E+00	2.10E+03
TOLUENE	0.00E+00	2.00E-01	ERR	4.19E+04
1,1,1-TRICHLOROETHANE	0.00E+00	9.00E-02	ERR	1.89E+04
TRICHLOROETHYLENE	1.10E-02	0.00E+00	4.45E+01	0.00E+00
TRICHLOROFLUOROETHANE	0.00E+00	0.00E+00	ERR	0.00E+00
TRICHLOROFLUOROMETHANE	0.00E+00	3.00E-01	ERR	6.29E+04

NOTE: RfD and Slope Factor (a.k.a. Cancer Potency Factor) values obtained from IRIS and/or HEAST 1992
 Inhalation exposure is not a factor for these parameters.

TABLE 6-SOIL RISK-(HAZARD INDEX) BASED ACTION LEVELS
 SEMI-VOLATILE COMPOUNDS
 CHARLESTON NAVAL SHIPYARD
 CHARLESTON, SOUTH CAROLINA

PARAMETER	SLOPE FACTOR ORAL (MG/KG/DAY) ⁻¹	REFERENCE DOSE ORAL (MG/KG/DAY)	CANCER RISK-BASED ACTION LEVEL (MG/KG)	HAZARD INDEX-BASED ACTION LEVEL (MG/KG)
ACENAPHTHENE	0.00E+00	6.00E-02	ERR	1.26E+04
ACENAPHTHYLENE	0.00E+00	0.00E+00	ERR	0.00E+00
AMINOPYRIDINE	0.00E+00	2.00E-05	ERR	4.19E+00
ANTHRACENE	0.00E+00	0.00E+00	ERR	0.00E+00
BENZO(A)ANTHRACENE	4.30E-01	0.00E+00	1.14E+00	0.00E+00
BENZO(B)FLUORANTHENE	4.30E-01	0.00E+00	1.14E+00	0.00E+00
BENZO(K)FLUORANTHENE	4.30E-01	0.00E+00	1.14E+00	0.00E+00
BENZO(A)PYRENE	5.80E+00	0.00E+00	8.44E-02	0.00E+00
bis(2-ETHYLHEXYL)PHTHALATE	1.40E-02	2.00E-02	3.49E+01	4.19E+03
BUTYLBENZYLPHthalATE	0.00E+00	2.00E-01	ERR	4.19E+04
CHRYSENE	4.30E-01	0.00E+00	1.14E+00	0.00E+00
CRESOL	0.00E+00	5.00E-02	ERR	1.05E+04
p-DICHLOROBENZENE	2.40E-02	2.00E-01	2.04E+01	4.19E+04
DICHLORODIMETHYLHYDRANT	0.00E+00	0.00E+00	ERR	0.00E+00
DICHLOROPHENOL	0.00E+00	0.00E+00	ERR	0.00E+00
DIETHYLENE TRIAMINE	0.00E+00	0.00E+00	ERR	0.00E+00
DIETHYL PHTHALATE	0.00E+00	8.00E-01	ERR	1.68E+05
4,6-DINITRO-o-CRESOL	0.00E+00	0.00E+00	ERR	0.00E+00
2,4-DINITROTOLUENE	6.80E-01	2.00E-03	7.20E-01	4.19E+02
FLUORANTHENE	0.00E+00	4.00E-02	ERR	8.39E+03
FLUORENE	0.00E+00	4.00E-02	ERR	8.39E+03
METHYL CELLOSOLVE	0.00E+00	0.00E+00	ERR	0.00E+00
HYDRAZINE	3.00E+00	0.00E+00	1.63E-01	0.00E+00
INDENO(1,2,3-cd)PYRENE	0.00E+00	0.00E+00	ERR	0.00E+00
1-METHYLNAPHTHALENE	0.00E+00	0.00E+00	ERR	0.00E+00
2-METHYLNAPHTHALENE	4.90E-03	0.00E+00	9.99E+01	0.00E+00
NAPHTHALENE	0.00E+00	4.00E-02	ERR	8.39E+03
n-NITROSODIPHENYLAMINE	4.90E-03	0.00E+00	9.99E+01	0.00E+00
PENTACHLOROPHENOL	1.20E-01	3.00E-02	4.08E+00	6.29E+03
PHENANTHRENE	0.00E+00	0.00E+00	ERR	0.00E+00
PHENOL	0.00E+00	6.00E-01	ERR	1.26E+05
PYRENE	0.00E+00	3.00E-02	ERR	6.29E+03
2,4,6-TRICHLOROPHENOL	1.10E-02	0.00E+00	4.45E+01	0.00E+00

NOTE: RfD and Slope Factor (a.k.a. Cancer Potency Factor) values obtained from IRIS and/or HEAST 1992
 Inhalation exposure is not a factor for these parameters; inhalation exposure pathway risk is not considered appropriate
 due to the non-volatile nature of these contaminants

TABLE 7-SOIL RISK-(HAZARD INDEX) BASED ACTION LEVELS
 PESTICIDE/PCB COMPOUNDS
 CHARLESTON NAVAL SHIPYARD
 CHARLESTON, SOUTH CAROLINA

PARAMETER	SLOPE FACTOR ORAL (MG/KG/DAY) ⁻¹	REFERENCE DOSE ORAL (MG/KG/DAY)	CANCER RISK-BASED ACTION LEVEL (MG/KG)	HAZARD INDEX-BASED ACTION LEVEL (MG/KG)
alpha-BHC	6.3	0	7.77E-02	0.00E+00
beta-BHC	1.8	0	2.72E-01	0.00E+00
delta-BHC	0	0	ERR	0.00E+00
gamma-BHC	1.3	0.0003	3.76E-01	6.29E+01
4,4'-DDT	0.34	0.0005	1.44E+00	1.05E+02
4,4'-DDD	0.24	0	2.04E+00	0.00E+00
4,4'-DDE	0.34	0	1.44E+00	0.00E+00
HEPTACHLOR	4.5	0.0005	1.09E-01	1.05E+02
AROCHLOR 1260	7.7	0	6.35E-02	0.00E+00

NOTE: RfD and Slope Factor (a.k.a. Cancer Potency Factor) values obtained from IRIS and/or HEAST 1992
 Inhalation exposure is not a factor for these parameters; inhalation exposure pathway risk is not considered
 appropriate due to the non-volatile nature of the contaminants.

TABLE 8-SOIL RISK-(HAZARD INDEX) BASED ACTION LEVELS
 INORGANIC COMPOUNDS
 CHARLESTON NAVAL SHIPYARD
 CHARLESTON, SOUTH CAROLINA

PARAMETER	SLOPE FACTOR ORAL (MG/KG/DAY) ⁻¹	REFERENCE DOSE ORAL (MG/KG/DAY)	CANCER RISK-BASED ACTION LEVEL (MG/KG)	HAZARD INDEX-BASED ACTION LEVEL (MG/KG)
ANTIMONY	0	0.0004	ERR	8.39E+01
ARSENIC	0.00	0.00	ERR	6.29E+01
BARIUM	0	0.07	ERR	1.47E+04
BERYLLIUM	4.3	0.005	1.14E-01	1.05E+03
CADMIUM	0	0.001	ERR	2.10E+02
CHROMIUM	0	0.005	ERR	1.05E+03
COPPER	0	0.037	ERR	7.76E+03
LEAD	0	0.0014	ERR	2.94E+02
MERCURY	0	0.0004	ERR	8.39E+01
NICKEL	0	0.02	ERR	4.19E+03
SELENIUM	0	0.005	ERR	1.05E+03
SILVER	0	0.005	ERR	1.05E+03
ZINC	0	0.2	ERR	4.19E+04

NOTE: RfD and Slope Factor (a.k.a. Cancer Potency Factor) values obtained from IRIS and/or HEAST 1992

Lead has been shown to be non-bioavailable at soil concentrations below 200 mg/kg (personal communication with Dr. Harlal Choudhury, USEPA/ECAO, June 1991)

the action levels computed for soils and groundwater using the methods described below. Table 9 provides alternative action levels for groundwater based on the Maximum Contaminant Levels (MCLs) established by the US EPA. Table 10 provides the exposure assumptions for the soil exposure pathway. Figures 1 and 2 provide the expanded formulae for calculating groundwater and soil action levels, respectively.

Due to a lack of existing data (qualitative and quantitative) for the surface water, sediment and related exposure pathways (i.e. fish and shellfish, recreation uses, etc.), it is premature to speculate on establishing Action Levels for these media. Once a preliminary body of data (qualitative at a minimum) for surface water and/or sediment is available, Action Levels will be established for these media.

Action Levels have been established for each compound/element identified (or suspected to be present) in soil and groundwater during previous investigations. If additional parameters are identified in either medium during the initial phase of the RFI, these compounds/elements will be added to the list of potential contaminants of concern and Action Levels will be established for these parameters.

This approach is applicable because remediation to 'background' is not feasible under conditions that exist at the CNSY. The CNSY facility consists of heterogeneous fill material which was dredged from the adjacent Cooper River. Previous studies have attempted to establish 'background' concentration but have been unsuccessful due to the variability of media composition. Use of the risk-based approach is justified in that 1) establishment of true background contaminant concentrations is not feasible due to site conditions; 2) the industrialized nature of the surrounding areas increases the probability that non site-related anthropogenic contaminants are ubiquitous in the area of the facility; and 3) the final remedy selection process will be based on reduction of identified contaminant concentrations to below risk-based cleanup criteria.

The CNSY and surrounding parcels may be characterized as light to heavy industrial facilities. Historical information supplied in previous site investigation documents indicates that the area has been heavily developed for at least 50 years. Furthermore, it is anticipated that the area will continue to exist under current usage patterns for the foreseeable future. As a result, any human health risk assessment performed subsequent to the RFI would utilize industrial exposure scenarios to characterize risk posed by the site. By applying residential scenario exposure assumptions on the 'front end', an Action Level (or risk) buffer factor of an order of magnitude or more will be realized for both the soil and groundwater exposure pathways. The existence of the risk 'buffer' will assist in protecting against exceedance of cumulative risk limits for media which have been impacted by multiple contaminants.

It should be mentioned that the Action Levels established for soil and groundwater are not necessarily protective from the standpoint of cross media contaminant transfer. Subsequent to collection of RFI data for both environmental media composition and characteristics, it may be necessary to evaluate the following cross media transfer pathways:

- Soil to Groundwater Transport (Leaching)

TABLE 9-ALTERNATIVE GROUNDWATER ACTION LEVELS
 MAXIMUM CONTAMINANT LEVELS (MCLs)
 CHARLESTON NAVAL SHIPYARD
 CHARLESTON, SOUTH CAROLINA

PARAMETER	MCL (MG/L)	NOTES		MCL (MG/L)	NOTES
VOLATILE COMPOUNDS			SEMI-VOLATILE COMPOUNDS		
BENZENE	0.005	MCL	ACENAPHTHENE	NA	
CARBON TETRACHLORIDE	0.005	MCL	ACENAPHTHYLENE	NA	
CHLOROBENZENE	NA		AMINOPYRIDINE	NA	
CHLOROFORM	0.1	MCL	ANTHRACENE	NA	
DIBROMOCHLOROMETHANE	NA		BENZO(A)ANTHRACENE	0.0001	MCL
DICHLOROFLUOROMETHANE	NA		BENZO(B)FLUORANTHENE	0.0002	MCL
DIETHYL ETHER	NA		BENZO(K)FLUORANTHENE	0.0002	MCL
ETHYLBENZENE	0.7	MCL	BENZO(A)PYRENE	0.0002	MCL
ETHYLENE DICHLORIDE	0.005	MCL	bis(2-ETHYLHEXYL)PHTHALATE	NA	
ETHYLENE OXIDE	NA		BUTYLBENZYLPHTHALATE	0.1	MCL
FORMALDEHYDE	1	LIFEHA	CHRYSENE	0.0002	MCL
METHYLENE CHLORIDE	0.005	MCL	CRESOL	NA	
METHYLETHYL KETONE	0.2	LIFEHA	p-DICHLOROBENZENE	0.075	MCL
METHYLISOBUTYL KETONE	NA		DICHLORODIMETHYLHYDRANT	NA	
1,1,2,2-TETRACHLOROETHANE	NA		DICHLOROPHENOL	0.02	LIFEHA
TETRACHLOROETHENE	0.005	MCL	DIETHYLENE TRIAMINE	NA	
TOLUENE	1	MCL	DIETHYL PHTHALATE	5	LIFEHA
1,1,1-TRICHLOROETHANE	0.2	MCL	4,6-DINITRO-o-CRESOL	NA	
TRICHLOROETHYLENE	NA		2,4-DINITROTOLUENE	NA	
TRICHLOROFLUOROETHANE	NA		FLUORANTHENE	NA	
TRICHLOROFLUOROMETHANE			FLUORENE	NA	
			METHYL CELLOSOLVE	NA	
			HYDRAZINE	NA	
PESTICIDES/PCBs COMPOUNDS					
alpha-BHC	NA		INDENO(1,2,3-cd)PYRENE	0.0004	MCL
beta-BHC	NA		1-METHYLNAPHTHALENE	NA	
delta-BHC	NA		2-METHYLNAPHTHALENE	NA	
gamma-BHC	0.0002	MCL	NAPHTHALENE	0.02	LIFEHA
4,4'-DDT	NA		n-NITROSODIPHENYLAMINE	NA	
4,4'-DDD	NA		PENTACHLOROPHENOL	0.001	MCL
4,4'-DDE	NA		PHENANTHRENE	NA	
HEPTACHLOR	0.0004	MCL	PHENOL	4	LIFEHA
AROCHLOR 1260	0.0005	MCL	PYRENE	NA	
			2,4,6-TRICHLOROPHENOL	0.003	UNITRISK
INORGANICS					
ANTIMONY	0.003	MCLG			
ARSENIC	0.05	MCL			
BARIUM	2	MCL			
BERYLLIUM	0.001	MCL			
CADMIUM	0.005	MCL			
CHROMIUM	0.1	MCL			
COPPER	1.3	MCLTT			
LEAD	0.015	MCLTT			
MERCURY	0.002	MCL			
NICKEL	0.1	MCL			
SELENIUM	0.05	MCL			
SILVER	0.1	LIFEHA			
ZINC	2	LIFEHA			

NOTES: MCL=MAXIMUM CONTAMINANT LEVEL; MCLG=MAXIMUM CONTAMINANT LEVEL GOAL;
 MCLTT=TREATMENT TECHNOLOGY-BASED MCL; LIFEHA=LIFETIME HEALTH ADVISORY LEVEL
 UNIT RISK=WATER CONCENTRATION EQUIVALENT TO 10⁻⁶ RISK

TABLE 10 Assumptions for Ingestion and Dermal Contact Exposure to Soil Contaminants of Concern at the Charleston Naval Ship Yard^a		
Exposure	Future Child Resident	Future Adult Resident
ORAL		
Daily soil ingestion level	200 mg	100 mg
Fraction of time on-site in contaminated areas	100 % ^b	100 % ^b
Portion of ingested contaminant absorbed	100 %	100 %
Days per year on-site	350 days	350 days
Years on-site	6 years	24 years
Body weight	16 kg	70 kg
Lifetime	Averaging time based on 30 years for non-carcinogens, and 70 years for carcinogens (see Soil Exposure Formulae Key)	
DERMAL		
Skin area contaminated	2430 cm ²	2300 cm ²
Soil adherence per cm ² of skin	2 mg	2 mg
Portion of contaminant absorbed	0.01 ^c	0.01 ^c
Days per year on-site	350 days	350 days
Years on-site	6 years	24 years
Body weight	16 kg	70 kg
Lifetime	Averaging time based on 30 years for non-carcinogens, and 70 years for carcinogens (see Soil Exposure Formulae Key)	

^a References values from USEPA, RAGS, 12/89 and OSWER Directive #9285.6-03.

^bUniform contaminant distribution over the entire site area is assumed. No fraction of time factor was utilized in these calculations, uniform exposure to the entire site (conservative).

^c 1.0% dermal transfer assumed; includes consideration of soil matrix effect

Figure 1
Formulae for Calculating Action Levels for
Groundwater

The following formulae for computing groundwater risk (carcinogenic and non-carcinogenic) were excerpted from RAGS, Volume I, Part A. If carcinogenic risk is set equal to the 10^{-6} point of departure and the hazard index is set equal to unity (1), the formulae may be rearranged to calculate individual groundwater contaminant levels which will pose carcinogenic and/or non-carcinogenic risk above the standard thresholds.

FUTURE SITE RESIDENT

Cancer Risk Formula:

$$\text{Risk} = \frac{[\text{contaminant}] \times \text{EF} \times \text{ED} \times [(\text{CPF}_i \times \text{K} \times \text{IR}_i) + (\text{CPF}_o \times \text{IR}_w)]}{\text{BW} \times \text{AT} \times 365 \text{ days/year}}$$

Non-Carcinogenic Risk (Hazard Index) Formula:

$$\text{Hazard Index} = \frac{[\text{contaminant}] \times \text{IR}_w \times \text{EF} \times \text{ED}}{\text{RfD}_o \times \text{BW} \times \text{AT} \times 365 \text{ days/year}} + \frac{[\text{contaminant}] \times \text{K} \times \text{IR}_i \times \text{EF} \times \text{ED}}{\text{RfD}_i \times \text{BW} \times \text{AT} \times 365 \text{ days/year}}$$

Where:

BW= Body Weight= 70 kg

EF= Exposure Frequency= 350 days/year

CPF_i= Inhalation cancer potency factor= chemical-specific

K= volatilization factor= 0.0005 x 1000 L/m³

IR_w= daily water ingestion rate= 2 L/day

RfD_i= inhalation reference dose= chemical-specific

AT= Averaging Time= 70 years

ED= Exposure Duration= 30 years

CPF_o= Oral cancer potency factor= chemical-specific

IR_i= daily indoor inhalation rate= 15 m³/day

RfD_o= oral reference dose= chemical-specific

Risk (hazard index) formulae were obtained from USEPA's Risk Assessment Guidance for Superfund, Volume I, Parts A & B.

Figure 2
Formulae for Calculating Action Levels for Soil

The following formulae for computing soil risk (carcinogenic and non-carcinogenic) were excerpted from RAGS, Volume I, Part A. If carcinogenic risk is set equal to the 10^{-6} point of departure and the hazard index is set equal to unity (1), the formulae may be rearranged to calculate individual soil contaminant levels which will pose carcinogenic and/or non-carcinogenic risk above the standard thresholds.

SOIL INGESTION PATHWAY

Age-adjusted Ingestion Factor ($IF_{soil/adj}$)

$$IF_{soil/adj} \text{ (mg-yr/kg-day)} = \frac{IR_{soil/age1-6} \times ED_{age1-6}}{BW_{age1-6}} + \frac{IR_{soil/age7-31} \times ED_{age7-31}}{BW_{age7-31}}$$

where:

$IF_{soil/adj}$	age-adjusted soil ingestion factor (mg-yr/kg-day)	<u>Default Value</u> 114 mg-yr/kg-day
BW_{age1-6}	average body weight from ages 1-6 (kg)	16 kg
$BW_{age7-31}$	average body weight from ages 7-31 (kg)	70 kg
ED_{age1-6}	exposure duration during ages 1-6 (yr)	6 years
$ED_{age7-31}$	exposure duration during ages 7-31 (yr)	24 years
$IR_{soil/age1-6}$	ingestion rate of soil age 1 -6 (mg/day)	200 mg/day
$IR_{soil/age7-31}$	ingestion rate of soil age 7-31 (mg/day)	100 mg/day
$IF_{soil/adj}$	age-adjusted ingestion factor (mg-yr/kg-day)	114 mg-yr/kg-day

DERMAL CONTACT PATHWAY

Age-adjusted Contact Factor ($CF_{soil/adj}$)

$$CF_{soil/adj} \text{ (mg-yr/kg-day)} = \frac{SA_{age1-6} \times AF \times ED_{age1-6}}{BW_{age1-6}} + \frac{SA_{age7-31} \times AF \times ED_{age7-31}}{BW_{age7-31}}$$

where:

$CF_{soil/adj}$	age-adjusted contact factor (mg-yr-event/kg-day)	<u>Default Values</u> 3520 mg-yr-event/kg-day
SA_{age1-6}	skin surface area available for contact (cm ² /event)	2430 cm ² /event
$SA_{age7-31}$	skin surface area available for contact (cm ² /event)	2300 cm ² /event
AF	soil to skin adherence factor (mg/cm ²)	2 mg/cm ²
ED_{age1-6}	exposure duration during age 1-6 (yr)	6 yr
$ED_{age7-31}$	exposure duration during age 7-31 (yr)	24 yr

RISK (HAZARD INDEX) BASED ON COMBINED DAILY ABSORBED DOSE (INGESTION + DERMAL CONTACT)

Non-Carcinogens

Hazard Index =

$$(C_s \times ((IF_{soil/adj} \times 10^{-6} \text{ kg/mg} \times EF_R) / AT_{NC}) + ((CF_{soil/adj} \times 10^{-6} \text{ kg/mg} \times EF_R \times ABS) / AT_{NC})) / RfD$$

Carcinogens

Risk =

$$(C_s \times ((IF_{soil/adj} \times 10^{-6} \text{ kg/mg} \times EF_R) / AT_C) + ((CF_{soil/adj} \times 10^{-6} \text{ kg/mg} \times EF_R \times ABS) / AT_C)) \times SF_0$$

where:

C_s	Chemical concentration in soil	<u>Default Values</u> Chemical-specific
EF_R	Residential exposure frequency	350 days/year
AT_{NC}	Averaging time (non-carcinogen)	10,950 days
AT_C	Averaging time (carcinogen)	25,550 days
ABS^*	Absorption factor (unitless)	0.01
RfD	Reference Dose (mg/kg/day)	Chemical-specific
SF_0	Slope Factor (mg/kg/day) ⁻¹	Chemical-specific

Action Level Formulae Notes
Figures 1 and 2

Notes:

^aReference: USEPA, RAGS, Volume I, Part A, 12/89, pp. 6-40 and 6-41 and USEPA, RAGS, Volume I, Part B, pp. 23-25

^bOral and dermal absorbed doses for the soil pathway are combined within the formulae. The sum is then multiplied by the CPF (or SF_d) to obtain the upper bound risk. The sum is divided by the RfD to obtain the Hazard Index (unitless) for noncarcinogens. The exposure assumptions listed in Table 3 were applied for future site resident exposure scenarios.

^cAbsorbed doses for ingestion exposure are assumed to be the equivalent of administered doses (100% oral ingestion). Therefore, no conversion factor is incorporated into the associated formulae.

* - absorption factor assumes one percent of contaminants present in adsorbed soils will be absorbed by the exposed individual via the dermal contact pathway.

** - Absorbed dose for the dermal exposure pathway is assumed to be 1% of the administered (adsorbed) dose.

- Groundwater to Surface Water Transport (Gaining Stream Phenomena)
- Soil to Air Transport (Volatilization and Fugitive Dust)
- Surface Water/Sediment Partitioning and Transport

Any data gaps which exist for the evaluation of these phenomena may be filled during subsequent RFI phases or during the CMS (if applicable).